	Class	Register Number
Name ______________________		

6091/02
PHYSICS
Paper 2

23/4P/6091/02

Wednesday **30 August 2023** **1 hour 45 minutes**

NIL SINE LABORE

VICTORIA SCHOOL

PRELIMINARY EXAMINATION
SECONDARY FOUR

READ THESE INSTRUCTIONS FIRST
Do not open this booklet until you are told to do so.

INSTRUCTIONS TO CANDIDATES

Write your name, class and index number in the spaces at the top of this page.
Write in dark blue or black pen. Answer all the questions within 1 hour 45 minutes.
You may use a HB pencil for any diagrams or graphs.

INFORMATION FOR CANDIDATES

The number of marks is given in brackets [ ] at the end of each questions or part questions.

Candidates are reminded that all quantitative answers should include appropriate units.

Candidates are advised to show all their working in a clear and orderly manner.

For Marker's Use		
Section A		/50
Section B		/30
Deduction	s. f.	
Total		/80

This paper consists of **25** printed pages, including the cover page.

[Turn over]

Section A

Answer **all** the questions in this section.

1 Fig. 1.1 shows the velocity-time graph of a cyclist.

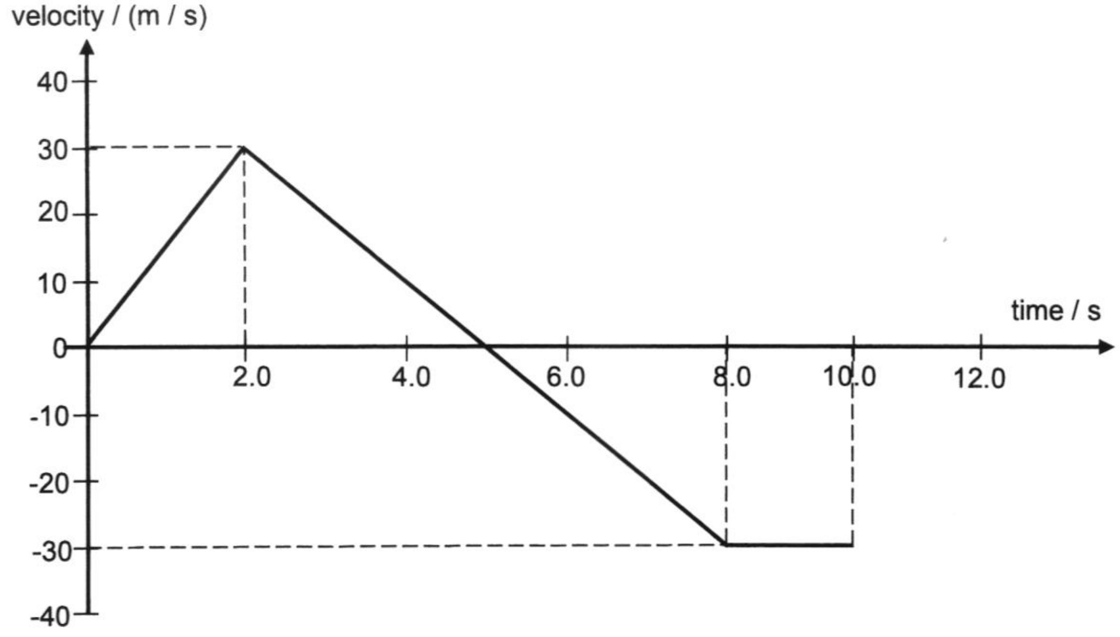


Fig. 1.1

(a) Calculate the displacement of the cyclist during the first 8.0 s.

displacement = ... [2]

(b) Determine the acceleration of the cyclist during the first 2.0 s.

acceleration = ... [1]

(c) Describe the motion of the cyclist between 2.0 s and 10.0 s.

....

....

....

.... [2]

(d) The cyclist applies the brakes with a decreasing acceleration and comes to a stop at 12.0 s.

On Fig. 1.1, draw the motion of the cyclist starting at 10.0 s. [1]

2 Fig. 2.1 shows a door and an automatic door-closer viewed from above.

When the door opens and closes, the hinge acts as a pivot while a force *F* is exerted by the door closer.

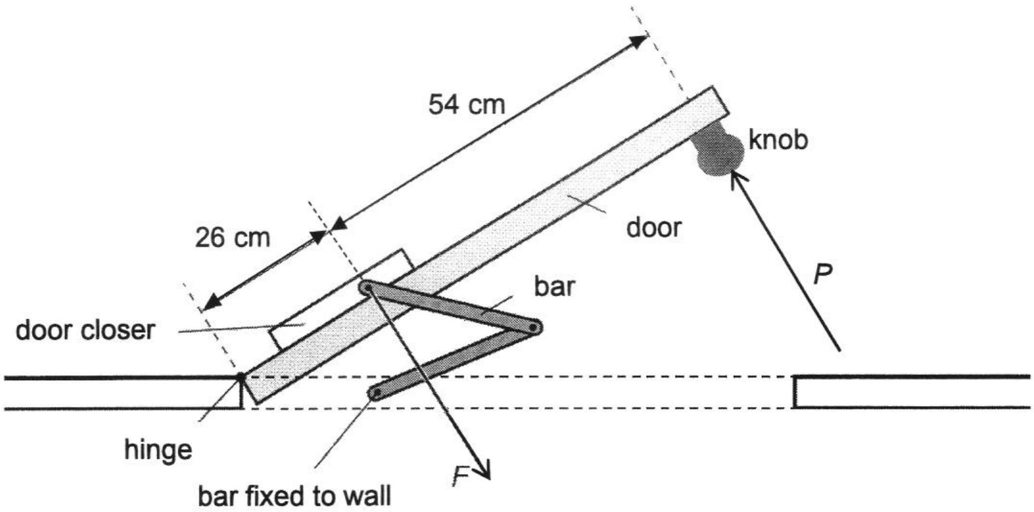


Fig. 2.1

A force *P* is applied on the knob of the door.

