SYDNEY GRAMMAR SCHOOL

2015

FORM V
ANNUAL EXAMINATION

Physics

Working Time: 2 hours

Thursday 27th August 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 (90)

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

Part A
Total marks **(14)**
- Attempt ALL Questions
- Allow about 20 minutes for this Part

Part B
Total marks **(76)**
- 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 – SRW	3 – PCK	5 – MRW	
2 – MTK	4 – AAH	6 – DGB	

EXAMINERS: AAH/PCK/SRW/DGB

1 In the Ptolemaic model of the universe, the retrograde motion of Mars and the outer planets was explained by:

(A) the planets orbiting the Sun.
(B) the planets orbiting the Earth in ellipses.
(C) an optical illusion caused by the phases of the moon.
(D) epicycles and deferents.

2 Which of the following alternatives best describes the characteristics of alpha particles?

(A) High penetrating power, deflected in both magnetic and electric fields, positively charged, low ionising power.
(B) Low penetrating power, deflected in both magnetic and electric fields, positively charged, high ionising power.
(C) High penetrating power, not deflected by magnetic or electric fields, not charged, high ionising power.
(D) Low penetrating power, deflected in both magnetic and electric fields, negatively charged, high ionising power.

3 Kepler's Second Law states that "the line joining the Sun to the planet sweeps out equal areas in equal times." One consequence of this is:

(A) planets travel at the same speed relative to each focus of the ellipse.
(B) planets travel at a constant speed around the Sun.
(C) planets travel fastest when they are furthest from the Sun.
(D) planets travel fastest when they are closest to the Sun.

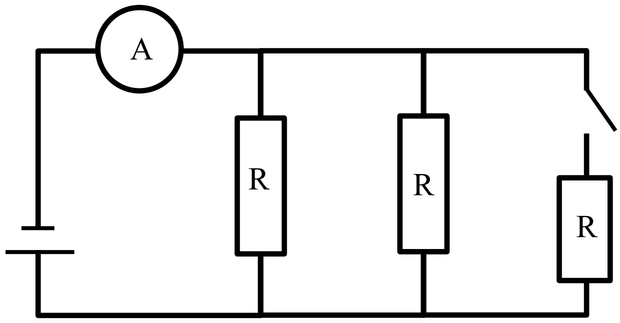
4 If the resistance of a light bulb is R, which equation below represents the power consumed by the bulb?

(A) IR^2
(B) IR
(C) VR
(D) V^2/R

5 The 3 wires in household electrical circuits are:

(A) active, neutral, earth.
(B) power output, power input, neutral.
(C) positive, negative, ground.
(D) AC, DC, ground.

6 Three identical resistors are connected in parallel in the circuit below.



When the switch is open a current of *I* is measured by the ammeter.
When the switch is closed, the current measured is:

(A) $I/3$
(B) I
(C) $1.5I$
(D) $3I$

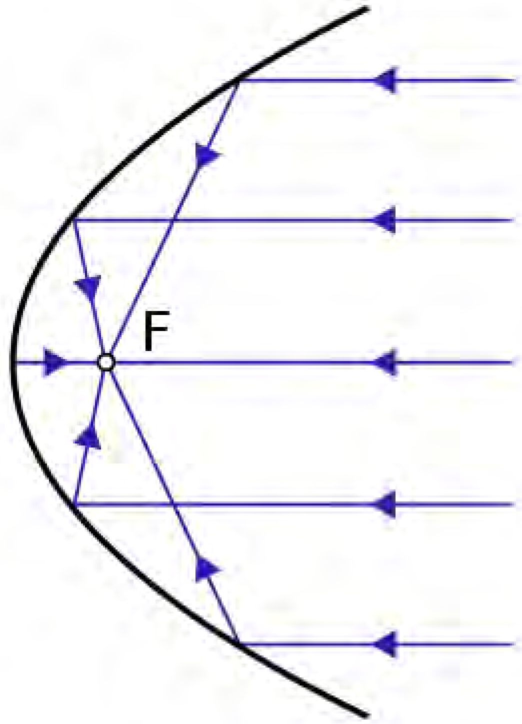
7 A radio station produces waves with a frequency of 96.0 MHz. The wavelength of the waves is:

(A) 9.60×10^{-7} m
(B) 0.320 m
(C) 3.13 m
(D) 2.88×10^{16} m

8 A boy strikes a drum when standing near a rock face. He finds that the time taken for the echo to reach him is 0.500 seconds from the time he struck the drum. If the speed of sound in air is 330 $m.s^{-1}$ then he is standing:

(A) 82.5 m from the rock face.
(B) 165 m from the rock face.
(C) 330 m from the rock face.
(D) 660 m from the rock face.

9 Light reflects from a parabolic mirror as shown below.



It is true to say that the law of reflection:

(A) holds for all rays striking the mirror.
(B) is only true for rays close to the axis of the mirror.
(C) is only true for rays travelling along the axis of the mirror.
(D) does not hold in this case as the surface is curved.

10 When a sound wave travelled from air into water it was found that the speed of the wave increased from 330 $m.s^{-1}$ to 1650 $m.s^{-1}$. If the frequency of the sound wave in air was 500 Hz, then it is true to say that:

(A) the frequency of the sound wave in water was 2500 Hz
(B) the frequency of the sound wave in water was 100 Hz
(C) the frequency of the sound wave in water was 500 Hz
(D) the frequency of the sound wave in water was 0.002 Hz

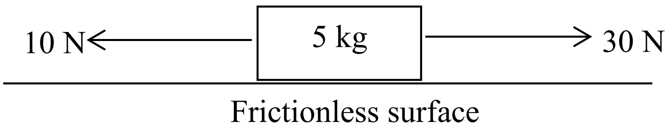
11 A speed of 45.0 $km.h^{-1}$ is equivalent to:

(A) 7.14 $m.s^{-1}$
(B) 12.5 $m.s^{-1}$
(C) 45.0 $m.s^{-1}$
(D) 162 $m.s^{-1}$

12 A train travelling at 35.0 ms^{-1} slows down and stops at a station in 22.0 s. The magnitude of the acceleration of the train is:

(A) 0.371 $m.s^{-2}$
(B) 0.591 $m.s^{-2}$
(C) 0.629 $m.s^{-2}$
(D) 1.59 $m.s^{-2}$

13 Calculate the magnitude of the acceleration of the 5 kg mass shown in the diagram below.



(A) 2 $m.s^{-2}$
(B) 4 $m.s^{-2}$
(C) 6 $m.s^{-2}$
(D) 8 $m.s^{-2}$

14 A boy of mass 45.0 kg is running at a speed of 6.00 ms^{-1}. His kinetic energy is:

(A) 270 J
(B) 338 J
(C) 810 J
(D) 1620 J

Class

Name

Part B

Total marks (78)
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 15 (4 marks) **Marks**

(a) Write the equation for the beta decay of strontium-90 into yttrium-90. **1**

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(b) Write the equation for the alpha decay of ${}^{225}_{89}\text{Ac}$. **2**

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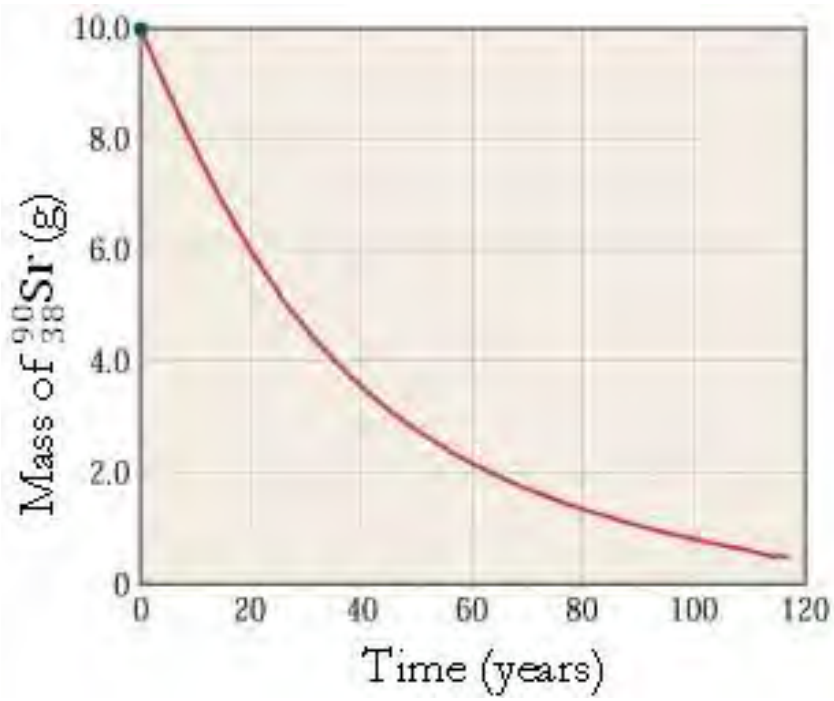
(c) Showing your working on the following decay curve, determine the half-life of strontium-90.



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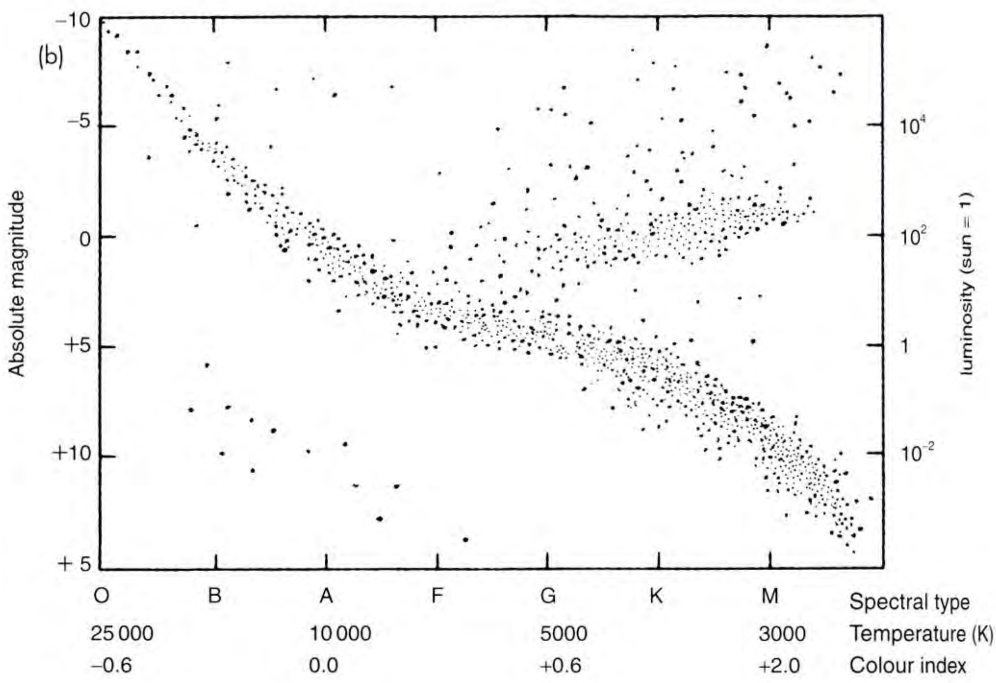
Class

Name

Question 16 (5 marks) **Marks**

A Hertzsprung-Russell diagram is shown below:



(a) Add labels to the diagram to indicate the positions of:

(i) the Main Sequence.

