DEVELOPING INTERACTIVE VOCABULARY LEARNING MULTIMEDIA FOR THE STUDENTS OF PHYSICS EDUCATION DEPARTMENT YOGYAKARTA STATE UNIVERSITY IN THE ACADEMIC YEAR OF 2012/2013

A THESIS

Presented as a Partial Fulfilment of the Requirement for the Attainment of *Sarjana Pendidikan* Degree in English Language Education

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APPROVAL SHEET

The thesis entitled *Developing Interactive Vocabulary Learning Multimedia for the Students of Physics Education Department Yogyakarta State University in the Academic Year of 2012/2013* has been approved by the supervisor and is ready to be examined.

Approved on 7 June 2014

by

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RATIFICATION

The thesis entitled *Developing Interactive Vocabulary Learning Multimedia for the Students of Physics Education Department Yogyakarta State University in the Academic Year of 2012/2013* has been accepted by the Board of Examiners of Faculty of Languages and Arts, Yogyakarta State University, on 7 July 2014 and declared to have fulfilled the Requirements for the Attainment of a *Sarjana Pendidikan* Degree in English Language Education.

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PERNYATAAN

Yang bertanda tangan di bawah ini, saya

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Yogyakarta, 7 Juni 2014

Penulis,

Alvan Bastoni Nuradila

MOTTOS

"Everyone has been made for some particular work,
and the desire for that work has been put in every heart."
-Rumi-

"Never forget people who underestimate you,
and always respect those who trust you.
Both are important to achieve what you pursue"
-Anonymous-

'Every era serves different war,
find your ultimate weapon"
-Anonymous-

DEDICATIONS

"I dedicate this thesis to my parents. Thank you for your support, pressure and most importantly, patience. This thesis is also dedicated to those who fulfill their dream by following their true path."

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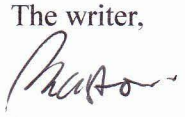
Finally, I wish to express my love and gratitude to my beloved family for their understanding and endless love.

Yogyakarta, 7 June 2014
The writer,



Alvan Bastoni Nuradila

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DEVELOPING INTERACTIVE VOCABULARY LEARNING MULTIMEDIA FOR THE STUDENTS OF PHYSICS EDUCATION DEPARTMENT YOGYAKARTA STATE UNIVERSITY IN THE ACADEMIC YEAR OF 2012/2013

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ABSTRACT

The aims of this study are: 1) to find out the target needs of students of Physics Education Department in learning English for *Fisika Zat Padat*, 2) to find out the learning needs of students of Physics Education Department in learning English for *Fisika Zat Padat*, and 3) to develop interactive vocabulary learning multimedia for students of Physics Education Department in learning English for *Fisika Zat Padat.*

This study is an Educational Research and Development (R & D) study. The model proposed by Lee and Owens (2004) is adapted and used in this research. The procedure is conducting needs analysis, design, development, and evaluation by content and media experts. The subjects of this research are the sixth semester students of Physics Education Department Yogyakarta State University in class A. Questionnaires, observation, and interview are used to collect the data. The data are analyzed qualitatively and quantitatively.

The findings of this study are described as follows. 1) The sixth semester students learn English in order to read their textbooks. 2) They want to learn vocabulary about the subject of *Fisika Zat Padat* in chapter 4 through explicit instruction using multimedia to know the definition, meaning, part of speech, and pronunciation of the target words by match the word with its definition and its meaning, dictionary activity, guess a meaning, flash card study, match the word with its image representation, crossword puzzle game, and complete some sentences. 3) The Units developed based on the target and learning needs are appropriate based on the result of expert judgment. It is indicated by the mean value ($\bar{x}$) obtained from the content and media expert. The range of the mean value of the data collected from language expert is 4 to 5 for all of four units. The range of the mean value from subject expert is also 4 to 5. The range of the mean value obtained from the media expert is 4.3 to 5. Based on the quantitative data conversion by Sudjono, (2003: 335), they fall in Good and Very Good categories. This study also suggests that the appropriate interactive vocabulary learning multimedia for the students of Physics Education Department, Yogyakarta State University consist of three parts, introduction, main part and summary.

CHAPTER I

INTRODUCTION

This chapter presents background of the study, identification of the problem, limitation of the problem, formulation of the problem, objectives of the study, and the significance of the study.

A. Background of the Study

In Physics Education Department of Yogyakarta State University, English is used to the read textbook. The students cannot rely only on the textbook in *Bahasa Indonesia*, but they also have to read textbook in English in order to master the subject. Here they find that it is difficult to relate the meaning of the words about physics in *Bahasa Indonesia* and in English. They are not familiar with the physics terms in English and other words that they rarely meet on the common use of English. To make them understand the subject from English textbooks, the lecturer often asks them to work in group and read the textbook, translate all the material needed, and then present it to the others. The students realize that they need to understand the materials in the textbooks, and that kind of classroom activity is not an effective ways of learning Physics because they spend their concentration over the translation rather than understanding their field of study which is Physics.

From the above explanation it can be seen that the primary use of English for the students of Physics Education Department is to understand their textbooks. It

means that they deal with English for academic purposes. Stiller and Grabe in Celce-Murcia (eds, 2001) stress the importance of a large recognition of vocabulary that is needed by the students in reading academic text.

They state that to comprehend an academic text, the learners need to develop essential reading processes and abilities such as rapid word recognition, vocabulary development, text-structure awareness, and strategic reading. Vocabulary development is identified as a part of recognizing process of the complex nature of reading through meaningful instruction.

The learners have to identify the words and to construct the meaning from what they read. Understanding vocabulary used in the text is a requirement to understand the meaning of the whole text and the purpose of the text.

Despite the importance of vocabulary understanding for the students of Physics Education Department, they only have 2 credits semester of English subject. The materials presented by the English lecturer are often inappropriate with their target use of English in Physics subject. They feel that they still inadequate to fully comprehend the textbooks in English. In an effort of make the students understand the textbook, Physics lecturers have to do a double job. They have to teach the Physics subject and they also have to teach the students the unknown words. It makes their classroom teaching and learning process less effective. What the students need is an English learning material that is closely related to what they are dealing with in the Physics subject especially in learning materials which can help them to understand

their Physics textbook. For that reason, they need to be facilitated and to be given with more engagement to do activities that lead to vocabulary learning.

Applying more sophisticated technology in teaching vocabulary can be the solution of this problem. Technology allows the development of an interactive learning multimedia which is attractive and yet effective in teaching vocabulary. While the textbooks only present texts and pictures, interactive multimedia offer much more than that as multimedia means combination of multiple media elements such as audio, video, graphics, text, and animation.

Using interactive learning multimedia in teaching and learning activities give benefit to the both of the lecturer and the students. The students are able to interact with the program so they will be stimulated to use the language which gives them advantage from learning vocabulary through textbooks. An attractive and authentic content gain the students' interest in learning English and hopefully they understand much better than if they only rely on the lecturer and dictionary. In line with that, the students can deepen their knowledge of the materials in the class by having discussion with their fellow and the lecturer, not merely present what they have translated from the textbooks. As for the Physics lecturer, it make their classroom activities more effective. The lecturer have extra time to teach the Physics materials to the students instead of helping the students in understanding the words in the textbook.

In fact, an interactive learning multimedia for learning vocabulary is not impossible to get. It can be gained by downloading or purchasing it from the internet

website. Unfortunately, the software still inadequate to be implemented since there is no interactive vocabulary learning multimedia about Physics. Concerning with that condition, the researcher had no other way but to develop the interactive learning multimedia based on the learners' needs and their level of proficiency.

Due to the facts above, this study is an attempt to develop the interactive vocabulary learning multimedia for the students of Physics Education Department of Yogyakarta State University. This media can be used especially outside of the classroom as a supplementary or additional source of vocabulary learning.

B. Identification of the Problem

Based on the observation, some problems related to the use of English for Students of Physics Education Department are identified. They use English to read their books concerning Physics subjects, in other words they use English for academic reading. Most of them admit that they feel difficult to cope with reading comprehension of the textbooks in their Physics subjects. In fact, they have to deal with so many textbooks in various subjects in their whole college study. In their first year, the students face some subjects that use English textbooks which are metode *Pengukuran Fisika, Kalkulus, Analisis Pengukuran Fisika, Matematika Fisika 1*, and *Mekanika*

In the second year, the subjects that use English textbook are *Getaran Gelombang, Termodinamika, Teori Relativitas Khusus, Mekanika Analitik, Matematika Fisika III*

English textbooks are also used in the subjects in their third year such as *Fisika Zat padat*, and *Mekanika Fluida*.

C. Limitation of the Problem

The focus of this study is to develop interactive vocabulary learning multimedia for the students of Physics Education Department Yogyakarta State University. It is designed for teen-adult users who want to improve their vocabulary mastery. The materials included in the media are some vocabularies related to the subject study of *Fisika Zat Padat* for sixth semester students of Physics Education Department Yogyakarta State University in class A. The third year students are selected since soon they are expected to end their study and in that limited time they have to master the Physics subject that they haven't understand yet.

The product is expected to be a supplementary source and media for vocabulary learning of students of Physics Education Department to be used especially outside of the classroom. By using interactive media, the learners are expected to be more engaged and emphasized in learning vocabulary and thus will help them in using English for their academic purpose.

D. Formulation of the Problem

Based on background of the problem, identification of the problem limitation of the problem above, the problems in this research are formulated as:

1. What are the target needs of students of Physics Education Department in the subject of *Fisika Zat Padat*?

2. What are the learning needs of students of Physics Education Department in the subject of *Fisika Zat Padat*?
3. What is the appropriate interactive vocabulary learning multimedia for students of Physics Education Department in the subject of *Fisika Zat Padat*?"

E. Objectives of the Study

In line with the formulation of the problem, the objective of this study are presented as follow:

1. To find out the target needs of students of Physics Education Department in the subject of *Fisika Zat Padat*.
2. To find out the learning needs of students of Physics Education Department in the subject of *Fisika Zat Padat*.
3. To develop appropriate interactive vocabulary learning multimedia for students of Physics Education Department in the subject of *Fisika Zat Padat*.

F. Significance

This study is expected to give some contributions to the English teaching and learning process at Physics Education Department Yogyakarta State University. The expected contributions are as follows:

1. The result of this study helps the students of Physics Education Department Yogyakarta State University in an effort to develop their vocabulary knowledge so they are able to develop their English proficiency to understand their textbook.
2. The result of this study is useful for Physics lecturer of Physics Education Department Yogyakarta State University in helping the teaching and learning

process in the subject of *Fisika Zat Padat* by providing the students a multimedia for vocabulary learning to understand their textbook.

3. The result of this study is useful for English lecturer in providing the students of Physics Education Department Yogyakarta State University a multimedia for vocabulary learning to understand their textbook. It also motivates them to conduct a similar research and develop another interactive learning multimedia.
4. The result of this study is used as a reference to conduct a research related to a research and development study on different cases.
5. The result of this study is useful for other media developers for conducting similar research and developing other interactive multimedia that help English learning process especially in vocabulary learning.

CHAPTER II

LITERATURE REVIEW AND CONCEPTUAL FRAMEWORK

This chapter presents a detailed discussion on some theories that supports the study. The discussion is divided into two sections which are literature review and conceptual framework. The first section describes some theories which present as a foundation for this study. The second section summarizes the researcher's framework and the steps in designing interactive learning multimedia for listening materials.

A. Literature Review

1. Vocabulary

a. The Definition of Vocabulary

Hornby (2000: 144) defines vocabulary as: (1) all the words that a person knows or uses; (2) all the words in particular language; (3) the words that people use when they are talking about a particular subject; (4) a list of words with their meaning.

In line with that, Samir (2007) states that, "vocabulary refers to a list or set of words for a particular language or a list or set of words individual speakers of a language might use". Native speakers used certain language which consists of words in their communication. The words of the native speaker used are enlisted in vocabulary.

Moreover, Thornbury (2002: 14) asserts that, “vocabulary means a large collection of items”. The items that he means are words. With a good knowledge of words the learners will have a better understanding of a text.

Vocabulary is a core component of language proficiency that becomes the basis knowledge for how the learners listen, speak, read and write (Richard & Renandya: 2002). He adds that extensive vocabulary and strategies for acquiring new vocabulary learners will get their true potential to use the language such as for listening, speaking reading or writing. Therefore having a good knowledge on vocabulary will help the learners to achieve a better result in learning language since they are able and importantly have courage to use the language in different context.

Furthermore, Hiebert & Kamil (2005: 3) define vocabulary as “the knowledge of meanings of words”. He adds that this definition makes vocabulary comes into oral vocabulary which is used in daily communication and print vocabulary which is not used in daily communication but in certain text. Besides, there are also receptive vocabulary which can be understood or recognized and productive vocabulary which can be used to write or speak.

In conclusion, vocabulary is the list of words and its meaning that serve as basic knowledge needed by the people in order to understand the words and how to use the words appropriately depend on the purpose of the words, whether to use them to express ideas or to grasp meaning from texts.

b. The Importance of Vocabulary

To be able to comprehend a text, learners need to have knowledge of vocabulary. According to Whipple (in Hiebert and Kamil, 2005: 1), vocabulary is an important aspect in reading comprehension, he says that "Growth in reading power means, therefore, continuous enriching and enlarging of the reading vocabulary and increasing clarity of discrimination in appreciation of word values". The vocabulary knowledge is so important that it will affect in the learners' comprehension in reading text. Davis in Hiebert and Kamil, (2005:1) described comprehension as comprised of two skills: word knowledge or vocabulary, and reasoning.

Vocabulary is a list of words and its meaning. In accordance with the words, Hayes, Wolfer, & Wolfe in Hiebert and Kamil (2005: 1) argue that, the complexity and the multiple meaning of the words are needed to be understood according to the context in the texts. The learners expected to understand the words in texts and also to understand many new words.

Besides, Wilkins in Thornbury (2002: 13) states that "without grammar very little can be conveyed, and without vocabulary nothing can be conveyed". Vocabulary is the main aspect in using language. With grammar, language users may only use language a little but with vocabulary language users are able to learn more about words and expression and therefore they can say almost anything.

The relation between vocabulary knowledge and reading comprehension is so tight. Biemiller in Hiebert and Kamil (eds, 2005: 223) found that the correlation of written vocabulary test to reading comprehension test is so high and

effectively equivalent, even the result says that r = 0.95. He adds that although the vocabulary knowledge has an essential factor in comprehending the text, many learners are able to read the words but fail at the level of understanding the meaning.

Moreover, National Reading Panel (2000) states that vocabulary is one of two aspects of comprehension instruction beside comprehension strategy instruction.

Furthermore, Bromley (2004: 2-3) argues that vocabulary is an asset for the learners. Words give the learners concepts of their sounds (phoneme) and meaning (morpheme). Vocabulary knowledge assists some roles in teaching and learning process as mentioned below:

1) Promoting fluency

Learners who understand many words read more quickly. Fluent readers read at a faster rate, process materials more quickly, and have better comprehension.

2) Boost comprehension

Researchers argue that vocabulary knowledge affect comprehension. It is stated that on a component of comprehension words meaning serve 74% of comprehension (Davis, 1942).

3) Improve achievement

Vocabulary knowledge assists learners' conceptual knowledge of the text and thus academic learning become easier. Stahl & Fairbanks (1986) research

shows that learners with better vocabulary knowledge score higher on achievement test.

4) Enhances thinking and communication

Words are used by the language user to analyze, infer, evaluate and reason. Large vocabulary knowledge allows language user to communicate in precise, powerful, persuasive and interesting ways.

c. The Nature of Vocabulary Acquisition

Different with listening, speaking, reading, and writing, vocabulary has its own characteristic of how it is understood by the learners. Hiebert & Kamil (2005: 2) states that "vocabulary is not a developmental skill or one that can ever be fully mastered. The expansion and elaboration of vocabularies is something that extends across a lifetime". It is almost impossible to understand all of the vocabularies of a language because language is about words and there are so many words that registered in certain language and even language itself is always develop and also change. The knowledge of vocabulary will be developed along with the learner's occurrence with the language. So, it is expected that the more the learners deal with the language the more knowledge of vocabulary that they can learn.

Schmitt (2002) proposes that an advanced language learner knows approximately ten thousand words. There is a difficulty in understanding of how learners learn those huge amounts of words. However, vocabulary acquisition has some essential features. First, vocabulary acquisition needs a gradual learning of different knowledge that belongs to single word (its spelling, its meaning, its use,

etc). Concerning with its numerous aspect of understanding, the learning process of vocabulary acquisition cannot be done at once.

He adds that there are some features dealing with vocabulary acquisition. One of those features is concerning with vocabulary acquisition's incremental nature. It refers to the gradual learning of different knowledge types that belong to a single word. The word cannot be fully learned in one time. Based on his research, he states that learners first learned a words' spelling, then the meaning of the words. There is also a continuum which the learners learned a word's basic meaning first and then learned other meanings of the word. It means that complete knowing of a word takes time.

The next feature is that vocabulary acquisition also deals with the distinctive between receptive and productive vocabulary. Receptive vocabulary is those which used to recognize and understand a word in written or spoken, however productive vocabulary is those which used to enable learners to express their meaning. Learners have to be able to recognize the different and the usage of those kinds of vocabulary.

The last feature is about retaining fragility. The learners may forget some knowledge about words in the process of vocabulary acquisition. Especially in the L2 learning, the learners more likely forget lexical knowledge than grammatical knowledge. So, vocabulary knowledge should be recycled systematically so the learners can retain the knowledge. Furthermore, the fragility of vocabulary knowledge exists because "vocabulary is made up individual units rather than a series of rules". Therefore, whether vocabulary items are learned partly or

completely, they should be recycled systematically to help strengthen the retaining process.

Vocabulary acquisition is processed by immersing the learners in certain kind of exposure over a period of time. Those exposures will affect the learners when they are dealing with English. Some occurrence such as when the learners of L2 feel like they have seen a particular word in a text or hear the words in certain conversation showed that they are in the process of vocabulary acquisition.

d. Vocabulary Size and Vocabulary to be Learnt

Thornbury (2002: 21) states that to be able to join conversation in daily communication, learners should know at least 2000 words. These are words that used in dictionary for language learners which native speaker usually used in daily communication. He also states that knowing 2000 words make the readers understand nearly nine out of ten words in most of written text.

In relation to the reading comprehension, the first 2000 high frequency words serve 80% of words in English text. Understanding all of those words makes the learners considerably to be described as having a good degree of comprehension of a text. In learning English for General purposes, the learners need to understand the most frequent 2000 words of English to have a good reading comprehension of a text. However, in reading academic texts, the learners need to understand 1000 more words from the most frequent words of academic texts (Nation in Hiebert and Kamil, 2005). The words that they should know include word families in which a base word and all of its derivation and inflection is count as one (Cameron, 2001). Regarding those vast amounts of vocabulary,

Cobb (1999) states that generally foreign language learners do not have enough time to learn those words incidentally.

Regarding with EFL context, Richard and Renandya (2002: 256) say that 4,500 target words identified in Cambridge English Lexicon (Hindmarsh, 1980) are needed to be taught to the school learners. For the learners in tertiary education studies, 3000-5000 words are suggested.

National Reading Panel Report (2000) does not mention about which vocabulary to be learnt by the students in connection to reading comprehension. It means that the words that should be taught in the syllabus remain a question. However some researchers have investigated some variables that should be considered in determining which word should be taught to the learners.

Related to the syllabus of learning vocabulary, Thornbury (2002: 14) suggests that lexical syllabus may be put into consideration. This syllabus is developed based on the frequency degree of the words in spoken and written forms. The other syllabus that can be highlighted is the use of lexical chunk as the basis of its development. Lexical chunk or multi-unit words is group of words that fixed or semi-fixed function in meaningful unit. Both of this syllabus help develop a new science in vocabulary syllabus which is called corpus linguistic.

According to Bennett (2010) a corpus is basically a collection of text that stored in the computer which can be gathered from spoken and written text. The important point is that the language in the corpus has to be natural. McCarten (2007: 2-3) argues that essentially there are some information that corpus about vocabulary can give us which are as mentioned below.

1) frequency: which words and expressions are most frequent and which are rare
2) differences in speaking and writing: which vocabulary is more often spoken and which is more often written
3) contexts of use: the situations in which people use certain vocabulary
4) collocation: which words are often used together
5) grammatical patterns: how words and grammar combine to form patterns
6) strategic use of vocabulary: which words and expressions used to organize and manage discourse

Concerning with reading academic text, Grabe and Stiller in Celce-Murcia (eds, 2001) describe the ways to choose the words to be learnt. The words should be categorized as follow.

1) + + : critical for comprehending the text and useful in other setting

2) + - : necessary for comprehending but not particularly useful in other context

3) - - : not necessary for comprehending the text nor in other context

The words in category + + and + - should be taught to the learners in direct instruction while those in category - - should be omitted. They suggest that it will be efficient to use not too many words at one time since presenting a large number of vocabularies at one time is not an effective teaching strategy.

e. Knowing a Word

Knowing a word is essential to understand vocabulary. It is likely the main purpose of learning vocabulary. To be able to know a word there are some aspects that should be concerned by the learners. They have to understand what is meant by knowing a word and the characteristics of knowing a word.

According to Thornbury (2002: 15), “At the most basic level, knowing a word involves knowing its form and meaning”. He adds that the form of a word is not enough to make the learners know about its meaning, they need to know its dictionary meaning. After the learners know the dictionary meaning of the word,

they also have to know what the word is usually associated with (its collocation) and its connotation, including its register and its cultural accretions.

Learners may think that learning a word means that they have to learn its pronunciation, spelling and meaning. In fact, a single word is not only formed from pronunciation, spelling and meaning. It is go beyond those aspects. For the learners to be called as knowing a word they have to have knowledge in the aspects of a particular word's pronunciation, spelling, word parts, meaning, grammatical properties, collocations, and contextual factors effecting its appropriate use (Nation in Herbert and Kamil, 2005)

In addition, Harmer (1991:158) proposes that knowing a word means more than just knowing its meaning, but also knowing word use, word formation, and word grammar. Considering with the word meaning, we have to set the thought that context where the word is used and its relation toward the other words will determine the word meaning. Word use also influence the state of knowing a word. Metaphors and idioms, collocation, and also style and register are ways to use words in various texts. The next concern is word formation which related to its part of speech, affixes, spelling and pronunciation. And the last is the word grammar which concern with its grammatical context such as noun, verb, adjective, etc. The diagram of knowing a word by Harmer (1991) is shown below.

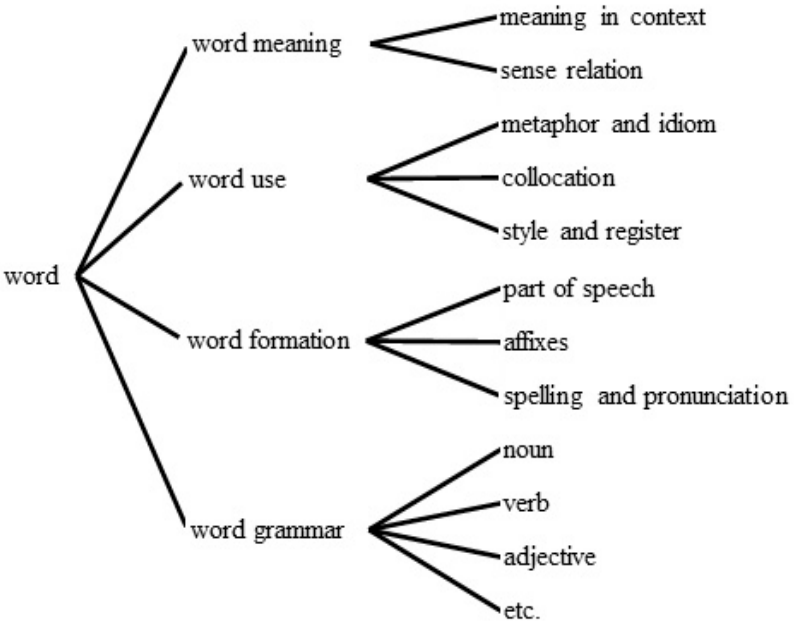


Figure 2.1. Diagram of Knowing a Word by Harmer (1991)

Related to vocabulary in academic reading, the learners should know about the word's meaning in context, the word's part of speech, its pronunciation and its parts (August: 2009, Grabe and Stiller: 2001).

f. Kinds of Vocabulary

Vocabulary knowledge is used to deal with different forms and purposes. Based on its form, Hiebert and Kamil (2005: 3) propose that vocabulary comes in two forms which are oral and print vocabulary. Oral vocabulary is the set of words for which we know the meanings when we speak or read orally. Print vocabulary consists of those words for which the meaning is known when we write or read silently. At the beginning readers, the words that they know are mainly oral vocabulary, then as they learn to read, print vocabulary plays greater role to understand the text rather than oral vocabulary.

Beside the oral vocabulary and print vocabulary, some researchers (Hiebert and Kamil, 2005; Nation, 2001; and Corson, 1997) state that vocabulary comes in productive and receptive vocabulary. Productive vocabulary is the set of words that an individual can use when writing or speaking. Corson (1997) calls this as motivated vocabulary. They are words that are well-known, familiar, and used frequently especially in daily communication. Receptive is that set of words for which an individual can assign meanings when listening or reading. Corson (1997) calls this as unmotivated vocabulary. The words included are those that rarely known and used by the learners. He adds that unmotivated vocabulary divided into two which are 1) words that the learners know imperfectly, and 2) words that not needed in daily communication.

Webb's (2009) concludes that receptive learning lead to larger learning development in receptive meaning while productive learning have a good impact on both receptive and productive form, and in-depth productive knowledge. Both of them can be used in learning process. However teachers may use receptive learning tasks to save time.

In addition, Hoffman (1993: 232) distinguishes vocabulary into two categories which are the core vocabulary and the peripheral vocabulary. The core vocabulary is vocabulary that contains the words used every day. The peripheral vocabulary is the vocabulary that is used only frequently and in certain occasion.

Another classification is made by Nation (2001) as presented below who puts vocabulary in the non-fiction texts into 4 categories:

1) High Frequency Words : this vocabulary constitute 80% of the running words in the text
2) Academic Words: this vocabulary cover 10% of the general academic text
3) Technical Words: this vocabulary made up about 5% of academic text
4) Low Frequency Words: this vocabulary cover 5% of running words in the text

Beck, McKeown, and Kucan (2002) classify vocabulary into three classes. They classification are presented as follow.

1) Tier One words

Tier One words are the words that used in everyday speech usually learned in the early grades. Although average native speaker do not consider them as a challenge, English language learners of any age have to give careful attention to them.

2) Tier Two words

Tier Two words usually refer to as general academic words. These words are more likely to appear in written texts than in speech. They appear in all sorts of texts: informational texts (i.e., relative, vary, formulate, specificity, and accumulate), technical texts (i.e., calibrate, itemize, periphery), and literary texts (i.e., misfortune, dignified, faltered, unabashedly). Tier Two words often saying relatively simple things in subtle or precise ways. Since Tier Two words are found across many types of texts, they are highly generalizable.

3) Tier Three words

Tier Three words are often referred to as domain-specific words. These words are specific to a domain or field of study (i.e., lava, carburetor, legislature, circumference, aorta) and they are keys to understanding a new concept within a text. Because of their specificity and close ties to content knowledge, Tier Three words are far more common in informational texts than in literature. Recognized as new and "hard" words for most readers (particularly student readers), they are often explicitly defined by the author of a text, repeatedly used, and otherwise heavily scaffolded (e.g., made a part of a glossary).

g. Procedure of Vocabulary Learning

Hunt and Beglar in Richard and Renandya (eds, 2002: 259) propose three approaches in vocabulary teaching and learning. They are presented as follow.

1) Incidental learning

It is expected that L2 learners require many vocabulary exposures since for native speakers themselves, a single exposure of vocabulary gives 10% chance that they learn the meaning from context. Thus the learners need more than a one-time exposure. The exposure can be gathered not only by reading, but also extensive listening. The teacher may assign extensive reading to add the exposure.

2) Explicit instruction

Explicit instruction or direct instruction relies on the identification of vocabulary target for the learners. It involves diagnosing the words learners need to know, presenting the new words, elaborating words knowledge, developing frequency with known words. Stahl and Fairbanks, (1986) argue that after specific

content-area terms have been taught in a specific way, it raises the learners comprehension ability to the 83rd percentile.

3) Independent strategy development

Promote the learners to guess meaning from context and use dictionary is important features of independent strategy development. This strategy provides the learners knowledge to be autonomous learners.

Teaching method is another thing that should be considered in developing vocabulary learning material. National Reading Panel (2000) identifies five methods of teaching vocabulary which are:

1) Explicit Instruction

Learners are given with specific algorithms or external cues to connect the words with meaning. A common example of this technique is the pre-teaching of vocabulary prior to reading a selection.

2) Indirect Instruction

In this method learners are exposed to words by doing a great deal of reading. It is assumed that students will infer any definitions they do not have. This implicit method simply suggests that students should be encouraged to do wide reading to increase vocabulary.

3) Capacity method

Reducing the cognitive capacity is the aim of this method. It focuses on making reading activity automatic. These methods allow the student to concentrate on meaning of words rather than their oral representations.

4) Association Methods

Learners are encouraged to draw connections between their background knowledge and the unfamiliar words. These associations can be semantic, contextual or even based on students' imagery in learning the words.

5) Multimedia Methods

Vocabulary is taught by going beyond text to include other media such as graphic representations, hypertext, and semantic mapping.

Related to instruction in building reading comprehension, National Reading Panel (2000) identifies eight specific findings concluded from many researches to be put into concern of vocabulary instruction. Here are the findings.

a) There is a need for direct instruction of vocabulary items required for a specific text.
b) Repetition and multiple exposures to vocabulary items are important. Students should be given items that will be likely to appear in many contexts.
c) Learning in rich contexts is valuable for vocabulary learning. Vocabulary words should be those that the learner will find useful in many contexts. When vocabulary items are derived from content learning materials, the learner will be better equipped to deal with specific reading matter in content areas.
d) Vocabulary tasks should be restructured as necessary. It is important to be certain that students fully understand what is asked of them in the context of reading, rather than focusing only on the words to be learned. Restructuring seems to be most effective for low-achieving or at-risk students.
e) Vocabulary learning is effective when it entails active engagement in learning tasks.
f) Computer technology can be used effectively to help teach vocabulary.
g) Vocabulary can be acquired through incidental learning. Much of a student's vocabulary will have to be learned in the course of doing things other than explicit vocabulary learning. Repetition, richness of context, and motivation may also add to the efficacy of incidental learning of vocabulary.
h) Dependence on a single vocabulary instruction method will not result in optimal learning. A variety of methods was used effectively with emphasis

> on multimedia aspects of learning, richness of context in which words are to be learned, and the number of exposures to words that learners receive.

In relation to academic reading, Grabe and Stiller in Celce-Murcia (ed, 2001) recommend some phases to be conducted in vocabulary teching and learning process which are:

1) focusing the key words

Key words are important in determining the target words and its learning activities. The learning activities should be built around those key words.

2) keeping the words active

Exercises and activities are needed to emphasize the target vocabulary. Explicit instruction can be used to save time. The words should be recycled in another task to ensure the learners get enough exposure and can retain the words in their long-term memory. Those tasks should be explored as part of discussion about the text and the meaning of the text. In other words the goal of the task is to help the learners in knowing the words to be used in comprehending the text.

3) incorporating them into a larger learning project

To make the leaners fully understand the words, they need to use it in a larger learning project. The larger learning project can be in the form of finding specific information about the text, summarizing, making an essay about the text or other learning project based on the learners' needs and target situation.

Moreover, Marzano (2004) also develops six steps of explicit vocabulary instruction that can be conducted in all across learners' proficiency. The steps are presented below.

1) A description, explanation, or examples of the new term are provided for the students.

Although it gives the words' definition, looking up words in dictionaries is not an effective activity since the text may have different context with the dictionaries. So context that provided by the materials is important to help the leaners in understanding the words along with teacher's explanation in everyday language. The teacher may give example that connects the words to the real world. A mental imagery of the words may be used to describe the words. The important thing that must be noted that elements which make the learners understand the words should be provided including the words' pronunciation.

2) Students restate the explanation of the new term in their own words.

To make the target words stored in the students' long term memory, they should state their own description, representation, and the new insight of the target words. They have to use their own words in restating what the teacher has presented before. The students may discuss it in groups and record the result on their vocabulary notebook.

3) Students create a nonlinguistic representation of the term.

The nonlinguistic representation can be in the form of graphic organizer, picture or pictographs. The picture should be simple and can be in the form of symbol. It does not have to be overdrawn. A simple sketch is enough to represent the words. The picture may not directly represent the words but it can a picture related to the word. The teacher may give the example first to help the leaners.

In deciding which word that is possible to be represented by an image, we should see the concreteness and the imageability of the word. Concreteness refers to the ease with which a word's referent can be experienced by the senses while imageability refers to the ease with which a word's referent can stimulate a mental image in a person's mind (Paivio, Yuille, & Madigan, 1968).

4) Students periodically do activities that help them add to their knowledge of vocabulary terms.

The students have to be given with certain amount of exposure. They should also meet the words in various ways. Highlighting the word's part will help them to remember the target words. They may put the words into certain classification, compare the similarities and differences among the words, and revisit the original description of the words to enhance the understanding. Translating the words is a good activity for L2 learners.

5) Periodically students are asked to discuss the terms with one another.

Discussing the words among themselves will deepen their understanding. They may compare their words' description, describe their picture to one another, explain the new information about the words, and seek clarification upon disagreement. They should also make revision to their own understanding of the words if necessary.

6) Periodically students are involved in games that allow them to play with the terms.

Vocabulary games are used to gain the interest in learning process. It can be in the form of crossword puzzle, hangman, charades, pictionary or any other

possible games that will stimulate the interest and enthusiasm as well as give them multiple exposures of the target words.

All of those activities in dealing with the words is important as what Decarrico in Celce-Murcia (ed, 2001) asserts that efficient learning vocabulary is an incremental process which requires meaningful recurring encounter with a word over time. Hiebert and Kamil (2005: 3) propose that the printed words may be decoded into its oral form then they should be able to comprehend the text as they put attention into its oral representation. Thus, related to the theory that said that comprehension is a function of oral language and word recognition, there are two steps that can be used by the learners to decode. The first is they have to be able to translate the printed words on a page into speech. Secondly, the words that they say should have sense.

Related with learners' strategies in vocabulary learning, Grave (2006) develops five effective strategies for leaners that can be used in acquiring vocabulary. They are presented as below:

1) Using context to unlock the meanings of unknown words

The learners find the meaning that makes sense. They should also notice the unknown word and slow down when encountering it. Reread the previous sentence to look for clues if necessary is suggested. They may substitute the meaning of the unknown to see the most correct sense.

2) Using word parts to unlock the meanings of words

More than 60% of new words can be broken down into its parts. Then learners can use the word parts to figure out the meanings.

3) Using dictionaries and related reference tools

Finding the word in appropriate dictionary and read the description given may needed to be done. The possibility of multiple meanings should be considered to decide which word's meaning that makes sense in the text.

4) Develop strategies for dealing with unknown words.

The learners have to recognize unknown words and then decide if they need to understand it to understand the passage. An attempt to infer the meaning from context, infer the meaning from word parts, and to sound out the words to see if it is familiar are also good consideration. Learners may use the dictionary or other resource.

5) Adopt a personal approach to build vocabulary and to develop word consciousness.

The most appropriate approach in learning vocabulary should be considered by the learners themselves. They know better about what kind of vocabulary learning that suit them the most.

In accordance with vocabulary for academic reading, Grabe and Stiller in Celce-Murcia (ed, 2001) state that extensive reading, explicit instruction, independent learning help the students in vocabulary learning. They suggest some activities that can be used in the vocabulary teaching and learning process. They are mentioned below.

1) analysis of word parts

In this activity, the learners analyze the root and the affixes of the words. The reason behind this activity is that knowledge of the root and the affixes

enables the learners in determining the meaning of the words. Affixes include prefixes and suffixes. Prefixes commonly augment the meaning of the attached words while suffixes commonly change the part of speech of the attached words. Along with teaching affixes, the word's root also instruction commonly teaches root words.

2) word association

A teacher or a student proposes a word and then the others states another word associated with the word proposed before. The students may explain the link between the words.

3) cognate awareness

It consists of a set of multiple-choice items. The students then are asked to select one from four definitions that has the same or close meaning that provided for each cognate or words that have a common etymological origin.

4) definition

The learners find the definition of certain words that appropriate with the context given. The definition can come from guessing from context which then the learners should confirm their definition with the teacher or dictionary.

5) dictionary activity

This activity enables the students to develop word consciousness, or an interest in words, as well as the strategy for becoming a word collector. They will increase their academic vocabularies when confronted with unknown words from varied disciplines.

6) discussion of words meaning

The learners discuss the word meaning with each other since a word may have some different meaning depend on the context. In the discussion the teacher may give clues to guide them to reach an appropriate word's meaning.

7) flash card

Flash card provides some information that useful for the learners to learn the new vocabulary. The information varies according to the learners' needs.

8) games

Vocabulary games may in the form of puzzle, crossword puzzle, etc. The games should be fun and engage the learners. Vocabulary games usually comes in certain themed and context.

9) illustration, drawings, realia

Illustration, drawings, realia will serve a representation of the unknown word. Thus they will develop the learners' vocabulary memory by helping them connect the words with its visual representation.

10) matching meaning and collocation

Matching meaning make the learners use their word understanding in L2 and L1. This activity will link heir L1 and L2 words. Matching the collocation is important since some words commonly followed with certain words which may produce different meaning. Understanding the collocation help the learners in understanding sentences.

11) mnemonic technique

Mnemonic technique helps to link a word form and its meaning using L1 keyword phonological or orthographic similarity with the L2 target word. A strong association between the keyword and target word must be constructed so that when learners encounter the target word they remember the keyword.

12) part of speech tables

This activity helps the learners in understanding the word's part of speech that presents in tables which make it more organized and then understandable. A word may have some different part of speech depend on its usage in the sentence.

13) semantic mapping and grids

Semantic mapping helps the learners to analyze relationship among words in a text and deepen understanding by creating associative networks for words. The learners are asked to draw a diagram of the relationship between particular words found in the text.

14) synonyms and antonyms

An exercise of synonyms (words that has similar meaning) and antonym (words with opposite meaning) may be conducted to develop the learners words understanding through exercises that using synonym or antonym of a word since they convey defining function of words.

15) word families exercises

A word family consists of a base word, its inflexion and its derivation. Since inflexion and derivation usually involve affixes, analyzing the root among

some words in certain word family is important for understanding the word. Word family exercises help the learners to understand words through its base word analysis.

Thus, there are a lot of considerations in developing vocabulary learning materials. The approach, method, criteria for a good vocabulary instruction, and the activities to be conducted in vocabulary teaching and learning process are elements that the material developers should take into account in developing vocabulary teaching materials.

2. Vocabulary for Students of Physics Education Department

Physics Education Department students use vocabulary knowledge primarily to read their academic textbook in many subjects such as *Metode Pengukuran Fisika, Kalkulus, Analisis Pengukuran Fisika, Matematika Fisika I, II, & III, Mekanika, Getaran Gelombang, Termodinamika, Teori Relativitas Khusus, Mekanika Analitik, Quantum, Elektrodinamika, Fisika Zat Padat,* and *Mekanika Fluida.*

The words that they meet in the textbook are words that rarely used in daily communication. It makes them difficult to understand the words due to their lack of encounter with the words. For example the word “propagate” which is encountered several times in the textbook of *Fisika Zat Padat* subject and it conveys important meaning in understanding the text. Thus the learners need to know this word to comprehend the text.

The word such as “excite” serves a different problem in understanding its meaning. Usually this word is recognized as a word that related with feeling. But

in their Physics textbook, “excite” conveys different meaning since it is associated with electron.

Those kinds of difficulties obstruct the learners in comprehending the text. Their concentration is distracted due to their effort to understand the unknown words and the Physics content.

Each of different subjects gives them different vocabulary target. It makes them obligated to understand a huge amount of target vocabulary to comprehend all of their textbooks. It means that they need to learn target vocabulary in a limited time. The materials should make the learners understand the target words in those limited time. The materials also need to be appropriately developed according to their target use.

Hiebert and Kamil (2005: 9) state that effective vocabulary learning process should provide multiple ways to learn and interact with words. They engage the learners and motivate them to listen for and look for new words. The learners should see words in rich context. National Reading Panel (2000) suggests that seeing vocabulary rich in context provided by authentic text is a characteristic of instruction which produce good vocabulary learning.

Although the students get an English subject in their third semester, they admit that it does not give enough vocabulary development for them since the new vocabulary given in that subject rarely meet their needs in learning Physics through reading their English textbooks. Thus they need to be taught using pedagogic corpora. Pedagogic corpus is a corpus that contains language used in classroom setting including academic textbooks. The students can make their own

corpus. By learning this corpus, the learners are ensured to learn useful words (Bennett: 2010).

Using pedagogic corpora means that the possibility of the words used as target language cannot be controlled by the researcher. Therefore corpus cannot tell whether the language is correct or not, or explain why something happen as the way it is, or provide all possible language at one time. (Bennet: 2010)

3. Interactive Multimedia

a. The Definition of Interactive Multimedia

Reddi in Mishra and Reddi (eds, 2003) define multimedia as an integration of more than one media elements such as audio, video, graphics, text, and animation into a new form that works synergistically and symbiotically that lead to more advantages for the users than if one of the media elements can provide.

In line with that, Fenrich (in Mishra and Reddi, 2003: 3) states that multimedia is an interesting combination of softwares. It allows the designer to integrate video, animation, audio, graphic and text to make an effective presentation.

Conforming to it, Phillips in Mishra and Reddi (2003: 3) describes features of multimedia which are the presence of text, pictures, sound, animation and video. Some or all of those features are organized into a coherent program.

In accordance with that, Bhatnagar, Mehta and Mitra (2002: 4) define multimedia as combination of text, motion or static graphics, sound, and video

which presented through computer. Thus, the computer becomes intrinsic part of multimedia.

Mishra and Reddi (2003: 4) describe the present multimedia as a combination of text, graphic art, sound, animation, and video elements which designed cautiously concerning with its purpose. When the user of a multimedia project is allowed to control 'what' and 'when' and 'how' the elements delivered and presented, it becomes interactive multimedia. From the above definition it is concluded that interactive media is a combination of multiple media such as text, graphic, sound, animation, and video which allow the user to interact with it.

b. Elements of Interactive Learning Multimedia

As the definition of multimedia states that multimedia consists of various elements which are text, audio, image, animation and video, we have to understand what those elements are. The explanation of the elements of interactive learning multimedia is presented below.

1) Text

In multimedia, the information is conveyed not only from the text, therefore text often play limited role. However, text is a predominant medium in multimedia since the users are easier to read and browse through text than listen or watch. Text should be used effectively, short, and to the point. Text is used for four major purposes which are titles, menus, navigation, and content. Bhatnagar, Mehta and Mitra (2002: 140-142) suggests some consideration in using text in multimedia which are presented below.

a) It is difficult to read text that is all in capital letters. It is easier to read words and sentences that use mixed uppercase and lowercase letters.

b) Moving text is more difficult to read than static text.
c) People read double-spaced text faster than single-spaced text.
d) Do not vary the type size by more than three points.
e) Lines of text should not be more than 40-60 characters.
f) Choose a simple typeface. Although we are used to Serif typefaces on paper, they are less legible on the computer screen. So, choose a Sans Serif font.
g) Use the same typeface throughout a project. You can vary the style to make text bold, italic, or underlined if you want to emphasize information.
h) Be consistent. Use the same font for information of the same type. When the font size changes, the reader assumes that a different kind of information is signaled and will pay attention. Use one font for all titles, another for all subheadings, and another for all buttons.
i) The font size should be readable. A font size between 9 and 12 points is the best.
j) A neat finish between lines of text, between letters, and in the margins. These blank spaces can interfere both with reading and with the look of your text. For a neat finish, you have to adjust letters to get the best fit. Spaces between lines of text, between letters, and in the margins can be adjusted to give a neat finish.

2) Audio

Audio is used to simulate the use of sounds in the real context. Audio also used to make multimedia become more attractive to the users. Bhatnagar, Mehta and Mitra (2002:14) categorize audio into two. They are content and ambient sound. Content sound provides information to audiences, for example, dialogs in movies or theater. While ambient sound consists of an array of background and sound effects.

a) content sound:

a) Narration: Narration provides information about an animation that is playing on the screen.
b) Testimonials: These could be auditory or video sound tracks used in presentations or movies.
c) Voice-overs: These are used for short instructions, for example, to navigate the multimedia application.
d) Music: Music may be used to communicate (as in a song).

b) ambient sounds:

a) Message reinforcement: The background sounds you hear in real life, such as the crowds at a ball game, can be used to reinforce the message that you wish to communicate.
b) Background music: Set the mood for the audience to receive and process information by starting and ending a presentation with music.
c) Sound effects: Sound effects are used in presentations to liven up the mood and add effects to your presentations, such as sound attached to bulleted lists.

3) Image

Image or graphic is an important aspect of multimedia. The image used in multimedia can be a picture, painting, photograph, design, or the combination between them. Lee and Owens: (2004-127) mention that the graphic design standards include file type, file size, file-naming convention, and color range.

Characteristic of graphics in multimedia is explained below.

a) They should advantageous to the content presentation and be simple in design.
b) They should not detract from textual information.
c) Graphics should be similar in size and placement, and any text that is included as call-outs must be readable.
d) Clarity and readability should not be dependent on color variations. There should not be more than four colors on a screen, and the entire course should use a palette of not more than seven colors.
e) The color use on screens should be consistent.
f) Manage color contrast appropriately: no red on black or blue on orange, and for most audiences minimal use of “hot” colors is best.

4) Animation

Weiss, Knowlton and Morrison (2002:467-468) assert that what considered as animation is a sequence of image rapid display of 2-D artwork or model positions in order to create an illusion of movement. It is an optical illusion of motion due to the phenomenon of persistence of vision, and can be created and

demonstrated in a number of ways. Presented below are five functions of animation in interactive multimedia.

a) cosmetic function: to make instruction attractive to learner,
b) attention gaining function: to gain the attention of learners at the beginning of and to signal salient points such as switching topics,
c) motivation function: to motivate learner when an incorrect answer is given,
d) presentation function: to provide a concrete reference and a visual context for ideas, and
e) clarification function: to provide a conceptual understanding without providing new information through visual.

5) Video

Video in multimedia is a very important communication tool for presentations. It gives the users an illustration of ideas and concepts and also real world events. There are two choices of video in interactive multimedia which are using very short video clips (not exceeding a minute or two) and using highly compressed video files like MPEG or AVI files that can be transformed to MPEG files. (Mishra and Reddi, 2004:46)

c. Advantages of Interactive Learning Multimedia

Mishra and Reddi (2003:5) state that there are several advantages of multimedia for the users, especially for teachers and learners. The users use their natural information processing abilities using eyes and ears and also the brain which result in a good system that gather information from meaningless sense of data. There are some benefits of multimedia to teachers which are:

a) allows for creative work;
b) saves time for more challenging topics;
c) replaces ineffective learning activities;
d) and increases student contact time for discussion.

As for the students, the use of multimedia makes the application more attractive and interesting. Thus because the image, even if only a few or have little pedagogical value, will stimulates the eye and relief them.

Concerning with the advantage of its interactivity, Lee and Owens (2004:123-124) state that the interactivity allows the interaction to be frequent and the students involvement.

d. The Principles of Interactive Learning Multimedia

In designing an interactive multimedia, we can consider seven basic principles of interactive multimedia that are recommended by Mayer (2005: 6-7). The lists are presented below.

a) Multimedia principle: Students learn better from combination of words and graphics than from words alone.
b) Split-attention principle: Students learn better when the corresponding words and graphics are placed closely to one another than separately.
c) Modality principle: Students learn better from graphics and narration than graphics and printed text.
d) Redundancy principle: Students learn better when the same information is not presented in more than one format.
e) Segmenting, pre-training, and modality principles: Students learn better when a multimedia message is presented in learned-paced segments rather than as a continuous unit, students know the names and characteristics of the main concepts, and the words are spoken rather than written.
f) Coherence, signaling, spatial contiguity, temporal contiguity, and redundancy principles: Students learn better when extraneous material is excluded rather than included, when cues are added that highlight the organization of the essential material, when corresponding words and pictures are presented near rather than far from each other on the screen or page or in time, and people learn better from graphics and narration than from graphics, narration, and on-screen text.
g) Personalization, voice, and image principles: Students learn better when the words of a multimedia presentation are in conversational style rather than formal style and when the words are spoken in a standard-accented human voice rather than a machine voice or foreign-accented human voice; but people do not necessarily learn better when the speaker's image is on the screen.

4. Materials Development

a. The Nature of Materials Development

Materials development refers to a process of producing and using the materials for language learning including materials evaluation, adaptation, design, production, exploitation and research (Tomlinson, 2012:143). It takes place on a process of decision making in planning a language course. In addition, Graves (2000:149) states that materials development is a planning process by which a teacher develops units that contain lessons to carry out the goals and objectives of the course.

b. Advantages of Developing Materials

Developing materials for a specific language course or language program has some advantages compared with using general English learning materials. Richards (2001:261) states four advantages of developing materials which are presented as follows.

1) Relevance: The materials will tend to be more relevant for students and institutional needs and reflect the local content, issues, and concerns.
2) Develop expertise: Developing materials benefit the other staffs language course to improve their expertise, giving them a greater understanding of the characteristic of effective materials.
3) Reputation: It will show the commitment to the language teaching because of providing relevant, specialized, and contextualized materials for the students.
4) Flexibility: The produced materials can be revised or adapted as needed, giving them greater flexibility than a commercial course book.

c. Principles of Materials Development

The purpose of the material development will decide the kind of course of the language program. The course should help the learners to meet their needs. Therefore considering the goal of the materials before starting to develop them

should be done by materials developers. Tomlinson (1998) describes the principles of materials development to help the materials developer develop a course that achieve the purpose of material design.

1) Materials should achieve impact

The materials affect the learners understanding by attracting learners' curiosity, interest, and attention. Materials can achieve impact through novelty, variety, attractive presentation and appealing content.

2) Materials should help learners to feel at ease

Materials can help learners to feel at ease by making sure that learners feel comfortable and relaxed. The materials should have a strong relationship with their culture and background knowledge. Learners also should be provided with materials that help them to learn. They must achieve the personal contact through revealing their own preferences, interests, and opinion.

3) What is being taught should be perceived by learners as relevant and useful

Materials should provide information that makes the learners recognize its potential relevance and utility. The points taught should be relevant with the learners' background study and needs. Serving the points with interesting and challenging tasks in varied ways may facilitate the learners to deepen the knowledge.

4) Materials should require and facilitate learner self-investment

Materials should facilitate the learners' self-discovery. They will get an opportunity to invest interest, effort, and attention by providing them with choices of focus and activity. They need to respond their interest globally and affectively. A mini project is a good example of this respond.

5) Learners must be ready to acquire the points being taught

To help the learners acquire the points of being taught, the materials should be presented in the formula of i + 1. “i” represents what has already been learned and “1” represents what is available for learning. The learners need a comprehensible input that they are already familiar and contain a potential to learn new elements.

6) Material should expose the learners to language in authentic use

A comprehensible input that provides enough exposure of authentic and comprehensible input is needed to facilitate the language acquisition. The exposure should be rich and varied and meet the learners’ proficiency.

7) Materials should take into account that the positive effect of instruction are usually delayed

Language acquisition is not an instant process but it needs a gradual process. In facilitating gradual process, the materials should recycle the knowledge that has been learnt. Frequent and ample exposures in the instructed language feature should also be given to the learners.

8) Materials should take into account that learners differ in learning styles

Each leaner may have different learning styles. Language learning styles may include visual, auditory, kinesthetic, experimental, analytic, global, dependent, and independent.

9) Materials should maximize learning potential by encouraging intellectual, aesthetic and emotional involvement which stimulates both right and left brain activities.

Materials that encourage many cerebral activities in the brain will maximize the recall of the new knowledge. Thus varied series of activities is needed such as analytic, creative, evaluative, and rehearsal demands on processing capacity can lead to deeper and more durable learning.

10) Materials should provide opportunities for outcome feedback

Feedback which focused on the effectiveness of the output and on its accuracy can lead to output which becomes profitable input source. It is important for the materials to provide activities that intend to produce outcome than just practicing language.

d. The Process of Materials Development

Dick and Carrey (1996) propose a Systematic Instructional Design. The materials developer will be able to link instructional learning strategy with the desired learning outcome by using this design. The design is organized to make the materials developer able to develop materials that will help the learners to achieve their target needs. The following table shows the steps of Systematic Instructional Design that will be used as the guide in developing the materials in this study.

Table 2.2. Components of Systematic Instructional Design by Dick and Carrey (1996)

No.	Steps	Comments
1.	Identifying an Instructional Goal	The first thing to do in this Instructional Design is to determine the expectation about what the learners able to do when they have completed the learning process.
2.	Conducting an Instructional Analysis	The next step after identifying the goals is to determine skills and procedures which will be included in the instructional design to carry the goal into the classroom.
3.	Analyzing Learners and Contexts	This stage includes the analysis of learners' context in which they will learn the skills. It is

		related to the characteristics of the instructional setting and the setting in which the skills will eventually be used.
4.	Writing Performance Objectives	This stage will identify the skills to be learned, the conditions under which the skills must be performed, and the criteria for successful performance.
5.	Developing Assessment Instruments	This instrument is to assess and measure the learners' ability to perform the objectives.
6.	Developing an Instructional Strategy	The information from the preceding steps will begin to identify the strategy that will be used in the instruction. The strategy will include sections on pre-sectional activities, presentation of information, practice and feedback, testing and follow through activities.
7.	Developing and selecting materials	The determined strategy in previous steps will be used to produce the instruction. The decision to develop originals materials will depend upon the type of learning to be taught, the availability of existing relevant materials, and developmental resources available.
8.	Designing and Conducting the Formative Evaluation	The draft of the materials will be evaluated in order to have it improved. The three types of formative evaluation are referred to a one-to-one evaluation, small group evaluation, and field evaluation. Each type of evaluation provides the designer with a different type of information that can be used to improve the instruction.
9.	Revising Materials	The final step (and the first step in a repeat cycle) is revising the materials. Data from the formative evaluation are summarized and interpreted to identify difficulties experienced by learners in achieving the objectives.
10.	Conducting Summative Evaluation	The main purpose of this stage is to find out the effectiveness of holistic instruction. However, it is not the part of the design process but it occurs after the instruction has been evaluated formatively and revised to meet the standards of the developer.

From the explanation of the materials development above, a need analysis must be the starting point for a materials development of instructional program. The next steps are about how the needs create a framework for developing materials. The following figure shows how the steps above are carried into practice.

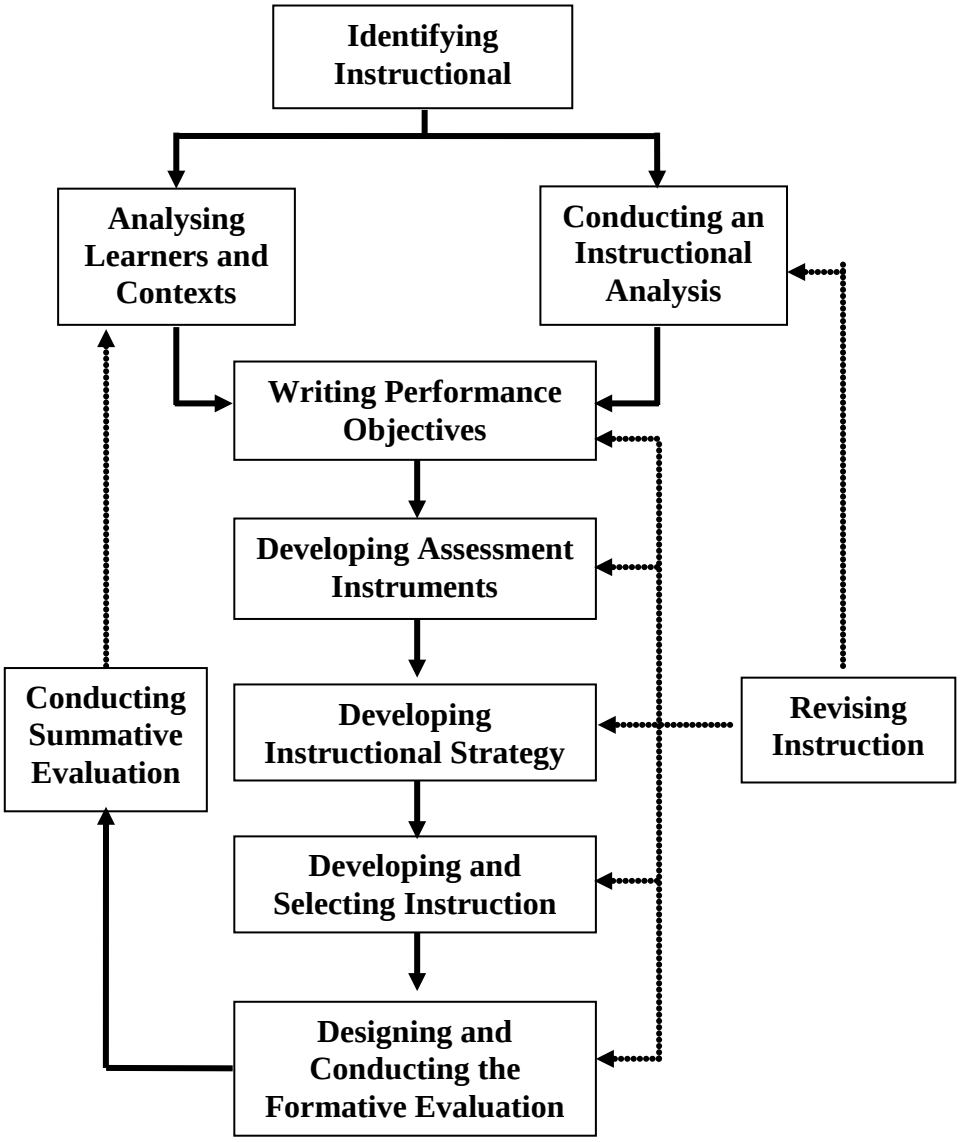


Figure 2.2. Dick and Carey Instructional Design (1996)

e. Materials Evaluation

To know whether the materials meet the learners need and suitable for the learners, an evaluation is needed. Materials evaluation refers to a procedure which involves value measurement of a set of learning materials (Tomlinson, 2003: 15). Richards and Lockhart in Tomlinson (1998: 222) add that evaluation provides an appraisal of the value of specific teaching activities for particular

groups of learners and perhaps serves as support to teachers to adopt a reflective approach to their own teaching. One way to encourage the systematic evaluation of materials after use may be to engage in micro evaluation by focusing on particular tasks. Ellis in Tomlinson (1998: 229) suggests five steps for conducting a task evaluation as follows:

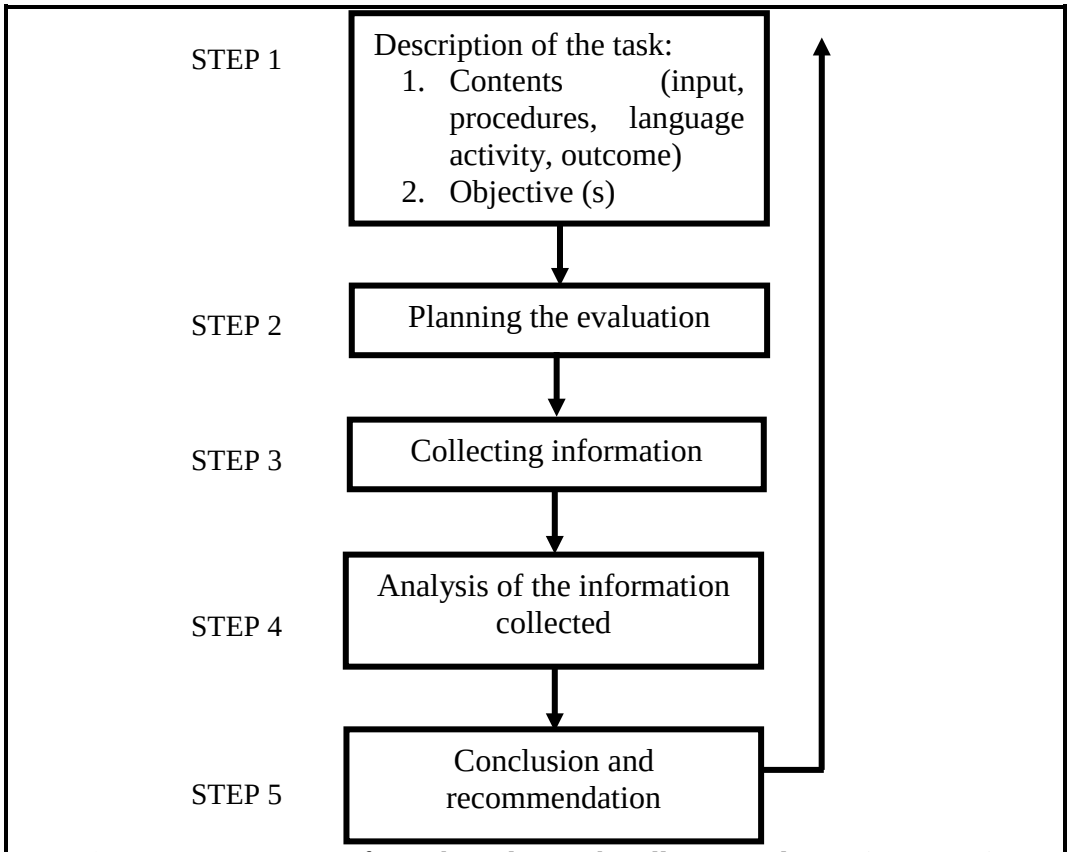


Figure 2.3. Five Steps of a Task Evaluation by Ellis in Tomlinson (1998: 229)

B. Conceptual Framework

Interactive media is a combination of multiple media elements such as text, graphic, sound, animation, and video which allow the user to interact with it. Interactive media is used to help teaching and learning process by presenting materials, task and activities in it so that it can be used in the classroom as supplementary or outside of the classroom. The interactive multimedia is

developed based on the students need and level of proficiency. The designed multimedia is limited to help the students of Physics Education Department in learning vocabulary to read their academic textbooks. The researcher takes a book from *Fisika Zat Padat* subject to be used as authentic material.

In reference with that, each unit of interactive learning multimedia for vocabulary learning materials has the following components. The first is introduction. The introduction consisted of an overview and indicators of the unit. The second is main part. The main part consisted of the tasks cycle which consisted of explanation of the target words, non-linguistic representation, target words' activities (matching, matching the words with its pronunciation, choosing the correct part of speech, find the correct words that represent certain part of speech, matching definition, and matching meaning), games (crossword puzzle), and completing sentences. The last is the summary. It was provided at the end of every unit to give students brief explanation about what they already learned.

In designing interactive learning multimedia, seven basic principles should be considered. The first is multimedia principle. Students learn better from combination of words and graphics than from words alone. Split-attention is the second principle in which students learn better when the corresponding words and graphics are placed closely to one another than separately. Next is modality principle; students learn better from graphics and narration than graphics and printed text. The fourth principle is redundancy; students learn better when the same information is not presented in more than one format. The fifth is segmenting, pre-training, and modality principles; students learn better when a

multimedia message is presented in learned-paced segments rather than as a continuous unit, students know the names and characteristics of the main concepts, and the words are spoken rather than written. The sixth is coherence, signaling, spatial contiguity, temporal contiguity, and redundancy principles; students learn better when extraneous material is excluded rather than included, when cues are added that highlight the organization of the essential material, when corresponding words and pictures are presented near rather than far from each other on the screen or page or in time, and people learn better from graphics and narration than from graphics, narration, and on-screen text. The last principle is personalization, voice, and image. Students learn better when the words of a multimedia presentation are spoken in a standard-accented human voice and it is not necessary to put the speaker's image on screen.

CHAPTER III

RESEARCH METHODS

This chapter presents type of study, research subjects, research procedure, techniques of data collecting, research instruments and data analysis techniques.

A. Type of Study

The objective of this research was to develop an appropriate interactive vocabulary learning multimedia for educational program especially for the students of Physics Education Department Yogyakarta State University. Thus, this study was categorized as Research and Development since its purpose was to develop a product that can be used in an educational program (Borg & Gall 2003:569). Seels & Richey in Richey, Klein and Nelson (2004: 1099) explain that the purpose of R&D is designing, developing and evaluating instructional programs, processes and products to meet the criteria of internal consistency and effectiveness.

B. Research Setting

The research was conducted from February up to June 2013 at Physics Education Department Yogyakarta State University which is located at Jl. Colombo, Karang Malang, Yogyakarta.

C. Research Subjects

The third year students in class A/6 of Physics Education Department Yogyakarta State University were the subjects of this research. There were 34 students of class A/6 involved in this research. The students of Physics Education

Department were able to access a multimedia program by themselves outside the campus.

D. Research Procedure

Since this research was conducted to develop an interactive learning multimedia of vocabulary for the students of Physics Education Department Yogyakarta State University, the model proposed by Lee and Owens (2004) was adapted. There were four phases followed by the researcher. They are mentioned below.

1. Needs assessment and analysis

In this phase, the objectives of this study were identified. Then the developer analyzed the audience, the syllabus and the textbook used in the classroom, the technology used to develop the product, and the media used to deliver the product.

2. Design

a. Writing the draft of the materials

Materials related to this study were developed. The material presentation also developed by considering its principles.

b. Designing Flowchart

After the draft of the materials was created, the next step was to make flowcharts of the multimedia. Flowchart is a symbol or picture which depicts the steps representing activities of processing the materials. This serves as a roadmap of interactive multimedia. It links one page to another.

c. Storyboarding

After the flowcharts were created, the developer made the storyboard. It describes how every screen in the presentation would be displayed. They refer to the operation shown in the flowcharts.

3. Development

a. Materials Collecting

The texts, pictures, animations and video were collected. In order to get the input, the developer adopts the textbook used in the senior high school.

b. Integrating the materials into the program

The developer used the authoring software such as Macromedia Flash CS4, Photoshop and other supporting programs to integrate the materials into the interactive multimedia program. This stage produced the first product.

c. Validation by the experts

The first product was consulted to the supervisor for validation.

4. Evaluation by experts judgment

The first product was evaluated by the content experts and media expert through questionnaires. The questionnaires were then analyzed to revise the product which led to the final product

E. Data Collecting Techniques

Three kinds of data collection technique were used in this research. They are observation, questionnaires and interview. The data about learners' characteristics, learning sources and the availability of multimedia in the institution were collected using observation that is conducted before the need analysis.

This research used two kinds of questionnaire. The first was questionnaire for needs analysis which obtains information about students' needs and learning needs. This includes questionnaire to make the corpus data of the vocabulary from the books. The second was questionnaire for expert judgment which was used get comments and suggestions from the materials and multimedia experts.

The researcher also use interview to conduct the needs analysis by asking a Physics Lecturer about the condition of the students. Before conducting the interview, a set of questions should be designed as the guidance.

F. Research Instruments

Observation guide, interview guide, and questionnaires were the instruments used in this study to gather data. They are described below.

1. Observation guide

Observation guide was used as a guide to collect data about learners' characteristics, learning sources and the availability of multimedia. The researcher conducts the observation before the need analysis.

2. Interview guide

Interview guide were used as a guide in conducting interview. Interview was conducted to obtain feedback from a lecturer of Physics subject about the students' condition and also the material used in teaching and learning process of the Physics subject. The feedback collected from the interview then was used to support the result of the needs analysis questionnaire which was distributed to the students.

3. Questionnaires

There were two kinds of questionnaire used in this research which were questionnaire for needs analysis and questionnaire for expert judgment. The questionnaire for needs analysis was used to obtain information about the target needs and the learning needs of the third year students of Physics Education Department Yogyakarta State University. Questionnaire for expert judgment was used to get comments and suggestions from the materials and multimedia expert. The feedbacks from the expert judgment were used to revise the materials.

G. Data Analysis Techniques

There were two types of data used in this research which were qualitative and quantitative data. The qualitative data were obtained from interview and observation in the form of observation field notes and interview transcripts.

The quantitative data were collected from questionnaires. The data of needs analysis questionnaire were analysed using frequency percentages while the expert judgement questionnaire used were analysed using descriptive statistics.

To measure the experts' opinion about the media the researcher used a Likert Scale. The scoring point is presented in the table below.

Table 3.1. The Scoring Point of Likert Scale

Scales	Categories
5	Strongly agree
4	Agree
3	Neither agree or disagree
2	Disagree
1	Strongly disagree

The data were then analyzed descriptively using quantitative data conversion proposed by Sudjono (2003: 335). The result of the conversion determined whether the product was already appropriate or not. The table below shows the quantitative data conversion.

Table 3.2. Quantitative Data Conversion (Sudjono, 2003: 335)

No.	Interval of Mean Value		Categories
	Formula	Score Range	
1	$\bar{x}$ > Mi + 1.8 SDi	$\bar{x} > 4.2$	Very Good
2	Mi + 0.6 SDi < $\bar{x}$ ≤ Mi + 1.8 SDi	$3.4 < \bar{x} \leq 4.2$	Good
3	Mi – 0.6 SDi < $\bar{x}$ ≤ Mi + 0.6 SDi	$2.6 < \bar{x} \leq 3.4$	Fair
4	Mi – 1.8 SDi < $\bar{x}$ ≤ Mi – 0.6 SDi	$1.8 < \bar{x} \leq 2.6$	Poor
5	$\bar{x}$ ≤ Mi – 1.8 SDi	$\bar{x} \leq 1.8$	Very Poor

Where:

$\bar{x}$ = mean value

Mi = the ideal mean

= $^1/_2$ (maximal score + minimal score)

= $^1/_2$ (5+1)

= 3

SDi = the ideal standard deviation

= $^1/_6$ (maximal score – minimal score)

= $^1/_6$ (5-1)

= $^2/_3$

CHAPTER IV

RESEARCH FINDINGS AND DISCUSSION

This chapter describes the findings and discussions of the research. The research findings covers the needs analysis, the course grid, the unit design, the flowchart, the first draft of multimedia, the review by experts and the final draft of multimedia.

A. Research Findings

1. The Needs Analysis

The needs analysis was divided into three parts which were description of target needs, learning needs. The target needs included necessities, lacks and wants while the learning needs included input, procedures, setting, and media.

a. Description of Target Needs

1) Necessities

Necessities refer to what the learner has to know in order to function effectively in the target situation. The result of needs analysis of necessities showed that 91.17% of students learned English to help them in reading textbooks. Fourteen students learned English to be able to communicate with foreign people. In relation with the subject of the textbooks, they need to learn about vocabulary in the subject of *Fisika Zat Padat* chapter 4 with 70.59%, *Fisika Zat Padat*, chapter 5 with 14.70% and the rest were *Fisika Zat Padat*, chapter 6, *Mekanika Fluida* chapter 5 and *Mekanika Fluida* chapter 6. The result is shown in Table 4.1. below.

Table 4.1. Target Needs: Necessities

Aspect	Question	Item	N	(%)
Necessities	The students need to learn English ….	a. to read textbooks	31	91.17%
		b. to be able to communicate with foreign people	14	41.17%
		c. to help in the future study	5	14.70%
		d. others	0	0%
	The students need to know about vocabulary in the subject of…	a. *Fisika Zat Padat*, chapter 4	24	70.59%
		b. *Fisika Zat Padat,* chapter *5*	5	14.70%
		c. *Fisika Zat Padat, chapter 6*	3	8.82%
		d. *Mekanika Fluida, chapter 5*	1	2.94%
		e. *Mekanika Fluida, chapter 6*	1	2.94%

The data from questionnaire about necessities from the table above was supported by the data from interview. Here is the result of the interview.

…….....

R : *Mahasiswa Jurusan Fisika perlu menggunakan Bahasa Inggris apa tidak Pak?* (Do the students of Physics Education Department need to use English?)

L : *Iya perlu mas.Soalnya mereka pakai buku berbahasa Inggris jadi perlu kemampuan* reading. (Yes they do. They need to use an English textbook so they need to use their reading skill)

…….....

2) Lacks

Lacks refer to the gaps between what the learner already knows and the necessities. The students' lacks are described in the table below.

Table 4.2. Target Needs: Lacks

Aspect	Question	Item	N	%
Lacks	Difficulty students face when reading textbook….	a. to understand the vocabulary	29	85.29%
		b. to understand the text's structure	10	29.41%
		c. to read rapidly	14	41.17%

		d. others	0	0%
	The students' ability in understanding the vocabulary in the textbooks….	a. very poor	6	17.65%
		b. poor	23	67.65%
		c. good	5	14.70%
		d. very good	0	0

Based on Table 4.2. above, the students face some difficulties in reading their English textbook. 85.29% of students felt that it was difficult to deal with the unknown vocabularies in the text. Ten students found that it was difficult to understand the text due to complexity of the text's structure. Fourteen students felt that they faced difficulty in reading textbook since they could not read rapidly. Moreover, it can be seen that more than half of all students thought that their ability in understanding vocabularies is poor. It can be said that the students' proficiency level of vocabulary was not enough to meet their target situation. The data above were supported by the interview. Below is the result of the interview.

…….....

R : *Kalau menurut Bapak sendiri bagaimana kemampuan reading mahasiswa?*(In your own opinion, how is the students' reading ability?)

T : *Sebagian sudah lumayan bagus, tapi sebagian besar mengalami kesulitan dalam memahami isinya soalnya mereka tidak tahu tentang kosakata tertentu.* (Some students have a good reading ability. But most of them are still face difficulty in understanding the text since they do not know about certain vocabularies.)

…….....

3) Wants

Wants related to the students' expectation after accomplishing their study. Table 4.3. shows that almost all of the students wanted to learn the definition, the meaning, the part of speech, and the pronunciation of the words.

However there were only twelve students who wanted to learn the word's part. The data of the students' wants is presented below.

Table 4.3. Target Needs: Wants

Aspect	Question	Item	N	(%)
Wants	The aspect of vocabulary that the students want to know …	a. the definition	25	73.52%
		b. the meaning (translation)	34	100%
		c. the part of speech	21	61.76%
		d. the pronunciation	19	55.89%
		e. the word's part	9	26.47%
		f. others (the image)	18	52.94%

It can be concluded that the students of Physics Education Department Yogyakarta University needed to learn English to understand their English textbook. They had a difficulty to understand vocabulary in the textbook. Therefore they want to learn about the word's definition, meaning, part of speech, and also pronunciation.

b. Description of Learning Needs

1) Input

Input refers to the types of data that will be used by the learners in working with the course of completing a task. The data of input chosen by students are presented below.

