5 WORK, ENERGY AND POWER

Atlas carrying the world on his shoulders.

THE CONCEPT OF WORK

OBJECTIVES

At the end of the topic, students should be able to:

- explain and give examples of work;
- calculate work done, when force and displacement are given;
- calculate the work done in a gravitational field.

Pushing a box

Pushing and pulling are example of forces. A force can make a body move. If a man pushes a box and moves it in the direction of the force, he is doing work. He does no work if the box does not move.

Work is done when a force causes a body to move in its direction. This happens anytime one pushes or pulls a body and causes it to move. The magnitude of work done depends on the size of the force and the distance covered in the direction of the force. *Work is energy transferred anytime a force moves a body*. Work is a scalar quantity.

Work done is the product of force and the distance moved in the direction of the force.

Work done = Force Ã— distance moved in the direction of force

W = F Ã— S

The unit of work is Newton metre (Nm) or joule (J).

1 Joule = 1 Newton metre

Large amount of work is measured in Kilojoules (KJ) or Megajoules (MJ).

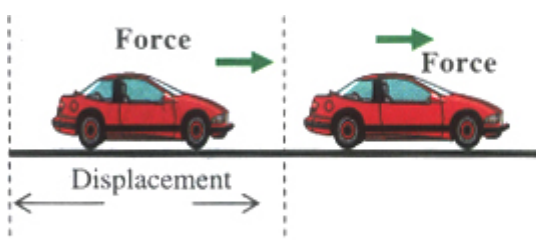


Figure 5.1 Work done by the car is the product of its weight and distance covered.

Joule is the amount of work done or energy transferred by a force of IN when it moves a body through a distance of 1m.

Examples of activities where work is done are:

- a boy lifting a heavy box from the floor to the top of a table.
- a girl pushing a wheelbarrow along a level road.
- a car climbing a hill.
- a man stretching a catapult or rubber band.

Figure 5.2 A car climbing a hill is doing work

When force is applied on a body, the body moves in the direction of the force as shown in all the examples stated above. The boy does work against the gravity in lifting the box to the tabletop. The girl pushing the wheelbarrow along the level ground is doing work against friction. Elastic work is done when a force stretches a rubber band.

No work is done if the applied force does not move the body or the distance moved has no part along the direction of the force. The following examples illustrate situations where no work is done:

- a boy carrying books on his head. The force exerted by the boy on the books has not changed the position of the books, therefore the work done is zero.
- a woman walking along a level ground with a heavy load on her head is not doing any work because no part of the force she exerts on the load is in the direction of her displacement.
- a man pushing a caterpillar does no work if the caterpillar does not move.

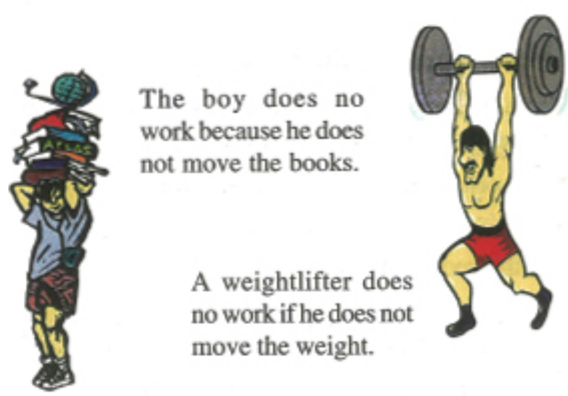


Figure 5.3 Work is not done when applied force covers no distane

Work done by inclined forces

An inclined force is a force whose direction acts at an angle (Î¸) to the displacement moved. Only the part of the force in the direction of the displacement moves the body. Figure 5.4 (a) shows a box pulled along a level ground with a constant force (F) inclined at an angle (*Î¸*) to the horizontal.

The force (F) has a vertical component F sin *Î¸* and a horizontal component Fcos *Î¸*.

