**Unit 3: MATTER IN MOTION**

## Part I “NEWTON’S LAWS OF MOTION”

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1. **In pairs or small groups, discuss the questions:**
2. What exactly is speed?
3. What is velocity?
4. What is acceleration?
5. **Do you remember Newton’s laws of motion?**
6. Every action of a force produces an equal and opposite reaction.
7. Bodies move in a straight line with a uniform speed, or remain stationary, unless a force acts to change their speed or direction.
8. Forces produce accelerations that are in proportion to the mass of a body (*F= ma*)
9. **Match the terms with their definitions.**

|  |  |
| --- | --- |
| 1. vector | 1. a force that stops something moving or makes it move more slowly |
| 1. work | 1. the form of energy that an object gains as it is lifted |
| 1. resistance | 1. the resistance of one surface to another surface or substance moving over or through it |
| 1. potential energy | 1. a quantity that has both size and direction |
| 1. power | 1. the quantity of movement of a moving object, measured as its mass multiplied by its speed |
| 1. momentum | 1. the use of force to produce movement |
| 1. kinetic energy | 1. the strength of energy contained in something |
| 1. friction | 1. energy produced by movement |

1. **Fill in the gaps with the words from the list.**

|  |  |  |  |
| --- | --- | --- | --- |
| *measure*  *speed*  *can’t*  *pushes* | *pairs*  *unbalanced*  *change*  *shape* | *slow*  *direction*  *effects*  *pulls* | *can*  *turn*  *balanced* |

**Force and Movement**

1. Forces are nearly \_\_\_\_\_\_\_\_\_\_\_\_\_\_ and \_\_\_\_\_\_\_\_\_\_\_\_\_\_.
2. Forces \_\_\_\_\_\_\_\_\_\_\_\_\_\_ be seen, but the \_\_\_\_\_\_\_\_\_\_\_\_\_\_ of a force \_\_\_\_\_\_\_\_\_\_\_\_\_\_ be seen.
3. They usually act in \_\_\_\_\_\_\_\_\_\_\_\_\_\_ .
4. They always act in a certain \_\_\_\_\_\_\_\_\_\_\_\_\_\_ .
5. A newton meter is used to \_\_\_\_\_\_\_\_\_\_\_\_\_\_ forces.
6. Forces can make objects do five things: \_\_\_\_\_\_\_\_\_\_\_\_\_\_ up, \_\_\_\_\_\_\_\_\_\_\_\_\_\_ down, \_\_\_\_\_\_\_\_\_\_\_\_\_\_ direction, \_\_\_\_\_\_\_\_\_\_\_\_\_\_ , change\_\_\_\_\_\_\_\_\_\_\_\_\_\_ .
7. \_\_\_\_\_\_\_\_\_\_\_\_\_\_ forces produce no change in movement.
8. \_\_\_\_\_\_\_\_\_\_\_\_\_\_ forces change the speed and or direction of moving objects.
9. **Decide if these statements are true or false.**
10. Velocity describes both the speed and direction of an object.
11. Velocity can’t be negative.
12. Deceleration is a negative acceleration.
13. Quantities that have magnitude and direction are called vectors.
14. Speed can be a negative number.
15. Resistance decreases as the speed of the object increases.
16. In a vacuum objects continue to fall with acceleration due to gravity of 10 m/s2
17. There is always a force in the direction of movement.
18. Weight is a force, which is measured in newtons (N).
19. An object has different mass on the Earth, the Moon and in outer space.
20. The total momentum of two objects before collision or explosion is different from the total momentum after.
21. **Read and complete the text using the words below and arrange the sentences of Paragraph 2** **in the right order**.

NEWTON’S LAWS of MOTION

1. Isaac Newton was one of the most prominent and influential scientists of all time. He helped to invent calculus, explained gravity and identified the constituent colors of white light. His three laws of motion describe why a golf ball follows a 1) \_\_\_\_\_\_\_\_\_\_\_\_\_ path, why we are pressed against the side of a cornering car and why we feel the force through a baseball bat as it strikes the ball.
2. (1- … )Then, when the university was closed for an outbreak of plague, Newton took the first steps to developing his three laws of motion. (2- …) An average student at Cambridge in the 1660s, Newton began by reading the great works of mathematics. (3- …)It took him highly inquisitive character to understand some of the most seemingly simple yet profound aspects of our world, such as how a thrown ball curves through the air, why things fall down rather than up and how the planets move around the Sun. (4- …) Through them he was drawn away from civic law into the laws of physics. (5- …) Newton, who lived in the 17th century, is considered one of the foremost intellects of science.
3. Borrowing Galileo’s principle of inertia, Newton formulated his fist law. It states that bodies do not move or 2) \_\_\_\_\_\_\_\_\_\_\_\_\_ their speed unless a force acts. Bodies that are not moving will remain stationary unless a 3) \_\_\_\_\_\_\_\_\_\_\_\_\_ is applied; bodies that are moving with some constant speed keep moving at that same speed unless acted upon by a force. A force supplies an acceleration that changes the velocity of the object. 4) \_\_\_\_\_\_\_\_\_\_\_\_\_ is a change in speed over some time.
4. This is hard to appreciate in our own experience. If we throw a hockey puck it skims along the ice but eventually slows due to friction with the ice. Friction causes a force that decelerates the puck. But Newton’s first law may be seen in a special case where there is no 5) \_\_\_\_\_\_\_\_\_\_\_\_\_ . The nearest we might get to this is in space, but even here there are forces such as gravity at work. Nevertheless, this first law provides a basic touchstone from which to understand forces and motion.
5. Newton’s second law of motion relates the size of the force to the acceleration it produces. The force needed to accelerate an object is proportional to the object’s mass. 6) \_\_\_\_\_\_\_\_\_\_\_\_\_ objects – or rather ones with large inertia – need more force to accelerate them than lighter objects. So to accelerate a car from standing still to 100 kilometers an hour in one minute would take a force equal to the car’s mass times its increase in speed per unit time. Newton’s second law is expressed algebraically as *‘F= ma’*, force (*F*) equals mass (*m*) times acceleration (*a*). Turning this definition around, the second law expressed in another way says that acceleration is equal to force per unit mass. For a constant acceleration, force per unit mass is also unchanged. So the 7) \_\_\_\_\_\_\_\_\_\_\_\_\_ amount of force is needed to move a kilogram mass whether it is part of a small or large body. This explains Galileo’s imaginary experiment that asks which would hit the ground first if dropped together: a cannonball or a feather? Visualizing it we may think that the cannonball would arrive ahead of the drifting feather. But this is simply due to the air resistance that wafts the feather. If there were no 8) \_\_\_\_\_\_\_\_\_\_\_\_\_ , then both would fall at the same rate, hitting the ground together. They experience the same acceleration, gravity, so they fall side by side. *Apollo 15* astronauts showed in 1971 that on the Moon, where there is no atmosphere to slow it down, the feather falls at the same rate as a geologist’s heavy hammer.
6. Newton’s third law states that any force applied to a body produces an equal and opposite reaction force in that body. In other words, for every action there is a reaction. The opposing force is felt as recoil. A marksman feels the kick of the rifle against his shoulder as he shoots. The recoil force is equal in size to that originally expressed in the shove or the bullet. In crime films the victim of a shooting often gets propelled 9) \_\_\_\_\_\_\_\_\_\_\_\_\_ by the force of the bullet. This is misleading. If the force was really so great then the shooter should also be hurled back by the recoil of his gun. Even if we jump off the ground, we exert a small downward force on the Earth, but because the Earth is so much massive than we are, it barely shows.
7. With these three laws, plus 10) \_\_\_\_\_\_\_\_\_\_\_\_\_ , Newton could explain the motion of practically all objects. Armed with these three equations he could confidently have climbed aboard a fast motorbike and sped up onto the wall of death, had such a thing existed in his day. How much trust would you place in Newton’s laws? The first law says that the cycle and its rider want to keep travelling in one direction at a certain speed. But to keep the cycle moving in a circle, according to the second law, a confining force needs to be provided to continually change its 11) \_\_\_\_\_\_\_\_\_\_\_\_\_, in this case applied by the track through the wheels. The force needed is equal to the mass of the cycle and rider multiplied by their acceleration. The third law then explains the pressure exerted by the cycle on the track, as a reactionary force is set up. It is this pressure that glues the stunt rider to the inclined wall, and if the bike goes fast enough it can even ride on a vertical wall. Where Newton’s laws do not hold is for things moving close to the speed of light or with very small masses. It is in these extremes that Einstein’s relativity and the science of quantum mechanics take over.

|  |  |  |
| --- | --- | --- |
| 1. backwards 2. heavy 3. direction 4. air | 1. gravity 2. curving 3. same 4. friction | 1. change 2. acceleration 3. force |

1. **Read the text again and find the words that mean the same as the following phrases.**

a. action of one object or surface moving against another;

b. to throw sth/sb violently in a particular direction;

c. a property of matter by which it stays still or if moving, continues moving in a straight line unless it is acted on by a force outside itself;

d. added a number to itself a particular number of times;

e. the force or weight with which sth pressed against sth else;

f. to move, or push sth forward or in a particular direction;

g. a sudden movement backwards, especially of a gun when it is fired;

h. a force that stops sth moving or makes it move more slowly;

i. to begin to have control of or responsibility for sth;

j. to use power to affect sb/sth;

k. repeated many times without interruption.

1. **In pairs, discuss and write definitions for the highlighted terms from the text. Use a dictionary to help you.**
2. **Identify the reason**.
3. In Paragraph 4 the author says *‘This is hard to appreciate in our own experience’* because:
4. In practice acceleration always changes the speed;
5. In real life friction always changes the speed or direction;
6. Only in space gravity helps its work.
7. On the Moon Apollo 15 astronauts demonstrated that the feather falls at the same time as a hammer because:
8. Without gravity they experienced the same acceleration;
9. Of gravity they fall at the same time;
10. There was almost no air resistance.
11. Newton’s laws don’t work for things moving at a speed of light or with small masses because:
12. Other laws work in extremes;
13. Kepler’s laws are used to explain their motion;
14. The weak and the strong forces govern their motion.
15. **Indentify the purpose**.
16. The author states that ‘the scenes in crime films when the victim of a shooting often gets propelled backwards by the force of a bullet are misleading ‘because:
17. The force of a flying bullet can’t be so great to hurl the victim backwards;
18. According to Newton’s third law of motion the shooter should also be hurled back by the recoil of the gun;
19. The victim has much less mass than the Earth, so the force of gravitation can’t be so great.
20. The author states that’ the first law provides a basic touchstone from which to understand forces and motion’ because:
21. It is the part of the second law of motion;
22. It helps to explain the behavior of objects;
23. It is the law that proved the existence of inertial systems.
24. The author says that’ with these three laws, plus gravity, Newton could explain the motion of practically all the objects, from falling acorns to balls fired from a cannon’ because:
25. He proved that these laws are able to measure and calculate the values of velocity, acceleration, different forces, mass as a unit of inertia, weight;
26. Despite the progress in science we still use these laws to design a new car or launch a spacecraft to Mars;
27. These laws explain any force exerted on an object.
28. **Choose the statement which better summarizes the content of the text.**

* Newton’s three laws of motion became the foundations of quantum physics.
* Newton’s three laws of motion gave the physicists the tools necessary for the beginning of the overall observation of all phenomena in our universe.
* The knowledge of Newton’s laws of motion is what you need to describe the forces of any moving object.

1. **For each set find one word mentioned in the text that fits all sentences.**

**A**

1. Lifting a big rock is pretty hard \_\_\_\_\_\_\_\_\_\_\_\_\_.
2. \_\_\_\_\_\_\_\_\_\_\_\_\_and energy are measured in Joules.
3. You can find all the necessary information in this \_\_\_\_\_\_\_\_\_\_\_\_\_of reference.

**B**

1. A meteorite is a space \_\_\_\_\_\_\_\_\_\_\_\_\_which falls on the earth’s surface.
2. His whole \_\_\_\_\_\_\_\_\_\_\_\_\_ was trembling with fear when he realized that he wouldn’t be able to stop his car.
3. The main \_\_\_\_\_\_\_\_\_\_\_\_\_ of the article was devoted to the Fermi paradox.

