REDSPOT

IGCSE

(Syllabus 0625)

PHYSICS

Paper 4 (Extended) - All Variants

(Topical)

period	2020 to 2025
contents	June & November, Paper 4 (All Variants) Worked Solutions
form	Topic By Topic
compiled for	IGCSE

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TOPIC 1

Physical Quantities & Measurement Techniques

Scalars & Vectors, Units and Measurement

1. ***[Nov 2021/P41/Q1]***

Some physical quantities are scalars and other physical quantities are vectors.

(a) State how a vector quantity differs from a scalar quantity.

....

.... [1]

(b) Circle the vector quantities in the list.

acceleration **energy** **mass** **momentum**

temperature **time** **speed** **velocity**

[2]

(c) A microphone in a recording studio has a mass of 0.55 kg and a weight *W*.

(i) Calculate *W*.

W = ... [1]

(ii) The microphone is suspended from the ceiling by a cord attached to a small ring. Fig. 1.1 shows the microphone pulled to one side and kept stationary by a horizontal thread.

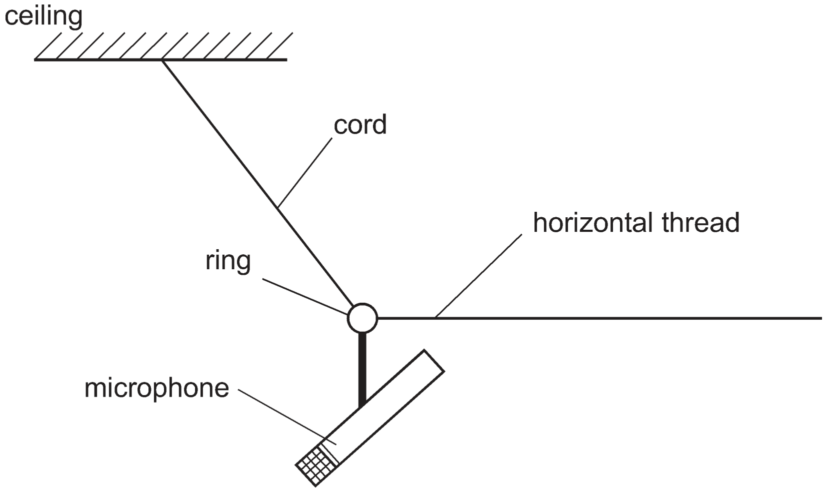


Fig. 1.1

The tension *T* in the horizontal thread is 8.1 N.

Determine graphically the magnitude and the direction, relative to the vertical, of the resultant of *W* and *T*. Use a scale of 1.0 cm to 1.0 N or greater. [3]

magnitude of resultant = ...

direction of resultant = ... relative to vertical

(iii) State and explain how the magnitude and direction of the resultant in **(c)(ii)** compares with the force on the ring due to the tension in the cord.

....

....

.... [2]

---

2. ***[June 2022/P42/Q3]***

(a) Fig. 3.1 shows water in a river moving parallel to the river bank at 4.0 m / s and a canoe travelling in the river.

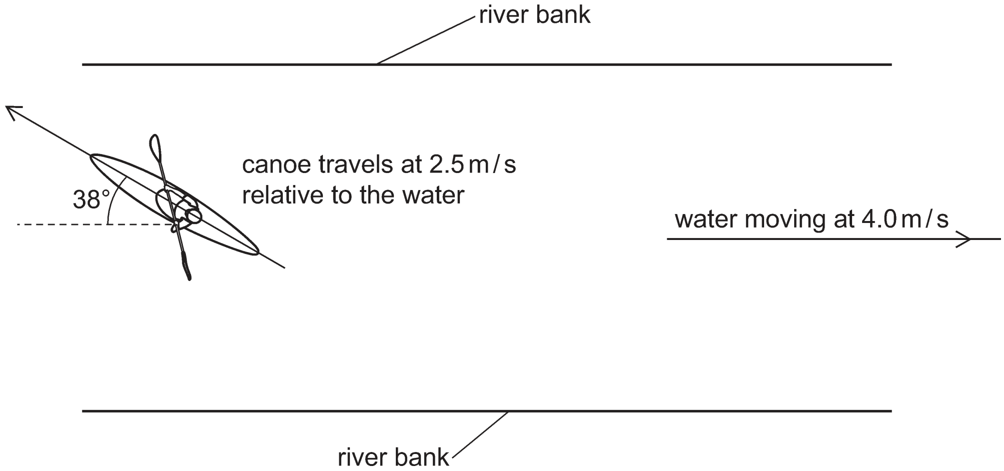


Fig. 3.1

The canoe travels at 2.5 m / s relative to the water and heads at an angle of 38° to the river bank.

Draw a scale diagram to determine the canoe's resultant velocity and state the scale you used.

scale ....

magnitude of resultant velocity ....

direction of resultant velocity (angle from the river bank) ....

[4]

(b) The mass of the canoeist is 65 kg.

Calculate her kinetic energy when travelling on still water at 2.5 m / s.

energy = ... [2]

---

3. ***[June 2022/P43/Q3]***

(a) Fig. 3.1 shows a boat stored in a shed. The boat is suspended from the ceiling of the shed by two ropes.

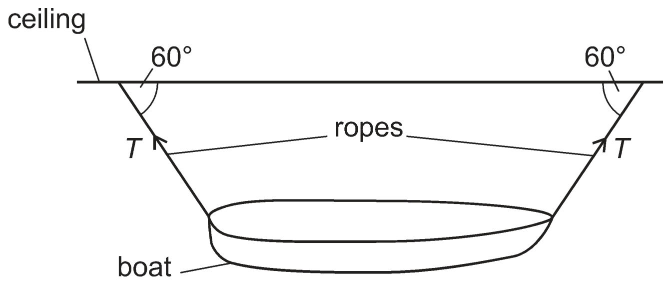


Fig. 3.1

The tension T in each of the ropes is 75 N.

(i) Draw a vector diagram to determine the resultant of the forces exerted by the two ropes on the boat. State the scale you used.

scale = ...

magnitude of resultant force = ...

direction of resultant force = ...

[4]

(ii) Determine the mass of the boat.

mass = ... [1]

(b) Force is a vector.

Draw a circle around **two** other quantities in the list which are vectors.

acceleration **density** **energy** **mass**

momentum **power** **refractive index**

[2]

4. ***[Nov 2022/P42/Q2]***

(a) A pendulum swings with a time period of approximately one second.

Describe how to use a stop-watch to determine the time period of the pendulum.

....

....

....

.... [3]

(b) Complete Table 2.1 by writing in each space of the right-hand column which **one** of the following devices is used to measure the quantity in the left-hand column.

digital balance　　measuring cylinder　　metre rule

micrometer screw gauge　　stop-watch　　thermocouple

Table 2.1

quantity	device
volume of water in a glass	
width of a small swimming pool	
thickness of a piece of aluminium foil	

[3]

5. ***[June 2023/P41/Q1]***

Fig. 1.1 shows a straight section of a river where the water is flowing from right to left at a speed of 0.54 m / s.

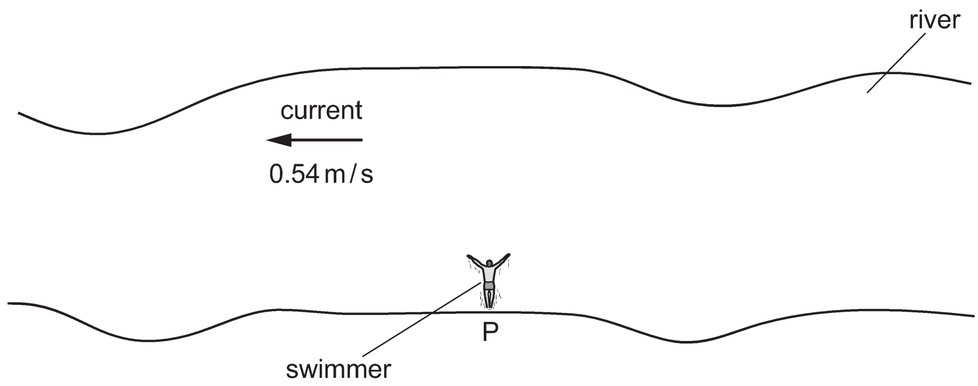


Fig. 1.1

A swimmer starts at point P and swims at a constant speed of 0.72 m / s relative to the water and at right angles to the current.

(a) **(i)** Determine, relative to the river bank, both the magnitude and direction of the swimmer's velocity.

magnitude of velocity = ...

direction of velocity = ...
[4]

(ii) After 1.5 minutes, the swimmer reaches point Q.
Calculate the distance between P and Q.

distance = ... [3]

(b) When the swimmer is crossing the river, his actions produce a constant forward force on his body.
Explain why he moves at a constant speed.

....

....

....

.... [2]

6. ***[Nov 2023/P42/Q3 b]***

Fig. 3.2 shows the directions of two forces acting on a balloon as it moves.

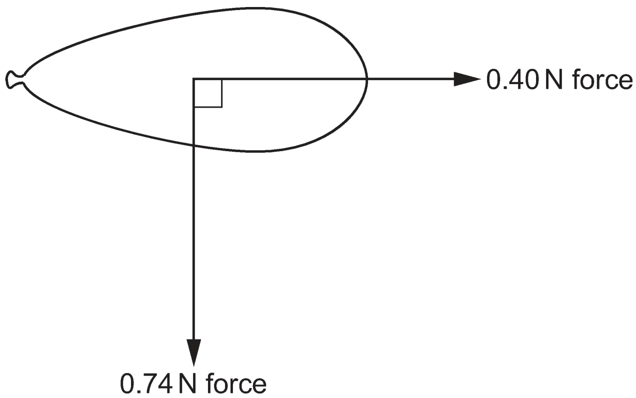


Fig. 3.2

Determine the magnitude and direction of the resultant force on the balloon.

magnitude ....

direction relative to horizontal force ....

[4]

---

7. ***[June 2024/P42/Q1]***

A load is suspended from a thread. The vertical force on the thread due to the load is 0.75 N.

(a) Calculate the mass of the load.

mass = ... [2]

(b) Fig. 1.1 shows the load suspended from the thread.

A wire is attached to the load at point X and pulled horizontally to the right.

The tension in the horizontal wire is 1.2 N.

By drawing a scale diagram or by calculation, determine:

- the magnitude of the resultant of the force at X due to the load and due to the tension in the wire
- the direction of the resultant relative to the vertical direction.

Show your working.

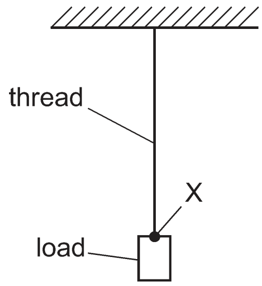


Fig. 1.1

magnitude of resultant force = ... N

direction of resultant relative to vertical = ... °

[4]

(c) Forces may produce changes in the size and the shape of an object.

State **two** other changes that forces may produce.

1 ....

2 ....

[2]

---

8. ***[Nov 2025/P42/Q1 a]***

(i) State the difference between a scalar quantity and a vector quantity.

....

.... [1]

(ii) In the list below, draw a line under each of the quantities that is a scalar quantity.

acceleration **mass** **momentum** **electric field strength**

energy **temperature**

[2]

SOLUTIONS

Topic - 1

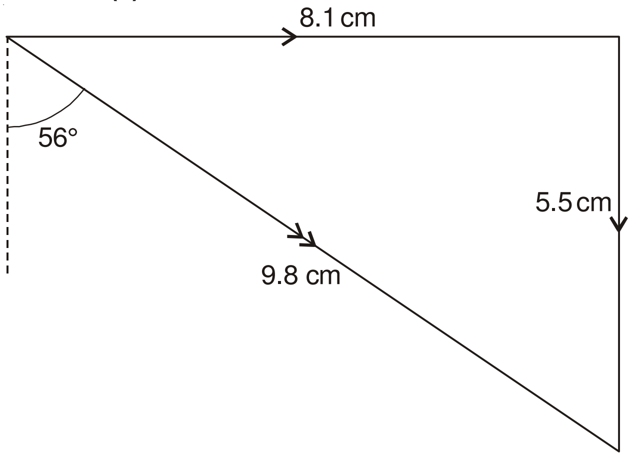
1. (a) Vector quantity has a direction whereas scalar quantity has no direction.

(b) Acceleration, momentum, velocity

(c) (i) $W = mg$

$= 0.55 \times 10 = 5.5$ N

(ii)

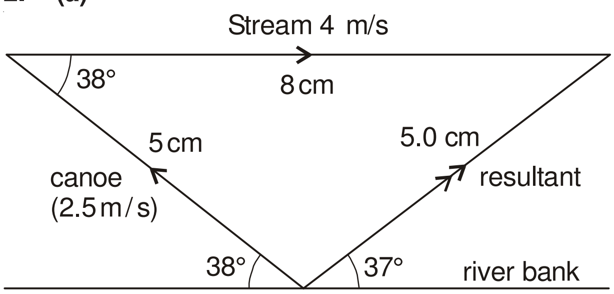


Magnitude of resultant = 9.8 N

Direction of resultant = 56^{o} relative to vertical

(iii) As the ring is in equilibrium, the force on the ring must be equal in magnitude and opposite in direction to the resultant force.

2. (a)



scale: 2 cm = 1 m/s.

Magnitude of resultant velocity: 2.5 m/s

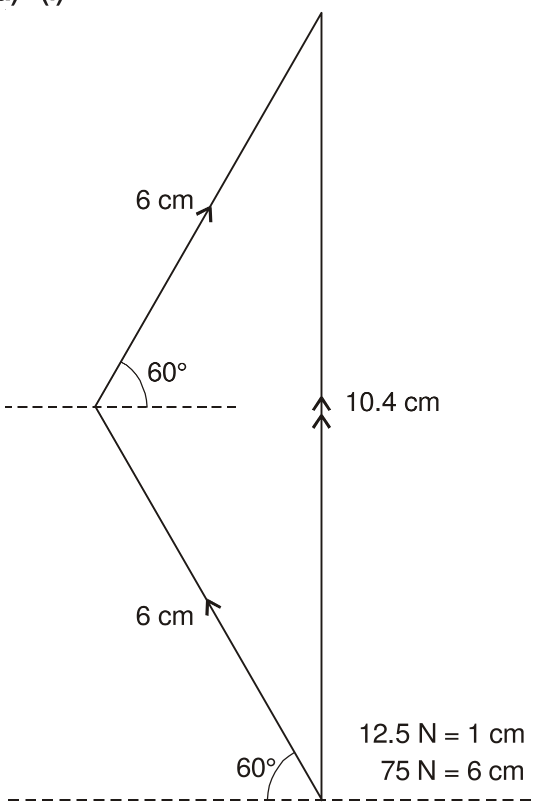
Direction of resultant velocity:
37° downstream (from river bank):

(b) Kinetic energy $= \frac{1}{2}mv^2$

$= \frac{1}{2}(65)(2.5)^2$

$= 203.125 \text{ J} \approx 200 \text{ J}$

3. (a) (i)



Scale : 1 cm = 12.5 N

Magnitude of resultant force
$= 10.4 \times 12.5 = 130$ N

Direction of resultant force
= vertically upward

(ii) As, the boat is suspended freely, it shows that, upward force on boat = downward force on boat.

