2000

nov

physics

complete yearly solutions

5053

2000 Nov Paper 1 5053/1

MCQs

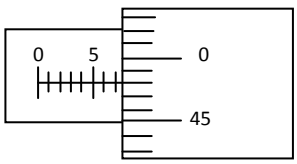
Answer all questions.

1. [Newtonian Mechanics]

Solution

Approach I – Instruments

The diagram shows the scale of a micrometer screw gauge when measuring the thickness of a book.



∴ Main scale shows 2 markings aft 5mm = 7mm.

Micro scale shows 3 markings aft 0.45mm = 0.48 mm.

∴ **Thickness of the book**

= 7 mm + 0.48 mm = 7.48 mm **(ans)**

☒ 5.25 mm ☒ 5.48 mm

☒ 7.02 mm ☑ 7.48 mm

(D) (ans)

☺ **CheckBack**

If the answer is 7.48 mm,

- **5.25 mm** – is *not* possible as the micrometer screw gauge is way beyond the 5 mm mark.
- **5.48 mm** – is *not* possible as the micrometer screw gauge is way beyond the 5 mm mark.
- **7.02 mm** – is *not* possible as the micrometer screw gauge is way beyond the 7.0 mm mark.

(checked)

☺ **Exam Report**

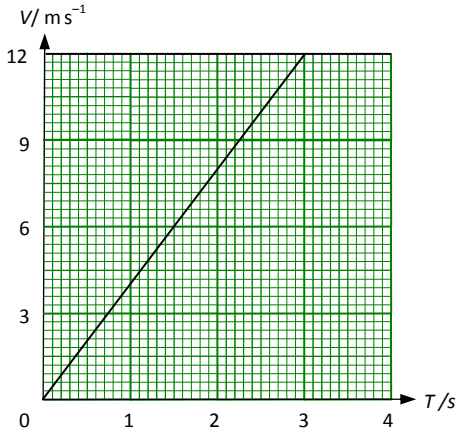
Most candidates gave the correct answer.

2. [Newtonian Mechanics]

Solution

Approach I – Graph

The speed against time graph of a car moved from rest is shown.



∴ **For the first 3 seconds,**

Distance travelled

= Area under speed-time graph

= 0.5 × 3 × 12 = 18 m

∴ **The average speed of car**

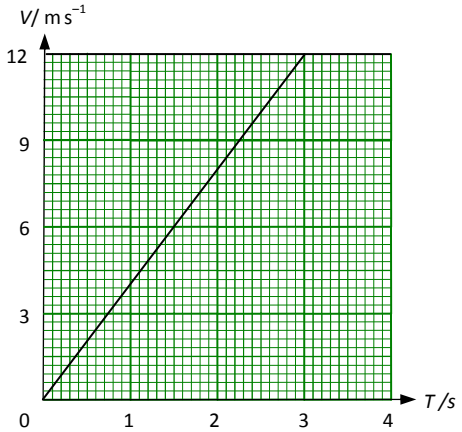
$= \frac{\text{Distance}}{\text{Time}}$

$= \frac{18}{3}$

= 6 m/s **(ans)**

Approach II – Average speed

The speed against time graph of a car moved from rest is shown.



∴ **For the first 3 seconds, the average speed of car**

$$= \frac{\text{Final Speed} - \text{Initial Speed}}{2} \text{ (linear)}$$

$$= \frac{12 - 0}{2}$$

= 6 m/s **(ans)**

☒ 4 m/s ☒ 18 m/s

☒ 36 m/s ☑ 6 m/s

(B) (ans)

☺ **CheckBack**

If the answer is 6 m/s,

- For 3 seconds, the car would have travelled
  = speed × time
  = 6 m/s × 3 s = 18 m (Area under graph)

(checked)

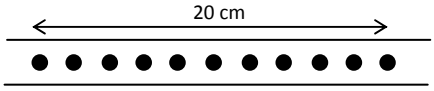
☺ **Exam Report**

Most candidates gave the correct answer.

3. [Newtonian Mechanics]

Solution

The paper strip shown below has been pulled with constant speed under a vibrating machine that makes 50 dots per second at a regular pace.



∴ Per second → 50 dot–interval

Hence, for a 10 dot–interval of 20 cm, it will take $\frac{1}{5}$ s.

Distance travelled per second = 20 × 5 cm = 100cm

Speed the paper was being pulled = 100 cm/s **(ans)**

∴ The speed at which the paper is being pulled:

☒ 2.0 cm/s ☒ 5.0 cm/s

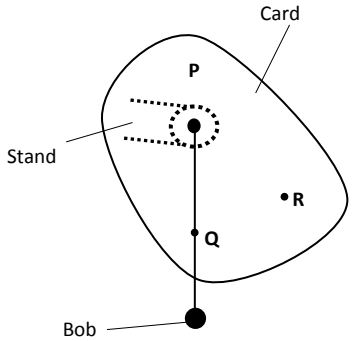
☒ 200 cm/s ☑ 100 cm/s

(C) (ans)

4. [Newtonian Mechanics]

Solution

The aim of the experiment below is to find the position of the center of mass of a thin card. The first step is as shown.



∴ The second step of the experiment is to hang the card from point **R** and mark its vertical line of point **R** at rest.

☒ Find the midpoint of **PQ**.

☒ Measure the mass of the card.

☒ Measure the thickness of the card.

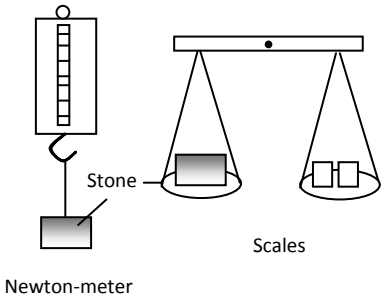
☑ Hang the card from point **R**.

(B) (ans)

5. [Newtonian Mechanics]

Solution

The weight of a mass is measured using two methods, a Newton-meter and a pair of scales.



∴ If this experiment is repeated on the Moon, **the reading on the Newton-meter** will be <u>different</u> as the reading on the Newton-meter is dependent on the gravitational force acting on it. Gravity is different on the Moon and on the Earth.

The reading on the scales will be the same as the reading on the scales is dependent on the relative comparison of masses. Gravity acting on both the stone and comparison masses remains constant.

∴ The readings on each balance when taken on Earth and on the Moon:

	On Newton-meter	On Scales
☒	different ☑	different
☒	same	different
☒	same	same ☑
☑	different ☑	same ☑

(B) (ans)

6. [Newtonian Mechanics]

Solution

∴ For an object moving across a horizontal surface, it found that **the direction of the frictional force** always act against the direction of the motion. **(ans)**

☒ In the direction of the gravitational force

☒ Opposite to the direction of the gravitational force

☒ In the direction of motion

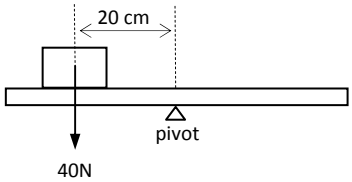
☑ Opposite to the direction of motion

(D) (ans)

7. [Newtonian Mechanics]

Solution

A uniform beam is pivoted at its midpoint. A load of 40N is placed on the beam.



∴ To balance the anticlockwise moment due to the 40N, balancing force should give an equivalent clockwise moment about its pivot, *i.e.*, either downwards acting on the right of the pivot, or upwards acting on the left of the pivot.

Taking moments (clockwise +ve, M_c) about its pivot:

$M_c - (40 \times 0.20) = 0$ — ❶

Only by applying a clockwise moment, $M_c = +8.0$Nm about its pivot can balance the above equation ❶.

∴ The force and placement that will balance the uniform beam are:

☒ 20 N upwards, 40 cm to the right of the midpoint, *i.e.*, $M_c = -8.0$Nm.

☒ 50 N downwards, 10 cm to the right of the midpoint, *i.e.*, $M_c = +5.0$Nm.

☒ 50 N upwards, 10 cm to the left of the midpoint, *i.e.*, $M_c = +5.0$Nm.

☑ 20 N downwards, 40 cm to the right of the midpoint, *i.e.*, $M_c = +8.0$Nm.

