SERANGOON JUNIOR COLLEGE
General Certificate of Education Advanced Level
Higher 1

NAME

CG | INDEX NO.

PHYSICS 8866

Preliminary Examination **21st August 2014**
Paper 2 Structured Questions **2 hours**

Candidates answer on the Question Paper.

No Additional Materials are required.

READ THIS INSTRUCTIONS FIRST

Write your name, civics group and index number in the spaces at the top of this page.

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.

You are advised to spend about an hour on each section.

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

For Examiners' Use	
Q1	/ 6
Q2	/ 7
Q3	/ 7
Q4	/ 8
Q5	/ 12
Q6	/ 20
Q7	/ 20
Q8	/ 20
Total marks	/ 80

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	=	$R_1 + R_2 + \dots$
resistors in parallel,	$1/R$	=	$1/R_1 + 1/R_2 + \dots$

For Examiner's Use

Section A

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

1 **(a)** A stone is thrown horizontally with a speed of 8.20 m s^{-1} from the top of a cliff into the sea. The path of the stone is shown in Fig 1.1.

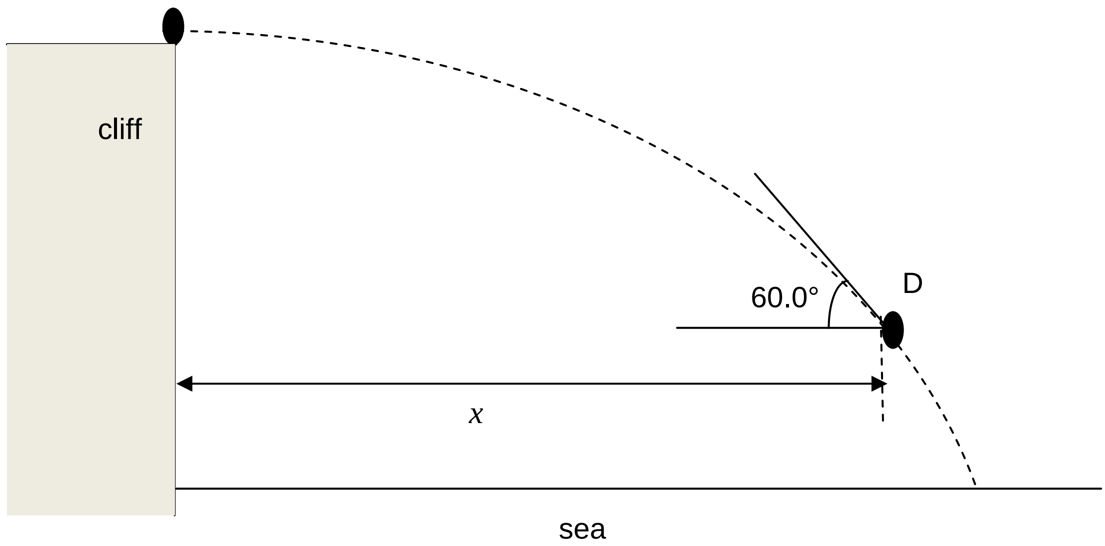


Fig. 1.1

At point D on the path of the stone, the stone is at a horizontal distance x from the cliff and is moving at an angle of 60.0° to the horizontal. Air resistance is negligible.

For the stone at point D,

(i) show that the vertical component of its velocity is 14.2 m s^{-1}. [1]

(ii) calculate the horizontal distance x.

x = ……………………………… m [2]

(b) Another stone is thrown vertically downwards into the sea such that it enters the sea at a high speed.

(i) Describe the motion of the stone as it falls in the sea.

………

………

………

……… [2]

(ii) State for a similar stone of a heavier mass whether it will reach the same, higher or lower terminal velocity if it enters the sea with the same speed as the lighter stone.

………

……… [1]

2 (a) As shown in Fig. 2.1, Block A of mass 2.5 kg is resting on a rough table. The static frictional force acting on Block A by the table is 5.0 N. Block B of mass 4.0 kg is attached to block A via an inelastic string which passes over a smooth pulley. The other end of block A is held by an inelastic string attached to a wall while the other end of block B is attached to a spring that is being compressed by 2.0 cm. The spring constant is 1000 N m^{-1}.

