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Stage 1 – Vocabulary

Newton's Theory of Gravity

 centre ['sentə] <i>n</i> constant ['kɒnstənt] <i>n</i> culminating ['kʌlmɪneɪtɪŋ] <i>a</i> diameter [daɪ'æmɪtə] <i>n</i> formulation [fɔːmju'leɪʃ(ə)n] <i>n</i> geographical [dʒɪə'græfɪkəl] <i>a</i> gravitation [grævɪ'teɪʃ(ə)n] <i>n</i>	gravity ['grævɪtɪ] <i>n</i> integrate ['ɪntɪɡreɪt] <i>v</i> mathematician [ˌmæθɪmə'tɪʃ(ə)n] <i>n</i> mathematics [ˌmæθɪ'mætɪks] <i>n</i> optics ['ɒptɪks] <i>n</i> orbit ['ɔːbrɪt] <i>n</i>	physicist ['fɪzɪsɪst] <i>n</i> principle ['prɪnsəpl] <i>n</i> process ['prəʊses] <i>n</i> proportional [prə'pɔːʃ(ə)nəl] <i>a</i> revolution [ˌrevə'lʊːʃ(ə)n] <i>n</i> symmetric(al) [sɪ'metrɪk(əl)] <i>a</i> symmetry ['sɪmɪtri] <i>n</i>
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achieve [ə'tʃiːv] *v* достигать
altitude ['æltɪtuːd] *n* высота
apply [ə'plai] *v* применять
arise [ə'raɪz] *v* (arose; arisen) возникать, появляться
assume [ə'sjuːm] *v* предполагать, допускать
attract [ə'trækt] *v* притягивать
attraction [ə'trækʃ(ə)n] *n* притяжение, тяготение
attribute ['ætrɪbjʊːt] *n* свойство, признак
balance ['bæləns] *v* балансировать; сохранять равновесие; уравнивать
bring about [brɪŋ] *v* (brought) осуществлять
bring in [brɪŋ] *v* (brought) выдвигать, вносить (*предложение*); вводить (*новые идеи*)
calculus ['kælkjʊləs] *n* исчисление
centrifugal [sen'trɪfʊɡ(ə)l] *a* центробежный
colour ['klʌə] *n* цвет
composition [ˌkɒmpə'zɪʃ(ə)n] *n* структура, состав
converse ['kɒnvɜːs] *n* обратное утверждение
curve [kɜːv] *n* кривая (линия); дуга
decrease [diː'kriːs] *v* уменьшать(ся)
directly [dɪ'rektli] *adv* прямо, непосредственно
elevation [ˌelɪ'veɪʃ(ə)n] *a* высота (*над уровнем моря*)
enable [ɪ'neɪbl] *v* давать возможность
essentially [ɪ'senʃ(ə)li] *adv* существенно
 образом; по существу
exert [ɪɡ'zɜːt] *v* напрягать (*силы*)
experience [ɪks'pɪəriəns] *v* испытывать
explain [ɪks'pleɪn] *v* объяснять
extent [ɪks'tent] *n* степень, мера
fall [fɑːl] *v* (fell, fallen) понижаться; падать
happen ['hæpən] *v* случаться, иметь место
increase [ɪn'kriːs] *v* возрастать, увеличивать(ся)
indirectly [ˌɪndɪ'rektli] *adv* косвенно
infinitesimal [ˌɪnfɪnɪ'tesɪm(ə)l] *a* бесконечно малый

influence ['ɪnfluəns] *n* влияние, (воз)действие
inversely [ɪn'vɜːsli] *adv* обратно
just [dʒʌst] *adv* 1) точно, как раз, именно; 2) только что; 3) совсем, просто; 4) едва
latitude ['lætɪtuːd] *n* *асмп., 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 [piːs] *n* часть; отдельный предмет
product ['prɒdʌkt] *n* *мат.* произведение
prove [pruːv] *v* доказывать
publish ['pʌblɪʃ] *v* издавать
reach [riːtʃ] *v* достигать, доходить
reduce [rɪ'djuːs] *v* понижать
region ['riːdʒən] *v* область
responsible (for) [rɪs'pɒnsəbl] *a* ответственный (*за что-л.*)
respectively [rɪs'pektɪvli] *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'wɔːdz] *prep* (по направлению) к
variable ['veəriəbl] *a* изменчивый, непостоянный, переменный
vary ['veəri] *v* изменяться
weigh [wei] *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 ['sɪmɪtri] – symmetric(al) [sɪ'metrɪk(ə)];
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.