(ii) the White Dwarfs. **2**

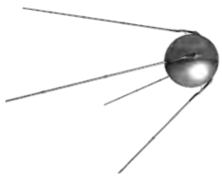
(b) With reference to the diagram above, describe the life-cycle of a star like the Sun. **3**

Class

Name

Question 17 (4 marks) **Marks**

Earth's first artificial satellite, *Sputnik I*, had an orbital period of 5760 s. Australia's first *AUSSAT* satellite, which was launched in 1985, had an orbital period of 24 hours, giving it a *geosynchronous* orbit. To achieve this orbital period, *AUSSAT* was placed at an orbital radius 4.216×10^7 m from the centre of the Earth.



(a) State Kepler's Law of Periods (i.e. Kepler's Third Law). **1**

(b) Determine the orbital radius of *Sputnik I* around the Earth. **3**

Class

Name

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Class

Name

Question 18 (4 marks) **Marks**

Explain how the astronomical observations of Galileo Galilei helped to improve the understanding of the solar system. **4**

Class

Name

Question 19 (3 marks) **Marks**

A student notices that a boat bobbing up and down in the ocean takes 2 seconds to travel from its maximum to its minimum position relative to equilibrium. He also notices that the wavelength of the ocean waves is 10 metres.

(a) Determine the period of the water waves. **1**

(b) Determine the frequency of the water waves. **1**

(c) Determine the speed of the waves. **1**

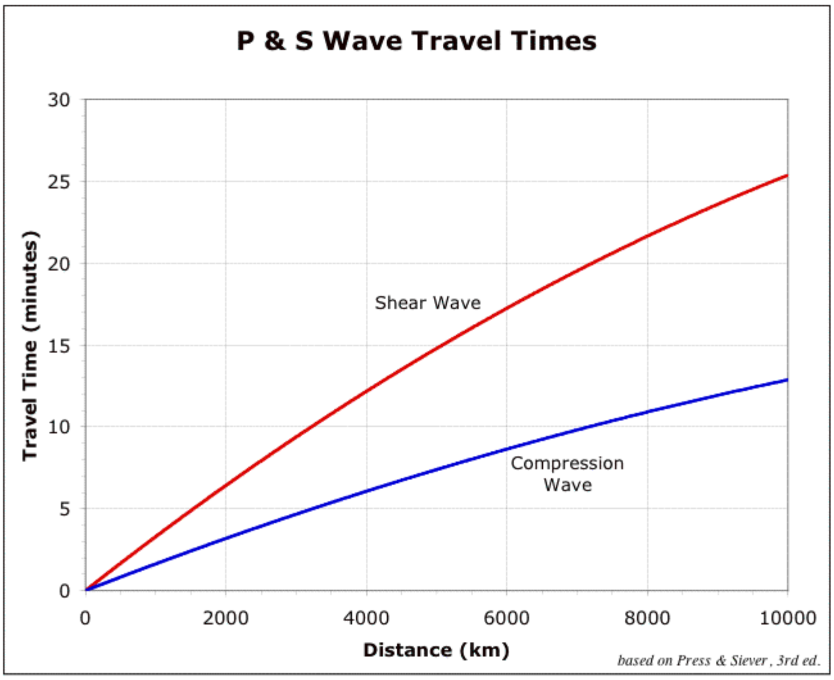
Class

Name

Question 20 (2 marks) **Marks**

An earthquake wave consists of two types of waves: P (compressional) and S (shear wave). The speed of these two types of waves is different. It is found that, at a city struck by these waves, the P wave arrives 5 minutes before the S wave.

(a) Using the graph below determine the distance of the origin of the earthquake from the city. **1**



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(b) If another city is located 6000 km from the earthquake, determine the time interval between the arrival of the P and S waves. **1**

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Class

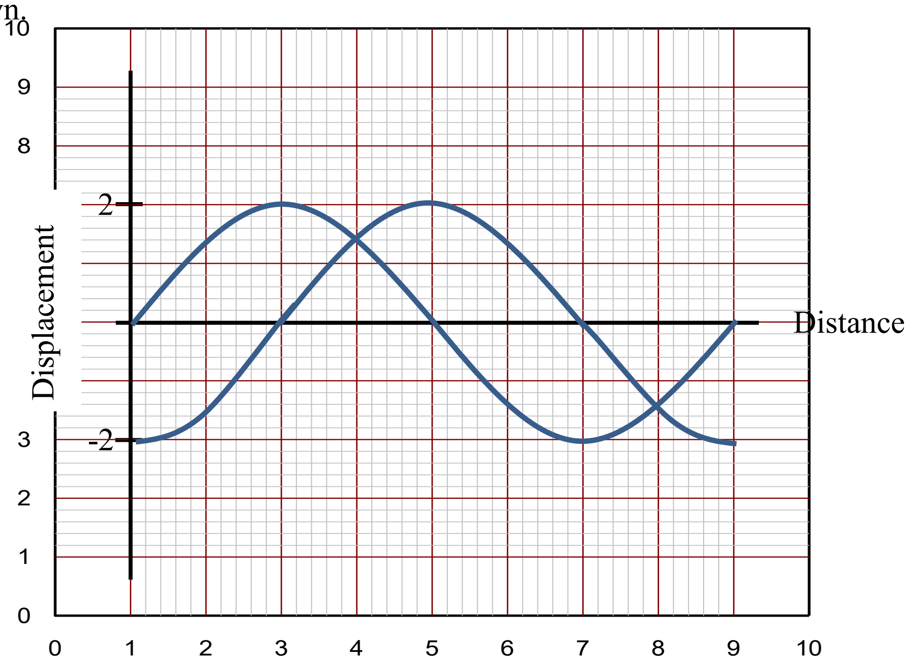
Name

Question 21 (3 marks) **Marks**

Two students are standing 10 m apart in a direct line from a point light source. If one student measures an intensity of $2x10^{-3}$ W.m^{-2} while the other student measures $1x10^{-3}$ W.m^{-2} determine the distance of the closest student to the light source. **3**

Question 22 (3 marks)

On the graph paper below, draw the superposition of the two waves shown.



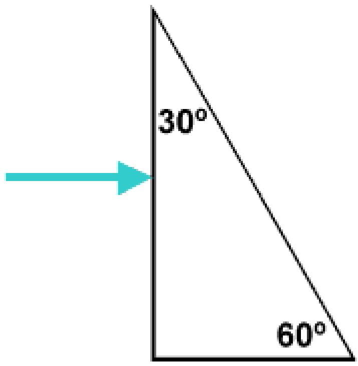
3

Class

Name

Question 23 (4 marks) **Marks**

Consider the diagram below for a light ray of wavelength 700 nm travelling along the normal from air into a glass prism of refractive index = 1.5.



(a) Determine the speed of the light in the glass prism. **1**

(b) Determine the wavelength of the light in the glass prism. **1**

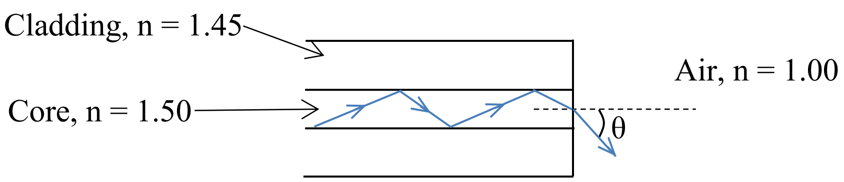
(c) Determine the angle of refraction when the light leaves the glass prism. **2**

Class

Name

Question 24 (5 marks) **Marks**

The diagram below shows light travelling through an optical fibre and out into the air beyond.



(a) Calculate the critical angle for light at the boundary between the core and the cladding. **2**

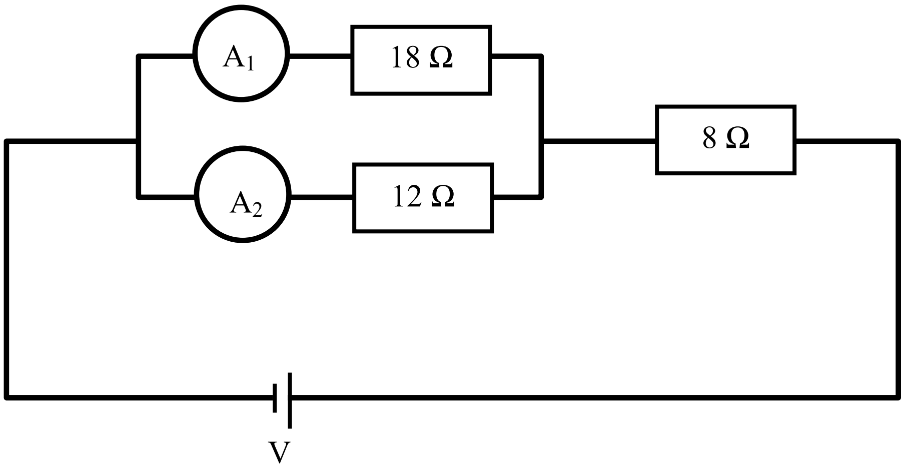
(b) Calculate the maximum angle, θ, at which light can leave the end of the fibre. **3**

Class

Name

Question 25 (5 marks) **Marks**

(a) In the following circuit, Ammeter A_1, reads 2 A, and Ammeter A_2 reads 3.0 A.



Determine the voltage, V that must be applied for this to occur. **2**

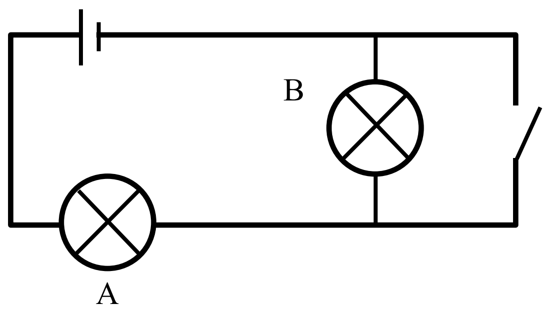
Question 25 continued on next page.

