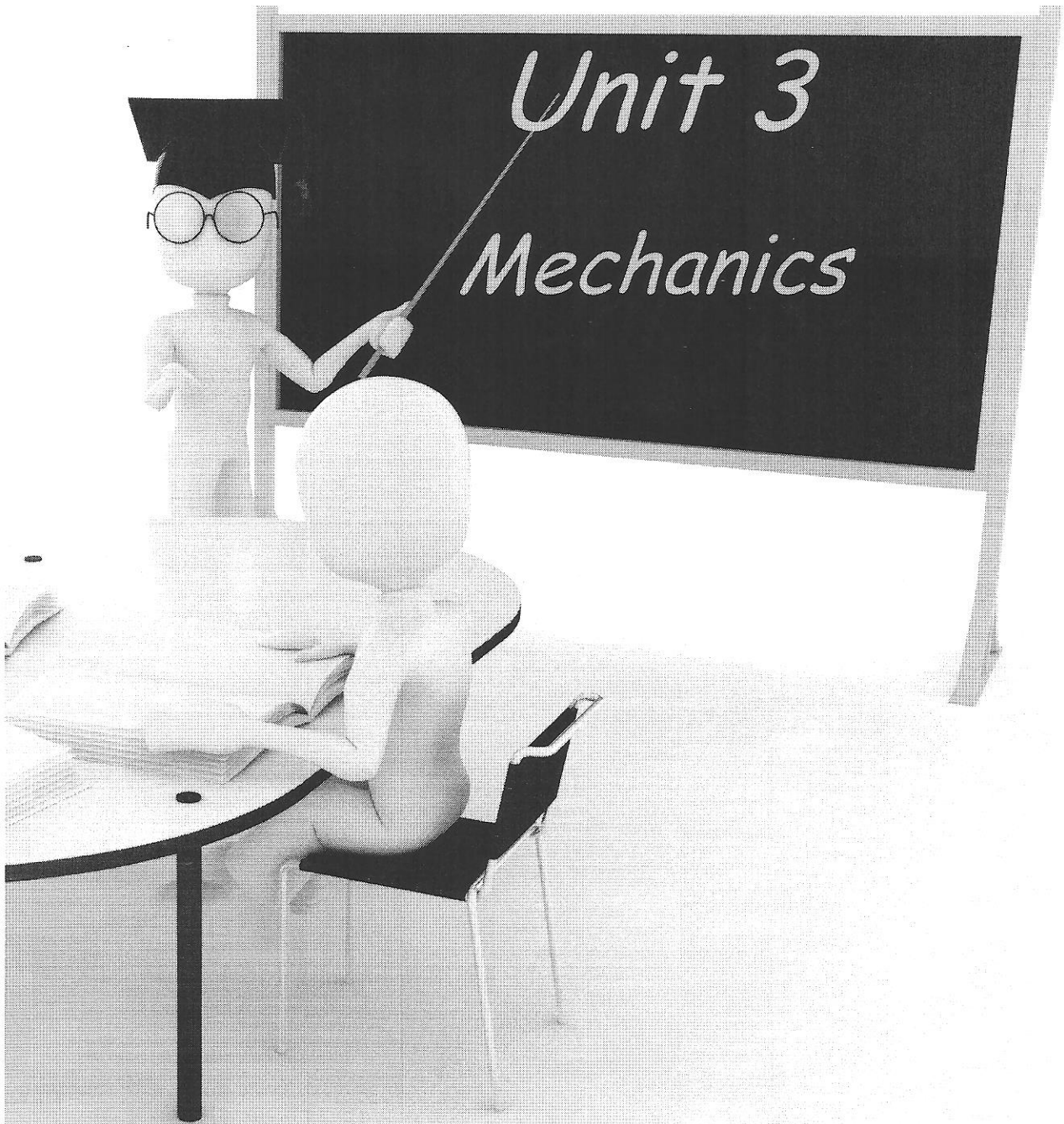

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Mechanics

Stage 1 – Vocabulary

civilization [ˌsɪvɪlaɪ'zeɪʃ(ə)n] *n*	interval ['ɪntəv(ə)l] *n*	planet ['plænɪt] *n*
comet ['kɔmɪt] *n*	kinematics [ˌkɪnɪ'mætɪks]/[ˌkaɪ–] *n*	position [pə'zɪʃ(ə)n] *n*
coordinate [kəu'ɔ:dnɪt] *n*	kinetics [kɪ'netɪks]/[kaɪ'–] *n*	symbol ['sɪmb(ə)l] *n*
discipline ['dɪsɪplɪn] *n*	mechanics [mɪ'kænɪks] *n*	symbolize ['sɪmbəlaɪz] *v*
dynamics [daɪ'næmɪks] *n*	normal ['nɔ:məl] *a*	synonym ['sɪnənɪm] *n*
galaxy ['gæləksɪ] *n*	periodic [ˌpɪərɪ'ɔdɪk] *a*	vector ['vektə] *n*

acceleration [æk,selə'reɪʃ(ə)n] *n* ускорение
act [ækt] действовать
affect [ə'fekt] *v* влиять, (воз)действовать
appear [ə'pɪə] *v* появляться
average ['ævərɪdʒ] *a* средний (*о величине*)
both [bəuθ] 1) *pron* оба;
2) *cj* **both ... and ...** – как ... так и ...
broad [brɔ:d] *a* широкий
cause [kɔ:z] **1)** *n* причина, основание, повод;
2) *v* причинять, вызывать, заставлять
comparatively [kəm'perətɪvlɪ] *a* сравнительно; относительно
complete [kəm'pli:t] *a* полный
concern [kən'sə:n] *v* касаться, иметь отношение
condition [kən'dɪʃ(ə)n] *n* 1) условие; 2) *pl.* обстоятельства; **under conditions** – при условиях, обстоятельствах
consider [kən'sɪdə] *v* 1) рассматривать, обсуждать; 2) полагать, считать
convenient [kən'vi:njənt] *a* удобный, подходящий
cover ['kʌvə] *v* проходить (*расстояние*)
describe [dɪs'kraɪb] *v* описывать
dimension [daɪ'menʃ(ə)n]/[dɪ'–] *n* измерение; размерность; (*pl.*) размеры, величина
direction [daɪ'rekʃ(ə)n]/[dɪ'–] *n* направление
displacement [dɪs'pleɪsmənt] *n* перемещение
distinction [dɪs'tɪŋkʃ(ə)n] *n* 1) различение; разграничение; 2) различие, отличие; разница
duration [dju(ə)'reɪʃ(ə)ŋ] *n* продолжительность
earth [ə:θ] *n* (планета) земля
effect [ɪ'fekt] **1)** *n* (воз)действие, влияние;
2) *v* производить, осуществлять, совершать
environment [ɪn'vaɪər(ə)nmənt] *n* окружение, окружающая обстановка; окружающая среда
equilibrium [ˌi:kwɪ'lɪbrɪəm] *n* равновесие
fluid ['flu(:)ɪd] *n* жидкость
foundation [faun'deɪʃ(ə)n] *n* фундамент; основание, основа
heavenly ['hevnlɪ] *a* небесный
indicate ['ɪndɪkeɪt] *v* означать
instant ['ɪnstənt] *n* мгновение, момент
invention [ɪn'venʃ(ə)n] *n* изобретение
location [lə(u)'keɪʃ(ə)n] *n* местонахождение
numerically [nju(:)'merɪk(ə)lɪ] *adv* 1) в цифрах, с помощью цифр; 2) в числовом отношении
ordinary ['ɔ:d(ə)nɪrɪ] *a* обычный; простой
path [pɑ:θ, *pl* pɑ:ðz] *n* путь, траектория;
curved path – кривая
plane [pleɪn] *n* плоскость, проекция
precise [prɪ'saɪs] *a* точный
produce [prə'dju:s] *v* 1) производить; создавать; 2) вызывать, быть причиной
rate [reɪt] *n* темп; ход, скорость
recent ['ri:snt] *a* недавний, последний; новый, свежий, современный
refer (to) [rɪ'fə:] *v* 1) ссылаться (на); 2) рассматривать, говорить (о), упоминать
reference ['refrəns] *n* ссылка
remain [rɪ'meɪn] *v* оставаться
sense [sens] *n* смысл, значение
signify ['sɪgnɪfaɪ] *v* значить, означать
speed [spi:d] *n* скорость
standpoint ['stændpɔɪnt] *n* точка зрения
star [stɑ:] *n* звезда; светило
state [steɪt] **1)** *n* состояние; **2)** *v* точно определять, устанавливать
subject *n* ['sʌbdʒɪkt] **1)** *n* предмет; объект;
2) *v* [sʌb'dʒekt] подвергать (*воздействию*)
subsequent ['sʌbsɪkwənt] *a* последующий
total [təutl] *a* общий; полный
uniform ['ju:nɪfɔ:m] *a* однообразный, однородный; постоянный

to be concerned with – касаться чего-либо, иметь дело с чем-либо **as far as … is concerned** – что касается; *e.g.:* *As far as length* ***is concerned****, it varies. –* ***Что касается*** *длины, то она меняется.* **by the way** – между прочим **in relation to** – относительно, что касается	**in other words** – другими словами **with reference to** – относительно, в отношении, ссылаясь на; **without reference to** – безотносительно к, без ссылки на, независимо от **with respect to** – относительно

Task I. Pay attention to …

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

a) dimension [daɪ'menʃ(ə)n] / [dɪ'menʃ(ə)n]
direction [daɪ'rekʃən] / [dɪ'rekʃən]
kinematics [ˌkɪnɪ'mætɪks] / [ˌkaɪnɪ'mætɪks]
kinetics [kɪ'netɪks] / [kaɪ'netɪks]

These words can be pronounced in two ways.

b) **subject** ['sʌbdʒɪkt] **1)** *n* 1) тема; 2) предмет, дисциплина; 3) объект, предмет; 4) субъект, человек
2) *v* [sʌb'dʒekt] 1) подвергать (*воздействию, влиянию и т.п.*); 2) предоставлять, представлять; 3) подчинять

This word is stressed in two different ways according to the part of speech.

c) **separate 1)** *a* ['seprɪt] 1) отдельный; 2) разный
2) *v* ['sepəreɪt] отделять(ся), разделять(ся)

This word is pronounced 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. Mechanics is concerned with the behaviour of physical bodies when **subjected** to forces.
2. Various **subjects** are studied in mechanics.
3. The major division of the mechanics discipline **separates** classical mechanics from quantum one.
4. This word has two **separate** meanings.

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

accelerate → acceleration;
compare → comparative → comparatively;
continuous → continuously; define → definition;
describe → description; direct → direction;
displace ← **place** → placement;
↳displacement ↵
distinct → distinction; invent → invention;
mathematics → mathematical; mean → meaning;
mechanics → mechanical; locate → location;
necessary → necessarily; numerical → numerically;
observer ← **observe** → observation; ordinary → ordinarily;
original ← **origin** → originate; period → periodical;
quantity → quantitative → quantitatively;
read → reading; recent → recently; refer → reference;
symbol → symbolize

Suffixes:
-ate *n* → *v*
-ation/-(t)ion/sion *v* → *n*
-ative *v* → *a*
-al *n* → *a*
-ence *v* → *n*
-er *v* → *n*
-ing *v* → *n*
-ize *n* → *v*
-ly *a* → *adv*
-ment *v* → *n*

Prefixes:
dis- *'to remove'*

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

*III. Pay attention to '**noun** + **noun**' combinations. Read and translate.*

physical body behaviour; motion laws and causes; motion description; time duration; clock reading; vector quantity

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.

discipline ['dɪsɪplɪn] *n* 1) дисциплина, порядок; 2) дисциплинированность; 3) дисциплина (*отрасль знания*); 4) наказание

distance ['dɪstəns] *n* расстояние, длина, дистанция

effect [ɪ'fekt] **1)** *n* 1) следствие, результат; 2) действие, влияние; воздействие; 3) эффект, впечатление; 4) цель, намерение; 5) *тех.* полезный эффект, производительность (*машины*)

interval ['ɪntəv(ə)l] *n* 1) промежуток, расстояние, интервал; 2) пауза, перерыв, перемена

major ['meɪdʒə] **1)** *a* 1) более важный, бóльший; 2) старший; 3) главный; 4) *муз.* мажорный; **2)** *n амер.* профилирующая дисциплина

object ['ɔbdʒɪkt] *n* 1) предмет; вещь; 2) объект (*изучения и т.п.*); 3) цель; 4) тело; 5) *грам.* дополнение

ordinary ['ɔ:d(ə)nɪrɪ] *a* обычный, обыкновенный; простой; ординарный

position [pə'zɪʃ(ə)n] *n* 1) место; (место)положение; расположение, позиция; 2) точка зрения, отношение; 3) возможность; 4) положение, должность

subject *n* ['sʌbdʒɪkt] **1)** *n* 1) тема; предмет разговора; 2) предмет, дисциплина; 3) объект, предмет (of); 4) субъект, человек; 5) *грам.* подлежащее

total [təutl] **1)** *n* целое, сумма; итог; **2)** *a* 1) общий; весь, целый; суммарный; 2) полный, абсолютный; 3) тотальный

Find the meaning that correctly explains the use of the words in bold and translate the sentences.