(A) (ans)

8. [Newtonian Mechanics]

Solution

A physical scalar quantity has magnitude and does not require its direction of application be known, while a physical vector quantity requires both its magnitude and direction of application be known.

∴ Example of a scalar quantity is energy (heat).

Examples of vector quantities are force or thrust and directed effort.

∴ The option that is not a vector quantity:

☒ braking force to stop a car

☒ effort to hammer a nail

☒ thrust to lift a rocket off the ground

☑ heat to boil water

(C) (ans)

9. [Newtonian Mechanics]

Solution

A lamp has a power output of 6 W.

∴ **Amount of energy the lamp produces in 2 minutes**

$= \text{Power} \times \text{Time}$

$= 6 \times 2 \times 60$

$= 720$ J **(ans)**

☒ 3 J ☒ 12 J

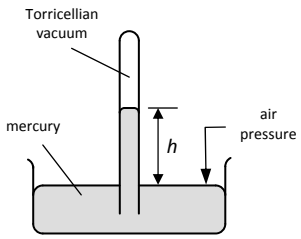
☒ 120 J ☑ 720 J

(D) (ans)

10. [Newtonian Mechanics]

Solution

A barometer was brought from the 1st to the 20th storey of a building. The reading on the barometer decreases.



∴ The barometer registers a reading because the air surrounding the barometer exerts a downward pressure on its external reservoir. At higher height, the amount of air surrounding the barometer is less, hence, exerts a lower downward pressure. The reading of the barometer will fall.

∴ **Explanation for the decrease in barometer reading:**

☒ Air pressure increased.

☒ Gravity decreased.

☒ Temperature increased.

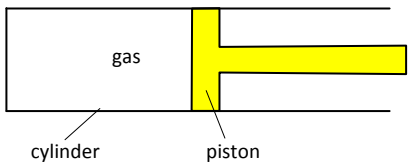
☑ There is less air above the barometer.

(D) (ans)

11. [Newtonian Mechanics]

Solution

A cylinder with a piston is filled with gas. The cylinder is then heated while the piston is held fixed, the pressure of the gas is found to increase.



∴ Upon heating, the fixed number of fixed-sized molecules inside the cylinder absorbs energy, thus, kinetic energy increases. With the higher energies, the gas molecules will move faster and come into contact and collide with the cylinder walls more often. Pressure of the cylinder is just a macro-measure of the number of times these gas molecules collide with the walls.

∴ **Explanation:**

☒ Gas molecules expand.

☒ Molecules move at same speed, but hit the walls more often.

☒ Number of molecules of gas increases.

☑ Molecules move faster and hit the walls more often.

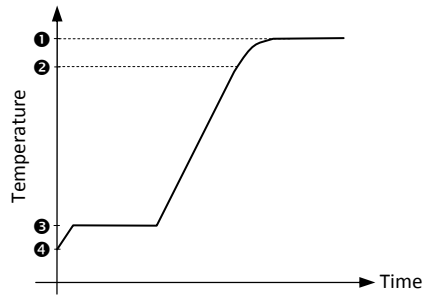
(C) (ans)

12. [Newtonian Mechanics]

Solution

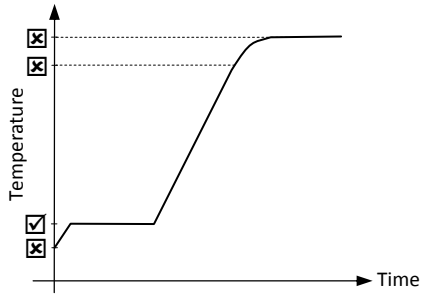
Some ice cubes are taken from a freezer and placed in a metal container which is heated at a steady rate, while temperature/time readings are taken.

These readings are presented as a graph as shown.



∴ When heat is absorbed, the temperature of the ice cubes raises from sub-zero °C. Then, melting first occurs at 0°C. During melting, temperature remains constant, the heat absorbed are used for phase change from solid to liquid.

∴ **The temperature that corresponds to 0°C:**



(C) (ans)

13. [Thermal Physics]

Solution

The factors affecting sensitivity of a liquid-in-glass thermometer are the volume of liquid used and the diameter of the bore of the thermometer.

∴ High sensitivity is defined as a small change in temperature will cause a large increase in the reading.

Increase in volume of liquid increases the change in volume per unit temperature.

Decreasing the bore of the thermometer causes a larger rise in liquid for the same rise in temperature.

∴ **The changes that produce a thermometer of greatest sensitivity:**

	Volume of liquid	Bore diameter
☒	decrease	decrease ☑
☒	decrease	increase
☒	increase ☑	increase
☑	increase ☑	decrease ☑

(C) (ans)

14. [Thermal Physics]

Solution

∴ *Convection* is the transfer of heat through currents which make use of the changes in the density of gas when heated. As gas is heated up, volume increases significantly, causing the density of the gas to decrease. As a result, heated gas rises above the colder, denser gas, resulting in convection currents.

Conduction is the transfer of heat that takes place in all forms of matter, viz. solids, liquids, gases and plasmas, but does not require any bulk motion of matter. In solids, it is due to the combination of vibrations of the molecules in a lattice and the energy transport by free electrons. In gases and liquids, conduction is due to the collisions and diffusion of the molecules during their random motion.

Radiation is the transfer of heat between an object and its environment or another object via electromagnetic waves. No medium is required for heat transfer by radiation and the heat transfer can be done through vacuum.

∴ **The method(s) of thermal energy transfer due to density changes:**

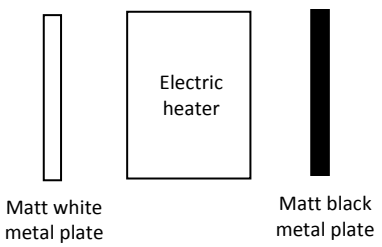
☒ conduction only
☒ radiation only
☒ conduction, convection and radiation
☑ convection only

(B) (ans)

15. [Thermal Physics]

Solution

Two identical metal plates are painted different colours, one black and one white. They are equidistant away from an electric heater, which transmits heat through radiation. The heater is switched on for a short time interval.



∴ When radiant light hits the white metal plate, it is re-emitted almost immediately. The black metal plate holds on to the energy for a longer period of time. As a result, it is able to absorb more and enough energy to emit a photon of light and thus, also emits more energy than the white metal plate.

∴ The metal plate that absorbs more energy and the metal plate that emits more energy in this time interval:

	Absorbs more	Emits more
☒	black ☑	white
☒	white	black ☑
☒	white	white
☑	black ☑	black ☑

(A) (ans)

16. [Waves]

Solution

A ray of light passes from glass into air.

∴ Deduce from the velocity definition,

velocity = frequency × wavelength

From glass to air, velocity increases as it travels from a denser material to a material that is less dense.

Since frequency is a characteristics of the wave and is invariant, while velocity increases, wavelength must therefore increase.

∴ The corresponding changes in frequency and wavelength of this ray of light:

☒ frequency decreases because speed decreases
☒ frequency increases because speed increases
☒ wavelength decreases because speed decreases
☑ wavelength increases because speed increases

(D) (ans)

17. [Waves]

Solution

The electromagnetic spectrum includes X-rays, visible light and radio waves.

∴ The frequency of X-rays is the highest, followed by visible light and then, radio waves.

Deduce from the velocity definition,

velocity = frequency × wavelength

Since the velocity of electromagnetic waves is constant in space, it can be deduced that the wavelength of X-Rays is the shortest, followed by visible light and then, radio waves.

∴ The order of the electromagnetic waves in increasing wavelength:

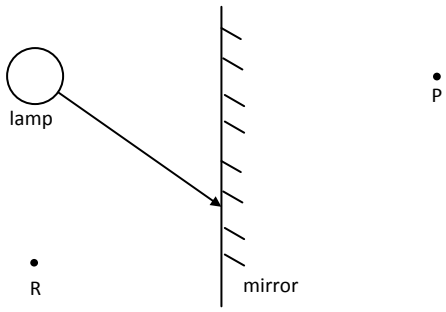
	Shortest → Longest		
☒	Radio waves	X-rays	Visible light
☒	Radio waves	Visible light ☑	X-rays
☒	X-rays ☑	Radio waves	Visible light
☑	X-rays ☑	Visible light ☑	Radio waves ☑

(D) (ans)

18. [Waves]

Solution

A ray of light from the lamp strikes the mirror as shown in the diagram.