**C**

1. His sole \_\_\_\_\_\_\_\_\_\_\_\_\_in life is to explore the properties of dark matter.
2. When a falling \_\_\_\_\_\_\_\_\_\_\_\_\_reaches terminal speed, its speed can’t increase anymore.
3. A transitive verb has a direct \_\_\_\_\_\_\_\_\_\_\_\_\_ .
4. **Answer the questions to the text.**
5. What does the first law of motion postulate? Where can we see the action of the law in practice?
6. What does the second law of motion state? How is it expressed algebraically? Can you give examples of its work?
7. What is the third law of motion? How does it work?
8. Where don’t Newton’s laws of motion work? Why? What theories explain the motion there?
9. **Read the sentences and mark (T) True or (F) false.**
10. There are no perfect demonstrations of the first law of motion, as friction causes a force to act on a moving body.
11. Newton’s second law states that for every action there is reaction.
12. Friction causes a force that decelerates the object.
13. The force needed to accelerate an object is proportional to the object’s size.
14. Newton’s laws still work for the objects moving close to the speed of light.
15. Newton introduced the terms of acceleration and mass into the first law.
16. According to the third law mass is a unit of matter.
17. Acceleration depends on the object’s weight.
18. To move with a steady speed the forces must be in balance.
19. The first two laws are related to the motion of two objects.
20. **Fill in the gaps with the new words:**

**Part A**

*constant pressure proportional resistance inertia*

*velocity decelerate wheels constituent exert*

1. Air \_\_\_\_\_\_\_\_\_\_\_ pushes against objects which are moving through the air.
2. We are confronted with a large number of particles, which together seem to be the fundamental \_\_\_\_\_\_\_\_\_\_\_ of matter.
3. \_\_\_\_\_\_\_\_\_\_\_ is measured in pascals (Pa).
4. No force means no acceleration, and hence the body will maintain its \_\_\_\_\_\_\_\_\_\_\_.
5. The alteration of motion is ever \_\_\_\_\_\_\_\_\_\_\_ to the motive force impressed.
6. According to Newton, whenever objects A and B interact with each other, they \_\_\_\_\_\_\_\_\_\_\_ forces upon each other.
7. When you accelerate a car from rest, the road provides an unbalanced force on the spinning \_\_\_\_\_\_\_\_\_\_\_ to push the car forward.
8. Have you ever experienced \_\_\_\_\_\_\_\_\_\_\_ in a car while it is braking to a stop?
9. Colliding with the wall, an unbalanced force acts upon the car to abruptly \_\_\_\_\_\_\_\_\_\_\_ it to stop.
10. As the car maintains a \_\_\_\_\_\_\_\_\_\_\_ speed, the passengers maintain a \_\_\_\_\_\_\_\_\_\_\_ speed as well.

**Part B**

*confined incline take over kinetic potential*

*propelling stationary recoil hurled friction*

1. \_\_\_\_\_\_\_\_\_\_\_ between moving parts warms up the gears and bearings.
2. If no force is acting on an object, it is either \_\_\_\_\_\_\_\_\_\_\_ or moving with a constant speed in a straight line.
3. At first he succeeded in \_\_\_\_\_\_\_\_\_\_\_ the car through the mud then the wheels got stuck in it.
4. When the crew of the shuttle went to bed Mission Control and the shuttle’s computers \_\_\_\_\_\_\_\_\_\_\_ for the night.
5. The \_\_\_\_\_\_\_\_\_\_\_ energy depends on the mass of the object and on the square of the speed.
6. The land \_\_\_\_\_\_\_\_\_\_\_ gently towards the shore.
7. Rocket propulsion is essentially the same as the \_\_\_\_\_\_\_\_\_\_\_ of a gun.
8. Gravitational \_\_\_\_\_\_\_\_\_\_\_ energy is the stored energy that an object has because of its position above the surface of the Earth.
9. This theory was actually \_\_\_\_\_\_\_\_\_\_\_ to geometrical optics and didn’t deal with the phenomena of physics optics.
10. He \_\_\_\_\_\_\_\_\_\_\_ a brick through the window.
11. **Use the words given in brackets to form a word that suits in the gaps**.
12. The \_\_\_\_\_\_\_\_\_\_\_ forces always act against the direction of motion (*resist*).
13. Acceleration is \_\_\_\_\_\_\_\_\_\_\_ of a velocity-time graph (*grade*).
14. It’s dangerous to cycle on a \_\_\_\_\_\_\_\_\_\_\_ icy surface (*friction*).
15. Faraday’s law subjected to \_\_\_\_\_\_\_\_\_\_\_ test, is one of the most exact laws in \_\_\_\_\_\_\_\_\_\_\_ science (*experiment*, *physics*).
16. All books are\_\_\_\_ into two classes: the books of the hour, and the books of the time (*divide*). (J.Ruskin)
17. Accurate \_\_\_\_\_\_\_\_\_\_\_ of the task was the only aim of the work (*complete*).
18. The second \_\_\_\_\_\_\_\_\_\_\_ is far more serious (*limit*).
19. Unfortunately, his speculations were \_\_\_\_\_\_\_\_\_\_\_ (*logic*).
20. Despite all preventive actions the radiation loss was \_\_\_\_\_\_\_\_\_\_\_ (*avoid*).
21. This problem should be solved in all its \_\_\_\_\_\_\_\_\_\_\_ (*complex*).
22. **Complete these sentences with information that reflects your personal views.**
23. There are many applications of Newton’s first law of motion…
24. The behavior of all objects can be described by saying that objects tend to ‘keep on doing what they’re doing’…
25. Newton’s laws are not applicable on non-inertial frames of reference…
26. **In pairs, discuss the following diagram.**

|  |  |
| --- | --- |
| **FORCES ARE BALANCED** | |
| ↙ | ↘ |
| **Objects at Rest**  **(v = 0 m/s)** | **Objects in Motion**  **(v~~≠~~0 m/s)** |
| ↓ | ↓ |
| **a= 0 m/s 2** | **a = 0 m/s2** |
| ↓ | ↓ |
| **Stay at Rest** | **Stay in Motion** |

1. **Watch a video ‘Newton’s laws of motion’ and do the task.**
2. Describe the first experiment and explain it.
3. Tell what the acceleration of an object depends on.
4. Describe the second experiment and explain what happens if the mass has doubled.
5. What equation expresses the relationship between force, mass, and acceleration?
6. Tell how the third law of motion explains the flight of the rocket into space.
7. **Complete each sentence by matching it with the appropriate ending.**

|  |  |
| --- | --- |
| 1 In most real situations there are at least | 1. Straight downwards |
| 2 To keep going at a steady speed | 1. When he discovered the principle of inertia |
| 3 Acceleration is the same | 1. Continues in its state of rest or uniform motion unless an unbalanced force cats on it |
| 4 When a resultant force acts on an object | 1. It has a motion of rotation |
| 5 When something falls | 1. Two forces acting on an object along any direction |
| 6 Gravity always acts | 1. It causes a change in momentum in the same direction as the forces |
| 7 Power is | 1. Its gravitational potential energy is converted into kinetic energy |
| 8 The first law of motion states that a body | 1. The work done, or energy transferred, divided by time |
| 9 If a body turns on a fixed axis | 1. there must be zero resultant force |
| 10 Galileo made a great advance in the understanding of motion | 1. is the same direction as the force. |

1. **Check your understanding**
2. While driving down the road, a firefly strikes the windshield of a bus and makes a quite obvious mess in front of the face of the driver. This is the clear case of Newton’s third law of motion. The firefly hits the bus and the bus hits the firefly. Which of the two forces is greater: the force on the firefly or the force on the bus?
3. For years, space travel was believed to be impossible because there was nothing that rockets could push off of in space in order to provide the propulsion necessary to accelerate. This inability of a rocket to provide propulsion is because…
4. … space is void of air so the rockets have nothing to push off of.
5. … gravity is absent in space.
6. … space is void of air and so there is no air resistance in space.
7. … nonsense! Rockets do accelerate in space and have been able to do so for a long time.
8. Many people are familiar with the fact that a rifle recoils when fired. This recoil is the result of action-reaction force pairs. A gunpowder explosion creates hot gases that expand outward allowing the rifle to push forward on the bullet. Consistent with the Newton’s third law of motion, the bullet pushes backwards upon the rifle. The acceleration of the recoiling rifle is…
9. … greater than the acceleration of the bullet.
10. … smaller than the acceleration of the bullet.
11. … the same size as the acceleration of the bullet.
12. **In pairs, role-play conversations in which two scientists discuss the significance of Newton’s laws of motion.**
13. **Choose the correct answer A, B, or C from the list below.**

**John Harrison’s Clock’s**

In the 17th and early 18th centuries sailors’ lives were (1) \_\_\_\_\_\_\_\_ because of their inability to (2)\_\_\_\_\_\_\_\_ where they were. The British government offered a cash prize of £20,000 to someone who could overcome the technical problems of longitude measurement.

Because of the time differences as you travel from east to west across the globe, longitude can be measured by (3) \_\_\_\_\_\_\_\_ your local time at sea, say at midday, with the time at some other known place, such as Greenwich in London. Greenwich lies at zero degrees (4) \_\_\_\_\_\_\_\_ because time was noted relative to the (5) \_\_\_\_\_\_\_\_ there; we now call it Greenwich Mean Time. This was all well and good, but how could you know the time in Greenwich if you were in the middle of the Atlantic? At the start of the 18th century, this was not easy.

Clock technology at that time was not so advanced and the most (6) \_\_\_\_\_\_\_\_ timepieces incorporated pendulums that were useless on a (7) \_\_\_\_\_\_\_\_ ship. John Harrison, a British watchmaker, invented new devices that used rocking weights on (8) \_\_\_\_\_\_\_\_ instead of a dangling pendulum. But in sea tests even these (9) \_\_\_\_\_\_\_\_ to impress. One problem with using springs for timing was that their stretchiness changes with (10). \_\_\_\_\_\_\_\_. For ships sailing from the tropics to the poles this made them impractical. Harrison came up with a novel solution. He incorporated into the clock a bimetallic (11) \_\_\_\_\_\_\_\_, made from two different metals bonded together. The two metals, such as brass and steel, expand by different amounts as they warm up, causing the strip to (12) \_\_\_\_\_\_\_\_. Incorporated into the clock mechanism the strip compensated for the temperature changes. Harrison’s new clock, called a (13)\_\_\_\_\_\_\_\_, won the cash prize and solved the longitude problem.

1 A dangerous B in peril C troublesome;

2 A determine B locate C pinpoint;

3 A comparing B calculating C identifying;

4 A longitude B latitude C height;

5 A observer B Big Ben C observatory;

6 A reliable B accurate C expensive;

7 A sailing B rocking C rolling;

8 A hooks B chains C springs;

9 A failed B succeeded C didn’t pass;

10 A pressure B humidity C temperature;

11 A stripe B strip C spring;

12 A bend B stretch C contract;

13 A grandfather clock B chronometer C watch.

1. **Test yourself.**

1) Can forces be seen? How do we know they’re there?

2) What are the units of force? What would you use to measure force?

3) What different things that forces can make objects do?

4) What do balanced forces produce? What do unbalanced forces do?

5) What is air resistance? What’s the best shape for avoiding air resistance?

6) Give good and bad points of friction.

7) What is pressure? Give the formula for calculating pressure.

8) Explain how an elephant can walk on dodgy sand but a car would sink.

9) What is the difference between instantaneous speed and average speed?

10) What is the weight of 2kg of sugar?

11) How much does a 100g apple weigh…

a) on the Earth; b) on the Moon?

12) Why is it difficult to walk on ice?

13) How does a rocket move in outer space where there is nothing to push against to get moving?

14) When you release a partly inflated balloon it flies around as it deflates. Explain why.

15) A book is placed on a table. What are the two interaction pairs of forces?

16) A toy car with mass of 0.5 kg and speed 4m/s collides with a toy truck of mass 2 kg. They both stop.

What is the speed of the truck?

17) Calculate the momentum of a ball of mass 2kg and velocity 5m/s.

18) A force of 50 N acts on a stationary object for 12 seconds. Calculate its gain in momentum.

1. **Translate the following paragraph into Russian**.

A variety of action-reaction force pairs are evident in nature. Consider the propulsion of a fish through the water. A fish uses its fins to push water backwards. But a push on the water will only serve to accelerate the water. Since forces result from mutual interactions, the water must also be pushing the fish forwards, propelling the fish through the water. The size of the force on the water equals the size of the force on the fish; the direction of the force on the water (backwards) is opposite the direction of the force on the fish (forwards). For every action, there is an equal (in size) and opposite (in direction) reaction force. Action-reaction force pairs make it possible for fish to swim.

1. **Translate the paragraph into English.**

Из трех фундаментальных законов движения Ньютона вытекают следствия, одно из которых – сложение количества движения по правилу параллелограмма. Ускорение тела зависит от величин, характеризующих действие других тел на данное тело, а также величин, определяющих особенности этого тела. Механическое действие на тело со стороны других тел, которое изменяет скорость движения данного тела, называют силой. Она может иметь разную природу. Изменение скорости движения тела зависит не от природы сил, а от их величины. Поскольку скорость и сила – векторы, то действие нескольких сил складывается по правилу параллелограмма. Свойство тела, от которого зависит приобретаемое им ускорение, есть инерция, измеряемая массой. В классической механике, имеющей дело со скоростями, значительно меньшими скорости света, масса является характеристикой самого тела, не зависящей от того, движется оно или нет. Масса тела в классической механике не зависит и от взаимодействия тела с другими телами. Это свойство массы побудило Ньютона принять массу за меру материи и считать, что величина ее определяет количество материи в теле. Таким образом, масса стала пониматься как количество материи.