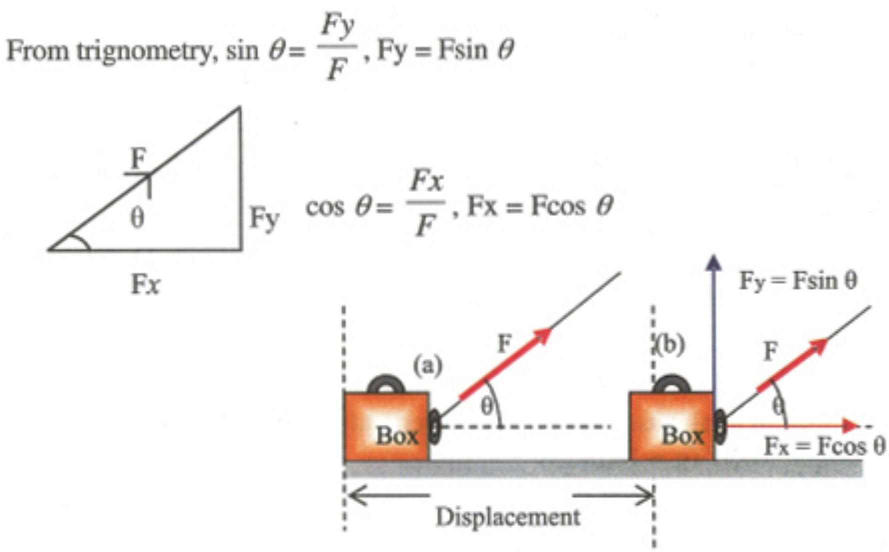


Figure 5.4 Work done by an inclined force

The horizontal part of the force moving the box in the direction shown in Figure 5.4 is Fx = Fcos *Î¸*. The other part is not doing any work because it is perpendicular to the displacement.

The work done in moving the box through the horizontal distance (s) is given by:

Work done = Part of force along the displacement Ã— Displacement.

W = Fcos *Î¸* Ã— s
W= Fs cos *Î¸*

Work done against friction

Work is done when a box is pushed along a rough floor with a constant force (F). The work done on the box is divided into two parts:

- work done to overcome friction
- work done in moving the box through the required distance

Work done against friction is transformed or changed to heat energy. This is the reason why moving objects become hot.

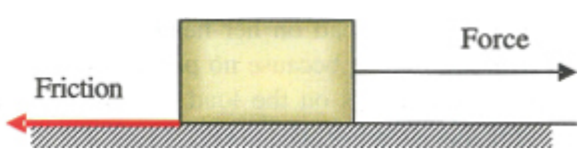


Figure 5.5

Work done against gravitational force field

Work is done in gravitational force field when a body is lifted up against force of gravity. Work done against gravity is stored in the body as gain in potential energy. If the body is allowed to fall, it uses the gain in gravitational energy to do work. The work done by the body is equal to the work done on it when it is lifted up against gravity. This is illustrated in Figure 5.6.

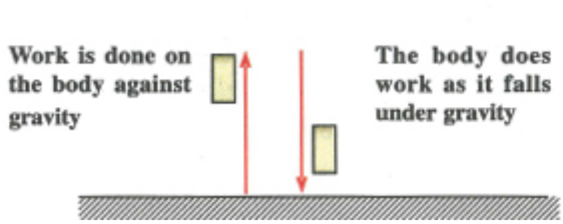


Figure 5.6 Work done on the body is equal to work the body does as it falls

Worked examples

1. A boy drags a bag of rice a distance of 42 m on a smooth floor with a constant horizontal force of 75 N, what is the work done by the boy in dragging the bag?

Solution

W = F Ã— S

Force = 75 N, displacement = 42 m

W = 75 Ã— 42 = 3150 J or 3.15 KJ

2. A weight lifter lifts a load of total mass 356g through a vertical height of 2.15 m. What is the work done by the weight lifter? (g = 10 m s^{-2})

Solution

Weight lifted =mass x gravity =356 x 10 =3560 N

Displacement = 2.15 m, force = 3560 N

W =F x S =3560 x 2.15 =7654 J or 7.654KJ

3. Amina pulls a box with a force 500 N inclined at 60Â° to the horizontal. Find the work done by Amina if her displacement is 200 m.

Solution

W = Fscos *Î¸* = 500 Ã— 200 Ã— cos 60Â° = 5 0000 J

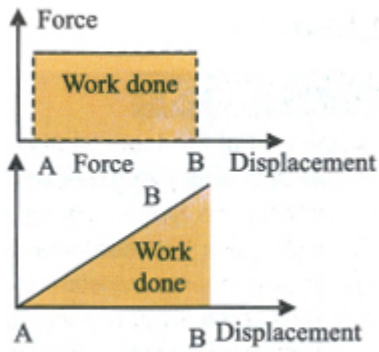


Figure 5.7 Area under the graph is the work done by the applied force

Force – displacement graph

Work is done any time an applied force causes a body to move in the direction of the force. The work done is proportional to the displacement of the body if the applied force is constant. When an application of a force moves a body between two points A and B, the force – displacement graphs are as shown in Figure 5.7.

The work done is the area under the line or curve of a force–displacement graph. The workdone is the area of a rectangle if theforce is constant. For a force whose magnitude is changing, workdone is the area of a triangle. These are illustrated in Figure 5.7.

Summary

- Work done is the product of force and the distance moved in the direction of the force.
- Joule is the amount of work done or energy transferred by a force of 1 N when it moves a body through a distance of 1 m.
- Work is done against friction when a box is pushed along a rough floor by a force.
- Work is done in gravitational force field when a body is lifted up against force of gravity. Work done against gravity is stored in the body as gain in potential energy.