- The force of gravity **decreases** as the distance from the Earth **increases**.
- 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 ['kɒnstənt] **1)** *n* физ., мат. постоянная (величина), константа; **2)** *a* 1) постоянный;
неизменный; 2) твердый; верный (идея и т.п.)

distance ['distəns] *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)] *a* 1) общий, всеобщий; общего характера; 2) повсеместный; 3) обычный; 4) главный, генеральный

general II ['dʒen(ə)r(ə)] *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 ['prɒdʌkt] *n* 1) продукт; продукция; изделие; 2) результат, плоды; 3) *мат.* произведение; 4) *хим.* продукты реакции

region ['riːdʒən] *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 [təʊtl] 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.

- Isaac Newton was the culminating **figure** in the science revolution of the 17th century.
- Newton's three laws of motion are the basic **principles** of modern physics.
- Newton was the first to begin the development of a **general** physics theory.
- Isaac Newton began to develop the theory of gravity when he was 24 years old. Twenty years later he returned to this **subject**.
- 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.
- The value of the **constant** G was not determined by Newton.
- The **region** in which one body attracts another body is called a gravitational field.
- A centrifugal force exactly **balances** the force of gravity.
- 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 [wɔːk] *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 [bi'twi:n] *prep* между (*двух предметов*)
- b) **discover** [dis'kʌvə] *v* открывать, делать (*научное*) открытие
open ['əʊp(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 [wɜ: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)

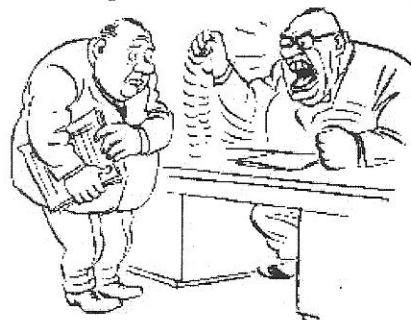
Каламбуры со словами одинакового звучания, разного написания, с разными значениями (омофоны)

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:

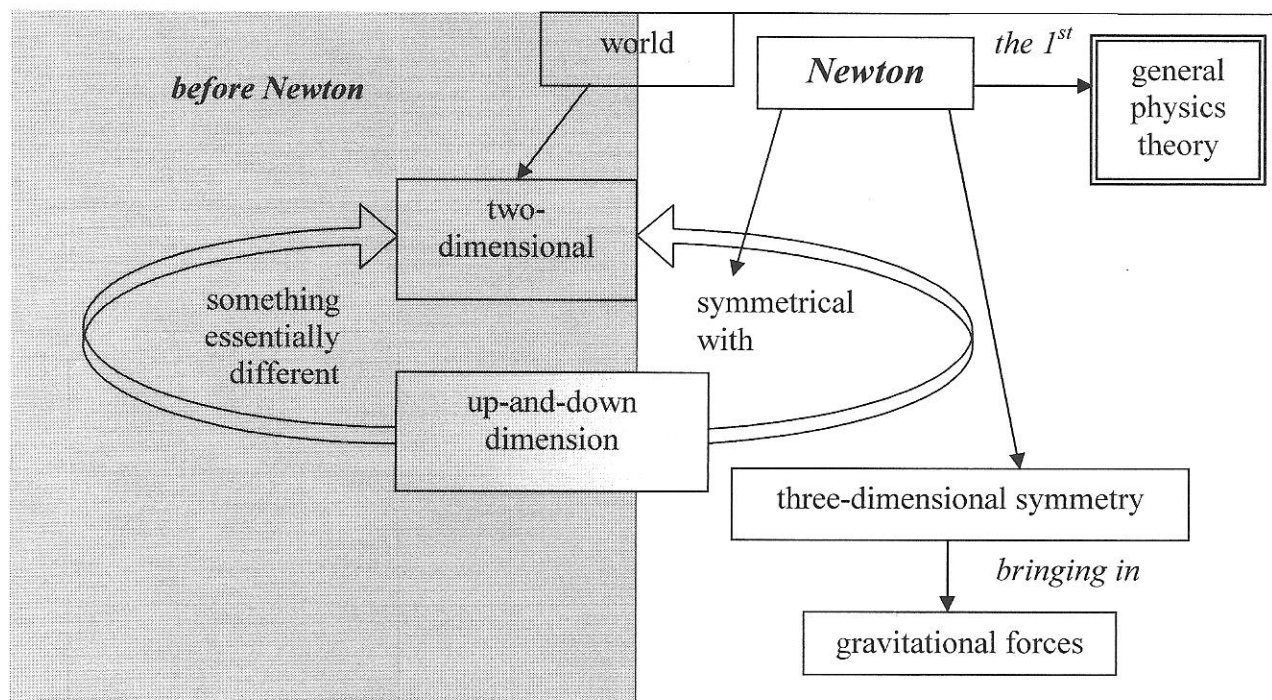
PRINCIPAL and **PRINCIPLE**

Your **principal** is your **pal**. A **principle** can be called a **rule**.