1. Mechanics studies the **effect** of forces on bodies.
2. The **major** division of the mechanics **discipline** separates classical mechanics from quantum one.
3. The following **subjects** are studied in mechanics: Newtonian mechanics, relativistic mechanics, celestial mechanics, biophysics, fluid statics, applied mechanics, *etc.*
4. In **ordinary** speech the word 'time' can have two different meanings.
5. Δt *(Delta t)* means an **interval** or duration of time.
6. Under **normal** experimental conditions, a body at rest does not move from its **position** in relation to the Earth.
7. An average speed is measured by the **total distance** travelled by an **object** divided by the **total** time taken to travel the **distance**.

V. Pay attention to the following easily confused words.

a) **affect** [ə'fekt] *v* влиять, (воз)действовать; вызывать изменения
effect [ɪ'fekt] *v* производить, осуществлять, совершать

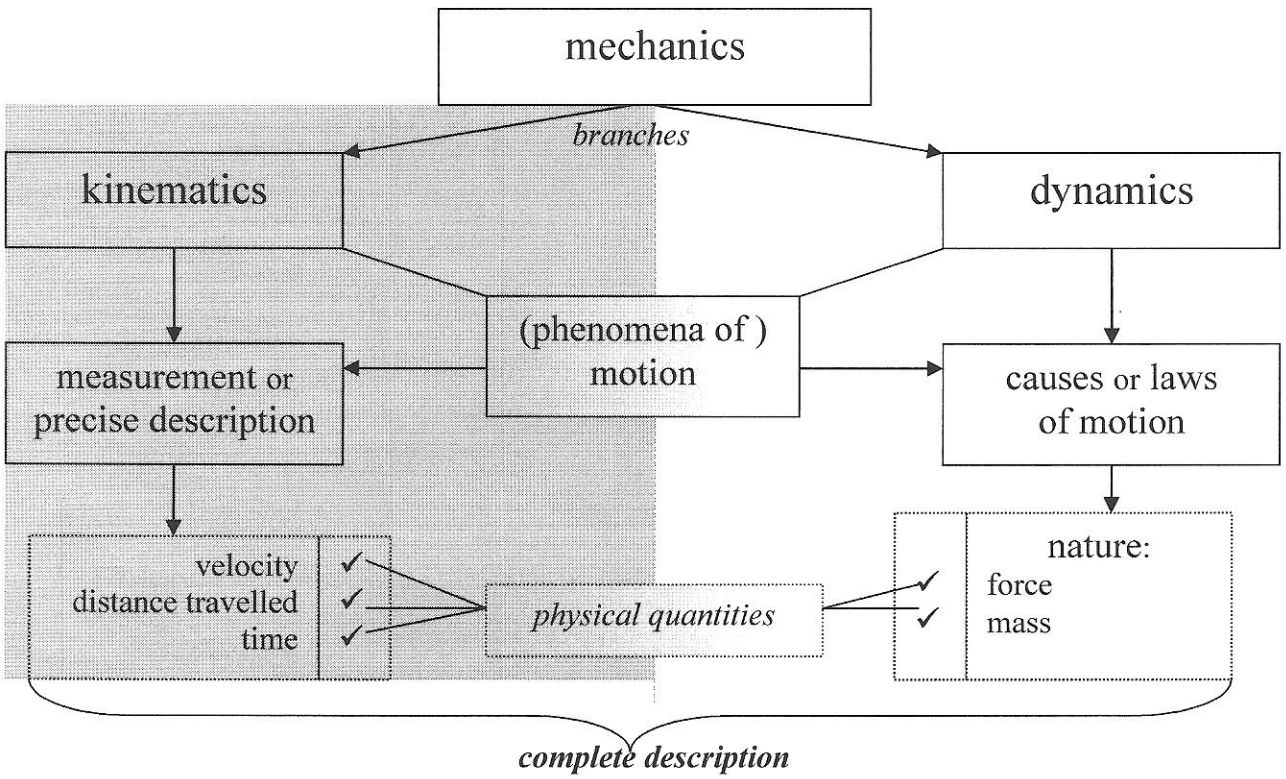
b) **cause** [kɔ:z] *n* причина, основание, повод
course [kɔ:s] *n* 1) курс, направление; 2) курс (*лекций, обучения*)

Choose the correct word to complete the meaning of the sentences.

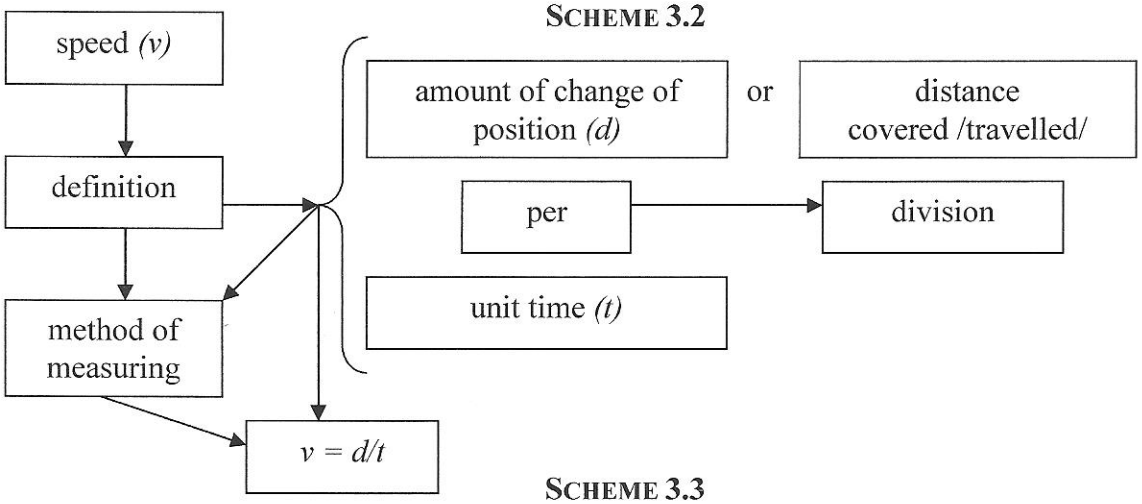
1. How force (*affects / effects*) motion is under study in dynamics.
2. Kinematics is not concerned with the forces (*affecting / effecting*) change of speed.
3. The acceleration is (*affected / effected*) by the force of gravity.
4. Dynamics deals with (*causes / courses*) or laws of motion.
5. The word 'velocity' means the speed in a definite (*cause / course*).

Stage 2 – Schemes

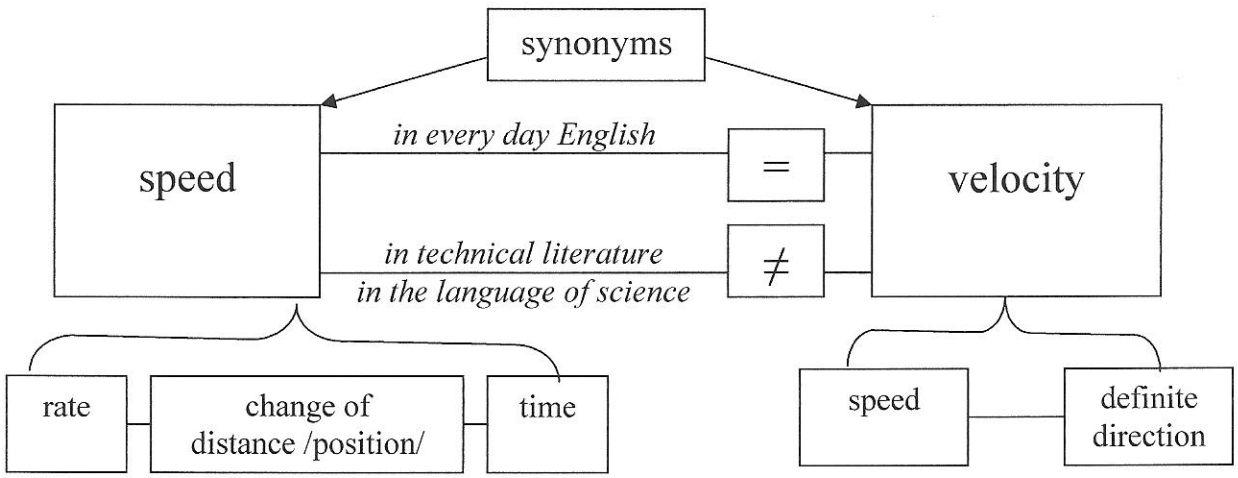
SCHEME 3.1



SCHEME 3.2



SCHEME 3.3



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

SCHEME 3.1

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

1. Dynamics and kinematics are the branches of mechanics.
2. Kinematics is concerned with the phenomena of motion with reference to the nature of a moving particle or object.
3. Kinematics deals with the phenomena of motion only from the standpoint of measurement or precise description.
4. No reference is made to the causes or laws of motion in kinematics.
5. Dynamics is concerned with the causes or laws of motion.
6. A complete description of a moving particle or body involves only its velocity, distance travelled, and time.
7. In kinematics we study only three physical quantities: velocity, distance travelled and time.
8. Reference is made to the force producing change of speed and mass of a moving particle or object in kinematics.

II. Answer the questions:

1. What are the branches of mechanics?
2. What is kinematics concerned with?
3. What does kinematics deal with?
4. What quantities does a complete description of a moving particle or body involve?
5. What physical quantities do we study in kinematics?
6. What physical quantities is kinematics not concerned with?

SCHEME 3.2

I. Complete the sentences:

1. We define speed as amount of change of position per … … .
2. The word 'per' indicates … .
3. The definition of speed gives us the method of … it.
4. To measure the speed of a moving particle or object we divide the … … (or distance covered) by the … it takes to get them from one position to another.
5. $v = d/t$ is the mathematical definition of speed, where v = … , d = … … , and t = … .

II. Answer the questions:

1. What is the definition of speed?
2. What does the definition of speed give us?
3. What do we do to measure the speed of a moving object or particle?
4. What is the mathematical definition of speed?

SCHEME 3.3

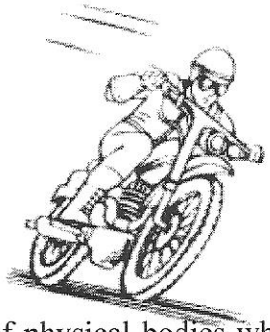
I. Choose the right variant:

1. The words 'velocity' and 'speed' (*are / are not*) synonyms in every day English.
2. The words 'velocity' and 'speed' (*are / are not*) synonyms in technical literature.
3. These words have (*different / the same*) meanings in the language of science.
4. The term (*'velocity' / 'speed'*) means the rate of change of distance with time.
5. The term "velocity" means speed in a (*definite / indefinite*) direction.
6. The term (*'velocity' / 'speed'*) is broader in its meaning and physicists use it more often.

II. Answer the questions:

1. Are the words 'velocity' and 'speed' synonyms in every day English or in technical literature?
2. Do these words have the same meanings in physics?
3. What does the word 'speed' mean?
4. What does the word 'velocity' mean?
5. Which of these two terms is more often used in the language of science and why?

Stage 3 – Text



Mechanics

Mechanics is the branch of physics concerned with the behaviour of physical bodies when subjected to forces or displacements, and the subsequent effect of the bodies on their environment. The discipline has its roots in several ancient civilizations. During the early modern period, scientists such as Galileo, Kepler, and especially Newton, laid the foundation for what is known as classical mechanics.

The major division of the mechanics discipline separates classical mechanics from quantum one. Historically, classical mechanics came first, while quantum mechanics is a comparatively recent invention. Classical mechanics originated with Isaac Newton's Laws of motion in Principia Mathematics, while quantum mechanics did not appear until 1900.

The following subjects are studied in mechanics:
Newtonian mechanics, the original theory of motion (kinematics) and forces (dynamics);
Relativistic or Einsteinian mechanics, universal gravitation;
Celestial mechanics, the motion of heavenly bodies: planets, comets, stars, galaxies;
Biophysics, physical properties in living organisms;
Fluid statics, liquids in equilibrium;
Applied / Engineering mechanics, *etc.*

Newtonian mechanics can be broken down into two great branches, kinematics and dynamics. The former is the science of studying the phenomena of motion from the standpoint of measurement or precise description of motion, *i.e.* it describes motion numerically. As far as dynamics is concerned it deals with causes or laws of motion, *i.e.* how force affects motion is under study in dynamics.