Table 4.4. Learning Needs: Input

Aspect	Question	Item	N	(%)
Input	Length of the text is…	a. < 251 words	6	17.65%
		b. 251 – 500 words	18	52.94%
		c. 501 – 750 words	10	29.41%
		d. > 750 words	0	0%
	The amount of vocabulary learned in each unit is …	a. < 6 words	6	17.65%
		b. 6 – 10 words	12	37.64%
		c. 11 – 15 words	16	47.06%

		d. > 15 words	0	0%
	Corpus data of vocabulary in Unit 1 are ….	1) boundary	24	70.59%
		2) differ	11	32.35%
		3) displaced	25	73.52%
		4) displacement	27	79.41%
		5) equilibrium	21	61.76%
		6) forth	27	79.41%
		7) generalization	15	44.11%
		8) independent	5	14.70%
		9) oscillate	27	79.41%
		10) perpendicular	18	52.94%
		11) propagate	21	61.76%
		12) propagation	24	70.59%
		13) regard	22	64.70%
		14) satisfied	18	61.76%
		15) vanish	26	76.47%
	Corpus data of vocabulary in Unit 2 are ….	16) adjacent	27	79.41%
		17) coincide	23	67.65%
		18) contain	13	38.23%
		19) essential	9	26.47%
		20) excite	28	82.35%
		21) gap	18	52.94%
		22) homogeneous	8	23.52%
		23) interleaved	28	82.35%
		24) pair	12	35.29%
		25) thereby	24	70.59%
	Corpus data of vocabulary in Unit 3 are ….	26) absorbed	18	61.76%
		27) absorption	20	58.82%
		28) chiefly	29	85.29%
		29) density	19	55.89%
		30) determine	7	20.28%
		31) determined	7	20.28%
		32) occupancy	26	76.47%
		33) occupied	29	85.29%
		34) occur	21	61.76%
		35) rarely	20	58.82%

		36) recoil	30	88.23%
		37) rigorously	31	91.17%
		38) suitable	13	38.23%
	Corpus data of vocabulary in Unit 4 are ….	39) decoupled	31	91.17%
		40) estimate	19	55.89%
		41) immersed	28	82.35%
		42) reduce	14	41.17%
		43) rest	23	67.65%
		44) sphere	27	79.41%
		45) unlike	7	20.28%

Table 4.4 above presents the input that desired by the students for learning vocabulary. There were 70.59% of students who wanted to learn vocabulary about the subject of *Fisika Zat Padat*, chapter 4. In term of input length, 52.94% of students preferred to use text with 251 up to 500 words, while ten students wanted to use text with 501-750 words. The amount of vocabulary learned in each unit that the students wanted was 11 up to 15 words with 47.05%. Twelve students wanted to learn six up to ten words in each unit, and the rest wanted to learn less than six words in each unit. The corpus data of vocabulary obtained from the second questionnaire showed that they wanted to know 45 words. The complete organization of corpus data can be seen on Appendix C.

2) Procedures

Procedures specify what learners will actually do with the input that forms the point of departure for the learning task. Table 4.5. below shows the result of the questionnaire which was administered to know the desired procedure for vocabulary learning of the students of Physics Education Department Yogyakarta State University.

Table 4.5. Learning Needs: Procedures

Aspect	Question	Item	N	(%)
Procedures	The approach of learning vocabulary is ….	a. incidental learning through extensive reading	4	11.76%
		b. explicit instruction through exercises	28	82.35%
		c. guessing meaning from context and dictionary activity	15	44.11%
	The type of activity for learning vocabulary is ….	a. analyzing word's parts	2	5.88%
		b. finding definition from the dictionary	12	35.30%
		c. matching the word with its definition	18	52.94%
		d. finding the meaning (translation) from the dictionary	17	50%
		e. matching the word with its meaning (translation)	28	82.35%
		f. Guessing meaning from context	14	41.17%
		g. matching the word with its pronunciation	19	55.89%
		h. flash cards	27	4.5%
		i. matching the word with its image representation	22	%
		j. matching the words with its synonym and antonym	3	8.82%
		k. making semantic map	2	5.88%
		l. crossword puzzle	19	55.89%
		m. hangman games	5	14.70%
		n. answering question from the text	5	14.70%
		o. completing sentences	18	52.94%

It can be seen that 82.35% of students wanted to learn vocabulary through explicit instruction. There were fifteen students who wanted to learn

vocabulary through dictionary activity and guessing meaning. Concerning with the activities to learn vocabulary, the students preferred to match the words with its definition, match the words with its meaning (translation), match the words with its pronunciation, flash cards, match the words with its image representation, use crossword puzzle, and complete sentences.

3) Setting

Setting requires consideration of whether the task is to be carried out wholly or partly outside the classroom. The table below explains the setting of learning that the students wanted.

Table 4.6. Learning Needs: Setting

Aspect	Question	Item	N	(%)
Setting	The students want to learn vocabulary ….	a. in the classroom	5	14.70%
		b. in outside of the classroom but still in campus	17	50%
		c. in computer laboratory	4	11.76%
		d. outside of the campus	28	82.35%

Table 4.6. above indicates that most students wanted to learn vocabulary outside of the classroom. There were twenty eight students that preferred to learn vocabulary outside of the campus while seventeen students want to learn vocabulary in outside of the classroom but still in campus. Only five students wanted to learn vocabulary in the classroom and four students wanted it in computer laboratory.

In short, students wanted to study English to help them in reading their textbooks since it was difficult to deal with the unknown vocabularies in the text. They wanted to learn the definition, the meaning, the part of speech, and the pronunciation of the words. They wanted to learn vocabulary about the subject of

Fisika Zat Padat, in chapter 4 with a text in length of 251-500 words presented 11 to 15 words. The students wanted to know 45 words in which it can be seen on Appendix B. They wanted to know them through explicit instruction by doing dictionary activity, guessing meaning, matching the words with its definition, matching the words with its meaning (translation), matching the words with its pronunciation, learning with flash cards, matching the words with its image representation, playing crossword puzzle, and completing sentences. They would like to do it all outside of the campus.

c. Description of Media

The last component of the needs analysis is description of media. There were six questions about the media in the needs analysis questionnaire. The questions helped the researcher to develop the multimedia based on what the students prefer. The table below shows the result of the questionnaire related to the multimedia.

Table 4.7. Learning Needs: Media

Aspect	Question	Item	N	(%)
Media	The media to learn vocabulary is…	a. textbook	4	11.76%
		b. hand out	5	14.70%
		c. multimedia	28	82.35%
		d. website	7	20.59%
		e. games	10	29.41%
		f. others	0	0%
	The background of multimedia that the students want is ….	a. similar on every pages	9	25.47%
		b. depend on its function	25	73.53%
		c. others	0	0%
	The type of font used in multimedia is ….	a. similar for the whole media	7	20.59%
		b. depend on its function	27	79.41%
		c. others	0	0 %
	The font size used	a. similar for the whole media	9	25.47%

	in multimedia is ….	b. depend on its function	25	73.53%
		c. others	0	0%
	The font color used in multimedia is ….	a. similar for the whole media	5	14.70%
		b. depend on its function	29	85.29%
		c. others	0	0%
	The use of pictures to support the materials is ….	a. not needed	0	0%
		b. sometimes needed	24	70.59%
		c. needed	10	29.41%
	The use of back sound in multimedia is ….	a. not needed	4	11.76%
		b. sometimes needed	19	55.89%
		c. needed	11	32.35%

The table above indicates that most of the students wanted multimedia as the media in learning vocabulary with 82.35%. 73.53% of the students wanted the background on the multimedia to be designed depend on its function. They also wanted the font type to be designed depend on its function with 79.41%. Twenty nine students believed that the font color in the multimedia also should be designed depend on its function. 70.59% of the students wanted the font size in the multimedia to be designed depend on its function. They believed that the use of pictures and back sound in multimedia was sometimes needed to make it more attractive.

2. The Course Grid

The course grid was developed after the questionnaire of needs analysis was analyzed. The course grid was used to develop the materials. It was developed based on the results of the needs analysis questionnaire, interview, and observation. The syllabus of the Physics subject was also considered.

The course grid consisted of syllabus description, indicators, unit titles, topics, input texts, vocabulary focus, and procedures. The procedures were

adapted from phases of teaching vocabulary that was proposed by Grabe and Stiller (2001) and steps of explicit vocabulary instruction which was developed by Marzano (2004). The course grid can be seen in Appendix C.

3. Unit Design

After the course grid was formulated, the next step was developing the materials. Based on the course grid, the materials consisted of four units. Each unit contained introduction, main part and summary. The introduction contained an overview and indicators of the unit. The overview and indicators were in the form of text. Pictures related to the topic were also provided.

The main part contained the phases of teaching vocabulary from Grabe and Stiller (2001) which were focusing the keyword, keeping the words active and incorporating the words in a larger learning project. In order to do that, Marzano's steps of explicit vocabulary instruction (2004) were used. It consisted of explanation of the target words, non-linguistic representation, target words' activities, and games.

In the explanation of target words, students learned the explanation of the words through flash cards. The flashcard in the text contained the meaning of the words, phonetic transcription and pronunciation of the words, definition, and Cobuild explanation.

In the non-linguistic representation, the students were provided with representation of some target words. To make it more attractive and explicit, the representations were in the form of animated picture. The students have to match the target word with its representation. The researcher was able to develop the

image representation of twenty nine words out of forty five words (85.29%). This step was divided into two different tasks.

There were also some other activities to keep the students work with the words. They were matching the words with its pronunciation, choosing the correct part of speech, finding the correct words that represent certain part of speech, matching definition, and matching meaning.

The material also provided the learners with a game. The game implemented in the multimedia was crossword puzzle. The game was developed to stimulate the students' interest and enthusiasm.

The last task was formulated to incorporate the target words in a larger learning project. The task should be done by the students by completing sentences of specific information from the text.

The summary was also provided at the end of each unit. It gave the students brief explanation about what they already learned. It consisted of the corpus data of the vocabulary added with the explanation of the target words.

The title of Unit 1 was "Crystal Vibration (Monatomic Basis)". In this unit, students were given with the text tilted "Vibrations of Crystal with Monoatomic Basis" and from that text some target words were obtained. They are boundary, differ, displaced, displacement, equilibrium, forth, generalization, independent, oscillate, perpendicular, propagate, propagation, regard, satisfied, and vanish.

"Crystal Vibration (Diatomic Basis)" was the title of Unit 2. Students given with target words which were adjacent, coincide, contain, essential, excite,

gap, homogeneous, interleaved, and pair. Those words were obtained from the text entitled “Two Atoms per Primitive Basis”.

Unit 3 in the multimedia was entitled “Phonon’s Characteristics”. There were three texts given in this unit which were “Quantization of Elastic Waves”, “Phonon Momentum”, and “Inelastic Scattering by Phonons”. They were grouped in Unit 3 since they shared the same topic which was the characteristics of phonon. From those texts, there were some target words that has been obtained which were absorbed, absorption, chiefly, density, determine, determined, occupancy, occupied, occur, rarely, recoil, rigorously, and suitable.

The title of Unit 4 is “Summary and Problems”. The texts included in this unit were the summary and problems of chapter 4 (Phonons I. Crystal Vibration). There were some target words obtained from the text which were decoupled, estimate, immersed, reduce, rest, sphere, and unlike.

There was also a dictionary to make it possible for the students if they wanted to do a dictionary activity. It contained the corpus data of the target words, and explanation which added with the image representation of the target words. To make it more accessible, it can be used directly from each unit and it contained the target words from the all units.

4. Flowchart

After the draft of the materials was created, the next step was developing flowcharts. Flowchart is a symbol or picture which depicts the server of steps representing a processing activity. This serves as a roadmap of media. It usually links one page to another. The flowchart can be seen in Appendix D.

5. The First Draft of the Interactive Multimedia

The first draft of the interactive multimedia was developed referring to the unit design. The complete draft can be seen in Appendix E, while the descriptions of basic part of the first draft of the interactive multimedia are presented below.

a. Start Screen

Start Screen is the first display appeared when the program is running. It contains the title and the designer of the media, the Yogyakarta State University logo, a start button, and an exit button. Below is the picture of the Start Screen.

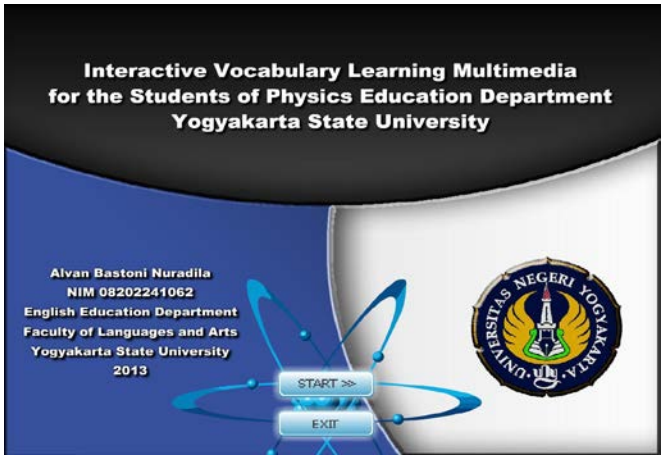


Figure 4.1. Start Screen

b. Home Page

After the Start Screen, there is a Homepage. It consists of the title of multimedia, the subject discussed, the textbook used, and some buttons linked to other page such as home, close, choose unit, dictionary, about the author, references, help, and music buttons. There are also home and close button. The picture of the page can be seen below.

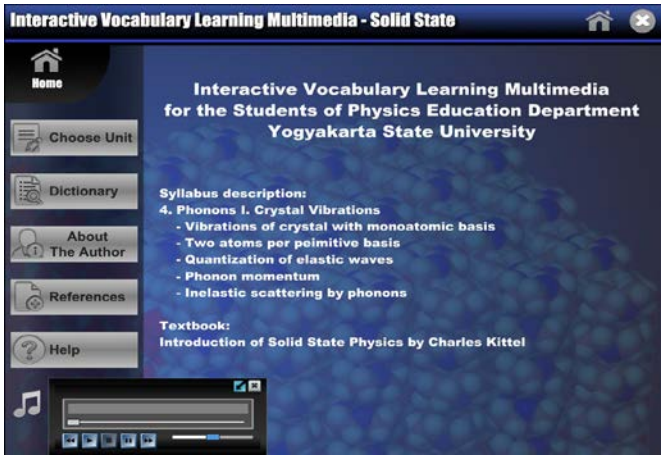


Figure 4.2. Home Page

c. Choose Unit Page

In this page, the users can choose the unit and task. A title of each unit is presented here. Each unit contains different target words but presented in the same task cycle which consists of introduction as an introduction, main part, and summary. There is an overview followed by Task 1 until Task 11 as the main part, and ended by summary of each unit. Below is the image of Choose Unit Page.

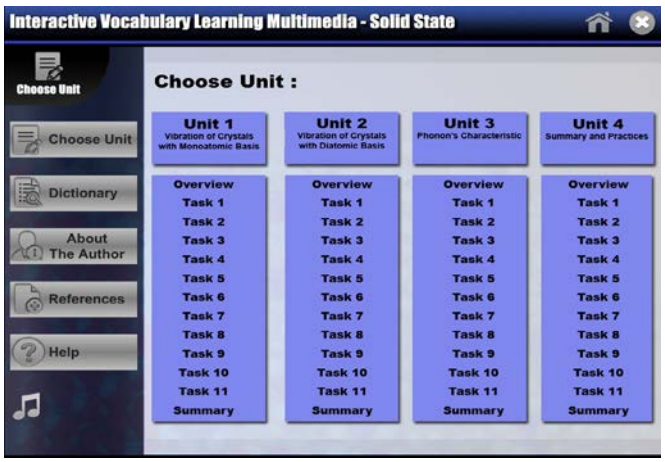


Figure 4.3. Choose Unit Page

d. Overview Page

This page provides the users a preview about what they will learn in a specific unit. Even though each unit consists of different target words to be learned, but they have similar aspects in order to know a word. The picture of Overview Page can be seen below.

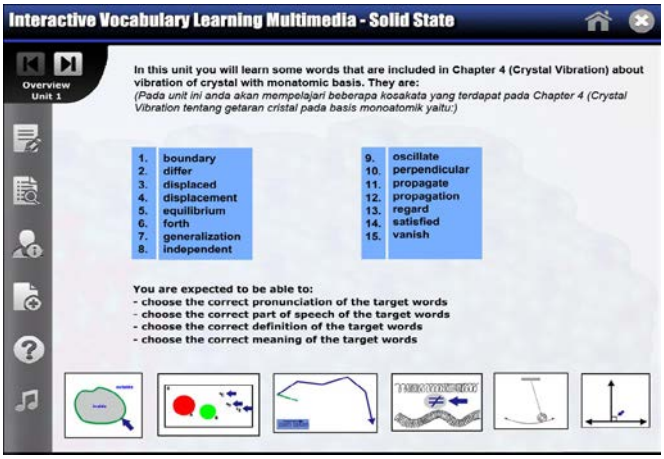


Figure 4.4. Overview Page

e. Task 1

Task 1 is a page where the users are allowed to start knowing a word by giving them target words' explanation. A text taken from the textbook given to the users in which it contain several target words. The text is divided into some parts. The explanation of the target words come in a form of flash cards. The flash cards appear by clicking on the underlined target words. Each flash card consists of the meaning, pronunciation, phonetic transcription, part of speech, the definition and often added with its cobuild definition. They are also used to give an explanation about the formulas and figures. The picture of the task is provided below.

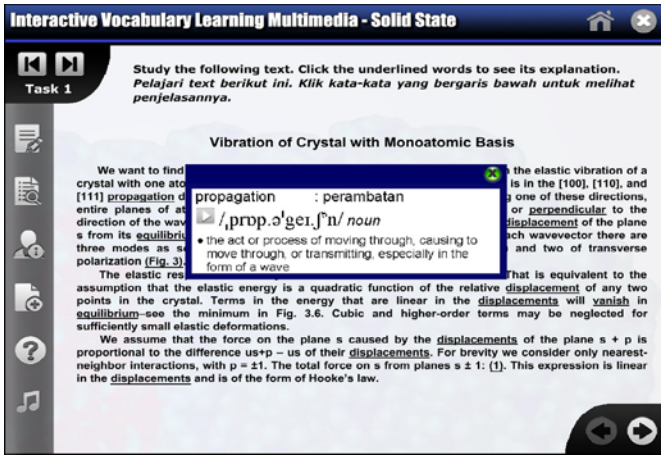


Figure 4.5. Task 1

f. Task 2

In this task, the users are asked to study the target words just like in Task 1. The text still has a continuance with that in Task 1 since they have similar topic. The text is separated due to the users preference gathered from the need analysis. The target words are also presented in flash cards. Below is the picture of the task.

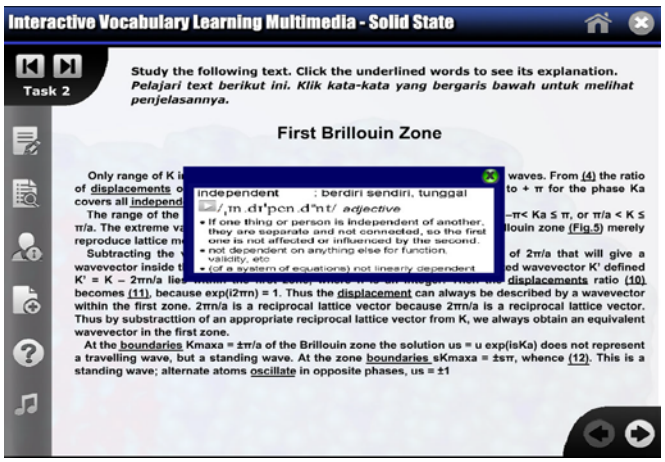


Figure 4.6. Task 2

g. Task 3

This is a page where the users are provided by non-linguistic representation. The non-linguistic representations are in the form of animated pictures. The users need to choose an animated picture that represents a certain target word. Task 3 consists of some pages in which each page presents one target words and its non-linguistic representation. At the end of the Task 3 the users can see how many times they can choose the non-linguistic representations correctly. There is also a button to try again. The picture of the task is provided below.

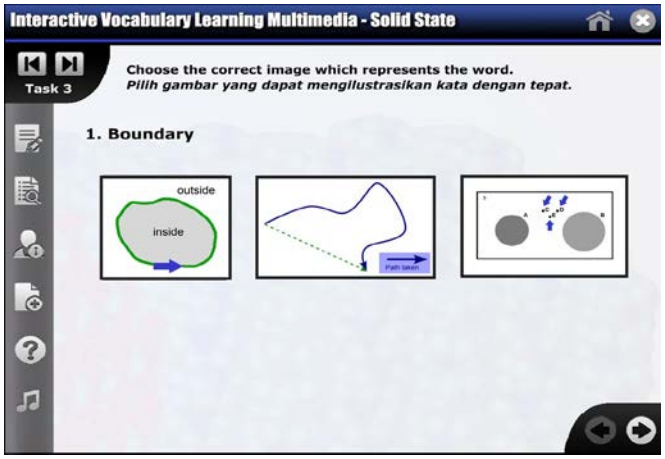


Figure 4.7. Task 3

h. Task 4

Similar with Task 3, Task 4 make the users match the target words with their non-linguistic representations. At that time, the users need to drag the correct target word into its correct representation. The representations are also in the form of animated pictures. The print screen of the page is presented below.

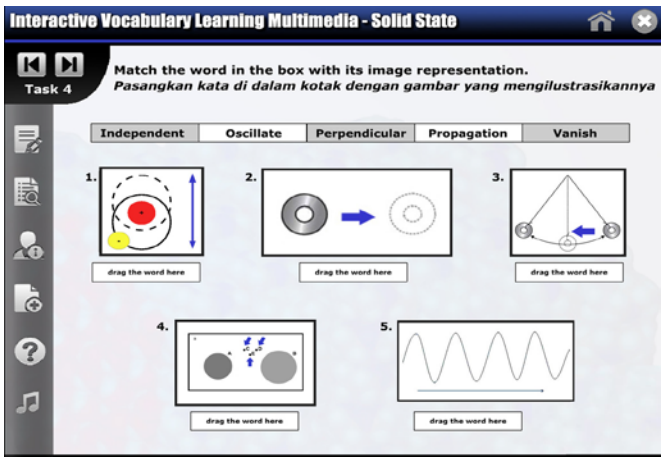


Figure 4.8. Task 4

i. Task 5

Task 5 is a page where the users need to match the words with its correct pronunciation by typing the alphabet of the pronunciation. To hear the pronunciation, the users just need to push the button on the pronunciation column. There are two buttons in the bottom of the column. A yellow button is made to check the answer while the red button is made to allow the users to try to do the task again. Below is the picture of the task.

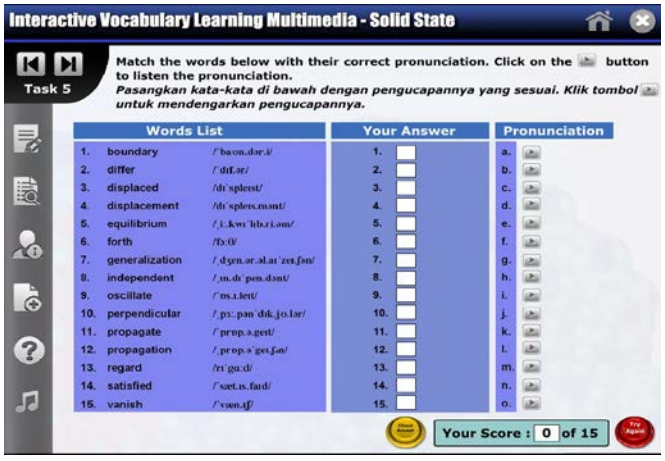


Figure 4.9. Task 5

j. Task 6

Task 6 is designed to make the users chose a correct part of speech. The users need to click on the correct part of speech and then the feedback in the form of visual and audio would appear. This task consists of several pages and in the last page there will be a score of the correct answer and a red button to try again the task. Below is the figure of Task 3.

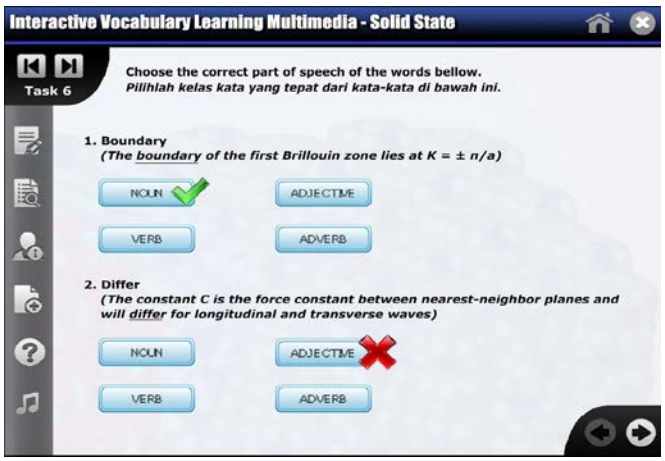


Figure 4.10. Task 6

k. Task 7

Task 7 is also developed to make the users learned the target word's part of speech. This task makes the users chose the correct target words that are categorized into a certain part of speech. By clicking the show text button, the users will be given with sentences that contain the target words from the textbook. The picture below is the appearance of Task 7.

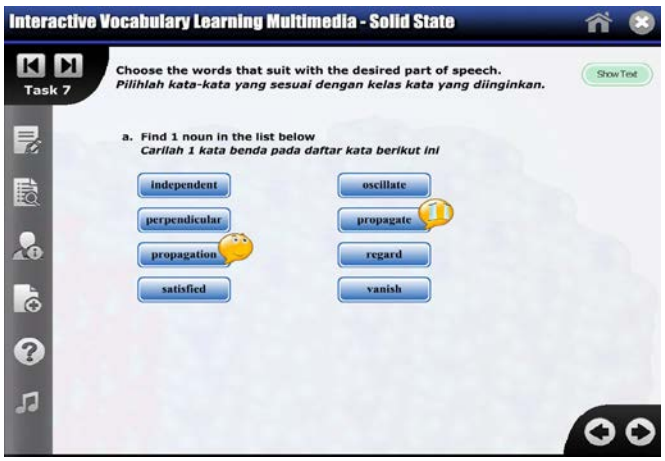


Figure 4.11. Task 7

l. Task 8

In this task, the users are asked to choose the correct definition of all the target words presented in each unit. The users chose the definition by typing the alphabet of the definition in the provided boxes. There are also a check answer and a try again button to check the users answer and to try the task again. The score of the correct answer is also provided. The picture of the task is provided below.

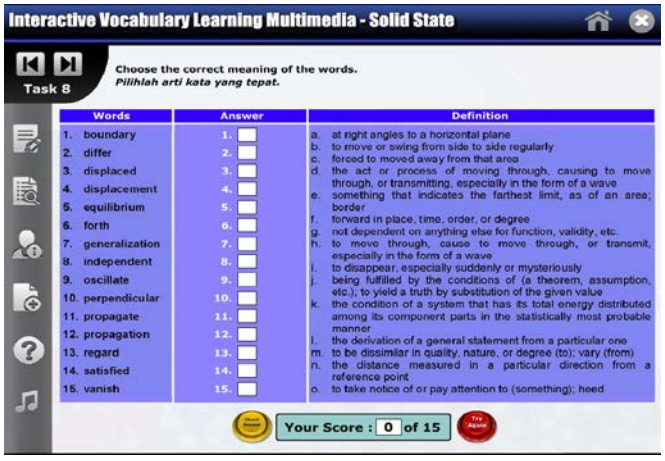


Figure 4.12. Task 8

m. Task 9

Task 9 is where the users are asked to match the target words with their meaning in Bahasa Indonesia. They needed to type the answers in the boxes provided. A check answer and a try again buttons are provided at the bottom of the page. The users can also know the score of the correct answer at the bottom of the page. Below is a figure of Task 9.

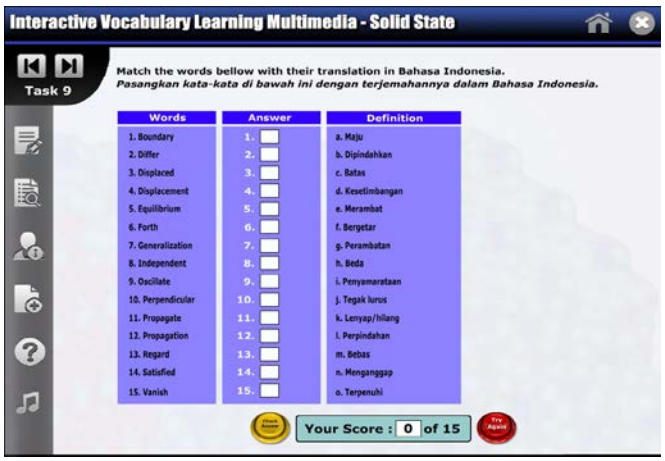


Figure 4.13. Task 9

n. Task 10

Task 10 is made to allow the users to play a crosswords puzzle. A question button is made to show the questions of the crossword puzzle. The answer of the crossword puzzle consists of the target words. Show clue button is made to help the users by giving them the list of the target words while hide clue button is made to hide that list. The picture of task 10 can be seen below.

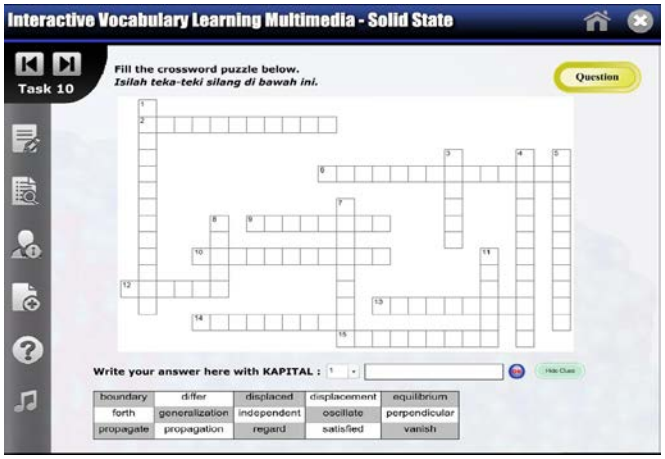


Figure 4.14. Task 10

o. Task 11

The last task is Task 11. It is developed to incorporate the target words in a larger learning project. The users are asked to complete some sentences with suitable words. So the users have to know the target words in the first place. The list of target words is provided to assist them. A check answer, a try again buttons, and the score of correct answer are provided at the bottom of the page. Below is a picture of Task 11.

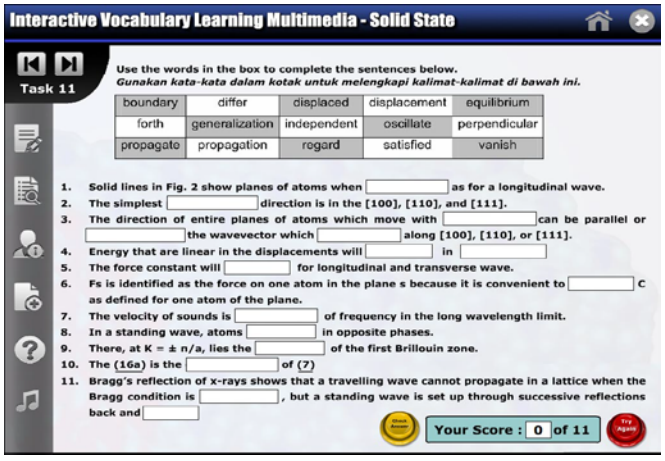


Figure 4.15. Task 11

p. Summary

Summary page is the last page of each unit. It presents the corpus data and the flash cards explanation of the target words based on its unit. The corpus data can be seen in Appendix C. In the flashcards there are the meaning, the pronunciation, the phonetic transcription, the part of speech, the definition, and some of them also are provided by cobuild examples of the target words. The picture of task 10 is provided below.

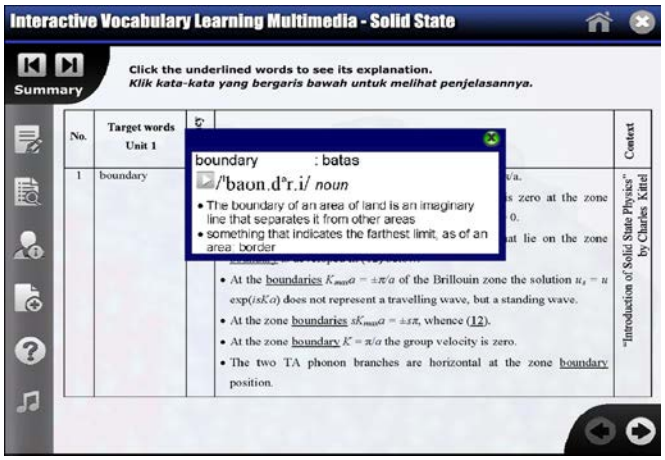


Figure 4.16. Summary

q. Dictionary

The dictionary presents the meaning, the pronunciation, the phonetic transcription, the part of speech, the definition, and some of them are provided with cobuild example of the target words. Some target words are also provided with non-linguistic representation in the form of animated pictures. The users can choose to see the target words' dictionary based on their unit.

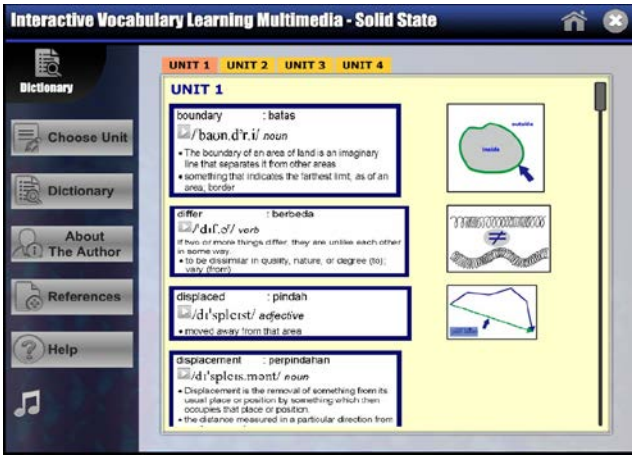


Figure 4.17. Dictionary

6. The Review of the First Draft by the Experts

The expert judgment is aimed to get the experts' suggestions about the first draft of the materials. The multimedia is reviewed by two content experts and a media expert. Since the multimedia is developed for the students of Physics Education Department, the content experts consist of language expert and subject expert. The feedbacks from the experts are used to design the final draft of the media and to assess whether the multimedia is appropriate or not. The questionnaires for the experts can be seen in Appendix A.

a. The Review from Content Experts

The language expert, who evaluated the English materials, suggested that some changes in the multimedia should be made. The first was to add an example in each task in all units. The example is needed to make the user easier to understand the instruction.

The pictures in Task 3 and Task 4 in all units needed to be changed into animated pictures. Twenty nine animated pictures were made to replace them. The

mistakes in writing the instruction on some tasks were the next point that should be revised.

The language expert recommended changing “that included” into “that are included” in the instructions of Task 1 in all units. The words “the desired” in the instruction of Task 7 in all units should also be changed into “the correct”. The words “of the words” which is contained in the instruction of Task 8 in all units should be omitted.

The subject expert, who evaluated the Physics content, suggested that some changes considering the meaning of some words should be made. The meaning of “generalization”, “propagate”, “propagation”, “excite”, “gap”, ”recoil”, and “sphere” were inappropriate and therefore they were revised. The meaning were revised from “*menyebar*”, “*penyebaran*”, “*meningkat (ke energi yang lebih tinggi)*”, “*celah*”, “*melompat*”, and “*bulatan*” into “*penyamarataan*”, “*merambat*”, “*perambatan*”, “*penyamarataan*”, “*pindah keluar (elektron)*”, ”*jarak*”, ”*melonjak*”, and “*bola*”.

The review that came as results of the questionnaire was then used to revise the materials and decide whether the multimedia was already appropriate or not. When the data of the mean values ($\bar{x}$) showed that they were ‘Fair’, ‘Good’, or ‘Very Good’, the units of the multimedia were considered as appropriate.

1) Evaluation and Validation of Unit 1

The language expert judgment of Unit 1 resulted in some changes that should be made. In the instruction in overview “that included” should be replaced by “that are included”. An example of how to do the task also should be added.

The pictures in Task 3 and Task 4 that work as representations of the target words should be changed into animated pictures. The words “the desired” in Task 7 instruction also should be changed into “the correct”. On the instruction of Task 8 the words “of the words” should be omitted. Table 4.8 below shows the result of the evaluation of Unit 1 from the content expert.

Table 4.8. The Evaluation of Unit1 from the Language Expert

Unit	Task	Evaluation	Revision
Unit 1	Overview	On the instruction, “that included” should be replaced with “that are included”.	revising the instruction
	Task 1 – Task 11	There is not any example available.	adding an example in each task in all units
	Task 3	The pictures should be replaced by animated pictures.	replacing the picture with animated picture
	Task 4	The pictures should be replaced by animated pictures.	replacing the picture with animated picture
	Task 7	On the instruction, “the desired” should be replaced with “the correct”.	revising the instruction
	Task 8	On the instruction, “of the words” should be omitted.	revising the instruction

The subject expert asked to consider doing some changes which were the meaning of “propagate” and the meaning of “propagation”. Both of them should be revised. The result of the evaluation from the content experts is shown in Table 4.8. below.

Table 4.9. The Evaluation of Unit 1from the Subject Expert

Unit	Task	Evaluation	Revision
Unit 1	Task 1, Task 2, Task 9 & Dictionary	The meaning of “propagate” was inappropriate.	revising the meaning
	Task 1, Task 2, Task 9 & Dictionary	The meaning of “propagation” was inappropriate.	revising the meaning

The content experts agreed that Unit 1 was appropriate. It was proven by the mean values ($\bar{x}$) in Table 4.10 and Table 4.11. The smallest mean was 4 while the biggest was 5 According to Sudjono (2003:335), the mean value ($\bar{x}$) of $3.4 < \bar{x} \leq 4.2$ is categorized as 'Good', and ($\bar{x}$) > 4.20 is categorized as 'Very Good'. The tables below explain the descriptive statistics of Unit 1.

Table 4.10. The Descriptive Statistic of the Language Expert Validation on the Appropriateness of Unit 1

No.	Element	n	Mean ($\bar{x}$)	Category
The Appropriateness of the Content				
1.	The Appropriateness with Syllabus	15	5	Very Good
2.	The Materials Supporting the Learning	14	4.7	Very Good
The Appropriateness of the Language				
3.	The Appropriateness with the Level of Students' Development	12	4	Good
4.	Communicative	5	5	Very Good
5.	Accuracy	8	4	Good
6.	Cohesive and Coherence	8	4	Good
The Appropriateness of the Presentation				
7.	Technique of Presentation	20	5	Very Good
8.	Learning Presentation	37	4.6	Very Good

Table 4.11. The Descriptive Statistic of the Subject Expert Validation on the Appropriateness of Unit 1

No.	Element	n	Mean ($\bar{x}$)	Explanation
1.	The Appropriateness with Syllabus	14	4.7	Very Good
2.	The Appropriateness of the Concept	12	4	Good
3.	The Appropriateness of the Word Choice	12	4	Good

2) Evaluation and Validation of Unit 2

The language expert judgment of Unit 2 suggested some revisions in similar parts of Unit 1. The words "that included" in the instruction in overview should be replaced by "that are included". To help the users do the thask, an example of how to do the task also should be added in all tasks. Representations

of the target words in Task 3 and Task 4 should be changed into animated pictures. The words “the desired” in instruction of Task 7 should be changed into “the correct”. The words “of the words” on the instruction of Task 8 should be omitted. Below is Table 4.12 that shows the result of the evaluation of Unit 2 from the content expert.

Table 4.12. The Evaluation of Unit 2 from the Language Expert

Unit	Task	Evaluation	Revision
Unit 2	Overview	On the instruction, “that included” should be replaced with “that are included”.	revising the instruction
	Task 1 – Task 11	There is not any example available.	adding an example in each task in all units
	Task 3	The pictures should be replaced by animated picture.	replacing the picture with animated picture
	Task 4	The pictures should be replaced by animated picture.	replacing the picture with animated picture
	Task 7	On the instruction, “the desired” should be replaced with “the correct”.	revising the instruction
	Task 8	On the instruction, “of the words” should be omitted.	revising the instruction

The subject expert suggested changing the meaning of “excite” and “gap”. Below is the result of the evaluation from the content experts which is shown in Table 4.13.

Table 4.13. The Evaluation of Unit 2 from the Subject Expert

Unit	Task	Evaluation	Revision
Unit 2	Task 1, Task 2, Task 9 & Dictionary	The meaning of “excite” was inappropriate.	revising the meaning
	Task 1, Task 2, Task 9 & Dictionary	The meaning of “gap” was inappropriate.	revising the meaning

The validation showed that Unit 2 was appropriate. This was supported by the mean values ($\bar{x}$) in Table 4.14 and Table 4.15. The smallest mean was 4 while the biggest was 5. According to Sudjono (2003:335), the mean value ($\bar{x}$) of $3.4 < \bar{x} \leq 4.2$ is categorized as 'Good', and ($\bar{x}$) > 4.20 is categorized as 'Very Good'. The tables below explain the descriptive statistics of Unit 2.

Table 4.14. The Descriptive Statistic of the Language Expert Validation on the Appropriateness of Unit 2

No.	Element	n	Mean ($\bar{x}$)	Explanation
The Appropriateness of the Content				
1.	The Appropriateness with Syllabus	15	5	Very Good
2.	The Materials Supporting the Learning	13	4.3	Very Good
The Appropriateness of the Language				
3.	The Appropriateness with the Level of Students' Development	15	5	Very Good
4.	Communicative	5	5	Very Good
5.	Accuracy	10	5	Very Good
6.	Cohesive and Coherence	10	5	Very Good
The Appropriateness of the Presentation				
7.	Technique of Presentation	20	5	Very Good
8.	Learning Presentation	40	5	Very Good

Table 4.15. The Descriptive Statistic of the Subject Expert Validation on the Appropriateness of Unit 2

No.	Element	N	Mean ($\bar{x}$)	Explanation
1.	The Appropriateness with Syllabus	14	4.7	Very Good
2.	The Appropriateness of the Concept	12	4	Good
3.	The Appropriateness of the Word Choice	12	4	Good

3) Evaluation and Validation of Unit 3

The judgment of the language expert toward Unit 3 resulted in some parts that should be revised. On the instruction in overview there were words "that included" which should be replaced by "that are included". To help the users do the task, an example of how to do the task also should be added in all tasks.

Representations of the target words in Task 3 and Task 4 should be changed into animated pictures. Instruction of Task 7 that include the words “the desired” should be changed into “the correct”. The words “of the words” on the instruction of Task 8 should be omitted. Below is Table 4.16 that shows the result of the evaluation of Unit 2 from the content expert.

Table 4.16. The Evaluation of Unit 3 from the Language Expert

Unit	Task	Evaluation	Revision
Unit 3	Overview	On the instruction, “that included” should be replaced with “that are included”.	revising the instruction
	Task 1 – 11	There is not any example available.	adding an example in each task in all units
	Task 3	The pictures should be replaced by animated picture.	replacing the picture with animated picture
	Task 4	The pictures should be replaced by animated picture.	replacing the picture with animated picture
	Task 7	On the instruction, “the desired” should be replaced with “the correct”.	revising the instruction
	Task 8	On the instruction, “of the words” should be omitted.	revising the instruction

A suggestion from the subject expert has been done by changing the meaning of “recoil”. Below is the result of the evaluation from the content experts which is shown in Table 4.17.

Table 4.17. The Evaluation of Unit 3 from the Subject Expert

Unit	Task	Evaluation	Revision
Unit 3	Task 1, Task 2, & Task 9	The meaning of “recoil” was inappropriate.	revising the meaning

Content experts believed that Unit 3 was appropriate. It was supported by the mean values ($\bar{x}$) in Table 4.18 and Table 4.19. The smallest mean was 4 while the biggest was 5. According to Sudjono (2003:335), the mean value ($\bar{x}$) of 3.4 <

$\bar{x} \leq 4.2$ is categorized as 'Good', and $(\bar{x}) > 4.20$ is categorized as 'Very Good'. Below are the tables explain the descriptive statistics of Unit 3.

Table 4.18. The Descriptive Statistic of the Language Expert Validation on the Appropriateness of Unit 3

No.	Element	N	Mean ($\bar{x}$)	Explanation
The Appropriateness of the Content				
1.	The Appropriateness with Syllabus	15	5	Very Good
2.	The Materials Supporting the Learning	15	5	Very Good
The Appropriateness of the Language				
3.	The Appropriateness with the Level of Students' Development	14	4.7	Very Good
4.	Communicative	4	4	
5.	Accuracy	8	4	Good
6.	Cohesive and Coherence	8	4	Good
The Appropriateness of the Presentation				
7.	Technique of Presentation	20	5	Very Good
8.	Learning Presentation	40	5	Very Good

Table 4.19. The Descriptive Statistic of the Subject Expert Validation on the Appropriateness of Unit 3

No.	Element	n	Mean ($\bar{x}$)	Explanation
1.	The Appropriateness with Syllabus	14	4.7	Very Good
2.	The Appropriateness of the Concept	12	4	Good
3.	The Appropriateness of the Word Choice	13	4.3	Very Good

4) Evaluation and Validation of Unit 4

The language expert judgment of Unit 4 suggested that some parts need revisions. The overview's instruction contained the words "that included" that should be replaced by "that are included". In all tasks, there is an example of how to do it that added. Pictures in Task 3 and Task 4 should be changed into animated pictures. The words "the desired" in instruction of Task 7 should be changed into "the correct". The words "of the words" on the instruction of Task 8 should be

omitted. Table 4.20 below shows the result of the evaluation of Unit 4 from the content expert.

Table 4.20. The Evaluation of Unit 4 from the Language Expert

Unit	Task	Evaluation	Revision
Unit 4	Overview	On the instruction, "that included" should be replaced with "that are included".	revising the instruction
	Task 1 – Task 11	There is not any example available.	adding an example in each task in all units
	Task 3	The pictures should be replaced by animated picture.	replacing the picture with animated picture
	Task 4	The pictures should be replaced by animated picture.	replacing the picture with animated picture
	Task 7	On the instruction, "the desired" should be replaced with "the correct".	revising the instruction
	Task 8	On the instruction, "of the words" should be omitted.	revising the instruction

There is only one suggestion from the subject expert which is changing the meaning of "recoil". The result of the evaluation from the content experts is shown in Table 4.21. below.

Table 4.21. The Evaluation of Unit 4 from the Subject Expert

Unit	Task	Evaluation	Revision
Unit 4	Task 1, Task 2, & Task 9	The meaning of "sphere" was inappropriate.	revising the meaning

Unit 4 was considered as appropriate by the content experts. This was supported by the mean values ($\bar{x}$) in Table 4.22 and Table 4.23. The smallest mean was 4 while the biggest was 5 According to Sudjono (2003:335), the mean value ($\bar{x}$) of $3.4 < \bar{x} \leq 4.2$ is categorized as 'Good', and ($\bar{x}$) > 4.20 is categorized as 'Very Good'. The following tables explain the descriptive statistics of Unit 4.

Table 4.22. The Descriptive Statistic of the Language Expert Validation on the Appropriateness of Unit 4

No.	Element	n	Mean ($\bar{x}$)	Explanation
The Appropriateness of the Content				
1.	The Appropriateness with Syllabus	15	5	Very Good
2.	The Materials Supporting the Learning	12	4	Good
The Appropriateness of the Language				
3.	The Appropriateness with the Level of Students' Development	15	5	Very Good
4.	Communicative	5	5	Very Good
5.	Accuracy	10	5	Very Good
6.	Cohesive and Coherence	8	4	Good
The Appropriateness of the Presentation				
7.	Technique of Presentation	20	5	Very Good
8.	Learning Presentation	40	5	Very Good

Table 4.23. The Descriptive Statistic of the Subject Expert Validation on the Appropriateness of Unit 4

No.	Element	n	Mean ($\bar{x}$)	Explanation
1.	The Appropriateness with Syllabus	14	4.7	Very Good
2.	The Appropriateness of the Concept	12	4	Good
3.	The Appropriateness of the Word Choice	13	4.3	Very Good

b. The Review from Media Experts

1) Evaluation and Validation from Media Experts

There were some suggestions which were given by the media expert. The first was related to the button of the media. There were some buttons that needs to be revised such as "Show Clues" button and "Show Text" in Unit 1. Both of them cannot work properly as what they supposed to be. A revision of their script needed to be done to make them meet their purpose.

The second was the display of the Help page content that was not clear enough. The display needed to be more visible to make the users understand the

content. To make it more visible, the opacity and the sharpness of the display needed to be increased.

The last was about the element of audio. The volumes of the audio were inconsistent; therefore they were needed to be edited so that the volumes are in the same level. Table 4.24 below explains the evaluation from the media expert.

Table 4.24. The Evaluation from the Media Expert

Element	Evaluation	Revision
Button	The "Show Text" button in Task 7 Unit 1 is not active	revising the script
	The "Show Clues" button in Task 10 Unit 1 is not active	revising the script
Display	The content of the Help page is not visible enough	adding the opacity of the content
	There is not any unit label on the task	adding unit label

Scores and feedback also obtained from the media expert. They were used to design the final draft of multimedia and decide whether the multimedia was already appropriate or not. Multimedia was considered as appropriate when the data of the mean values ($\bar{x}$) showed that they were 'Fair', 'Good,', or 'Very Good'. The table below shows the descriptive statistic of media expert validation.

Table 4.25. The Descriptive Statistic of Media Expert Validation on the Appropriateness of Multimedia

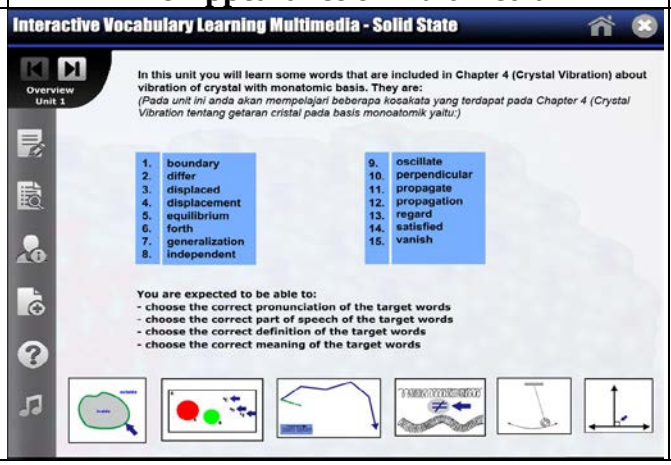
No.	Element	n	Mean ($\bar{x}$)	Explanation
Interface				
1.	General display	42	4.7	Very Good
2.	Text	33	4.7	Very good
3.	Audio	15	5	Very good
4.	Animation and picture	24	4.8	Very good
Navigation				
5.	Functions of the buttons	15	5	Very good
6.	Completeness of the buttons	13	4.3	Very good

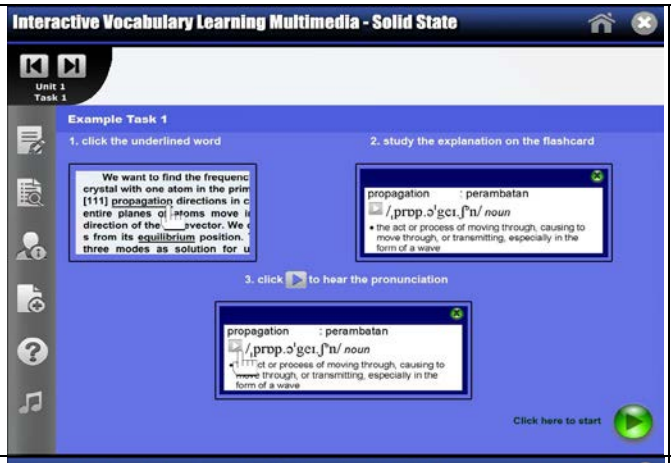
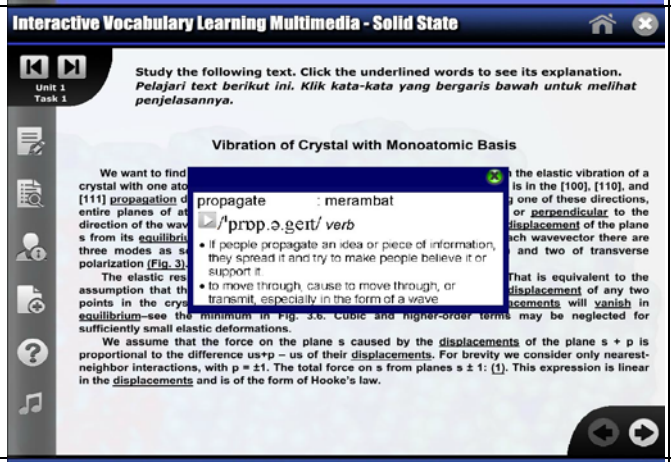
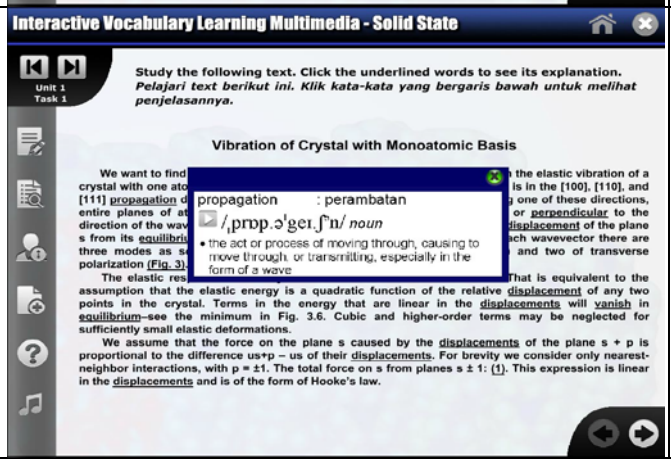
Based on the table above, the media expert agreed that the multimedia was appropriate for the students of Physics education Department Yogyakarta State University. The multimedia is appropriate when the mean value ($\bar{x}$) > 2.6 (Sudjono, 2003:335). Table 4.25 shows that the smallest mean is 4.3 and the biggest mean is 4.7

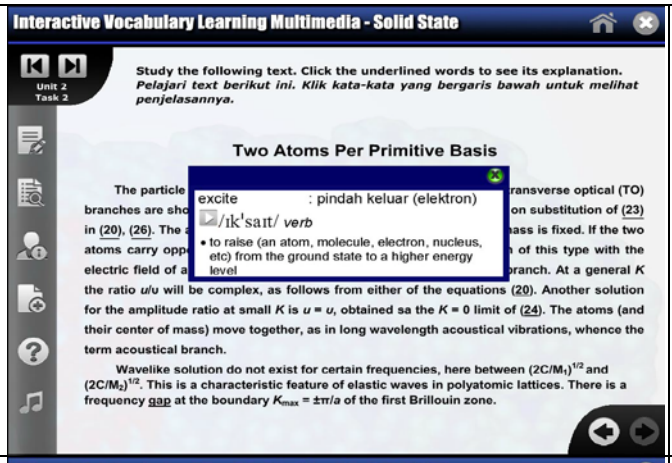
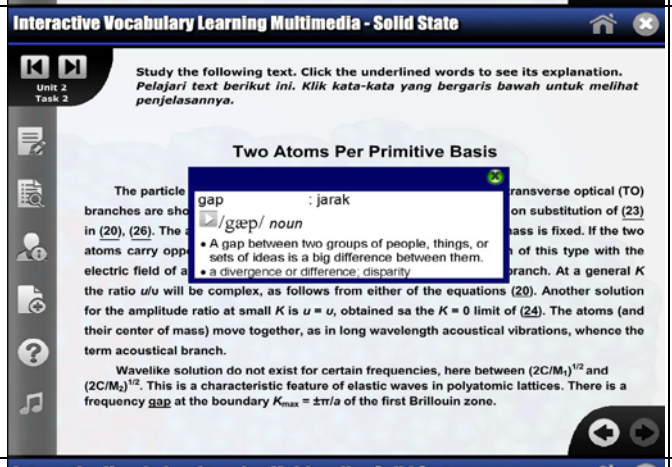
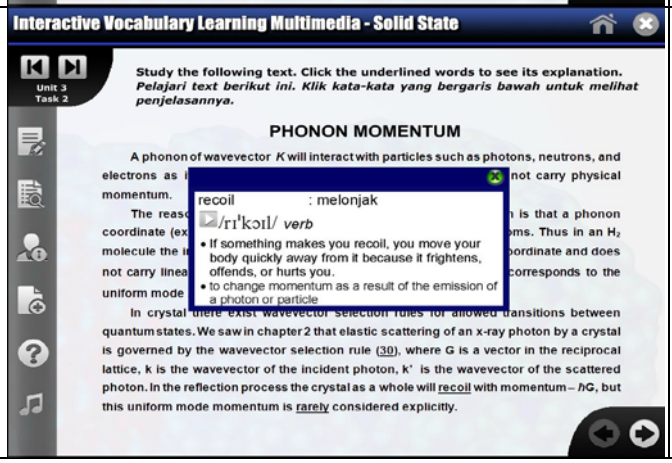
7. The Final Draft of the Interactive Multimedia

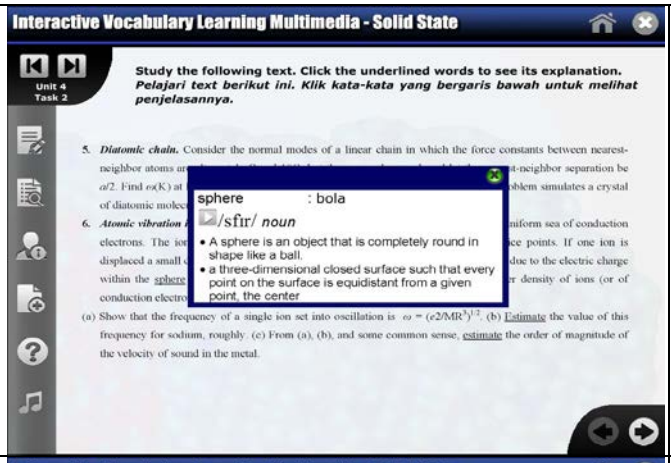
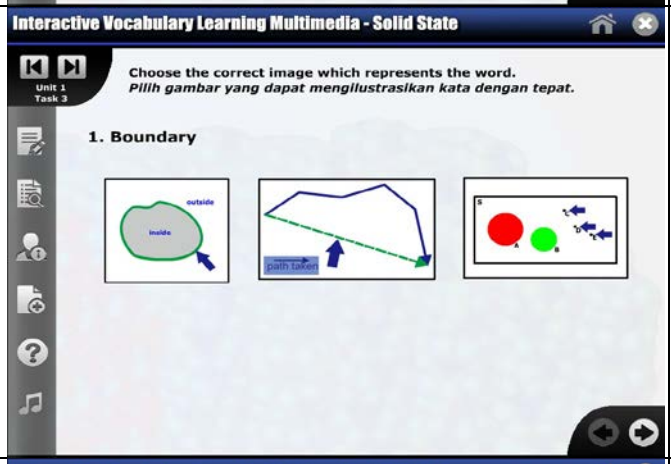
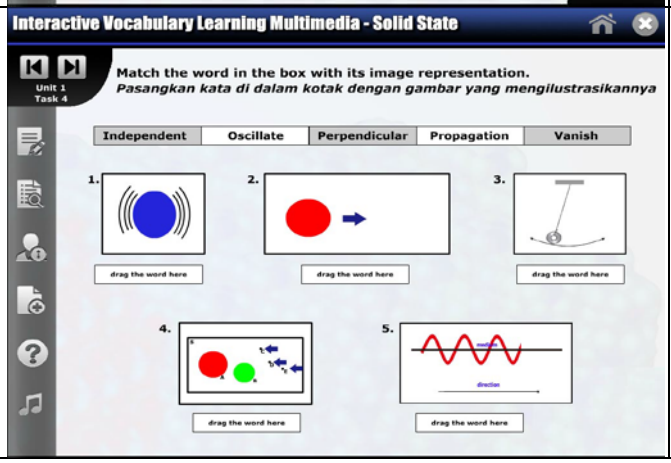
The final draft of the multimedia was designed after the first draft of multimedia was reviewed by the content and media experts. The final draft of the multimedia can be seen in Appendix G. Below is the table which presents revisions of the multimedia.

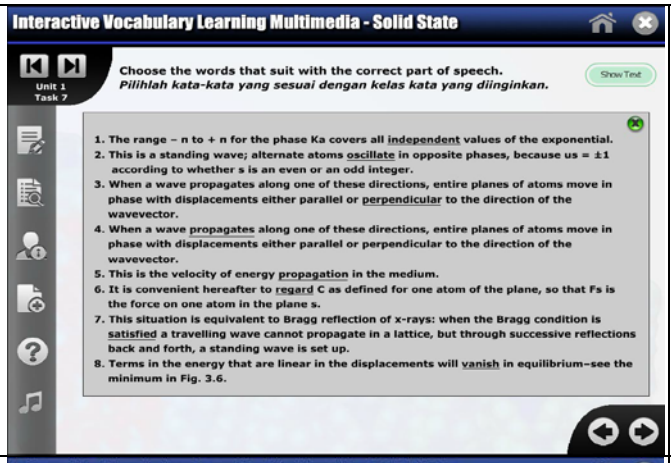
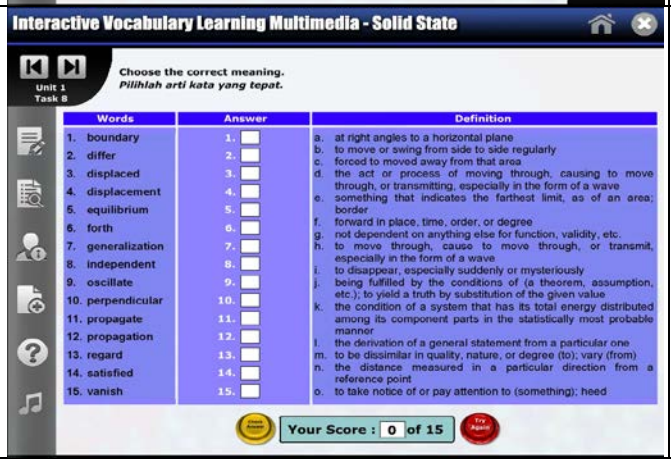
Table 4.26. The Revised Version of Interactive Multimedia

No.	The Appearance of Multimedia	Revision
1.		On the instruction of the overview, “that included” was replaced with “that are included”

2.		• An example for each task was added. • All tasks were labeled with their unit
3.		The meaning of “propagate” which was “menyebarkan” was changed into “merambat”.
4.		The meaning of “propagation” which was “penyebaran” was changed into “perambatan”.

5.		The meaning of “excite” which was “meningkat ke energi yang lebih tinggi” was changed into “pindah keluar (elektron)”
6.		The meaning of “gap” which was “celah” was changed into “jarak”
7.		The meaning of “recoil” which was “melompat” was changed into “melonjak”

8.		The meaning of “sphere” which was “bulatan” was changed into “bola”
9.		The pictures were replaced by animated pictures.
10.		The pictures of Task 4 in all units were replaced by animated pictures.

11.		• On the instruction of Task 7 in unit 1, “the desired” was replaced with “the correct”. • The “Show Text” button of Task 7 in unit 1 was repaired
12.		On the instruction of Task 8 in unit 1, “of the words” was omitted.

B. Discussion

English is used in Physics Education Department of Yogyakarta State University as the medium language in their textbooks. The students of Physics Education Department of Yogyakarta State University have to read so many English textbooks in their study. They feel that it is difficult to read the textbooks since they found many unknown words in it. Despite of the importance of the vocabulary understanding for the students, they only have 2 credits semester of English Subject in their first semester. They feel that it is not enough to make them understand the vocabulary in the textbooks. Even they can find any bilingual dictionary that related to the Physics Subject. So the students need to be facilitated and emphasized in learning vocabulary. Interactive media can be useful for the

students in dealing with that problem. They can learn the material outside the classroom since almost all of the students have the ability to access the media. But there are not any multimedia that can make them learn about vocabulary Physics Subjects. Considering the facts above, interactive learning multimedia which is appropriate with the learners' need and learning needs is developed.

Needs analysis was conducted to make sure that the interactive media could meet the students' target needs and learning needs. Theory proposed by Hutchinson and Waters (1987) about target needs and learning needs was used to develop the needs assessments questionnaire. The questionnaire also used theory from Bennett (2010) to analyze the target needs about the corpus data of vocabulary. Related with the media, theory from Bhatnagar, Mehta and Mitra (2002) was also used in the questionnaire about the learning needs.

The result of the needs analysis was needed to develop a course grid and a flowchart of the multimedia. The course grid was developed to provide a framework of the learning process. The flowchart was used to provide a framework of the multimedia. A syllabus of the Physics Subject was also considered in developing the material.

From the needs analysis, it can be inferred that students learned English to make them able to read their textbooks. The difficult they had when reading textbooks was to understand the vocabulary. The students need to know about vocabulary in the subject of *Fisika Zat Padat* in chapter 4. They feel that their ability in understanding the vocabulary in the Physics textbook was considered as

poor. They wanted to know about the definition, the meaning, the part of speech, the pronunciation, and the image representation of the words.

It was also found that the students wanted to learn the vocabulary in the texts that have approximately 251 – 500 words in length with the amount of 11 – 15 new vocabulary in each unit. The students have chosen the unknown vocabulary through the second questionnaire. During the learning process, they wanted to use explicit approach in learning the vocabulary. They also expected some activities to be included in the media such as matching the word with its definition, matching the word with its meaning, matching the word with its pronunciation, flash cards, matching the word with its image representation, crossword puzzle, and completing sentences. Considering with the setting, they wanted to learn the vocabulary outside of campus. In term of media, the students wanted to use multimedia. According to their preferences, the background, type of font, font size, and font color of the multimedia should be designed depend on its function. They also felt that sometimes picture and back sound are needed to be included in the multimedia.

Based on the findings above, four units of multimedia were developed. Each unit consisted of 11 tasks and added with a dictionary. The tasks were sequenced using phases of teaching vocabulary that was proposed by Grabe and Stiller (2001) and adapted from the steps of explicit vocabulary instruction which was developed by Marzano (2004). Each unit contained introduction, main part and summary. The introduction consisted of an overview and indicators of the unit. The main part consisted of the tasks cycle which consisted of explanation of

the target words, non-linguistic representation, target words' activities (matching, matching the words with its pronunciation, choosing the correct part of speech, find the correct words that represent certain part of speech, matching definition, and matching meaning), games (crossword puzzle), and completing sentences. The summary was also provided at the end of every unit to give students brief explanation about what they already learned.

According to the language expert, the materials were appropriate with the syllabus and support the students' learning process. The language used in the materials was appropriate with the level of students' development, communicative, accurate, cohesive, and coherence. In terms of the presentation, the materials were delivered with appropriate technique and learning presentation. The subject expert suggested that the materials were appropriate with syllabus of the Physics subject. The materials were also appropriate with the Physics concept. The choices of words in the materials were also considered as appropriate. In case of the media, the media expert believed that general display of the media was appropriate. The text and audio of the media were also appropriate. The media also had appropriate animation and picture. In terms of navigation, the media had fully functioned and complete buttons.

Based on the result of the expert judgment, the material was appropriate. It can be seen from the mean value of each item in the questionnaire of expert judgments on the content of the material. The first content expert, as the language expert, who reviewed the English materials showed that the range of the mean value was 4 to 5 for Unit 1, 4.3 to 5 for Unit 2, 4 to 5 for Unit 3, and 4 to 5 for

Unit 4. The second content expert, as the subject expert, who reviewed the Physics content showed that the range of the mean value was 4 to 4.7 for Unit 1, 4 to 4.7 for Unit 2, 4.3 to 4.7 for Unit 3, and 4.3 to 4.7 for Unit 4. The media was also analyzed by the media expert and the research findings showed that it was well-designed. The range of the mean value obtained from the media experts was 4.3 to 5. Based on Likert Scale, all of those ranges fall in the “Good” and “Very Good” categories. In conclusion, the interactive vocabulary learning for the students of Physics Education Department of Yogyakarta State University was developed appropriately.

CHAPTER V

CONCLUSIONS AND SUGGESTIONS

This chapter presents the conclusions of the research and the suggestions to other parties. The conclusions discusses about the target needs, the learning needs and the appropriate interactive vocabulary learning multimedia for the students of Physics Education Department Yogyakarta State University in the subject of *Fisika Zat Padat*. The suggestions are addressed to English Lecturers and other researchers.

A. Conclusions

The research findings and discussions in the previous chapter lead to the following conclusions:

1. Target Needs

It was found that the goal of learning English for Physics Education Students Yogyakarta state University was to help them in reading their English textbooks especially in the subject of *Fisika Zat Padat* in chapter 4.

They faced a difficulty in reading the textbook which was to understand the vocabulary in the text since they believed that they had insufficient ability in understanding the vocabulary. The findings also showed that related to the aspects of vocabulary, they were expected to know about the definition, the meaning, the part of speech, the pronunciation, and the image representation of the words.

2. Learning Needs

The students believed that they need to learn some words related to the subject of *Fisika Zat Padat* in chapter 4 which were boundary, differ, displaced, displacement, equilibrium, forth, generalization, independent, oscillate, perpendicular, propagate, propagation, regard, satisfied, and vanish to be included in Unit 1. Words such as adjacent, coincide, contain, essential, excite, gap, homogeneous, interleaved, pair, and thereby needed to be included in Unit 2. While Unit 3 should include some words such as absorbed, absorption, chiefly, density, determine, determined, occupancy, occupied, occur, rarely, recoil, rigorously, and suitable. They also needed to learn some words such as decoupled, estimate, immersed, reduce, rest, sphere, and unlike in Unit 4. They tended to learn the vocabulary in the text that 251 – 500 words in length with the amount of vocabulary learned in each unit was about 11-15 words.

The students desired to learn the vocabulary by using explicit approach. In learning the vocabulary they preferred to do some activities which were matching the word with its definition, matching the word with its meaning, matching the word with its pronunciation, explaining the words using flash cards, matching the word with its image representation, crossword puzzle, and completing sentences. They wanted to do those activities of learning vocabulary outside of the campus.

The desired media to learn the vocabulary was multimedia. According to the students, the background, the font type, the font color, and the font size in the multimedia should be designed depend on their functions. They also believed that

the use of pictures and back sound in the multimedia were sometimes needed to make it more attractive.

3. The Appropriate Interactive Vocabulary Learning Multimedia

Effective interactive vocabulary learning multimedia for the students of Physics Education Department Yogyakarta State University in the subject of *Fisika Zat Padat* had the following design.

a. The Introduction

It consists of an overview which provides the words to be learned in each unit and indicators of the unit.

b. The main part

It consists of tasks which are explaining the words, matching non-linguistic representation of the words, matching the words with its pronunciation, choosing the correct part of speech, finding the correct words that represent certain part of speech, matching definition, matching meaning, filling a crossword puzzle, and completing sentences.

c. The summary

It gives students brief explanation about what they already learned. The summary provides the students with the corpus data of the words, explanation of the target words and their image representation.

d. The dictionary

It provides the explanation of the target words from the whole unit and the image representation.

B. Suggestions

1. To English Lecturers

Since there may some words that the students of Physics Education Department Yogyakarta State University do not understand in another chapter or even another subject, the English lecturer should consider those words in their learning process to help the students understanding their textbook.

As the English lecture of the Physics Education Department Yogyakarta State University has a very limited time, it will be better if the lecturer also make an interactive vocabulary learning so the students are able to learn the vocabulary even when the English lecture is finished. In designing interactive multimedia, the theory of materials development and interactive learning multimedia should be considered. Moreover, research findings about appropriate interactive vocabulary learning multimedia for the students of Physics Education Department Yogyakarta State University should be referred.

2. To Other Researchers

The focus of this research is developing interactive vocabulary learning multimedia for the students of Physics Education Department Yogyakarta State University especially in the subject of *Fisika Zat Padat* in chapter 4. Since there are still other chapters and also another subject exist to be studied by the Physics Education Department students, it gives other researchers a possibility to design interactive learning multimedia for those other chapters or another subject.

The other researchers are also expected to design interactive vocabulary learning multimedia even for other field of study outside of Physics Education Students.

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APPENDICES

Appendix A

The Research Instruments

OBSERVATION GUIDE

The Materials, Media and Facilities

of Physics Education Department

Yogyakarta State University

No.	Place	Materials/ Media/ Facilities	Explanation
1			
2			
3			
4			
5			
6			
7			

INTERVIEW GUIDE

Interview guide for the Physics Lecturer

1. Materi apa yang Bapak gunakan?
   (What material do you use to teach the Physics subject?)
2. Kapan mahasiswa membutuhkan kemampuan Bahasa Inggris?
   (When do the students use their English proficiency?)
3. Bagaimana kemampuan Bahasa Inggris siswa kelas A/6 Jurusan Pendidikan Fisika UNY?
   (What is the English competence of the A/6 students of Physics Education Department Yogyakarta State University?)
4. Apa yang Bapak lakukan ketika mengajarkan materi Fisika?
   (What do you usually do when teaching the material?)
5. Kesulitan apa yang mahasiswa hadapi dalam menggunakan kemampuan Bahasa Inggris?
   (What is students' difficulty in using English?)
6. Apa yang Bapak lakukan dalam membantu mahasiswa mengatasi kesulitan mahasiswa?
   (What do you do when students have difficulties?)

Analisis Kebutuhan Siswa Akan Pembelajaran Kosakata Bahasa Inggris Melalui Multimedia Pembelajaran Interaktif Jurusan Pendidikan Fisika

Nama	:
Kelas	:
Jenis Kelamin	: L/P
Usia	:

Jawablah pertanyaan di bawah ini sesuai dengan keadaan Anda yang sebenarnya dengan memberi tanda centang (✓) pada pilihan jawaban yang tersedia. Anda dapat memilih jawaban lebih dari 1 pada butir yang memiliki tanda bintang (*).