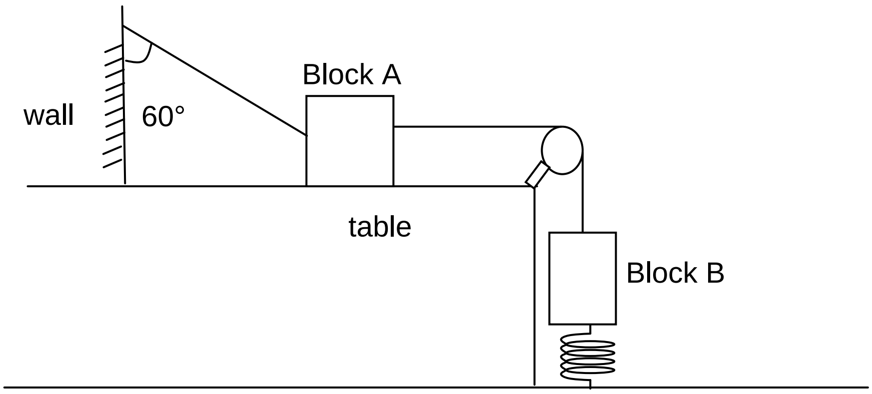


Fig 2.1

(i) Show that the tension in the string between block A and block B is 19.2 N. [1]

(ii) Hence or otherwise, calculate the normal contact force exerted by the table on block A.

normal force by table on block A = ………………………………N [3]

(b) Object X of mass 8.0 kg is moving towards the right with a speed of 1.5 m s^{-1} while object Y of mass 10.0 kg is moving behind it in the same direction. The relative speed of approach between the objects is 1.0 m s^{-1}. At 1.5 s, object Y caught up with object X and both objects collide.

Fig 2.2 shows a graph of momentum against time for object X.

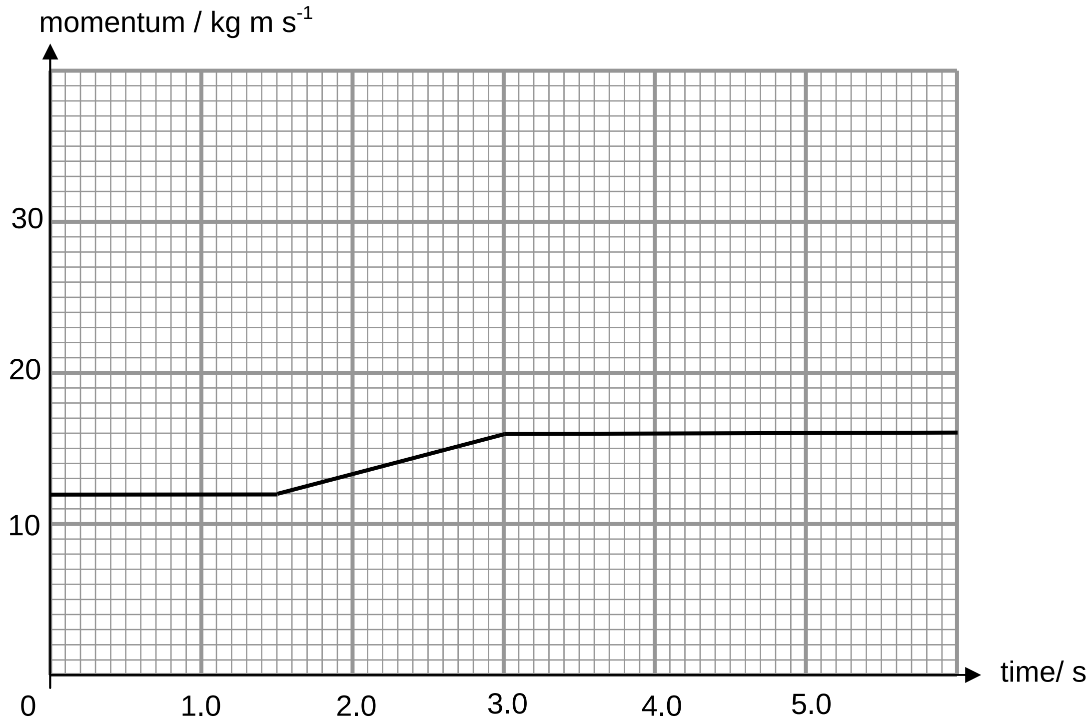


Fig 2.2

(i) Calculate the final momentum of object Y.

final momentum of object Y = ……..………..……….kg m s^{-1} [2]

(ii) Draw the momentum against time graph for colliding object Y in Fig. 2.2. [1]

For Examiner's Use

3 In Fig 3.1 below, a block of mass 2.0 kg is placed against a spring on a rough plane inclined at angle 35°. The block is held in position and it compresses the spring by x m. The spring has a spring constant of 1500 N m^{-1}.