Since kinematics describes motion quantitatively it does not specify the nature of a moving particle or object. In other words reference is made neither to the forces producing change of speed nor to the mass of a moving body. Only three physical quantities are under study in kinematics: the distance between two positions (points, locations), the speed (*i.e.* how fast a continuous change of position occurs), and the time it takes to get from one position to another. Whereas dynamics describes motion with respect to both forces acting on a moving body and its mass.

It should be emphasized that the words 'velocity' and 'speed' are considered synonyms unless they are used in technical literature. In the language of science there is a difference in their meaning. We define speed as the amount of change of position (*i.e.* the distance covered) per unit time. Generally the word 'per' indicates division. For instance, 'distance travelled per unit time' means distance travelled divided by the time it takes to get from one position to another. So the word 'speed' signifies the rate at which a distance is covered, while the word 'velocity' means the speed in a definite direction. Of the two terms 'velocity' is much more often used by physicists, for it is broader and more convenient.

By the way, in ordinary speech we use the word 'time' in two different senses, which are to be distinguished in physics. It can be used as in 'a short time', or 'our time there on the earth', to mean a length or duration of time, or it can be used to indicate a clock reading, as in 'I don't know what time it is,' or 'it is high time'. In symbols, t is ordinarily used to mean a point in time, while Δt signifies an interval or duration of time. As with time, a distinction should be made between a point in space, symbolized as a coordinate x, and a change in position, symbolized as Δx.

NOTES ON THE TEXT

Galileo ['gæləli:ɔ] Галилео; **Kepler** ['keplə] – Кеплер; Δ ['deltə] – delta

Task III. Read the paper and then do the following exercises.

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

- раздел физики
- последующее воздействие тел
- положили начало
- небесные тела
- гидростатика
- с точки зрения
- описывает движение количественно / в числовом отношении *(find 2 equivalents)*
- всего три физические величины изучаются
- время, которое требуется, чтобы
- в научном языке
- значение / смысл *(find 2 equivalents)*
- пройденное расстояние *(find 2 equivalents)*
- обычно *(find 2 equivalents)*
- значит / означает *(find 3 equivalents)*
- слово «в» означает деление
- в бытовой / повседневной речи
- продолжительность / промежуток времени *(find 3 equivalents)*
- время по часам
- момент времени

II. Make up as many sentences as possible:

A) e.g. Kinematics studies motion without reference to the nature of a moving body.

Kinematics Dynamics	(is the science that) (is the branch of mechanics which)	• is concerned with • deals with • refers to • studies • describes	motion	• with(out) reference to • with(out) respect to • in relation to • from the standpoint of	• measurement • precise description • nature • laws • causes • speed • time • distance covered / travelled • force • mass	• of motion • of a moving object • of a moving particle • of a moving body

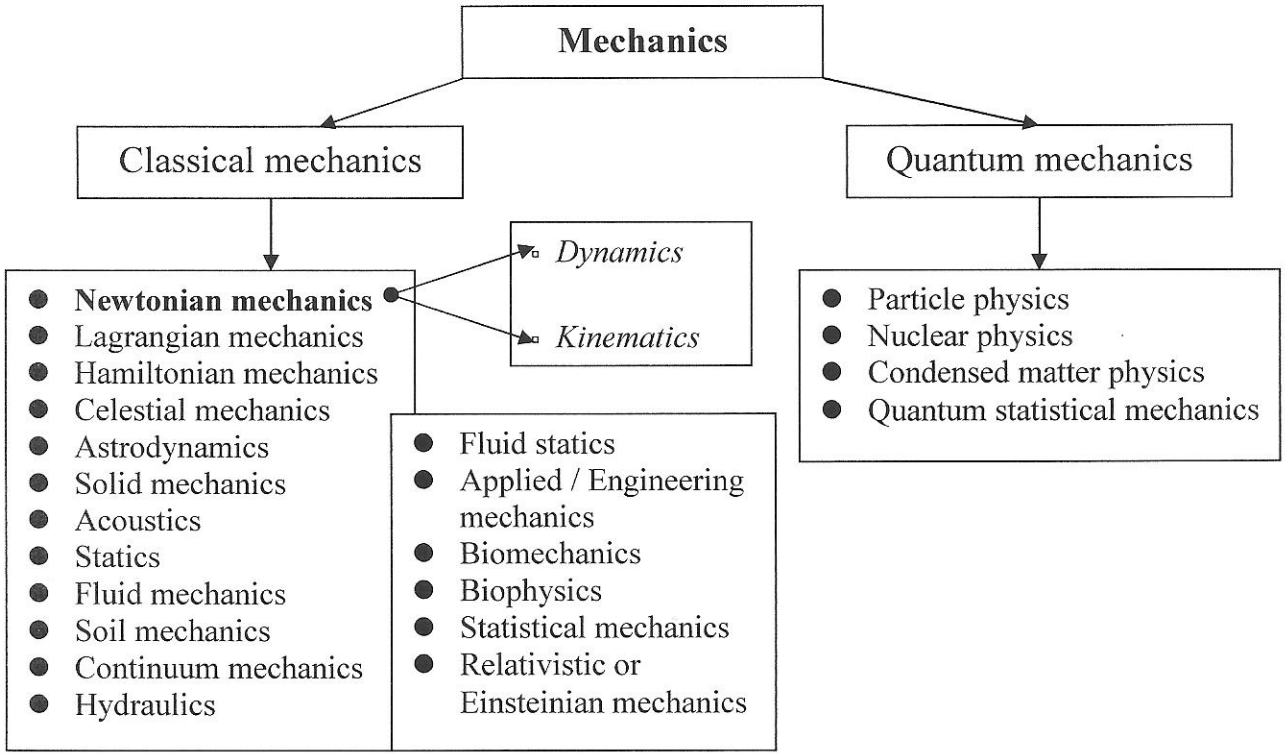
B) e.g. No reference is made to the nature of a moving body in kinematics.

(No) Reference	is made to (the)	• measurement • precise description • nature • laws • causes • speed • time • distance covered / travelled • force • mass	• of motion • of a moving object • of a moving particle • of a moving body	in kinematics in dynamics

III. Match the two halves of the sentences.

1. Mechanics deals with 2. Kinematics describes 3. Dynamics is concerned with 4. Velocity means 5. Speed is	a) the rate of change of position in a definite direction. b) the motion of objects without consideration of the circumstances leading to motion. c) the absolute value of the velocity, *i.e.* the velocity stripped of any information about direction. d) the relationship between the motion of objects and its causes. e) the effect of forces or displacements on bodies and the subsequent effect of the bodies on their environment.

IV. Speak on the branches of mechanics using the scheme. You can complete the scheme with appropriate key-words to detail the information given in the paper.



V. Match each symbol with its meaning. Make up sentences using the following synonyms: ***to mean, to indicate, to signify,*** *and* ***to stand for****.*

1) x	a) a duration of time
2) t	b) velocity
3) Δ (delta)	c) a point in space
4) Δx	d) the velocity of object A relative to object B
5) Δt	e) a distance or more precisely a change in x, which may be less than the distance travelled
6) v	f) a point in time, a clock reading
7) v_{AB}	g) 'change in'; the value of a variable afterwards minus its value before

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

1. Mechanics is the science of the action of forces on bodies.
2. Newtonian mechanics can be broken down into kinematics and dynamics.
3. The former is concerned with motion from the standpoint of measurement.
4. Precise description of motion is under study in kinematics.
5. Kinematics describes motion numerically.
6. It deals with the motion without reference to the nature of a moving particle.
7. Kinematics studies the phenomena of motion with respect to three physical quantities.
8. Dynamics deals with causes or laws of motion.
9. The word 'per' indicates division.
10. The word 'speed' means distance travelled per unit time.
11. In ordinary speech we use the word 'time' in two different senses.
12. The word 'time' is used to mean 'a length of time'.
13. In symbols, t is ordinarily used to mean a point in time.
14. Astronomy studies the movements of celestial bodies.

a) respect
b) effect
c) meaning
d) duration
e) in relation
f) in terms
g) accurate
h) to cover
i) to divide
j) to signify
k) to refer to
l) heavenly
m) generally
n) quantitatively

*VII. Rewrite sentences using **'as far as ... is / are concerned'** and translate them.*

Mechanics is the science of the action of forces on bodies.

***As far as** mechanics **is concerned** it is the science of the action of forces on bodies.*

***Что касается** механики, **то** это наука, изучающая воздействие сил на тела.*

1. The present paper refers to the branches of mechanics.
2. Newton laid the foundation for classical mechanics.
3. Quantum mechanics is a comparatively recent invention.
4. Newtonian mechanics can be divided into two great branches, kinematics and dynamics.
5. Kinematics describes motion numerically.
6. Dynamics studies motion with respect to the nature of a moving object or particle.
7. The terms 'velocity' and 'speed' are not synonyms in the language of science.
8. Speed is the amount of change of position per unit time.
9. Velocity is the speed in a definite direction.

VIII. Rewrite sentences as in the example.

The branches of mechanics are described in the present paper.

*The branches of mechanics **are under description** in the present paper.*

1. The original theory of motion and forces are studied in Newtonian mechanics.
2. Only three physical quantities are considered in kinematics.
3. The nature of a moving object is described in dynamics.
4. The difference between the meaning of the terms 'speed' and 'velocity' is discussed here.

IX. Of the following phrases, which refer to points in time, which refer to time intervals, and which refer to time in the abstract rather than as a measurable number?

1. In time you will solve the problem. 2. The time has come. 3. Time waits for no man. 4. She stays in all the time. 5. He was conducting a significant experiment this time yesterday. 6. The universe exists in space and time. 7. They go with the times.	a) point in time (t) b) a time interval (Δt) c) time in the abstract sense

X. Ask your friends

1) what mechanics deals with;
2) when the foundation for classical mechanics was laid;
3) what the major division of mechanics is;
4) what subjects are under study in mechanics;
5) whether Newtonian or relativistic mechanics is broken down into kinematics and dynamics;
6) what kinematics is concerned with;
7) what quantities are under consideration in kinematics;
8) whether dynamics describes motion with respect to the nature of moving particle;
9) if the terms 'velocity' and 'speed' have the same meaning in the language of science;
10) what these words mean;
11) what the difference between two symbols: x and Δx is;
12) if physicists use t or Δt to indicate a duration of time.

XI. Add details from the text "Mechanics" to schemes 3.1, 3.2 and 3.3 and then describe the schemes using your own words. While describing, make use of the following expressions.

The present paper is concerned with ...; ... is / are under consideration in the paper; at first the author V_s that ...; then he V_s that ...; it should be V_3 that ...; it is interesting to V that ...; another interesting point is ...; it is known that ... / ... is known to ...; as V_{ed} in the paper ...; as the author V_s ...; as far as I know / remember ...; as far as ... is concerned ...; I'd like to V that ...; in conclusion ...; (V – note / point out / mention / emphasize / indicate, *etc.*).

Stage 4 – Definitions *From "Longman Dictionary of Scientific Usage"*

mechanics The branch of physics studying mechanical *motion* (↓); the study of the effect of forces on bodies. It can be divided into the following branches: **statics**, the effect of forces on bodies in equilibrium; **dynamics** (↓), the effect of forces on bodies at *rest* (↓) or in motion; **kinematics** (↓), the quantitative description of motion without reference to the causes of that motion.

dynamics The study of the effect of forces on bodies at *rest* (↓) or in *motion* (↓). Dynamics so described is usually called classical, or Newtonian, dynamics, to distinguish it from relativistic dynamics. In dynamics reference is made to the cause of motion of bodies, *i.e.* the forces acting on a body, and the mass of the body, are both considered. The dimensions of a body may or may not be considered. Dynamics is concerned with forces, energy and work, and with the relationship between these *quantities* (→)[1].

kinematics The study of the change of position of points in a three-dimensional space during a specified time. *Motion* (↓) is described quantitatively in kinematics. In kinematics no reference is made to the cause of motion of actual bodies, *i.e.* no reference is made to the forces acting on a body, or to the mass of a body, or to the dimensions of the body. The body is considered to be a point in space. Kinematics is concerned with equations of motion, which relate distance, time, *velocity* (↓), and acceleration.

motion If an object is observed at two different instants, and it is seen to be in two different positions at those two instants, then the object is in motion or has been in motion during the interval between the two observations, *e.g.* **a)** the motion of planets round the sun; **b)** the motion of a stone falling under the force of *gravity* (→)[2]; **c)** the motion of a motor car going along a road.

rest A state of no motion in relation to an observer, *i.e.* a body at rest remains at the same distance from the observer. Under normal experimental conditions, a body at rest does not move from its position in relation to the Earth, *e.g.* a table is at rest on the floor of a house.