## 2_gravity2Part II “Newton’s laws of gravitation”

*‘Gravity is a habit that is hard to shake off’*

Terry Pratchet, 1992

1. **In pairs or small groups discuss the questions.**
2. Why does fruit fall from the trees?
3. Why doesn’t the Moon fall to the Earth?
4. What is gravity?

Newton’s Law of Gravitation says:

‘Every object in the universe attracts every other object along a line of the centers of the objects, proportional to each object’s mass, and inversely proportional to the square of the distance between the objects.’(1687)

1. **Read and complete the text with the words below.**

ALL FALL DOWN

1. Isaac Newton made a giant leap when he 1) \_\_\_\_\_\_\_\_\_\_\_\_ the motions of cannonballs and fruit falling from trees to the movements of the planets, thus linking heaven and earth. His law of gravitation remains one of the most powerful ideas of physics, explaining much of the physical 2) \_\_\_\_\_\_\_\_\_\_\_\_ of our world. Newton argued that all bodies attract each other through the force of gravity and the strength of that force drops off with distance squared.
2. When Olympic hammer-throwers spin on their heels, it is the 3) \_\_\_\_\_\_\_\_\_\_\_\_ on the string that keeps the hammer rotating. Without this pull the hammer would fly off in a straight line, just as it does on its release. It’s just the same with Newton’s cannonball -- without the centrally directed force 4)\_\_\_\_\_\_\_\_\_\_\_\_ the projectile to Earth, it would fly off into space. Thinking further, Newton reasoned that the Moon also hangs in the sky because it is held by the invisible tie of gravity. Without gravity it too would fly off into space.
3. (A) Newton showed that gravity follows an inverse law -- the strength of gravity decreases by 5)\_\_\_\_\_\_\_\_\_\_\_ of the distance from a body. So if you travel twice some distance from a body its gravity is four times less; the gravity exerted by the Sun would be four times less for a planet in an orbit twice as far from it as the Earth, or a planet three times distant would experience gravity nine times less.
4. (B) Newton’s law predicted that the planets travelled quicker near the Sun as they followed their elliptical paths. A planet feels a stronger gravitational force from the Sun when it travels close to it, which makes it 6) \_\_\_\_\_\_\_\_\_\_\_. As its speed increases the planet is thrown away from the Sun again, gradually slowing back down. (C) Thus, Newton pulled together all the earlier work into one profound theory.
5. (D) Newton then proposed that his theory of gravity applied to everything in the universe. Any body exerts a gravitational force in 7) \_\_\_\_\_\_\_\_\_\_\_\_ to its mass, and that force falls off as the inverse square of distance from it. So any two objects attract each other. But because gravity is a 8) \_\_\_\_\_\_\_\_\_\_\_\_ force we only really observe this for massive bodies as the Sun, Earth and planets.
6. If we look closer, though, it is possible to see tiny variations in the local strength of gravity on the surface of the Earth. Because massive mountains and rocks of differing density can raise or reduce the strength of gravity near them, it is possible to use a 9) \_\_\_\_\_\_\_\_\_\_\_\_ to map out geographic terrains and to learn about the structure of the Earth’s crust. Archaeologists also sometimes use tiny gravity changes to 10)\_\_\_\_\_\_\_\_\_\_\_\_ buried settlements. Recently, scientists have used gravity-measuring space satellites to record the amount of ice covering the Earth’s 11) \_\_\_\_\_\_\_\_\_\_\_\_ and also to detect changes in the Earth’s crust following large earthquakes.
7. Newton’s universal law of gravitation has stood for hundreds of years and still today gives a basic description of the motion of bodies. However, science does not stand still, and 20th-century scientists built upon its foundations, notably 12) \_\_\_\_\_\_\_\_\_\_\_\_ with his theory of general relativity. Newtonian gravity still works well for most objects we see and for the behavior of planets, comets and asteroids in the solar system that are spread over large distances from the Sun where gravity is relatively weak. Although Newton’s law of gravitation was powerful enough to predict the position of the planet 13)\_\_\_\_\_\_\_\_\_\_\_\_, discovered in 1846 at the expected location beyond Uranus, it was the orbit of another planet, 14) \_\_\_\_\_\_\_\_\_\_\_\_, that required physics beyond that of Newton. Thus general relativity is needed to explain situations where gravity is very strong, such as close to the Sun, stars and black holes.

|  |  |  |  |
| --- | --- | --- | --- |
| 1. *spot* 2. *proportion* 3. *Mercury* 4. *connected* | 1. *Einstein* 2. *gravity meter* 3. *weak* 4. *speed up* | 1. *poles* 2. *behavior* 3. *square* 4. *pull* | 1. *Neptune* 2. *tying* |

1. **Look at the four lettered spaces in the text (A), (B), (C), (D) that indicate where the following sentence** **can be added to the passage.** **Where would this sentence fit best?**

*Newton’s inverse square law of gravity explained in one equation the orbits of all the planets as described in the three of Johannes Kepler.*

1. **Read the text again and find the words that mean the same as the following phrases.**

a) not moving;

b) true at all times and in all places;

c) in the form of an ellipse;

d) makes something move towards something;

e) opposite in amount or position to something;

f) any object that is thrown as a weapon;

i) the number obtained when you multiply a number by itself;

j) plan or arrange something in a careful or detailed way.

1. **In pairs, discuss and write the definitions for the following terms from the text. Use a dictionary to help you.**
2. **Identify the meaning.**

**A.** By saying “Newton pulled together all the work into one profound theory” in Para 4 the author means:

1) He combined all laws of motion discovered by him into one theory;

2) He used his discoveries and Kepler’s laws to create the Law of gravitation;

3) All his previous laws were combined into one law of gravity.

**B.** The phrase “that required physics beyond that of Newton” from Para 7 means:

1. Newton’s laws weren’t able to discover Mercury;
2. Application of Newton’s laws were not enough to discover Mercury;
3. Astronomers didn’t use Newton’s laws to discover Mercury.

**C.** The author says in Para 2 that “the Moon also hangs in the sky” and it means:

1. The Moon never changes its constant orbit;
2. The Moon doesn’t move relatively to the Sun;
3. The Moon keeps its position in the sky because of gravity.
4. **Fill in the gaps with the new words from the text.**

*inversely, profound, rotate, elliptical, attract, reason, distance, map out, basic, satellite.*

**Part A**

1. The charges \_\_\_\_\_\_\_\_\_\_\_\_ each other across the dielectric.
2. The physical properties of molecules depend on the forces acting between them and the \_\_\_\_\_\_\_\_\_\_\_\_ between them.
3. The drive wheels of a locomotive are moving forward and at the same time \_\_\_\_\_\_\_\_\_\_\_\_ .
4. Being unacquainted with mathematical symbols and methods, Faraday always sought to explain his discoveries and to extend his research by purely physical \_\_\_\_\_\_\_\_\_\_\_\_ .
5. Kepler described how planets follow \_\_\_\_\_\_\_\_\_\_\_\_ orbits and how more distant planets orbit more slowly around the Sun.
6. The magnetic field can be \_\_\_\_\_\_\_\_\_\_\_\_ by applying iron fillings to a piece of pasteboard through which a heavy current-carrying conductor is passed.
7. A \_\_\_\_\_\_\_\_\_\_\_\_ property of matter is its mass.
8. The device which introduces resistance into a circuit is directly proportional to the applied voltage and \_\_\_\_\_\_\_\_\_\_\_\_ proportional to the resistance.
9. Pauli answered one of the most \_\_\_\_\_\_\_\_\_\_\_\_ questions in physics.
10. Kepler’s laws apply equally to any body in orbit around another, from comets, asteroids and moons in our solar system to planets around other stars and even artificial \_\_\_\_\_\_\_\_\_\_\_\_ whizzing around the Earth.

**Part B**

*spread, spot, still, density, universal, pull, release, gravity, motion, experience*

1. After this the rocket, if it were originally standing \_\_\_\_\_\_\_\_\_\_\_\_, will be moving with a small velocity.
2. Because macroscopic objects have minuscule wavelength, too small to see, we can’t \_\_\_\_\_\_\_\_\_\_\_\_ them behaving like waves.
3. Time and space distort when approaching the \_\_\_\_\_\_\_\_\_\_\_\_ speed of light.
4. A force is a push or a \_\_\_\_\_\_\_\_\_\_\_\_ that acts upon an object as a result of its interaction with another object.
5. As a result of these impacts, energy is \_\_\_\_\_\_\_\_\_\_\_\_ in the form of heat.
6. The quantity of electricity per unit area is called the surface charge \_\_\_\_\_\_\_\_\_\_\_\_\_ .
7. Under the influence of \_\_\_\_\_\_\_\_\_\_\_\_ alone all objects fall with the same acceleration.
8. Some bodies reverse their \_\_\_\_\_\_\_\_\_\_\_\_ from time to time and return at regular intervals to the original positions.
9. All large objects in space \_\_\_\_\_\_\_\_\_\_\_\_ gravity.
10. Millions of cosmic bodies are \_\_\_\_\_\_\_\_\_\_\_\_ all over our universe.
11. **For each set find one word that will fit in all sentences**.

**A**

1. From his \_\_\_\_\_\_\_\_\_\_\_\_ on the cliff top, he had a good view of the sea.
2. This put him and his colleagues in a difficult \_\_\_\_\_\_\_\_\_\_\_\_ .
3. He held a senior \_\_\_\_\_\_\_\_\_\_\_\_ in a large IT company.

**B**

1. The main \_\_\_\_\_\_\_\_\_\_\_\_ was a favorite place of rest of local people.
2. The \_\_\_\_\_\_\_\_\_\_\_\_ of 7 is 49.
3. The teams were all \_\_\_\_\_\_\_\_\_\_\_\_ at half-time.

**C**

1. Write the title of your essay on the top \_\_\_\_\_\_\_\_\_\_\_\_.
2. When they arrived at the airport they saw a lot of passengers standing in a \_\_\_\_\_\_\_\_\_\_ at the check-in.
3. Adidas is starting a new \_\_\_\_\_\_\_\_\_\_\_\_ of sportswear next month.
4. **Choose the correct answer A, B, or C from the list below.**

Rotating Earth

Pendulums are (1)\_\_\_\_\_\_\_\_\_ to the Earth’s rotation. The spin of the Earth causes the (2)\_\_\_\_\_\_\_\_\_\_\_ of its swing to slowly turn. If you imagine a pendulum hanging above the North Pole, it swings in a plane that is fixed (3) \_\_\_\_\_\_\_\_\_ to the stars. The Earth rotates (4) \_\_\_\_\_\_\_\_\_ it, so watching from a spot on the Earth its swinging motion seems to rotate 360 degrees in a day. There is no such rotation effect if the pendulum is hung above the (5) \_\_\_\_\_\_\_\_\_ because the pendulum rotates with the Earth, so its swing plane does not change. From any other (6) \_\_\_\_\_\_\_\_\_ the effect lies somewhere in between. So, the fact that the Earth is rotating can be proved by simply (7) \_\_\_\_\_\_\_\_\_ a pendulum.

French physicist Leon Foucault famously devised a very public demonstration of this by hanging a huge 70-metre-high pendulum from the ceiling of the Pantheon in Paris. Today, many museums around the world also host giant Foucault pendulums. To work, their first swing needs to be set off very (8) \_\_\_\_\_\_\_\_\_ so that the swing plane is (9) \_\_\_\_\_\_\_\_\_ and no (10) \_\_\_\_\_\_\_\_\_ are introduced. The traditional way to do this is to (11)\_\_\_\_\_\_\_\_\_\_\_ the bob back with a string and then (12) \_\_\_\_\_\_\_\_\_ through the string with the candle to release it gently. To keep the giant pendulums moving for a long time they are often motor assisted to offset slowing due to air resistance.