So, weight of the boat = 130 N

mass of the boat $(m) = \frac{W}{g}$

$= \frac{130}{10} = 13$ kg

(b) acceleration, momentum

4. **(a)**
- Mark the rest position of pendulum just below the bob on the table and set it swinging with a small amplitude.
- Use a stop-watch to time 10 or 20 oscillations. One complete to and fro motion of the pendulum about the fixed mark is called one oscillation.
- Time period $= \dfrac{\text{Time-recorded on stop-watch}}{\text{No. of oscillations}}$

(b)

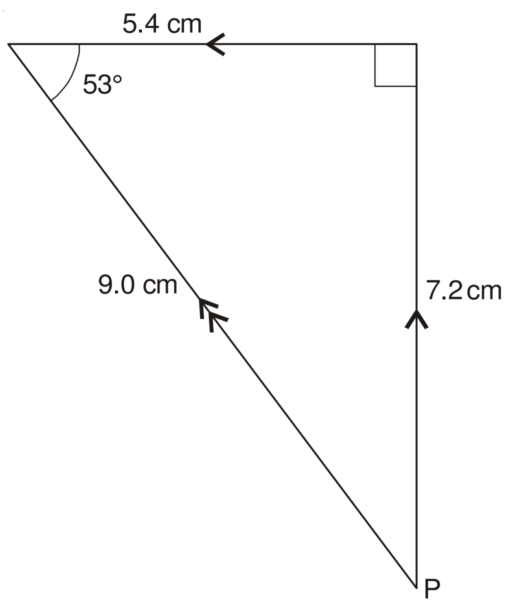
quantity	device
volume of water in a glass	measuring cylinder
width of a small swimming pool	metre rule
thickness of a piece of aluminium foil	micrometer screw gauge

5. **(a)** **(i)** Scale: $0.1 \text{ m/s} = 1 \text{ cm}$

$1 \text{ m/s} = 10 \text{ cm}$

$0.54 \text{ m/s} = 5.4 \text{ cm}$

$0.72 \text{ m/s} = 7.2 \text{ cm}$



Magnitude of velocity $= 9.0 \times 0.1$

$= 0.9 \text{ m/s}$

Direction of velocity = 53° to riverbank.

Alternatively:

Using pythagoras theorem, magnitude of velocity

$= \sqrt{(0.54)^2 + (0.72)^2}$

$= \sqrt{0.81} = 0.9 \text{ m/s.}$

For direction of velocity,

$\tan\theta = \dfrac{0.72}{0.54} \quad \Rightarrow \quad \theta = 53°$

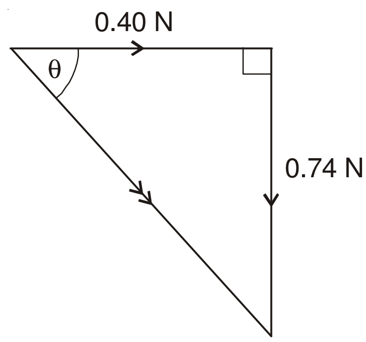
(ii) Distance = speed × time

$= 0.9 \text{ m/s} \times (1.5 \times 60) \text{ s}$

$= 81 \text{ m}$

(b) The swimmer's constant forward force is balanced by the water's backward resistance resulting in a zero resultant force on his body. As a result, he moves at a constant speed.

6.



Resultant force $= \sqrt{(0.74)^2 + (0.40)^2}$

$= 0.84 \text{ N}$

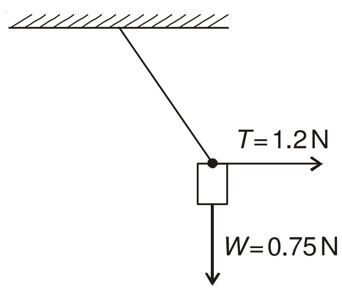
$\tan\theta = \dfrac{0.74}{0.40} \quad \Rightarrow \quad \theta = 61.6° \approx 62°$

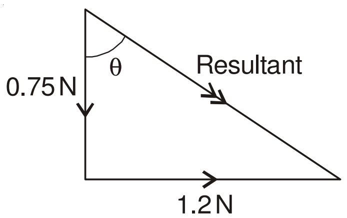
∴ Direction of the resultant force = 62° below the horizontal force

7. **(a)** $m = \dfrac{W}{g}$

$= \dfrac{0.75}{9.8} = 0.077 \text{ kg}$

(b)





Using Pythagoras Theorem,

resultant force $= \sqrt{(1.2)^2 + (0.75)^2}$

$= 1.4$ N

$\theta = \tan^{-1}\left(\dfrac{1.2}{0.75}\right) = 58°$

$\therefore$ Direction of resultant relative to vertical $= 58°$

(c) *Any two from:*

- Change in speed (or velocity) of a body
- Change in direction of motion of a body
- Change in acceleration / deceleration

8. **(i)** A scalar quantity has magnitude only.

A vector quantity has magnitude and direction both.

(ii) mass, energy and temperature

TOPIC 4

Forces

Balanced & Un-balanced Forces, Friction, Circular Motion,
Thinking & Braking distance

1. ***[Nov 2020/P43/Q3]***

(a) **(i)** Speed is a scalar quantity.

State **one** other scalar quantity.

.... [1]

(ii) Velocity is a vector quantity.

State **one** other vector quantity.

.... [1]

(b) Fig. 3.1 shows a model car travelling at constant speed on a flat circular track.

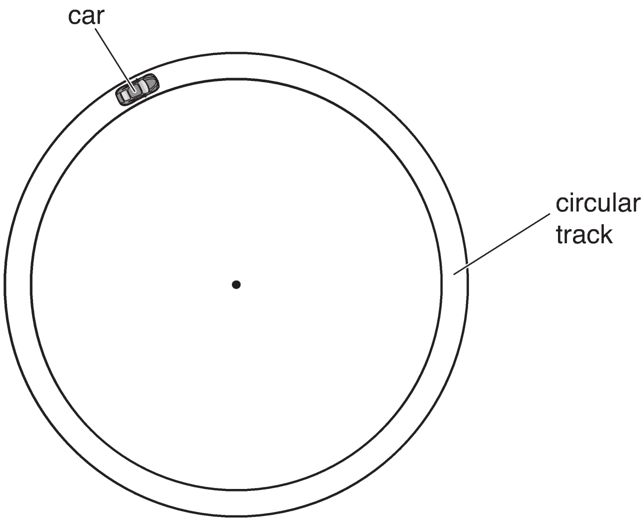


Fig. 3.1

The speed of the car is 0.30 m/s. In one complete revolution around the track, the car travels 3.9 m.

(i) Calculate the time taken for the car to complete one revolution around the track.

time = ... [2]

(ii) On Fig. 3.1, draw and label with the letter F an arrow to show the resultant force acting on the car. [1]

(iii) The speed of the car increases and at point P on Fig. 3.2 the car does not stay on the track.

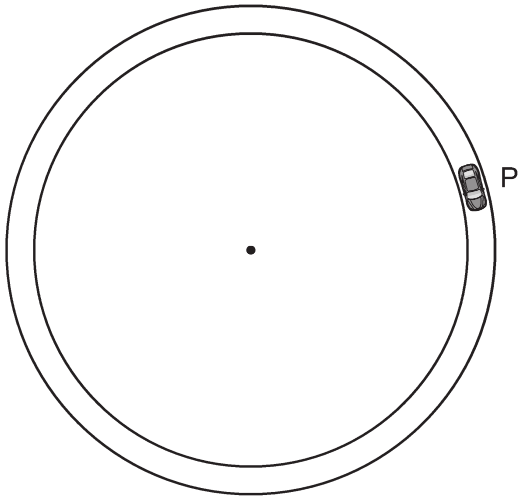


Fig. 3.2

1. Suggest, in terms of the force acting on the car, why the car does not stay on the track at point P.

....

.... [1]

2. On Fig. 3.2, draw and label an arrow with the letter S to show the direction of motion of the car as it leaves the track at point P. [1]

---

2. ***[June 2021/P41/Q1]***

A skydiver of mass 76 kg is falling vertically in still air. At time $t = 0$, the skydiver opens his parachute.

Fig. 1.1 is the speed–time graph for the skydiver from $t = 0$.

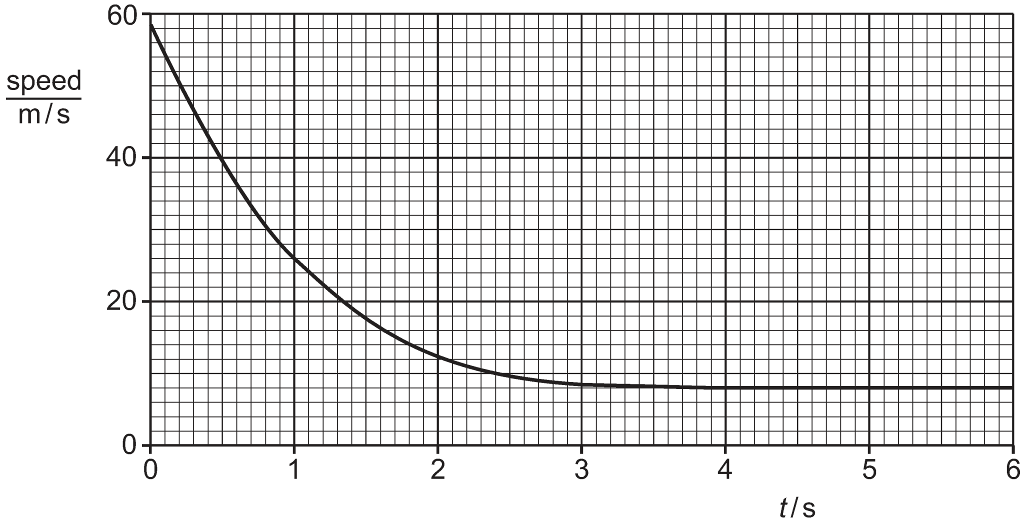


Fig. 1.1

(a) Using Fig. 1.1, determine:

(i) the deceleration of the skydiver immediately after the parachute opens

deceleration = ... [2]

(ii) the force due to air resistance acting on the skydiver immediately after the parachute opens.

force = ... [3]

(b) Explain, in terms of the forces acting on the skydiver, his motion between $t = 0$ and $t = 6.0$ s.

....

....

....

.... [3]

(c) Explain why opening the parachute cannot reduce the speed of the skydiver to zero.

....

....

.... [2]

---

3. ***[June 2021/P43/Q3]***

A car travels at constant speed v on a horizontal, straight road. The driver sees an obstacle on the road ahead.

(a) The distance travelled in the time between the driver seeing the obstruction and applying the brakes is the thinking distance.

Explain why the thinking distance is directly proportional to v.

....

.... [1]

(b) When the brakes are applied, the car decelerates uniformly to rest. The frictional force applied by the brakes is constant. The distance travelled between first applying the brakes and the car stopping is the braking distance.

Explain why the braking distance is proportional to v^2.

....

....

....

.... [3]

(c) The car is travelling at 22 m / s.

(i) The thinking distance is 15 m.

Calculate the time taken to travel the thinking distance.

time = ... [2]

(ii) The car has a mass of 1400 kg. The time taken for the car to stop after the brakes are applied is 2.1 s.

Calculate the force required to stop the car in this time.

force = ... [2]

---

4. ***[Nov 2021/P43/Q1 c]***

A ship sails in a straight line between two ports.
The acceleration of the ship is 0.0087 m / s^2. The total mass of the ship and its passengers is 2.3×10^7 kg.

(i) Calculate the resultant force on the ship.

force = ... [2]

(ii) Explain why the force on the ship due to the ship's engine is greater than the value you calculated in **(i)**.

....

.... [1]

5. ***[June 2022/P42/Q2]***

Fig. 2.1 shows an object of mass 2.0 kg on a bench. This object is connected by a cord, passing over a pulley, to an object of mass 3.0 kg

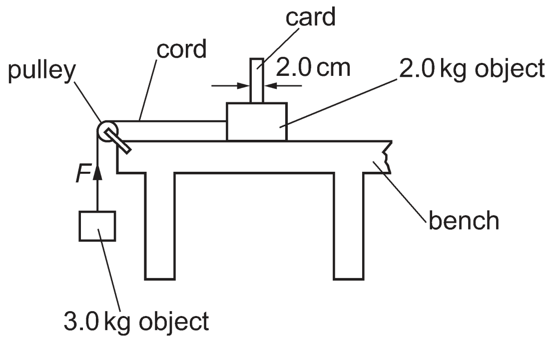


Fig. 2.1

The 2.0 kg object is released from rest and accelerates at 4.0 m / s^2.

(a) Calculate the resultant force acting on the 2.0 kg object.

force = ... [2]

(b) Calculate the upward force F exerted by the cord on the 3.0 kg object.

force F = ... [3]

(c) The objects have a constant acceleration.

(i) Show that the speed of the objects 0.80 s after release is 3.2 m / s.

[2]

(ii) A card, of width 2.0 cm, is fixed to the 2.0 kg object. As the 2.0 kg object moves to the left, the card passes through a beam of light that is perpendicular to the card.

Using the speed given in **(c)(i)**, calculate the time taken for the card to pass through the beam of light.

time = ... [2]

---

6. ***[June 2022/P43/Q1 a]***

A battery provides energy to an electric car.

The electric car has an acceleration of 2.9 m / s^2 when it moves from rest.