When force *P* is 35 N, the door remains stationary.

(a) State the condition for the door to remain stationary.

....

.... [1]

(b) Calculate the moment of force *P* about the hinge.

moment = ... [1]

(c) Hence, determine the magnitude of force *F*.

F = ... [2]

(d) Force *P* increases and the door swings open at a steady rate.

Compare and explain the magnitude of force *F* with force *P*.

....

....

.... [1]

3 Fig. 3.1 shows part of a roller coaster track XYZ.

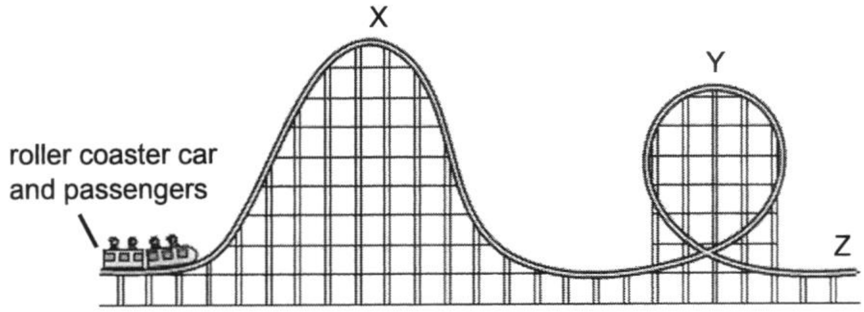


Fig. 3.1

A machine lifts the car and passengers to point X.

The machine has a power of 1.3 MW. The time taken to reach point X is 20 s.

The efficiency of the machine in raising the car and the passengers to point X is 40 %.

(a) State what is meant by the *efficiency* of the machine.

....

....

.... [1]

(b) The mass of the roller coaster car and passengers is 1500 kg. The gravitational field strength is 10 N / kg.

Calculate the maximum height gained by the roller coaster car when it reaches point X.

maximum height = ... [2]

(c) Describe the energy changes of the roller coaster car from point X to point Y.

....

....

....

....

....

.... [3]

(d) When the roller coaster car reaches point Z, work done by a machine slows it to a stop.

State what is meant by *work done* by a machine.

....

....

.... [1]

4 Fig. 4.1 shows the equipment that is being used to measure the pressure of the gas in the flask at sea level.

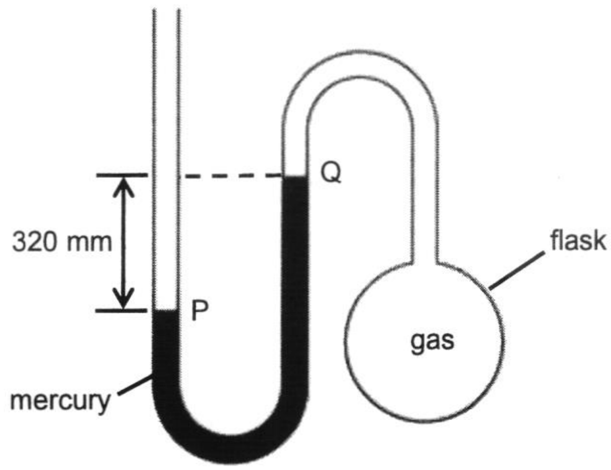


Fig. 4.1

(a) Define *pressure*.

....

.... [1]

(b) State the name of the equipment shown in Fig. 4.1 that is used to measure the pressure of the gas.

.... [1]

(c) The atmospheric pressure is 1.0×10^5 Pa at sea level.

The distance between mercury level P and mercury level Q is 320 mm.

The density of mercury is 13.6 g / cm^3 and the gravitational field strength is 10 N / kg.

Determine the pressure of the gas inside the flask.

pressure = ... Pa [2]

(d) The equipment is brought to the top of a mountain.

Describe and explain the effect on the mercury level P and level Q when the atmospheric pressure decreases.

....

....

....

.... [2]

5 Fig. 5.1 shows a car with emitters that emit an ultrasound of 3.0 MHz when the car is reversing. The sensors that are fitted to the rear will detect the ultrasound reflected by the stationary lorry. A buzzer will produce audible beeps to alert the car driver.

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

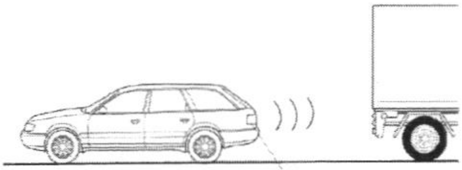


Fig. 5.1

(a) State the meaning of *an ultrasound of 3.0 MHz*.

....

.... [1]

(b) Describe how the ultrasound is transferred in the air.

....

....

....

.... [2]

(c) The time taken for the ultrasound to echo back is 4.0 ms.

Calculate the distance between the rear of the car and the back of the lorry at this instant.

distance = ... [2]

(d) The pitch and loudness of the buzzer becomes higher as the car moves closer to the lorry.

Describe how the frequency and amplitude of the buzzer changes.

....

.... [1]

6 Fig. 6.1 shows a circuit diagram of a lighting system with two identical light bulbs P and Q. The system consists of a fixed resistor R, a potential divider XY, light dependent resistor (LDR), an ammeter and two switches S_1 and S_2.