1. A relative B sensitive C connected;
2. A plane B axis C angle;
3. A irrespective B tilted C relative;
4. A above B perpendicular C beneath;
5. A equator B poles C any place on the surface;
6. A longitude B place C latitude;
7. A swinging B watching C stopping;
8. A slowly B smoothly C abruptly;
9. A steady B inclined C fixed;
10. A curves B rotations C twists;
11. A press B tie C push;
12. A burn B stretch C cut.
13. **Answer the questions to the text.**
14. Why do all bodies attract each other?
15. How is gravity quantified? Give some examples.
16. How does the Newton’s law of gravitation explain the elliptical paths of the planets?
17. What variations in the local strength of gravity can be seen on the surface of the Earth?
18. What discoveries did this law predict?
19. What new theories were built upon its foundations?
20. **Complete these sentences with information that reflects your personal views.**
21. Newton’s law of gravitation also explains…
22. Gravity never goes to zero…
23. Stars feel the gravity from…
24. There is no way to get rid of gravity..
25. **Watch a video about gravitation and finish the sentences.**
26. Gravity is the force to hold us…
27. The gravitation force between two objects also depend on how …
28. You and the Earth both have mass therefore you …
29. When you jump you push away from the Earth that’s because…
30. Astronauts on the Moon experience ….
31. Gravity even holds…
32. **Read the sentences and circle (T) True or (F) False.**
33. Newton stated that his gravity law worked for any two objects with mass.
34. Gravity depends only on the masses of the two attracting objects.
35. Gravity can be either attractive or repulsive.
36. Newton’s law of gravity also explained Kepler’s 1st and 2nd laws.
37. Gravity has direct relation with distance.
38. Gravity never goes to zero.
39. Gravity depends on the chemical composition or density.
40. On the surface of a planet, gravity makes all things accelerate towards the ground, all with the same acceleration.
41. An object has the same weight whether it’s on Earth or on the Moon – but its mass will be different.
42. Weight is caused by the pull of gravity.
43. **Use the words given in brackets to form a word that fits in the gap.**
44. Whether this could be achieved with a \_\_\_\_\_\_\_\_\_\_ mechanization was to be determined (**three).**
45. These \_\_\_\_\_\_\_\_\_\_\_\_ represent a direct demonstration of the applicability of this method (**find).**
46. This process is presently seen as \_\_\_\_ from the point of view of less developed countries (**problem**).
47. A \_\_\_\_\_\_\_\_\_\_\_\_ decrease in yield was observed (**six).**
48. Rather than solving one problem the technique involves the \_\_\_\_\_\_\_\_\_\_\_\_ solution of a series of sub-problems (**repeat).**
49. The lattice \_\_\_\_\_\_\_\_\_\_\_\_ may result from mechanical polishing (**distort)**.
50. Zero seems like an \_\_\_\_\_\_\_\_\_\_\_, like nothing, how then can we legitimately refer to zero as if it were something, a genuine number? (**empty)**
51. Intuitive conclusions based on immediate observation are not always to be trusted, for they often \_\_\_\_\_\_\_\_\_\_\_\_ (**lead).**
52. In some phenomena the \_\_\_\_\_\_\_\_\_\_\_\_ appears only after several super-imposed \_\_\_\_\_\_\_\_\_\_\_\_ have been analyzed out (**period, period).**
53. The results were affected by the presence of \_\_\_\_\_\_\_\_\_\_\_\_ **(pure).**
54. **In pairs or small groups, discuss the following questions.**
55. What basic fundamental assumption did Newton make about the laws of nature on the Earth and in space?
56. Why is gravity often the most important force in astronomical interactions?
57. What things does gravity depend on?
58. How does gravity vary with distance between objects and with respect to what do you measure the distances?
59. What would happen to the Earth’s orbit if the Sun suddenly turned into a black hole (of the same mass)?
60. How would antimatter respond to gravity?
61. What important laws of planet motion can be derived from Newton’s law of gravity?
62. **In pairs, role-play conversations in which you discuss the discoveries related to the Newton’s law of** **gravity.**
63. **Now write a list of specific questions to a tester on the Newton’s Law of Gravity.**
64. **Translate the paragraph into Russian**.

The Discovery of Neptune

The planet Neptune was discovered thanks to the Newton’s law of gravitation. In the early 19th century, astronomers noticed that Uranus did not follow a simple orbit but acted as though another body was disturbing it. Various predictions were made based on Newton’s law and in 1846 the new planet, named Neptune after sea god, was discovered close to the expected position.

British and French astronomers disagreed over who had made the discovery, which is credited to both John Couch Adams and Urbian Le Verrier. Neptune has a mass 17 times that of the Earth and is a gas giant with a thick atmosphere of hydrogen, helium, ammonia and methane smothering a solid core. The blue color of Neptune’s clouds is due to methane. Its winds are the strongest in the solar system, reaching as much as 2500 kilometers per hour.

1. **Translate the paragraph into English.**

Тяготение действует на огромных расстояниях во Вселенной. Но Ньютон утверждал, что взаимно притягиваются все предметы. А правда ли, что любые два предмета притягивают друг друга? Только представьте, что Земля притягивает вас, сидящих на стуле. Но задумывались ли о том, что карандаш и ручка, лежащие на столе, притягивают друг друга. В этом случае в формулу закона притяжения подставляем массу ручки, массу карандаша, делим на квадрат расстояния между ними, с учетом гравитационной постоянной, получаем силу их взаимного притяжения. Но, она выйдет настолько маленькой, что мы не ощущаем ее наличие. Другое дело, когда речь идет о земле и о стуле, или Солнце и Земле. Массы значительные, а значит действие силы мы уже можем оценить.

1. **Test yourself.**
2. How do the acceleration and force due to gravity depend on the radius and mass of a planet?
3. How does the mass of a falling object affect the rate at which it falls in a gravitational field?
4. Why do inner planets move faster than the outer planets?
5. Does gravity go forever?
6. Why do some scientists think that the term ‘weightlessness’ is not really true?
7. Can we figure out how hard the Earth is pulling us?
8. How does the Newton’s Second Law of Motion relate to gravity?
9. What happens as the rocket burns its fuel?
10. Are astronauts really weightless in orbit?
11. How can you experience free fall without leaving the Earth?
12. Would you weigh more or less on Mercury than you do on the Earth? How about Jupiter?
13. How much would you weigh on the Moon?
14. If the satellite weighs 150 000 kg on the surface of the Earth, how much does weigh in an orbit of 600 km away the Earth’s surface?

HOW TO READ MATHEMATICAL EXPRESSIONS

1. **Study the material.**

Addition

|  |  |
| --- | --- |
|  | One plus three equals four; one and three makes four; the sum of one and three is four; one and three total four; one and; one and three amount to four. |

Subtraction

|  |  |
| --- | --- |
|  | Ten minus five equals five; five from ten leaves five; taking five from ten gives five; substraction five from ten gives five |

Multiplication

|  |  |
| --- | --- |
|  | Four times two equals eight; four multiplied by two equals eight; the product of four and two is eight; twice four is eight |

Division

|  |  |
| --- | --- |
|  | Nine divided by three equals three; |
|  | Divide five hundred by 37 gives the quotient 14 and five thirty- seventh |

Decimal numbers

|  |  |
| --- | --- |
|  | Zero point one four five |
|  | One hundred two point three three five |
|  | Three point three recurring |
|  | One point zero three six three recurring |

When decimal numbers are repeating, they are called *recurring, circulating* or *repeating*.

Fractions

|  |  |
| --- | --- |
|  | One half |
|  | One fourth/ a quarter |
|  | Three quarters/ three fourths |
|  | Three and half |
|  | One hundred twenty over five hundred eleven/  One hundred twenty divided by five hundred eleven/  One twenty divided by five eleven |

Powers and roots

|  |  |
| --- | --- |
|  | *a* squared |
|  | *b* cubed |
|  | *a* to the fourth power |
|  | ***a*** to the negative fifth |
|  | ***a*** to the ***n*** minus ***b*** |
|  | ***a*** to the sixth divided by ***b*** cubed |
|  | The square root of six |
|  | The ***n*** th root of ***x*** |

Proportion

|  |  |
| --- | --- |
|  | Three is to nine as one to three;  The ratio of three to nine equals that of one to three;  The two ratios between three to nine and one two three are equal |

Equations with parentheses and brackets

|  |  |
| --- | --- |
|  | One minus four fifths, and all multiplied by 2 and one third |
|  | ***x***equals***c*** (open) curly bracket***a*** (open) bracket small  *z* over large *Z* (open) parenthesis d minus one over the quantity of small *y* minus large *Y* squared, (close)  parenthesis (close) bracket and curly bracket |
|  | *x* equals a times *b* to the minus one (power) plus a squared times *b* to the n minus two (power) down to  *a* to the *n th*(power) |

MINI GRAMMAR

ARTICLES

1. **Study the explanations and examples.**
2. We can use *the* when we make generalizations about classes of things using **singular countable** **nouns.** Compare the use of **the** and **a/an** in these sentences;

* *The* ***computer*** *has revolutionized publishing. (this refers to computers in general) but not A* ***computer*** *has revolutionized publishing.( Computers in general have done this, not an individual computer)*
* *The* ***computer*** *is an important research tool. And*
* *A* ***computer*** *is an important research tool. (This statement is true of both the general class and the individual item)*

1. As an alternative to **the + singular countable** noun we can use a plural countable noun to talk about a class of things:

* ***Computers*** *are an important research tool.*

1. Note that if **the** is used with plural and uncountable nouns we refer to a specific thing or group:

* ***The computers*** *have arrived. Where shall I put them?*
* ***The music*** *was wonderful. I could have listened to* ***the orchestra*** *all night.*

1. When we define something or say what is typical of a particular class of people or things, we generally use **a/an** rather than **the**:

* *A corkscrew is a gadget for getting corks out of bottles.*

1. **Choose the correct or more likely answer. In some sentences both answers are possible.**
2. We get some strange requests in our service station. We had the customer/ a customer the other day who wanted us to decorate his car with road signs.
3. It often seems that the individual/ an individual can have little impact on government policy.
4. The invention of a car/ the car is normally attributed to the German engineer Gottlieb Daimler.
5. The television/ a television has changed the way we think more than any other modern invention.
6. The campaign against smoking in public places argues that its harmful effects are not confined to the smoker/ a smoker.

**Part III “CONSERVATION OF ENERGY”**

*“It is a strange fact that we can calculate some number and when we finish watching nature go through her tricks and calculate the number again, it is the same.”*

Richard Feynman, 1961

1. **In pairs or small groups discuss the questions**.
2. What is energy?
3. How many forms of energy exist? What types of energy do you know?
4. What types of energy are the most frequent?
5. **Match the terms with their definitions**.

|  |  |
| --- | --- |
| 1conversion | a) is the product of an object’s mass and its velocity |
| 2 conservation | b) a process of changing something from one form, use or system to another |
| 3 angular momentum | c) the act of prevention something from being lost, wasted, damaged or destroyed |
| 4 linear momentum | d) is the product of the object’s mass, its speed, and its distance from the axis of rotation |

1. **Read the text and fill in the gaps with missing sentences. One sentence is extra.**
2. Conservation of angular momentum is used to effect in performances by spinning ice skaters.
3. This energy is released in a nuclear explosion or in the fusion reactors that power our Sun.
4. More cannot be created and it can never be destroyed.
5. A compressed spring can store within it elastic energy that can be released on demand.
6. One is gravitational potential energy, which may raise a body above the Earth in opposition to gravity.
7. Two other concepts are closely related – the conservation of linear momentum and the conservation of angular momentum.
8. Energy is an animating force that makes things move or change. It comes in many guises and may manifest itself as a change in height or speed, travelling electromagnetic waves or the **(a) vibrations** of atoms that cause heat. Although energy can metamorphose between these types, the **(b) overall** amount of energy is always conserved. (1) \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_
9. Coming in so different guises, energy is difficult to define. Even now, physicists do not know intrinsically what it is, even though they are expert at describing what it does and how to **(c) handle** it. Energy is a property of matter and space, a sort of **(d) fuel** or encapsulated drive with the potential to create, to move or to change. Philosophers of nature going back to the Greeks had a vague notion of energy as a force or essence that gives life to objects, and this idea has stuck with us through the ages.
10. It was Galileo who first spotted that energy might be transformed from one type to another. Watching a pendulum swinging back and forth, he saw that the bob exchanges height for forward motion, and vice versa and repeats the cycle. The pendulum bob has no sideways velocity when it is at either peak of its **(e) swing**, and moves quickly as it passes through the lowest point.
11. Galileo reasoned that there are two forms of energy being swapped by the swinging bob. (2)\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_
12. Gravitational energy needs to be added to lift a mass higher, and is released when it falls. If you have ever cycled up a steep hill you will know it takes a lot of energy to combat gravity. The other type of energy in the bob is kinetic energy – the energy of motion that accompanies speed. So the pendulum converts gravitational potential energy into kinetic energy and **(f) vice versa**.
13. Energy manifests as many different types that can be held temporarily in different ways. (3)\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_
14. Heat energy increases the vibrations of atoms and molecules in the hot material. So a metal pan on a cooker heats up because the atoms within it are being made to **(g) wobble** faster by the (h) input of energy. Energy can also be transmitted as electric and magnetic waves, such as light or radio waves, and **(j) stored** chemical energy may be released by chemical reactions, as happens in our own digestive systems.
15. Einstein revealed that mass itself has an associated energy that can be released if the matter is destroyed. So, mass and energy are equivalent. This is his famous *E*= *mc2* equation - the energy (*E*) released by the **(k) destruction** of a mass (*m*) is *m* times the speed of light (*c*) squared. Energy conservation as a rule of physics is much more than reducing our use of household energy; it states that the total amount of energy is unchanged even though it may switch between different types.
16. It was noticed that kinetic energy alone was not conserved. Balls or flywheels slowed down and didn’t move forever. But fast motions did often cause machines to heat up by friction, such as when boring metal cannon tubes, so experimenters **(l) deduced** that heat was one destination for released energy. Gradually, on accounting for all the different types of energy in built machines, the scientists began to show that the energy is transferred from one type to another and is not destroyed or created.
17. The idea of conservation in physics is not limited to energy. (4)\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_
18. Linear momentum is defined as the product of mass and velocity, and describes the difficulty of slowing a moving body. A heavy object moving quickly has high momentum and is difficult to **(m) deflect** or to stop. So a truck moving at 60 km an hour has more momentum than a car moving at the same speed, and would do even more damage if it hit you. Momentum has not just a size but, because of the velocity, it also acts in a specific direction. Objects that collide exchange momentum such that overall it is conserved, both in amount and direction. If you have ever played billiards or pool you have used this law. As two balls collide, they transfer motion from one to the other so as to conserve momentum. So if you hit a still ball with a moving one, the final paths of both balls will be a combination of the velocity and direction of the initial moving ball. The speed and direction of both can be worked out assuming that momentum is conserved in all directions.
19. Angular momentum conservation is similar. Angular momentum, for an object spinning about a point, is defined as the product of the object’s linear momentum and the distance it is away from the rotation point. (5)\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ When their arms and legs are stretched out they **(n) whirl** slowly, but just pulling their limbs in to their body they can spin faster. This is because the smaller dimensions require an increased rotation speed to **(o)compensate**.
20. Conservation of energy and momentum are still basic tenets of modern physics. They are concepts that have found a home even in contemporary fields such as general relativity and quantum mechanics.
21. **Read the text again and find the words that mean the same as the following phrases**.
22. Deal with a situation, area of work or something else;
23. Formed an opinion about something based on the information that is available;
24. Kept somewhere to use later;
25. Change direction or make something change direction;
26. The act of putting something in;
27. In total;
28. A continuous shaking movement;
29. Move from side to side in an unsteady way;
30. Any material that produces heat or power;
31. The act of destroying something;
32. Movement from side to side while hanging from a fixed point;
33. Provide something good to balance or reduce the bad effects of damage;
34. Move, or make something or somebody move, around quickly in a circle;
35. Used to say that the opposite of what is also true;
36. **In pairs, discuss and write definitions for the following terms from the text.**