Practice questions 5a

1. Under what condition is force said to do work?
2. When is the work done by a force zero?
3. Calculate the work done when a force of 50 N moves a body through a distance of 13.8 m in the direction of the force.
4. A bag of rice weighing 25 kg was lifted to a height of 18.2 m above the ground, calculate the work done against gravity on the bag. {$g = 10\ m\ s^{-2}$}
5. A girl pulls her school box with a force 78 N inclined at 27Â° to

the ground, calculate: the part of the force moving the box along the ground, (b) the work done if the displacement is 125m.

6. An Olympic gold winner in weight lifting competition raised a total mass of 750 kg through a vertical height of 2.53 m. He held the weight for 35 seconds before dropping it.
   (a) What is the work done by the weight lifter?
   (b) Explain why the lifter does no work for the 35 seconds he held the weight before dropping it? [$g = 10\ m\ s^{-1}$]
7. Find the amount of work done when:
   (a) a man pulls 100 kg sack a distance of 25m along the ground by a constant force of 150 N.
   (b) a 250 kg car climbs a slope of 500 m up a mountain road gaining a vertical height of 75m. ($g = 10\ m\ s^{-1}$)

ENERGY

OBJECTIVES

At the end of the topic, students should be able to:

- explain and give examples of energy;
- identify the type of energy possessed by bodies under given conditions;
- distinguish between kinetic and potential energy;
- identify energy transformation from one form to another;
- state the laws of conservation of energy;
- explain renewable and non-renewable energy sources.

Concept of Energy

Energy is the ability or capacity to do work.

Energy is measured by the amount of work done on the body. The unit of energy is Joule (J) in honour of James Joule.

Forms of energy

Energy exists in many different forms. Table 5.1 shows different forms of energy, their sources and definitions.

Forms of energy	**Source**	**Definition**
Mechanical	Bodies in motion and position of a body in a field (e.g. moving car)	Energy of a body in motion or energy of a body due to its position in a field.
Chemical	People get chemical energy from food. Breaking up of atomic bonding of fuels and	Energy stored in the molecules of fuels and chemicals or energy

	chemicals e.g. petrol or kerosene.	released when atomic bonding is broken.
Electrical	Motion and position of charged particles in an electric field leads to release of electrical energy.	Energy of charged particles due to their position or motion in an electric field.
Heat or thermal	Agitation or thermal motion of molecules of substances.	Energy transfer due to temperature difference between two points.
Light	Accelerating charges	Light energy which is a visible form of energy.
Nuclear	Rearrangement of nuclear particles leads to release of nuclear energy.	Energy released due to changes in the nuclear content of an atom.
Sound	Vibrating objects e.g when a drum is played	Energy released by vibrating objects.
Solar	The sun releases solar energy	Group of energy radiated from the sun.
Biomass	The sun	Biomass energy from the sun is released when plants are eaten or when we burn wood.

Table 5.1 Forms of energy, sources and definitions

Mechanical energy

Mechanical energy exists in two different forms: **potential energy** and **kinetic energy.**

a. The potential energy

Potential energy is the energy stored in a body due to its position in a field.

The potential energy stored in a body when it is raised to a height above the ground is due to its position in a gravitational field. The energy stored in compressed springs, explosives or fireworks, chemicals, etc., is convertible to other forms due to their mechanical state or position.

Types of potential energy

1) **Elastic potential energy** is energy stored in the molecules of stretched or compressed materials such as in elastic part of a catapult or in a stretched bow.

2) **Chemical potential energy** is energy stored in the molecules of fuels and chemicals.

3) **Electric potential energy** is the energy stored in cells and capacitors when positive and negative charges are separated it is stored in the battery.

4) **Gravitational potential energy** is the energy stored in a body when it is lifted up against gravity.

Gravitational potential energy

Work is energy transferred when a force moves. Work is done when a force moves a body to a certain height (h) against the gravitational attraction.

Work done on a body in a gravitational field is stored in it as gain in potential energy (E_p). As the body (m) is moved from the level A to height B, it gains potential energy due to the height h. If potential energy is represented by Ep,

E_p = Weight of the body Ã— vertical height moved

E_p = Mass Ã— gravity Ã— height

E_p = mgh

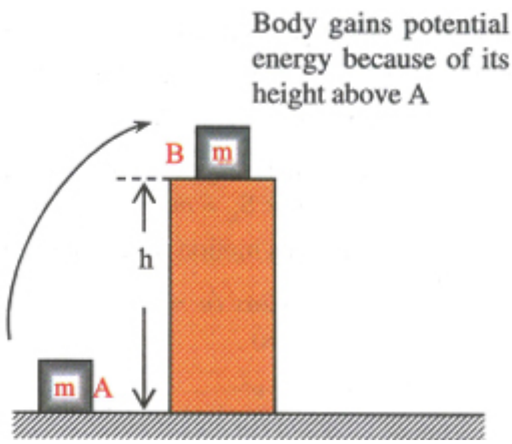


Figure 5.8 Gain in potential energy = Workdone against friction in lifting the body from A to B

Worked example

4. A spacecraft of total mass 250 000 kg orbits the earth at a height of 300 km above the sea level, calculate the gain in potential energy of the spacecraft, (g = 10 m s^{-2})

Solution

If Ep = Potential energy
Ep = mgh
Mass of spacecraft = 250 000 kg, height = 300 000 m
Ep = 250 000 x 10 Ã— 300 000
= 7.5 Ã— 10^{11} J

b. Kinetic energy

Kinetic energy is the energy possessed by a body in motion or energy stored in a moving body.

