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Theories of Light

Stage 1 – Vocabulary

 adequate ['ædɪkwɪt] <i>a</i> advocate ['ædvəktɪ] <i>n</i> barrier ['bæriə] <i>n</i> corpuscle ['kɔ:pʌsl] <i>n</i> corpuscular [kɔ:'pʌskjʊlə] <i>a</i> correct [kə'rekt] <i>a</i> deviation [ˌdi:vɪ'eɪʃ(ə)n] <i>n</i> diffraction [dɪ'frækʃ(ə)n] <i>n</i> electron [ɪ'lektrɒn] <i>n</i>	elementary [ˌelɪ'ment(ə)rɪ] <i>a</i> evolution [ˌi:və'l(j)u:ʃ(ə)n] <i>n</i> hypothesis [haɪ'pɒθɪsɪs] <i>n</i> (<i>pl</i> -ses) illustrate ['ɪləstreɪt] <i>v</i> interference [ˌɪntə'fɪər(ə)ns] <i>n</i> modification [ˌmɒdɪfɪ'keɪʃ(ə)n] <i>n</i> mystery ['mɪst(ə)rɪ] <i>n</i> ocean ['əʊʃ(ə)n] <i>n</i> photoelectric [ˌfəʊtə(u)'lɛktrɪk] <i>a</i>	pioneer [ˌpaɪə'niə] <i>n</i> photon ['fəʊtɒn] <i>n</i> polarization [ˌpəʊl(ə)'raɪ'zeɪʃ(ə)n] <i>n</i> postulate ['pɒstjuleɪt] <i>v</i> prestige [pres'ti:ʒ] <i>n</i> reality [rɪ(:)'ælɪtɪ] <i>n</i> reputation [ˌrepju(:)'teɪʃ(ə)n] <i>n</i> terminology [ˌtɜ:mɪ'nɒlədʒɪ] <i>n</i>
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abandon [ə'bændən] <i>v</i> отказываться от argue ['ɑ:gju:] <i>v</i> доказывать; утверждать circumstance ['sə:kəmstəns] <i>n</i> 1) случай, обстоятельство; 2) <i>pl.</i> обстоятельства, условия; under the circumstances – при данных обстоятельствах, при /в/ этих условиях collide [kə'laid] <i>v</i> сталкиваться combine [kəm'baɪn] <i>v</i> объединять(ся) community [kə'mju:nəti] <i>n</i> сообщество compelling [kəm'peliŋ] <i>a</i> мощный; убедительный complementary [ˌkɒmplɪ'mentəri] <i>a</i> дополнительный compound <i>a</i> ['kɒmpaʊnd] сложный; составной conclude [kən'klu:d] <i>v</i> прийти к выводу confirm [kən'fə:m] <i>v</i> 1) подтверждать; 2) утверждать, закреплять consequence ['kɒnsɪkwəns] <i>n</i> 1) (по)следствие; 2) вывод, заключение contradict [ˌkɒntrə'dɪkt] <i>v</i> 1) противоречить, возражать; 2) опровергать, отрицать convincingly [kən'vɪn(t)sɪŋli] <i>adv</i> убедительный degree [dɪ'ɡri:] <i>n</i> степень, уровень despite [dɪ'spaɪt] <i>prep</i> несмотря на doubt [daʊt] <i>n</i> сомнение empirical [em'pɪrɪk(ə)] <i>a</i> эмпирический, основанный на опыте establish [ɪs'tæblɪʃ] <i>v</i> создавать, основывать evidence ['eɪvɪdəns] <i>n</i> 1) доказательство; 2) очевидность; 3) основание, данные exact [ɪg'zækt] <i>a</i> точный	examine [ɪg'zæmɪn] <i>v</i> рассматривать, исследовать exhibit [ɪg'zɪbɪt] <i>v</i> показывать, проявлять fail [feɪl] <i>v</i> не удаваться favour ['feɪvə] 1) <i>n</i> одобрение; in favour of – за, в защиту; 2) <i>v</i> 1) помогать, поддерживать; 2) оказывать предпочтение finite ['faɪnaɪt] <i>a</i> ограниченный, имеющий предел fulfil [ful'fɪl] <i>v</i> 1) выполнять, завершать; 2) удовлетворять (требованиям, условиям) generalization [ˌdʒenərəlaɪ'zeɪʃ(ə)n] <i>n</i> обобщение, общее правило initial [ɪ'nɪʃ(ə)l] <i>a</i> (перво)начальный intentional [ɪn'tenʃənəl] <i>a</i> целенаправленный, намеренный, умышленный investigate [ɪn'vestɪgeɪt] <i>v</i> исследовать, изучать lack (of) [læk] <i>n</i> отсутствие, недостаток manner ['mænə] <i>n</i> способ, метод, образ действия merely ['miəli] <i>adv</i> только, просто nitrogen ['naɪtrədʒən] <i>n</i> хим. азот numerous ['nju:m (ə)rəs] <i>a</i> многочисленный obviously ['ɒbvɪəslɪ] <i>a</i> очевидно, явно overwhelming [ˌəʊvə'welmɪŋ] <i>a</i> подавляющий, превосходящий (<i>по количеству, качеству</i>) partly ['pɑ:tlɪ] <i>adv</i> частично; отчасти percept ['pɜ:səpt] <i>n</i> объект perform [pə'fɔ:m] <i>v</i> 1) выполнять, делать, совершать; 2) представлять (<i>что-л. перед аудиторией</i>) prominent ['prɒmɪnənt] <i>a</i> выдающийся, знаменитый, известный
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<p>propagate ['prɒpəgeɪt] <i>v</i> передаваться через среду, распространяться</p> <p>propose [prə'pəʊz] <i>v</i> предлагать</p> <p>put forward [put 'fɔ:wəd] <i>v</i> предлагать, выдвигать</p> <p>puzzle ['plʌzl] <i>v</i> приводить в затруднение, ставить в тупик; озадачивать</p> <p>query ['kwɪəri] <i>n</i> вопрос; сомнение</p> <p>rather ['rɑ:ðə] <i>adv</i> скорее, вернее, предпочтительнее; rather than – а не; вместо</p> <p>rational ['reɪʃ(ə)n(ə)l] <i>a</i> разумный</p> <p>reasonable ['ri:zənəbl] <i>a</i> разумный, приемлемый</p> <p>reasoning ['ri:znɪŋ] <i>n</i> рассуждения; объяснения</p> <p>reconcile ['rek(ə)nsaɪl] <i>v</i> согласовывать, приводить в соответствие</p> <p>regard [rɪ'gɑ:d] <i>v</i> высоко ценить, почитать, уважать</p> <p>rest (upon) [rest] <i>v</i> основываться, опираться (на)</p> <p>sample [sɑ:mpəl] <i>n</i> образец</p> <p>screen [skri:n] <i>n</i> экран</p> <p>sense [sens] <i>n</i> 1) чувство, ощущение; 2) смысл, значение</p> <p>series ['siəri:z] <i>n</i> (<i>pl</i> без изменений) ряд, последовательность, серия</p> <p>shadow ['ʃædəʊ] <i>n</i> тень</p> <p>significant [sɪg'nɪfɪkənt] <i>a</i> значительный, важный, существенный, знаменательный</p> <p>similar (to) ['sɪmələ] <i>a</i> подобный</p> <p>spectator [spek'tetə] <i>n</i> наблюдатель</p>	<p>speculation [ˌspekju'leɪʃ(ə)n] <i>n</i> 1) размышление; 2) теория, предположение</p> <p>steady ['stedɪ] <i>a</i> постоянный</p> <p>stream [stri:m] <i>n</i> течение, поток</p> <p>struggle ['strʌgl] <i>n</i> борьба</p> <p>successful [sək'sesfʊl] <i>a</i> успешный, удачный</p> <p>support [sə'pɔ:t] <i>v</i> поддерживать</p> <p>trial [traɪəl] <i>n</i> испытание</p> <p>unchallenged [ʌn'tʃælɪndʒd] <i>a</i> принимаемый без возражений, необсуждаемый</p> <p>undergo ['ʌndə'gəʊ] (<i>underwent</i>; <i>undergone</i>) <i>v</i> испытывать, подвергаться чему-л.</p> <p>valid ['vælɪd] <i>a</i> 1) веский, основательный; 2) действительный, имеющий силу</p> <p>vehicle ['vi:ɪkl] <i>n</i> средство</p> <p>viewpoint ['vjʊ:pɔɪnt] <i>n</i> точка зрения</p> <p>verify ['verɪfaɪ] <i>v</i> подтверждать</p> <p>way [weɪ] <i>n</i> метод, средство, способ</p> <p>to be made up of – быть сделанным из чего-л.</p> <p>by means of – с помощью, посредством</p> <p>cause-and-effect – причинно-следственный</p> <p>in particular – в частности, в особенности</p> <p>in reality – фактически, в действительности, на самом деле</p> <p>on account of – из-за, вследствие</p> <p>putting it another way – иначе говоря; другими словами</p> <p>this is not the case – это не так</p> <p>to a certain extent – в определенной степени</p>
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Task I. Pay attention to ...

I. Pay attention to the pronunciation of the following words.

- advocate** 1) *n* ['ædvəkeɪt] 1) защитник; сторонник, приверженец (*точки зрения, образа жизни*); 2) адвокат;
 2) *v* ['ædvəkeɪt] 1) отстаивать, выступать в поддержку, пропагандировать (*взгляды, позицию*); 2) советовать, рекомендовать
- postulate** 1) *n* ['pɒstjʊleɪt] 1) постулат; аксиома; 2) предварительное условие, важное допущение; вероятное предположение
 2) *v* ['pɒstjuleɪt] постулировать, принимать без доказательств, теоретически допустить

These words are pronounced in two different ways according to the part of speech.

compound 1) *n* ['kɒmpaʊnd] смесь, состав, соединение

2) *a* ['kɒmpaʊnd] сложный; составной

3) *v* [kəm'paʊnd] смешивать, комбинировать, сочетать, составлять

present 1) *a* ['preznt] 1) присутствующий; 2) настоящий, теперешний; современный; 3) данный, этот самый

2) *v* [prɪ'zent] 1) дарить (with); преподносить; 2) представлять

These words are stressed in two different ways according to the part of speech.

Read and translate the sentences. Pay special attention to the words in dark type.

1. The **present** paper refers to the corpuscular theory of light. Newton was a strong **advocate** of the theory.
2. Newton **advocated** the corpuscular theory of light.
3. The particle-like nature of light was **postulated**.
4. Newton **presented** his speculations in *Optiks* in the form of series of queries rather than as a set of **postulates**.
5. Atoms and molecules are **compound** particles.
6. The substance was **compounded** with certain chemicals.
7. At **present** light phenomena are interpreted in terms of both particles and waves.
8. He **advocated** us that this phenomenon should be analyzed in terms of the wave theory.

II. Pay attention to the following derivatives and translate them.

spectate → spectator

convince → convincing → convincingly

corpuscle → corpuscular

challenge → challenged → unchallenged

part → partly

reason → reasonable

strong → strongly

initial → initially

high → highly

general → generalize → generalization

science → scientist

success → successful

Suffixes:

-able *n* → *a*

-ar *n* → *a*

-ation/- (t)ion *v* → *n*

-ence *v* → *n*

-ful *n* → *a*

-ist *n* → *n*

-ize *v* → *n*

-ly *a* → *adv*

-ment *v* → *n*

-or *v* → *n*

Prefixes:

un- 'the opposite of' / 'not'

A fuller list of affixes is given on pp 9-13.