∴ Deduce that mirror images are always

- Virtual, and
- The same distance away from the mirror in the opposite direction.

Thus image is at P.

∴ The image of the lamp formed by the mirror is:

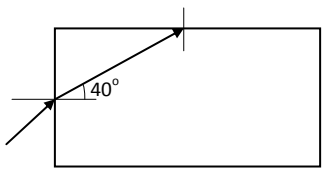
☒ real and at P.
☒ real and at R.
☒ virtual and at R.
☑ virtual and at P.

(B) (ans)

19. [Waves]

Solution

A ray of light falls on a glass block. It is incident on one side of the rectangular glass block and the angle is shown in the diagram below.



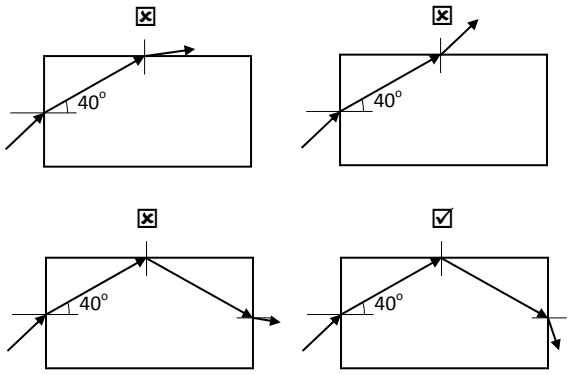
∴ From observation and measurement, the angle of refraction in the glass is found to be 40°. The critical angle for the glass is 42°.

The ray of light from the first refraction hits the top surface of the glass at an incidence of 50° which is more

than the critical angle of the glass 42°, thus it is totally internally reflected back into the glass. The ray of light from the internal reflection hits the right hand side of the glass surface at 40° which is lesser than the critical angle of glass.

The ray of light is not being reflected. The ray of light emerges from the glass at the same angle as when it enters.

∴ The correct and complete ray diagram is:



(C) (ans)

20. [Waves]

Solution

Sound travels through the vibration of the molecules, passing on the sound energy through a medium.

∴ Sound travels fastest in solids since the molecules are close to one another and thus, pass on the energy very fast. Liquid molecules are less close together but are nearer than gas molecules, thus, gas molecules pass on sound energy the slowest.

∴ **The correct order for the speed of sound in air, steel and water:**

	Slowest → Fastest		
☒	Air ☑	Steel	Water
☒	Water	Air	Steel ☑
☒	Water	Steel	Air
☑	Air ☑	Water ☑	Steel ☑

(B) (ans)

21. [Waves]

Solution

A sound transmitter and its echo are used to determine the length of a room.

A time interval of 0.060s is measured between transmitting a sound pulse from one end of the room and receiving the echo.

The speed of sound in air is 330 m/s.

∴ Distance = Time × speed

= 0.060 × 330 = 19.8 m

Distance travelled = 2 × length of the room.

∴ **Length of the room**

$= \frac{19.8}{2}$

= 9.9 m **(ans)**

☒ 5.5 m ☒ 11 m ☒ 20 m ☑ 9.9 m

(B) (ans)

22. [Electricity & Magnetism]

Solution

Only magnets will cause the compass needle to move because the compass is made of a magnet which helps identify north and south poles. Since only magnets have north and south poles, a magnetic material will be able to change the direction of a compass needle.

∴ If we were to ask a question, what question should that be to enable us to differentiate between a magnetic material and a non-magnetic material:

☒ Is it a metal or non-metal?

☒ Is it a conductor or an insulator?

☒ Can it be given an electric charge?

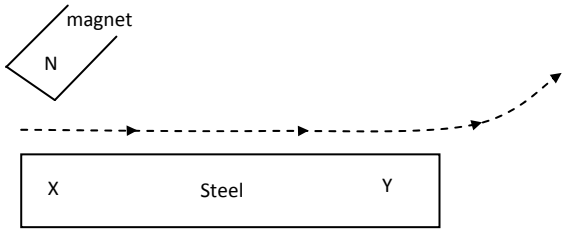
☑ Does it affect the direction in which a compass needle point?

(D) (ans)

23. [Electricity & Magnetism]

Solution

The diagram shows how a steel bar can be magnetized by stroking it with a magnet. The magnet follows the motion of the dotted line shown below.



∴ As the north pole of the magnet moves from X to Y, it attracts all the south poles (in the steel) which point towards Y, forming a south pole at Y. This leaves the north poles pointing to X.

As such, the pole formed at Y is South and the pole formed at X is North.

∴ The poles that are formed at X and Y:

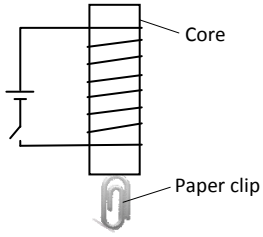
	X	Y
☒	North ☑	North
☒	South	North
☒	South	South ☑
☑	North ☑	South ☑

(B) (ans)

24. [Electricity & Magnetism]

Solution

Four different substances are used separately as the core of an electromagnet to find out which one would be the most suitable as the core of a transformer.



The number of paper clips held is recorded when the current is on and when the current is switched off.

∴ The substance most suitable as the core of a transformer will have the greatest difference in number of paper clips held with and without current (6 in this case). This means that the substance was magnetized to the greatest extent and would be most suitable as a core of a transformer to concentrate the magnetic flux.

	Number of paper clips held with current	Number of paper clips held without current
☒	8	4
☒	5	1
☒	4	0 ☑
☑	6 ☑	0 ☑

(B) (ans)

25. [Electricity & Magnetism]

Solution

An electrostatically charged object will be able to pick up small pieces of paper.

∴ It implies that **object that is not able to pick up small pieces of paper** is when it is not electrostatically charged.

☒ a plastic comb pulled through dry hair, can be electrostatically charged

☒ a polythene rod rubbed with woollen cloth, can be electrostatically charged

☒ a rubber balloon rubbed on a nylon shirt, can be electrostatically charged.

☑ an earthed metal rod rubbed with a duster, cannot be electrostatically charged.

(A) (ans)

26. [Electricity & Magnetism]

Solution

Birds escape unharmed even when standing on an overhead transmission line.

∴ If there is no potential difference between the feet of the bird, it will be impossible for any current to pass through to the bird through its feet. Thus, the bird does not get electrocuted.

∴ Suitable explanation:

☒ Their bodies have high resistance.

☒ Their feet are good insulators.

☒ The spaces between their feathers act as insulators.

☑ There is no potential difference between their feet.

(C) (ans)

27. [Electricity & Magnetism]

Solution

The terminals of a battery are linked together by a length of wire with resistance.