Class

Name

Question 25 continued.

(b) For the circuit shown below, predict and explain the effect of closing the switch on the brightness of light bulbs A and B, compared to when the switch is open.



3

Class

Name

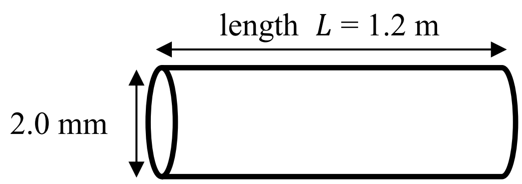
Question 26 (2 marks) **Marks**

The resistance of a resistive metal wire with a cylindrical shape is given by the equation:

$$R = \rho \frac{L}{A}$$

Where: L is the length of the wire
A is the cross-sectional area of the cylinder
ρ is the *'resistivity'* of the wire.

The wire shown below is made from a material with a resistivity of 1.10×10^{-6} Ω.m



Calculate the resistance of the wire shown above. **2**

Class

Name

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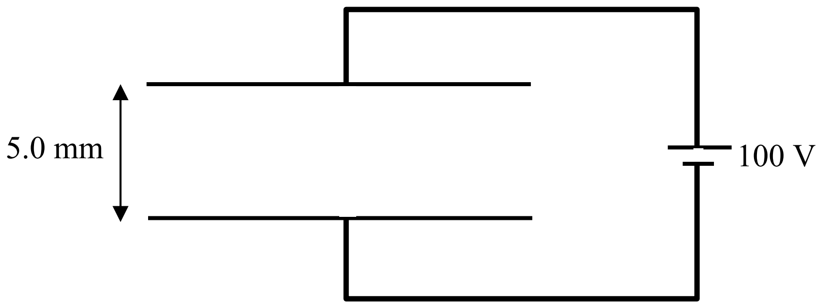
Class

Name

Question 27 (4 marks) **Marks**

Two metal plates are separated by 5.0 mm and 100 V is applied across them.



(a) Draw the electric field between these two plates. **2**

(b) What is the magnitude of the electric field strength between these plates? **1**

____

____

(c) What would be the direction of the electrical force on a negative charge placed between the plates? **1**

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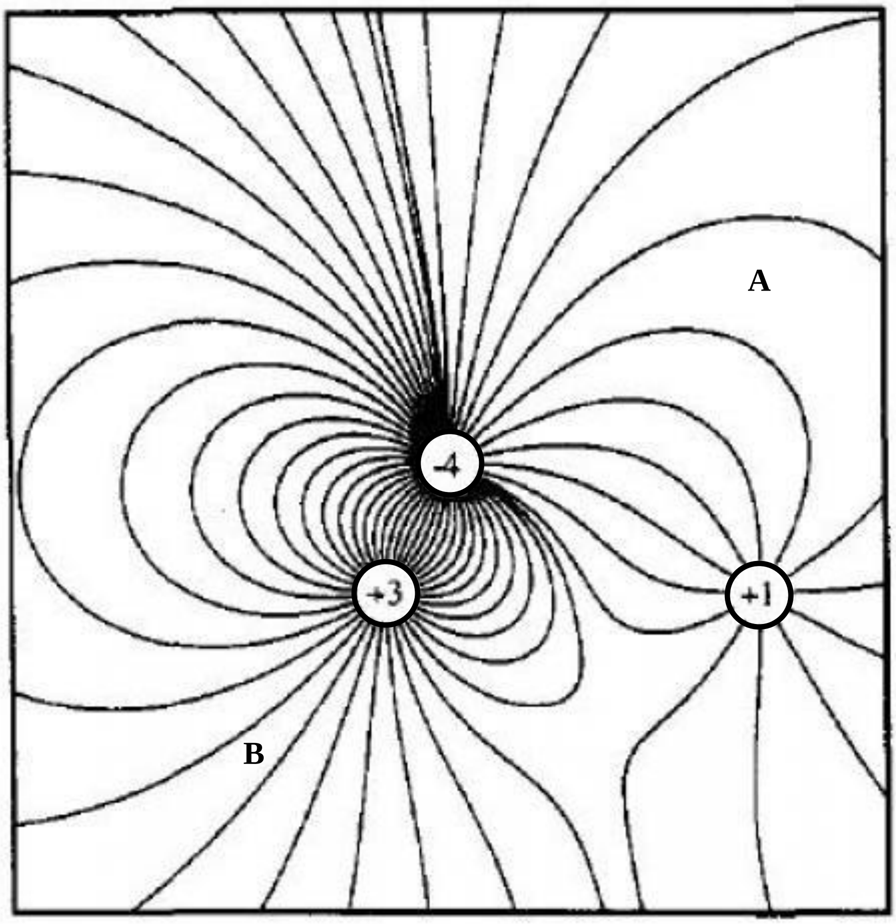
Class

Name

Question 28 (4 marks) **Marks**

The following diagram shows the electric field produced by three charges +3 C, +1 C and -4 C.



(a) Draw arrows on the above diagram showing the direction of the electric field at A and at B **1**

Question 28 continued on next page.

Class

Name

Question 28 continued. **Marks**

(b) Is the electric field strength greater at point A or point B? Justify your answer. **2**

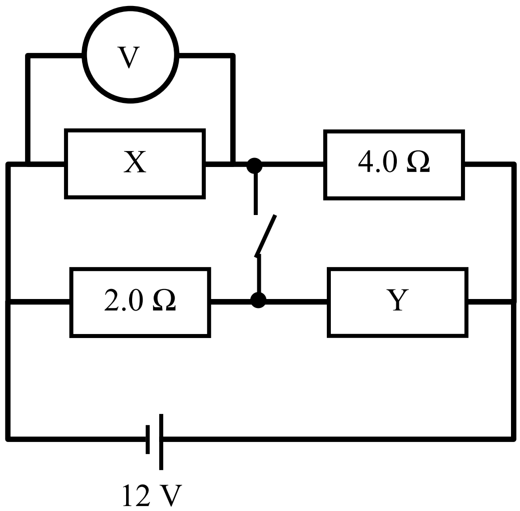
(c) A +2 C charge is placed at point A and experiences a 5 N force. Calculate the magnitude of the electric field strength at point A. **1**

Class

Name

Question 29 (4 marks) **Marks**

The following circuit has two unknown resistors, X and Y.



The following measurements were made when the switch was open and closed.

	Voltmeter (V)
Switch open	9.6
Switch closed	4.8

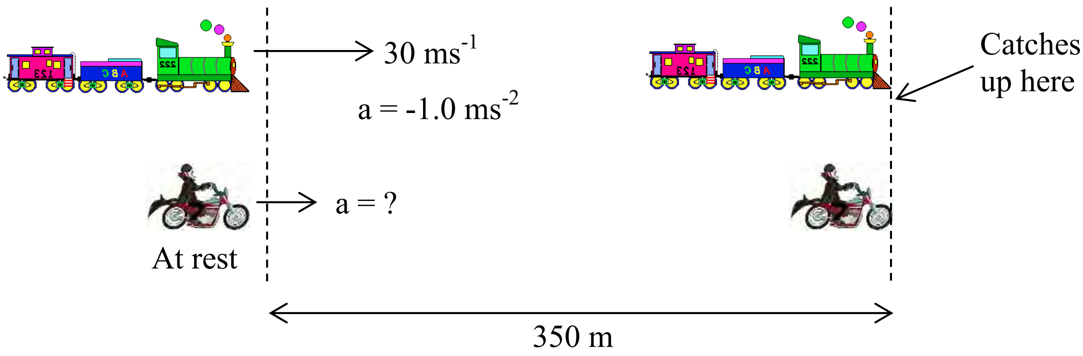
Determine the value of the resistances X and Y. **4**

Class

Name

Question 30 (3 marks) **Marks**

As part of an action sequence for a film, a stunt driver on a motorcycle tries to catch up with a speeding train, as shown in the diagram below.



When it passes the motorcyclist, the train is travelling at 30 ms^{-1} but decelerating at 1.0 ms^{-2}. The motorcyclist, who is initially at rest, immediately gives chase, accelerating at a constant rate until he catches up with the train.

The motorcyclist catches up with the train 350 m down the track.

Determine the acceleration of the motorcycle. **3**

Class

Name

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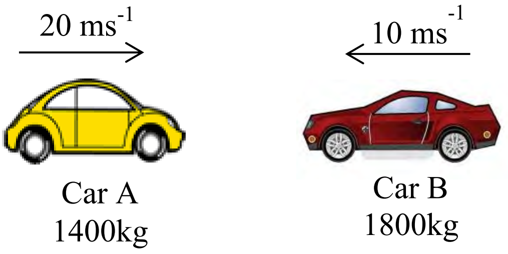
Class

Name

Question 31 (2 marks) **Marks**

Car A, of mass 1400 kg travelling at 20 ms^{-1} to the right, collides head on with Car B, of mass 1800 kg travelling at 10 ms^{-1} to the left. After the collision, the two cars stick together.