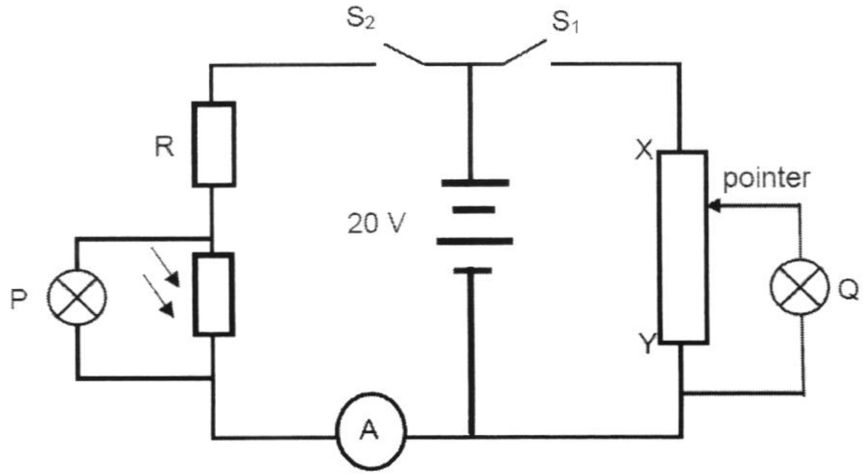


Fig. 6.1

(a) Switch S_1 closes and S_2 opens.

(i) Describe how the brightness of light bulb Q changes as the pointer moves from X to Y.

....

.... [1]

(ii) Explain your answer in **(a)(i)**.

....

.... [1]

(b) Switch S_1 opens and S_2 closes.

(i) Explain how the brightness of light bulb P changes as the light intensity of the surrounding decreases.

....

....

....

.... [2]

(ii) The potential difference (p.d.) across light bulb P is 6.5 V.

The ammeter reading is 0.40 A.

Calculate the resistance of the fixed resistor R.

resistance = ... [2]

(c) State an advantage of using an LDR instead of a potential divider in the lighting system shown in Fig. 6.1.

....

.... [1]

7 Fig. 7.1 shows appliances R and S connected to a 240 V mains supply. Appliance R has a resistance of 80 Ω and appliance S has a resistance of 40 Ω.

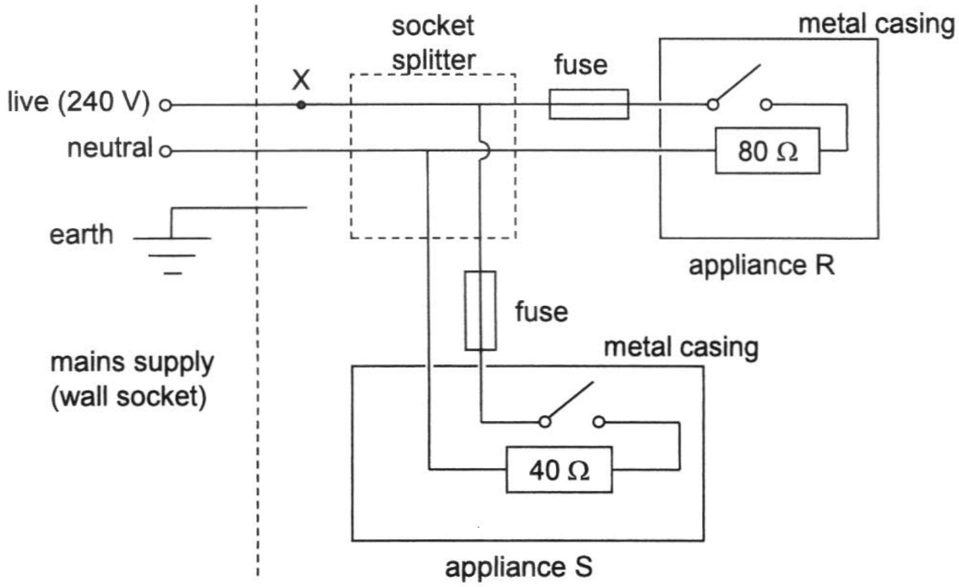


Fig. 7.1

(a) On Fig. 7.1, draw lines to complete the connection of the earth wire to the appliances. [1]

(b) Explain why a fuse is placed on the 'live' wire leading into the appliance instead of the 'neutral' wire leading out of the appliance.

....

.... [1]

(c) Determine the energy, in kWh, that appliance R uses after it is switched on for a whole day.

energy used by appliance R = ... kWh [2]

(d) State if a 9 A fuse placed at the point marked X on the 'live' wire is sufficient. Support your answer with calculation.

....

.... [2]

8 (a) Fig. 8.1 shows a section of a long straight wire carrying a steady current to the right placed within an external uniform magnetic field, labelled B as shown.

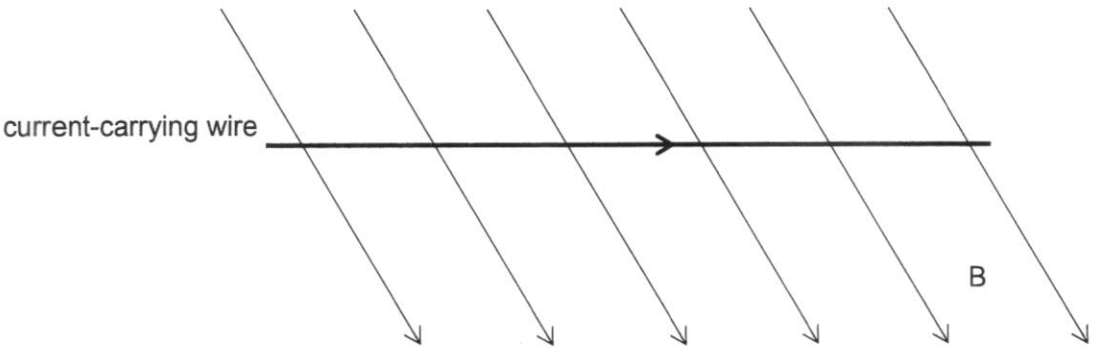


Fig. 8.1

State the direction of the magnetic force acting on the wire.