∴ **The change that will increase the current through the battery independently** is by reducing the total resistance of the connecting wire:

- connecting an identical wire in series with the first one, *will increase the total resistance of the connecting wire.*
- covering the wire with plastic insulation, *will increase the temperature of the wire gradually through internal heat accumulation, thus increases the total resistance of the connecting wire.*

$$\text{Resistance} = \frac{\text{Resistivity} \times \text{Length}}{\text{Area}}$$

- using a thinner wire of same material and length, *implies that the cross-sectional area of the wire is reduced, thus implying increase in the total resistance of the connecting wire.*
- using a shorter wire of same material and thickness, *implies that the length of the wire is reduced, thus implying decrease in the total resistance of the connecting wire.*

☒ connecting an identical wire in series with the first one

☒ covering the wire with plastic insulation

☒ using a thinner wire of same material and length

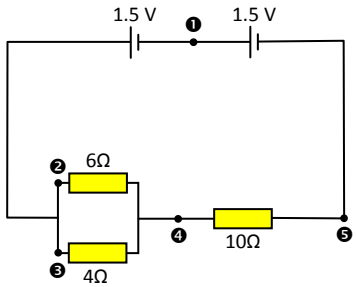
☑ using a shorter wire of same material and thickness

(C) (ans)

28. [Electricity & Magnetism]

Solution

A circuit is set up as below.



$$\therefore \text{ Effective resistance} = 10 + \frac{1}{\frac{1}{6}+\frac{1}{4}} = 12.4\ \Omega$$

$$\text{At ❶, current} = \frac{\text{Voltage}}{\text{Resistance}} = \frac{3}{12.4} = 0.24\ \text{A}$$

At ❹, current is same as at A = 0.24 A

Between ❹ and ❺, potential diff = $10 \times 0.24 = 2.4$ V

Between ❷/❸ and ❹, potential diff = $3 - 2.4 = 0.6$ V

$$\text{At ❷, current} = \frac{0.6}{6} = 0.1\ \text{A}$$

$$\text{At ❸, current} = \frac{0.6}{4} = 0.15\ \text{A}$$

∴ The point at which current is the smallest:

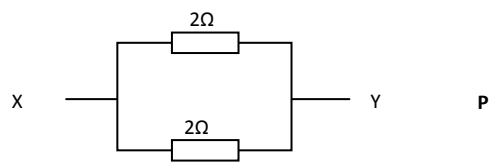
☒ ❶ ☑ ❷ ☒ ❸ ☒ ❹

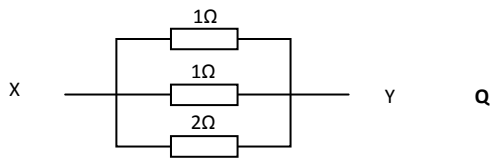
(B) (ans)

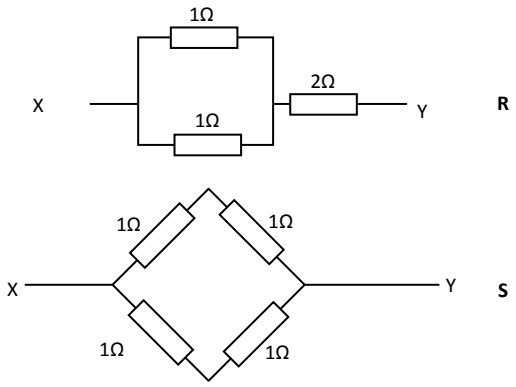
29. [Electricity & Magnetism]

Solution

Four different combinations of circuits were set up as follows:







P: $\frac{1}{\frac{1}{2}+\frac{1}{2}} = 1\ \Omega$

Q: $\frac{1}{\frac{1}{1}+\frac{1}{1}+\frac{1}{2}} = \frac{2}{5}\ \Omega$

R: $\frac{1}{\frac{1}{1}+\frac{1}{1}} + 2 = \frac{5}{2}\ \Omega$

S: $\frac{1}{\frac{1}{2}+\frac{1}{2}} = 1\ \Omega$

∴ **The two set-ups that have the same effective resistance between X and Y:**

☒ P and Q ☒ Q and R

☒ R and S ☑ P and S

(B) (ans)

30. [Electricity & Magnetism]

Solution

In mains powered equipment, the earth connection allows exposed metal parts to be connected to ground to prevent human contact with a dangerous voltage if electrical insulation fails.

∴ **The earth wire of an electric appliance should be connected to the:**

☒ Fuse

☒ On/Off switch

☒ Plastic handle

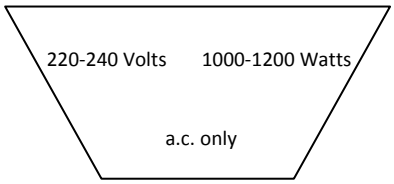
☑ Metal case

(B) (ans)

31. [Electricity & Magnetism]

Solution

The diagram represents what was found at the back of an electric iron.



Electricity costs 14 cents per unit. The iron is used at maximum power for 10 hours.

∴ Maximum power is 1200 W.

1200W = 1.2 kW

The unit of electricity is kWh.

Amount of electricity used = $1.2 \times 10 = 12$ kWh

Cost = $12 \times 14 = 168$ cents. **(ans)**

The cost to use the iron at maximum power for 10 hours:

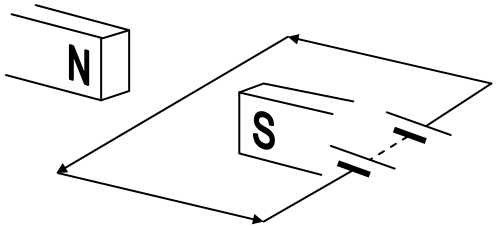
☒ 34 c ☒ 140 c ☒ 440 c ☑ 168 c

(C) (ans)

32. [Electricity & Magnetism]

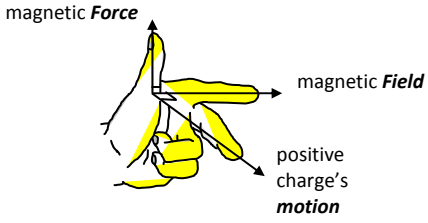
Solution

A current carrying wire is placed between a north and a south pole.



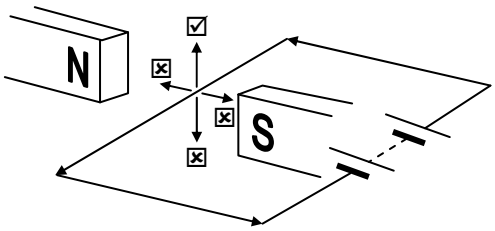
∴ Magnetic field goes from north to south pole. The current flowing in the wire is from higher to lower potential.

Applying Fleming's left hand rule,



The force acting on the wire will be upwards.

∴ The direction of the force on wire:

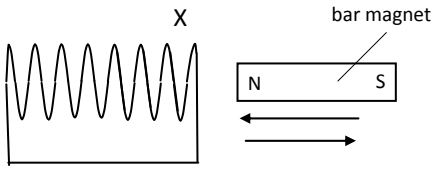


(A) (ans)

33. [Electricity & Magnetism]

Solution

The diagram shows a magnet moving in and out of a coil of wire.



By Lenz's Law, the direction of the induced current that flows in the coil is such that its magnetic effect opposes the change producing it.

Thus, if the North pole of the bar magnet is moving towards the coil, a North pole will be induced at X to oppose the change. The two like poles (North) repel, and thus, the magnetic effect of the coil opposes the oncoming bar magnet.

Likewise, when the North pole of the bar magnet leaves the coil, a South pole will be induced at X to oppose the change. The two unlike poles attract, and thus, the magnetic effect of the coil opposes the outgoing bar magnet.

∴ The poles produced in the coil at X by the movement of the magnet:

	North pole in	North pole out
☒	N ☑	N
☒	S	N
☒	S	S ☑
☑	N ☑	S ☑

(B) (ans)

34. [Electricity & Magnetism]

Solution

Electrical energy is transmitted at high alternating voltages.

However, alternating current is not safer than direct current.

∴ Invalid reason for transmitting electrical energy at high alternating voltages:

☒ For a given power, there is a lower current with a higher voltage.

☒ There is a smaller energy loss at higher voltage and lower current.

☒ The transmission lines can be thinner with a lower current.

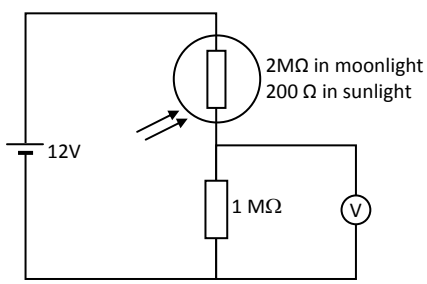
☑ At high voltage, a.c. is safer than d.c.

(A) (ans)

35. [Electricity & Magnetism]

Solution

Changes in light levels can be detected using a circuit with a light dependent resistor. Cells which add up to 12 V are attached to the circuit.



