Class	Index Number	Name
14		

ST. ANDREW'S JUNIOR COLLEGE
JC 2 2015
Preliminary Examinations

PHYSICS, Higher 1 — **8866 / 02**
Paper 2 Structured Questions

2 Sept 2015
2 hours
0800-1000 hrs

Candidates answer on the question paper.
No additional materials are required.

READ THESE INSTRUCTIONS FIRST

Write your name, index number and Civics Group on all the work you hand in.
Write in dark blue or black pen on both sides of the paper.
You may use a soft pencil for any diagrams, graphs or rough working.
Do not use staples, paper clips, highlighters, glue or correction fluid..

Section A
Answer **all** questions.

Section B
Answer **any two** questions.

At the end of the examination, fasten all your work securely together.
The number of marks is given in brackets **[ ]** at the end of each question or part question.

For Examiner's Use	
Section A	
1	
2	
3	
4	
5	
Section B	
6	
7	
8	
Total	

This document consists of **23** printed pages including this page.

DATA AND FORMULAE

Data

speed of light in free space	c	=	3.00×10^{8} m s^{-1}
elementary charge	e	=	1.60×10^{-19} C
the Planck constant	h	=	6.63×10^{-34} J s
unified atomic mass constant	u	=	1.66×10^{-27} kg
rest mass of electron	m_e	=	9.11×10^{-31} kg
rest mass of proton	m_p	=	1.67×10^{-27} kg
acceleration of free fall	g	=	9.81 m s^{-2}

Formulae

uniformly accelerated motion	s	=	$ut + \frac{1}{2}at^2$
	v^2	=	$u^2 + 2as$
work done on/by a gas	W	=	$p\Delta V$
hydrostatic pressure	p	=	ρgh
resistors in series	R	=	$R_1 + R_2 + ...$
resistors in parallel	$1/R$	=	$1/R_1 + 1/R_2 + ...$

Section A

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

1. A car is stopped by varying the braking force. The braking force is increased to a maximum and then reduced, at the same rate, to zero just as stopping occurs. In this way a passenger in the car is subjected to the least possible jerk. The acceleration of the car, during the 10 s braking time, is shown in Fig. 1.1.

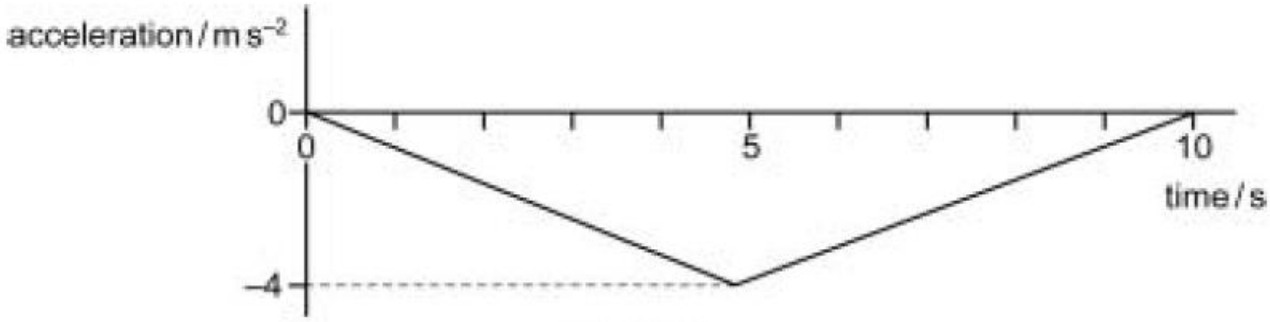

Fig. 1.1

(a) State what is meant by the term acceleration.

....

.... [1]

(b) On the axes of Fig.1.2, sketch a graph to show how the velocity of the car will change during 10 seconds braking time. The car starts with a velocity of 20 m s^{-1}.