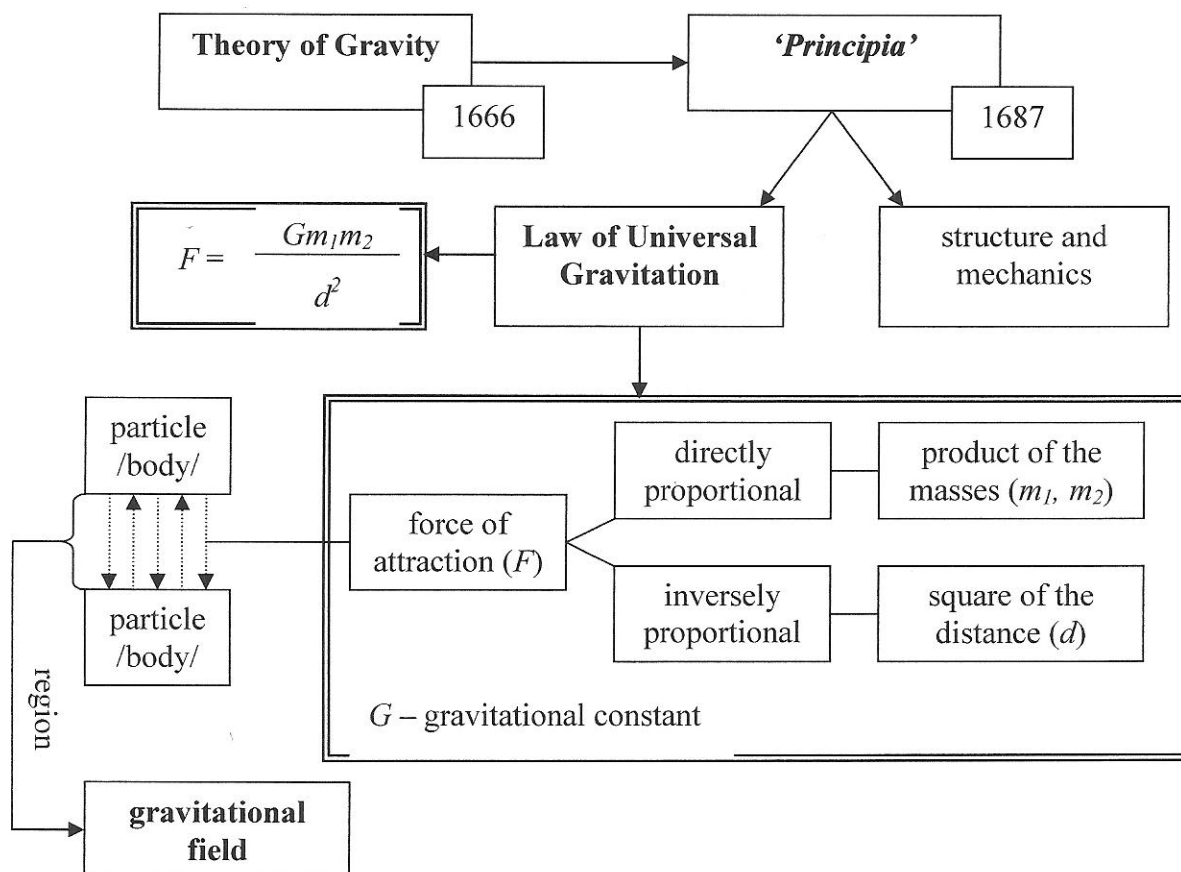
A fuller list of spelling mnemonics is given on page 16.

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.