The kinetic energy of a body is proportional to the **square of its speed** and **to its mass.**

$$E_K = \frac{1}{2}mv^2$$

Different types of kinetic energy are:

(i) **Translational kinetic energy:** The energy of a body due its motion in straight line.

(ii) **Rotational kinetic energy:** The energy of a body due its rotational motion or motion along a curved path.

(iii) **Vibratory kinetic energy:** The energy possessed by a vibrating body.

Formula for kinetic energy

The kinetic energy gained by the body is measured by the amount of work done on it.
A moving object has kinetic energy because of its speed. When a force acts on the body, its speed or kinetic energy changes and work is done.

Gain in kinetic energy = Work done

Kinetic Energy = Force Ã— distance, but F = ma,
E_K = F Ã— S_K = *ma Ã— s* = m (as)

If the body begins its motion from rest, the initial velocity u is zero; the final Î½ is given by

$$v^2 = u^2 + 2as \ (u = 0)$$
$$v^2 = 2(as)$$
$$(as) = \tfrac{1}{2}v^2$$
$$\therefore E_K = \tfrac{1}{2}mv^2$$

Worked examples

1. A bullet of mass 100 g leaves the barrel of a gun with a speed of 300 m s^{-1}, calculate the kinetic energy of the bullet.

Solution

$$E_K = \tfrac{1}{2}mv^2$$
Mass of bullet (m) = 100 g = 0.1 kg
Speed of bullet (v) = 300 m s^{-1}
$$E_K = \tfrac{1}{2} \times 0.1 \times 300^2 = 4500 \text{ J or } 4.5\text{KJ}$$

2. A ball of mass of 1.8 kg is dropped from 28m above the ground.

Calculate the:

(i) potential energy before it was dropped.

(ii) speed with which the ball hit the ground. ($g = 10\ m\ s^{-2}$)

Solution

(i) $E_p = mgh$

$E_p = 1.8 \times 10 \times 28 = 504\ J$

(ii) At the point of landing, all the potential energy is transformed to kinetic energy.

$$\tfrac{1}{2}mv^2 = mgh$$

$$v = \sqrt{2\times10\times28}$$
$$= 23.7\ m\ s^{-1}$$

Energy transformation in a mechanical system

A system which changes potential energy to kinetic energy only and vice versa, is a mechanical system. Figure 5.9 shows a transformation from potential to kinetic energy if a fruit is allowed to fall from the top of a tree. A fruit at the top of the tree has only potential energy. As it drops, gravity pulls it towards the centre of the earth, the potential energy is changed or transformed gradually to kinetic energy. ***At any stage of the fall of the fruit, the sum of its potential and kinetic energies (total energy) remains constant.*** At the top of the tree, the energy of the fruit is only potential, midway during the fall, the kinetic energy is equal to the potential energy. ***Just before the fruit hits the ground, all the potential energy at the top has been transformed into kinetic energy.*** At any stage of the fall, the total energy of the fruit remains the same. This is called the principle of conservation of mechanical energy.

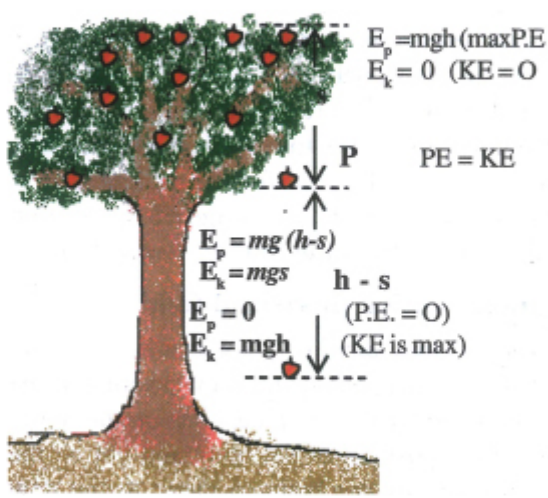


Figure 5.9 Energy transformations in a mechanical system

The principle of conservation of mechanical energy states that

in an enclosed system, the total mechanical energy is constant.

An enclosed system is one in which no energy is gained from or lost to the surrounding. The conservation principle of energy is stated mathematically as:

$$\text{Total energy} = \text{Potential energy} + \text{Kinetic energy}$$

$$E = E_p + E_k$$

The potential energy of the fruit at the top of the tree is $\mathbf{E_p = mgh}$. The fruit loses potential energy and gains kinetic energy as it falls from the tree top towards the ground. When the fruit has fallen through a vertical height, s metres, the potential energy $\mathbf{E_p = mg\ (h - s)}$ while the kinetic energy $\mathbf{E_k = mgs}$ or $\frac{1}{2}mv^2$ if velocity of the fruit is known.