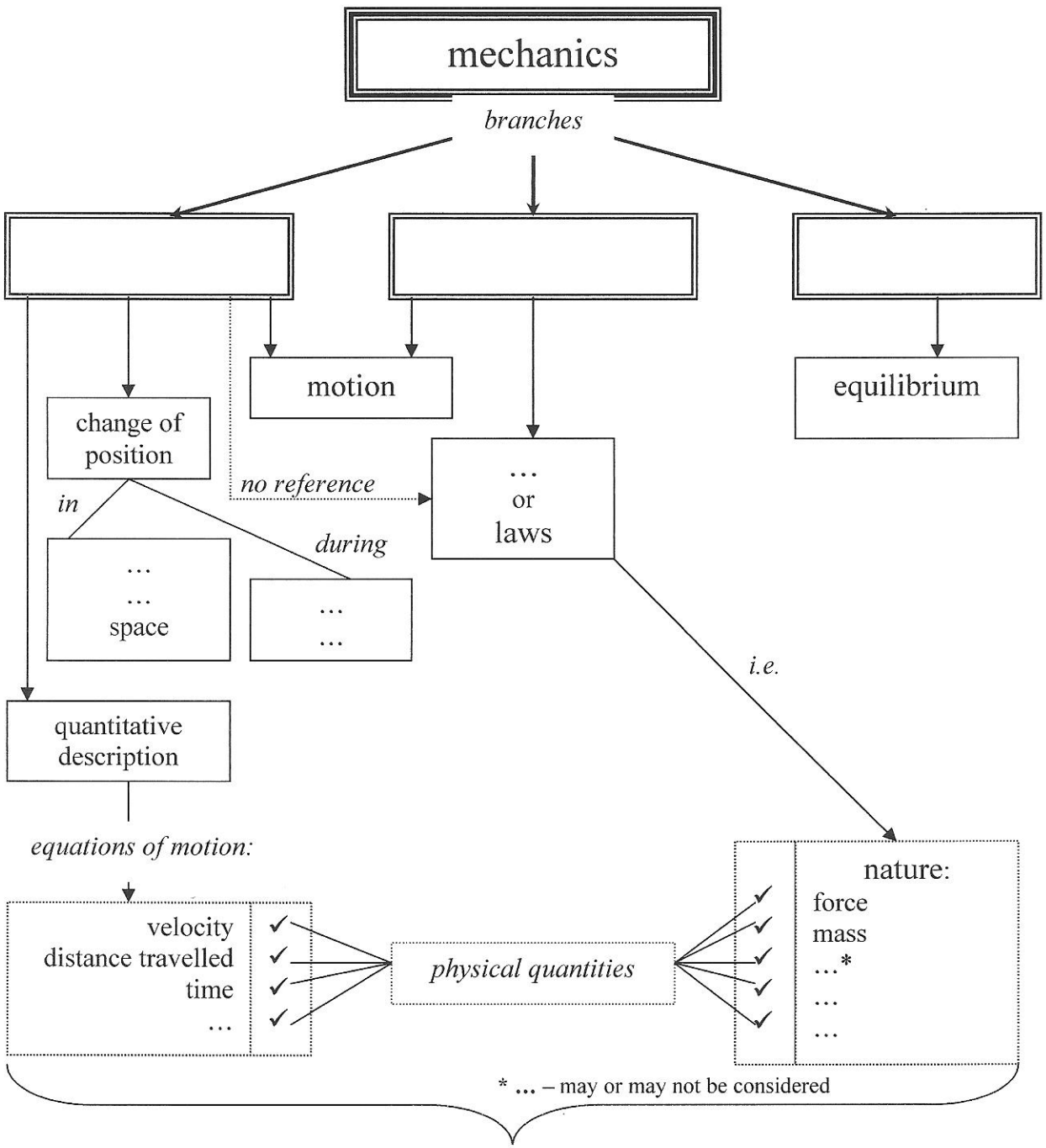
speed The rate of change of distance with time. An average speed *is measured* (→)[1] by the total distance travelled by a body divided by the total time taken to travel the distance. The path is not necessarily a straight line and the direction of the path is not stated when speed is measured.

velocity The rate of change of displacement with time; the rate of change of distance travelled with time in a specified direction. Velocity is a vector *quantity* (→)[1]. The symbol for the quantity, velocity, is u or v. The *unit of measurement* (→)[1] is metres per second (m s^{-1}). Note that a body travelling along a curved path will have a uniform speed, if equal distances are travelled at the same period of time, but the velocity of the body will be continuously changing as the direction of motion is continuously changing.

[1] – see "UNITS OF MEASUREMENT"
[2] – see "NEWTON'S THEORY OF GRAVITY"

Task IV. Read the definitions of the terms from "Longman Dictionary of Scientific Usage" and complete the scheme.

SCHEME 3.3



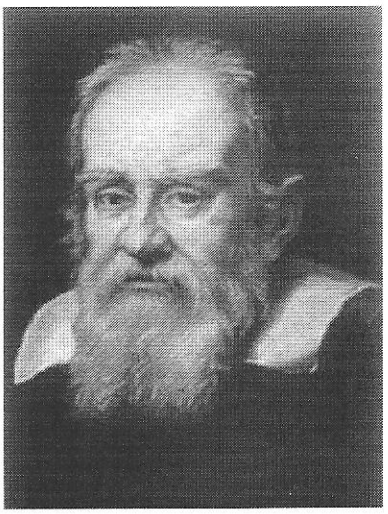
complete description

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

- **Branches of Mechanics:**
  - ✓ **Dynamics**
  - ✓ **Kinematics**
  - ✓ **Statics**
- **'Speed' and 'Velocity' in the Language of Science**

Stage 5 – In Addition

Read the text and answer the questions given below.



Galileo and Pendulums[1]

Galileo Galilei, an Italian physicist, astronomer and philosopher, is considered to be 'the father of science'. For a number of years the scientist's interests were centred in the field of dynamics – that is, the study of the laws of motion. In particular, he tried to solve the following problems. Why is the period[2] of the pendulum independent of the amplitude[3] of the swing? Why do a light and a heavy stone at the end of the same string swing with the same period? Galileo never solved the first problem, since its solution required knowledge of the calculus, which was invented by Newton almost a century later. And although he never solved the second problem either, he certainly contributed to the formulation of both, if not to their solution.

The motion of a pendulum is a special case of the fall caused by gravity. If we drop a stone, it will fall straight to the ground. If, however, the stone is tied to a string, it is forced to fall along an arc of a circle. If swinging as pendulums a light and a heavy stone will come to rest at the same time. That is why these two stones also take the same time to fall to the ground if they are dropped at the same moment.

NOTE ON THE TEXT

Galileo Galilei ['gæləli:ɔ / gælɪ'leɪəu 'gælɪleɪ] Галилео Галилей

---

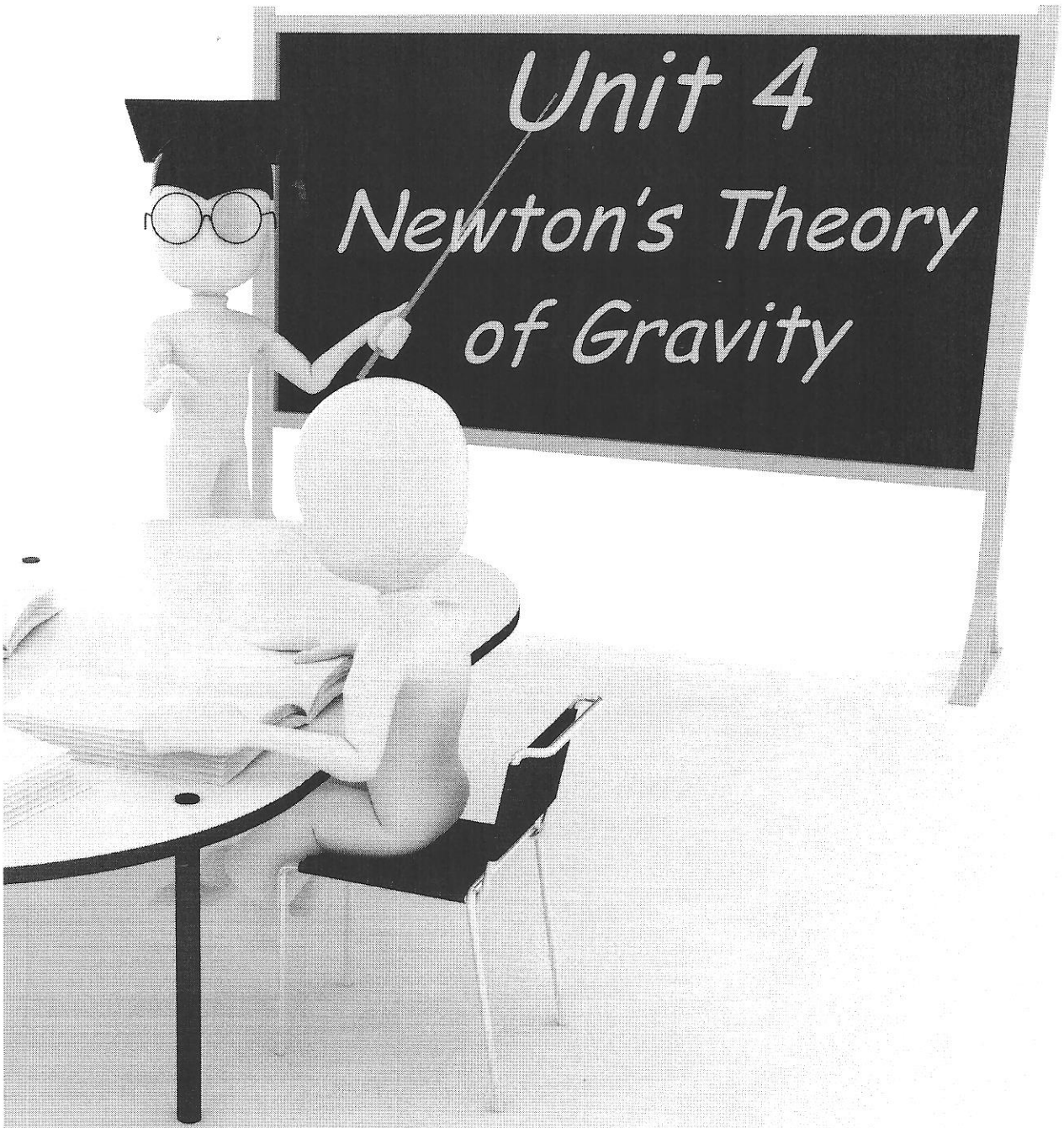
[1] **pendulum** ['pendjuləm] a body pivoted above its centre of gravity so that it can swing freely in a vertical plane. The simplest type is a **bob** at the end of a string. When given an impulse, a pendulum swings from side to side with a periodic motion. An ideal pendulum consists of a weightless, inextendible string with the mass concentrated at one point in the bob and the angle of amplitude of swing less than 5°.
bob [bɔd] a heavy mass of metal used in a pendulum.

[2] **period** ['pɪərɪəd] if an event occurs regularly in time, then the time taken between successive events is called the period. In the motion of pendulum, the period is the time taken between the pendulum bob successively passing through the same point in the same direction.

[3] **amplitude** ['æmplɪtju:d] the maximum displacement, on either side of a mean position, of an oscillating particle, *e.g.* the amplitude of a pendulum is half the length of its swing.
(from "Longman Dictionary of Scientific Usage")

Answer the questions.

1. What was Galileo interested in?
2. Did Galileo solve the problems of the pendulum?
3. What is a pendulum?
4. What is the period of a pendulum?
5. What do we understand by the amplitude of the swing?
6. What happens if we drop a stone?
7. What happens if the stone is tied to a string?
8. Can you answer Galileo's questions?