1. Tujuan saya belajar Bahasa Inggris adalah…*
   - ☐ untuk membaca buku teks
   - ☐ dapat berkomunikasi menggunakan bahasa inggris dengan baik
   - ☐ untuk melanjutkan studi
   - ☐ lain-lain, ... (sebutkan)

2. Kendala saya dalam membaca buku teks yang menggunakan Bahasa Inggris adalah…*
   - ☐ memahami kosakata
   - ☐ memahami struktur kalimat
   - ☐ tidak bisa membaca teks bahasa inggris dengan cepat
   - ☐ lain-lain, ... (sebutkan)

3. Penguasaan saya dalam memahami kosakata Bahasa Inggris dalam buku teks…
   - ☐ sangat kurang
   - ☐ kurang
   - ☐ baik
   - ☐ sangat baik

4. Pengetahuan tentang kosakata Bahasa Inggris yang saya butuhkan…*
   - ☐ definisi
   - ☐ arti kata
   - ☐ fungsi kata
   - ☐ pelafalan
   - ☐ kata dasar dan imbuhannya
   - ☐ lain-lain, ... (sebutkan)

5. Saya ingin mempelajari kosakata yang digunakan dalam mata kuliah…
   - ☐ Fisika Zat Padat, Bab…
   - ☐ Mekanika Fluida, Bab…

6. Jumlah kata dalam teks yang saya inginkan dalam belajar kosakata?
   - ☐ < 251 kata
   - ☐ 251 – 500 kata
   - ☐ 501 – 750 kata
   - ☐ > 750 baris

7. Jumlah kata yang ingin saya pelajari dalam satu unit adalah…
   - ☐ < 6
   - ☐ 6 – 10
   - ☐ 11 – 15
   - ☐ >15

8. Cara belajar kosakata yang saya inginkan*
   - ☐ dengan membaca banyak teks termasuk selain teks pelajaran
   - ☐ dengan pemilihan kosakata yang sulit diikuti cara pemahamannya
   - ☐ dengan mencari arti kata yang tidak diketahui di kamus atau menerka sendiri

9. Bentuk latihan kosakata seperti yang saya inginkan*
   - ☐ menganalisis bagian – bagian kata (kata dasar dan imbuhannya)

- ☐ menganalisis definisi kosakata menggunakan kamus
- ☐ mencocokkan kosakata dengan definisi yang tersedia
- ☐ mencari arti kata dalam bahasa indonesia menggunakan kamus
- ☐ mencocokkan kosakata dengan artinya dalam bahasa Indonesia
- ☐ menerka arti dari konteks
- ☐ mencocokkan kosakata dengan pengucapannya
- ☐ flash card
- ☐ mencocokkan kosakata dengan gambar
- ☐ mencari persamaan kata atau lawan kata
- ☐ membuat *semantic map*
- ☐ permainan teka-teki silang
- ☐ permainan *hangman*
- ☐ menjawab pertanyaan dari teks
- ☐ melengkapi kalimat berdasarkan informasi dari teks
- ☐ lain-lain, ... (sebutkan)

10. Saya merasa nyaman dalam melaksanakan proses pembelajaran kosakata…*
    - ☐ di ruang kelas
    - ☐ di luar kelas tetapi masih di lingkungan kampus
    - ☐ di ruang laboratorium komputer
    - ☐ di luar lingkungan kampus

11. Media yang ingin saya gunakan untuk belajar kosakata Bahasa Inggris adalah…
    - ☐ buku tulis
    - ☐ hand out
    - ☐ multimedia
    - ☐ website
    - ☐ games
    - ☐ lain-lain, ... (sebutkan)

12. Saya ingin latar dalam multimedia…
    - ☐ sama di tiap halaman

- ☐ berbeda-beda di tiap halaman
- ☐ lain-lain, ... (sebutkan)

13. Jenis huruf yang digunakan dalam multimedia sebaiknya…
    - ☐ sama untuk seluruh media
    - ☐ tergantung fungsinya
    - ☐ lain-lain, ... (sebutkan)

14. Ukuran huruf yang digunakan dalam multimedia sebaiknya…
    - ☐ sama untuk seluruh media
    - ☐ tergantung fungsinya
    - ☐ lain-lain, ... (sebutkan)
15. Warna huruf yang digunakan dalam multimedia sebaiknya…
    - ☐ sama untuk seluruh media
    - ☐ tergantung fungsinya
    - ☐ lain-lain, ... (sebutkan)

16. Penggunaan gambar dalam materi…
    - ☐ tidak diperlukan
    - ☐ kadang-kadang diperlukan
    - ☐ diperlukan

17. Penggunaan suara latar dalam multimedia…
    - ☐ tidak diperlukan
    - ☐ kadang-kadang diperlukan
    - ☐ diperlukan

– Terima kasih –

Analisis Kebutuhan Siswa Akan Pembelajaran Kosakata Bahasa Inggris Melalui Multimedia Pembelajaran Interaktif Jurusan Pendidikan Fisika

Nama	:
Kelas	:
Jenis Kelamin	: L/P
Usia	:

Dari buku "Introduction to Solid State Physics" bab 4, tuliskan kosakata yang menurut anda masih perlu untuk anda dipelajari.

Teks: *Crystal Vibration with Monatomic Basis*

Teks: *Two Atoms per Primitive Basis*

Teks: *Quantization of Elastic Waves, Phonon Momentum, & Inelastic Scattering by Phonon*

Teks: *Summary and Problems*

– Terima kasih –

Lembar Evaluasi Multimedia Interaktif Pembelajaran Kosakata Bahasa Inggris untuk Mahasiswa Jurusan Pendidikan Fisika UNY
Unit 1: Crystal Vibration (Monatomic Basis)
(untuk Ahli Materi I)

Pengantar

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Petunjuk Pengisian

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Keterangan:

SS = Sangat Setuju/Sangat Sesuai
S = Setuju/Sesuai
RR = Ragu-ragu
TS = Tidak Setuju/Tidak Sesuai
STS = Sangat Tidak Setuju/Sangat Tidak Sesuai

I. KOMPONEN KELAYAKAN ISI

No.	Pernyataan	SS	S	RR	TS	STS
A.	**Kesesuaian Uraian Materi dengan Silabus**					
1	Materi yang dikembangkan sesuai dengan Silabus.					
2	Multimedia menyajikan teks yang relevan dengan kebutuhan pengguna.					
3	Materi mencakup isi buku yang digunakan dalam kegiatan pembelajaran Fisika Zat Padat.					
	Saran:					
B.	**Materi Pendukung Pembelajaran**					
4	Bahan ajar (teks, gambar, dll.) untuk setiap teks relevan dengan topik yang dibahas.					
5	Teks dan tindak komunikatif menjadikan					

	pengguna mengembangkan kemampuan kosakata.					
6	Teks dan tindak komunikatif tersedia dalam jumlah yang cukup.					
	Saran:					

II. KOMPONEN KELAYAKAN BAHASA

No.	Pernyataan	SS	S	RR	TS	STS
A.	**Kesesuaian Dengan Tingkat Perkembangan Pengguna**					
1	Bahasa yang digunakan dalam penjelasan sesuai dengan tingkat perkembangan kognitif pengguna.					
2	Bahasa yang digunakan dalam instruksi sesuai dengan tingkat perkembangan kognitif pengguna.					
3	Bahasa yang digunakan sesuai dengan perkembangan kemampuan berbahasa pengguna.					
	Saran:					
B.	**Komunikatif**					
4	Pesan yang disajikan jelas dan mudah dipahami oleh pengguna.					
	Saran:					
C.	**Akurasi**					
5	Tata bahasa yang digunakan sesuai kaidah Bahasa Inggris.					
6	Pengejaan kata yang digunakan sesuai kaidah Bahasa Inggris.					
	Saran:					
D.	**Keruntutan dan Kesatuan Gagasan**					
6	Materi yang disajikan dalam satu bagian/bab/subbab/paragraf/kalimat mencerminkan keruntutan penyampaian makna.					
7	Materi yang disajikan mencerminkan ketertautan makna antar bagian/bab/subbab/paragraf/kalimat.					
	Saran:					

III. KOMPONEN KELAYAKAN PENYAJIAN

No.	Pernyataan	SS	S	RR	TS	STS
A.	**Teknik Penyajian**					
1	Materi memiliki bagian pendahulu (*overview*).					
2	Materi memiliki bagian isi (*task cycle*).					
3	Materi memiliki bagian penyudah (rangkuman).					
4	Materi dan tugas disajikan dalam bentuk teks, tindak komunikatif, ilustrasi dan lambang secara seimbang.					
	Saran:					
B.	**Penyajian Pembelajaran**					
5	Penyajian materi dan tugas dapat menarik pengguna untuk menggunakannya.					
6	Penyajian materi dan tugas memberikan pengguna keleluasaan dalam memilih apa yang dibutuhkan.					
7	Penyajian materi dan tugas memberikan keleluasaan pada pengguna dalam mengerjakannya.					
8	Penyajian materi dan tugas memberikan kesempatan bagi pengguna untuk mempersiapkan diri dalam mempelajarinya.					
9	Penyajian materi dan tugas dapat membuat pengguna merasa tertantang dalam menggunakan kemampuan intelektualnya.					
10	Penyajian materi dan tugas memberi pengguna kesempatan untuk menggunakan gaya belajar yang mereka sukai.					
11	Penyajian materi dan tugas mendorong pengguna untuk percaya diri dan bertanggung jawab atas proses belajarnya sendiri.					
12	Penyajian materi dan tugas mendorong pengguna untuk mengenali keberhasilan dan kekurangan mereka dalam melaksanakan kegiatan belajar.					
	Saran:					

Lembar Evaluasi Multimedia Interaktif Pembelajaran Kosakata Bahasa Inggris untuk Mahasiswa Jurusan Pendidikan Fisika UNY
Unit 2: Crystal Vibration (Diatomic Basis)
(untuk Ahli Materi I)

Pengantar

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S = Setuju/Sesuai
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TS = Tidak Setuju/Tidak Sesuai
STS = Sangat Tidak Setuju/Sangat Tidak Sesuai

I. KOMPONEN KELAYAKAN ISI

No.	Pernyataan	SS	S	RR	TS	STS
A.	**Kesesuaian Uraian Materi dengan Silabus**					
1	Materi yang dikembangkan sesuai dengan Silabus.					
2	Multimedia menyajikan teks yang relevan dengan kebutuhan pengguna.					
3	Materi mencakup isi buku yang digunakan dalam kegiatan pembelajaran Fisika Zat Padat.					
	Saran:					
B.	**Materi Pendukung Pembelajaran**					
4	Bahan ajar (teks, gambar, dll.) untuk setiap teks relevan dengan topik yang dibahas.					

5	Teks dan tindak komunikatif menjadikan pengguna mengembangkan kemampuan kosakata.					
6	Teks dan tindak komunikatif tersedia dalam jumlah yang cukup.					
	Saran:					

II. KOMPONEN KELAYAKAN BAHASA

No.	Pernyataan	SS	S	RR	TS	STS
A.	**Kesesuaian Dengan Tingkat Perkembangan Pengguna**					
1	Bahasa yang digunakan dalam penjelasan sesuai dengan tingkat perkembangan kognitif pengguna.					
2	Bahasa yang digunakan dalam instruksi sesuai dengan tingkat perkembangan kognitif pengguna.					
3	Bahasa yang digunakan sesuai dengan perkembangan kemampuan berbahasa pengguna.					
	Saran:					
B.	**Komunikatif**					
4	Pesan yang disajikan jelas dan mudah dipahami oleh pengguna.					
	Saran:					
C.	**Akurasi**					
5	Tata bahasa yang digunakan sesuai kaidah Bahasa Inggris.					
6	Pengejaan kata yang digunakan sesuai kaidah Bahasa Inggris.					
	Saran:					
D.	**Keruntutan dan Kesatuan Gagasan**					
6	Materi yang disajikan dalam satu bagian/bab/subbab/paragraf/kalimat mencerminkan keruntutan penyampaian makna.					
7	Materi yang disajikan mencerminkan ketertautan makna antar bagian/bab/subbab/paragraf/kalimat.					
	Saran:					

III. KOMPONEN KELAYAKAN PENYAJIAN

No.	Pernyataan	SS	S	RR	TS	STS
A.	**Teknik Penyajian**					
1	Materi memiliki bagian pendahulu (*overview*).					
2	Materi memiliki bagian isi (*task cycle*).					
3	Materi memiliki bagian penyudah (rangkuman).					
4	Materi dan tugas disajikan dalam bentuk teks, tindak komunikatif, ilustrasi dan lambang secara seimbang.					
	Saran:					
B.	**Penyajian Pembelajaran**					
5	Penyajian materi dan tugas dapat menarik pengguna untuk menggunakannya.					
6	Penyajian materi dan tugas memberikan pengguna keleluasaan dalam memilih apa yang dibutuhkan.					
7	Penyajian materi dan tugas memberikan keleluasaan pada pengguna dalam mengerjakannya.					
8	Penyajian materi dan tugas memberikan kesempatan bagi pengguna untuk mempersiapkan diri dalam mempelajarinya.					
9	Penyajian materi dan tugas dapat membuat pengguna merasa tertantang dalam menggunakan kemampuan intelektualnya.					
10	Penyajian materi dan tugas memberi pengguna kesempatan untuk menggunakan gaya belajar yang mereka sukai.					
11	Penyajian materi dan tugas mendorong pengguna untuk percaya diri dan bertanggung jawab atas proses belajarnya sendiri.					
12	Penyajian materi dan tugas mendorong pengguna untuk mengenali keberhasilan dan kekurangan mereka dalam melaksanakan kegiatan belajar.					
	Saran:					

Lembar Evaluasi Multimedia Interaktif Pembelajaran Kosakata Bahasa Inggris untuk Mahasiswa Jurusan Pendidikan Fisika UNY
Unit 3: Phonon's Characteristics
(untuk Ahli Materi I)

Pengantar

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Petunjuk Pengisian

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S = Setuju/Sesuai
RR = Ragu-ragu
TS = Tidak Setuju/Tidak Sesuai
STS = Sangat Tidak Setuju/Sangat Tidak Sesuai

I. KOMPONEN KELAYAKAN ISI

No.	Pernyataan	SS	S	RR	TS	STS
A.	**Kesesuaian Uraian Materi dengan Silabus**					
1	Materi yang dikembangkan sesuai dengan Silabus.					
2	Multimedia menyajikan teks yang relevan dengan kebutuhan pengguna.					
3	Materi mencakup isi buku yang digunakan dalam kegiatan pembelajaran Fisika Zat Padat.					
	Saran:					
B.	**Materi Pendukung Pembelajaran**					
4	Bahan ajar (teks, gambar, dll.) untuk setiap teks relevan dengan topik yang dibahas.					

5	Teks dan tindak komunikatif menjadikan pengguna mengembangkan kemampuan kosakata.					
6	Teks dan tindak komunikatif tersedia dalam jumlah yang cukup.					
	Saran:					

II. KOMPONEN KELAYAKAN BAHASA

No.	Pernyataan	SS	S	RR	TS	STS
A.	**Kesesuaian Dengan Tingkat Perkembangan Pengguna**					
1	Bahasa yang digunakan dalam penjelasan sesuai dengan tingkat perkembangan kognitif pengguna.					
2	Bahasa yang digunakan dalam instruksi sesuai dengan tingkat perkembangan kognitif pengguna.					
3	Bahasa yang digunakan sesuai dengan perkembangan kemampuan berbahasa pengguna.					
	Saran:					
B.	**Komunikatif**					
4	Pesan yang disajikan jelas dan mudah dipahami oleh pengguna.					
	Saran:					
C.	**Akurasi**					
5	Tata bahasa yang digunakan sesuai kaidah Bahasa Inggris.					
6	Pengejaan kata yang digunakan sesuai kaidah Bahasa Inggris.					
	Saran:					
D.	**Keruntutan dan Kesatuan Gagasan**					
6	Materi yang disajikan dalam satu bagian/bab/subbab/paragraf/kalimat mencerminkan keruntutan penyampaian makna.					
7	Materi yang disajikan mencerminkan ketertautan makna antar bagian/bab/subbab/paragraf/kalimat.					
	Saran:					

III. KOMPONEN KELAYAKAN PENYAJIAN

No.	Pernyataan	SS	S	RR	TS	STS
A.	**Teknik Penyajian**					
1	Materi memiliki bagian pendahulu (*overview*).					
2	Materi memiliki bagian isi (*task cycle*).					
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4	Materi dan tugas disajikan dalam bentuk teks, tindak komunikatif, ilustrasi dan lambang secara seimbang.					
	Saran:					
B.	**Penyajian Pembelajaran**					
5	Penyajian materi dan tugas dapat menarik pengguna untuk menggunakannya.					
6	Penyajian materi dan tugas memberikan pengguna keleluasaan dalam memilih apa yang dibutuhkan.					
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9	Penyajian materi dan tugas dapat membuat pengguna merasa tertantang dalam menggunakan kemampuan intelektualnya.					
10	Penyajian materi dan tugas memberi pengguna kesempatan untuk menggunakan gaya belajar yang mereka sukai.					
11	Penyajian materi dan tugas mendorong pengguna untuk percaya diri dan bertanggung jawab atas proses belajarnya sendiri.					
12	Penyajian materi dan tugas mendorong pengguna untuk mengenali keberhasilan dan kekurangan mereka dalam melaksanakan kegiatan belajar.					
	Saran:					

Lembar Evaluasi Multimedia Interaktif Pembelajaran Kosakata Bahasa Inggris untuk Mahasiswa Jurusan Pendidikan Fisika UNY
Unit 4: Summary and Problems
(untuk Ahli Materi I)

Pengantar

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S = Setuju/Sesuai
RR = Ragu-ragu
TS = Tidak Setuju/Tidak Sesuai
STS = Sangat Tidak Setuju/Sangat Tidak Sesuai

I. KOMPONEN KELAYAKAN ISI

No.	Pernyataan	SS	S	RR	TS	STS
A.	**Kesesuaian Uraian Materi dengan Silabus**					
1	Materi yang dikembangkan sesuai dengan Silabus.					
2	Multimedia menyajikan teks yang relevan dengan kebutuhan pengguna.					
3	Materi mencakup isi buku yang digunakan dalam kegiatan pembelajaran Fisika Zat Padat.					
	Saran:					
B.	**Materi Pendukung Pembelajaran**					
4	Bahan ajar (teks, gambar, dll.) untuk setiap teks relevan dengan topik yang dibahas.					

5	Teks dan tindak komunikatif menjadikan pengguna mengembangkan kemampuan kosakata.					
6	Teks dan tindak komunikatif tersedia dalam jumlah yang cukup.					
	Saran:					

II. KOMPONEN KELAYAKAN BAHASA

No.	Pernyataan	SS	S	RR	TS	STS
A.	**Kesesuaian Dengan Tingkat Perkembangan Pengguna**					
1	Bahasa yang digunakan dalam penjelasan sesuai dengan tingkat perkembangan kognitif pengguna.					
2	Bahasa yang digunakan dalam instruksi sesuai dengan tingkat perkembangan kognitif pengguna.					
3	Bahasa yang digunakan sesuai dengan perkembangan kemampuan berbahasa pengguna.					
	Saran:					
B.	**Komunikatif**					
4	Pesan yang disajikan jelas dan mudah dipahami oleh pengguna.					
	Saran:					
C.	**Akurasi**					
5	Tata bahasa yang digunakan sesuai kaidah Bahasa Inggris.					
6	Pengejaan kata yang digunakan sesuai kaidah Bahasa Inggris.					
	Saran:					
D.	**Keruntutan dan Kesatuan Gagasan**					
6	Materi yang disajikan dalam satu bagian/bab/subbab/paragraf/kalimat mencerminkan keruntutan penyampaian makna.					
7	Materi yang disajikan mencerminkan ketertautan makna antar bagian/bab/subbab/paragraf/kalimat.					
	Saran:					

III. KOMPONEN KELAYAKAN PENYAJIAN

No.	Pernyataan	SS	S	RR	TS	STS
A.	**Teknik Penyajian**					
1	Materi memiliki bagian pendahulu (*overview*).					
2	Materi memiliki bagian isi (*task cycle*).					
3	Materi memiliki bagian penyudah (rangkuman).					
4	Materi dan tugas disajikan dalam bentuk teks, tindak komunikatif, ilustrasi dan lambang secara seimbang.					
	Saran:					
B.	**Penyajian Pembelajaran**					
5	Penyajian materi dan tugas dapat menarik pengguna untuk menggunakannya.					
6	Penyajian materi dan tugas memberikan pengguna keleluasaan dalam memilih apa yang dibutuhkan.					
7	Penyajian materi dan tugas memberikan keleluasaan pada pengguna dalam mengerjakannya.					
8	Penyajian materi dan tugas memberikan kesempatan bagi pengguna untuk mempersiapkan diri dalam mempelajarinya.					
9	Penyajian materi dan tugas dapat membuat pengguna merasa tertantang dalam menggunakan kemampuan intelektualnya.					
10	Penyajian materi dan tugas memberi pengguna kesempatan untuk menggunakan gaya belajar yang mereka sukai.					
11	Penyajian materi dan tugas mendorong pengguna untuk percaya diri dan bertanggung jawab atas proses belajarnya sendiri.					
12	Penyajian materi dan tugas mendorong pengguna untuk mengenali keberhasilan dan kekurangan mereka dalam melaksanakan kegiatan belajar.					
	Saran:					

Lembar Evaluasi Multimedia Interaktif Pembelajaran Kosakata Bahasa Inggris untuk Mahasiswa Jurusan Pendidikan Fisika UNY
Unit 1: Crystal Vibration (Monatomic Basis)
(untuk Ahli Materi II)

Pengantar

Kuesioner ini merupakan instrumen penilaian terhadap multimedia pembelajaran Bahasa Inggris berjudul *Interactive Vocabulary Learning Multimedia for The Students of Physics Education Department Yogyakarta State University* yang saya kembangkan untuk penyelesaian tugas akhir skripsi. Saya sangat mengharapkan kesediaan Bapak/Ibu untuk mengisi kuesioner ini sebagai masukan atas media yang saya kembangkan. Atas kesediaan Bapak/Ibu, saya sampaikan terimakasih.

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S = Setuju/Sesuai
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TS = Tidak Setuju/Tidak Sesuai
STS = Sangat Tidak Setuju/Sangat Tidak Sesuai

IV. KESESUAIAN URAIAN MATERI DENGAN SILABUS

No.	Pernyataan	SS	S	RR	TS	STS
1	Materi yang dikembangkan sesuai dengan Silabus.					
2	Materi menggunakan teks yang relevan dengan kebutuhan pengguna.					
3	Materi mencakup isi buku yang digunakan dalam kegiatan pembelajaran Fisika Zat Padat.					
	Saran:					

V. KETEPATAN KONSEP

No.	Pernyataan	SS	S	RR	TS	STS
4	Kosakata yang diajarkan sesuai untuk memahami informasi dari buku teks.					

5	Gambar dan ilustrasi sesuai dengan konsep Fisika yang diajarkan.					
6	Tugas yang diberikan sesuai dengan konsep Fisika yang diajarkan.					
	Saran:					

VI. KETEPATAN PEMILIHAN KATA

No.	Pernyataan	SS	S	RR	TS	STS
7	Penjelasan kosakata sudah tepat					
8	Arti kosakata sudah tepat					
9	Istilah bidang Fisika yang digunakan dalam latihan sudah tepat					
	Saran:					

Lembar Evaluasi Multimedia Interaktif Pembelajaran Kosakata Bahasa Inggris untuk Mahasiswa Jurusan Pendidikan Fisika UNY
Unit 2: Crystal Vibration (Diatomic Basis)
(untuk Ahli Materi II)

Pengantar

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S = Setuju/Sesuai
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TS = Tidak Setuju/Tidak Sesuai
STS = Sangat Tidak Setuju/Sangat Tidak Sesuai

I. KESESUAIAN URAIAN MATERI DENGAN SILABUS

No.	Pernyataan	SS	S	RR	TS	STS
1	Materi yang dikembangkan sesuai dengan Silabus.					
2	Materi menggunakan teks yang relevan dengan kebutuhan pengguna.					
3	Materi mencakup isi buku yang digunakan dalam kegiatan pembelajaran Fisika Zat Padat.					
	Saran:					

II. KETEPATAN KONSEP

No.	Pernyataan	SS	S	RR	TS	STS
4	Kosakata yang diajarkan sesuai untuk memahami informasi dari buku teks.					

5	Gambar dan ilustrasi sesuai dengan konsep Fisika yang diajarkan.					
6	Tugas yang diberikan sesuai dengan konsep Fisika yang diajarkan.					
	Saran:					

III. KETEPATAN PEMILIHAN KATA

No.	Pernyataan	SS	S	RR	TS	STS
7	Penjelasan kosakata sudah tepat					
8	Arti kosakata sudah tepat					
9	Istilah bidang Fisika yang digunakan dalam latihan sudah tepat					
	Saran:					

Lembar Evaluasi Multimedia Interaktif Pembelajaran Kosakata Bahasa Inggris untuk Mahasiswa Jurusan Pendidikan Fisika UNY
Unit 3: Phonon's Characteristics
(untuk Ahli Materi II)

Pengantar

Kuesioner ini merupakan instrumen penilaian terhadap multimedia pembelajaran Bahasa Inggris berjudul *Interactive Vocabulary Learning Multimedia for The Students of Physics Education Department Yogyakarta State University* yang saya kembangkan untuk penyelesaian tugas akhir skripsi. Saya sangat mengharapkan kesediaan Bapak/Ibu untuk mengisi kuesioner ini sebagai masukan atas media yang saya kembangkan. Atas kesediaan Bapak/Ibu, saya sampaikan terimakasih.

Petunjuk Pengisian

Berikut ini adalah pernyataan-pernyataan yang berkaitan dengan multimedia pembelajaran Bahasa Inggris yang telah dikembangkan. Bapak/Ibu dimohon untuk memberikan penilaian atas setiap butir dengan memberikan tanda *check* (✓) berdasarkan skala penilaian berikut.

Keterangan:

SS = Sangat Setuju/Sangat Sesuai
S = Setuju/Sesuai
RR = Ragu-ragu
TS = Tidak Setuju/Tidak Sesuai
STS = Sangat Tidak Setuju/Sangat Tidak Sesuai

I. KESESUAIAN URAIAN MATERI DENGAN SILABUS

No.	Pernyataan	SS	S	RR	TS	STS
1	Materi yang dikembangkan sesuai dengan Silabus.					
2	Materi menggunakan teks yang relevan dengan kebutuhan pengguna.					
3	Materi mencakup isi buku yang digunakan dalam kegiatan pembelajaran Fisika Zat Padat.					
	Saran:					

II. KETEPATAN KONSEP

No.	Pernyataan	SS	S	RR	TS	STS
4	Kosakata yang diajarkan sesuai untuk memahami informasi dari buku teks.					

5	Gambar dan ilustrasi sesuai dengan konsep Fisika yang diajarkan.					
6	Tugas yang diberikan sesuai dengan konsep Fisika yang diajarkan.					
	Saran:					

III. KETEPATAN PEMILIHAN KATA

No.	Pernyataan	SS	S	RR	TS	STS
7	Penjelasan kosakata sudah tepat					
8	Arti kosakata sudah tepat					
9	Istilah bidang Fisika yang digunakan dalam latihan sudah tepat					
	Saran:					

Lembar Evaluasi Multimedia Interaktif Pembelajaran Kosakata Bahasa Inggris untuk Mahasiswa Jurusan Pendidikan Fisika UNY
Unit 4: Summary and Problems
(untuk Ahli Materi II)

Pengantar

Kuesioner ini merupakan instrumen penilaian terhadap multimedia pembelajaran Bahasa Inggris berjudul *Interactive Vocabulary Learning Multimedia for The Students of Physics Education Department Yogyakarta State University* yang saya kembangkan untuk penyelesaian tugas akhir skripsi. Saya sangat mengharapkan kesediaan Bapak/Ibu untuk mengisi kuesioner ini sebagai masukan atas media yang saya kembangkan. Atas kesediaan Bapak/Ibu, saya sampaikan terimakasih.

Petunjuk Pengisian

Berikut ini adalah pernyataan-pernyataan yang berkaitan dengan multimedia pembelajaran Bahasa Inggris yang telah dikembangkan. Bapak/Ibu dimohon untuk memberikan penilaian atas setiap butir dengan memberikan tanda *check* (✓) berdasarkan skala penilaian berikut.

Keterangan:

SS = Sangat Setuju/Sangat Sesuai
S = Setuju/Sesuai
RR = Ragu-ragu
TS = Tidak Setuju/Tidak Sesuai
STS = Sangat Tidak Setuju/Sangat Tidak Sesuai

I. KESESUAIAN URAIAN MATERI DENGAN SILABUS

No.	Pernyataan	SS	S	RR	TS	STS
1	Materi yang dikembangkan sesuai dengan Silabus.					
2	Materi menggunakan teks yang relevan dengan kebutuhan pengguna.					
3	Materi mencakup isi buku yang digunakan dalam kegiatan pembelajaran Fisika Zat Padat.					
	Saran:					

II. KETEPATAN KONSEP

No.	Pernyataan	SS	S	RR	TS	STS
4	Kosakata yang diajarkan sesuai untuk memahami informasi dari buku teks.					

5	Gambar dan ilustrasi sesuai dengan konsep Fisika yang diajarkan.					
6	Tugas yang diberikan sesuai dengan konsep Fisika yang diajarkan.					
	Saran:					

III. KETEPATAN PEMILIHAN KATA

No.	Pernyataan	SS	S	RR	TS	STS
7	Penjelasan kosakata sudah tepat					
8	Arti kosakata sudah tepat					
9	Istilah bidang Fisika yang digunakan dalam latihan sudah tepat					
	Saran:					

Lembar Evaluasi Multimedia Interaktif Pembelajaran Kosakata Bahasa Inggris untuk Mahasiswa Jurusan Pendidikan Fisika UNY

(untuk Ahli Media)

Pengantar

Kuesioner ini merupakan instrumen penilaian terhadap multimedia pembelajaran Bahasa Inggris berjudul *Interactive Vocabulary Learning Multimedia for The Students of Physics Education Department Yogyakarta State University* yang saya kembangkan. Saya sangat mengharapkan kesediaan Bapak/Ibu untuk mengisi kuesioner ini sebagai masukan atas media yang saya kembangkan. Atas kesediaan Bapak/Ibu, saya sampaikan terimakasih.

Petunjuk Pengisian

Berikut ini adalah pernyataan-pernyataan yang berkaitan dengan multimedia pembelajaran Bahasa Inggris yang telah dikembangkan. Bapak/Ibu dimohon untuk memberikan penilaian atas setiap butir dengan memberikan tanda *check* (✓) berdasarkan skala penilaian berikut.

Keterangan:

SS = Sangat Setuju/Sangat Sesuai
S = Setuju/Sesuai
RR = Ragu-ragu
TS = Tidak Setuju/Tidak Sesuai
STS = Sangat Tidak Setuju/Sangat Tidak Sesuai

VII.ANTRAMUKA (INTERFACE)

No.	Pernyataan	SS	S	RR	TS	STS
C.	**Tampilan Umum**					
1	Resolusi multimedia sesuai dengan resolusi monitor.					
2	Penempatan gambar, animasi dan teks tidak melebihi print area dari monitor.					
3	Penampilan unsur tata letak secara harmonis memiliki memiliki irama dan kesatuan (unity).					
4	Penempatan unsur tata letak konsisten berdasarkan pola.					
5	Komposisi dan ukuran unsur tata letak (judul, ilustrasi, tombol, dll.), proposional, seimbang dan seirama dengan tata letak isi.					
6	Media menampilkan pusat pandang (center point) yang baik.					

7	Warna unsur tata letak harmonis dan memperjelas fungsi.					
8	Bentuk, warna, ukuran, dan proporsi obyek sesuai realita.					
9	Perpindahan dan pergerakan multimedia halus.					
	Saran:					
D.	**Teks**					
10	Tidak menggunakan terlalu banyak kombinasi jenis huruf.					
11	Jenis huruf yang digunakan pada teks mudah untuk dibaca.					
12	Jenis huruf sesuai dengan isi buku dan tidak menggunakan huruf hias berlebihan.					
13	Ukuran huruf yang digunakan tidak terlalu kecil dan tidak terlalu besar.					
14	Spasi yang digunakan tidak terlalu dekat dan tidak terlalu jauh.					
15	Teks ditata dengan rapi dan tidak bertumpukan.					
16	Pemisahan antar paragraf					
	Saran:					
E.	**Audio**					
17	Audio yang digunakan dapat didengar dengan jelas.					
18	Volume audio tidak terlalu besar dan tidak terlalu kecil.					
19	Audio yang digunakan sesuai dengan isi materi.					
	Saran:					
F.	**Gambar dan Animasi**					
20	Gambar yang digunakan sesuai dengan materi.					
21	Penataan gambar teratur dan rapi.					
22	Penataan gambar tidak bertumpukan.					
23	Animasi berjalan dengan baik.					
24	Animasi yang digunakan sesuai dengan materi.					
	Saran:					

VIII. NAVIGASI

No.	Pernyataan	SS	S	RR	TS	STS
A.	**Fungsi Tombol**					
25	Fungsi tombol dapat diketahui dengan mudah.					
26	Tombol berfungsi dengan baik.					
27	Warna atau bentuk tombol berubah ketika disorot atau ditekan.					
	Saran:					
B.	**Kelengkapan Tombol**					
28	Terdapat tombol untuk berpindah ke frame atau scene tertentu.					
29	Terdapat tombol untuk mengecek jawaban					
30	Terdapat tomboluntuk mengatur latar suara					
	Saran:					

Appendix B

The Research Data

OBSERVATION FORM

The Materials, Media and Facilities

of Physics Education Department

Yogyakarta State University

No.	Place	Materials/ Media/ Facilities	Explanation
1	classroom	Facilities	Almost all of the students bring laptop to the class.
2	classroom	Facilities	Some classrooms in the Faculty of Physics Education Department are provided with LCD projector
3	computer laboratory	Facilities	The students are allowed to access the computer.
4	classroom	media	There is not any media available to help them in understanding the textbook.
5	classroom	materials	There is not any material available to help them in understanding the textbook.
6	faculty and university library	materials	There is not any Physics Bilingual Dictionary (English – Bahasa Indonesia) available.
7	nearby library and bookstore	materials	There is not any Physics Bilingual Dictionary (English – Bahasa Indonesia) available.

INTERVIEW RESULTS

R	= Researcher
L	= Physics Lecturer

R : Mahasiswa Jurusan Fisika perlu menggunakan Bahasa Inggris apa tidak Pak?
(Do the Physics Education Department's students need English?)

L : Iya perlu mas, soalnya mereka pakai buku berbahasa Inggris. Jadi terutama meraka memerlukan kemampuan *reading* yang cukup.
(Yes, they do because they need to use some English books. So especially they need sufficient reading skill.)

R : Jadi dalam pengajaran Bapak memakai buku berbahasa Inggris? Buku apa?
(Does in the learning activity you use English book? What book it is?)

L : Iya, pakai buku "Introduction to Solid State Physics" itu *e-book* mas.
(Yes, I use an English book entitled "Introduction to Solid State Physics", it is an e-book.)

R : Materinya mencakup bagian apa saja Pak?
(What are the scopes of the materials?)

L : Dari bab 1 sampai bab 8.
(It is from Unit 1 until Unit 8)

R : Lalu bagaimana dengan silabusnya Pak?
(What about the syllabus?)

L : Silabusnya seperti bab dalam buku itu kok mas.
(I use a syllabus following the units in the book)

R : Semua bagian dari bab 1 sampai bab 8 Pak?
(Are they the entire materials start from Unit 1to Unit 8?)

L : Iya, semuanya.
(Yes, they are)

R : Bagaimana cara Bapak mengajarkan materi Fisika?
(How do you teach Physics to them?)

L : Biasanya saya meyuruh mereka berkelompok lalu tiap kelompok dapat jatah mempresentasikan 1 bab.
(I usually ask them to work in groups then each group makes a presentation that covers 1 unit)

R : Kalau menurut Bapak sendiri bagaimana kemampuan *reading* mahasiswa?
(How is the reading skill of the students?)

THE ORGANIZATION OF THE NEEDS ANALYSIS QUESTIONNAIRE

Aspect		The purpose of the questions	Questionnaire No.	References
Target Needs	**Necessities**	To find out the type of needs by the demands of target situation	1,5	Hutchinson and Waters (1987), Bennett (2010)
	Lacks	To find out the gap between learners' proficiency and target situation necessities.	2,3	Hutchinson and Waters (1987)
	Wants	To find out the learners' wants of learning English.	4	Hutchinson and Waters (1987)
Learning Needs	**Input**	To find out the suitable input for English learning materials that students want the most	6,7, and the 2nd questionnaire	Hutchinson and Waters (1987), Bennett (2010)
	Procedures	To find out the suitable procedures that students want the most	8,9	Hutchinson and Waters (1987) and
	Setting	To find out the desired setting in learning process that the students want the most	10	Hutchinson and Waters (1987)
	Media	To find out the most suitable media that the students want the most	11,12,13,14,15 ,16,17	Bhatnagar, Mehta and Mitra (2002)

THE RESULT OF NEEDS ANALYSIS

		Questions	Items	N	(%)
Target needs	**Necessities**	The students need to learn English…	a. to read textbooks	31	91.17%
			b. to be able to communicate with foreign people	14	41.17%
			c. to help in the future study	5	14.70%
			d. others	0	0%
		The students want to know about vocabulary in the subject of…	a. *Fisika Zat Padat*, chapter 4	24	70.59%
			b. *Fisika Zat Padat*, chapter *5*	5	14.70%
			c. *Fisika Zat Padat, chapter 6*	3	8.82%
			d. *Mekanika Fluida, chapter 5*	1	2.94%
			e. *Mekanika Fluida, chapter 6*	1	2.94%
	Lacks	Difficulty students face when reading textbook…	a. to understand the vocabularies	29	85.29%
			b. to understand the text's structure	10	29.41%
			c. to read rapidly	14	41.17%
			d. others	0	0%
		The students' ability in understanding the vocabulary in the textbooks…	a. very poor	6	17.65%
			b. poor	23	67.65%
			c. good	5	14.70%
			d. very good	0	0
	Wants	The aspect of vocabulary that the students want to know…	a. the definition	25	73.52%
			b. the meaning (translation)	34	100%
			c. the part of speech	21	61.76%
			d. the pronunciation	19	55.89%
			e. the word's part	9	26.47%
			f. others	0	0%
Learning Needs	**Input**	Length of the text is…	a. < 251 words	6	17.65%
			b. 251 – 500 words	18	52.94%
			c. 501 – 750 words	10	29.41%
			d. > 750 words	0	0%
		The amount of vocabulary learned in each unit is…	a. < 6 words	6	17.65%
			b. 6 – 10 words	12	37.64%
			c. 11 – 15 words	16	47.06%
			d. > 15 words	0	0%
		Corpus data of vocabulary in Unit 1 are…	1) boundary	24	70.59%
			2) differ	11	32.35%
			3) displaced	25	73.52%
			4) displacement	27	79.41%

		Questions	Items	N	(%)
Learning Needs	**Input**	Corpus data of vocabulary in Unit 1 are…	5) equilibrium	21	61.76%
			6) forth	27	79.41%
			7) generalization	15	44.11%
			8) independent	5	14.70%
			9) oscillate	27	79.41%
			10) perpendicular	18	52.94%
			11) propagate	21	61.76%
			12) propagation	24	70.59%
			13) regard	22	64.70%
			14) satisfied	18	61.76%
			15) vanish	26	76.47%
		Corpus data of vocabulary in Unit 2 are…	16) adjacent	27	79.41%
			17) coincide	23	67.65%
			18) contain	13	38.23%
			19) essential	9	26.47%
			20) excite	28	82.35%
			21) gap	18	52.94%
			22) homogeneous	8	23.52%
			23) interleaved	28	82.35%
			24) pair	12	35.29%
			25) thereby	24	70.59%
		Corpus data of vocabulary in Unit 3 are…	26) absorbed	18	61.76%
			27) absorption	20	58.82%
			28) chiefly	29	85.29%
			29) density	19	55.89%
			30) determine	7	20.28%
			31) determined	7	20.28%
			32) occupancy	26	76.47%
			33) occupied	29	85.29%
			34) occur	21	61.76%
			35) rarely	20	58.82%
			36) recoil	30	88.23%
			37) rigorously	31	91.17%
			38) suitable	13	38.23%
		Corpus data of vocabulary in Unit 4 are…	39) decoupled	31	91.17%
			40) estimate	19	55.89%
			41) immersed	28	82.35%
			42) reduce	14	41.17%
			43) rest	23	67.65%
			44) sphere	27	79.41%
			45) unlike	7	20.28%

Learning Needs	**Procedures**	The approach of learning vocabulary is…	a. incidental learning through extensive reading	4	11.76%
			b. explicit instruction through exercises	28	82.35%
			c. guessing meaning from context and dictionary activity	15	44.11%
		The type of activity for learning vocabulary is…	a. analysing word's parts	2	5.88%
			b. finding definition from the dictionary	12	35.30%
			c. matching the word with its definition	18	52.94%
			d. finding the meaning (translation) from the dictionary	17	50%
			e. matching the word with its meaning (translation)	28	82.35%
			f. Guessing meaning from context	14	41.17%
			g. matching the word with its pronunciation	19	55.89%
			h. flash cards	27	4.5%
			i. matching the word with its image representation	22	%
			j. matching the words with its synonym and antonym	3	8.82%
			k. making semantic map	2	5.88%
			l. crossword puzzle	19	55.89%
			m. hangman games	5	14.70%
			n. answering question from the text	5	14.70%
			o. completing sentences	18	52.94%
	Setting	The students learn vocabulary…	a. in the classroom	5	14.70%
			b. in outside of the classroom but still in campus	17	50%
			c. in computer laboratory	4	11.76%
			d. outside of the campus	28	82.35%
	Media	The media to learn vocabulary is…	a. textbook	4	11.76%
			b. hand out	5	14.70%
			c. multimedia	28	82.35%

Learning Needs	**Media**		d. website	7	20.59%
			e. games	10	29.41%
			f. others	0	0%
		The background of multimedia that the students want is…	a. similar on every pages	9	25.47%
			b. depend on its function	25	73.53%
			c. others	0	0%
		The type of font used in multimedia is…	a. similar for the whole media	7	20.59%
			b. depend on its function	27	79.41%
			c. others	0	0 %
		The font size used in multimedia is…	a. similar for the whole media	9	25.47%
			b. depend on its function	25	73.53%
			c. others	0	0%
		The font color used in multimedia is…	a. similar for the whole media	5	14.70%
			b. depend on its function	29	85.29%
			c. others	0	0%
		The use of pictures to support the materials is…	a. not needed	0	0%
			b. sometimes needed	24	70.59%
			c. needed	10	29.41%
		The use of back sound in multimedia is…	a. not needed	4	11.76%
			b. sometimes needed	19	55.89%
			c. needed	11	32.35%

DATA OF CONTENT EXPERTS QUESTIONNAIRE

Data from the First Content Expert (Language Expert)

Unit 1				
No.	**Element**	**n**	**Mean** ($\bar{x}$)	**Category**
The Appropriateness of the Content				
1.	The Appropriateness with Syllabus	15	5	Very Good
2.	The Materials Supporting the Learning	14	4.7	Very Good
The Appropriateness of the Language				
3.	The Appropriateness with the Level of Students' Development	12	4	Good
4.	Communicative	5	5	Very Good
5.	Accuracy	8	4	Good
6.	Cohesive and Coherence	8	4	Good
The Appropriateness of the Presentation				
7.	Technique of Presentation	20	5	Very Good
8.	Learning Presentation	37	4.6	Very Good
Unit 2				
No.	**Element**	**n**	**Mean** ($\bar{x}$)	**Explanation**
The Appropriateness of the Content				
1.	The Appropriateness with Syllabus	15	5	Very Good
2.	The Materials Supporting the Learning	13	4.3	Very Good
The Appropriateness of the Language				
3.	The Appropriateness with the Level of Students' Development	15	5	Very Good
4.	Communicative	5	5	Very Good
5.	Accuracy	10	5	Very Good
6.	Cohesive and Coherence	10	5	Very Good
The Appropriateness of the Presentation				
7.	Technique of Presentation	20	5	Very Good
8.	Learning Presentation	40	5	Very Good
Unit 3				
No.	**Element**	**N**	**Mean** ($\bar{x}$)	**Explanation**
The Appropriateness of the Content				
1.	The Appropriateness with Syllabus	15	5	Very Good
2.	The Materials Supporting the Learning	15	5	Very Good
The Appropriateness of the Language				
3.	The Appropriateness with the Level of Students' Development	14	4.7	Very Good
4.	Communicative	4	4	
5.	Accuracy	8	4	Good

Unit 3				
No.	**Element**	**N**	**Mean** ($\bar{x}$)	**Explanation**
6.	Cohesive and Coherence	8	4	Good
The Appropriateness of the Presentation				
7.	Technique of Presentation	20	5	Very Good
8.	Learning Presentation	40	5	Very Good
Unit 4				
No.	**Element**	**n**	**Mean** ($\bar{x}$)	**Explanation**
The Appropriateness of the Content				
1.	The Appropriateness with Syllabus	15	5	Very Good
2.	The Materials Supporting the Learning	12	4	Good
The Appropriateness of the Language				
3.	The Appropriateness with the Level of Students' Development	15	5	Very Good
4.	Communicative	5	5	Very Good
5.	Accuracy	10	5	Very Good
6.	Cohesive and Coherence	8	4	Good
The Appropriateness of the Presentation				
7.	Technique of Presentation	20	5	Very Good
8.	Learning Presentation	40	5	Very Good

Data from the Second Content Expert (Subject Expert)

Unit 1				
No.	**Element**	**n**	**Mean** ($\bar{x}$)	**Explanation**
1.	The Appropriateness with Syllabus	14	4.7	Very Good
2.	The Appropriateness of the Concept	12	4	Good
3.	The Appropriateness of the Word Choice	12	4	Good
Unit 2				
No.	**Element**	**N**	**Mean** ($\bar{x}$)	**Explanation**
1.	The Appropriateness with Syllabus	14	4.7	Very Good
2.	The Appropriateness of the Concept	12	4	Good
3.	The Appropriateness of the Word Choice	12	4	Good
Unit 3				
No.	**Element**	**n**	**Mean** ($\bar{x}$)	**Explanation**
1.	The Appropriateness with Syllabus	14	4.7	Very Good
2.	The Appropriateness of the Concept	12	4	Good
3.	The Appropriateness of the Word Choice	13	4.3	Very Good

Unit 4				
No.	**Element**	**n**	**Mean** ($\bar{x}$)	**Explanation**
1.	The Appropriateness with Syllabus	14	4.7	Very Good
2.	The Appropriateness of the Concept	12	4	Good
3.	The Appropriateness of the Word Choice	13	4.3	Very Good

Data from the Media Expert

No.	**Element**	**n**	**Mean** ($\bar{x}$)	**Explanation**
Interface				
1.	General display	42	4.7	Very Good
2.	Text	33	4.7	Very good
3.	Audio	15	5	Very good
4.	Animation and picture	24	4.8	Very good
Navigation				
5.	Functions of the buttons	15	5	Very good
6.	Completeness of the buttons	13	4.3	Very good

SURAT REKOMENDASI VALIDASI

Yang bertanda tangan di bawah ini:

Nama	: Lusi Nurhayati, M.App. Ling.
NIP	: 19760205 200312 2 001
Institusi	: FBS UNY
Bidang Keahlian	: Materi

Menyatakan bahwa **Interactive Vocabulary Learning Multimedia for the Students of Physics Education Department Yogyakarta State University** dari mahasiswa:

Nama	: Alvan Bastoni Nuradila
NIM	: 08202241062

Belum layak/layak/layak dengan syarat* menambahkan beberapa saran berikut.

1. Memperbaiki instruks.

Demikian surat rekomendasi ini kami buat untuk dapat digunakan seperlunya.

Evaluator/Validator,

Lusi Nurhayati, M.App. Ling.

NIP. 19760205 200312 2 001

*coret yang tidak perlu

SURAT REKOMENDASI VALIDASI

Yang bertanda tangan di bawah ini:

Nama : Dr. Heru Kuswanto

NIP : 19611112 198702 1 001

Institusi : FMIPA UNY

Bidang Keahlian : Materi

Menyatakan bahwa **Interactive Vocabulary Learning Multimedia for the Students of Physics Education Department Yogyakarta State University** dari mahasiswa:

Nama : Alvan Bastoni Nuradila

NIM : 08202241062

Belum layak/layak/layak dengan syarat* menambahkan beberapa saran berikut.

Gunakan bahasa baku dengan memanfaatkan Kamus Fisika yang diterbitkan oleh Balai Pustaka.

Demikian surat rekomendasi ini kami buat untuk dapat digunakan seperlunya.

Evaluator/Validator,

Dr. Heru Kuswanto

19611112 198702 1 001

*coret yang tidak perlu

SURAT REKOMENDASI VALIDASI

Yang bertanda tangan di bawah ini:

Nama	: Widyanti Anggita Lestari, S.Pd
NIP	: 19900602 201402 2 005
Institusi	: SMK Negeri 6 Surakarta
Pendidikan terakhir	: Pendidikan Teknik Informatika, FT, UNY
Bidang Keahlian	: Multimedia

Menyatakan bahwa **Interactive Vocabulary Learning Multimedia for the Students of Physics Education Department Yogyakarta State University** dari mahasiswa:

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Belum layak/layak/layak dengan syarat* menambahkan beberapa saran berikut.

1. Beberapa tombol perlu diperbaiki/tidak berfungsi
2. Isi pada help perlu diperjelas
3. Tambahkan label unit pada tiap task

Demikian surat rekomendasi ini kami buat untuk dapat digunakan seperlunya.

Evaluator/Validator,

Widyanti Anggita Lestari, S.Pd
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*coret yang tidak perlu

Appendix C

The Physics Content

Syllabus Descriptions
of the *Fisika Zat Padat* Subject

Name of the Institution : Physics Education Department
Yogyakarta State University
Class/Semester : Regular/6
Subject : *Fisika Zat Padat*
Textbook : Introduction to Solid State Physics by Charles Kittel

No.	Syllabus Descriptions
1.	**Crystal Structure:** - Periodic Array of Atoms - Fundamental Types of Lattices - Index Systems for Crystal Planes - Simple Crystal Structures - Direct Imaging of Atomic Structure - Non-ideal Crystal Structures - Crystal Structure Data
2.	**Wave Diffraction and the Reciprocal Lattice:** - Diffraction of Waves by Crystals - Scattered Wave Amplitude - Brillouin Zones - Fourier Analysis of the Basis
3.	**Crystal Binding and Elastic Constants:** - Crystals of Inert Gases - Ionic Crystals - Covalent Crystals - Elastic Waves in Cubic Crystals - Elastic Compliance and Stiffness - Hydrogen Bonds - Metals - Atomic Radii - Analysis of Elastic Strains - Constants
4.	**Phonons I. Crystal Vibrations:** - Vibration of Crystal with Monatomic Basis - Two Atoms per Primitive Basis - Quantization of Elastics Waves - Phonon Momentum - Inelastic Scattering by Phonons
5.	**Phonons II. Crystal Vibrations:** - Phonon Heat Capacity - Anharmonic Crystal Interactions - Thermal Conductivity

6.	**Free Electron Fermi Gas:**	
	- Energy Levels in One Dimension - Effect of Temperature on the Fermi-Dirac Distribution - Dirac Distribution - Free Electron Gas in Three Dimensions	- Heat Capacity of the Electron - Electrical Conductivity and Ohm's Law - Motion in Magnetic Fields - Thermal Conductivity of metals

Corpus Data of the Multimedia

The corpus data contain of:

1) frequency

Frequency of the target words is limited only in the discussed chapter of the book (Chapter 4).

2) contexts of use

The corpus is consisted of the unknown words used in the textbook of the Solid State Physics subject in Physics Education Department Yogyakarta State University which is "Introduction to Solid State Physics" by Charles Kittel. It is considered as pedagogical corpus since it is formulated from a textbook that contribute in the classroom language (Bennett, 2010).

3) strategic use of vocabulary

The strategic use of the target words will be represented by the sentence in which they are found.

A. Unit 1

No.	Target Words Unit 1	frequency	Strategic Use	Context
1	boundary	11	• The boundary of the first Brillouin zone lies at K = ± π/a. • We show from (7) that the slope of ω versus K is zero at the zone boundary: (8) at K = ±π/a, for here sin Ka = sin (±π) = 0. • The special significance of phonon wavevectors that lie on the zone boundary is developed in (12) below. • At the boundaries $K_{max}a = \pm\pi/a$ of the Brillouin zone the solution $u_s = u \exp(isKa)$ does not represent a travelling wave, but a standing wave. • At the zone boundaries $sK_{max}a = \pm s\pi$, whence	"Introduction of Solid State Physics" by Charles

			(12). • At the zone boundary $K = \pi/a$ the group velocity is zero. • The two TA phonon branches are horizontal at the zone boundary position. • We show in chapter 5 by application of periodic boundary conditions to the modes of the crystal of volume V that there is one K value in the volume $(2\pi)^3/V$ in Fourier space. • We can solve this equation exactly for ω2 but it is simpler to examine the limiting cases Ka $\ll$ 1 and Ka = $\pm\pi$ at the zone boundary. • There is a frequency gap at the boundary Kmax = $\pm\pi$/a of the first Brillouin zone. • Show that ω2 is negative (unstable mode) at the zone boundary Ka = π if σ > 0.475 or 4/7ζ(3), where ζ is a Riemann zeta function.	
2	differ	1	• The constant C is the force constant between nearest-neighbor planes and will differ for longitudinal and transverse waves	
3	displaced	2	• (Solid lines) Planes of atoms when displaced as for a longitudinal wave. • Planes of atoms as displaced during passage of a transverse wave.	
4	displacement	20	• The coordinate *u* measures the displacement of the planes. • When a wave propagates along one of these directions, entire planes of atoms move in phase with displacements either parallel or perpendicular to the direction of the wavevector. • We can describe with a single coordinate us the displacement of the planes from its	

			equilibrium position. • That is equivalent to the assumption that the elastic energy is a quadratic function of the relative displacement of any two points in the crystal. • Terms in the energy that are linear in the displacements will vanish in equilibrium–see the minimum in Fig. 3.6 • We assume that the force on the plane s caused by the displacement of the plane s + p is proportional to the difference us+p- us of their displacements. • We assume that the force on the plane s caused by the displacement of the plane s + p is proportional to the difference us+p- us of their displacements. • This expression is linear in the displacements and is of the form of Hooke's law. • We look for solutions with all displacements having the time dependence exp(–iωt). Then d2us/dt2 = – ω2us and (2) becomes (3). • This is a difference equation in the displacements u and has traveling wave solutions of the form: (4), where a is the spacing between planes and K is the wavevector. • From (4) the ratio of the displacements of two successive planes is given by (10). • Then the displacement ratio (10) becomes (11), because exp(i2πn) = 1. • Thus the displacement can always be described by a wavevector within the first zone.	

			• With x-rays it is possible to have n equal to other integers besides unity because the amplitude of the electromagnetic wave has a meaning in the space between atoms, but the displacement amplitude of an elastic wave usually has a meaning only at the atoms themselves. • The displacement of atoms M_1 are denoted by u_{s-1}, u_s, u_{s+1}, . . . , and of atoms M_2 by υ_{s-1}, υ_s, υ_{s+1}. • The particle displacements in the transverse acoustical (TA) and transverse optical (TO) branches are shown in Fig. 10. • Transverse optical and transverse acoustical waves in a disatomic linear lattice, illustrated by the particle displacements for the two modes at the same wavelength. • Here *u* is the displacement of a volume element from its equilibrium position at x in the crystal. • This relates the displacement in a given mode to the phonon occupancy n of the mode.	
5	equilibrium	8	• (Dashed lines) Planes of atoms when in equilibrium. • We can describe with a single coordinate us the displacement of the planes from its equilibrium position. • Terms in the energy that are linear in the displacements will vanish in equilibrium–see the minimum in Fig. 3.6. • Here u is the displacement of a volume element from its equilibrium position at x in the crystal.	

			• The ions are imagined to be in stable equilibrium when at regular lattice points. • If one ion is displaced a small distance r from its equilibrium position, the restoring force is largely due to the electric charge within the sphere of radius r centered at the equilibrium position. • If one ion is displaced a small distance r from its equilibrium position, the restoring force is largely due to the electric charge within the sphere of radius r centered at the equilibrium position. • Show that the contribution of the coulomb interaction to the atomic force constants is $C_{pC} = 2(-1)^{P} p^2/^3 a^3$, where a is the equilibrium nearest-neighbor distance.	
6	forth	1	• This situation is equivalent to Bragg reflection of x-rays: when the Bragg condition is satisfied a travelling wave cannot propagate in a lattice, but through successive reflections back and forth, a standing wave is set up.	
7	generalization	1	• The generalization of dispersion relation (7) to p nearest planes is easily found to be (16a)	
8	independent	3	• The range $-\pi$ to $+\pi$ for the phase Ka covers all independent values of the exponential. • The result that the frequency is directly proportional to the wavevector in the long wavelength limit is equivalent to the statement that the velocity of sound is independent of frequency in this limit. • We solve for the interplanar force constants Cp by multiplying both sides by cos rKa, where r is an integer, and integrating over the	

			range of independent values of K: (16b).	
9	oscillate	1	• This is a standing wave; alternate atoms oscillate in opposite phases, because us = ±1 according to whether s is an even or an odd integer.	
10	perpendicular	1	• When a wave propagates along one of these directions, entire planes of atoms move in phase with displacements either parallel or perpendicular to the direction of the wavevector.	
11	propagate	4	• When a wave propagates along one of these directions, entire planes of atoms move in phase with displacements either parallel or perpendicular to the direction of the wavevector. • This situation is equivalent to Bragg reflection of x-rays: when the Bragg condition is satisfied a travelling wave cannot propagate in a lattice, but through successive reflections back and forth, a standing wave is set up. • We treat waves that propagate in a symmetry direction such that a single plane contains only a single type of ion; such direction are [111] in the NaCl structure and [100] in the CsCl structure. • Consider a longitudinal wave $u_s = u \cos(\omega t - sKa)$ which propagates in a monatomic linear lattice of atoms of mass M, spacing a, and nearest-neighbor interaction C.	
12	propagation	3	• The simples mathematical solution is in the [100], [110], and [111] propagation directions in cubic crystals. • This is the velocity of energy propagation in	

			the medium. • For each polarization mode in a given propagation direction the dispersion relation ω versus K develops two branches, known as the acoustical and optical branches as in Fig 7.	
13	regard	1	• It is convenient hereafter to regard *C* as defined for one atom of the plane, so that F_s is the force on one atom in the plane s.	
14	satisfied	1	• This situation is equivalent to Bragg reflection of x-rays: when the Bragg condition is satisfied a travelling wave cannot propagate in a lattice, but through successive reflections back and forth, a standing wave is set up.	
15	vanish	3	• Terms in the energy that are linear in the displacements will vanish in equilibrium–see the minimum in Fig. 3.6. • The integral vanishes except for p = r. Thus (17) gives the force constant at range pa, for a structure with monoatomic basis. • The homogeneous linear equations have a solution only if the determinant of the coefficients of the unknown u, υ vanishes: (21) or (22).	

B. Unit 2

No.	**Target Words Unit 2**	**frequency**	**Strategic Use**	**Context**
1	adjacent	1	• A diatomic crystal structure with masses M_1, M_2 connected by force constant C between adjacent planes.	"Introduction
2	coincide	1	• The LO and TO branches coincide at *K* = 0;	

			this is also a consequence of the crystal symmetry of Ge.	
3	contain	1	• We treat waves that propagate in a symmetry direction such that a single plane contains only a single type of ion; such direction are [111] in the NaCl structure and [100] in the CsCl structure.	
4	essential	1	• It is not essential that the masses be different, but either the force constant or the masses will be different if the two atoms of the basis are in non-equivalent sites.	
5	excite	1	• If the two atoms carry opposite charges, as in Fig. 10, we may excite a motion of this type with the electric field of a light wave, so that the branch is called the optical branch.	
6	gap	1	• There is a frequency gap at the boundary Kmax = ±π/a of the first Brillouin zone.	
7	homogeneous	1	• The homogeneous linear equations have a solution only if the determinant of the coefficients of the unknown *u*, υ vanishes: (21) or (22).	
8	interleaved	1	• We consider a cubic crystal where atoms of mass M_1 lie on one set of planes of atoms of mass M_2 lie on planes interleaved between those and the first set (Fig. 9).	
9	pair	1	• We write the equation of motion under the assumption that each planes interact only with its nearest-neighbor planes and that the force constants are identical between all pairs of nearest-neighbor planes	
10	thereby	1	• Thus the LA and the two branches have a total of 3N modes, thereby accounting for 3N of the total degrees of freedom.	

C. Unit 3

No.	Target words Unit 3	frequency	Strategic Use	Context
1	absorbed	3	• If a phonon K is absorbed in the process, we have instead the relation (32). • Here K is the wavevector of the phonon created (+) or absorbed (–) in the scattering process, and G is any reciprocal lattice vector. • The statement of conservation of energy is (34), where $\hbar\omega$ is the energy of the phonon created (+) or absorbed (–) in the process.	"Introduction of Solid State Physics" by Charles Kittel
2	absorption		• Phonon dispersion relations $\omega(\mathbf{K})$ are most often determined experimentally by the inelastic scattering of neutrons with the emission or absorption of a phonon.	
3	chiefly	1	• A neutron sees the crystal lattice chiefly by interaction with the nuclei of the atoms.	
4	density	3	• The kinetic energy density is is $\frac{1}{2}\rho\partial u/\partial t)^2$, where ρ is the mass density. • The kinetic energy density is 1/2ρ u/ t)2, where ρ is the mass density. • Take the number density of ions (or of conduction electrons) as 3/4πR3, which defines R.	
5	determine	1	• To determine the dispersion relation using (33) and (34) it is necessary in the experiment to find the energy gain or loss of the scattered neutrons as a function of the scattering direction **k - k'**.	
6	determined	1	• Phonon dispersion relations $\omega(\mathbf{K})$ are most often determined experimentally by the	

			inelastic scattering of neutrons with the emission or absorption of a phonon.	
7	occupancy	1	• This relates the displacement in a given mode to the phonon occupancy n of the mode.	
8	occupied	1	• The energy of an elastic mode of angular frequency ω is (27) when the mode is excited to quantum number *n*; that is, when the mode is occupied by *n* phonons	
9	occur	1	• It occurs for both phonons and photons as a consequence of their equivalence to a quantum harmonic oscilator of frequency ω, for which the energy eigenvalues are also $(n + \frac{1}{2})\omega$. The quantum theory of phonon is developed in Appendix C.	
10	rarely	1	• In the reflection process the crystal as a whole will recoil with momentum $-\hbar\mathbf{G}$, but this uniform mode momentum is rarely considered explicitly.	
11	recoil	1	• In the reflection process the crystal as a whole will recoil with momentum $-\hbar\mathbf{G}$, but this uniform mode momentum is rarely considered explicitly.	
12	rigorously		• The true momentum of the whole system always is rigorously conserved.	
13	suitable	1	• But the energy of a phonon must be positive, so it is conventional and suitable to view ω as positive.	

D. Unit 4

No.	Target words Unit 3	frequency	Strategic Use	Context
1	decoupled	1	• Show that at this value of K the two lattices act as if decoupled: one lattice remains at rest while the other lattice moves.	"Introduction of Solid State Physics" by Charles Kittel
2	estimate	2	• Estimate the value of this frequency for sodium, roughly. • From (a), (b), and some common sense, estimate the order of magnitude of the velocity of sound in the metal.	
3	immersed	1	• Consider point ions of mass M and charge immersed in a uniform sea of conduction electrons.	
4	reduce	1	• Show that for long wavelengths the equation of motion (2) reduces to the continuum elastic wave equation.	
5	rest	1	• Show that at this value of K the two lattices act as if decoupled: one lattice remains at rest while the other lattice moves.	
6	sphere	1	• If one ion is displaced a small distance r from its equilibrium position, the restoring force is largely due to the electric charge within the sphere of radius r centered at the equilibrium position.	
7	unlike	1	• *Basis of two unlike atoms.*	

Dictionary Materials of the Multimedia

A. Unit 1

No.	Target Words Unit 1	Explanation
1	boundary	boundary: batas /ˈbaʊn.dᵊr.i/ *noun* • The boundary of an area of land is an imaginary line that separates it from other areas • something that indicates the farthest limit, as of an area; border
2	differ	differ: berbeda /ˈdɪf.ər/ verb • If two or more things differ, they are unlike each other in some way. • to be dissimilar in quality, nature, or degree (to); vary (from)
3	displaced	displaced : pindah /dɪˈspleɪst/ adjective • moved away from that area
4	displacement	displacement : perpindahan /dɪˈspleɪs.mənt/ noun • Displacement is the removal of something from its usual place or position by something which then occupies that place or position. • the distance measured in a particular direction from a reference point
5	equilibrium	equilibrium: kesetimbangan /ˌiː.kwɪˈlɪb.ri.əm/ noun • Equilibrium is a balance between several different influences or aspects of a situation. • the condition of a system that has its total energy

		distributed among its component parts in the statistically most probable manner
6	forth	forth: maju /fɔːθ/ adverb • When someone goes forth from a place, they leave it. • forward in place, time, order, or degree
7	generalization	generalization: penyamarataan /ˌdʒen.ə r.əl.aɪˈzeɪ.ʃən/ noun • A generalization is a statement that seems to be true in most situations or for most people, but that may not be completely true in all cases • the derivation of a general statement from a particular one
8	independent	independent: berdiri sendiri, tunggal /ˌɪn.dɪˈpen.dənt/ adjective • If one thing or person is independent of another, they are separate and not connected, so the first one is not affected or influenced by the second. • not dependent on anything else for function, validity, etc (of a system of equations) not linearly dependent
9	oscillate	oscillate: bergetar /ˈɒs.ɪ.leɪt/ verb • If an object oscillates, it moves repeatedly from one position to another and back again, or keeps getting bigger and smaller. • to move or swing from side to side regularly
10	perpendicular	perpendicular: tegak lurus /ˌpɜː.pənˈdɪk.jʊ.lər/ adjective • at right angles to a horizontal plane
11	propagate	propagate: merambat /ˈprɒp.ə.geɪt/ verb • If people propagate an idea or piece of information, they spread it and try to make people believe it or support it.

		• to move through, cause to move through, or transmit, especially in the form of a wave
12	propagation	propagation : perambatan /ˌprɒp.əˈgeɪ.ʃən/ noun • the act or process of moving through, causing to move through, or transmitting, especially in the form of a wave
13	regard	regard: menganggap /rɪˈgɑːd/ verb • If you regard something or someone with a feeling such as dislike or respect, you have that feeling about them. • to look upon or consider in a specified way • to take notice of or pay attention to (something); heed
14	satisfied	satisfied: terpenuhi /ˈsæt.ɪs.faɪd/ adjective • If you are satisfied that something is true or has been done properly, you are convinced about this after checking it. • being fulfilled by the conditions of (a theorem, assumption, etc); to yield a truth by substitution of the given value
15	vanish	vanish: lenyap/hilang /ˈvæn.ɪʃ/ verb • If someone or something vanishes, they disappear suddenly or in a way that cannot be explained. • to disappear, especially suddenly or mysteriously • to become zero

B. Unit 2

No.	Target Words Unit 2	Explanation
1	adjacent	adjacent: bersebelahan /ədʒeɪ.sənt/ adjective

		• If one thing is adjacent to another, the two things are next to each other. • joined by a common edge
2	coincide	coincide: bertepatan /koʊ.ɪnsaɪd/ verb • If one event coincides with another, they happen at the same time. • to occur or exist simultaneously
3	contain	contain: mengandung /kənteɪn/ verb • If a substance contains something, that thing is a part of it. • to hold or be capable of holding or including within a fixed limit or area
4	essential	essential: penting /ɪsen.tʃəl/ verb • Something that is essential is extremely important or absolutely necessary to a particular subject, situation, or activity. • vitally important; absolutely necessary
5	excite	excite: pindah ke energi lebih tinggi (elektron) /ɪkˈsaɪt/ verb • to raise (an atom, molecule, electron, nucleus, etc) from the ground state to a higher energy level
6	gap	gap: jarak /gæp/ noun • A gap between two groups of people, things, or sets of ideas is a big difference between them. • a divergence or difference; disparity
7	homogeneous	homogeneous: serbasama /hoʊ.moʊdʒi:.ni.əs/ adjective • Group or thing which has members or parts that are all the same.

		• containing terms of the same degree with respect to all the variables
8	interleaved	interleaved: menyelip /ˌɪntəˈliːvd/ adjective • place at intervals in or among
9	pair	pair: pasangan /per/ noun • A pair of things are two things of the same size and shape that are used together or are both part of something, for example shoes, earrings, or parts of the body. • an object considered to be two identical or similar things joined together
10	thereby	thereby: oleh karena itu /ˌðerˈbaɪ/ adverb • You use thereby to introduce an important result or consequence of the event or action you have just mentioned. • by that means; because of that

C. Unit 3

No.	Target words Unit 3	Explanation
1	absorbed	absorbed: terserap /əbˈzɔːrbd/ adjective • If you are absorbed in something or someone, you are very interested in them and they take up all your attention and energy. • taken in (all or part of incident radiated energy) and retain the part that is not reflected or transmitted
2	absorption	absorption: penyerapan /əbzɔrpˌʃən/ noun • The absorption of a liquid, gas, or other substance is the

		process of it being soaked up or taken in. • a reduction of the intensity of any form of radiated energy as a result of energy conversion in a medium, such as the conversion of sound energy into heat
3	chiefly	chiefly: terutama /ˈtʃiː.fli/ adverb • You use chiefly to indicate that a particular reason, emotion, method, or feature is the main or most important one. • especially or essentially; above all
4	density	density: kepadatan /ˈdent.sə.t̬i/ noun • In science, the density of a substance or object is the relation of its mass or weight to its volume. • a measure of the compactness of a substance, expressed as its mass per unit volume. It is measured in kilograms per cubic metre or pounds per cubic foot.
5	determine	determine: menentukan /dɪtɝ.mɪn/ verb • To determine a fact means to discover it as a result of investigation. • to fix or specify the position, form, or configuration of
6	determined	determined: ditentukan /dɪtɝ.mɪnd/ adjective • If you are determined to do something, you have made a firm decision to do it and will not let anything stop you. • resolute; firm
7	occupancy	occupancy: pengisian /ˈɑː.kjə.pənt .si/ noun • Occupancy is the act of using a room, building, or area of land, usually for a fixed period of time. • the act of occupying; possession of a property
8	occupied	occupied: terisi

		/ˈɑː.kjʊ.paɪd/ adjective • If a room or something such as a seat is occupied, someone is using it, so that it is not available for anyone else. • in use and so not available for anyone else
9	occur	occur: berlaku /əˈkɝː/ verb • When something occurs, it happens. • to happen; take place; come about
10	rarely	rarely: jarang /ˈrerli/ adverb • If something rarely happens, it does not happen very often. • hardly ever; seldom
11	recoil	recoil: melonjak /rɪˈkɔɪl/ verb • If something makes you recoil, you move your body quickly away from it because it frightens, offends, or hurts you. • to change momentum as a result of the emission of a photon or particle
12	rigorously	rigorously: dengan tegas dan jelas /ˈrɪg.ər. ɚ.sli/ adverb • A test, system, or procedure that was done rigorously is very thorough and strict. • the validity of the successive steps in a completely explicit manner
13	suitable	suitable: sesuai, tepat /ˈsuː.tɚ.bl/ adjective • Someone or something that is suitable for a particular purpose or occasion is right or acceptable for it. • appropriate; proper; fit

D. Unit 4

No.	Target words Unit 3	Strategic Use
1	decoupled	decoupled: memisahkan diri /ˌdiːˈkʌpəl/ adjective • If two countries, organizations, or ideas that were connected in some way are decoupled, the connection between them is ended. • separated (joined or coupled subsystems) thereby enabling them to exist and operate separately
2	estimate	estimate: memperkirakan /ˈes.tɪ.meɪt/ verb • If you estimate a quantity or value, you make an approximate judgment or calculation of it. • to form an approximate idea of (distance, size, cost, etc); calculate roughly; gauge
3	immersed	immersed: menyelam /ɪˈmɜːsd/ adjective • If something is immersed in a liquid, someone puts it into the liquid so that it is completely covered. • plunged or dip into liquid
4	reduce	reduce: mengurangi /rɪˈduːs/ verb • If something is changed to a different or less complicated form, you can say that it is reduced to that form. • to modify or simplify the form of (an expression or equation), especially by substitution of one term by another
5	rest	rest: diam /rest/ verb • When an object that has been moving comes to rest, it finally stops.

		• to remain without further attention or action
6	sphere	sphere: bulatan /sfɪr/ noun • A sphere is an object that is completely round in shape like a ball. • a three-dimensional closed surface such that every point on the surface is equidistant from a given point, the center
7	unlike	unlike: berbeda, tidak sama /ʌnˈlaɪk/ adjective • If one thing is unlike another thing, the two things have different qualities or characteristics from each other • not alike; dissimilar or unequal; different

Appendix D

Course Grid

Course Grid

Name of the Institution : Physics Education Department Yogyakarta State University

Class/Semester : A /6

Subject : *Fisika Zat Padat*

Textbook : Introduction to Solid State Physics by Charles Kittel

Syllabus description :

4. Phonons I: vibration of crystal with monoatomic basis, two atoms per primitive basis, quantization of elastics waves, phonon momentum, inelastic scattering by phonons, summary, and problems.