**Concept, to swap, a bob, to reveal, contemporary, to manifest, a property**, **equivalent, a** **spring, to encapsulate**.

1. **Choose the phrase which** **could** **replace** **parts of these phrases.**
2. It comes in many guises
3. Energy can have some different types at the same time;
4. It has a lot of properties;
5. It can exist in different types;
6. Greeks had a vague notion of energy
7. Greeks didn’t have a clear idea about nature of energy;
8. Greeks couldn’t explain anything about energy;
9. Greeks were not interested in investigation of energy;
10. Energy is difficult to define
11. It’s not easy to work out the amount of energy;
12. Scientists still can’t explain exactly the nature of energy;
13. It is hard to identify all the properties of energy;
14. There are two forms of energy being swapped by the swinging bob
15. Being exchanged;
16. Being transferred one into another;
17. Being replaced;
18. … energy, which may raise a body above the Earth in opposition to gravity
19. Overcoming gravity;
20. Destroying gravity;
21. Together with gravity.
22. **Fill in the gaps with the new words**.

**Part A**

*Deflect, concept, deduce, overall, reflect, dimension, swirl, pendulum, deflect, vice versa, encapsulate.*

1. Because colour applies only to quarks, not to real particles like protons, the \_\_\_\_\_\_\_\_\_\_\_\_ colour of a real particle must be white.
2. Stellar-mass black holes can also be identified by detecting the X-rays from gas\_\_\_\_\_\_\_\_\_\_\_\_ around them.
3. Higgs boson’s existence was\_\_\_\_\_\_\_\_\_\_\_\_ for the purpose of breaking symmetry in electroweak interactions.
4. In 1964 John Bell\_\_\_\_\_\_\_\_\_\_\_\_ the difference between quantum and hidden- variable theories in equations.
5. They fired two beams of light at right angles to one another,\_\_\_\_\_\_\_\_\_\_\_\_ them back off identical mirrors displaced by exactly the same distance.
6. Every boson has a corresponding fermion or ‘superpartner’ whose spin differs by ½ a unit, and …
7. Einstein treated the three\_\_\_\_\_\_\_\_\_\_\_\_ of space and one of time as aspects of ‘space-time’.
8. The\_\_\_\_\_\_\_\_\_\_\_\_ of nuclear electrons quickly turned out to be false.
9. Very fine slits spread out the light more widely; and the red is\_\_\_\_\_\_\_\_\_\_\_\_ more than blue light.
10. If we pull a mass aside and release\_\_\_\_\_\_\_\_\_\_\_\_ , it swings back and forth.

**Part B**

*Compensate, manifest, swap, define, conserve, momentum, spring, contemporary, store, handle.*

1. Elastic energy is the formula for a\_\_\_\_\_\_\_\_\_\_\_\_ when it is stretched.
2. … energy in a substance is called potential energy.
3. The\_\_\_\_\_\_\_\_\_\_\_\_ of an object is a product of its mass and its velocity.
4. Cosmology suggests space can hold a negative pressure that\_\_\_\_\_\_\_\_\_\_\_\_ itself as dark energy, accelerating the expansion of the universe.
5. In the printout the numbers were rounded up to three decimal places, but the computer’s memory was\_\_\_\_\_\_\_\_\_\_\_\_ numbers with six decimal places.
6. In the case of the refrigerator, cooling the orange juice decreases its entropy, but this is\_\_\_\_\_\_\_\_\_\_\_\_ for by the hot air that the appliance produces.
7. Newton’s fiercest battles about his theory of color were with his equally famous\_\_\_\_\_\_\_\_\_\_\_\_ , Robert Hooke.
8. Energy may\_\_\_\_\_\_\_\_\_\_\_\_ from one type to another.
9. The longer period of time, the more precisely energy can be\_\_\_\_\_\_\_\_\_\_\_\_
10. Momentum has a direction as well as a size, and both aspects are\_\_\_\_\_\_\_\_\_\_\_\_ together.
11. **Choose a sentence which expresses the main idea of the text.**
12. The Law of conservation has become the foundations of modern physics.
13. Energy can change its type but not its amount, so it can’t be destroyed.
14. The conservation of energy is connected with the conservation of linear momentum and the conservation of angular momentum.
15. **For each set find one word mentioned in the text that will fit all sentences**.

**A**

1. The car hit a truck coming in the opposite\_\_\_\_\_\_\_\_\_\_\_\_
2. All the work in the laboratory was produced by the students under the\_\_\_\_\_\_\_\_\_\_\_\_ of their supervisor.
3. He again won the Oscar for\_\_\_\_\_\_\_\_\_\_\_\_ of his new film.

**B**

1. The\_\_\_\_\_\_\_\_\_\_\_\_ is that you should repeat the experiment but other substances.
2. The task of you lab work is to measure the freezing\_\_\_\_\_\_\_\_\_\_\_\_ of different liquids.
3. The numerous experiments described in his article were a strong\_\_\_\_\_\_\_\_\_\_\_\_ of his research.

**C**

1. You can\_\_\_\_\_\_\_\_\_\_\_\_ thousands of pieces of information in computer’s memory.
2. Zara is a famous chain\_\_\_\_\_\_\_\_\_\_\_\_ in the world.
3. Researching needs a vast\_\_\_\_\_\_\_\_\_\_\_\_ of knowledge.
4. **Use the words in brackets to form a word that fits in the gaps.**
5. Dutch physicist Huygens devised a practical way for predicting the\_\_\_\_\_\_\_\_\_ of waves (progress).
6. Huygens was the first to demonstrate that the planet was girdled by a\_\_\_\_\_\_\_\_\_\_\_\_ (flat) disk rather than flanked by extra moons or a changing\_\_\_\_\_\_\_\_\_\_\_\_ (equator) bulge.
7. His principle is only a useful tool for predicting the\_\_\_\_\_\_\_\_\_\_\_\_ (evolve) of waves rather than a fully\_\_\_\_\_\_\_\_\_\_\_ (explain) law.
8. Materials can be designed to possess specific refractive\_\_\_\_\_\_\_\_\_\_ , which may be useful (index).
9. About one in ten stars have planets, and this has\_\_\_\_\_\_\_\_\_\_\_\_ speculation that some may even harbor forms of life (fuel).
10. The first\_\_\_\_\_\_\_\_\_\_\_\_ planets were detected around a pulsar in 1992 and around a normal star in 1995 (solar).
11. He claimed to have seen the Doppler effect recorded in the colours of light from\_\_\_\_\_\_\_\_\_\_\_\_ stars, but this was in his day (pair).
12. When lightning strikes, the electric\_\_\_\_\_\_\_\_\_\_\_\_ flows very quickly through the ionized air to the ground (charge).
13. Transformers control the\_\_\_\_\_\_\_\_\_\_\_\_ of energy across the electric grid (transmit).
14. It is interesting to note the\_\_\_\_\_\_\_\_\_\_\_\_ between the megajoule energies we consume as food and the joule-sized energies we expend in physical activities (proportion).

SPEAKING

1. **Here are some examples of types of energy that can be measured using joules. Match the types of energy with the examples.**

|  |  |
| --- | --- |
| **Type of energy** | **Examples** |
| 1) Chemical energy released by burning | 1. MJ are required to melt 1 kg of tin. |
| 2) Energy required to break an object | 1. 1 kg of uranium oxide fuel consumed by reactor releases 2×1012J of stored nuclear energy |
| 3) Energy required to melt a solid substance | 1. Lifting 1.0 kg through a height of 1.0 m requires 9.8 J |
| 4) Chemical energy released by digesting food | 1. When a person suffers a spiral fracture of the thighbone (a common type in skiing accidents), about 2J of energy go into breaking the bone |
| 5) Raising a mass against the force of gravity | 1. A bowl of Cheerios with milk provides us with about 800 kJ of usable energy |
| 6) Nuclear energy released in fission | 1. About 50 MJ are released by burning 1 kg of gasoline |

1. **Answer the questions.**
2. Who was the first scientist who supposed that energy could be transformed from one type to another? What observations made him think so?
3. What conclusions did he come to watching a swinging pendulum?
4. Will you give some examples of different types of energy?
5. What was Einstein’s contribution to understanding energy?
6. What does the law of Conservation of Energy state?
7. What are the two other concepts closely related to energy?
8. What is the conservation of linear momentum? Give some examples to illustrate its action.
9. What is the conservation of angular momentum? Give some examples to reveal its action.
10. **Read the sentences and mark T (true) or F (false).**
11. The Conservation Law is a fundamental law of mechanics which is particularly true for isolated systems.
12. Energy is measured with the same units as work, Joules.
13. The sum of kinetic energy of the particles before collision is less than the kinetic energy of the particles after collision.
14. Potential energy does not depend on velocities.
15. The kinetic energy is quadratic form with regard to velocities.
16. Conservation of energy for finite systems is value in all modern physical theories, such as special and general relativity and quantum theory.
17. Conservation of energy is implied by the empirical fact that the laws of physics sometimes change with time itself.
18. The human is a non- conservative system.
19. The Law of conservation of energy includes the possibility of perpetual- motion machines of the first kind.
20. In ancient Greece, Galileo Galilei was the first to realize that energy seemed to be conserved, although he had no means of proving it.
21. **In pairs prepare a dialogue between an examiner and a student who is examined on the Law of Conservation of energy.**
22. **Discussion questions.**
23. Suppose that, like Einstein, you were trying out different equations for kinetic energy to see if they agreed with the experimental data. Based on the positive and negative signs of velocity, why would you suspect that a proportionality to *mv* would less likely than *mv*2?
24. If all the air molecules in the room settled down in a thin film on the floor, would that violate conservation of momentum as well as conservation of energy?
25. A helicopter has, in addition to the huge fan blades on top, a smaller propeller mounted on the tail that rotates in a vertical plane. Why?
26. If you throw a feather straight up in the air. When it comes back down to the height from which you released it, you will find that it is going slower. How do you reconcile this with conservation of energy?
27. Hydroelectric power (water flowing over a dam to spin turbines) appears to be completely free. Does this violate conservation of energy? If not, then what is the ultimate force of the electrical energy produced by a hydroelectric plant?
28. Heat is a form of energy and what about temperature?
29. Many types of energy are just variations of them. Do you agree?
30. a) You release a magnet on a tabletop near a big piece of the iron and the magnet leaps across the table to the iron. Does the magnetic potential energy increase or decrease? Explain.

b) Suppose instead that you have two repelling magnets. You give them an initial push towards each other, so they decelerate while approaching each other. Does the magnetic potential energy increase or decrease? Explain.

1. Energy is consumed in melting and evaporation. Explain in terms of conservation of energy why sweating cools your body, (even though the sweat is at the same temperature as your body).