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Stage 2 - *Schemes and Pre-Text Exercises* 84
Stage 3 - *Text and After-Text Exercises* 87
Stage 4 - *Definitions of the Basic Terms* 92
Stage 5 - *In Addition* 94

Stage 1 – Vocabulary Newton's Theory of Gravity

centre ['sentə] *n*	gravity ['grævɪtɪ] *n*	physicist ['fɪzɪsɪst] *n*
constant ['kɔnstənt] *n*	integrate ['ɪntɪgreɪt] *v*	principle ['prɪnsəpl] *n*
culminating ['kʌlmɪneɪtɪŋ] *a*	mathematician [ˌmæθɪmə'tɪʃ(ə)n] *n*	process ['prəuses] *n*
diameter [daɪ'æmɪtə] *n*	mathematics [ˌmæθɪ'mætɪks] *n*	proportional [prə'pɔ:ʃ(ə)nəl] *a*
formulation [ˌfɔ:mju'leɪʃ(ə)n] *n*	optics ['ɔptɪks] *n*	revolution [ˌrevə'lu:ʃ(ə)n] *n*
geographical [ˌdʒɪə'græfɪkəl] *a*	orbit ['ɔ:bɪt] *n*	symmetric(al) [sɪ'metrɪk(əl)] *a*
gravitation [ˌgrævɪ'teɪʃ(ə)n] *n*		symmetry ['sɪmɪtrɪ] *n*

achieve [ə'tʃi:v] *v* достигать
altitude ['æltɪtu:d] *n* высота
apply [ə'plaɪ] *v* применять
arise [ə'raɪz] *v* (arose; arisen) возникать, появляться
assume [ə'sju:m] *v* предполагать, допускать
attract [ə'trækt] *v* притягивать
attraction [ə'trækʃ(ə)n] *n* притяжение, тяготение
attribute ['ætrɪbju:t] *n* свойство, признак
balance ['bæləns] *v* балансировать; сохранять равновесие; уравновешивать
bring about [brɪŋ] *v* (brought) осуществлять
bring in [brɪŋ] *v* (brought) выдвигать, вносить (*предложение*); вводить (*новые идеи*)
calculus ['kælkjuləs] *n* исчисление
centrifugal [sen'trɪfjug(ə)l] *a* центробежный
colour ['kʌlə] *n* цвет
composition [ˌkɔmpə'zɪʃ(ə)n] *n* структура, состав
converse ['kɔnvə:s] *n* обратное утверждение
curve [kə:v] *n* кривая (линия); дуга
decrease [di:'kri:s] *v* уменьшать(ся)
directly [dɪ'rektlɪ] *adv* прямо, непосредственно
elevation [ˌelɪ'veɪʃ(ə)n] *a* высота (*над уровнем моря*)
enable [ɪ'neɪbl] *v* давать возможность
essentially [ɪ'senʃ(ə)lɪ] *adv* существенным образом; по существу
exert [ɪg'zə:t] *v* напрягать (*силы*)
experience [ɪks'pɪərɪəns] *v* испытывать
explain [ɪks'pleɪn] *v* объяснять
extent [ɪks'tent] *n* степень, мера
fall [fɑ:l] *v* (fell, fallen) понижаться; падать
happen ['hæpən] *v* случаться, иметь место
increase [ɪn'kri:s] *v* возрастать, увеличивать(ся)
indirectly [ˌɪndɪ'rektlɪ] *adv* косвенно
infinitesimal [ˌɪnfɪnɪ'tesɪm(ə)l] *a* бесконечно малый
influence ['ɪnfluəns] *n* влияние, (воз)действие
inversely [ɪn'və:slɪ] *adv* обратно
just [dʒʌst] *adv* 1) точно, как раз, именно; 2) только что; 3) совсем, просто; 4) едва
latitude ['lætɪtu:d] *n астр., геогр.* широта
lay [leɪ] *v* (laid) класть; **to lay down the law** – устанавливать, формулировать закон
net [net] *a* чистый, суммарный;
net force – результирующая сила
piece [pi:s] *n* часть; отдельный предмет
product ['prɔdʌkt] *n мат.* произведение
prove [pru:v] *v* доказывать
publish ['pʌblɪʃ] *v* издавать
reach [ri:tʃ] *v* достигать, доходить
reduce [rɪ'dju:s] *v* понижать
region ['ri:dʒən] *v* область
responsible (for) [rɪs'pɔnsəbl] *a* ответственный (за *что-л.*)
respectively [rɪs'pektɪvlɪ] *adv* соответственно
rest [rest] *n* покой, отдых;
at rest – в состоянии покоя
result in [rɪ'zʌlt] *v* кончаться *чем-л.*, иметь результатом *что-л.*, приводить к *чему-л.*
satellite ['sætəlaɪt] *n* спутник
state [steɪt] *v* излагать, формулировать
strength [streŋθ] *n* сила
suggest [sə'dʒest] *v* предлагать
towards [tə'wɔ:dz] *prep* (по направлению) к
variable ['vɛərɪəbl] *a* изменчивый, непостоянный, переменный
vary ['vɛərɪ] *v* изменяться
weigh [weɪ] *v* взвешивать, оценивать
weight [weɪt] *n* 1) вес; 2) тяжесть

take place – случаться, происходить

Task I. Pay attention to …

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

a) symmetry ['sɪmɪtrɪ] – symmetric(al) [sɪ'metrɪk(əl)];
finite ['faɪnaɪt] – infinite ['ɪnf(ɪ)nɪt]

b) decrease **1)** *n* ['di:kri:s] уменьшение; **2)** *v* [di:'kri:s] уменьшать(ся)
increase **1)** *n* ['ɪnkri:s] возрастание, рост; увеличение;
2) *v* [ɪn'kri:s] возрастать, увеличивать(ся), расти

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

1. The force of gravity **decreases** as the distance from the Earth **increases**.
2. If the length is **increased** from 3 to 5 metres, the **increase** is 2 metres. / If the length is **decreased** from 5 to 3 metres, the **decrease** is 2 metres.

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

attractive ← **attract** → attraction;
calculus → calculate;
compose → composition;
develop → development;
dimension → dimensional;
direct → directly → indirectly;
discovery ← **discover** → discoverer;
essential → essentially;
finite → infinite;
formula → formulate → formulation;
found → foundation;
gravitation → gravitational → gravitationally;
inverse → inversely;
mass → massive;
mathematics → mathematical → mathematically
↓
mathematician;
physics → physicist;
predict → prediction;
proportion → proportional → proportionality;
symmetry → symmetric(al);
universe → universal → universally; vary → variable

Suffixes:
-able *v* → *a*
-ation/-(t)ion *v* → *n*
-al *n* → *a*
-ate *n* → *v*
-er *v* → *n*
-ian *n* → *n*
-ic(al) *n* → *a*
-ist *n* → *n*
-ity *a* → *n*
-ive *v* → *a*
-ly *a* → *adv*
-ment *v* → *n*
-y *v* → *n*

Prefixes:
in- *'the opposite of' / 'not'*

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

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

two + dimensional = two-dimensional;
three + dimensional = three-dimensional

*Pay attention to '**noun + noun**' combinations.Read and translate.*

the science revolution; a (general) physics theory; an (inverse) square law; an object weight; a vector field

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.

balance ['bæləns] *v* 1) балансировать; сохранять равновесие, быть в равновесии; уравновешивать; 2) колебаться (between); 3) подводить баланс

constant ['kɔnstənt] **1)** *n физ., мат.* постоянная (величина), константа; **2)** *a* 1) постоянный; неизменный; 2) твердый; верный (*идее и т.п.*)

distance ['dɪstəns] *n* расстояние, длина, дистанция

figure ['fɪgə] *n* 1) фигура; внешний вид; облик, образ; 2) личность, деятель, фигура; 3) изображение, картина; статуя; 4) иллюстрация, рисунок (*в книге*); диаграмма, чертеж; 5) *геом.* фигура, тело; 6) цифра; *pl* (цифровые) данные; 7) *pl* арифметика

general I ['dʒen(ə)r(ə)l] *a* 1) общий, всеобщий; общего характера; 2) повсеместный; 3) обычный; 4) главный, генеральный

general II ['dʒen(ə)r(ə)l] *n* генерал; полководец

principle ['prɪnsəpl] *n* 1) принцип; правило; закон; 2) первопричина; причина; источник; 3) *хим.* составная часть, элемент; 4) принцип устройства (*механизма, машины и т.п.*); 5) *pl* начала (науки)

product ['prɔdʌkt] *n* 1) продукт; продукция; изделие; 2) результат, плоды; 3) *мат.* произведение; 4) *хим.* продукты реакции

region ['ri:dʒən] *v* 1) страна; край; область; округа; *перен.* сфера; 2) регион; район; 3) зона, полоса; 4) слой (*атмосферы*)

subject *n* ['sʌbdʒɪkt] **1)** *n* 1) тема; предмет разговора; 2) предмет, дисциплина; 3) объект, предмет (of); 4) субъект, человек; 5) *грам.* подлежащее

total [təutl] **1)** *n* целое, сумма; итог; результат; **2)** *a* 1) общий; весь, целый; суммарный; 2) полный, абсолютный; 3) тотальный

Translate the sentences. Pay special attention to the words in bold.

1. Isaac Newton was the culminating **figure** in the science revolution of the 17th century.
2. Newton's three laws of motion are the basic **principles** of modern physics.
3. Newton was the first to begin the development of a **general** physics theory.
4. Isaac Newton began to develop the theory of gravity when he was 24 years old. Twenty years later he returned to this **subject**.
5. Every particle attracts every other particle with a force which is directly proportional to the **product** of the masses of the particles and inversely proportional to the square of the **distance** between them.
6. The value of the **constant** G was not determined by Newton.
7. The **region** in which one body attracts another body is called a gravitational field.
8. A centrifugal force exactly **balances** the force of gravity.
9. If we observe an object moving with **constant** velocity along a straight line, then the **total** force on it must be zero.

V. Pay attention to the phrasal verbs.

bring [brɪŋ] *v* (brought) приносить; приводить

bring about – осуществлять

bring in – выдвигать, вносить (*предложение*); вводить (*новые идеи*)

lay [leɪ] *v* (laid) класть

to lay against – прикладывать (что-л. к чему-л.)

to lay down – 1) составить (*план*); 2) закладывать (*здание, основание*); 3) устанавливать, утверждать (*условия, правила, законы и т.п.*)

result [rɪ'zʌlt] **1)** *n* 1) результат, исход; **2)** *v*:

result from – происходить в результате (*чего-л.*); следовать, проистекать из

result in – кончаться *чем-л.*, иметь результатом *что-л.*, приводить (к *чему-л.*)

walk [wɔ:k] *v* ходить, идти (пешком)

walk about / around – прогуливаться, прохаживаться

walk into – 1) входить (*куда-л.*); 2) проникать (*куда-л.*); 3) удариться (обо *что-л.*); 4) легко добиться (*работы*)

Choose the correct particle to complete the meaning of the sentence.

1. Newton's three laws of motion resulted (*from / in*) the formulation of the law of universal gravitation.
2. Newton brought (*about / in*) the first main step in the process of development of a general physics theory. Before Newton, people looked on the world as having the two dimensions in which one can walk (*about / into*).
3. To prove that the up-and-down direction is symmetrical with the other two directions Newton brought (*about / in*) gravitational forces.
4. In '*Principia*' Newton laid (*against / down*) the law of Universal Gravitation.
5. The SI is entirely decimal, thanks to the same logical people who brought (*about / in*) the French Revolution.
6. He was the first to walk (*about / into*) the laboratory.
7. If you lay the blue cloth (*against / down*) the green, both colours seem to change.

VI. Pay attention to the following easily confused words.

a) **among** [ə'mʌŋ] *prep* среди (*трех и более предметов*)
between [bɪ'twi:n] *prep* между (*двух предметов*)

b) **discover** [dɪs'kʌvə] *v* открывать, делать (научное) открытие
open ['əup(ə)n] *v* открывать (*что-л. закрытое*)

c) **later** ['leɪtə] *adv.* позже
latter ['lætə] *adv.* последний (из двух названных)

d) **peace** [pi:s] *n* 1) мир; 2) спокойствие, тишина
piece [pi:s] *n* 1) кусок, часть (целого); 2) отдельный предмет

e) **principal** ['prɪn(t)səp(ə)l] 1) *n* глава, начальник, директор; 2) *a* главный, основной
principle ['prɪnsəpl] *n* принцип; правило; закон

f) **same** [seɪm] *pron* тот (же) самый; один и тот же; одинаковый; аналогичный
some [sʌp] *pron* некоторое количество, несколько, некоторый

g) **weigh** [weɪ] *v* взвешивать, оценивать
weight [weɪt] *n* 1) вес; 2) тяжесть

h) **walk** [wɔ:k] *n/v* прогулка / гулять
work [wə:k] *n/v* работа / работать

Choose the correct word to complete the meaning of the sentence.

1. (*Among / Between*) Newton's (*principal / principle*) discoveries are the composition of white light, the formulation of the law of universal gravitation. Newton's three laws of motion are the basic (*principals / principles*) of modern physics. He also (*discovered / opened*) the infinitesimal calculus.
2. Isaac Newton began to develop the theory of gravity when he was 24 years old. (*Same / Some*) years (*later / latter*) he returned to this subject.
3. The attractive force (*among / between*) any two (*peaces / pieces*) of matter, *i.e.* material bodies is called gravitation.
4. An object (*weigh / weight*) is not a fixed property of that object. Objects (*weigh / weight*) more in (*same / some*) places than in others, depending on the local strength of gravity. It is their mass that always stays the (*same / some*).
5. Physics can be divided into two great branches, theoretical and experimental. The (*later / latter*) is the science of making observations and conducting experiments.
6. A body is a separate (*peace / piece*) of matter.
7. There are two types of energy: potential and kinetic. The (*later / latter*) is the energy of motion of a body; it is equal to the (*walk / work*) the body can do in coming to rest.
8. Our laboratory is (*discovered / opened*) at nine o'clock.
9. Nick and Ann study physics, the (*later / latter*) (*walks / works*) as a laboratory assistant. Nobody was surprised when he (*walked / worked*) into this (*walk / work*).