(a) Calculate the magnitude of the initial momentum of Car A. **1**

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___

(b) Calculate the magnitude of the velocity of Car A immediately after the collision. **1**

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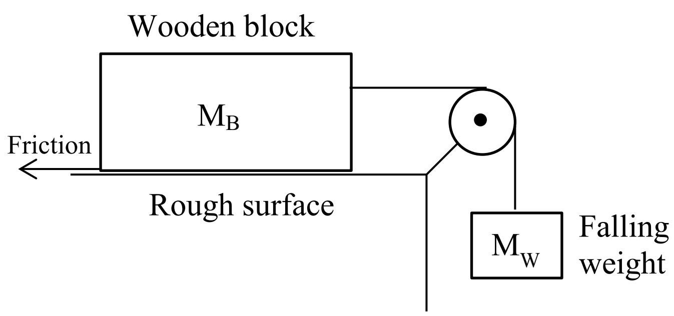
Class

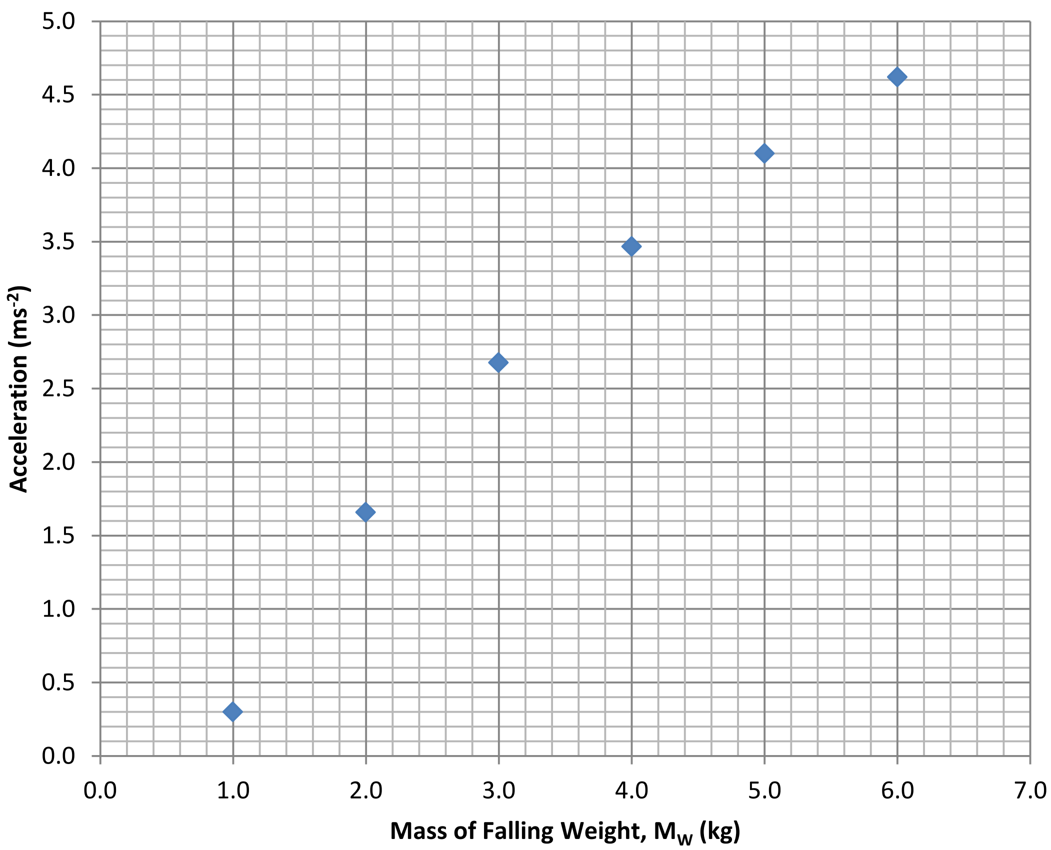
Name

Question 32 (3 marks) **Marks**

A pupil performs an experiment with the Atwood machine shown below.



The pupil varies the mass of the falling weight, M_w and measures the acceleration of the system. His results are shown on the graph below:



Question 32 continued on next page.

Class

Name

Question 32 continued. **Marks**

Using the graph on the previous page, determine:

(a) the friction acting on the wooden block. **1**

___

___

(b) the mass of the wooden block. **2**

___

___

___

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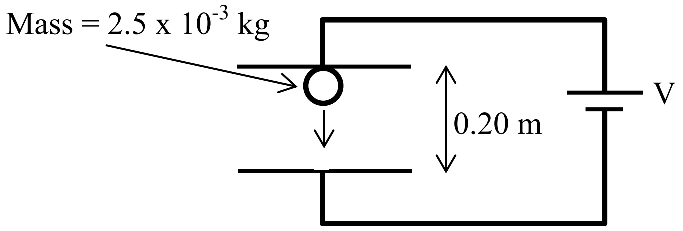
Class

Name

Question 33 (6 marks) **Marks**

In the experiment below, a charged sphere of mass $2.5\text{x}10^{-3}$ kg is allowed to fall through an electric field, as shown.



The voltage between the plates is varied, and the velocity of the sphere as it hits the lower plate is measured.

Theoretically, the relationship between the voltage, *V*, across the plates and the velocity, *v*, of the sphere is found by conserving energy, and is given by:

$$v^2 = 2gd + 2Vq/m \qquad \textbf{(Equation 1)}$$

where: *d* is the separation of the plates
g is the acceleration due to gravity
q is the charge on the sphere and
m is its mass.

The results obtained in the experiment are shown below:

Voltage (V)	Velocity (ms^{-1})		
100	2.14		
200	2.30		
400	2.58		
600	2.83		
800	3.06		
1000	3.27		

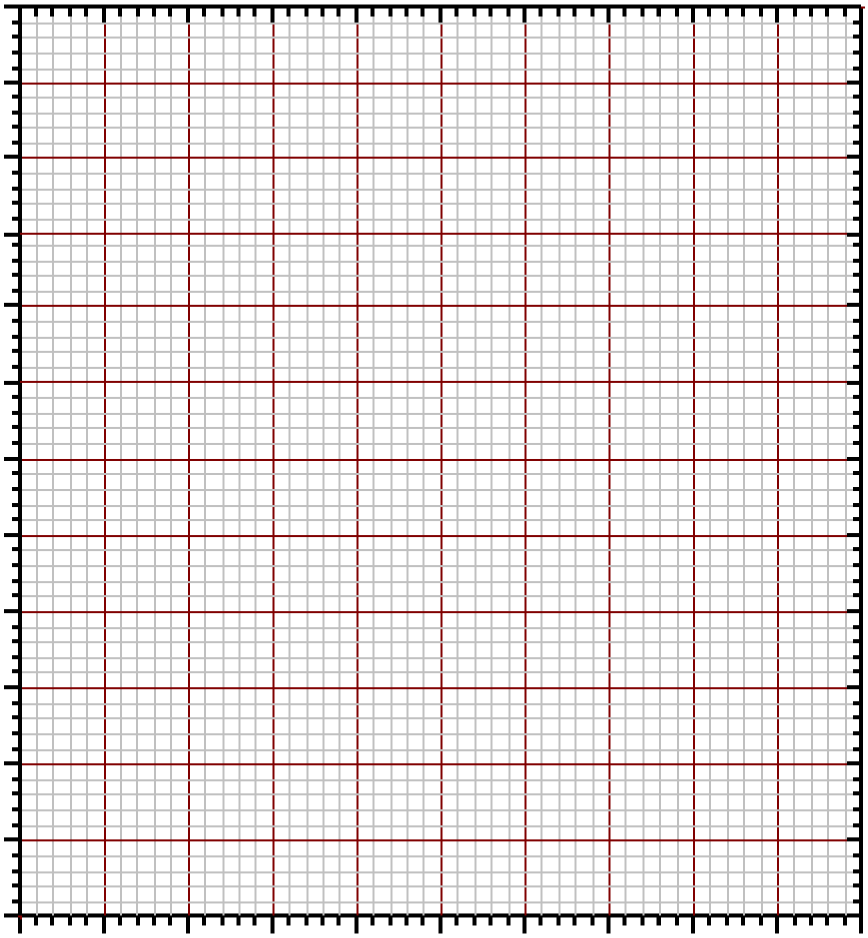
Question 33 continued on next page.

Class

Name

Question 33 continued. **Marks**

(a) Using the data given on the previous page, plot a **straight line graph** that will allow you to verify Equation 1 for this data. (NOTE: extra columns have been provided in the table, should you need them.)



4

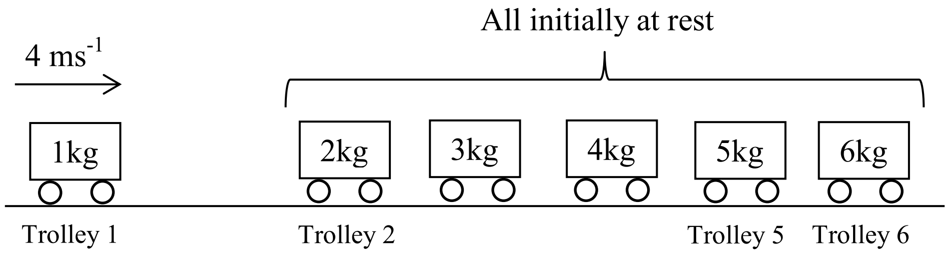
(b) Calculate the charge on the sphere. **2**

Class

Name

Question 34 (6 marks) **Marks**

The diagram below shows a series of trolleys on a frictionless surface.



Initially, Trolley 1 is travelling at a speed of 4 ms^{-1}, and the other trolleys are stationary. The trolleys are not connected, and are set up so that, when they collide, they do so elastically.

(a) Calculate the velocity of Trolley 2, immediately after it collides with Trolley 1. **3**

Question 34 continued on next page.

Class

Name

Question 34 continued. **Marks**

(b) Calculate the velocity of Trolley 6, immediately after it collides with Trolley 5. **3**

Class

Name

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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^{2}C^{-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

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

$$F = BIl\sin\theta$$

$$\tau = Fd$$

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

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

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

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

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

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

$$F = qvB\sin\theta$$

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

$$E = hf$$

$$c = f\lambda$$

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

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

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

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

$$Z = \rho v$$

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

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

PERIODIC TABLE OF THE ELEMENTS

KEY

Atomic Number	79
Symbol	Au
Standard Atomic Weight	197.0
Name	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

MTK
Class
CRIB
Name

Physics
Part A
ANSWER SHEET

2015
FORM V
ANNUAL EXAMINATION

General Instructions

- Write your class and candidate number in the space provided.
- Attempt all questions 1 – 14
- 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.

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

1 In the Ptolemaic model of the universe, the retrograde motion of Mars and the outer planets was explained by:

(A) the planets orbiting the Sun.
(B) the planets orbiting the Earth in ellipses.
(C) an optical illusion caused by the phases of the moon.
(D) epicycles and deferents.

2 Which of the following alternatives best describes the characteristics of alpha particles?

(A) High penetrating power, deflected in both magnetic and electric fields, positively charged, low ionising power.
(B) Low penetrating power, deflected in both magnetic and electric fields, positively charged, high ionising power.
(C) High penetrating power, not deflected by magnetic or electric fields, not charged, high ionising power.
(D) Low penetrating power, deflected in both magnetic and electric fields, negatively charged, high ionising power.

3 Kepler's Second Law states that "the line joining the Sun to the planet sweeps out equal areas in equal times." One consequence of this is:

(A) planets travel at the same speed relative to each focus of the ellipse.
(B) planets travel at a constant speed around the Sun.
(C) planets travel fastest when they are furthest from the Sun.
(D) planets travel fastest when they are closest to the Sun.

