南洋女子中学校
NANYANG GIRLS' HIGH SCHOOL
Preliminary Examination 2024
Secondary Four 'O' Level

CANDIDATE NAME										
CENTRE NUMBER	S					INDEX NUMBER				

PHYSICS **6091/02**

Paper 2 **26 Aug 2024, Monday**

1 hour 45 minutes

Candidates answer on the Question Paper.

No Additional Materials are required.

READ THESE INSTRUCTIONS FIRST

Write your class, index number and name on all the work you hand in.
Write in dark blue or black pen.
You may use an HB pencil for any diagrams or graphs.
Do not use staples, paper clips, glue or correction fluid.
DO **NOT** WRITE ON ANY BARCODES.

Section A
Answer **all** questions.
Write your answers in the spaces provided.

Section B
Answer **one** question.
Write your answers in the spaces provided.

Candidates are reminded that **all** quantitative answers should include appropriate units.
The use of an approved scientific calculator is expected, where appropriate.
Candidates are advised to show all their working in a clear and orderly manner, as more marks are awarded for sound use of Physics than for correct answers.

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

Examiner's Use	
Paper 1	
Section A	
1	
2	
3	
4	
5	
6	
7	
8	
9	
10	
11	
12	
Section B	
13	
14	
Total	
120	
%	

Section A (70 marks)

Answer **all** questions in this section.

1 Fig. 1.1 shows a toy water rocket.

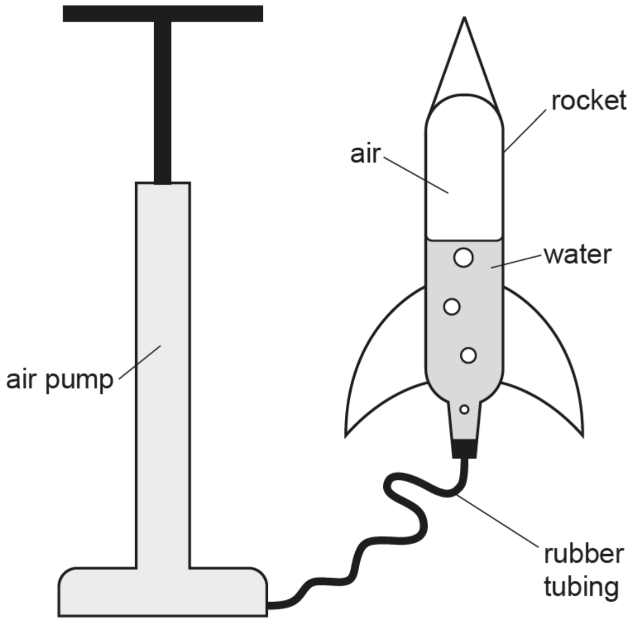


Fig. 1.1

The rocket is half-filled with water and connected by rubber tubing to a pump.

(a) Explain, in terms of particles, how air molecules inside the rocket create a pressure on the walls of the rocket.

....

....

....

.... [2]

(b) The rocket is placed on a launch platform. Air is then pumped into the rocket so that the pressure of the air inside the rocket increases. The rocket takes off vertically.

Fig. 1.2 shows the rocket's motion in the first 2.0 s. Air resistance is ignored.

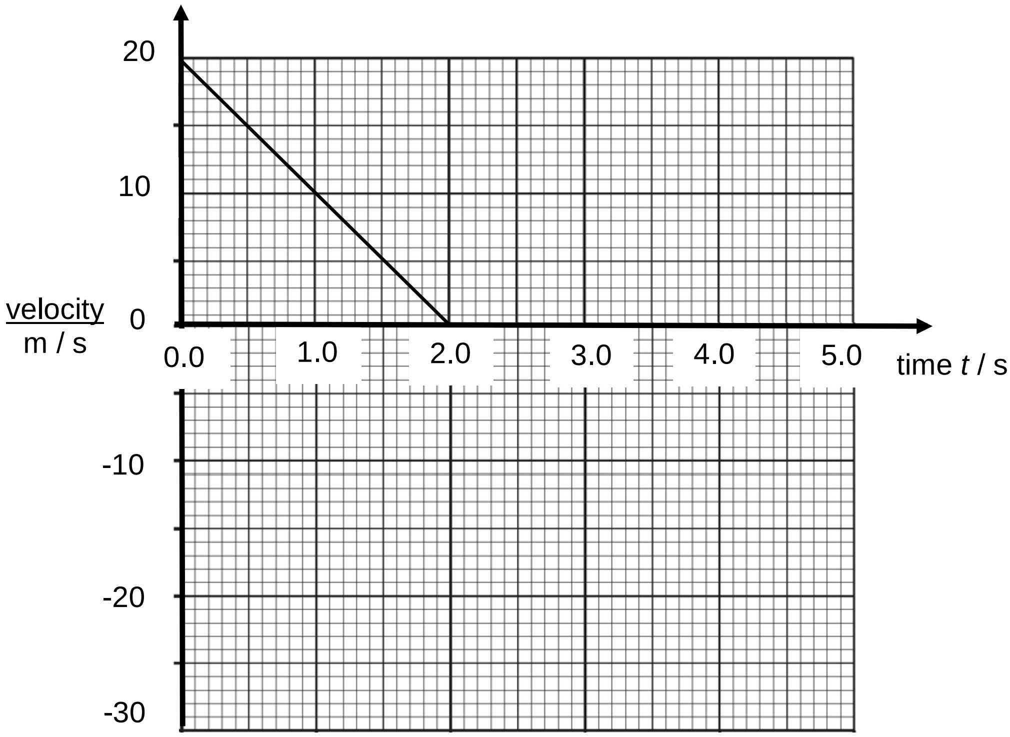


Fig. 1.2

(i) Determine the maximum height rocket risen by the rocket.

height = ...[2]

(ii) Complete the velocity time graph in Fig. 1.2 until the rocket hits the ground at t = 4.5 s. [1]

(iii) Determine the height of the launch platform.

height = ...[1]

2 A plane, irregular lamina has a mass of 50 g. It hangs from a nail that passes through a small hole H near to the edge of the lamina.

The nail acts as a pivot and the lamina can swing about it. The lamina is held in the position shown in Fig. 2.1, a small distance above a horizontal bench.

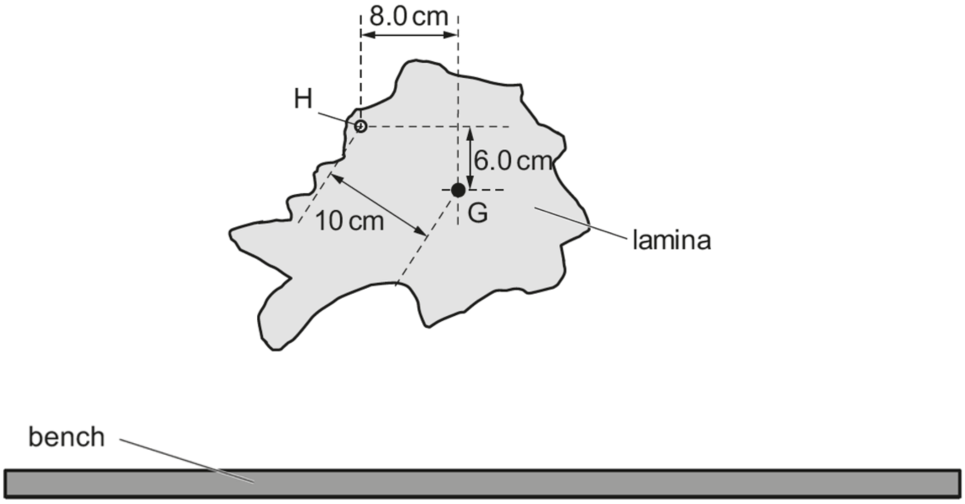


Fig. 2.1

(a) The centre of gravity of the lamina is at G.