.... [1]

(b) Fig. 8.2 shows a horseshoe magnet on a top-pan balance with a wire situated between the poles of the magnet.

The reading on the balance increases when a current flows through the wire in the direction X to Y.

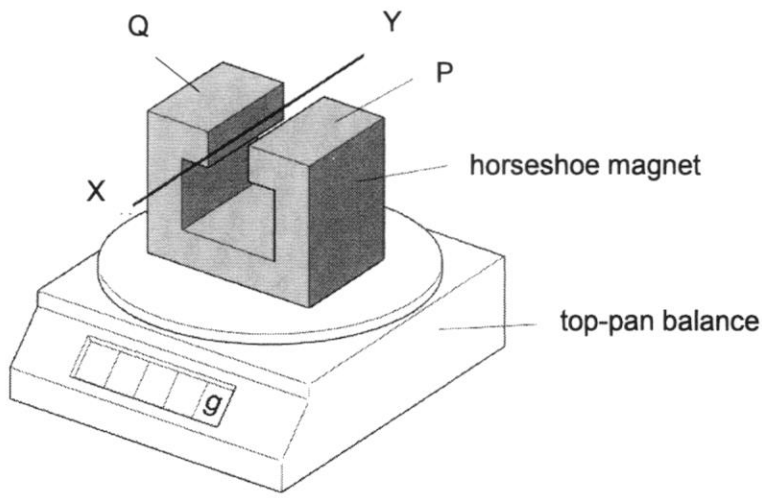


Fig. 8.2

(i) Explain why the reading on the balance increases.

....

....

....

....

....

.... [3]

(ii) Hence state the magnetic poles at P and Q of the horseshoe magnet.

P : ....

Q : .... [1]

(c) On Fig. 8.3, draw the resultant magnetic field of the current-carrying wire and the magnetic poles. The direction of the current in the wire between the magnetic poles is out of the page. [2]

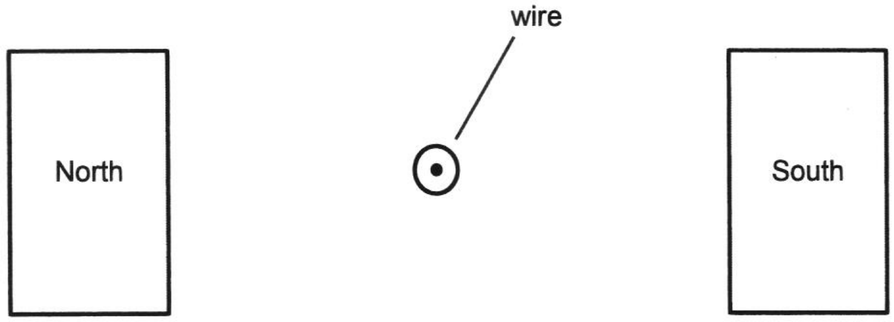


Fig. 8.3

Section B

Answer **all** the questions in this section.

Answer only one of the two alternative questions in **Question 11**.

9 Fig. 9.1 shows the structure of a water cooler that supplies cold water.

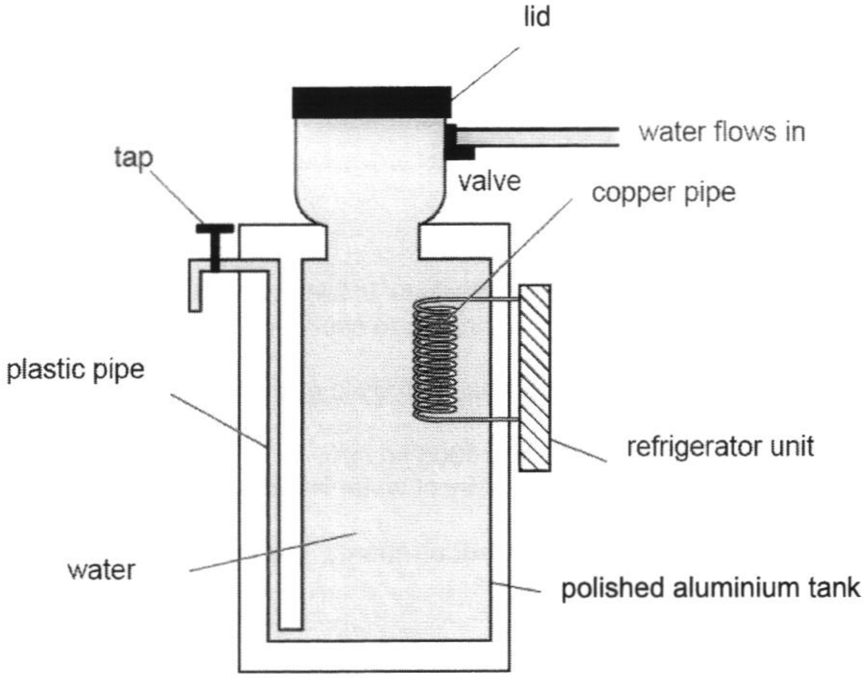


Fig. 9.1

(a) Describe the motion of the water molecules in the tank.

....

.... [1]

(b) In the refrigerator unit, a coolant is pumped through the copper pipe. Heat flows from the water to the refrigerator unit.

Using ideas about molecules,

(i) explain how heat is transferred through the copper pipe to the coolant,

....

....

.... [1]

(ii) describe and explain how water is cooled inside the tank.

....

....

....

.... [2]

(c) Explain how the tank of the water cooler keeps the water cold.

....

.... [1]

(d) With the valve closed, the tank is filled completely with 0.013 m^3 of water at 25 °C. The water cooler is turned on to cool down the water for 1.5 hours.