The combined mass of the car and its driver is 1600 kg.

(i) Calculate the time taken to reach a speed of 28 m / s.

time = ... [2]

(ii) Calculate the force required to produce this acceleration.

force = ... [2]

(iii) Calculate the kinetic energy of the car when its speed is 28 m / s.

kinetic energy = ... [2]

SOLUTIONS

Topic - 4

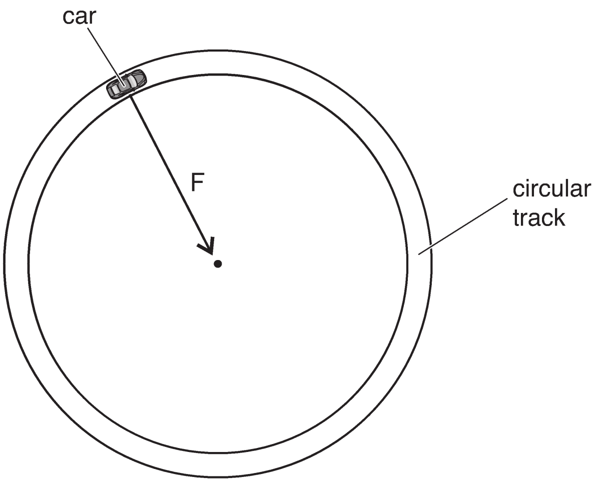
1. (a) (i) Mass

(ii) Acceleration

(b) (i) $\text{Time} = \dfrac{\text{distance}}{\text{speed}}$

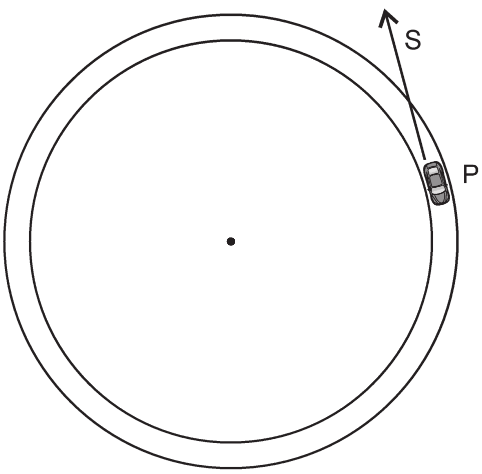
$= \dfrac{3.9}{0.30} = 13 \text{ s}$

(ii)



(iii) 1. The inward (centripetal) force is not sufficient at higher speed, so the car cannot follow the curved path and leaves the track at P.

2.



2. (a) (i) Deceleration

= gradient of graph from 0 to 0.5 s

$= \dfrac{58-40}{0.5} = 36 \text{ m/s}^2$

(ii) Immediately after the parachute opens,

Air resistance, F_{air} > Weight

By Newton's 2nd law

Net force $= ma$

$\Rightarrow \quad F_{air} - W = ma$

$\Rightarrow \quad F_{air} = ma + mg$

$\Rightarrow \quad F_{air} = 76(36) + 76(10)$

$= 2736 + 760 = 3496 \text{ N}$

(b) At $t = 0$, upward air resistance on skydiver is greater than his weight so there is a resultant upward force and he decelerates. As his speed decreases, the air resistance also decreases, so the resultant upward force becomes smaller and the deceleration decreases. Eventually, the air resistance becomes equal to the weight, and so he continues to fall at a constant terminal speed.

(c) At zero speed there will be no air resistance to oppose skydiver's weight. The weight of skydiver is still acting downwards, so there would be a resultant downward force. As a result, the skydiver cannot remain at zero speed.

3. (a) Distance = speed × time.
The thinking time is constant, so the distance travelled depends only on the speed. Therefore, thinking distance is directly proportional to speed (v).

(b) When the brakes are applied, the car's kinetic energy is reduced as work is done against the frictional force. Therefore

$\dfrac{1}{2}mv^2 = Fd$. Since F is constant, the braking distance is proportional to v^2.

(c) **(i)** Time taken, $t = \dfrac{d}{v}$

$= \dfrac{15}{22} = 0.68$ s.

(ii) Impulse = Change in momentum

$F \times t = mv - mu$

$F = \dfrac{m(v-u)}{t}$

$F = \dfrac{1400(0-22)}{2.1}$

$= -14666.67 \approx -15000$ N

$\therefore$ Force = 15000 N

4. **(i)** $F = ma$

$= (2.3 \times 10^7) \times 0.0087$

$= 2.0 \times 10^5$ N

(ii) Because some force is used to overcome water resistance (drag) acting backwards, which in not calculated in **(i)**.

5. **(a)** Resultant force $(F) = m \times a$

$= 2.0 \times 4.0$

$= 8.0$ N

(b) $W - F = ma$

$mg - F = ma$

$F = mg - ma$

$F = (3.0 \times 10) - (3.0 \times 4.0)$

$F = 18$ N

(c) **(i)** $v - u = at$

$v - 0 = 4.0 \times 0.80$

$v = 3.2$ m/s

(ii) Time $(t) = \dfrac{d}{v}$

$= \dfrac{2.0 \text{ cm}}{3.2 \text{ m/s}}$

$= \dfrac{0.02 \text{ m}}{3.2 \text{ m/s}} = 6.3 \times 10^{-3}$ s

6. **(i)** $v = u + at$

$28 = 0 + (2.9)t$

$t = 9.655 \approx 9.7$ s

(ii) Force $(F) = m \times a$

$= 1600 \times 2.9$

$= 4640$ N ≈ 4600 N

(iii) Kinetic energy $= \dfrac{1}{2}mv^2$

$= \dfrac{1}{2} \times 1600 \times (28)^2$

$= 627\ 200$

$\approx 6.3 \times 10^5$ J

7. **(a)** **(i)** Speed $(v) = u + at$

$= 0 + (7.2 \times 5.3)$

$= 38.16 \approx 38$ m/s

(ii) $F = ma$

$= 240 \times 7.2$

$= 1728$ N ≈ 1700 N

(b) **(i)** A vector has a direction as well as a magnitude whereas a scalar does not have a direction.

(ii) The velocity of the motorcyclist changes as his direction of motion changes while moving around the bend.

(iii) Since, the motorcyclist is accelerating due to the continuous change in her direction of motion, hence there must be a resultant force acting on her, directed towards the centre of the bend's circular path in order to keep her moving in the circular path.

8. **(a)** **(i)** Condition 1: The resultant force on the helicopter is equal to zero.

Condition 2: The resultant moment on the helicopter is equal to zero.

(ii) $\Delta E_p = mg\Delta h$

$= 3200 \times 9.8 \times 1500$

$= 4.7 \times 10^7$ J

TOPIC 8

Energy, Work and Power

Energy Forms, Energy Resources, Work, Efficiency, Power

1. ***[Nov 2020/P41/Q2]***

A vertical tube contains a liquid. A metal ball is held at rest by a thread just below the surface of the liquid, as shown in Fig. 2.1.

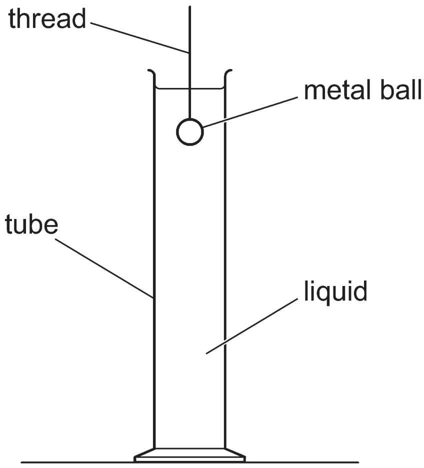


Fig. 2.1

The diameter of the tube is much greater than the diameter of the ball. The ball is released and it accelerates downwards uniformly for a short period of time.

(a) Describe what happens to the velocity of the ball in the short period of time as it accelerates downwards uniformly.

....

.... [2]

(b) The ball reaches terminal velocity.

Describe and explain the motion of the ball from when it is released until it reaches terminal velocity.

....

....

....

.... [3]

(c) The metal ball has a mass of 2.1 g. It falls a distance of 0.80 m between being released and reaching the bottom of the tube.

(i) Calculate the gravitational potential energy transferred from the ball as it falls.

gravitational potential energy transferred = ... [2]

(ii) When the ball reaches the bottom of the tube, it has a speed of 1.2 m / s. Calculate the kinetic energy of the ball at the bottom of the tube.

kinetic energy = ... [3]

(iii) Explain why the value calculated in **(c)(i)** is different from that calculated in **(c)(ii)**.

....

.... [1]

2. ***[Nov 2020/P42/Q3]***

The kinetic energy of air passing through a wind turbine every minute is 720 000 J. The electrical output of the turbine is 9.0 A at a potential difference (p.d.) of 240 V.

Calculate the efficiency (%) of the wind turbine.

efficiency = ... % [5]

3. ***[Nov 2020/P43/Q2]***

Fig. 2.1 shows a cliff edge with water below it.

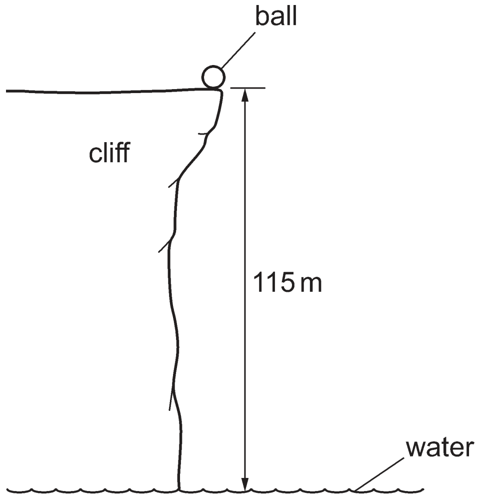


Fig. 2.1

A ball falls over the edge of the cliff. The mass of the ball is 160 g. The height of the cliff is 115 m.

(a) Calculate the vertical speed of the ball as it hits the water. Air resistance can be ignored.

speed = ... [3]

(b) Calculate the vertical momentum of the ball as it hits the water.

momentum = ... [2]

4. ***[June 2021/P42/Q3]***

Fig. 3.1 shows water flowing at very slow speed over a cliff edge.

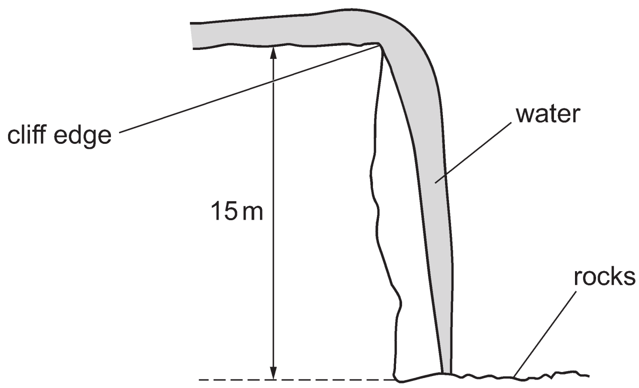


Fig. 3.1

The water falls 15 m onto the rocks below.

(a) Show that the velocity of the water when it strikes the rocks is 17 m / s.

[4]

(b) 30 kg of water flows over the cliff edge every second.

Calculate the force exerted by the rocks on the falling water. Ignore any splashing.

force = ... [3]

---

5. ***[Nov 2021/P41/Q4]***

A train of mass 1.8×10^5 kg is at rest in a station. At time $t = 0$, the train begins to accelerate along a straight, horizontal track and reaches a speed of 20 m / s at $t = 15$ s. The train continues at a speed of 20 m / s for 10 s.

At $t = 25$ s, the driver applies the brakes and the resistive force on the train causes it to decelerate uniformly to rest in a further 24 s.

Fig. 4.1 is an incomplete distance–time graph for this journey.

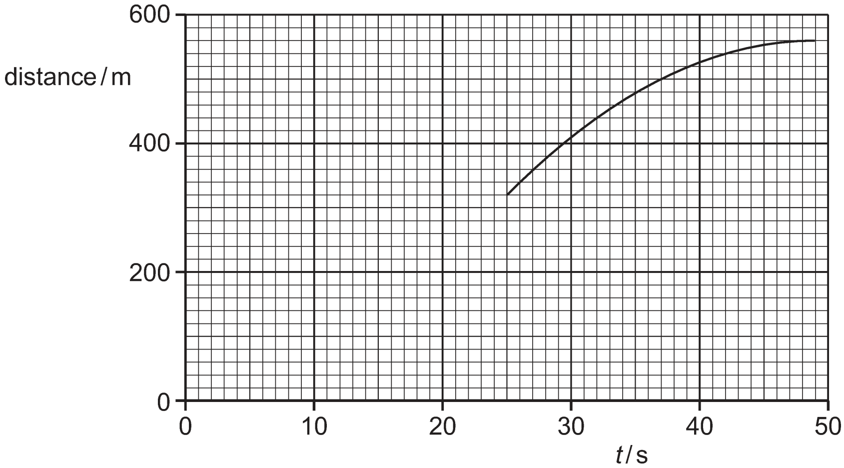


Fig. 4.1

(a) Complete Fig. 4.1 by drawing:

(i) a line to represent the motion of the train between $t = 15$ s and $t = 25$ s [1]

(ii) a curve to represent the motion of the train between $t = 0$ and $t = 15$ s. [1]

(b) Calculate the kinetic energy of the train between $t = 15$ s and $t = 25$ s.

kinetic energy = ... [3]

(c) While the train decelerates to rest, it does work against the resistive force and its kinetic energy decreases.

(i) Define *work done*.

....

.... [2]

(ii) Using Fig. 4.1, determine the distance moved by the train while it decelerates.

distance moved = ... [1]

(iii) Calculate the resultant force acting on the train while it decelerates.

resultant force = ... [2]

(b) The archer releases the bow string. All the energy in **(a)** is transferred to the arrow.

The arrow moves off at an initial speed *v*. The mass of the arrow is 0.030 kg.

(i) Calculate the initial speed *v* of the arrow.

initial speed *v* = ... [3]

(ii) Explain why the speed of the arrow as it hits the target is less than the value in **(b)(i)**.

....

.... [2]

---

23. ***[Nov 2025/P41/Q1]***

A train travels with a constant velocity of 56 m / s on a horizontal track. The mass of the train is 440 000 kg.

(a) State the difference between the velocity of the train and its speed.