The total energy at Ï is given by:

$E = E_p + E_k$

$E = mg\ (h - s) + mgs$

$E = mgh = \text{constant}$

Total energy (E) = mgh = a constant

Energy transformation in a simple pendulum

Figure 5.10 illustrates energy transformation in a simple pendulum. At the ends A and E, the energy of the bob is only potential because it is at rest momentarily. Bodies in position of rest possess energy. The potential energy is slowly changed to kinetic energy as the bob moves towards the centre C. It has only kinetic energy at C. Its potential and kinetic energies are equal at B and D. As it continues its motion towards E, the kinetic energy at C is gradually transformed or changed to potential energy. **At any stage of the motion of the bob, the total energy is constant.**

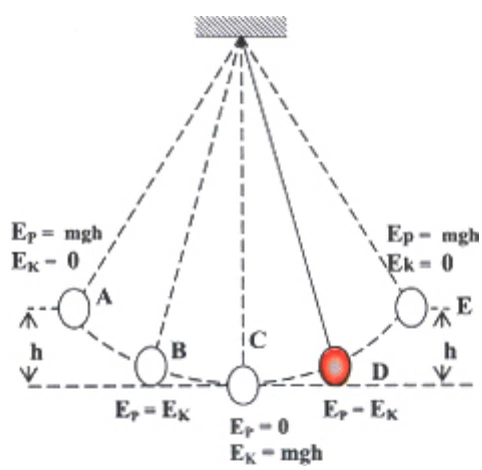


Figure 5.10 Energy transformations in a simple pendulum

Conservative force and field

Work is done anytime a force moves a body from its initial position to a new position. If the work done by the force depends on the initial and final position of the body and not on the path taken by the body to move to the new position, the force is **conservative**. ***The work done by a conservative force in a closed path is zero.*** If a stone is thrown upwards in a gravitational field and returns to the same level, the total displacement is zero; therefore, the total work done by the stone is zero. **Gravitational field** is an example of **conservative field**. When a body is placed at a height, e.g a book on a wardrobe, it possesses gravitational potential energy. Gravitational potential energy is the work done in moving a body up against gravity, its value depends on the initial and final positions of the body in the gravitational field.

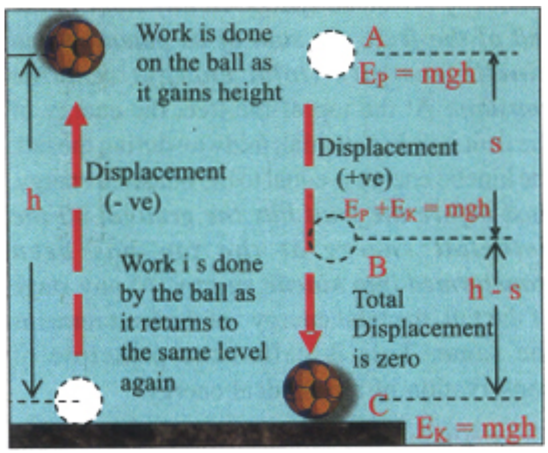


Figure 5.11 Work done in a closed path in a conservative field is zero

Worked examples

1. A stone of mass 60 g was released from the top of a tower 50 m tall. Find the:
   (i) potential energy of the stone just before it was released;
   (ii) potential and kinetic energies of the stone after it has fallen through a vertical height of 20 m;
   (iii) velocity of the stone just before it hit the ground.

Solution

(a) $E_p = mgh$

Mass (m) = 60 g = 0.06 kg

Height (h) = 20 m

$E_p = 0.06 \times 10 \times 50$

$= 30$ J

(b) $E_p = mg(h - s)$

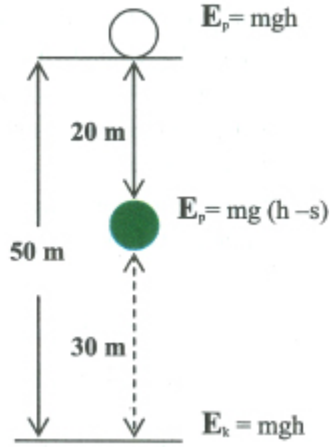
$= 0.06 \times 10\,(50 - 20)$

$= 18$ J

$E_k = mgs$

$= 0.06 \times 10 \times 20$

$= 12$ J



(c) $v^2 = \sqrt{2gh} = \sqrt{2 \times 10 \times 50} = v = 31.6ms^{-1}$

2. A simple pendulum consists of a thin string of negligible mass with a steel ball of mass 400 g attached at one end. The length of the pendulum is 100 cm, if the pendulum is displaced slightly through an angle of 30Â° with the vertical and released, calculate

(i) the potential energy of the bob at this position.