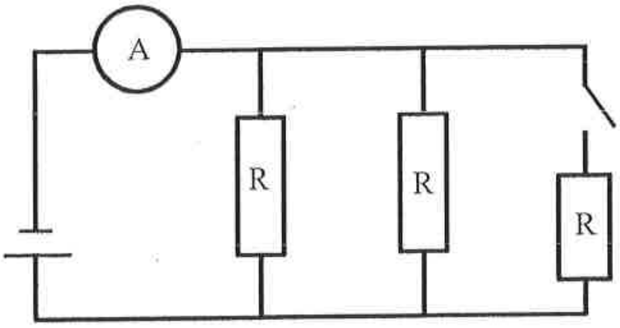
4 If the resistance of a light bulb is R, which equation below represents the power consumed by the bulb?

(A) IR^2
(B) IR
(C) VR
(D) V^2/R

5 The 3 wires in household electrical circuits are:

(A) active, neutral, earth.
(B) power output, power input, neutral.
(C) positive, negative, ground.
(D) AC, DC, ground.

6 Three identical resistors are connected in parallel in the circuit below.



When the switch is open a current of I is measured by the ammeter. When the switch is closed, the current measured is:

(A) $I/3$
(B) I
(C) $1.5I$
(D) $3I$

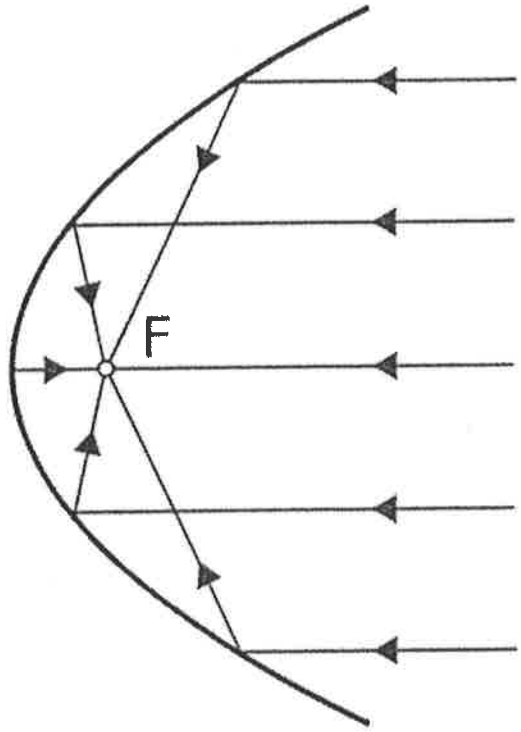
7 A radio station produces waves with a frequency of 96.0 MHz. The wavelength of the waves is:

(A) 9.60×10^{-7} m
(B) 0.320 m
(C) 3.13 m
(D) 2.88×10^{16} m

8 A boy strikes a drum when standing near a rock face. He finds that the time taken for the echo to reach him is 0.500 seconds from the time he struck the drum. If the speed of sound in air is 330 $m.s^{-1}$ then he is standing:

(A) 82.5 m from the rock face.
(B) 165 m from the rock face.
(C) 330 m from the rock face.
(D) 660 m from the rock face.

9 Light reflects from a parabolic mirror as shown below.



It is true to say that the law of reflection:

(A) holds for all rays striking the mirror.
(B) is only true for rays close to the axis of the mirror.
(C) is only true for rays travelling along the axis of the mirror.
(D) does not hold in this case as the surface is curved.

10 When a sound wave travelled from air into water it was found that the speed of the wave increased from 330 $m.s^{-1}$ to 1650 $m.s^{-1}$. If the frequency of the sound wave in air was 500 Hz, then it is true to say that:

(A) the frequency of the sound wave in water was 2500 Hz
(B) the frequency of the sound wave in water was 100 Hz
(C) the frequency of the sound wave in water was 500 Hz
(D) the frequency of the sound wave in water was 0.002 Hz

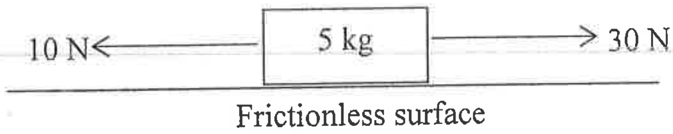
11 A speed of 45.0 $km.h^{-1}$ is equivalent to:

(A) 7.14 $m.s^{-1}$
(B) 12.5 $m.s^{-1}$
(C) 45.0 $m.s^{-1}$
(D) 162 $m.s^{-1}$

12 A train travelling at 35.0 ms^{-1} slows down and stops at a station in 22.0 s. The magnitude of the acceleration of the train is:

(A) 0.371 $m.s^{-2}$
(B) 0.591 $m.s^{-2}$
(C) 0.629 $m.s^{-2}$
(D) 1.59 $m.s^{-2}$

13 Calculate the magnitude of the acceleration of the 5 kg mass shown in the diagram below.



(A) 2 $m.s^{-2}$
(B) 4 $m.s^{-2}$
(C) 6 $m.s^{-2}$
(D) 8 $m.s^{-2}$

14 A boy of mass 45.0 kg is running at a speed of 6.00 ms^{-1}. His kinetic energy is:

(A) 270 J
(B) 338 J
(C) 810 J
(D) 1620 J

Class

Name

Part B
Total marks (78)
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 15 (4 marks) **Marks**

(a) Write the equation for the beta decay of strontium-90 into yttrium-90. 1

$^{90}_{38}Sr \longrightarrow {}^{90}_{39}Y + {}^{0}_{-1}e$

× superscripts/subscripts reversed.

correct symbols needed.

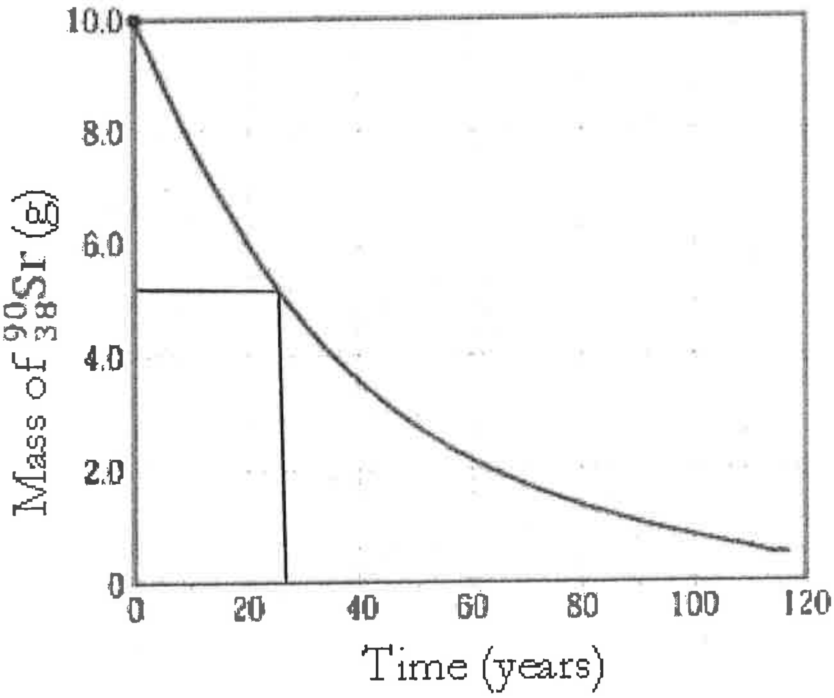
(b) Write the equation for the alpha decay of $^{225}_{89}Ac$. 2

$^{225}_{89}Ac \longrightarrow {}^{221}_{87}Fr + {}^{4}_{2}He$

✓ ① mk ✓ ① mk. correct symbol..

* must be products

(c) Showing your working on the following decay curve, determine the half-life of strontium-90.



28 years Range. [23 – 33 years] ✓ ① mk

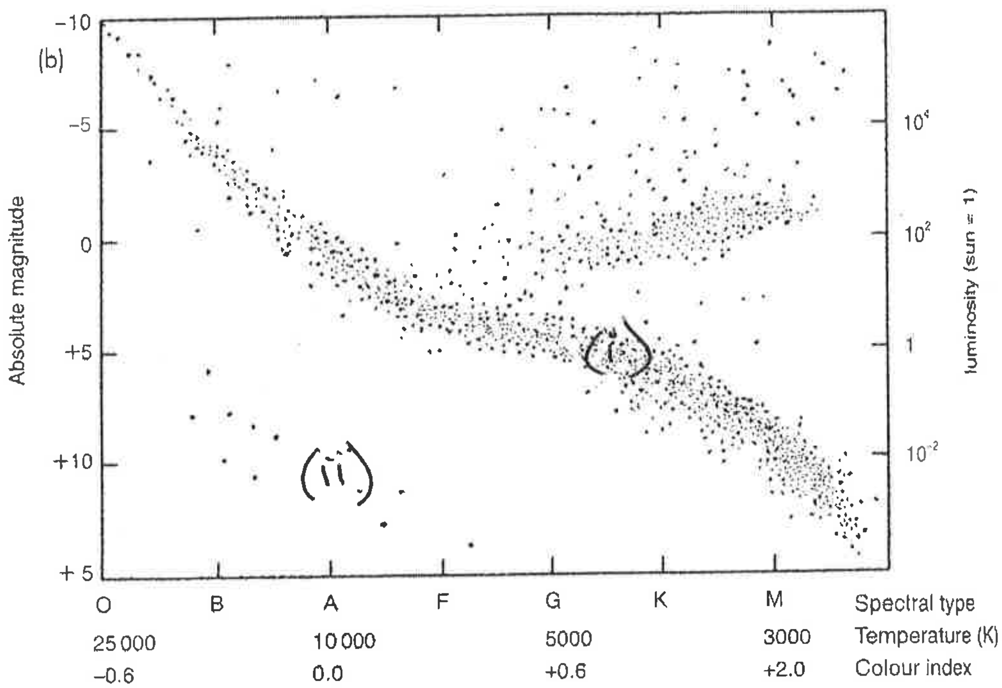
Range of answers with some indication of working on curve.. 1

Class

Name

Question 16 (5 marks) **Marks**

A Hertzsprung-Russell diagram is shown below:



(a) Add labels to the diagram to indicate the positions of:

(i) the Main Sequence. ✓ ① mk

(ii) the White Dwarfs. ✓ ① mk. 2

(b) With reference to the diagram above, describe the life-cycle of a star like the Sun. 3

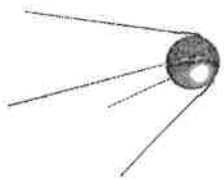
correct sequence described.
from Main Sequence to Red
Giant to White Dwarf. ✓✓✓ 3 mks.
–1 mk for each error
[error(s) identified on student
answers.