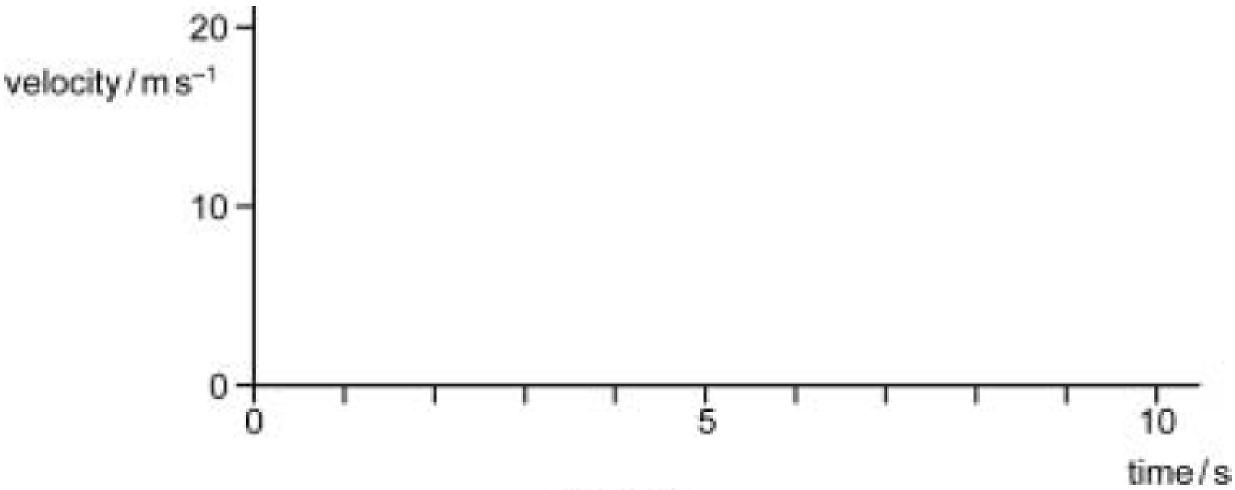

Fig. 1.2

[3]

(i) State the feature of a velocity-time graph that gives the displacement

....

.... [1]

(ii) Estimate the total distance travelled while braking. Show your reasoning.

stopping distance = ... m [2]

(iii) On the axes of Fig. 1.3, sketch a displacement-time graph for the car for the 10 seconds braking time.

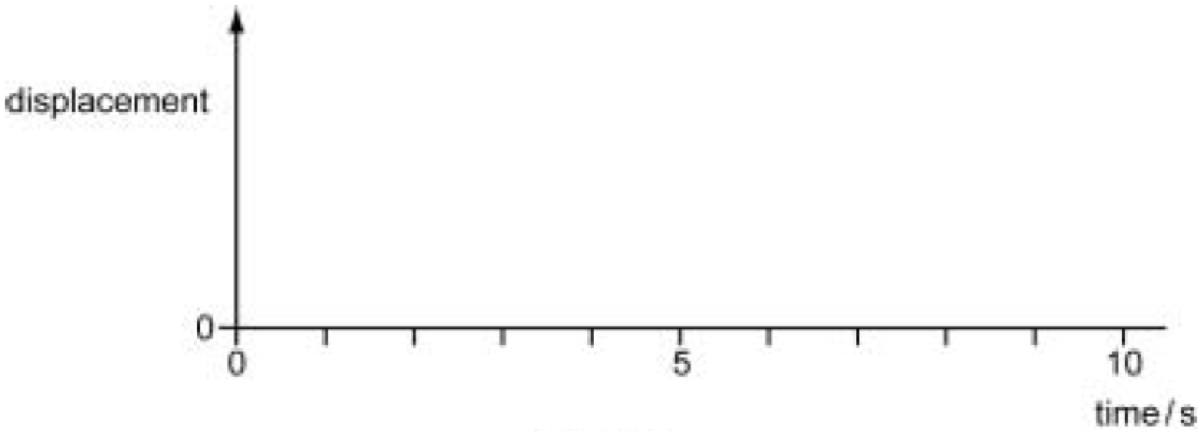

Fig. 1.3

[2]

(c) Suggest why this method of stopping is more comfortable for the passenger than a more usual method where the braking force is kept constant during deceleration.

....

....

....

.... [2]

2 **(a)** State the principle of conservation of *linear momentum*.

……………………………………………………………………………………..

……………………………………………………………………………………..

…………………………………………………………………………………… [2]

(b) A railway truck of mass 22000 kg and moving at a speed of 3 m s^{-1} catches up and collides with a truck of mass 66 000 kg moving at 1 m s^{-1} moving in the same direction as shown in Fig.2.1.

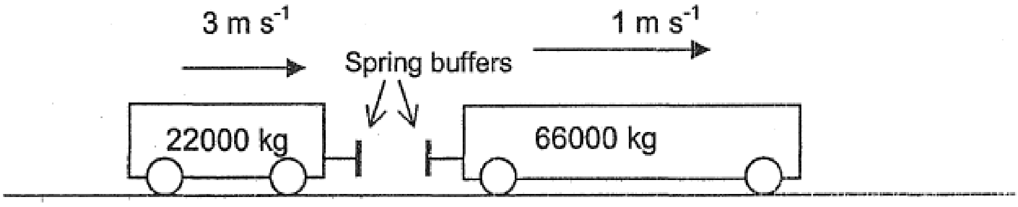

Fig. 2.1

Fig. 2.2 shows the speeds of the trucks before, during and after the collision.