Make nouns from the following verbs and then underline the word that is different.

1) attract, develop, formulate, modify, predict, propagate, reflect, refract, relate, suggest

2) explain, form, interfere, interpret, observe

3) absorb, assume, conclude, describe, diffract, permit

III. Pay attention to the compounds. Read and translate them.

a: fast + moving = fast-moving; particle + like = particle-like; wave + like = wave-like

n: cause + and + effect = cause-and-effect

fast-moving particles, particle-like properties, wave-like nature, cause-and-effect relationship, wave-particle duality

☞ IV. Pay attention to the following international words. They are often called 'false friends of a translator' as they can be translated in different ways.

adequate ['ædɪkwɪt] *a* 1) адекватный, соответствующий; **Syn.** *corresponding, respective* 2) достаточный; **Syn.** *enough, satisfactory, sufficient* 3) компетентный; отвечающий требованиям, пригодный (к какой-либо деятельности); **Syn.** *qualified, suitable*

advocate v ['ædvəkeɪt] 1) отстаивать, выступать в поддержку, быть сторонником, пропагандировать (взгляды, позицию); **Syn.** *support, defend*; 2) советовать, рекомендовать; **Syn.** *advise, recommend*

evolution [ˌi:vəʊl(j)uːʃ(ə)n] *n* 1) эволюция, развитие; **Syn.** *development*; 2) выделение, выпускание (тепла, газа, света, звука); **Syn.** *emission*; 3) мат. извлечение корня; **Syn.** *Rooting*

examine [ɪg'zæmɪn] *v* 1) рассматривать, исследовать, изучать; **Syn.** *investigate, study*; 2) экзаменовывать, принимать экзамен; **Syn.** *test, question*

illustrate ['ɪləstreɪt] *v* 1) иллюстрировать, делать иллюстрации; **Syn.** *decorate*; 2) иллюстрировать, пояснять (примерами, цитатами, графиками, схемами и т.н.); **Syn.** *demonstrate, explain, show*

postulate ['pɒstjuleɪt] *v*

puzzle ['pʌzl] *v* приводить в затруднение, ставить в тупик; озадачивать; **Syn.** *perplex, confuse*;

puzzle out – разобраться в (чем-л.); разгадать; найти решение; понять; **Syn.** *work out, understand*

puzzle over – ломать голову над; **Syn.** *think hard about, deliberate on*

Match the word in bold with the corresponding word in the column to the right.

1. An adequate theory of light must explain our observations about light.	a) sufficient
2. I hope he is adequate enough to conduct such a significant experiment.	b) corresponding
3. It will be adequate to mention just several phenomena of light.	c) qualified
4. The corpuscular theory was initially advocated by most scientists.	d) advised
5. However, he advocated us to use this approach.	e) supported
6. Thomas Young performed an experiment that strongly advocated the wave-like nature of light.	
7. Evolution is a mathematical operation.	f) development
8. The process of the light evolution caused by high temperature is called incandescence.	g) emission
9. The evolution of physics is considered to have two periods, classical and modern.	h) rooting
10. In the paper we are going to examine the theories of light.	i) investigate
11. The prominent scientist will examine the students in physics.	j) test
12. A collection of light particles leaving a source is illustrated in Fig. 2.	k) decorated
13. The book is illustrated with photographs.	l) demonstrated
14. The phenomenon of wave-particle duality can be illustrated by the following example.	
15. The exact nature of visible light is a mystery that has puzzled man for centuries.	m) perplexed
16. Scientists puzzled out the nature of light.	n) thought hard about
17. She puzzled over the problem.	o) understood

☞ V. Pay attention to the following easily confused words.

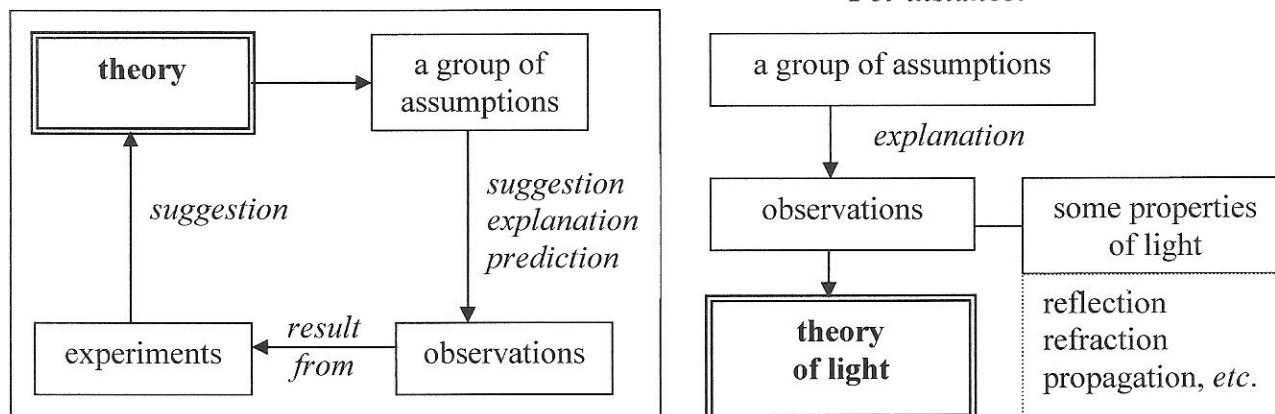
- a) **shade** [ʃeɪd] *n* тень (*protection from the sun*)
shadow ['ʃædəʊ] *n* тень (*the 'picture' made by something that blocks out light*)
- b) **so** [səʊ] *a* такой (*before adjective, adverb, 'much', 'many', 'few', and 'little'*)
such [sʌtʃ] *a* такой (*before noun, adjective + noun*)
- c) **same** [seɪm] *pron* один и тот же; одинаковый
some [sʌm] *pron* несколько, некоторый

Choose the correct word to complete the sentences.

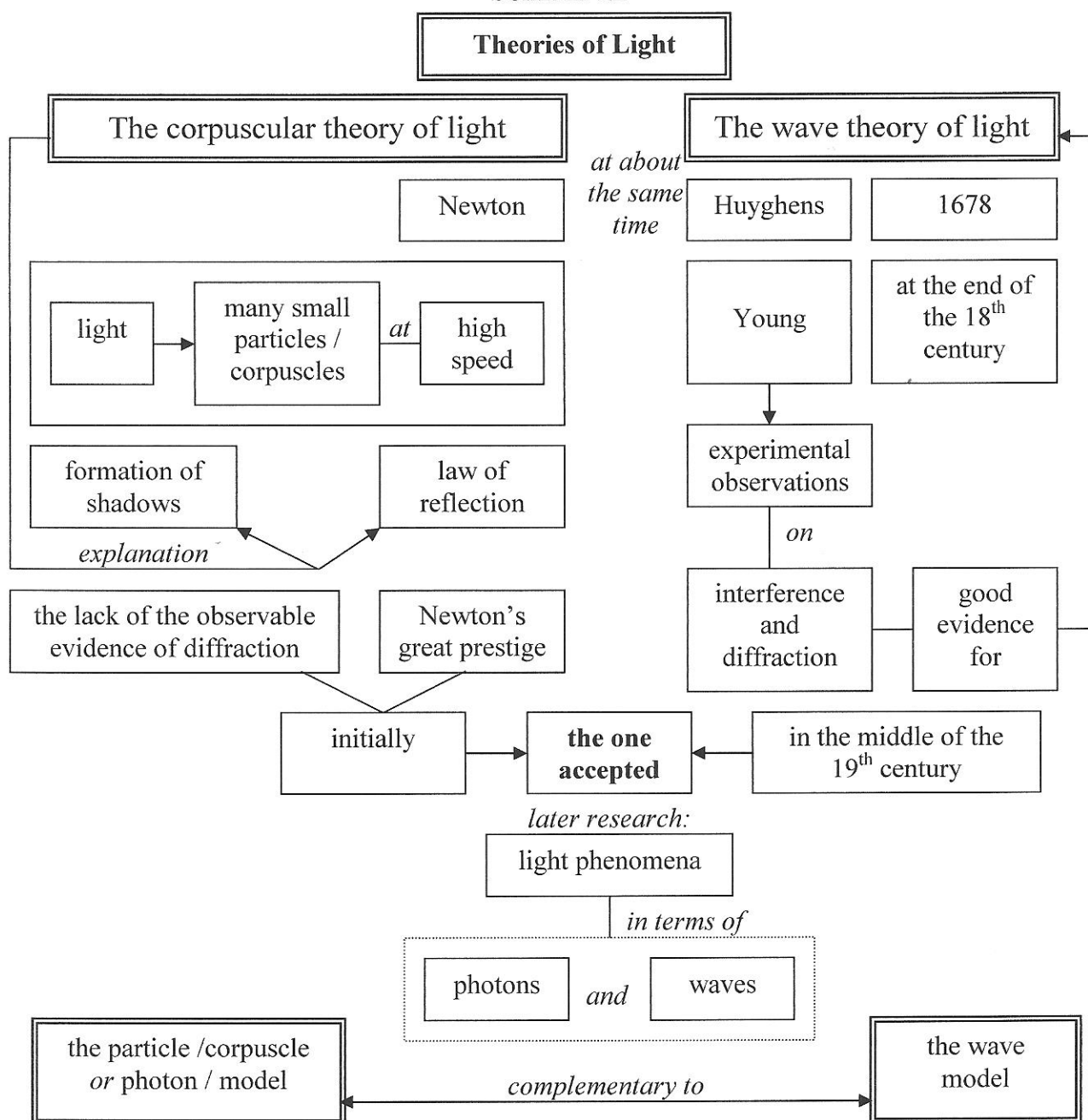
1. The corpuscular theory accounts for the formation of (*shade / shadow*).
2. The temperature is 30 degrees in the (*shade / shadow*).
3. Newton's prestige was (*so / such*) great that most scientists accepted his theory of light.
4. Newton had (*so / such*) a great prestige that most scientists accepted his theory of light.
5. His prestige in the scientific community carried (*so / such*) much weight that his theory on the nature of light was originally accepted by most scientists.
6. When two beams of (*so / such*) particles are crossed, (*same / some*) of the particles would collide with each other.
7. The two descriptions are merely the two different ways of interpreting one and the (*same / some*) phenomenon.
8. The corpuscular theory explains (*same / some*) properties of light.
9. Both theories were proposed almost at the (*same / some*) time.
10. A theory must be universal, or as (*same / some*) call it, adequate.

Stage 2 – Schemes

SCHEME 7.1

For instance:

SCHEME 7.2



Task 1. Do the following exercises, using the schemes given on the left-hand page as a prompt.

SCHEME 19

I. Complete the sentences:

1. A theory is a group of ... suggested by ... to explain the ... and to predict other ... which result from ... suggested by the
2. For instance, a group of ... which explains the observations of some ... of light such as ..., ..., etc., constitutes a theory of

II. Answer the following questions:

1. What is a theory?
2. What constitutes a theory of light?

SCHEME 20

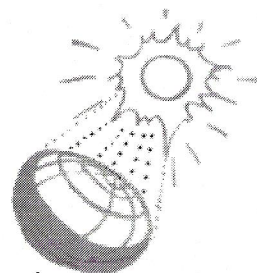
I. Confirm or refute the following statements (make use of the expressions given on page 169):

1. There is one theory of light: the corpuscular theory.
2. Both theories were developed at about the same time.
3. The corpuscular theory was developed by Young.
4. Newton assumed that light consists of many small particles or corpuscles moving at a high speed.
5. The corpuscular theory does not explain the formation of shadows and the law of reflection.
6. Largely due to the lack of the observed evidence of diffraction of light and to Newton's great prestige, the wave theory was initially the only accepted by most scientists.
7. Originally the wave theory was put forward by Young in 1678.
8. At the end of the 18th century the wave theory of light was developed by Young.
9. Young's experimental observations on interference and diffraction were a good evidence for the wave theory of light.
10. In the middle of the 19th century the corpuscular theory was accepted by most scientists.
11. Later research has shown that light phenomena must be considered in terms of waves only.
12. Thus the particle /corpuscle or photon/ model is complementary to the wave model.