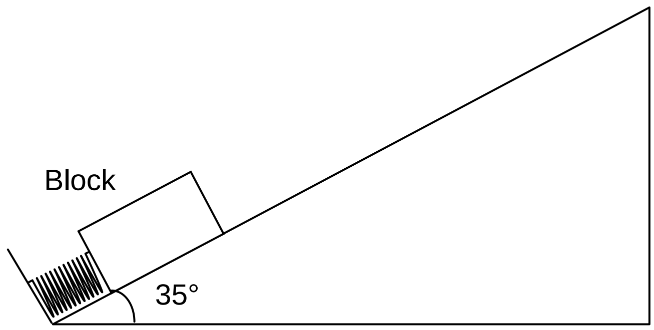


Fig 3.1

The block is then released. It moves upwards along the slope and after separating itself from the spring, it moves up by 0.50 m along the plane before coming to a momentary stop as shown in Fig. 3.2. The average frictional force experienced by the block as it moves up the plane is 2.0 N.

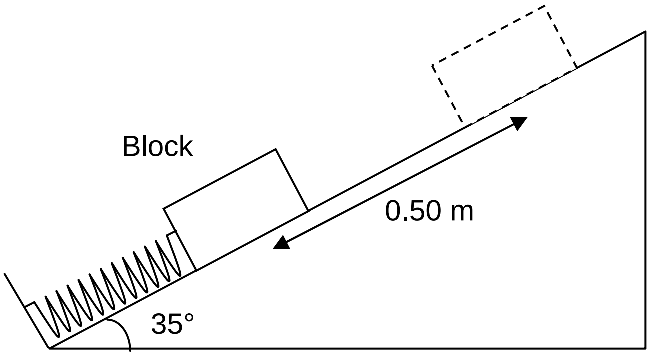


Fig 3.2

For Examiner's Use

(a) In terms of x, write down an expression for the work done by friction from the time the block is released until it comes to a momentary stop.

work done by friction = …….………..………J [1]

(b) Calculate the value of x.

x = …….……….………. m [2]

For Examiner's Use

(c) In the graph below, sketch the following graphs from the time the block separates itself from the spring until it reaches a momentary stop.

The distance represents the distance along the plane.

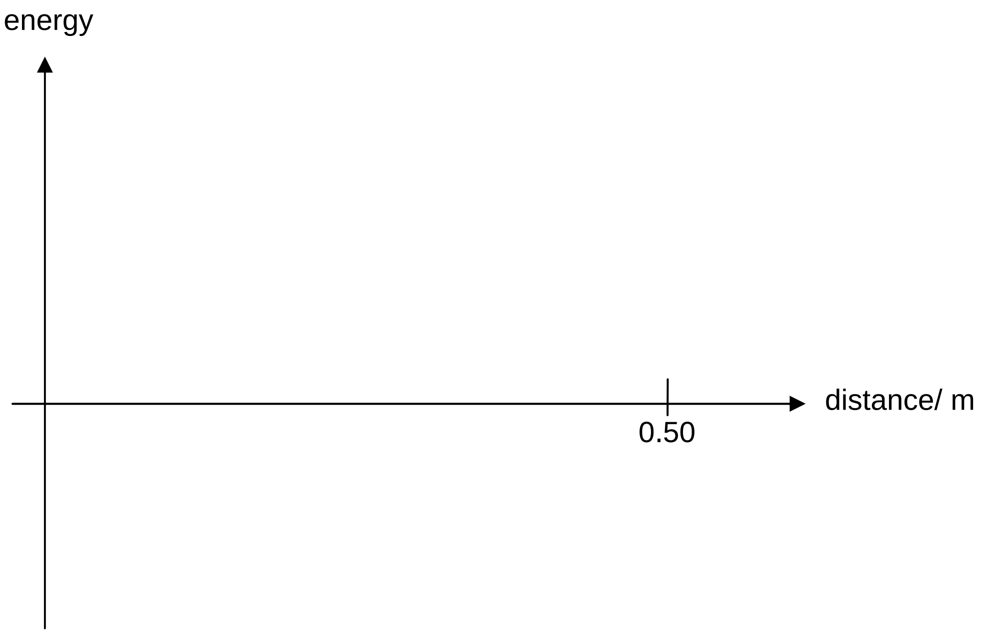
(i) work done against friction (WD) against distance [1]

(ii) total mechanical energy (TME) of block against distance [1]

(iii) gravitational potential energy (GPE) against distance [1]

(iv) kinetic energy (KE) against distance [1]

Label each of the graphs as WD, TME, GPE and KE respectively.