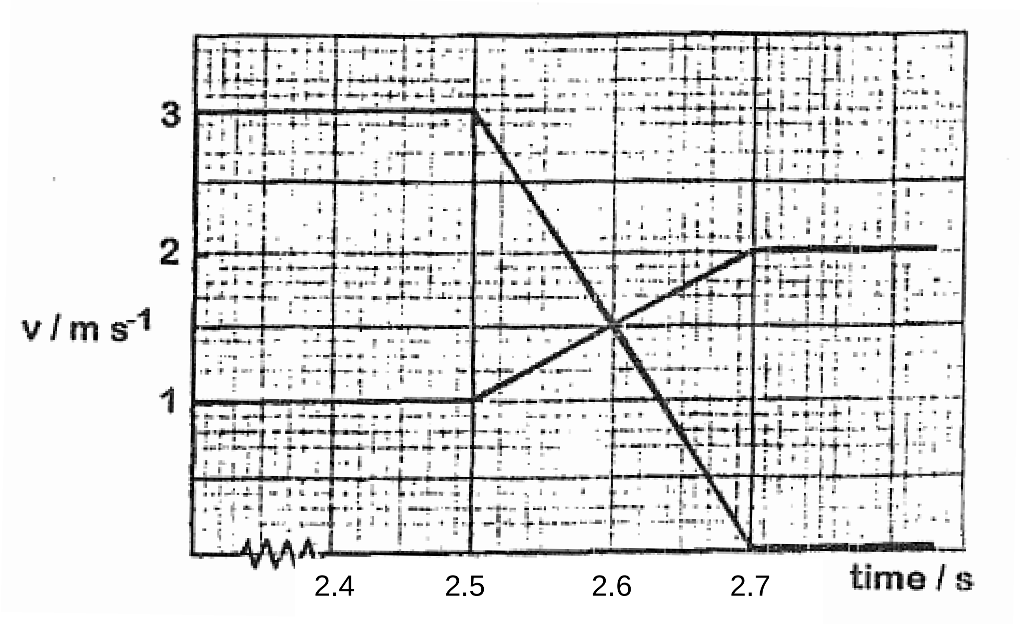

Fig. 2.2

(i) Calculate the magnitude of the impulse exerted by the lighter truck on the heavier truck during the collision.

impulse …………………N s [2]

(ii) Use the information from **Fig. 2.2** to determine whether the collision is elastic. [2]

(iii) The total kinetic energy at the instant halfway through the collision at t = 2.6 s is **lower** than the total kinetic energy of the trucks after the collision. Suggest a reason for this difference.

……………………………………………………………………………………

……………………………………………………………………………………

………………………………………………………………………………… [1]

3 The drag force F acting on a solid object moving with a velocity v through a fluid is given by

$$F = kv^2$$

where k = 13360 N m^{-2} s^2.

(a) State the direction of this drag force with respect to the motion of object.

………………………………………………………………………………… [1]

(b) A submarine travels in water at a uniform velocity of 5.0 m s^{-1}. Show that the power supplied by the engine is 1.67 MW. [2]

(c) If the engine is 60% efficient, determine its power input.

input power …………………W [2]

4 **(a)** Define *magnetic flux density*.

…………………………………………………………………………………………..

…………………………………………………………………………………………..

……………………………………………………………………………………… [2]

(b) Fig. 4 shows the position of a current carrying wire in a magnetic field where the magnetic flux density *B* is 0.40 T towards the right.

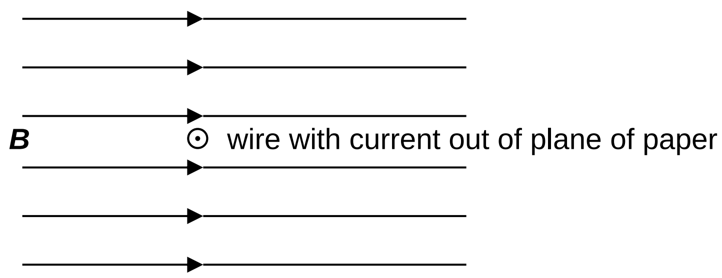

Fig. 4

The wire, which is of length 0.12 m, carries a current of 3.0 A out of the plane of the paper.

(i) Draw a diagram to show the shape and direction of the magnetic field due to the current in the wire [2]

(ii) Calculate the force acting on the wire.

force = ……………… [2]

5 An object that is at a higher temperature than its surrounding loses thermal energy by emitting electromagnetic radiation. For loss of thermal energy as electromagnetic radiation, the intensity I_λ of the emitted radiation of wavelength λ varies with wavelength λ as shown in Fig. 5.1.