II. Answer the following questions:

1. What theories of light do you know?
2. Who developed the corpuscular theory of light?
3. What does light consist of according to the corpuscular theory?
4. What does the corpuscular theory explain?
5. Why was the corpuscular theory initially the one accepted by most scientists?
6. Who put forward the wave theory of light?
7. When was the wave theory of light developed by Young?
8. What is the evidence for the wave theory obtained from?
9. When was the wave theory of light accepted by most scientists?
10. Do we have to consider light phenomena in terms of photons or waves?
11. Is the particle /corpuscle or photon/ model complementary to the wave one?

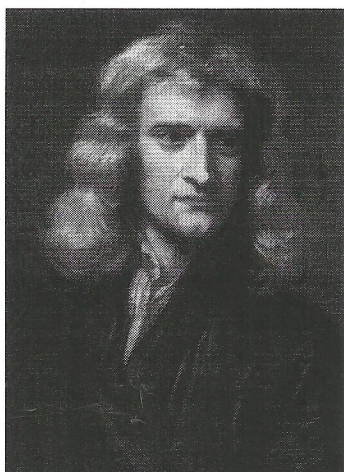
III. Discuss the theories of light.

Stage 3 – Text**Theories of Light**

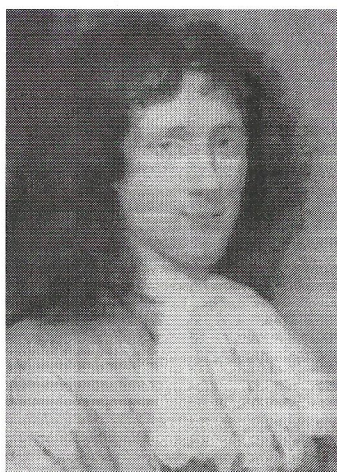
The origin of the word “theory” comes from the Greek word “*thorós*” meaning spectator. The word’s origin emphasizes the fact that all theories are mental models of the perceived reality.

A theory is a coherent set of assumptions or facts suggested by observations that can be used to make a rational interpretation of cause-and-effect relationship among observed phenomena and a successful prediction of other natural phenomena which result from experiments suggested by the theory. For instance, a group of assumptions which enables us to provide a reasonable explanation of the observed behaviour and properties of light such as reflection, refraction, absorption, *etc.*, constitutes a theory of light.

In the paper we are going to examine the theories of light. The exact nature of visible light is a mystery that has puzzled man for centuries. Light was thought either to consist of fast-moving particles or of propagating waves. Greek scientists from the ancient Pythagorean discipline postulated that every visible object emits a steady stream of particles, while Aristotle concluded that light travels in a manner similar to waves in the ocean. These ideas have undergone numerous modifications and a significant degree of development over the past 20 centuries.



Sir Isaac Newton
(1642-1727)



Christian Huygens
(1629-1695)

Fig. 1

Pioneers in Visible Light Physics

Hence the history of modern optics is to a certain extent a history of the struggle of the two theories: the corpuscular and wave theories of light. Both theories were proposed almost at the same time. The corpuscular theory of light was developed by Newton in 1672. Huygens, the Dutch physicist, formulated the wave theory in 1678. The corpuscular theory of light was initially favoured over the wave theory partly on account of Newton’s great prestige and partly due to the lack of observed evidence of diffraction of light. Newton’s particle viewpoint went essentially unchallenged for over a century. Young’s experimental observations on interference and diffraction (1803) became a compelling evidence for the wave theory of light and in the middle of the 19th century it was accepted by most physicists. Later research has shown that in reality both theories turned to be correct, *i.e.* the two descriptions are merely the two different ways of interpreting one and the same phenomenon.

The most prominent advocate of the corpuscular theory of light was Isaac Newton. According to this theory light is supposed to be made up of many small discrete particles called 'corpuscles' (little particles) travelling in straight lines with a finite velocity and possessing kinetic energy.

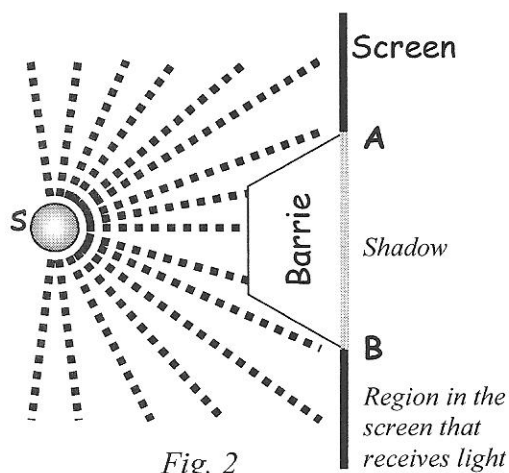


Fig. 2

A theory must be universal, or as some call it, adequate; that is, an adequate theory of light must explain our observations about light. The corpuscular theory accounts for several properties of light, in particular the photoelectric effect. The formation of shadows by opaque objects can also be interpreted using the terminology of the corpuscular theory. Fig. 2 illustrates a collection of light particles leaving a source S in many different directions. No light particles from S striking the screen between points A and B because of the barrier, this part of the screen is in a shadow. Newton could easily explain the law of reflection in terms of the corpuscular theory as well. To reconcile his particle model with the phenomenon of refraction, Newton

assumed particles of different colours of light to have slightly different masses, resulting in different speeds in transparent media and hence different angles of refraction. Newton presented his speculations in *Optiks* in the form of series of queries rather than as a set of postulates. However, the corpuscular theory fails to explain other effects, such as double refraction, interference, diffraction and polarization of light.

Although Newton, himself, appeared to have some doubt about his corpuscular theory, his prestige in the scientific community carried so much weight that his theory on the nature of light was originally accepted by most scientists. Despite the highly regarded reputation of Sir Isaac Newton, a number of prominent scientists in the early 1700s did not agree with his corpuscular theory. Some argued that if light consisted of particles, then when two beams of such particles were crossed, some of the particles would collide with each other to produce a deviation in the light beams. Obviously, this is not the case, so they concluded that light must not be composed of discrete particles.

Almost a hundred years after Newton and Huygens proposed their theories, an English physicist Thomas Young performed an experiment that strongly supported a wave-like nature of light. In the middle of the nineteenth century the evidence for a wave nature of light became overwhelming. Theoretical and experimental work convincingly established light as an electromagnetic wave, and the original corpuscular theory of light was abandoned in favour of the wave one.

The quantum theory put forward by Max Planck in 1900 combined both theories and showed that light does sometimes behave like a particle and sometimes like a wave. All particles were proved to possess a wave nature and vice versa. This phenomenon has been verified not only for elementary particles, but also for compound ones like atoms and even molecules. For instance, electrons undergo diffraction and interference with each other as waves, but they also exhibit particle-like properties. Hence light phenomena must be interpreted in terms of both particles (corpuscles / photons) and waves, putting it another way, the two theories are complementary to each other. The phenomenon is called the wave-particle duality.

NOTES ON THE TEXT

Pythagorean [paɪ,θæɡ(ə)'ri:ən] – 1) пифагорейский;

2) пифагореец, последователь Пифагора

Aristotle ['arɪstɒt(ə)l] – Аристотель

Dutch [dʌtʃ] – нидерландский, голландский

Christian Huygens ['krɪstɪən 'haɪɡənz] –

Христиан Гюйгенс

Thomas Young ['tɒməs jʌŋ] – Томас Юнг

Planck Max [mæks plɑ:nk] – Макс Планк

Task II. Read the text and then do the following exercises.

I. In the text, find the English equivalents for the words and phrases below:

- | | |
|---|---|
| <ul style="list-style-type: none"> ○ мысленные / умозрительные модели ○ причинно-следственная связь ○ разумное объяснение (<i>find two equivalents</i>) ○ загадка, которая ставила в тупик ○ быстрые частицы ○ ученые, последователи древнего учения Пифагора ○ непрерывный поток частиц ○ распространяется подобно волнам ○ подверглись многочисленным (видо)изменениям ○ корпускулярную теорию света первоначально предпочитали волновой теории ○ существенным образом, не вызывала никаких возражений | <ul style="list-style-type: none"> ○ всего лишь два различных способа толкования / объяснения ○ самый знаменитый сторонник ○ так как ни одна частица из (источника) S не ударяет экран ○ в виде ряда вопросов, а не как ряда постулатов ○ корпускулярная теория не может объяснить ○ очевидно, что это не так ○ волновая природа света ○ от первоначальной корпускулярной теории света отказались в пользу волновой ○ свет, на самом деле, ведет себя иногда как |
|---|---|

III. Make up as many sentences as possible:

e.g. In 1678 the corpuscular theory of light was presented by Newton.

Originally the wave theory was abandoned by the majority of scientists.

Initially the wave theory was not accepted by most physicists.

<ul style="list-style-type: none"> • In 1672 • In 1678 • In 1900 • Originally • Initially • Later • In (the middle of) the 19th century • At the beginning of / In the 20th century 	<ul style="list-style-type: none"> • the corpuscular theory • the wave theory • the quantum theory • the wave-particle duality 	was (not)	<ul style="list-style-type: none"> • brought in • developed • formulated • presented • proposed • put forward • suggested 	by	<ul style="list-style-type: none"> • Newton • Huygens • Planck 	
			<ul style="list-style-type: none"> • accepted • abandoned 		<ul style="list-style-type: none"> • most • many • the majority of • a lot of • lots of • plenty of • a considerable number of • a huge number of • a small number of • a tiny number of • few 	<ul style="list-style-type: none"> • scientists • physicists
			<ul style="list-style-type: none"> • favoured over • abandoned in favour of 		<ul style="list-style-type: none"> • the corpuscular theory • the wave theory 	

III. Use suitable forms of the words from the box instead of the underlined ones.

1. The word “theory” takes its origin from the Greek word “thorós” meaning spectator.
2. The corpuscular theory of light was initially accepted due to Newton’s great prestige.
3. Newton’s particle viewpoint went essentially unchallenged for over a century.
4. Light is made up of many small discrete particles called ‘corpuscles’ travelling in straight lines.
5. Fig. 2 illustrates a collection of light particles.
6. No light particles from S strike the screen between points A and B because of the barrier.
7. Newton presented his speculations in *Optiks* in the form of series of queries.
8. Young’s experiment strongly supported the wave theory of light.
9. Both theories are merely the two different ways of interpreting one and the same reality.
10. This phenomenon has been verified not only for elementary particles.

- a) authority
- b) consideration
- c) method
- d) observer
- e) question
- f) set
- g) standpoint
- h) separate
- i) to advocate
- j) to confirm
- k) to demonstrate
- l) to explain
- m) to move
- n) to hit
- o) to consist of
- p) heavily
- q) originally
- r) simply
- s) on account of

IV. Rewrite sentences as in the example.

The wave theory gives an explanation for interference of light.