LISTENING

1. **Listen or watch the video” conservation of energy”. Read the sentences and make the right choice. Sometimes more than one option is possible.**
2. The unit was named a Joule after
3. Joules Hooke;
4. Joules James;
5. James Prescott Joules;
6. He came up with the really innovative way to look at
7. measuring energy;
8. energy transfer;
9. types of energy;
10. When an object is at a height it has
11. magnetic potential energy;
12. potential energy of stretching;
13. gravitational potential energy;
14. The speaker compares conservation of energy with a teeter- totter which means
15. a see-saw;
16. a pendulum;
17. a spring;
18. The amount of energy before the interaction of two objects and after is
19. exactly the same;
20. almost the same;
21. different;
22. The energy could be transferred through
23. work;
24. collision;
25. the magnetic field;
26. The energy that drives a car is
27. electrical energy;
28. chemical energy:
29. electromagnetic energy;
30. Through the combustion the energy is transferred into
31. mechanical energy;
32. heat;
33. light;
34. gravitational energy ;
35. chemical energy;
36. When you put your hand on an engine you’ll notice that it
37. stays cool;
38. vibrates;
39. hot.
40. **In pairs or small groups, choose any topic from the list below and prepare an oral report.**

1) Hubble’s Law and conservation of energy.

2) Discrepancies in the conservation of energy.

3) Dark energy and conservation of energy.

4) Perpetual motion machines.

1. **Momentum and kinetic energy are both measures of the quantity of motion but there are some differences. Say which of them:**
2. is always positive, and cannot cancel out;
3. is always conserved in a closed system;
4. is a vector;
5. is a scalar;
6. cancels with momentum in the opposite direction;
7. is doubled if the velocity is doubled;
8. is not changed by a force perpendicular to the motion which changes only the direction of the velocity vector;
9. can be traded for forms of energy that do not involve motion;
10. is changed by any force, since a change in either the magnitude or direction of the velocity vector will result in a change in the momentum vector;
11. is quadrupled if the velocity is doubled.
12. **Answer the questions.**
13. Is the accelerated expansion of the universe consistent with conservation of energy?
14. Does Big Bang violate the conservation of energy?
15. Why can’t energy be created or destroyed?
16. When they say that the universe cooled after Big Bang, where did the heat go?
17. Is energy absolutely conserved in our universe?
18. What will happen if Law of Conservation of energy is violated? Which theories will lose their foundations? What kind of effect will we have in our understanding of universe?
19. Does the Law of Conservation of energy act on atoms?
20. What does a scientist have to do to establish the existence of a new form of energy?
21. Can the kinetic energy of an object be negative?
22. A ball thrown straight up will have the same speed on impact with the ground as a ball thrown straight down at the same speed . How can this be explained using potential energy?
23. **Translate the paragraph into Russian.**

The idea of energy as the cause of transformations was familiar to the ancient Greeks – *energia* means activity in Greek. We know that its magnitude scales with the force we apply and the distance by which an object subjected to it shifts. But energy is still a slippery concept for scientists. It was in investigating the nature of energy that the ideas of quantum physics originated. When we push a supermarket trolley, it rolls along because we are giving it energy. The trolley is being powered by the chemicals combusted in our bodies, transmitted by the force of our muscles. When we throw a ball we also convert chemical energy into motion. The Sun’s heat comes from nuclear fusion, where atomic nuclei are crushed together, and give out energy in process.

1. **Translate the paragraph into English.**

В реальных процессах, где действуют силы трения, наблюдается отклонение от закона сохранения механической энергии. Например, при падении тела на Землю сначала кинетическая энергия возрастает, поскольку увеличивается скорость. Возрастает и сила сопротивления, которая увеличивается с возрастанием скорости. Со временем она будет компенсировать силу тяжести, и в дальнейшем при уменьшении потенциальной энергии относительно Земли кинетическая энергия не возрастает. Это явление выходит за рамки механики, поскольку работа сил сопротивления приводит к изменению температуры тела. Нагревание тел при действии трения легко обнаружить, потерев ладони друг о друга. Таким образом, в механике закон сохранения энергии имеет довольно жесткие границы.

MINI GRAMMAR

COMMAS AND OTHER PUNCTUATION

**COMMAS**

* To separate items in a list:

*e.g. Einstein, Schrodinger and others had difficulty dropping their firm beliefs in an external, deterministic and verifiable universe.*

* To separate some final elements such as question tags and participle clauses:

*e.g. Cycling at night, you may have used a dynamo to power your bicycle lights.*

*You can prove anything with statistics, can’t you?*

* Around inserted phrases and clauses:

*e.g. The body hits the airbag, which is compressed, increasing the distance the body moves and the time it takes to stop.*

*The universe, as we know, looks roughly the same in all directions.*

* To separate off an introductory word, phrase or clause:

*e.g. Instead, Hoile preferred to believe in a more sustainable vision of cosmos.*

*In such a situation, the momentum will ultimately be halted by means of the rope, thus preventing a disastrous fall to the ground.*

*If the collision takes place over a longer time, then the stopping force will be less.*

*When a resultant force acts on an object, it causes a change in momentum in the same direction as the force.*

*Following the big bang explosion, the fabric is also continually expanding.*

* In direct speech:

*e.g. Michael Faraday said:’ Nothing is too wonderful to be true if it be consistent with the laws of nature.’*

* Optional before **and, or, but,:**

*e.g. The incoming electron, or other particle, absorbs a photon to produce a second more energetic electron.*

*The W boson is not seen in the products of the interaction, but is involved in the intermediate stage*.

Note: the use of the comma before and in a list is much more common in America English than in British English.

**OTHER PUNCTUATION**

**COLON (:)**

* to introduce a list:

*e.g. Young children are natural scientists: they ask questions, pick up sticks and bugs outside, and are curious about the world around them.*

* before a phrase that gives more information or an example:

*e.g. There are different forces for you to know: gravity always acting straight downwards; reactionforce acting straight upwards ;push or pull speeding something up; friction slowing the thingdown and others.*

* to introduce a quotation.

*e.g. As Albert Einstein said: “As far as the laws of mathematics refer to reality, they are not certain; and as far as they are certain, they do not refer to reality.”*

**SEMI-COLON (;)**

* to separate two main clauses that are closely linked in meaning, so that a full stop would be too strong break between them:

*e.g. When the Moon passes into the Earth’s shadow it is dark; when stars burn out they leave husks too faint to see; even a planet as big as Jupiter would be invisible if it was set free to wander far from the Sun.*

**DASH (--)**

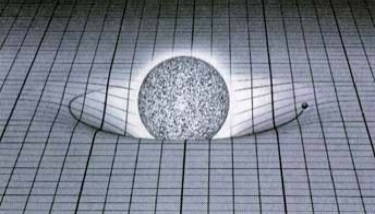
* in informal writing, to separate a part of a sentence which adds extra information:

*e.g. By solving the problem of beta decay, Pauli and Fermi opened a new world of electro-like substitutes-- called leptons -- as well as predicting the existence of neutrino.*

1. **Read these sentences and work out the rules for punctuation.**
2. Particles of opposite charge attract one another; those with like charges repel.
3. Neutrons, as the name suggests, have no charge and so are ‘neutral’.
4. Electricity may remain static, as a fixed distribution of charges, or flow, as an electrical current.
5. If the object is moving, it continues to move at the same speed and in the same direction.
6. Physics is the science studying various phenomena in nature: mechanical motion, heat, sound, electricity, magnetism and light.
7. Physics is divided into a lot of different fields – mechanics, sound, heat, electricity and magnetism, light, molecular, atomic and nuclear physics.
8. If we exert a certain push with our arms on an object that is light, it moves easily; if we push just as hard on another object that is much heavier, it moves much less rapidly.
9. **Punctuate these sentences.**
10. All wave crests have the same phase and all troughs are half a circle away from them. If you imagine an ocean wave the distance between two wave peaks known as its wavelength is maybe 100 meters. Its frequencies or the number of wavelengths that pass some point in one second might be one wavelength of 100 meters in 60 seconds or 1 cycle per minute.
11. Mechanical energy potential and kinetic is measured in the same units as work.
12. The rapid progress of atomic power engineering can be explained by its advantages over conventional types energy production atomic power stations do not pollute the atmosphere atomic energy is economical.
13. The momentum of an object is a product of two parts its mass and its velocity.
14. First we’ll start with the Newtonian approximation that mass is constant the same all the time and that further when we put two objects together their masses add.
15. In the case of gravitation Newton gave us the complete law of the force. In the case of very complicated forces between the atoms he was not aware of the right laws for the forces however he discovered one rule one general property of forces which is expressed in the Third Law and that is the total knowledge that Newton had about nature of forces the law of gravitation and this principle but no other details.

**ARTICLES**

1. **Fill in the gaps with the (- ), (a/an), or (the) articles.**
2. (…)Energy has (…) large number of (…) different forms, and there is (…) formula for each one.
3. We can illustrate (…) existence of (…) in other forms by (…) following example.
4. If we pull down on (…) spring, we must do some work, for when we have it down, we can lift (…) weight with it.
5. Elastic energy is (…) formula for (…) spring when it is stretched.
6. Associated with (…) relativity theory, there is (…) modification of (…) laws of (…) kinetic energy, so that (…) kinetic energy is combined with another thing called (…) mass energy.
7. (…) object has energy from its sheer existence. If we have (…) positron and (…) electron, standing still doing nothing and they come together and disappear, (…) radiant energy will be liberated, in (…) definite amount, and (…) amount can be calculated. All we need to know is (…) mass of (…) object.
8. (…) law of (…) conservation of (…) energy was discovered in (…) middle of (…) 19th century.
9. Special credit in (…) discovery of this law belongs to (…) German scientists Robert Meyer and (…) British scientist James Joule.
10. (…) great Russian scientist Mikhail Lomonosov discovered another law – (…) law of (…) conservation of mass – (…) hundred years before (…) discovery of (…) law of (…) conservation of energy.
11. For many centuries (…) energy of (…) wind or running water has been used to set in motion (…) machines, such as (…) mills.

**Part IV “GENERAL RELATIVITY”**

*“Time and space and gravitation have no separate existence from matter”*

Albert Einstien, 1915

1. **In pairs, or small groups, discuss the questions.**
2. Why is Albert Einstein considered to be a scientist of genius?
3. What Einstein’s theories did you study?
4. What do you know about application of his discoveries?
5. **Match the terms with their definitions.**

|  |  |
| --- | --- |
| 1. Gravity | a) a measurement in space; |
| 1. Gravitational lensing | b) the universe considered as a continuum with four measurements inside which any event or physical object is located; |
| 1. Worm hole | c) a phenomenon which multiplies images of the same distant astronomical object visible in the sky; |
| 1. Black hole | d) a possible connection between regions of space-time that are far apart; |
| 1. Dimension | e) an area in space that nothing, even light, can escape from, because of gravity; |
| 1. Space-time | f) the force that attracts objects towards each other, and that on the Earth pulls them towards the centre of the planet, so that things fall to the ground when they are dropped. |

1. **Read the text and fill in the missing sentences. One sentence is extra.**
2. Another aspect of relativity is that waves can be set up in the space-time sheet.
3. On 29 May 1919 the world’s astronomers gathered to test Einstein’s predictions by observing a total eclipse of the Sun.
4. They are so deep and steep that anything that comes close enough can fall in, even light.
5. Over the next few years Einstein explored the consequences.
6. When moving and accelerating, it is this space-time metric that distorts to maintain the fixed speed of light.
7. If you then threw in a smaller ball, say as an asteroid, it would roll down the slope towards the Earth.