∴ In moonlight,

Effective resistance of circuit = 1 + 2 = 3 MΩ

Voltage across fixed resistor = $\frac{12}{3} \times 1 = 4\text{V}$

In sunlight,

Effective resistance of circuit = 1 + 0.000200
= 1.000200 MΩ

Voltage across fixed resistor = $\frac{12}{1.000200} \times 1 \approx 12\text{V}$

∴ **The approximate voltmeter readings in moon light and in sunlight:**

	Reading in moonlight / V	Reading in sunlight / V
☒	4 ☑	0
☒	8	0
☒	8	4
☑	4 ☑	12 ☑

(B) (ans)

36. [Nuclear Physics]

Solution

It is harmful to be exposed to continuous ionizing radiation.

∴ **The action that will increase a person's exposure to radioactivity the most:**

☒ eating food that has been sterilized by exposure to gamma rays, *is not harmful as gamma rays don't linger after exposure.*

☒ opening the windows of a house, *is not harmful as our cloud cover protects us from most harmful radiation.*

☒ using a Geiger-Muller tube and counter, *is not harmful as the instrument is non-radioactive.*

☑ going for a flight in a high-flying aircraft, *is the most harmful among the choices as high-flying aircraft normally flies above the cloud cover and comes into direct exposure to the sun's strong ionizing radiation.*

(B) (ans)

37. [Nuclear Physics]

Solution

∴ Nuclear fission occurs when nucleus of a massive atom splits into smaller parts, often producing free neutrons and lighter nuclei.

∴ **An example of a nuclear fission reaction:**

☒ 2 heavy hydrogen nuclei becoming helium, ${}^{2}_{1}\mathrm{H} + {}^{2}_{1}\mathrm{H} \rightarrow {}^{4}_{2}\mathrm{He}$

☒ Nitrogen-14 and a neutron becoming Nitrogen-15, ${}^{14}_{7}\mathrm{N} + \text{neutron} \rightarrow {}^{15}_{7}\mathrm{N}$

☒ Plutonium-241 decaying to Uranium-237 and an alpha-particle, ${}^{241}_{94}\mathrm{Pu} \rightarrow {}^{237}_{92}\mathrm{U} + \alpha - \text{particle}$

☑ Uranium-239 decaying to form Strontium-95 and Xenon-141 and 3 neutrons, ${}^{239}_{92}\mathrm{U} \rightarrow {}^{95}_{38}\mathrm{Sr} + {}^{141}_{54}\mathrm{Xe} + 3\,\text{neutrons}$

(D) (ans)

38. [Nuclear Physics]

Solution

The table shows the activity of a substance as it changes over a given time interval. The readings below have taken into consideration background radiation.

Time/ minutes	Activity / counts per second
0	114
5	102
10	90
15	83
20	73
25	65
30	57
35	51
40	45

∴ Since half-life is the time taken for a radioactive substance to half its number of particles and number of particles is proportional to the activity of a substance, time taken to half the activity of the substance is also its half life.

Original activity is 114 at time, t = 0 minutes. At t = 30 minutes, the activity first reaches 57 (114 divided by two).

∴ **The half-life, $T_{1/2}$ of the substance:**

☒ 73 min ☒ 57 min ☒ 20 min ☑ 30 min

(C) (ans)

39. [Newtonian Physics]

Solution

Energy = Power × time

∴ **The unit of energy** = unit of power × time.

Unit of power × time = Watt second, which can also be used a unit of energy.

∴ The alternative unit of energy is:

☒ Newton per metre

☒ Volt ampere

☒ Volt per coloumb

☑ Watt second

(D) (ans)

40. [Electricity & Magnetism]

Solution

A load of 60 N is moved through a height of 2m in 4 seconds by a 12 V electric motor. The motor is assumed to operate at full efficiency.

∴ Work done = power × time

= volt × current × time

$$\text{Average current} = \frac{\text{Work Done}}{\text{Volt} \times \text{Time}}$$

$$= \frac{\text{Force} \times \text{Distance}}{\text{Volt} \times \text{Time}} = \frac{60 \times 2}{12 \times 4}\ \text{A}$$ **(ans)**

∴ The average current running through the motor:

☒ $\frac{4}{60 \times 2 \times 12}$ A ☒ $\frac{12 \times 4}{60 \times 2}$ A

☒ $\frac{60 \times 2 \times 4}{12}$ A ☑ $\frac{60 \times 2}{12 \times 4}$ A

(C) (ans)

[2000 Nov Paper 1 MCQ Key]

Q.	Key	Q.	Key	Q.	Key	Q.	Key
1.	D	11.	C	21.	B	31.	C
2.	B	12.	C	22.	D	32.	A
3.	C	13.	C	23.	B	33.	B
4.	B	14.	B	24.	B	34.	A
5.	B	15.	A	25.	A	35.	B
6.	D	16.	D	26.	C	36.	B
7.	A	17.	D	27.	C	37.	D
8.	C	18.	B	28.	B	38.	C
9.	D	19.	C	29.	B	39.	D
10.	D	20.	B	30.	B	40.	C

In summary:

A – 5 **B** – 15 **C** – 11 **D** – 9

2000 Nov Paper 2 5053/2

Questions

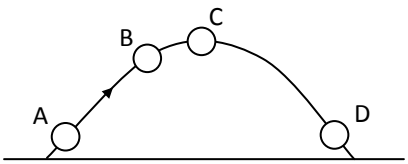
Section A

Answer all questions.

1. [Newtonian Mechanics]

Solution

The figure shows a ball thrown from **A** travelling through a parabolic path.



(a)

(i) ∴ **The point at which the ball travels the slowest** is C. **(ans)**

(ii) Based on ideas about the kinetic energy and the potential energy of the ball,

∴ The choice in (a)(i) is chosen because throughout the path of the ball, ignoring air resistance, energy is conserved. Total energy remains constant.

total energy = potential energy + kinetic energy

Thus, to find where the ball is slowest, kinetic energy would be a minimum if potential energy is at its maximum.

Potential energy of an object of mass m kg and at height h m = mgh, where g is the acceleration due to gravity.

Thus, potential energy is maximum at the highest point in the curve (point C) and hence, implies kinetic energy is at its minimum. The ball thus moves slowest at point C. **(ans)** [3]

(b) The mass of the ball is 0.20kg. At point A, the ball has kinetic energy 2.5 J. Taking the gravitational force on mass of 1.0kg to be 10 N,

(i) ∴ **The weight of the ball**

= mass × acceleration due to gravity

= 0.20 × 10

= 2.0 N (2sf) **(ans)**

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

$2.5 = \frac{1}{2} \times 0.20 \times v^2$

∴ Speed of the ball at point A,

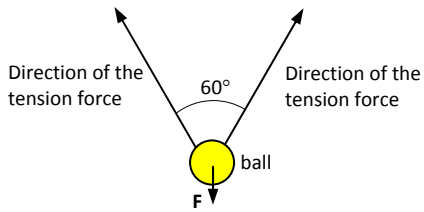
$v = \sqrt{\frac{2.5 \times 2}{0.20}}$

$= 5.0\,\text{m s}^{-1}$ (2sf) **(ans)** [4]

2. [Newtonian Mechanics]

Solution

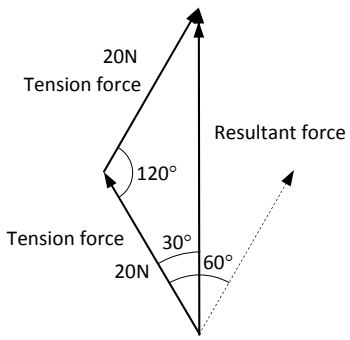
The diagram below shows the forces exerted on a ball by a catapult when the ball is pulled back with force F, creating tension in the rubber sling of the catapult.



(a) The two tension forces make an angle of 60° to each other and each force is 20N as shown in the diagram above.

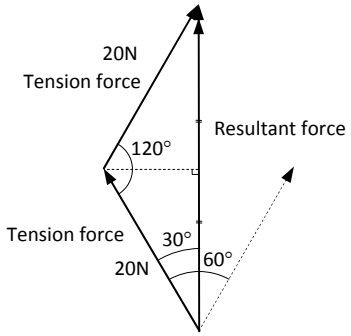
∴

- Using a scale drawing of 4cm to represent 10N, **the resultant of these two tension forces acting on the ball** is constructed as shown and measured to be 34.5N (represented by 13.8 cm).