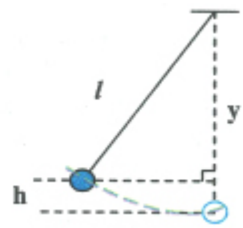
(ii) the speed of the bob when the kinetic energy is greatest, (g = 10 m s^{-2})

Solution

(a) $y = l\cos\theta = 100\cos 30^o = 86.6$ cm.

$h = l - y = 100 - 86.6 = 13.4$ cm

$Ep = mgh = 0.4 \times 10 \times 0.134 = 0.536$ J



(b) The kinetic energy is greatest when all the potential energy have been changed to kinetic energy, i.e. Ek = Ep = 0.536 J

$$\frac{1}{2}mv^2 = 0.536$$

$$v = \sqrt{\frac{0.536 \times 2}{0.4}} = 1.64\,m\,s^{-1}$$

Summary

- Energy is the ability or capacity to do work.
- Potential energy is the energy stored in a body due to its position in field or its mechanical condition.
- The energy possessed by a body in motion is called kinetic energy.
- The principle of conservation of mechanical energy states that, in an enclosed system, the total mechanical energy is constant. In other words, in an enclosed system, the total

energy remains constant though, it can be changed from one form to another.

- Renewable energy sources are the sources of energy which are constantly replaced by natural means.
- Non – renewable energy sources cannot be renewed or replaced easily by natural process when they finish or run out.

Practice questions 5b

1. What is energy? Why is it important?
2. Distinguish between kinetic and potential energy. What happens to the kinetic energy of a fast moving car when it is suddenly brought to rest?
3. State five sources of energy and describe how each can be transformed to electrical energy.
4. Explain the terms **renewable** and **non – renewable** energy sources. Give **three** examples of each.
5. (a) State the principle of **conservation of energy.**
   (b) Describe the energy transformation in a mechanical system using the motion of simple pendulum.
   (c) A simple pendulum has a length 1.2 m and a bob of mass 0.05 kg. When it is displaced through an angle of 15Â° with the vertical and released, it performs simple harmonic motion. Calculate the maximum potential energy and the maximum speed, (g = 10 m s^2)
6. (a) Explain the terms **work, potential energy** and **kinetic energy.** What is the link between energy and work?
   (b) A ball of mass 1.5 kg is dropped from a height of 224 m above ground. Calculate its potential energy before it was dropped.
   (c) What is the potential and kinetic energy of the ball when it is 120 m from the ground?
   (d) What is the speed of the ball just before it hits the ground? (g = 10 m s^{-1})
7. (a) What is kinetic energy? State the factors that determine the magnitude of kinetic energy of a body.
   (b) A bullet of mass 50 g is fired from a rifle with speed of 500 m s^{-1}, calculate its kinetic energy.
   (c) What happens to the kinetic energy if the bullet is stopped after penetrating a block of wood?

POWER

OBJECTIVES

At the end of the topic, students should be able to:

- explain the term power and give examples to illustrate power;
- show the relation between power, force and velocity;
- solve simple problems on power.

Concept of power

Power is the time rate of doing work. Alternatively, power is the time rate at which energy is expended.

Physicists are not only interested in the quantity of work done by a person or a machine, but also at the rate (how fast) the work is being done too. If two racing cars of the same weight cover the same distance, they will do the same amount of work but the car with the greater power covers the distance in a shorter time. Work done per unit time is power.

$$\text{Power} = \frac{\text{Work done}}{\text{Time}}$$

The unit of power is watt (W) or joule per second (J s^{-1}). 1 watt = 1 J s^{-1} Other units of power are kilowatt (KW), megawatt (MW) and horsepower (hp). A horsepower is approximately 750 watts and is equivalent to the work done per second by a horse.

Power and speed

The motion or speed of a body depends on its power. The greater the power of a machine, the faster it moves. Power is related to speed of a moving object.

Power = Force x Speed
P = F x V

Proof

$$\text{Power} = \frac{\text{Work done}}{\text{Time}} \quad P = \frac{F \times S}{t} \quad \Rightarrow \quad P = F \times v$$

Worked examples

1. A water pump raises 400 kg of water to a height 15 m in 20 seconds. What is the power of the pump in kilowatt?

Solution

$$\text{Work done} = \text{Mass} \times \text{acceleration due to gravity} \times \text{height}$$
$$= 400 \times 10 \times 15$$
$$= 60\,000 \text{ J}$$
$$\text{Power} = \frac{\text{Work done}}{\text{Time}} = P = \frac{60\,000}{20} = 3000 \text{ W} = 3 \text{ KW}$$

2. A racing car pushes against air resistance with a speed of 75 m s^{-1}. If the thrust of the engine is 2000 N, find the power of the car.