(i) Calculate the weight, *W* of the lamina on Earth

weight = ……………………………[1]

(ii) Describe the other force that is part of Newton's Third Law action-reaction pair with *W*.

....

....[1]

(b) *W* produces a moment about the pivot through H.

(i) Using Fig. 2.1, calculate the moment of the weight about the pivot.

moment = ……………………………[2]

(ii) The lamina is now released from the position shown in Fig. 2.1. The lamina oscillates initially. Explain the final position of the lamina at equilibrium.

....

....

....

....[2]

3 Fig. 3.1 shows the particles (molecules) in a sample of liquid water.

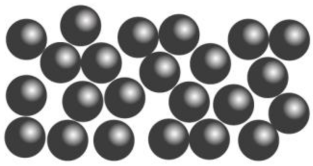


Fig. 3.1

(a) Explain, using ideas about particles, why liquids expand more than solids for the same temperature rise.

....

....

....

.... [2]

(b) An electric heater is used to heat a sample of metal, as shown in Fig. 3.2.

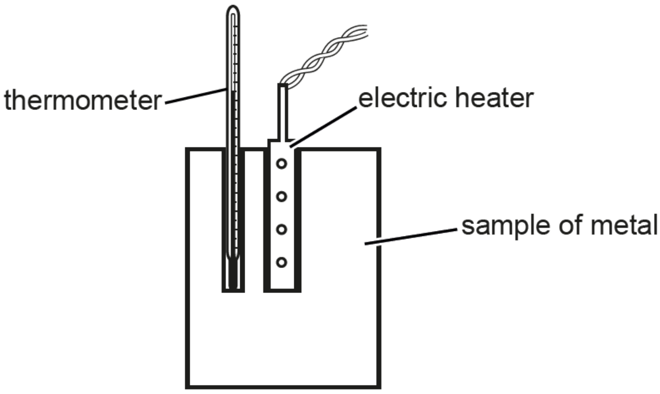


Fig. 3.2

The metal has a mass of 200 g and is initially at 15 °C.

The heater is switched on for 2.0 minutes and then switched off. The maximum temperature reached by the metal is 40 °C. The power of the heater is 20 W.

Calculate the specific heat capacity of the metal.

specific heat capacity = ……………………………….[3]

4 An oscillator is attached to one end of a long elastic string as shown in Fig. 4.1. The other end of the string is stretched taut.

Fig. 4.1 shows the shape of the string a certain time after the oscillator has started. P is a point on the string.

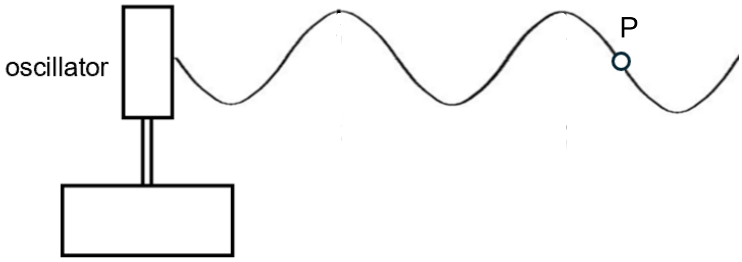


Fig. 4.1

(a) A student suggests that the wave produced along the string is a transverse wave.

Explain if you agree with the suggestion.

....

....

.... [2]

(b) On Fig. 4.1, sketch the waveform in the string half a period later. Locate the position of P in your sketch and label it X. [2]

5 Fig. 5.1 shows two flat metal plates positioned horizontally, one above the other. The positive terminal of a high-voltage supply unit is connected to the bottom plate and the negative terminal is connected to the top plate.

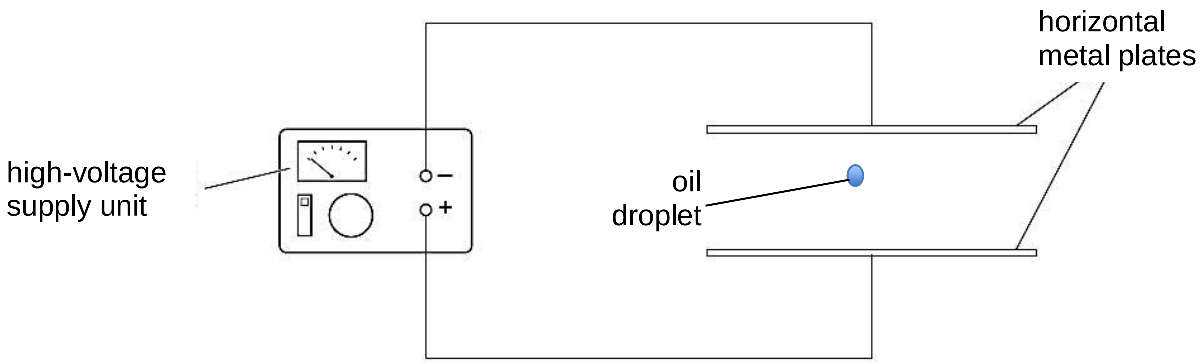


Fig. 5.1

The high-voltage supply is switched on. A small charged oil droplet is placed between the two metal plates. The oil droplet remains stationary in mid-air.

(a) State the charge of the oil droplet.

.... [1]

(b) Explain in terms of the forces acting why the oil droplet remains stationary.

....

....

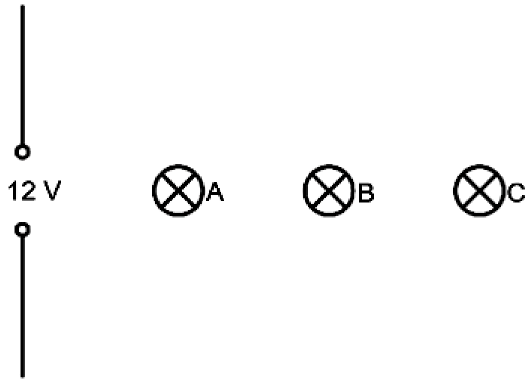
....

.... [2]

6 Fig. 6.1 shows part of a lighting circuit for a toy-house. It consists of a 12 V power supply and three identical lamps A, B and C.

On Fig. 6.1, complete the circuit, adding circuit components as necessary, such that:

- when one lamp blows, the other lamps remain lit,
- lamp A is switched on or off by one switch, lamps B and C are switched on or off together by another switch,
- the total current in the circuit can be measured by adding a suitable instrument. the potential difference across lamp C can be measured by adding a suitable instrument.



[3]

Fig. 6.1

7 Fig. 7.1 shows an electric circuit containing a filament lamp, a resistor R, a 12 V battery and three ammeters and two voltmeters.