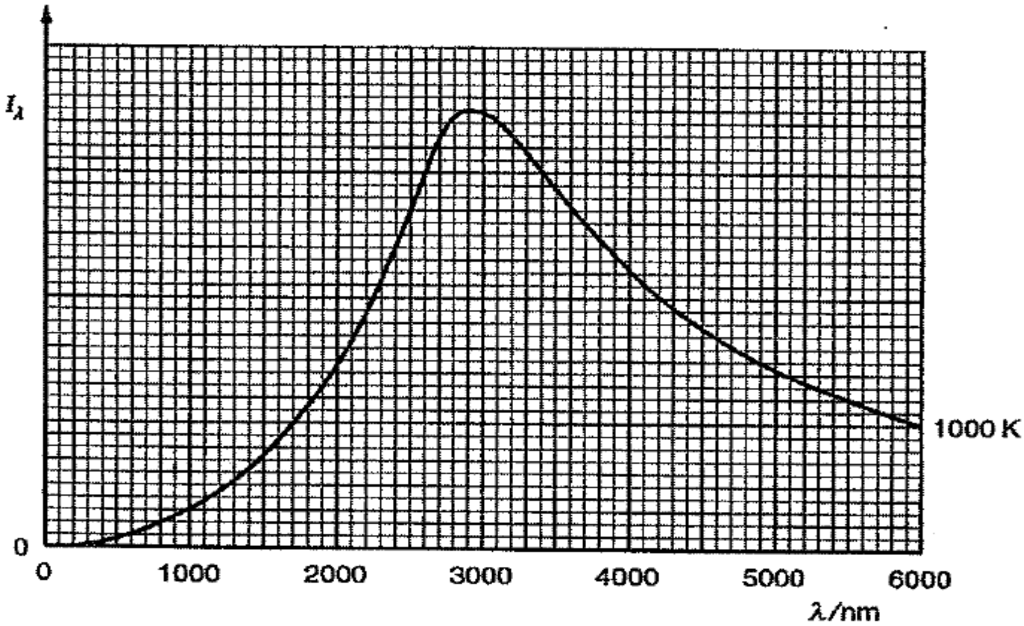

Fig. 5.1

Fig. 5.1 shows the variation of I_λ with λ for the body when it is at 1000 K. The distribution of intensity is different at different temperatures. This is illustrated in Fig. 5.2.

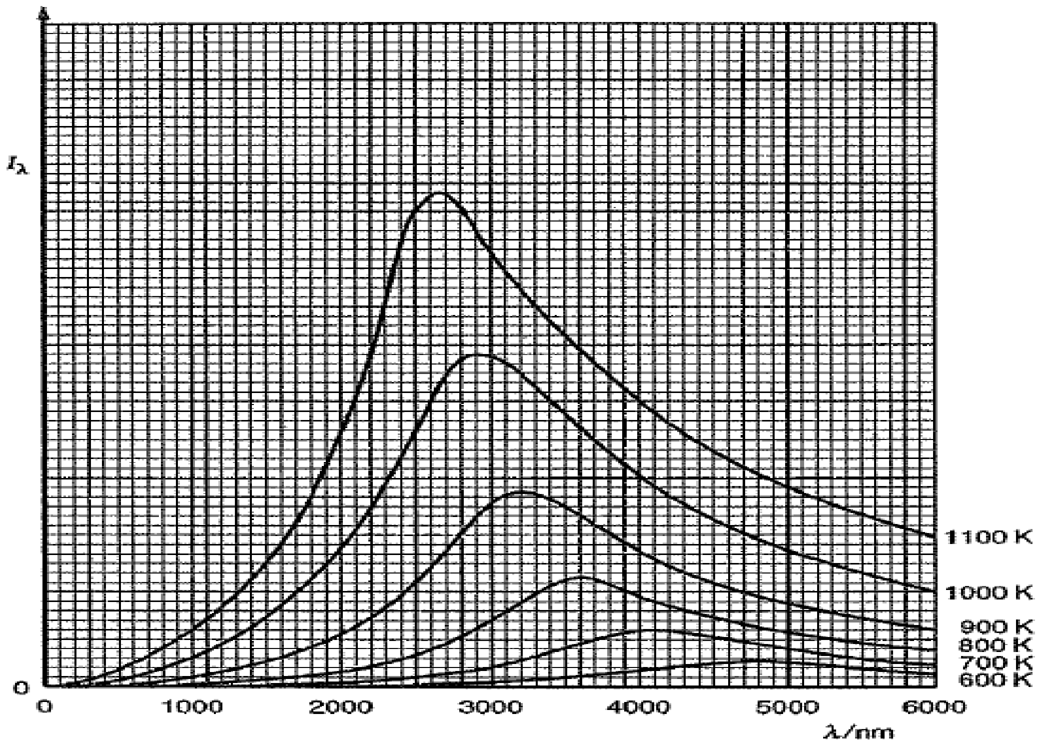

Fig. 5.2

5 (a) (i) On the horizontal axis of Fig. 5.2, indicate with the letter V a wavelength that is in the visible region of the electromagnetic spectrum. [1]

(ii) Hence, suggest why, at a temperature of 1100 K, the object would glow with a red colour.

…………………………………………………………………………………………

…………………………………………………………………………………………

…………………………………………………………………………………………

………………………………………………………………………………………… [1]

(b) At any temperature T, the graph of Fig. 5.2 shows a peak corresponding to a wavelength λ_{max} and an intensity I_{max}. Data for T and λ_{max} are shown in Fig. 5.3.

T / K	λ_{max} / nm
600	4830
700	4140
800	3610
900	3210
1000	2900
1100	2630

Fig. 5.3

(i) Without drawing a graph, show that

$$T \times \lambda_{max} = \text{constant},$$

and determine this constant.

constant = ……………. [3]

(ii) Hence determine the wavelength for maximum intensity at a temperature T of 1200 K.

wavelength= ……………. m [1]

(c) The total intensity of emitted radiation from a particular body at temperature T is I_{tot}. Fig. 5.4 shows the values of lg(T/K) plotted against the corresponding values of lg(I_{tot}/W m^{-2}).