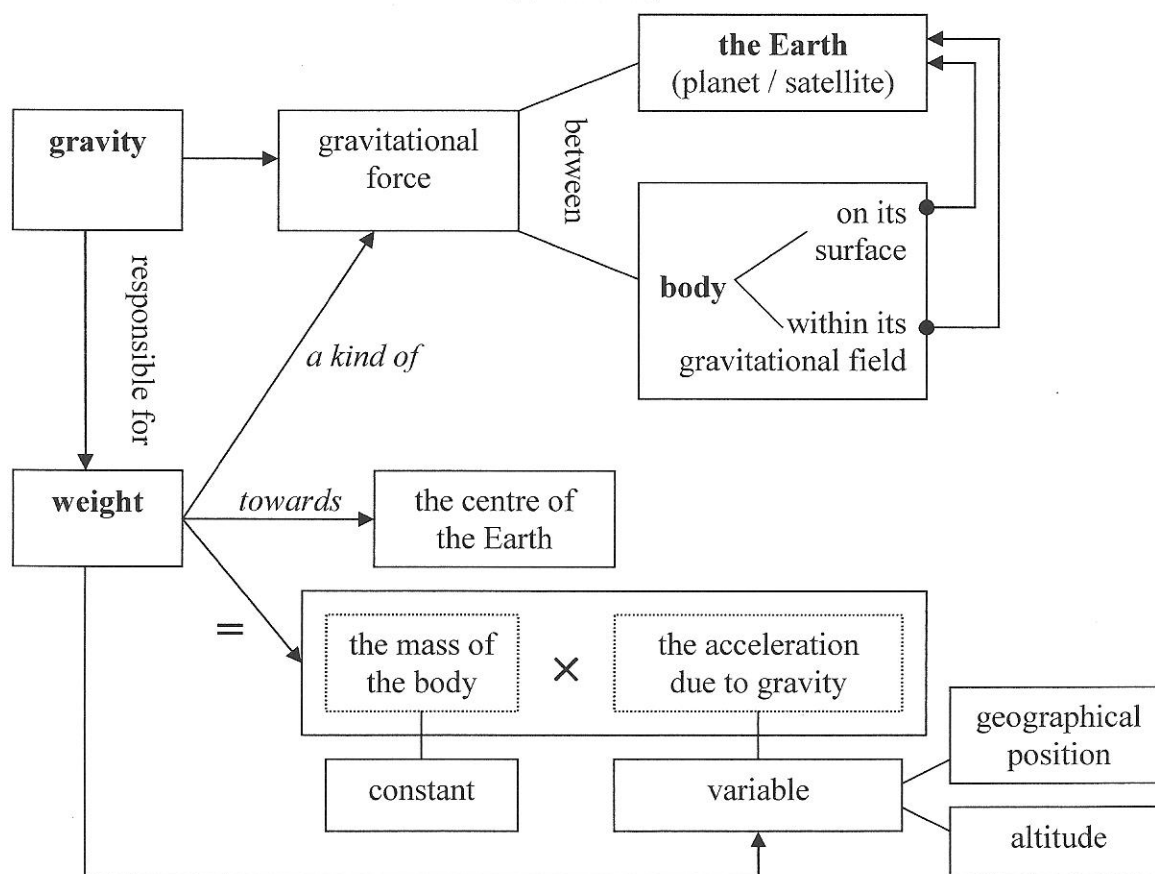
9. The region in which one body exerts a force of attraction on another body is called a gravitational field.

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:

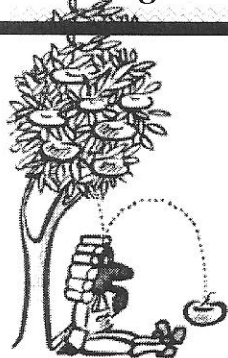
- Gravity is a (*gravitational / magnetic*) force between the Earth (or another planet or satellite) and a body on its surface or within its gravitational field.
- Gravity is responsible for the (*mass / weight*) of a body.
- The weight of a body is one kind of (*electrical / gravitational*) force which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

II. Answer the questions:

- What is gravity?
- What is gravity responsible for?
- What is the weight of a body?
- Is the weight of a body directed towards the centre of the Earth?
- What is the weight of a body equal to?
- Is the mass of a body constant or variable?
- 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 | ○ закон обратных квадратов |
| ○ исчисление бесконечно малых величин | ○ можно сформулировать математически |
| ○ ввело такие явления, как цвета, в науку о свете | ○ для двух масс в один килограмм |
| ○ фундаментальные законы современной физики | ○ долгое время спустя |
| ○ общая физика | ○ действует с силой притяжения на / притягивает |
| ○ вертикальное измерение | ○ считают килограмм единицей измерения веса / принимают килограмм за ... |
| ○ вертикальное направление | ○ ускорение свободного падения |
| ○ что-то / нечто существенно отличное | ○ изменяется в зависимости от географической широты и высоты |
| ○ прямо пропорционально | ○ в состоянии покоя |
| ○ обратно пропорционально | ○ 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.