(ans)

- **Otherwise**, studying half of the triangle below,



$\frac{1}{2} \times$ resultant force $= 20 \cos 30°$

∴ Resultant of these two tension forces acting on the ball

$= 40 \cos 30°$

$= 34.6$ N **(ans)** [3]

(b) When the ball is pulled back, the average value of force **F** is 16N. Force **F** causes the ball to move 0.20m in the direction of the force.

∴ Stating the equation used,

Work done = Force × Distance

$= 16 \times 0.20$

$= 3.2$ J (2sf) **(ans)** [2]

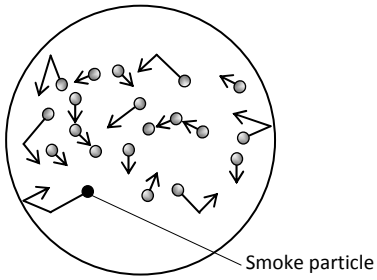
3. [Thermal Physics]

Solution

The motion of tiny particles suspended in a liquid or gas is commonly called Brownian motion. It can be observed when a container of smoke is viewed under the microscope.

(a) ∴ **Brownian motion is observed when** the tiny smoke particles are bombarded by the surrounding liquid/gas molecules. The smoke particles have random speeds and irregular paths of motion. **(ans)** [2]

(b) ∴ **The diagram showing the path a smoke particle takes when observed under the microscope:**



(ans) [1]

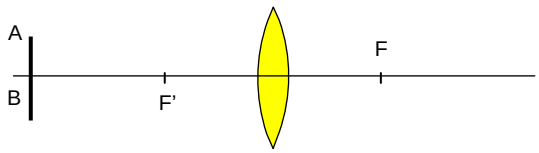
(c) Convection currents do not cause Brownian motion.

∴ Smoke particles that are in a convection current are observed to move in rather regular speeds and similar non-random closed-path motion. **(ans)** [1]

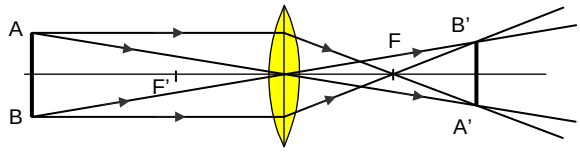
4. [Waves]

Solution

An object AB lies near a converging lens. The principal foci of the lens are at F and F'.



(a) ∴ **The positions of the image points A and B can be found by drawing rays as shown below**:



(ans) [3]

(b) The image of the object AB is real.

∴ Two other characteristics of the image are:

1. inverted, and
2. diminished. **(ans)** [2]

(c) ∴ **An optical device that uses a lens to form a real image of an object is** the camera. **(ans)** [1]

5. [Thermal Physics]

Solution

Pure steam enters at 100 °C into a jug with cold water at 20 °C. The cold water in the jug is 500g. Eventually the water in the jug reaches a temperature of 100 °C. The specific heat capacity of water is 4.20 J/ (g°C) and the specific latent heat of vaporization of water is 2250 J/g.

(a) **∴ Specific latent heat of vaporization of water is** the quantity of heat needed to change a unit mass of water from liquid state (water) to vapour state (water vapour) without a change in temperature. It is a scalar quantity. **(ans)** [2]

(b) **∴ The mass of water in the jug increases because** the steam is cooled and condenses as water in the jug and hence, the total mass of water increases in the jug. **(ans)** [1]

(c) **∴ Energy needed to warm 500g of water from 20°C to 100°C**

$= mc\Delta\theta$

$= 500 \times 4.20 \times 80$

$= 168$ kJ (3sf) **(ans)** [2]

(d) ∴ When the temperature of water has reached 100°C,

Energy gained by water = energy loss by steam

168 kJ = mass of steam × latent heat of vaporization

168 000 = mass of steam × 2250

mass of steam = 74.7 g

∴ **Final mass of water in jug**

$= 74.7 + 500$

$= 574.7$ g

$= 574.7$ g (1dp) **(ans)** [2]

6. [Electricity & Magnetism]

Solution

Fig 6.1 shows four plotting compasses near a wire with no current. The arrow in each compass points towards to the earth's North.

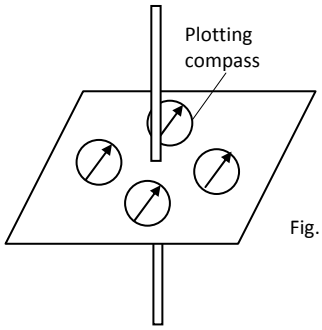


Fig. 6.1

Fig 6.2 shows four compasses around a wire with current flowing downwards.

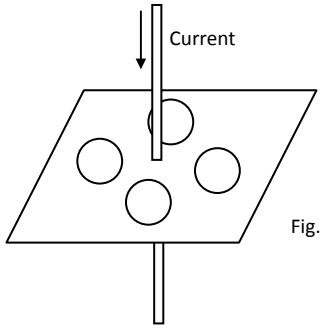


Fig. 6.2

(a)

(i) ∴ **The direction arrows on each compass is drawn** on Fig 6.2:

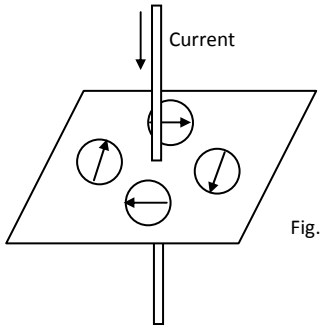
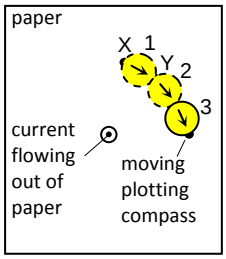


Fig. 6.2

(ans)

(ii) ∴ Magnetic field strength decreases with distance from the flowing current. Thus, **magnetic field due to the current, with the greatest strength, is located** in the region nearest to the wire (at points where the wire meets the card). **(ans)** [3]

(b) ∴ **Using one plotting compass to plot the lines of the magnetic field around the wire in Fig. 6.2,**



❶ Place the plotting compass at a distance from the centre of the conducting wire as shown.

❷ Mark the positions of the ends N and S, of the plotting compass needle by pencil dots, as like X and Y. Move the plotting compass until one end is exactly over Y and mark the new position of the other with a third dot.

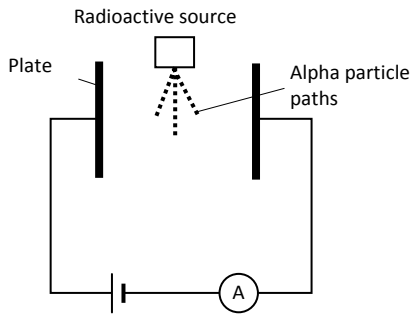
❸ Repeat step ❷ until the plotting compass reaches the point X again. Join the series of dots and this will give a field line of the magnetic field. Repeat for various distances from the conducting wire.

(ans) [3]

7. [Nuclear Physics]

Solution

A radioactive source emits alpha particles. The diagram shows a set-up of a smoke detector. The alpha particles ionize the air between the two plates, creating charged ions, creating a current in the circuit. When smoke is present, the current decreases.



(a) ∴ **The nature of an alpha particle is** a helium nucleus. **(ans)** [1]

(b) ∴ **A source that emits beta particles is not used in the detector is because** beta particles have much weaker ionizing strength than alpha particles, causing very little current to be produced in the circuit. When smoke is present, the decrease in current detected is not as obvious and hence, insignificant. **(ans)** [1]

(c) ∴ When air is ionized, positive and negative ions are formed and they act like mobile charge carriers which move through air towards the attracting plates. **A current is** hence **produced in the air between the plates. (ans)** [1]

(d) The radioactive source that emits the alpha particle contains Americium-241.

A nucleus of Americium-241 can be represented by $^{241}_{95}\text{Am}$, and decays to form Neptunium-237 (Np).