*The wave theory **explains** interference of light.*

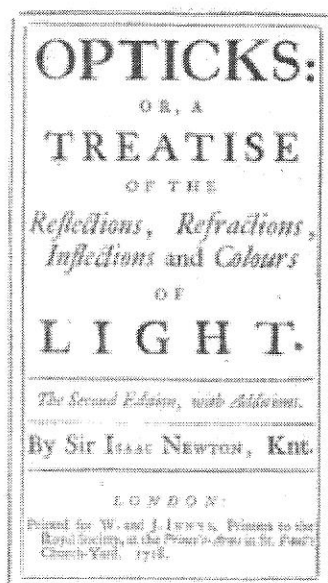
1. Newton made an assumption that light consists of small particles.
2. Huygens put forward a suggestion that light possesses a wave-like nature.
3. We cannot make an observation of diffraction under ordinary conditions.
4. The corpuscular theory provides an explanation for the law of reflection.
5. Newton made a supposition that corpuscles are attracted by the refracting surfaces.
6. A theory is a set of assumptions which enables us to make an interpretation of our observations and a prediction of natural phenomena.

V. Change the following sentences from active into passive as in the example.

The wave theory gives a reasonable explanation for interference of light.

A reasonable explanation for interference of light is given by the wave theory.

1. Newton made an assumption that light consists of small particles.
2. Huygens put forward a suggestion that light possesses a wave-like nature.
3. We cannot make an observation of diffraction under ordinary conditions.
4. The corpuscular theory provides an explanation for the law of reflection.
5. Newton made a supposition that corpuscles are attracted by the refracting surfaces.
6. Newton presented speculations about light in his great work *Optiks*.



VI. Rewrite the sentences using emphatic constructions, as in the example, and translate them.

A) 'it is / was ... that / which / who' – **именно, только**

Huygens proposed the wave theory.

It was Huygens that / who proposed the wave theory.

Именно Гюйгенс предложил волновую теорию.

The wave theory explains diffraction of light.

It is the wave theory that / which explains diffraction of light.

Именно волновая теория объясняет дифракцию света.

1. Greek scientists from the ancient Pythagorean discipline postulated that every visible object emits a steady stream of particles.
2. Aristotle concluded that light travels in a manner similar to waves in the ocean.
3. Young's experimental observations on interference and diffraction became a compelling evidence for the wave theory of light.
4. Thomas Young performed an experiment that strongly supported a wave-like nature of light.
5. The quantum theory put forward by Max Planck in 1900 combined both theories.
6. The corpuscular theory accounts for the photoelectric effect.

B) 'do / does / did + V' – **действительно, на самом деле, все же, несомненно, фактически, ведь**

Light behaves sometimes like a particle and sometimes like a wave.

Light does behave sometimes like a particle and sometimes like a wave.

Свет, на самом деле, ведет себя иногда как частица, а иногда как волна.

7. The origin of the word 'theory' emphasizes the fact that all theories are mental models of the perceived reality.
8. Most scientists accepted the corpuscular theory because of to the lack of observed evidence of diffraction of light.
9. A number of prominent scientists in the early 1700s abandoned the corpuscular theory.
10. However, the corpuscular theory fails to explain other effects, such as interference and diffraction of light.
11. All particles posses a wave nature and vice versa.
12. At present we interpret light phenomena in terms of both particles and waves.

VII. Rewrite sentences emphasising the underlined words.

The wave theory explains diffraction of light.

It is the wave theory that / which explains diffraction of light.

The wave theory explains diffraction of light.

It is diffraction of light that the wave theory explains.

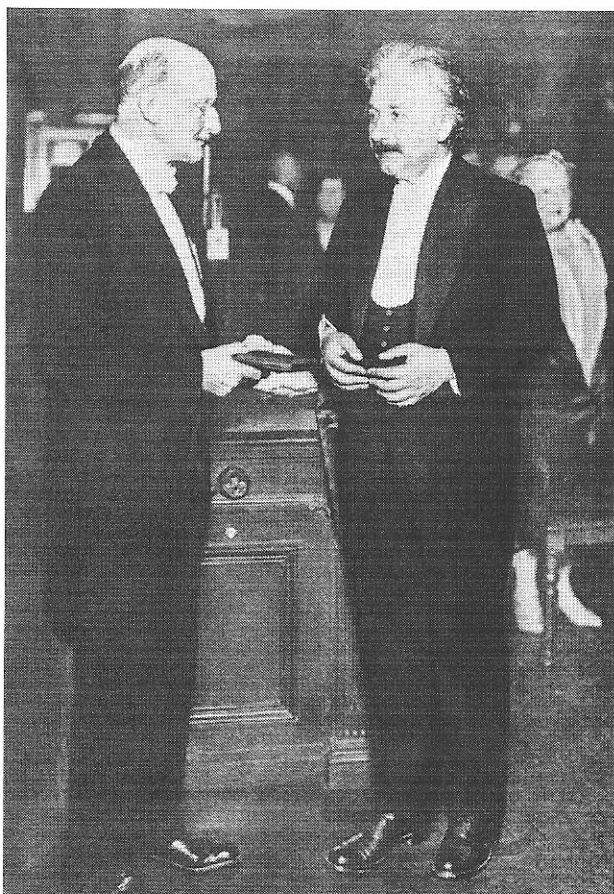
1. Many scientists accepted the corpuscular theory due to Newton's great prestige.
2. Many scientists accepted the corpuscular theory due to Newton's great prestige.
3. Newton could easily account for the law of reflection in terms of the corpuscular theory.
4. Newton could easily account for the law of reflection in terms of the corpuscular theory.
5. An adequate theory of light must explain our observations about light.
6. The wave theory of light was initially abandoned by the majority of scientists.
7. The evidence for a wave nature of light became overwhelming in the 19th century.
8. Thomas Young performed his famous experiment almost a hundred years after Newton and Huygens proposed their theories.
9. The wave-particle duality is used to interpret the behaviour of light.

The student makes ...
It is the student that / who makes ...
 Students make ...
It is students that / who make ...
 Students made ...
It was students that / who made ...
 Science makes ...
It is science that / which makes ...
 Science made ...
It was science that / which made ...

V → do V
 V_s → does V
 V₂ → did V

subject → **who / which / that**
 object → **that**
 adverbial phrase → **that**

VIII. Read the passage below and say if the photon theory developed by Einstein is a revision of the corpuscular theory formulated by Newton.



In 1900 M. Planck introduced rather a startling hypothesis that light is emitted in bundles in the black body enclosure and that the amount of energy in each bundle is related to the frequency of light by $E = h\nu$. In this way h , Planck's constant ($h = 6.626 \times 10^{-34} \text{ J sec}$), the quantum of action, was first introduced.

Five years later A. Einstein picked up the theme first introduced by Planck and proposed that light is not only emitted in units of energy $E = h\nu$, but it is also absorbed in such bundles which he called photons. The photon theory did not abandon the wave concept completely but stated that the energy of light is not distributed over the whole front, but rather is concentrated or localized in tiny bundles 'photons'.

One must not think that the photon theory is a revision of the corpuscular theory. Corpuscles were thought of as actual particles of matter, whereas photons represent bundles of energy that have no rest mass¹. This means once the photon stops, it ceases existing and its energy is transferred to whatever stopped it.

¹ **rest mass** ['rest 'mæs] the measured mass of particle, or a body, if it were motionless, or at rest, relative to an observer (from "Longman Dictionary of Scientific Usage")

IX. Answer the questions based on the text.

1. What does the word "theory" mean?
2. Did ancient scientists consider light to be particles or waves?
3. Who were the pioneers in visible light physics? What theories of light did they develop?
4. Was the corpuscular or wave theory initially accepted by most scientists? Why?
5. Could Newton easily explain the formation of shadows in terms of the corpuscular theory?
6. What phenomena of light are also accounted for by Newton's particle viewpoint?
7. Did the corpuscular theory explain all the properties of light?
8. Originally nobody accepted the wave theory of light, true or false?
9. When did the evidence for a wave nature of light become overwhelming?
10. What theory of light turned out to be correct?

X. Add details from the text "Theories of Light" to schemes 7.1 and 7.2 and then describe the schemes using your own words. While describing, make use of

- 1) the following grammar structures:
 - a) emphatic constructions 'it is / was ... that / which / who'; 'do / does / did V';
 - b) complex object '... consider/considers ... to V/ V_{ing} / V_2 ';
 - c) complex subject '... is/are known to V/ V_{ing} / V_2 ';
- 2) the expressions given on pages 167 – 168.

XI. Write an abstract (a summary) of the text. The instructions for writing an abstract are given on pages 173 – 175.

Stage 4 – Definitions**From “Longman Dictionary of Scientific Usage”
Set A**

theory 1. A theory is a structure in which each step depends on preceding steps. The structure can be stated in terms of concepts in relation. The whole structure rests upon *observations* (↓) and on theoretical *assumptions* (↓). The advantages of scientific theory are that it can be used for the description, the classification, and the explanation of *observed* (↓) events. It can also be used for *the prediction* (↓) of future events. Take the Kinetic Theory of gases as an example. Step 1: observations are made on the pressure, volume, temperature and mass of samples of different gases. These are the empirical foundations of the theory. Step 2: concepts of pressure, volume, temperature and mass are formulated. Step 3: the theoretical concept of the molecules is introduced and it is given theoretical properties. Step 4: concepts arising from Newton’s Principles (momentum, force, energy) are introduced. These are related to the concepts of pressure, volume, and temperature. These relations lead to the final statement of the theory in mathematical terms. Step 5: $pV = \frac{1}{2}nm\bar{u}^2$. Steps 2 to 5 are the structure of the theory. This statement can be used to explain: Boyle’s Law, Charles’ Law, Graham’s law of Diffusion, and the evaporation of liquids. It can be used to predict *the velocities* (→)¹ of molecules in specific gases at certain temperatures. **2.** The process of investigation by logical or mathematical reasoning, rather than by *experiment* (↓). Also the principles and reasoning associated with a practical process, e.g. the theory of an experiment to determine *refractive index* (→)² may depend on *Snell’s law* (→)² and the principle of no-parallax. **3** An idea or thought about the reasons for or causes behind a phenomenon. In this sense theory is used in the same way as *hypothesis* (↓), e.g. my theory is that all solids have an absorbed layer of gas on their surface.

observe To perceive in a special way concentrating on particular phenomena with a view to describing or understanding them, e.g. a man sees a star as he sees a passing bird but when he observes a star, he isolates a star from the rest of his percepts, examines it carefully, and describes it and its motion accurately in the terms available in astronomy. – **observation** (n.)

observation Intentional use of the sense, or the extended senses, for a special purpose, e.g. one can make an observation of light interference by means of *reflection* (→)² and *refraction* (→)² of light. – **observe** (v.)

assume To take a statement or a fact to be true for the purpose of a particular discussion, and not necessarily to have to prove or to show it to be true during the discussion, e.g. **a)** assume molecules to be completely elastic in gaseous collisions; **b)** assume the formula for the volume of a sphere in a calculation; **c)** assume *the value* (→)³ of *gravitational acceleration* (→)⁴ to be 10 m s^{-2} (correct value is 9.8065 m s^{-2}) in order to make calculation easier. – **assumption** (n.)

assumption That which is assumed, i.e. a fact that is taken to be true without any *evidence* (↓). – **assume** (v.)

predict To give a description of future events in which certain principles and conditions are assumed to be valid. If the principles and conditions are fulfilled, then the event will follow, e.g. it is possible to predict the behaviour of celestial bodies in terms of Newton’s Theory of Gravity. – **prediction** (n.), **predictable** (a.)

evidence The *observations* (↑) or *generalizations* (↓) on which a law, *hypothesis* (↓), principle, or *theory* (↑) may be based, e.g. evidence for the wave theory of light is obtained from experimental observations on *interference* (→)⁵ and *diffraction* (→)⁵. – **evident** (a.)