The rate at which thermal energy is gained by the refrigerator unit is 80 J / s.

The density of water is 1000 kg / m^3.
The specific heat capacity of water is 4200 J / (kg °C).

(i) Calculate the thermal energy gained by the refrigerator unit at the end of 1.5 hours.

energy = ... [2]

(ii) Calculate the final temperature of the water at the end of 1.5 hours.

final temperature = ... [2]

(e) Suggest a reason why the actual final temperature of the water is higher than in **(d)**.

....

.... [1]

10 (a) Fig. 10.1 shows the components of an electromagnetic spectrum.

X ray	visible light	ultra-violet ray	radio wave	infra-red wave

Fig. 10.1

(i) List the components that have longer wavelength than ultra-violet ray by arranging them in descending order.

....

.... [1]

(ii) The speed of electromagnetic waves in a vacuum is 3.0×10^8 m / s.

A television remote controller uses infra-red wave of wavelength 0.95 μm.

Calculate the frequency of this infra-red wave.

frequency = ... [1]

(b) Fig. 10.2 shows light ray 1 entering and exiting a glass block at point X. Light ray 2 enters the glass block from the left and meets light ray 1 at point X.

The critical angle of the glass is 46 °.

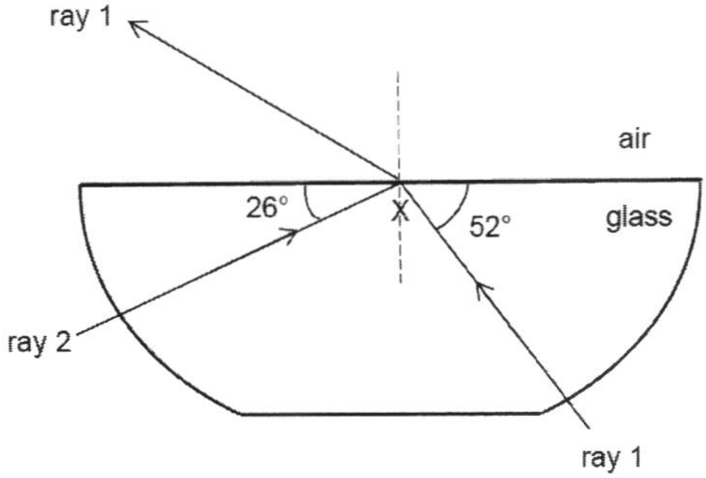


Fig. 10.2 (not drawn to scale)

(i) Explain how the light rays enter the glass block without bending.

....

.... [1]

(ii) Determine the refractive index of glass.

refractive index = ... [1]

(iii) Explain why ray 1 exits the glass block and refracts in air.

....

.... [1]

(iv) On Fig. 10.2,

1. label the angle of refraction as ray 1 emerges into air, [1]

2. complete the path of ray 2 from point X. [1]

Show your workings in the space below.

(c) Fig. 10.3 shows a photo-enlarger using a converging lens, an object O, and the image I produced by the lens.

The image I formed is real and has a linear magnification of 4.0.

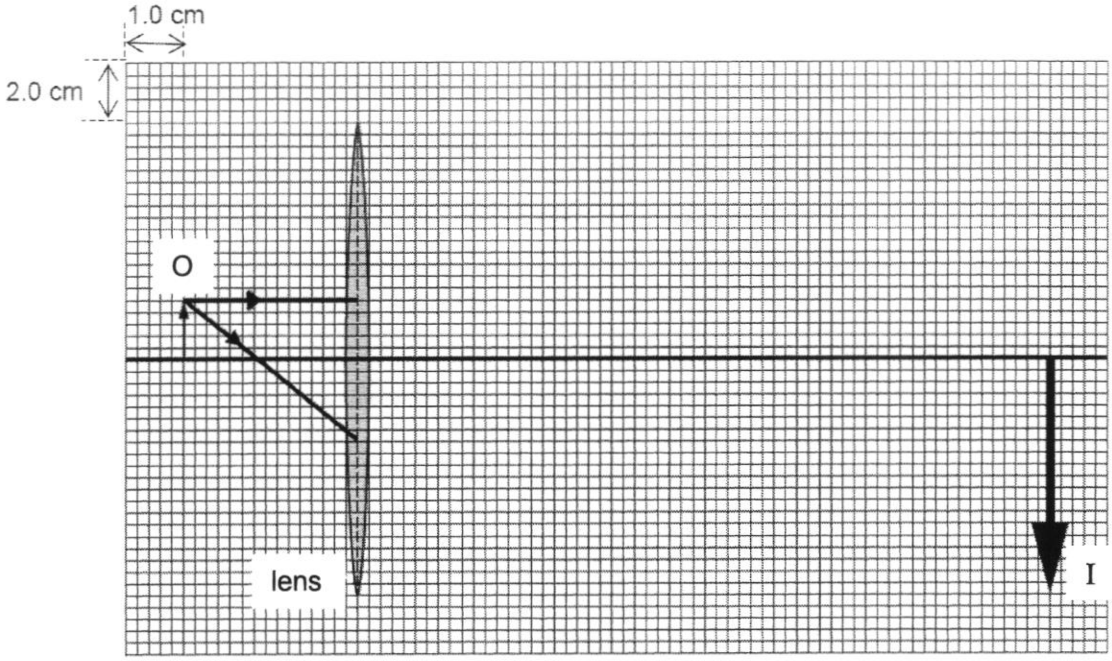


Fig. 10.3

(i) Show that the linear magnification is 4.0. [1]

(ii) On Fig. 10.3,

1. complete the path of the two light rays, and

2. determine the focal length of the lens, labelling it with the letter F.

focal length = ... [2]

11 Either

(a) Fig. 11.1 shows an alternating current (a.c.) generator.