Class

Name

Question 17 (4 marks) **Marks**

Earth's first artificial satellite, *Sputnik I*, had an orbital period of 5760 s. Australia's first *AUSSAT* satellite, which was launched in 1985, had an orbital period of 24 hours, giving it a *geosynchronous* orbit. To achieve this orbital period, *AUSSAT* was placed at an orbital radius 4.216×10^7 m from the centre of the Earth.



(a) State Kepler's Law of Periods (i.e. Kepler's Third Law). 1

R^3/T^2 is constant for all objects orbiting the same central body ✓ ① mk.

(b) Determine the orbital radius of *Sputnik I* around the Earth. 3

$r_A = 4.21 \times 10^7$ m

$r_s = ?$

$T_A = 24$ hrs $(= 24 \times 60 \times 60)$ s.

$T_s = 5760$ s.

$$\frac{r_A^3}{T_A^2} = \frac{r_s^3}{T_s^2}$$ ✓ ① mk for relationship.

$$\frac{(4.216 \times 10^7)^3}{(24 \times 60 \times 60)^2} = \frac{r^3}{(5760)^2}$$ ✓ ① mk. for correct substitution with units for T_A and T_s same.

$r = 6.93 \times 10^6$ m ✓ ① mk. for correct answer based on substitution.

[Note: $r_s^3 = 3.31 \times 10^{20}$ m scores 2 mks (forgot $\sqrt[3]{}$)

Question 18 (4 marks) **Marks**

Explain how the astronomical observations of Galileo Galilei helped to improve the understanding of the solar system. 4

Marking criteria	Marks
• *At least 2 relevant astronomical observations (e.g. rough surface of the Moon, Jupiter's moons, changing phases of Venus).* *AND* • *At least 2 thorough explanations of how this observation helped to improve the understanding of the solar system.*	4
• *At least 2 relevant astronomical observations.* *AND* • *At least 2 sound explanations of how this observation helped to improve the understanding of the solar system OR only 1 thorough explanation.*	3
• *At least 2 relevant astronomical observations but no explanation of how this observation helped to improve the understanding of the solar system.* *OR* • *1 relevant astronomical observation AND 1 thorough explanation of how this observation helped to improve the understanding of the solar system.*	2
• *Any relevant astronomical observation OR relevant idea on how Galileo Galilei helped to improve the understanding of the solar system.*	1

Marker's comment:

Most of the boys who did not get full marks lost marks because they were unable to precisely describe/explain how the observation(s) led to a better understanding of the known universe.

e.g. *Stating that "Galileo observed craters on the Moon and therefore it showed that the Moon (as probably other heavenly bodies) was not perfect" is a good start, but it doesn't explain how this led to reconsider the place of the Earth as the centre of the universe.*

→ *In the Christian conception of the Universe, the Earth was at the centre because God intended it that way (it's where God placed Its creation). The Earth was corrupt (original sin) and therefore not perfectly spherical and smooth, unlike the Heavenly bodies like the Moon and the planets, that have been conceived perfectly and placed in the Sky by God.*

When Galileo discovered that the Moon had craters and mountains, and therefore was as "corrupt" as the Earth, it's the whole Christian perfect geocentric model of the universe that collapsed. If the system created by Ptolemy and endorsed by the Church was not true for the Moon, why would it be true for the place of the Earth at the centre of it? And if the Moon is a mere rock, what holds it up there?? It had to obey the same laws of Physics that we have on Earth, since it's not a perfect Heavenly body… This prepared the work of Newton.

Question 19 (3 marks) **Marks**

A student notices that a boat bobbing up and down in the ocean takes 2 seconds to travel from its maximum to its minimum position relative to equilibrium. He also notices that the wavelength of the ocean waves is 10 metres,

(a) Determine the period of the water wave. 1

$T = 2 \times 2s = 4s$ *(period: max* $\xrightarrow{2s}$ *min* $\xrightarrow{2s}$ *max)*

(b) Determine the frequency of the water waves. 1

$f = \frac{1}{T} = \frac{1}{4} = 0.25\ Hz$

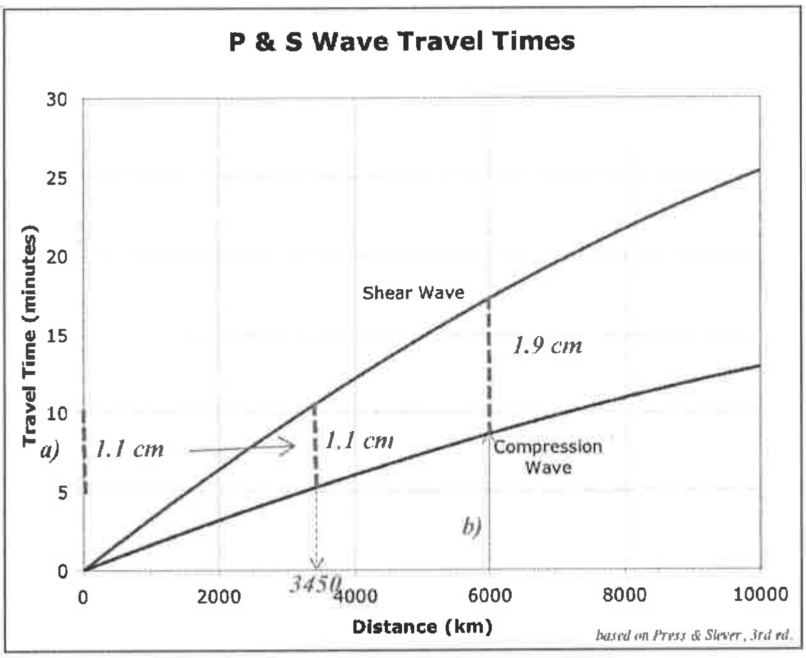
(c) Determine the speed of the waves. 1

$v = f\lambda = \lambda/T = \frac{10}{4} = 2.5\ m.s^{-1}$

Question 20 (2 marks) **Marks**

An earthquake wave consists of two types of waves: P (compressional) and S (shear wave). The speed of these two types of waves is different. It is found that at a city struck by these waves, the P wave arrives 5 minutes before the S wave.

(a) Using the graph below determine the distance of the origin of the earthquake from the city. 1



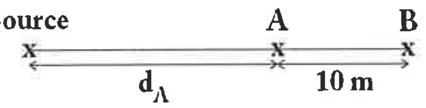
On the y-axis, 5 min are represented by 1.1 cm.
Let's find the distance on the x-axis for which the separation between the two curves is 1.1 cm: $d \approx 3450$ *km.*

(b) If another city is located 6000 km from the earthquake, determine the time interval between the arrival of the P and S waves. 1

Let's find the separation between the two curves when $d = 6000$*km.*
On the graph, we measure a separation of around 1.9 cm. On the y-axis, 5 min are represented by 1.1 cm so 1.9 cm represents a time $t \approx 8$ *min 40 s.*

Question 21 (3 marks) **Marks**

Two students are standing 10m apart in a direct line from a point light source. If one student measures an intensity of $2x10^{-3}$ W/m^2 while the other student measures $1x10^{-3}$ W/m^2 determine the distance of the closest student to the light source. 3



- *1 mark for $d_B = d_A + 10$*
- *1 mark for equation $I_A d_A^2 = I_B d_B^2$ [so $I_A d_A^2 = I_B (d_A+10)^2$]*
- *1 mark for solving the quadratic equation properly.*

Sample answer:

$d_B = d_A + 10$

$I_A d_A^2 = I_B d_B^2$ *so* $I_A d_A^2 = I_B (d_A+10)^2$ *so* $2x10^{-3}\, d_A^2 = 1x10^{-3}\, (d_A+10)^2$

Thus,

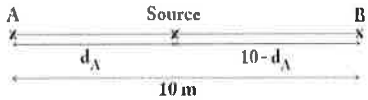
$$2d_A^2 = (d_A+10)^2 \Rightarrow 2d_A^2 = d_A^2 + 20d_A + 100 \Rightarrow d_A^2 - 20d_A - 100 = 0$$

2 solutions: $d_A = \frac{20+\sqrt{20^2+4x100}}{2x1} = 24.14\ m$ *or* $d_A = \frac{20-\sqrt{20^2+4x100}}{2x1} = -4.14\ m$ *physically impossible (because negative value)*

The only acceptable solution is $\underline{d_A = 24.14\ m}$

Markers' comments:

- ***Boys who solved the problem with the source between the two students (see diagram) did not read the text properly: "in a direct live FROM a point light source"... However, they were not penalised if they carried out the calculations properly.***

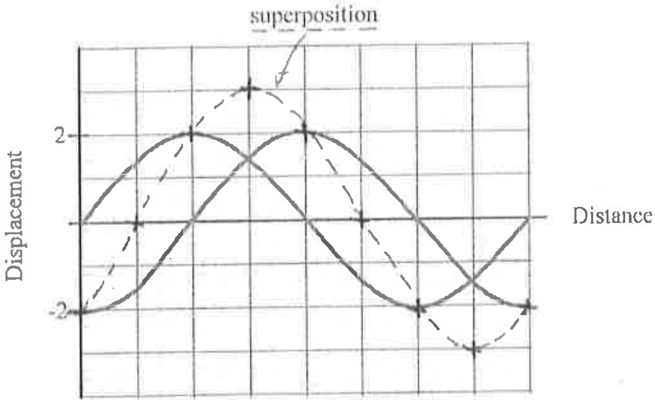


- ***A lot of boys got the signs wrong when manipulating the original equation to get the quadratic equation $ax^2 + bx + c = 0$.***

Question 22 (3 marks)

On the graph paper below determine and draw the superposition of the two waves.

- *Neatness,*
- *Precision of superposition,*
- *How correctly the points are connected.*



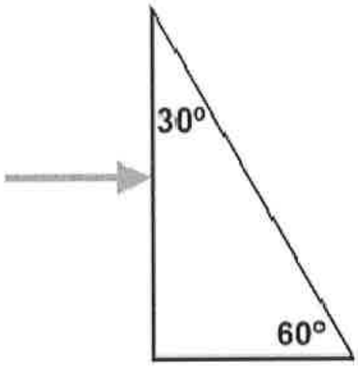
Class

SRW

Name

Question 23 (4 marks) **Marks**

Consider the diagram below for a light ray of wavelength 700 nm travelling along the normal from air into a glass prism of refractive index = 1.5.