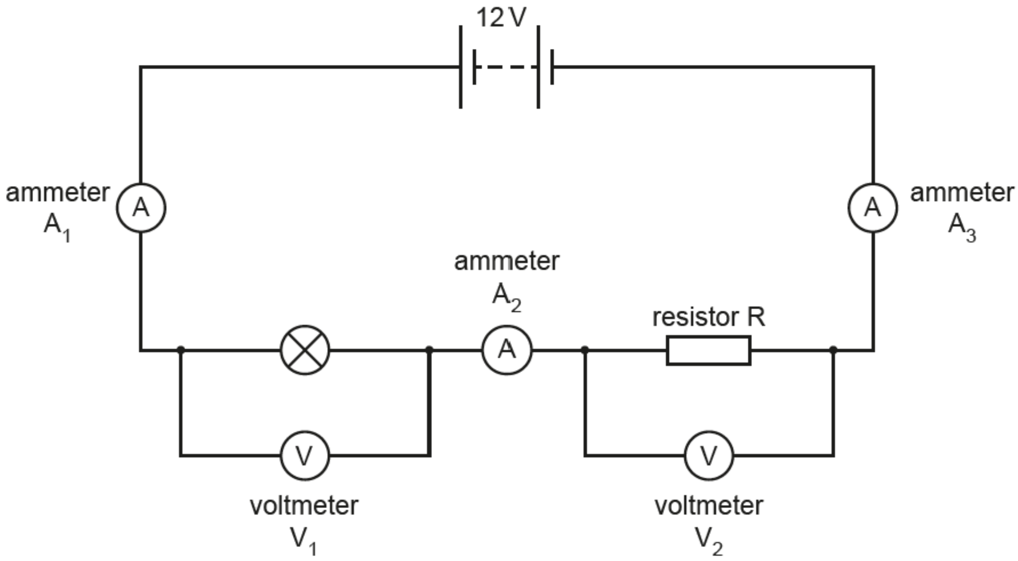


Fig. 7.1

(a) The reading on ammeter A_1 is 0.20 A. The reading on voltmeter V_1 is 4.0 V.

(i) State the readings on the other meters.

reading on ammeter A_2 = ...

reading on ammeter A_3 = ...

reading on voltmeter V_2 = ...[2]

(ii) Calculate the resistance of resistor R.

resistance = ...[2]

(b) Fig. 7.2 shows the current–voltage graph for the filament lamp.

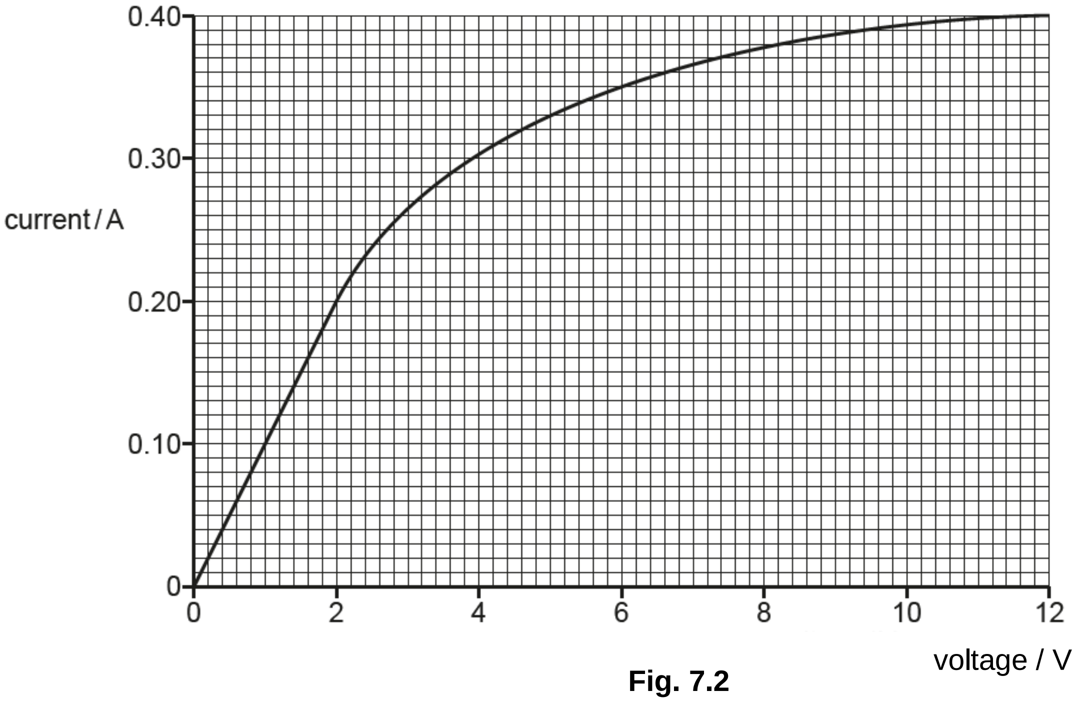


Fig. 7.2

(i) On Fig. 7.2, draw the current-voltage graph of resistor R. [1]

(ii) A student rearranges the circuit such that the lamp and the resistor are connected in **parallel**. Determine the current draw from the battery. Show your working clearly.

current = ...[2]

8 Fig. 8.1 shows a set-up that can be used to measure the daylight hours of the day. It can measure the length of time during which the daylight is at a certain brightness.

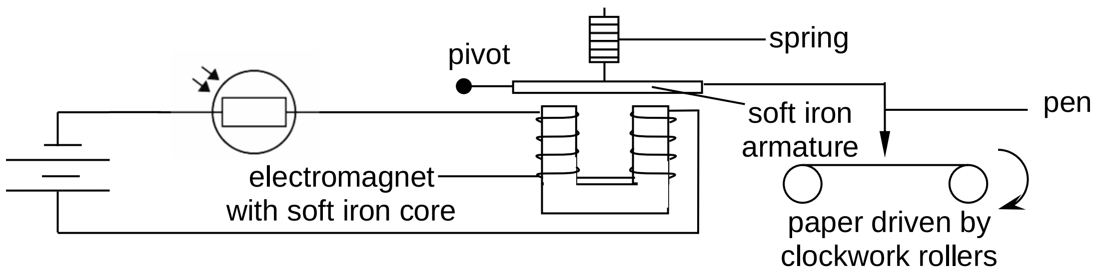


Fig. 8.1

(a) State how the resistance of the LDR changes with **decreasing** light intensity.

....[1]

(b) The pen draws a trace on the paper when sufficient light starts to fall on the LDR.

Explain why the pen stops writing when the surrounding of the LDR becomes dark.

.

....

....

.... [2]

(c) Explain why the trace will not show accurate results when the soft iron core is replaced with a steel bar.

....

....

.... [1]

9 Fig. 9.1 shows a solenoid around a soft iron core. A wire perpendicular to the page is placed next to it. A current flows in the wire and the direction is as shown in Fig. 9.1.

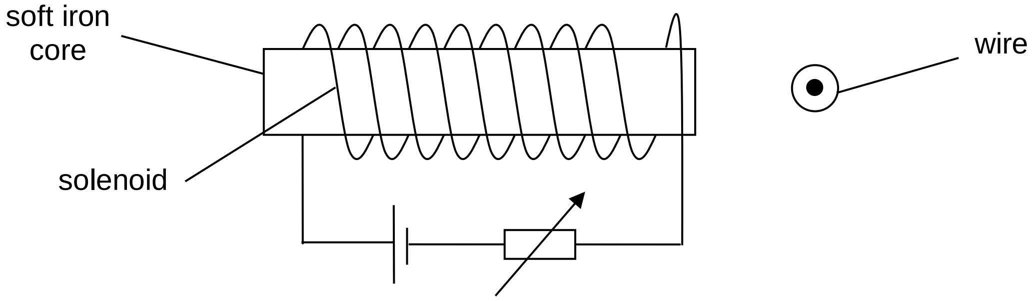


Fig. 9.1

(a) On Fig. 9.1, draw the magnetic field pattern inside the solenoid. Include three magnetic field lines in your drawing. [2]

(b) Explain why the wire experiences a magnetic force.

....

....

.... [1]

(c) On Fig. 9.1, draw an arrow to show the direction of the force on the wire and label it F. [1]

(d) State the effect on the magnitude of the force on the wire when the resistance of the rheostat is increased.