**GENERAL RELATIVITY**

1. Incorporating gravity into his theory of special relativity, Einstein’s theory of general relativity revolutionized our view of space and time. Going beyond Newton’s laws, it opened up a universe of black holes, worm holes and gravitational lenses.
2. Imagine a person jumping off a tall building, or parachuting from a plane, being accelerated towards the ground by gravity. Albert Einstein realized that in this state of free fall they did not experience gravity. In other words, they were weightless. Trainee astronauts today recreate the zero gravity conditions of space in just this way, by flying a passenger jet in a path that mimics a roller coaster. When the plane flies upwards the passengers are glued to their seats as they experience even stronger forces of gravity. But when the plane tips forwards and **(1) plummets** downwards, they are released from gravity’s pull and can **(2)** **float** in the body of the aircraft.
3. Einstein recognized that this acceleration was equivalent to the force of gravity. So, just as special relativity describes what happens in reference frames, or inertial frames, moving at some constant speed **(3) relative** to one another, gravity was a consequence of being in a reference frame that is accelerating. He called this the happiest thought of his life**. A** [\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_].
4. Talking through his ideas with trusted colleagues and using the latest mathematical formalisms to encapsulate them, he **(4) pieced** **together** the full theory of relativity that he called general relativity. The year 1915 when he published the work proved especially busy and almost immediately he revised it several times. His **(5) peers** were astounded by his progress. The theory even produced bizarre testable predictions, including the idea that light could be bent by a gravitational field and also that Mercury’s elliptical orbit would rotate slowly because of the gravity of the Sun.
5. In general relativity theory, the three dimensions of space and one of time are combined into a four-dimensional space-time **(6) grid**, or metric. Light’s speed is still fixed, and nothing can **(7) exceed** it. **B**[\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_].
6. General relativity is the best imagined by visualizing space-time as a rubber sheet stretched across a **(8)hollow** table top. Objects with mass like weighted balls placed on the sheet. They depress space-time around them. Imagine you place a ball representing the Earth on the sheet. It forms a depression in the rubber plane in which it sits. **C** [\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_]. This shows how it feels gravity. If the smaller ball was moving fast enough and the Earth’s dip was deep enough, then just as a daredevil cyclist can ride around an inclined track, that body would maintain a moon-like circular orbit. You can think of the whole universe as a giant rubber sheet. Every one of the planets and stars and galaxies causes a depression that can attract or deflect passing smaller objects, rolling over the contours of a golf course.
7. Einstein understood that, because of this warping of space time, light would be deflected if it passed near a massive body, such as the Sun. He predicted that the position of a star observed just behind the Sun would shift a little because light from it is bent as it passes the Sun’s mass. **D** [\_\_\_\_\_\_\_\_\_\_\_ \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_]. It proved one of his greatest moments, showing that the theory some thought crazy was in fact close to the truth.
8. The bending of light rays has now been confirmed with light that has travelled right across the universe. Light from very distant galaxies clearly **(9) flexes** when it passes a very massive region such a giant cluster of galaxies or a really big galaxy. The background dot of light is **(10) smeared out** into an arc. Because this mimics a lens the effect is known as gravitational lensing. If the background galaxy is sitting right behind the heavy **(11) intervening** object then its light is smeared out into a complete circle, called an Einstein ring. Many beautiful photographs of this spectacle have been taken with the Hubble Space Telescope.
9. Einstein’s theory of general relativity is now widely applied to modeling the whole universe. Space-time can be thought of like a landscape, complete with hills, valleys and pot holes. General relativity has lived up to all observational tests so far. The regions where it is tested most are where gravity is extremely strong, or perhaps very weak.
10. Black holes are extremely deep wells in the space-time sheet. **E** [\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_]. Moreover, holes, or singularities, in space-time may also warp into worm holes, or tubes, but no one has actually seen such a thing yet.
11. At the other end of the scale, where gravity is very weak it might be expected to break up eventually into tiny quanta, similar to light that is made up of individual photon building blocks. But no one has yet seen any graininess in gravity. Quantum theories of gravity are being developed but, without evidence to back it up, the unification of quantum theory and gravity is **(12) elusive**. This hope occupied Einstein for the rest of his career but even he did not manage it and the challenge still stands.
12. **Read the text again and find the words (in bold) that mean the same as the following phrases.**
13. Spread soft substance over a surface in a rough or careless way;
14. Considered and judged by being compared with something else;
15. Falls suddenly and quickly from a high level or position;
16. Put all the separate parts of something together to make a complete whole;
17. People of the same age or who have the same social status as somebody;
18. Coming or existing between two events, dates, objects;
19. Having a hole or empty space inside;
20. A pattern of straight lines, usually crossing each other to form squares;
21. To move slowly on the water or in the air;
22. Bends;
23. To be greater than a particular number or amount;
24. Difficult to find, define, or achieve.
25. **In pairs, discuss and write definitions for the following terms from the text. Use a dictionary to** **help you.**

|  |  |
| --- | --- |
| *to warp*  *to shift*  *a plane*  *consequences*  *cluster*  *a dip* | *metric*  *to distort*  *gravitational lenses*  *deflect*  *reference frames* |

1. **Choose the phrase that means the same.**
2. Incorporating gravity into his theory…
3. adapting gravity to his theory;
4. explaining gravity with the help of his theory;
5. including gravity in his theory;
6. They depress space-time around them …
7. they suppress space-time;
8. they put down space-time;
9. they crush space-time;
10. General relativity has lived up to all observational tests so far.
11. it has remained as perfect as before;
12. it has been developed;
13. it has turned out to be as true as before;
14. The background dot of light is smeared out into an arc.
15. the light turns into a curved band;
16. the light looks like semicircle;
17. the light obtains the semicircular shape;
18. The objects with mass are like weighted balls placed on the sheet.
19. balls with measured weight;
20. heavy balls;
21. balls with definite weight.
22. **Read the sentences and mark (T) true or (F) false.**
23. Objects can’t be free from gravity.
24. Gravity was a consequence of Einstein’s special theory of relativity.
25. At that time it was impossible to test the general relativity theory.
26. Einstein claimed that space-time grid changes the speed of light.
27. Objects with large mass depress space-time around them.
28. An Einstein ring is a shape which light gets passing the massive space bodies.
29. The Hubble Space Telescope has helped astronomers to explore better the regions with weak gravity.
30. Space-time may warp into black holes or worm holes.
31. In space regions where gravity is weak it broke up into tiny quanta.
32. The unification of quantum theory and gravity is quite probable.
33. **Fill in the gaps with the new words.**

**Part A**

*hollow, plummet, distort, shift, smear out, plane, peers, intervening, space-time, worm hole.*

1. Even the tiniest spot gets blurred because the light is \_\_\_\_\_\_\_\_\_\_\_\_as it passes through the eye or camera aperture.
2. When the rounded wavefronts reach the aperture \_\_\_\_\_\_\_\_\_\_\_\_, it cuts through them like a knife cuts through the layers of an onion sliced off centre.
3. Anything that falls within the event horizon \_\_\_\_\_\_\_\_\_\_\_\_into the black hole, including light.
4. If the \_\_\_\_\_\_\_\_\_\_\_\_space between us and a distant galaxy swells steadily as the universe expands.
5. The electrical field pattern set up with a Faraday cage – a \_\_\_\_\_\_\_\_\_\_\_\_conductor – means that all the charge is carried on the outside of the cage, and inside the cage it is completely neutral.
6. Newton’s \_\_\_\_\_\_\_\_\_\_\_\_argued against it, preferring to believe that colors arose from combinations of white light and darkness, as a type of shadow.
7. That’s because nothing can travel faster than the speed of light, so time and space themselves \_\_\_\_\_\_\_\_\_\_\_\_when approaching this universal speed limit.
8. The Lorenz attractor looks like a series of overlapping figures of eight slightly \_\_\_\_\_\_\_\_\_\_\_\_and distorted from one another, mirroring the shape of butterflies’ wings.
9. If the tubes were joined together, then you could imagine a tube or \_\_\_\_\_\_\_\_\_\_\_\_being formed between the two mouths of the black holes.
10. It is a hole in the sheet of \_\_\_\_\_\_\_\_\_\_\_\_, like a basketball net.

**Part B**

*Resistance, exceed, metric, frame of reference, bend, float, relative, gravitational lensing, warp, general relativity.*

1. It is because light travels at different speeds in air and water, causing the rays to \_\_\_\_\_\_\_\_\_\_\_\_
2. Inertial frames are spaces that move \_\_\_\_\_\_\_\_\_\_\_\_to one another at a constant speed, without experiencing accelerations or forces.
3. A metal is a lattice of positive charged nuclei about which a ‘sea’ of electrons is free to \_\_\_\_\_\_\_\_ .
4. In the event that the gravity \_\_\_\_\_\_\_\_\_\_\_\_the weight as for the largest stars, further contraction ultimately produces a black hole.
5. General relativity is a \_\_\_\_\_\_\_\_\_\_\_\_theory of gravitation.
6. Einstein deduced that there is no fixed \_\_\_\_\_\_\_\_\_\_\_\_in the universe.
7. We can measure mass in two different ways: either we weigh it or measure its \_\_\_\_\_\_\_\_\_\_\_\_to acceleration.
8. The \_\_\_\_\_\_\_\_\_\_\_\_of space-time around a black hole is more intense than anywhere else.
9. The equations of \_\_\_\_\_\_\_\_\_\_\_\_predict a number of phenomena many of which have been confirmed.
10. \_\_\_\_\_\_\_\_\_\_\_\_refers to a distribution of matter between a distant source and an observer, that is capable of bending the light from the source, as it travels towards the observer.
11. **Use the words given in brackets to form a word that suits in the gap**.
12. The Pauli exclusion principle explains why normal atoms cannot \_\_\_\_\_\_\_\_\_\_\_\_in the same region of space *(exist).*
13. \_\_\_\_\_\_\_\_\_\_\_\_are fluids that have no viscosity so they can flow through a tube forever without any friction *(fluid).*
14. At \_\_\_\_\_\_\_\_\_\_\_\_temperatures, group of bosons can behave very strangely *(cold).*
15. A single electron must follow Pauli’s exclusion principle, that forbids such particles with \_\_\_\_\_\_\_\_\_\_\_\_ wave functions from sharing the same quantum state *(symmetry).*
16. The scientists designed a material that became a superconductor at temperatures of about 90 kelvins, warmer than the widely used \_\_\_\_\_\_\_\_\_\_\_\_liquid nitrogen *(cool).*
17. At very high temperatures, all the atoms in a magnet are disordered, their \_\_\_\_\_\_\_\_\_\_\_\_magnetic fields are all random and the material is not magnetic *(build).*
18. In 1961, Frank Drake wrote down an equation for the probability of a \_\_\_\_\_\_\_\_\_\_\_\_alien civilization living on another planet in the Milky Way *(contact).*
19. Radio astronomers are scouring nearby stars for signs of \_\_\_\_\_\_\_\_\_\_\_\_signals *(nature).*
20. The universe operates in \_\_\_\_\_\_\_\_\_\_\_\_ways, and we can only witness part of the picture at any time *(see).*
21. It could be that slightly \_\_\_\_\_\_\_\_\_amounts of each particle were created in the Big Bang *(similar).*
22. **For each set find one word mentioned in the text that fits all sentences.**

**A**

1. Is she \_\_\_\_\_\_\_\_\_\_\_\_enough to travel?
2. The conference was very \_\_\_\_\_\_\_\_\_\_\_\_organized.
3. The sides of the \_\_\_\_\_\_\_\_\_\_\_\_are covered with brick or stone.

**B**

1. Shall I give you a \_\_\_\_\_\_\_\_\_\_\_\_?
2. I gave the porter a \_\_\_\_\_\_\_\_\_\_\_\_.
3. I had his name on the \_\_\_\_\_\_\_\_\_\_\_\_of my tongue.

**C**

1. He dug a deep \_\_\_\_\_\_\_\_\_\_\_\_in the garden.
2. The children climbed through a \_\_\_\_\_\_\_\_\_\_\_\_in the fence.
3. I am not going to bring up my child in this \_\_\_\_\_\_\_\_\_\_\_\_.
4. **Match the halves of the sentences**.

|  |  |
| --- | --- |
| 1. General relativity generalizes 2. The curvature of space-time is directly related to 3. The bending of light by gravity 4. Deflection of light has been confirmed 5. Astronomically, the most important property of compact objects is 6. Light around a massive object, such as a black hole, 7. The orbit of Mercury is shifting very gradually over time 8. Orbiting objects follow the path 9. The planets move in ellipses, 10. The warping of space-time around a black hole is | 1. More intense than anywhere else; 2. Due to curvature of space-time around the massive Sun; 3. A special relativity and Newton’s law of universal gravity; 4. By observing the light of stars or distant quasars being deflected as it passes the Sun; 5. The energy and momentum of whatever matter and radiation are preserved; 6. That they provide a supremely efficient mechanism for converting gravitational energy into electromagnetic radiation; 7. Can lead to the phenomenon of gravitational lensing; 8. Is bent causing it to act as a lens for the things that lie behind it; 9. The most energy-efficient path in the gravity well of the Sun; 10. That is shortest and requires the least amount of energy. |

LISTENING

1. **Watch a video “General relativity under three minutes” Read the beginning of the sentences and choose the right ending, sometimes there are more than one.**
2. Einstein’s Special theory only applies to bodies …
3. in acceleration;
4. at rest;
5. in a constant state of motion;
6. Einstein returned to his theory to try to deal it with acceleration in …
7. 1911;
8. 1907;
9. 1915;
10. Einstein supposed that gravitational mass and inertial mass …
11. are the same;
12. are similar to each other;
13. are completely different;
14. Einstein hated that …
15. there is no reliable theory to explain these phenomena;
16. two theories are needed to explain one phenomenon;
17. it is impossible to unite these two phenomena;
18. Einstein had the happiest thought of …
19. The principle of equivalence;
20. A person free falling in space who experienced gravity;
21. Gravity which accelerates the object downwards;
22. General relativity theory is …

a) connection between space and time;

b) equivalence of inertia and gravitation;

c) time slowing down with gravity;

1. He came up with a notion of the fabric of space and time as if it was

a) trampoline fabric;

b) stretching fabric;

c) concave fabric;

1. the experiment with a bowling ball and billiard balls proves

a) the action of gravitation on objects;

b) the validity of four dimensional space;

c) the action of gravitational waves.