....

.... [1]

(b) Calculate the kinetic energy stored in the moving train.

kinetic energy = ... [2]

(c) **(i)** The train has a uniform deceleration of 1.2 m / s^2.

Calculate the constant braking force which brings the train to rest.

force = ... [2]

(ii) Calculate the distance travelled by the train as it comes to rest.

distance = ... [3]

---

24. ***[Nov 2025/P41/Q3]***

Fig. 3.1 shows a simplified diagram of a solar cell.

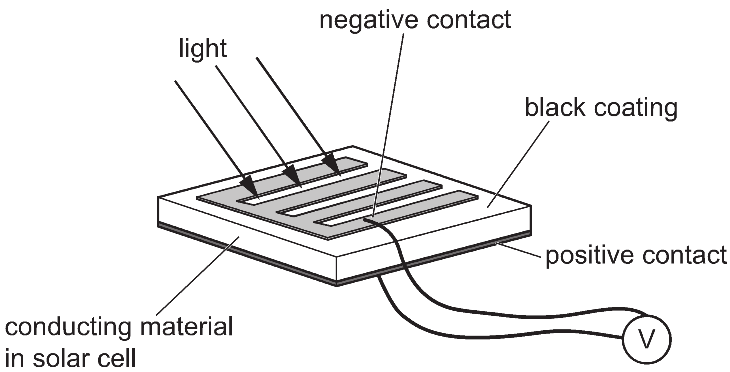


Fig. 3.1

(a) Describe the energy transfer in the solar cell.

.... [2]

(b) Suggest how the black coating allows the solar cell to transfer more energy.

....

.... [1]

(c) 0.72 kW of light is incident on the solar cell in Fig. 3.1. The cell has an efficiency of 75%.

(i) Calculate the output power of the cell.

output power = ... [2]

(ii) State the meaning of the term kilowatt-hour (kWh).

....

.... [1]

(iii) Energy is produced by each solar cell for an average of 6 hours per day. A household uses approximately 7400 kWh of electrical energy per year.

Calculate the number of solar cells needed to produce energy for one household. Give your answer as a whole number of solar cells.

number of solar cells = ... [3]

25. ***[Nov 2025/P42/Q3 a,b]***

Fig. 3.1 shows black solar panels installed on the roof of a house and a large rechargeable battery.

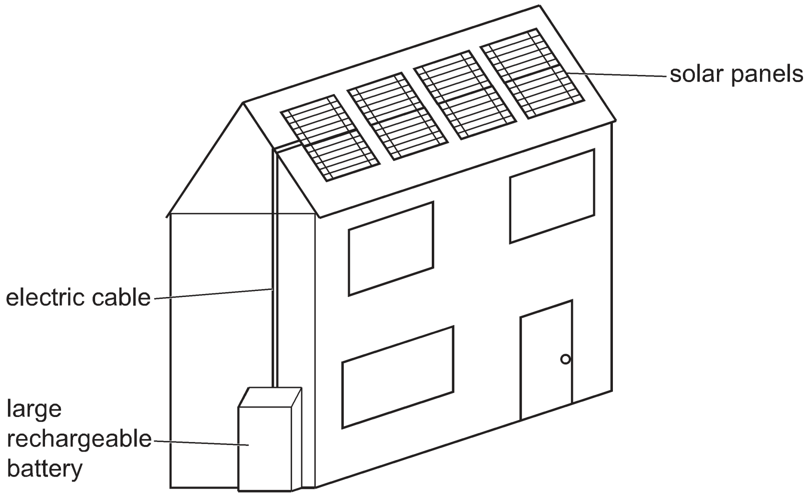


Fig. 3.1

The solar panels produce electricity and give a maximum power output of 3.5 kW. The efficiency of the solar panels is 16%.

(a) State and explain **one** advantage of using black solar panels.

....

....

.... [2]

(b) Calculate the power received by the solar panels from the Sun.

power = ... [3]

26. ***[Nov 2025/P43/Q1 a(iii,iv),c]***

(a) A hard ball is dropped vertically downwards from a height of 1.8 m.

(i) The mass of the ball is 0.54 kg. Calculate the gravitational potential energy stored in the ball immediately before it is dropped.

gravitational potential energy = ... [2]

(ii) Determine the kinetic energy of the ball when it has fallen half way to the ground.

kinetic energy = ... [1]

(b) A soft ball is dropped by a student so that it bounces on the ground.

Fig. 1.2 shows the height–time graph for the ball. The height is measured from the ground.

The ball bounces four times.

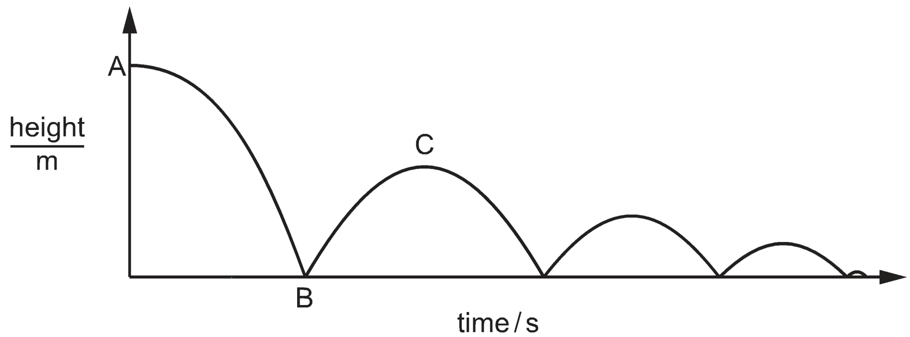


Fig. 1.2

Explain why the change in height of the ball between B and C is less than the change in height between A and B.

....

....

....

.... [2]

27. ***[Nov 2025/P43/Q3]***

(a) Fig. 3.1 shows a Sankey diagram for the power transfer in a coal-fired power station.

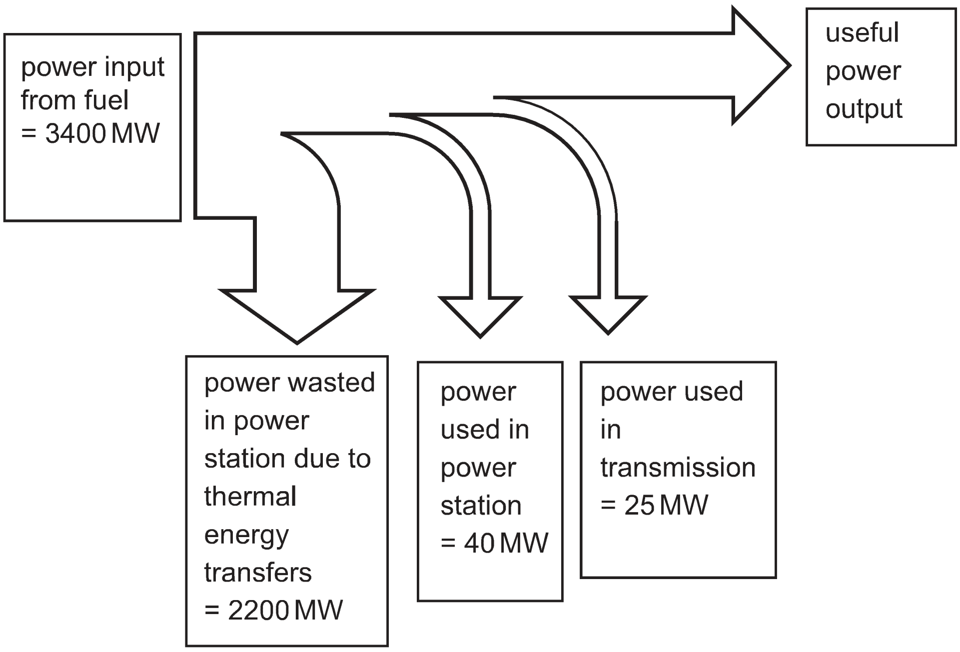


Fig. 3.1

(i) Show that the useful power output from the power station is approximately 1100 MW.

[2]

(ii) Calculate the efficiency of the power station.

efficiency = ... [2]

(b) Describe how useful energy may be obtained from geothermal resources.

....

....

....

....

.... [2]

SOLUTIONS

Topic - 8

1. (a) Velocity of ball increases with time at a constant rate.

(b) Initially the ball accelerates downwards due to its weight. Then as the speed of the ball increases, the drag acting upwards also increases which reduces the resultant downward force, so its acceleration decreases. Eventually, at a certain speed, the drag force becomes equal to the weight of the ball. The resultant force is then zero, so the ball moves down with constant velocity which is known as terminal velocity.

(c) (i) G.P.E. $= mgh$

$$= \frac{2.1}{1000} \times 10 \times 0.80$$
$$= 0.017 \text{ J}$$

(ii) K.E. $= \frac{1}{2}mv^2$

$$= \frac{1}{2} \times \frac{2.1}{1000} \times (1.2)^2$$
$$= 0.001512 \approx 1.5 \times 10^{-3} \text{ J}$$

(iii) Because some of the potential energy is used to do work against the drag force of the liquid. This energy is dissipated as thermal energy in the liquid.

2. Power input $= \dfrac{\text{energy}}{\text{time}}$

$$= \frac{720000}{60} = 12000 \text{ W}$$

Power output $= VI$

$$= 240 \times 9.0 = 2160 \text{ W}$$

Efficiency $= \dfrac{\text{power output}}{\text{power input}} \times 100$

$$= \frac{2160}{12000} \times 100 = 18\%$$

3. (a) Loss in P.E. = gain in K.E. at water surface

$$mgh = \frac{1}{2}mv^2$$
$$2gh = v^2$$
$$v = \sqrt{2gh}$$
$$= \sqrt{2 \times 10 \times 115}$$
$$= 47.96 \approx 48 \text{ m/s}$$

(b) Momentum $= mv$

$$= \frac{160}{1000} \times 48 = 7.7 \text{ kgm/s}$$

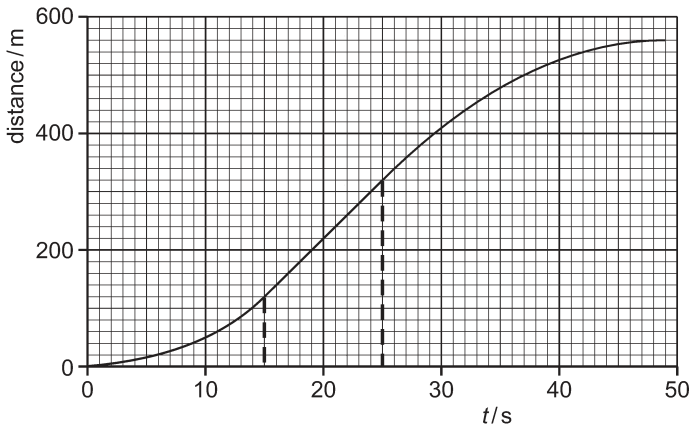
4. (a) Loss in PE of water at the top = gain in KE of water at the bottom

$$mgh = \frac{1}{2}mv^2$$
$$gh = \frac{1}{2}v^2$$
$$v^2 = 2gh$$
$$v = \sqrt{2gh}$$
$$v = \sqrt{2 \times 10 \times 15}$$
$$v = 17.32 \approx 17 \text{ m/s}$$

(b) $F = \dfrac{\Delta p}{\Delta t}$

$$= \frac{m\Delta v}{\Delta t}$$
$$= \frac{30(17.32)}{1} = 520 \text{ N}$$

5. (a) (i) & (ii)



(b) $K.E = \frac{1}{2}mv^2$

$= \frac{1}{2} \times (1.8 \times 10^5) \times (20)^2$

$= 3.6 \times 10^7$ J

(c) (i) Work done = force × distance moved in the direction of the force.

(ii) Distance moved = 560 − 320 = 240 m

(iii) Work done = change in KE = $F \times d$

$\Rightarrow \quad 3.6 \times 10^7 = F \times 240$

$\Rightarrow \quad F = \dfrac{3.6 \times 10^7}{240} = 1.5 \times 10^5$ N

6. (a) Statement: renewable

Explanation: Wind energy is a renewable source because the wind is constantly replaced naturally and will not run out.

(b)
- Geothermal energy
- Nuclear energy
- Tidal energy

(c) *Fossil fuels:* Chemical energy.

Water behind hydroelectric dams: Gravitational potential energy.

7. (a) Rate of transfer of G.P.E. $= \dfrac{\text{G.P.E. lost}}{\text{time}}$

$= \dfrac{mgh}{t}$

$= \dfrac{(12)(10)(1.7)}{1200}$

≈ 0.17 W

(b) Efficiency $= \dfrac{\text{useful power output}}{\text{total power input}} \times 100$

$= \dfrac{0.10}{0.17} \times 100$

$= 59\%$

(c) A gravity lamp does not need fossil fuel. No cost to run. It does not produce any air pollution.

8. (a) (i) Energy $(E) = P \times t$

$= 600 \times (60 \times 60)$

$= 2160000$

$\approx 2.2 \times 10^6$

(ii) Chemical energy

(b) Energy (E) = Power × time

time $(t) = \dfrac{\text{Energy}}{\text{Power}}$

$= \dfrac{2.2 \times 10^6}{250}$

$= 8800$ s $= 2.4$ hours

(c) *Any two from:*
- It does not produce harmful gases like CO_2 to pollute the environment.
- A bicycle does not produce noise.
- It does not use fossil fuel, so it does not contribute to the greenhouse effect.
- It does not produce acid rain.

9. (a) Gravitational potential energy

(b) (i) Rate or power $(P) = \dfrac{E}{t}$

$= \dfrac{mgh}{t}$

$= \dfrac{480 \times 10 \times 410}{1}$

$= 1968\,000$

$\approx 2.0 \times 10^6$ J/s

(ii) Efficiency $= \dfrac{\text{useful power out}}{\text{total power in}} \times 100$

$= \dfrac{V \times I}{2.0 \times 10^6} \times 100$

$= \dfrac{6000 \times 270}{2.0 \times 10^6} \times 100$

$= 81\,\%$

(c) (i) *Any one from:*
- Damage to habitats for fish
- Construction is expensive
- Flood risk if dam bursts

(ii) *Any one from:*

Biofuel, Wind energy, Geothermal energy, Tidal energy, Solar energy

10. (a) Change in G.P.E. $= mgh$

$= 0.50 \times 10 \times 0.45$

$= 2.3$ J

(b) (i) Impulse (I) = change in momentum

$= m\Delta v$

$= 2.0 \times 0.60$

$= 1.2$ Ns

(ii) As the block A moves, part of its kinetic energy is converted into thermal energy due to the friction with the rough horizontal surface and hence, its K.E. decreases and the block A slows down. The block A finally, decelerates to rest and its K.E. is converted to thermal energy when the block B hits the ground.