For Examiner's Use

4 Fig. 4.1 below shows a simple form of current balance. ABCD is a rectangular loop and all sides are made of copper loop except for section AD which is made of an insulator. ABCDEF all lie on the same horizontal plane.
When a current I flows through the solenoid and the loop, a rider of mass 10^{-4} kg has to be placed at the end of EF in order to restore equilibrium. The length of AB, BC and EF are 25 cm, 15 cm and 30 cm respectively.

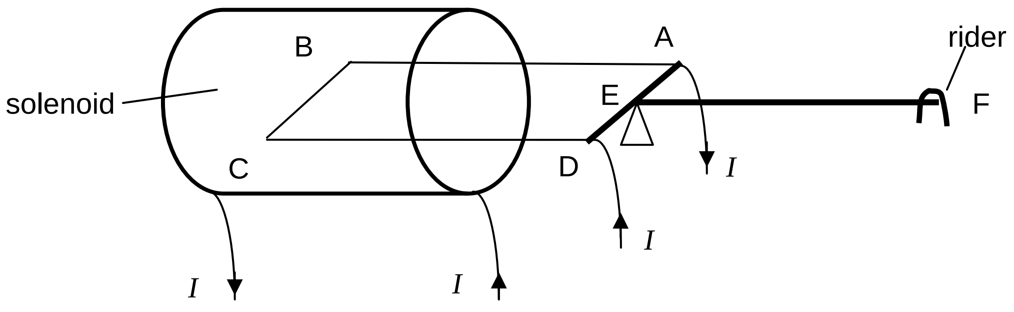


Fig. 4.1

(a) State the direction of magnetic field inside the solenoid.

……… [1]

(b) **(i)** The magnetic flux density inside the solenoid is $3.0 \times 10^{-3} I$. Write down, in terms of I, the force acting on arm BC.

force = …………………………………… [1]

(ii) Hence, deduce the value of I.

I = …………………………………… A [2]

For Examiner's Use

(c) State and explain what will happen to equilibrium when the direction of current I is reversed.

……………………………………………………………………………………………………

……………………………………………………………………………………………………

……………………………………………………………………………………………………

…………………………………………………………………………………………………… [2]

(d) An ammeter was placed across wire BC as shown in Fig. 4.2 and a current was detected.

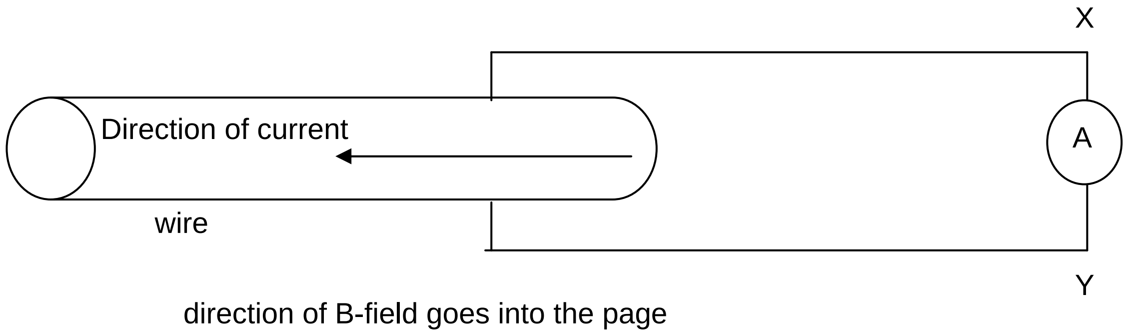


Fig. 4.2

(i) Explain why a current flow was detected by the ammeter.

……………………………………………………………………………………………………

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

(ii) State the direction of the current flow through the ammeter.

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

5 Wind power can be harnessed to generate electric power. Fig. 5.1 below shows a particular type of wind turbine. The wind causes the rotor blades to turn, and they drive a generator located inside the generator housing.