....

....

.... [1]

10 Fig. 10.1 shows a simple a.c. generator.

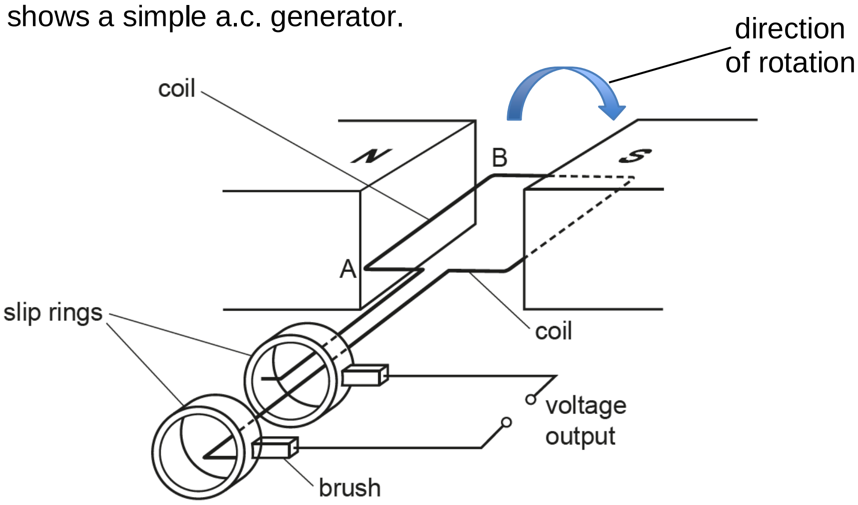


Fig. 10.1

(a) Explain why a voltage is induced in the coil when the coil is turned.

....

....

....[2]

(b) In Fig. 10.1 the coil is horizontal, with side AB on the left. The output voltage is +6.0 V.

State the output voltage when the coil is

(i) horizontal with AB on the right ……………………. [1]

(ii) vertical with AB on top ……………………. [1]

(c) The coil is turned in the direction shown in Fig. 10.1.

(i) Draw an arrow in Fig. 10.1 to show the direction of the induced current in side AB of the coil. [1]

(ii) Using Fleming's Left Hand Rule, explain why the current induced makes it harder to turn the coil.

....

....

....[1]

(d) Both A.C. generators and D.C. motors contain coils and brushes. State one difference between the structures of the A.C. generators and D.C. motors.

....

....[1]

[Turn over

11 One of the considerations in the design of bridge structures is the ability of the bridge pier to withstand a direct collision with a ship.

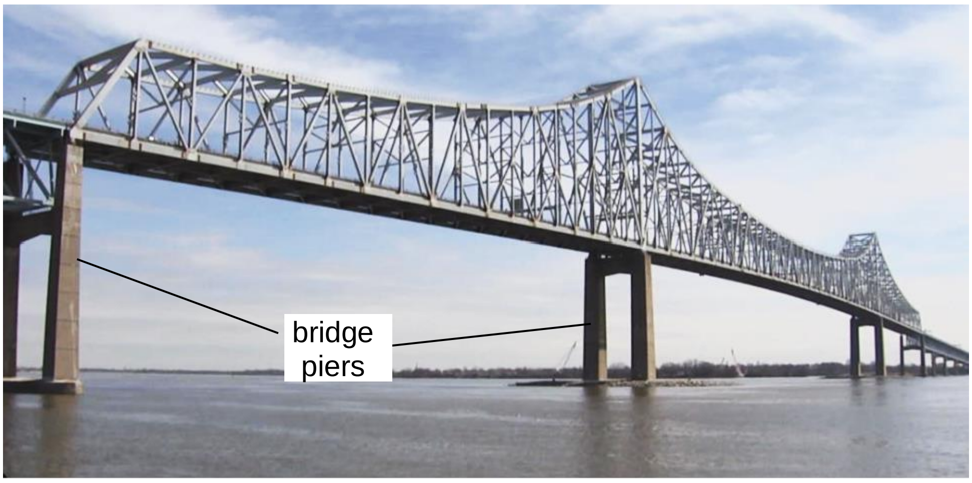


Fig. 11.1

In a collision incident, a ship of mass 1.0 x 10^8 kg collided into a bridge. The speed-time graph of the ship before and after the collision, in Fig. 11.2.

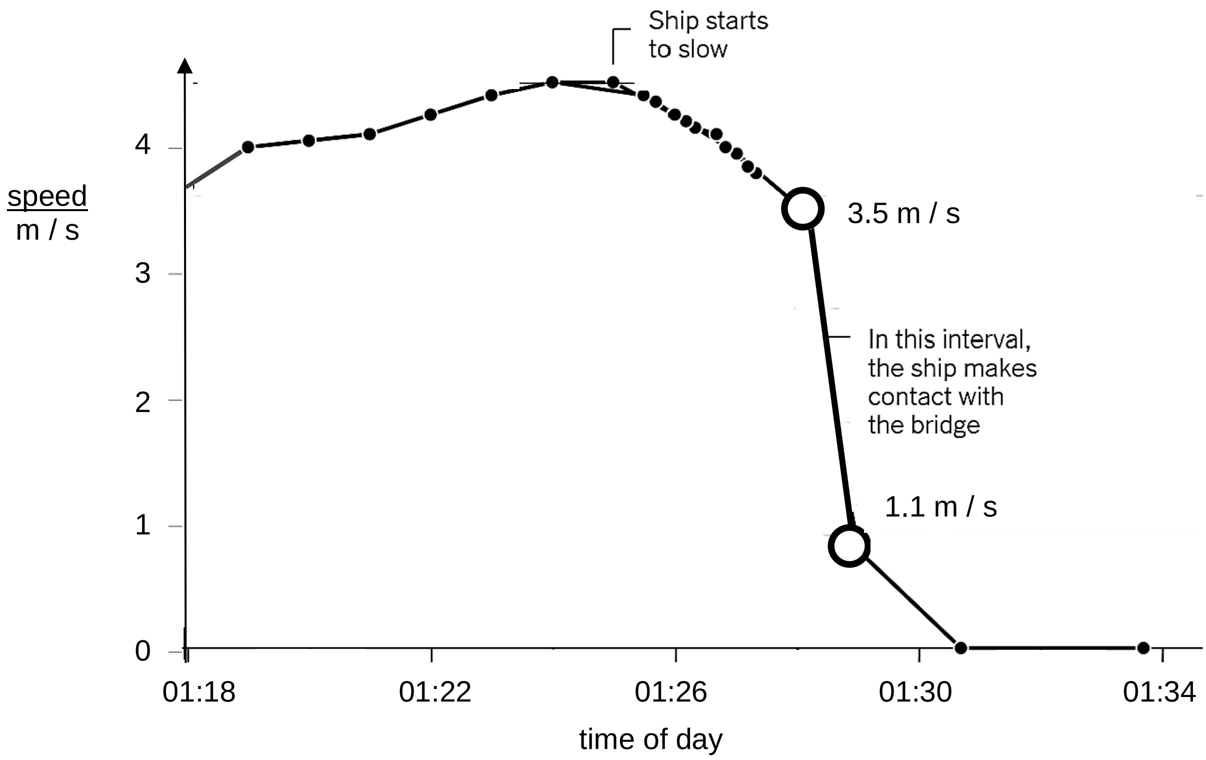


Fig. 11.2

(a) State what is meant by *acceleration*.

....

....[1]

(b) The ship is in contact with the bridge for 38 seconds.
By determining the deceleration of the ship when it is in contact with the bridge, show that the average force F exerted by the bridge on the ship is about 6×10^6 N.