Unit	Indicators	Unit Title	Topic	Input Text	Vocabulary focus	Procedures
1	- Students are able to choose the correct pronunciation of the target words - Students are able to choose the correct part	Crystal vibration (monatomic basis)	Vibration of crystal with monatomic basis	**Informational text (science)** • Vibrations of crystal with monoatomic basis	**Target Words:** • boundary • differ • displaced • displacement • equilibrium • forth • generalization • independent • oscillate • perpendicular • propagate	**I. Introduction** **Focusing the keywords:** Overview **II. Main part** **Keeping the words active:** A. Explanation of target words 1. Studying the target words through flash cards (text 1) 2. Studying the target words through flash cards (text 2) B. Non-linguistic representation 3. Matching the target words with their

	of speech of the target words - Students are able to choose the correct definition of target words - Students are able to choose the correct meaning of the target words				• propagation • regard • satisfied • vanish	image representation 4. Matching image representation with the correct word. C. Activities 5. Matching the words with its pronunciation 6. Choosing the correct part of speech 7. Find the correct words that represent certain part of speech 8. Matching definition 9. Matching meaning D. Games 10. Crossword puzzle **Incorporating in a larger learning project:** 11. Completing sentences of specific information **III. Summary**

Unit	Indicators	Unit Title	Topic	Text Type	Vocabulary focus	Procedures
2	- Students are able to choose the correct pronunciation	Crystal Vibration (Diatomic Basis)	Vibration of crystal with diatomic basis	**Informational text (science)** • Two atoms per primitive basis	**Target Words:** • adjacent • coincide • contain • essential	**I. Introduction** **Focusing the keywords:** Overview **II. Main part** **Keeping the words active:**

	of the target words - Students are able to choose the correct part of speech of the target words - Students are able to choose the correct definition of target words - Students are able to choose the correct meaning of the target words				• excite • gap • homogeneous • interleaved • pair • thereby	A. Explanation of target words 1. Studying the target words through flash cards (text 1) 2. Studying the target words through flash cards (text 2) B. Non-linguistic representation 3. Matching the target words with their image representation 4. Matching image representation with the correct word. C. Activities 5. Matching the words with its pronunciation 6. Choosing the correct part of speech 7. Find the correct words that represent certain part of speech 8. Matching definition 9. Matching meaning D. Games 10. Crossword puzzle **Incorporating in a larger learning project:** 11. Completing sentences of specific information **III. Summary**

Unit	Indicators	Unit Title	Topic	Input Text	Vocabulary focus	Procedures
3	- Students are able to choose the correct pronunciation of the target words - Students are able to choose the correct part of speech of the target words - Students are able to choose the correct definition of target words - Students are able to choose the correct meaning of	Phonon's Characteristics	Characteristics of phonon	**Informational text (science)** • Quantization of Elastic waves • Phonon Momentum • Inelastic scattering by phonons	**Target Words:** • absorbed • absorption • chiefly • density • determine • determined • occupancy • occupied • occur • rarely • recoil • rigorously • suitable	**I. Introduction** **Focusing the keywords:** Overview **II. Main part** **Keeping the words active:** A. Explanation of target words 1. Studying the target words through flash cards (text 1) 2. Studying the target words through flash cards (text 2) B. Non-linguistic representation 3. Matching the target words with their image representation 4. Matching image representation with the correct word. C. Activities 5. Matching the words with its pronunciation 6. Choosing the correct part of speech 7. Find the correct words that represent certain part of speech 8. Matching definition 9. Matching meaning D. Games 10. Crossword puzzle

	the target words					**Incorporating in a larger learning project:** 11. Completing sentences of specific information **III. Summary**

Unit	Indicators	Unit Title	Topic	Input Text	Vocabulary focus	Procedures
4	- Students are able to choose the correct pronunciation of the target words - Students are able to choose the correct part of speech of the target words - Students are able to choose the correct	Summary and Problems	Summary and problems of the crystal vibration and phonon	**Informational text (science)** • Summary • Problems	**Target Words:** • decoupled • estimate • immersed • reduce • rest • sphere • unlike	**I. Introduction** **Focusing the keywords:** Overview **II. Main part** **Keeping the words active:** A. Explanation of target words 1. Studying the target words through flash cards (text 1) 2. Studying the target words through flash cards (text 2) B. Non-linguistic representation 3. Matching the target words with their image representation 4. Matching image representation with the correct word. C. Activities 5. Matching the words with its pronunciation

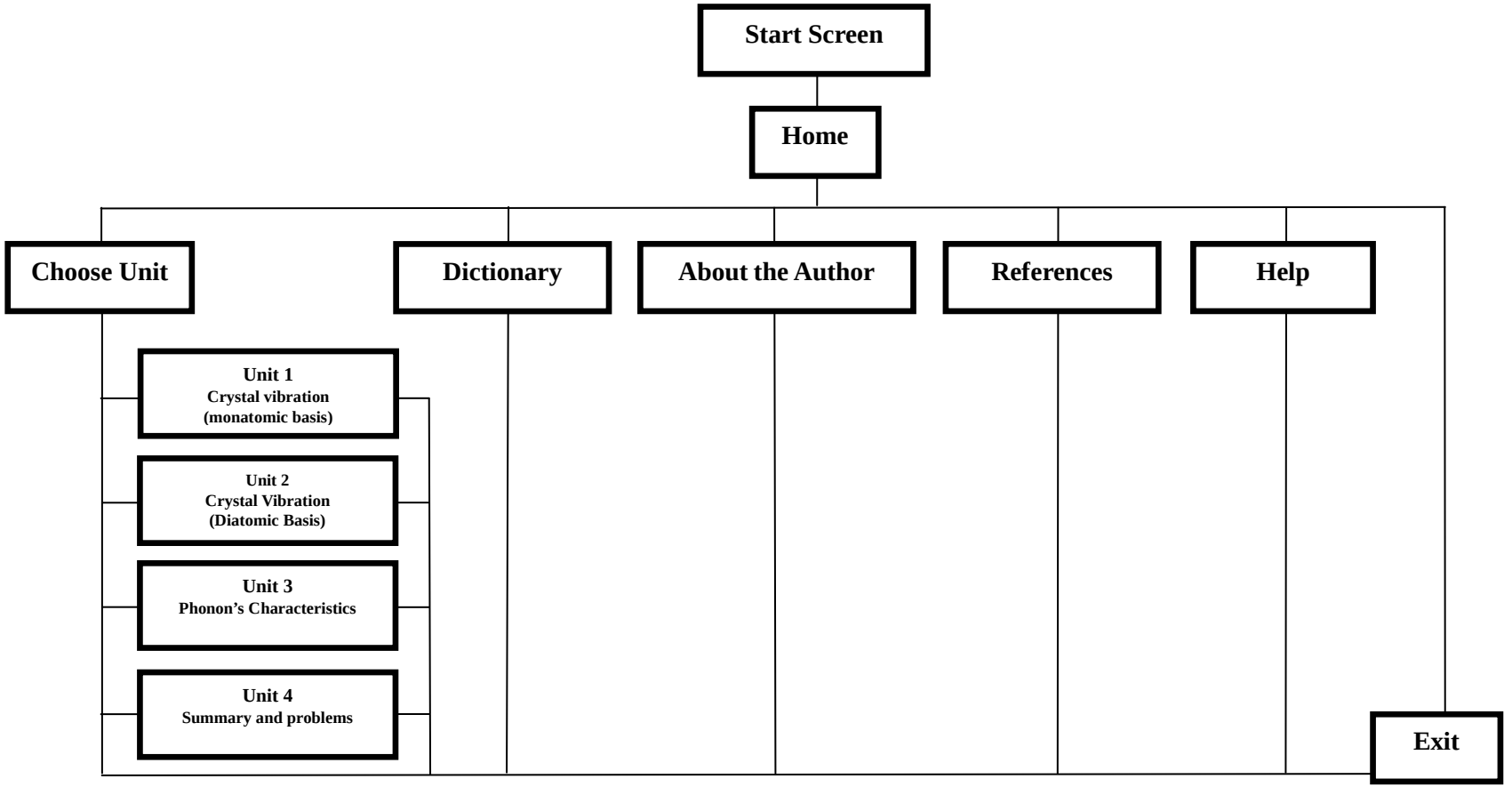
	definition of target words - Students are able to choose the correct meaning of the target words					6. Choosing the correct part of speech 7. Find the correct words that represent certain part of speech 8. Matching definition 9. Matching meaning D. Games 10. Crossword puzzle **Incorporating in a larger learning project:** 11. Completing sentences of specific information **III. Summary**

Appendix E

Flowchart

Flowcharts of Interactive Vocabulary Learning Multimedia

for the Students of Physics Education Department Yogyakarta State University



Appendix F

The First Draft of the Multimedia

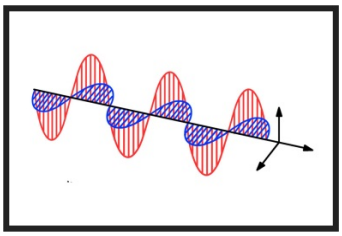
UNIT 1

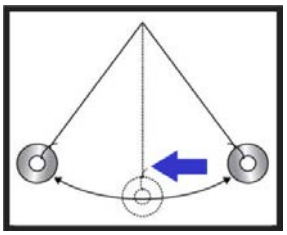
Crystal Vibration (Monatomic Basis)

OVERVIEW

In this unit you will learn some words that included in Chapter 4 about vibration of crystal with monoatomic basis. They are:

boundary	oscillate
differ	perpendicular
displaced	propagate
displacements	propagation
equilibrium	regard
forth	satisfied
generalization	vanish
independent	





You are expected to be able to:

- choose the correct pronunciation of the target words
- choose the correct part of speech of the target words
- choose the correct definition of the target words
- choose the correct the meaning of the target words

Task 1

Study the following text. Click the underlined words to see its explanation.

Pelajari text berikut ini. Klik kata-kata yang bergaris bawah untuk melihat penjelasannya

VIBRATION OF CRYSTAL WITH MONOATOMIC BASIS

Consider the elastic vibrations of a crystal with one atom in the primitive cell. We want to find the frequency of an elastic wave in terms of the wavevector that describes the wave and in terms of the elastic constants.

The mathematical solution is simplest in the [100], [110], and [111] propagation directions in cubic crystals. These are the directions of the cube edge) face diagonal, and body diagonal. When a wave propagates along one of these

directions, entire planes of atoms move in phase with displacements either parallel or perpendicular to the direction of the wavevector. We can describe with a single coordinate us the displacement of the planes from its equilibrium position. The problem is now one dimensional. For each wavevector there are three modes as solutions for u_s, one of longitudinal polarization (Fig. 2) and two of transverse polarization (Fig. 3).

We assume that the elastic response of the crystal is a linear function of the forces. That is equivalent to the assumption that the elastic energy is a quadratic function of the relative displacement of any two points in the crystal. Terms in the energy that are linear in the displacements will vanish in equilibrium–see the minimum in Fig. 3.6. Cubic and higher-order terms may be neglected for sufficiently small elastic deformations.

We assume that the force on the plane *s* caused by the displacement of the plane s + *p* is proportional to the difference u_{s+p}- u_s of their displacements. For brevity we consider only nearest-neighbor interactions, with $p = \pm 1$. The total force on *s* from planes $s \pm 1$: (1). This expression is linear in the displacements and is of the form of Hooke's law.

The constant *C* is the **force constant** between nearest-neighbor planes and will differ for longitudinal and transverse waves. It is convenient hereafter to regard *C* as defined for one atom of the plane, so that F_s is the force on one atom in the plane *s*.

The equation of motion of an atom in the plane *s* is (2), where *M* is the mass of an atom. We look for solutions with all displacements having the time dependence $\exp(-i\omega t)$. Then $d^2u_s/dt^2 = -\omega^2 u_s$ and (2) becomes (3).

This is a difference equation in the displacements *u* and has traveling wave solutions of the form: (4), where *a* is the spacing between planes and *K* is the wavevector. The value to use for *a* will depend on the direction of *K*. With (4), we have from (3): (5). We cancel $u \exp(isKa)$ from both sides, to leave (6). With the identity $2 \cos Ka = \exp(iKa) + \exp(-iKa)$, we have the **dispersion relation** $\omega(K)$. (7)

The boundary of the first Brillouin zone lies at $K = \pm \pi/a$. We show from (7) that the slope of ω versus K is zero at the zone boundary: (8) at $K = \pm\pi/a$, for here sin Ka = sin ($\pm\pi$) = 0. The special significance of phonon wavevectors that lie on the zone boundary is developed in (12) below.

By a trigonometric identity, (7) may be written as (9). A plot of ω vesus K is given in Fig.4.

Task 2

Study the following text. Click the underlined words to see its explanation.
Pelajari text berikut ini. Klik kata-kata yang bergaris bawah untuk melihat penjelasannya

First Brillouin Zone

What range of K is physically significant for elastic waves? Only those in the first Brillouin zone. From (4) the ratio of the displacements of two successive planes is given by (10). The range $-\pi$ to $+\pi$ for the phase Ka covers all independent values of the exponential.

The range of the first Brillouin Zone of the linear lattice *(K)* is specified by $-\pi < Ka \leq \pi$, or $\frac{\pi}{a} < K \leq \frac{\pi}{a}$. The extreme values are $K_{max} = \pm\pi/a$. Values of K outside of the first Brillouin zone (Fig.5) merely reproduce lattice motions described by values within the limits $\pm\pi/a$.

We may treat a value of K outside these limits by subtracting the integral multiple of $2\pi/a$ that will give a wavevector inside these limits. Suppose K lies outside the first zone, but a related wavevector K' defined $K' = K - 2\pi n/a$ lies within the first zone, where n is an integer. Then the displacement ratio (10) becomes (11), because exp($i2\pi n$) = 1. Thus the displacement can always be described by a wavevector within the first zone. We note that $2\pi n/a$ is a reciprocal lattice vector because $2\pi n/a$ is a reciprocal lattice vector. Thus by subtraction of an appropriate reciprocal lattice vector from K, we always obtain an equivalent wavevector in the first zone.

At the boundaries $K_{max}a = \pm\pi/a$ of the Brillouin zone the solution $u_s = u \exp(isKa)$ does not represent a travelling wave, but a standing wave. At the zone boundaries $sK_{max}a = \pm s\pi$, whence (12). This is a standing wave; alternate atoms oscillate in opposite phases, because $u_s = \pm 1$ according to whether s is an even or an odd integer. The wave moves neither to the right nor to the left.

This situation is equivalent to Bragg reflection of x-rays: when the Bragg condition is satisfied a travelling wave cannot propagate in a lattice, but through successive reflections back and forth, a standing wave is set up.

The critical value $K_{max} = \pm\pi/a$ found here satisfies the Bragg condition $2d \sin\theta = n\lambda$: we have $\theta = \frac{1}{2}\pi$, $d = a$, $K = 2\pi/\lambda$, $n = 1$, so that $\lambda = 2a$. With x-rays it is possible to have n equal to other integers besides unity because the amplitude of the electromagnetic wave has a meaning in the space between atoms, but the displacement amplitude of an elastic wave usually has a meaning only at the atoms themselves.

Group Velocity

The transmission velocity of a wave packet is the **group velocity**, given as $v_g = d\omega/dK$, or (13), the gradient frequency with respect to **K**. This is the velocity of energy propagation in the medium.

With the particular dispersion relation (9), the group velocity (Fig. 6) is (14). This is zero at the edge of the zone where $Ka = \pi/a$. Here the wave is a standing wave, as in (12), and we expect zero net transmission velocity for a standing wave.

Long Wavelength Limit

When $Ka \ll 1$ we expand $\cos Ka \equiv 1 - \frac{1}{2}(Ka)^2$, so that the dispersion relation (7) becomes (15). The result that the frequency is directly proportional to the wavevector in the long wavelength limit is equivalent to the statement that the velocity of sound is independent of frequency in this limit. Thus $v = \omega/K$, exactly as in the continuum theory of elastic waves—in the continuum limit $Ka \ll 1$.

Derivation of Force Constants from Experiment

In metals the effective forces may be of quite long range and are carried from ion to ion through the conduction electron sea. Interactions have been found between planes of atoms separated by as many as 20 planes. We can make a statement about the range of the forces from the observed experimental dispersion relation for ω. The generalization of dispersion relation (7) to p nearest planes is easily found to be (16a).

We solve for the interplanar force constants C_p by multiplying both sides by cos rKa, where r is an integer, and integrating over the range of independent values of K: (16b). The integral vanishes except for $p = r$. Thus (17) gives the force constant at range pa, for a structure with monoatomic basis.

Flash Cards for Task 1 & 2:

No.	Flash card
1.	boundary : batas /ˈbaʊn.dər.i/ *noun* • The boundary of an area of land is an imaginary line that separates it from other areas • something that indicates the farthest limit, as of an area; border
2.	differ : berbeda /ˈdɪf.ər/ *verb* • If two or more things differ, they are unlike each other in some way. • to be dissimilar in quality, nature, or degree (to); vary (from)
3.	displaced : dipindahkan /dɪˈspleɪst/ *adjective* • moved away from that area
4.	displacement : perpindahan /dɪˈspleɪs.mənt/ *noun* • Displacement is the removal of something from its usual place or position by something which then occupies that place or position. • the distance measured in a particular direction from a reference point
5.	equilibrium : kesetimbangan /ˌiː.kwɪˈlɪb.ri.əm/ *noun* • Equilibrium is a balance between several different influences or aspects of a situation. • the condition of a system that has its total energy distributed among its component parts in the statistically most probable manner
6.	forth : maju /fɔːθ/ *adverb* • When someone goes forth from a place, they leave it.

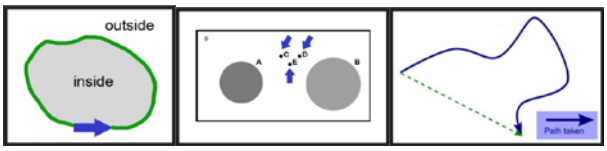
	• forward in place, time, order, or degree
7.	generalization : perluasan /ˌdʒen.ər.əl.aɪˈzeɪ.ʃən/ *noun* • A generalization is a statement that seems to be true in most situations or for most people, but that may not be completely true in all cases • the derivation of a general statement from a particular one
8.	independent : berdiri sendiri, tunggal /ˌɪn.dɪˈpen.dənt/ *adjective* • If one thing or person is independent of another, they are separate and not connected, so the first one is not affected or influenced by the second. • not dependent on anything else for function, validity, etc. • (of a system of equations) not linearly dependent
9.	oscillate : bergetar /ˈɒs.ɪ.leɪt/ *verb* • If an object oscillates, it moves repeatedly from one position to another and back again, or keeps getting bigger and smaller. • to move or swing from side to side regularly
10.	perpendicular : tegak lurus /ˌpɜː.pənˈdɪk.jʊ.lər/ *adjective* • at right angles to a horizontal plane
11.	propagate : menyebar /ˈprɒp.ə.geɪt/ *verb* • If people propagate an idea or piece of information, they spread it and try to make people believe it or support it. • to move through, cause to move through, or transmit, especially in the form of a wave
12.	propagation : penyebaran /ˌprɒp.əˈgeɪ.ʃən/ *noun* • the act or process of moving through, causing to move through, or transmitting, especially in the form of a wave
13.	regard : menganggap /rɪˈgɑːd/ *verb* • If you regard something or someone with a feeling such as dislike or respect, you have that feeling about them. • to look upon or consider in a specified way • to take notice of or pay attention to (something); heed
14.	satisfied : terpenuhi /ˈsæt.ɪs.faɪd/ *adjective* • If you are satisfied that something is true or has been done properly, you are convinced about this after checking it.
15.	vanish : lenyap/hilang /ˈvæn.ɪʃ/ *verb* • If someone or something vanishes, they disappear suddenly or in a way that cannot be explained. • to disappear, especially suddenly or mysteriously

Task 3

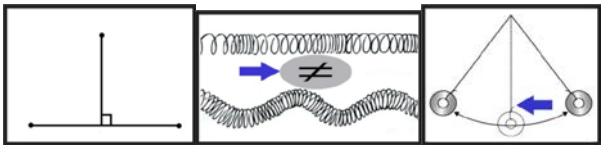
Choose the correct image which represents the word.

Pilih gambar yang dapat mengilustrasikan kata dengan tepat.

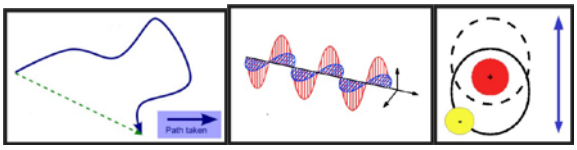
1. boundary



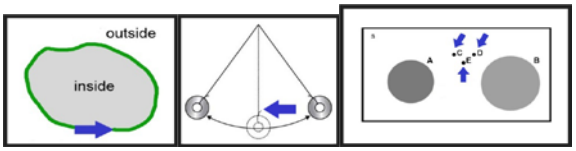
2. differ



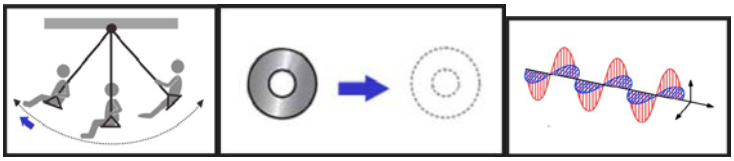
3. displacement



4. equilibrium



5. forth



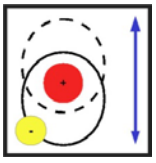
Task 4

Match the word in the box with its image representation.

Pasangkan kata di dalam kotak dengan gambar yang mengilustrasikannya.

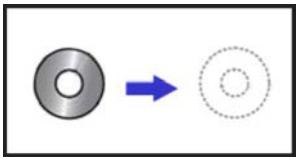
independent	oscillate	perpendicular	propagation	vanish

1.



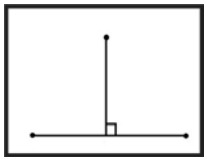
drag the word here

2.



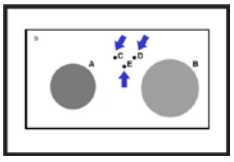
drag the word here

3.

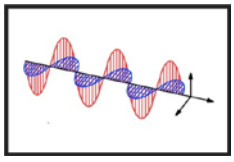


drag the word here

4.



5.



drag the word here	drag the word here

Task 5

Match the words below with their correct pronunciation. Click on the button to listen the pronunciation.

Pasangkan kata-kata di bawah dengan pengucapannya yang sesuai. Klik tombol untuk mendengarkan pengucapannya.

Word list		Your answer		Pronunciation
1. boundary	/ˈbaʊn.dər.i/	b	√ / X	a.
2. differ	/ˈdɪf.ər/	g		b.
3. displaced	/dɪˈspleɪst/	m		c.
4. displacement	/dɪˈspleɪs.mənt/	f		d.
5. equilibrium	/ˌiː.kwɪˈlɪb.ri.əm/	l		e.
6. forth	/fɔːθ/	j		f.
7. generalization	/ˌdʒen.ər.əl.aɪˈzeɪ.ʃən/	d		g.
8. independent	/ˌɪn.dɪˈpen.dənt/	h		h.
9. oscillate	/ˈɒs.ɪ.leɪt/	n		i.
10. perpendicular	/ˌpɜː.pənˈdɪk.jʊ.lər/	a		j.
11. propagate	/ˈprɒp.ə.geɪt/	o		k.
12. propagation	/ˌprɒp.əˈgeɪ.ʃən/	e		l.
13. regard	/rɪˈgɑːd/	i		m.
14. satisfied	/ˈsæt.ɪs.faɪd/	c		n.
15. vanish	/ˈvæn.ɪʃ/	k		o.

Task 6

Choose the correct part of speech of the words below.

Pilihlah kelas kata yang tepat dari kata-kata di bawah ini.

1. boundary

   (The <u>boundary</u> of the first Brillouin zone lies at K = ± π/a.)

noun	√ / X	adjective	√ / X
verb	√ / X	adverb	√ / X

2. differ

   (The constant C is the force constant between nearest-neighbor planes and will <u>differ</u> for longitudinal and transverse waves)

noun	√ / X	adjective	√ / X

verb	√ / X	adverb	√ / X

3. displaced

(Planes of atoms as displaced during passage of a transverse wave.)

noun	√ / X	adjective	√ / X
verb	√ / X	adverb	√ / X

4. displacement

(The coordinate u measures the displacement of the planes.)

noun	√ / X	adjective	√ / X
verb	√ / X	adverb	√ / X

5. equilibrium

(We can describe with a single coordinate us the displacement of the planes from its equilibrium position.)

noun	√ / X	adjective	√ / X
verb	√ / X	adverb	√ / X

6. forth

(This situation is equivalent to Bragg reflection of x-rays: when the Bragg condition is satisfied a travelling wave cannot propagate in a lattice, but through successive reflections back and forth, a standing wave is set up.)

noun	√ / X	adjective	√ / X
verb	√ / X	adverb	√ / X

7. generalization

(The generalization of dispersion relation (7) to p nearest planes is easily found to be (16a))

noun	√ / X	adjective	√ / X
verb	√ / X	adverb	√ / X

Task 7

Choose the words that suit with the desired part of speech.

Pilih kata-kata yang sesuai dengan kelas kata yang diinginkan.

- The range $-\pi$ to $+\pi$ for the phase *Ka* covers all independent values of the exponential.
- This is a standing wave; alternate atoms oscillate in opposite phases, because us = ±1 according to whether s is an even or an odd integer.

- When a wave propagates along one of these directions, entire planes of atoms move in phase with displacements either parallel or perpendicular to the direction of the wavevector.
- When a wave propagates along one of these directions, entire planes of atoms move in phase with displacements either parallel or perpendicular to the direction of the wavevector.
- This is the velocity of energy propagation in the medium.
- It is convenient hereafter to regard *C* as defined for one atom of the plane, so that F_s is the force on one atom in the plane s.
- This situation is equivalent to Bragg reflection of x-rays: when the Bragg condition is satisfied a travelling wave cannot propagate in a lattice, but through successive reflections back and forth, a standing wave is set up.
- Terms in the energy that are linear in the displacements will vanish in equilibrium–see the minimum in Fig. 3.6.

a. Find the noun (total words to find: 1)

Carilah kata benda (total kata tersedia: 1)

independent	☺/☹	oscillate	☺/☹
perpendicular	☺/☹	propagate	☺/☹
propagation	☺/☹	regard	☺/☹
satisfied	☺/☹	vanish	☺/☹

b. Find the verbs (total words to find: 4)

Carilah kata kerja (total kata tersedia: 4)

independent	☺/☹	oscillate	☺/☹
perpendicular	☺/☹	propagate	☺/☹
propagation	☺/☹	regard	☺/☹
satisfied	☺/☹	vanish	☺/☹

c. Find the adjectives (total words to find: 3)

Carilah kata sifat yang memnberi keterangan pada kata benda (total kata tersedia: 3)

independent	☺/☹	oscillate	☺/☹
perpendicular	☺/☹	propagate	☺/☹
propagation	☺/☹	regard	☺/☹
satisfied	☺/☹	vanish	☺/☹

Task 8

Choose the correct definition of the words.

Pilihlah definisi kata yang tepat.

Word list	Your answer		Definition
1. boundary	e	√ / X	a. at right angles to a horizontal plane
2. differ	m		b. to move or swing from side to side regularly
3. displaced	c		c. forced to moved away from that area
4. displacement	n		d. the act or process of moving through, causing to move through, or transmitting, especially in the form of a wave
5. equilibrium	k		e. something that indicates the farthest limit, as of an area; border
6. forth	f		f. forward in place, time, order, or degree
7. generalization	l		g. not dependent on anything else for function, validity, etc.
8. independent	g		h. to move through, cause to move through, or transmit, especially in the form of a wave
9. oscillate	b		i. to disappear, especially suddenly or mysteriously
10. perpendicular	a		j. being fulfilled by the conditions of (a theorem, assumption, etc); to yield a truth by substitution of the given value
11. propagate	h		k. the condition of a system that has its total energy distributed among its component parts in the statistically most probable manner
12. propagation	d		l. the derivation of a general statement from a particular one
13. regard	o		m. to be dissimilar in quality, nature, or degree (to); vary (from)
14. satisfied	j		n. the distance measured in a particular direction from a reference point
15. vanish	i		o. to take notice of or pay attention to (something); heed

Task 9

Match the words below with their translation in Bahasa Indonesia

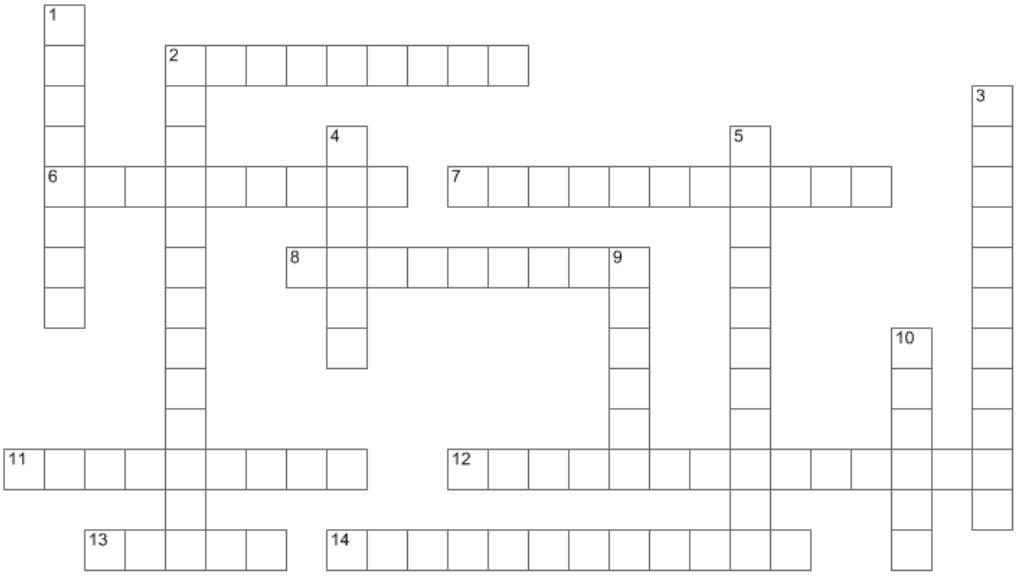
Pasangkan kata-kata di bawah ini dengan terjemahannya dalam Bahasa Indonesia.

Word list	Your answer	√ / X	Meaning
1. boundary	c		a. maju
2. differ	h		b. dipindahkan
3. displaced	b		c. batas
4. displacement	l		d. kesetimbangan
5. equilibrium	d		e. menyebar
6. forth	a		f. bergetar
7. generalization	i		g. penyebaran
8. independent	m		h. berbeda
9. oscillate	f		i. perluasan
10. perpendicular	j		j. tegak lurus
11. propagate	e		k. lenyap/hilang
12. propagation	g		l. perpindahan
13. regard	n		m. bebas
14. satisfied	o		n. menganggap
15. vanish	k		o. terpenuhi

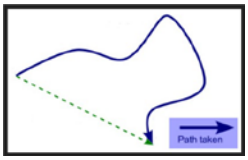
Task 10

Fill the crossword puzzle below using the words in the box.

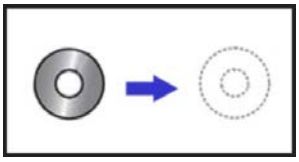
Isilah teka-teki silang di bawah ini menggunakan kata-kata di dalam kotak.



Across:

2. to move through, cause to move through, or transmit, especially in the form of a wave
6. 
7. **kesetimbangan**
8. being fulfilled by the conditions of (a theorem, assumption, etc); to yield a truth by substitution of the given value
11. to move or swing from side to side regularly
12. 
13. maju
14. 

Down:

1. something that indicates the farthest limit, as of an area; border
2. tegak lurus
3. not dependent on anything else for function, validity, etc
4. 
5. penyebaran
9. 
10. 

boundary	differ	displaced	displacement	equilibrium
forth	generalization	independent	oscillate	perpendicular
propagate	propagation	regard	satisfied	vanish

Task 11

Use the words in the box to complete the sentences below.

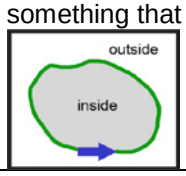
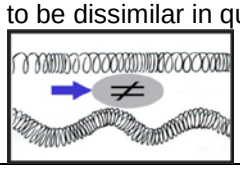
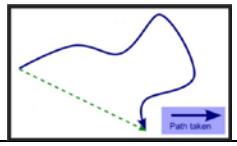
Gunakan kata-kata dalam kotak untuk melengkapi kalimat-kalimat di bawah ini

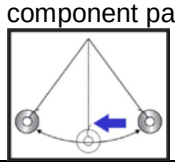
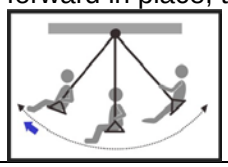
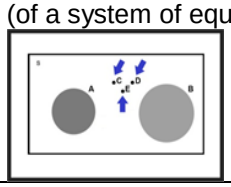
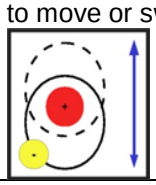
boundary	differ	displaced	displacement	equilibrium
forth	generalization	independent	oscillate	perpendicular
propagate	propagation	regard	satisfied	vanish

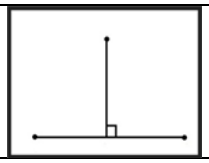
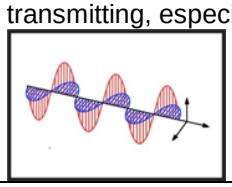
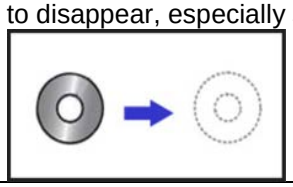
1. Solid lines in Fig. 2 show planes of atoms when _____ as for a longitudinal wave.
2. The simplest _____ direction is in the [100], [110], and [111].
3. The direction of entire planes of atoms which move with _____ can be parallel or _____ of the wavevector which _____ along [100], [110], or [111].
4. Energy that is linear in the displacements will _____ in _____ .
5. The force constant will _____ for longitudinal and transverse wave.
6. F_s is identified as the force on one atom in the plane *s* because it is convenient to _____ C as defined for one atom of the plane.

7. The velocity of sounds is [ ] of frequency in the long wavelength limit.
8. In a standing wave, atoms [ ] in opposite phases.
9. There, at $K = \pm \pi/a$, lies the [ ] of the first Brillouin zone.
10. The (16a) is the [ ] of (7)
11. Bragg's reflection of x-rays shows that a travelling wave cannot propagate in a lattice when the Bragg condition is [ ], but a standing wave is set up through successive reflections back and [ ].

SUMMARY

No.	Summary
1	boundary : batas /ˈbaʊn.dər.i/ *noun* • The boundary of an area of land is an imaginary line that separates it from other areas • something that indicates the farthest limit, as of an area; border 
2	differ : berbeda /ˈdɪf.ər/ *verb* • If two or more things differ, they are unlike each other in some way. • to be dissimilar in quality, nature, or degree (to); vary (from) 
3	displaced : dipindahkan /dɪˈspleɪst/ *adjective* • moved away from that area
4	displacement : perpindahan /dɪˈspleɪs.mənt/ *noun* • Displacement is the removal of something from its usual place or position by something which then occupies that place or position. • the distance measured in a particular direction from a reference point 

5	equilibrium : kesetimbangan /ˌiː.kwɪˈlɪb.ri.əm/ *noun* • Equilibrium is a balance between several different influences or aspects of a situation. • the condition of a system that has its total energy distributed among its component parts in the statistically most probable manner 
6	forth : maju /fɔːθ/ *adverb* • When someone goes forth from a place, they leave it. • forward in place, time, order, or degree 
7	generalization : perluasan /ˌdʒen.ər.əl.aɪˈzeɪ.ʃən/ *noun* • A generalization is a statement that seems to be true in most situations or for most people, but that may not be completely true in all cases • the derivation of a general statement from a particular one
8	independent : berdiri sendiri, tunggal /ˌɪn.dɪˈpen.dənt/ *adjective* • If one thing or person is independent of another, they are separate and not connected, so the first one is not affected or influenced by the second. • not dependent on anything else for function, validity, etc. • (of a system of equations) not linearly dependent 
9	oscillate : bergetar /ˈɒs.ɪ.leɪt/ *verb* • If an object oscillates, it moves repeatedly from one position to another and back again, or keeps getting bigger and smaller. • to move or swing from side to side regularly 
10	perpendicular : tegak lurus /ˌpɜː.pənˈdɪk.jʊ.lər/ *adjective* • at right angles to a horizontal plane

	
11	propagate : menyebar /ˈprɒp.ə.geɪt/ *verb* • If people propagate an idea or piece of information, they spread it and try to make people believe it or support it. • to move through, cause to move through, or transmit, especially in the form of a wave
12	propagation : penyebaran /ˌprɒp.əˈgeɪ.ʃən/ *noun* • the act or process of moving through, causing to move through, or transmitting, especially in the form of a wave 
13	regard : menganggap /rɪˈgɑːd/ *verb* • If you regard something or someone with a feeling such as dislike or respect, you have that feeling about them. • to look upon or consider in a specified way • to take notice of or pay attention to (something); heed
14	satisfied : terpenuhi /ˈsæt.ɪs.faɪd/ *adjective* • If you are satisfied that something is true or has been done properly, you are convinced about this after checking it.
15	vanish : lenyap/hilang /ˈvæn.ɪʃ/ *verb* • If someone or something vanishes, they disappear suddenly or in a way that cannot be explained. • to disappear, especially suddenly or mysteriously 

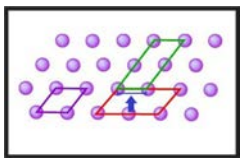
UNIT 2:

Crystal Vibration (Diatomic Basis)

OVERVIEW

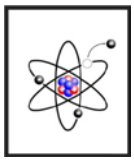
In this unit you will learn some words that included in Chapter 4 about vibration of crystal with diatomic basis. They are:

adjacent	gap
coincide	homogeneous
contain	interleaved
essential	pair
excite	thereby



You are expected to be able to:

- choose the correct pronunciation of the target words
- choose the correct part of speech of the target words
- choose the correct definition of the target words
- choose the correct the meaning of the target words



Task 1

Study the following text. Click the underlined words to see its explanation.

Pelajari text berikut ini. Klik kata-kata yang bergaris bawah untuk melihat penjelasannya

TWO ATOMS PER PRIMITIVE BASIS

The phonon dispersion relation shows new features in crystal with two or more atoms per primitive basis. Consider, for example, the NaCl or diamond structures, with two atoms in the primitive cell. For each polarization mode in a given propagation direction the dispersion relation ω versus K develops two branches, known as the acoustical and optical branches as in Fig 7. We have longitudinal LA and transverse acoustical TA modes, and longitudinal LO and transverse optical TO modes.

If there are p atoms in the primitive cell, there are $3p$ branches to the dispersion relation: 3 acoustical branches and $3p$ – 3 optical branches. Thus

germanium (Fig.8a) and KBr (Fig. 8b), each with two atoms in a primitive cell, have six branches: one LA, one LO, two TA, and Two TO.

The numerology of the branches follows from the number of degrees of freedoms of the atoms. With *p* atoms in the primitive cell and *N* primitive cells, there are *pN* atoms. Each atom has three degrees of freedom, one for each of the *x, y, z* directions, making a total of 3*pN* degrees of freedom for the crystal. The number of allowed *K* values in a single branch is just *N* for one Brillouin zone[1]. Thus the LA and the two branches have a total of 3N modes, thereby accounting for 3N of the total degrees of freedom. The remaining $(3p - 3)N$ degrees of freedom are accommodated by the optical branches.

[1]We show in chapter 5 by application of periodic boundary conditions to the modes of the crystal of volume V that there is one **K** value in the volume $(2\pi)^3/V$ in Fourier space. The volume of a Brillouin zone is $(2\pi)^3/V_c$, where Vc is the volume of a crystal primitive cell. Thus the number of allowed K values in a Brillouin zone is V/V_c, which is just *N*, the number of primitive cells in the crystal.

Task 2

Study the following text. Click the underlined words to see its explanation.

Pelajari text berikut ini. Klik kata-kata yang bergaris bawah untuk melihat penjelasannya

We consider a cubic crystal where atoms of mass M_1 lie on one set of planes of atoms of mass M_2 lie on planes interleaved between those and the first set (Fig. 9). It is not essential that the masses be different, but either the force constant or the masses will be different if the two atoms of the basis are in non-equivalent sites. Let *a* denote the repeat distance of the lattice in the direction normal to the lattice planes considered. We treat waves that propagate in a symmetry direction such that a single plane contains only a single type of ion; such direction are [111] in the NaCl structure and [100] in the CsCl structure.

We write the equation of motion under the assumption that each planes interact only with its nearest-neighbor planes and that the force constants are identical between all pairs of nearest-neighbor planes. We refer to Fig.9 to obtain (18).

We look for a solution in the form of traveling wave, now with different amplitudes u, v on alternate planes: (19).

We define a in Fig. 9 as the distance between nearest identical planes, not nearest-neighbor planes.

On substitution of (19) in (18) we have (20). The homogeneous linear equations have a solution only if the determinant of the coefficients of the unknown u, v vanishes: (21) or (22).

We can solve this equation exactly for ω^2 but it is simpler to examine the limiting cases $Ka \ll 1$ and $Ka = \pm\pi$ at the zone boundary. For small Ka we have cos $Ka \cong 1 - \frac{1}{2}K^2a^2 + \ldots$, and the two roots are (23) (optical branch); (24) acoustical branch. The extent of the first Brillouin zone is $-\pi/a$, where a is the repeat distance of the lattice. At $K_{max} = \pm\pi/a$, the roots are (25). The dependence of ω on K is shown in Fig. 7 for $M_1 > M_2$.

The particle displacements in the transverse acoustical (TA) and transverse optical (TO) branches are shown in Fig. 10. For the optical branch at $K = 0$ we find, on substitution of (23) in (20), (26). The atoms vibrate against each other, but their center of mass is fixed. If the two atoms carry opposite charges, as in Fig. 10, we may excite a motion of this type with the electric field of a light wave, so that the branch is called the optical branch. At a general K the ratio u/υ will be complex, as follows from either of the equations (20). Another solution for the amplitude ratio at small K is $u = v$, obtained sa the $K = 0$ limit of (24). The atoms (and their center of mass) move together, as in long wavelength acoustical vibrations, whence the term acoustical branch.

Wavelike solution do not exist for certain frequencies, here between $(2C/M_1)^{1/2}$ and $(2C/M_2)^{1/2}$. This is a characteristic feature of elastic waves in polyatomic lattices. There is a frequency gap at the boundary $K_{max} = \pm\pi/a$ of the first Brillouin zone.

Flash Cards for Task 1 & 2:

No.	Flash card
1	adjacent : bersebelahan /ədʒeɪ.sənt/ *adjective* • If one thing is adjacent to another, the two things are next to each other. • joined by a common edge
2	coincide : bertepatan /koʊ.ɪnsaɪd/ *verb* • If one event coincides with another, they happen at the same time. • to occur or exist simultaneously
3	contain : mengandung /kənteɪn/ *verb* • If a substance contains something, that thing is a part of it. • to hold or be capable of holding or including within a fixed limit or area
4	essential : penting / ɪsen.tʃəl/ *verb* • Something that is essential is extremely important or absolutely necessary to a particular subject, situation, or activity. • vitally important; absolutely necessary
5	excite : meningkat ke energi yang lebih tinggi /ɪkˈsaɪt/ *verb* • to raise (an atom, molecule, electron, nucleus, etc) from the ground state to a higher energy level
6	gap : celah /gæp/ *noun* • A gap between two groups of people, things, or sets of ideas is a big difference between them. • a divergence or difference; disparity
7	homogeneous : serbasama /hoʊ.moʊdʒiː.ni.əs/*adjective* • Group or thing which has members or parts that are all the same. • containing terms of the same degree with respect to all the variables
8	interleaved : menyelip /ˌɪntəˈliːvd/ *adjective* • place at intervals in or among
9	pair : pasangan /per/ *noun* (plural: pairs) • A pair of things are two things of the same size and shape that are used together or are both part of something, for example shoes, earrings, or parts of the body. • an object considered to be two identical or similar things joined together

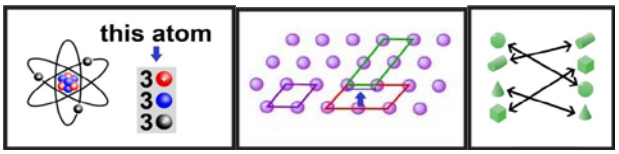
10	thereby : oleh karena itu /ˌðerˈbaɪ/ *adverb* • You use thereby to introduce an important result or consequence of the event or action you have just mentioned. • by that means; because of that

Task 3

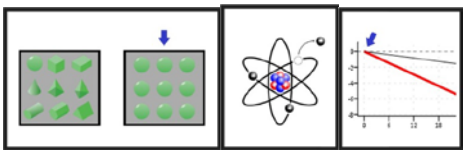
Choose the correct image which represents the word.

Pilih gambar yang dapat mengilustrasikan kata dengan tepat.

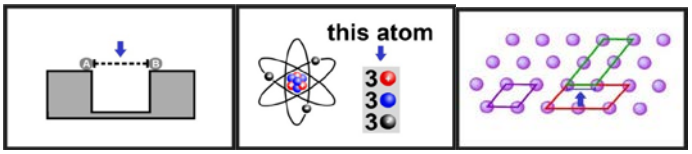
1. adjacent



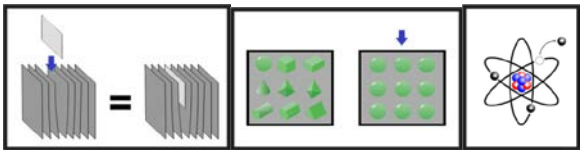
2. coincide



3. contain



4. excite

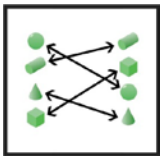


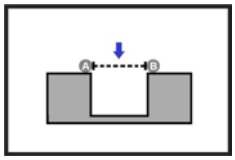
Task 4

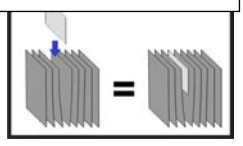
Match the word in the box with its image representation.

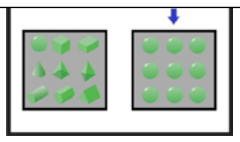
Pasangkan kata di dalam kotak dengan gambar yang mengilustrasikannya.

gap	homogeneous	interleaved	pair

1. 

2. 

3. drag the word here 

4. drag the word here 

drag the word here	drag the word here

Task 5

Match the words below with their correct pronunciation. Click on the button to listen the pronunciation.

Pasangkan kata-kata di bawah dengan pengucapannya yang sesuai. Klik tombol untuk mendengarkan pengucapannya.

Word list		Your answer		Pronunciation
1. adjacent	/ədʒeɪ.sənt/	b	√ / X	a.
2. coincide	/koʊ.ɪnsaɪd/	c		b.
3. contain	/kənˈteɪn/	h		c.
4. essential	/ɪsen.tʃᵊl/	j		d.
5. excite	/ɪkˈsaɪt/	i		e.
6. gap	/gæp/	a		f.
7. homogeneous	/hoʊ.moʊdʒiː.ni.əs/	e		g.
8. interleaved	/ˌɪntəˈliːvd/	h		h.
9. pair	/per/	f		i.
10. thereby	/ˌðerˈbaɪ/	d		j.

Task 6

Choose the correct part of speech of the words below.

Pilihlah kelas kata yang tepat dari kata-kata di bawah ini.

1. adjacent

   (A diatomic crystal structure with masses M_1, M_2 connected by force constant C between adjacent planes.)

noun	√ / X	adjective	√ / X
verb	√ / X	adverb	√ / X

2. coincide

   (The LO and TO branches coincide at $K = 0$; this is also a consequence of the crystal symmetry of Ge.)

noun	√ / X	adjective	√ / X
verb	√ / X	adverb	√ / X

3. contain

(We treat waves that propagate in a symmetry direction such that a single plane contains only a single type of ion; such direction are [111] in the NaCl structure and [100] in the CsCl structure.)

noun	√ / X	adjective	√ / X
verb	√ / X	adverb	√ / X

4. essential

(It is not essential that the masses be different, but either the force constant or the masses will be different if the two atoms of the basis are in non-equivalent sites.)

noun	√ / X	adjective	√ / X
verb	√ / X	adverb	√ / X

Task 7

Choose the words that suit with the desired part of speech.

Pilih kata-kata yang sesuai dengan kelas kata yang diinginkan.

- If the two atoms carry opposite charges, as in Fig. 10, we may excite a motion of this type with the electric field of a light wave, so that the branch is called the optical branch.
- There is a frequency gap at the boundary Kmax = ±π/a of the first Brillouin zone.
- The homogeneous linear equations have a solution only if the determinant of the coefficients of the unknown *u*, υ vanishes: (21) or (22).
- We consider a cubic crystal where atoms of mass M1 lie on one set of planes of atoms of mass M2 lie on planes interleaved between those and the first set (Fig. 9).
- We write the equation of motion under the assumption that each planes interact only with its nearest-neighbor planes and that the force constants are identical between all pairs of nearest-neighbor planes
- Thus the LA and the two branches have a total of 3N modes, thereby accounting for 3N of the total degrees of freedom.

a. Find the noun (total words to find: 2)

Carilah kata benda (total kata tersedia: 2)

excite	☺/☹	gap	☺/☹
homogeneous	☺/☹	interleaved	☺/☹
pair	☺/☹	thereby	☺/☹

b. Find the verb (total words to find: 1)

Carilah kata kerja (total kata tersedia: 1)

excite	☺/☹	gap	☺/☹
homogeneous	☺/☹	interleaved	☺/☹
pair	☺/☹	thereby	☺/☹

c. Find the adjectives (total words to find: 2)

Carilah kata sifat yang memberi keterangan pada kata benda (total kata tersedia: 2)

excite	☺/☹	gap	☺/☹
homogeneous	☺/☹	interleaved	☺/☹
pair	☺/☹	thereby	☺/☹

d. Find the adverb (total words to find: 1)

Carilah kata sifat yang memberi keterangan pada kata kerja (total kata tersedia: 1)

excite	☺/☹	gap	☺/☹
homogeneous	☺/☹	interleaved	☺/☹
pair	☺/☹	thereby	☺/☹

Task 8

Choose the correct meaning of the words.

Pilihlah arti kata yang tepat.

Word list	Your answer		Definition
1. adjacent	(i)	√ / X	a. vitally important; absolutely necessary
2. coincide	(f)		b. a divergence or difference; disparity
3. contain	(h)		c. by that means; because of that
4. essential	(a)		d. containing terms of the same degree with respect to all the variables
5. excite	(e)		e. to raise (an atom, molecule, electron, nucleus, etc) from the ground state to a higher energy level
6. gap	(b)		f. to occur or exist simultaneously
7. homogeneous	(d)		g. an object considered to be two identical
8. interleaved	(j)		
9. pair	(g)		
10. thereby	(c)		

			or similar things joined together h. to hold or be capable of holding or including within a fixed limit or area i. joined by a common edge j. place at intervals in or among

Task 9

Match the words below with their translation in Bahasa Indonesia

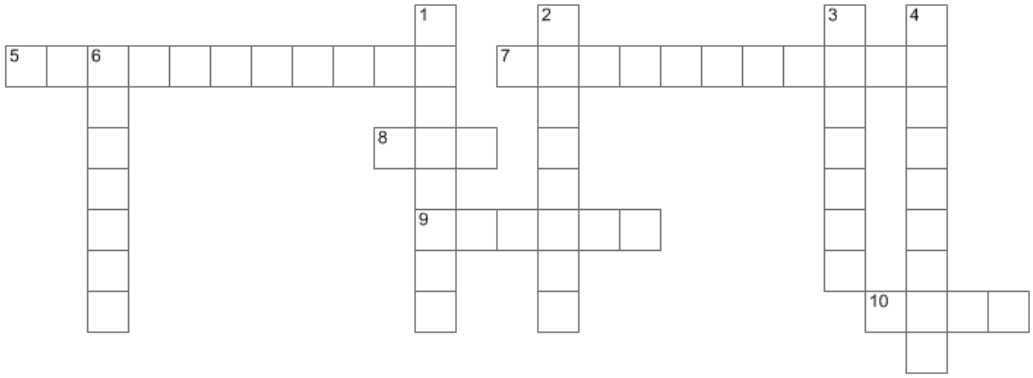
Pasangkan kata-kata di bawah ini dengan terjemahannya dalam Bahasa Indonesia.

Word list	Your answer		Definition
1. adjacent	(c)	√ / X	a. meningkat ke energi yang lebih tinggi
2. coincide	(g)		b. serbasama
3. contain	(d)		c. bersebelahan
4. essential	(f)		d. mengandung
5. excite	(a)		e. menyelip
6. gap	(i)		f. penting
7. homogeneous	(b)		g. bertepatan
8. interleaved	(e)		h. pasangan
9. pair	(h)		i. celah
10. thereby	(j)		j. oleh karena itu

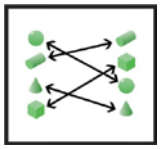
Task 10

Fill the crossword puzzle below using the words in the box.

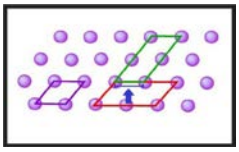
Isilah teka-teki silang di bawah ini menggunakan kata-kata di dalam kotak.



Across

5.
7. serbasama
8.
9. to raise (an atom, molecule, electron, nucleus, etc) from the ground state to a higher energy level
10. 

Down

1. 
2.
3. to hold or be capable of holding or including

4. 6. oleh karena itu

adjacent	coincide	contain	essential	excite
gap	homogeneous	interleaved	pair	thereby

Task 11

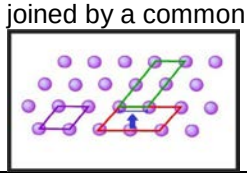
Use the words in the box to complete the sentences below.

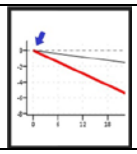
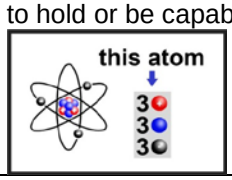
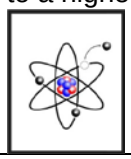
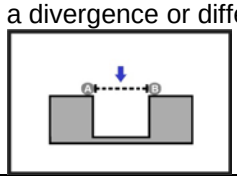
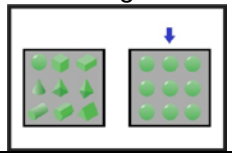
Gunakan kata-kata dalam kotak untuk melengkapi kalimat-kalimat di bawah ini

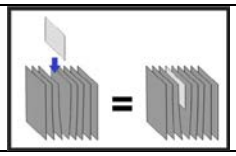
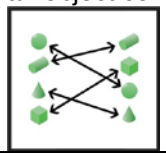
adjacent	coincide	contain	essential	excite
gap	homogeneous	interleaved	pair	thereby

1. Fig. 8a shows that LO and TO branches _____ at *K=0*.
2. Fig.9 shows that M_1 and M_2 are connected by force constant *C* which located between _____ planes.
3. A single plane in the wave that propagates in some direction such as [111] in the NaCl and [100] in the CsCl _____ only a single type of ion.
4. We write the equation of motion under the assumption that each planes interact only with its nearest-neighbor planes and that the force constants are identical between all _____ of nearest-neighbor planes
5. The _____ linear equations have a solution only if the determinant of the coefficients of the unknown *u*, υ vanishes in (21) and (22)
6. Thus the LA and the two branches have a total of 3N modes, _____ accounting for 3N of the total degrees of freedom.
7. From Fig.9, we can consider that atom of mass M_2 lie on planes that located _____ between planes of the first set.
8. In Fig.9, the different of the masses M_1 and M_2 is not _____
9. The branch in Fig.10 is called optical branch because the two atoms carry opposite charges and we may _____ a motion of this type with the electric field of a light wave.
10. There is a frequency _____ at the boundary Kmax = ±*π/a* of the first Brillouin zone.

SUMMARY

No.	Summary
1	adjacent : bersebelahan /ədʒeɪ.sənt/ *adjective* • If one thing is adjacent to another, the two things are next to each other. • joined by a common edge 
2	coincide : bertepatan /koʊ.ɪnsaɪd/ *verb* • If one event coincides with another, they happen at the same time. • to occur or exist simultaneously

	
3	contain : mengandung /kənteɪn/ *verb* • If a substance contains something, that thing is a part of it. • to hold or be capable of holding or including within a fixed limit or area 
4	essential : penting / ɪsen.tʃəl/ *verb* • Something that is essential is extremely important or absolutely necessary to a particular subject, situation, or activity. • vitally important; absolutely necessary
5	excite : meningkat ke energi yang lebih tinggi /ɪkˈsaɪt/ *verb* • to raise (an atom, molecule, electron, nucleus, etc) from the ground state to a higher energy level 
6	gap : celah /gæp/ *noun* • A gap between two groups of people, things, or sets of ideas is a big difference between them. • a divergence or difference; disparity 
7	homogeneous : serbasama /hoʊ.moʊdʒiː.ni.əs/*adjective* • Group or thing which has members or parts that are all the same. • containing terms of the same degree with respect to all the variables 
8	interleaved : menyelip /ˌɪntəˈliːvd/ *adjective* • place at intervals in or among

	
9	pair : pasangan /per/ *noun* (plural: pairs) • A pair of things are two things of the same size and shape that are used together or are both part of something, for example shoes, earrings, or parts of the body. • an object considered to be two identical or similar things joined together 

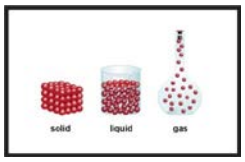
UNIT 3:

Phonon's Characteristics

OVERVIEW

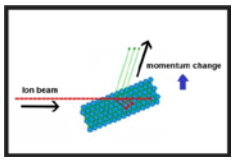
In this unit you will learn some words that included in Chapter 4 about characteristics of phonon. They are:

absorbed	occupied
absorption	occur
chiefly	rarely
density	recoil
determine	rigorously
determined	suitable
occupancy	



You are expected to be able to:

- choose the correct pronunciation of the target words
- choose the correct part of speech of the target words
- choose the correct definition of the target words
- choose the correct the meaning of the target words



Task 1

Study the following text. Click the underlined words to see its explanation.

Pelajari text berikut ini. Klik kata-kata yang bergaris bawah untuk melihat penjelasannya

QUANTIZATION OF ELASTIC WAVES

The energy of a lattice vibration is quantized. The quantum of energy is called a **phonon** in analogy with the photon of the electromagnetic wave. The energy of an elastic mode of angular frequency ω is (27) when the mode is excited to quantum number n; that is, when the mode is occupied by n phonons. The term $\frac{1}{2}\hbar\omega$ is the zero point energy of the mode. It occurs for both phonons and photons as a consequence of their equivalence to a quantum harmonic oscilator of

frequency ω, for which the energy eigenvalues are also (n + $\frac{1}{2}\omega$). The quantum theory of phonon is developed in Appendix C.

We can quantize the mean square phonon amplitude. Consider the standing wave mode of amplitude $u = u_0 \cos Kx \cos \omega t$. Here u is the displacement of a volume element fromits equilibrium position at x in the crystal. The energy in the mode, as in any harmonic oscilator, is half kinetic energy and half potential energy, when averaged over time. The kinetic energy density is $\frac{1}{2}\rho(\partial u/\partial t)^2$, where ρ is the mass density. In a crystal of volume V, the volume integral of the kinetic energy is $\frac{1}{4}\rho V\omega^2 u_0^2 \sin^2 \omega t$. The time average kinetic energy is (28) because $<\sin^2 \omega t> = \frac{1}{2}$. The square of the amplitude of the mode is (29). This relates the displacement in a given mode to the phonon occupancy n of the mode.

What is the sign of ω? The equations of motion such as (2) are equations for ω^2, and if this is positive then ω can have either sign, + or –. But the energy of a phonon must be positive, so it is conventional and suitable to view ω as positive. Is the crystal structure is unstable, then ω^2 will be negative and ω will be imaginary.

Task 2

Study the following text. Click the underlined words to see its explanation.

Pelajari text berikut ini. Klik kata-kata yang bergaris bawah untuk melihat penjelasannya

PHONON MOMENTUM

A phonon of wavevector K will interact with particles such as photons, neutrons, and electrons as if it had a momentum $\hbar K$. However, a phonon does not carry physical momentum.

The reason that phonons on a lattice do not carry momentum is that a phonon coordinate (except for $K = 0$) involves relative coordinates of the atoms. Thus in an H_2 molecule the internuclear vibrational coordinate $\mathbf{r}_1 - \mathbf{r}_2$ is a relative

coordinate and does not carry linear momentum; the center of mass coordinate $\frac{1}{2}(\mathbf{r}_1 - \mathbf{r}_2)$ corresponds to the uniform mode $K = 0$ and can carry linear momentum.

In crystal there exist wavevector selection rules for allowed transitions between quantum states. We saw in chapter 2 that elastic scattering of an x-ray photon by a crystal is governed by the wavevector selection rule (30), where **G** is a vector in the reciprocal lattice, **k** is the wavevector of the incident photon, **k'** is the wavevector of the scattered photon. In the reflection process the crystal as a whole will recoil with momentum $-\hbar\mathbf{G}$, but this uniform mode momentum is rarely considered explicitly.

Equation (30) is an example of the rule that the total wavevector of interacting waves is conserved in a periodic lattice, with the possible addition of a reciprocal lattice vector **G**. The true momentum of the whole system always is rigorously conserved. If the scattering of the photon is inelastic, with the creation of a phonon of wavevector **K**, then the wavevector selection rule becomes (31). If a phonon K is absorbed in the process, we have instead the relation (32). Relations (31) and (32) are the natural extensions of (30).

INELASTIC SCATTERING BY PHONONS

Phonon dispersion relations $\omega(\mathbf{K})$ are most often determined experimentally by the inelastic scattering of neutrons with the emission or absorption of a phonon. A neutron sees the crystal lattice chiefly by interaction with the nuclei of the atoms. The kinematics of the scattering of a neutron beam by a crystal lattice are described by the general wavevector selection rule: (33) and by the requirement of conservation of energy. Here K is the wavevector of the phonon created (+) or absorbed (–) in the scattering process, and G is any reciprocal lattice vector. For a phonon we choose G such that K lies in the first Brillouin zone.

The kinetic energy of the incident neutron is $p^2/^2M_n$, where M_n is the mass of the neutron. The momentum **p** is given by $\hbar\mathbf{k}$, where **k** is the wavevector of the neutron. Thus $\hbar^2k^2/2M_n$ is the kinetic energy of the incident neutron. If k' is the wavevector of the scattered neutron, the energy of the scattered neutron is

h2k'2/2Mn. The statement of conservation of energy is (34), where $\hbar\omega$ is the energy of the phonon created (+) or absorbed (–) in the process.

To determine the dispersion relation using (33) and (34) it is necessary in the experiment to find the energy gain or loss of the scattered neutrons as a function of the scattering direction **k** - **k'**. Results for germanium and KBr are given in Fig. 8; results for sodium are given in Fig. 11. A spectrometer used for phonon studies is shown in Fig. 12.

Flash Cards for Task 1 & 2:

No.	Flash card
1	absorbed : terserap /əbˈzɔːrbd/ *adjective* • If you are absorbed in something or someone, you are very interested in them and they take up all your attention and energy. • taken in (all or part of incident radiated energy) and retain the part that is not reflected or transmitted
2	absorption : penyerapan /əbzɔrp.ʃən/ *noun* • The absorption of a liquid, gas, or other substance is the process of it being soaked up or taken in. • a reduction of the intensity of any form of radiated energy as a result of energy conversion in a medium, such as the conversion of sound energy into heat
3	chiefly : terutama /ˈtʃiːf.fli/ *adverb* • You use chiefly to indicate that a particular reason, emotion, method, or feature is the main or most important one. • especially or essentially; above all
4	density : kepadatan /ˈdent.sə.t̬i/ *noun* • In science, the density of a substance or object is the relation of its mass or weight to its volume. • a measure of the compactness of a substance, expressed as its mass per unit volume. It is measured in kilograms per cubic metre or pounds per cubic foot.
5	determine : menentukan /dɪtɜ˞.mɪn/ *verb* • To determine a fact means to discover it as a result of investigation. • to fix or specify the position, form, or configuration of
6	determined : ditentukan /dɪtɜ˞.mɪnd/ *adjective* • If you are determined to do something, you have made a firm decision to do it and will not let anything stop you. • resolute; firm

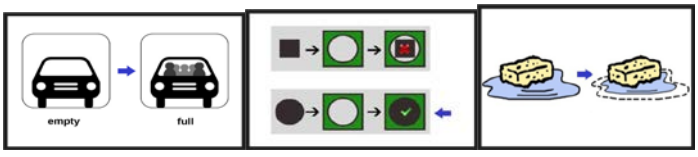
7	occupancy : pengisian /ˈɑː.kjə.pən*t*.si/ *noun* • Occupancy is the act of using a room, building, or area of land, usually for a fixed period of time. • the act of occupying; possession of a property
8	occupied : terisi /ˈɑː.kjʊ.paɪd/ *adjective* • If a room or something such as a seat is occupied, someone is using it, so that it is not available for anyone else. • in use and so not available for anyone else
9	occur : berlaku /əˈkɜː/ *verb* • When something occurs, it happens. • to happen; take place; come about
10	rarely : jarang /ˈrerli/ *adverb* • If something rarely happens, it does not happen very often. • hardly ever; seldom
11	recoil : melompat /rɪˈkɔɪl/ *verb* • If something makes you recoil, you move your body quickly away from it because it frightens, offends, or hurts you. • to change momentum as a result of the emission of a photon or particle
12	rigorously : dengan tegas dan jelas /ˈrɪg.ər.ə˞.sli/ *adverb* • A test, system, or procedure that was done rigorously is very thorough and strict. • the validity of the successive steps in a completely explicit manner
13	suitable : sesuai, tepat /ˈsuː.t̬ə.bl/ *adjective* • Someone or something that is suitable for a particular purpose or occasion is right or acceptable for it. • appropriate; proper; fit

Task 3

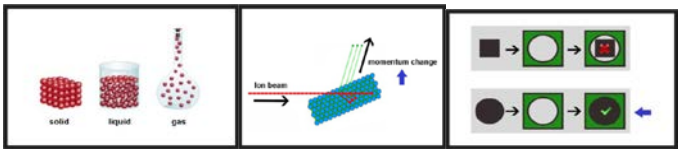
Choose the correct image which represents the word.

Pilih gambar yang dapat mengilustrasikan kata dengan tepat.

1. absorption



2. density

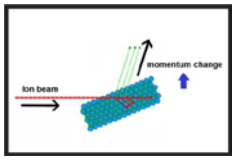


Task 4

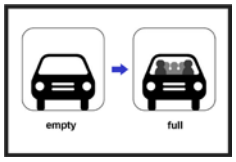
Match the word in the box with its image representation.

Pasangkan kata di dalam kotak dengan gambar yang mengilustrasikannya.

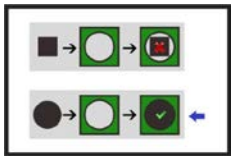
occupancy	recoil	suitable

1. 

drag the word here

2. 

drag the word here

3. 

drag the word here

Task 5

Match the words below with their correct pronunciation. Click on the button to listen the pronunciation.

Pasangkan kata-kata di bawah dengan pengucapannya yang sesuai. Klik tombol untuk mendengarkan pengucapannya.

Words list		Your answer		Pronunciation
1. absorbed	/əbˈzɔːrbd/	j	√ / X	a.
2. absorption	/əbzɔrp.ʃən/	f		b.
3. chiefly	/ˈtʃiː.fli/	k		c.
4. density	/ˈdent.sə.t̬i/	b		d.
5. determine	/dɪtɝ.mɪn/	d		e.
6. determined	/dɪtɝ.mɪnd/	m		f.
7. occupancy	/ˈɑː.kjə.pənt .si/	i		g.
8. occupied	/ˈɑː.kjʊ.paɪd/	c		h.
9. occur	/ əˈkɝː/	g		i.
10. rarely	/ˈrerli/	a		j.
11. recoil	/rɪˈkɔɪl/	h		k.
12. rigorously	/ˈrɪg.ər.ə.sli/	e		l.
13. suitable	/ˈsuː.t̬ə.bl/	l		m.

Task 6

Choose the correct part of speech of the words below.

Pilihlah kelas kata yang tepat dari kata-kata di bawah ini.

1. absorbed

   (If a phonon K is absorbed in the process, we have instead the relation (32).)

noun	√ / X	adjective	√ / X
verb	√ / X	adverb	√ / X

2. absorption

   (Phonon dispersion relations $\omega(\mathbf{K})$ are most often determined experimentally by the inelastic scattering of neutrons with the emission or absorption of a phonon.)

noun	√ / X	adjective	√ / X
verb	√ / X	adverb	√ / X

3. chiefly

   (A neutron sees the crystal lattice chiefly by interaction with the nuclei of the atoms.)

noun	√ / X	adjective	√ / X
verb	√ / X	adverb	√ / X

4. density

   (The kinetic energy density is is $\frac{1}{2}\rho\partial u/\partial t)^2$, where ρ is the mass density.)

noun	√ / X	adjective	√ / X
verb	√ / X	adverb	√ / X

5. determine

   (To determine the dispersion relation using (33) and (34) it is necessary in the experiment to find the energy gain or loss of the scattered neutrons as a function of the scattering direction **k** - **k'**.)

noun	√ / X	adjective	√ / X
verb	√ / X	adverb	√ / X

6. determined

   (Phonon dispersion relations ω(K) are most often determined experimentally by the inelastic scattering of neutrons with the emission or absorption of a phonon.)

noun	√ / X	adjective	√ / X
verb	√ / X	adverb	√ / X

7. occupancy
   (This relates the displacement in a given mode to the phonon occupancy n of the mode.)

noun	√ / X	adjective	√ / X
verb	√ / X	adverb	√ / X

Task 7

Choose the words that suit with the desired part of speech.

Pilih kata-kata yang sesuai dengan kelas kata yang diinginkan.

- The energy of an elastic mode of angular frequency ω is (27) when the mode is excited to quantum number n; that is, when the mode is occupied by n phonons.
- It occurs for both phonons and photons as a consequence of their equivalence to a quantum harmonic oscilator of frequency ω, for which the energy eigenvalues are also (n + $\frac{1}{2}\omega$. The quantum theory of phonon is developed in Appendix C.
- In the reflection process the crystal as a whole will recoil with momentum – $\hbar\mathbf{G}$, but this uniform mode momentum is rarely considered explicitly.
- In the reflection process the crystal as a whole will recoil with momentum – $\hbar\mathbf{G}$, but this uniform mode momentum is rarely considered explicitly.
- The true momentum of the whole system always is rigorously conserved.
- But the energy of a phonon must be positive, so it is conventional and suitable to view ω as positive.

a. Find the verbs (total words to find: 2)
   Carilah kata kerja (total kata tersedia: 2)

occupied	☺/☹	occur	☺/☹
rarely	☺/☹	recoil	☺/☹
rigorously	☺/☹	suitable	☺/☹

b. Find the adjectives (total words to find: 2)
   Carilah kata sifat yang memberi keterangan pada kata benda (total kata tersedia: 2)

occupied	☺/☹	occur	☺/☹
rarely	☺/☹	recoil	☺/☹
rigorously	☺/☹	suitable	☺/☹

c. Find the adverbs (total words to find: 2)
Carilah kata sifat yang memberi keterangan pada kata kerja (total kata tersedia: 3)

occupied	☺/☹	occur	☺/☹
rarely	☺/☹	recoil	☺/☹
rigorously	☺/☹	suitable	☺/☹

Task 8

Choose the correct meaning of the words.

Pilihlah arti kata yang tepat.

Word list	Your answer	√ / X	Definition
1. absorbed	(g)		a. a measure of the compactness of a substance, expressed as its mass per unit volume. It is measured in kilograms per cubic meter or pounds per cubic foot
2. absorption	(f)		b. the act of occupying; possession of a property
3. chiefly	(c)		c. especially or essentially; above all
4. density	(a)		d. the validity of the successive steps in a completely explicit manner
5. determine	(m)		e. hardly ever; seldom
6. determined	(j)		f. a reduction of the intensity of any form of radiated energy as a result of energy conversion in a medium, such as the conversion of sound energy into heat
7. occupancy	(b)		g. taken in (all or part of incident radiated energy) and retain the part that is not reflected or transmitted
8. occupied	(k)		h. to happen; take place; come about
9. occur	(h)		i. appropriate; proper; fit
10. rarely	(e)		j. resolute; firm
11. recoil	(l)		k. If a room or something such as a seat is occupied, someone is using it, so that it is not available for anyone else.
12. rigorously	(d)		l. to change momentum as a result of the emission of a photon or particle
13. suitable	(i)		m. to fix or specify the position, form, or configuration of

Task 9

Match the words below with their translation in Bahasa Indonesia

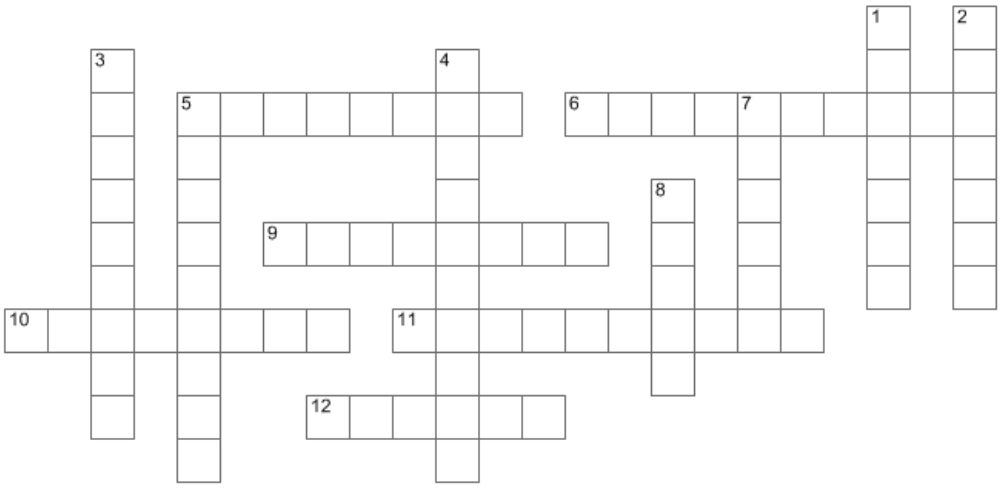
Pasangkan kata-kata di bawah ini dengan terjemahannya dalam Bahasa Indonesia.

Word list	Your answer		Definition
1. absorbed	(k)	√ / X	a. kepadatan
2. absorption	(m)		b. terutama
3. chiefly	(b)		c. ditentukan
4. density	(a)		d. berlaku
5. determine	(g)		e. terisi
6. determined	(c)		f. pengisian
7. occupancy	(f)		g. menentukan
8. occupied	(e)		h. sesuai, tepat
9. occur	(d)		i. melompat
10. rarely	(j)		j. jarang
11. recoil	(i)		k. terserap
12. rigorously	(l)		l. dengan tegas dan jelas
13. suitable	(h)		m. penyerapan

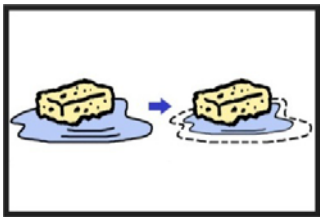
Task 10

Fill the crossword puzzle below using the words in the box.

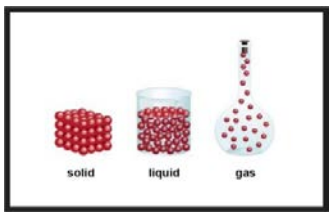
Isilah teka-teki silang di bawah ini menggunakan kata-kata di dalam kotak.



Across

5. terisi
6. 
9. taken in (all or part of incident radiated energy) and retain the part that is not reflected or transmitted
10.
11. dengan tegas dan jelas
12.

Down

1. terutama
2. 

5. the act of occupying; possession of a property
3. menentukan
4.
7. to change momentum as a result of the emission of a photon or particle
8.

absorbed	absorption	chiefly	density	determine
determined	occupancy	occupied	occur	rarely
	recoil	rigorously	suitable	

Task 11

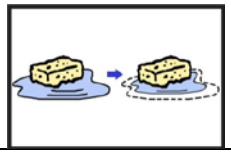
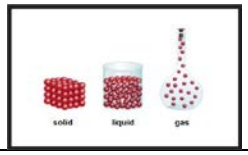
Use the words in the box to complete the sentences below.