¹ – see “KINEMATICS”

² – see “GEOMETRICAL OPTICS”

³ – see “UNITS OF MEASUREMENT”

⁴ – see “NEWTON’S THEORY OF GRAVITY”

⁵ – see “THEORIES OF LIGHT” (Set B)

generalization The process or result of making a statement about a class of objects from a statement about one individual object or a statement about a few individuals. A generalization is a jump from a number of **singular statements** to a **universal one**.

A **singular statement** is the one made about individual objects, organisms, concepts, e.g. 'this man has hair' is a singular statement about one particular man; it is based on *observations* (↑). Similar statements can be made about other men, or other animals, e.g. 'this cat has hair'.

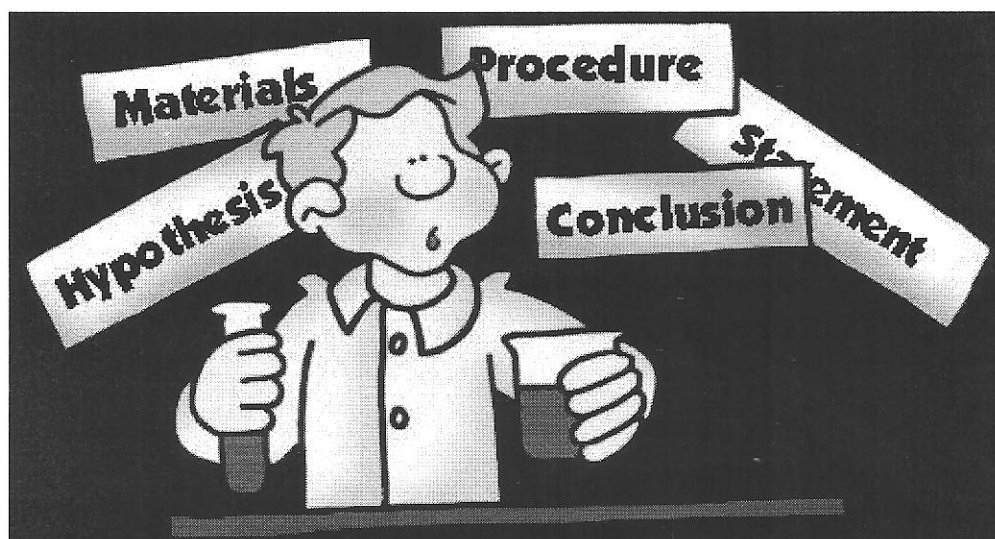
A **universal statement** is the one made about a whole class of objects, organisms, concepts e.g. 'all men have hair' and 'all mammals have hair' are universal statements made by generalization of the singular statements above. Note that generalizations are not necessarily true. They are only true within the limits of the original observations.

empirical generalization A *generalization* (↑) made from *observations* (↑) or *experimental* (↓) *evidence* (↑).

experiment An experiment is an operation carried out to study by *observation* (↑) the behaviour of substances, materials or organisms under definite circumstances. The circumstances are controlled by the observer to isolate that part of a phenomenon or reaction he wishes to observe and the conditions under which they happen. The

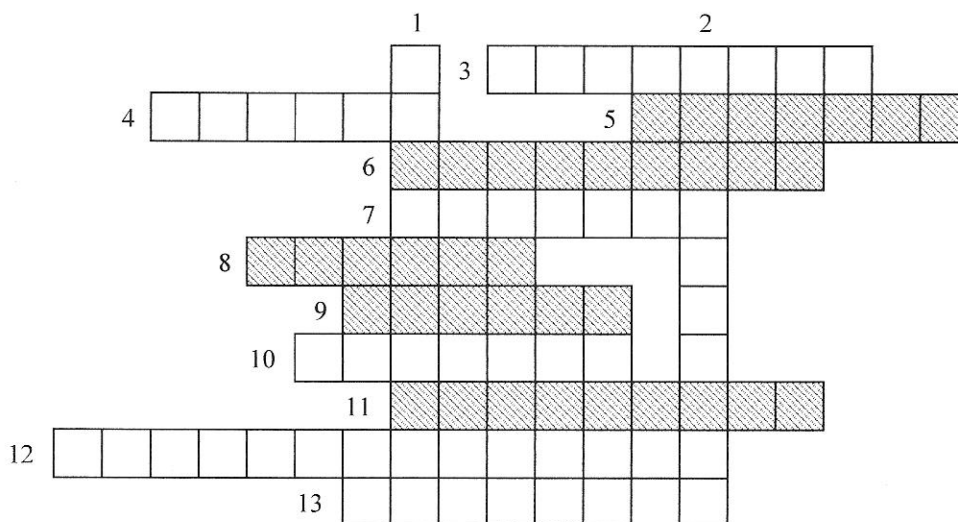
object of an experiment is to obtain new knowledge. Experiments may lead to new *empirical generalizations* (↑) or may test *hypotheses* (↓) and *theories* (↑), e.g. experiments carried out to study the propagation of light under definite circumstances led to the foundation of Special Theory of Relativity. – **experimental** (a.)

hypothesis A hypothesis is any sentence which has a consequence of at least one *empirical generalization* (↑). In addition, a statement which contradicts the hypothesis cannot be proved after a definite number of *observations* (↑). A hypothesis always contains theoretical terms, e.g. Avogadro's Hypothesis: the sentence 'Equal volumes of all gases at the same temperature and pressure contain the same number of molecules' is a hypothesis. The theoretical term is a molecule. The empirical generalization which is a consequence of the hypothesis is 32 g of oxygen, 28 g of nitrogen, 2g of hydrogen, at standard temperature and pressure each has a volume of 22.4 dm³. The contradiction would be 'At the same temperature and pressure all gases contain different numbers of molecules'. This statement would require as many observations as there are gases at every possible temperature and pressure. Each of these observations would need to be confirmed by a number of different observers. – **hypothetical** (a.)



Task III (A). Read the definitions of the terms from “Longman Dictionary of Scientific Usage” and do the following exercises.

I. Crossword Place the words into the crossword. Pay attention to the fact that some terms have not been defined in the list of definitions given above. (You find them in the shaded columns reading across.) Complete this list after solving the puzzle.



Down

- 1) any sentence which has a consequence of at least one empirical generalization;
- 2) a trial made in order to study by observation the behaviour of substances under definite conditions.

Across

- 3) the observation or generalization on which a law, hypothesis, principle, or theory may be based
- 4) a structure based on observations and on theoretical assumptions; it can be used for the explanation of observed events and for prediction of future events;
- 5) to make (something) clear by speaking or writing; to give reasons for a statement or a series of statements; to account for
- 6) a hypothesis accepted as a suitable starting point for theoretical work, *e.g.* Avogadro's Hypothesis is now known as Avogadro's ..., as it is used as a starting point for theoretical work on gases;
- 7) to watch carefully, to perceive in a special way concentrating on particular phenomena with a view to describing or understanding them;
- 8) an elementary particle; a quantum of electromagnetic radiation;
- 9) a dark area produced when an opaque object is placed in the path of a beam of light;
- 10) to see or describe a future happening as a result of valid reasons, conditions, knowledge, *etc.*
- 11) a vehicle by which we move from thought to language; it finds expressions as a spoken or written sentence; it can be discussed or explained; it can be true or false; it can be singular or universal;
- 12) the act of making a general statement resulting from the consideration of particular cases;
- 13) to take as true without any proof for the purpose of a particular discussion.

II. Read the paper carefully and correct mistakes, viz., match the basic principles of the scientific method and their descriptions. Then write your own example of the cycle of theory and experiment in terms of your speciality.

THE SCIENTIFIC METHOD

... Most scientists today would agree on the basic principles of the scientific method listed below:

BASIC PRINCIPLES	DESCRIPTION
(1) <i>Science is a cycle of theory and experiment.</i>	(a) An experiment should be treated with suspicion if it only works for one person, or only in one part of the world. Anyone with the necessary skills and equipment should be able to get the same results from the same experiment. This implies that science transcends national and ethnic boundaries; you can be sure that nobody is doing actual science who claims that their work is “Aryan, not Jewish,” “Marxist, not bourgeois,” or “Christian, not atheistic.” An experiment cannot be reproduced if it is secret, so science is necessarily a public enterprise.
(2) <i>Theories should both predict and explain.</i>	(b) Scientific theories are created to explain the results of experiments that were created under certain conditions. A successful theory will also make new predictions about new experiments under new conditions. Eventually, though, it always seems to happen that a new experiment comes along, showing that under certain conditions the theory is not a good approximation or is not valid at all. The ball is then back in the theorists’ court. If an experiment disagrees with the current theory, the theory has to be changed, not the experiment.
(3) <i>Experiments should be reproducible.</i>	(c) The requirement of predictive power means that a theory is only meaningful if it predicts something that can be checked against experimental measurements that the theorist did not already have at hand. That is, a theory should be testable. Explanatory value means that many phenomena should be accounted for with few basic principles. If you answer every “why” question with “because that’s the way it is,” then your theory has no explanatory value. Collecting lots of data without being able to find any basic underlying principles is not science.

As an example of the cycle of theory and experiment, a vital step toward modern chemistry was the experimental observation that the chemical elements could not be transformed into each other, e.g. lead could not be turned into gold. This led to the theory that chemical reactions consisted of rearrangements of the elements in different combinations, without any change in the identities of the elements themselves. The theory worked for hundreds of years, and was confirmed experimentally over a wide range of pressures and temperatures and with many combinations of elements. Only in the twentieth century did we learn that one element could be transformed into one another under the conditions of extremely high pressure and temperature existing in a nuclear bomb or inside a star. That observation didn’t completely invalidate the original theory of the immutability of the elements, but it showed that it was only an approximation, valid at ordinary temperatures and pressures.

From ‘Light and Matter’ by Benjamin Crowell

*Aryan [’eɪən] а арийский

*Jewish [’dʒu:ɪʃ] а еврейский; иудейский

*Marxist [’mɑ:ksɪst] а марксистский

*Christian [’krɪstjən] а христианский

III. Translate into English in pen.

Основным методом физики является научный метод исследования. Научный метод исследования можно разделить на следующие последовательные /consecutive/ этапы:

- 1) проводятся наблюдения и опыты (эксперименты);
- 2) вводятся понятия и величины, описывающие свойства наблюдаемых процессов или объектов;
- 3) создаются* модели наблюдаемых процессов или объектов;
- 4) выдвигаются гипотезы, т.е. предположения о закономерных связях различных характеристик наблюдаемых процессов или объектов;
- 5) проводятся эксперименты, позволяющие установить (определить) справедливость /validity/ выдвинутых гипотез;
- 6) формулируются законы, принципы; создаются* теории;
- 7) применяются сформулированные законы; создаются* теории к решению частных задач;
- 8) создаются* устройства; решаются задачи прикладного характера на основе полученных знаний.