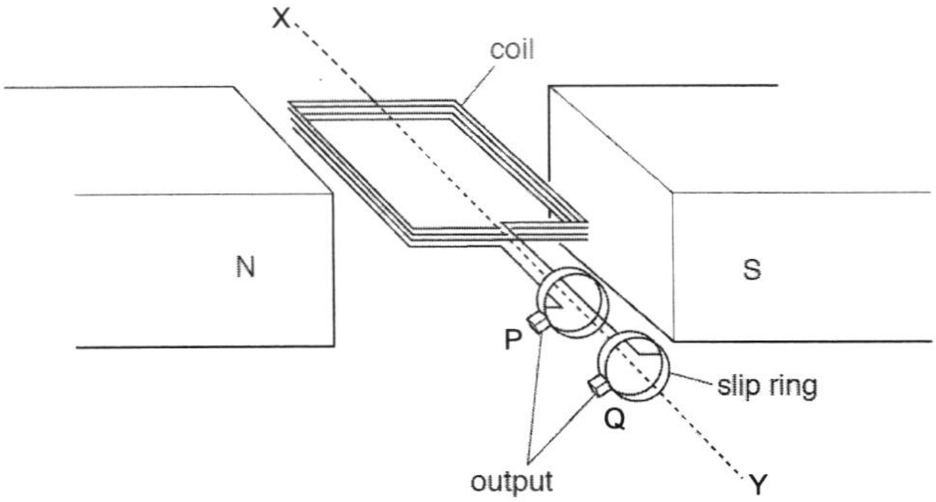


Fig. 11.1

The terminal attached to brush P has a positive potential while the terminal attached to brush Q has a negative potential.

(i) State the direction in which the coil rotates when viewed from Y.

.... [1]

(ii) The coil starts to rotate from the position shown in Fig. 11.1.

Explain why the electromotive force (e.m.f.) induced is a maximum at this instant.

....

....

....

.... [2]

(iii) The coil is rotating, and its alternating voltage output is shown in Fig. 11.2. The peak output voltage is 5.0 V.

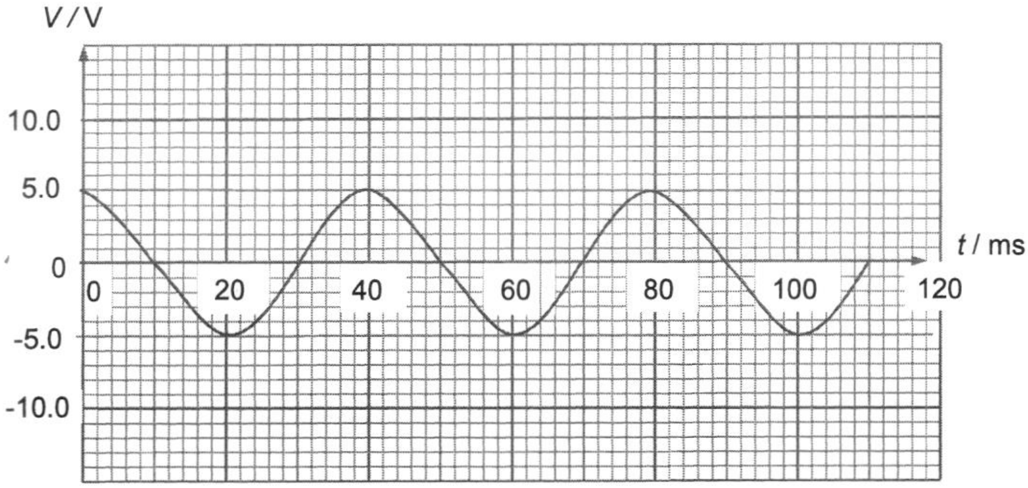


Fig. 11.2

The speed of rotation of the coil is now doubled.

On Fig. 11.2, sketch the variation with time of the output voltage. [2]

(b) A hair dryer used in Singapore is rated at "240 V, 1000 W". A student plans to bring the dryer to a country where the mains voltage is 120 V.

(i) Explain why the current from the mains is an alternating current rather than a direct current.

....

....

....

.... [2]

(ii) It was suggested that the student needs to bring a transformer along to the country to operate the dryer.

Determine the transformer's turns ratio $\frac{N_S}{N_P}$.

turns ratio = ... [1]

(iii) The efficiency of the transformer is 76 %.

Determine the current drawn by the transformer in the country when the dryer is operating at 1000 W.

current = ... [2]

Or

Fig. 11.3 shows a helicopter flying vertically upwards in the air with an increasing speed.

The total mass of the helicopter and the passengers is 860 kg.

An upthrust is exerted on the helicopter to fly upwards and air resistance is acting on the helicopter.

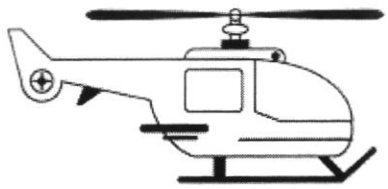


Fig. 11.3

(a) Calculate the weight of the helicopter and passengers.

weight = ... [1]

(b) On Fig. 11.3, draw and label the forces acting on the helicopter. [1]

(c) The helicopter is accelerating at 4.0 m / s^2 and the air resistance acting on the helicopter is 400 N.

Calculate the upthrust on the helicopter.

upthrust = ... [2]

(d) A parachutist jumps out of the helicopter when it is hovering above the ground.

Fig. 11.4 shows a parachutist falling vertically towards the ground. As he is falling, there is air resistance acting on him.

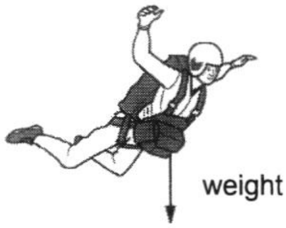


Fig. 11.4

The parachutist falls from rest at 0 s.