[3]

(c) The calculation in **(b)** assumes the ship slowed at a uniform rate over 38 seconds. In reality, most of the deceleration happens in the first few seconds upon impact.

Fig. 11.3 estimates how the force F **in MN** depends on the duration of the collision, t.

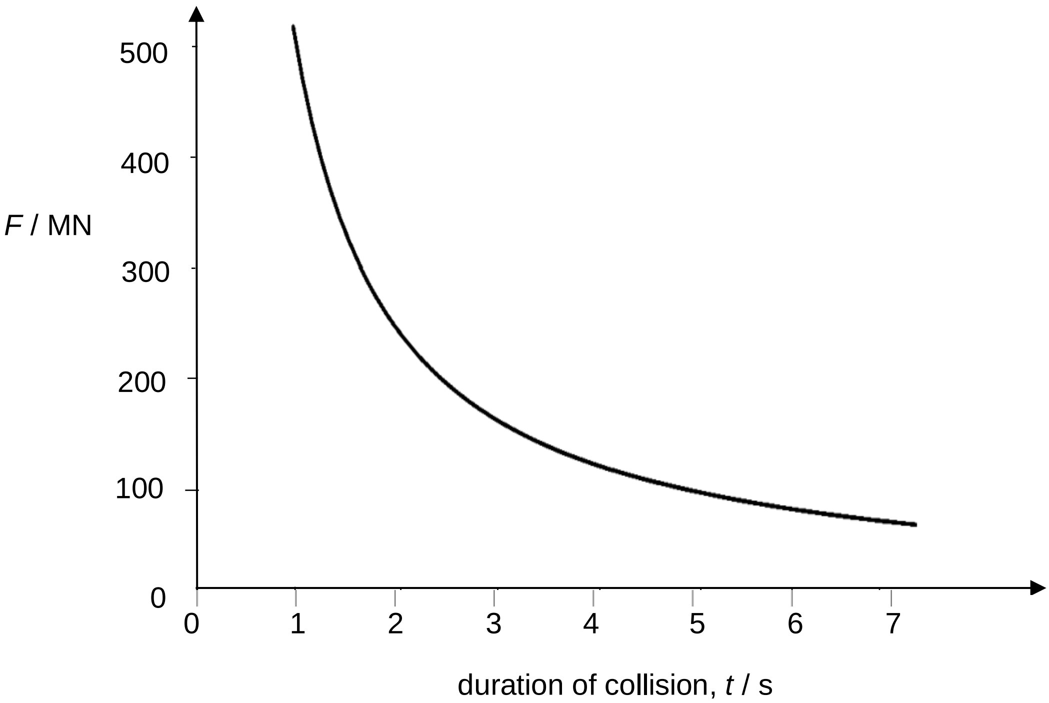


Fig. 11.3

Given that F is inversely proportional to t, use the information in Fig. 11.3 to estimate the value of F if the duration of collision is 9 seconds. Show your working clearly.

F = ... [2]

(d) One way to protect the bridge is to build flexible parts around the pier that move upon impact.

Fig. 11.4 shows the top view of a small ship of mass 1.2×10^6 kg. As the ship comes in to dock, it moves slowly sideways at a speed of 0.40 m / s and hits the flexible wooden pillar.

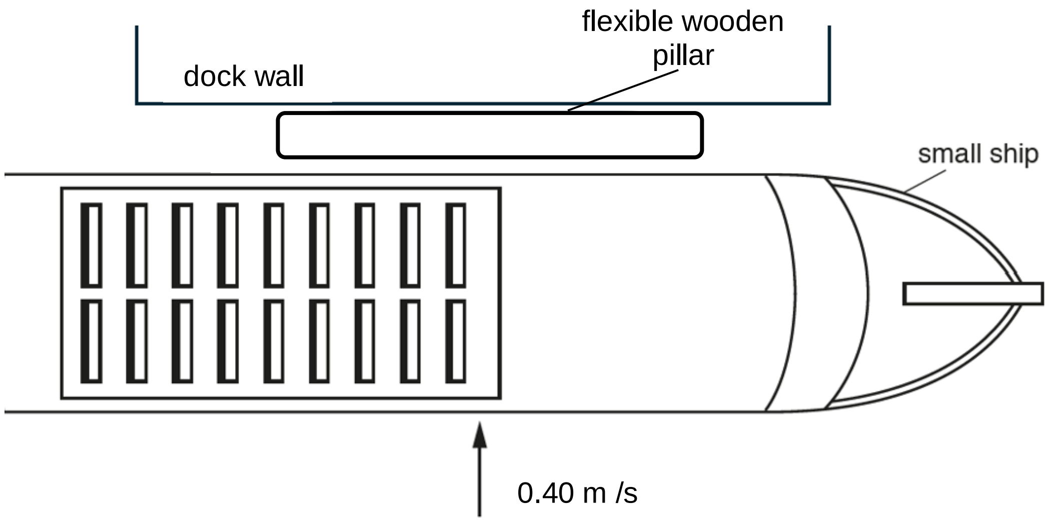


Fig. 11.4

(i) Calculate the kinetic energy of the ship before it hits the pillar.

kinetic energy = ……………………….[2]

(ii) When the ship hits the wooden pillar, the pillar move backward 0.45 m towards the dock wall until the ship comes to rest.

Assume that all the kinetic energy of the ship went into moving the pillar backward, calculate the decelerating force exerted by the pillar.

decelerating force = ……………………….[2]

adapted from New York Times article
https://www.nytimes.com/interactive/2024/03/28/upshot/baltimore-bridge-ship-force.html?unlocked_article_code=1.gU0.irpq.44SOz3-azEnR&smid=url-share

12 Sodium-24 and sodium-23 are two of the isotopes of sodium. Sodium-24 is a radioactive isotope that emits beta particles and gamma-rays as it decays.

The nuclide notation for the isotope sodium-24 is $^{24}_{11}\mathrm{Na}$.

(a) State how the composition of a nucleus of sodium-24 differs from the composition of a nucleus of sodium-23.

....

....[1]

(b) A nucleus of sodium-24 decays. It emits a beta-particle and produces a nucleus of magnesium (Mg).

Complete the decay equation below for this decay.

$$^{24}_{11}\mathrm{Na} \rightarrow \,^{\cdots\cdots}_{\cdots\cdots}\beta + \,^{\cdots\cdots}_{\cdots\cdots}\mathrm{Mg}$$

[2]

(c) Fig. 12.1 shows a beam of beta particles and a beam of gamma-rays entering the electric field between two oppositely charged plates.

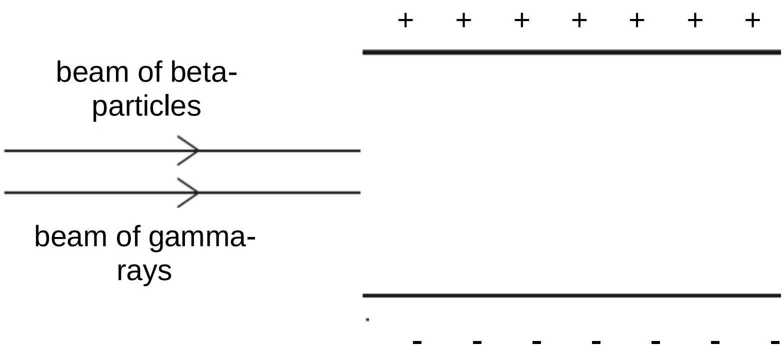


Fig. 12.1

On figure 12.1, draw the path of the beta particles and gamma-rays in the electric field between the charged plates. [2]

(c) The half-life of sodium-24 is 15 hours.