*создавать –

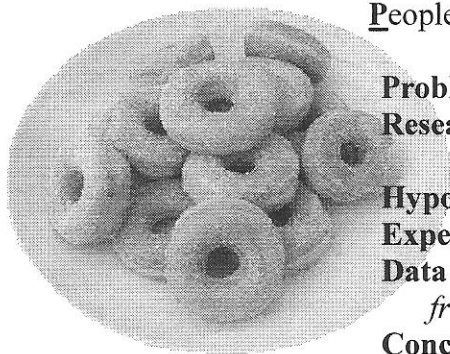
- 1) create (в разн. значениях);
- 2) found (об учении, теории);
- 3) set up (об организации и т.п.)

Fun with
Words

МNEMONIC DEVICES
МНЕМОНИЧЕСКИЕ ПРИЕМЫ

The following mnemonic helps you remember fundamental steps in the scientific method. The first letter of each word gives you the first letter the step.

People Really Hate Eating Doughnuts And Cold Cider.



Problem (ask a question and formulate a **problem**)

Research (do background **research** – gain information about the problem)

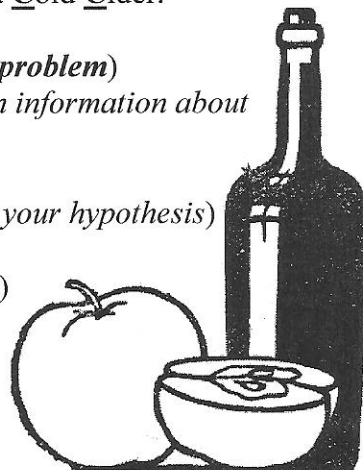
Hypothesis (form a **hypothesis**)

Experiment (conduct **experiments** to test your hypothesis)

Data and Analysis (record **data** obtained from the experiment and **analyze** them)

Conclusion (draw a **conclusion** if your hypothesis is correct or not)

Communication (report your results)



Set B

wave 1. A disturbance which passes on *energy* (\rightarrow)⁶ through a material medium by means of the elastic and internal characteristics of the medium. The disturbance causes displacement of the particles of the medium, the particles returning to their position of rest after the disturbance has passed. The displacement of a particle follows a pattern of oscillation about its position of rest, and passing through its position of rest; it oscillates from side to side, with its displacement being relatively small. The disturbance is passed on from particle to particle by the elasticity of the medium, and the internal characteristics of the medium help to determine the speed with which the energy is passed on. Waves on the sea are a simple example; a boat rises and falls with the waves, but it does not travel with them. **2.** A disturbance which passes on *energy* (\rightarrow)¹ through empty space by variations in the electric and magnetic properties of space. The electric and magnetic fields at a particular point in space increase and decrease regularly. Transmission of energy in this way is by electromagnetic waves.

wave motion The transmission of energy through a medium by the forward movement of waves. In a material medium the particles do not move forward, only the disturbances represented by waves move forward. The essential characteristics of wave motion are *interference* (\downarrow) and *diffraction* (\downarrow); these differentiate the transference of energy by wave motion from the transference of energy by a stream of particles. *Transverse wave motion* (\downarrow) can be polarized; *longitudinal wave motion* (\downarrow) cannot be polarized.

transverse wave motion 1 A form of transference of energy in which disturbances of the particles in a material medium displace the particles in a direction at right angles to the direction of propagation. **2** Electromagnetic waves are transmitted in space, or in a material medium, by transverse waves. In either case, disturbance of the medium produces variations in electric or magnetic properties of the medium which are

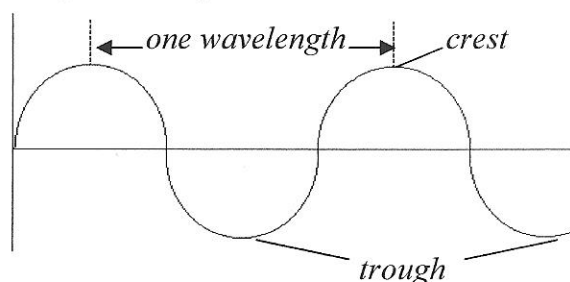
both at right angles to the direction of propagation and at right angles to each other.

longitudinal wave motion A form of transference of energy in which disturbances of the particles in a material medium displace the particles in the same direction as that of propagation, e.g. sound waves are longitudinal waves, with alternating regions of compression and *refraction* (\rightarrow)⁷.

wavelength In a regular wave, the distance between one oscillating particle and the nearest oscillating particle with the same displacement and moving in the same direction (such particles are in *phase* (\downarrow)). In a *transverse wave motion* (\uparrow) it is the distance between *the crest* (\downarrow) of one wave and the crest of an adjacent wave. In a *longitudinal wave motion* (\uparrow) it is the distance between one point of the maximum compression and an adjacent point of the maximum compression. Wavelength is defined as the distance between any two successive points of a wave, which are in the same phase. The symbol for wavelength is λ (the Greek letter lambda).

crest The position of the maximum displacement or disturbance in a wave. In a graph of the wave form, it is the upper limit of the curve of a wave. A regular *wave motion* (\uparrow) consists of a number of equidistant crests.

trough The position of the maximum



displacement or disturbance opposite to the displacement at a crest. A trough exists between any two crests of a regular *wave motion* (\uparrow). It is one of the points at which the wave form has a minimum *value* (\rightarrow)⁸.

¹ – see “PHYSICS”

² – see “GEOMETRICAL OPTICS”

³ – see “UNITS OF MEASUREMENT”

wave train A succession of groups of *waves* (↑) travelling in the same direction and originating from the same *source* (→)¹.

phase Particles, or points, in the path of a *wave motion* (↑), are said to be in phase if their displacements are of the same *magnitude* (→)² and the particles, or points, are travelling in identical directions. If two waves are travelling in the same direction and their *crests* (↑) coincide in time, the waves are in phase. Any two waves not in phase are said to be out of phase.

frequency The number of complete oscillations performed in one second. In a *transverse* (↑) *wave* (↑) this is the same as the number of *wave crests* (↑) assumed to pass a reference point in one second. In a *longitudinal* (↑) *wave* it is the same as the number of points of the maximum compression assumed to pass a reference point in one second. The symbol of frequency is *f* or *ν* (the Greek letter nu), and frequency is measured in hertz (Hz)

amplitude The maximum displacement, on either side of a mean position, of an oscillating particle, e.g. in a wave it is a displacement between the rest or zero position and a *crest* (↑) (or *trough* (↑)).

wave front The surface formed by joining adjacent points which possess the same *phase* (↑) in the path of a *wave motion* (↑). Generally it is regarded as the advancing limit of a wave motion in two or three dimensions in a medium.

coherent 1. Describes the electromagnetic waves that have identical *phases* (↑). 2. Describes *sources* (→)¹ of electromagnetic radiation that produce coherent waves. Coherent sources are usually formed by doubling a single source using two slits.

interference The interaction of two *wave trains* (↑) when they are superposed. The wave trains must be *coherent* (↑) and of the same *frequency* (↑), and must be of the same, or of comparable, *amplitude* (↑). In such wave trains, if the *crest* (↑) of one wave is

superposed on the *trough* (↑) of another, the wave is destroyed at that point; if a crest is superposed on a crest, the waves reinforce each other. The amplitudes of the waves at any point, when superposed, are added algebraically. The superposition of two wave trains of light produce alternate bands of brightness and darkness; this is interference. Similarly, other *wave motions* (↑) produce alternate bands of no energy and higher energy than the individual waves. The examples of interference are, **a**) beats formed by sound waves; **b**) the phenomenon of *diffraction* (↓). Interference is a phenomenon which distinguishes the transmission of energy by a wave motion from the transmission by a *beam* (→)¹ of particles.

interference bands The bands of alternate high *amplitude* (↑) and low amplitude formed by the superposition of two *coherent* (↑) *wave trains* (↑). With a *monochromatic* (↓) *source* (→)¹ of light, the bands are alternately bright and dark; with white light, the interference bands are coloured. A similar effect, invisible but detectable, is formed by other monochromatic *wave motions* (↑).

diffraction A phenomenon associated with a *wave motion* (↑) when a *wave train* (↑) passes the edge of an obstacle opaque to the wave motion; the phenomenon is a particular case of interference. The waves are bent at the edge of the obstacle, which acts as a *source* (→)¹ of secondary waves, all *coherent* (↑). Interference between a primary wave and a secondary wave produces diffraction bands, which are, in fact, *interference bands* (↑). Although a wave motion travels by rectilinear propagation, the edge of the geometric shadow of an obstacle is marked by interference bands. With white light, coloured diffraction bands are formed; with monochromatic light, bright and dark bands are formed. If the wave motion is passed through a slit, the intensity of the band is increased when the width of the slit is of the same order of *magnitude* (→)² as the *wavelength* (↑) of the wave motion.

¹ – see “PHOTOMETRY”

² – see “UNITS OF MEASUREMENT”

diffraction grating A device for dispersing a wave train (↑) into its constituent wavelengths (↑). It consists of a series of parallel obstacles (opaque to the wave) or a series of parallel slits, each of the width of the same order as the wavelength in the wave train. Each slit causes diffraction and the bending of the wave is proportional to the wavelength of the impinging wave train.

monochromatic 1. Describes light, or any other electromagnetic radiation, of one wavelength (↑) only. 2. Describes a source (→)¹ that emits monochromatic radiation.

polychromatic 1. Describes light, or any other electromagnetic radiation composed of many different wavelengths (↑). 2. Describes a source (→)¹ of polychromatic radiation.

¹ – see “PHOTOMETRY”

Task III (B). Read the definitions of the terms from “Longman Dictionary of Scientific Usage” and then do the following exercises.

☞ I. **Pairs of Definitions** Match the two definitions given in English and Russian for the same term and then write the term (in English and in Russian) for each pair of definition.

the distance between any two successive points of a wave, which are in the same phase

1

a

волна, в которой возмущения ориентированы перпендикулярно направлению ее распространения

a device for dispersing a wave train into its constituent wavelengths; it consists of a series of parallel obstacles (opaque to the wave) or a series of parallel slits, each of the width of the same order as the wavelength in the wave train

2

b

волна, в которой возмущения ориентированы вдоль направления ее распространения

a wave in which disturbances of the particles displace the particles in the same direction as that of propagation

3

c

состояние, на которое распространяется волна за время, равное периоду колебания точки среды

electromagnetic waves that have identical phases

4

d

электромагнитные волны одинаковой частоты, если разность фаз не зависит от времени


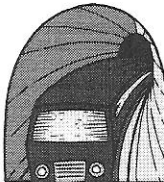
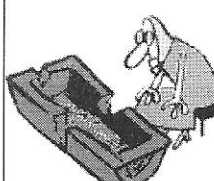

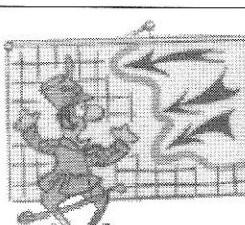

a wave in which disturbances of the particles displace the particles in a direction at right angles to the direction of propagation

5

e

совокупность большого числа узких параллельных щелей, имеющих одинаковую ширину и расположенных в плоскости на одинаковом расстоянии друг от друга

✎ **II. Scientific and Everyday English** The words in the middle column below all have more than one meaning. Match each of them with a picture and a definition of everyday English and with a definition of scientific English.