- Newton brought about the first main step in the development of a general physics theory.
- Newton enabled us to pass to a picture with a three-dimensional symmetry.
- Newton’s three laws of motion are the basic principles of modern physics.
- Gravity is responsible for the weight of a body.
- 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.

- The value of G was not determined by Newton.
- The region in which one massive body exerts a force of attraction on another massive body is called a gravitational field.
- The magnitude of the acceleration due to gravity depends on the geographical location and altitude.
- An object weight is not a fixed property of that object.
- What happens if the total force on an object is not zero?
- Numerical 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/seconds². 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 (<i>the quantity of matter in a body / the force by which the earth attracts a body towards its centre</i>).	Weight is (<i>the quantity of matter in a body / the force by which the earth attracts a body towards its centre</i>).
2.	Mass is a (<i>scalar / vector</i>) quantity.	Weight is a (<i>scalar / vector</i>) quantity.
3.	Mass of a body (<i>varies from place to place / is always constant everywhere in the universe</i>).	Weight of a body (<i>varies from place to place / is always constant everywhere in the universe</i>).
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) (<i>spring / ordinary</i>) balance.	Weight is measured by a(n) (<i>spring / ordinary</i>) balance.
6.	A unit of mass in the SI is the (<i>newton / kilogram</i>).	A unit of weight in the SI is the (<i>newton / kilogram</i>).

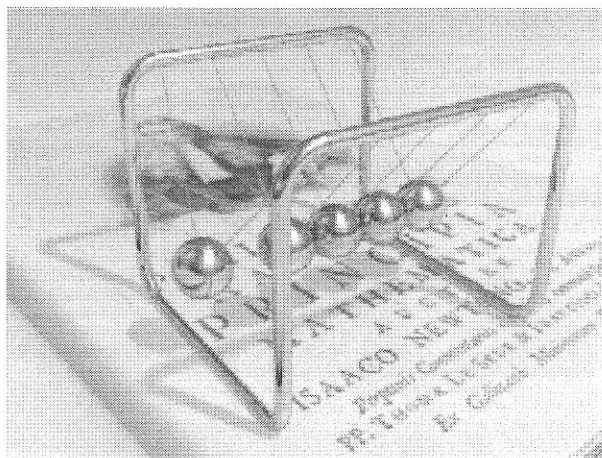
C) Complete the last paragraph of the text with details. Use the following expressions:

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 ...
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2.

	V:	V ₃ :
The author V _s that ... It is interesting to V that ... It is important to V that ... It is useful to V that ... It should be V ₃ that ...	point out note emphasize mention make it clear draw one’s attention to the fact	<i>regular verb</i> <i>regular verb</i> <i>regular verb</i> <i>regular verb</i> made 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		
					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 $6.672 \times 10^{-11} \text{ N m}^2 \text{ kg}^{-2}$.

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 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* (↑).

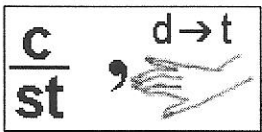
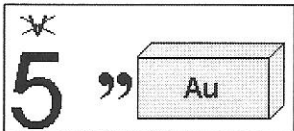


weight The force with which the Earth attracts a body is the weight of that body; *weight is measured* (→)² in newtons. At any one point on the Earth, weight is proportional to mass as the force of gravity produces a constant acceleration at that point. The mass of a body is constant (by Newton’s principles), 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”