11. (a) (i) *Any one from*:
- Solar panels / solar cells
- Fossil fuels (coal, oil)
- Biofuel (from wood, crops)
- Hydro power
- Wind power

(ii) *Any one from*:
- Nuclear energy
- Geothermal energy

(b) (i) Yes, it is renewable. Due to the Moon, tides are formed continuously. Hence, the tides are an unlimited resource of energy.

(ii) K.E. of water $= \frac{1}{2}mv^2$

$= \frac{1}{2} \times 6.0 \times 10^3 \times (2.0)^2$

$= 12000$ J

$$\text{Efficiency} = \frac{\text{output power}}{\text{input power}} \times 100$$

$$40\% = \frac{\text{output power}}{12000} \times 100$$

$$\text{output power} = \frac{40 \times 12000}{100}$$

$$= 4800 \text{ W}$$

12. (a) **Gravitational potential** energy of the **water** in the **tidal bay** is transferred to **kinetic** energy in the rotating **turbines**. This energy is used in the generator to produce electrical power.

(b) *Any one advantage from:*
- Renewable resource
- Reliable or predictable
- Running cost low
- Does not produce harmful pollution

Any one disadvantage from:
- High cost of construction
- Possible effects on marine life
- Not available all day
- Limited number of sites
- Difficult maintenance due to increased corrosion.

(c) Moon's gravity. (or, sun's gravity).

13. (a) Kinetic energy $= \frac{1}{2} \times m \times v^2$

$= \frac{1}{2} \times \frac{160}{1000} \times (18)^2$

$= 25.92 \approx 26$ J

(b) Force, $F = m \times a$

$= m \times \left(\frac{v-u}{t}\right)$

$= 0.16 \times \left(\frac{0-18}{0.12}\right) = -24$ N

$\therefore$ Average force $= 24$ N

(c) Since, $F \propto \frac{1}{t}$, so moving the hands backwards increases the time of impact of the ball with hands and as such reduces the impact (force) on the hands.

14. (a) *Any two from:*
- Geothermal energy
- Nuclear energy
- Tidal

(b) (i) Statement: It is non-renewable

Explanation: This is because the nuclear fuel is used up and the supplies of nuclear fuel are finite.

(ii) Statement: Yes, it is renewable.

Explanation: The power generation from waves in the sea is infinite as the waves are produced by the wind which will always continue.

15. (a) In hydroelectric power station water stored in a high lake is allowed to flow down through spillway. This flowing water makes turbine to rotate converting gravitational potential energy of water to kinetic energy of turbine. Turbine turns electrical generator producing electrical energy.

TOPIC 20

Electric Circuits

Circuit Diagrams & Circuit Components, Series & Parallel Circuits, Action and Use of Circuit Components

1. ***[June 2020/P42/Q8]***

(a) A light-emitting diode (LED) is a diode that emits light when there is a current in it. Draw a circuit diagram showing an LED, connected so that it is lit, in series with a battery and a fixed resistor. Use standard electrical symbols.

[4]

(b) The p.d. across the LED when lit is 3.1 V and the current in the LED is 0.030 A.

Calculate the value of the resistance of the LED when lit.

resistance = ... [2]

(c) Fig. 8.1 shows a power supply of e.m.f. 10.5 V connected in series with a lamp and a heater. The p.d. across the lamp is 2.1 V and the current in the lamp is 1.5 A.

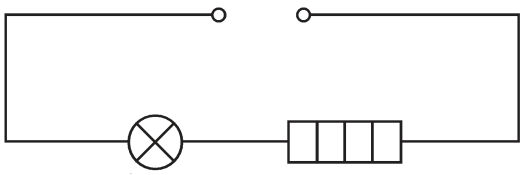


Fig. 8.1

Calculate:

(i) the resistance of the heater

resistance = ... [2]

(ii) the power of the heater.

power = ... [2]

---

2. ***[Nov 2020/P41/Q8]***

(a) Explain what is meant by *electromotive force* (*e.m.f.*).

....

....

.... [2]

(b) An electric heater contains two heating elements R_1 and R_2. An electric motor operates a fan. The fan blows cool air over the heating elements.

Fig. 8.1 shows the circuit.

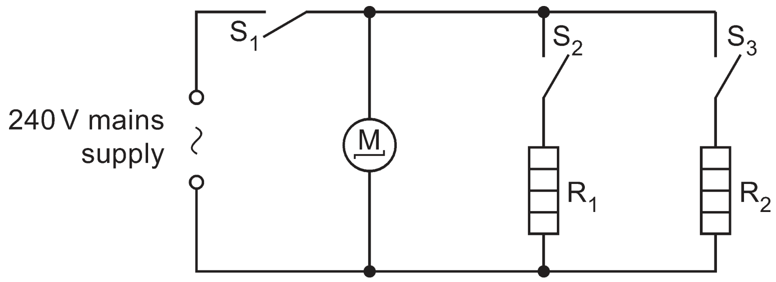


Fig. 8.1

The heater is powered by a mains supply of e.m.f. 240 V.

Switches S_1 and S_2 are closed. Heating element R_1 gets hot. The resistance of R_1 is 30 Ω.

(i) Calculate the current in heating element R_1.

current = ... [1]

(ii) Calculate the power produced in heating element R_1.

power = ... [2]

(iii) The resistance of heating element R_2 is 60 Ω.

Switches S_1, S_2 and S_3 are closed.

1. State and explain how the current in R_2 compares with the current in R_1.

....

....

.... [2]

2. The current in the motor is 0.10 A. The cable from the electric heater to the plug for the mains socket is safe when the current in it is less than 20 A.

Suggest and explain a suitable fuse rating for this circuit.

....

....

....

.... [2]

---

3. ***[Nov 2020/P42/Q10]***

Fig. 10.1 shows an incomplete electrical circuit.

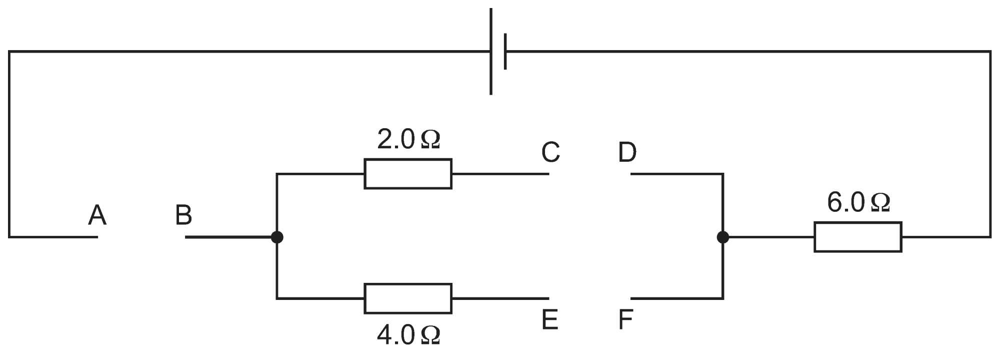


Fig. 10.1

(a) (i) A student completes the circuit and measures the current in the 6.0 Ω resistor.

On Fig. 10.1, draw an ammeter symbol in one gap and straight lines to indicate wires in the other gaps to show how the student should do this. [1]

(ii) A voltmeter is connected to measure the potential difference (p.d.) across the 4.0 Ω resistor.

On Fig. 10.1, draw a voltmeter symbol connected in the correct position. [2]

(iii) With the circuit completed, the current in the $2.0\,\Omega$ resistor is 2.5 A.

Calculate the current in the $6.0\,\Omega$ resistor.

current = ... [4]

(b) Fig. 10.2 shows the same electrical circuit with an alternating current (a.c.) power supply and a wire in the gap AB.

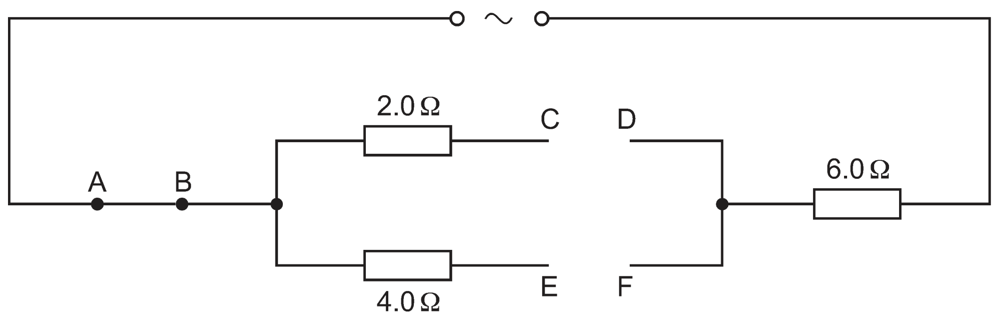


Fig. 10.2

On Fig. 10.2, draw a diode symbol in one gap and a straight line to indicate a wire in the other gap so that there is a current from right to left in the $4.0\,\Omega$ resistor and an alternating current in the $2.0\,\Omega$ resistor. [2]

4. ***[Nov 2020/P43/Q8 a]***

(i) Fig. 8.1 shows an electrical circuit. The resistor has a resistance of $4.0\,\Omega$. The reading on the voltmeter is 3.0 V.

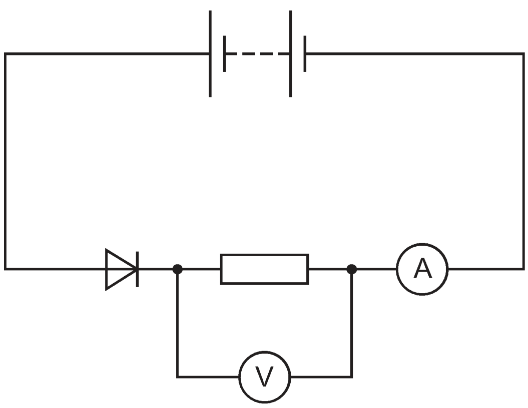


Fig. 8.1

Calculate the current in the resistor.

current = ... [2]

(ii) Fig. 8.2 shows the same circuit with one component reversed.

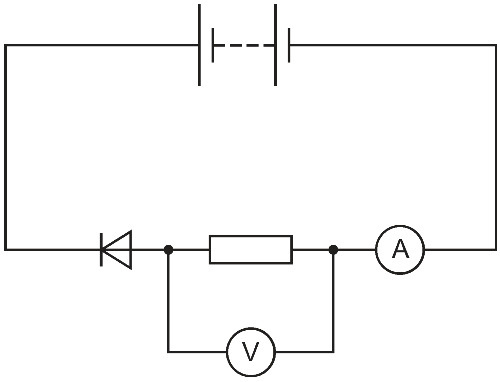


Fig. 8.2

State the reading on the voltmeter and explain your answer.

reading = ...

explanation ....

....
[2]

---

5. ***[Nov 2020/P43/Q10]***

Fig. 10.1 shows a relay.

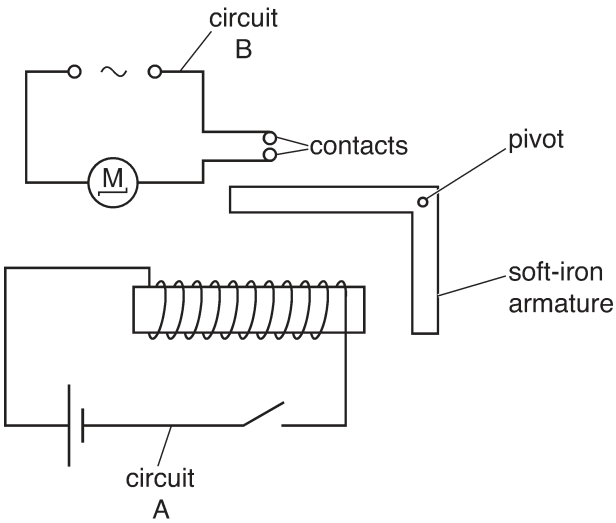


Fig. 10.1

(a) The switch in circuit A is closed. Describe how this operates the motor in circuit B.

....

....

....

.... [3]

(b) The switch in circuit A is opened. The soft-iron armature is replaced with a steel armature The switch in circuit A is closed.

Explain what happens when the switch in circuit A is then opened.

....

....

.... [2]

---

6. ***[June 2021/P41/Q8]***

A student sets up a circuit that includes a 12 V battery, an 800 Ω resistor, a voltmeter and a thermistor. Fig. 8.1 is an incomplete circuit diagram because the symbol for the thermistor is missing.

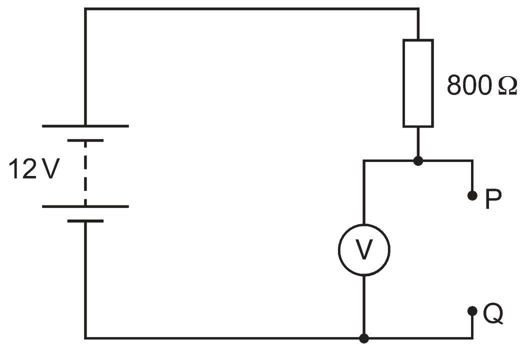


Fig. 8.1

The thermistor is connected between terminals P and Q.

(a) Complete Fig. 8.1 by drawing the symbol for a thermistor between terminals P and Q. [1]

(b) The 12 V battery consists of eight identical cells connected in series.

Calculate the electromotive force (e.m.f.) of each cell.

e.m.f. = ... [1]

(c) The reading on the voltmeter is 8.0 V.

(i) Determine the resistance of the thermistor.

resistance = ... [3]

(ii) A few hours later, the student notices that the reading on the voltmeter is greater.

Explain what can be deduced from this observation.

....

....

....

.... [3]

---

7. ***[June 2021/P42/Q10 b,c]***

(a) Fig. 10.2 shows a circuit containing component K.

At low temperature, component K has a much greater resistance than resistor R.

At high temperature, component K has a much smaller resistance than resistor R.

State and explain the effect on the lamp when the temperature changes from very low to very high.