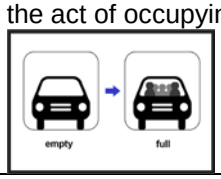
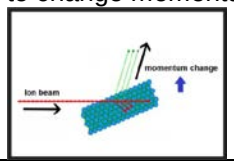
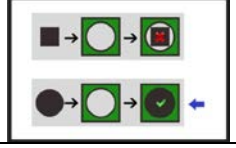
Gunakan kata-kata dalam kotak untuk melengkapi kalimat-kalimat di bawah ini.

absorbed	absorption	chiefly	density	determine
determined	occupancy	occupied	occur	rarely
	recoil	rigorously	suitable	

1. The energy of an elastic mode of angular frequency ω is (27) that is, when the mode is [ ] by n phonons
2. It [ ] for both phonons and photons as a consequence of their equivalence to a quantum harmonic oscilator of frequency ω, for which the energy eigenvalues are also $(n + \frac{1}{2}\omega)$.
3. In $\frac{1}{2}\rho(\partial u/\partial t)^2$, ρ is the mass [ ].
4. The square of the amplitude of the mode is (29) is related with the displacement in a given mode to the phonon [ ] n of the mode
5. The energy of a phonon must be positive, so it is conventional and [ ] view ω as positive.
6. In the reflection process the crystal as a whole will [ ] with momentum $-\hbar\mathbf{G}$, but this uniform mode momentum is [ ] considered explicitly.
7. The true momentum of the whole lattice system always is [ ] conserved.
8. If a phonon K is [ ] in the process, we have instead the relation (32).
9. Phonon dispersion relations $\omega(\mathbf{K})$ are most often [ ] experimentally by the inelastic scattering of neutrons with the emission or [ ] of a phonon.
10. A neutron sees the crystal lattice [ ] by interaction with the nuclei of the atoms.
11. To [ ] the dispersion relation using (33) and (34) it is necessary to find the energy gain or loss of the scattered neutrons.

SUMMARY

No.	Flash card
1	absorbed : terserap /əbˈzɔːrbd/ *adjective* • If you are absorbed in something or someone, you are very interested in them and they take up all your attention and energy. • taken in (all or part of incident radiated energy) and retain the part that is not reflected or transmitted
2	absorption : penyerapan /əbzɔrp.ʃən/ *noun* • The absorption of a liquid, gas, or other substance is the process of it being soaked up or taken in. • a reduction of the intensity of any form of radiated energy as a result of energy conversion in a medium, such as the conversion of sound energy into heat 
3	chiefly : terutama /ˈtʃiː.fli/ *adverb* • You use chiefly to indicate that a particular reason, emotion, method, or feature is the main or most important one. • especially or essentially; above all
4	density : kepadatan /ˈdent.sə.t̬i/ *noun* • In science, the density of a substance or object is the relation of its mass or weight to its volume. • a measure of the compactness of a substance, expressed as its mass per unit volume. It is measured in kilograms per cubic metre or pounds per cubic foot. 
5	determine : menentukan /dɪtɜ˞.mɪn/ *verb* • To determine a fact means to discover it as a result of investigation. • to fix or specify the position, form, or configuration of
6	determined : ditentukan /dɪtɜ˞.mɪnd/ *adjective* • If you are determined to do something, you have made a firm decision to do it and will not let anything stop you. • resolute; firm
7	occupancy : pengisian /ˈɑː.kjə.pən*t*.si/ *noun*

	• Occupancy is the act of using a room, building, or area of land, usually for a fixed period of time. • the act of occupying; possession of a property 
8	occupied : terisi /ˈɑː.kjʊ.paɪd/ *adjective* • If a room or something such as a seat is occupied, someone is using it, so that it is not available for anyone else. • in use and so not available for anyone else
9	occur : berlaku /əˈkɜː/ *verb* • When something occurs, it happens. • to happen; take place; come about
10	rarely : jarang /ˈrerli/ *adverb* • If something rarely happens, it does not happen very often. • hardly ever; seldom
11	recoil : melompat /rɪˈkɔɪl/ *verb* • If something makes you recoil, you move your body quickly away from it because it frightens, offends, or hurts you. • to change momentum as a result of the emission of a photon or particle 
12	rigorously : dengan tegas dan jelas /ˈrɪg.ər.ɚ.sli/ *adverb* • A test, system, or procedure that was done rigorously is very thorough and strict. • the validity of the successive steps in a completely explicit manner
13	suitable : sesuai, tepat /ˈsuː.t̬ə.bl/ *adjective* • Someone or something that is suitable for a particular purpose or occasion is right or acceptable for it. • appropriate; proper; fit 

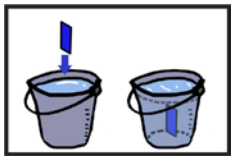
UNIT 4:

Summary and Problems

OVERVIEW

In this unit you will learn some words that included in Chapter 4 about summary and problems of the crystal vibration and phonon. They are:

decoupled	rest
estimate	sphere
immersed	unlike
reduce	



You are expected to be able to:

- choose the correct pronunciation of the target words
- choose the correct part of speech of the target words
- choose the correct definition of the target words
- choose the correct the meaning of the target words

Task 1

Study the following text. Click the underlined words to see its explanation.

Pelajari text berikut ini. Klik kata-kata yang bergaris bawah untuk melihat penjelasannya.

SUMMARY

- The quantum unit of a crystal vibration is a phonon. If the angular frequency is ω, the energy of the phonon is $\hbar\omega$.
- When a phonon of wavevector **K** is created by the inelastic scattering of a photon or neutron from wavevector **k** to **k'**, the wavevector selection rule that governs the process is

  $$\mathbf{k} = \mathbf{k}' + \mathbf{K} + \mathbf{G},$$

  where G is a reciprocal lattice vector.
- All elastic waves can be described by wavevectors that lie within the first Brillouin zone in reciprocal space.

- If there are p atoms in the primitive cell, the phonon dispersion relation will have 3 acoustical phonon branches and 3*p* - 3 optical phonon branches.

Problems

1. ***Monatomic linear lattice.*** Consider a longitudinal wave $u_s = u\cos(\omega t - sKa)$ which propagates in a monatomic linear lattice of atoms of mass M, spacing a, and nearest-neighbor interaction C.

   (a). Show that the total energy of the wave is

$$E = \frac{1}{2}M\sum_s (du_s/dt)^2 + \frac{1}{2}C\sum_s (u_s - u_{s+1})^2$$

   where *s* runs over all atoms.

   (b). By substitution of u_s in this expression, show that the time-average total energy per atom is

$$\frac{1}{4}M\omega^2u^2 + \frac{1}{2}C(1-\cos Ka)u^2 = \frac{1}{2}M\omega^2u^2$$

   where in the last step we have used the dispersion relation (9) for this problem.

2. ***Continuum wave equation***. Show that for long wavelengths the equation of motion (2) reduces to the continuum elastic wave equation

$$\frac{\partial^2 u}{\partial t^2} = \tilde{o}^2\frac{\partial^2 u}{\partial x^2}$$

   where υ is the velocity of sound.

3. ***Basis of two unlike atoms.*** For the problem treated by (18) to (26), find the amplitude ratios u/υ for the two branches at $K_{max} = \pi/a$. Show that at this value of K the two lattices act as if decoupled: one lattice remains at rest while the other lattice moves.

4. ***Kahn anomaly***. We suppose that the interplanar force constant C_p between planes s and *s* + *p* is of the form

$$C_p = A\frac{\sin pk_0a}{pa}$$

   where A and k_0 are constants and *p* runs over all integers. Such a form is expected in metals. Use this and Eq. (l6a) to find an expression for $\omega 2$ and also for $\omega\partial 2/iJK$. Prove that $\partial\omega^2/\partial K$ is infinite when K = k_0. Thus a plot of

ω^2 versus K or of ω versus K has a vertical tangent at k_0: there is a kink at k_0 in the phonon dispersion relation $\omega(K)$.

Task 2

Study the following text. Click the underlined words to see its explanation.

Pelajari text berikut ini. Klik kata-kata yang bergaris bawah untuk melihat penjelasannya.

5. ***Diatomic chain.*** Consider the normal modes of a linear chain in which the force constants between nearest-neighbor atoms are alternately C and 10C. Let the masses be equal, and let the nearest-neighbor separation be $a/2$. Find ω(K) at K = 0 and K = π/a. Sketch in the dispersion relation by eye. This problem simulates a crystal of diatomic molecules such as H_2.

6. ***Atomic vibration in metal.*** Consider point ions of mass M and charge immersed in a uniform sea of conduction electrons. The ions are imagined to be in stable equilibrium when at regular lattice points. If one ion is displaced a small distance r from its equilibrium position, the restoring force is largely due to the electric charge within the sphere of radius r centered at the equilibrium position. Take the number density of ions (or of conduction electrons) as $3/4\pi R^3$, which defines R.

(a) Show that the frequency of a single ion set into oscillation is $\omega = (e2/MR^3)^{1/2}$. (b) Estimate the value of this frequency for sodium, roughly. (c) From (a), (b), and some common sense, estimate the order of magnitude of the velocity of sound in the metal.

7. ***Soft phonon modes.*** Consider a line of ions of equal mass but alternating in charge, with $e_p = e\ (-1)^p$ as the charge on the pth ion. The interatomic potential is the sum of two contributions: (1) a short-range interaction of force constant $C_{1R} = \gamma$ that acts between nearest neighbors only, and (2) a coulomb interaction between all ions. (a) Show that the contribution of the coulomb interaction to the atomic force constants is

$C_{pC} = 2(-l)^P p^2/{}^3a^3$,

where *a* is the equilibrium nearest-neighbor distance. (b) From (16a) show that the dispersion relation may be

written as

$$\omega^2 / \omega_0^2\omega_0^2 - \sin^2\frac{1}{2}Ka + \sigma\sum_{p-1}^{\infty}(-1)^p\,(1-\cos pKa\,)p^{-3}$$

where ω_0^2 = 4γ/M and σ = $e^2/\gamma a^3$. (c) Show that ω^2 is negative (unstable mode) at the zone boundary $Ka = \pi$ if σ > 0.475 or 4/7ζ(3), where ζ is a Riemann zeta function. Show further that the speed of sound at small *Ka* is imaginary if σ > $(2 \ln 2)^{-1}$ = 0.721. Thus ω^2 goes to zero and the lattice is unstable for some value of *Ka* in the interval (0, π) if 0.475 < σ < 0.721. Notice that the phonon spectrum is not that of a diatomic lattice because the interaction of any ion with its neighbors is the same as that of any other ion.

Flash Cards for Task 1 & 2:

No.	Flash Card
1	decouple : memisahkan diri /ˌdiːˈkʌpəl/ *adjective* • If two countries, organizations, or ideas that were connected in some way are decoupled, the connection between them is ended. • to separate (joined or coupled subsystems) thereby enabling them to exist and operate separately
2	estimate : memperkirakan /ˈes.tɪ.meɪt/ *verb* • If you estimate a quantity or value, you make an approximate judgment or calculation of it. • to form an approximate idea of (distance, size, cost, etc); calculate roughly; gauge
3	immersed : menyelam /ɪˈmɜːsd/ *adjective* • If something is immersed in a liquid, someone puts it into the liquid so that it is completely covered. • plunged or dip into liquid
4	reduce : mengurangi /rɪˈduːs/ *verb* • If something is changed to a different or less complicated form, you can say that it is reduced to that form. • to modify or simplify the form of (an expression or equation), especially by

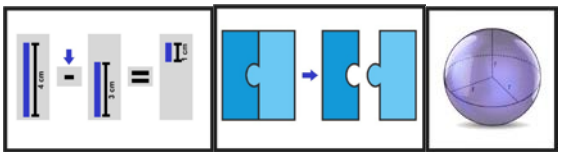
	substitution of one term by another
5	rest : diam /rest/ *verb* • When an object that has been moving comes to rest, it finally stops. • to remain without further attention or action
6	sphere : bulatan /sfɪr/ *noun* • A sphere is an object that is completely round in shape like a ball. • a three-dimensional closed surface such that every point on the surface is equidistant from a given point, the center
7	unlike : berbeda, tidak sama /ʌnˈlaɪk/ *adjective* • If one thing is unlike another thing, the two things have different qualities or characteristics from each other • not alike; dissimilar or unequal; different

Task 3

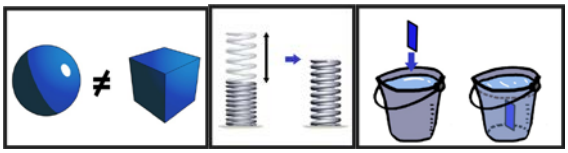
Choose the correct image which represents the word.

Pilih gambar yang dapat mengilustrasikan kata dengan tepat.

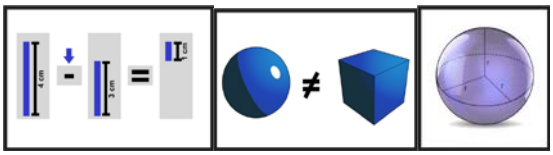
1. decoupled



2. immersed



3. reduce



Task 4

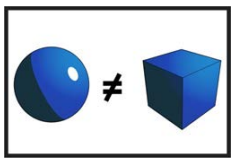
Match the word in the box with its image representation.

Pasangkan kata di dalam kotak dengan gambar yang mengilustrasikannya.

rest	sphere	unlike

1. 

drag the word here

2. 

drag the word here

3. 

drag the word here

Task 5

Match the words below with their correct pronunciation. Click on the button to listen the pronunciation.

Pasangkan kata-kata di bawah dengan pengucapannya yang sesuai. Klik tombol untuk mendengarkan pengucapannya.

Words list		Your answer		Pronunciation
1. decoupled	/ˌdiːˈkʌpəl/	d	√ / X	a.
2. estimate	/ˈes.tɪ.meɪt/	b		b.
3. immersed	/ɪˈmɝːsd/	b		c.
4. reduce	/rɪˈduːs/	f		d.
5. rest	/rest/	g		e.
6. sphere	/sfɪr/	c		f.
7. unlike	/ʌnˈlaɪk/	e		g.

Task 6

Choose the correct part of speech of the words below.

Pilihlah kelas kata yang tepat dari kata-kata di bawah ini.

1. decoupled

   (Show that at this value of K the two lattices act as if <u>decoupled</u>: one lattice remains at rest while the other lattice moves)

noun	√ / X	adjective	√ / X
verb	√ / X	adverb	√ / X

2. estimate
   (Estimate the value of this frequency for sodium, roughly.)

noun	√ / X	adjective	√ / X
verb	√ / X	adverb	√ / X

3. immersed
   (Consider point ions of mass M and charge immersed in a uniform sea of conduction electrons.)

noun	√ / X	adjective	√ / X
verb	√ / X	adverb	√ / X

Task 7

Choose the words that suit with the desired part of speech.

Pilih kata-kata yang sesuai dengan kelas kata yang diinginkan.

- Show that for long wavelengths the equation of motion (2) reduces to the continuum elastic wave equation.
- Show that at this value of K the two lattices act as if decoupled: one lattice remains at rest while the other lattice moves.
- If one ion is displaced a small distance r from its equilibrium position, the restoring force is largely due to the electric charge within the sphere of radius r centered at the equilibrium position
- *Basis of two unlike atoms.*

a. Find the noun (total words to find: 1)
   Carilah kata benda (total kata tersedia: 1)

reduce	☺/☹	rest	☺/☹
sphere	☺/☹	unlike	☺/☹

b. Find the verbs (total words to find: 2)
   Carilah kata kerja (total kata tersedia: 2)

reduce	☺/☹	rest	☺/☹
sphere	☺/☹	unlike	☺/☹

c. Find the adjective (total word to find: 1)
   Carilah kata sifat yang memberi keterangan (total kata tersedia: 1)

reduce	☺/☹	rest	☺/☹
sphere	☺/☹	unlike	☺/☹

Task 8

Choose the correct meaning of the words.

Pilihlah arti kata yang tepat.

Words	Your answer		Definition
1. decoupled 2. estimate 3. immersed 4. reduce 5. rest 6. sphere 7. unlike	(e) (g) (b) (d) (a) (c) (f)	√ / X	a. to remain without further attention or action b. plunged or dip into liquid c. a three-dimensional closed surface such that every point on the surface is equidistant from a given point, the center d. to modify or simplify the form of (an expression or equation), especially by substitution of one term by another e. separated (joined or coupled subsystems) thereby enabling them to exist and operate separately f. not alike; dissimilar or unequal; different g. to form an approximate idea of (distance, size, cost, etc); calculate roughly; gauge

Task 9

Match the words below with their translation in Bahasa Indonesia

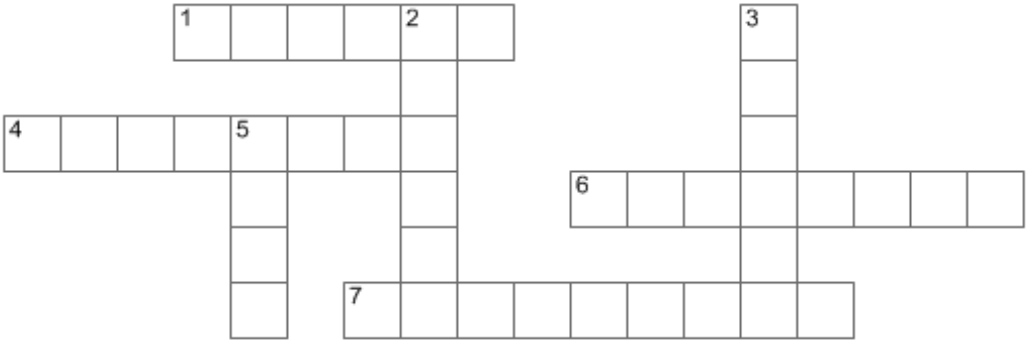
Pasangkan kata-kata di bawah ini dengan terjemahannya dalam Bahasa Indonesia.

Words	Your answer		Translation
decoupled estimate immersed reduce rest sphere unlike	(d) (a) (g) (f) (b) (e) (c)		a. memperkirakan b. diam c. berbeda, tidak sama d. memisahkan diri e. bulatan f. mengurangi g. menyelam

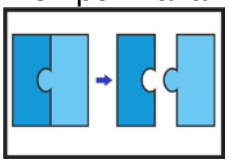
Task 10

Fill the crossword puzzle below using the words in the box.

Isilah teka-teki silang di bawah ini menggunakan kata-kata di dalam kotak.



Across

1. a three-dimensional closed surface such that every point on the surface is equidistant from a given point, the center
4.
6. memperkirakan
7. 

Down

2. to modify or simplify the form of (an expression or equation), especially by substitution of one term by another
3. berbeda, tidak sama
5. 

decoupled	estimate	immersed	reduce	determine
	rest	sphere	unlike	

Task 11

Use the words in the box to complete the sentences below.

Gunakan kata-kata dalam kotak untuk melengkapi kalimat-kalimat di bawah ini

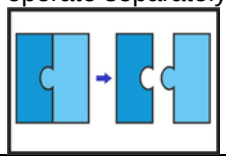
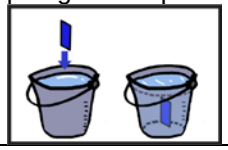
decoupled	estimate	immersed	reduce	determine
	rest	sphere	unlike	

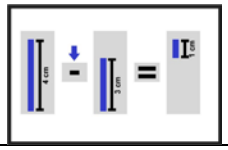
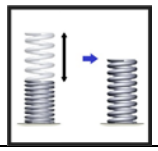
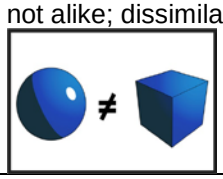
1. Wavelengths of the equation of motion (2) [ ] the continuum elastic wave equation of:

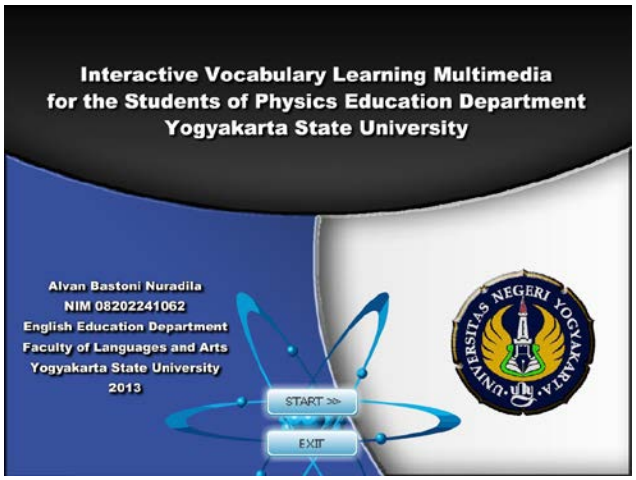
$\frac{\partial^2 u}{\partial t^2} = v^2 \frac{\partial^2 u}{\partial x^2}$ where v is the velocity of sound.

2. In the basis of two [ ] atoms, we can see that two lattices act as if [ ] one lattice remains at [ ] while the other lattice moves.
3. Consider point ions of mass M and charge [ ] in a uniform sea of conduction electrons. If one ion is displaced a small distance r from its equilibrium position, the restoring force is largely due to the electric charge within the [ ] of radius r centered at the equilibrium position.
4. From $\omega = (e2/MR^3)^{1/2}$ we may [ ] the value of this frequency for sodium, roughly.

SUMMARY

No.	Flash Card
1	decouple : memisahkan diri /ˌdiːˈkʌpᵊl/ *adjective* • If two countries, organizations, or ideas that were connected in some way are decoupled, the connection between them is ended. • to separate (joined or coupled subsystems) thereby enabling them to exist and operate separately 
2	estimate : memperkirakan /ˈes.tɪ.meɪt/ *verb* • If you estimate a quantity or value, you make an approximate judgment or calculation of it. • to form an approximate idea of (distance, size, cost, etc); calculate roughly; gauge
3	immersed : menyelam /ɪˈmɜːsd/ *adjective* • If something is immersed in a liquid, someone puts it into the liquid so that it is completely covered. • plunged or dip into liquid 
4	reduce : mengurangi /rɪˈduːs/ *verb* • If something is changed to a different or less complicated form, you can say that it is reduced to that form. • to modify or simplify the form of (an expression or equation), especially by

	substitution of one term by another 
5	rest : diam /rest/ *verb* • When an object that has been moving comes to rest, it finally stops. • to remain without further attention or action 
6	sphere : bulatan /sfɪr/ *noun* • A sphere is an object that is completely round in shape like a ball. • a three-dimensional closed surface such that every point on the surface is equidistant from a given point, the center 
7	unlike : berbeda, tidak sama /ʌnˈlaɪk/ *adjective* • If one thing is unlike another thing, the two things have different qualities or characteristics from each other • not alike; dissimilar or unequal; different 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NIM 08202241062
English Education Department
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2013
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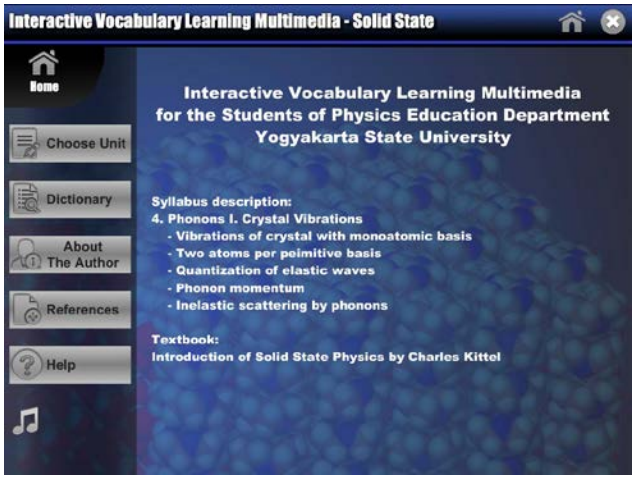
EXIT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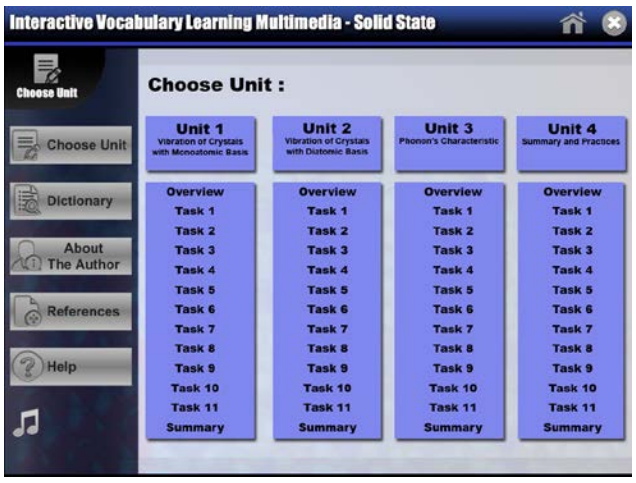
Syllabus description:
4. Phonons I. Crystal Vibrations
- Vibrations of crystal with monoatomic basis
- Two atoms per peimitive basis
- Quantization of elastic waves
- Phonon momentum
- Inelastic scattering by phonons
Textbook:
Introduction of Solid State Physics by Charles Kittel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Unit 1
Vibration of Crystals with Monoatomic Basis
Unit 2
Vibration of Crystals with Diatomic Basis
Unit 3
Phonon's Characteristic
Unit 4
Summary and Practices
Overview
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Task 2
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Task 5
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Task 7
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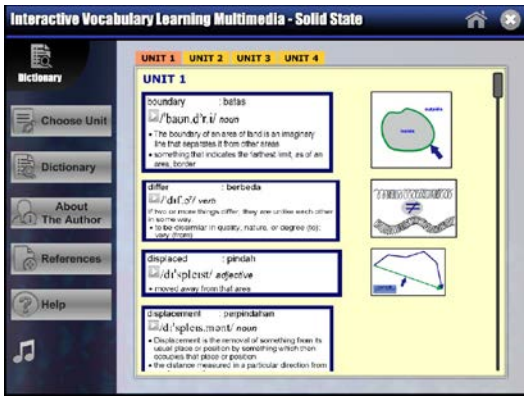
Task 10
Task 11
Summary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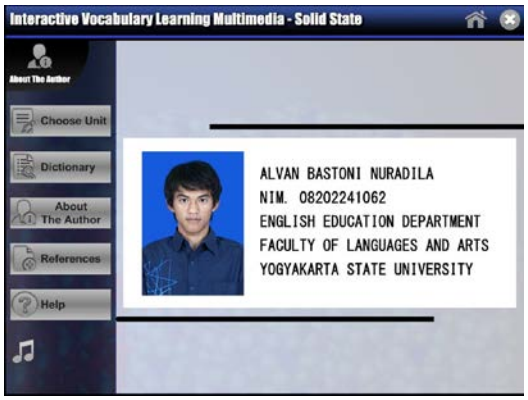
UNIT 1 UNIT 2 UNIT 3 UNIT 4
UNIT 1
boundary : batas
/'baun.d'r.i/ noun
differ : berbeda
/dɪf.ɚ/ verb
displaced : pindah
/dɪ'splest/ adjective
displacement : perpindahan
/dɪ'spleɪs.mənt/ noun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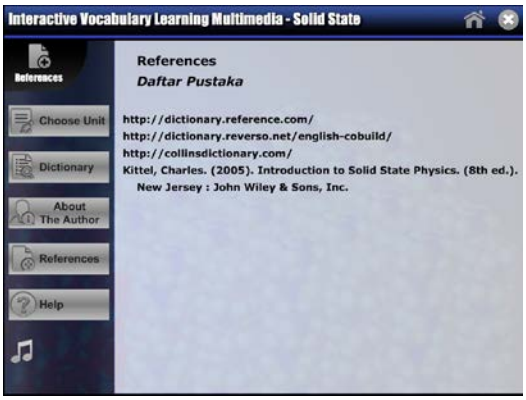
FACULTY OF LANGUAGES AND ARTS
YOGYAKARTA STATE UNIVERSITY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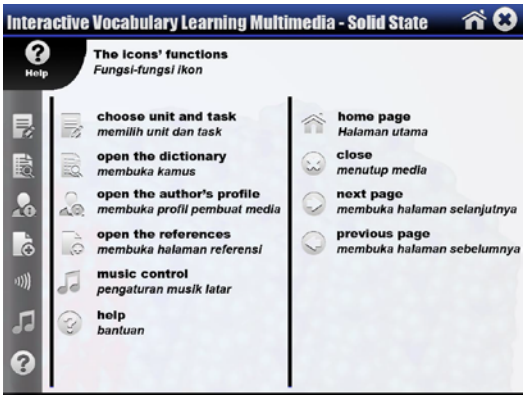
http://collinsdictionary.com/
Kittel, Charles. (2005). Introduction to Solid State Physics. (8th ed.).
New Jersey : John Wiley & Sons, Inc.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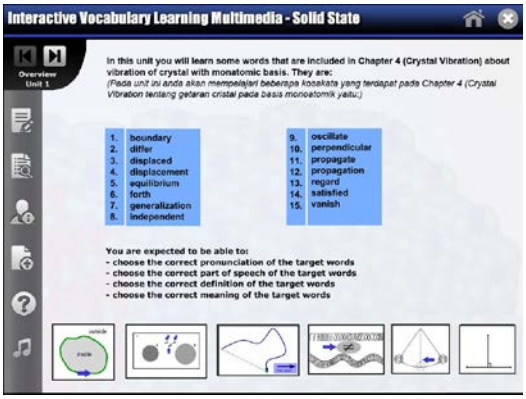
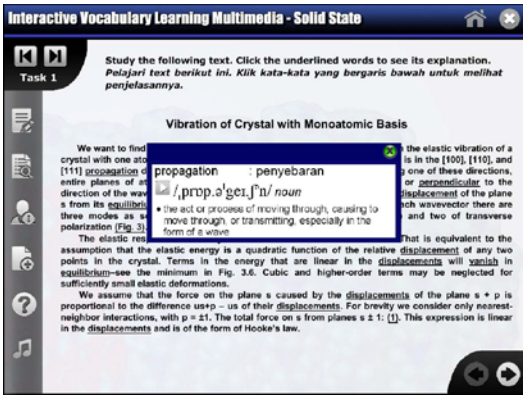
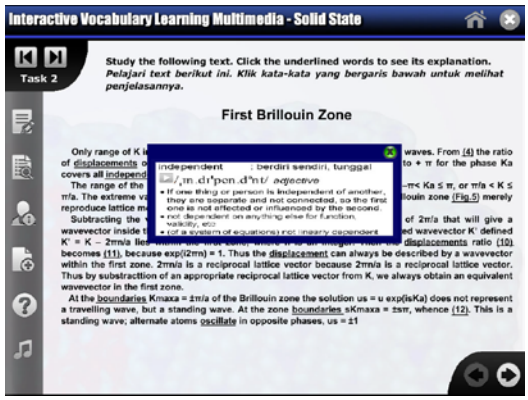
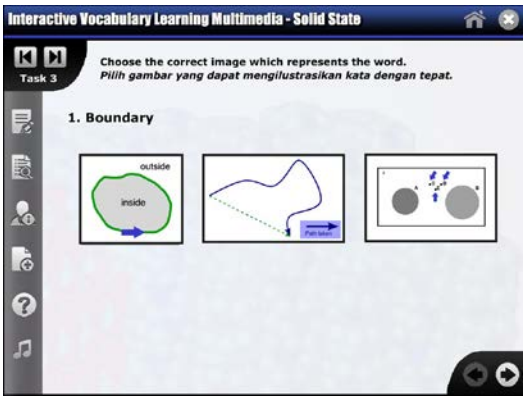
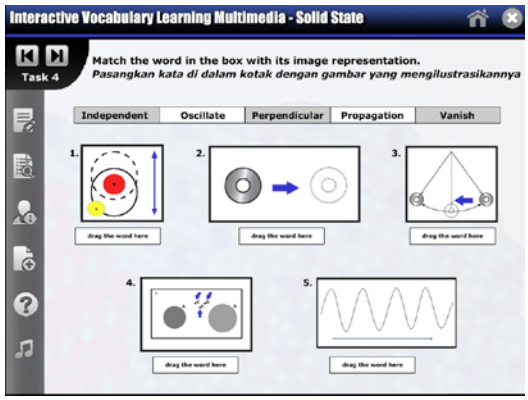
membuka halaman sebelumnya

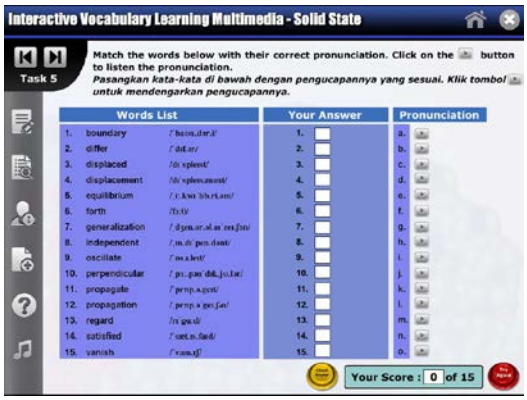

Interactive Vocabulary Learning Multimedia - Solid State
Overview Unit 1
In this unit you will learn some words that are included in Chapter 4 (Crystal Vibration) about vibration of crystal with monatomic basis. They are:
(Pada unit ini anda akan mempelajari beberapa kosakata yang terdapat pada Chapter 4 (Crystal Vibration tentang getaran cristal pada basis monoatomik yaitu:)
1. boundary
2. differ
3. displaced
4. displacement
5. equilibrium
6. forth
7. generalization
8. independent
9. oscillate
10. perpendicular
11. propagate
12. propagation
13. regard
14. satisfied
15. vanish
You are expected to be able to:
- choose the correct pronunciation of the target words
- choose the correct part of speech of the target words
- choose the correct definition of the target words
- choose the correct meaning of the target words

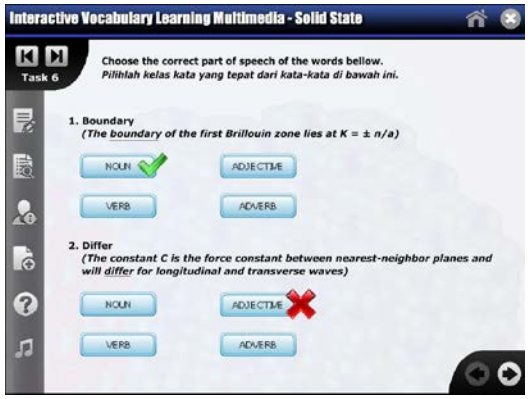

Interactive Vocabulary Learning Multimedia - Solid State
Task 1
Study the following text. Click the underlined words to see its explanation.
Pelajari text berikut ini. Klik kata-kata yang bergaris bawah untuk melihat penjelasannya.
Vibration of Crystal with Monoatomic Basis
propagation : penyebaran
/ˌprɒp.ə'geɪ.ʃ'n/ noun
• the act or process of moving through, causing to move through, or transmitting, especially in the form of a wave

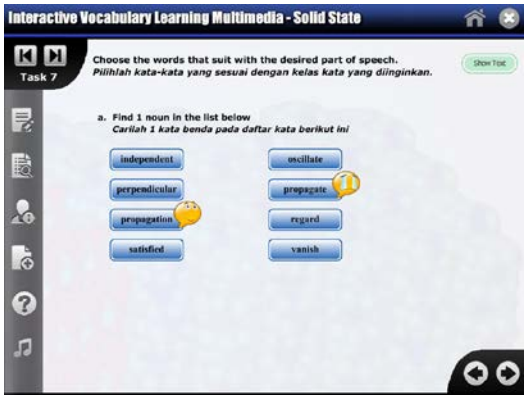

Interactive Vocabulary Learning Multimedia - Solid State
Task 2
Study the following text. Click the underlined words to see its explanation.
Pelajari text berikut ini. Klik kata-kata yang bergaris bawah untuk melihat penjelasannya.
First Brillouin Zone
independent : berdiri sendiri, tunggal
/ˌɪn.dɪˈpen.dənt/ adjective
• If one thing or person is independent of another, they are separate and not connected, so the first one is not affected or influenced by the second.
• not dependent on anything else for function, validity, etc
• (of a system of equations) not linearly dependent

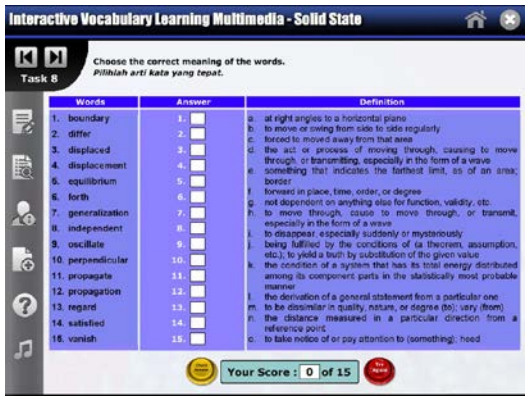

Interactive Vocabulary Learning Multimedia - Solid State
Task 3
Choose the correct image which represents the word.
Pilih gambar yang dapat mengilustrasikan kata dengan tepat.
1. Boundary
outside
inside

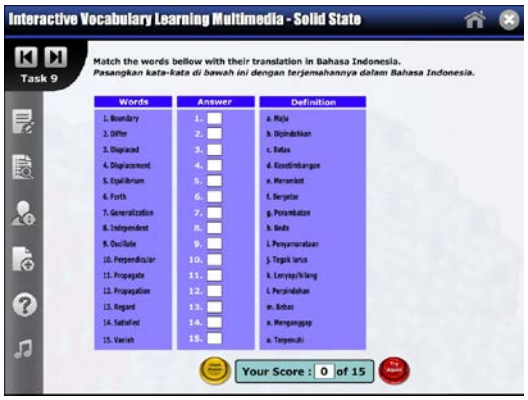

Interactive Vocabulary Learning Multimedia - Solid State
Task 4
Match the word in the box with its image representation.
Pasangkan kata di dalam kotak dengan gambar yang mengilustrasikannya
Independent
Oscillate
Perpendicular
Propagation
Vanish
drag the word here


Interactive Vocabulary Learning Multimedia - Solid State
Task 5
Match the words below with their correct pronunciation. Click on the button to listen the pronunciation.
Pasangkan kata-kata di bawah dengan pengucapannya yang sesuai. Klik tombol untuk mendengarkan pengucapannya.
Words List
Your Answer
Pronunciation
1. boundary
2. differ
3. displaced
4. displacement
5. equilibrium
6. forth
7. generalization
8. independent
9. oscillate
10. perpendicular
11. propagate
12. propagation
13. regard
14. satisfied
15. vanish
Your Score : 0 of 15


Interactive Vocabulary Learning Multimedia - Solid State
Task 6
Choose the correct part of speech of the words bellow.
Pilihlah kelas kata yang tepat dari kata-kata di bawah ini.
1. Boundary
(The boundary of the first Brillouin zone lies at K = ± n/a)
NOUN
ADJECTIVE
VERB
ADVERB
2. Differ
(The constant C is the force constant between nearest-neighbor planes and will differ for longitudinal and transverse waves)
NOUN
ADJECTIVE
VERB
ADVERB


Interactive Vocabulary Learning Multimedia - Solid State
Task 7
Choose the words that suit with the desired part of speech.
Pilihlah kata-kata yang sesuai dengan kelas kata yang diinginkan.
Show Text
a. Find 1 noun in the list below
Carilah 1 kata benda pada daftar kata berikut ini
independent
perpendicular
propagation
satisfied
oscillate
propagate
regard
vanish


Interactive Vocabulary Learning Multimedia - Solid State
Task 8
Choose the correct meaning of the words.
Pilihlah arti kata yang tepat.
Words
Answer
Definition
1. boundary
2. differ
3. displaced
4. displacement
5. equilibrium
6. forth
7. generalization
8. independent
9. oscillate
10. perpendicular
11. propagate
12. propagation
13. regard
14. satisfied
15. vanish
a. at right angles to a horizontal plane
b. to move or swing from side to side regularly
c. forced to moved away from that area
d. the act or process of moving through, causing to move through, or transmitting, especially in the form of a wave
e. something that indicates the farthest limit, as of an area; border
f. forward in place, time, order, or degree
g. not dependent on anything else for function, validity, etc.
h. to move through, cause to move through, or transmit, especially in the form of a wave
i. to disappear, especially suddenly or mysteriously
j. being fulfilled by the conditions of (a theorem, assumption, etc.); to yield a truth by substitution of the given value
k. the condition of a system that has its total energy distributed among its component parts in the statistically most probable manner
l. the derivation of a general statement from a particular one
m. to be dissimilar in quality, nature, or degree (to); vary (from)
n. the distance measured in a particular direction from a reference point
o. to take notice of or pay attention to (something); heed
Your Score : 0 of 15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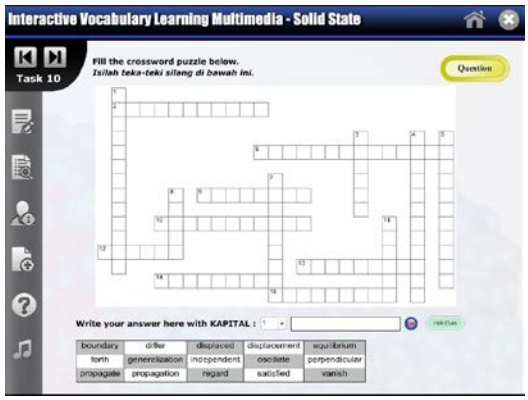
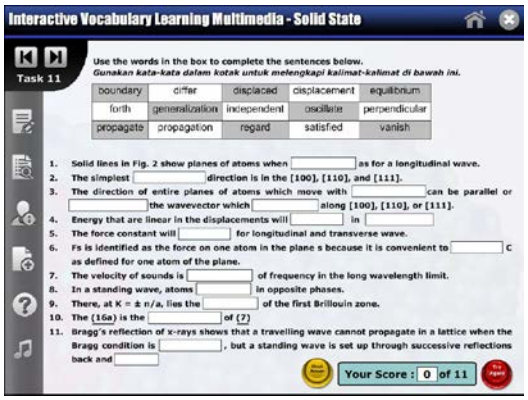
Task 9
Match the words bellow with their translation in Bahasa Indonesia.
Pasangkan kata-kata di bawah ini dengan terjemahannya dalam Bahasa Indonesia.
Words
Answer
Definition
Your Score : 0 of 15


Interactive Vocabulary Learning Multimedia - Solid State
Task 10
Fill the crossword puzzle below.
Isilah teka-teki silang di bawah ini.
Question
Write your answer here with KAPITAL :
boundary
differ
displaced
displacement
equilibrium
forth
generalization
independent
oscillate
perpendicular
propagate
propagation
regard
satisfied
vanish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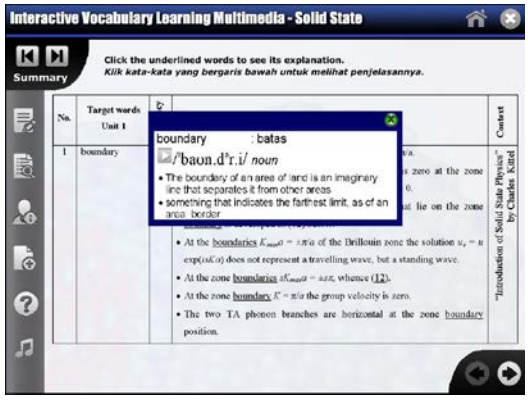
Task 11
Use the words in the box to complete the sentences below.
Gunakan kata-kata dalam kotak untuk melengkapi kalimat-kalimat di bawah ini.
boundary
differ
displaced
displacement
equilibrium
forth
generalization
independent
oscillate
perpendicular
propagate
propagation
regard
satisfied
vanish
1. Solid lines in Fig. 2 show planes of atoms when as for a longitudinal wave.
2. The simplest direction is in the [100], [110], and [111].
3. The direction of entire planes of atoms which move with can be parallel or the wavevector which along [100], [110], or [111].
4. Energy that are linear in the displacements will in
5. The force constant will for longitudinal and transverse wave.
6. Fs is identified as the force on one atom in the plane s because it is convenient to C as defined for one atom of the plane.
7. The velocity of sounds is of frequency in the long wavelength limit.
8. In a standing wave, atoms in opposite phases.
9. There, at K = ± π/a, lies the of the first Brillouin zone.
10. The (16a) is the of (7)
11. Bragg's reflection of x-rays shows that a travelling wave cannot propagate in a lattice when the Bragg condition is , but a standing wave is set up through successive reflections back and
Your Score : 0 of 11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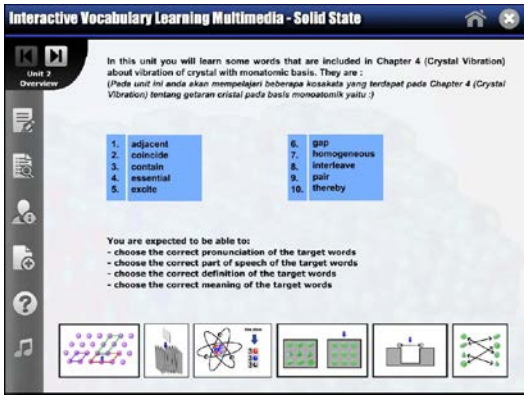
Summary
Click the underlined words to see its explanation.
Klik kata-kata yang bergaris bawah untuk melihat penjelasannya.
No.
Target words Unit 1
Context
1
boundary
boundary : batas
/'baun.d'r.i/ noun
• The boundary of an area of land is an imaginary line that separates it from other areas
• something that indicates the farthest limit, as of an area; border
"Introduction of Solid State Physics" by Charles Kittel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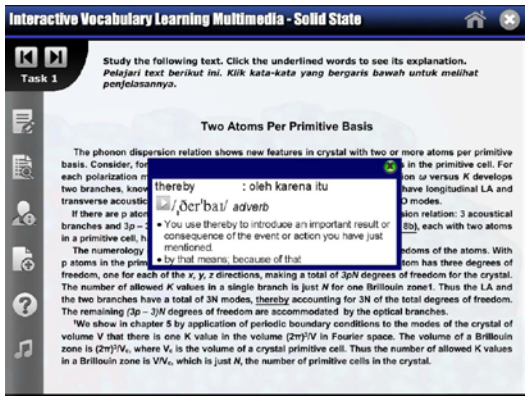
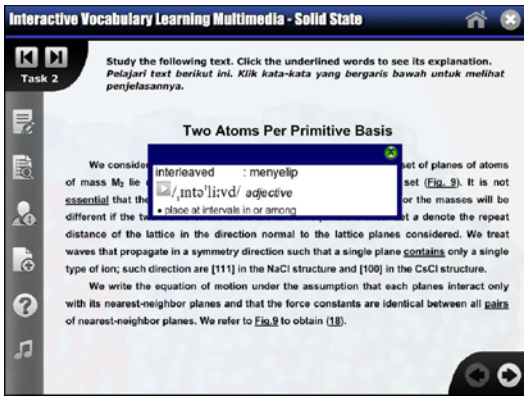
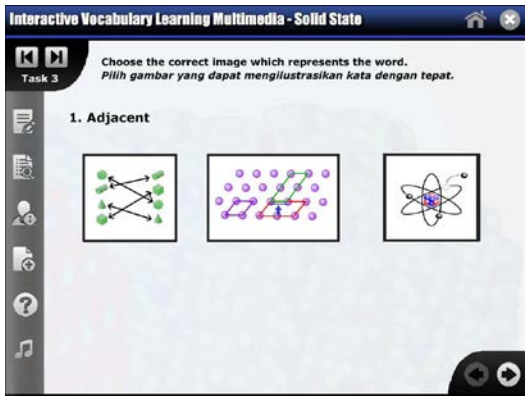
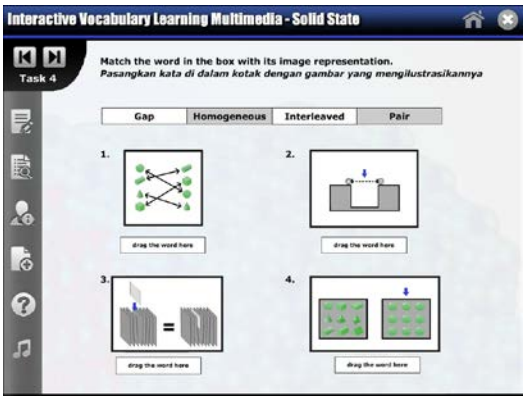
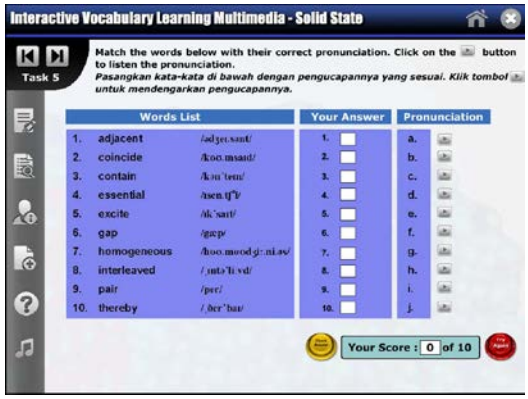
Unit 2 Overview
In this unit you will learn some words that are included in Chapter 4 (Crystal Vibration) about vibration of crystal with monatomic basis. They are :
(Pada unit ini anda akan mempelajari beberapa kosakata yang terdapat pada Chapter 4 (Crystal Vibration) tentang getaran cristal pada basis monoatomik yaitu :)
1. adjacent
2. coincide
3. contain
4. essential
5. excite
6. gap
7. homogenous
8. interleave
9. pair
10. thereby
You are expected to be able to:
- choose the correct pronunciation of the target words
- choose the correct part of speech of the target words
- choose the correct definition of the target words
- choose the correct meaning of the target words

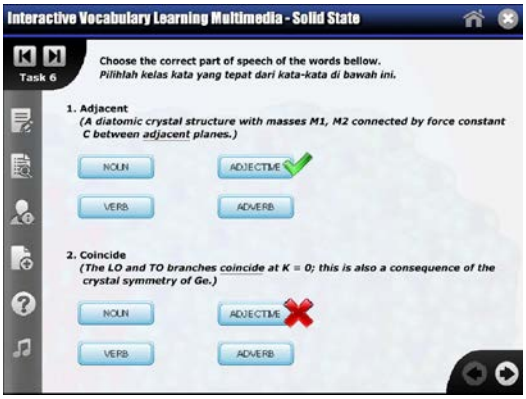

Interactive Vocabulary Learning Multimedia - Solid State
Task 1
Study the following text. Click the underlined words to see its explanation.
Pelajari text berikut ini. Klik kata-kata yang bergaris bawah untuk melihat penjelasannya.
Two Atoms Per Primitive Basis
thereby : oleh karena itu
/ˌðerˈbaɪ/ adverb
• You use thereby to introduce an important result or consequence of the event or action you have just mentioned.
• by that means; because of that

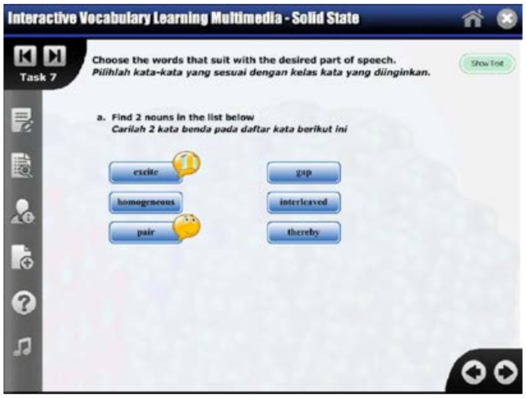

Interactive Vocabulary Learning Multimedia - Solid State
Task 2
Study the following text. Click the underlined words to see its explanation.
Pelajari text berikut ini. Klik kata-kata yang bergaris bawah untuk melihat penjelasannya.
Two Atoms Per Primitive Basis
interleaved : menyelip
/ˌɪntəˈliːvd/ adjective
• place at intervals in or among

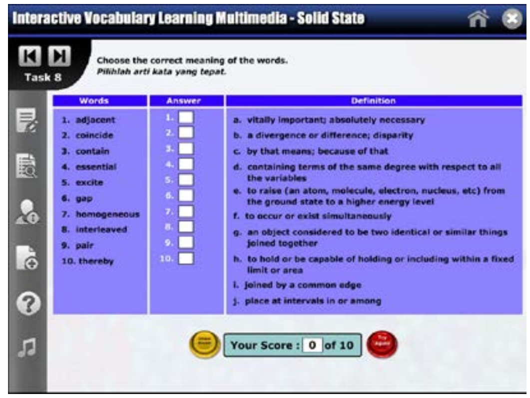

Interactive Vocabulary Learning Multimedia - Solid State
Task 3
Choose the correct image which represents the word.
Pilih gambar yang dapat mengilustrasikan kata dengan tepat.
1. Adjacent

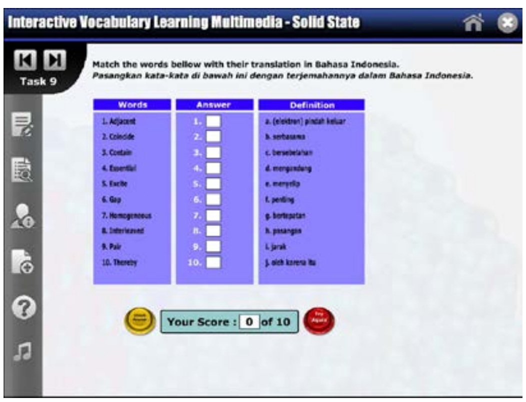

Interactive Vocabulary Learning Multimedia - Solid State
Task 4
Match the word in the box with its image representation.
Pasangkan kata di dalam kotak dengan gambar yang mengilustrasikannya
Gap
Homogeneous
Interleaved
Pair
1.
2.
3.
4.

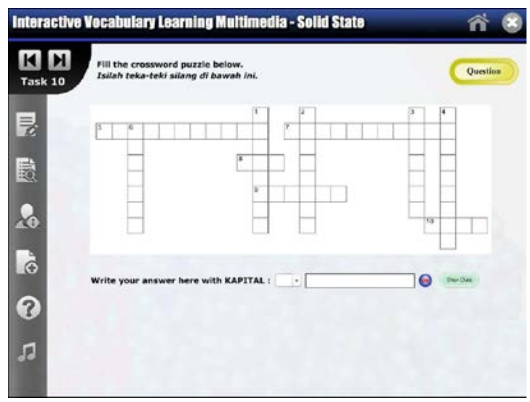

Interactive Vocabulary Learning Multimedia - Solid State
Task 5
Match the words below with their correct pronunciation. Click on the button to listen the pronunciation.
Pasangkan kata-kata di bawah dengan pengucapannya yang sesuai. Klik tombol untuk mendengarkan pengucapannya.
Words List
Your Answer
Pronunciation
1. adjacent /əˈdʒeɪsənt/
2. coincide /ˌkəʊɪnˈsaɪd/
3. contain /kənˈteɪn/
4. essential /ɪˈsenʃl/
5. excite /ɪkˈsaɪt/
6. gap /gæp/
7. homogeneous /ˌhɒməʊdʒɪˈniːəs/
8. interleaved /ˌɪntəˈliːvd/
9. pair /peə/
10. thereby /ðeəˈbaɪ/
Your Score : 0 of 10

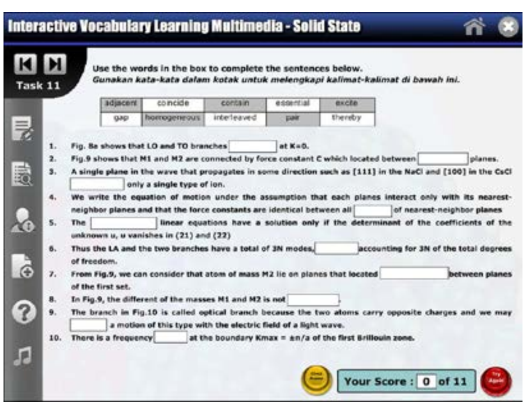

Interactive Vocabulary Learning Multimedia - Solid State
Task 6
Choose the correct part of speech of the words bellow.
Pilihlah kelas kata yang tepat dari kata-kata di bawah ini.
1. Adjacent
(A diatomic crystal structure with masses M1, M2 connected by force constant C between adjacent planes.)
NOUN
ADJECTIVE
VERB
ADVERB
2. Coincide
(The LO and TO branches coincide at K = 0; this is also a consequence of the crystal symmetry of Ge.)
NOUN
ADJECTIVE
VERB
ADVERB

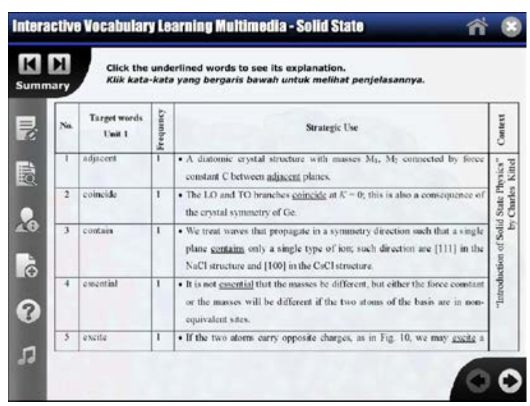

Interactive Vocabulary Learning Multimedia - Solid State
Task 7
Choose the words that suit with the desired part of speech.
Pilihlah kata-kata yang sesuai dengan kelas kata yang diinginkan.
a. Find 2 nouns in the list below
Carilah 2 kata benda pada daftar kata berikut ini
excite
gap
homogeneous
interleaved
pair
thereby

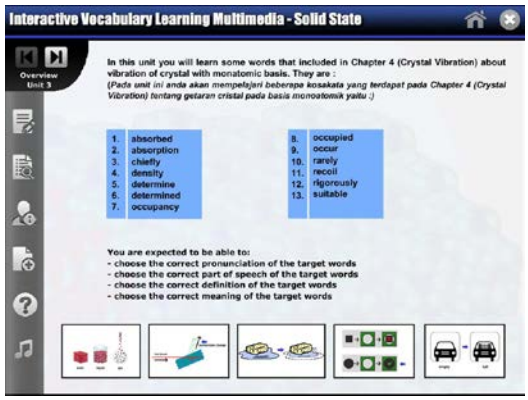

Interactive Vocabulary Learning Multimedia - Solid State
Task 8
Choose the correct meaning of the words.
Pilihlah arti kata yang tepat.
Words
Answer
Definition
1. adjacent
2. coincide
3. contain
4. essential
5. excite
6. gap
7. homogeneous
8. interleaved
9. pair
10. thereby
a. vitally important; absolutely necessary
b. a divergence or difference; disparity
c. by that means; because of that
d. containing terms of the same degree with respect to all the variables
e. to raise (an atom, molecule, electron, nucleus, etc) from the ground state to a higher energy level
f. to occur or exist simultaneously
g. an object considered to be two identical or similar things joined together
h. to hold or be capable of holding or including within a fixed limit or area
i. joined by a common edge
j. place at intervals in or among
Your Score : 0 of 10

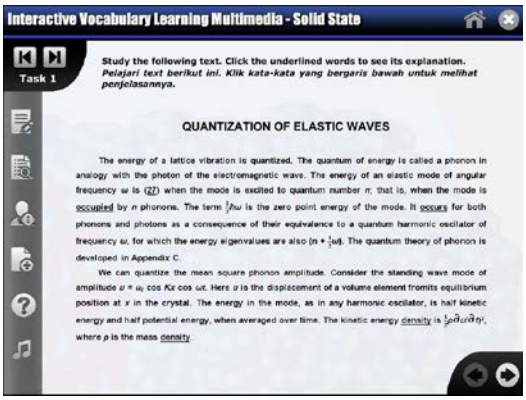

Interactive Vocabulary Learning Multimedia - Solid State
Task 9
Match the words bellow with their translation in Bahasa Indonesia.
Pasangkan kata-kata di bawah ini dengan terjemahannya dalam Bahasa Indonesia.
Words
Answer
Definition
Your Score : 0 of 10

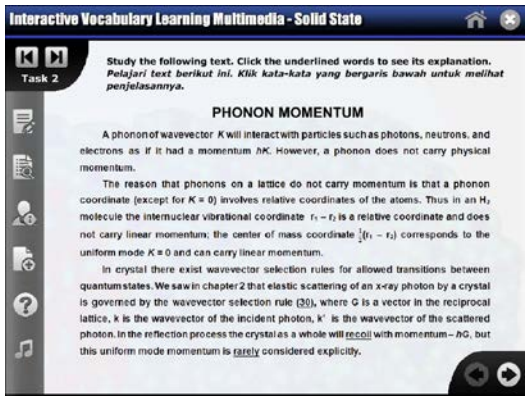

Interactive Vocabulary Learning Multimedia - Solid State
Task 10
Fill the crossword puzzle below.
Isilah teka-teki silang di bawah ini.
Question
Write your answer here with KAPITAL :

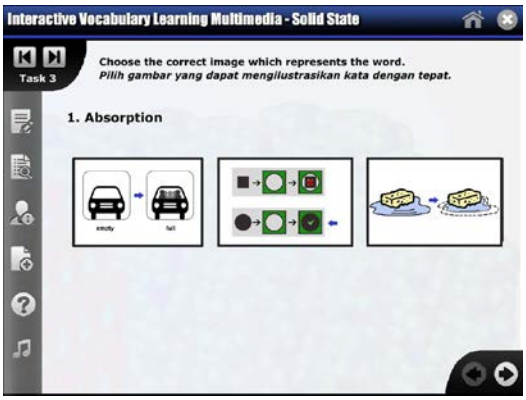

Interactive Vocabulary Learning Multimedia - Solid State
Task 11
Use the words in the box to complete the sentences below.
Gunakan kata-kata dalam kotak untuk melengkapi kalimat-kalimat di bawah ini.
adjacent
coincide
contain
essential
excite
gap
homogeneous
interleaved
pair
thereby
Your Score : 0 of 11

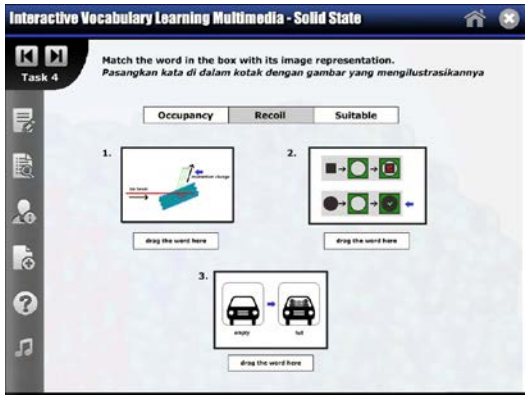

Interactive Vocabulary Learning Multimedia - Solid State
Summary
Click the underlined words to see its explanation.
Klik kata-kata yang bergaris bawah untuk melihat penjelasannya.

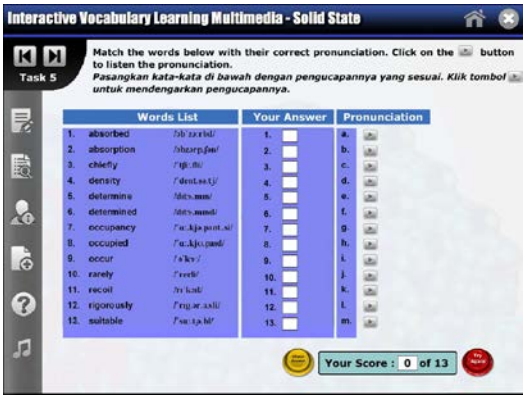

Interactive Vocabulary Learning Multimedia - Solid State
Overview Unit 3
In this unit you will learn some words that included in Chapter 4 (Crystal Vibration) about vibration of crystal with monatomic basis. They are :
(Pada unit ini anda akan mempelajari beberapa kosakata yang terdapat pada Chapter 4 (Crystal Vibration) tentang getaran cristal pada basis monoatomik yaitu :)
1. absorbed
2. absorption
3. chiefly
4. density
5. determine
6. determined
7. occupancy
8. occupied
9. occur
10. rarely
11. recoil
12. rigorously
13. suitable
You are expected to be able to:
- choose the correct pronunciation of the target words
- choose the correct part of speech of the target words
- choose the correct definition of the target words
- choose the correct meaning of the target words

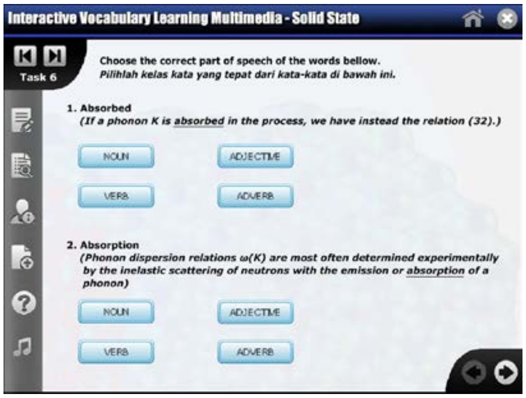

Interactive Vocabulary Learning Multimedia - Solid State
Task 1
Study the following text. Click the underlined words to see its explanation.
Pelajari text berikut ini. Klik kata-kata yang bergaris bawah untuk melihat penjelasannya.
QUANTIZATION OF ELASTIC WAVES
The energy of a lattice vibration is quantized. The quantum of energy is called a phonon in analogy with the photon of the electromagnetic wave. The energy of an elastic mode of angular frequency ω is (27) when the mode is excited to quantum number n, that is, when the mode is occupied by n phonons. The term ½ħω is the zero point energy of the mode. It occurs for both phonons and photons as a consequence of their equivalence to a quantum harmonic oscillator of frequency ω, for which the energy eigenvalues are also (n + ½)ω. The quantum theory of phonon is developed in Appendix C.
We can quantize the mean square phonon amplitude. Consider the standing wave mode of amplitude u = u0 cos Kx cos ωt. Here u is the displacement of a volume element from its equilibrium position at x in the crystal. The energy in the mode, as in any harmonic oscillator, is half kinetic energy and half potential energy, when averaged over time. The kinetic energy density is ¼ρω²u0², where ρ is the mass density.

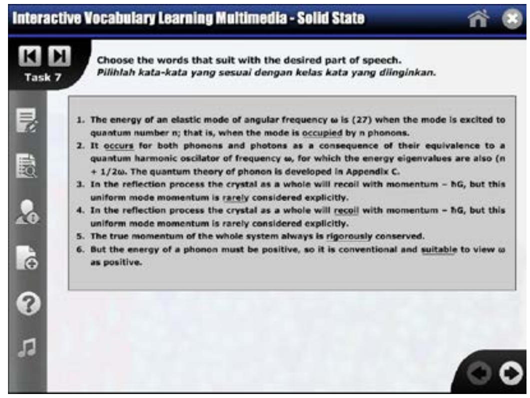

Interactive Vocabulary Learning Multimedia - Solid State
Task 2
Study the following text. Click the underlined words to see its explanation.
Pelajari text berikut ini. Klik kata-kata yang bergaris bawah untuk melihat penjelasannya.
PHONON MOMENTUM
A phonon of wavevector K will interact with particles such as photons, neutrons, and electrons as if it had a momentum ħK. However, a phonon does not carry physical momentum.
The reason that phonons on a lattice do not carry momentum is that a phonon coordinate (except for K = 0) involves relative coordinates of the atoms. Thus in an H2 molecule the internuclear vibrational coordinate r1 − r2 is a relative coordinate and does not carry linear momentum; the center of mass coordinate ½(r1 − r2) corresponds to the uniform mode K = 0 and can carry linear momentum.
In crystal there exist wavevector selection rules for allowed transitions between quantum states. We saw in chapter 2 that elastic scattering of an x-ray photon by a crystal is governed by the wavevector selection rule (30), where G is a vector in the reciprocal lattice, k is the wavevector of the incident photon, k' is the wavevector of the scattered photon. In the reflection process the crystal as a whole will recoil with momentum −ħG, but this uniform mode momentum is rarely considered explicitly.

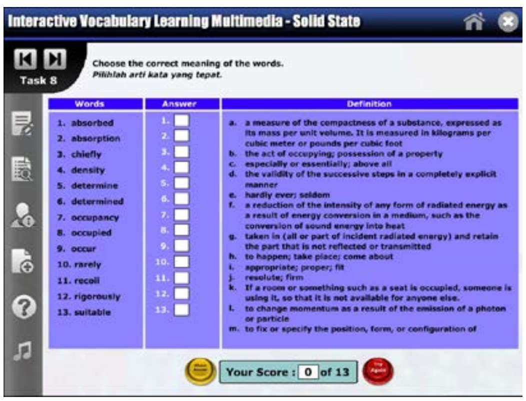

Interactive Vocabulary Learning Multimedia - Solid State
Task 3
Choose the correct image which represents the word.
Pilih gambar yang dapat mengilustrasikan kata dengan tepat.
1. Absorption
empty
full

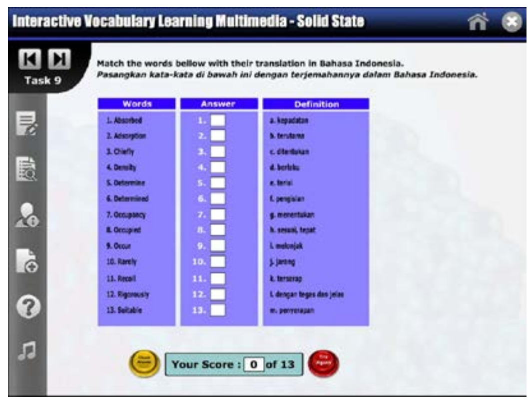

Interactive Vocabulary Learning Multimedia - Solid State
Task 4
Match the word in the box with its image representation.
Pasangkan kata di dalam kotak dengan gambar yang mengilustrasikannya
Occupancy
Recoil
Suitable
1.
2.
3.
drag the word here
drag the word here
drag the word here

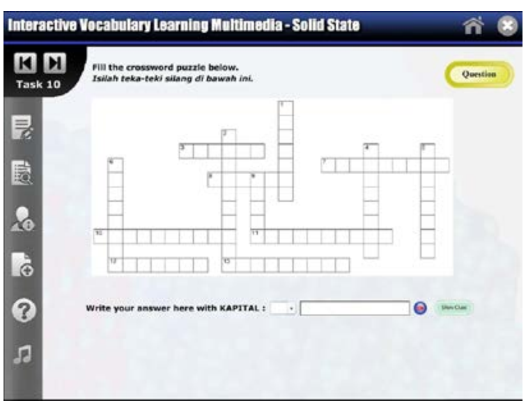

Interactive Vocabulary Learning Multimedia - Solid State
Task 5
Match the words below with their correct pronunciation. Click on the button to listen the pronunciation.
Pasangkan kata-kata di bawah dengan pengucapannya yang sesuai. Klik tombol untuk mendengarkan pengucapannya.
Words List
Your Answer
Pronunciation
1. absorbed
2. absorption
3. chiefly
4. density
5. determine
6. determined
7. occupancy
8. occupied
9. occur
10. rarely
11. recoil
12. rigorously
13. suitable
Your Score : 0 of 13

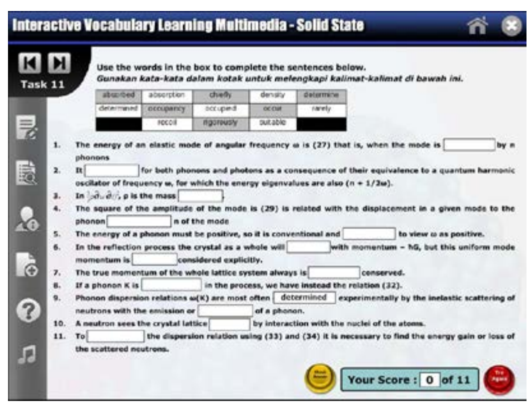

Interactive Vocabulary Learning Multimedia - Solid State
Task 6
Choose the correct part of speech of the words bellow.
Pilihlah kelas kata yang tepat dari kata-kata di bawah ini.
1. Absorbed
(If a phonon K is absorbed in the process, we have instead the relation (32).)
NOUN
ADJECTIVE
VERB
ADVERB
2. Absorption
(Phonon dispersion relations ω(K) are most often determined experimentally by the inelastic scattering of neutrons with the emission or absorption of a phonon)
NOUN
ADJECTIVE
VERB
ADVERB

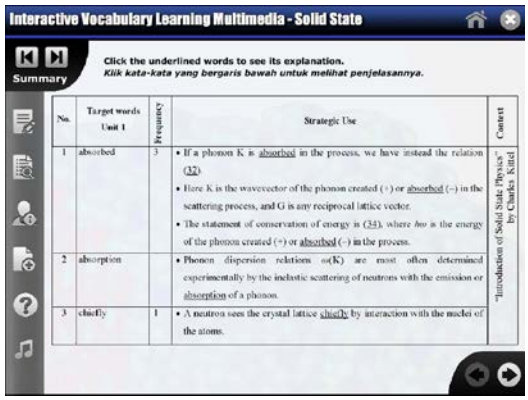

Interactive Vocabulary Learning Multimedia - Solid State
Task 7
Choose the words that suit with the desired part of speech.
Pilihlah kata-kata yang sesuai dengan kelas kata yang diinginkan.
1. The energy of an elastic mode of angular frequency ω is (27) when the mode is excited to quantum number n; that is, when the mode is occupied by n phonons.
2. It occurs for both phonons and photons as a consequence of their equivalence to a quantum harmonic oscilator of frequency ω, for which the energy eigenvalues are also (n + 1/2ω. The quantum theory of phonon is developed in Appendix C.
3. In the reflection process the crystal as a whole will recoil with momentum – ħG, but this uniform mode momentum is rarely considered explicitly.
4. In the reflection process the crystal as a whole will recoil with momentum – ħG, but this uniform mode momentum is rarely considered explicitly.
5. The true momentum of the whole system always is rigorously conserved.
6. But the energy of a phonon must be positive, so it is conventional and suitable to view ω as positive.