Everyday English	Terms	Scientific English
 <p>1) a showy tuft or outgrowth on a bird's or animal's head</p>	trough	a) (of a wave) the advancing limit of a wave motion in two or three dimensions in a medium
 <p>2) a line of connected railway carriages drawn by engine</p>		
 <p>3) a long narrow boxlike container, especially for holding water or food for animals</p>	crest	b) one of the points at which the wave form has a minimum value
 <p>4) a singular or particular movement or a way of moving (e.g.: He made a ... with his hand as if to greet me.)</p>		
 <p>5) a line along which fighting takes place in time of war</p>	motion	c) they are formed by the superposition of two coherent wave trains
 <p>6) a set of musicians</p>		
	band	d) one of the points at which the wave form has a maximum value
	front	e) (of a wave) a succession of groups of waves travelling in the same direction and originating from the same point
	train	f) (of a wave) the transmission of energy through a medium by forward movement of waves

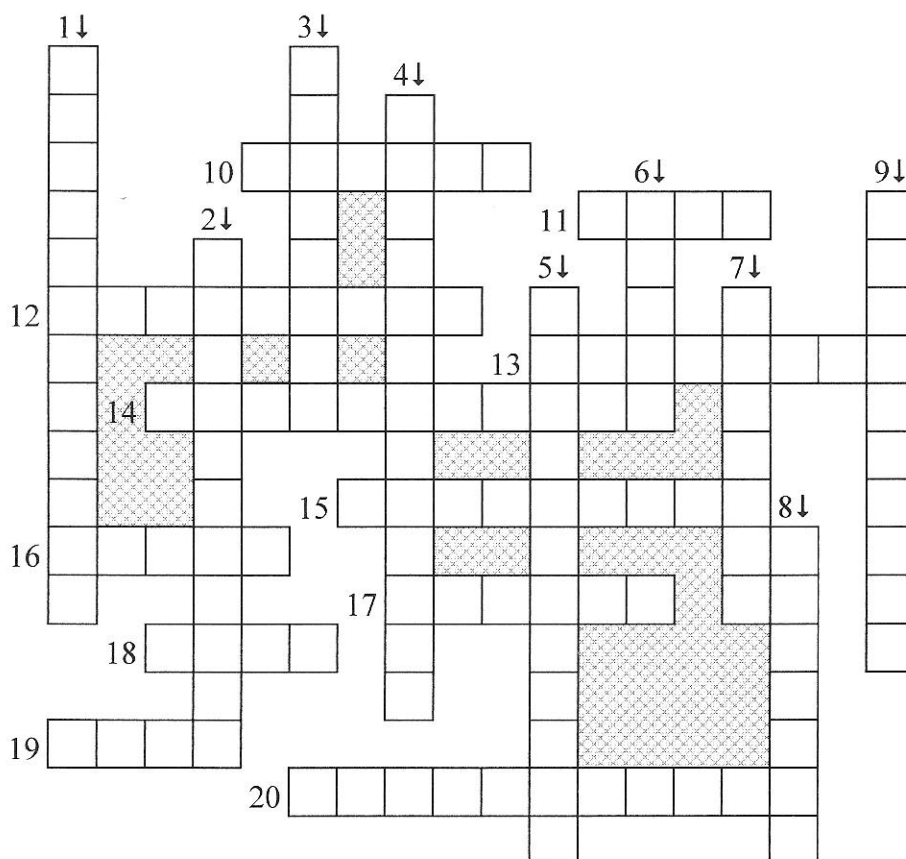
III. Crossword

Down:

- 1) the superposition of the two wave trains of light producing alternate bands of brightness and darkness;
- 2) at an equal distance;
- 3) electromagnetic waves that have identical phases;
- 4) light composed of many different wavelengths;
- 5) (of a wave motion) a form of transference of energy in which disturbances of the particles in a material medium displace the particles in the same direction as that of propagation;
- 6) if the particles are travelling in identical directions and if their displacements are of the same magnitude, these particles are in ...;
- 7) a model;
- 8) a series of parallel slits, each of the width of the same order as the wavelength in the wave train;
- 9) the distance between the crest of one wave and the crest of an adjacent wave.

Across:

- 10) a set of assumptions which enables us to explain observations;
- 11) a round mark or a stain;
- 12) the number of complete oscillations performed in one second;
- 13) something that stands in the way and prevents action or success;
- 14) an act of changing the usual or natural condition;
- 15) a displacement between the rest or zero position and a crest;
- 16) one of the points at which the wave form has a maximum value;
- 17) one of the points at which the wave form has a minimum value;
- 18) a stripe;
- 19) a narrow straight cut or opening;
- 20) a particular case of interference.



☛ IV. Translate into English in pen.

Волны – возмущения (изменения состояния вещества или поля), распространяющиеся в среде или пространстве с конечной /finite/ скоростью. Распространение волн связано с переносом энергии без переноса вещества.

Наиболее важные виды волн: упругие /elastic/ (механические) волны (в том числе звук, ультразвук), волны на поверхности жидкости, электромагнитные волны (в том числе радиоволны, свет, рентгеновское излучение и т.д.).

При распространении волн возможны явления **отражения, преломления, дисперсии, дифракции, интерференции, поглощения и рассеяния.**

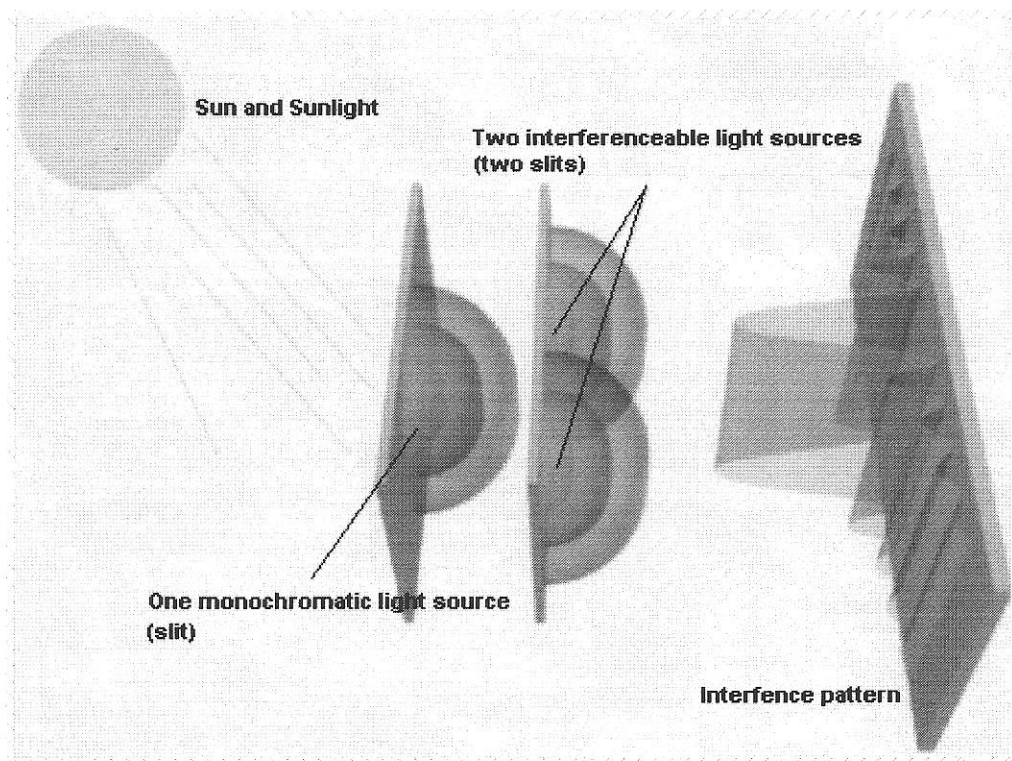
По ориентации возмущения относительно направления распространения волны делятся на **продольные** и **поперечные**.

Упругие (механические) волны – механические возмущения, распространяющиеся в упругих средах. В твердых телах могут распространяться и продольные и поперечные упругие волны, а в жидкостях и газах – только продольные.

Электромагнитная волна – распространяющееся в пространстве переменное электромагнитное поле. Все электромагнитные волны являются поперечными.

Task IV. Let's play the game 'Research Conference'. The instructions are given on pages 170 – 172. Discuss the following topics:

- ❑ The Scientific Method
- ❑ The Corpuscular Theory of Light
- ❑ Waves. Wave Motion. Wavelength
- ❑ The Wave Theory of Light
- ❑ Interference and Diffraction of Light
- ❑ Young's Experimental Procedure
- ❑ Diffraction Grating



Stage 5 – In Addition**Shadows**

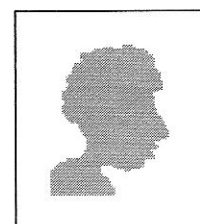
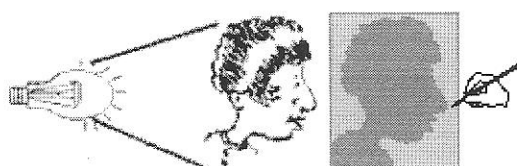
Ой, тени, тени черные,
Кого вы не нагоните?
Кого не перегоните,
Вас только, тени черные,
Нельзя поймать, объять!

Некрасов

Caught Shadows

Our ancestors could ‘catch’ shadows and derive benefit from them. How did they do that? They drew silhouettes [ˌsɪlu(:)ʔets] by means of shadows. Nowadays due to the photography we have got the opportunity to impress¹ both our own features and those of our relatives and friends in the memory. But in the 18th century our ancestors were not so happy. Portraits were very expensive and few people could order them. That is why silhouettes were so popular. They replaced photography to some extent. Figure 1 shows an age-old way of making silhouettes. So, silhouettes can be said to be a ‘caught’ and ‘fixed’ shadows.

You also can ‘catch’ your shadow following the instructions given below.



1. Stand between a bright light and an empty wall. Stand sideways so the shadow of your profile falls on the wall. Use a bright lamp or pick a sunny day when the sun casts² a strong shadow.
2. Fasten³ a sheet of dark paper on the wall, so your shadow falls on the paper. If the light is bright, it will cast a shadow even on black paper. The shadow is a silhouette.
3. Ask someone to outline⁴ your silhouette on the paper. Remember to stand still! Now, you can finish by yourself.
4. Very carefully, cut out the silhouette.
5. Place it in the centre of a white piece of cardboard and glue⁵ it in place.
6. You can make the silhouette into a present for someone by decorating it. For instance, cut out hearts from red or pink paper and glue them around your silhouette. If you really want to be fancy, add a bit of paper lace. Such a silhouette makes an especially nice Valentine's gift. Do you know anyone who would like one?



¹ **impress** [ɪmˈpres] to fix in the mind

² **cast** [kɑːst] (often lit) to throw or drop

³ **fasten** [fɑːsn] fix firmly, tie or join together

⁴ **outline** [ˈaʊtlaɪn] 1) a line showing the shape of something; 2) to draw in outline

⁵ **glue** [gluː] 1) sticky substance used for joining things together; 2) to fasten with glue
(from "Active Dictionary of English")

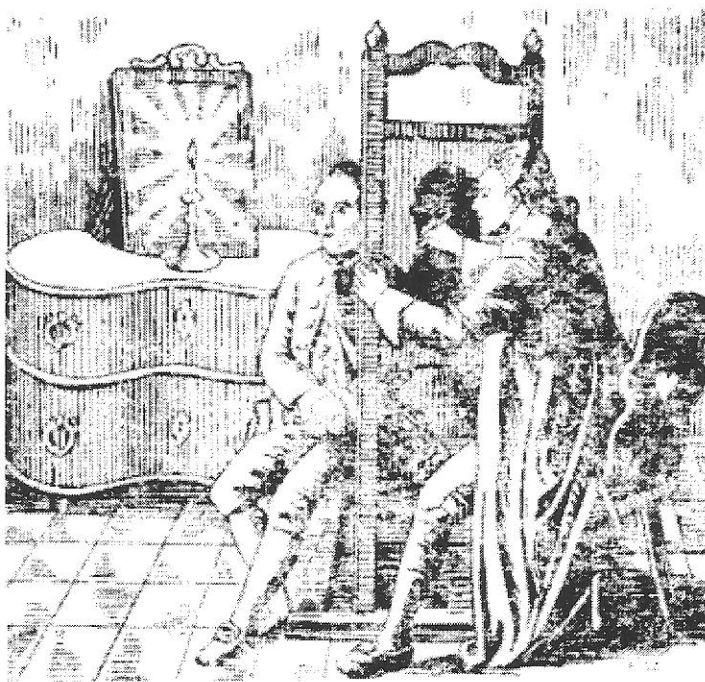


Fig1. A device used to make silhouettes

Experiment

What a great surprise!