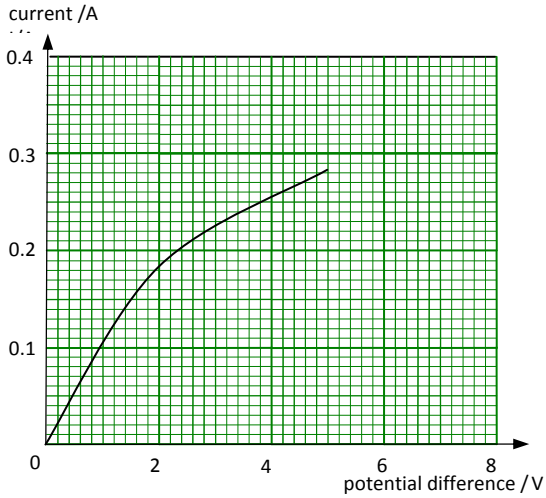
∴ A nuclear equation for the emission of an alpha particle from $^{241}_{95}\text{Am}$ is

$$^{241}_{95}\text{Am} \rightarrow {}^{237}_{93}\text{Np} + {}^{4}_{2}\text{He}$$ **(ans)** [2]

8. [Electricity & Magnetism]

Solution

The graph above shows how the current in the filament of lamp varies with the potential difference across it.



(a) **Answers are in an appropriate number of significant figures.**

∴ When current is 0.25 A,

potential difference = 3.8 V (from graph)

∴ **Resistance of the filament**

$$= \frac{\text{potential difference}}{\text{current}}$$

$$= \frac{3.80}{0.250}$$

= 15.2 Ω (3sf) **(ans)** [3]

(b) ∴ When the p.d. increases and hence, current passing through the filament of the bulb increases, more moving electrons collide with the atomic nuclei of the filament. The atomic nuclei gain kinetic energies and vibrate more vigorously. Since temperature is directly proportional to its kinetic energies, the filament gets hotter. At the same time, the more vigorous vibrations of the atomic nuclei impede further movement of the moving electrons. Hence, increases the effective resistance of the filament.

Since resistance is the reciprocal of the gradient of the graph, the gradient by becoming more gradual with increasing potential difference applied, implies that the resistance increases. **As such, as shown in the graph, as temperature rises, resistance increases. (ans)** [2]

Section B

Answer all questions.

9. [Electricity & Magnetism]

Solution

A lamp is marked 6.0V, 36W. Power is supplied to the lamp in either alternating or direct current.

(a) ∴ The lamp needs a p.d. of 6.0V across it to operate at normal brightness.

(i) ∴ The **potential difference** across a component in the circuit **is** the work done to drive a unit charge through the component. **(ans)**

(ii) ∴ **Current through the lamp when it operates at normal brightness,**

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

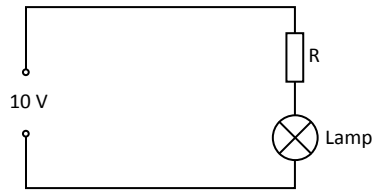
$$= \frac{36}{6.0}$$

$$= 6.0 \text{ A (2sf)} \quad \textbf{(ans)}$$

(iii) ∴ **The lamp should not be connected directly across a 10V power supply since** the applied potential difference across the filament is higher than its rated value, it will eventually overheat the filament of the lamp and cause the bulb to blow. **(ans)** [6]

(b) Two students A and B have come up with different methods to run the lamp at normal brightness using a 10V power supply.

(i) Student A suggests connecting the lamp in series with a resistor R.



For the lamp to operate normally,

∴ P.d. across resistor R

= 10.0 – 6.0

= 4.0 V

∴ Current through R

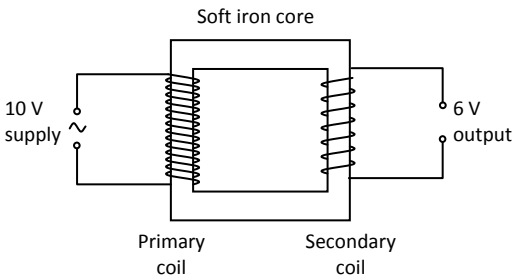
= current through the lamp operating normally

= answer to (a)(ii)

= 6.0 A (2sf) **(ans)**

(ii) Student B suggests the usage of a transformer to step down the 10 V power supply to 6 V.

1. ∴ **A labelled diagram of the transformer mentioned above is drawn**:



$$\frac{N_s}{N_p} = \frac{V_s}{V_p} = \frac{6}{10} = \frac{3}{5}$$

∴ Suggested number of turns in primary coil

= 5

∴ Suggested number of turns in secondary coil

= 3 **(ans)**

2. ∴ The alternating current in the primary coil produces a changing magnetic field resulting in a changing magnetic flux linkage in the secondary coil, which will in turn electromagnetically induce an alternating e.m.f.. **The transformer produces an output voltage. (ans)**

(iii) Student B **has the better solution.**

∴ Explanation:

Student A's suggestion will allow energy to be lost in the form of heat in the resistor *R*. Student B's suggestion does not have any resistive component and that minimizes energy lost to non-productive components, hence a superior suggestion. **(ans)**

[9]

10. [Electricity & Magnetism]

Solution

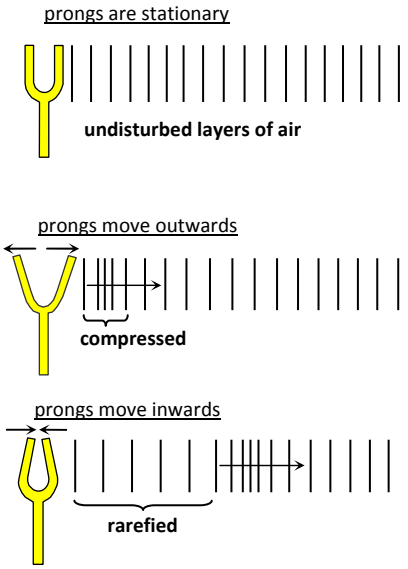
(a) **Sound is a longitudinal wave.**

∴ With the aid of a diagram,

Sound is a mechanical wave and is normally associated with our sense of hearing. Sound is produced by vibrating sources in material media.

For example,

❶ Vibration in the tuning fork produces disturbances in the surrounding air. When the prongs' movement is outwards, the prongs push the surrounding air molecules away, creating a local compression.

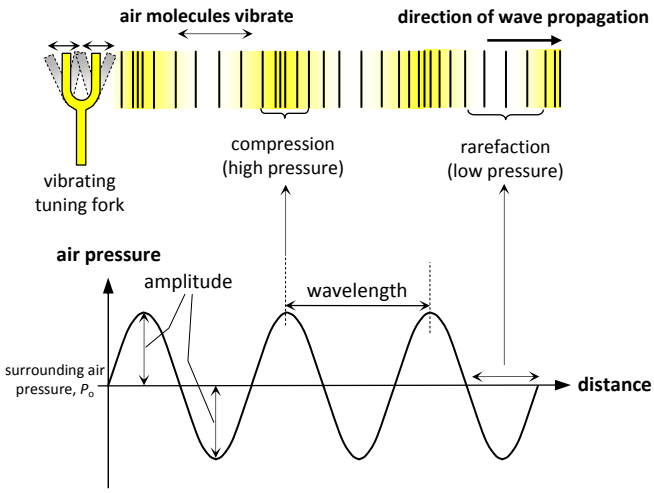


❷ This disturbance of air layers is then passed from molecule to molecule by collisions, causing the local compression to move outwardly.

❸ When the prongs' movement is inwards, a partial void, or rarefaction is created.

Pressure differences cause the air molecules to rush back into the region again. This periodic to-and-fro movement of the prongs will create alternating regions of compressions and rarefactions. **The sound waves span outwardly parallel to the direction of the wave propagation** (**longitudinal nature**).

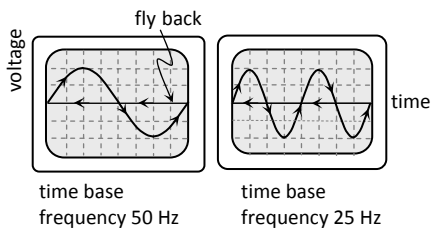
In air, compressions are regions where the pressure is higher than the surrounding air and rarefactions are regions where pressure is lower than the surrounding air.



sound wave travelling in air to the right & its graphical representation in terms of

(ans) [4]

(b) Sounds can be used to produce waveforms on a cathode-ray oscilloscope as shown.