Refer to the voltage at point X in your explanation.

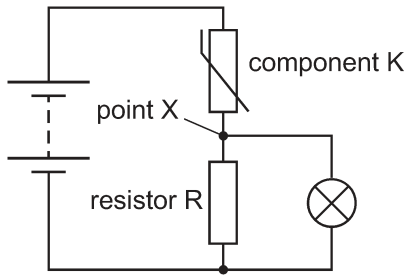


Fig. 10.2

statement ....

explanation ....

....

....

....

.... [4]

(b) State the name of component K.

.... [1]

26. ***[June 2025/P42/Q8 b]***

Fig. 8.2 shows a circuit diagram.

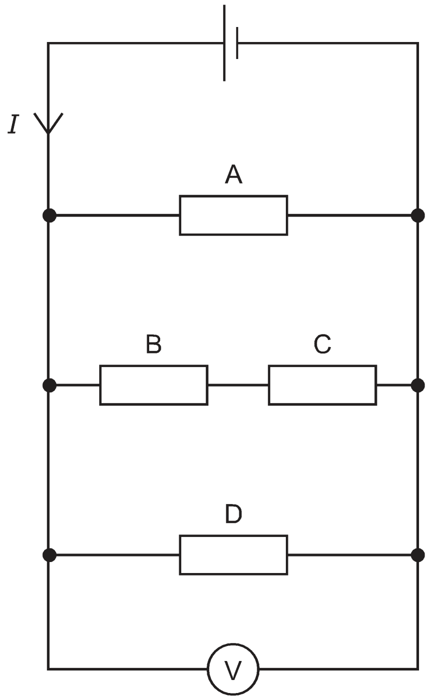


Fig. 8.2

Resistors A, B, C and D are identical. The current in resistor A is 2.4 A.

(i) State the value of the current in resistor B. Explain your answer.

current in resistor B ....

explanation ....

....

[2]

(ii) Calculate the value of the current I.

current I = ... [1]

(iii) The reading on the voltmeter is 5.0 V.

Calculate the resistance of resistor A.

resistance = ... [2]

27. ***[June 2025/P43/Q7]***

A student sets up the circuit shown in Fig. 7.1.

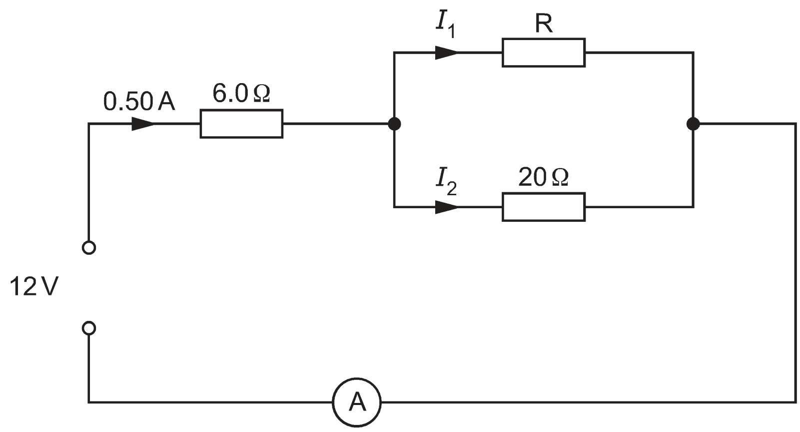


Fig. 7.1

(a) Determine the value of the current measured by the ammeter.

current = ... [1]

(b) Calculate the potential difference (p.d.) across the 6.0 Ω resistor.

p.d. = ... [2]

(c) Show that the p.d. across the 20 Ω resistor is 9.0 V.

[1]

(d) Calculate the resistance of resistor R.

resistance = ... [3]

28. ***[Nov 2025/P41/Q7]***

Fig. 7.1 shows a circuit containing a 6.0 V battery of cells and three identical resistors.

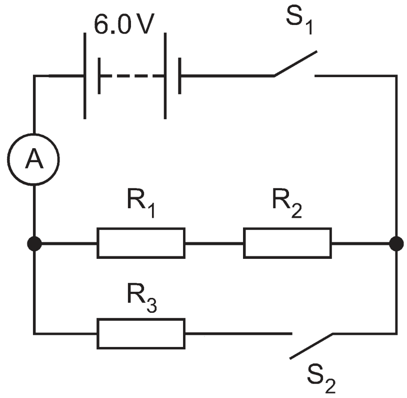


Fig. 7.1

(a) S_1 is closed and S_2 is open. The current in the ammeter is 0.080 A.

Calculate the resistance of R_1.

resistance = ... [2]

(b) S_1 and S_2 are both closed.

(i) Determine the reading on the ammeter. Show your working.

ammeter reading = ... [3]

(ii) Explain in terms of work done and potential difference why there is a larger heating effect in R_3 than in R_1.

....

....

.... [2]

29. ***[Nov 2025/P42/Q7]***

A circuit consists of an a.c. supply and two lamps. The lamps are connected in parallel.

(a) Draw the circuit diagram.

[2]

(b) The electromotive force (e.m.f.) of the a.c. supply is 230 V. When connected to the 230 V supply, the resistance of one lamp is 1200 Ω and the resistance of the other lamp is 800 Ω.

(i) Calculate the current in the 800 Ω lamp.

current = ... [2]

(ii) Calculate the energy used by the 800 Ω lamp in 5.0 hours.

Give your answer in kWh.

energy = ... kWh [3]

(iii) Calculate the combined resistance of the two lamps in this circuit.

resistance = ... [2]

30. ***[Nov 2025/P43/Q6]***

(a) Fig. 6.1 shows a circuit which includes an LDR (light-dependent resistor).

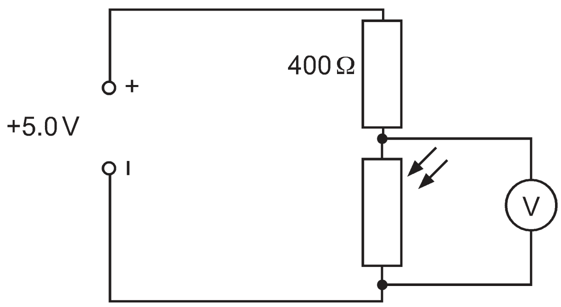


Fig. 6.1

The LDR is in a brightly lit room. The voltmeter reads 1.8 V.

(i) Calculate the current in the 400 Ω resistor.

current = ... [3]

(ii) The light level in the room changes from bright to dark.

State and explain the effect on the voltmeter reading.

statement ....

explanation ....

....

....

....
[3]

(b) Fig. 6.2 shows two light-emitting diodes (LEDs) connected in parallel in a circuit. R is a red LED and G is a green LED.

The voltmeter across the LEDs shows a potential difference (p.d.) of 2.0 V.

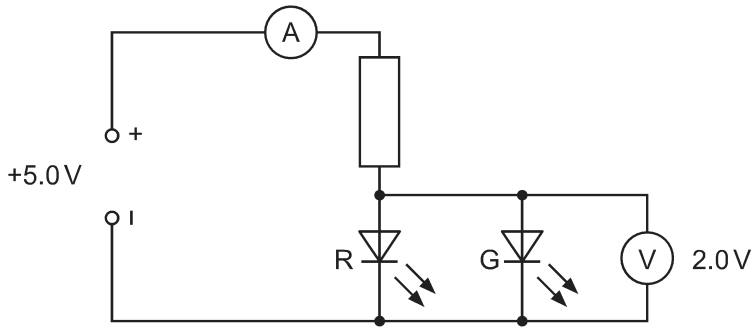


Fig. 6.2

(i) Fig. 6.3 shows a current-p.d. graph for the LEDs.

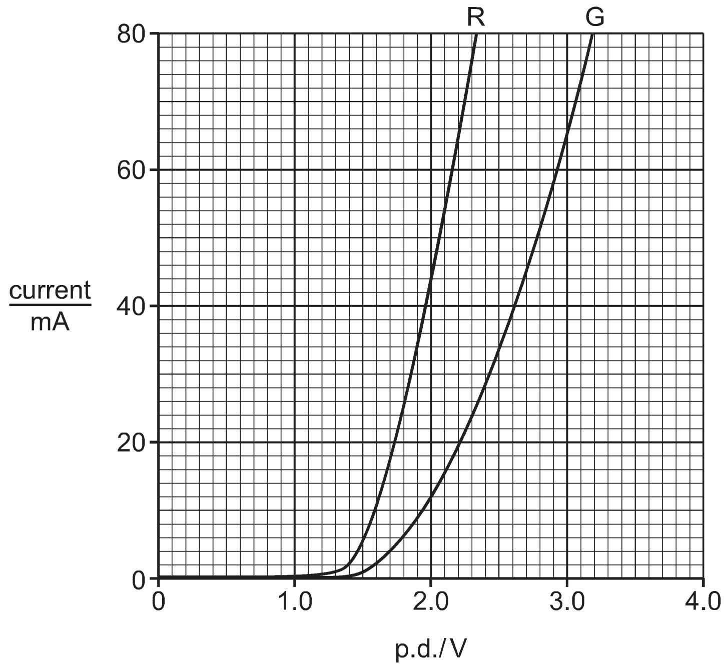


Fig. 6.3

Use Fig. 6.3 to determine the current in the ammeter.

current = ... [2]

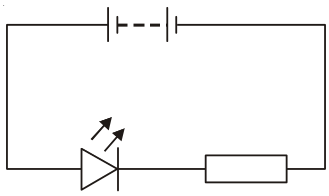
(ii) The connections to the power supply are reversed. State the reading on the ammeter.

current = ... [1]

SOLUTIONS

Topic - 20

1. (a)



(b) $R = \dfrac{V}{I}$

$= \dfrac{3.1}{0.030} = 100\ \Omega$

(c) (i) Voltage across heater $= 10.5 - 2.1$

$= 8.4$ V

$R = \dfrac{V}{I}$

$= \dfrac{8.4}{1.5} = 5.6\ \Omega$

(ii) $P = VI$

$= 8.4 \times 1.5 = 12.6$ W

2. (a) e.m.f is the electrical work done by a source (cell or battery) in moving a unit charge around a complete circuit.

(b) (i) $I = \dfrac{V}{R}$

$= \dfrac{240}{30} = 8$ A

(ii) $P = VI$

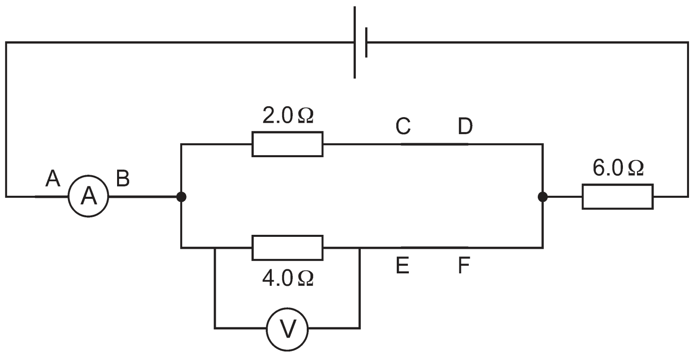
$= 240 \times 8$

$= 1920 \approx 1900$ W

(iii) 1. Since the voltage across R_1 and R_2 is same, and the resistance of R_2 is double than R_1, Therefore, the current would be half in R_1, as I and R are inversely proportional for a constant voltage.

2. Total current in the circuit is 8 + 4 + 0.10 = 12.1 A, so the fuse of rating 14 A will be suitable as it is slightly more than the maximum current in the circuit.

3. (a) (i) & (ii)



(iii) Voltage across 2.0 Ω resistor,

$V = IR$

$= 2.5 \times 2.0 = 5.0$ V

Current in 4.0 Ω resistor,

$I = \dfrac{V}{R}$

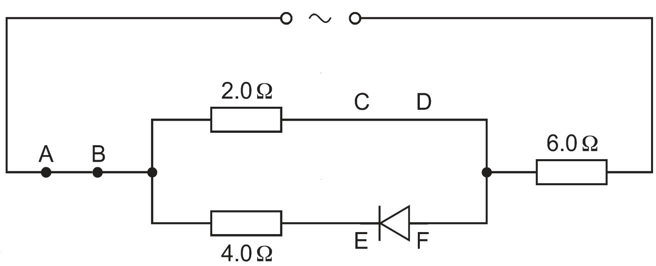
$= \dfrac{5.0}{4.0} = 1.25$ A

So, current in 6.0 Ω resistor

$= 2.5 + 1.25$

$= 3.75 \approx 3.8$ A

(b)



4. (i) $I = \dfrac{V}{R}$

$= \dfrac{3}{4} = 0.75$ A

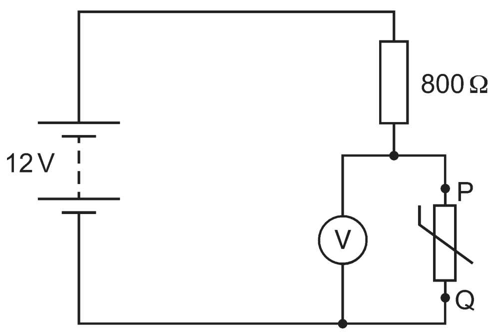
(ii) Reading = Zero volt

Explanation: Diode is placed in reverse direction so it does not pass current.

5. (a) When the switch in circuit A is closed, the coil with the iron core becomes an electromagnet. The electromagnet attracts the lower arm of the soft-iron armature, which causes the upper arm of the armature to move up pushing the contacts together. This completes circuit B, allowing current to flow and operate the motor.

(b) When the switch in circuit A is opened, the current in circuit B does not stop. This is because the steel armature remains magnetised, even when the current in the coil is turned off.

6. (a)



(b) e.m.f. of each cell $= \frac{12}{8} = 1.5$ V

(c) (i) Voltage across 800 Ω resistor,
$V = 12 - 8 = 4$ V

Using 800 Ω resistor, current in the circuit is, $I = \frac{V}{R}$

$= \frac{4}{800} = 0.0050$ A

Resistance of thermistor $= \frac{V}{I}$

$= \frac{8.0}{0.0050}$

$= 1600\ \Omega$

(ii) An increased voltage means a larger proportion of the e.m.f. is across the thermistor. This indicates that the temperature of the thermistor has decreased, causing its resistance to increase.

7. (a) Statement: The brightness of the bulb increases from low to high.