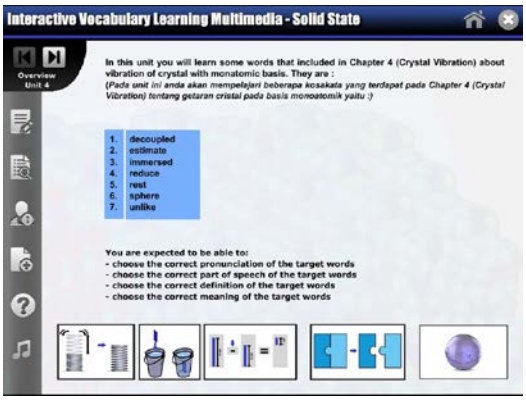

Interactive Vocabulary Learning Multimedia - Solid State
Task 8
Choose the correct meaning of the words.
Pilihlah arti kata yang tepat.
Words
Answer
Definition
1. absorbed
2. absorption
3. chiefly
4. density
5. determine
6. determined
7. occupancy
8. occupied
9. occur
10. rarely
11. recoil
12. rigorously
13. suitable
a. a measure of the compactness of a substance, expressed as its mass per unit volume. It is measured in kilograms per cubic meter or pounds per cubic foot
b. the act of occupying; possession of a property
c. especially or essentially; above all
d. the validity of the successive steps in a completely explicit manner
e. hardly ever; seldom
f. a reduction of the intensity of any form of radiated energy as a result of energy conversion in a medium, such as the conversion of sound energy into heat
g. taken in (all or part of incident radiated energy) and retain the part that is not reflected or transmitted
h. to happen; take place; come about
i. appropriate; proper; fit
j. resolute; firm
k. If a room or something such as a seat is occupied, someone is using it, so that it is not available for anyone else.
l. to change momentum as a result of the emission of a photon or particle
m. to fix or specify the position, form, or configuration of
Your Score : 0 of 13

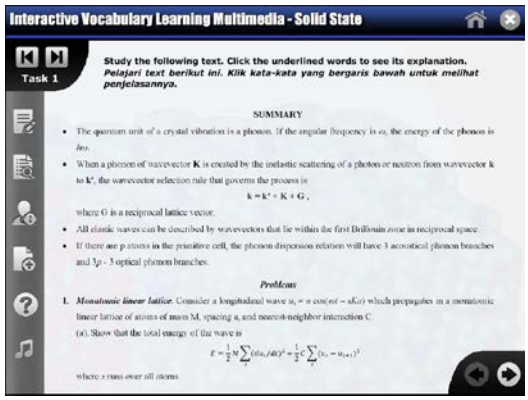

Interactive Vocabulary Learning Multimedia - Solid State
Task 9
Match the words bellow with their translation in Bahasa Indonesia.
Pasangkan kata-kata di bawah ini dengan terjemahannya dalam Bahasa Indonesia.
Words
Answer
Definition
1. Absorbed
2. Adsorption
3. Chiefly
4. Density
5. Determine
6. Determined
7. Occupancy
8. Occupied
9. Occur
10. Rarely
11. Recoil
12. Rigorously
13. Suitable
a. kepadatan
b. terutama
c. ditentukan
d. berlaku
e. terisi
f. pengisian
g. menentukan
h. sesuai, tepat
i. melonjak
j. jarang
k. terserap
l. dengan tegas dan jelas
m. penyerapan
Your Score : 0 of 13

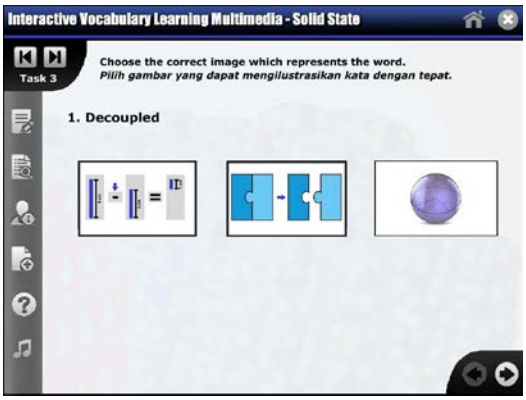

Interactive Vocabulary Learning Multimedia - Solid State
Task 10
Fill the crossword puzzle below.
Isilah teka-teki silang di bawah ini.
Question
Write your answer here with KAPITAL :

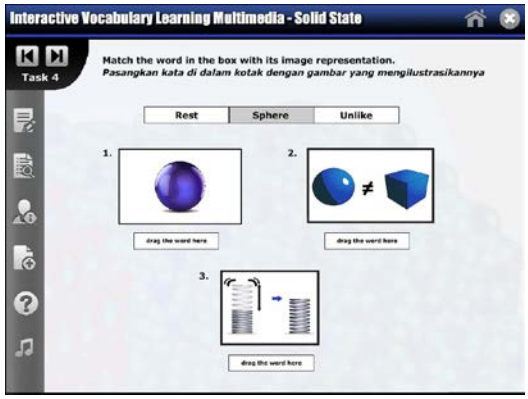

Interactive Vocabulary Learning Multimedia - Solid State
Task 11
Use the words in the box to complete the sentences below.
Gunakan kata-kata dalam kotak untuk melengkapi kalimat-kalimat di bawah ini.
absorbed
absorption
chiefly
density
determine
determined
occupancy
occupied
occur
rarely
recoil
rigorously
suitable
1. The energy of an elastic mode of angular frequency ω is (27) that is, when the mode is [ ] by n phonons
2. It [ ] for both phonons and photons as a consequence of their equivalence to a quantum harmonic oscilator of frequency ω, for which the energy eigenvalues are also (n + 1/2ω).
3. In [ ], ρ is the mass [ ].
4. The square of the amplitude of the mode is (29) is related with the displacement in a given mode to the phonon [ ] n of the mode
5. The energy of a phonon must be positive, so it is conventional and [ ] to view ω as positive.
6. In the reflection process the crystal as a whole will [ ] with momentum – ħG, but this uniform mode momentum is [ ] considered explicitly.
7. The true momentum of the whole lattice system always is [ ] conserved.
8. If a phonon K is [ ] in the process, we have instead the relation (32).
9. Phonon dispersion relations ω(K) are most often [determined] experimentally by the inelastic scattering of neutrons with the emission or [ ] of a phonon.
10. A neutron sees the crystal lattice [ ] by interaction with the nuclei of the atoms.
11. To [ ] the dispersion relation using (33) and (34) it is necessary to find the energy gain or loss of the scattered neutrons.
Your Score : 0 of 11

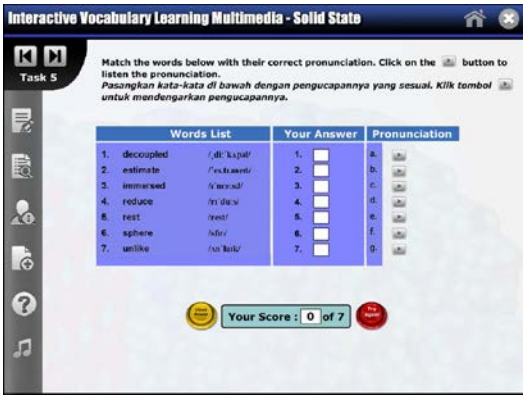

Interactive Vocabulary Learning Multimedia - Solid State
Summary
Click the underlined words to see its explanation.
Klik kata-kata yang bergaris bawah untuk melihat penjelasannya.
No.
Target words Unit 1
Frequency
Strategic Use
Context
1
absorbed
3
• If a phonon K is absorbed in the process, we have instead the relation (32).
• Here K is the wavevector of the phonon created (+) or absorbed (–) in the scattering process, and G is any reciprocal lattice vector.
• The statement of conservation of energy is (34), where ħω is the energy of the phonon created (+) or absorbed (–) in the process.
"Introduction of Solid State Physics" by Charles Kittel
2
absorption
• Phonon dispersion relations ω(K) are most often determined experimentally by the inelastic scattering of neutrons with the emission or absorption of a phonon.
3
chiefly
1
• A neutron sees the crystal lattice chiefly by interaction with the nuclei of the atoms.

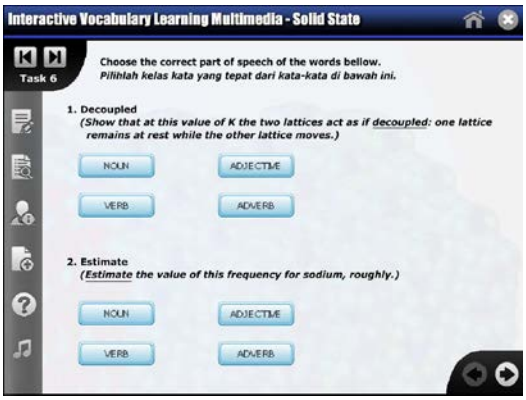

Interactive Vocabulary Learning Multimedia - Solid State
Overview Unit 4
In this unit you will learn some words that included in Chapter 4 (Crystal Vibration) about vibration of crystal with monatomic basis. They are :
(Pada unit ini anda akan mempelajari beberapa kosakata yang terdapat pada Chapter 4 (Crystal Vibration) tentang getaran cristal pada basis monoatomik yaitu :)
1. decoupled
2. estimate
3. immersed
4. reduce
5. rest
6. sphere
7. unlike
You are expected to be able to:
- choose the correct pronunciation of the target words
- choose the correct part of speech of the target words
- choose the correct definition of the target words
- choose the correct meaning of the target words

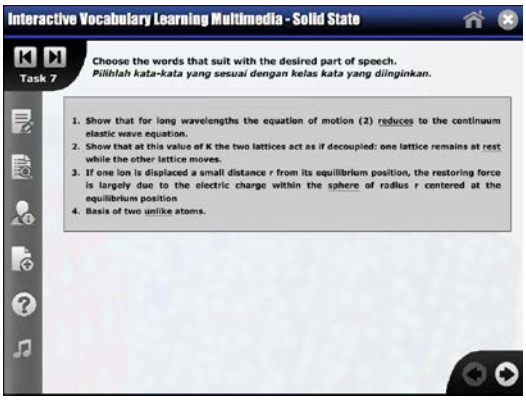

Interactive Vocabulary Learning Multimedia - Solid State
Task 1
Study the following text. Click the underlined words to see its explanation.
Pelajari text berikut ini. Klik kata-kata yang bergaris bawah untuk melihat penjelasannya.
SUMMARY
• The quantum unit of a crystal vibration is a phonon. If the angular frequency is ω, the energy of the phonon is ħω.
• When a phonon of wavevector K is created by the inelastic scattering of a photon or neutron from wavevector k to k', the wavevector selection rule that governs the process is
k = k' + K + G ,
where G is a reciprocal lattice vector.
• All elastic waves can be described by wavevectors that lie within the first Brillouin zone in reciprocal space.
• If there are p atoms in the primitive cell, the phonon dispersion relation will have 3 acoustical phonon branches and 3p - 3 optical phonon branches.
Problems
1. Monatomic linear lattice. Consider a longitudinal wave u_s = u cos(ωt – sKa) which propagates in a monatomic linear lattice of atoms of mass M, spacing a, and nearest-neighbor interaction C.
(a). Show that the total energy of the wave is
E = ½ M Σ_s (du_s/dt)² + ½ C Σ_s (u_s – u_{s+1})²
where s runs over all atoms.

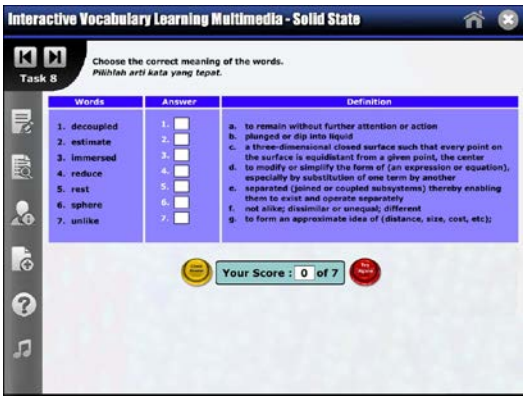

Interactive Vocabulary Learning Multimedia - Solid State
Task 3
Choose the correct image which represents the word.
Pilih gambar yang dapat mengilustrasikan kata dengan tepat.
1. Decoupled


Interactive Vocabulary Learning Multimedia - Solid State
Task 4
Match the word in the box with its image representation.
Pasangkan kata di dalam kotak dengan gambar yang mengilustrasikannya
Rest
Sphere
Unlike
1.
2.
3.
drag the word here

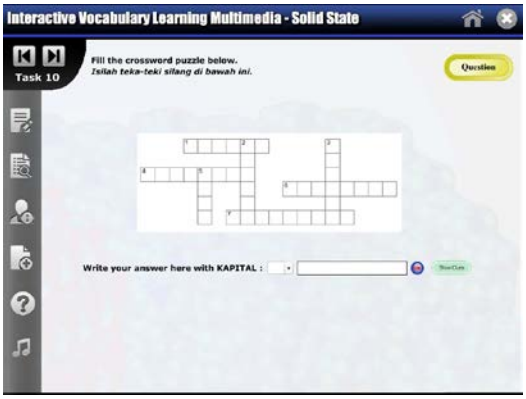

Interactive Vocabulary Learning Multimedia - Solid State
Task 5
Match the words below with their correct pronunciation. Click on the button to listen the pronunciation.
Pasangkan kata-kata di bawah dengan pengucapannya yang sesuai. Klik tombol untuk mendengarkan pengucapannya.
Words List
Your Answer
Pronunciation
1. decoupled
2. estimate
3. immersed
4. reduce
5. rest
6. sphere
7. unlike
Your Score : 0 of 7

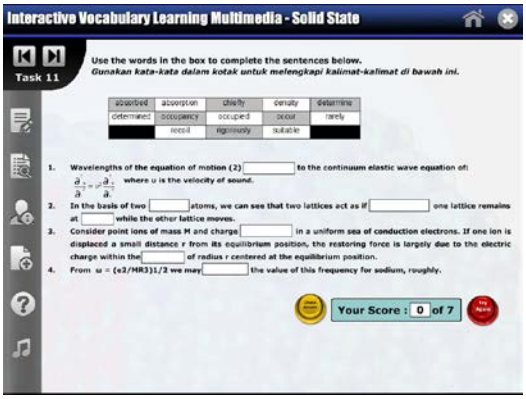

Interactive Vocabulary Learning Multimedia - Solid State
Task 6
Choose the correct part of speech of the words bellow.
Pilihlah kelas kata yang tepat dari kata-kata di bawah ini.
1. Decoupled
(Show that at this value of K the two lattices act as if decoupled: one lattice remains at rest while the other lattice moves.)
NOUN
ADJECTIVE
VERB
ADVERB
2. Estimate
(Estimate the value of this frequency for sodium, roughly.)
NOUN
ADJECTIVE
VERB
ADVERB


Interactive Vocabulary Learning Multimedia - Solid State
Task 7
Choose the words that suit with the desired part of speech.
Pilihlah kata-kata yang sesuai dengan kelas kata yang diinginkan.
1. Show that for long wavelengths the equation of motion (2) reduces to the continuum elastic wave equation.
2. Show that at this value of K the two lattices act as if decoupled: one lattice remains at rest while the other lattice moves.
3. If one ion is displaced a small distance r from its equilibrium position, the restoring force is largely due to the electric charge within the sphere of radius r centered at the equilibrium position
4. Basis of two unlike atoms.


Interactive Vocabulary Learning Multimedia - Solid State
Task 8
Choose the correct meaning of the words.
Pilihlah arti kata yang tepat.
Words
Answer
Definition
1. decoupled
2. estimate
3. immersed
4. reduce
5. rest
6. sphere
7. unlike
a. to remain without further attention or action
b. plunged or dip into liquid
c. a three-dimensional closed surface such that every point on the surface is equidistant from a given point, the center
d. to modify or simplify the form of (an expression or equation), especially by substitution of one term by another
e. separated (joined or coupled subsystems) thereby enabling them to exist and operate separately
f. not alike; dissimilar or unequal; different
g. to form an approximate idea of (distance, size, cost, etc);
Your Score : 0 of 7


Interactive Vocabulary Learning Multimedia - Solid State
Task 9
Match the words bellow with their translation in Bahasa Indonesia.
Pasangkan kata-kata di bawah ini dengan terjemahannya dalam Bahasa Indonesia.
Words
Answer
Definition
1. Decoupled
2. Estimate
3. Immersed
4. Reduce
5. Rest
6. Sphere
7. Unlike
a. memperkirakan
b. diam
c. terbenam, tidak sama
d. memisahkan diri
e. bulatan
f. mengurangi
g. menyelam
Your Score : 0 of 7


Interactive Vocabulary Learning Multimedia - Solid State
Task 10
Fill the crossword puzzle below.
Isilah teka-teki silang di bawah ini.
Question
Write your answer here with KAPITAL :


Interactive Vocabulary Learning Multimedia - Solid State
Task 11
Use the words in the box to complete the sentences below.
Gunakan kata-kata dalam kotak untuk melengkapi kalimat-kalimat di bawah ini.
absorbed
absorption
chiefly
density
determine
determined
occupancy
occupied
about
rarely
recoil
rigorously
suitable
1. Wavelengths of the equation of motion (2) to the continuum elastic wave equation of: where u is the velocity of sound.
2. In the basis of two atoms, we can see that two lattices act as if one lattice remains at while the other lattice moves.
3. Consider point ions of mass M and charge in a uniform sea of conduction electrons. If one ion is displaced a small distance r from its equilibrium position, the restoring force is largely due to the electric charge within the of radius r centered at the equilibrium position.
4. From ω = (e2/MR3)1/2 we may the value of this frequency for sodium, roughly.
Your Score : 0 of 7

Appendix G

The Final Draft

of the Multimedia

UNIT 1

Crystal Vibration (Monatomic Basis)

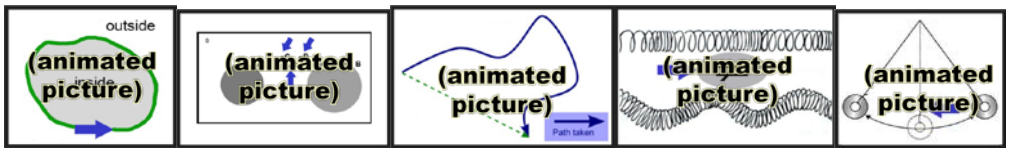
OVERVIEW

In this unit you will learn some words that are included in Chapter 4 about vibration of crystal with monoatomic basis. They are:

boundary	oscillate
differ	perpendicular
displaced	propagate
displacements	propagation
equilibrium	regard
forth	satisfied
generalization	vanish
independent	

You are expected to be able to:

- choose the correct pronunciation of the target words
- choose the correct part of speech of the target words
- choose the correct definition of the target words
- choose the correct the meaning of the target words



Task 1

Study the following text. Click the underlined words to see its explanation.

Pelajari text berikut ini. Klik kata-kata yang bergaris bawah untuk melihat penjelasannya

VIBRATION OF CRYSTAL WITH MONOATOMIC BASIS

Consider the elastic vibrations of a crystal with one atom in the primitive cell. We want to find the frequency of an elastic wave in terms of the wavevector that describes the wave and in terms of the elastic constants.

The mathematical solution is simplest in the [100], [110], and [111] propagation directions in cubic crystals. These are the directions of the cube edge) face diagonal, and body diagonal. When a wave propagates along one of these directions, entire planes of atoms move in phase with displacements either parallel or perpendicular to the direction of the wavevector. We can describe with a single coordinate us the displacement of the planes from its equilibrium position. The problem is now one dimensional. For each wavevector there are three modes as solutions for u_s, one of longitudinal polarization (Fig. 2) and two of transverse polarization (Fig. 3).

We assume that the elastic response of the crystal is a linear function of the forces. That is equivalent to the assumption that the elastic energy is a quadratic function of the relative displacement of any two points in the crystal. Terms in the energy that are linear in the displacements will vanish in equilibrium–see the minimum in Fig. 3.6. Cubic and higher-order terms may be neglected for sufficiently small elastic deformations.

We assume that the force on the plane *s* caused by the displacement of the plane s + *p* is proportional to the difference u_{s+p}- u_s of their displacements. For brevity we consider only nearest-neighbor interactions, with $p = \pm 1$. The total force on *s* from planes $s \pm 1$: (1). This expression is linear in the displacements and is of the form of Hooke's law.

The constant *C* is the **force constant** between nearest-neighbor planes and will differ for longitudinal and transverse waves. It is convenient hereafter to

regard C as defined for one atom of the plane, so that F_s is the force on one atom in the plane s.

The equation of motion of an atom in the plane s is (2), where M is the mass of an atom. We look for solutions with all displacements having the time dependence $\exp(-i\omega t)$. Then $d^2u_s/dt^2 = -\omega^2 u_s$ and (2) becomes (3).

This is a difference equation in the displacements u and has traveling wave solutions of the form: (4), where a is the spacing between planes and K is the wavevector. The value to use for a will depend on the direction of K. With (4), we have from (3): (5). We cancel $u \exp(isKa)$ from both sides, to leave (6). With the identity $2 \cos Ka = \exp(iKa) + \exp(-iKa)$, we have the **dispersion relation** $\omega(K)$. (7)

The boundary of the first Brillouin zone lies at $K = \pm \pi/a$. We show from (7) that the slope of ω versus K is zero at the zone boundary: (8) at $K = \pm\pi/a$, for here $\sin Ka = \sin(\pm\pi) = 0$. The special significance of phonon wavevectors that lie on the zone boundary is developed in (12) below.

By a trigonometric identity, (7) may be written as (9). A plot of ω vesus K is given in Fig.4.

Task 2

Study the following text. Click the underlined words to see its explanation.
Pelajari text berikut ini. Klik kata-kata yang bergaris bawah untuk melihat penjelasannya

First Brillouin Zone

What range of K is physically significant for elastic waves? Only those in the first Brillouin zone. From (4) the ratio of the displacements of two successive planes is given by (10). The range $-\pi$ to $+\pi$ for the phase Ka covers all independent values of the exponential.

The range of the first Brillouin Zone of the linear lattice *(K)* is specified by $-\pi < Ka \leq \pi$, or $\frac{\pi}{a} < K \leq \frac{\pi}{a}$. The extreme values are $K_{max} = \pm\pi/a$. Values of K outside

of the first Brillouin zone (Fig.5) merely reproduce lattice motions described by values within the limits $\pm\pi/a$.

We may treat a value of K outside these limits by subtracting the integral multiple of $2\pi/a$ that will give a wavevector inside these limits. Suppose K lies outside the first zone, but a related wavevector K' defined $K' = K - 2\pi n/a$ lies within the first zone, where n is an integer. Then the displacement ratio (10) becomes (11), because $\exp(i2\pi n) = 1$. Thus the displacement can always be described by a wavevector within the first zone. We note that $2\pi n/a$ is a reciprocal lattice vector because $2\pi n/a$ is a reciprocal lattice vector. Thus by subtraction of an appropriate reciprocal lattice vector from K, we always obtain an equivalent wavevector in the first zone.

At the boundaries $K_{max}a = \pm\pi/a$ of the Brillouin zone the solution $u_s = u \exp(isKa)$ does not represent a travelling wave, but a standing wave. At the zone boundaries $sK_{max}a = \pm s\pi$, whence (12). This is a standing wave; alternate atoms oscillate in opposite phases, because $u_s = \pm 1$ according to whether s is an even or an odd integer. The wave moves neither to the right nor to the left.

This situation is equivalent to Bragg reflection of x-rays: when the Bragg condition is satisfied a travelling wave cannot propagate in a lattice, but through successive reflections back and forth, a standing wave is set up.

The critical value $K_{max} = \pm\pi/a$ found here satisfies the Bragg condition $2d \sin\theta = n\lambda$: we have $\theta = \frac{1}{2}\pi$, $d = a$, $K = 2\pi/\lambda$, $n = 1$, *so* that $\lambda = 2a$. With x-rays it is possible to have n equal to other integers besides unity because the amplitude of the electromagnetic wave has a meaning in the space between atoms, but the displacement amplitude of an elastic wave usually has a meaning only at the atoms themselves.

Group Velocity

The transmission velocity of a wave packet is the **group velocity**, given as $v_g = d\omega/dK$, or (13), the gradient frequency with respect to **K**. This is the velocity of energy propagation in the medium.

With the particular dispersion relation (9), the group velocity (Fig. 6) is (14). This is zero at the edge of the zone where $Ka = \pi/a$. Here the wave is a

standing wave, as in (12), and we expect zero net transmission velocity for a standing wave.

Long Wavelength Limit

When $Ka \ll 1$ we expand $\cos Ka \equiv 1 - \frac{1}{2}(Ka)^2$, so that the dispersion relation (7) becomes (15). The result that the frequency is directly proportional to the wavevector in the long wavelength limit is equivalent to the statement that the velocity of sound is independent of frequency in this limit. Thus $v = \omega/K$, exactly as in the continuum theory of elastic waves—in the continuum limit $Ka \ll 1$.

Derivation of Force Constants from Experiment

In metals the effective forces may be of quite long range and are carried from ion to ion through the conduction electron sea. Interactions have been found between planes of atoms separated by as many as 20 planes. We can make a statement about the range of the forces from the observed experimental dispersion relation for ω. The generalization of dispersion relation (7) to p nearest planes is easily found to be (16a).

We solve for the interplanar force constants C_p by multiplying both sides by cos rKa, where r is an integer, and integrating over the range of independent values of K: (16b). The integral vanishes except for $p = r$. Thus (17) gives the force constant at range pa, for a structure with monoatomic basis.

Flash Cards for Task 1 & 2:

No.	Flash card
1.	boundary : batas /ˈbaʊn.dər.i/ *noun* • The boundary of an area of land is an imaginary line that separates it from other areas • something that indicates the farthest limit, as of an area; border
2.	differ : berbeda /ˈdɪf.ər/ *verb* • If two or more things differ, they are unlike each other in some way. • to be dissimilar in quality, nature, or degree (to); vary (from)
3.	displaced : dipindahkan /dɪˈspleɪst/ *adjective* • moved away from that area

4.	displacement : perpindahan /dɪˈspleɪs.mənt/ *noun* • Displacement is the removal of something from its usual place or position by something which then occupies that place or position. • the distance measured in a particular direction from a reference point
5.	equilibrium : kesetimbangan /ˌiː.kwɪˈlɪb.ri.əm/ *noun* • Equilibrium is a balance between several different influences or aspects of a situation. • the condition of a system that has its total energy distributed among its component parts in the statistically most probable manner
6.	forth : maju /fɔːθ/ *adverb* • When someone goes forth from a place, they leave it. • forward in place, time, order, or degree
7.	generalization : penyamarataan /ˌdʒen.ər.əl.aɪˈzeɪ.ʃən/ *noun* • A generalization is a statement that seems to be true in most situations or for most people, but that may not be completely true in all cases • the derivation of a general statement from a particular one
8.	independent : berdiri sendiri, tunggal /ˌɪn.dɪˈpen.dənt/ *adjective* • If one thing or person is independent of another, they are separate and not connected, so the first one is not affected or influenced by the second. • not dependent on anything else for function, validity, etc. • (of a system of equations) not linearly dependent
9.	oscillate : bergetar /ˈɒs.ɪ.leɪt/ *verb* • If an object oscillates, it moves repeatedly from one position to another and back again, or keeps getting bigger and smaller. • to move or swing from side to side regularly
10.	perpendicular : tegak lurus /ˌpɜː.pənˈdɪk.jʊ.lər/ *adjective* • at right angles to a horizontal plane
11.	propagate : merambat /ˈprɒp.ə.geɪt/ *verb* • If people propagate an idea or piece of information, they spread it and try to make people believe it or support it. • to move through, cause to move through, or transmit, especially in the form of a wave
12.	propagation : perambatan /ˌprɒp.əˈgeɪ.ʃən/ *noun* • the act or process of moving through, causing to move through, or transmitting, especially in the form of a wave

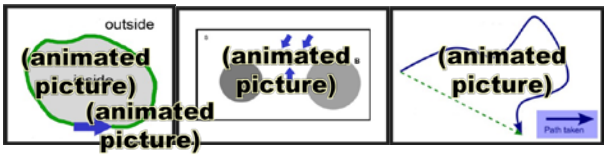
13.	regard : menganggap /rɪˈgɑːd/ *verb* • If you regard something or someone with a feeling such as dislike or respect, you have that feeling about them. • to look upon or consider in a specified way • to take notice of or pay attention to (something); heed
14.	satisfied : terpenuhi /ˈsæt.ɪs.faɪd/ *adjective* • If you are satisfied that something is true or has been done properly, you are convinced about this after checking it.
15.	vanish : lenyap/hilang /ˈvæn.ɪʃ/ *verb* • If someone or something vanishes, they disappear suddenly or in a way that cannot be explained. • to disappear, especially suddenly or mysteriously

Task 3

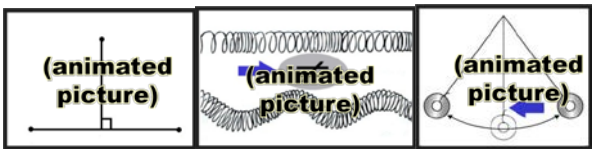
Choose the correct image which represents the word.

Pilih gambar yang dapat mengilustrasikan kata dengan tepat.

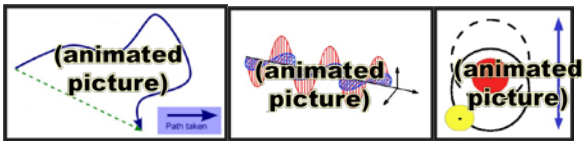
1. boundary



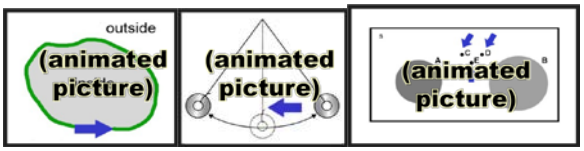
2. differ



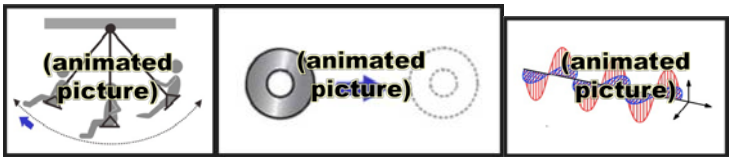
3. displacement



4. equilibrium



5. forth

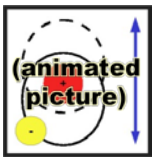


Task 4

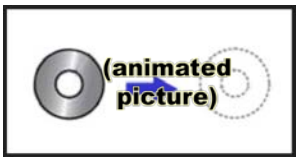
Match the word in the box with its image representation.

Pasangkan kata di dalam kotak dengan gambar yang mengilustrasikannya.

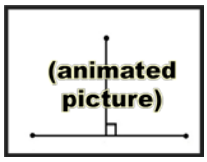
independent	oscillate	perpendicular	propagation	vanish

1. 

drag the word here

2. 

drag the word here

3. 

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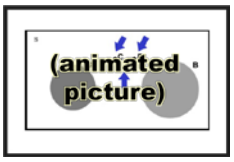
4. 

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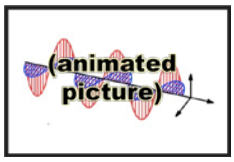
5. 

drag the word here

Task 5

Match the words below with their correct pronunciation. Click on the button to listen the pronunciation.

Pasangkan kata-kata di bawah dengan pengucapannya yang sesuai. Klik tombol untuk mendengarkan pengucapannya.

Word list		Your answer		Pronunciation
1. boundary	/ˈbaʊn.dər.i/	b	√ / X	a.
2. differ	/ˈdɪf.ər/	g		b.
3. displaced	/dɪˈspleɪst/	m		c.
4. displacement	/dɪˈspleɪs.mənt/	f		d.
5. equilibrium	/ˌiː.kwɪˈlɪb.ri.əm/	l		e.
6. forth	/fɔːθ/	j		f.
7. generalization	/ˌdʒen.ər.əl.aɪˈzeɪ.ʃən/	d		g.
8. independent	/ˌɪn.dɪˈpen.dənt/	h		h.
9. oscillate	/ˈɒs.ɪ.leɪt/	n		i.
10. perpendicular	/ˌpɜː.pənˈdɪk.jʊ.lər/	a		j.
11. propagate	/ˈprɒp.ə.geɪt/	o		k.
12. propagation	/ˌprɒp.əˈgeɪ.ʃən/	e		l.

13. regard	/rɪˈgɑːd/	i		m.
14. satisfied	/ˈsæt.ɪs.faɪd/	c		n.
15. vanish	/ˈvæn.ɪʃ/	k		o.

Task 6

Choose the correct part of speech of the words below.

Pilihlah kelas kata yang tepat dari kata-kata di bawah ini.

1. boundary

   (The <u>boundary</u> of the first Brillouin zone lies at K = ± π/a.)

noun	√ / X	adjective	√ / X
verb	√ / X	adverb	√ / X

2. differ

   (The constant C is the force constant between nearest-neighbor planes and will <u>differ</u> for longitudinal and transverse waves)

noun	√ / X	adjective	√ / X
verb	√ / X	adverb	√ / X

3. displaced

   (Planes of atoms as <u>displaced</u> during passage of a transverse wave.)

noun	√ / X	adjective	√ / X
verb	√ / X	adverb	√ / X

4. displacement

   (The coordinate u measures the displacement of the planes.)

noun	√ / X	adjective	√ / X
verb	√ / X	adverb	√ / X

5. equilibrium

   (We can describe with a single coordinate us the displacement of the planes from its equilibrium position.)

noun	√ / X	adjective	√ / X
verb	√ / X	adverb	√ / X

6. forth

   (This situation is equivalent to Bragg reflection of x-rays: when the Bragg condition is satisfied a travelling wave cannot propagate in a lattice, but through successive reflections back and <u>forth</u>, a standing wave is set up.)

noun	√ / X	adjective	√ / X
verb	√ / X	adverb	√ / X

7. generalization

(The generalization of dispersion relation (7) to p nearest planes is easily found to be (16a))

noun	√ / X	adjective	√ / X
verb	√ / X	adverb	√ / X

Task 7

Choose the words that suit with the correct part of speech.

Pilih kata-kata yang sesuai dengan kelas kata yang diinginkan.

- The range $-\pi$ to $+\pi$ for the phase *Ka* covers all independent values of the exponential.
- This is a standing wave; alternate atoms oscillate in opposite phases, because us = ±1 according to whether s is an even or an odd integer.
- When a wave propagates along one of these directions, entire planes of atoms move in phase with displacements either parallel or perpendicular to the direction of the wavevector.
- When a wave propagates along one of these directions, entire planes of atoms move in phase with displacements either parallel or perpendicular to the direction of the wavevector.
- This is the velocity of energy propagation in the medium.
- It is convenient hereafter to regard *C* as defined for one atom of the plane, so that F_s is the force on one atom in the plane s.
- This situation is equivalent to Bragg reflection of x-rays: when the Bragg condition is satisfied a travelling wave cannot propagate in a lattice, but through successive reflections back and forth, a standing wave is set up.
- Terms in the energy that are linear in the displacements will vanish in equilibrium–see the minimum in Fig. 3.6.

a. Find 1 noun.

Carilah 1 kata benda.

independent	☺/☹	oscillate	☺/☹
perpendicular	☺/☹	propagate	☺/☹
propagation	☺/☹	regard	☺/☹
satisfied	☺/☹	vanish	☺/☹

b. Find 4 verbs.

Carilah 4 kata kerja.

independent	☺/☹	oscillate	☺/☹
perpendicular	☺/☹	propagate	☺/☹
propagation	☺/☹	regard	☺/☹
satisfied	☺/☹	Vanish	☺/☹

c. Find 3 adjectives.

Carilah 3 kata sifat yang memnberi keterangan pada kata benda.

independent	☺/☹	oscillate	☺/☹
perpendicular	☺/☹	propagate	☺/☹
propagation	☺/☹	regard	☺/☹
satisfied	☺/☹	vanish	☺/☹

Task 8

Choose the correct definition.

Pilihlah definisi kata yang tepat.

Word list	Your answer		Definition
1. boundary	e	√ / X	a. at right angles to a horizontal plane
2. differ	m		b. to move or swing from side to side regularly
3. displaced	c		c. forced to moved away from that area
4. displacement	n		d. the act or process of moving through, causing to move through, or transmitting, especially in the form of a wave
5. equilibrium	k		
6. forth	f		
7. generalization	l		e. something that indicates the farthest limit, as of an area; border
8. independent	g		
9. oscillate	b		f. forward in place, time, order, or degree
10. perpendicular	a		g. not dependent on anything else for function, validity, etc.
11. propagate	h		
12. propagation	d		h. to move through, cause to move through, or transmit, especially in the form of a wave
13. regard	o		

14. satisfied 15. vanish	j i		i. to disappear, especially suddenly or mysteriously j. being fulfilled by the conditions of (a theorem, assumption, etc); to yield a truth by substitution of the given value k. the condition of a system that has its total energy distributed among its component parts in the statistically most probable manner l. the derivation of a general statement from a particular one m. to be dissimilar in quality, nature, or degree (to); vary (from) n. the distance measured in a particular direction from a reference point o. to take notice of or pay attention to (something); heed

Task 9

Match the words below with their translation in Bahasa Indonesia

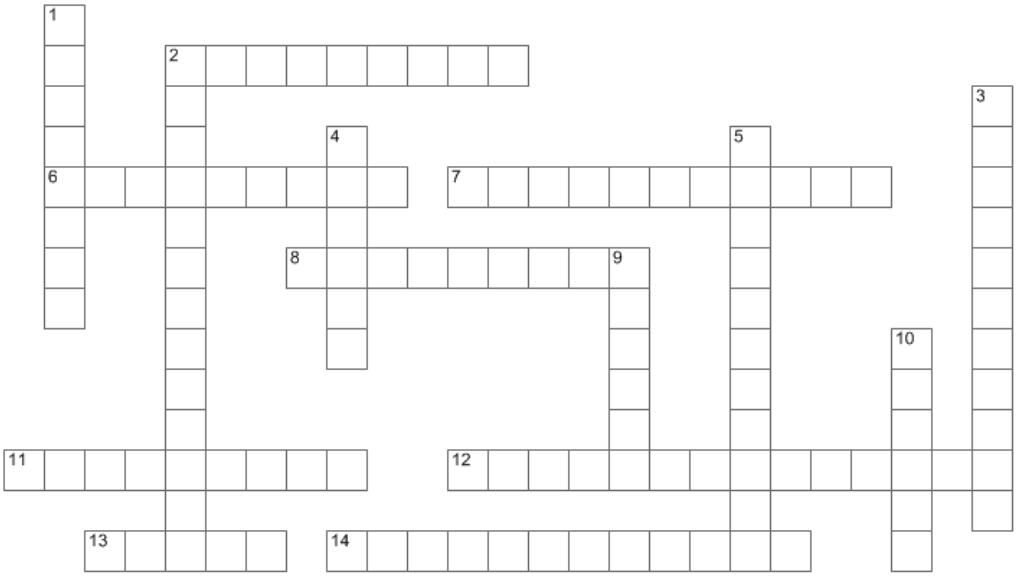
Pasangkan kata-kata di bawah ini dengan terjemahannya dalam Bahasa Indonesia.

Word list	Your answer		Meaning
1. boundary	c	√ / X	a. maju
2. differ	h		b. dipindahkan
3. displaced	b		c. batas
4. displacement	l		d. kesetimbangan
5. equilibrium	d		e. merambat
6. forth	a		f. bergetar
7. generalization	i		g. perambatan
8. independent	m		h. beda
9. oscillate	f		i. penyamarataan
10. perpendicular	j		j. tegak lurus
11. propagate	e		k. lenyap/hilang
12. propagation	g		l. perpindahan
13. regard	n		m. bebas
14. satisfied	o		n. menganggap
15. vanish	k		o. terpenuhi

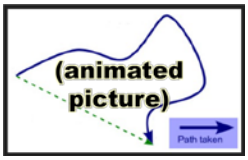
Task 10

Fill the crossword puzzle below using the words in the box.

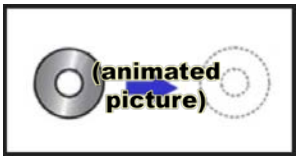
Isilah teka-teki silang di bawah ini menggunakan kata-kata di dalam kotak.



Across:

2. to move through, cause to move through, or transmit, especially in the form of a wave
6. 
7. **kesetimbangan**
8. being fulfilled by the conditions of (a theorem, assumption, etc); to yield a truth by substitution of the given value
11. to move or swing from side to side regularly
12. 
13. maju
14. 

Down:

1. something that indicates the farthest limit, as of an area; border
2. tegak lurus
3. not dependent on anything else for function, validity, etc
4. 
5. perambatan
9. 
10. 

boundary	differ	displaced	displacement	equilibrium
forth	generalization	independent	oscillate	perpendicular
propagate	propagation	regard	satisfied	vanish

Task 11

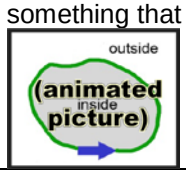
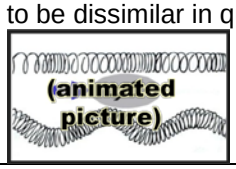
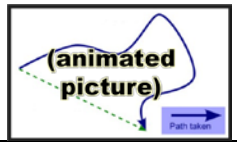
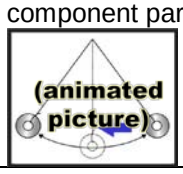
Use the words in the box to complete the sentences below.

Gunakan kata-kata dalam kotak untuk melengkapi kalimat-kalimat di bawah ini

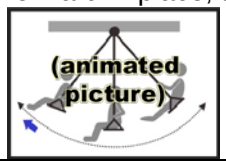
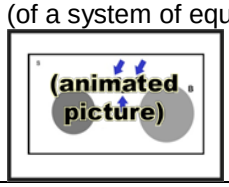
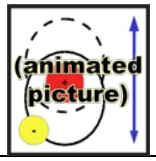
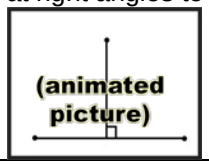
boundary	differ	displaced	displacement	equilibrium
forth	generalization	independent	oscillate	perpendicular
propagate	propagation	regard	satisfied	vanish

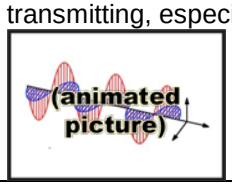
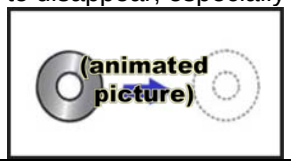
1. Solid lines in Fig. 2 show planes of atoms when [ ] as for a longitudinal wave.
2. The simplest [ ] direction is in the [100], [110], and [111].
3. The direction of entire planes of atoms which move with [ ] can be parallel or [ ] of the wavevector which [ ] along [100], [110], or [111].
4. Energy that is linear in the displacements will [ ] in [ ] .
5. The force constant will [ ] for longitudinal and transverse wave.
6. F_s is identified as the force on one atom in the plane *s* because it is convenient to [ ] C as defined for one atom of the plane.
7. The velocity of sounds is [ ] of frequency in the long wavelength limit.
8. In a standing wave, atoms [ ] in opposite phases.
9. There, at $K = \pm \pi/a$, lies the [ ] of the first Brillouin zone.
10. The (16a) is the [ ] of (7)
11. Bragg's reflection of x-rays shows that a travelling wave cannot propagate in a lattice when the Bragg condition is [ ] , but a standing wave is set up through successive reflections back and [ ].

SUMMARY

No.	Summary
1.	boundary : batas /ˈbaʊn.dər.i/ *noun* • The boundary of an area of land is an imaginary line that separates it from other areas • something that indicates the farthest limit, as of an area; border 
2.	differ : berbeda /ˈdɪf.ər/ *verb* • If two or more things differ, they are unlike each each other in some way. • to be dissimilar in quality, nature, or degree (to); vary (from) 
3.	displaced : dipindahkan /dɪˈspleɪst/ *adjective* • moved away from that area
4.	displacement : perpindahan /dɪˈspleɪs.mənt/ *noun* • Displacement is the removal of something from its usual place or position by something which then occupies that place or position. • the distance measured in a particular direction from a reference point 
5.	equilibrium : kesetimbangan /ˌiː.kwɪˈlɪb.ri.əm/ *noun* • Equilibrium is a balance between several different influences or aspects of a situation. • the condition of a system that has its total energy distributed among its component parts in the statistically most probable manner 

6.	forth	: maju

	/fɔːθ/ *adverb* • When someone goes forth from a place, they leave it. • forward in place, time, order, or degree 
7.	generalization : penyamarataan /ˌdʒen.ər.əl.aɪˈzeɪ.ʃən/ *noun* • A generalization is a statement that seems to be true in most situations or for most people, but that may not be completely true in all cases • the derivation of a general statement from a particular one
8.	independent : berdiri sendiri, tunggal /ˌɪn.dɪˈpen.dənt/ *adjective* • If one thing or person is independent of another, they are separate and not connected, so the first one is not affected or influenced by the second. • not dependent on anything else for function, validity, etc. • (of a system of equations) not linearly dependent 
9.	oscillate : bergetar /ˈɒs.ɪ.leɪt/ *verb* • If an object oscillates, it moves repeatedly from one position to another and back again, or keeps getting bigger and smaller. • to move or swing from side to side regularly 
10.	perpendicular : tegak lurus /ˌpɜː.pənˈdɪk.jʊ.lər/ *adjective* • at right angles to a horizontal plane 
11.	propagate : merambat /ˈprɒp.ə.geɪt/ *verb* • If people propagate an idea or piece of information, they spread it and try to make people believe it or support it. • to move through, cause to move through, or transmit, especially in the form of a wave
12.	propagation : perambatan

	/ˌprɒp.əˈgeɪ.ʃən/ *noun* • the act or process of moving through, causing to move through, or transmitting, especially in the form of a wave 
13.	regard : menganggap /rɪˈgɑːd/ *verb* • If you regard something or someone with a feeling such as dislike or respect, you have that feeling about them. • to look upon or consider in a specified way • to take notice of or pay attention to (something); heed
14.	satisfied : terpenuhi /ˈsæt.ɪs.faɪd/ *adjective* • If you are satisfied that something is true or has been done properly, you are convinced about this after checking it.
15.	vanish : lenyap/hilang /ˈvæn.ɪʃ/ *verb* • If someone or something vanishes, they disappear suddenly or in a way that cannot be explained. • to disappear, especially suddenly or mysteriously 

UNIT 2:

Crystal Vibration (Diatomic Basis)

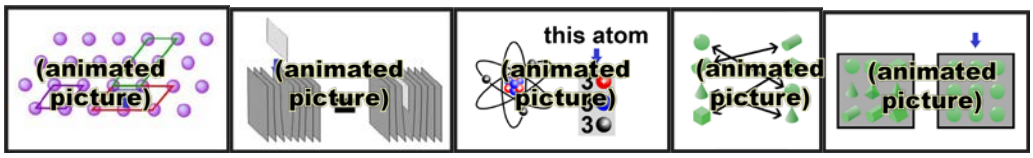
OVERVIEW

In this unit you will learn some words that are included in Chapter 4 about vibration of crystal with diatomic basis. They are:

adjacent	gap
coincide	homogeneous
contain	interleaved
essential	pair
excite	thereby

You are expected to be able to:

- choose the correct pronunciation of the target words
- choose the correct part of speech of the target words
- choose the correct definition of the target words
- choose the correct the meaning of the target words



Task 1

Study the following text. Click the underlined words to see its explanation.

Pelajari text berikut ini. Klik kata-kata yang bergaris bawah untuk melihat penjelasannya

TWO ATOMS PER PRIMITIVE BASIS

The phonon dispersion relation shows new features in crystal with two or more atoms per primitive basis. Consider, for example, the NaCl or diamond structures, with two atoms in the primitive cell. For each polarization mode in a given propagation direction the dispersion relation ω versus K develops two

branches, known as the acoustical and optical branches as in Fig 7. We have longitudinal LA and transverse acoustical TA modes, and longitudinal LO and transverse optical TO modes.

If there are p atoms in the primitive cell, there are $3p$ branches to the dispersion relation: 3 acoustical branches and $3p - 3$ optical branches. Thus germanium (Fig.8a) and KBr (Fig. 8b), each with two atoms in a primitive cell, have six branches: one LA, one LO, two TA, and Two TO.

The numerology of the branches follows from the number of degrees of freedoms of the atoms. With p atoms in the primitive cell and N primitive cells, there are pN atoms. Each atom has three degrees of freedom, one for each of the x, y, z directions, making a total of $3pN$ degrees of freedom for the crystal. The number of allowed K values in a single branch is just N for one Brillouin zone[1]. Thus the LA and the two branches have a total of 3N modes, thereby accounting for 3N of the total degrees of freedom. The remaining $(3p - 3)N$ degrees of freedom are accommodated by the optical branches.

[1]We show in chapter 5 by application of periodic boundary conditions to the modes of the crystal of volume V that there is one **K** value in the volume $(2\pi)^3/V$ in Fourier space. The volume of a Brillouin zone is $(2\pi)^3/V_c$, where Vc is the volume of a crystal primitive cell. Thus the number of allowed K values in a Brillouin zone is V/V_c, which is just N, the number of primitive cells in the crystal.

Task 2

Study the following text. Click the underlined words to see its explanation.

Pelajari text berikut ini. Klik kata-kata yang bergaris bawah untuk melihat penjelasannya

We consider a cubic crystal where atoms of mass M_1 lie on one set of planes of atoms of mass M_2 lie on planes interleaved between those and the first set (Fig. 9). It is not essential that the masses be different, but either the force constant or the masses will be different if the two atoms of the basis are in non-equivalent sites. Let a denote the repeat distance of the lattice in the direction normal to the lattice planes considered. We treat waves that propagate in a symmetry direction

such that a single plane contains only a single type of ion; such direction are [111] in the NaCl structure and [100] in the CsCl structure.

We write the equation of motion under the assumption that each planes interact only with its nearest-neighbor planes and that the force constants are identical between all pairs of nearest-neighbor planes. We refer to Fig.9 to obtain (18).

We look for a solution in the form of traveling wave, now with different amplitudes u, v on alternate planes: (19).

We define a in Fig. 9 as the distance between nearest identical planes, not nearest-neighbor planes.

On substitution of (19) in (18) we have (20). The homogeneous linear equations have a solution only if the determinant of the coefficients of the unknown u, v vanishes: (21) or (22).

We can solve this equation exactly for ω^2 but it is simpler to examine the limiting cases $Ka \ll 1$ and $Ka = \pm\pi$ at the zone boundary. For small Ka we have cos $Ka \cong 1 - \frac{1}{2}K^2a^2 + \ldots$, and the two roots are (23) (optical branch); (24) acoustical branch. The extent of the first Brillouin zone is $-\pi/a$, where a is the repeat distance of the lattice. At $K_{max} = \pm \pi/a$, the roots are (25). The dependence of ω on K is shown in Fig. 7 for $M_1 > M_2$.

The particle displacements in the transverse acoustical (TA) and transverse optical (TO) branches are shown in Fig. 10. For the optical branch at $K = 0$ we find, on substitution of (23) in (20), (26). The atoms vibrate against each other, but their center of mass is fixed. If the two atoms carry opposite charges, as in Fig. 10, we may excite a motion of this type with the electric field of a light wave, so that the branch is called the optical branch. At a general K the ratio u/v will be complex, as follows from either of the equations (20). Another solution for the amplitude ratio at small K is $u = v$, obtained sa the $K = 0$ limit of (24). The atoms (and their center of mass) move together, as in long wavelength acoustical vibrations, whence the term acoustical branch.

Wavelike solution do not exist for certain frequencies, here between $(2C/M_1)^{1/2}$ and $(2C/M_2)^{1/2}$. This is a characteristic feature of elastic waves in

polyatomic lattices. There is a frequency gap at the boundary $K_{max} = \pm\pi/a$ of the first Brillouin zone.

Flash Cards for Task 1 & 2:

No.	Flash card
1.	adjacent : bersebelahan /ədʒeɪ.sənt/ *adjective* • If one thing is adjacent to another, the two things are next to each other. • joined by a common edge
2.	coincide : bertepatan /koʊ.ɪnsaɪd/ *verb* • If one event coincides with another, they happen at the same time. • to occur or exist simultaneously
3.	contain : mengandung /kənteɪn/ *verb* • If a substance contains something, that thing is a part of it. • to hold or be capable of holding or including within a fixed limit or area
4.	essential : penting / ɪsen.tʃəl/ *verb* • Something that is essential is extremely important or absolutely necessary to a particular subject, situation, or activity. • vitally important; absolutely necessary
5.	excite : pindah keluar (elektron) /ɪkˈsaɪt/ *verb* • to raise (an atom, molecule, electron, nucleus, etc) from the ground state to a higher energy level
6.	gap : jarak /gæp/ *noun* • A gap between two groups of people, things, or sets of ideas is a big difference between them. • a divergence or difference; disparity
7.	homogeneous : serbasama /hoʊ.moʊdʒiː.ni.əs/*adjective* • Group or thing which has members or parts that are all the same. • containing terms of the same degree with respect to all the variables
8.	interleaved : menyelip /ˌɪntəˈliːvd/ *adjective* • place at intervals in or among

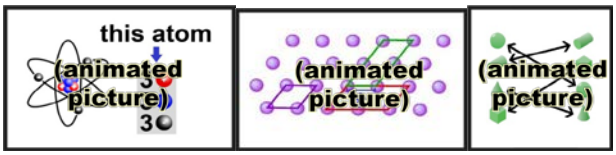
9.	pair : pasangan /per/ *noun* (plural: pairs) • A pair of things are two things of the same size and shape that are used together or are both part of something, for example shoes, earrings, or parts of the body. • an object considered to be two identical or similar things joined together
10.	thereby : oleh karena itu /ˌðerˈbaɪ/ *adverb* • You use thereby to introduce an important result or consequence of the event or action you have just mentioned. • by that means; because of that

Task 3

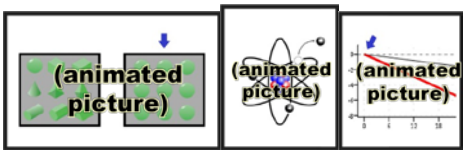
Choose the correct image which represents the word.

Pilih gambar yang dapat mengilustrasikan kata dengan tepat.

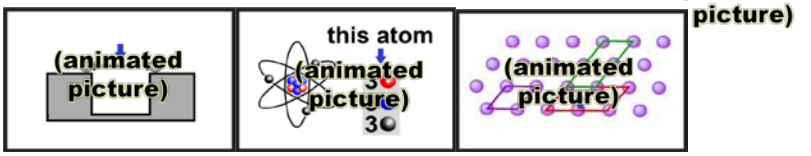
1. adjacent



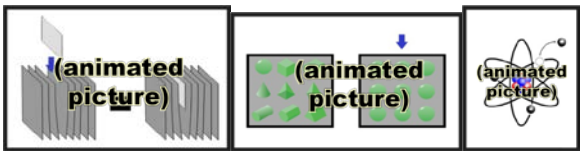
2. coincide



3. contain



4. excite



Task 4

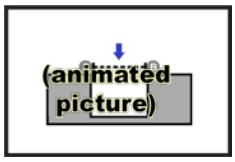
Match the word in the box with its image representation.

Pasangkan kata di dalam kotak dengan gambar yang mengilustrasikannya.

gap	homogeneous	interleaved	pair

1. 

drag the word here

2. 

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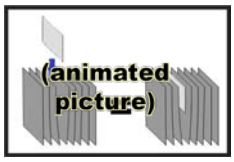
3. 

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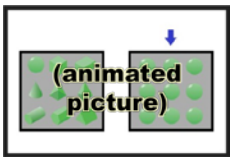
4. 

drag the word here

Task 5

Match the words below with their correct pronunciation. Click on the button to listen the pronunciation.

Pasangkan kata-kata di bawah dengan pengucapannya yang sesuai. Klik tombol untuk mendengarkan pengucapannya.

Word list		Your answer		Pronunciation
1. adjacent	/ədʒeɪ.sənt/	b	√ / X	a.
2. coincide	/koʊ.ɪnsaɪd/	c		b.
3. contain	/kənˈteɪn/	h		c.
4. essential	/ɪsen.tʃ^{ə}l/	j		d.
5. excite	/ɪkˈsaɪt/	i		e.
6. gap	/gæp/	a		f.
7. homogeneous	/hoʊ.moʊdʒiː.ni.əs/	e		g.
8. interleaved	/ˌɪntəˈliːvd/	h		h.
9. pair	/per/	f		i.
10. thereby	/ˌðerˈbaɪ/	d		j.

Task 6

Choose the correct part of speech of the words below.

Pilihlah kelas kata yang tepat dari kata-kata di bawah ini.

1. adjacent

   (A diatomic crystal structure with masses M_1, M_2 connected by force constant C between adjacent planes.)

noun	√ / X	adjective	√ / X
verb	√ / X	adverb	√ / X

2. coincide

(The LO and TO branches coincide at $K = 0$; this is also a consequence of the crystal symmetry of Ge.)

noun	√ / X	adjective	√ / X
verb	√ / X	adverb	√ / X

3. contain

(We treat waves that propagate in a symmetry direction such that a single plane contains only a single type of ion; such direction are [111] in the NaCl structure and [100] in the CsCl structure.)

noun	√ / X	adjective	√ / X
verb	√ / X	adverb	√ / X

4. essential

(It is not essential that the masses be different, but either the force constant or the masses will be different if the two atoms of the basis are in non-equivalent sites.)

noun	√ / X	adjective	√ / X
verb	√ / X	adverb	√ / X

Task 7

Choose the words that suit with the correct part of speech.

Pilih kata-kata yang sesuai dengan kelas kata yang diinginkan.

- If the two atoms carry opposite charges, as in Fig. 10, we may excite a motion of this type with the electric field of a light wave, so that the branch is called the optical branch.
- There is a frequency gap at the boundary Kmax = ±π/a of the first Brillouin zone.
- The homogeneous linear equations have a solution only if the determinant of the coefficients of the unknown *u*, υ vanishes: (21) or (22).
- We consider a cubic crystal where atoms of mass M1 lie on one set of planes of atoms of mass M2 lie on planes interleaved between those and the first set (Fig. 9).
- We write the equation of motion under the assumption that each planes interact only with its nearest-neighbor planes and that the force constants are identical between all pairs of nearest-neighbor planes
- Thus the LA and the two branches have a total of 3N modes, thereby accounting for 3N of the total degrees of freedom.

a. Find 2 noun
   Carilah 2 kata benda

Excite	☺/☹	gap	☺/☹
Homogeneous	☺/☹	interleaved	☺/☹
Pair	☺/☹	thereby	☺/☹

b. Find 1 verb
   Carilah 1 kata kerja

Excite	☺/☹	gap	☺/☹
homogeneous	☺/☹	interleaved	☺/☹
pair	☺/☹	thereby	☺/☹

c. Find 2 adjectives
   Carilah 2 kata sifat yang memberi keterangan pada kata benda

excite	☺/☹	gap	☺/☹
homogeneous	☺/☹	interleaved	☺/☹
pair	☺/☹	thereby	☺/☹

d. Find the adverb (total words to find: 1)
   Carilah kata sifat yang memberi keterangan pada kata kerja (total kata tersedia: 1)

excite	☺/☹	gap	☺/☹
homogeneous	☺/☹	interleaved	☺/☹
pair	☺/☹	thereby	☺/☹

Task 8

Choose the correct meaning.

Pilihlah arti kata yang tepat.

Word list	Your answer		Definition
1. adjacent	(i)	√ / X	a. vitally important; absolutely necessary
2. coincide	(f)		b. a divergence or difference; disparity
3. contain	(h)		c. by that means; because of that
4. essential	(a)		d. containing terms of the same degree with respect to all the variables
5. excite	(e)		e. to raise (an atom, molecule, electron, nucleus, etc) from the ground state to a higher energy level
6. gap	(b)		f. to occur or exist simultaneously
7. homogeneous	(d)		g. an object considered to be two identical
8. interleaved	(j)		
9. pair	(g)		
10. thereby	(c)		

			or similar things joined together h. to hold or be capable of holding or including within a fixed limit or area i. joined by a common edge j. place at intervals in or among

Task 9

Match the words below with their translation in Bahasa Indonesia

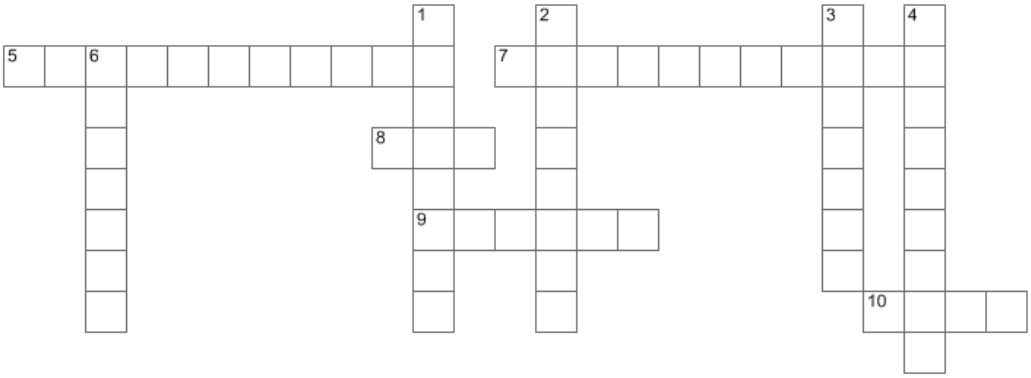
Pasangkan kata-kata di bawah ini dengan terjemahannya dalam Bahasa Indonesia.

Word list	Your answer		Definition
1. adjacent	(c)	√ / X	a. (elektron) pindah keluar
2. coincide	(g)		b. serbasama
3. contain	(d)		c. bersebelahan
4. essential	(f)		d. mengandung
5. excite	(a)		e. menyelip
6. gap	(i)		f. penting
7. homogeneous	(b)		g. bertepatan
8. interleaved	(e)		h. pasangan
9. pair	(h)		i. jarak
10. thereby	(j)		j. oleh karena itu

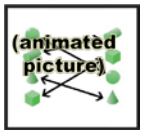
Task 10

Fill the crossword puzzle below using the words in the box.

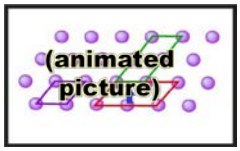
Isilah teka-teki silang di bawah ini menggunakan kata-kata di dalam kotak.



Across

5.
7. serbasama
8.
9. to raise (an atom, molecule, electron, nucleus, etc) from the ground state to a higher energy level
10. 

Down

1. 

2.
3. to hold or be capable of holding or including
4.
6. oleh karena itu

adjacent	coincide	contain	essential	excite
gap	homogeneous	interleaved	pair	thereby

Task 11

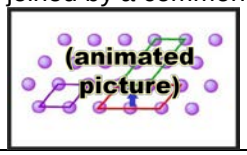
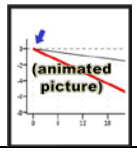
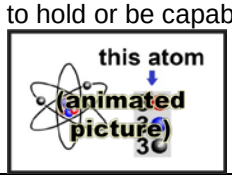
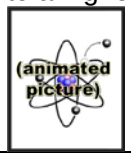
Use the words in the box to complete the sentences below.

Gunakan kata-kata dalam kotak untuk melengkapi kalimat-kalimat di bawah ini

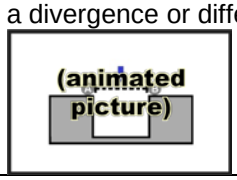
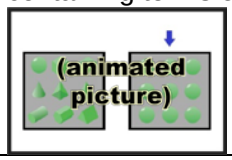
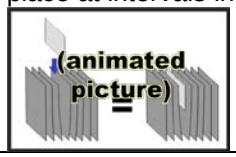
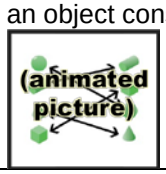
adjacent	coincide	contain	essential	excite
gap	homogeneous	interleaved	pair	thereby

1. Fig. 8a shows that LO and TO branches [ ] at *K=0.*
2. Fig.9 shows that M_1 and M_2 are connected by force constant *C* which located between [ ] planes.
3. A single plane in the wave that propagates in some direction such as [111] in the NaCl and [100] in the CsCl [ ] only a single type of ion.
4. We write the equation of motion under the assumption that each planes interact only with its nearest-neighbor planes and that the force constants are identical between all [ ] of nearest-neighbor planes
5. The [ ] linear equations have a solution only if the determinant of the coefficients of the unknown *u*, υ vanishes in (21) and (22)
6. Thus the LA and the two branches have a total of 3N modes, [ ] accounting for 3N of the total degrees of freedom.
7. From Fig.9, we can consider that atom of mass M_2 lie on planes that located [ ] between planes of the first set.
8. In Fig.9, the different of the masses M_1 and M_2 is not [ ]
9. The branch in Fig.10 is called optical branch because the two atoms carry opposite charges and we may [ ] a motion of this type with the electric field of a light wave.
10. There is a frequency [ ] at the boundary Kmax = $\pm\pi/a$ of the first Brillouin zone.

SUMMARY

No.	Summary
1.	adjacent : bersebelahan /ədʒeɪ.sənt/ *adjective* • If one thing is adjacent to another, the two things are next to each other. • joined by a common edge 
2.	coincide : bertepatan /koʊ.ɪnsaɪd/ *verb* • If one event coincides with another, they happen at the same time. • to occur or exist simultaneously 
3.	contain : mengandung /kənteɪn/ *verb* • If a substance contains something, that thing is a part of it. • to hold or be capable of holding or including within a fixed limit or area 
4.	essential : penting / ɪsen.tʃəl/ *verb* • Something that is essential is extremely important or absolutely necessary to a particular subject, situation, or activity. • vitally important; absolutely necessary
5.	excite : pindah keluar (elektron) /ɪkˈsaɪt/ *verb* • to raise (an atom, molecule, electron, nucleus, etc) from the ground state to a higher energy level 

6.	gap : jarak

	/gæp/ *noun* • A gap between two groups of people, things, or sets of ideas is a big difference between them. • a divergence or difference; disparity 
7.	homogeneous : serbasama /hoʊ.moʊdʒiː.ni.əs/*adjective* • Group or thing which has members or parts that are all the same. • containing terms of the same degree with respect to all the variables 
8.	interleaved : menyelip /ˌɪntəˈliːvd/ *adjective* • place at intervals in or among 
9.	pair : pasangan /per/ *noun* (plural: pairs) • A pair of things are two things of the same size and shape that are used together or are both part of something, for example shoes, earrings, or parts of the body. • an object considered to be two identical or similar things joined together 
10.	thereby : oleh karena itu /ˌðerˈbaɪ/ *adverb* • You use thereby to introduce an important result or consequence of the event or action you have just mentioned. • by that means; because of that

UNIT 3:

Phonon's Characteristics

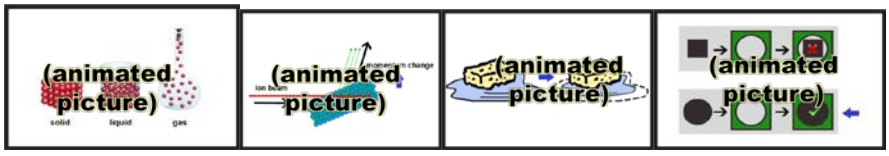
OVERVIEW

In this unit you will learn some words that are included in Chapter 4 about characteristics of phonon. They are:

absorbed	occupied
absorption	occur
chiefly	rarely
density	recoil
determine	rigorously
determined	suitable
occupancy	

You are expected to be able to:

- choose the correct pronunciation of the target words
- choose the correct part of speech of the target words
- choose the correct definition of the target words
- choose the correct the meaning of the target words



Task 1

Study the following text. Click the underlined words to see its explanation.

Pelajari text berikut ini. Klik kata-kata yang bergaris bawah untuk melihat penjelasannya

QUANTIZATION OF ELASTIC WAVES

The energy of a lattice vibration is quantized. The quantum of energy is called a **phonon** in analogy with the photon of the electromagnetic wave. The energy of an elastic mode of angular frequency ω is (27) when the mode is excited

to quantum number *n*; that is, when the mode is occupied by *n* phonons. The term $\frac{1}{2}\hbar\omega$ is the zero point energy of the mode. It occurs for both phonons and photons as a consequence of their equivalence to a quantum harmonic oscilator of frequency ω, for which the energy eigenvalues are also (n + $\frac{1}{2}\omega$). The quantum theory of phonon is developed in Appendix C.

We can quantize the mean square phonon amplitude. Consider the standing wave mode of amplitude $u = u_0 \cos Kx \cos \omega t$. Here *u* is the displacement of a volume element fromits equilibrium position at *x* in the crystal. The energy in the mode, as in any harmonic oscilator, is half kinetic energy and half potential energy, when averaged over time. The kinetic energy density is $\frac{1}{2}\rho(\partial u/\partial t)^2$, where ρ is the mass density. In a crystal of volume V, the volume integral of the kinetic energy is $\frac{1}{4}\rho V\omega^2 u_0^2 \sin^2 \omega t$. The time average kinetic energy is (28) because $\langle \sin^2 \omega t \rangle = \frac{1}{2}$. The square of the amplitude of the mode is (29). This relates the displacement in a given mode to the phonon occupancy *n* of the mode.

What is the sign of ω? The equations of motion such as (2) are equations for ω^2, and if this is positive then ω can have either sign, + or –. But the energy of a phonon must be positive, so it is conventional and suitable to view ω as positive. Is the crystal structure is unstable, then ω^2 will be negative and ω will be imaginary.

Task 2

Study the following text. Click the underlined words to see its explanation.

Pelajari text berikut ini. Klik kata-kata yang bergaris bawah untuk melihat penjelasannya

PHONON MOMENTUM

A phonon of wavevector *K* will interact with particles such as photons, neutrons, and electrons as if it had a momentum $\hbar K$. However, a phonon does not carry physical momentum.

The reason that phonons on a lattice do not carry momentum is that a phonon coordinate (except for $K = 0$) involves relative coordinates of the atoms. Thus in an H_2 molecule the internuclear vibrational coordinate $\mathbf{r}_1 - \mathbf{r}_2$ is a relative coordinate and does not carry linear momentum; the center of mass coordinate $\frac{1}{2}(\mathbf{r}_1 - \mathbf{r}_2)$ corresponds to the uniform mode $K = 0$ and can carry linear momentum.

In crystal there exist wavevector selection rules for allowed transitions between quantum states. We saw in chapter 2 that elastic scattering of an x-ray photon by a crystal is governed by the wavevector selection rule (30), where **G** is a vector in the reciprocal lattice, **k** is the wavevector of the incident photon, **k'** is the wavevector of the scattered photon. In the reflection process the crystal as a whole will recoil with momentum $-\hbar\mathbf{G}$, but this uniform mode momentum is rarely considered explicitly.

Equation (30) is an example of the rule that the total wavevector of interacting waves is conserved in a periodic lattice, with the possible addition of a reciprocal lattice vector **G**. The true momentum of the whole system always is rigorously conserved. If the scattering of the photon is inelastic, with the creation of a phonon of wavevector **K**, then the wavevector selection rule becomes (31). If a phonon K is absorbed in the process, we have instead the relation (32). Relations (31) and (32) are the natural extensions of (30).

INELASTIC SCATTERING BY PHONONS

Phonon dispersion relations $\omega(\mathbf{K})$ are most often determined experimentally by the inelastic scattering of neutrons with the emission or absorption of a phonon. A neutron sees the crystal lattice chiefly by interaction with the nuclei of the atoms. The kinematics of the scattering of a neutron beam by a crystal lattice are described by the general wavevector selection rule: (33) and by the requirement of conservation of energy. Here K is the wavevector of the phonon created (+) or absorbed (–) in the scattering process, and G is any reciprocal lattice vector. For a phonon we choose G such that K lies in the first Brillouin zone.

The kinetic energy of the incident neutron is $p^2/2M_n$, where M_n is the mass of the neutron. The momentum **p** is given by $\hbar\mathbf{k}$, where **k** is the wavevector of the

neutron. Thus $\hbar^2k^2/2M_n$ is the kinetic energy of the incident neutron. If k' is the wavevector of the scattered neutron, the energy of the scattered neutron is h2k'2/2Mn. The statement of conservation of energy is (34), where $\hbar\omega$ is the energy of the phonon created (+) or absorbed (–) in the process.

To determine the dispersion relation using (33) and (34) it is necessary in the experiment to find the energy gain or loss of the scattered neutrons as a function of the scattering direction **k** - **k'**. Results for germanium and KBr are given in Fig. 8; results for sodium are given in Fig. 11. A spectrometer used for phonon studies is shown in Fig. 12.

Flash Cards for Task 1 & 2:

No.	Flash card
1	absorbed : terserap /əbˈzɔːrbd/ *adjective* • If you are absorbed in something or someone, you are very interested in them and they take up all your attention and energy. • taken in (all or part of incident radiated energy) and retain the part that is not reflected or transmitted
2	absorption : penyerapan /əbzɔrp.ʃən/ *noun* • The absorption of a liquid, gas, or other substance is the process of it being soaked up or taken in. • a reduction of the intensity of any form of radiated energy as a result of energy conversion in a medium, such as the conversion of sound energy into heat
3	chiefly : terutama /ˈtʃiːfli/ *adverb* • You use chiefly to indicate that a particular reason, emotion, method, or feature is the main or most important one. • especially or essentially; above all
4	density : kepadatan /ˈdent.sə.t̬i/ *noun* • In science, the density of a substance or object is the relation of its mass or weight to its volume. • a measure of the compactness of a substance, expressed as its mass per unit volume. It is measured in kilograms per cubic metre or pounds per cubic foot.
5	determine : menentukan /dɪtɝ.mɪn/ *verb* • To determine a fact means to discover it as a result of investigation. • to fix or specify the position, form, or configuration of

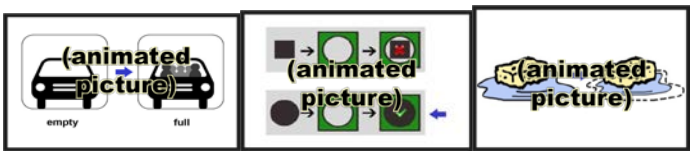
6	determined : ditentukan /dɪtɜ˞.mɪnd/ *adjective* • If you are determined to do something, you have made a firm decision to do it and will not let anything stop you. • resolute; firm
7	occupancy : pengisian /ˈɑː.kjə.pən*t*.si/ *noun* • Occupancy is the act of using a room, building, or area of land, usually for a fixed period of time. • the act of occupying; possession of a property
8	occupied : terisi /ˈɑː.kjʊ.paɪd/ *adjective* • If a room or something such as a seat is occupied, someone is using it, so that it is not available for anyone else. • in use and so not available for anyone else
9	occur : berlaku /əˈkɜː/ *verb* • When something occurs, it happens. • to happen; take place; come about
10	rarely : jarang /ˈrerli/ *adverb* • If something rarely happens, it does not happen very often. • hardly ever; seldom
11	recoil : melonjak /rɪˈkɔɪl/ *verb* • If something makes you recoil, you move your body quickly away from it because it frightens, offends, or hurts you. • to change momentum as a result of the emission of a photon or particle
12	rigorously : dengan tegas dan jelas /ˈrɪg.ər.ə˞.sli/ *adverb* • A test, system, or procedure that was done rigorously is very thorough and strict. • the validity of the successive steps in a completely explicit manner
13	suitable : sesuai, tepat /ˈsuː.t̬ə.bl/ *adjective* • Someone or something that is suitable for a particular purpose or occasion is right or acceptable for it. • appropriate; proper; fit

Task 3

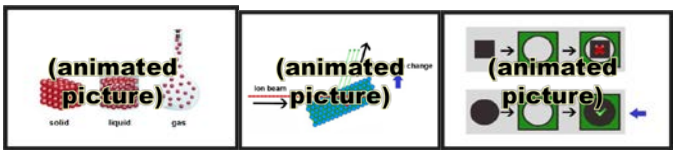
Choose the correct image which represents the word.

Pilih gambar yang dapat mengilustrasikan kata dengan tepat.

1. absorption



2. density

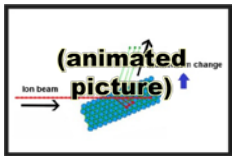


Task 4

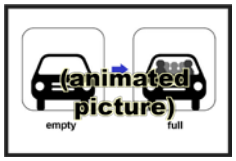
Match the word in the box with its image representation.

Pasangkan kata di dalam kotak dengan gambar yang mengilustrasikannya.

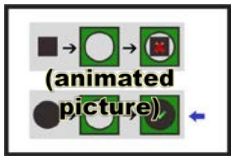
occupancy	recoil	suitable

1. 

drag the word here

2. 

drag the word here

3. 

drag the word here

Task 5

Match the words below with their correct pronunciation. Click on the button to listen the pronunciation.