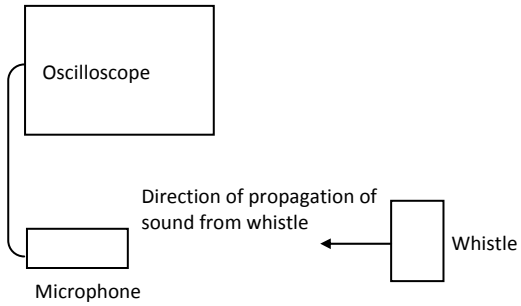


Using a cathode-ray oscilloscope and other apparatus to produce the display as shown above:

(i) ∴ Connect a microphone to a cathode-ray oscilloscope and place the microphone in the path of the sound wave **produced by a whistle**. This will **yield the regular wave form from a whistle as seen in the diagram.**

(ii) ∴ To **measure the time of one oscillation of the sound emitted by the whistle:**

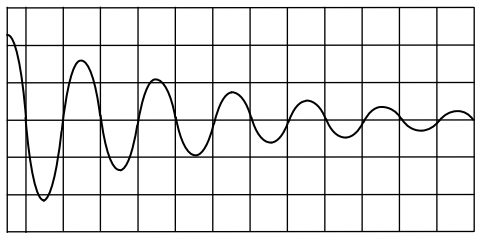
The **diagram of the apparatus** is **sketched** below:



Use a **whistle** with an **audible frequency** of 10,000 Hz and set up the apparatus as shown above. In order **to obtain a waveform,** first we switch off the time-base (*x*-axis, time axis) of the **cathode-ray oscilloscope**, we **adjust** the *y*-gain (voltage axis) to obtain a large enough deflection on the screen. Without touching the voltage axis gain setting, we then switch back on the time axis. Vary the time axis gain settings until we can capture two or more complete visible wavelets on the screen. **The readings to be taken are** those of the 1 complete wavelet (*x*-axis) of the wave displayed on the screen. Different readings from 6 whistle blowing are recorded. **Time taken for one oscillation can be obtained by averaging the 6 readings taken**. **(ans)** [7]

(c)

(i) From the waveform below,



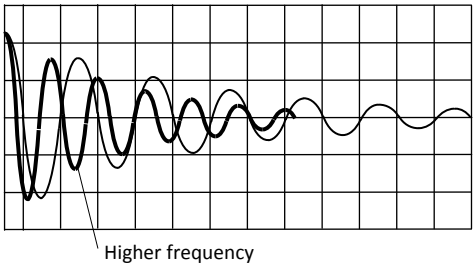
1. ∴ We can **deduce that the loudness of the sound is decreasing** from the decreasing amplitude of the waveform.

2. ∴ We can **deduce that the frequency of sound is constant** since the wavelength for each complete wavelet and hence, the period is constant.

(ans)

(ii) The separate waveforms of two whistles with different frequencies are obtained on an oscilloscope screen simultaneously.

∴ **The two waveforms observed are drawn as follows. The waveform with the higher frequency is labelled.**



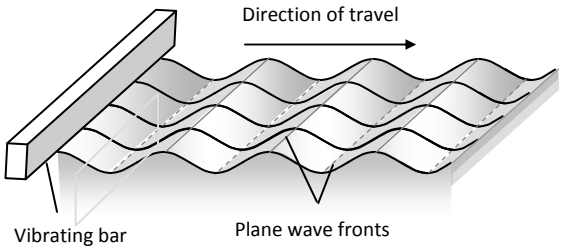
(ans) [4]

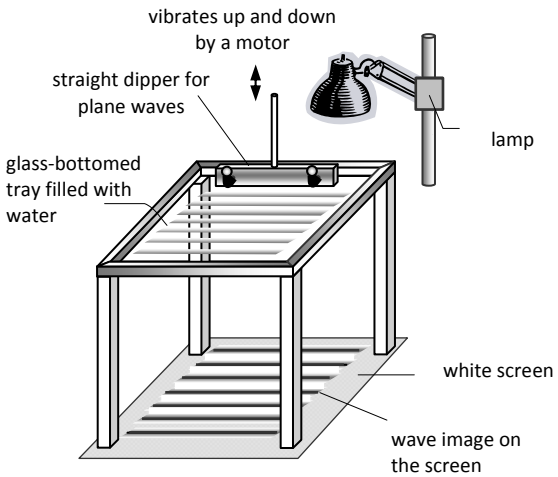
11. [Waves]

Solution

(a) Ripple tanks may be used to produce plane water waves.

∴ **A labelled diagram of such a ripple tank showing how waves are made and how they are observed is drawn** as follows:



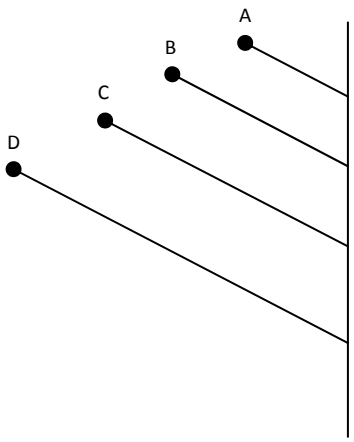


The ripple tank is a piece of apparatus used to generate water waves in a laboratory. It is useful in demonstrating wave properties such as reflection, refraction, diffraction and interference. It consists of a shallow tray of water with a transparent base, a light source directly above the tray and a white screen beneath the tray to capture the image of the shadows formed when water waves spread across the tank as shown in the figure.

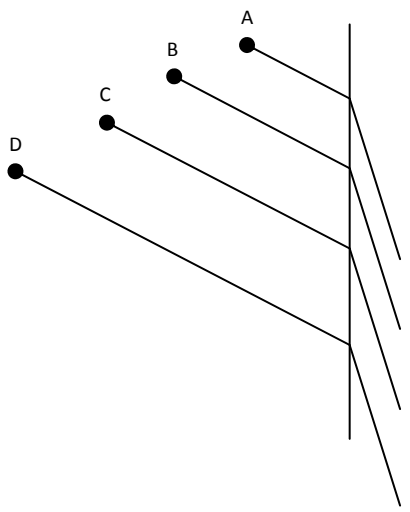
Straight waves can be set up by using a **straight dipper**, while circular waves can be formed by using a **spherical dipper**. Both dippers are vibrated up and down by a motor.

The waves will be seen in bright and dark patches on the screen below the tray. These patches show the position of the crests (dark) and troughs (bright) of the waves. **(ans)** [4]

(b) Water waves may be refracted at a boundary. The following figure shows four wave fronts incident on a boundary. They refract upon crossing the boundary.



(i) ∴ **The diagram above is copied and the refracted wave fronts are drawn** as follows:



(ans)

(ii) ∴ **The ripple tank in (a) could be used to produce the refraction by** placing a piece of glass at an angle across the tank such that the wave fronts meet the glass at an angle. **(ans)**

(iii) ∴ The depth of water in the tank will be shallower over the boundary than elsewhere. The speed of a wave in water depends on the depth, so the ripples slow down as they pass over the boundary. Since the frequency remains unchanged, this causes the wavelength to decrease. If the boundary between the deep and shallow water is at an angle to the wavefront, **therefore the waves will refract. (ans)** [5]

(c) **The wave fronts in the diagram are traced full-scale to the paper.** It takes 0.75s for a wavefront to travel from A to D.

Using measurements taken from Fig 11.1, determine for this wave,

(i) ∴ **Speed**

$$= \frac{\text{Distance}}{\text{Time}}$$

$$= \frac{4.5}{0.75}$$

$= 6.0\ \text{cm s}^{-1}$ (2sf) **(ans)**

(ii) ∴ **Wavelength**

$$= \frac{4.5}{3}$$

$= 1.5$ cm (2sf) **(ans)**

(iii) ∴ **Frequency**

$$= \frac{\text{Velocity}}{\text{Wavelength}}$$

$$= \frac{6.0}{1.5}$$

$= 4.0$ Hz (2sf) **(ans)** [6]

Notes: