SYDNEY GRAMMAR SCHOOL

2016

FORM V
ANNUAL EXAMINATION

Physics

Working Time: 2 hours

Friday 2nd September 8.40AM

General Instructions

- Working time – 2 hours
- Board-approved calculators may be used
- Write using blue or black pen
- Draw diagrams using pencil
- A Data Sheet, Formula Sheet and Periodic Table are provided at the back of this paper
- Write your name at the top of the Multiple Choice Answer Sheet & all pages of Part B
- Hand in your Multiple Choice Sheet and all of Part B in one bundle. (Do not staple together)

Total marks (95)

This paper has two parts: Part A and Part B.

Part A
Total marks **(13)**
- Attempt ALL Questions
- Allow about 20 minutes for this Part

Part B
Total marks **(82)**
- Attempt ALL Questions
- Allow about 1 hour 40 minutes for this Part

CHECKLIST	
Each boy should have the following:	
1 Question Paper	
1 Multiple Choice Answer Sheet	

1 – AAH	3 – PCK	5 – MRW	7 – MTK
2 – SRW	4 – DGB	6 – SRW	

EXAMINERS:
MRW/AAH/PCK/SRW/DGB

Part A

Total marks (13)
Attempt ALL Questions
Allow about 20 minutes for this Part

Use the multiple-choice Answer Sheet.

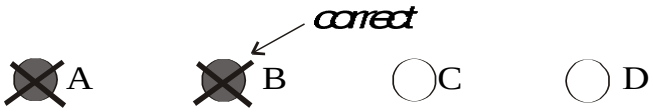
Select the alternative A, B, C or D that best answers the question. Fill the response circle completely.

Sample 2 + 4 =

(A) 2 (B) 6 (C) 8 (D) 9

If you think you have made a mistake, put a cross through the incorrect answer and fill in the new answer.

If you change your mind and have crossed out what you consider to be the correct answer, then indicate this by writing the word *correct* and drawing an arrow as follows.



1 75 $km \cdot h^{-1}$ is equivalent to:

(A) 1.3 $m \cdot s^{-1}$
(B) 13 $m \cdot s^{-1}$
(C) 21 $m \cdot s^{-1}$
(D) 270 $m \cdot s^{-1}$

2 A train accelerates uniformly from 15 $m \cdot s^{-1}$ to 35 $m \cdot s^{-1}$ over a distance of 300 m.
The acceleration of the train is:

(A) 0.067 $m \cdot s^{-2}$
(B) 0.67 $m \cdot s^{-2}$
(C) 1.7 $m \cdot s^{-2}$
(D) 3.3 $m \cdot s^{-2}$

3 A car of mass 1500 kg is moving at 25 $m \cdot s^{-1}$.
Its kinetic energy is:

(A) 1.9×10^4 J
(B) 3.8×10^4 J
(C) 4.7×10^5 J
(D) 9.4×10^5 J

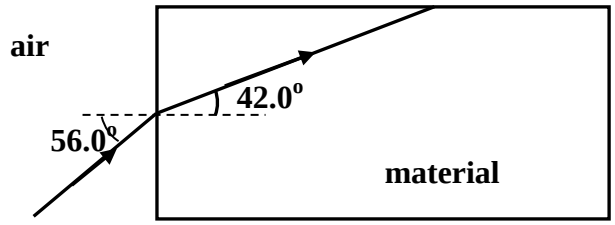
4 An ice-hockey puck of mass 0.16 kg is hit with an initial velocity of 18 $m \cdot s^{-1}$. It slides across a rough, horizontal surface, and takes 8.3 seconds to stop.
The magnitude of the force of friction acting on the puck is:

(A) 0.35 N
(B) 2.2 N
(C) 3.1 N
(D) 14 N

5 When a sound wave travelled from air into a container of pure carbon dioxide gas, it was found that the speed of the wave decreased from 330 $m \cdot s^{-1}$ to 280 $m \cdot s^{-1}$.
If the frequency of the sound wave in air was 800 Hz, then it is true to say that:

(A) the frequency of the sound wave in pure carbon dioxide was 679 Hz.
(B) the frequency of the sound wave in pure carbon dioxide was 750 Hz.
(C) the frequency of the sound wave in pure carbon dioxide was 800 Hz.
(D) the frequency of the sound wave in pure carbon dioxide was 943 Hz.

6 A ray of light travels through air and strikes a block of transparent material as shown in the following diagram.



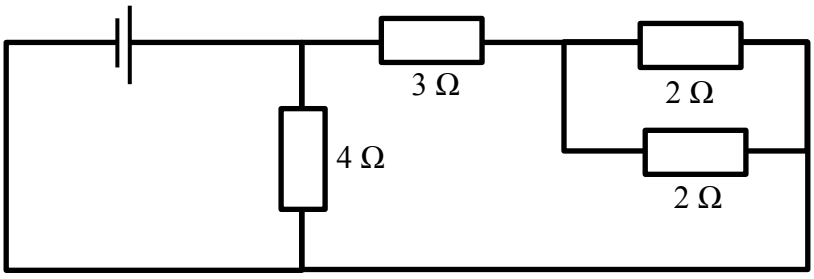
What is the speed of the light in this material?

(A) 2.28×10^{8} m·s^{-1}
(B) 2.42×10^{8} m·s^{-1}
(C) 2.51×10^{8} m·s^{-1}
(D) 2.99×10^{8} m·s^{-1}

7 It is true to say that our Sun is a:-

(A) white dwarf.
(B) proto-star.
(C) red giant.
(D) main sequence star.

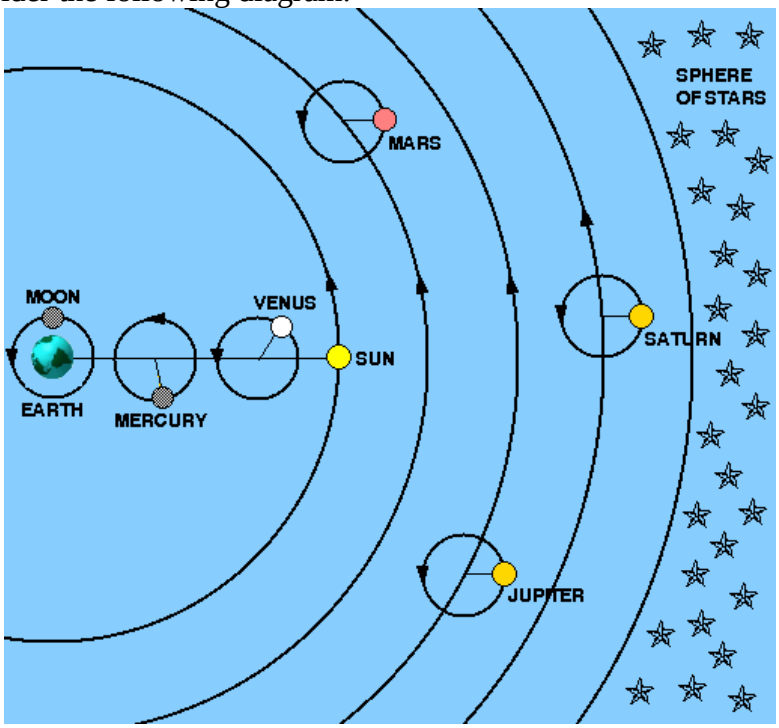
8 Consider the following circuit.



What fraction of the current flowing out of the battery flows through one of the 2 Ω resistors?

(A) $\frac{1}{2}$
(B) $\frac{2}{11}$
(C) $\frac{1}{4}$
(D) $\frac{2}{5}$

9 Consider the following diagram.



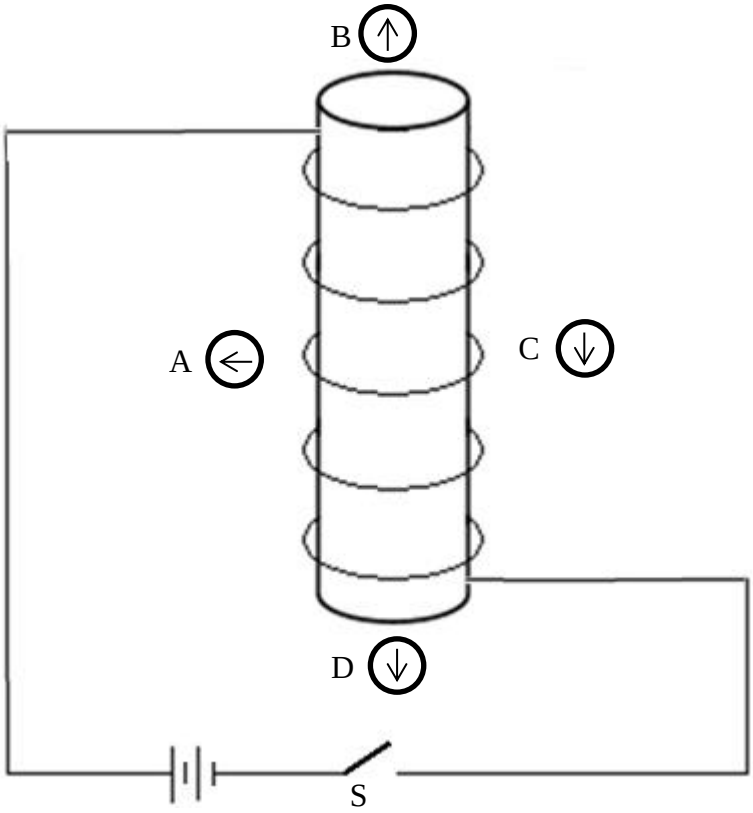
Which astronomer was responsible for the model of the Universe shown above?

(A) Copernicus
(B) Kepler
(C) Newton
(D) Ptolemy

10 If $^{211}_{83}$Bi decays by beta minus decay and the product of this decay then undergoes alpha decay, the final resultant nucleus is:-

(A) $^{205}_{82}$Pb
(B) $^{206}_{82}$Pb
(C) $^{207}_{82}$Pb
(D) $^{208}_{82}$Pb

11 The following diagram shows a soft iron bar with a coil of wire wrapped around it and connected to a switch, S and a battery.
Four compasses (A, B, C and D) are placed near the coil of wire.



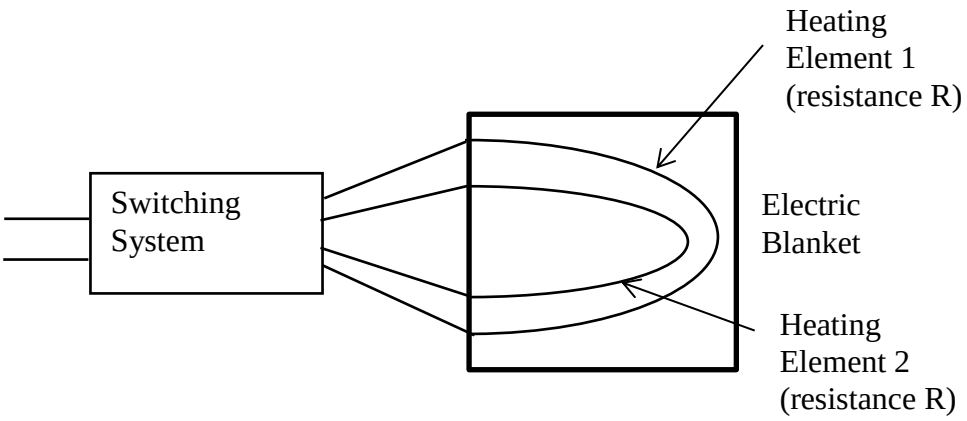
When the switch, S, is closed, which compass is correctly indicating the direction that its needle would point?

(A) Compass A
(B) Compass B
(C) Compass C
(D) Compass D

12 Nova radio station has a frequency of 96.9 MHz.
What is the period of the radio waves transmitted by this station?

(A) 1.03×10^{-8} s
(B) 1.03×10^{-2} s
(C) 3.10 s
(D) 96.9 s

13 This question refers to the following diagram of a single bed electric blanket.



The electric blanket consists of two identical heating elements. In order to obtain three heat settings (high, medium and low), the blanket has a heat selector switch. The switching system is used to connect the two elements to the 240 V supply in the following combinations:-

X: elements 1 and 2 are connected in parallel.
Y: elements 1 and 2 are connected in series.
Z: only element 1 is connected, element 2 is not used.

Which of the following correctly indicates the way that the two elements must be connected to provide the three heat settings?

	High	Medium	Low
(A)	X	Y	Z
(B)	X	Z	Y
(C)	Y	X	Z
(D)	Y	Z	X

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Class

Name

Part B

Total marks (82)
Attempt ALL Questions
Allow about 1 hour and 40 minutes for this Part

Answer the questions in the spaces provided.
Show all relevant working in questions involving calculations.

Question 14 (6 marks) **Marks**

The following photograph is taken for the planet Mars over several weeks.

(a) Name the phenomenon shown in the photograph above. **1**

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(b) How did Ptolemy explain this motion? **2**

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Question 14 continued on next page.

Question 14 continued **Marks**

(c) With the aid of a diagram, explain how Copernicus explained this motion. **3**

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Question 15 (4 marks) **Marks**

Carbon-14 decays by beta minus decay with a half-life of 5730 years.

(a) Write a nuclear decay equation for this reaction. **2**

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(b) The carbon-14 content of an ancient piece of wood was found to have only one eighth of its original carbon-14 remaining.

Determine the age (in years) of this ancient piece of wood. **2**

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Question 16 (4 marks) **Marks**

Two of the major moons of Jupiter are Europa and Ganymede. The distance of Europa from Jupiter is 671,100 km while the distance of Ganymede from Jupiter is 1,070,400 km. The orbital period of Ganymede around Jupiter is 7.15 days.

(a) Determine the orbital period of Europa around Jupiter. **2**

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(b) What was the impact of Galileo's discovery of these moons in January 1610 on the model of the Universe? **2**

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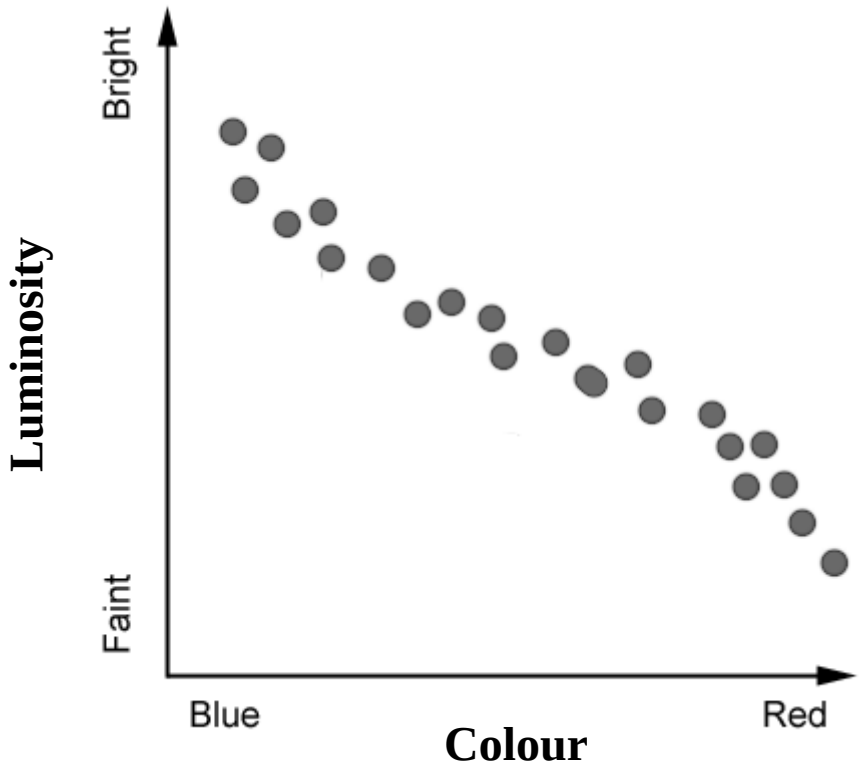
Question 17 (3 marks) **Marks**

Consider the Hertzsprung-Russell Diagram below for stars found in a globular cluster. It is known that the stars in a globular cluster are formed roughly at the same time.



(a) Circle the hottest star shown on the diagram above. **1**

(b) An astronomer looking at this diagram suggests that the stars are young. Explain the reasoning behind this suggestion. **2**

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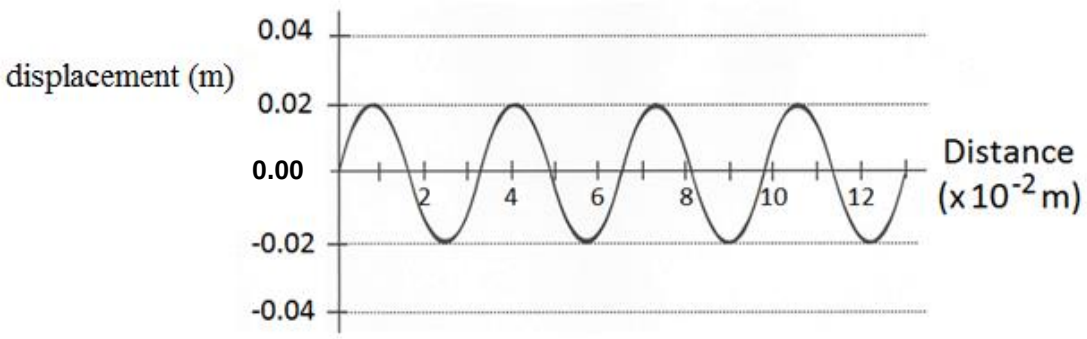
Question 18 (4 marks) **Marks**

The diagram below shows a displacement versus distance graph for a wave travelling through a medium. The frequency of this wave is 45.0 Hz.



Use this information to find:

(a) the wavelength of the wave. **1**

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(b) the amplitude of the wave. **1**

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(c) the period of the wave. **1**

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(d) the velocity of the wave. **1**

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Question 19 (2 marks) **Marks**

The intensity of a point source of light is 40.0 $W \cdot m^{-2}$ at a distance of 8.00 m away from the source.

Calculate the intensity of the light at a distance of 12.0 m away from the same point source. **2**

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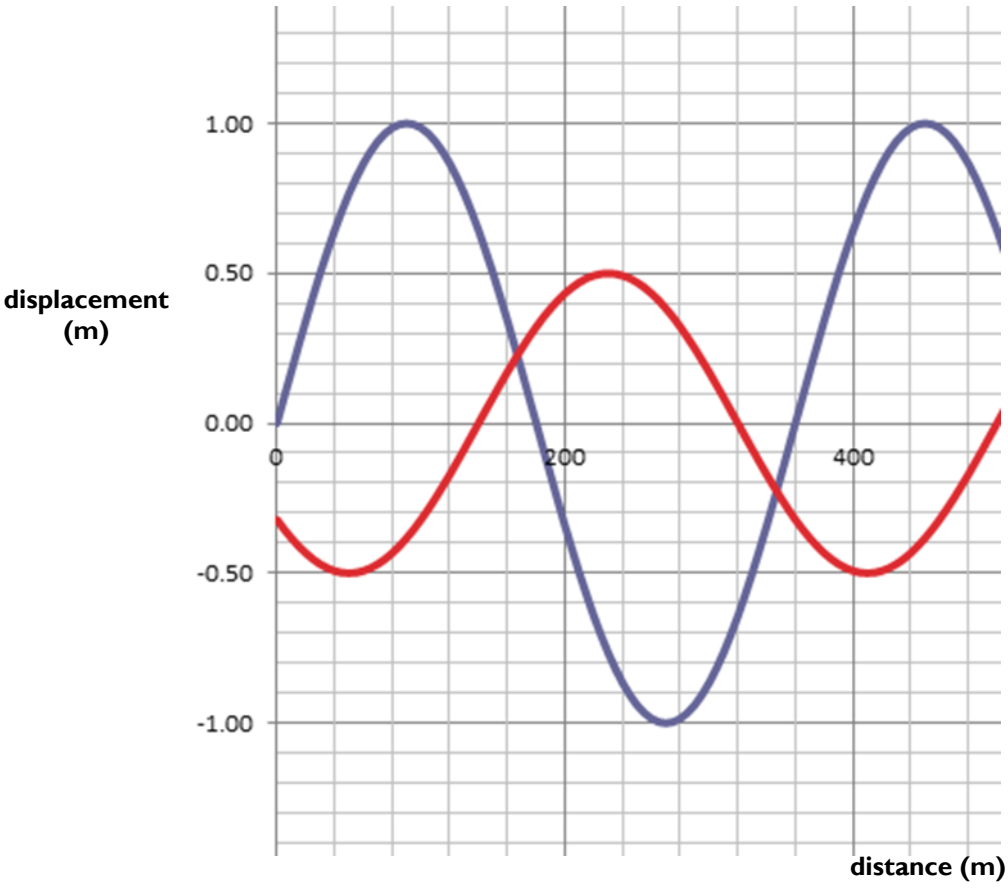
Question 20 (2 marks)

The following graph shows a medium with two waves moving through it simultaneously.



On the grid above, accurately draw the combined displacement of the medium as a result of these two waves at this instance. **2**

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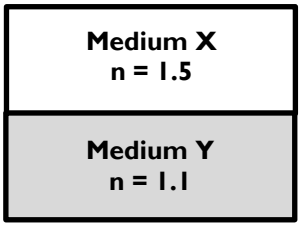
Question 21 (6 marks) **Marks**

The diagram below shows a pair of transparent media, X and Y.



(a) Using the information provided in the diagram, determine the critical angle for this pair of media. **2**

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(b) Determine the speed of a light ray travelling in Medium Y. **1**

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(c) Using a labelled diagram, describe how total internal reflection is used in a fibre optic cable. **3**

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Question 22 (4 marks) **Marks**

This question is about the formation of standing waves in a microwave oven which can be used to determine the speed of light.

Marshmallow sweets can be served melted. An attempt to melt a plate of marshmallows is made in a microwave oven **from which the turntable has been removed,** so that the tray can sit still in the oven. (see Figure 1).

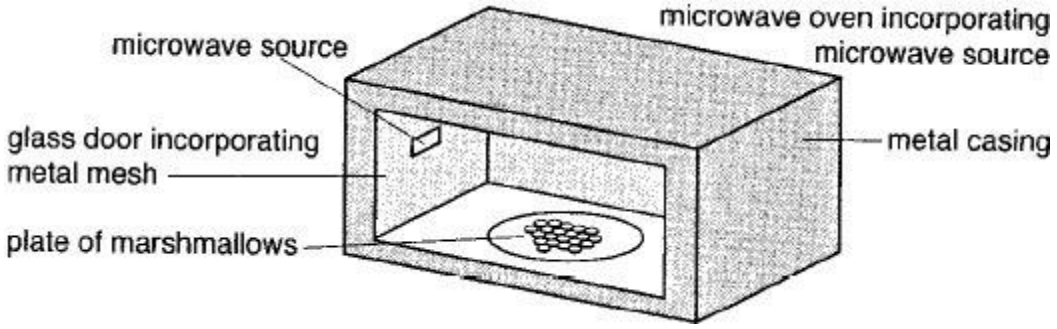

Figure 1

(a) The marshmallows do not melt uniformly. The melting is concentrated at regularly spaced spots 0.057 m apart as shown in Figure 2.

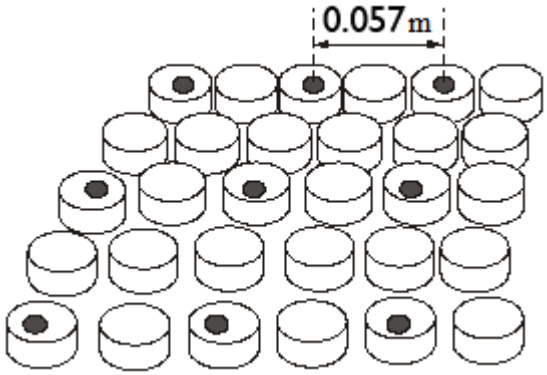

Figure 2

Question 22 continued on next page.

Question 22 continued **Marks**

The design of the microwave oven allows for the formation of standing waves within the cavity and the melted spots occur at the **antinodes** of a standing wave set up in the microwave oven.

Figure 3 represents the variation in amplitude of the microwaves along part of one such standing wave.

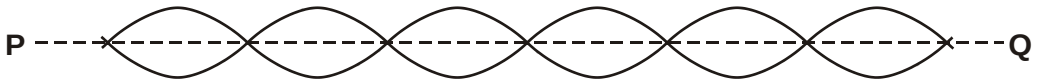

Figure 3

i) Along the line **PQ**, mark with an "M", **two** positions where a melted spot might be expected to form. **1**

ii) On Figure 3, mark a distance equal to one wavelength. Label it λ. **1**

(b) The label on the back of the oven states that the frequency of the microwaves is 2.45×10^9 Hz.

Calculate the speed of the ***microwaves*** in the microwave oven. **2**

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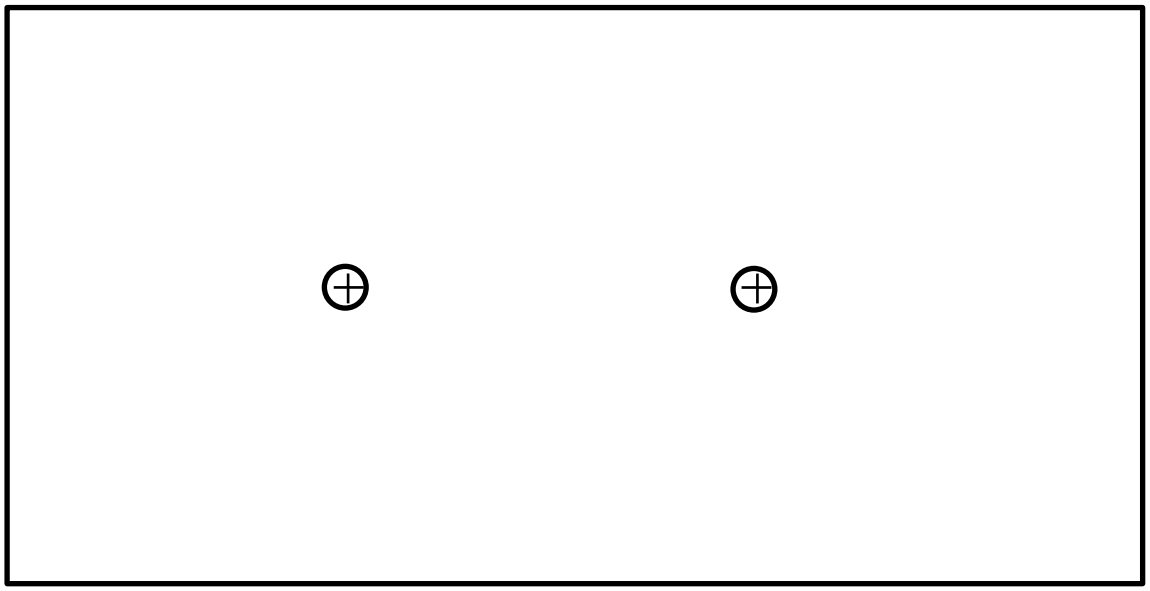
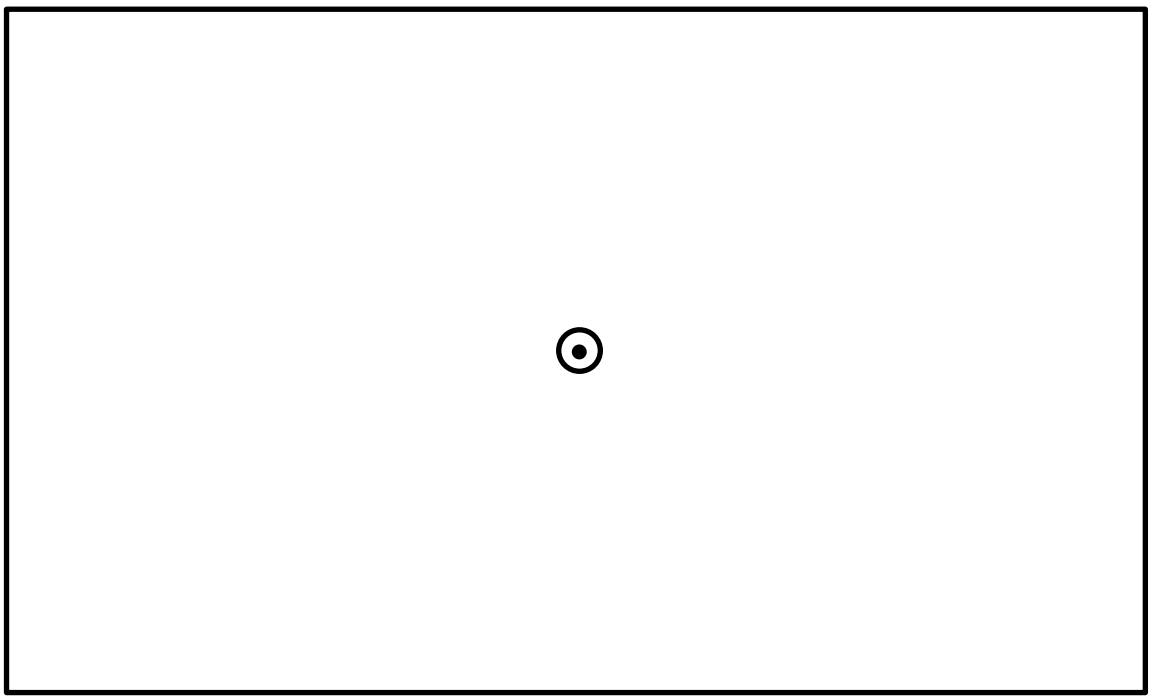
Question 23 (4 marks) **Marks**

(a) In the box provided below, draw the electric field around the two charges shown. **2**

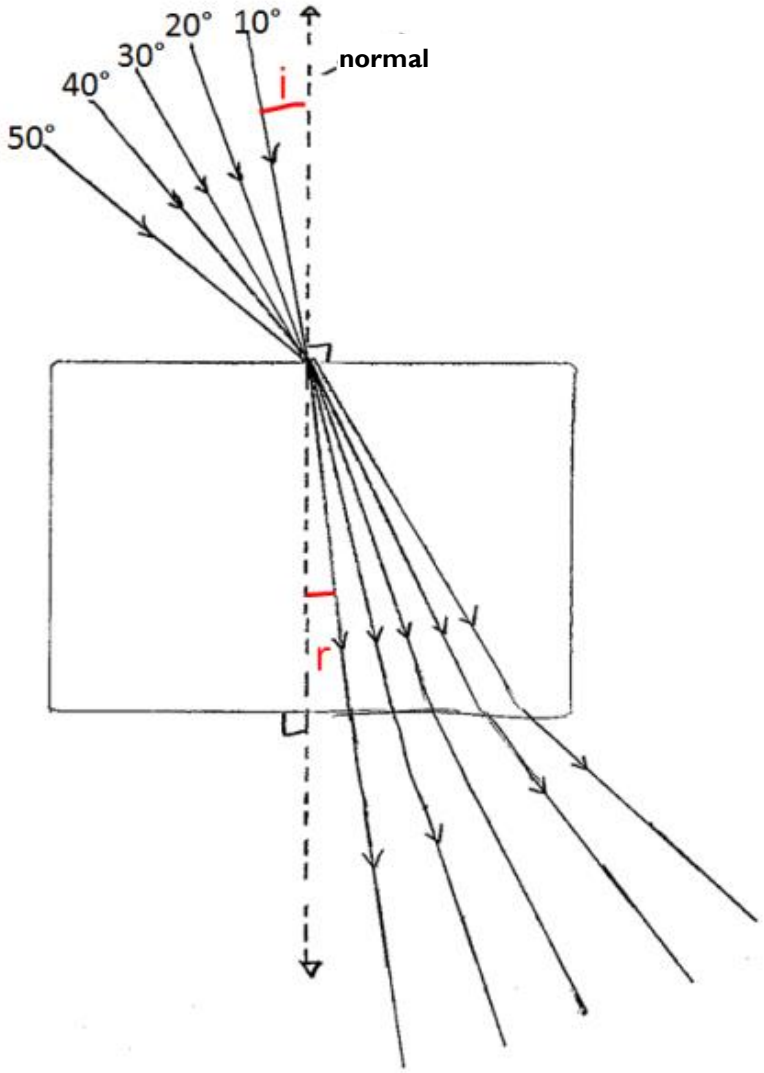


(b) In the box provided below, draw the magnetic field around the current carrying conductor shown. **2**



Question 24 (2 marks) **Marks**

A student performed an experiment to measure the refractive index of a block of unknown transparent material. A ray of red light is shone into the block and the angles of incidence and refraction were recorded.



His results were plotted on a graph shown on the next page.

Question 24 continued on next page.

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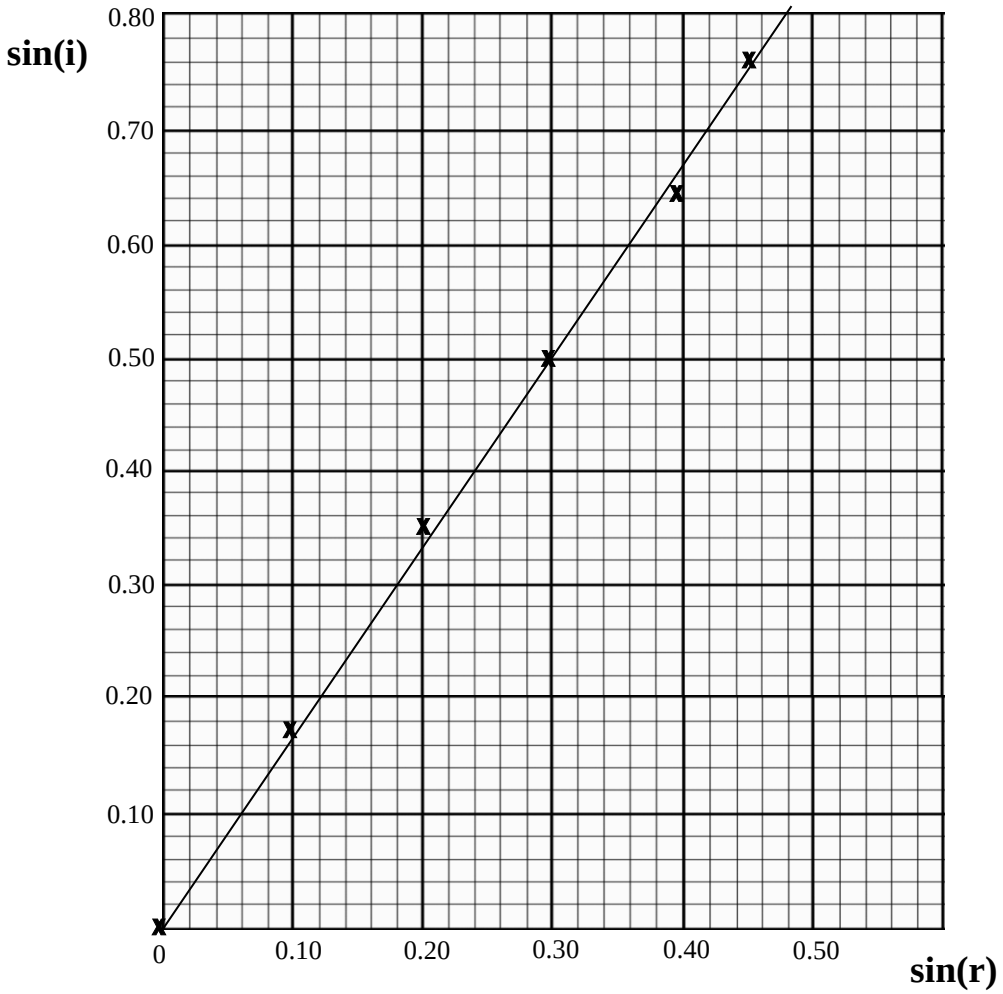
Question 24 continued **Marks**



Use the graph above to determine the value of the refractive index of the block of unknown material. **2**

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Question 25 (4 marks) **Marks**

An electric kettle when connected to a 240 V supply operates at a power of 2.40 kW. In order to boil 1.70 L of water, it must provide 0.640 MJ of energy.

(a) Calculate the time taken to boil the water. **2**

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(b) What current flows through the kettle? **1**

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(c) A power failure occurs and the mains voltage is halved.

How long does the kettle now take to boil the water? **1**

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Question 26 (4 marks) **Marks**

Two horizontal parallel metal plates are separated by a distance of 7.0×10^{-3} m. A potential difference of 200 V is connected across them. A small object with a mass of 2.1×10^{-12} kg is given a positive charge of 1.5×10^{-5} C. It is released from rest near the positive plate. Ignore the effects of gravity.

(a) Calculate the magnitude of the electric field strength between the plates. **1**

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(b) Calculate the work done to move the $+1.5\times10^{-5}$ C charge through the potential difference of 200 volts. **1**

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(c) Calculate the speed gained by the positive charge when it reaches the negative plate. **2**

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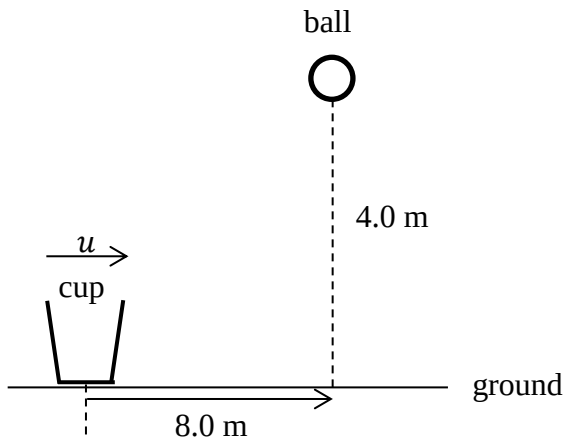
Question 27 (5 marks) **Marks**

A ball is dropped from a height of 4.0 m. At the same time, a cup is moving horizontally with an initial velocity, u, 8.0 m away as shown in the following diagram.



(a) How long will it take for the ball to fall vertically to the ground? **2**

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(b) In order for the ball to land in the cup, what does the initial horizontal speed, u, of the cup have to be:-

i) assuming the cup will slide without friction. **1**

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ii) assuming a frictional force acts on the cup causing it to decelerate across the surface at 1.2 $m \cdot s^{-2}$. **2**

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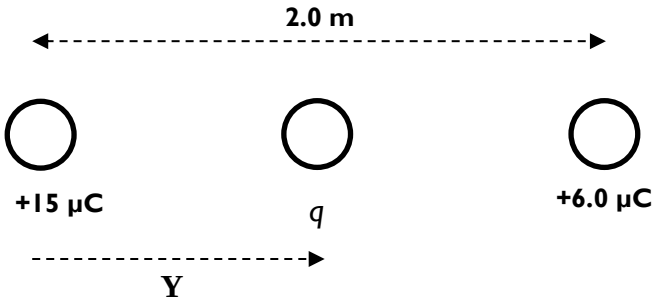
Question 28 (4 marks) **Marks**

Two point charges, +15 μC and +6.0 μC are fixed in place and separated by 2.0 m.



Not drawn to scale

A negative charge, q, is now placed between the two charges so that the three charges lie along a straight line as shown in the diagram above.

(a) Calculate the position, **Y**, from the +15 μC charge where the negative charge, q, must be placed so that the resultant electrical force on it is zero. **3**

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(b) If at the position **Y** you calculated in (a) the change q was replaced with a positive charge that is double the charge of the original q, what would be the resultant force on this new charge. **1**

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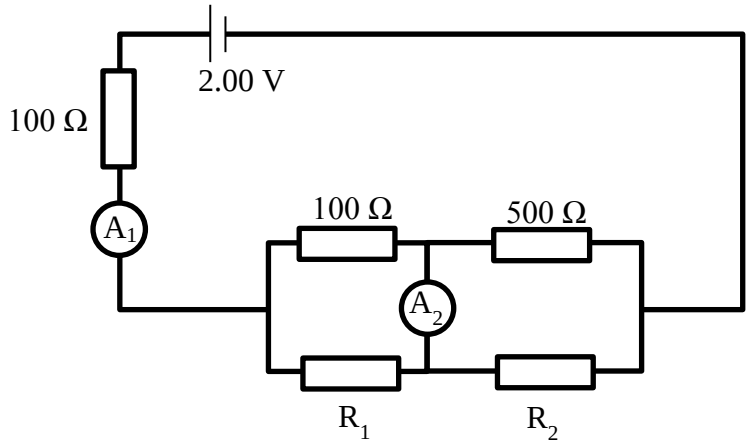
Question 29 (3 marks) **Marks**

Consider the following circuit diagram.



Ammeter, A_1, reads 8.00 mA and ammeter, A_2 reads 0 A.

What is the value of R_1 in ohms? **3**

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Question 30 (4 marks) **Marks**

The diagram below shows two balls A and B. Initially, ball A of mass $3m$ has a velocity of u to the right and ball B of mass m has a velocity of u to the left. The two balls A and B then collide elastically.

Calculate the values of the final velocities (a and b of balls A and B respectively) as a function of the initial speed u. **4**

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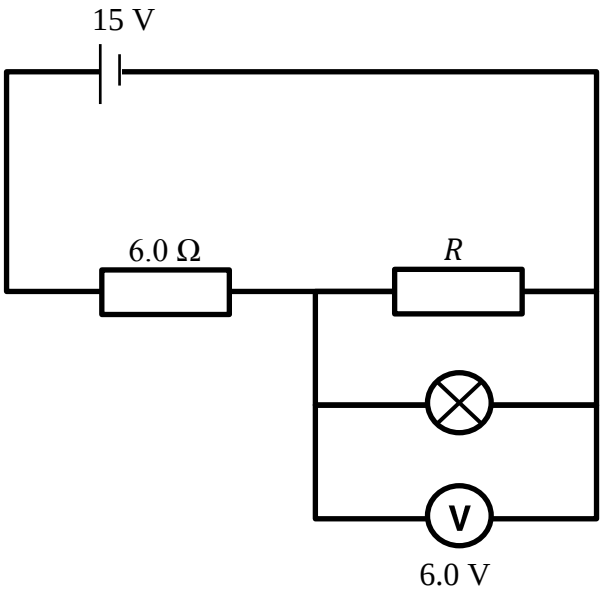
Class

Name

Question 31 (4 marks) **Marks**

Consider the following circuit.



A current of 0.60 A flows through the light globe.

(a) In terms of energy, what is meant by the term '15 V battery'? **1**

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(b) Calculate the value of the resistance labelled *R*. **3**

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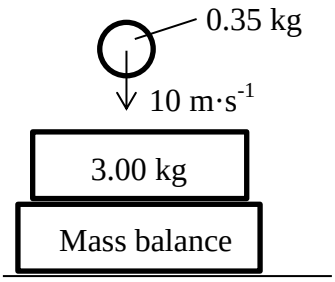
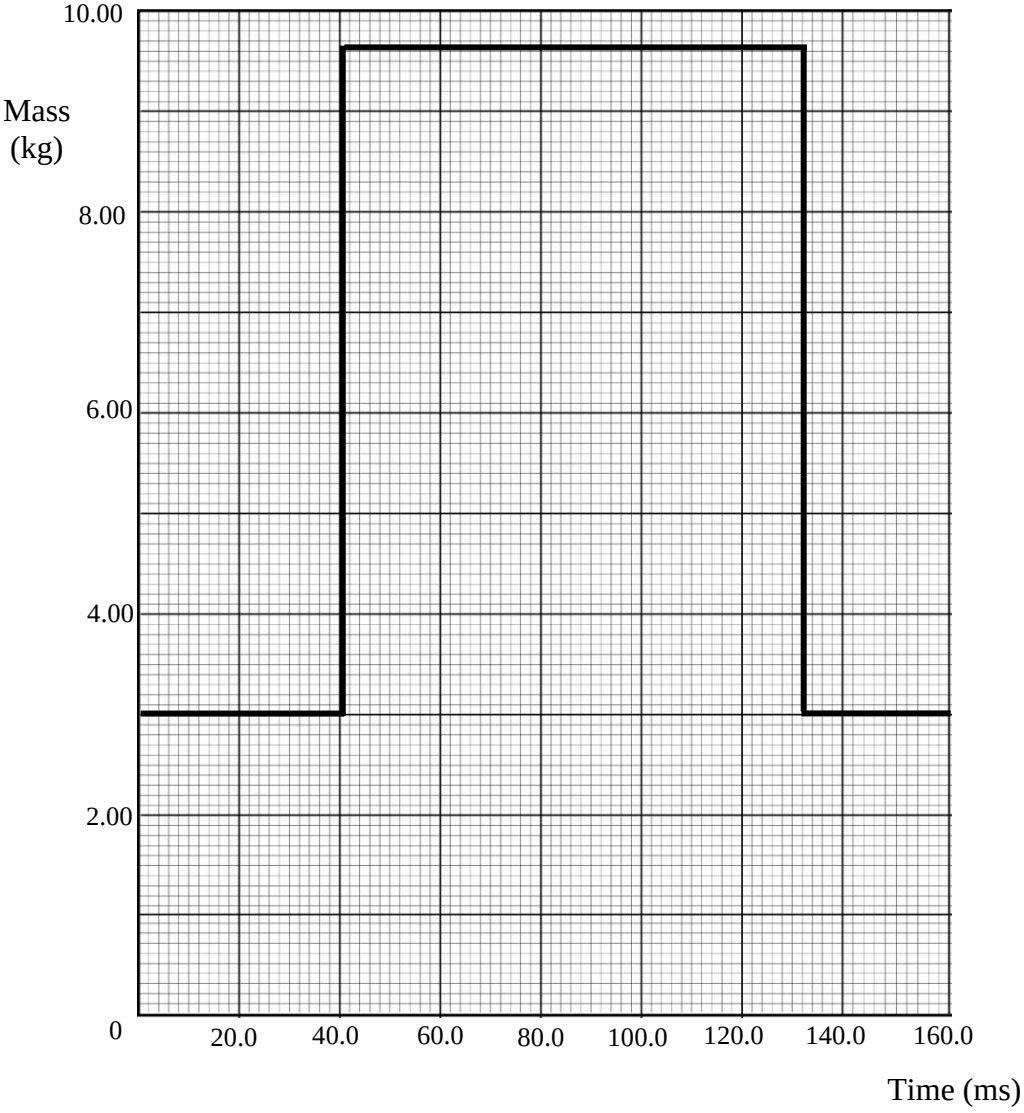
Question 32 (5 marks) **Marks**

The diagram below shows a ball of mass 0.35 kg falling onto a 3.00 kg block which is sitting on a sensitive mass balance calibrated in kg. The ball hits the 3.00 kg block at a speed of 10 $m \cdot s^{-1}$.



The graph below shows how the reading on the mass balance varies just before, during and just after the ball hits the block.



Question 32 continued on next page.

Question 32 continued **Marks**

(a) Calculate the magnitude of the momentum of the ball just before it hits the 3.00 kg block. **1**

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(b) Calculate how high the ball bounces (relative to the top of the block) after impact with the 3.00 kg block. **4**

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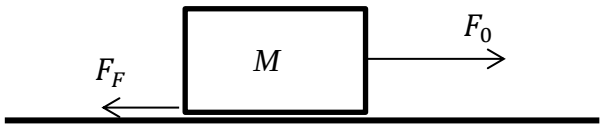
Question 33 (8 marks) **Marks**

A boy performs the following experiment to investigate friction.



The boy pulls blocks of different masses, M, along a horizontal surface with a constant force, F_0, and measures their acceleration.

The boy assumes that the force of friction, F_F, acting on the blocks is directly proportional to the weight of the blocks, Mg, and is given by the equation:

$$F_F = \mu Mg$$

where μ is called the 'coefficient of friction' and can be assumed to be constant.

The results obtained by the boy are given in the table below.

Mass of block (kg)	**Acceleration of block ($m \cdot s^{-2}$)**		
1.00	10.5		
1.50	6.35		
2.00	4.39		
3.00	2.51		
4.00	1.42		
5.00	0.78		

The boy knows that the motion of the blocks is subject to Newton's Second Law, and assumes that the block obeys the relationship:

$$F_0 - \mu Mg = Ma$$

which can be written as

$$a = F_0\left(\frac{1}{M}\right) - \mu g$$

Question 33 continued on next page.

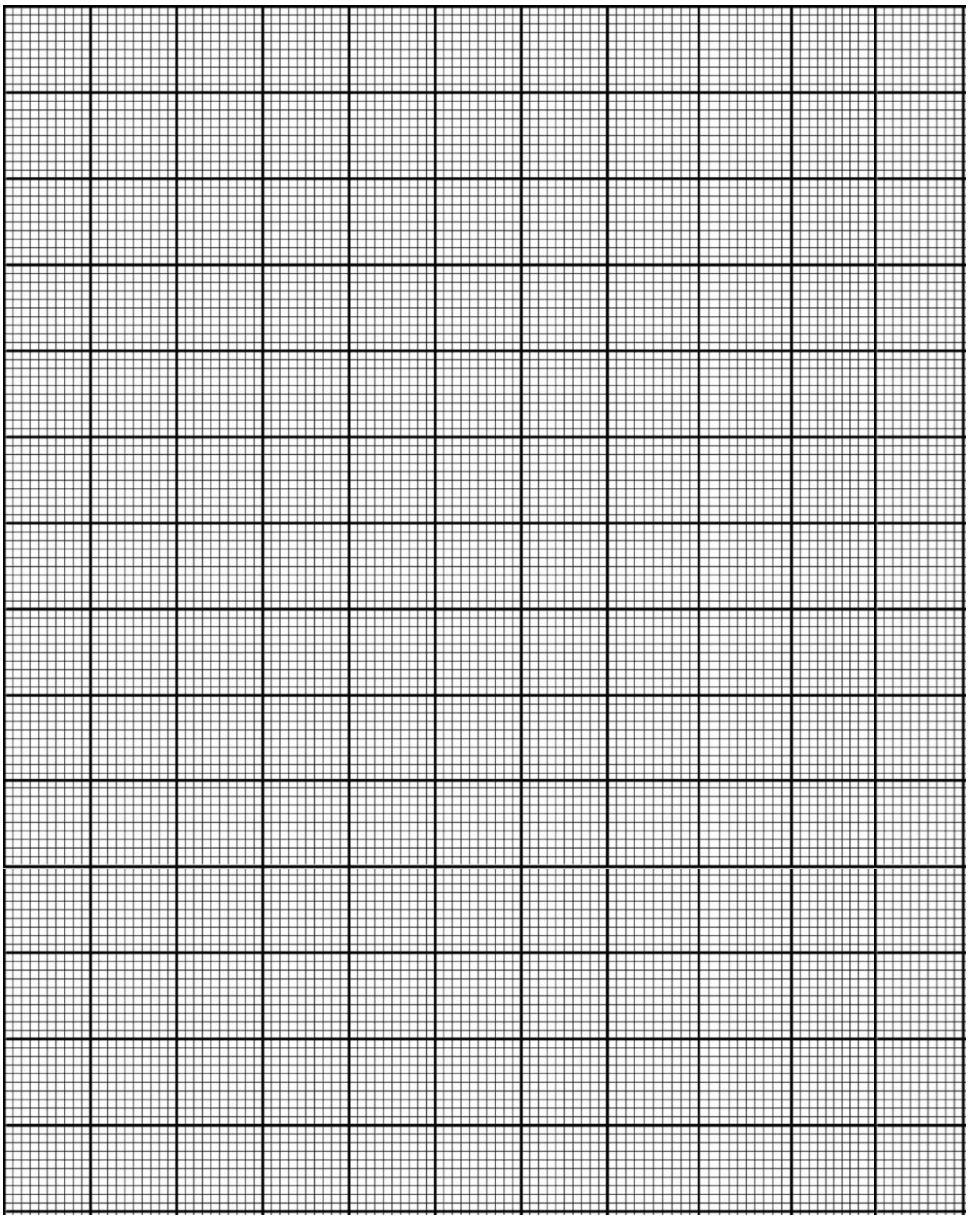
Class

Name

Question 33 continued **Marks**

(a) Plot a **straight line graph** to confirm the relationship between the acceleration and the mass of the blocks, given on the previous page.

(Extra columns have been provided in the table on the previous page, for you to use if you need them.)



4

Question 33 continued on next page.

Question 33 continued **Marks**

(b) Use your graph to determine:

i) the constant force, F_0. **2**

.....

.....

.....

.....

ii) the coefficient of friction, μ. **2**

.....

.....

.....

.....

Physics

Data Sheet

Charge on the electron, q_e	-1.602×10^{-19} C
Mass of electron, m_e	9.109×10^{-31} kg
Mass of neutron, m_n	1.675×10^{-27} kg
Mass of proton, m_p	1.673×10^{-27} kg
Speed of sound in air	330 m s^{-1}
Earth's gravitational acceleration, g	9.8 m s^{-2}
Radius of Earth, R_E	6.4×10^6 m
Speed of light, c	3.00×10^8 m s^{-1}
Magnetic force constant, $\left(k \equiv \frac{\mu_0}{2\pi}\right)$	2×10^{-7} N A^{-2}
Universal gravitational constant, G	6.7×10^{-11} N m^2 kg^{-2}
Mass of Earth	6.0×10^{24} kg
Planck's constant, h	6.626×10^{-34} J s
Rydberg's constant, R (hydrogen)	1.097×10^7 m^{-1}
Atomic mass unit, u	1.661×10^{-27} kg 931.5 MeV/c^2
1 eV	1.602×10^{-19} J
Density of water, ρ	1.00×10^3 kg m^{-3}
Specific heat capacity of water	4.18×10^3 J kg^{-1} K^{-1}
Coulomb's constant, k	9.0×10^9 Nm^2C^{-2}

FORMULAE SHEET FORM V ONLY

$$v_{av} = \frac{\Delta r}{\Delta t}$$

$$a_{av} = \frac{\Delta v}{\Delta t} = \frac{v-u}{t}$$

$$v = u + at$$

$$v^2 = u^2 + 2ar$$

$$r = ut + \frac{1}{2}at^2$$

$$\sum F = ma$$

$$F = \frac{mv^2}{r}$$

$$E_k = \frac{1}{2}mv^2$$

$$E_p = mgh$$

$$W = Fr$$

$$p = mv$$

$$\Delta p = F_n t$$

$$F = mg$$

$$E = \frac{F}{q}$$

$$E = \frac{V}{d}$$

$$F = \frac{kQ_1Q_2}{d^2}$$

$$I = \frac{Q}{t}$$

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

$$P = VI$$

$$Energy = VIt$$

$$v = f\lambda$$

$$f = \frac{1}{T}$$

$$I \propto \frac{1}{d^2}$$

$$\frac{v_1}{v_2} = \frac{\sin i}{\sin r}$$

$$n\lambda = d\sin\theta$$

$$n\lambda = \frac{dx}{L}$$

$$E_p = -\frac{Gm_1m_2}{r}$$

$$\frac{r^3}{T^2} = \frac{GM}{4\pi^2}$$

$$F = \frac{Gm_1m_2}{d^2}$$

$$E = mc^2$$

FORMULAE SHEET

$$\frac{F}{l} = k\frac{I_1 I_2}{d}$$

$$F = BIl\sin\theta$$

$$\tau = Fd$$

$$\tau = nBIA\cos\theta$$

$$\frac{V_p}{V_s} = \frac{n_p}{n_s}$$

$$F = qvB\sin\theta$$

$$E = \frac{V}{d}$$

$$E = hf$$

$$c = f\lambda$$

$$Z = \rho v$$

$$\frac{I_r}{I_0} = \frac{\left[Z_2 - Z_1\right]^2}{\left[Z_2 + Z_1\right]^2}$$

$$d = \frac{1}{P}$$

$$M = m - 5\log\left(\frac{d}{10}\right)$$

$$\frac{I_A}{I_B} = 100\left(m_B - m_A\right)/5$$

$$m_1 + m_2 = \frac{4\pi^2 r^3}{GT^2}$$

$$\frac{1}{\lambda} = R_H\left[\frac{1}{n_f^2} - \frac{1}{n_i^2}\right]$$

$$\lambda = \frac{h}{mv}$$

$$A_0 = \frac{V_{out}}{V_{in}}$$

$$\frac{V_{out}}{V_{in}} = -\frac{R_f}{R_i}$$

Surface area of a sphere of radius, R	=	$4\pi R^2$

PERIODIC TABLE OF THE ELEMENTS

KEY

Atomic Number
Symbol
Standard Atomic Weight
Name

79 Au 197.0 Gold

1 H 1.008 Hydrogen																	2 He 4.003 Helium
3 Li 6.941 Lithium	4 Be 9.012 Beryllium											5 B 10.81 Boron	6 C 12.01 Carbon	7 N 14.01 Nitrogen	8 O 16.00 Oxygen	9 F 19.00 Fluorine	10 Ne 20.18 Neon
11 Na 22.99 Sodium	12 Mg 24.31 Magnesium											13 Al 26.98 Aluminium	14 Si 28.09 Silicon	15 P 30.97 Phosphorus	16 S 32.07 Sulfur	17 Cl 35.45 Chlorine	18 Ar 39.95 Argon
19 K 39.10 Potassium	20 Ca 40.08 Calcium	21 Sc 44.96 Scandium	22 Ti 47.87 Titanium	23 V 50.94 Vanadium	24 Cr 52.00 Chromium	25 Mn 54.94 Manganese	26 Fe 55.85 Iron	27 Co 58.93 Cobalt	28 Ni 58.69 Nickel	29 Cu 63.55 Copper	30 Zn 65.38 Zinc	31 Ga 69.72 Gallium	32 Ge 72.64 Germanium	33 As 74.92 Arsenic	34 Se 78.96 Selenium	35 Br 79.90 Bromine	36 Kr 83.80 Krypton
37 Rb 85.47 Rubidium	38 Sr 87.61 Strontium	39 Y 88.91 Yttrium	40 Zr 91.22 Zirconium	41 Nb 92.91 Niobium	42 Mo 95.96 Molybdenum	43 Tc Technetium	44 Ru 101.1 Ruthenium	45 Rh 102.9 Rhodium	46 Pd 106.4 Palladium	47 Ag 107.9 Silver	48 Cd 112.4 Cadmium	49 In 114.8 Indium	50 Sn 118.7 Tin	51 Sb 121.8 Antimony	52 Te 127.6 Tellurium	53 I 126.9 Iodine	54 Xe 131.3 Xenon
55 Cs 132.9 Caesium	56 Ba 137.3 Barium	57–71 Lanthanoids	72 Hf 178.5 Hafnium	73 Ta 180.9 Tantalum	74 W 183.9 Tungsten	75 Re 186.2 Rhenium	76 Os 190.2 Osmium	77 Ir 192.2 Iridium	78 Pt 195.1 Platinum	79 Au 197.0 Gold	80 Hg 200.6 Mercury	81 Tl 204.4 Thallium	82 Pb 207.2 Lead	83 Bi 209.0 Bismuth	84 Po Polonium	85 At Astatine	86 Rn Radon
87 Fr Francium	88 Ra Radium	89–103 Actinoids	104 Rf Rutherfordium	105 Db Dubnium	106 Sg Seaborgium	107 Bh Bohrium	108 Hs Hassium	109 Mt Meitnerium	110 Ds Darmstadtium	111 Rg Roentgenium	112 Cn Copernicium						

Lanthanoids

57 La 138.9 Lanthanum	58 Ce 140.1 Cerium	59 Pr 140.9 Praseodymium	60 Nd 144.2 Neodymium	61 Pm Promethium	62 Sm 150.4 Samarium	63 Eu 152.0 Europium	64 Gd 157.3 Gadolinium	65 Tb 158.9 Terbium	66 Dy 162.5 Dysprosium	67 Ho 164.9 Holmium	68 Er 167.3 Erbium	69 Tm 168.9 Thulium	70 Yb 173.1 Ytterbium	71 Lu 175.0 Lutetium

Actinoids

89 Ac Actinium	90 Th 232.0 Thorium	91 Pa 231.0 Protactinium	92 U 238.0 Uranium	93 Np Neptunium	94 Pu Plutonium	95 Am Americium	96 Cm Curium	97 Bk Berkelium	98 Cf Californium	99 Es Einsteinium	100 Fm Fermium	101 Md Mendelevium	102 No Nobelium	103 Lr Lawrencium

Elements with atomic numbers 112 and above have been reported but not fully authenticated.

Standard atomic weights are abridged to four significant figures.

Elements with no reported values in the table have no stable nuclides.

The International Union of Pure and Applied Chemistry Periodic Table of the Elements (February 2010 version) is the principal source of data. Some data may have been modified.

SYDNEY GRAMMAR SCHOOL

CRIB
Class

WARD
Name

2016
FORM V
ANNUAL EXAMINATION

Physics
Part A
ANSWER SHEET

General Instructions

- Write your class and candidate number in the space provided.
- Attempt all questions 1 – 13
- Use a blue or black pen
- Select the alternative A, B, C, or D that best answers the question.
- Fill in the response circle completely.

1.	A	B	**C**	D
2.	A	B	**C**	D
3.	A	B	**C**	D
4.	**A**	B	C	D
5.	A	B	**C**	D
6.	A	**B**	C	D
7.	A	B	C	**D**
8.	A	B	**C**	D
9.	A	B	C	**D**
10.	A	B	**C**	D
11.	A	B	C	**D**
12.	**A**	B	C	D
13.	A	**B**	C	D

Class

SRW

Name

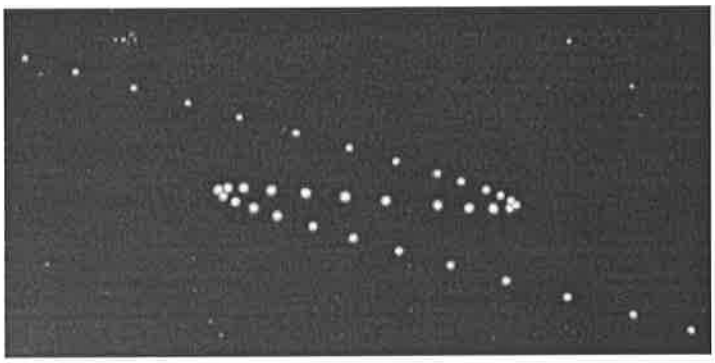
Part B

Total marks (82)
Attempt ALL Questions
Allow about 1 hour and 40 minutes for this Part

Answer the questions in the spaces provided.
Show all relevant working in questions involving calculations.

Question 14 (6 marks) **Marks**

The following photograph is taken for the planet Mars over several weeks.



(a) Name the phenomenon shown in the photograph above. **1**

Retrograde motion

(b) How did Ptolemy explain this motion? **2**

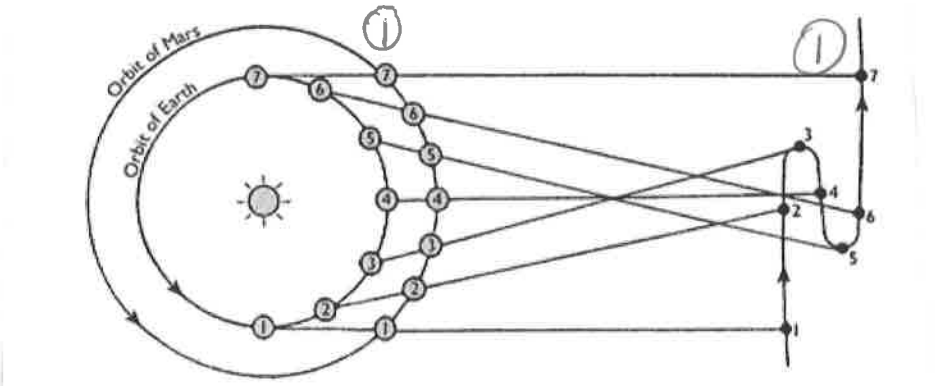
① epicycles.

① As the planet moved on its epicycle sometimes it would be moving forward and then backwards

Question 14 continued on next page.

Question 14 continued **Marks**

(c) With the aid of a diagram, explain how Copernicus explained this motion. **3**



(1) As Earth overtakes Mars it will appear to move backwards then forwards

Class

Name

Question 15 (4 marks) **Marks**

Carbon-14 decays by beta minus decay with a half-life of 5730 years.

(a) Write a nuclear decay equation for this reaction. **2**

$^{14}_{6}C \longrightarrow {}^{0}_{-1}e + {}^{14}_{7}N$ (1) (1)

(b) The carbon-14 content of an ancient piece of wood was found to have only one eighth of its original carbon-14 remaining.

Determine the age (in years) of this ancient piece of wood. **2**

$\frac{1}{8} = (\frac{1}{2})^3 \Rightarrow$ 3 half lives (1)

$\Longrightarrow 3 \times 5730 = 17190$ years (1)

Question 16 (4 marks) **Marks**

Two of the major moons of Jupiter are Europa and Ganymede. The distance of Europa from Jupiter is 671,100 km while the distance of Ganymede from Jupiter is 1,070,400 km. The orbital period of Ganymede around Jupiter is 7.15 days.

(a) Determine the orbital period of Europa around Jupiter. **2**

$T = T_G \sqrt{\left(\frac{r_E}{r_G}\right)^3}$ ①

3.55 days ①

(b) What was the impact of Galileo's discovery of these moons in January 1610 on the model of the Universe? **2**

① As not everything is orbiting Earth

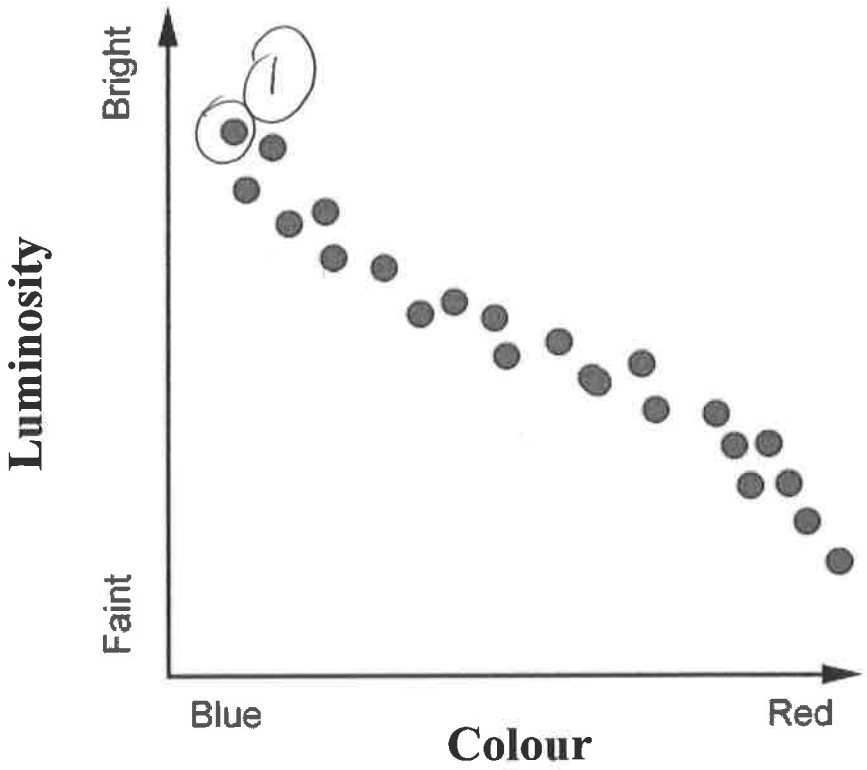
① Therefore evidence that Geocentric model is wrong.

Class

Name

Question 17 (3 marks) **Marks**

Consider the Hertzsprung-Russell Diagram below for stars found in a globular cluster. It is known that the stars in a globular cluster are formed roughly at the same time.



(a) Circle the hottest star shown on the diagram above. **1**

(b) An astronomer looking at this diagram suggests that the stars are young. Explain the reasoning behind this suggestion. **2**

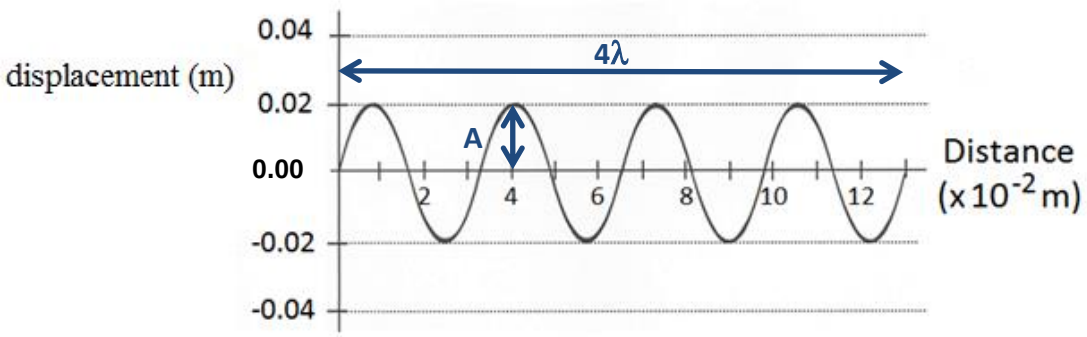
(1) Only main sequence stars.

(1) no red giants, white dwarfs etc. that are evidence of older stars

- DGB -

Question 18 (4 marks) **Marks**

The diagram below shows a displacement versus distance graph for a wave travelling through a medium. The frequency of this wave is 45.0 Hz.



Use this information to find:

(a) the wavelength of the wave. **1**

Criteria	Marks
• Correct value determined (range: ±0.25 cm accepted).	1 (91%)

Sample answer: *From the graph, $4\lambda = 13 \times 10^{-2}$ m*
so $\lambda = 13 \times 10^{-2} / 4 =$ 3.25×10^{-2} m (= 0.00325 m = 3.25 cm)

(b) the amplitude of the wave. **1**

Criteria	Marks
• Correct value determined.	1 (97%)

Sample answer: *A = 0.02 m*

(c) the period of the wave. **1**

Criteria	Marks
• Correct value determined.	1 (99%)

Sample answer: $T = \frac{1}{f} = \frac{1}{45.0} = 2.22 \times 10^{-2}$ s

(d) the velocity of the wave. **1**

Criteria	Marks
• Correct value determined [carry-over errors from (a) allowed].	1 (94%)

Sample answer: $v = f\lambda = 45.0 \times 3.25 \times 10^{-2} = 1.46$ m.s^{-1}

Question 19 (2 marks) **Marks**

The intensity of a point source of light is 40.0 $W \cdot m^{-2}$ at a distance of 8.00 m away from the source.

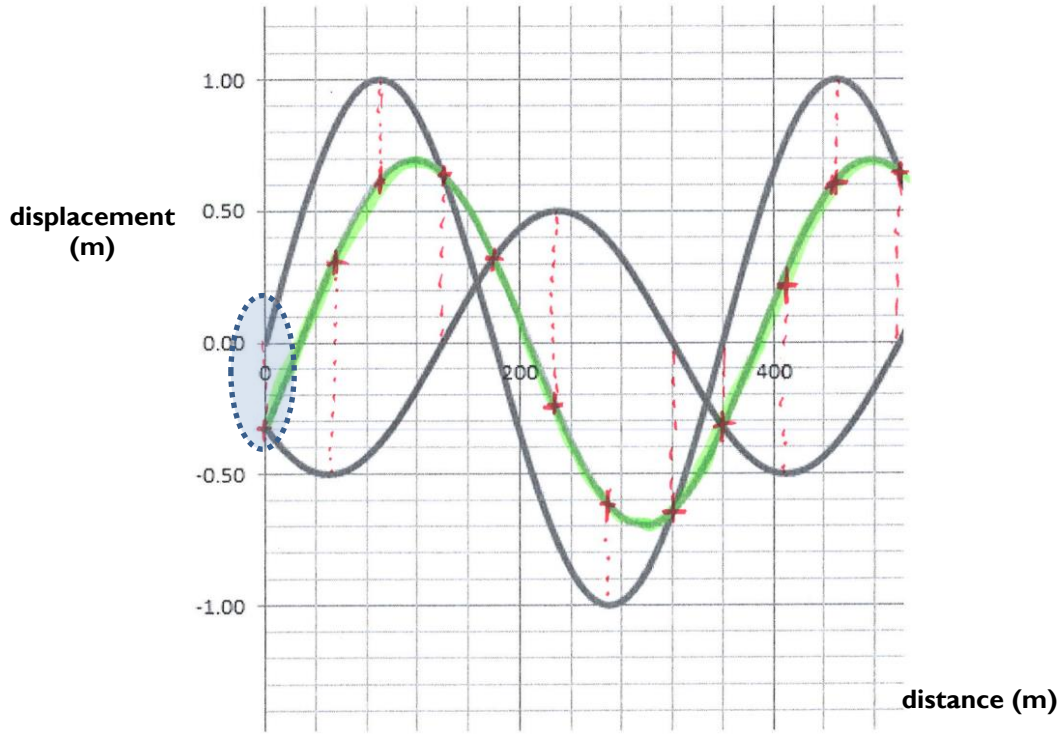
Calculate the intensity of the light at a distance of 12.0 m away from the same point source. **2**

Criteria	Marks
• Appropriate equation used. • Correct substitution and result.	2 (90%)
• Appropriate equation used but calculation error.	1 (7%)

Sample answer: $I_1 d_1^2 = I_2 d_2^2 \Rightarrow I_2 = I_1 \frac{d_1^2}{d_2^2} = 40.0 \times \frac{8.0^2}{12.0^2} = \underline{17.8\ W.m^{-2}}$

Question 20 (2 marks)

The following graph shows a medium with two waves moving through it simultaneously. **2**

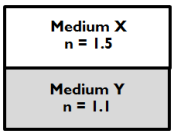


Criteria	Marks
• Correct shape. • Reasonable accuracy.	2 (80%)
• Any mistakes: -1 mark (especially the first point on the left).	1 (19%)

On the grid above, accurately draw the combined displacement of the medium as a result of these two waves at this instance.

Question 21 (6 marks) **Marks**

The diagram below shows a pair of transparent media, X and Y.



(a) Using the information provided in the diagram, determine the critical angle for this pair of media. **2**

Criteria	Marks
• Appropriate equation used. • Correct substitution ($r = 90^o$ when $i = i_c$) and result.	2 (94%)
• Appropriate equation but calculation error.	1 (4%)

Sample answer: $n_x \sin i_c = n_y \sin 90^o \Rightarrow i_c = \sin^{-1}\left(\frac{n_y}{n_x} \sin 90^o\right) = \sin^{-1}\left(\frac{1.1}{1.5} \text{x} 1\right) = \underline{47.17^o}$

(b) Determine the speed of a light ray travelling in Medium Y. **1**

Criteria	Marks
• Correct value determined.	1 (88%)

Sample answer: $n_y = \frac{c}{v_y} \Rightarrow v_y = \frac{c}{n_y} = \frac{3.0 \times 10^8}{1.1} = \text{x } 3.25 \text{ x } 10^{-2} = \underline{2.72 \text{ x } 10^8 \text{ m.s}^{-1}}$

(c) Using a labelled diagram, describe how total internal reflection is used in a fibre optic cable. **3**

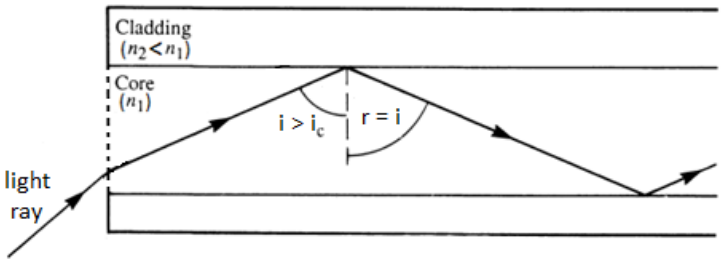
Criteria	Marks
• Appropriate diagram (with labels), showing important angles and the different parts of the optic fibre (cladding + core, and respective indices of refraction). AND • Clear and thorough explanation of how Total Internal Reflection (TIR) is used in optic fibres, especially in terms of angle of incidence ($i > i_c$) and of relative indices of refraction between the two media ($n_{cladding} < n_{core}$).	3 (37%)
• One of the above bullet points missing or poorly described.	2 (27%)
• Any appropriate comment (or element in the diagram) showing any basic understanding of how Total Internal Reflection is used in optic fibres.	1 (26%)

Marker's comments:

- Many boys just stated that optical fibres could transfer information by using Total Internal Reflection, usually with a poorly drawn diagram (missing cladding or light rays or angles or respective indices of refraction).
- Angles are ALWAYS measured from the normal to the surface.

Sample answer:

An optical fibre is comprised of a light-carrying core (higher refractive index) surrounded by a cladding (lower refractive index).



This construction traps the light in the core by the principle of Total Internal Reflection.
Since the fibre core has a slightly higher refractive index, the light in the core is totally reflected at the boundary of the cladding for all light that strikes at greater angles than the critical angle for this pair of materials (which should be as small as possible).
As a consequence, very little light is absorbed by the glass: the light getting in at one end undergoes repeated total internal reflection (even when the fibre is bent) and emerges at the other end.

Question 22 (4 marks) **Marks**

This question is about the formation of standing waves in a microwave oven which can be used to determine the speed of light.

Marshmallow sweets can be served melted. An attempt to melt a plate of marshmallows is made in a microwave oven **from which the turntable has been removed,** so that the tray can sit still in the oven. (see Figure 1).

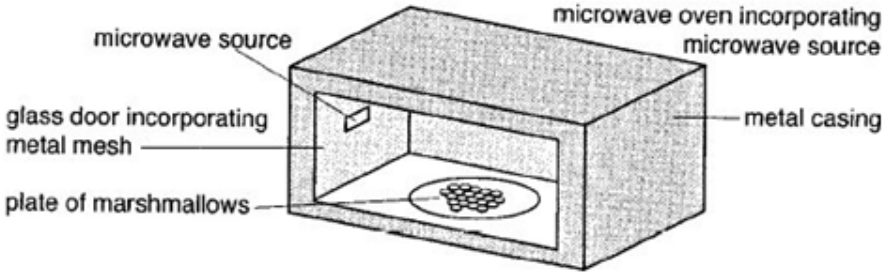


Figure 1

(a) The marshmallows do not melt uniformly. The melting is concentrated at regularly spaced spots 0.057 m apart as shown in Figure 2.

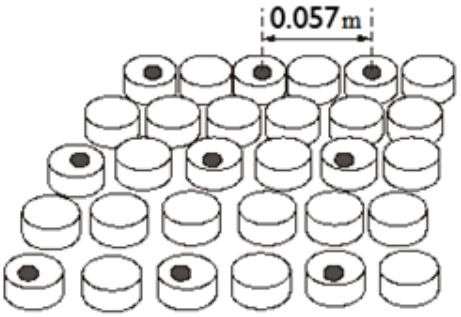


Figure 2

Question 22 continued on next page.

Question 22 continued **Marks**

The design of the microwave oven allows for the formation of standing waves within the cavity and the melted spots occur at the **antinodes** of a standing wave set up in the microwave oven.

Figure 3 represents the variation in amplitude of the microwaves along part of one such standing wave.

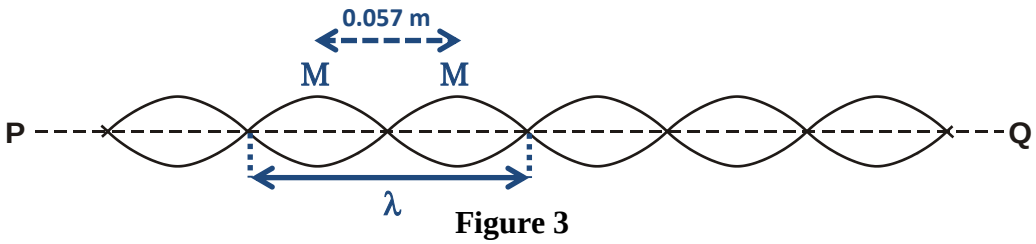


Figure 3

i) Along the line **PQ**, mark with an "M", **two** positions where a melted spot might be expected to form. **1**

Criteria	Marks
• Correct positions marked (M).	1 (54%)

Sample answer: ***see diagram above.***

ii) On Figure 3, mark a distance equal to one wavelength. Label it λ. **1**

Criteria	Marks
• Correct distance marked (λ).	1 (54%)

Sample answer: ***see diagram above.***

(d) The label on the back of the oven states that the frequency of the microwaves is 2.45×10^9 Hz.

Calculate the speed of the ***microwaves*** in the microwave oven. **2**

Criteria	Marks
• Appropriate equation used. • Correct substitution (λ = 2 x 0.057 = 0.114 m) and result.	2 (74%)
• Appropriate equation but calculation error (mainly, λ=0.057 m).	1 (23%)

Sample answer: **v = f λ with λ=2 x 0.057 m = 0.114 m (see diagram above)**

⇨ ***v = 2.45 x 10^9 x 0.114 = $\underline{2.79 \times 10^8\ m.s^{-1}}$***

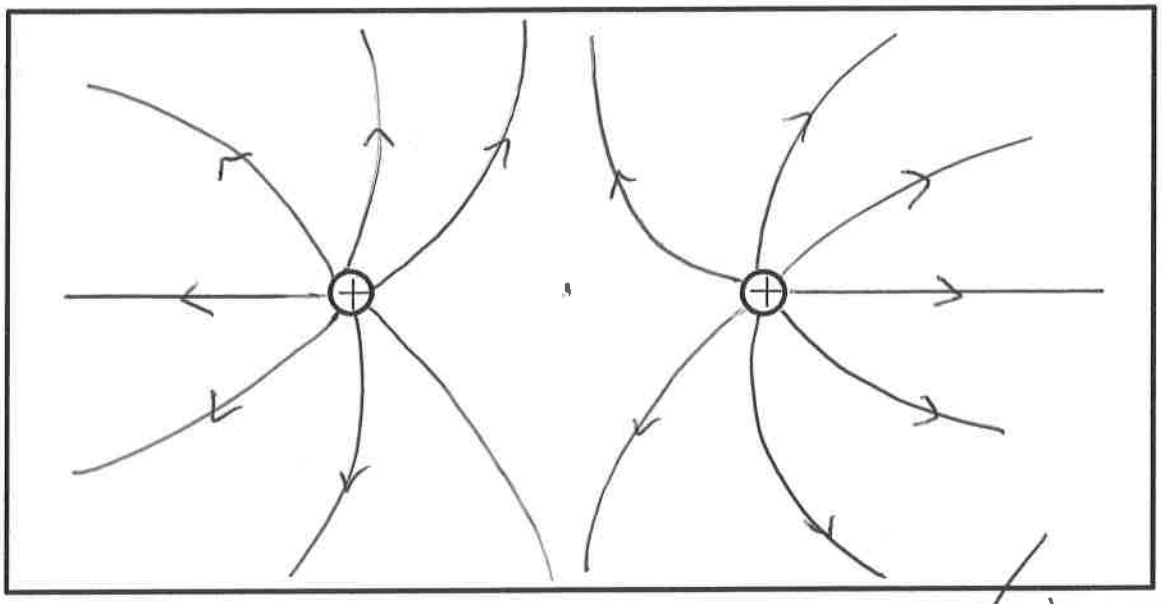
Class

WARD

Name

Question 23 (4 marks) **Marks**

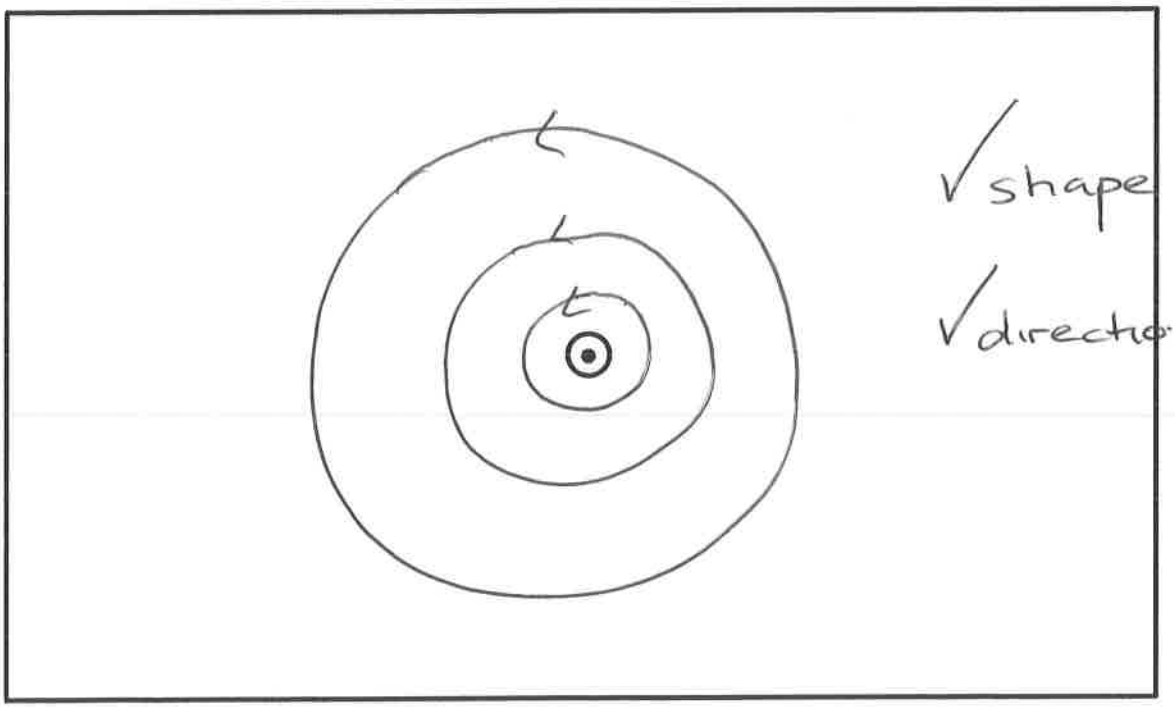
(a) In the box provided below, draw the electric field around the two charges shown. **2**



✓shape

✓direction

(b) In the box provided below, draw the magnetic field around the current carrying conductor shown. **2**

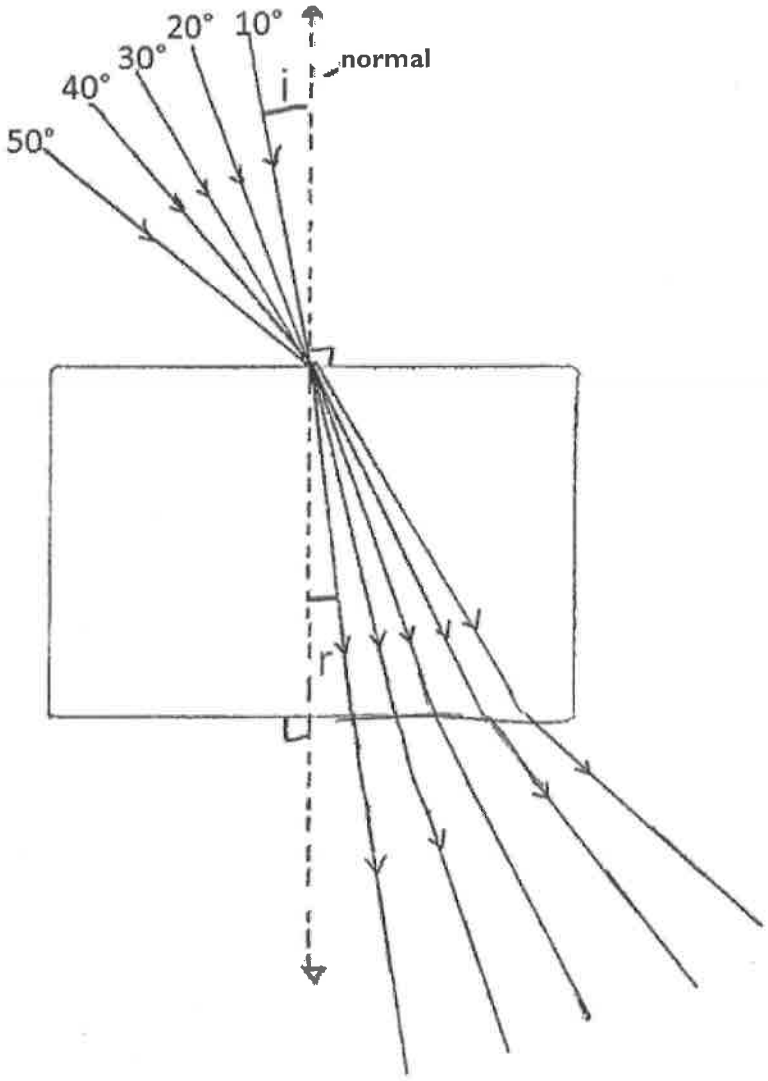


✓shape

✓direction

Question 24 (2 marks) **Marks**

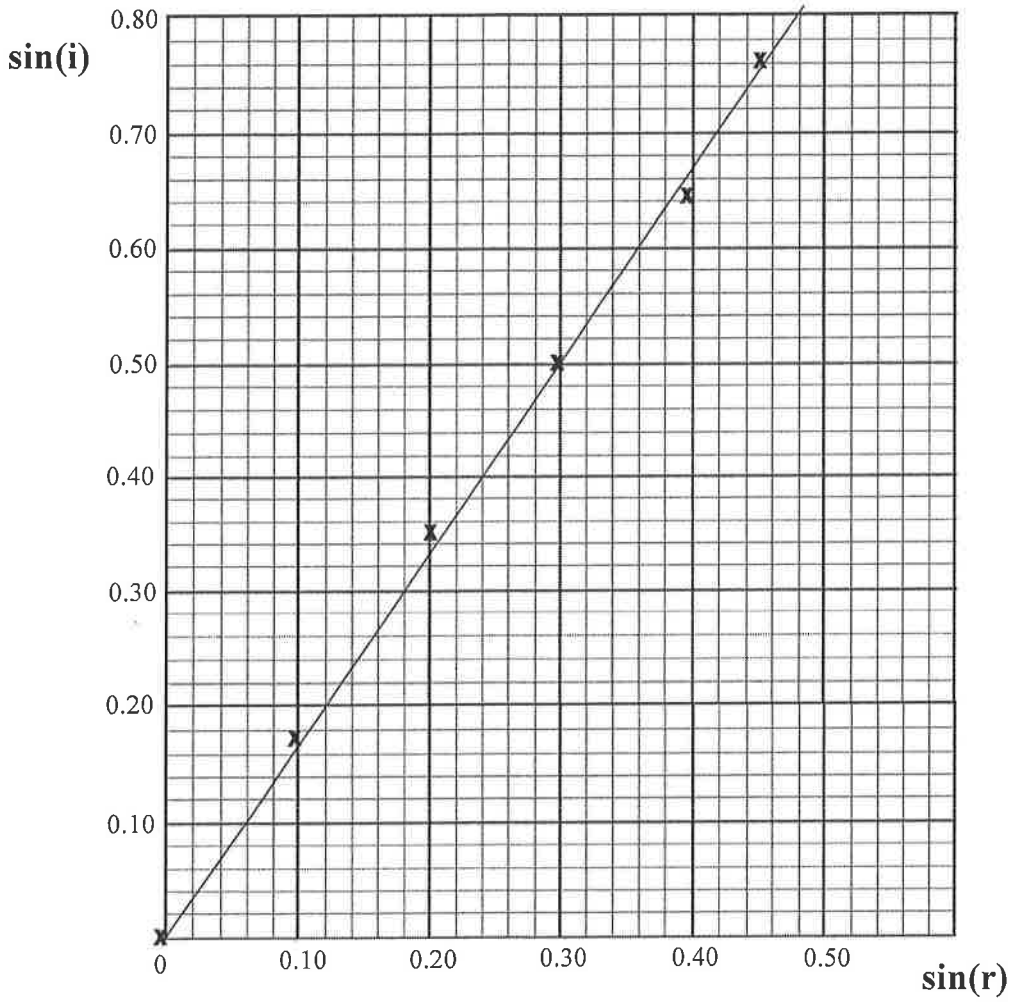
A student performed an experiment to measure the refractive index of a block of unknown transparent material. A ray of red light is shone into the block and the angles of incidence and refraction were recorded.



His results were plotted on a graph shown on the next page.

Question 24 continued on next page.

Question 24 continued **Marks**



Use the graph above to determine the value of the refractive index of the block of unknown material. **2**

$n = \sin i / \sin r$

$= 0.50/0.30$

$= 1.7$

−1 mk for each mistake made.

if $\frac{\sin 0.50}{\sin 0.30}$ then ✓x 1mk for recognition of ratio but incorrect substitution

Question 25 (4 marks) **Marks**

An electric kettle when connected to a 240 V supply operates at a power of 2.40 kW.
In order to boil 1.70 L of water, it must provide 0.640 MJ of energy.

(a) Calculate the time taken to boil the water. **2**

$EE = VIt$

$0.640 \times 10^6 = 240 \times \frac{2400}{240} \times t$

$t = 267\text{s}$

or $E = P \times t$

$0.640 \times 10^6 = 2.4 \times 10^3 t$

✓ correct substitution

✓ correct answer based on substitution.

(b) What current flows through the kettle? **1**

$P = VI$

$2.40 \times 10^3 = 240I \quad \therefore I = 10\text{A}$ ✓ (1) mk. Answer only.

[correct substitution into a correct formula]

(c) A power failure occurs and the mains voltage is halved.

How long does the kettle now take to boil the water? **1**

$EE = P \times t$ (4× longer)

$0.640 \times 10^6 = \frac{120^2}{24} \times t \quad t = 1066.7\text{s}$ ✓ (1) mk.. for answer 4 × Ans(a)

[or $0.640 \times 10^6 = \frac{240}{2} \times 5 \times t$]

if V halved, then since R = 24Ω is constant, I = 5A.

Most candidates assumed I was still equal to 10A.

$\therefore t = 533.33\text{s}$

✗ 0 mks

Note: from $V = IR$

$240 = 10 \times R$

$R = 24\Omega$.

Class

Name

Question 26 (4 marks) **Marks**

Two horizontal parallel metal plates are separated by a distance of 7.0×10^{-3} m. A potential difference of 200 V is connected across them. A small object with a mass of 2.1×10^{-12} kg is given a positive charge of 1.5×10^{-5} C. It is released from rest near the positive plate. Ignore the effects of gravity.

(a) Calculate the magnitude of the electric field strength between the plates. 1

$E = V/d = 200/7\times10^{-3}$ ✓① correct substitution

$= 2.86\times10^{4}\ NC^{-1}$

(b) Calculate the work done to move the $+1.5\times10^{-5}$ C charge through the potential difference of 200 volts. 1

$W = qV = 1.5\times10^{-5}\times200 = 3\times10^{-3}\ J$

or $W = qEd = 1.5\times10^{-5}\times \text{Ans(a)} \times 7.0\times10^{-3}$

(c) Calculate the speed gained by the positive charge when it reaches the negative plate. 2

CE = carry through error

Method 1: $W = \Delta KE$

$\text{Ans(b)} = \frac{1}{2}\times2.1\times10^{-12}v^2$ −1 mark for each mistake

$v = 5.3\times10^{4}\ ms^{-1}$

Method 2:

$F = ma = qE$

$2.1\times10^{-12}a = 1.5\times10^{-5}\times \text{Ans(a)}$

$a = 2.04\times10^{11}\ ms^{-2}$ ✓① mk. for correct value.

$v^2 = u^2 + 2as$

$v^2 = 0^2 + 2\times2.04\times10^{11}\times7\times10^{-3}$ ✓① mk for correct substitution

$v = 5.35\times10^{4}\ ms^{-1}$

Note: if wrong answer with no working = 0 mks.

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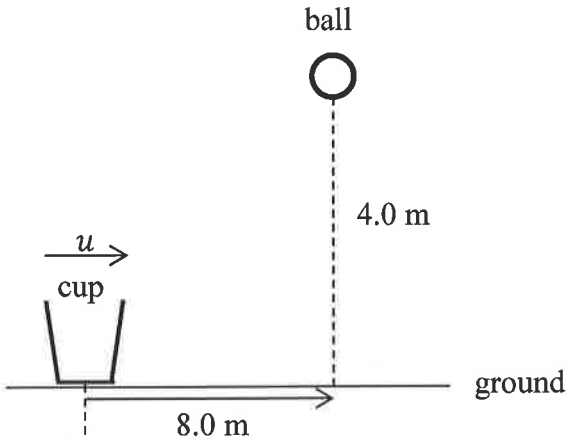
Question 27 (5 marks) **Marks**

A ball is dropped from a height of 4.0 m. At the same time, a cup is moving horizontally with an initial velocity, u, 8.0 m away as shown in the following diagram.



(a) How long will it take for the ball to fall vertically to the ground? **2**

$u = 0$ $s = \frac{1}{2}at^2$

$a = -9.8\ m/s^2$ $t = \sqrt{\frac{2s}{a}}$ ① solve for time and use $g = 9.8\ m/s^2$

$s = -4m$ $= \sqrt{\frac{2\times(-4)}{-9.8}} = 0.90\ s$ ① correct answer

(2 sig fig)

(b) In order for the ball to land in the cup, what does the initial horizontal speed, u, of the cup have to be:-

i) assuming the cup will slide without friction. **1**

$s = 8m$, $t = 0.90$ $s = ut$, $u = \frac{s}{t} = \frac{8}{0.90} = 8.9$ (2 sig fig)

① mark for correct answer

ii) assuming a frictional force acts on the cup causing it to decelerate across the surface at 1.2 $m \cdot s^{-2}$. **2**

$a = -1.2\ m/s^2$

$s = ut + \frac{1}{2}at^2$

$u = \frac{s - \frac{1}{2}at^2}{t}$ ① mark for correctly using $a = -1.2\ m/s^2$ in correct equation

$= \frac{s}{t} - \frac{1}{2}at = \frac{8.0}{0.90} - \frac{(-1.2)}{2}(0.90)$

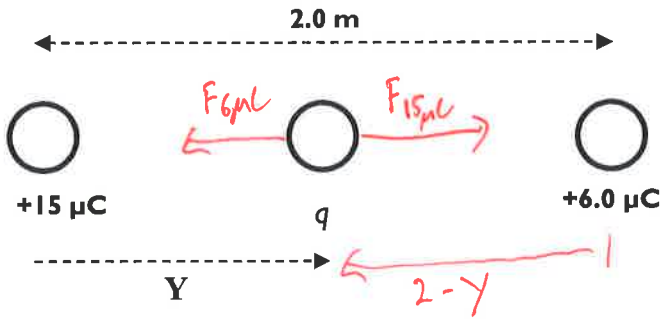
$= \frac{8.0}{0.90} + \frac{1.2}{2}(0.90) = 9.4\ m/s$ (2 sig fig)

① mark for correct answer

76% achieved 5/5 for this page

Question 28 (4 marks) **Marks**

Two point charges, +15 μC and +6.0 μC are fixed in place and separated by 2.0 m.



Not drawn to scale

many answers do not recognise that there are 2 forces on q from each charge and the net force is the sum of these forces.

A negative charge, q, is now placed between the two charges so that the three charges lie along a straight line as shown in the diagram above.

(a) Calculate the position, **Y**, from the +15 μC charge where the negative charge, q, must be placed so that the resultant electrical force on it is zero. **3**

$\Sigma F = 0 = \frac{k(15\times10^{-6})(q)}{Y^2} - \frac{k(6\times10^{-6})(q)}{(2-Y)^2}$

equate, cancel out $\frac{k(15\times10^{-6})(q)}{Y^2} = \frac{k(6\times10^{-6})(q)}{(2-Y)^2}$

multiply by denominators $15(2-Y)^2 = 6Y^2 = 15(4-4Y+Y^2)$

$15Y^2 - 6Y^2 - 60Y + 60 = 0$

quadratic: $9Y^2 - 60Y + 60 = 0$ or $3Y^2 - 20Y + 20 = 0$

$Y = \frac{20 \pm \sqrt{20^2 - 4(3)(20)}}{2\times3}$, $Y = 3\frac{1}{3} \pm \frac{2}{3}\sqrt{10}$

$Y = 1.2$ (2 sig fig) or 5.4 (2 sig fig)

only $Y = 1.2$ is a valid solution. $(0 < Y < 2)$

(1) Equating the forces from 15μC, 6μC using $F = \frac{kq_1q_2}{r^2}$

(1) getting to a solvable quadratic

(1) Giving only correct valid solution

(38% of form 3/3, 37% 0/3)

(b) If at the position **Y** you calculated in (a) the change q was replaced with a positive charge that is double the charge of the original q, what would be the resultant force on this new charge. **1**

ΣF is Zero. Both forces contain q, so value and sign cancel out.

(1) Identifies that the net force is zero

(35% of form 1/1)

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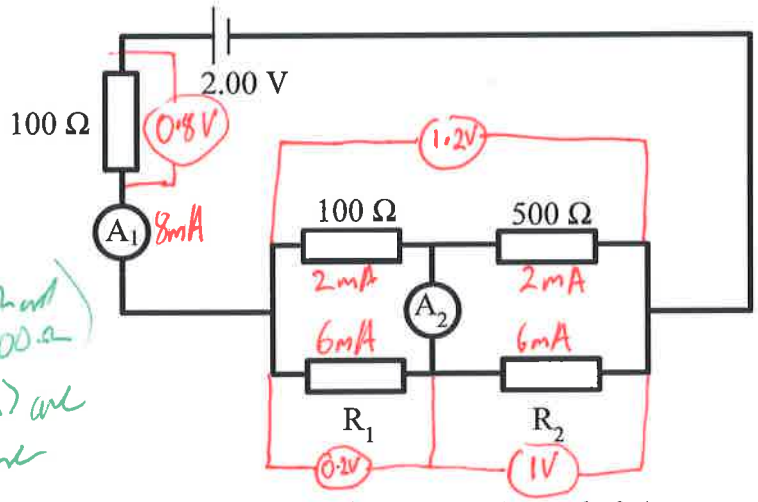
Question 29 (3 marks) **Marks**

Consider the following circuit diagram.



$A_2 = 0$ means current in (100Ω and 500Ω) and (R_1, R_2) are the same

Only 12% of form recieved full marks.

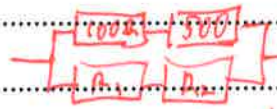
Ammeter, A_1, reads 8.00 mA and ammeter, A_2 reads 0 A.

What is the value of R_1 in ohms? **3**

(1) Find total resistance $R_T = \frac{2V}{8mA} = 250\Omega$. (Resistance of parallel branch = 150Ω)

(2) Find voltage across parallel branch R_p. $V_{100\Omega} = 8mA \times 100 = 0.8V$

so $R_p = 2 - 0.8 = 1.2V$

(3) When $A_2 = 0$  same current in 100Ω & 500Ω ($I = \frac{V}{R} = \frac{1.2}{600} = 2mA$)

(4) 8mA in circuit, 2mA in top branch, means 6mA through R_1 and R_2.

(5) circuit is still also  means same voltage on (R_1, 100Ω) and (R_2, 500Ω)

voltage on 100Ω resistor $V = IR = 2mA \times 100\Omega = 0.2V$ (same as R_2)

(6) Resistor R_1 has 6mA current and 0·2V so $R_1 = \frac{V}{I} = \frac{0.2}{6mA} = 33\frac{1}{3}\Omega$

($R_2 = \frac{1V}{6mA} = 166\frac{2}{3}\Omega$)

$R_1 = 33\frac{1}{3}\Omega$ (1 mark.)

Marking: There were many paths to the correct solution. Marks were issued for finding relationships that would lead to a solution

(1) mark ✓ for any two of. each

- Resistance of parallel branch is 150Ω
- Voltage of parallel branch is 1·2V
- $\frac{R_2}{R_1} = 5$

1 mark for $R_1 = 33\frac{1}{3}\Omega$.

- Current in each branch is 2mA and 6mA ($100\Omega + 500\Omega$) (R_1 and R_2)
- $R_1 + R_2 = 200\Omega$
- $\frac{R_1}{R_1 + R_2} = \frac{1}{6}$

Question 30 (4 marks) **Marks**

The diagram below shows two balls A and B. Initially, ball A of mass $3m$ has a velocity of u to the right and ball B of mass m has a velocity of u to the left. The two balls A and B then collide elastically.

Calculate the values of the final velocities (a and b of balls A and B respectively) as a function of the initial speed u.

$\Sigma p_i = \Sigma p_f$ $3mu - mu = 3ma + mb$

momentum conserved $3a + b = 2u$ (1) or $b = 2u - 3a$

$2\Sigma KE_i = 2\Sigma KE_f$ $3mu^2 + mu^2 = 3ma^2 + mb^2$

Kinetic energy conserved $3a^2 + b^2 = 4u^2$ (2)

substitute (1) into (2) $3a^2 + (2u - 3a)^2 = 4u^2$

$3a^2 + (4u^2 - 12au + 9a^2) = 4u^2$

$12a^2 - 12au = 0$

$12a(a - u) = 0$ gives $a = u$ or 0

When $a = 0$ $b = 2u - 3\times 0 = 2u$ } → solutions $(a=0, b=2u)$

When $a = u$ $b = 2u - 3u = -u$ or $(a=u, b=-u)$ - this is initial condition. and objects couldn't pass through each other

so valid solution $a = 0$, $b = 2u$

4 only 23% got 4/4

many don't simplify eqs before substitution

Alternate method: Relative velocity

$\Delta u = -\Delta v$

$u_A - u_B = -(v_A - v_B)$

$u - (-u) = -(a - b)$

$2u = b - a$ (3)

sub (3) into (1) $2u = 2u - 3a - a$

$4a = 0$, $a = 0$ $b = 2u$

Centre of mass

$a = 2\left(\frac{2mu}{4m}\right) - u$

$= u - u = 0$

$b = 2\left(\frac{2mu}{4m}\right) - (-u)$

$= u + u = 2u$

(1) mark for correct momentum equation

(1) mark for correct KE or relative velocity equation

(1) mark for attempting to eliminate a, b by substitution.

(1) mark for correct a, b or consistent valid $a =$ / $b =$ answers with u

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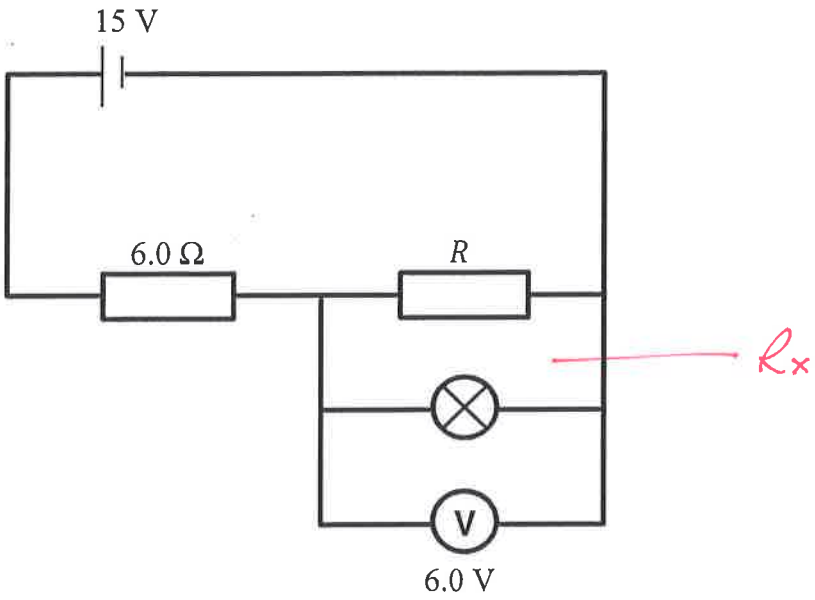
Question 31 (4 marks) **Marks**

Consider the following circuit.



Rx

A current of 0.60 A flows through the light globe.

(a) In terms of energy, what is meant by the term '15 V battery'? **1**

• ACCEPTED ANYTHING RELATED TO THE DEFINITION OF P.D.

e.g. 15V = 15J/C — (1)

(b) Calculate the value of the resistance labelled *R*. **3**

MULTIPLE METHODS:

$R_{TOT} = 10\Omega$ *
$R_X = 4\Omega$ *

MINE →

$R_{BULB} = 6/0.6 = 10\Omega$ *

$I_{TOT} = \frac{15-6}{6} = 1.5A$ * — (1)

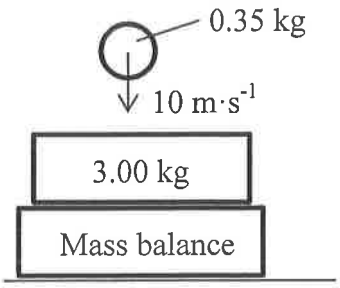
$\therefore I_R = 1.5 - 0.6 = 0.9$ — (2)

$\therefore R_R = 6/0.9 = 6.67\Omega$ — (3)

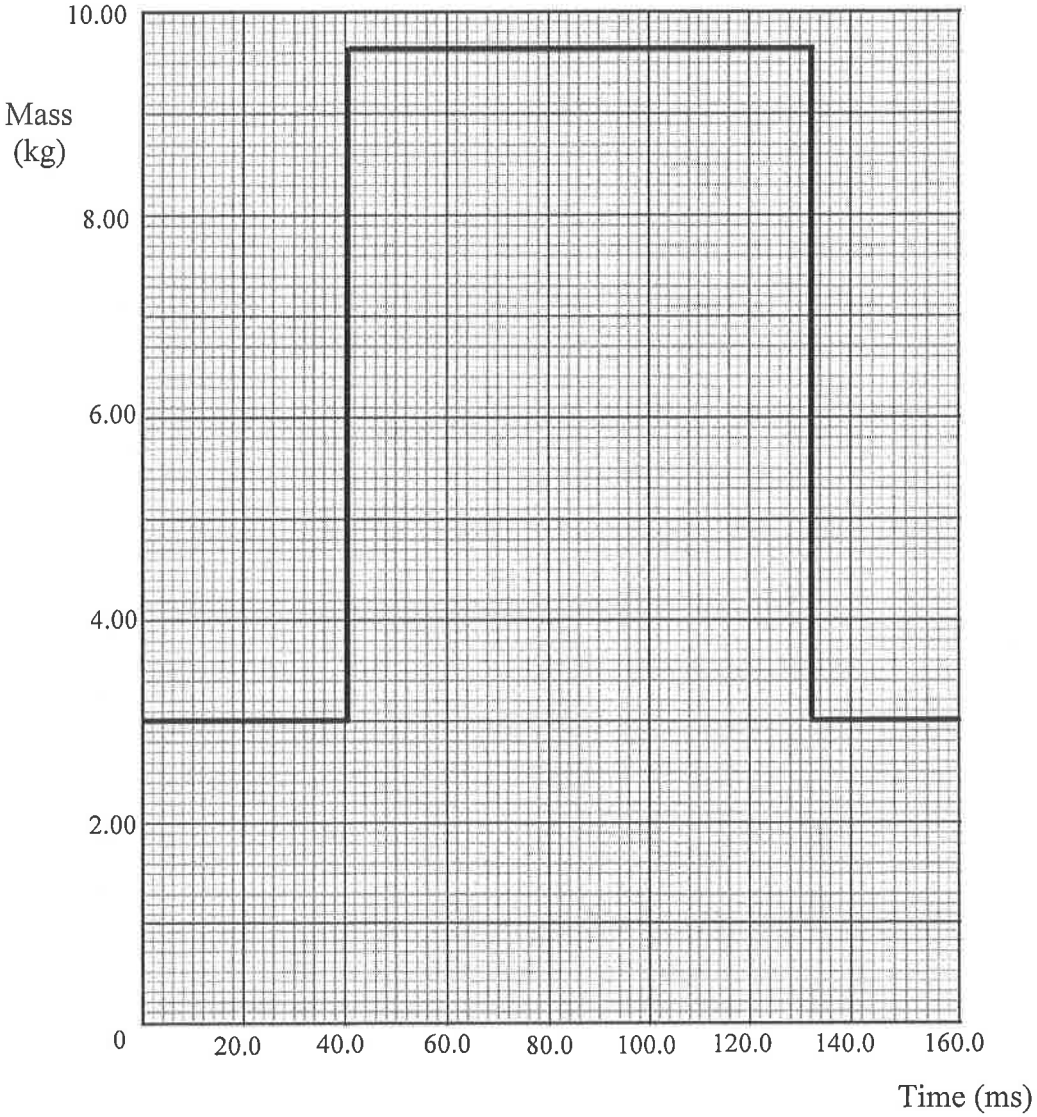
* ALL POTENTIALLY WORTH (1) IN ABSENCE OF A CORRECT ANSWER

Question 32 (5 marks) **Marks**

The diagram below shows a ball of mass 0.35 kg falling onto a 3.00 kg block which is sitting on a sensitive mass balance calibrated in kg. The ball hits the 3.00 kg block at a speed of 10 $m \cdot s^{-1}$.



The graph below shows how the reading on the mass balance varies just before, during and just after the ball hits the block.



Question 32 continued on next page.

Question 32 continued **Marks**

(a) Calculate the magnitude of the momentum of the ball just before it hits the 3.00 kg block. **1**

$= 0.35 \times 10 = 3.5 \text{ kgms}^{-1}$ — (1)

(b) Calculate how high the ball bounces (relative to the top of the block) after impact with the 3.00 kg block. **4**

$\Delta p = F \times t = (9.6 - 3.00^{*}) \times (132 - 40) \times 10^{-3} \times 9.8$

$\therefore \Delta p = 5.95 \text{ Ns}$ — (1)

$\therefore p_{\text{after}} = 5.95 - 3.5 = 2.45 \text{ kgms}^{-1}$ — (2)

$\therefore \vec{u}_{\text{after}} = \frac{2.45}{0.35} = 7.0 \text{ ms}^{-1}$ — (3)

$\therefore s = \frac{v^2 - u^2}{2a} = \frac{7.0^2}{19.6} = 2.5 \text{ m}$ — (4)

FOR (1) ACCEPTED A CALCULATION OF v, IF BASED ON A REASONABLE ASSUMPTION (eg $u \leq 10 \text{ ms}^{-1}$)

ACCEPT A REASONABLE ERROR MARGIN.

* NB – this should be 3.35, to include the mass of the BALL.

NO BODY INCLUDED THIS ∴ IT WAS NOT PENALISED.

BUT, INCLUDING IT, THE ANSWERS SHOULD BE: $\Delta p = 5.635 \text{ Ns}$, $p_F = 2.135 \text{ kgms}^{-1}$, $u_F = 6.1 \text{ ms}^{-1}$, $s = 1.90 \text{ m}$.

(actually, I think one boy did, but he made a mistake elsewhere...).

Question 33 (8 marks) **Marks**

A boy performs the following experiment to investigate friction.

The boy pulls blocks of different masses, M, along a horizontal surface with a constant force, F_0, and measures their acceleration.

The boy assumes that the force of friction, F_F, acting on the blocks is directly proportional to the weight of the blocks, Mg, and is given by the equation:

$$F_F = \mu Mg$$

where μ is called the 'coefficient of friction' and can be assumed to be constant. PQR SE

The results obtained by the boy are given in the table below. NOT MARKED,

Mass of block (kg)	Acceleration of block ($m \cdot s^{-2}$)	$1/M$	
1.00	10.5	1·0	
1.50	6.35	0·67	
2.00	4.39	0·50	
3.00	2.51	0·33	
4.00	1.42	0·25	
5.00	0.78	0·20	

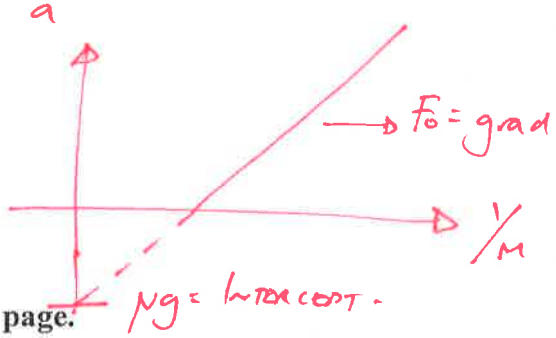
The boy knows that the motion of the blocks is subject to Newton's Second Law, and assumes that the block obeys the relationship:

$$F_0 - \mu Mg = Ma$$

which can be written as

$$a = F_0\left(\frac{1}{M}\right) - \mu g$$

BEST GUESS ...

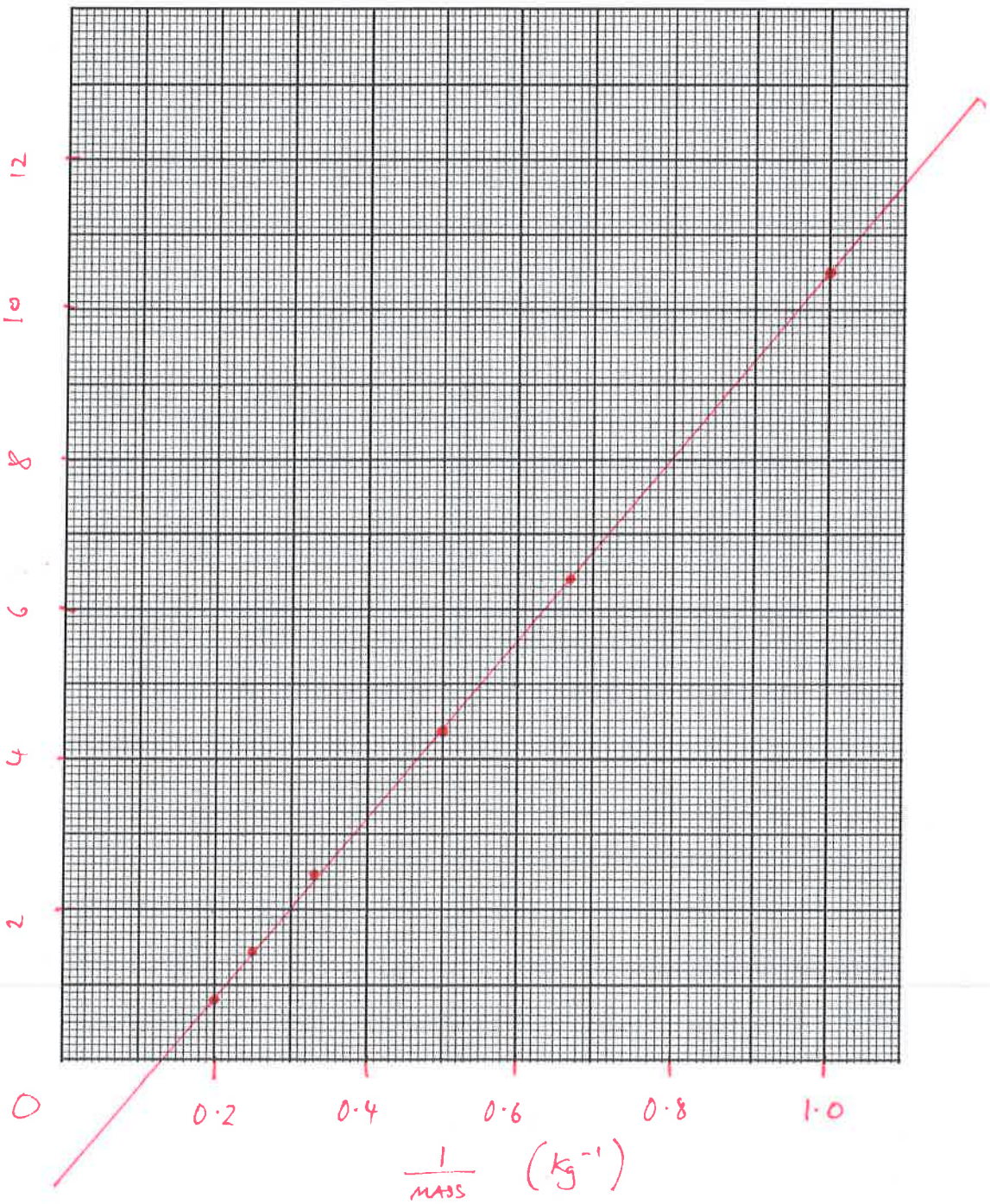


Question 33 continued on next page.

Question 33 continued **Marks**

(a) Plot a **straight line graph** to confirm the relationship between the acceleration and the mass of the blocks, given on the previous page.

(Extra columns have been provided in the table on the previous page, for you to use if you need them.)



4

Question 33 continued on next page.

SEE NEXT PAGE FOR MARKING SCHEME.

Question 33 continued **Marks**

(b) Use your graph to determine:

i) the constant force, F_0. **2**

F_0 = GRADIENT = e.g. $\frac{(10.5 - 0)}{(1.0 - 0.13)}$ = 12.1 N — (2)

(1)

ACCEPTED REASONABLE RANGE

ii) the coefficient of friction, μ. **2**

EITHER B$_y$ INTERCEPT OR: WHEN $a = 0$ $F_0 \cdot \frac{1}{M} = \mu g$.

$\frac{1}{M} = 0.13$ $\therefore$ $F_0 \times 0.13 = \mu \cdot 9.8$

$\mu = 0.16$ — (2).

(1)

a) STANDARD GRAPHING MARK SCHEME : POINTS ; AXES ; LABELS ; LOBF ; SCALE ; QUALITY → (4).

NB1 — IF GRAPH IS NOT A STRAIGHT LINE GRAPH, MAX (2) !!

↳ (e.g. a v M)

NB2 — NOT ALL STRAIGHT LINE GRAPHS DEMONSTRATE THE "RELATIONSHIP BETWEEN $\underline{a}$ AND $\underline{M}$" !!!

b) IF GRAPH IN a) IS NOT A STRAIGHT LINE THEN b) CAN BE ANSWERED USING SIMULTANEOUS EQUATIONS : 2 × (1) VALID EQUATION

2 × (1) FOR F_0 AND μ.