Pasangkan kata-kata di bawah dengan pengucapannya yang sesuai. Klik tombol untuk mendengarkan pengucapannya.

Words list		Your answer		Pronunciation
1. absorbed	/əbˈzɔːrbd/	j	√ / X	a.
2. absorption	/əbzɔrp.ʃən/	f		b.
3. chiefly	/ˈʧiː.fli/	k		c.
4. density	/ˈdent.sə.tɟ/	b		d.
5. determine	/dɪtɝ.mɪn/	d		e.
6. determined	/dɪtɝ.mɪnd/	m		f.
7. occupancy	/ˈɑː.kjə.pənt .si/	i		g.
8. occupied	/ˈɑː.kjʊ.paɪd/	c		h.
9. occur	/ əˈkɝː/	g		i.
10. rarely	/ˈrerli/	a		j.
11. recoil	/rɪˈkɔɪl/	h		k.
12. rigorously	/ˈrɪg.ər.ə.sli/	e		l.
13. suitable	/ˈsuː.tɟ.bl/	l		m.

Task 6

Choose the correct part of speech of the words below.

Pilihlah kelas kata yang tepat dari kata-kata di bawah ini.

1. absorbed

   (If a phonon K is absorbed in the process, we have instead the relation (32).)

noun	√ / X	adjective	√ / X
verb	√ / X	adverb	√ / X

2. absorption

   (Phonon dispersion relations $\omega(\mathbf{K})$ are most often determined experimentally by the inelastic scattering of neutrons with the emission or absorption of a phonon.)

noun	√ / X	adjective	√ / X
verb	√ / X	adverb	√ / X

3. chiefly

(A neutron sees the crystal lattice chiefly by interaction with the nuclei of the atoms.)

noun	√ / X	adjective	√ / X
verb	√ / X	adverb	√ / X

4. density

(The kinetic energy density is is $\frac{1}{2}\rho\partial u/\partial t)^2$, where ρ is the mass density.)

noun	√ / X	adjective	√ / X
verb	√ / X	adverb	√ / X

5. determine

(To determine the dispersion relation using (33) and (34) it is necessary in the experiment to find the energy gain or loss of the scattered neutrons as a function of the scattering direction **k** - **k'**.)

noun	√ / X	adjective	√ / X
verb	√ / X	adverb	√ / X

6. determined

(Phonon dispersion relations ω(K) are most often determined experimentally by the inelastic scattering of neutrons with the emission or absorption of a phonon.)

noun	√ / X	adjective	√ / X
verb	√ / X	adverb	√ / X

7. occupancy

(This relates the displacement in a given mode to the phonon occupancy n of the mode.)

noun	√ / X	adjective	√ / X
verb	√ / X	adverb	√ / X

Task 7

Choose the words that suit with the desired part of speech.

Pilih kata-kata yang sesuai dengan kelas kata yang diinginkan.

- The energy of an elastic mode of angular frequency ω is (27) when the mode is excited to quantum number n; that is, when the mode is occupied by n phonons.
- It occurs for both phonons and photons as a consequence of their equivalence to a quantum harmonic oscilator of frequency ω, for which the energy

eigenvalues are also $(n + \frac{1}{2})\omega$. The quantum theory of phonon is developed in Appendix C.

- In the reflection process the crystal as a whole will recoil with momentum $-\hbar\mathbf{G}$, but this uniform mode momentum is <u>rarely</u> considered explicitly.
- In the reflection process the crystal as a whole will <u>recoil</u> with momentum $-\hbar\mathbf{G}$, but this uniform mode momentum is rarely considered explicitly.
- The true momentum of the whole system always is <u>rigorously</u> conserved.
- But the energy of a phonon must be positive, so it is conventional and <u>suitable</u> to view ω as positive.

a. Find 2 verbs
Carilah 2 kata kerja

occupied	☺/☹	occur	☺/☹
rarely	☺/☹	recoil	☺/☹
rigorously	☺/☹	suitable	☺/☹

b. Find 2 adjectives
Carilah 2 kata sifat yang memberi keterangan pada kata benda

occupied	☺/☹	occur	☺/☹
rarely	☺/☹	recoil	☺/☹
rigorously	☺/☹	suitable	☺/☹

c. Find 2 adverbs (total words to find: 2)
Carilah 2 kata sifat yang memberi keterangan pada kata kerja

occupied	☺/☹	occur	☺/☹
rarely	☺/☹	recoil	☺/☹
rigorously	☺/☹	suitable	☺/☹

Task 8

Choose the correct meaning.

Pilihlah arti kata yang tepat.

Word list	Your answer		Definition
1. absorbed	(g)	√ / X	a. a measure of the compactness of a substance, expressed as its mass per unit volume. It is measured in kilograms per cubic meter or pounds per cubic foot
2. absorption	(f)		b. the act of occupying; possession of a property
3. chiefly	(c)		c. especially or essentially; above all
4. density	(a)		d. the validity of the successive steps in a completely explicit manner
5. determine	(m)		e. hardly ever; seldom
6. determined	(j)		f. a reduction of the intensity of any form of radiated energy as a result of energy conversion in a medium, such as the conversion of sound energy into heat
7. occupancy	(b)		g. taken in (all or part of incident radiated energy) and retain the part that is not reflected or transmitted
8. occupied	(k)		h. to happen; take place; come about
9. occur	(h)		i. appropriate; proper; fit
10. rarely	(e)		j. resolute; firm
11. recoil	(l)		k. If a room or something such as a seat is occupied, someone is using it, so that it is not available for anyone else.
12. rigorously	(d)		l. to change momentum as a result of the emission of a photon or particle
13. suitable	(i)		m. to fix or specify the position, form, or configuration of

Task 9

Match the words below with their translation in Bahasa Indonesia

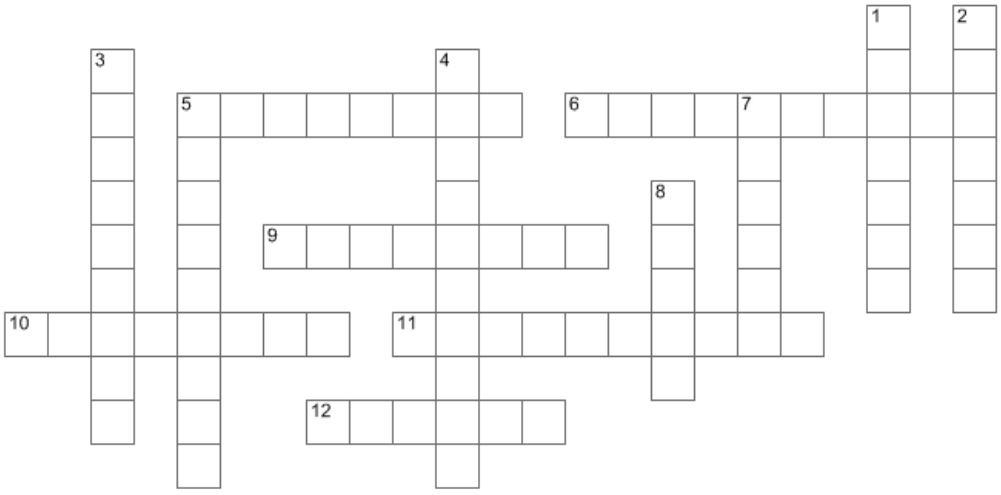
Pasangkan kata-kata di bawah ini dengan terjemahannya dalam Bahasa Indonesia.

Word list	Your answer		Definition
1. absorbed	(k)	√ / X	a. kepadatan
2. absorption	(m)		b. terutama
3. chiefly	(b)		c. ditentukan
4. density	(a)		d. berlaku
5. determine	(g)		e. terisi
6. determined	(c)		f. pengisian
7. occupancy	(f)		g. menentukan
8. occupied	(e)		h. sesuai, tepat
9. occur	(d)		i. melonjak
10. rarely	(j)		j. jarang
11. recoil	(i)		k. terserap
12. rigorously	(l)		l. dengan tegas dan jelas
13. suitable	(h)		m. penyerapan

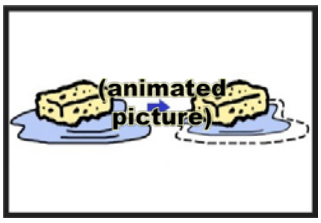
Task 10

Fill the crossword puzzle below using the words in the box.

Isilah teka-teki silang di bawah ini menggunakan kata-kata di dalam kotak.

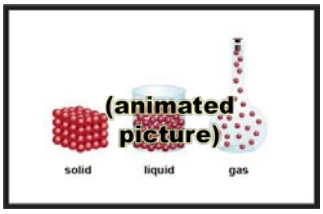


Across

5. terisi
6. 

9. taken in (all or part of incident radiated energy) and retain the part that is not reflected or transmitted
10.
11. dengan tegas dan jelas
12.

Down

1. terutama
2. 

5. the act of occupying; possession of a property
3. menentukan
4.
7. to change momentum as a result of the emission of a photon or particle
8.

absorbed	absorption	chiefly	density	determine
determined	occupancy	occupied	occur	rarely
	recoil	rigorously	suitable	

Task 11

Use the words in the box to complete the sentences below.

Gunakan kata-kata dalam kotak untuk melengkapi kalimat-kalimat di bawah ini.

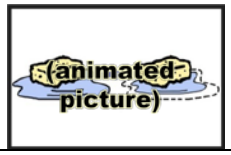
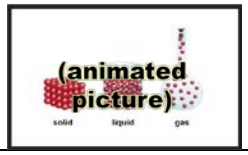
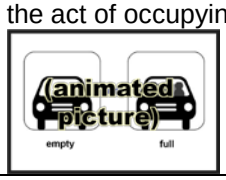
absorbed	absorption	chiefly	density	determine
determined	occupancy	occupied	occur	rarely
	recoil	rigorously	suitable	

1. The energy of an elastic mode of angular frequency ω is (27) that is, when the mode is [ ] by *n* phonons
2. It [ ] for both phonons and photons as a consequence of their equivalence to a quantum harmonic oscilator of frequency ω, for which the energy eigenvalues are also $(n + \frac{1}{2}\omega)$.
3. In $\frac{1}{2}\rho(\partial u/\partial t)^2$, ρ is the mass [ ].
4. The square of the amplitude of the mode is (29) is related with the displacement in a given mode to the phonon [ ] *n* of the mode
5. The energy of a phonon must be positive, so it is conventional and [ ] view ω as positive.
6. In the reflection process the crystal as a whole will [ ] with momentum $-\hbar\mathbf{G}$, but this uniform mode momentum is [ ] considered explicitly.
7. The true momentum of the whole lattice system always is [ ] conserved.
8. If a phonon K is [ ] in the process, we have instead the relation (32).
9. Phonon dispersion relations $\omega(\mathbf{K})$ are most often [ ] experimentally by the inelastic scattering of neutrons with the emission or [ ] of a phonon.
10. A neutron sees the crystal lattice [ ] by interaction with the nuclei of the atoms.
11. To [ ] the dispersion relation using (33) and (34) it is necessary to find the energy gain or loss of the scattered neutrons.

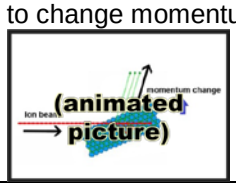
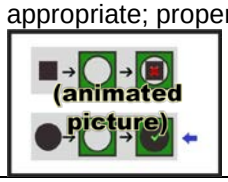
SUMMARY

No.	Flash card
1.	absorbed : terserap /əbˈzɔːrbd/ *adjective* • If you are absorbed in something or someone, you are very interested in them and they take up all your attention and energy. • taken in (all or part of incident radiated energy) and retain the part that is not reflected or transmitted

2.	absorption : penyerapan /əbzɔrp.ʃən/ *noun* • The absorption of a liquid, gas, or other substance is the process of it being soaked up or taken in.

	• a reduction of the intensity of any form of radiated energy as a result of energy conversion in a medium, such as the conversion of sound energy into heat 
3.	chiefly : terutama /ˈtʃiː.fli/ *adverb* • You use chiefly to indicate that a particular reason, emotion, method, or feature is the main or most important one. • especially or essentially; above all
4.	density : kepadatan /ˈdent.sə.t̬i/ *noun* • In science, the density of a substance or object is the relation of its mass or weight to its volume. • a measure of the compactness of a substance, expressed as its mass per unit volume. It is measured in kilograms per cubic metre or pounds per cubic foot. 
5.	determine : menentukan /dɪtɜː.mɪn/ *verb* • To determine a fact means to discover it as a result of investigation. • to fix or specify the position, form, or configuration of
6.	determined : ditentukan /dɪtɜː.mɪnd/ *adjective* • If you are determined to do something, you have made a firm decision to do it and will not let anything stop you. • resolute; firm
7.	occupancy : pengisian /ˈɑː.kjə.pənt.si/ *noun* • Occupancy is the act of using a room, building, or area of land, usually for a fixed period of time. • the act of occupying; possession of a property 

8.	occupied : terisi /ˈɑː.kjʊ.paɪd/ *adjective* • If a room or something such as a seat is occupied, someone is using it, so that it is not available for anyone else.

	• in use and so not available for anyone else
9.	occur : berlaku /əˈkɜː/ *verb* • When something occurs, it happens. • to happen; take place; come about
10.	rarely : jarang /ˈrerli/ *adverb* • If something rarely happens, it does not happen very often. • hardly ever; seldom
11.	recoil : melonjak /rɪˈkɔɪl/ *verb* • If something makes you recoil, you move your body quickly away from it because it frightens, offends, or hurts you. • to change momentum as a result of the emission of a photon or particle 
12.	rigorously : dengan tegas dan jelas /ˈrɪg.ər.ɚ.sli/ *adverb* • A test, system, or procedure that was done rigorously is very thorough and strict. • the validity of the successive steps in a completely explicit manner
13.	suitable : sesuai, tepat /ˈsuː.t̬ə.bl/ *adjective* • Someone or something that is suitable for a particular purpose or occasion is right or acceptable for it. • appropriate; proper; fit 

UNIT 4:

Summary and Problems

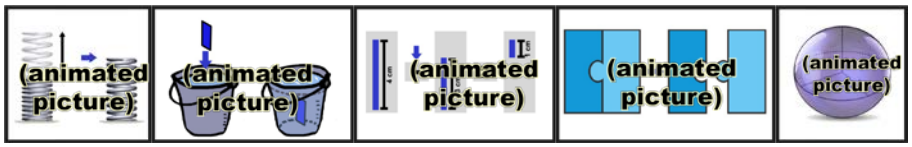
OVERVIEW

In this unit you will learn some words that are included in Chapter 4 about summary and problems of the crystal vibration and phonon. They are:

decoupled	rest
estimate	sphere
immersed	unlike
reduce	

You are expected to be able to:

- choose the correct pronunciation of the target words
- choose the correct part of speech of the target words
- choose the correct definition of the target words
- choose the correct the meaning of the target words



Task 1

Study the following text. Click the underlined words to see its explanation.

Pelajari text berikut ini. Klik kata-kata yang bergaris bawah untuk melihat penjelasannya.

SUMMARY

- The quantum unit of a crystal vibration is a phonon. If the angular frequency is ω, the energy of the phonon is $\hbar\omega$.

- When a phonon of wavevector **K** is created by the inelastic scattering of a photon or neutron from wavevector **k** to **k'**, the wavevector selection rule that governs the process is

$$\mathbf{k} = \mathbf{k}' + \mathbf{K} + \mathbf{G}\ ,$$

where G is a reciprocal lattice vector.

- All elastic waves can be described by wavevectors that lie within the first Brillouin zone in reciprocal space.
- If there are p atoms in the primitive cell, the phonon dispersion relation will have 3 acoustical phonon branches and 3*p* - 3 optical phonon branches.

Problems

1. Monatomic linear lattice. Consider a longitudinal wave $u_s = u\cos(\omega t - sKa)$ which propagates in a monatomic linear lattice of atoms of mass M, spacing a, and nearest-neighbor interaction C.

(a). Show that the total energy of the wave is

$$E = \frac{1}{2}M\sum_s (du_s/dt)^2 + \frac{1}{2}C\sum_s (u_s - u_{s+1})^2$$

where *s* runs over all atoms.

(b). By substitution of u_s in this expression, show that the time-average total energy per atom is

$$\frac{1}{4}M\omega^2u^2 + \frac{1}{2}C(1-\cos Ka)u^2 = \frac{1}{2}M\omega^2u^2$$

where in the last step we have used the dispersion relation (9) for this problem.

2. Continuum wave equation. Show that for long wavelengths the equation of motion (2) reduces to the continuum elastic wave equation

$$\frac{\partial^2 u}{\partial t^2} = \upsilon^2\frac{\partial^2 u}{\partial x^2}$$

where υ is the velocity of sound.

3. Basis of two <u>unlike</u> atoms. For the problem treated by (18) to (26), find the amplitude ratios u/υ for the two branches at $K_{max} = \pi/a$. Show that at this

value of K the two lattices act as if decoupled: one lattice remains at rest while the other lattice moves.

4. ***Kahn anomaly***. We suppose that the interplanar force constant C_p between planes s and $s + p$ is of the form

$$C_p = A\frac{\sin pk_0a}{pa}$$

where A and k_0 are constants and p runs over all integers. Such a form is expected in metals. Use this and Eq. (l6a) to find an expression for $\omega 2$ and also for $\omega\partial 2/iJK$. Prove that $\partial\omega^2/\partial K$ is infinite when $K = k_0$. Thus a plot of ω^2 versus K or of ω versus K has a vertical tangent at k_0: there is a kink at k_0 in the phonon dispersion relation $\omega(K)$.

Task 2

Study the following text. Click the underlined words to see its explanation.

Pelajari text berikut ini. Klik kata-kata yang bergaris bawah untuk melihat penjelasannya.

5. ***Diatomic chain.*** Consider the normal modes of a linear chain in which the force constants between nearest-neighbor atoms are alternately C and 10C. Let the masses be equal, and let the nearest-neighbor separation be $a/2$. Find ω(K) at K = 0 and K = π/a. Sketch in the dispersion relation by eye. This problem simulates a crystal of diatomic molecules such as H_2.
6. ***Atomic vibration in metal.*** Consider point ions of mass M and charge immersed in a uniform sea of conduction electrons. The ions are imagined to be in stable equilibrium when at regular lattice points. If one ion is displaced a small distance r from its equilibrium position, the restoring force is largely due to the electric charge within the sphere of radius r centered at the equilibrium position. Take the number density of ions (or of conduction electrons) as $3/4\pi R^3$, which defines R.

(a) Show that the frequency of a single ion set into oscillation is $\omega = (e2/MR^3)^{1/2}$. (b) Estimate the value of this frequency for sodium, roughly. (c) From (a),

(b), and some common sense, estimate the order of magnitude of the velocity of sound in the metal.

7. ***Soft phonon modes.*** Consider a line of ions of equal mass but alternating in charge, with $e_p = e\ (-1)^p$ as the charge on the pth ion. The interatomic potential is the sum of two contributions: (1) a short-range interaction of force constant $C_{1R} = \gamma$ that acts between nearest neighbors only, and (2) a coulomb interaction between all ions. (a) Show that the contribution of the coulomb interaction to the atomic force constants is

$C_{pC} = 2(-l)^P p^2/{}^3a^3$,

where a is the equilibrium nearest-neighbor distance. (b) From (16a) show that the dispersion relation may be written as

$$\grave{u}^2 / \grave{u}_0^2 \grave{u}_0^2 - \sin^2 \frac{1}{2} Ka + \acute{o} \sum_{p-1}^{\infty} (-1)^p (1 - \cos pKa\ ) p^{-3}$$

where $\grave{u}_0^2 = 4\gamma/M$ and $\sigma = e^2/\gamma a^3$. (c) Show that ω^2 is negative (unstable mode) at the zone boundary $Ka = \pi$ if $\sigma > 0.475$ or $4/7\zeta(3)$, where ζ is a Riemann zeta function. Show further that the speed of sound at small Ka is imaginary if $\sigma > (2 \ln 2)^{-1} = 0.721$. Thus ω^2 goes to zero and the lattice is unstable for some value of Ka in the interval $(0, \pi)$ if $0.475 < \sigma < 0.721$. Notice that the phonon spectrum is not that of a diatomic lattice because the interaction of any ion with its neighbors is the same as that of any other ion.

Flash Cards for Task 1 & 2:

No.	Flash Card
1.	decouple : memisahkan diri /ˌdiːˈkʌpəl/ *adjective* • If two countries, organizations, or ideas that were connected in some way are decoupled, the connection between them is ended. • to separate (joined or coupled subsystems) thereby enabling them to exist and operate separately

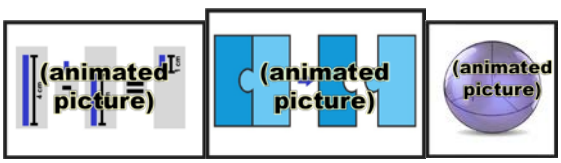
2.	estimate : memperkirakan /ˈes.tɪ.meɪt/ *verb* • If you estimate a quantity or value, you make an approximate judgment or calculation of it. • to form an approximate idea of (distance, size, cost, etc); calculate roughly; gauge
3.	immersed : menyelam /ɪˈmɜːsd/ *adjective* • If something is immersed in a liquid, someone puts it into the liquid so that it is completely covered. • .plunged or dip into liquid
4.	reduce : mengurangi /rɪˈduːs/ *verb* • If something is changed to a different or less complicated form, you can say that it is reduced to that form. • to modify or simplify the form of (an expression or equation), especially by substitution of one term by another
5.	rest : diam /rest/ *verb* • When an object that has been moving comes to rest, it finally stops. • to remain without further attention or action
6.	sphere : bulatan /sfɪr/ *noun* • A sphere is an object that is completely round in shape like a ball. • a three-dimensional closed surface such that every point on the surface is equidistant from a given point, the center
7.	unlike : berbeda, tidak sama /ʌnˈlaɪk/ *adjective* • If one thing is unlike another thing, the two things have different qualities or characteristics from each other • not alike; dissimilar or unequal; different

Task 3

Choose the correct image which represents the word.

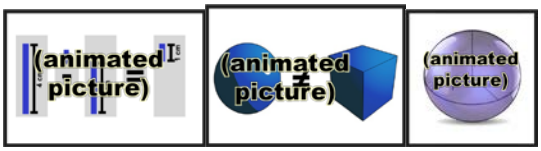
Pilih gambar yang dapat mengilustrasikan kata dengan tepat.

1. decoupled



2. immersed

3. reduce



Task 4

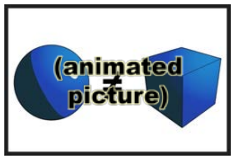
Match the word in the box with its image representation.

Pasangkan kata di dalam kotak dengan gambar yang mengilustrasikannya.

rest	sphere	unlike

1. 

drag the word here

2. 

drag the word here

3. 

drag the word here

Task 5

Match the words below with their correct pronunciation. Click on the button to listen the pronunciation.

Pasangkan kata-kata di bawah dengan pengucapannya yang sesuai. Klik tombol untuk mendengarkan pengucapannya.

Words list		Your answer		Pronunciation
1. decoupled	/ˌdiːˈkʌpəl/	d	√ / X	a.
2. estimate	/ˈes.tɪ.meɪt/	b		b.
3. immersed	/ɪˈmɝːsd/	b		c.
4. reduce	/rɪˈduːs/	f		d.
5. rest	/rest/	g		e.
6. sphere	/sfɪr/	c		f.
7. unlike	/ʌnˈlaɪk/	e		g.

Task 6

Choose the correct part of speech of the words below.

Pilihlah kelas kata yang tepat dari kata-kata di bawah ini.

1. decoupled
   (Show that at this value of K the two lattices act as if decoupled: one lattice remains at rest while the other lattice moves)

noun	√ / X	adjective	√ / X
verb	√ / X	adverb	√ / X

2. estimate
   (Estimate the value of this frequency for sodium, roughly.)

noun	√ / X	adjective	√ / X
verb	√ / X	adverb	√ / X

3. immersed
   (Consider point ions of mass M and charge immersed in a uniform sea of conduction electrons.)

noun	√ / X	adjective	√ / X
verb	√ / X	adverb	√ / X

Task 7

Choose the words that suit with the correct part of speech.

Pilih kata-kata yang sesuai dengan kelas kata yang diinginkan.

- Show that for long wavelengths the equation of motion (2) reduces to the continuum elastic wave equation.
- Show that at this value of K the two lattices act as if decoupled: one lattice remains at rest while the other lattice moves.
- If one ion is displaced a small distance r from its equilibrium position, the restoring force is largely due to the electric charge within the sphere of radius r centered at the equilibrium position
- *Basis of two unlike atoms.*

a. Find 1 noun.
   Carilah 1 benda.

reduce	☺/☹	rest	☺/☹
sphere	☺/☹	unlike	☺/☹

b. Find 2 verbs.

Carilah 2 kata kerja.

reduce	☺/☹	rest	☺/☹
sphere	☺/☹	unlike	☺/☹

c. Find 1 adjective.

Carilah 1 kata sifat yang memberi keterangan pada kata benda.

reduce	☺/☹	rest	☺/☹
sphere	☺/☹	unlike	☺/☹

Task 8

Choose the correct meaning.

Pilihlah arti kata yang tepat.

Words	Your answer		Definition
1. decoupled	(e)	√ / X	a. to remain without further attention or action
2. estimate	(g)		b. plunged or dip into liquid
3. immersed	(b)		c. a three-dimensional closed surface such that every point on the surface is equidistant from a given point, the center
4. reduce	(d)		d. to modify or simplify the form of (an expression or equation), especially by substitution of one term by another
5. rest	(a)		e. separated (joined or coupled subsystems) thereby enabling them to exist and operate separately
6. sphere	(c)		f. not alike; dissimilar or unequal; different
7. unlike	(f)		g. to form an approximate idea of (distance, size, cost, etc); calculate roughly; gauge

Task 9

Match the words below with their translation in Bahasa Indonesia.

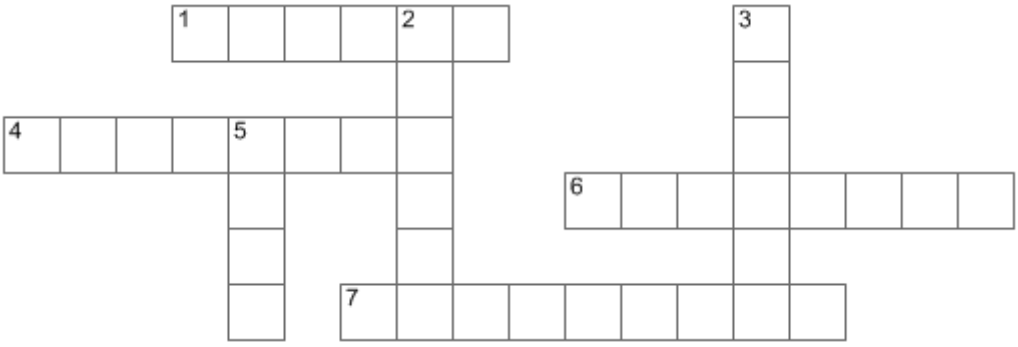
Pasangkan kata-kata di bawah ini dengan terjemahannya dalam Bahasa Indonesia.

Words	Your answer		Translation
decoupled	(d)		a. memperkirakan
estimate	(a)		b. diam
immersed	(g)		c. berbeda, tidak sama
reduce	(f)		d. memisahkan diri
rest	(b)		e. bulatan
sphere	(e)		f. mengurangi
unlike	(c)		g. menyelam

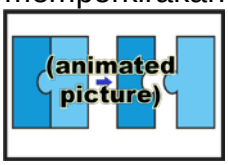
Task 10

Fill the crossword puzzle below using the words in the box.

Isilah teka-teki silang di bawah ini menggunakan kata-kata di dalam kotak.



Across

1. a three-dimensional closed surface such that every point on the surface is equidistant from a given point, the center
4.
6. memperkirakan
7. 

Down

2. to modify or simplify the form of (an expression or equation), especially by substitution of one term by another
3. berbeda, tidak sama
5. 

decoupled	estimate	immersed	reduce	determine
	rest	sphere	unlike	

Task 11

Use the words in the box to complete the sentences below.

Gunakan kata-kata dalam kotak untuk melengkapi kalimat-kalimat di bawah ini

decoupled	estimate	immersed	reduce	determine
	rest	sphere	unlike	

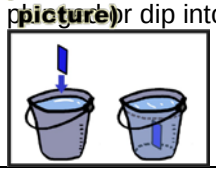
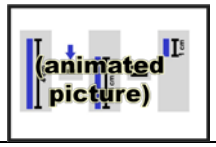
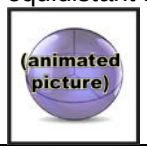
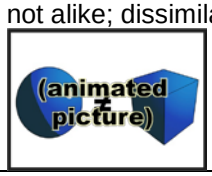
1. Wavelengths of the equation of motion (2) [ ] the continuum elastic wave equation of:

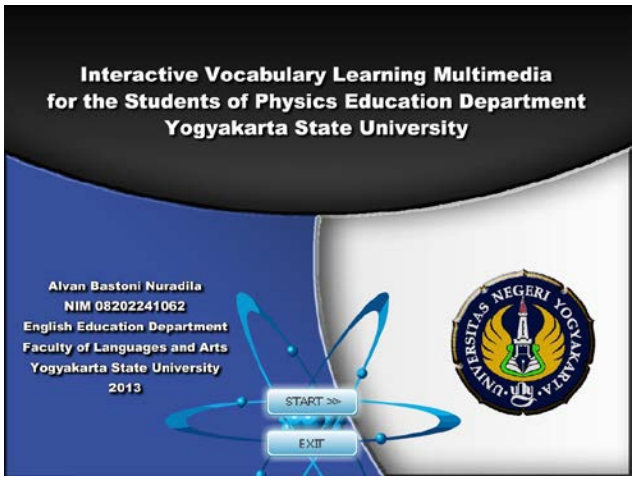
$$\frac{\partial^2 u}{\partial t^2} = \tilde{o}^2 \frac{\partial^2 u}{\partial x^2}$$ where υ is the velocity of sound.

2. In the basis of two [ ] atoms, we can see that two lattices act as if [ ] one lattice remains at [ ] while the other lattice moves.
3. Consider point ions of mass M and charge [ ] in a uniform sea of conduction electrons. If one ion is displaced a small distance r from its equilibrium position, the restoring force is largely due to the electric charge within the [ ] of radius r centered at the equilibrium position.
4. From $\omega = (e2/MR^3)^{1/2}$ we may [ ] the value of this frequency for sodium, roughly.

SUMMARY

No.	Flash Card
1.	decouple : memisahkan diri /ˌdiːˈkʌpəl/ *adjective* • If two countries, organizations, or ideas that were connected in some way are decoupled, the connection between them is ended. • to separate (joined or coupled subsystems) thereby enabling them to exist and operate separately (animated picture)
2.	estimate : memperkirakan /ˈes.tɪ.meɪt/ *verb* • If you estimate a quantity or value, you make an approximate judgment or calculation of it. • to form an approximate idea of (distance, size, cost, etc); calculate roughly; gauge

3.	immersed : menyelam /ɪˈmɜːsd/ *adjective* • If something is immersed in a liquid, someone puts it into the liquid so that it is completely covered. • put under or dip into liquid 
4.	reduce : mengurangi /rɪˈduːs/ *verb* • If something is changed to a different or less complicated form, you can say that it is reduced to that form. • to modify or simplify the form of (an expression or equation), especially by substitution of one term by another 
5.	rest : diam /rest/ *verb* • When an object that has been moving comes to rest, it finally stops. • to remain without further attention or action 
6.	sphere : bola /sfɪr/ *noun* • A sphere is an object that is completely round in shape like a ball. • a three-dimensional closed surface such that every point on the surface is equidistant from a given point, the center 
7.	unlike : berbeda, tidak sama /ʌnˈlaɪk/ *adjective* • If one thing is unlike another thing, the two things have different qualities or characteristics from each other • not alike; dissimilar or unequal; different 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NIM 08202241062
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Yogyakarta State University
2013
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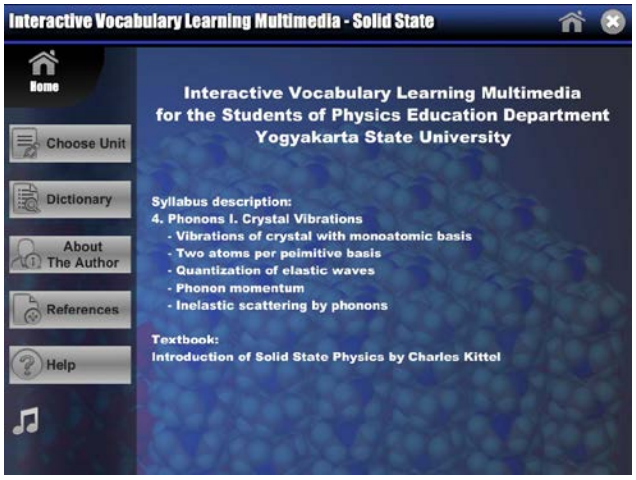
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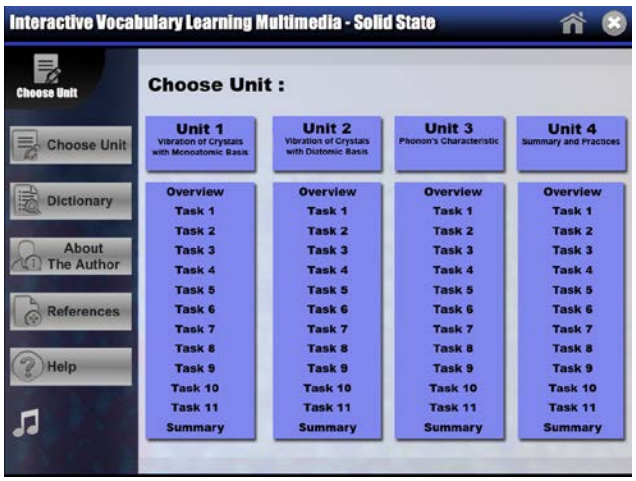
Interactive Vocabulary Learning Multimedia
for the Students of Physics Education Department
Yogyakarta State University
Syllabus description:
4. Phonons I. Crystal Vibrations
- Vibrations of crystal with monoatomic basis
- Two atoms per peimitive basis
- Quantization of elastic waves
- Phonon momentum
- Inelastic scattering by phonons
Textbook:
Introduction of Solid State Physics by Charles Kittel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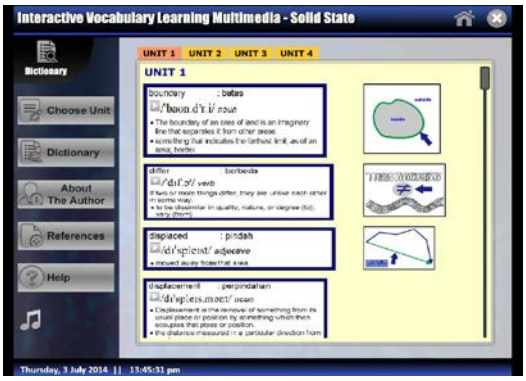
Unit 1
Vibration of Crystals with Monoatomic Basis
Unit 2
Vibration of Crystals with Diatomic Basis
Unit 3
Phonon's Characteristic
Unit 4
Summary and Practices
Overview
Task 1
Task 2
Task 3
Task 4
Task 5
Task 6
Task 7
Task 8
Task 9
Task 10
Task 11
Summary


Interactive Vocabulary Learning Multimedia - Solid State
Dictionary
UNIT 1 UNIT 2 UNIT 3 UNIT 4
UNIT 1
boundary : batas
/'baun.dr.i/ noun
differ : berbeda
/'dɪf.ɚ/ verb
displaced : pindah
/dɪ'spleɪst/ adjecave
displacement : perpindahan
/dɪ'spleɪs.mənt/ noun
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Thursday, 3 July 2014 || 13:45:31 pm


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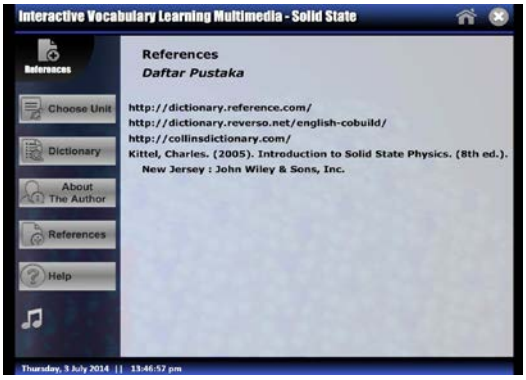
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References
Daftar Pustaka
http://dictionary.reference.com/
http://dictionary.reverso.net/english-cobuild/
http://collinsdictionary.com/
Kittel, Charles. (2005). Introduction to Solid State Physics. (8th ed.).
New Jersey : John Wiley & Sons, Inc.
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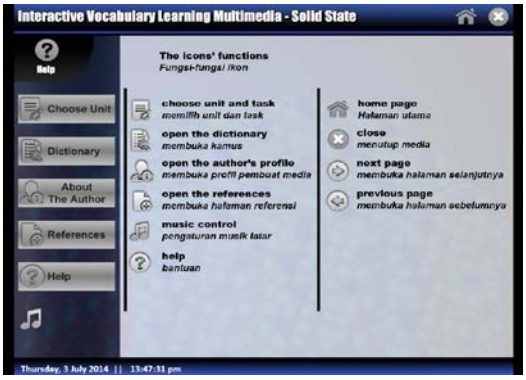
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previous page
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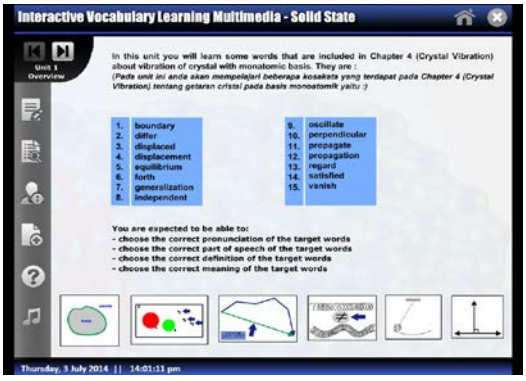
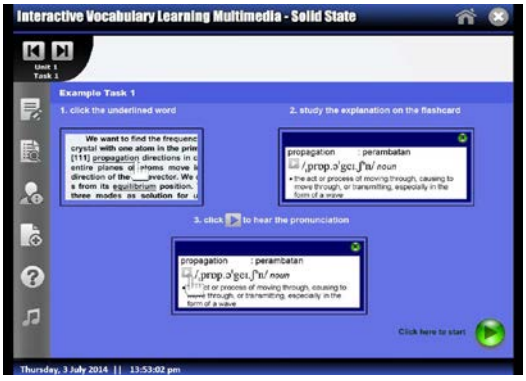
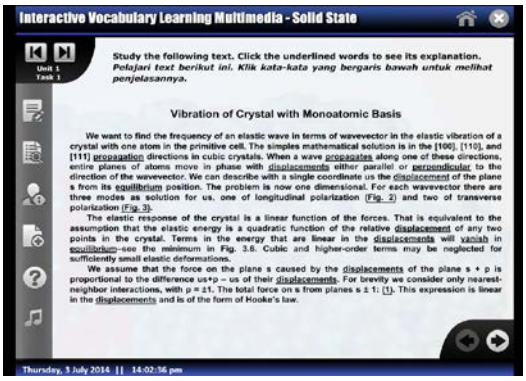
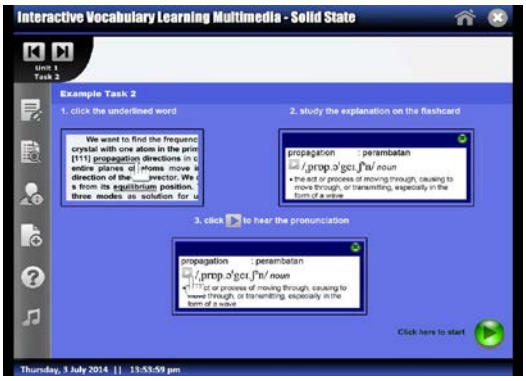
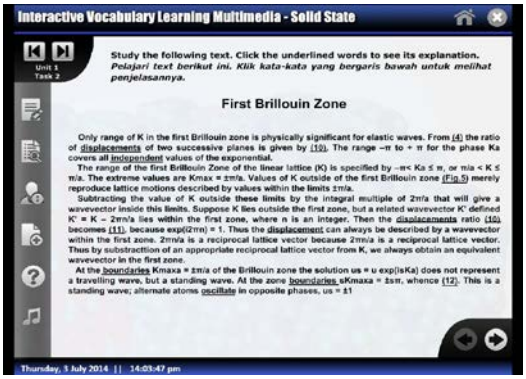

Interactive Vocabulary Learning Multimedia - Solid State
Unit 1 Overview
In this unit you will learn some words that are included in Chapter 4 (Crystal Vibration) about vibration of crystal with monatomic basis. They are :
1. boundary
2. differ
3. displaced
4. displacement
5. equilibrium
6. forth
7. generalization
8. independent
9. oscillate
10. perpendicular
11. propagate
12. propagation
13. regard
14. satisfied
15. vanish
You are expected to be able to:
- choose the correct pronunciation of the target words
- choose the correct part of speech of the target words
- choose the correct definition of the target words
- choose the correct meaning of the target words
Thursday, 3 July 2014 || 14:01:11 pm

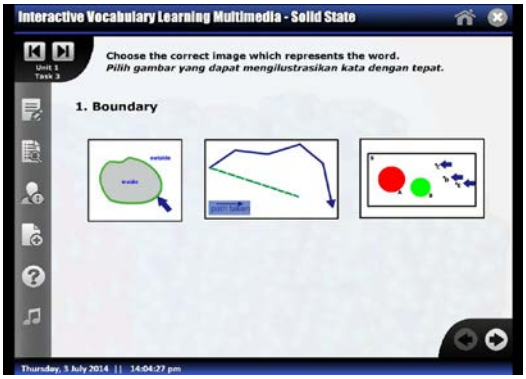

Interactive Vocabulary Learning Multimedia - Solid State
Unit 1 Task 1
Example Task 1
1. click the underlined word
2. study the explanation on the flashcard
propagation : perambatan
/ˌprɒp.əˈgeɪ.ʃn/ noun
3. click to hear the pronunciation
Click here to start
Thursday, 3 July 2014 || 13:53:02 pm

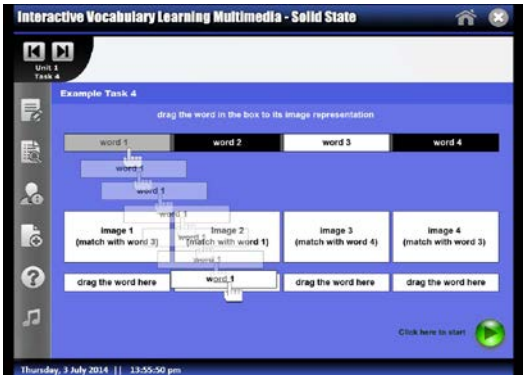

Interactive Vocabulary Learning Multimedia - Solid State
Unit 1 Task 1
Study the following text. Click the underlined words to see its explanation.
Pelajari text berikut ini. Klik kata-kata yang bergaris bawah untuk melihat penjelasannya.
Vibration of Crystal with Monoatomic Basis
We want to find the frequency of an elastic wave in terms of wavevector in the elastic vibration of a crystal with one atom in the primitive cell. The simples mathematical solution is in the [100], [110], and [111] propagation directions in cubic crystals. When a wave propagates along one of these directions, entire planes of atoms move in phase with displacements either parallel or perpendicular to the direction of the wavevector. We can describe with a single coordinate us the displacement of the plane s from its equilibrium position. The problem is now one dimensional. For each wavevector there are three modes as solution for us, one of longitudinal polarization (Fig. 2) and two of transverse polarization (Fig. 3).
The elastic response of the crystal is a linear function of the forces. That is equivalent to the assumption that the elastic energy is a quadratic function of the relative displacement of any two points in the crystal. Terms in the energy that are linear in the displacements will vanish in equilibrium—see the minimum in Fig. 3.6. Cubic and higher-order terms may be neglected for sufficiently small elastic deformations.
We assume that the force on the plane s caused by the displacements of the plane s + p is proportional to the difference us+p − us of their displacements. For brevity we consider only nearest-neighbor interactions, with p = ±1. The total force on s from planes s ± 1: (1). This expression is linear in the displacements and is of the form of Hooke's law.
Thursday, 3 July 2014 || 14:02:36 pm

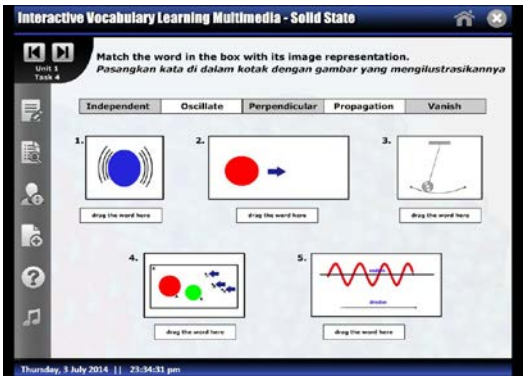

Interactive Vocabulary Learning Multimedia - Solid State
Unit 1 Task 2
Example Task 2
1. click the underlined word
2. study the explanation on the flashcard
3. click to hear the pronunciation
propagation : perambatan
/ˌprɒp.əˈɡeɪ.ʃn/ noun
the act or process of moving through, causing to move through, or transmitting, especially in the form of a wave
Click here to start
Thursday, 3 July 2014 || 13:53:59 pm

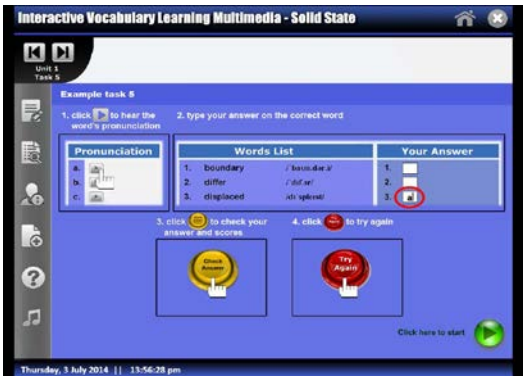

Interactive Vocabulary Learning Multimedia - Solid State
Unit 1 Task 2
Study the following text. Click the underlined words to see its explanation.
Pelajari text berikut ini. Klik kata-kata yang bergaris bawah untuk melihat penjelasannya.
First Brillouin Zone
Only range of K in the first Brillouin zone is physically significant for elastic waves. From (4) the ratio of displacements of two successive planes is given by (12). The range −π to + π for the phase Ka covers all independent values of the exponential.
The range of the first Brillouin Zone of the linear lattice (K) is specified by −π< Ka ≤ π, or π/a < K ≤ π/a. The extreme values are Kmax = ±π/a. Values of K outside of the first Brillouin zone (Fig.5) merely reproduce lattice motions described by values within the limits ±π/a.
Subtracting the value of K outside these limits by the integral multiple of 2π/a that will give a wavevector inside this limits. Suppose K lies outside the first zone, but a related wavevector K' defined K' = K – 2π/a lies within the first zone, where n is an integer. Then the displacements ratio (10) becomes (11), because exp(i2πn) = 1. Thus the displacement can always be described by a wavevector within the first zone. 2π/a is a reciprocal lattice vector because 2π/a is a reciprocal lattice vector. Thus by substraction of an appropriate reciprocal lattice vector from K, we always obtain an equivalent wavevector in the first zone.
At the boundaries Kmaxa = ±π/a of the Brillouin zone the solution us = u exp(isKa) does not represent a travelling wave, but a standing wave. At the zone boundaries sKmaxa = ±sπ, whence (12). This is a standing wave; alternate atoms oscillate in opposite phases, us = ±1
Thursday, 3 July 2014 || 14:03:47 pm

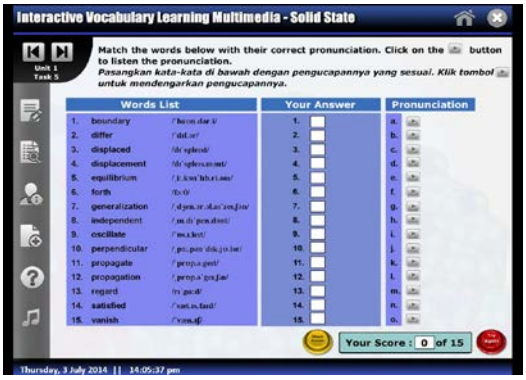

Interactive Vocabulary Learning Multimedia - Solid State
Unit 1 Task 3
Example Task 3
1. click the correct image which represent the word
2. the answer is correct if there is a check sign ( )
3. the answer is wrong if there is a cross sign ( )
image 1
image 2
image 3
4. click to open the next page
5. click to check your answer and scores
6. click to try again
Click here to start
Thursday, 3 July 2014 || 13:54:26 pm

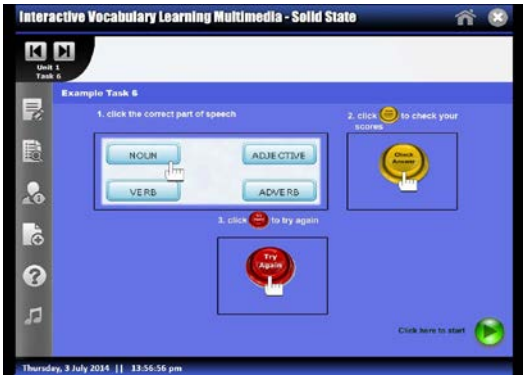

Interactive Vocabulary Learning Multimedia - Solid State
Unit 1 Task 3
Choose the correct image which represents the word.
Pilih gambar yang dapat mengilustrasikan kata dengan tepat.
1. Boundary
Thursday, 3 July 2014 || 14:04:27 pm

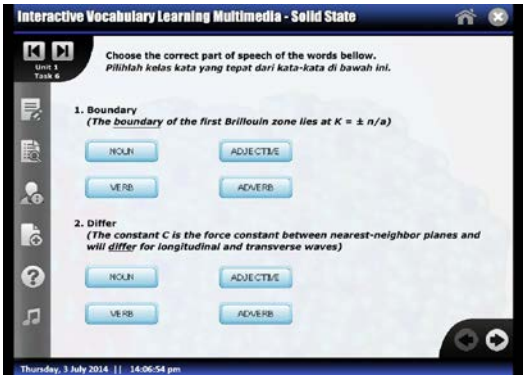

Interactive Vocabulary Learning Multimedia - Solid State
Unit 1 Task 4
Example Task 4
drag the word in the box to its image representation
word 1
word 2
word 3
word 4
image 1 (match with word 3)
image 2 (match with word 1)
image 3 (match with word 4)
image 4 (match with word 3)
drag the word here
Click here to start
Thursday, 3 July 2014 || 13:55:50 pm

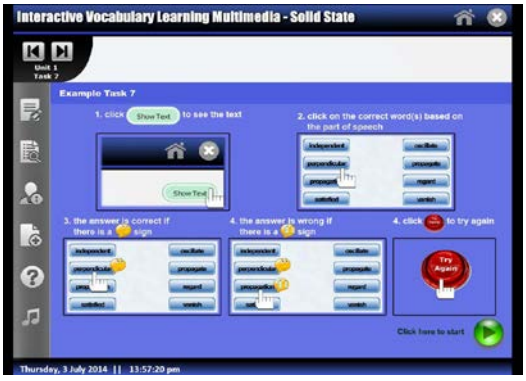

Interactive Vocabulary Learning Multimedia - Solid State
Match the word in the box with its image representation.
Pasangkan kata di dalam kotak dengan gambar yang mengilustrasikannya
Independent
Oscillate
Perpendicular
Propagation
Vanish


Interactive Vocabulary Learning Multimedia - Solid State
Example task 5
1. click to hear the word's pronunciation
2. type your answer on the correct word
Pronunciation
Words List
Your Answer
3. click to check your answer and scores
4. click to try again
Click here to start


Interactive Vocabulary Learning Multimedia - Solid State
Match the words below with their correct pronunciation. Click on the button to listen the pronunciation.
Pasangkan kata-kata di bawah dengan pengucapannya yang sesuai. Klik tombol untuk mendengarkan pengucapannya.
Words List
Your Answer
Pronunciation
Your Score : 0 of 15


Interactive Vocabulary Learning Multimedia - Solid State
Example Task 6
1. click the correct part of speech
2. click to check your scores
NOUN
ADJECTIVE
VERB
ADVERB
3. click to try again
Click here to start


Interactive Vocabulary Learning Multimedia - Solid State
Choose the correct part of speech of the words bellow.
Pilihlah kelas kata yang tepat dari kata-kata di bawah ini.
1. Boundary
(The boundary of the first Brillouin zone lies at K = ± π/a)
NOUN
ADJECTIVE
VERB
ADVERB
2. Differ
(The constant C is the force constant between nearest-neighbor planes and will differ for longitudinal and transverse waves)
NOUN
ADJECTIVE
VERB
ADVERB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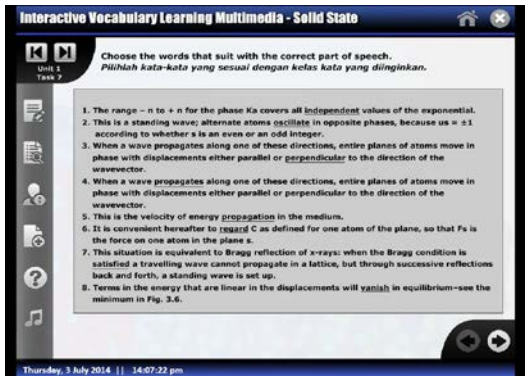
Example Task 7
1. click Show Text to see the text
2. click on the correct word(s) based on the part of speech
3. the answer is correct if there is a sign
4. the answer is wrong if there is a sign
4. click to try again
Click here to start


Interactive Vocabulary Learning Multimedia - Solid State
Unit 1
Task 7
Choose the words that suit with the correct part of speech.
Pilihlah kata-kata yang sesuai dengan kelas kata yang diinginkan.
1. The range – n to + n for the phase Ka covers all independent values of the exponential.
2. This is a standing wave; alternate atoms oscillate in opposite phases, because us = ±1 according to whether s is an even or an odd integer.
3. When a wave propagates along one of these directions, entire planes of atoms move in phase with displacements either parallel or perpendicular to the direction of the wavevector.
4. When a wave propagates along one of these directions, entire planes of atoms move in phase with displacements either parallel or perpendicular to the direction of the wavevector.
5. This is the velocity of energy propagation in the medium.
6. It is convenient hereafter to regard C as defined for one atom of the plane, so that Fs is the force on one atom in the plane s.
7. This situation is equivalent to Bragg reflection of x-rays: when the Bragg condition is satisfied a travelling wave cannot propagate in a lattice, but through successive reflections back and forth, a standing wave is set up.
8. Terms in the energy that are linear in the displacements will vanish in equilibrium–see the minimum in Fig. 3.6.
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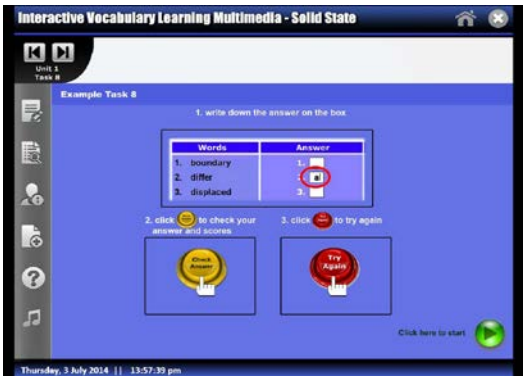
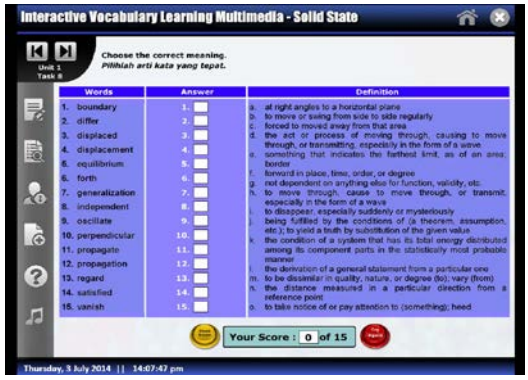
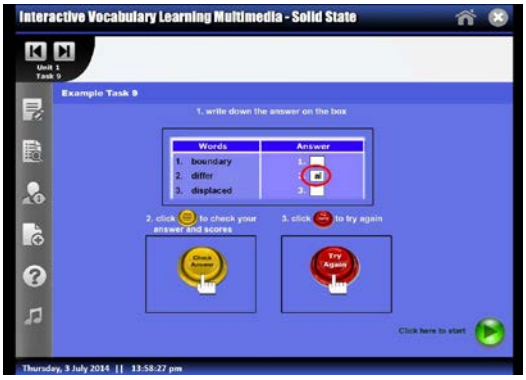
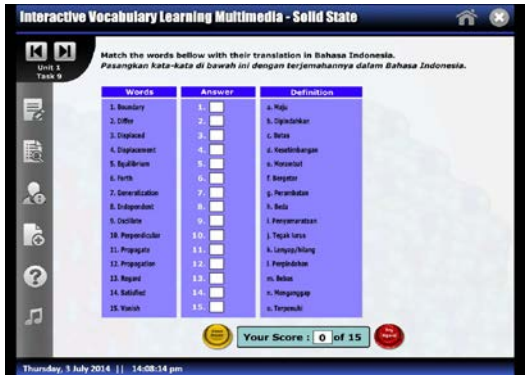
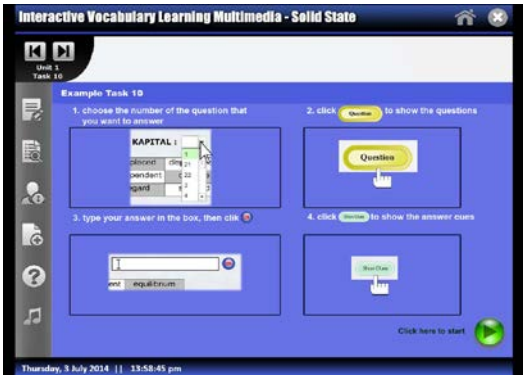
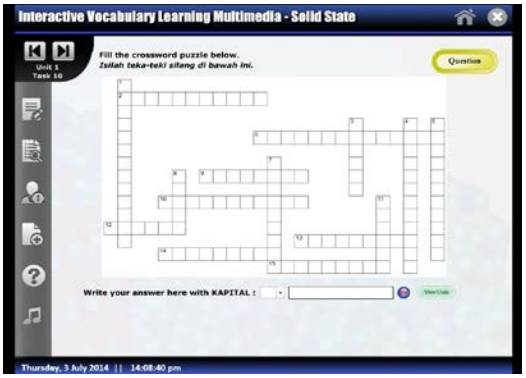

Interactive Vocabulary Learning Multimedia - Solid State
Unit 1
Task 8
Example Task 8
1. write down the answer on the box
Words
Answer
1. boundary
2. differ
3. displaced
2. click to check your answer and scores
3. click to try again
Check Answer
Try Again
Click here to start
Thursday, 3 July 2014 || 13:57:39 pm

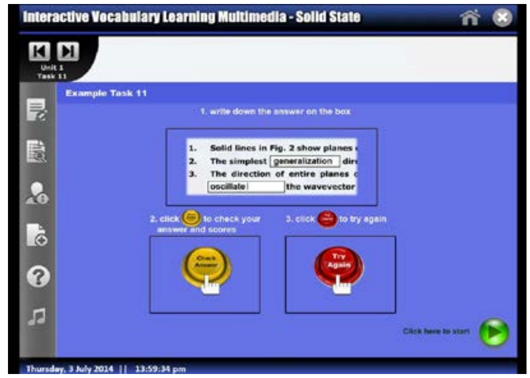

Interactive Vocabulary Learning Multimedia - Solid State
Unit 1
Task 8
Choose the correct meaning.
Pilihlah arti kata yang tepat.
Words
Answer
Definition
1. boundary
2. differ
3. displaced
4. displacement
5. equilibrium
6. forth
7. generalization
8. independent
9. oscillate
10. perpendicular
11. propagate
12. propagation
13. regard
14. satisfied
15. vanish
a. at right angles to a horizontal plane
b. to move or swing from side to side regularly
c. forced to moved away from that area
d. the act or process of moving through, causing to move through, or transmitting, especially in the form of a wave
e. something that indicates the farthest limit, as of an area; border
f. forward in place, time, order, or degree
g. not dependent on anything else for function, validity, etc.
h. to move through, cause to move through, or transmit, especially in the form of a wave
i. to disappear, especially suddenly or mysteriously
j. being fulfilled by the conditions of (a theorem, assumption, etc.); to yield a truth by substitution of the given value
k. the condition of a system that has its total energy distributed among its component parts in the statistically most probable manner
l. the derivation of a general statement from a particular one
m. to be dissimilar in quality, nature, or degree (to); vary (from)
n. the distance measured in a particular direction from a reference point
o. to take notice of or pay attention to (something); heed
Your Score : 0 of 15
Thursday, 3 July 2014 || 14:07:47 pm

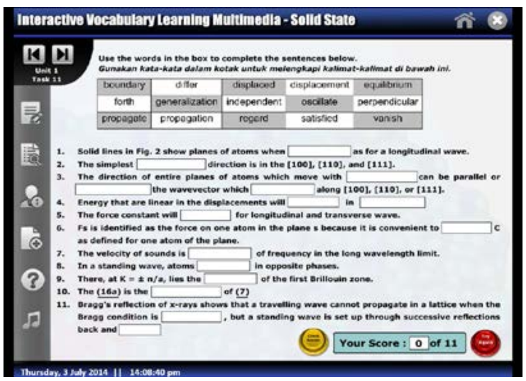

Interactive Vocabulary Learning Multimedia - Solid State
Unit 1
Task 9
Example Task 9
1. write down the answer on the box
Words
Answer
1. boundary
2. differ
3. displaced
2. click to check your answer and scores
3. click to try again
Check Answer
Try Again
Click here to start
Thursday, 3 July 2014 || 13:58:27 pm

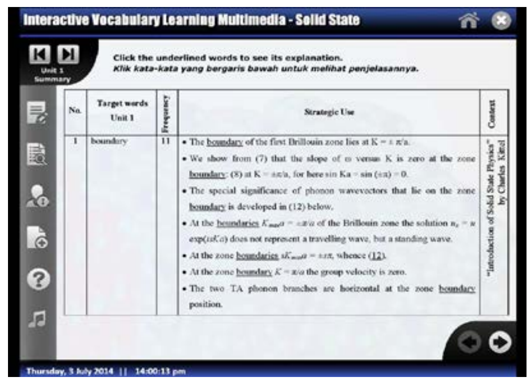

Interactive Vocabulary Learning Multimedia - Solid State
Unit 1
Task 9
Match the words bellow with their translation in Bahasa Indonesia.
Pasangkan kata-kata di bawah ini dengan terjemahannya dalam Bahasa Indonesia.
Words
Answer
Definition
1. Boundary
2. Differ
3. Displaced
4. Displacement
5. Equilibrium
6. Forth
7. Generalization
8. Independent
9. Oscillate
10. Perpendicular
11. Propagate
12. Propagation
13. Regard
14. Satisfied
15. Vanish
Your Score : 0 of 15
Thursday, 3 July 2014 || 14:08:14 pm

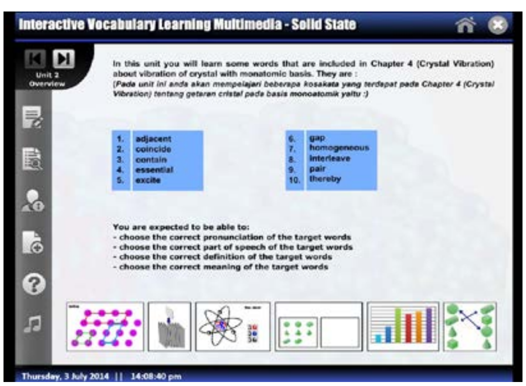

Interactive Vocabulary Learning Multimedia - Solid State
Unit 1
Task 10
Example Task 10
1. choose the number of the question that you want to answer
2. click to show the questions
Question
3. type your answer in the box, then clik
4. click to show the answer cues
Click here to start
Thursday, 3 July 2014 || 13:58:45 pm

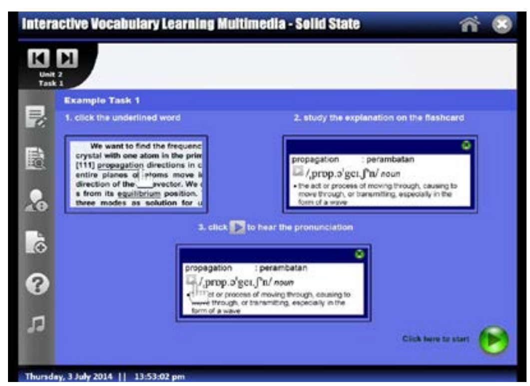

Interactive Vocabulary Learning Multimedia - Solid State
Unit 1 Task 10
Fill the crossword puzzle below.
Isilah teka-teki silang di bawah ini.
Question
Write your answer here with KAPITAL :
Thursday, 3 July 2014 || 14:08:40 pm

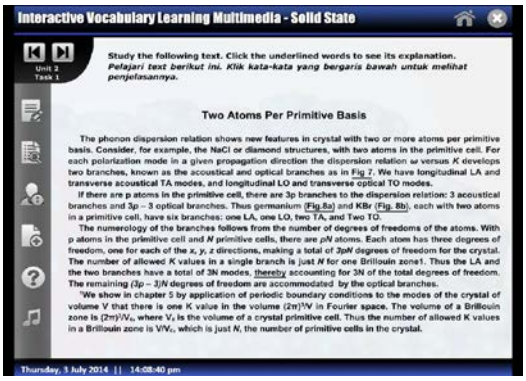

Interactive Vocabulary Learning Multimedia - Solid State
Unit 1 Task 11
Example Task 11
1. write down the answer on the box
2. click to check your answer and scores
3. click to try again
Click here to start
Thursday, 3 July 2014 || 13:59:34 pm

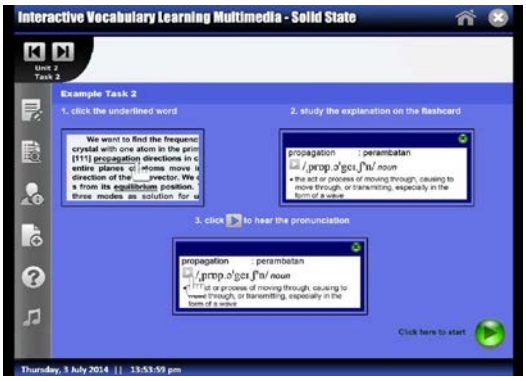

Interactive Vocabulary Learning Multimedia - Solid State
Unit 1 Task 11
Use the words in the box to complete the sentences below.
Gunakan kata-kata dalam kotak untuk melengkapi kalimat-kalimat di bawah ini.
boundary differ displaced displacement equilibrium
forth generalization independent oscillate perpendicular
propagate propagation regard satisfied vanish
Your Score : 0 of 11
Thursday, 3 July 2014 || 14:08:40 pm

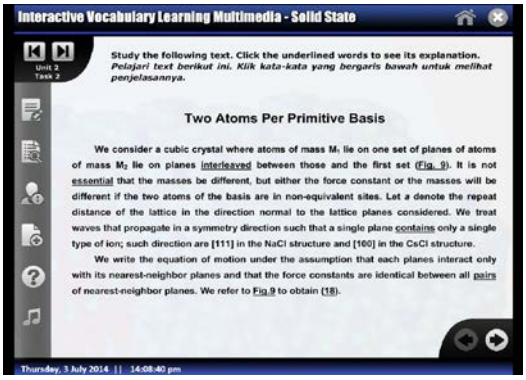

Interactive Vocabulary Learning Multimedia - Solid State
Unit 1 Summary
Click the underlined words to see its explanation.
Klik kata-kata yang bergaris bawah untuk melihat penjelasannya.
No.
Target words Unit 1
Frequency
Strategic Use
Context
1
boundary
11
"Introduction of Solid State Physics" by Charles Kittel
Thursday, 3 July 2014 || 14:00:13 pm


Interactive Vocabulary Learning Multimedia - Solid State
Unit 2 Overview
In this unit you will learn some words that are included in Chapter 4 (Crystal Vibration) about vibration of crystal with monatomic basis. They are :
1. adjacent
2. coincide
3. contain
4. essential
5. excite
6. gap
7. homogeneous
8. interleave
9. pair
10. thereby
You are expected to be able to:
- choose the correct pronunciation of the target words
- choose the correct part of speech of the target words
- choose the correct definition of the target words
- choose the correct meaning of the target words
Thursday, 3 July 2014 || 14:08:40 pm

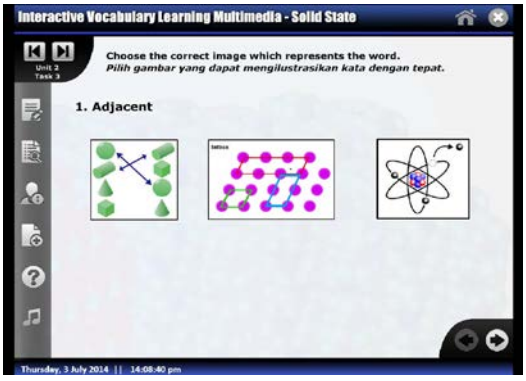

Interactive Vocabulary Learning Multimedia - Solid State
Unit 2 Task 1
Example Task 1
1. click the underlined word
2. study the explanation on the flashcard
3. click to hear the pronunciation
propagation : perambatan
Click here to start
Thursday, 3 July 2014 || 13:53:02 pm

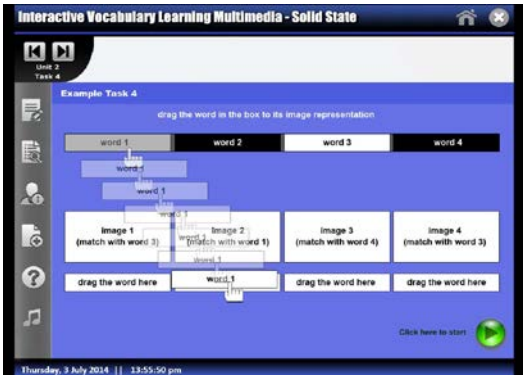

Interactive Vocabulary Learning Multimedia - Solid State
Unit 2 Task 1
Study the following text. Click the underlined words to see its explanation.
Pelajari text berikut ini. Klik kata-kata yang bergaris bawah untuk melihat penjelasannya.
Two Atoms Per Primitive Basis
The phonon dispersion relation shows new features in crystal with two or more atoms per primitive basis. Consider, for example, the NaCl or diamond structures, with two atoms in the primitive cell. For each polarization mode in a given propagation direction the dispersion relation ω versus K develops two branches, known as the acoustical and optical branches as in Fig 7. We have longitudinal LA and transverse acoustical TA modes, and longitudinal LO and transverse optical TO modes.
If there are p atoms in the primitive cell, there are 3p branches to the dispersion relation: 3 acoustical branches and 3p – 3 optical branches. Thus germanium (Fig.8a) and KBr (Fig. 8b), each with two atoms in a primitive cell, have six branches: one LA, one LO, two TA, and Two TO.
The numerology of the branches follows from the number of degrees of freedoms of the atoms. With p atoms in the primitive cell and N primitive cells, there are pN atoms. Each atom has three degrees of freedom, one for each of the x, y, z directions, making a total of 3pN degrees of freedom for the crystal. The number of allowed K values in a single branch is just N for one Brillouin zone1. Thus the LA and the two branches have a total of 3N modes, thereby accounting for 3N of the total degrees of freedom. The remaining (3p – 3)N degrees of freedom are accommodated by the optical branches.
[1]We show in chapter 5 by application of periodic boundary conditions to the modes of the crystal of volume V that there is one K value in the volume $(2\pi)^3/V$ in Fourier space. The volume of a Brillouin zone is $(2\pi)^3/V_c$, where V_c is the volume of a crystal primitive cell. Thus the number of allowed K values in a Brillouin zone is V/V_c, which is just N, the number of primitive cells in the crystal.
Thursday, 3 July 2014 || 14:08:40 pm

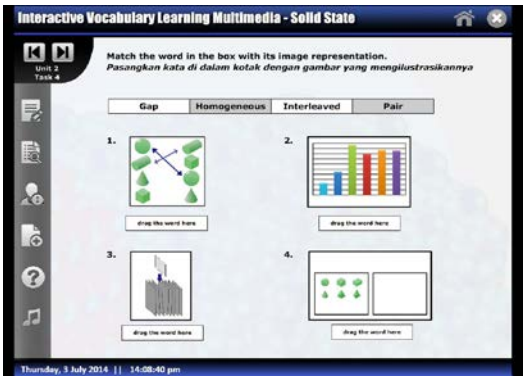

Interactive Vocabulary Learning Multimedia - Solid State
Unit 2 Task 2
Example Task 2
1. click the underlined word
2. study the explanation on the flashcard
3. click to hear the pronunciation
propagation : perambatan
Click here to start
Thursday, 3 July 2014 || 13:53:59 pm

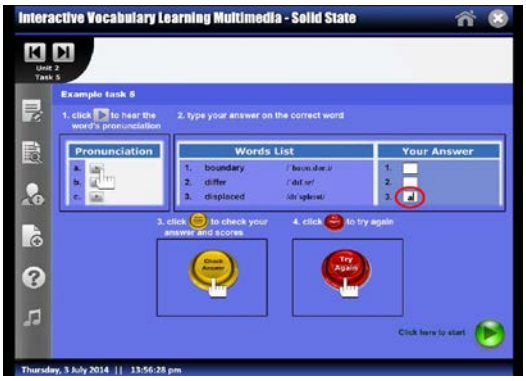

Interactive Vocabulary Learning Multimedia - Solid State
Unit 2 Task 2
Study the following text. Click the underlined words to see its explanation.
Pelajari text berikut ini. Klik kata-kata yang bergaris bawah untuk melihat penjelasannya.
Two Atoms Per Primitive Basis
We consider a cubic crystal where atoms of mass M1 lie on one set of planes of atoms of mass M2 lie on planes interleaved between those and the first set (Fig. 9). It is not essential that the masses be different, but either the force constant or the masses will be different if the two atoms of the basis are in non-equivalent sites. Let a denote the repeat distance of the lattice in the direction normal to the lattice planes considered. We treat waves that propagate in a symmetry direction such that a single plane contains only a single type of ion; such direction are [111] in the NaCl structure and [100] in the CsCl structure.
We write the equation of motion under the assumption that each planes interact only with its nearest-neighbor planes and that the force constants are identical between all pairs of nearest-neighbor planes. We refer to Fig.9 to obtain (18).
Thursday, 3 July 2014 || 14:08:40 pm