Table 11.1 shows the motion of the parachutist in the 100 s.

Table 11.1

time / s	description of the motion of the parachutist
0 to 30	accelerates non uniformly
30 to 40	falls with terminal velocity of 55 m / s
40	parachute opens
40 to 45	decelerates and reaches a smaller terminal velocity of 6 m / s
45 to 100	falls at 6 m / s
100	lands on ground

(i) Calculate the deceleration of the falling parachutist from 40 to 45 s.

deceleration = ... [1]

(ii) Explain, in terms of the forces acting, why

1. the parachutist reaches a terminal velocity at 30 s.

....

....

....

.... [2]

2. the parachutist decelerates when the parachute opens.

....

....

....

.... [2]

3. the second terminal velocity, after the parachute is opened, is smaller than the first terminal velocity.

....

....

.... [1]

End of Paper

VS 2023 Preliminary Examination

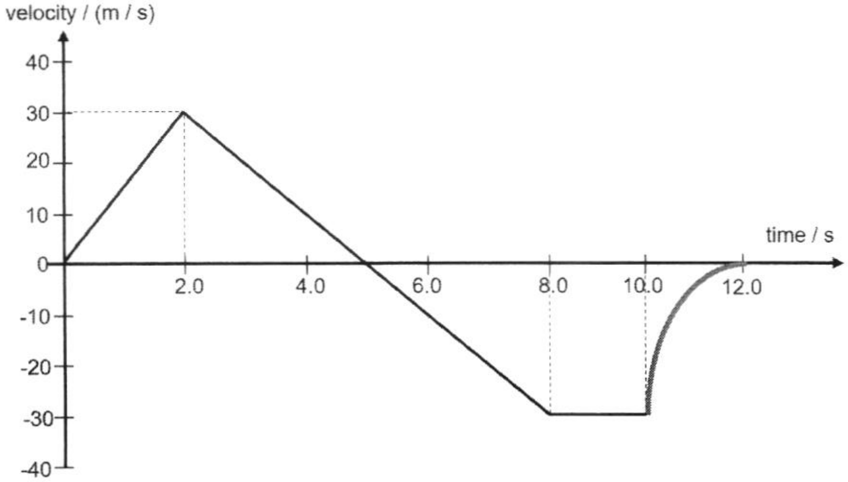
2023 Prelim exam mark scheme

Paper1

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

Paper 2 Section A

Qn	Suggested solution
1a)	displacement = ½ (5.0 x 30) – (1/2 x 3.0 x 30) = 75 – 45 = 30 m
(b)	acceleration of the cyclist = 30 / (2.0) = 15 m / s^2
(c)	The cyclist moves with constant deceleration from 2 s to 5 s. It moves with constant acceleration from 5 s to 8 s in the opposite direction. Or the cyclist moves with constant negative acceleration from 2 s to 8 s. It moves with constant velocity of 30 m / s in the opposite direction.

(d)	 **Fig. 1.1** Correct shape – 1 mark

2(a)	Any 1 condition The resultant moment about any point is zero. or The resultant force acting on the door is zero.
(b)	Moment = 0.80 m x 35 N = 28 Nm
(c)	Taking moment about the hinge, Sum of Clockwise moment = Sum of anticlockwise moment $0.80 \times 35 = F \times 0.26$ $F = 108$ N (3 s.f.)
(d)	Force *F* will remain larger than force *P* since its **perpendicular distance from the hinge is smaller than *P*'s**. The door is in equilibrium when it opens at a steady rate.

3 (a)	Efficiency is the **percentage of total input energy that is converted to useful output energy**.
(b)	Total input energy = $1.3 \times 10^6 \times 20\text{s} = 2.6 \times 10^7$ J Maximum height = $\frac{0.40 \times 2.6 \times 10^7}{1500 \times 10}$ = 693 m

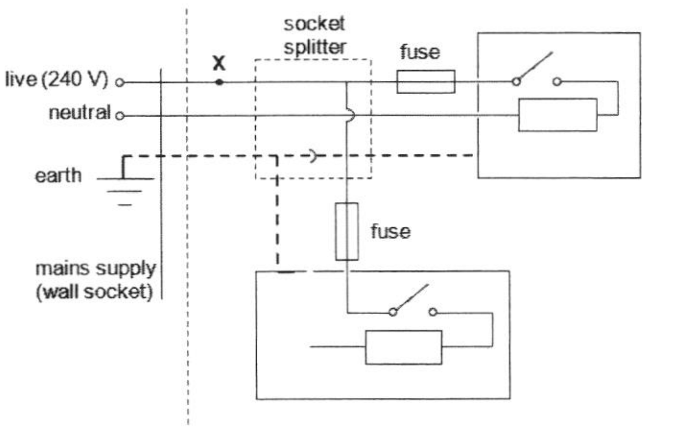
(c)	At point X, the **gravitational potential energy** of the roller coaster car is the **maximum**. As it moves to the lowest point between point X and Y, its **kinetic energy is the maximum** as its gravitational potential energy is converted to kinetic energy. At point Y, it possesses **both kinetic energy and gravitational potential energy** which is gained from the increase in its vertical height.
(d)	Work done is the **product of the force exerted by the machine and the distance travelled in the direction of the force**.