(a) Determine the speed of the light in the glass prism. 1

$v = \frac{c}{n} = \frac{3\times10^8}{1.5} = 2\times10^8$ m/s

(b) Determine the wavelength of the light in the glass prism. 1

$\lambda = \frac{700}{1.5} = 4.67\times10^{-7}$ m

(c) Determine the angle of refraction when the light leaves the glass prism. 2

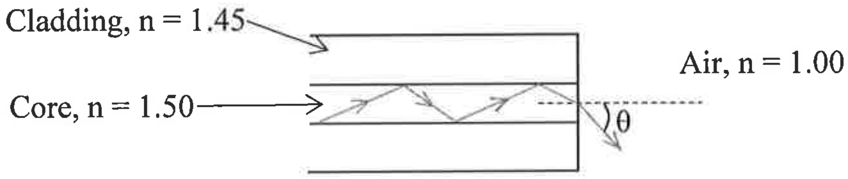
$\frac{\sin 30}{\sin r} = \frac{1}{1.5}$ ① $r = 48.6°$ ①

Class

Name

Question 24 (5 marks) **Marks**

The diagram below shows light travelling through an optical fibre and out into the air beyond.



(a) Calculate the critical angle for light at the boundary between the core and the cladding. 2

$\frac{\sin i_c}{\sin 90} = \frac{1.45}{1.5}$ ①

$i_c = 75.16°$ ①

(b) Calculate the maximum angle, *θ*, at which light can leave the end of the fibre. 3

① $i = 14.84°$ $(90 - 75.16°)$

① $\frac{\sin(14.84)}{\sin\theta} = \frac{1}{1.5}$

$\therefore$ $\theta = 22.59°$ ①

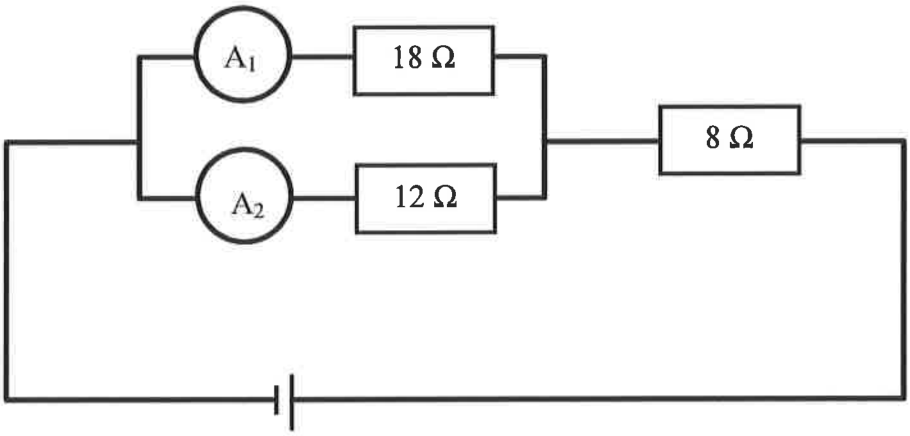
Many boys calculate just the critical angle $\theta_c = 41.81°$
I gave ① mark for this.

Class

Name

Question 25 (5 marks) **Marks**

(a) In the following circuit, Ammeter A_1, reads 2 A, and Ammeter A_2 reads 3.0 A.



Determine the voltage, V that must be applied for this to occur. **2**

$2 \times 18 + 5 \times 8 = 76\,V$

36 V ①   ①

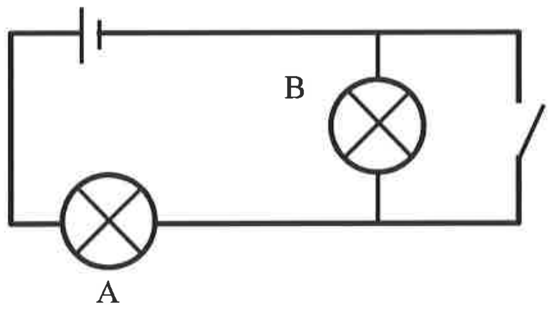
Question 25 continued on next page.

Class

Name

Question 25 continued.

(b) For the circuit shown below, predict and explain the effect of closing the switch on the brightness of light bulbs A and B, compared to when the switch is open.



3

① A gets brighter
① B goes out (A lot of boys said B gets dimmer!)

① { closing switch short circuits B ∴ no current flows through B
" " reduces resistance hence current increases through A making it brighter }

Class

Name

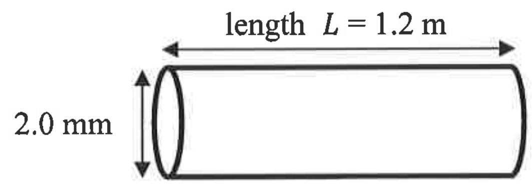
Question 26 (2 marks) **Marks**

The resistance of a resistive metal wire with a cylindrical shape is given by the equation:

$$R = \rho \frac{L}{A}$$

Where: L is the length of the wire
A is the cross-sectional area of the cylinder
ρ is the *'resistivity'* of the wire.

The wire shown below is made from a material with a resistivity of 1.10×10^{-6} Ω.m



Calculate the resistance of the wire shown above. 2

$A = \pi r^2 = \pi \times (0.001)^2$ (1)

$\therefore R = \rho \frac{L}{A} = 0.42\ \Omega$

If you forgot to halve the diameter I still gave you (1) mark.

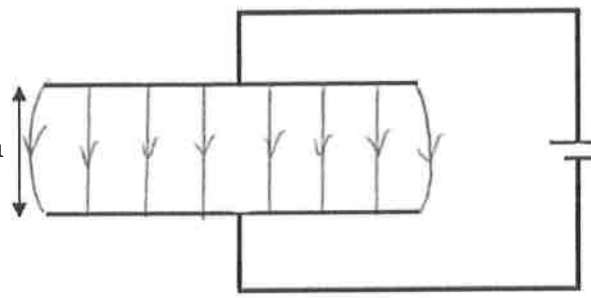
Class

Name

Question 27 (4 marks) **Marks**

Two metal plates are separated by 5.0 mm and 100 V is applied across them.

Full marks
- Ruled straight lines from plate to plate
- equally spaced – all the way across
- arrows down



(a) Draw the electric field between these two plates. **2**

(b) What is the magnitude of the electric field strength between these plates? **1**

$E = \frac{V}{d} = \frac{100}{5\times10^{-3}} = 20{,}000\ V/m$ (or NC^{-1})

(units not needed)

(c) What would be the direction of the electrical force on a negative charge placed between the plates? **1**

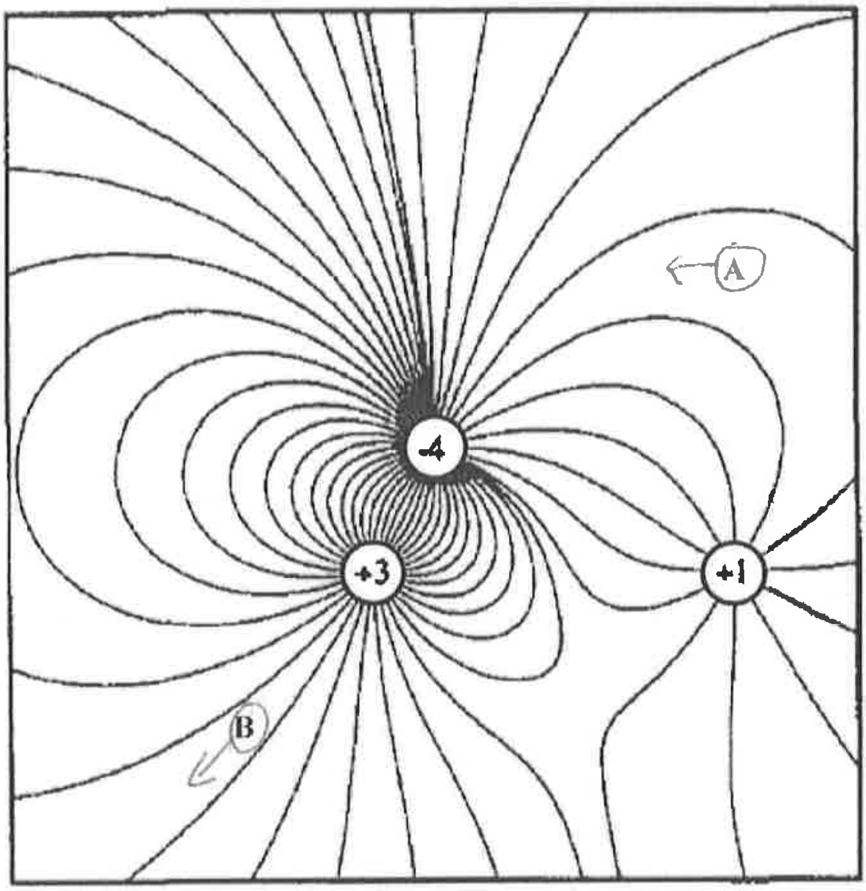
Upwards (or answer consistent with diagram) – no carry forward error

Class

Name

Question 28 (4 marks) **Marks**

The following diagram shows the electric field produced by three charges +3 C, +1 C and -4 C.



(a) Draw arrows on the above diagram showing the direction of the electric field at A and at B 1

A clear indication of the field at direction at A and B

Question 28 continued on next page.

Class

Name

Question 28 continued. **Marks**

(b) Is the electric field strength greater at point A or point B? Justify your answer. 2

B (1) The ~~E~~ Electric field lines are closer together (1)

(c) A +2 C charge is placed at point A and experiences a 5 N force. Calculate the magnitude of the electric field strength at point A. 1

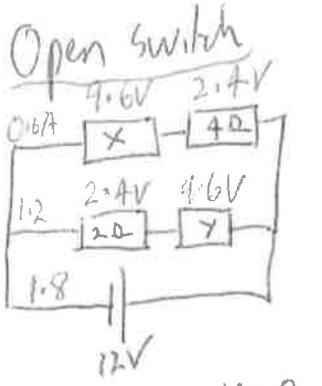
$F = qE$, $E = \frac{F}{q} = 5/2 = 2.5\,NC^{-1}$

Class

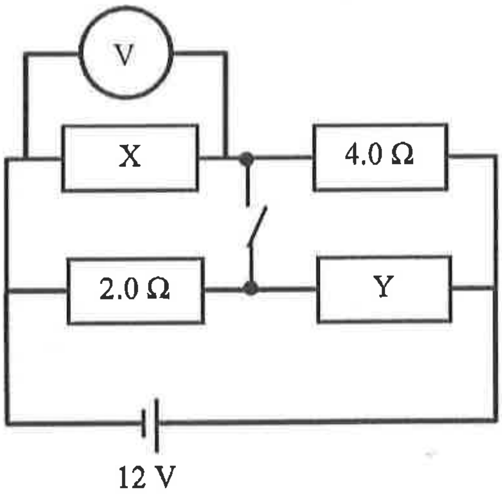
Name

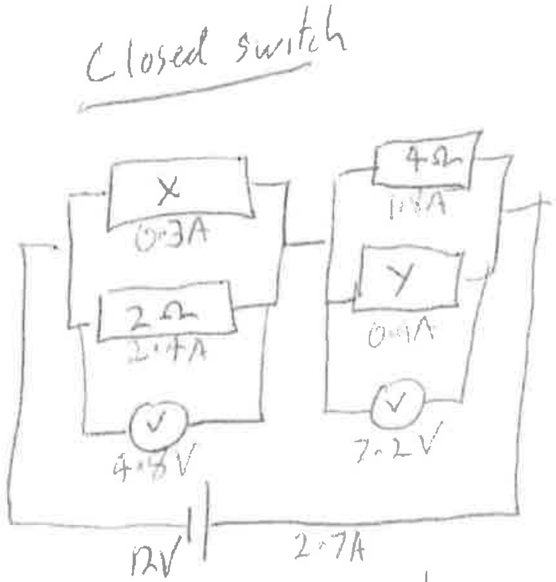
Question 29 (4 marks) **Marks**

The following circuit has two unknown resistors, X and Y.



total Resistance = $6\frac{2}{3}\Omega$.