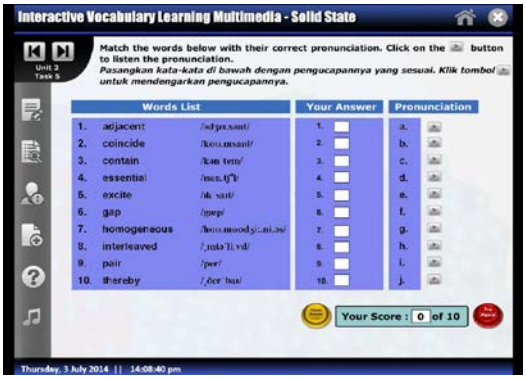

Interactive Vocabulary Learning Multimedia - Solid State
Unit 2 Task 3
Example Task 3
1. click the correct image which represent the word
2. the answer is correct if there is a check sign
3. the answer is wrong if there is a cross sign
image 1
image 2
image 3
4. click to open the next page
5. click to check your answer and scores
6. click to try again
Click here to start
Thursday, 3 July 2014 || 13:54:26 pm

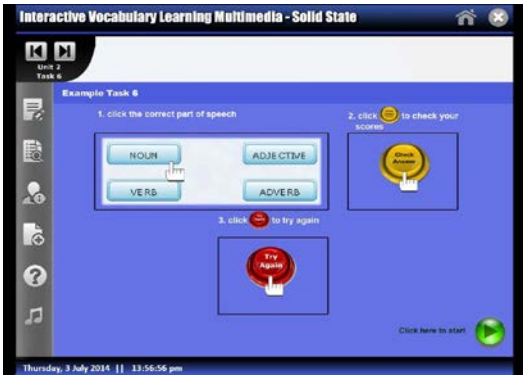

Interactive Vocabulary Learning Multimedia - Solid State
Unit 2 Task 3
Choose the correct image which represents the word.
Pilih gambar yang dapat mengilustrasikan kata dengan tepat.
1. Adjacent
Thursday, 3 July 2014 || 14:08:40 pm

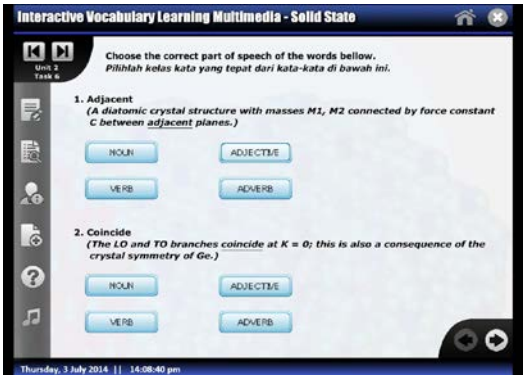

Interactive Vocabulary Learning Multimedia - Solid State
Unit 2 Task 4
Example Task 4
drag the word in the box to its image representation
word 1
word 2
word 3
word 4
image 1 (match with word 3)
image 2 (match with word 1)
image 3 (match with word 4)
image 4 (match with word 3)
drag the word here
Click here to start
Thursday, 3 July 2014 || 13:55:50 pm

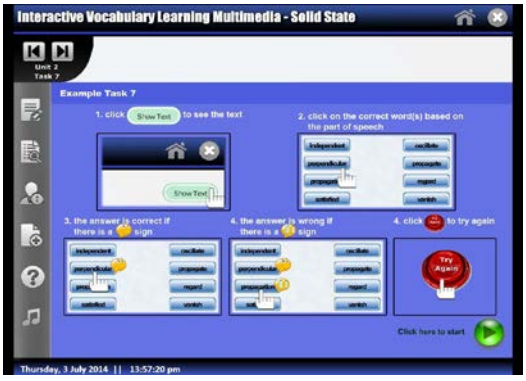

Interactive Vocabulary Learning Multimedia - Solid State
Match the word in the box with its image representation.
Pasangkan kata di dalam kotak dengan gambar yang mengilustrasikannya
Gap
Homogeneous
Interleaved
Pair

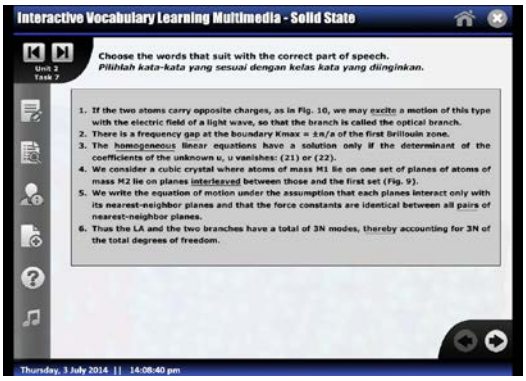

Interactive Vocabulary Learning Multimedia - Solid State
Example task 5
Pronunciation
Words List
Your Answer
boundary
differ
displaced

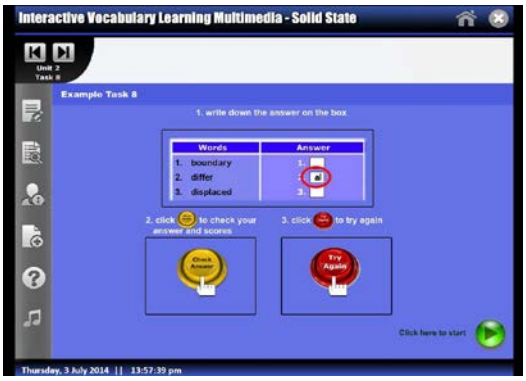

Interactive Vocabulary Learning Multimedia - Solid State
Match the words below with their correct pronunciation. Click on the button to listen the pronunciation.
Words List
Your Answer
Pronunciation
Your Score : 0 of 10

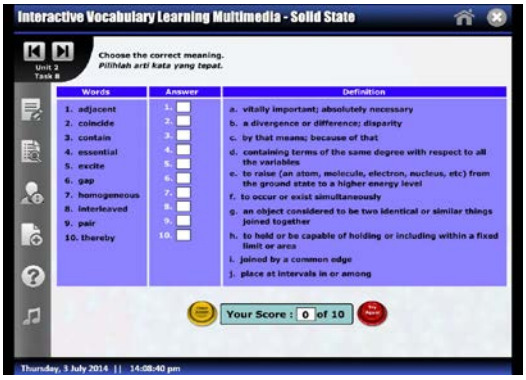

Interactive Vocabulary Learning Multimedia - Solid State
Example Task 6
NOUN
ADJECTIVE
VERB
ADVERB

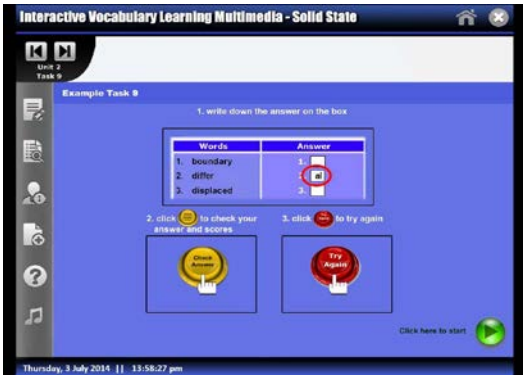

Interactive Vocabulary Learning Multimedia - Solid State
Choose the correct part of speech of the words bellow.
1. Adjacent
2. Coincide
NOUN
ADJECTIVE
VERB
ADVERB

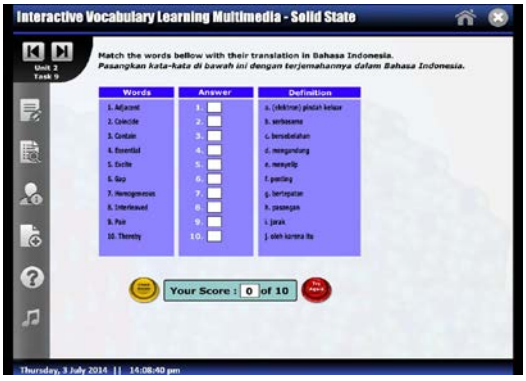

Interactive Vocabulary Learning Multimedia - Solid State
Example Task 7

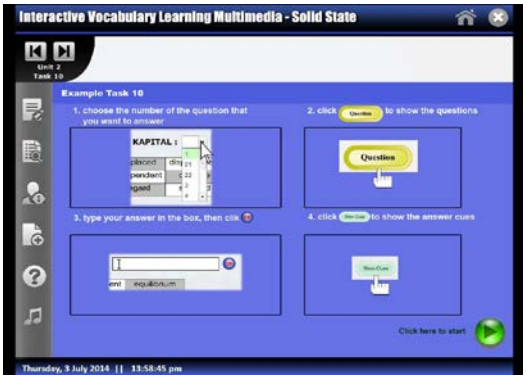

Interactive Vocabulary Learning Multimedia - Solid State
Unit 2 Task 7
Choose the words that suit with the correct part of speech.
Pilihlah kata-kata yang sesuai dengan kelas kata yang diinginkan.
1. If the two atoms carry opposite charges, as in Fig. 10, we may excite a motion of this type with the electric field of a light wave, so that the branch is called the optical branch.
2. There is a frequency gap at the boundary Kmax = π/a of the first Brillouin zone.
3. The homogeneous linear equations have a solution only if the determinant of the coefficients of the unknown u, u vanishes: (21) or (22).
4. We consider a cubic crystal where atoms of mass M1 lie on one set of planes of atoms of mass M2 lie on planes interleaved between those and the first set (Fig. 9).
5. We write the equation of motion under the assumption that each planes interact only with its nearest-neighbor planes and that the force constants are identical between all pairs of nearest-neighbor planes.
6. Thus the LA and the two branches have a total of 3N modes, thereby accounting for 3N of the total degrees of freedom.
Thursday, 3 July 2014 || 14:08:40 pm

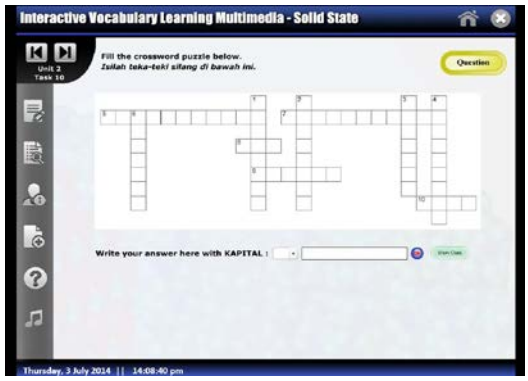

Interactive Vocabulary Learning Multimedia - Solid State
Unit 2 Task 8
Example Task 8
1. write down the answer on the box
Words
Answer
1. boundary
2. differ
3. displaced
2. click to check your answer and scores
3. click to try again
Check Answer
Try Again
Click here to start
Thursday, 3 July 2014 || 13:57:39 pm

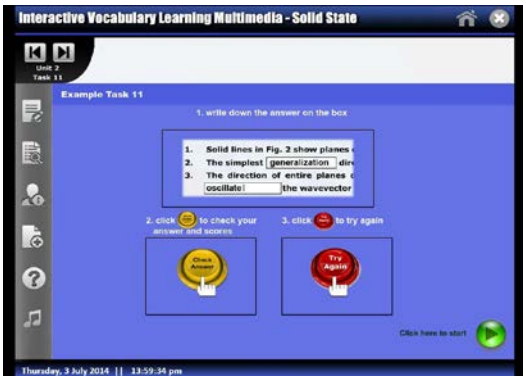

Interactive Vocabulary Learning Multimedia - Solid State
Unit 2 Task 8
Choose the correct meaning.
Pilihlah arti kata yang tepat.
Words
Answer
Definition
1. adjacent
2. coincide
3. contain
4. essential
5. excite
6. gap
7. homogeneous
8. interleaved
9. pair
10. thereby
a. vitally important; absolutely necessary
b. a divergence or difference; disparity
c. by that means; because of that
d. containing terms of the same degree with respect to all the variables
e. to raise (an atom, molecule, electron, nucleus, etc) from the ground state to a higher energy level
f. to occur or exist simultaneously
g. an object considered to be two identical or similar things joined together
h. to hold or be capable of holding or including within a fixed limit or area
i. joined by a common edge
j. place at intervals in or among
Your Score : 0 of 10
Thursday, 3 July 2014 || 14:08:40 pm

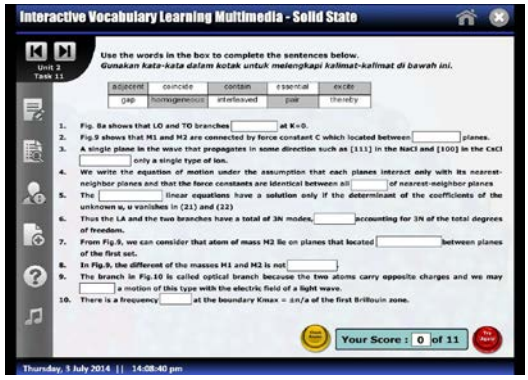

Interactive Vocabulary Learning Multimedia - Solid State
Unit 2 Task 9
Example Task 9
1. write down the answer on the box
Words
Answer
1. boundary
2. differ
3. displaced
2. click to check your answer and scores
3. click to try again
Check Answer
Try Again
Click here to start
Thursday, 3 July 2014 || 13:58:27 pm

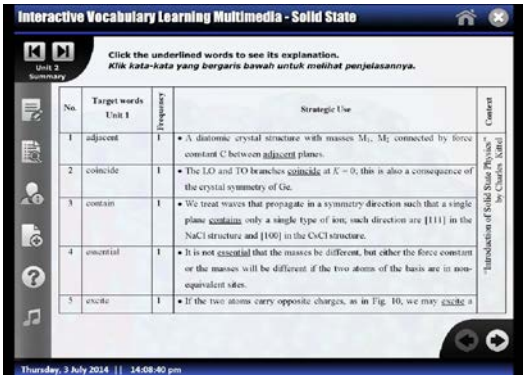

Interactive Vocabulary Learning Multimedia - Solid State
Unit 2 Task 9
Match the words bellow with their translation in Bahasa Indonesia.
Pasangkan kata-kata di bawah ini dengan terjemahannya dalam Bahasa Indonesia.
Words
Answer
Definition
Your Score : 0 of 10
Thursday, 3 July 2014 || 14:08:40 pm

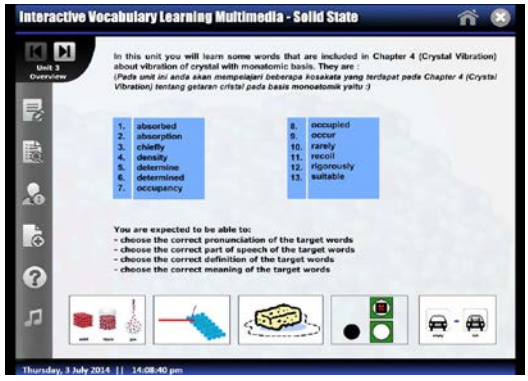

Interactive Vocabulary Learning Multimedia - Solid State
Unit 2 Task 10
Example Task 10
1. choose the number of the question that you want to answer
2. click to show the questions
Question
3. type your answer in the box, then clik
4. click to show the answer cues
Click here to start
Thursday, 3 July 2014 || 13:58:45 pm

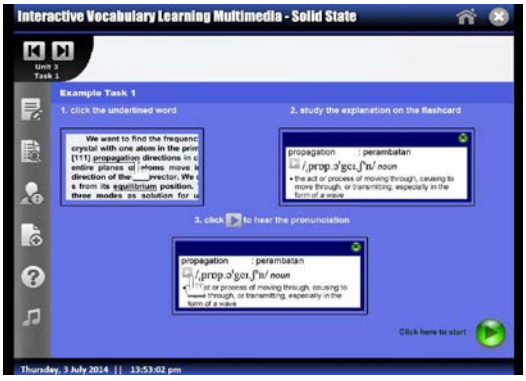

Interactive Vocabulary Learning Multimedia - Solid State
Unit 2 Task 10
Fill the crossword puzzle below.
Isilah teka-teki silang di bawah ini.
Question
Write your answer here with KAPITAL :
Thursday, 3 July 2014 || 14:08:40 pm

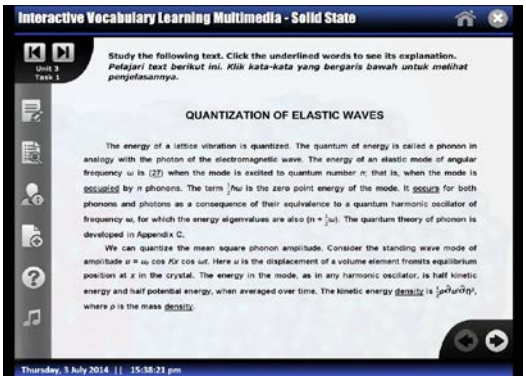

Interactive Vocabulary Learning Multimedia - Solid State
Unit 2 Task 11
Example Task 11
1. write down the answer on the box
1. Solid lines in Fig. 2 show planes
2. The simplest generalization dir
3. The direction of entire planes
oscillate the wavevector
2. click to check your answer and scores
3. click to try again
Check Answer
Try Again
Click here to start
Thursday, 3 July 2014 || 13:59:34 pm

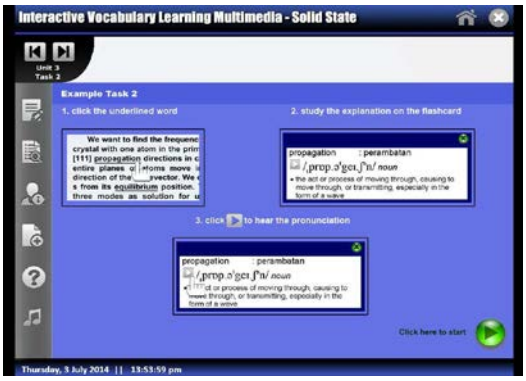

Interactive Vocabulary Learning Multimedia - Solid State
Unit 2 Task 11
Use the words in the box to complete the sentences below.
Gunakan kata-kata dalam kotak untuk melengkapi kalimat-kalimat di bawah ini.
adjacent coincide contain essential excite
gap homogeneous interleaved pair thereby
1. Fig. 8a shows that LO and TO branches at K=0.
2. Fig.9 shows that M1 and M2 are connected by force constant C which located between planes.
3. A single plane in the wave that propagates in some direction such as [111] in the NaCl and [100] in the CsCl only a single type of ion.
4. We write the equation of motion under the assumption that each planes interact only with its nearest-neighbor planes and that the force constants are identical between all of nearest-neighbor planes
5. The linear equations have a solution only if the determinant of the coefficients of the unknown u, v vanishes in (21) and (22)
6. Thus the LA and the two branches have a total of 3N modes, accounting for 3N of the total degrees of freedom.
7. From Fig.9, we can consider that atom of mass M2 lie on planes that located between planes of the first set.
8. In Fig.9, the different of the masses M1 and M2 is not
9. The branch in Fig.10 is called optical branch because the two atoms carry opposite charges and we may a motion of this type with the electric field of a light wave.
10. There is a frequency at the boundary Kmax = π/a of the first Brillouin zone.
Your Score : 0 of 11
Thursday, 3 July 2014 || 14:08:40 pm

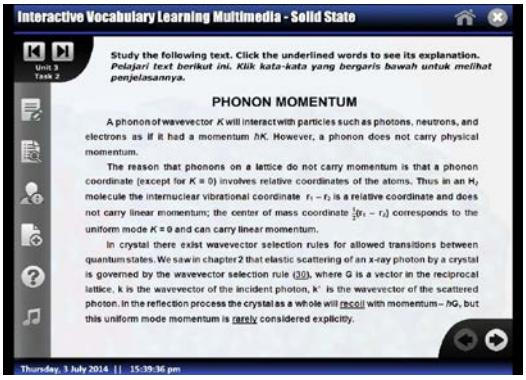

Interactive Vocabulary Learning Multimedia - Solid State
Unit 2 Summary
Click the underlined words to see its explanation.
Klik kata-kata yang bergaris bawah untuk melihat penjelasannya.
No. | Target words Unit 1 | Frequency | Strategic Use | Content
1 adjacent 1 • A diatomic crystal structure with masses M1, M2 connected by force constant C between adjacent planes.
2 coincide 1 • The LO and TO branches coincide at K = 0; this is also a consequence of the crystal symmetry of Ge.
3 contain 1 • We treat waves that propagate in a symmetry direction such that a single plane contains only a single type of ion; such direction are [111] in the NaCl structure and [100] in the CsCl structure.
4 essential 1 • It is not essential that the masses be different, but either the force constant or the masses will be different if the two atoms of the basis are in non-equivalent sites.
5 excite 1 • If the two atoms carry opposite charges, as in Fig. 10, we may excite a
"Introduction of Solid State Physics" by Charles Kittel
Thursday, 3 July 2014 || 14:08:40 pm


Interactive Vocabulary Learning Multimedia - Solid State
Unit 3 Overview
In this unit you will learn some words that are included in Chapter 4 (Crystal Vibration) about vibration of crystal with monoatomic basis. They are :
(Pada unit ini anda akan mempelajari beberapa kosakata yang terdapat pada Chapter 4 (Crystal Vibration) tentang getaran cristal pada basis monoatomik yaitu :)
1. absorbed
2. absorption
3. chiefly
4. density
5. determine
6. determined
7. occupancy
8. occupied
9. occur
10. rarely
11. recoil
12. rigorously
13. suitable
You are expected to be able to:
- choose the correct pronunciation of the target words
- choose the correct part of speech of the target words
- choose the correct definition of the target words
- choose the correct meaning of the target words
Thursday, 3 July 2014 || 14:08:40 pm

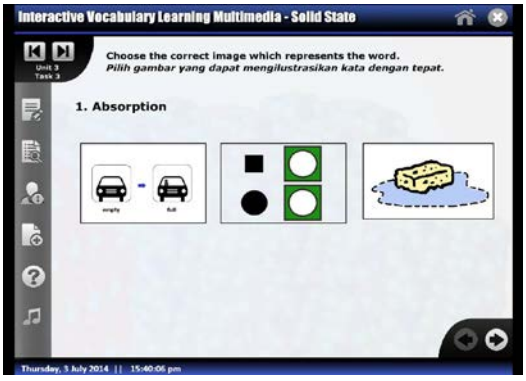

Interactive Vocabulary Learning Multimedia - Solid State
Unit 3 Task 1
Example Task 1
1. click the underlined word
2. study the explanation on the flashcard
propagation : perambatan
/ˌprɒp.əˈgeɪ.ʃn/ noun
• the act or process of moving through, causing to move through, or transmitting, especially in the form of a wave
3. click to hear the pronunciation
Click here to start
Thursday, 3 July 2014 || 13:53:02 pm

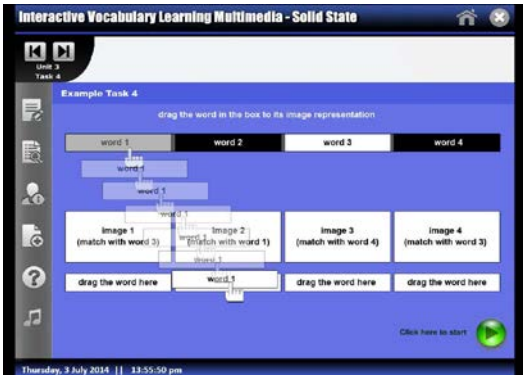

Interactive Vocabulary Learning Multimedia - Solid State
Unit 3
Task 1
Study the following text. Click the underlined words to see its explanation.
Pelajari text berikut ini. Klik kata-kata yang bergaris bawah untuk melihat penjelasannya.
QUANTIZATION OF ELASTIC WAVES
The energy of a lattice vibration is quantized. The quantum of energy is called a phonon in analogy with the photon of the electromagnetic wave. The energy of an elastic mode of angular frequency ω is (27) when the mode is excited to quantum number n; that is, when the mode is occupied by n phonons. The term ½ħω is the zero point energy of the mode. It occurs for both phonons and photons as a consequence of their equivalence to a quantum harmonic oscillator of frequency ω, for which the energy eigenvalues are also (n + ½)ω. The quantum theory of phonon is developed in Appendix C.
We can quantize the mean square phonon amplitude. Consider the standing wave mode of amplitude α = u0 cos Kx cos ωt. Here u is the displacement of a volume element from its equilibrium position at x in the crystal. The energy in the mode, as in any harmonic oscillator, is half kinetic energy and half potential energy, when averaged over time. The kinetic energy density is ½ρ∂u/∂t², where ρ is the mass density.
Thursday, 3 July 2014 || 15:38:21 pm

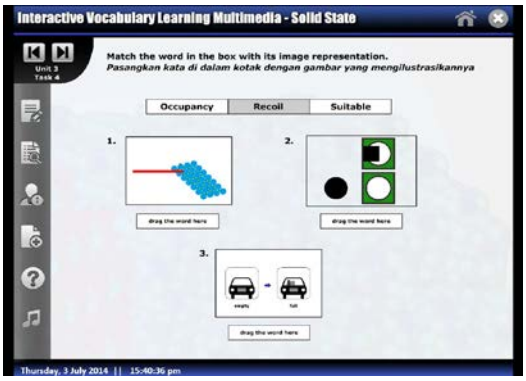

Interactive Vocabulary Learning Multimedia - Solid State
Unit 3
Task 2
Example Task 2
1. click the underlined word
2. study the explanation on the flashcard
propagation : perambatan
/ˌprɒp.əˈgeɪ.ʃən/ noun
• the act or process of moving through, causing to move through, or transmitting, especially in the form of a wave
3. click to hear the pronunciation
Click here to start
Thursday, 3 July 2014 || 13:53:59 pm

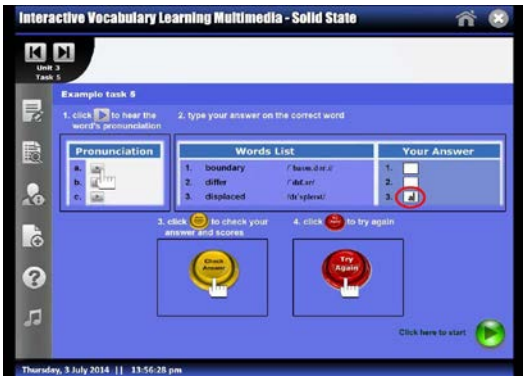

Interactive Vocabulary Learning Multimedia - Solid State
Unit 3
Task 2
Study the following text. Click the underlined words to see its explanation.
Pelajari text berikut ini. Klik kata-kata yang bergaris bawah untuk melihat penjelasannya.
PHONON MOMENTUM
A phonon of wavevector K will interact with particles such as photons, neutrons, and electrons as if it had a momentum ħK. However, a phonon does not carry physical momentum.
The reason that phonons on a lattice do not carry momentum is that a phonon coordinate (except for K = 0) involves relative coordinates of the atoms. Thus in an H2 molecule the internuclear vibrational coordinate r1 – r2 is a relative coordinate and does not carry linear momentum; the center of mass coordinate ½(r1 – r2) corresponds to the uniform mode K = 0 and can carry linear momentum.
In crystal there exist wavevector selection rules for allowed transitions between quantum states. We saw in chapter 2 that elastic scattering of an x-ray photon by a crystal is governed by the wavevector selection rule (30), where G is a vector in the reciprocal lattice, k is the wavevector of the incident photon, k' is the wavevector of the scattered photon. In the reflection process the crystal as a whole will recoil with momentum – ħG, but this uniform mode momentum is rarely considered explicitly.
Thursday, 3 July 2014 || 15:39:36 pm

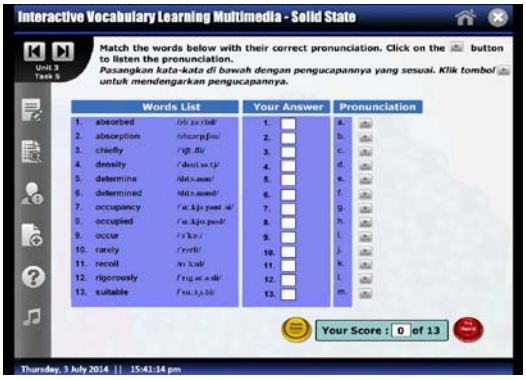

Interactive Vocabulary Learning Multimedia - Solid State
Unit 3
Task 3
Example Task 3
1. click the correct image which represent the word
2. the answer is correct if there is a check sign
3. the answer is wrong if there is a cross sign
image 1
image 2
image 3
4. click to open the next page
5. click to check your answer and scores
6. click to try again
Check Answer
Try Again
Click here to start
Thursday, 3 July 2014 || 13:54:26 pm


Interactive Vocabulary Learning Multimedia - Solid State
Unit 3
Task 3
Choose the correct image which represents the word.
Pilih gambar yang dapat mengilustrasikan kata dengan tepat.
1. Absorption
Thursday, 3 July 2014 || 15:40:06 pm

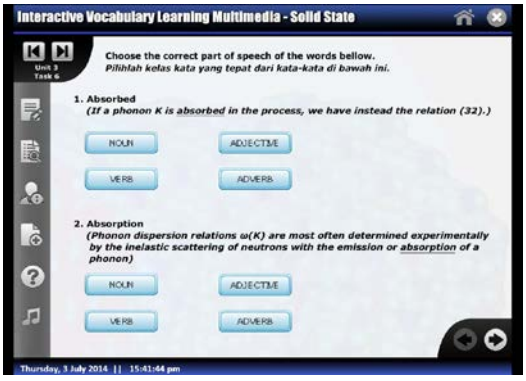

Interactive Vocabulary Learning Multimedia - Solid State
Unit 3
Task 4
Example Task 4
drag the word in the box to its image representation
word 1
word 2
word 3
word 4
image 1 (match with word 3)
image 2 (match with word 1)
image 3 (match with word 4)
image 4 (match with word 3)
drag the word here
drag the word here
drag the word here
Click here to start
Thursday, 3 July 2014 || 13:55:50 pm

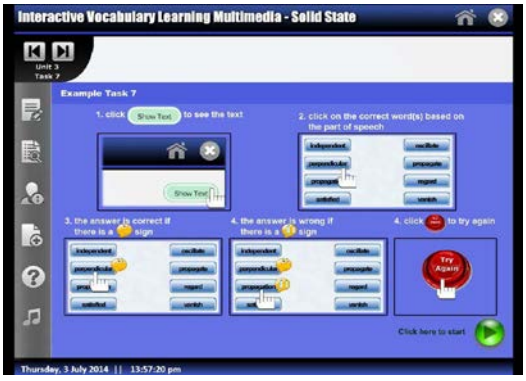

Interactive Vocabulary Learning Multimedia - Solid State
Match the word in the box with its image representation.
Pasangkan kata di dalam kotak dengan gambar yang mengilustrasikannya
Occupancy
Recoil
Suitable
1.
2.
3.
drag the word here
drag the word here
drag the word here
Thursday, 3 July 2014 || 15:40:36 pm

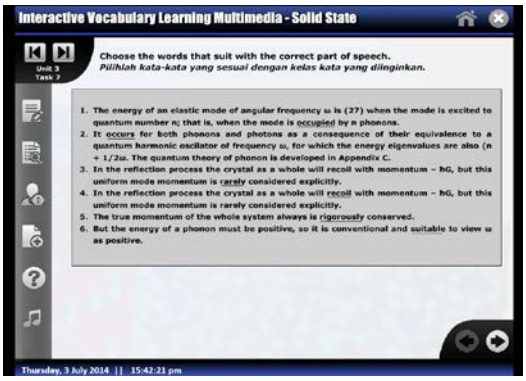

Interactive Vocabulary Learning Multimedia - Solid State
Example task 5
1. click to hear the word's pronunciation
2. type your answer on the correct word
Pronunciation
Words List
Your Answer
1. boundary
2. differ
3. displaced
3. click to check your answer and scores
4. click to try again
Check Answer
Try Again
Click here to start
Thursday, 3 July 2014 || 13:56:28 pm

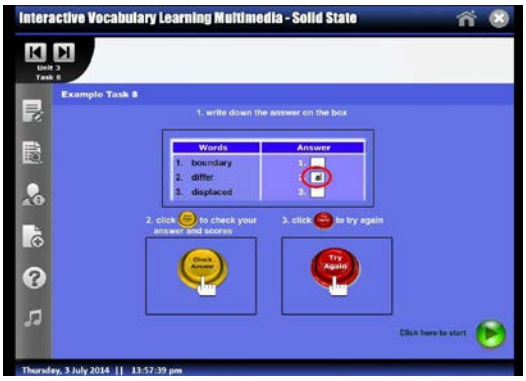

Interactive Vocabulary Learning Multimedia - Solid State
Match the words below with their correct pronunciation. Click on the button to listen the pronunciation.
Pasangkan kata-kata di bawah dengan pengucapannya yang sesuai. Klik tombol untuk mendengarkan pengucapannya.
Words List
Your Answer
Pronunciation
1. absorbed
2. absorption
3. chiefly
4. density
5. determine
6. determined
7. occupancy
8. occupied
9. occur
10. rarely
11. recoil
12. rigorously
13. suitable
Your Score : 0 of 13
Thursday, 3 July 2014 || 15:41:14 pm

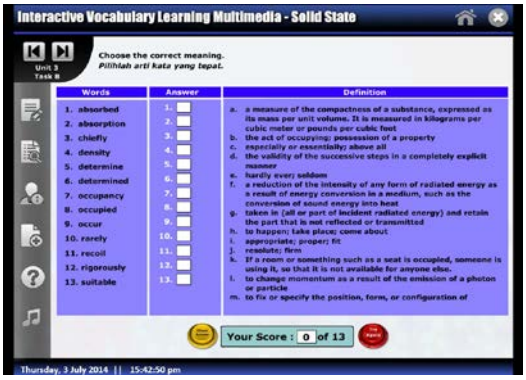

Interactive Vocabulary Learning Multimedia - Solid State
Example Task 6
1. click the correct part of speech
2. click to check your scores
NOUN
ADJECTIVE
VERB
ADVERB
3. click to try again
Check Answer
Try Again
Click here to start
Thursday, 3 July 2014 || 13:56:56 pm

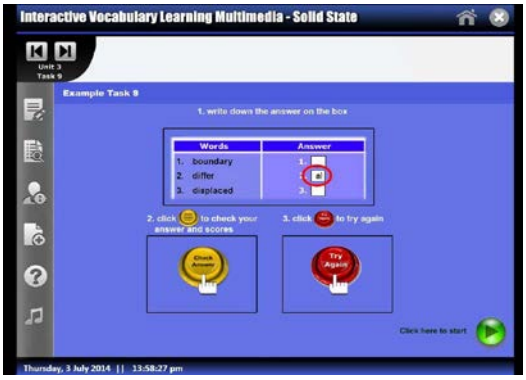

Interactive Vocabulary Learning Multimedia - Solid State
Choose the correct part of speech of the words bellow.
Pilihlah kelas kata yang tepat dari kata-kata di bawah ini.
1. Absorbed
(If a phonon K is absorbed in the process, we have instead the relation (32).)
NOUN
ADJECTIVE
VERB
ADVERB
2. Absorption
(Phonon dispersion relations ω(K) are most often determined experimentally by the inelastic scattering of neutrons with the emission or absorption of a phonon)
NOUN
ADJECTIVE
VERB
ADVERB
Thursday, 3 July 2014 || 15:41:44 pm

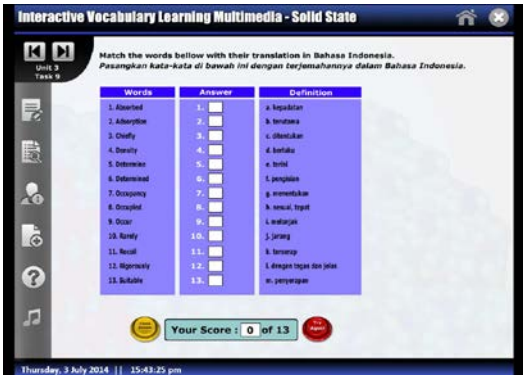

Interactive Vocabulary Learning Multimedia - Solid State
Example Task 7
1. click Show Text to see the text
2. click on the correct word(s) based on the part of speech
3. the answer is correct if there is a sign
4. the answer is wrong if there is a sign
4. click to try again
Try Again
Click here to start
Thursday, 3 July 2014 || 13:57:20 pm

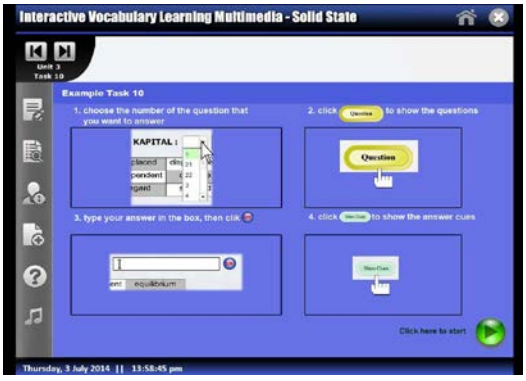

Interactive Vocabulary Learning Multimedia - Solid State
Unit 3
Task 7
Choose the words that suit with the correct part of speech.
Pilihlah kata-kata yang sesuai dengan kelas kata yang diinginkan.
1. The energy of an elastic mode of angular frequency ω is (27) when the mode is excited to quantum number n; that is, when the mode is occupied by n phonons.
2. It occurs for both phonons and photons as a consequence of their equivalence to a quantum harmonic oscillator of frequency ω, for which the energy eigenvalues are also (n + 1/2)ω. The quantum theory of phonon is developed in Appendix C.
3. In the reflection process the crystal as a whole will recoil with momentum − ħG, but this uniform mode momentum is rarely considered explicitly.
4. In the reflection process the crystal as a whole will recoil with momentum − ħG, but this uniform mode momentum is rarely considered explicitly.
5. The true momentum of the whole system always is rigorously conserved.
6. But the energy of a phonon must be positive, so it is conventional and suitable to view ω as positive.
Thursday, 3 July 2014 || 15:42:21 pm

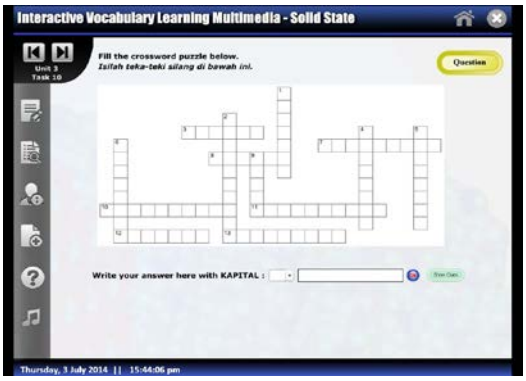

Interactive Vocabulary Learning Multimedia - Solid State
Unit 3
Task 8
Example Task 8
1. write down the answer on the box
Words
Answer
1. boundary
2. differ
3. displaced
2. click to check your answer and scores
3. click to try again
Check Answer
Try Again
Click here to start
Thursday, 3 July 2014 || 13:57:39 pm

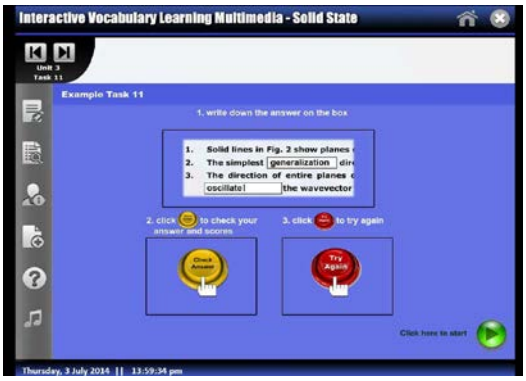

Interactive Vocabulary Learning Multimedia - Solid State
Unit 3
Task 8
Choose the correct meaning.
Pilihlah arti kata yang tepat.
Words
Answer
Definition
1. absorbed
2. absorption
3. chiefly
4. density
5. determine
6. determined
7. occupancy
8. occupied
9. occur
10. rarely
11. recoil
12. rigorously
13. suitable
a. a measure of the compactness of a substance, expressed as its mass per unit volume. It is measured in kilograms per cubic meter or pounds per cubic foot
b. the act of occupying; possession of a property
c. especially or essentially; above all
d. the validity of the successive steps in a completely explicit manner
e. hardly ever; seldom
f. a reduction of the intensity of any form of radiated energy as a result of energy conversion in a medium, such as the conversion of sound energy into heat
g. taken in (all or part of incident radiated energy) and retain the part that is not reflected or transmitted
h. to happen; take place; come about
i. appropriate; proper; fit
j. resolute; firm
k. If a room or something such as a seat is occupied, someone is using it, so that it is not available for anyone else.
l. to change momentum as a result of the emission of a photon or particle
m. to fix or specify the position, form, or configuration of
Your Score : 0 of 13
Thursday, 3 July 2014 || 15:42:50 pm

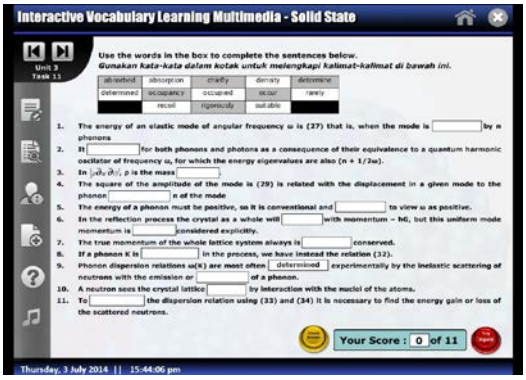

Interactive Vocabulary Learning Multimedia - Solid State
Unit 3
Task 9
Example Task 9
1. write down the answer on the box
Words
Answer
1. boundary
2. differ
3. displaced
2. click to check your answer and scores
3. click to try again
Check Answer
Try Again
Click here to start
Thursday, 3 July 2014 || 13:58:27 pm

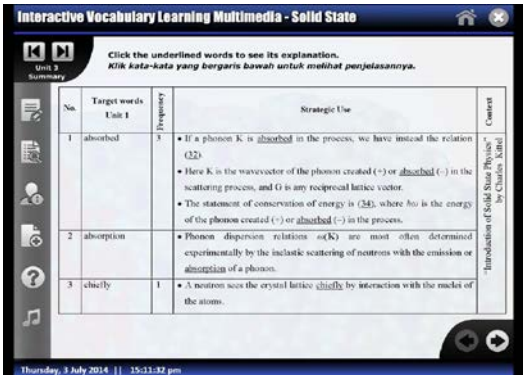

Interactive Vocabulary Learning Multimedia - Solid State
Unit 3
Task 9
Match the words bellow with their translation in Bahasa Indonesia.
Pasangkan kata-kata di bawah ini dengan terjemahannya dalam Bahasa Indonesia.
Words
Answer
Definition
Your Score : 0 of 13
Thursday, 3 July 2014 || 15:43:25 pm

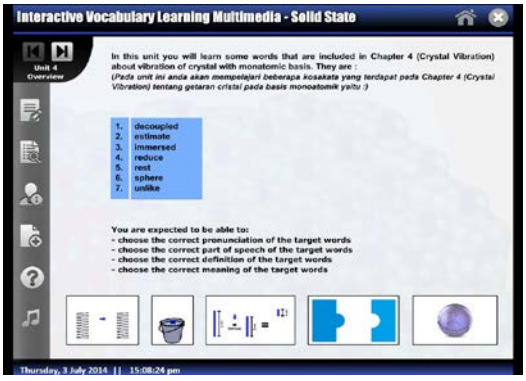

Interactive Vocabulary Learning Multimedia - Solid State
Unit 3
Task 10
Example Task 10
1. choose the number of the question that you want to answer
2. click to show the questions
Question
3. type your answer in the box, then clik
4. click to show the answer cues
Click here to start
Thursday, 3 July 2014 || 13:58:45 pm

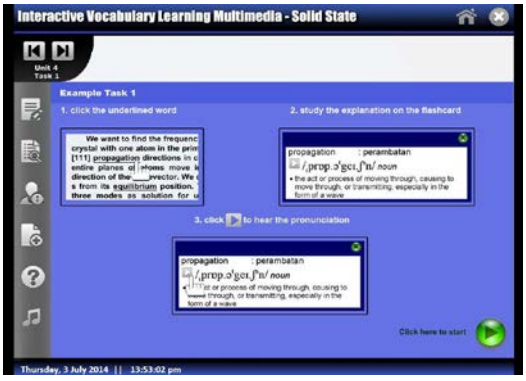

Interactive Vocabulary Learning Multimedia - Solid State
Unit 3 Task 10
Fill the crossword puzzle below.
Isilah teka-teki silang di bawah ini.
Question
Write your answer here with KAPITAL :
Thursday, 3 July 2014 || 15:44:06 pm

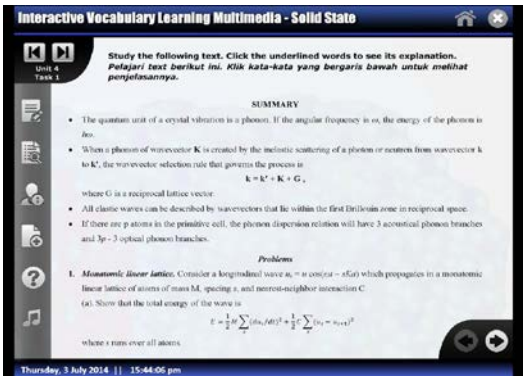

Interactive Vocabulary Learning Multimedia - Solid State
Unit 3 Task 11
Example Task 11
1. write down the answer on the box
1. Solid lines in Fig. 2 show planes
2. The simplest generalization dir
3. The direction of entire planes
oscillate the wavevector
2. click to check your answer and scores
3. click to try again
Check Answer
Try Again
Click here to start
Thursday, 3 July 2014 || 13:59:34 pm

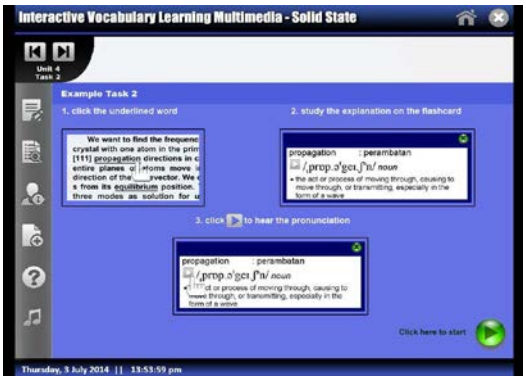

Interactive Vocabulary Learning Multimedia - Solid State
Unit 3 Task 11
Use the words in the box to complete the sentences below.
Gunakan kata-kata dalam kotak untuk melengkapi kalimat-kalimat di bawah ini.
absorbed absorption chiefly density determine
determined occupancy occupied occur rarely
recoil rigorously suitable
1. The energy of an elastic mode of angular frequency ω is (27) that is, when the mode is by n phonons
2. It for both phonons and photons as a consequence of their equivalence to a quantum harmonic oscillator of frequency ω, for which the energy eigenvalues are also (n + 1/2)ω).
3. In ρ is the mass
4. The square of the amplitude of the mode is (29) is related with the displacement in a given mode to the phonon n of the mode
5. The energy of a phonon must be positive, so it is conventional and to view ω as positive.
6. In the reflection process the crystal as a whole will with momentum – hG, but this uniform mode momentum is considered explicitly.
7. The true momentum of the whole lattice system always is conserved.
8. If a phonon K is in the process, we have instead the relation (32).
9. Phonon dispersion relations ω(K) are most often determined experimentally by the inelastic scattering of neutrons with the emission or of a phonon.
10. A neutron sees the crystal lattice by interaction with the nuclei of the atoms.
11. To the dispersion relation using (33) and (34) it is necessary to find the energy gain or loss of the scattered neutrons.
Your Score : 0 of 11
Thursday, 3 July 2014 || 15:44:06 pm

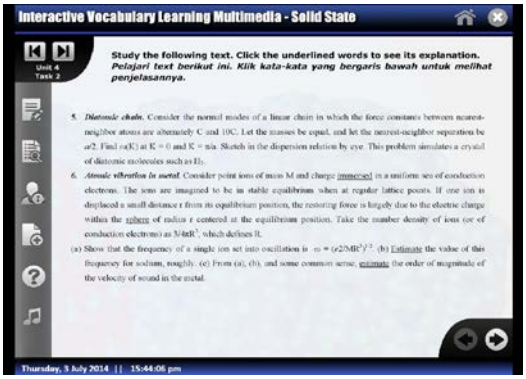

Interactive Vocabulary Learning Multimedia - Solid State
Unit 3 Summary
Click the underlined words to see its explanation.
Klik kata-kata yang bergaris bawah untuk melihat penjelasannya.
No. | Target words Unit 1 | Frequency | Strategic Use | Context
1 absorbed 3
• If a phonon K is absorbed in the process, we have instead the relation (32).
• Here K is the wavevector of the phonon created (+) or absorbed (–) in the scattering process, and G is any reciprocal lattice vector.
• The statement of conservation of energy is (34), where ħω is the energy of the phonon created (+) or absorbed (–) in the process.
2 absorption
• Phonon dispersion relations ω(K) are most often determined experimentally by the inelastic scattering of neutrons with the emission or absorption of a phonon.
3 chiefly 1
• A neutron sees the crystal lattice chiefly by interaction with the nuclei of the atoms.
"Introduction of Solid State Physics" by Charles Kittel
Thursday, 3 July 2014 || 15:11:32 pm


Interactive Vocabulary Learning Multimedia - Solid State
Unit 4 Overview
In this unit you will learn some words that are included in Chapter 4 (Crystal Vibration) about vibration of crystal with monatomic basis. They are :
(Pada unit ini anda akan mempelajari beberapa kosakata yang terdapat pada Chapter 4 (Crystal Vibration) tentang getaran cristal pada basis monoatomik yaitu :)
1. decoupled
2. estimate
3. immersed
4. reduce
5. rest
6. sphere
7. unlike
You are expected to be able to:
- choose the correct pronunciation of the target words
- choose the correct part of speech of the target words
- choose the correct definition of the target words
- choose the correct meaning of the target words
Thursday, 3 July 2014 || 15:08:24 pm

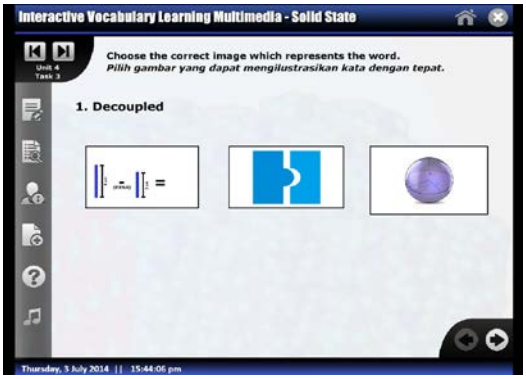

Interactive Vocabulary Learning Multimedia - Solid State
Unit 4 Task 1
Example Task 1
1. click the underlined word
2. study the explanation on the flashcard
propagation : perambatan
/ˌprɒp.əˈgeɪ.ʃn/ noun
• the act or process of moving through, causing to move through, or transmitting, especially in the form of a wave
3. click to hear the pronunciation
Click here to start
Thursday, 3 July 2014 || 13:53:02 pm

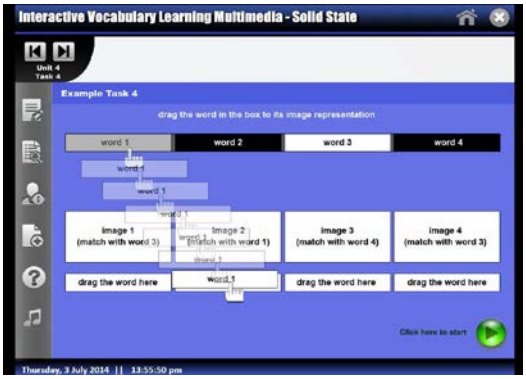

Interactive Vocabulary Learning Multimedia - Solid State
Unit 4 Task 1
Study the following text. Click the underlined words to see its explanation.
Pelajari text berikut ini. Klik kata-kata yang bergaris bawah untuk melihat penjelasannya.
SUMMARY
Problems
Thursday, 3 July 2014 || 15:44:06 pm

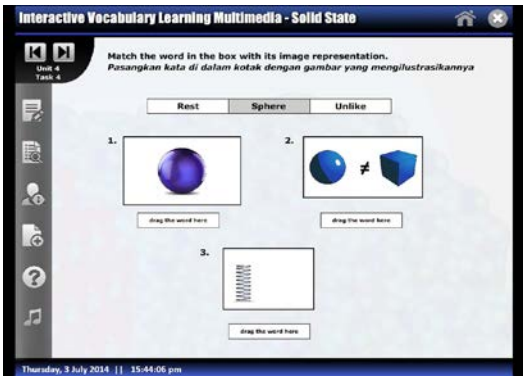

Interactive Vocabulary Learning Multimedia - Solid State
Unit 4 Task 2
Example Task 2
1. click the underlined word
2. study the explanation on the flashcard
3. click to hear the pronunciation
propagation : perambatan
Click here to start
Thursday, 3 July 2014 || 13:53:59 pm

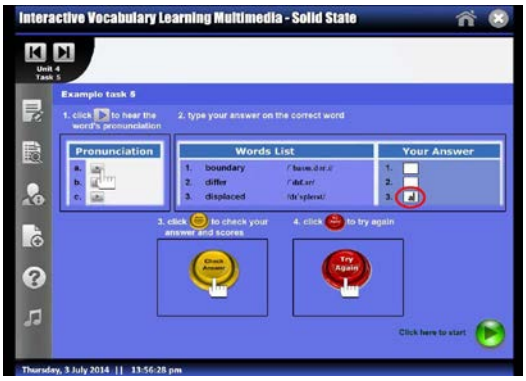

Interactive Vocabulary Learning Multimedia - Solid State
Unit 4 Task 2
Study the following text. Click the underlined words to see its explanation.
Pelajari text berikut ini. Klik kata-kata yang bergaris bawah untuk melihat penjelasannya.
Thursday, 3 July 2014 || 15:44:06 pm

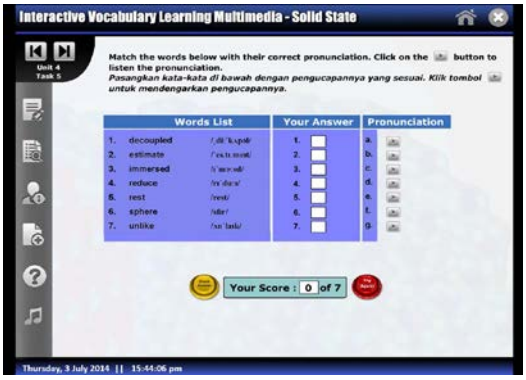

Interactive Vocabulary Learning Multimedia - Solid State
Unit 4 Task 3
Example Task 3
1. click the correct image which represent the word
2. the answer is correct if there is a check sign
3. the answer is wrong if there is a cross sign
image 1
image 2
image 3
4. click to open the next page
5. click to check your answer and scores
6. click to try again
Try Again
Click here to start
Thursday, 3 July 2014 || 13:54:26 pm


Interactive Vocabulary Learning Multimedia - Solid State
Unit 4 Task 3
Choose the correct image which represents the word.
Pilih gambar yang dapat mengilustrasikan kata dengan tepat.
1. Decoupled
Thursday, 3 July 2014 || 15:44:06 pm

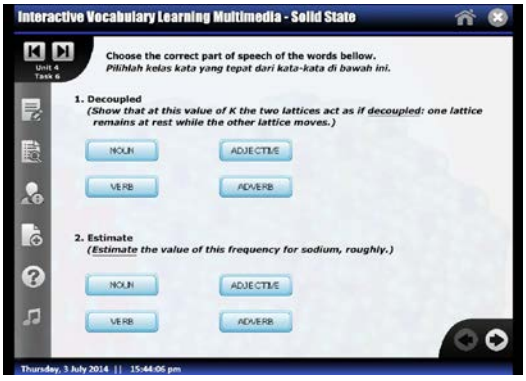

Interactive Vocabulary Learning Multimedia - Solid State
Unit 4 Task 4
Example Task 4
drag the word in the box to its image representation
word 1
word 2
word 3
word 4
image 1 (match with word 3)
image 2 (match with word 1)
image 3 (match with word 4)
image 4 (match with word 3)
drag the word here
Click here to start
Thursday, 3 July 2014 || 13:55:50 pm

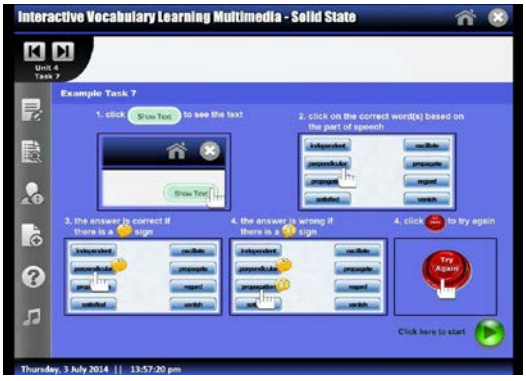

Interactive Vocabulary Learning Multimedia - Solid State
Match the word in the box with its image representation.
Pasangkan kata di dalam kotak dengan gambar yang mengilustrasikannya
Rest
Sphere
Unlike
1.
2.
3.
drag the word here
drag the word here
drag the word here
Thursday, 3 July 2014 || 15:44:06 pm

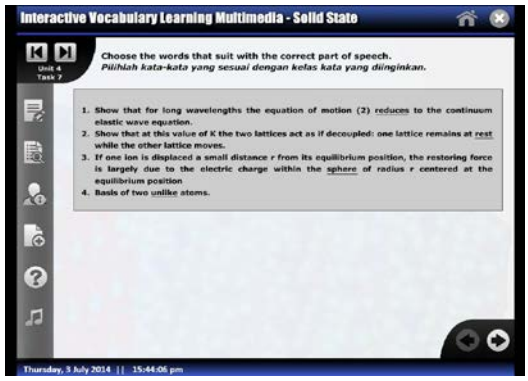

Interactive Vocabulary Learning Multimedia - Solid State
Example task 5
1. click to hear the word's pronunciation
2. type your answer on the correct word
Pronunciation
Words List
Your Answer
1. boundary
2. differ
3. displaced
3. click to check your answer and scores
4. click to try again
Check Answer
Try Again
Click here to start
Thursday, 3 July 2014 || 13:56:28 pm

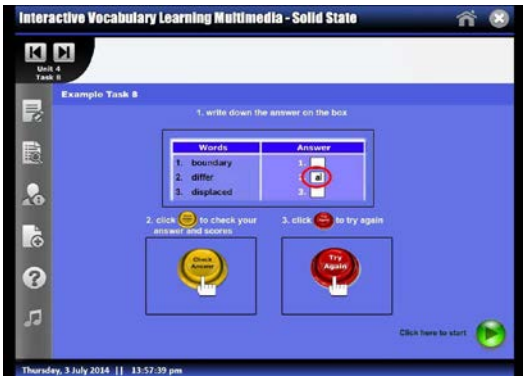

Interactive Vocabulary Learning Multimedia - Solid State
Match the words below with their correct pronunciation. Click on the button to listen the pronunciation.
Pasangkan kata-kata di bawah dengan pengucapannya yang sesuai. Klik tombol untuk mendengarkan pengucapannya.
Words List
Your Answer
Pronunciation
1. decoupled
2. estimate
3. immersed
4. reduce
5. rest
6. sphere
7. unlike
Your Score : 0 of 7
Thursday, 3 July 2014 || 15:44:06 pm

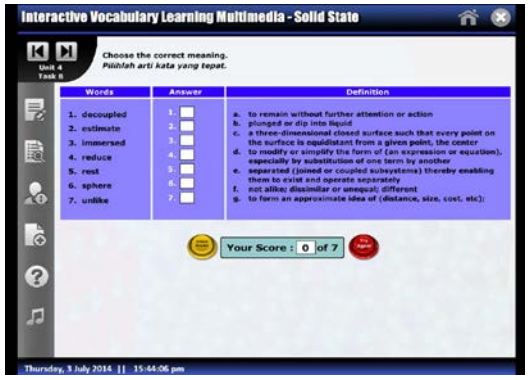

Interactive Vocabulary Learning Multimedia - Solid State
Example Task 6
1. click the correct part of speech
2. click to check your scores
NOUN
ADJECTIVE
VERB
ADVERB
3. click to try again
Try Again
Click here to start
Thursday, 3 July 2014 || 13:56:56 pm

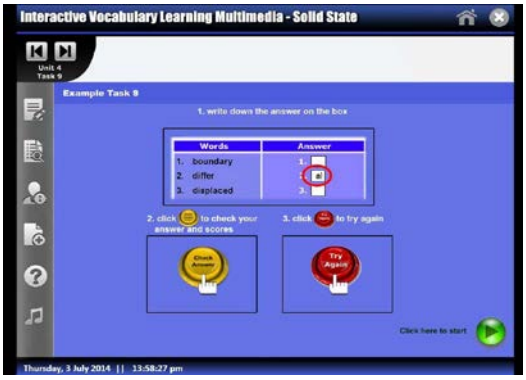

Interactive Vocabulary Learning Multimedia - Solid State
Choose the correct part of speech of the words bellow.
Pilihlah kelas kata yang tepat dari kata-kata di bawah ini.
1. Decoupled
(Show that at this value of K the two lattices act as if decoupled: one lattice remains at rest while the other lattice moves.)
NOUN
ADJECTIVE
VERB
ADVERB
2. Estimate
(Estimate the value of this frequency for sodium, roughly.)
NOUN
ADJECTIVE
VERB
ADVERB
Thursday, 3 July 2014 || 15:44:06 pm

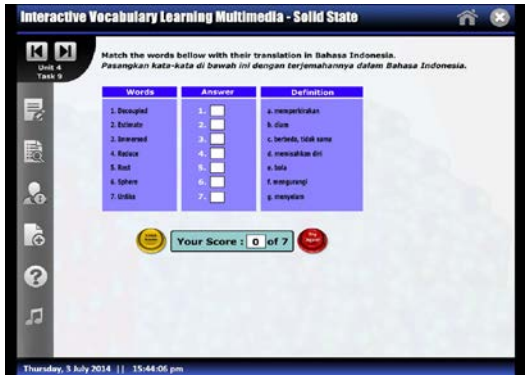

Interactive Vocabulary Learning Multimedia - Solid State
Example Task 7
1. click Show Text to see the text
2. click on the correct word(s) based on the part of speech
3. the answer is correct if there is a sign
4. the answer is wrong if there is a sign
4. click to try again
Try Again
Click here to start
Thursday, 3 July 2014 || 13:57:20 pm

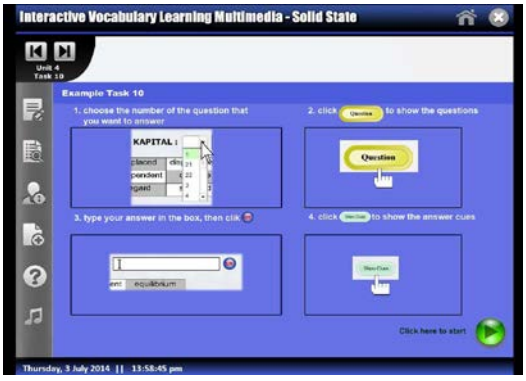

Interactive Vocabulary Learning Multimedia - Solid State
Unit 4 Task 7
Choose the words that suit with the correct part of speech.
Pilihlah kata-kata yang sesuai dengan kelas kata yang diinginkan.
1. Show that for long wavelengths the equation of motion (2) reduces to the continuum elastic wave equation.
2. Show that at this value of K the two lattices act as if decoupled: one lattice remains at rest while the other lattice moves.
3. If one ion is displaced a small distance r from its equilibrium position, the restoring force is largely due to the electric charge within the sphere of radius r centered at the equilibrium position
4. Basis of two unlike atoms.
Thursday, 3 July 2014 || 15:44:06 pm

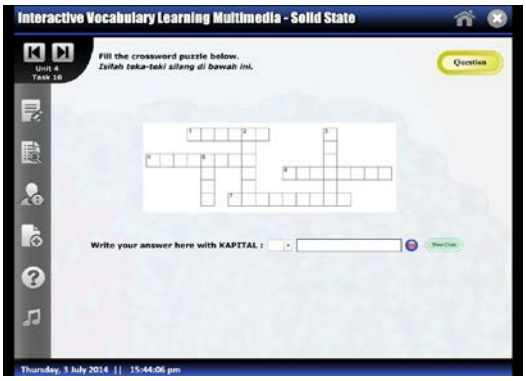

Interactive Vocabulary Learning Multimedia - Solid State
Unit 4 Task 8
Example Task 8
1. write down the answer on the box
Words
Answer
1. boundary
2. differ
3. displaced
2. click to check your answer and scores
3. click to try again
Check Answer
Try Again
Click here to start
Thursday, 3 July 2014 || 13:57:39 pm

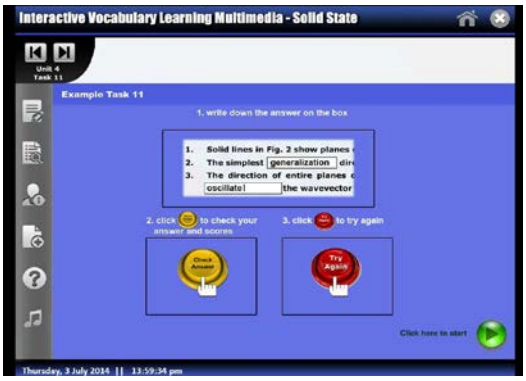

Interactive Vocabulary Learning Multimedia - Solid State
Unit 4 Task 8
Choose the correct meaning.
Pilihlah arti kata yang tepat.
Words
Answer
Definition
1. decoupled
2. estimate
3. immersed
4. reduce
5. rest
6. sphere
7. unlike
a. to remain without further attention or action
b. plunged or dip into liquid
c. a three-dimensional closed surface such that every point on the surface is equidistant from a given point, the center
d. to modify or simplify the form of (an expression or equation), especially by substitution of one term by another
e. separated (joined or coupled subsystems) thereby enabling them to exist and operate separately
f. not alike; dissimilar or unequal; different
g. to form an approximate idea of (distance, size, cost, etc);
Your Score : 0 of 7
Thursday, 3 July 2014 || 15:44:06 pm

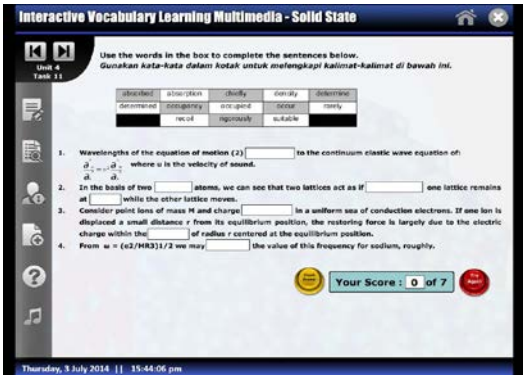

Interactive Vocabulary Learning Multimedia - Solid State
Unit 4 Task 9
Example Task 9
1. write down the answer on the box
Words
Answer
1. boundary
2. differ
3. displaced
2. click to check your answer and scores
3. click to try again
Check Answer
Try Again
Click here to start
Thursday, 3 July 2014 || 13:58:27 pm

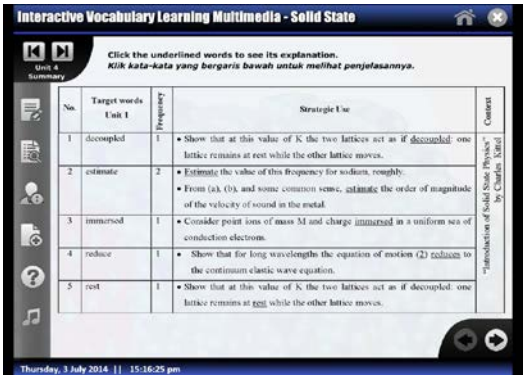

Interactive Vocabulary Learning Multimedia - Solid State
Unit 4 Task 9
Match the words bellow with their translation in Bahasa Indonesia.
Pasangkan kata-kata di bawah ini dengan terjemahannya dalam Bahasa Indonesia.
Words
Answer
Definition
Your Score : 0 of 7
Thursday, 3 July 2014 || 15:44:06 pm

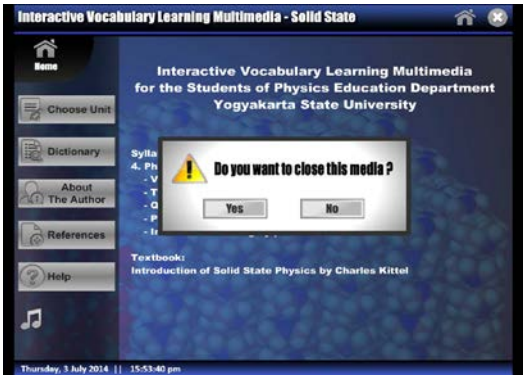

Interactive Vocabulary Learning Multimedia - Solid State
Unit 4 Task 10
Example Task 10
1. choose the number of the question that you want to answer
2. click to show the questions
Question
3. type your answer in the box, then clik
4. click to show the answer cues
Click here to start
Thursday, 3 July 2014 || 13:58:45 pm

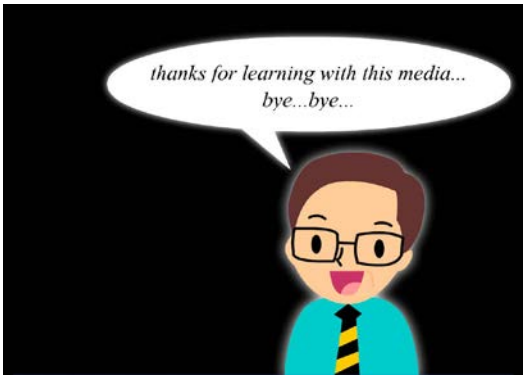

Interactive Vocabulary Learning Multimedia - Solid State
Unit 4
Task 10
Fill the crossword puzzle below.
Isilah teka-teki silang di bawah ini.
Question
Write your answer here with KAPITAL :
Thursday, 3 July 2014 || 15:44:06 pm


Interactive Vocabulary Learning Multimedia - Solid State
Unit 4
Task 11
Example Task 11
1. write down the answer on the box
1. Solid lines in Fig. 2 show planes
2. The simplest generalization
3. The direction of entire planes
oscillate
the wavevector
2. click to check your answer and scores
3. click to try again
Check Answer
Try Again
Click here to start
Thursday, 3 July 2014 || 13:59:34 pm


Interactive Vocabulary Learning Multimedia - Solid State
Unit 4
Task 11
Use the words in the box to complete the sentences below.
Gunakan kata-kata dalam kotak untuk melengkapi kalimat-kalimat di bawah ini.
absorbed
description
chiefly
density
determine
determined
homogeneity
occupied
social
rarely
record
rigorously
suitable
1. Wavelengths of the equation of motion (2) to the continuum elastic wave equation of: where u is the velocity of sound.
2. In the basis of two atoms, we can see that two lattices act as if one lattice remains at while the other lattice moves.
3. Consider point ions of mass M and charge in a uniform sea of conduction electrons. If one ion is displaced a small distance r from its equilibrium position, the restoring force is largely due to the electric charge within the of radius r centered at the equilibrium position.
4. From ω = (ω2/NR3)1/2 we may the value of this frequency for sodium, roughly.
Your Score : 0 of 7
Thursday, 3 July 2014 || 15:44:06 pm


Interactive Vocabulary Learning Multimedia - Solid State
Unit 4
Summary
Click the underlined words to see its explanation.
Klik kata-kata yang bergaris bawah untuk melihat penjelasannya.
No.
Target words Unit 1
Frequency
Strategic Use
Context
1 decoupled 1 • Show that at this value of K the two lattices act as if decoupled: one lattice remains at rest while the other lattice moves.
2 estimate 2 • Estimate the value of this frequency for sodium, roughly.
• From (a), (b), and some common sense, estimate the order of magnitude of the velocity of sound in the metal.
3 immersed 1 • Consider point ions of mass M and charge immersed in a uniform sea of conduction electrons.
4 reduce 1 • Show that for long wavelengths the equation of motion (2) reduces to the continuum elastic wave equation.
5 rest 1 • Show that at this value of K the two lattices act as if decoupled: one lattice remains at rest while the other lattice moves.
"Introduction of Solid State Physics" by Charles Kittel
Thursday, 3 July 2014 || 15:16:25 pm


Interactive Vocabulary Learning Multimedia - Solid State
Home
Choose Unit
Dictionary
About The Author
References
Help
Interactive Vocabulary Learning Multimedia
for the Students of Physics Education Department
Yogyakarta State University
Do you want to close this media ?
Yes
No
Textbook:
Introduction of Solid State Physics by Charles Kittel
Thursday, 3 July 2014 || 15:53:40 pm


thanks for learning with this media...
bye...bye...

Appendix H

Research Letters

APPROVAL

Developing Interactive Vocabulary Learning Multimedia
For The Students of Physics Education Department
Yogyakarta State University

Written by

Alvan Bastoni Nuradila

08202241062

Approved by the consultants on April, 2013

Consultant,

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First Vice Dean,

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NIP. 19530423 197903 1 004

KEMENTERIAN PENDIDIKAN DAN KEBUDAYAAN
UNIVERSITAS NEGERI YOGYAKARTA
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Alamat: Karangmalang, Yogyakarta 55281 ☎ (0274) 550843, 548207 Fax. (0274) 548207
http: //www.fbs.uny.ac.id//

FRM/FBS/33-01
10 Jan 2011

Nomor : 0436/UN.34.12/DT/IV/2013 30 April 2013
Lampiran : 1 Berkas Proposal
Hal : **Permohonan Izin Penelitian**

Kepada Yth.
Dekan FMIPA UNY

Kami beritahukan dengan hormat bahwa mahasiswa kami dari Fakultas Bahasa dan Seni Universitas Negeri Yogyakarta bermaksud mengadakan **Penelitian** untuk memperoleh data guna menyusun Tugas Akhir Skripsi (TAS)/Tugas Akhir Karya Seni (TAKS)/Tugas Akhir Bukan Skripsi (TABS), dengan judul :

DEVELOPING INTERACTIVE VOCABULARY LEARNING MULTIMEDIA FOR THE STUDENTS OF PHYSICS EDUCATION DEPARTEMENT YOGYAKARTA STATE UNIVERSITY

Mahasiswa dimaksud adalah :

Nama	: ALVAN BASTONI NURADILA
NIM	: 08202241062
Jurusan/ Program Studi	: Pendidikan Bahasa Inggris
Waktu Pelaksanaan	: Mei – Juni 2013
Lokasi Penelitian	: Jurusan Pendidikan Fisika FMIPA UNY

Untuk dapat terlaksananya maksud tersebut, kami mohon izin dan bantuan seperlunya.

Atas izin dan kerjasama Bapak/Ibu, kami sampaikan terima kasih.

a.n. Dekan
Kasubbag Pendidikan FBS,

Indun Probo Utami, S.E.
NIP 19670704 199312 2 001

Tembusan:
1. Kepala Jurusan Pendidikan Fisika FMIPA UNY

KEMENTERIAN PENDIDIKAN DAN KEBUDAYAAN
UNIVERSITAS NEGERI YOGYAKARTA
FAKULTAS BAHASA DAN SENI
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NIP 19670704 199312 2 001

Tembusan:
1. Kepala Jurusan Pendidikan Fisika FMIPA UNY