Explanation: As the temperature rises, the resistance of K decreases, so more current flows through the lamp. This also increases the voltage at point X across R, allowing a larger current through the lamp, making it glow brighter.

(b) Component K is thermistor.

8. (a) The rate of flow of electric charge is called electric current.

(b) Current in the 450 Ω resistor $= I_2 - I_1$

(c) Voltage across 450 Ω resistor $= IR$
$= 0.012 \times 450 = 5.4$ V

Voltage across 800 Ω resistor
$= 9.0 - 5.4 = 3.6$ V

Power dissipated in 800 Ω resistor is,

$P = \frac{V^2}{R}$

$= \frac{(3.6)^2}{800} = 1.6 \times 10^{-2}$ W

(d) As the brightness of the light on the LDR increases, its resistance decreases. This increases the current in the circuit and reduces the combined resistance of LDR and 450 Ω resistor, joined in parallel. As a result, the potential difference across the 450 Ω resistor decreases.

9. (i) $\frac{R_1 R_2}{R_1 + R_2} + R = 4.4$

$\Rightarrow \frac{2.0 \times 3.0}{2.0 + 3.0} + R = 4.4$

$\Rightarrow 1.2 + R = 4.4$

$\Rightarrow R = 4.4 - 1.2 \quad \Rightarrow \quad R = 3.2\ \Omega$

(ii) $V = IR$

$= 0.94 \times 4.4$

$= 4.136 \approx 4.1$ V

25. (i) It is the energy transferred at the rate of 1 kW in one hour.

(ii) 1. Energy $= P \times t$

$= 25\text{ W} \times 220\text{ h}$

$= 0.025\text{ kW} \times 220\text{ h}$

$= 5.5\text{ kWh}$

2. $P = VI$

$I = \dfrac{P}{V}$

$I = \dfrac{25}{230} \approx 0.11\text{ A}$

26. (i) Current in resistor B: 1.2 A

Explanation: Total resistance of two identical resistors in series is added and doubled. So for same potential difference the current is reduced to half.

(ii) $I = 2.4 + 1.2 + 2.4 = 6.0\text{ A}$

(iii) $R = \dfrac{V}{I}$

$R = \dfrac{5.0}{2.4}$

$= 2.08 \approx 2.1\ \Omega$

27. (a) Current $= 0.50$ A

(b) $V = IR$

$= 0.50 \times 6.0 = 3.0\text{ V}$

(c) emf $= V_{6\Omega} + V_{20\Omega}$

$12 = 3.0 + V_{20\Omega}$

$V_{20\Omega} = 12 - 3.0 = 9.0\text{ V}$

(d) For 20 Ω, $I_2 = \dfrac{9.0}{20} = 0.45\text{ A}$

$I_1 + I_2 = 0.50\text{ A}$

$I_1 = 0.50 - I_2$

$I_1 = 0.50 - 0.45$

$= 0.05\text{ A}$

Now, $R = \dfrac{V}{I_1}$

$= \dfrac{9.0}{0.05} = 180\ \Omega$

28. (a) p.d. across $R_1 = \dfrac{6.0}{2} = 3.0\text{ V}$

Resistance of $R_1 = \dfrac{V}{I}$

$= \dfrac{3.0}{0.080} = 37.5 \approx 38\ \Omega$

(b) (i) Combined resistance of R_1 and R_2

$= R_1 + R_2$

$= 37.5 + 37.5 = 75\ \Omega$

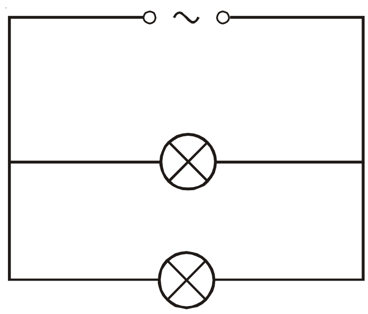
$R_{\text{total}} = \dfrac{75 \times 37.5}{75 + 37.5} = 25\ \Omega$

$\therefore$ Current, $I = \dfrac{V}{R}$

$= \dfrac{6.0}{25} = 0.24\text{ A}$

(ii) The potential difference across R_3 is larger than the potential difference across R_1. Therefore, more work is done in passing charge through R_3, resulting in a greater heating effect.

29. (a)



(b) (i) Current, $I = \dfrac{V}{R}$

$= \dfrac{230}{800} = 0.2875 \approx 0.29\text{ A}$

(ii) Energy, $E = VIt$

$= 230 \times 0.29 \times 5.0$

$= 333.5\text{ Wh}$

$= \dfrac{333.5}{1000} = 0.33\text{ kWh}$

(iii) Resistance, $R = \dfrac{800 \times 1200}{800 + 1200}$

$= \dfrac{960000}{2000} = 480\ \Omega$

30. (a) (i) Voltage across 400 Ω resistor is,

$V = 5.0 - 1.8 = 3.2$ V

Current, $I = \dfrac{V}{R}$

$= \dfrac{3.2}{400} = 0.0080$ A

(ii) Statement: Voltmeter reading increases

Explanation: When the light level decreases, the resistance of the LDR increases. The supply voltage is shared between the fixed resistor and the LDR. As the resistance of the LDR increases, a larger proportion of the supply voltage is across the LDR, so the p.d. across the LDR increases and the voltmeter reading rises.

(b) (i) From graph, at 2.0 V

Current through R = 44 mA

Current through G = 12 mA

$\therefore$ Current in the ammeter $= 44 + 12$

$= 56$ mA

(ii) Current = 0 A.

When the connections are reversed, both LEDs become reverse biased and do not conduct current. Therefore, no current flows in the circuit.

TOPIC 23

Electromagnetic Induction

Principles of Electromagnetic Induction, The A.C. Generator, The Transformer

1. ***[June 2020/P41/Q7]***

An electromagnet consists of a solenoid X that is made of copper wire. The solenoid contains an iron core.

(a) Explain why:

(i) the structure of copper makes it a suitable material for the wire

....

.... [2]

(ii) iron is a suitable material for the core of an electromagnet.

....

....

.... [2]

(b) Fig. 7.1 shows the electromagnet inside a second solenoid Y.

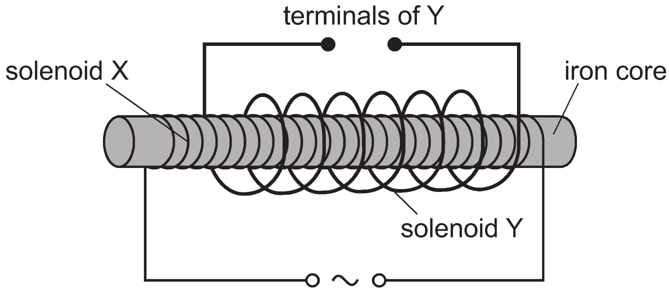


Fig. 7.1

(i) Describe and explain what happens in solenoid Y when solenoid X is connected to an alternating current (a.c.) power supply.

....

....

....

.... [3]

(ii) A switch and a lamp are connected in series with the terminals of solenoid Y. When the switch is closed, the lamp lights up at normal brightness.

Describe and explain what happens to the current in solenoid X when the switch is closed.

....

....

.... [2]

---

2. ***[June 2020/P42/Q7]***

(a) A student makes a transformer that uses an alternating current (a.c.) supply with an electromotive force (e.m.f.) of 12.0 V to induce an output potential difference (p.d.) of 2.0 V.

The student is provided with two lengths of insulated wire and the U-shaped piece of iron shown in Fig. 7.1.

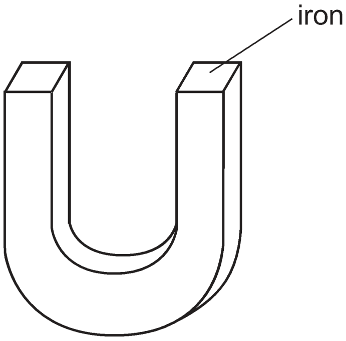


Fig. 7.1

(i) Complete and label Fig. 7.1 to show the transformer connected to the supply and the output from the transformer. [3]

(ii) Explain the function of the piece of iron in the transformer.

....

....

.... [2]

(iii) The output of the transformer is connected to a lamp. The current in the lamp is 100 mA. The transformer is 100% efficient.

Calculate the input current to the transformer.

current = ... [2]

(b) Another transformer is used in a school laboratory to step down a mains supply with a p.d. of 110 V to 12 V. This transformer is mounted in a metal case.

State and explain an essential safety feature required for this arrangement.

....

.... [2]

---

3. ***[Nov 2020/P43/Q9]***

(a) Electrical power is produced in a power station by an alternating current (a.c.) generator. The output of the generator has a voltage of 22 000 V. The electrical power is transmitted at a voltage of 400 000 V.

Explain why electrical power is transmitted at a voltage of 400 000 V and not 22 000 V.

....

....

....

....

....

.... [3]

(b) A computer contains a transformer.

The input voltage to the transformer is 240 V. The output voltage from the transformer is 20 V and the output current is 2.3 A.

The efficiency of the transformer is 90%.

Calculate the input current to the transformer.

current = ... [5]

15. ***[June 2025/P41/Q8]***

Fig. 8.1 shows a diagram of part of a simple a.c. generator.

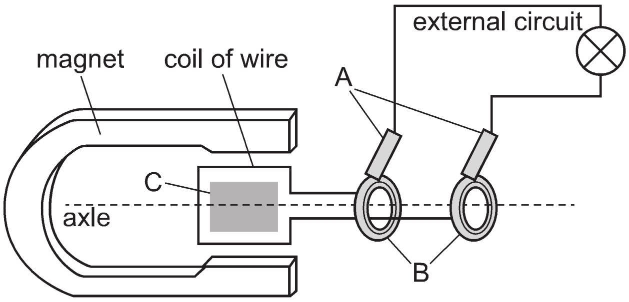


Fig. 8.1

(a) (i) Identify components A and B in Fig. 8.1.

A ....

B ....
[2]

(ii) Component C is made of soft iron.
Describe the effect of this component on the generator.

....

.... [1]

(b) The coil of the generator rotates at a constant speed of two complete revolutions per second.
Sketch a graph of the e.m.f. generated against time on the axes in Fig. 8.2. The coil is in the position shown in Fig. 8.1 at time = 0. [3]

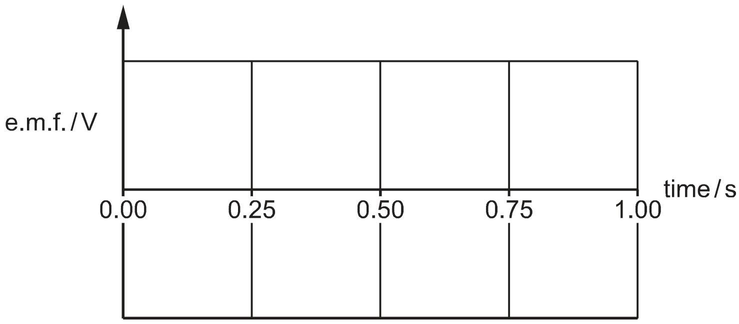


Fig. 8.2

(c) In power stations, transformers are used to step up the voltage of electricity generated before it is transmitted through cables over long distances.

(i) Explain the advantages of transmitting electricity at high voltages.

....

....

.... [2]

(ii) A power station generates electricity at 25 000 V. A transformer steps up the voltage to 300 000 V. The primary coil of the step-up transformer has 450 turns.

Calculate the number of turns N_s on the secondary coil of the transformer.

N_s = ... [2]

---

16. ***[June 2025/P42/Q8 a]***

Fig. 8.1 shows a simplified diagram of an a.c. generator.

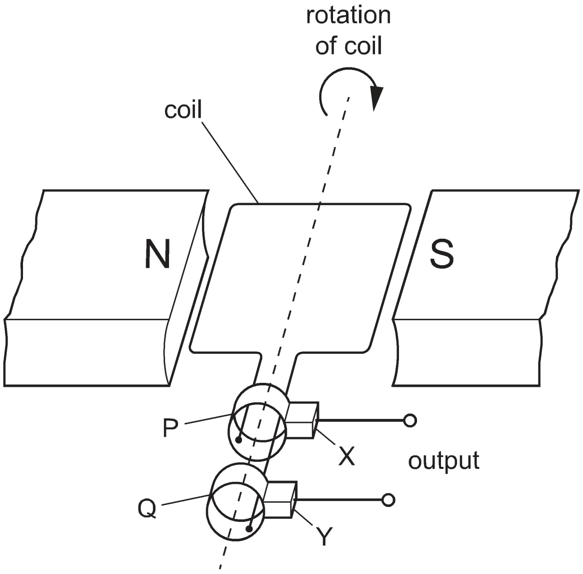


Fig. 8.1

(i) State the names of components:

P and Q. ....

X and Y. ....

[2]

(ii) Explain why an electromotive force (e.m.f.) is only induced when the coil is turning.

....

.... [1]

(iii) State **one** possible change that causes a larger e.m.f. to be induced.

.... [1]

17. ***[June 2025/P43/Q9]***

(a) Fig. 9.1 shows a transformer.

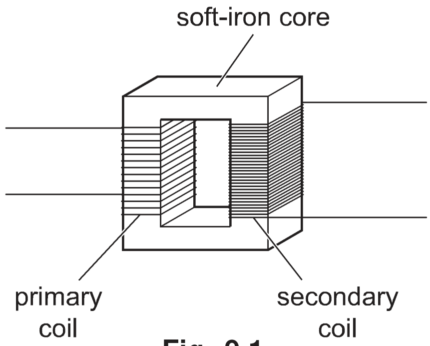


Fig. 9.1

(i) There is an alternating current in the primary coil. Describe how an alternating current is produced in the secondary coil.

....

....

....

....

....

.... [3]

(ii) A step-up transformer has a turns ratio of 1 : 20. The voltage across the primary coil is 12 V.

Calculate the voltage across the secondary coil.

voltage across secondary coil = ... [2]

(b) The power lost in a cable is 1.25×10^{-3} W. The resistance of the cable is 0.050 Ω.

Calculate the current in the cable.

current = ... [2]

(c) State **two** advantages of high-voltage transmission.

1 ....

....

2 ....

....

[2]

18. ***[Nov 2025/P42/Q8]***

(a) State what is meant by a magnetic field.

....

.... [1]

(b) Fig. 8.1 shows an ammeter connected to a coil wound on a thin plastic cylinder. A small trolley is placed on a curved track which passes through the cylinder.