Solution

Power = Force Ã— Speed

= 2000Ã—75 = 150 000 W = 150KW

Summary

- Power is the time rate at which work is done or the time rate at which energy is expended.
- The motion or speed of a body depends on its power. The greater the power of a machine the faster it moves.
- Power = Force Ã— speed

Practice questions 5c

1. (a) What is power? How is power of a machine related to its speed?

   (b) A luxury bus engine produces a total force of 75 000 N when it is running at a maximum speed of 120 km h^{-1}? What is the power of the luxury bus?

2. (a) How is **power** related to **work?** Two boys working at different rates do the same amount of work, state with reason, which of the boys have greater energy.

   (b) It takes a boy of mass 62.7 kg only 15 seconds to climb 48 steps. If each step is 0.25 m high calculate the total height gained by the boy and his average power. [g = 10ms^{-2}]

3. (a) Explain the terms **work, energy** and **power** and state the link between them.

   (b) A space shuttle lifts up with a thrust of 350 000 N and reaches a height of 339 km in 30 seconds. At what power is the shuttle operating?

4. An electric filament bulb is rated 100 watts, calculate the amount of energy it radiates in 1 hour.

5. How long will it take a car working at the rate of 20.8 kw to cover a distance of 150 km. If the force of the engine is 5000 N. What is the speed of the car?

6. A water pump is used to lift 600 kg of water to a height of 20 m in 30 seconds. Calculate the work done in lifting the water to the stated height and the power of the pump.

Past questions

1. A man of mass 75 kg expends energy at the rate of 200 W in ascending a vertical height of 44 m. Determine the time taken to ascend the height. [g = 10 m s^{-1}]
   A. 33.0 s
   B. 117.3 s
   C. 165.0 s
   D. 340.9 s

WASSCE

2. The kinetic energy of a bullet fired from a gun is 40 J. If the mass of the bullet is 0.1 kg, calculate the initial speed of the bullet.
   A. 4.0 m s^{-1}
   B. 20.0 m s^{-1}
   C. 28.28 m s^{-1}
   D. 40.0 m s^{-1}

WASSCE

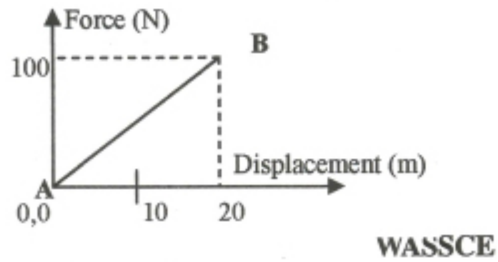
3. Electrical resistance is a property of an electrical conductor that causes electrical energy to be converted into
   A. mechanical energy
   B. heat energy
   C. magnetic energy
   D. chemical energy

WASSCE

4. A crate is pulled a distance d along a smooth horizontal floor by a force of magnitude **F,** inclined to the horizontal at an angle *Î¸*. The work done is
   A. Fdsin *Î¸*
   B. Fdcos *Î¸*
   C. Fdsec *Î¸*
   D. Fdcosec *Î¸*

WASSCE

5. How long will it take a 60 kg man to climb a height of 22 m if he expends energy at the rate of 0.25 KW? [g = 10 m s^{-1}]
   A. 5.3 s
   B. 20.0 s
   C. 34.5 s
   D. 52.8 s



WASSCE

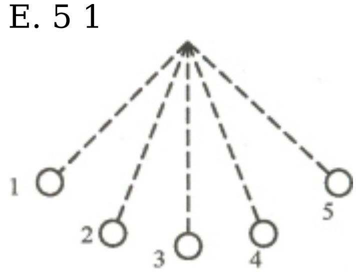
6. Using the force – displacement diagram shown above, calculate the work done.
   A. 2000 J
   B. 1000 J
   C. 20 J
   D. 5 J

WASSCE

7. To keep a lorry moving at a constant speed v, requires power **P,** from the engine. The force provided by the engine is
   A. $\frac{1}{2}v$
   B. pv
   C. $\frac{P}{V}$
   D. pv^2
   E. $\frac{P}{V^2}$

NECO

8. The diagram below shows five positions of the bob of a simple pendulum. At which of these positions does the bob have a maximum kinetic energy?
   A. 1
   B. 2
   C. 3
   D. 4
   E. 5 1



NECO

9. A constant force of 40 N acting on a body initially at rest gives it an acceleration of 0.1 m s^{-2} for 4 s. Calculate the work done by the force.
   A. 8 J
   B. 10 J

C. 32 J
D. 160 J

JAMB

10. A body rolls down a slope from a height of 100m. Its velocity at the foot of the slope is $20ms^{-1}$. What percentage of its initial potential energy is converted into kinetic energy?[$g = 10\ m\ s^{-2}$]
A. 40%
B. 35%
C. 20%
D. 15%

JAMB

11. A stone of mass m kg is held h metres above the floor for 50 s. The work done in joules over this period is
A. mh
B. mgh
C. $\frac{mgh}{50}$
D. 0