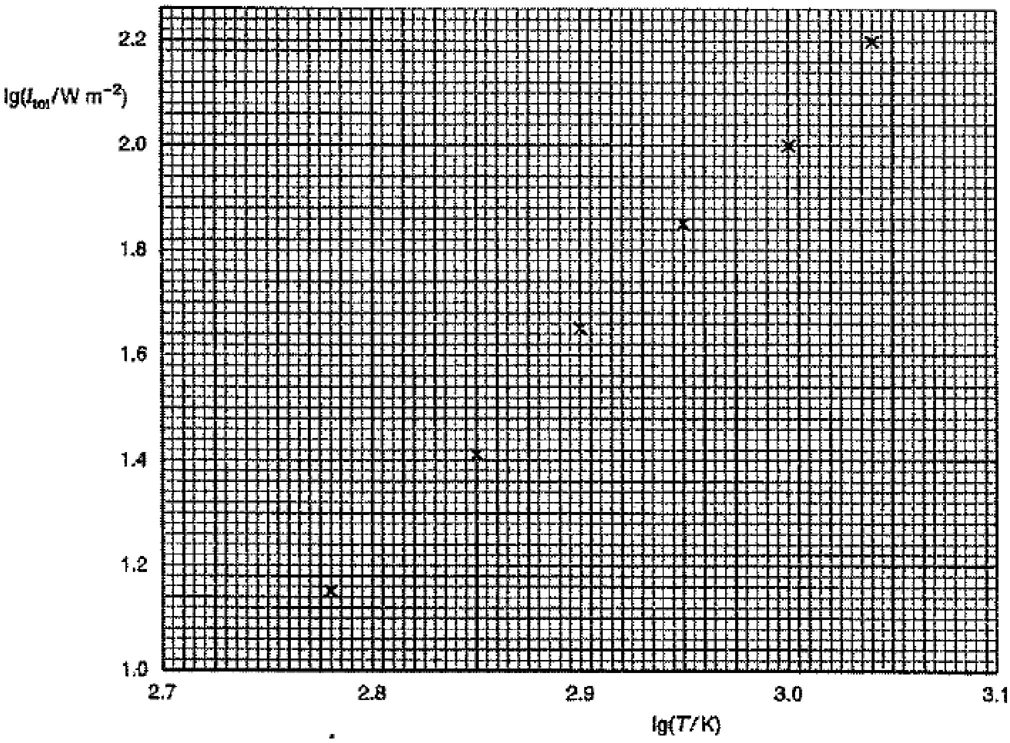

Fig. 5.3

It is known that I_{tot} varies with T according to the relation

$$I_{tot} = cT^n$$

where c and n are constants.

(i) Use Fig. 5.4 to determine a value for n.

n = ……………. [3]

(ii) For this body at T = 900 K, I_{tot} is found to be 71 W m^{-2}. Use the data and your answer to **(i)** to determine I_{tot} for the body of a temperature of 1200 K.

I_{tot} = ……………. W m^{-2} [2]

Section B

Answer **two** of the questions in this section.

6 (a) Explain what is meant by the *principle of superposition* of waves.

....

....

....[2]

(b) A vibrating dipper causes a water wave of small amplitude to travel in a tank of water 0.026 m deep, as shown in Fig. 6.1. The mean speed v of the travelling water wave is given by $v = k\sqrt{h}$ where h is the water depth and k is a constant.

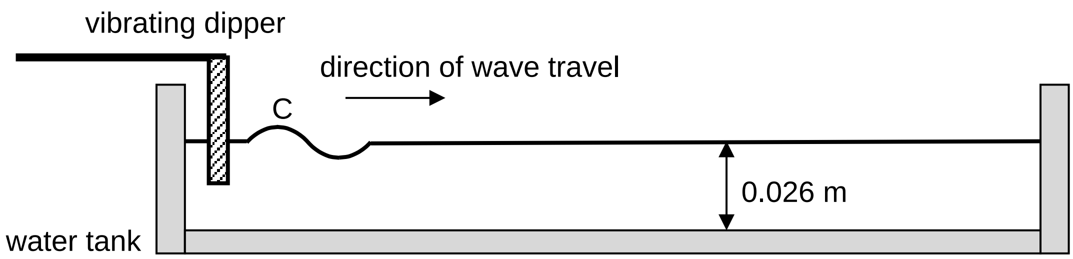

Fig. 6.1

(i) Determine the unit of the constant k in the equation.

unit = ... [2]

(ii) Given that k is 3.13, show that the mean speed of the water wave is 0.50 $m\,s^{-1}$. Hence, calculate the frequency of the vibrating dipper, given that the distance between 2 adjacent crests of the water wave is 0.025 m.

frequency = ... Hz [2]

(iii) Calculate the time taken for crest C to travel a distance of 0.125 m.

time taken = ... s [2]

(c) Two such dippers S_1 and S_2 are set to vibrate with the same frequency and in anti-phase. The plan view of the dippers is shown in Fig. 6.2.