Fun with Words

PLAY UPON WORDS
ИГРА СЛОВ

Play upon words with the same spelling, the same sound, different meaning (homographs)
Каламбуры со словами одинакового написания, одинакового звучания, но с разными значениями (омографы)

***

go down *v* 1) опускаться, падать; 2) быть проглоченным
heavy *a* 1) тяжелый; **as heavy as lead** – очень тяжелый; 2) плохо пропеченный (*о хлебе, пироге и т.п.*)

– It was a good cake, but it defied the law of gravity.
– How?
– It was as heavy as lead, but it didn't go down.

***

change *n* 1) перемена, изменение; 2) сдача, мелочь
rest *n* 1) отдых, покой; состояние покоя; 2) **the rest** остаток, остальное

– I went to a hotel for a change and a rest.
– Did you get it?
– The bellboy got the change and the hotel got the rest.

***

– So you're just back from your holiday. Feel any change?
– Not a penny.

***

carry *n* 1) нести, носить, переносить; 2) иметь; **to carry weight** – иметь вес, влияние

An elephant's opinion carries a lot of weight.

***

to have a good head for *figures* – хорошо разбираться в математике (*досл.* – в цифрах), иметь хорошие математические способности
to have a great eye for *figures* – быть знатоком, любителем (*зд.* женских) фигур

The old man who had a good head for figures now has a grandson who has a great eye for them.

Play upon words with the same sound, different spelling, different meaning (homophones)
Каламбуры со словами одинакового звучания, разного написания, с разными значениями (омофоны)

***

peace [pi:s] *n* 1) мир; 2) спокойствие, тишина
piece [pi:s] *n* музыкальное произведение, пьеса

Rock is a piece of music performed in this style.
But peace and music never go together, especially in the case of hard rock.

MNEMONIC DEVICES
МНЕМОНИЧЕСКИЕ ПРИЕМЫ

These phrases help you to remember the spelling of the following words:

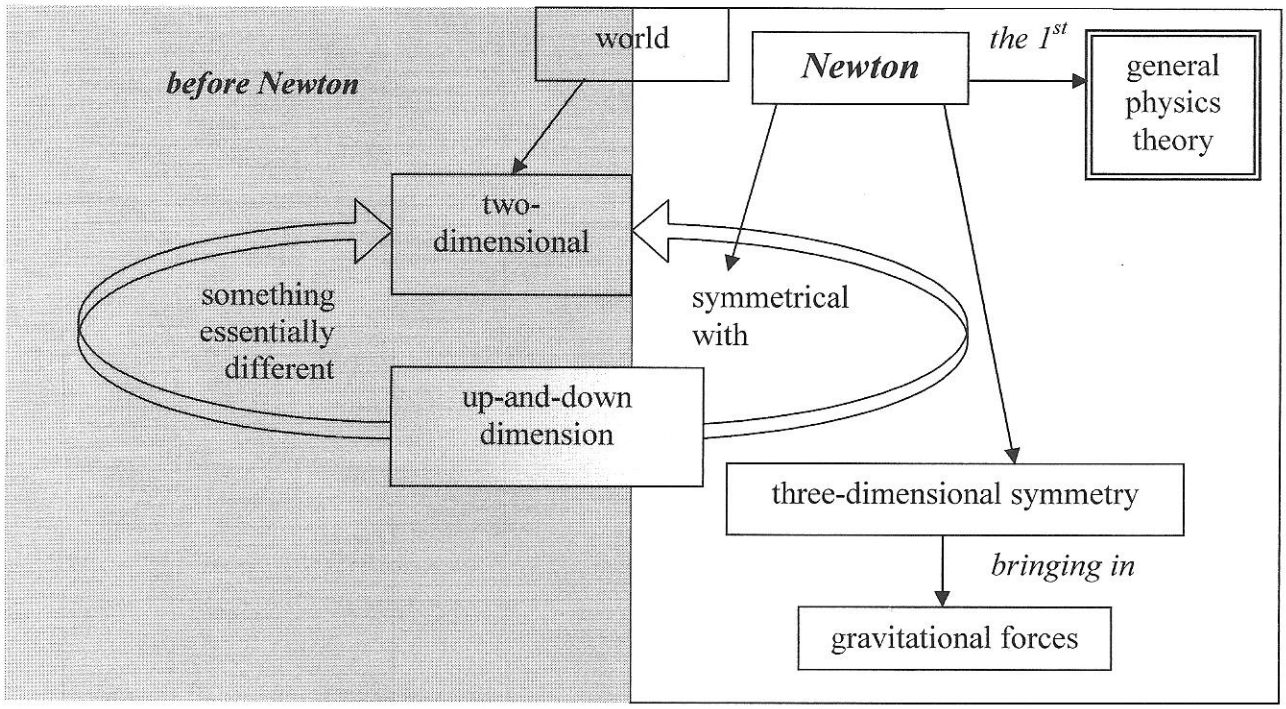
PRINCIPAL *and* PRINCIPLE

Your princi**pal** is your **pal**. A princi**ple** can be called a ru**le**.

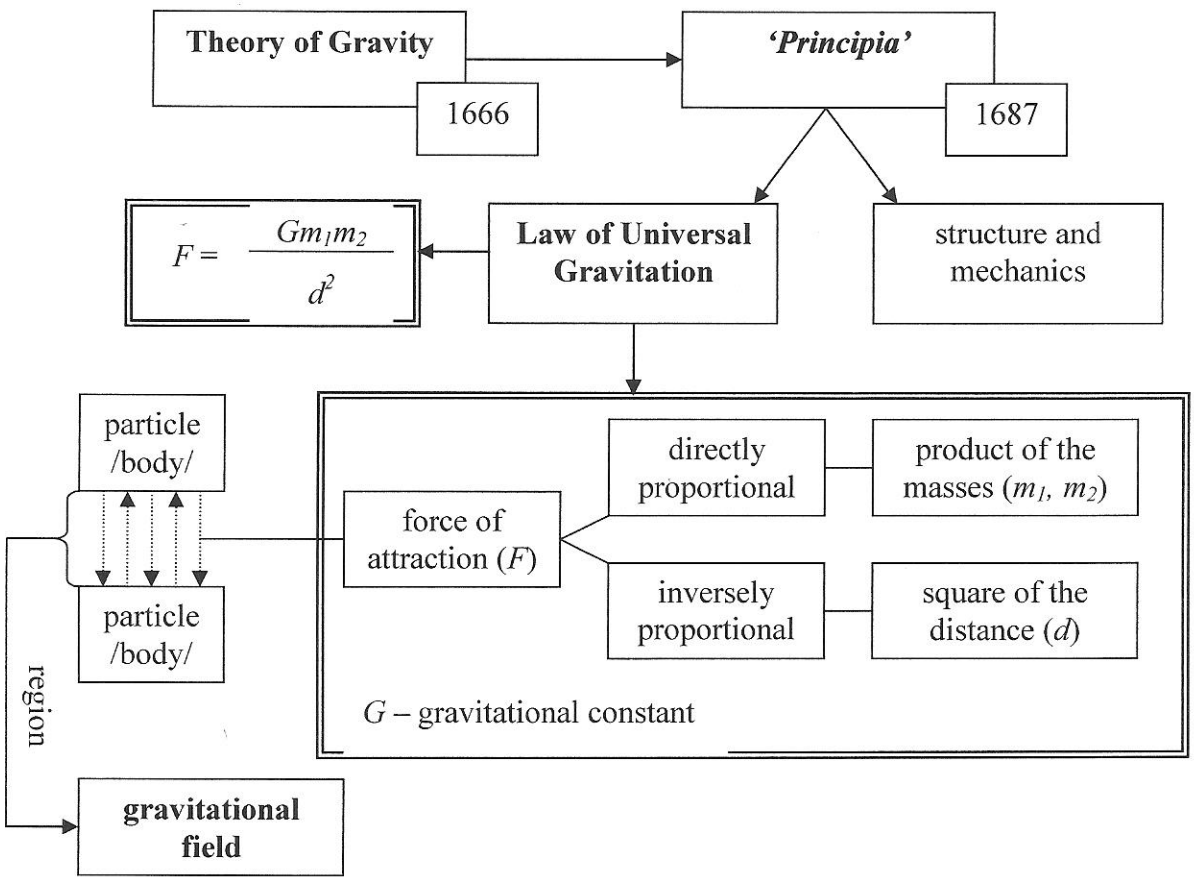
A fuller list of spelling mnemonics is given on page 16.

Stage 2 – Schemes

SCHEME 4.1



SCHEME 4.2
Newton's Law of Universal Gravitation



Task II. Use the schemes given on the left-hand page as a prompt to do the following exercises.

SCHEME 4.1

I. Complete the sentences:

1. Newton was the first to begin the development of a … … … .
2. Before Newton, people supposed the world to be … .
3. They considered the up-and-down dimension to be … … … .
4. Newton showed that the up-and-down dimension is … with the other two dimensions.
5. He suggested a three-dimensional symmetry by bringing in … … .

II. Answer the following questions:

1. Who was the first to begin the development of a general physical theory?
2. What did people think about the world before Newton?
3. What did people think about up-and-down dimension?
4. Did Newton agree with that point of view?
5. What did Newton suggest by bringing in gravitational forces?

SCHEME 4.2

I. Agree or disagree with the following sentences (statements expressing agreement and disagreement can be found on page 169):

1. Isaac Newton developed the theory of gravity in 1687.
2. In 1678 his great work '*Principia*' was published.
3. In '*Principia*' Newton explained the structure and mechanics of the Universe.
4. In this work he also laid down the law of gravitation.
5. Every particle in the Universe attracts every other particle.
6. This force of attraction is inversely proportional to the product of the masses of the particles.
7. The force of attraction between two particles or bodies is directly proportional to the square of the distance between them.
8. Let F be the force of attraction between two bodies, m_1 and m_2 – the masses of these bodies, d – the distance between them and G – the gravitational constant then

$$F = \frac{Gm_1m_2}{d^2}$$

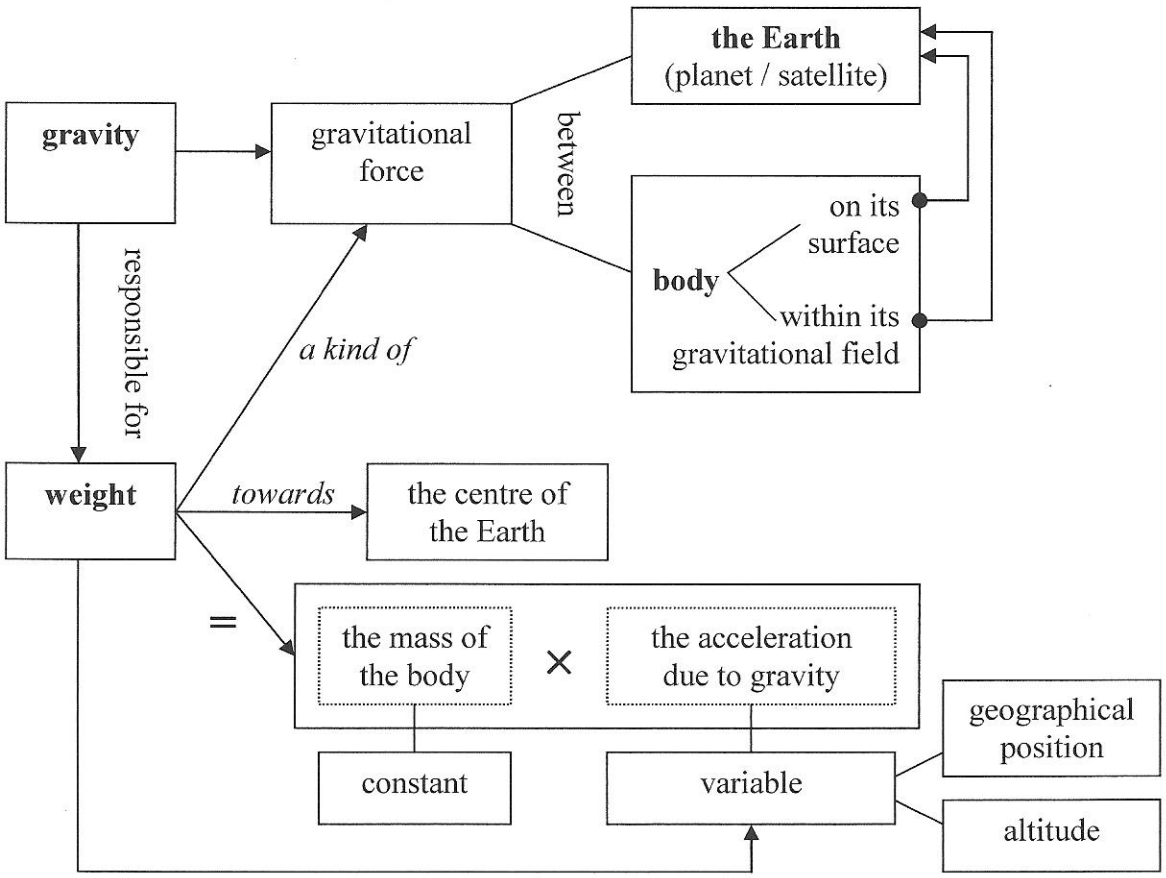
   is the mathematical definition of the force of attraction.
9. The region in which one body exerts a force of attraction on another body is called a gravitational field.