Sodium 24 is sometimes used in diagnosing medical conditions. State one reason why a half-life of 15 hours makes the isotope suitable for use in the human body.

....

....[1]

(d) A sample of sodium-24 is placed close to a radiation detector in a laboratory. There are no other radioactive samples in the laboratory. A counter records the count rate.

Fig. 12.2 shows the count rate plotted against time. The scale on the time axis is intentionally omitted.

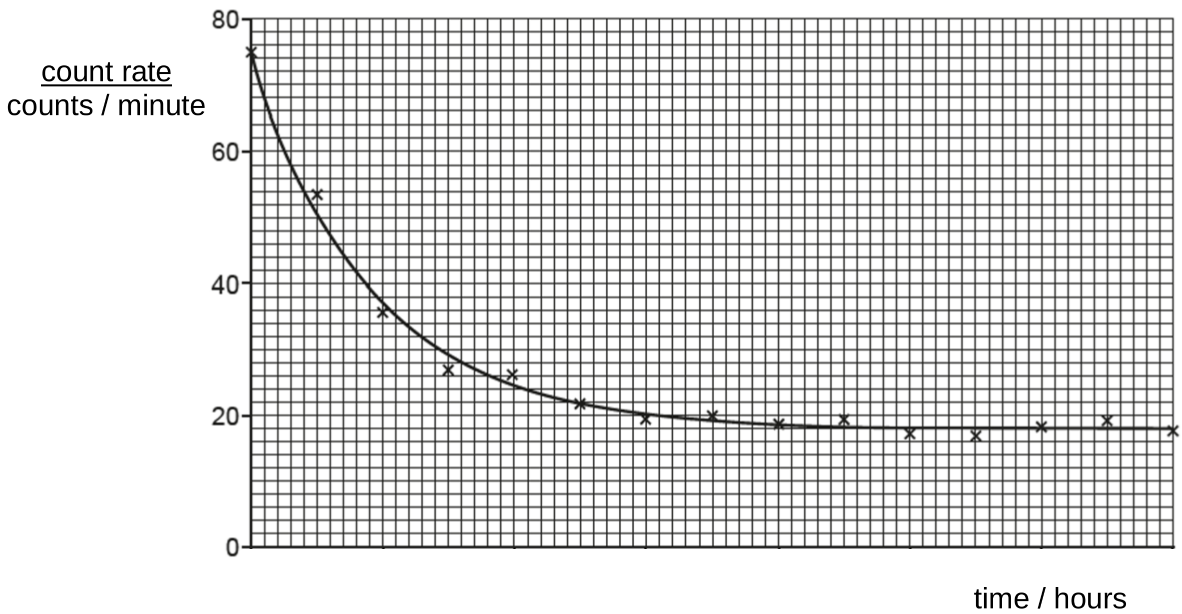


Fig. 12.2

(i) State the average background count rate.

count rate = ……………………. counts / minute [1]

(ii) The initial count rate detected by the radiation detector is 75 counts / minute. Given that the half-life of sodium-24 is 15 hours, determine the count rate detected after 45 hours. Show your working clearly.

count rate = ……………………. counts / minute [3]

Section B

Answer **one** question from this section.

13 For this question, the speed of light in air is assumed to be the same as in vacuum.

Red light of frequency 4.7 x10^{14} Hz travels in air.

(a) **(i)** Calculate the wavelength of this red light in air.

wavelength = ... [2]

(ii) Express your answer in **(i)** in nanometers.

wavelength = ...nm [1]

(b) Fig. 13.1 shows a narrow beam of this red light striking the surface of a parallel-sided glass block.

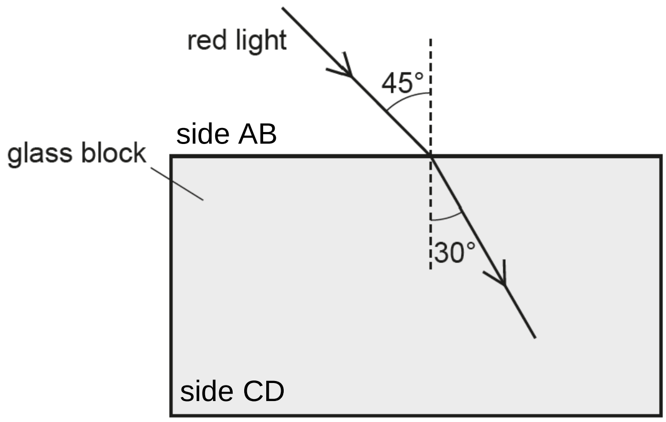


Fig. 13.1

(iii) State the effect (increases, decreases or unchanged) on the speed, frequency and wavelength of the light as it enters the block.

1. speed ....
2. frequency ....
3. wavelength .... [2]

[Turn over

(iv) Using the angles shown on Fig. 13.1, calculate the refractive index of the glass.

refractive index = ... [2]

(v) The light continues along the path shown in Fig. 13.1 until it strikes the bottom surface of the block. Light then emerges into the air.

Draw on Fig. 13.1 to show the path taken by the light until it strikes the bottom surface and the path of the light that emerges into the air. [1]

(vi) Explain whether it is possible for total internal reflection to occur at side CD of the glass block.

....

....

....

....[2]

14 Fig. 14.1 shows an air cooler that cools the air in a room by evaporation.

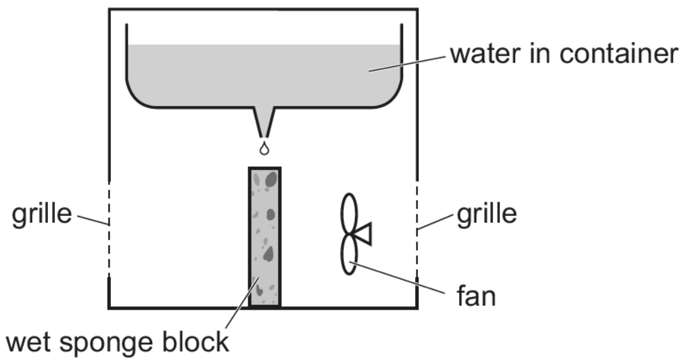


Fig. 14.1

Water drips from a container onto a sponge block and keeps the block wet.

A fan draws air in through one grille and drives the air out through the grille on the other side. As the air flows through the wet sponge block, the water in the sponge block evaporates.

(a) When the water evaporates, the temperature of water remaining in the sponge block decreases.

(i) Explain, in terms of the movement of particles, why this decrease in temperature occurs.

....

....

....[2]

(ii) State two ways in which evaporation differs from boiling.

1. ....

....

2. ....

....[2]

(b) The height of water is 28 cm when the water container is full,

Calculate the pressure at the bottom of the container due to the water. The density of water is 1000 kg / m^3.

pressure = ... [2]

[Turn over

(c) The evaporative air cooler is rated 120 W. It is switched on for 8 hours daily.

(i) Calculate the **weekly** cost savings when the evaporative air cooler is used instead of an air conditioner which is rated 900 W when it is running at maximum power. Cost of electrical energy is 23 cents per unit.