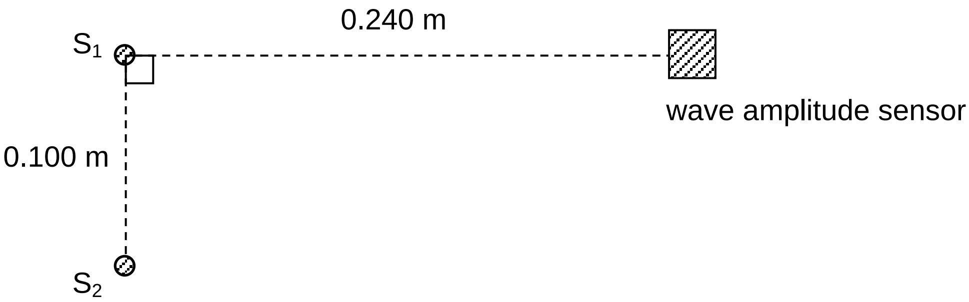

Fig. 6.2

A wave amplitude sensor is positioned at a perpendicular distance of 0.240 m from S_1.

(i) Both dippers are now driven at a frequency of 50 Hz, with the mean speed of the water wave remaining unchanged at 0.50 $m\,s^{-1}$.

1. Calculate the path difference between the waves from S_1 and S_2 arriving at the sensor, in terms of multiples of the wavelength λ.

path difference = ... λ [2]

2. Hence, state the amplitude of waves detected by the sensor.

.... [1]

(ii) If the frequency of the dippers were to be increased slowly to 100 Hz, explain what the sensor will detect during this change.

....

....

....

....

.... [3]

(d) A layer of fine sand is now sprinkled at the bottom of the tank and the water depth is reduced. The dipper is now replaced by a plane dipper which is made to oscillate vertically in the water so that plane waves can be set up in the water tank. A barrier is also placed at the opposite end of the tank so that the plane waves will strike it. Fig. 6.3 shows the plan view of the plane waves in the water tank.

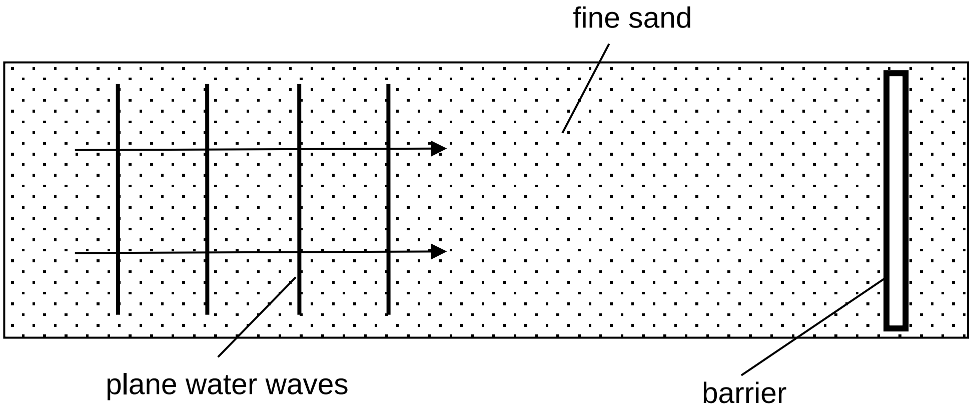

Fig. 6.3

The sand settles down into equally-spaced sand ridges parallel to the barrier. Fig. 6.4 shows the front view of the sand ridges in the water tank.

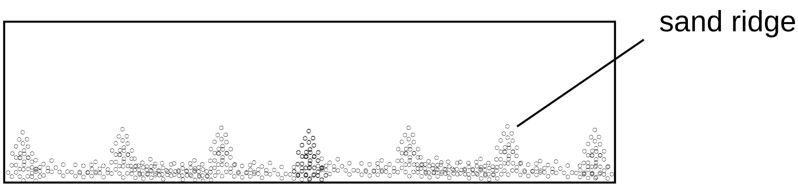

Fig. 6.4

(i) Explain the formation of the sand ridges.

....

....

....

....

....

.... [3]

(ii) Adjacent ridges are spaced 0.018 m apart when the plane dipper vibrates at 12 Hz. Calculate the new water depth for the formation of the sand ridges.

depth = ... m [3]

7 (a) On Fig. 7.1 and Fig. 7.2, sketch the current-voltage (I – V) characteristics of

(i) a metallic conductor at a constant temperature,

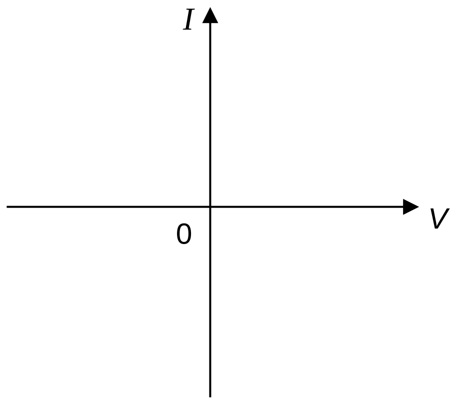

Fig. 7.1

[1]

(ii) an ideal semiconductor diode.

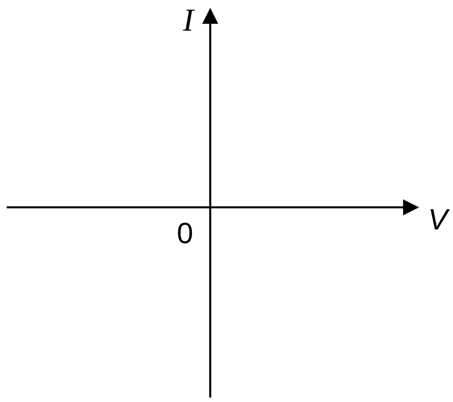

Fig. 7.2

[1]

(b) Fig. 7.3 shows the I – V characteristics of a thermistor.