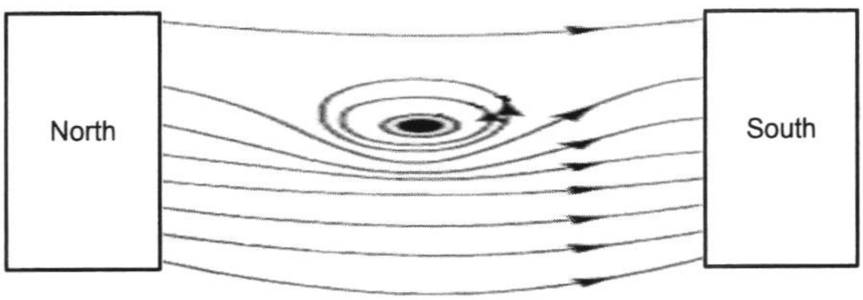
4 (a)	Pressure is **force per unit area.**
(b)	Manometer
(c)	Pressure of the gas in the flask = atmospheric pressure - hpg $= 1.0 \times 10^5 - 0.32 \times 13600 \times 10$ $= 56480$ $= 56.5$ kPa
(d)	The level of mercury at **P will rise** and level at **Q will drop** and their difference will be **less than 320 mm.**

5(a)	3.0×10^6 complete cycles are produced in a second.
(b)	The air particles vibrate/oscillate about their equilibrium position parallel to the direction of the wave motion. They transfer energy through a series of compression and rarefactions from one point to another.
(c)	distance = speed x (time / 2) $= 330 \times (4.0 \times 10^{-4} / 2)$ $= 0.66$ m
(d)	The frequency and amplitude of the sound is greater.

6(a) (i)	The brightness of P decreases to zero.
(ii)	The potential difference (p.d.) across P at X is 20 V and decreases to 0 at Y.
(b) (i)	When the light intensity of the surrounding decreases, the resistance of LDR increases. The p.d. across LDR increases.

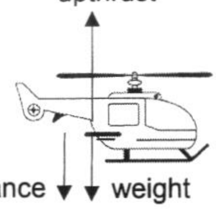
	Since light bulb P is in parallel with LDR, p.d. across P increases. The brightness of P increases.
(ii)	p.d. across R = 20 – 6.5 = 13.5 V resistance of R = 13.5 / 0.40 = 33.8 Ω
(c)	The brightness of P using the LDR changes <u>automatically</u> as compared to Q that needs manual adjustment to change its brightness.

7(a)	
(b)	The fuse is connected on the 'live' wire so that when it blows due to excessive current, the appliance will be <u>disconnected before current reaches the appliances.</u>
(c)	$P = V^2 / R$ $= 240^2 / 80$ = 720 W = 0.72 kW E = Pt = 0.72 x 24 = 17.3 kWh
(d)	Current in appliance 1 = 240/80 = 3.0 A Current in appliance 2 = 240/40 = 6.0 A The total current required when both appliances are on is 9.0 A
	The fuse used should be higher than 9.0 A, hence rating of 9.0 A is insufficient.

8(a)	Direction of the magnetic force points into the page
(b) (i)	When a current flows in the wire XY, the wire will experience a magnetic force due to the interaction with the magnetic field of the horseshoe magnet.
	Using Fleming's left-hand rule, the direction of force by the horseshoe magnet on the wire is upwards. Where the current points from X to Y, magnetic field points from P to Q. **Or** The concentration of the magnetic field below the wire is higher than above the wire. And the magnetic force on the wire is upwards.
	By Newton's third law of motion, the **magnetic force by the wire on the horseshoe magnet will be downwards**. Hence the reading increases.
(b) (ii)	P: North Q: South
(c)	 **Fig. 8.3** Correct direction of magnetic field lines – 1 mark Spacing between magnetic field lines below the wire is smaller – 1 mark

Section B

Qn	**Suggested Solution**
9(a)	The water molecules are moving in constant random motion.
(b) (i)	Heat transfer by conduction from pipe to coolant. Molecules of the pipe vibrate about their positions and heat is passed through collision with neighbouring molecules of the coolant.
(b) (ii)	The water near the copper pipe loses thermal energy (heat) to the pipe and become denser and sink to the bottom of the tank. The warmer water being less dense will rise and be cooled by the refrigerator unit. This cycle repeats and forms a convection current in the tank.
(c)	The shiny aluminum tank is good reflector of radiant heat (infra-red radiation). It reduces heat gain from the surrounding by infra-red radiation.
(d)	**(i)** energy = P × t = 80 × (1.5 × 60 × 60) = 432 000 J = 432 kJ
	(ii) Let the final temperature be T according to principle of conservation of energy, Heat gain by refrigerator unit = Heat lost by the water energy = m × c × (25 – T) 432 000 = (1000 × 0.013) × 4200 × (25 – T) final temperature, T = 17 °C
(e)	The refrigerator unit will also need to remove heat from the copper pipe and / or the aluminum tank to cool the water. Hence the heat remove is not enough to bring the final temperature of the water to 17 °C. *Do not accept answer that is not specific and only state heat is gained from surrounding.

Or	
11(a)	Weight = 860 x 10 = 8600 N
(b)	Refer to Fig. 11.3  The arrow length of upthrust should be drawn longer than the combined length of air resistance and weight.
(c)	Upthrust - air resistance - 8600 = m a Upthrust - 400 – 8600 = 860 x 4.0 Upthrust = 12 400 N
(d) (i)	Acceleration = (6.0 - 55) / 5.0 = - 9.8 m / s^2 deceleration is 9.8 m / s^2
(ii) 1.	As velocity increases, the force due to air resistance increases. When the force due to air resistance equals to the weight of the parachutist, the resultant force will be zero and there'll be no acceleration.
2.	When the parachute opens, the force due to air resistance increases to become greater than the weight of the parachutist. The resultant force acts upwards, and the parachutist decelerates. (The velocity decreases at a decreasing rate.)
3.	With the parachute opened, the force due to air resistance will be equal to the weight of the parachutist at a smaller speed. Hence the velocity of the parachutist will decrease until an equilibrium is reached.