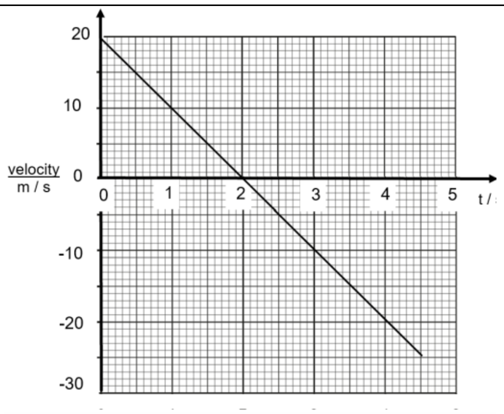
weekly cost savings = ... [3]

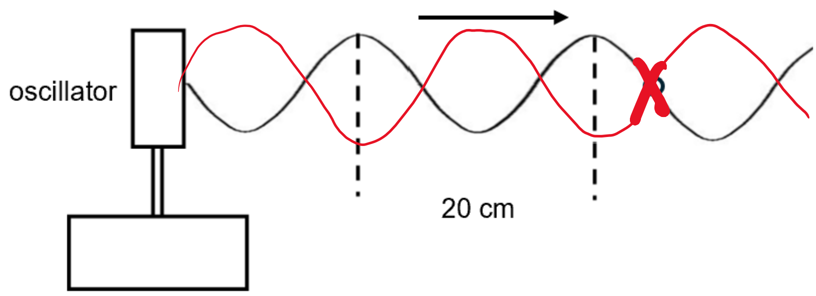
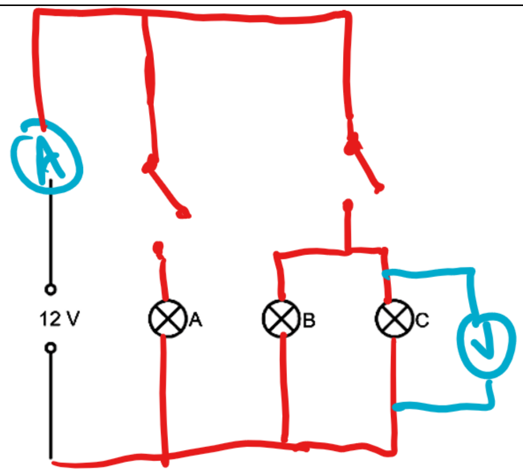
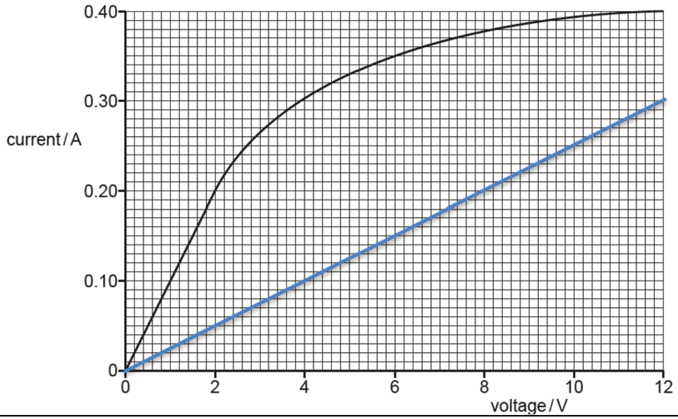
(ii) Suggest one reason why the actual cost savings may not be as high as calculated in **(c)(i)**.

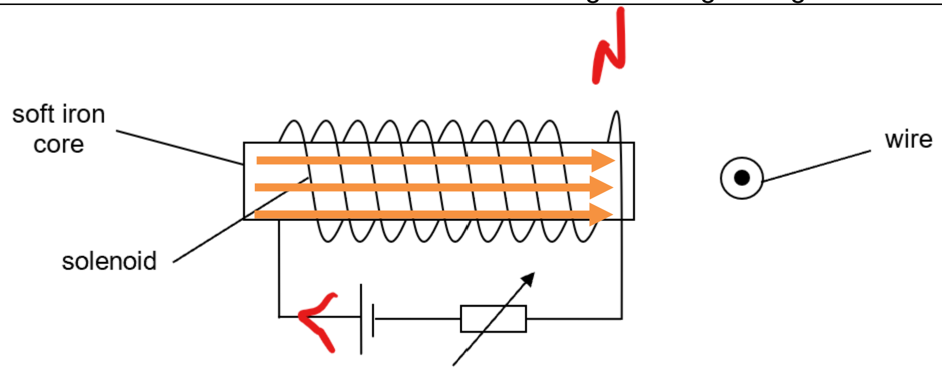
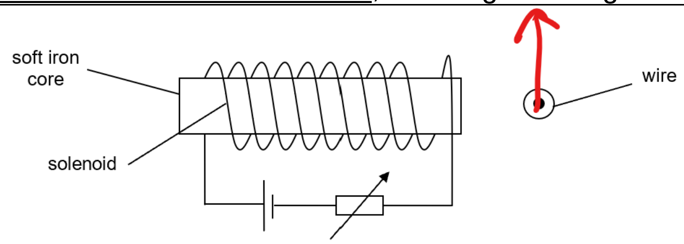
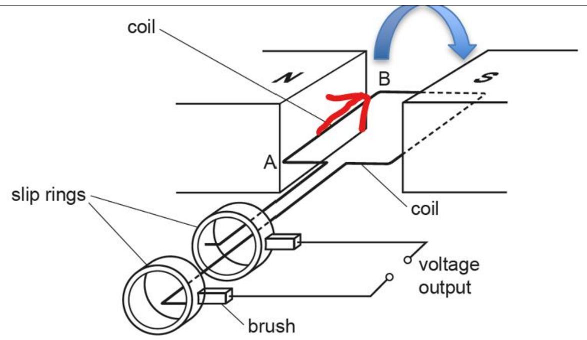
....

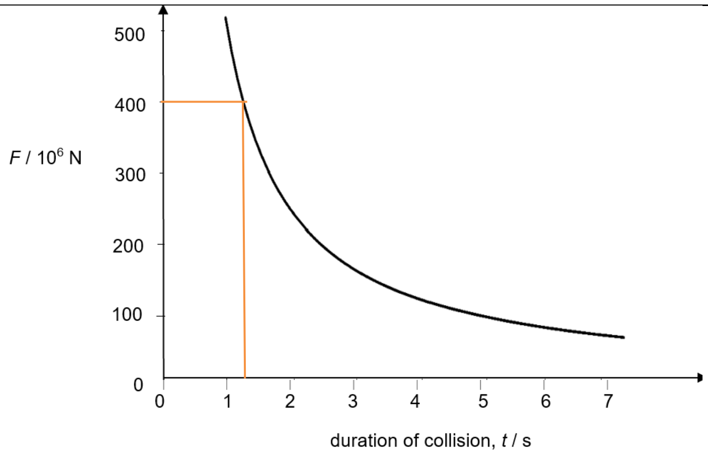
....

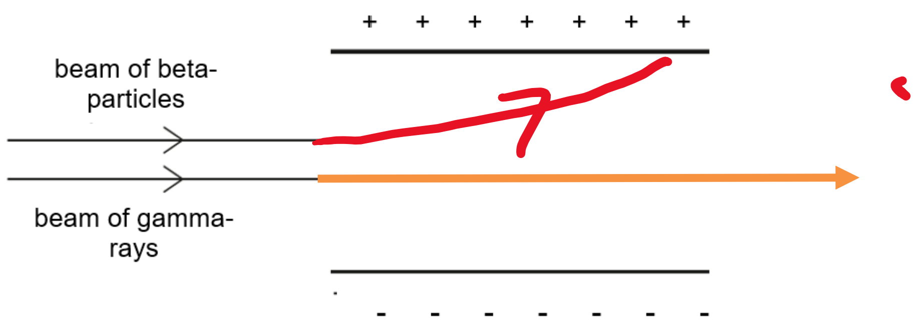
....[1]