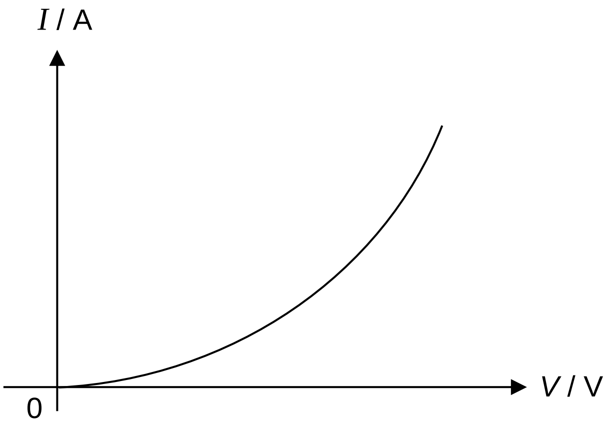

Fig. 7.3

(i) Explain why the resistance of the thermistor decreases with current.

....

....

....

.... [2]

(ii) Explain how the resistance of the thermistor can be obtained from Fig. 7.3.

....

.... [1]

(iii) On Fig. 7.4, sketch the variation of the power *P* of the thermistor with potential difference *V*.

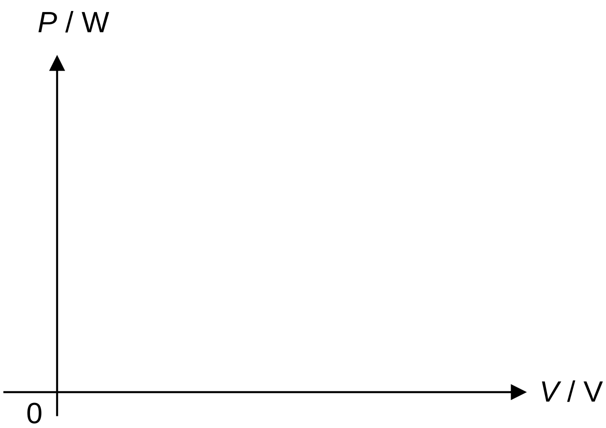

Fig. 7.4

[2]

(iv) The thermistor and a 500 Ω resistor form a potential divider between voltage lines held at +120 V and 0 V as shown in Fig. 7.5.

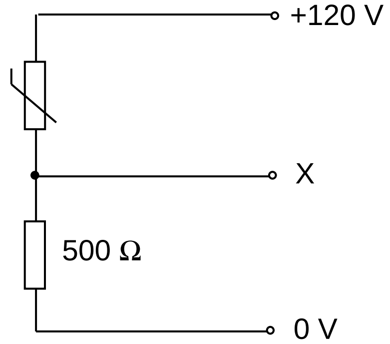

Fig. 7.5

The resistance of the thermistor is 1000 Ω at low temperature but then drops to 100 Ω at high temperature. Determine the corresponding change in the potential at X.

change in potential = ... V [3]

(c) Three identical lamps with a rating of 6 V and 10 W are connected to a cell of e.m.f. 12 V as shown in Fig. 7.6.

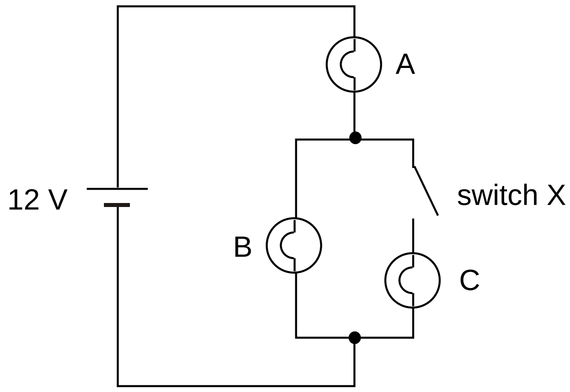

Fig. 7.6

Switch X is closed. Explain how the brightness of the lamps A and B changes.

....

....

....

....

.... [3]

(d) A lamp X of resistance 48 Ω is connected to a cell of e.m.f. 12 V and internal resistance 3.9 Ω as shown in Fig. 7.7.

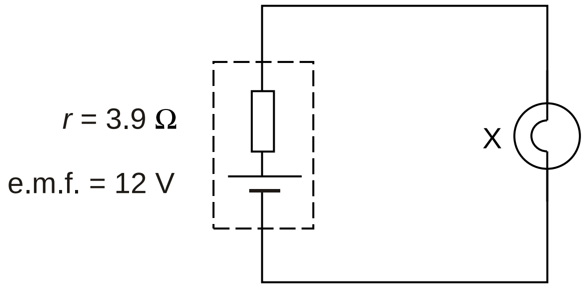

Fig. 7.7

(i) Determine the power dissipated by lamp X.

power = ... W [2]

(ii) If lamp X has been switched on for 1.0 minute, determine the amount of charge that passes through the cell.

charge = ... C [2]

(iii) Hence, determine the efficiency of the circuit in transmitting energy from the cell to lamp X.

efficiency = ... % [3]

8 **(a)** Fig. 8.1 shows a photocell, which consist of an emitter and collector inside an evacuated tube.