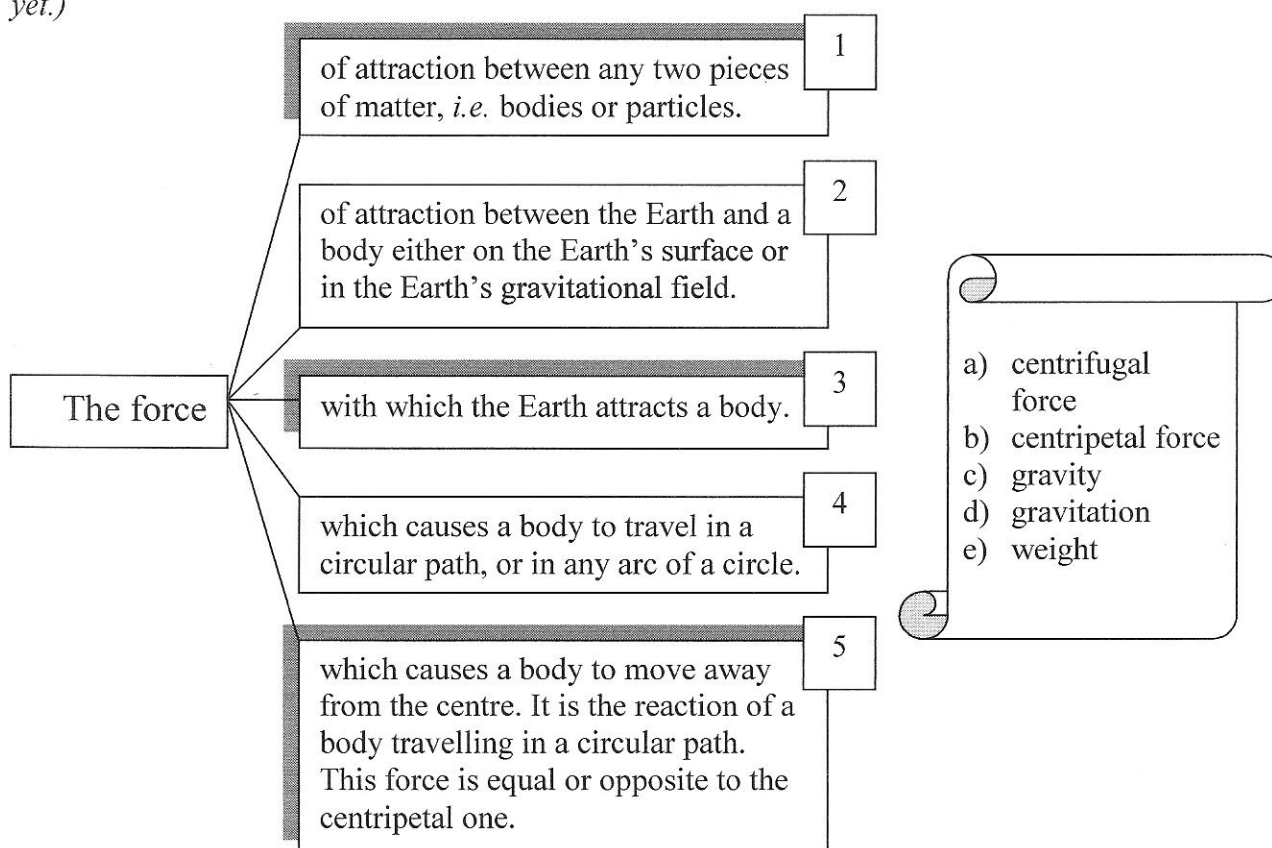
² – see “UNITS OF MEASUREMENT”

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.)



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: <i>to reach the floor</i> <i>later</i>
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.	<i>to reach the floor</i> <i>at the same time</i>
8. Ask your fellow-students to explain why the two experiments differed in their results.	<i>equal / different size</i> <i>nearly equal / different shape</i> <i>to offer (greater) resistance</i> <i>to fall at different speeds / at the same speed</i> <i>vacuum</i>

Think and Guess

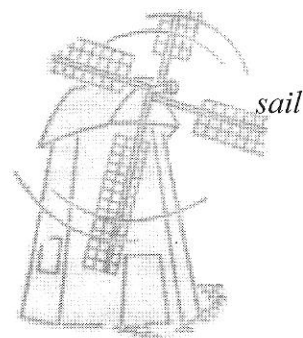
1. Newton’s Windmill¹

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!

¹ **windmill** [ˈwɪndmɪl] 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”)



windmill

2. Newton’s Distraction¹

Put the sentences of the story in the correct order.

- a) The housekeeper², however, sent one of the maids³ into his study with an egg and a saucepan⁴ 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.

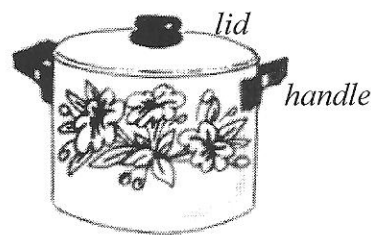
¹ **distraction** [dɪsˈtrækʃən] the habit of forgetting everything or not noticing what is happening, what one is doing

² **housekeeper** [ˈhaʊsˈkiːpə] 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** [ˈsɔːspən] 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 hit³ if you have no aim in life.
4. No matter how much you trying to improve Mother Nature, you are not kidding⁴ Father Time.
5. You cannot keep the home circle square with a triangle.⁵
6. If you file⁶ 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** [ˈælɪməni] *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 [ˈsævidʒ] *n* дикарь, дикарка