Do you want to play a trick on your friend?

You will need a mirror, a sheet of paper covering the surface of this mirror, and a table-lamp or a candle. Take a sheet of paper and cut out absurd squint eyes, a deformed crooked nose, and an ugly mouth with bared teeth. Fasten this sheet of paper on the mirror. Invite your friend to enter the room illuminated by a table-lamp or a candle only. Ask him (or her) to stand so that his (or her) shadow falls on the wall and to shut his (or her) eyes. Take the mirror and put it so that rays of light reflected from the slits (*i.e.* the cut eyes, nose, and mouth) form a funny face on the shadow of your friend. It will be a great surprise for your friend when he (or she) opens his (or her) eyes!

Why not to play such a practical joke on your friend on April 1?

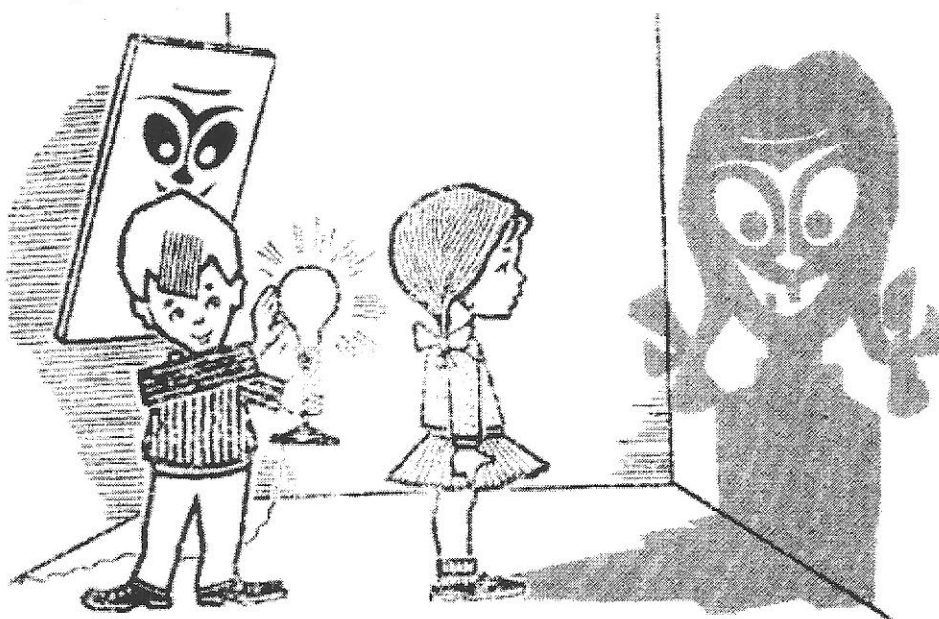
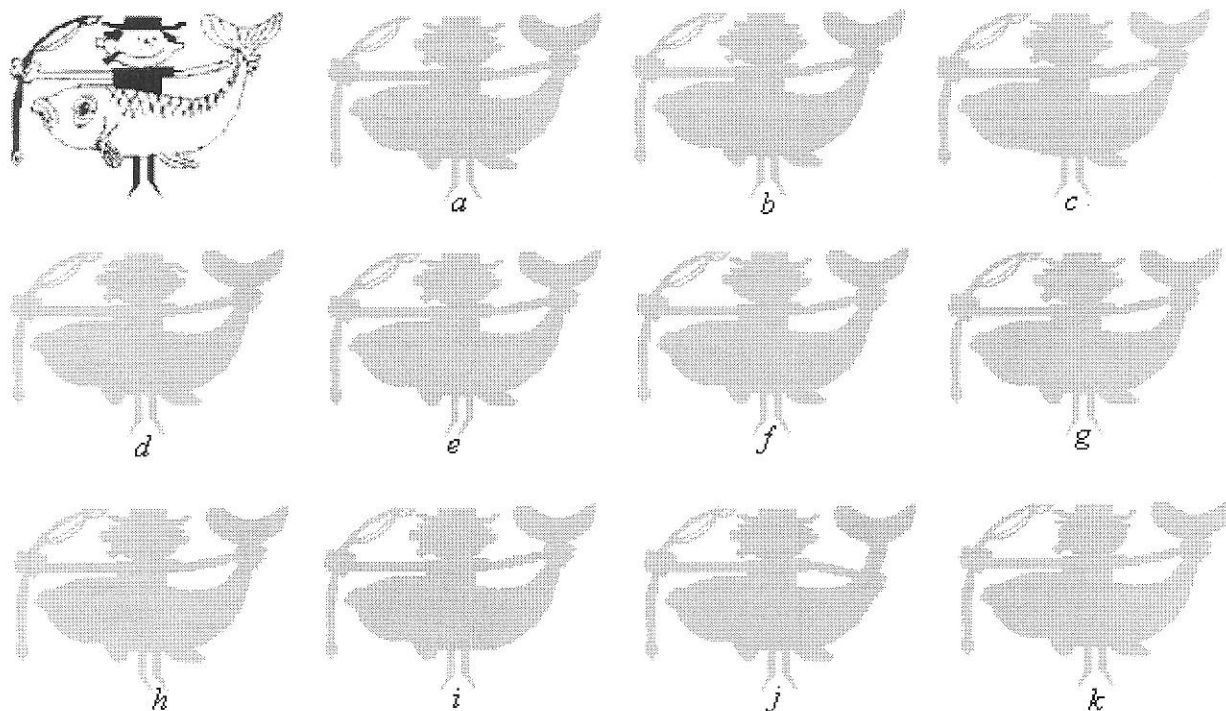


Fig. 2

Think and Guess

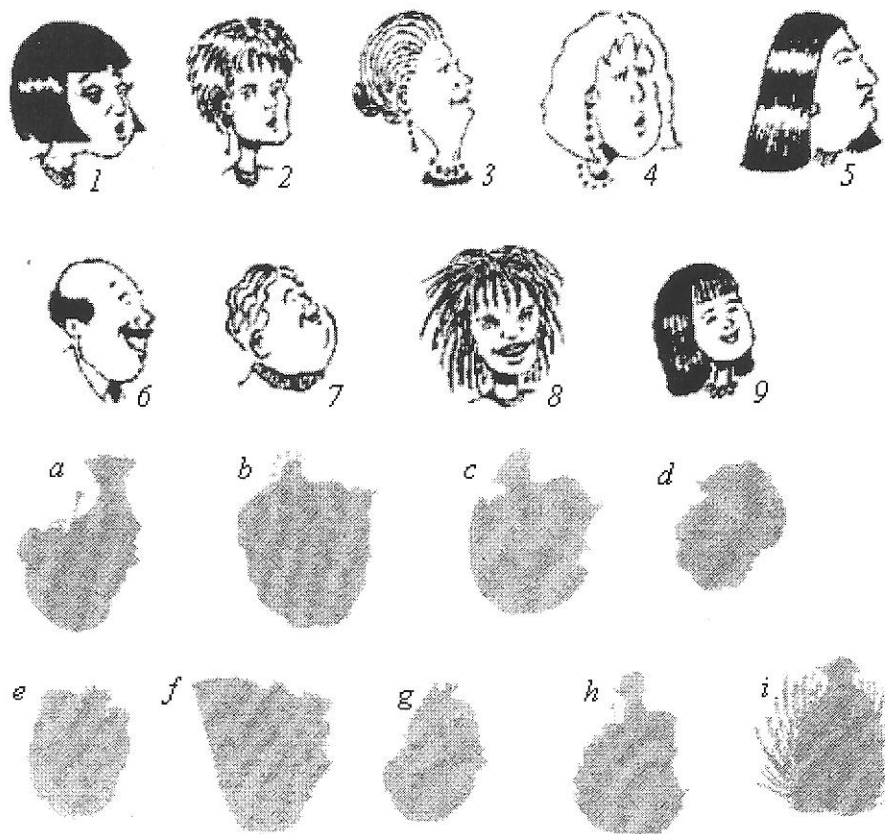
1. False Shadows

Only one of the shadows matches the picture, which one?



2. Turned Shadows

Match each person with his or her shadow.



3. Shadow Idioms

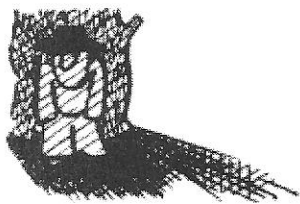


Fig. 1

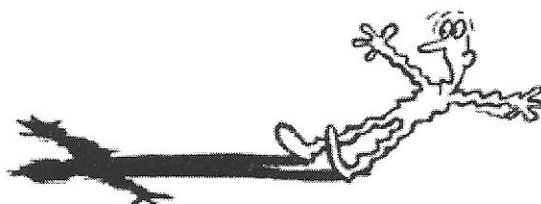


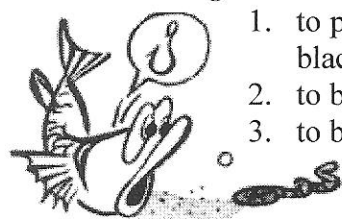
Fig. 2



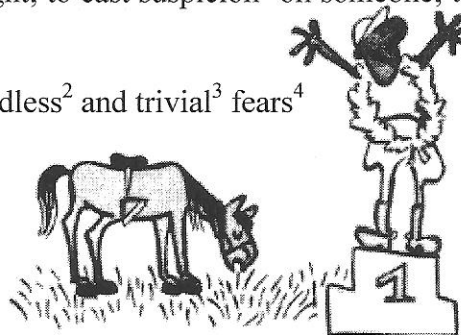
Fig. 3

There are some idioms and sayings in Russian that are connected with the word 'shadow'. Three of them are illustrated here (Figures 1-3). What are they? Write down these Russian idiomatic expressions and then match each of them with its correct meaning and its English equivalent.

Correct meanings:



1. to put someone or something in a bad light; to cast suspicion¹ on someone; to blacken someone's reputation;
2. to behave so as to remain unnoticed;
3. to be unreasonably nervous due to groundless² and trivial³ fears⁴



English equivalents:

- a) to be afraid of one's own shadow;
- b) to cast a slur⁵ on someone's reputation / good name;
- c) to stay in the background

¹ **suspicion** [səs'pɪʃən] an unconfirmed belief

² **groundless** ['graundlɪs] (of feelings, ideas, etc.) without base or good reason

³ **trivial** ['trɪvɪəl] of little importance

⁴ **fear** [fɪə] the feeling that one has when danger is near; the feeling that something (usually unpleasant) is likely to happen

⁵ **slur** [slə:] a discredit remark

(from "Active Dictionary of English")