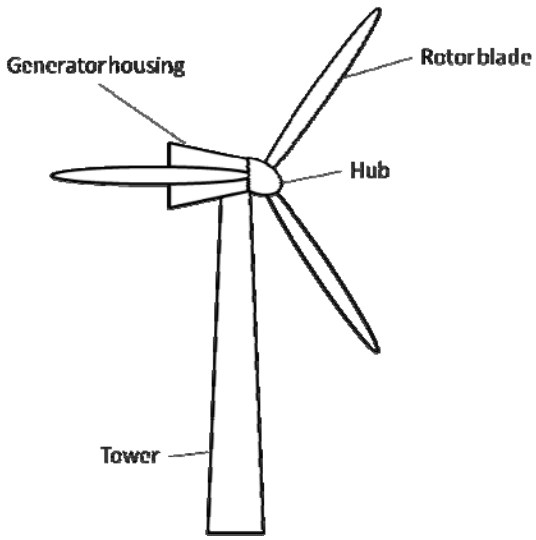


Fig. 5.1

Information about the performance of the wind turbine is provided by the manufacturer, as shown in Fig. 5.2.

Output Power / kW vs. Wind Speed / m s^{-1}

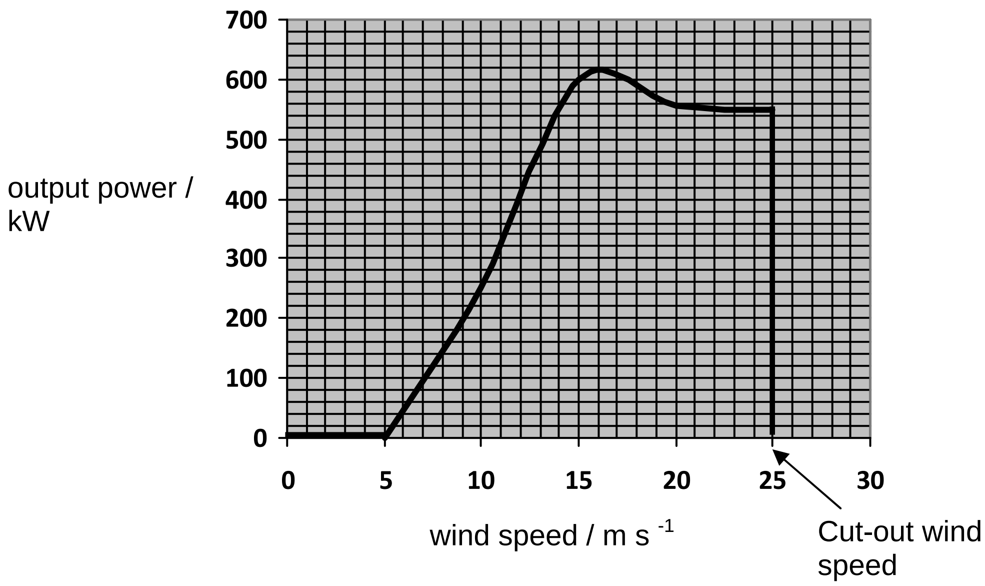


Fig. 5.2

From the information provided by the manufacturer,

(a) Explain why there is no output power below a wind speed of 5.0 m s^{-1}.

………

……… [1]

(b) Suggest why is there a need for a cut-off wind speed.

………

……… [1]

(c) Air of density ρ and speed v is incident normally on a rotor of radius r at a rate of m_t , mass per unit time t.

(i) Determine the expression for m_t in terms of r, v and ρ.

m_t = …………………………………… [2]

(ii) Show that $E_t = ½ \pi r^2 v^3 \rho$, where E_t is the kinetic energy of the wind incident on the rotors per unit time. [2]

For Examiner's Use

(d) When the wind turbine operates at maximum output power,

(i) determine the value of E_t. The air has density 1.25 kg m^{-3} and the rotor diameter is 40 m.

E_t = ……………………….. W [2]

(ii) calculate the overall efficiency of the generation of electric power.

efficiency = …………………. % [2]

(e) Suggest two practical constraints in generating electricity using wind turbines in Singapore.

………

………

………

……… [2]

Section B

Answer **two** questions from this section.

6 **(a)** State the *Principle of Superposition*.