JAMB

12. A man whose mass is 80kg climbs a staircase in 20 s and expends a power of 120 W. Find the height of the staircase, [$g = 10\ m\ s^{-2}$]
A. 1.8 m
B. 2.0m
C. 2.5 m
D. 3.0 m

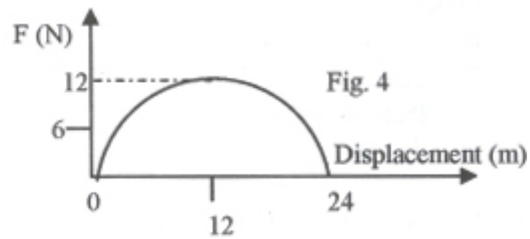
JAMB

13. If the force and velocity on a system are each simultaneously reduced by half, the power of the system is
A. doubled
B. constant
C. reduced to a quarter
D. reduced to half.

JAMB

14. A stone of mass 1kg is dropped from a height of 10 m above the ground and falls freely under gravity. Its kinetic energy 5 m above the ground is equal to
A. its kinetic energy on the ground
B. twice its initial potential energy
C. its initial potential energy
D. half its initial potential energy

JAMB



15. A body is under the action of force F such that the force – displacement graph of the body is semicircular as shown in Fig. 4. The work done on the body by the force in moving through 24 metres is
    A. 36Ï€ J
    B. 72Ï€ J
    C. 144 Ï€ J
    D. 288 Ï€ J

JAMB

16. Which of the following units has the same unit as the watt?
    A. Force Ã— time
    B. Force Ã— distance
    C. Force Ã— acceleration
    D. Force Ã— velocity

JAMB

17. Which of the following correctly describes the energy changes i ation of light by a hydroelectric I on?
    A. Electrical â†’ Mechanical â†’ Potential light
    B Potential â†’ Mechanical â†’ Electrical â†’ Light
    C. Mechanical â†’ Sound â†’ Electrical â†’ Light
    D. Kinetic â†’ Mechanical â†’ Electrical â†’ Light

JAMB

18. An object of mass 50 kg is released from the height of 2 m. Find the kinetic energy just before it strikes the ground.
    ($g = 10ms^{-2}$)
    A. 250 J
    B. 1000 J
    C. 10000 J
    D. 100000 J

JAMB

19. An engine raises 100 kg of water through a height of 60 m in 20 s, what is the power of the engine? [$g = 10\ m\ s^{-1}$]
    A. 120,000 W
    B. 3000 W
    C. 333 W
    D. 300 W

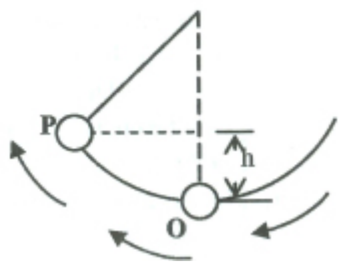
E. 30 W

WAEC

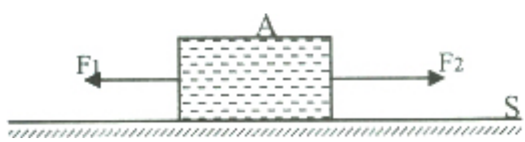
20. Power is defined as the
    A. capacity to exert a force
    B. product of force and time
    C. product of force and distance
    D. ability to do work
    E. energy expended per unit time.

WAEC

21. An oscillating pendulum has a velocity of 2 m s^{-1} at the equilibrium position O and the velocity at the point Ï is 0 m s–^{1}. Using the diagram, calculate the height **h** of **P** above O. [g = 10 m s^{-1}]
    A. 5.0 m
    B. 2.0 m
    C. 0.4 m
    D. 0.2m
    E. 0.1m



22. (a) (i) Define *work* and *energy*.
    (ii) State the unit of each.
    (b) The diagram below shows two forces F_1 *and* F_2 acting on an object, A, of mass 5kg resting on a frictionless surface, S.



    (i) State the condition under which the object will remain at rest.
    (ii) If are 10 N and 18 N respectively, calculate the work done when the object moves a distance of 2 m.
    (iii) Calculate the acceleration of the object.
    (iv) An additional mass is placed on A while remain the same. What effect will this have on the acceleration of the system?
    (c) A motor car converts chemical energy of petrol to mechanical energy at 30% efficiency. Calculate the mechanical energy obtained from 10 litres of petrol. {1 litre of petrol contains 2.8 kJ of chemical energy}.

WASSCE

23. A body of mass 0.6 kg is thrown vertically upward from the ground with a speed of 20 m s^{-1}. Calculate its
    (i) potential energy at the maximum height reached;
    (ii) kinetic energy just before it hits the ground.

WASSCE

24. (a) (i) What is meant by *energy?*
    (ii) State **three** renewable and **three** non – renewable energy sources.

WASSCE

25. (a) Explain **work** and **power**.

WASSCE

Atlas, carrying the world on his shoulders,
is doing no work because he is not moving!

Atlas with the world on his shoulders.