II. Answer the following questions:

1. When did Newton develop the theory of gravity?
2. When was Newton's great work '*Principia*' published?
3. What did Newton explain in '*Principia*'?
4. What law did he lay down in this work?
5. What does the force of attraction between two particles depend on?
6. What is the mathematical definition of the force of attraction?
7. What is a gravitational field?

III. Discuss Newton's Law of Universal Gravitation using the scheme.

SCHEME 4.3



SCHEME 4.3

I. Choose the right variant:

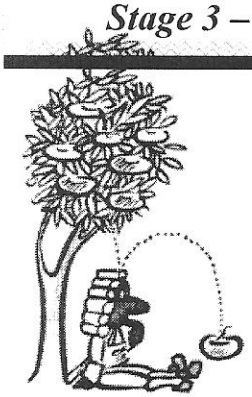
1. Gravity is a (*gravitational / magnetic*) force between the Earth (or another planet or satellite) and a body on its surface or within its gravitational field.
2. Gravity is responsible for the (*mass / weight*) of a body.
3. The weight of a body is one kind of (*electrical / gravitational*) force which the Earth exerts on that body.
4. The weight of a body is always directed towards the centre of (*the Earth / another body*).
5. The weight of a body is equal to the mass of the body (*divided / multiplied*) by the acceleration due to gravity.
6. The mass of a body is (*constant / variable*). The acceleration due to gravity varies with the geographical position and altitude.
7. Thus the weight of a body is a (*constant / variable*) quantity.

II. Answer the questions:

1. What is gravity?
2. What is gravity responsible for?
3. What is the weight of a body?
4. Is the weight of a body directed towards the centre of the Earth?
5. What is the weight of a body equal to?
6. Is the mass of a body constant or variable?
7. Is the weight of a body constant or variable?

III. Talk about the gravity and the weight of a body using the scheme.

Stage 3 – Text



GRAVITY

A poem by an unknown school-master

Attraction is a curious power,
That none can understand:
Its influence is everywhere –
In water, air and land;
It keeps the Earth compact and tight,
As though strong bolts were through it;
And, what is more mysterious yet,
It binds us mortals to it.

Newton's Theory of Gravity

Isaac Newton, English physicist and mathematician, was the culminating figure in the scientific revolution of the 17th century. In mathematics, he was the original discoverer of the infinitesimal calculus. In optics, his discovery of the composition of white light integrated such phenomena as colours into the science of light and laid the foundation for modern physical optics. In mechanics, his three laws of motion, the basic principles of modern physics, resulted in the formulation of the law of universal gravitation. Newton brought about the first main step in the process of development of a general physics theory.

Before Newton, people considered the world to be essentially two-dimensional, *i.e.* they dealt with the two dimensions in which one can walk about, while the up-and-down dimension seemed to be something essentially different. Newton proved the up-and-down direction to be symmetrical with the other two directions, by bringing in gravitational forces and showing how they take their place in physical theory. In other words Newton enabled us to pass from a picture with a two-dimensional symmetry to a picture with a three-dimensional one.

Isaac Newton began to develop the theory of gravity when he was 24 years old. Twenty years later he returned to this subject and in 1687 his great work '*Principia*' was published. Newton explained the structure and mechanics of the Universe in it and laid down the law of Universal Gravitation. He proved mathematically that every particle in the Universe attracts every other particle with a force which is directly proportional to the product of the masses of the particles and inversely proportional to the square of the distance between them. Thus, the law of Universal Gravitation is an inverse square law, and the force of attraction between the two masses m_1 and m_2 in kilograms separated by a distance d of meters may be stated mathematically as $F = \frac{Gm_1m_2}{d^2}$ newtons, where G is the gravitational constant. The constant G tells us how many newtons the attractive force is for two 1-kg masses separated by a distance of 1 m. The value of G was not determined by Newton. This difficult measurement was not determined until long after Newton's death.

The region in which one massive body (*i.e.* a body possessing the attribute of mass) exerts a force of attraction on another massive body is called a gravitational field. The gravitational force between the Earth (or another planet or satellite) and a body on its surface, or within its gravitational field is called gravity. According to Newton's inverse square law the gravity on a planet or satellite in terms of the Earth's gravity is given by $\frac{1}{m_p} \times \frac{d_p^2}{d_e^2}$ where m_p is the mass of the planet in the Earth masses and d_p and d_e are the diameters of the planet and the Earth, respectively. The gravity on the surface of the Moon was found to be 1/6 of that on the surface of the Earth.

Gravity is responsible for the weight of a body. People commonly refer to the kilogram as a unit of weight, but the kilogram is a unit of mass. The weight of a body is just one kind of the gravitational force of attraction which the Earth exerts on that body and is always directed towards the centre of the Earth. The SI unit of weight is therefore a newton. Gravity causes bodies to fall to the Earth with a uniform acceleration, but the magnitude of the acceleration due to gravity varies with the geographical location (latitude) and altitude (elevation). Thus, an object weight is not a fixed property of that object. Objects weigh more in some places than in others, depending on the local strength of gravity. It is their mass that always stays the same.

(Do exercise I to finish the text.)

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

I. This is the last paragraph of the text. Having read the information given in the box you are to choose the right variant.

Gravity is reduced to a very small extent by the centrifugal force caused by the Earth's rotation (for an object at rest on its surface). In order to stay in orbit around the Earth it is necessary for an orbiting body to achieve a velocity producing a (*centrifugal / centripetal*) force which exactly balances the force of gravity. For instance, the Moon travels in a (*straight / curved*) path around the Earth. This means that it (*is / is not*) continually changing the direction of its velocity, *i.e.* the Moon (*is not / is*) in a state of continual acceleration and the net force on it (*is not / is*) zero.

Newton's First Law

If the total force on an object is zero, its centre of mass continues in the same state of motion.

In other words, an object initially at rest is predicted to remain at rest if the total force on it is zero, and an object in motion remains in motion with the same velocity in the same direction. The converse of Newton's first law is also true: if we observe an object moving with constant velocity along a straight line, then the total force on it must be zero.

What happens if the total force on an object is not zero? It accelerates. Numerical prediction of the resulting acceleration is the topic of Newton's second law.

II. In the text, find the English equivalents for the words and phrases below. (The last paragraph is included.)

- научная революция
- исчисление бесконечно малых величин
- ввело такие явления, как цвета, в науку о свете
- фундаментальные законы современной физики
- общая физика
- вертикальное измерение
- вертикальное направление
- что-то / нечто существенно отличное
- прямо пропорционально
- обратно пропорционально
- закон обратных квадратов
- можно сформулировать математически
- для двух масс в один килограмм
- долгое время спустя
- действует с силой притяжения на / притягивает
- считают килограмм единицей измерения веса / принимают килограмм за …
- ускорение свободного падения
- изменяется в зависимости от географической широты и высоты
- в состоянии покоя
- по кривой
- результирующая / равнодействующая сила

*III. Rewrite sentences using **'it is … that / which / who'** and translate them.*

An object mass always stays the same.
***It is** an object mass **that / which** always stays the same.*
***Именно** масса тела всегда остается одной и той же.*

1. Newton brought about the first main step in the development of a general physics theory.
2. Newton enabled us to pass to a picture with a three-dimensional symmetry.
3. Newton's three laws of motion are the basic principles of modern physics.
4. Gravity is responsible for the weight of a body.
5. The centrifugal force caused by the Earth rotation reduces gravity.

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 make …
***It is** science **that / which** makes …*
Science made …
***It was** science **that / which** made …*

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

1. The value of G was not <u>determined</u> by Newton.
2. The region in which one massive body <u>exerts a force of attraction on</u> another massive body is called a gravitational field.
3. The magnitude of the acceleration due to gravity depends on the geographical location and <u>altitude</u>.
4. An object weight is not a <u>fixed</u> property of that object.
5. What happens if the <u>total</u> force on an object is not zero?
6. <u>Numerical</u> prediction of the resulting acceleration is the topic of Newton's second law.

a) constant
b) elevation
c) net
d) to attract
e) to calculate
f) quantitative

V. Read the paper and then complete the tasks given below.

Though the terms weight and mass are used interchangeably in common language, in science there is distinct difference between the two terms. The weight of an object is a force of gravity felt by that object but the mass of an object is the amount of matter the object has. Mass is a measure of the object's resistance to acceleration: a push on a skateboard will make it roll away quickly but the same push on a more massive car will hardly move it.

An object's weight depends on the pull of the gravitating object but the object's mass is independent of the gravity. For example, Joe Average weighs himself on the Earth's surface and then on the Moon's surface. His weight on the Moon will be about six times less than on the Earth but the number of atoms in his body has not changed so his mass is the same at the two places. In the old English unit system, there is a 'pound' of force and a 'pound' of mass. Only on the Earth's

surface, an object's pound of mass is equal to the number of pounds of force felt by the object due to the Earth's gravity.

In the metric system there is no confusion of terms. A kilogram is a quantity of *mass* and a newton is a quantity of force. One kilogram (kg) equals 2.205 pounds of mass and 1 pound of force is 4.45 newtons (N). If someone uses 'pounds', be sure you understand if force or mass is meant!

To find something's weight in newtons, you multiply the mass in kilograms by the acceleration due to gravity in the units of meters/seconds^2. For example: Mister X has a mass of 63.5 kg and he feels a force of gravity on the Earth which is equal to

$$63.5 \text{ kg} \times 9.8 \text{ m/s}^2 = 623 \text{ kg m/s}^2 = 623 \text{ N}.$$

His weight is 623 N. The other value in the preceding equation, 9.8 m/s^2, is the acceleration due to gravity close to the Earth's surface. Mister X's weight at other places in the universe will be different but his mass will remain the same.

A) Calculate your own weight on Earth.

B) Underline the right variant.

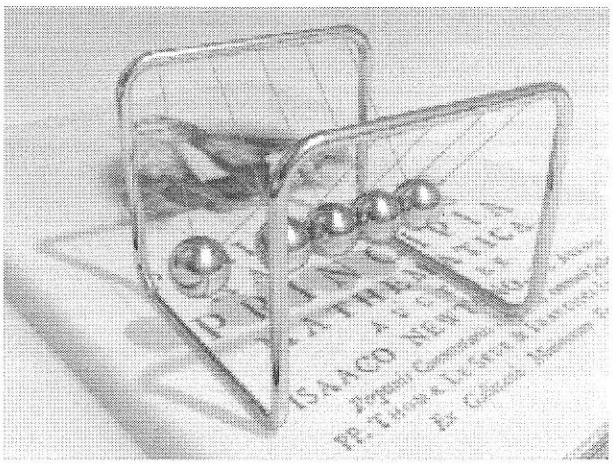
	MASS	WEIGHT
1.	Mass is (*the quantity of matter in a body / the force by which the earth attracts a body towards its centre*).	Weight is (*the quantity of matter in a body / the force by which the earth attracts a body towards its centre*).
2.	Mass is a (*scalar / vector*) quantity.	Weight is a (*scalar / vector*) quantity.
3.	Mass of a body (*varies from place to place / is always constant everywhere in the universe*).	Weight of a body (*varies from place to place / is always constant everywhere in the universe*).
4.	Mass of a moving body is $m = (\frac{F}{a} / mg)$	Weight of a body is $W = (\frac{F}{a} / mg)$
5.	Mass can be determined by a(n) (*spring / ordinary*) balance.	Weight is measured by a(n) (*spring / ordinary*) balance.
6.	A unit of mass in the SI is the (*newton / kilogram*).	A unit of weight in the SI is the (*newton / kilogram*).