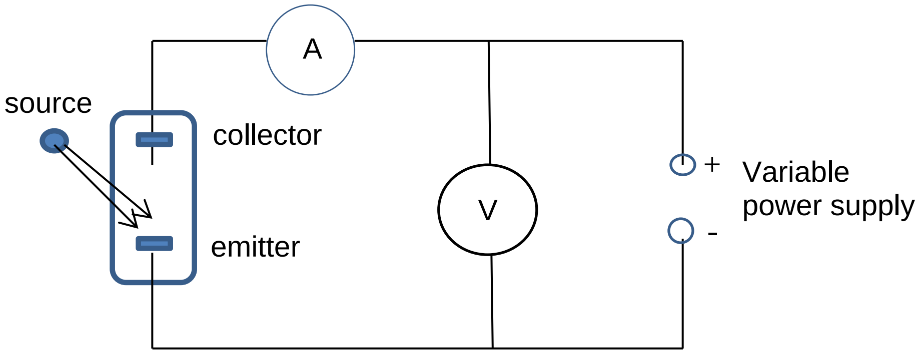

Fig 8.1

When the clean metal surface of the emitter is exposed to electromagnetic radiation from a source, photoelectrons are ejected. The collector collects the photoelectrons and the sensitive ammeter indicates the presence of a small current.

(i) Explain why photoelectrons are emitted with kinetic energies ranging from zero to a maximum.

....

....

....

.... [2]

(ii) In a particular experiment, the emitter, having a surface area of 12.0 x 10^{-4} m^2, is illuminated with a source of radiation of wavelength 254 nm. The intensity of the emitter surface by the radiation is 0.23 Wm^{-1}.

If 5.0 % of the incident photons cause the ejection of electrons from the surface,

1. show that the rate of photons emitted is 3.52 x 10^{14} s^{-1}.

[2]

2. Calculate the maximum current reading on the ammeter.

current = ... A [2]

(iii) State and explain how would you expect the maximum current reading on the ammeter to change, if any,

1. when air is allowed to enter the tube of the photocell,

....

....

....

....

.... [2]

2. when the source of radiation is moved further away from the emitter.

....

....

.... [2]

(b) **(i)** Explain how a line emission spectrum leads to an understanding of the existence of discrete energy levels in atoms.

....

....

....

....

....

[3]

(ii) Fig. 8.2 represents some of the allowed energy levels within a cool gas atom. The energy for each level is given in the diagram, with level 1 being the lowest energy state.

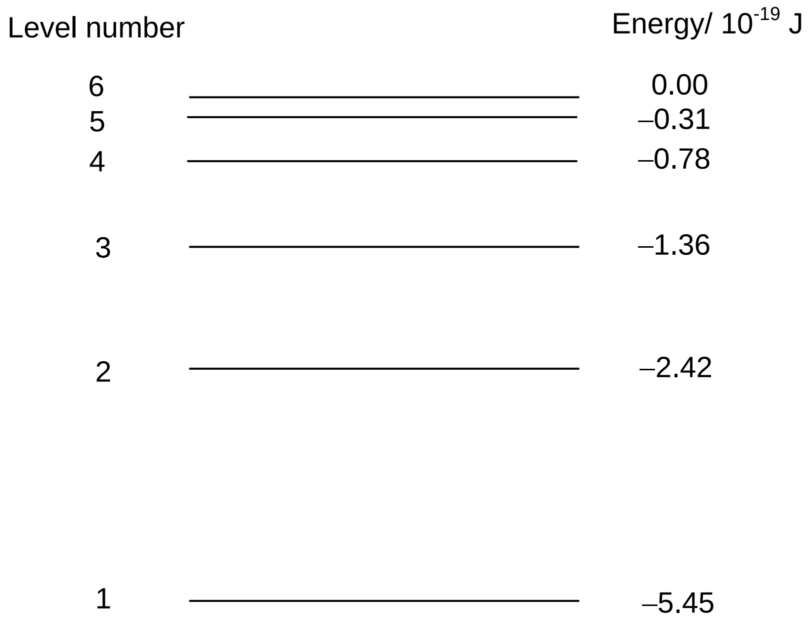

Fig 8.2

An electron of kinetic energy 5.00×10^{-19} J collides with this atom. The atom is excited to level 4 and the electron is scattered with a reduced velocity. Ignoring the recoil of the atom, determine

1. the de Broglie wavelength of the scattered electron,

de-Broglie wavelength = ... m [4]

2. the longest wavelength of the photons emitted from the excited atom.

wavelength = = ... m [2]

3. Draw an arrow on Fig. 8.2 to show the electronic transition corresponding to this wavelength calculated in b(ii)(2), [1]

End of Paper