SPEAKING

1. **Answer the questions.**
2. What is the significance of Einstein’s general relativity theory for science?
3. What did Einstein call the happiest thought of his life?
4. How did Einstein come to his discovery?
5. What testable predictions did Einstein make with the help of this theory?
6. What is the essence of general relativity theory?
7. How can we imagine what space-time is?
8. What event convinced Einstein’s peers in the validity of his theory?
9. How was the bending of light rays proved?
10. How did differences in the strength of gravity influence the universe?
11. **Read the sentences and mark (T) True or (F) False.**
12. Einstein’s theory predicted that the direction of light propagation should be changed in a gravitational field.
13. The General theory of relativity predicts that light coming from a weak gravitational field should have its wavelength shifted to large values.
14. The gravitational field can have waves that carry energy and are called gravitational waves.
15. Gravitational waves are easy to detect because they are very strong.
16. Accelerating masses can emit gravitational waves.
17. The warping of space-time around a black hole is less intense than anywhere else.
18. The moon orbits the Earth not as a result of its inertial motion through the curved space-time, but because the Earth is pulling on it.
19. Einstein’s theory predicted that the amount of space in the universe must be either increasing or decreasing.
20. Acceleration of an object in a gravitational field depends on its mass.
21. The inertial mass of any object is apparently identical to its gravitational mass.
22. **In groups, choose and tell about twelve things you must know about general relativity theory.**
23. **In groups, discuss and be ready to tell the group the basics of General relativity. Use the diagram and information given after it, but the sentences are mixed and can be incorrect.**

General relativity rests on the Einstein Equivalence Principle (EEP) which consists of three parts:

1. Universality of Free Fall (UFF), also called the Weak Equivalence Principle
2. Local Lorentz Invariance (LLI), which implies the local validity of Special Relativity
3. Local Position Invariance (LPI), which implies the universality of the gravitational red shift.

|  |
| --- |
| General Relativity |

|  |
| --- |
| Metric theories of Gravitation |

|  |
| --- |
| Einstein Equivalence principle (EEP) |

|  |  |  |
| --- | --- | --- |
| U F F | Local Position Invariance  Time independence of fundamental constants;  Universality of gravitational frequency shift | L L I |

1. \_\_\_\_\_\_\_states that in a gravitational field all structureless point-like particles with the same initial velocity follow the same path.
2. \_\_\_\_\_\_\_ states that at appoint and in a sufficient small neighborhood Special Relativity is not valid.
3. \_\_\_\_\_\_\_ states that all local nongravitational experiments are not influenced by the gravitational field.
4. The consequence of \_\_\_\_\_\_\_ is that at each point in space-time there is a unit of height and of time which are related by the speed of light.
5. According to \_\_\_\_\_\_\_the outcome of any non-gravitational experiment is dependent of where and when in the universe it is performed.
6. The consequence of this postulate is that all length and time scales introduced at different points by means of the previous postulate, are the same.
7. The consequence of the \_\_\_\_\_\_\_is that gravity has to be described by means of a space-time metric.
8. **Answer the questions.**
9. What is gravitational lensing?
10. What is an Einstein ring?
11. What is the principle of equivalence?
12. What is gravitational mass?
13. What is an inertial or unaccelerated system? Are they really the same thing?
14. Is a freely falling observer in an inertial frame? Since such an observer feels no acceleration how does one handle the transformations between accelerated systems?
15. Why is gravity fundamentally different from other forces?
16. How exactly does curved space-time describe the force of gravity?
17. What are the most important applications of the general relativity theory?
18. When does light travel in a straight line and when does it travel in a curved space?
19. **Imagine: you are the teacher of the year. Tell your pupils about general relativity and be ready to answer their questions.**
20. **Explain this statement by Albert Einstein**

*“If all accelerated systems are equivalent, then Euclidean geometry cannot hold in all of them”.*

**Why?**

1. **Read the following in English.**

T^{\alpha \beta} = \, -\frac{1}{\mu_0} \left( F^{\alpha}{}^{\psi} F_{\psi}{}^{\beta} + {1 \over 4} g^{\alpha \beta} F_{\psi\tau} F^{\psi\tau}\right)  

R_{\mu \nu} = \frac{\Lambda}{\tfrac{D}{2} -1} g_{\mu \nu} \,.

R^{\alpha \beta} - {1 \over 2}R g^{\alpha \beta} + g^{\alpha \beta} \Lambda = \frac{8 \pi G}{c^4 \mu_0} \left( F^{\alpha}{}^{\psi} F_{\psi}{}^{\beta} + {1 \over 4} g^{\alpha \beta} F_{\psi\tau} F^{\psi\tau}\right).

F_{[\alpha\beta;\gamma]}=\frac{1}{3}\left(F_{\alpha\beta;\gamma} + F_{\beta\gamma;\alpha}+F_{\gamma\alpha;\beta}\right)=\frac{1}{3}\left(F_{\alpha\beta,\gamma} + F_{\beta\gamma,\alpha}+F_{\gamma\alpha,\beta}\right)= 0. \!


\det(g) = \frac{1}{24} \varepsilon^{\alpha\beta\gamma\delta} \varepsilon^{\kappa\lambda\mu\nu} g_{\alpha\kappa} g_{\beta\lambda} g_{\gamma\mu} g_{\delta\nu}
\,

1. **Think of the word which best fits each. Use only one word in each space.**

Einstein worked 1\_\_\_\_\_\_\_\_\_how the laws of motion could be rewritten 2\_\_\_\_\_\_\_\_\_observers travelling 3\_\_\_\_\_\_\_\_\_different speeds. He ruled out the existence of a stationary frame of reference, 4\_\_\_\_\_\_\_\_\_as the ether, and stated that 5\_\_\_\_\_\_\_\_\_motion was relative with 6\_\_\_\_\_\_\_\_\_privileged viewpoint. If you are sitting on a train and see the train 7\_\_\_\_\_\_\_\_\_to you moving, you may know 8\_\_\_\_\_\_\_\_\_it is your train or the 9\_\_\_\_\_\_\_\_\_one pulling out. Moreover, even if you can see your train is stationary at the platform you can’t assume that you are immobile, just that you are not moving relative to that platform. We 10\_\_\_\_\_\_\_\_\_feel the motion of the Earth 11\_\_\_\_\_\_\_\_\_the Sun; similarly, we 12\_\_\_\_\_\_\_\_\_notice the Sun’s path 13\_\_\_\_\_\_\_\_\_our own Galaxy.

1. **Translate the paragraph into Russian**

GRAVITY WAVES

Another aspect of general relativity is that waves can be set up in the space-time sheet. Gravitational waves can radiate, especially from black holes and dense spinning compact stars like pulsars. Astronomers have seen pulsars’ spin decreasing so they expect that this energy will have been lost to gravity waves, but the waves have not yet been detected. Physicists are building giant detectors on Earth and in space that use the expected rocking of extremely long laser beams to spot the waves as they pass by. If gravity waves were detected then this would be another coup for Einstein’s general relativity theory.

**MINI GRAMMAR**

**ARTICLES**

1. **Put *a/an, the* or *zero* in the spaces.**

If you could fly above 1 \_\_\_\_ mountains to 2 \_\_\_\_ top of 3 \_\_\_\_ atmosphere, perhaps out into 4 \_\_\_\_ space, 5\_\_\_\_ pressure would drop to almost zero. 6 \_\_\_\_ perfect vacuum would not contain any atoms, but nowhere in 7 \_\_\_\_ universe is this true. Even in outer space there are sparsely spread atoms, numbering just 8 \_\_\_\_ few hydrogen atoms per cubic centimeter. 9 \_\_\_\_ Greek philosophers Plato and Aristotle did not believe that 10\_\_\_\_ pure vacuum could exist.

1. **Use the right punctuation.**
2. Electronics has given us radio (…) telephones (…) television and what not.
3. The electrons which revolve about the nucleus do not follow random orbits (…) they fall into definite energy levels.
4. The shell (…) or energy level (…) closest to the centre carries a single electron or two electrons.
5. From series observations comes a beautiful description of the molecule (…) the numbers and states of the electrons (…) their energetic levels (…) and so on.
6. The vacuum is perfect (…) that it does not contain any other particles or atoms (…) but it must be noted that such a concept is purely imaginative.
7. Even at this extreme low pressure (…) many times smaller than that in a thermionic valve (…) there are about 10 -13 molecules per cubic meter.

**WRITING**

**DESCRIBNG GRAPHS AND TABLES**

1. What are the purposes of describing tables and graphs?

They are the following:

1. To make it easier to understand the concepts by using a visual rather than by just using words;
2. To provide more exact details than is desirable in the text;
3. To provide information which is additional to that provided in the text.
4. To draw attention to the most important aspects of the information shown in the graph or table.
5. Understanding graphs and tables involves understanding the following details:

What is the information or data in the graph or table about?

What are the units of measurement used?

What is the area (place) involved?

What is the time-scale involved?

What is the purpose of the graph or table?

1. Instructions.
2. You are not asked to discuss the information, but generally to ‘write a report describing’ the information;
3. It is not necessary to write an introduction;
4. You do not need to write a conclusion which gives any kind of opinion about the significance of the information;
5. So how do you begin? **There are three steps.**

Step 1: identify the main idea behind the graph or table. This will be the focus of your first sentence.

Step 2: consider the details of what is being shown – the units of measurement and the time frame – and decide how much you need to include.

Step 3: consider the language to use – the introductory expressions, the tenses of the verbs, the correct expressions of the time/or measurement etc.

1. What introductory expressions to use

**The graph/table shows/indicates/illustrates/reveals/represents**

**It is clear from the graph/ table**

**It can be seen from the graph/table**

**From the graph/table it is clear**

1. Expressions of measurement

*Quantities*

**Amount, figure**, **the total quantity, the whole of the, the majority of, the maximum, the minimum**, **the total number, the whole amount**;

*Other measurements*

**Range, rate, level, degree, extent, ratio, proportion, percent, percentage, length, weight, distance, height, altitude, frequency, duration, volume, size;**

1. Mathematical expressions

**half/halves n. halve vb. double n./vb.**

**triple n. treble vb. threefold adj.**

**quarter n./vb multiply vb. divide vb.**

**average adj./vb/n total adj. partial adj. equal adj./n**

**fraction n.**

1. Common adjectives:

These are some of the more common adjectives, with examples of appropriate collocations:

**high/low: a high/low percentage large: a large number**

**great: a great number;**

**significant: a significant number/percentage/amount;**

**considerable: a considerable amount/increase;**

**substantial: a substantial increase/decrease;**

**major: a major increase/ decrease;**

**steady: a steady decrease**

1. Other parts of speech

Contrast and similarity can be shown by using specific, adjectives, and nouns:

Verbs: Adjectives: Nouns:

**compare (with/to) compared (with/to) comparison in/with**

**contrast (with) contrasting contrast in/to**

**differ (from) different (from) difference ( between)**

**distinguish (between) distinct (from) as distinction (between)**

**resemble same/the same as resemblance (to/with)**

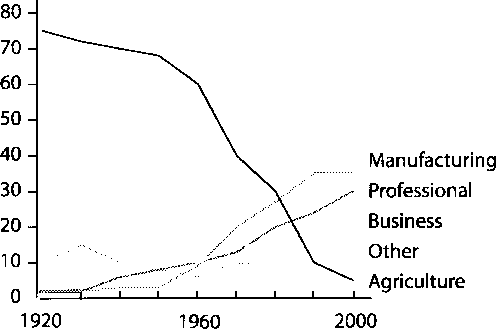
**-** **similar (to) similarity (with)**

**vary (from/between) - variation (between)**

**change (from/to) - change (from)**

1. Fill in the gaps in the following description, using expressions from the above lists. Try to vary the expressions you use to avoid repetition.

Employment Patterns in Alia, 1920— 2000



In 1920, 75% of the labor force in Alia was employed in agriculture 1\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ only 10% worked in business and trade. At the same time 2\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ the manufacturing sector the professional sector 3\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ constituted just 2% of the workforce each. This situation changed only very gradually over the next 20 years, 4\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ the professional workforce, which increased more than threefold. 5\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ by 1970 there had been a significant change in the pattern of employment. 6\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ the agricultural employees had declined in number to 40% of the workforce, manufacturing employees 7\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ professionals had increased their share to 13% and 10% respectively. 8\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ the business sector did not increase until 1970. The most dramatic 9\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ could be seen by 1990, when the proportion of agricultural workers was reduced to just 10% 10\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ the three other major sectors had all increased to over 20% of the workforce.

VOCABULARY LIST

angular adj

basic adj

cluster n

compensate vb

concept n

confine vb

consequence n

conservation n

constituent n

contemporary adj

continually adv

curve vb

decelerate vb

deduce vb

define vb

deflect vb

density n

destruction n

dimension n

dip n/vb

distort vb

elliptical adj

elusive adj

encapsulate vb

exceed vb

exert vb

experience vb

flex vb

float vb

friction n

grid n

handle vb

hollow adj

hurl vb

input vb/n

intervening adj

inverse adj

kinetic adj

linear adj

manifest vb

map out vb

metric adj

momentum n

overall adj

pendulum n

piece vb

plummet vb

potential adj

profound adj

projectile n

proportional adj

reason vb

recoil vb/n

reference frames

reflect vb

relative to adj

resistance n

shift vb/n

smear out vb

stationary adj

still adj

store vb

swap vb

swing vb

swirl vb

vague adj

vice versa

wobble vb