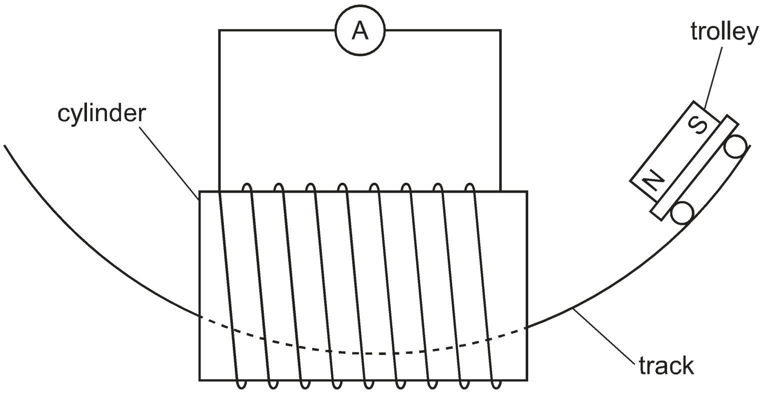


Fig. 8.1

The trolley is released from the position shown in Fig. 8.1. It travels through the coil from right to left. The trolley travels back from left to right. It has a lower maximum speed when it travels from left to right.

The plastic cylinder does not affect any magnetic field. A magnet is fixed to the trolley.

(i) State why there is a lower maximum speed when the trolley travels back from left to right.

....

.... [1]

(ii) Fig. 8.2 shows a close-up view of the ammeter.

As the trolley enters the coil moving from right to left, the ammeter needle deflects to the left and then returns to zero.

State and explain any changes to the deflection on the ammeter as the trolley enters the coil when moving back from left to right.

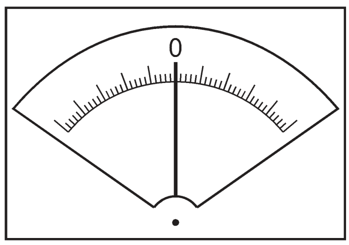


Fig. 8.2

....

....

....

....

.... [3]

19. ***[Nov 2025/P43/Q7]***

Fig. 7.1 shows a simple a.c. generator.

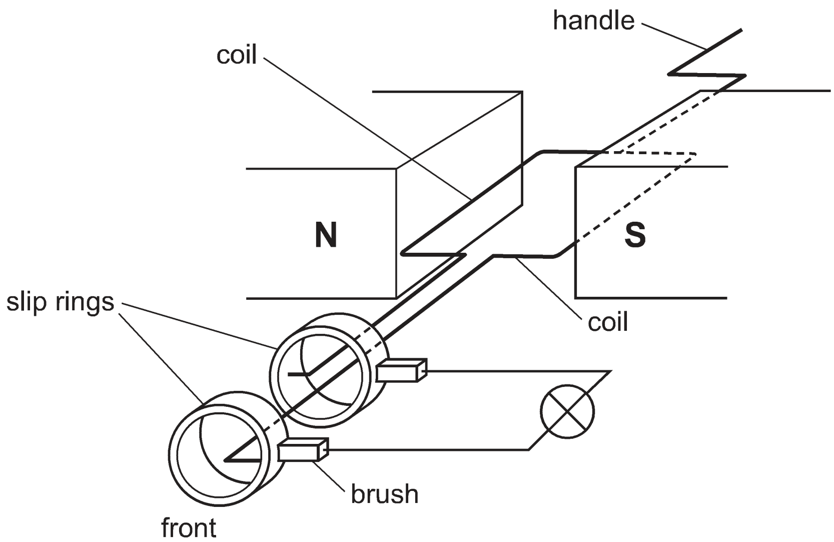


Fig. 7.1

(a) (i) Explain the function of the slip rings and brushes.

....

....

.... [1]

(ii) Describe how an alternating current is generated in the lamp.

....

....

....

....

....

.... [3]

(iii) State **two** possible changes that cause a larger maximum current in the lamp.

1 ....

2 ....

[2]

(b) Fig. 7.2 is a graph to show how the electromotive force (e.m.f.) varies with time for the coil.

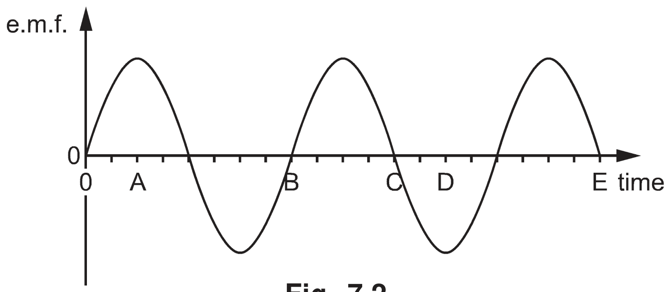


Fig. 7.2

(i) Determine how many revolutions the coil has made, from time = 0 to E.

number of revolutions = ... [1]

(ii) Fig. 7.3 shows the end view of the position of the plane of the coil at time = 0.
The coil is rotating anti-clockwise.

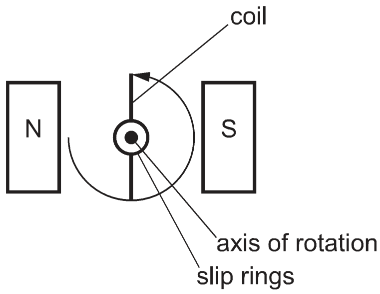


Fig. 7.3

On Fig. 7.4, draw **four** lines to match the coil position to the times A, B, C and D. The coil is viewed from the front.

Each coil position may be used once, more than once or not at all. [3]

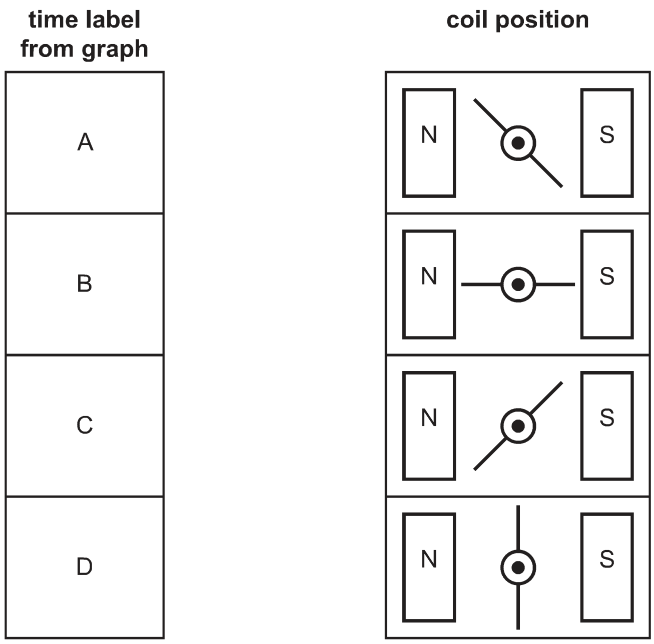


Fig. 7.4

SOLUTIONS

Topic - 23

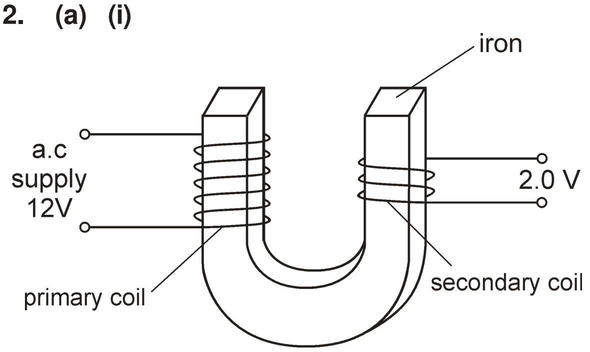
1. (a) (i) Copper contains large number of free electrons and therefore are good conductors of electricity.

(ii) Iron is a magnetically soft material. It is easily and strongly magnetised, and it can also be completely demagnetised.

(b) (i) The alternating current in solenoid X produces a changing magnetic field. This changing magnetic field produces induced e.m.f. in solenoid Y. Therefore, there is alternating voltage in terminals of Y.

(ii) Current in solenoid X increases in order to supply power used in the lamp.

2. (a) (i)



(ii) It links the magnetic field of the primary coil to the secondary coil. The iron is magnetically soft, so it produces a strong and easily changing magnetic field. This gives a stronger magnetic field in the secondary coil and so, better electromagnetic induction.

(iii) $V_1 I_1 = V_2 I_2$

$$I_1 = \frac{V_2 I_2}{V_1}$$

$$I_1 = \frac{2 \times 0.10}{12} = 0.017 \text{ A}$$

(b) Metal casing should be earthed. If the live wire touches it, a large current flows safely to earth. This causes fuse to blow, disconnecting the supply and protecting the user from electric shock.

3. (a) Electrical power is transmitted at 400000 V so that the current in the cable is much lower for the same power output. Since the heating of the wires (power loss) depends on the square of the current $(P = I^2 R)$, a lower current reduces energy lost as heat. This also allows thinner, cheaper cables to be used for transmission.

(b) Efficiency $= \dfrac{\text{power output}}{\text{power input}} \times 100$

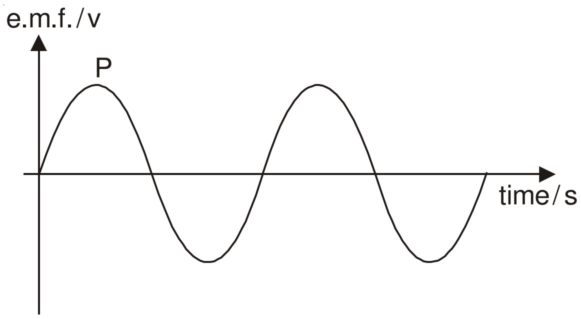
$$90 = \frac{V_{out}\, I_{out}}{V_{in}\, I_{in}} \times 100$$

$$90 = \frac{20 \times 2.3}{240 \times I_{in}} \times 100$$

$$I_{in} = \frac{20 \times 2.3}{240 \times 90} \times 100$$

$$I_{in} = 0.21 \text{ A}$$

4. (a) (i) & (ii)



(iii) 1. Maximum e.m.f. increases

2. e.m.f. changes direction more frequently.

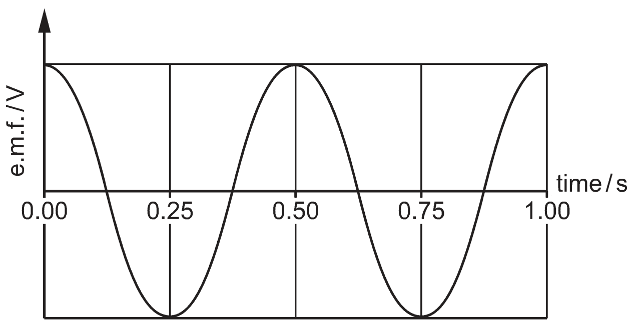
(ii) The transformer is not 100% efficient because some energy is lost as thermal energy to the phone or surroundings.

15. (a) (i) A: Carbon brushes

B: Slip rings

(ii) Iron concentrates the magnetic field and strengthens the magnetic field of the magnet in the generator.

(b)



(c) (i) For the same power transmission, if the voltage is high the current will be low (as $P = VI$). As a result there will be less power losses in the cables due to low current because, $P_{Loss} = I^2 R$. Also, with lower current, we can use thinner and cheaper cables.

(ii) $\frac{V_p}{V_s} = \frac{N_p}{N_s}$

$N_s = N_p \times \frac{V_s}{V_p}$

$= 450 \times \frac{300000}{25000}$

$= 5400$

16. (i) P and Q: Slip rings

X and Y: Carbon brushes

(ii) e.m.f. is only induced in a coil when the coil cuts the magnetic field lines or when there is a changing magnetic field linked with the coil.

(iii)
- Increase strength of magnetic field.
- Increase speed of rotation of coil
- Increase number of turns of coil.

17. (a) (i) The alternating current in the primary coil produces a changing magnetic field. The magnetic field in the primary coil is linked with the iron core, and the iron core transfers this magnetic field to the secondary coil. The secondary coil cuts through the changing magnetic field, which induces an e.m.f. in the secondary coil. Because the magnetic field keeps changing direction, the induced current in the secondary coil is also alternating

(ii) $\frac{V_p}{V_s} = \frac{N_p}{N_s}$

$\frac{12}{V_s} = \frac{1}{20}$

$V_s = 12 \times 20 \quad \Rightarrow \quad V_s = 240 \text{ V}$

(b) $P_{loss} = I^2 R$

$\Rightarrow \; 1.25 \times 10^{-3} = I^2 \times 0.050$

$\Rightarrow \; I^2 = \frac{1.25 \times 10^{-3}}{0.050}$

$\Rightarrow \; I = \sqrt{\frac{1.25 \times 10^{-3}}{0.050}} = 0.158 \approx 0.16 \text{ A}$

(c) *Any two from,*
- There are less power and energy losses due to reduced current.
- Thinner and cheaper cables can be used.
- Pylons can be placed further apart, so fewer pylons are needed.
- It allows electrical energy to be transferred over longer distances efficiently.

18. (a) A magnetic field is a region in which a magnetic pole experiences a force.

(b) (i) When the trolley travels back from left to right, the induced current produces a magnetic field that opposes the magnetic field responsible for producing the induced current. This reduces the speed of trolley.

(ii) When the trolley enters the coil from left to right, the ammeter needle still deflects to the left because the direction of the induced current does not change. The deflection is smaller because the rate of change of magnetic field is smaller. This smaller rate of change of magnetic field induces a smaller e.m.f. and current in the coil.

19. (a) (i) The slip rings and brushes provide a continuous electrical connection between the rotating coil and the external circuit, allowing current to flow while preventing the wires from becoming twisted and ensuring that the current reverses every half turn.

(ii) When the coil is rotated in the magnetic field, it cuts the magnetic field lines and an e.m.f. is induced in the coil. As the coil is part of a complete circuit, a current flows through the lamp. During rotation, the coil sides move in the opposite direction every half turn, so the induced current also reverses direction every half turn, producing an alternating current.

(iii) *Any two from*:

- Increase the strength of the magnetic field.
- Increase the speed of rotation of the coil.
- Increase the number of turns on the coil.

(b) (i) Number of revolutions = 2.5

(ii)