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………

………[2]

(b) Monochromatic light illuminates a narrow slit which is 4.0 m away from a screen. Two very narrow parallel slits 0.50 mm apart are placed midway between the single slit and the screen so that interference fringes are obtained.

(i) Explain how diffraction and interference play a part in formation of the interference fringes.

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………

………

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………

………[2]

(ii) The spacing of five bright fringes is 10 mm, calculate the wavelength of the light.

wavelength = ……………………….. m [2]

(iii) State the changes in the fringes, if any, when the screen is moved closer to the double slit.

………

………

………

………[2]

(iv) The intensity of the bright fringe is I. A very thin paper is placed in front of one of the double slits such that the intensity of the light passing through the slit is now halved. Determine the intensity, in terms of I, of the new minima.

intensity = ………………….. [3]

(v) The monochromatic light source is now replaced by a light source producing red and blue light. State and explain what will be observed at the central fringe.

………

………

………

………

………[2]

(c) Suggest a reason for each of the scenarios below:

1. When the light beams from the two headlamps of a car overlap, explain why it is not possible to have an observable interference pattern.

……

……

……[1]

2. When a source producing sound waves of wavelength 5.0 m is connected to two loudspeakers which are placed 2.0 m apart facing each other, explain why is it not possible to locate a position along a straight line joining the two sources where there will be a minima.

……

……

……

……[2]

(d) A diffraction grating contains many closely spaced slits through which a beam of light can be split. The beams passing through the slits then interfere and produce a many-slit interference pattern. With a large number of slits, the intensity maxima are no longer evenly spaced and the position (or angle) of the nth order intensity maxima can be determined by :

$$d \sin \theta_n = n\lambda$$

where d is the separation between slits
n is the order of diffraction (an integer)
θ_n is the angle between the nth order intensity maxima and the normal to the grating
λ is the wavelength of the incident beam
as shown in Fig. 6.1

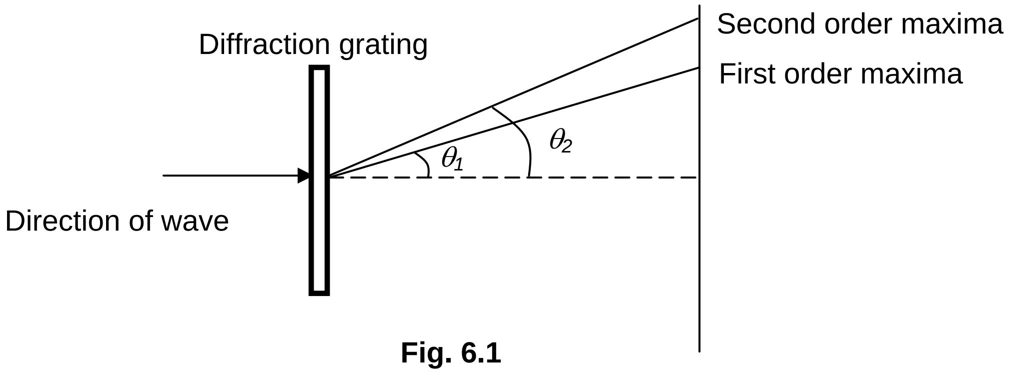

Fig. 6.1

For Examiner's Use

A monochromatic light of wavelength 700 nm is incident on a diffraction grating that has a slit separation of 3.63×10^{-6} m. The second order spectrum appears at a distance of 3.0 cm away from the zeroth order spectrum as shown in Fig.6.2.

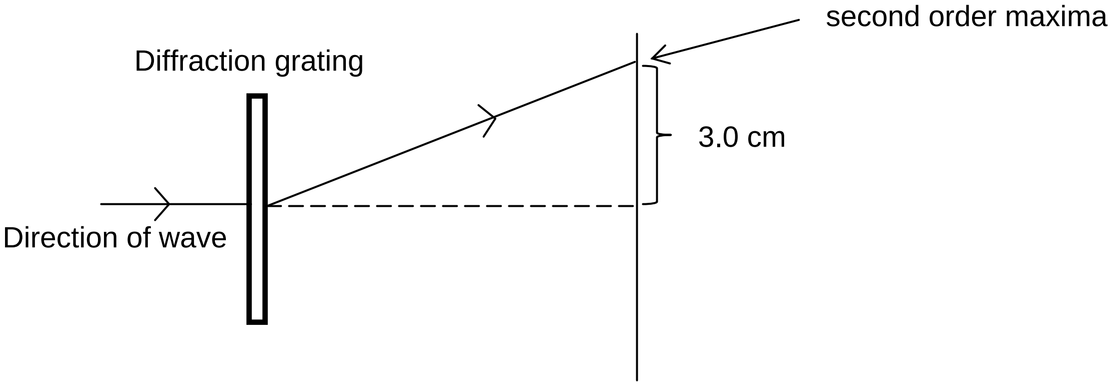

Fig. 6.2

(i) Determine how far the screen is away from the diffraction grating.