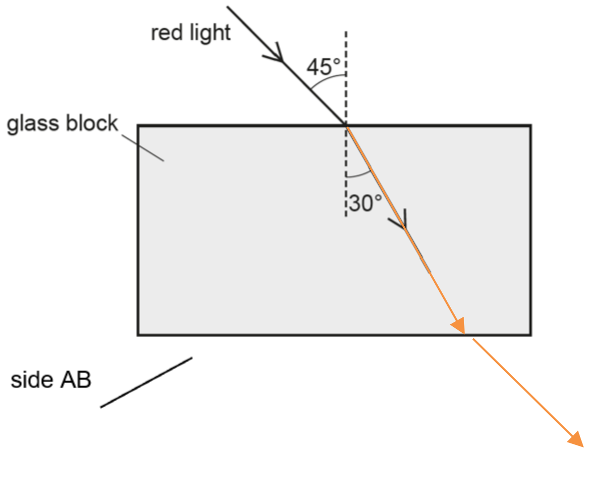
1		
a	Air particles are in <u>continuous</u> motion, <u>colliding</u> with the walls of rocket, exerting a <u>force</u>. Since <u>pressure is force per unit area</u>, pressure is exerted.	1 1
bi	Area under the graph from <u>t = 0 to 2</u> s = ½ x 2 x 20 = 20 m	1 1
bii		1 (ends at t = 4.5s)
biii	½ x 2.5 x 25 – 20 = 11.25 m = 11 m	 1
2ai	W = mg = (50/1000) x 10 = 0.50 N	 1
Aii	Force <u>exerted by the lamina on Earth</u>	1
Bi	Moment = f x d =0.50 x (8.0/100) = 0.040 Nm (accept Ncm)	 1 1
Bii	The final position of the lamina is with <u>CG (G) vertically below H.</u> The <u>perpendicular distance from G to H is 0</u>. There is <u>no moment</u> due to the weight.	1 1
3a	When heated, particles <u>move faster</u> and <u>collide</u> with their other particles more vigorously, <u>increasing separation</u>. The <u>intermolecular forces in liquid is not as strong</u> as compared to solids therefore they are able to move further apart compared to solids.	1 (mechanics of expansion) 1 (compare intermolecular forces)
Bi	energy supplied = mc (Δ θ) 20 x 2.0 x 60 = 0.200 x c x (40-15) c = 480 J /(kg °C)	 1, 1 (Pxt, m$\Delta\theta$) 1
4a	Agree, the <u>rope vibrates</u> vertically, which is <u>perpendicular to the direction the wave is travelling</u> (horizontally)	1 1

B		1 (waveform) 1 (X)
5a	Positive	1
5b	As the droplet remains stationary, by <u>Newton's first law,</u> the forces acting on the droplet must be <u>balanced</u>. The <u>electrostatic force</u> acting upwards balances the <u>weight</u> acting downwards	1 (N1L, balanced forces) 1 (mention the 2 forces)
6		1 (all lamps in parallel) 1 (switches symbols and positions) 1 (ammeter voltmeter symbols and positions)
7ai	A2= 0.20 A A3 = 0.20 A V2 = 8.0 V	1 (for A2 and A3) 1 (for V2)
7bii	R = V/I = 8.0/0.20 = 40 Ω	1 1
7bi		1
7bii	In parallel, both lamp and resistor have pd 12 V Total current drawn = 0.40 + 0.30 = 0.70 A (accept if pd resistor found by calculation)	 1 1
8a	Increases	1
8b	As it becomes dark, the resistance of the LDR increases and the <u>current in a circuit decreases</u>.	 1

	The electromagnet becomes weaker and is unable to attract the soft iron armature. Therefore the pen stops writing	1
8c	Steel retains its magnetism and therefore will continue attracting the soft iron armature even when the current is no longer strong enough.	1
9a	 **Fig. 9.1**	1 (direction) 1 (parallel, evenly spaced)
9b	The magnetic field due to the solenoid interacts with the magnetic field due to the current in the wire, resulting in a magnetic force	1
9c	 **Fig. 9.1**	1
9d	When the resistance in the circuit increases, the current in the solenoid decreases, hence reducing the magnitude of the force.	1
10a	When the coil turns, there is a change in the magnetic flux linked to the coil. By Faraday's law, an emf whose magnitude is proportional to the rate of change of magnetic flux in the circuit is induced	1 1
10b	(i) -6.0 V (ii) 0 V	1 1
10ci		1
10cii	By Flemming's left hand rule, the induced current from flowing from A to B would produce a force acting downwards. This makes it harder to turn the coil clockwise	1
10d	The DC motor has a split ring commutator whereas the AC generator has split rings	1

11a	Rate of change of velocity.	1
B	A = v-u / t = (3.5 – 1.1) / 38 = 0.0632 m/s^2 F = ma = 1.0 x 10^8 x 0.632 = 6.3 x 10^6 N	 1 1 1
c	 F = k/t 400= k /1.2 k = 480 If t = 9, F = 480/9 =53 F is approx.= 53 x10^6 N	1 (method to find k) 1 (correct method to find F)
Di	KE = ½ mv^2 = ½ x 1.2 × 10^6 x 0.40^2 = 96 kJ	 1 1
dii	KE = fxd 96 000 = f x 0.45 F = 210 kN	 1 1
12a	The nucleus of sodium-24 contains 13 neutrons whereas the nucleus of sodium-23 contains 12 neutrons Accept the nucleus of sodium-24 contains 1 more meutron than sodium-23.	1
12b	${}^{24}_{11}Na \rightarrow {}^{0}_{-1}\beta + {}^{24}_{12}Mg$	1 (beta) 1 (Mg)

12b		1 1
12c	A short half life of 15 hours would ensure that the radioactive isotope <u>will not remain in the body for a long time</u>	1
12di	18	1
12dii	Initial corrected count rate = 75-18 = 57 45 hours = 45/15 = 3 half lifes Final corrected count rate = $57/2^3$ =7 Detected count rate = 7+18 = 25 counts/min Award 2m if did not correct for background	 1(evidence of dividing to get number of half lives) 1 (evidence of dividing to get count rate) 1
13ai	V = f λ $3.0 \times 10^8 = 4.70 \times 10^{14} \times \lambda$ $\Lambda = 6.4 \times 10^{-7}$ m	 1(prefix),1 1
13aii	$6.4 \times 10^{-7} = 6.4 \times 100 \times 10^{-9}$ = 640 nm	 1
13bi	Speed decreases Frequency unchanged Wavelength decreases	1 1
13bii	n = sin (45°)/sin(30°) = 1.4	1 1

13biii	 **Fig. 13.1**	1
13biv	For total internal reflection to occur at side CD, the angle of incidence must be greater than the critical angle. However, it is not possible for light to enter the glass block at side AB with the angle of incidence greater than 90°. Therefore it is impossible for TIR to occur at site CD	1 1
14ai	The more energetic particles close to the surface of the water have enough energy to overcome intermolecular forces and escape as vapor. The average KE of the remaining particles is now lower, leading to a decrease in temperature	1 1
14aii	Evaporation happens only at the surface, boiling occurs throughout the volume of the liquid. Evaporation happens at all temperatures, boiling only occurs at the boiling point. Bubbles are seen during boiling whereas no bubbles are seen during evaporation. Boiling requires an external heat source whereas evaporation does not.	1,1 Any 2
14b	P = hpg = (28/100) x 1000 x 10 = 2800 Pa	 1 (evidence of) 1
14ci	Savings = ((900-120)/1000)x8x7x0.23 =$10	1 (evidence of E=pxt), 1 (cost) 1
14cii	The airconditioner although rated 900 W, is not running at maximum power throughout the 8 hours OR Once the temperature is reached, the airconditioner switches to fan mode which is does not need 900 W. Any reasonable answer	1