C) Complete the last paragraph of the text with details. Use the following expressions:

I might / should I'd like to I want to ⟹ add that …	Я мог бы Я хотел бы Я хочу ⟹ добавить, что …
It should be added that …	Следует добавить, что …
In addition, I want to note that …	Кроме того, / вдобавок я хочу заметить, что …
In addition to the above …	В дополнение к вышесказанному …

VI. Ask your friend the following questions. Start with the words:

Do you know ...?
Do you remember ...?
Can / Could you tell me ...?
Have you any idea ...?
I want to know ...
I'd like to know ...
I wonder ...



1. Was Newton the original discoverer in different fields of science? What are these fields?
2. What did Newton prove by bringing in gravitational forces?
3. What is his great work '*Principia*' concerned with?
4. Why is the law of Universal Gravitation often called an inverse square law?
5. What is gravitational field?
6. What is gravity? What is gravity on a planet or satellite equal to?
7. Is there any difference between mass and weight?
8. What is gravity reduced by?

VII. Annotate schemes 4.1, 4.2 and 4.3 using the text "Newton's Theory of Gravity" and then describe the schemes in your own words. Don't forget to use the following statements.

1.

The paper	refers to ... is concerned with ... provides information on ...	*and*	In the paper	we get a picture of ... we have a description of ...

2.

	V:	**V_3:**
The author V_s that ...	**point** out	*regular verb*
It is interesting to **V** that ...	**note**	*regular verb*
It is important to **V** that ...	**emphasize**	*regular verb*
It is useful to **V** that ...	**mention**	*regular verb*
It should be V_3 that ...	**make** it clear	***made***
	draw *one's* attention to the fact	***drawn***

3. In conclusion

the author V_s that ..., *etc.* (see 2)

4. In my opinion / To my mind

the (present) paper		is	(not) interesting (not) important useful / useless		for those who	study ...
the problem the question the subject the fact	considered discussed dealt with under study	is of	much some great no	interest importance use	for us since we	are interested in ...

You can find some more useful expressions on pages 167 – 168.

VIII. 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"

gravitation The attractive force between any two pieces of *matter* (→)[1], *i.e.* material bodies; the magnitude of the force depends on the mass of the bodies and the distance between them.

Newton's law of universal gravitation Any two pieces of *matter* (→)[1] attract one another with a force which is proportional to the product of their masses and inversely proportional to the square of their distance apart. The force of attraction, F, between the two masses, m_1 and m_2, respectively, when placed at a distance, d, is $F = \frac{Gm_1m_2}{d^2}$ where G is *the gravitational constant* (↓).

gravitational constant The constant of proportionality, G, in *Newton's Law of universal gravitation* (↑). If two equal masses of 1 kg are placed 1 m apart, the force between them is 6.672×10^{-11} newtons. The *value* (→)[2] of the gravitational constant is $6.672\times10^{-11}\ \text{N m}^2\text{kg}^{-2}$.

gravitational field The region around an object in which another object experiences a gravitational force of attraction. It is a vector field and can be represented by lines of gravitational force, which indicate the direction of the vector at any point. The density of the field (the number of lines per unit area) is proportional to the magnitude of the field. The gravitational field of a planet is the region under its influence.

gravity The gravitational force between the Earth and a body either on the Earth's surface or in the Earth's gravitational field. The force decreases as the distance from the Earth increases; the force of gravity is inversely proportional to the square of the distance.

universal gravitation A more complete description of *gravitation* (↑) indicating that the force of gravity exists throughout the universe.

acceleration due to gravity The acceleration caused by the force of *gravity* (↑) acting on a body falling freely in a vacuum; it varies (by about ± 0.3 per cent from a mean value) in different localities on the Earth. The mean accepted value is $9.8065\ \text{m s}^{-2}$; the acceleration being least at the Equator and greatest at the Poles. The variation in value arises from the variation of the distance of the Earth's surface from its centre of mass. The symbol for the acceleration due to gravity is g.

acceleration of free fall An alternative term for ACCELERATION DUE TO GRAVITY (↑).

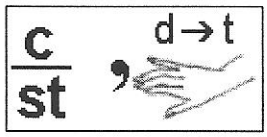
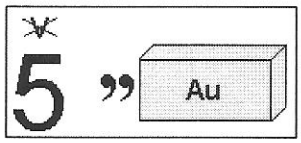
gravitational mass The mass of a body can be defined from the gravitational attraction it has to other bodies; it is calculated from the equation for *the universal gravitation* (↑).

weight The force with which the Earth attracts a body is the weight of that body; weight *is measured* (→)[2] in newtons. At any one point on the Earth, weight is proportional to mass as the force of gravity produces a constant acceleration at that point. The mass of a body is constant (by Newton's principles), but its weight varies depending upon its position on the Earth's surface (the weight is least at the Equator and greatest at the Poles), and upon its height above the Earth's surface (the greater the height, the less the weight).

[1] – see "PHYSICS"
[2] – see "UNITS OF MEASUREMENT"

Task IV. Read the definitions of the terms from "Longman Dictionary of Scientific Usage" and do the following exercise.

I. **Rebuses** *Solve the rebuses and then match each term with its definition.*

1) gravitational 	a) the mass of a body can be defined from the gravitational attraction it has to other bodies; it is calculated from the equation for the universal gravitation
2) gravitational 	b) the constant of proportionality in Newton's Law of universal gravitation
3) gravitational 	c) the force of attraction
4) gravitational 	d) the region around an object in which another object experiences a gravitational force

II. There are different kinds of forces. Match each definition of the force with its term. (Pay attention to the fact that the definitions of centrifugal and centripetal forces haven't been discussed yet.)

The force

1 – of attraction between any two pieces of matter, *i.e.* bodies or particles.

2 – of attraction between the Earth and a body either on the Earth's surface or in the Earth's gravitational field.

3 – with which the Earth attracts a body.

4 – which causes a body to travel in a circular path, or in any arc of a circle.

5 – which causes a body to move away from the centre. It is the reaction of a body travelling in a circular path. This force is equal or opposite to the centripetal one.

a) centrifugal force
b) centripetal force
c) gravity
d) gravitation
e) weight

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

- **Newton's Law of Universal Gravitation**
- **The Weight of a Body**

Stage 5 – In Addition

Dialogue

Read the dialogue and then make up your own one. Try to explain to your fellow-student what gravity is. Underlined phrases should be used in your dialogue.

A: We were discussing gravity in physics last week and I just can't understand what it's all about. Can you explain it to me?
B: Easily. Gravity is the force that pulls everything towards the centre of the Earth. Now do you get it?
A: That's beyond me. I just don't understand.
B: You are slow on the uptake!
A: Only in this case. I'm usually quite quick.
B: Perhaps this example will make it a bit clearer. Suppose you take an iron ball and I take a paper ball, both of the same size, and drop them in vacuum. Which would reach the ground first?
A: The iron ball, of course.
B: It's obvious you've no idea when it comes to physics. They would arrive at the same time.
A: What! Does paper fall as fast as iron?
B: It's curious, isn't it? But it's a fact. A scientist called Galileo discovered it.
A: How did he do it?
B: He dropped various things from the Leaning Tower of Pisa.
A: But I still can't believe that a paper ball can fall as fast as an iron one.
B: That's quite natural. We're so used to seeing gravity at work that we scarcely notice it. But it's very important.
A: Rubbish! Gravity is just something our teacher plagues us with.
B: Oh, no. If gravity stopped working for even an instant, everything would fly away into space, you and me, the air, the water in the ocean, and everything else.
A: And our physics teacher! Well, perhaps gravity is a bit more interesting after all. I am just beginning to realize how important it is. I'll have to study it a little more carefully.

Experiment

Conduct the following experiment, asking your fellow-students to watch what you are doing and to comment on the individual stages of the experiment. In doing so, follow these instructions.

Experimenter:	**Students:**
1. Stand up, take a pen and a sheet of paper. 2. State that you are going to conduct an important experiment. 3. Drop the two things. 4. Ask what your fellow-students observed when the two things hit the floor.	In your explanations use the following words: *to reach the floor* *later*
5. Say that you are going to conduct another experiment. Take a pen and a book. 6. Drop the two things. 7. Ask the students to state what they observed.	*to reach the floor* *at the same time*
8. Ask your fellow-students to explain why the two experiments differed in their results.	*equal / different size* *nearly equal / different shape* *to offer (greater) resistance* *to fall at different speeds / at the same speed* *vacuum*

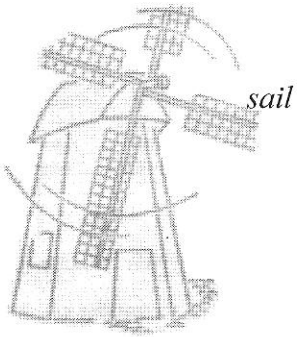
Think and Guess

1. Newton's Windmill[1]

Read the story and answer the question.

As a boy Isaac Newton built a model of windmill, the sails of which could turn even when there was no wind. All people were surprised when they saw it. They could not believe their eyes.

What was the secret of Newton's windmill? Try to guess!



windmill

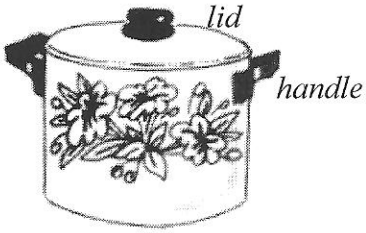
[1] **windmill** ['wɪndmɪl] a building containing a machine that crushes corn, provides electricity, pumps water, *etc.*, and is driven by large sails which are turned round by wind
(from "Active Dictionary of English")

2. Newton's Distraction[1]

Put the sentences of the story in the correct order.

a) The housekeeper[2], however, sent one of the maids[3] into his study with an egg and a saucepan[4] of water.
b) But as he wished to be alone, Newton sent her away, saying that he would cook it himself.
c) While working on different questions Newton forgot everything else.
d) The maid had been told to boil the egg and stay while he ate it.
e) Soon she returned and found Newton standing deep in thought, the egg in his hand, while his watch was boiling in the saucepan.
f) On such days he stayed in his room and did not allow anyone to disturb him.
g) The maid left the egg near his watch on the table and went out of the room.
h) One morning he was working very hard, and did not leave his room to go and have breakfast with his family.

[1] **distraction** [dɪs'trækʃən] the habit of forgetting everything or not noticing what is happening, what one is doing
[2] **housekeeper** ['haus'ki:pə] a person employed to be in charge of keeping house and to look after a household (all the people living together in a house)
[3] **maid** [meɪd] a woman employed to work as a servant
[4] **saucepan** ['sɔ:spən] a deep round metal cooking pot with handles and a lid
(from "Active Dictionary of English")



saucepan

Fun with Words

PLAY UPON WORDS
ИГРА СЛОВ

1. *You have studied* ***the Law of Universal Gravitation****. Here you can find* ***Universal Laws of Life****.*

1. You cannot save your face if you lose your head.[1]
2. There are only two ways to avoid alimony: either you stay single or stay married. Alimony is the high cost of leaving.[2]
3. You cannot make a hit[3] if you have no aim in life.
4. No matter how much you trying to improve Mother Nature, you are not kidding[4] Father Time.
5. You cannot keep the home circle square with a triangle.[5]
6. If you file[6] it, you'll know where it is but never need it. If you don't file it, you'll need it but never know where it is.
7. It is a wise wife who knows when to overlook and when to oversee.[7]
8. A man's thought: All women are divided into three classes: the looked at, the looked over and the overlooked.
   A woman's view: And so are men – the intelligent, the handsome and the majority.[8]
9. No matter how busy people are, they are never too busy to stop and talk about how busy they are.
10. By the time you have learned to make the most of life, most of it is gone.[9]

[1] **to save face** – сохранить (свое) лицо, репутацию, доброе имя; не уронить достоинства; **to lose one's head** – потерять голову, утратить самообладание, растеряться

[2] **alimony** ['ælɪmənɪ] *n* алименты; **high cost of leaving** – *сравните*: **high cost of living** – дороговизна

[3] **to make a hit** – иметь успех, произвести сенсацию; *букв.* попасть в цель, поражать цель

[4] **to kid** – одурачить, обмануть кого-л.

[5] **home circle** – домашний очаг; **square** – 1) квадратный; 2) честный; **triangle** – треугольник, *зд.* любовный треугольник

[6] **to file** – хранить в определенном месте

[7] **to overlook** – не обращать внимание, не придавать значение; **to oversee** – надзирать; следить, наблюдать за

[8] **to look at** – быть достойным внимания, представлять интерес; **to look over** – внимательно изучать, *зд.* засматриваться

[9] **to make the most of** – использовать наилучшим образом, в полной мере, максимально

2. Punctuation. *When the sentence you can see below was given to a class to punctuate correctly, the boys were found to take it one way, the girls another. Try to guess these two ways of punctuation.*

Woman without her man is a savage.

savage ['sævɪdʒ] *n* дикарь, дикарка