distance = …………………….. cm [2]

(ii) When a patient receives a chest x-ray at the hospital, the x-rays pass through a series of parallel ribs in the patient's chest. Explain if the ribs act as a diffraction grating for x-rays.

…………………………………………………………………………………………………

…………………………………………………………………………………………………

…………………………………………………………………………………………………

…………………………………………………………………………………………………[2]

For Examiner's Use

7 A thermistor is often used in an electrical circuit to detect temperature changes.

(a) Describe and explain using the definition of potential difference why the potential difference across a thermistor connected directly to an e.m.f. source in a circuit with no other components does not change when temperature of the thermistor increases.

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....[3]

(b) The setup shown in Fig. 7.1 was used to detect the variation in temperature of the environment through observing the brightness of a filament lamp in the setup.

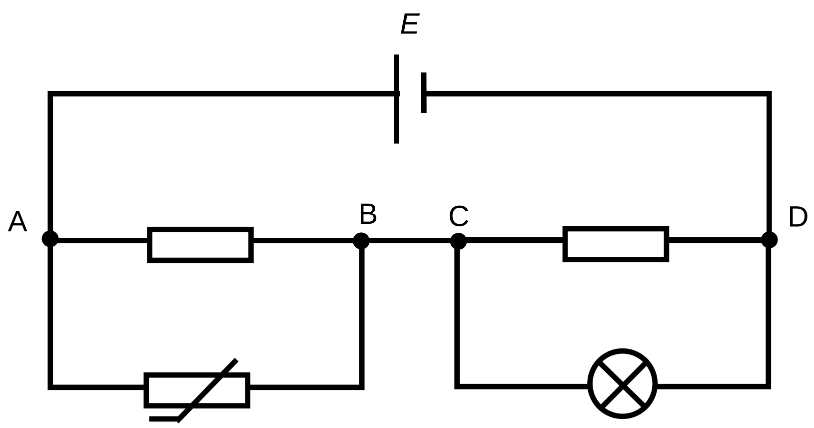

Fig. 7.1

Describe and explain the variation of the potential difference across the lamp over time when temperature of the environment and also the lamp increases.

…………………………………………………………………………………………………

…………………………………………………………………………………………………

…………………………………………………………………………………………………

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…………………………………………………………………………………………………

……………………………………………………………………………………………….[4]

(c) The electrons within an electrical circuit is moving at a speed (also known as drift velocity) of 10^{-4} m s^{-1}.

(i) Explain how it is possible for a light bulb connected by metre long wires as shown in Fig. 7.2 to be lighted up almost immediately when the switch is closed.

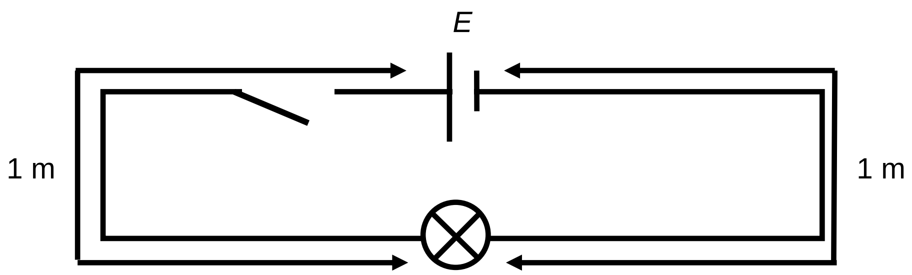

Fig. 7.2

…………………………………………………………………………………………………

…………………………………………………………………………………………………

…………………………………………………………………………………………………

…………………………………………………………………………………………………

…………………………………………………………………………………………………

……………………………………………………………………………………………….[2]

(ii) The cross-sectional area of the wire is 3.14×10^{-6} m^2 and the average number of electrons per unit volume of the wire (also known as electron density) is 8.5×10^{28} electrons m^{-3}.

Determine the current in the wire.

current = …………………. A [2]

(d) Fig. 7.3a and Fig. 7.3b shows 2 similar fixed resistors of resistance *R* in two different connection setup, supplied by identical e.m.f. source *E*.

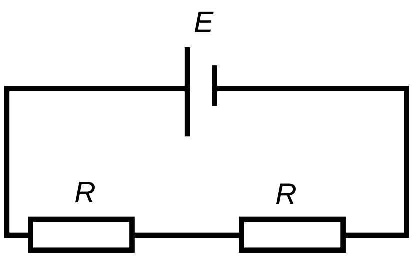

Fig. 7.3a

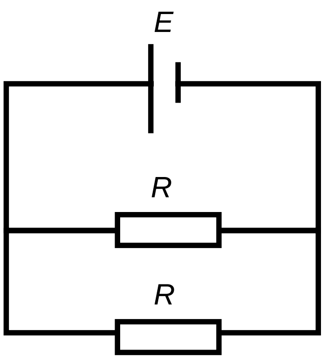

Fig. 7.3b

(i) State and explain whether the cell in Fig. 7.3a or Fig. 7.3b will last longer before it stops supplying power to the resistor.

……………………………………………………………………………………………………

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……………………………………………………………………………………………………

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……………………………………………………………………………………………………

……………………………………………………………………………………………………[4]

For Examiner's Use

(ii) The internal resistance of the e.m.f. source is 2*R*.

Determine the power supplied to the circuit when the connection in the setups in Fig. 7.3a and Fig. 7.3b in terms of *R* and *E*.

power supplied in Fig. 7.3a = ………………………….

power supplied in Fig. 7.3b = ………………………… [3]

(iii) The Maximum Power Theorem states that the power supplied to the circuit is maximum when the internal resistance is equal to the total external resistance of the circuit. State and explain whether your answer in **(d) (ii)** contradicts this theorem.

……………………………………………………………………………………………….

……………………………………………………………………………………………….

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……………………………………………………………………………………………….

……………………………………………………………………………………………..[2]

For Examiner's Use

8 **(a)** When electromagnetic radiation falls on a metal surface, electrons may be emitted. This is the photoelectric effect.

(i) Write down Einstein's photoelectric equation and state what each term represents.

……

……

……

……[2]

(ii) Explain why, for a particular metal, electrons are emitted only when the frequency of the incident radiation is greater than a threshold frequency.

……

……

……

……[2]

(b) In a photoelectric experiment, the stopping potential for electrons emitted from a metal illuminated by light of wavelength 501 nm is 0.850 V.

(i) Calculate the work function of the metal.

work function = …………………… J [2]

(iii) Calculate the threshold frequency for the surface.

threshold frequency = ………………….. Hz [1]

(ii) Suggest a physical quantity of the metal that affects the work function.

……………………………………………………………………………………………………

……………………………………………………………………………………………………

……………………………………………………………………………………………………[2]

(c) In 1924, Louis-Victor de Broglie proposed a theory of wave-particle duality.

Name an experiment that gives evidence for the wave nature of particles. Explain how the observations of the experiment support the fact that particles have wave properties.

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……………………………………………………………………………………………………

……………………………………………………………………………………………………

……………………………………………………………………………………………………[2]

(d) A particle of mass *m* is confined to a narrow tube of length *L*, the de Broglie waves of the particle can "resonate" in the tube. These waves can be taken to be stationary waves with nodes at both ends of the tube.

(i) When resonance occurs, show that the de Broglie wavelengths λ are quantized and can be expressed as

$$\lambda_n = \frac{2L}{n}, \text{ where } n = 1, 2, 3, \ldots$$ [2]

(ii) State the relationship between the de Broglie wavelength λ and the speed of the particle *v*. [1]

(iii) Hence, show that the corresponding kinetic energies *K* of the particle can only have discrete values and can be expressed as

$$K_n = \frac{h^2 n^2}{8mL^2}$$, where *n* = 1, 2, 3, … [2]

(iv) The particle is an electron and *L* = 100 pm, determine the smallest amount of kinetic energy the electron can have.

smallest kinetic energy = …………………… J [2]

For Examiner's Use

(v) Suggest how the confined electron, which is described in **(d) (iii)**, can be excited to higher energy levels.

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……[2]

End of Paper