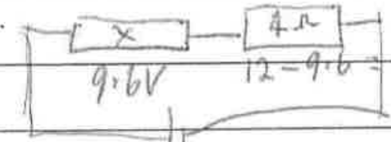


The following measurements were made when the switch was open and closed. total resistance = 4.4 Ω

	Voltmeter (V)
Switch open	9.6
Switch closed	4.8

Determine the value of the resistances X and Y. 4

Open:

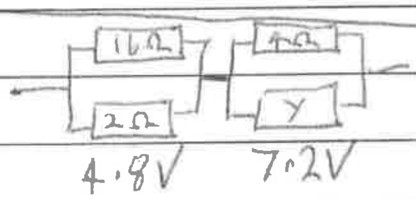


current in 4 Ω = current in X

$I = \frac{2.4}{4} = 0.6A$

$R_X = \frac{V}{I} = \frac{9.6}{0.6} = 16\,\Omega$

Closed



Resistance of left side $= \left(\frac{1}{16}+\frac{1}{2}\right)^{-1} = 1.7\Omega$

① ② Total current $= \frac{4.8}{1.7}$

$= 2.7A$

③ Current in 4 Ω $= \frac{7.2V}{4\Omega} = 1.8A$ ④ Current (Y) $= 2.7 - 1.8$ $(= 0.9A)$

⑤ Resistance Y $= \frac{7.2V}{0.9A} = 8\,\Omega$

$\boxed{X = 16\,\Omega}$ $\boxed{Y = 8\,\Omega}$

(2 marks) (2 marks)

Additional marks awarded for correct formulation at markers discretion.

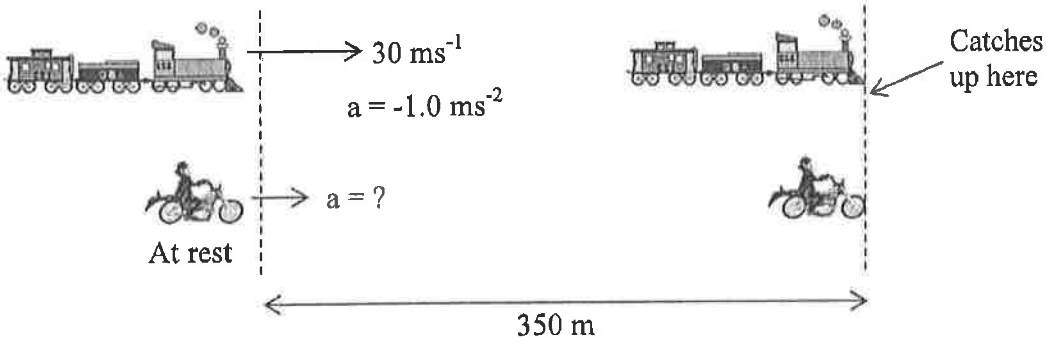
only 11 in the form achieved full marks

Class

Name

Question 30 (3 marks) **Marks**

As part of an action sequence for a film, a stunt driver on a motorcycle tries to catch up with a speeding train, as shown in the diagram below.



When it passes the motorcyclist, the train is travelling at 30 ms^{-1} but decelerating at 1.0 ms^{-2}. The motorcyclist, who is initially at rest, immediately gives chase, accelerating at a constant rate until he catches up with the train.

The motorcyclist catches up with the train 350 m down the track.

Determine the acceleration of the motorcycle. **3**

Find time for train to cover 350m

$r = ut + \frac{1}{2}at^2 \Rightarrow 350 = 30t - \frac{1}{2}t^2$ OR $v = \pm\sqrt{u^2 + 2ar} = \sqrt{30^2 - 2\times350}$

solve $t^2 - 60t + 700 = 0$ $= 14.14$ m/s (positive solution)

$t = 10(3 \pm \sqrt{2})$

$t = 15.858$s, 44.142s $t = \frac{v-u}{a} = \frac{14.14-30}{-1} = 15.858$s

Find acceleration of motorcycle to cover 350m in the same time.

$r = ut + \frac{1}{2}at^2$, $u = 0$, so $a = \frac{2r}{t^2} = \frac{2\times350}{15.858^2}$

$a = 2.78$ m/s² or 2.8 m/s²

If solving the quadratic you get 2 solutions, $t = 15.9$s is 1st time train passed 350m, $t = 44$s is second time after train has stopped and reversed back to 350m. (gives $a = 0.36$ m/s²)

(1) Mark – Valid equation to find time
(1) Mark – Find time
(1) mark – find acceleration

Both solutions OK, 1st solution only OK
2nd solution only – mark lost.

AAH
Class

CRIB.
Name

Question 31 (2 marks) **Marks**

Car A, of mass 1400 kg travelling at 20 ms^{-1} to the right, collides head on with Car B, of mass 1800 kg travelling at 10 ms^{-1} to the left. After the collision, the two cars stick together.

(a) Calculate the magnitude of the initial momentum of Car A. 1

(1) = 20 × 1400 = 28 000 kgms^{-1}

(b) Calculate the magnitude of the velocity of Car A immediately after the collision. 1

(1) 28 000 − 18 000 = 3200. V

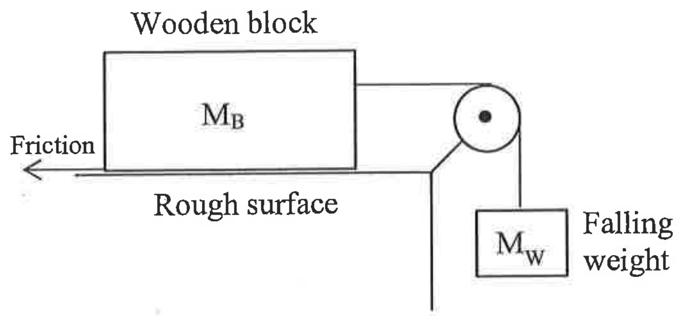
∴ V = 3·125 ms^{-1}

Class

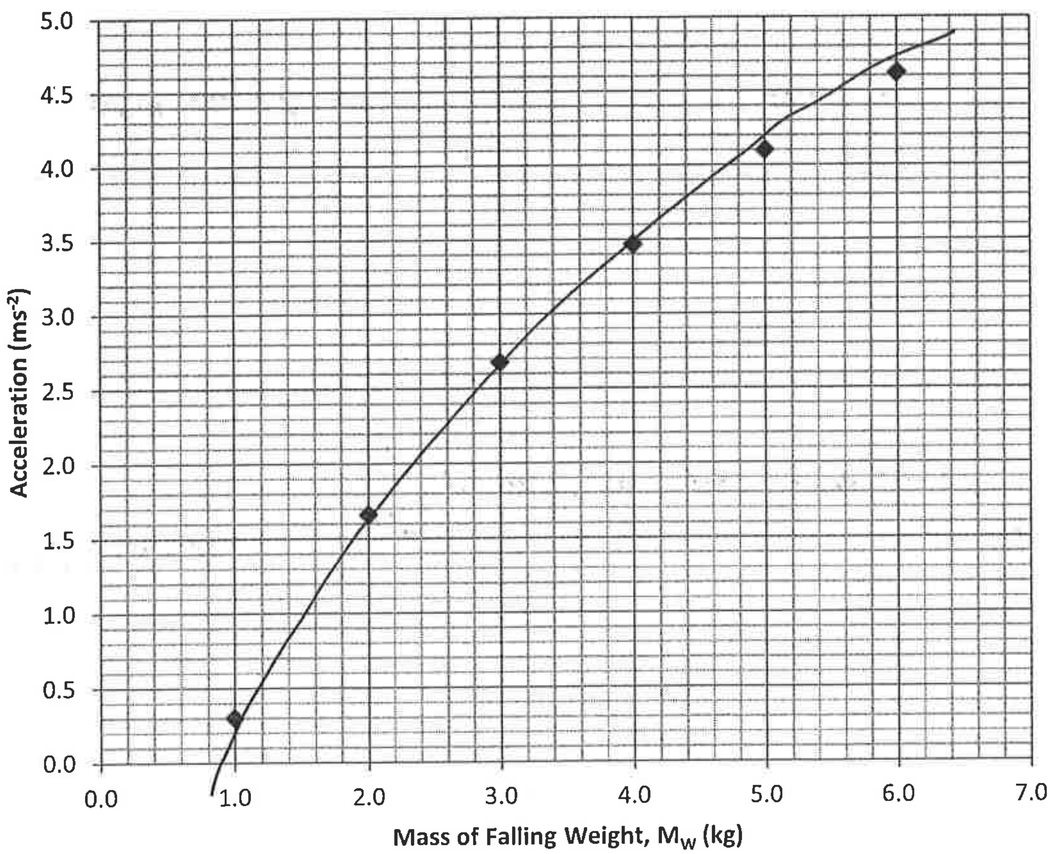
Name

Question 32 (3 marks) **Marks**

A pupil performs an experiment with the Atwood machine shown below.



The pupil varies the mass of the falling weight, M_w and measures the acceleration of the system. His results are shown on the graph below:



Question 32 continued on next page.

Class

Name

Question 32 continued. **Marks**

Using the graph on the previous page, determine:

FROM INTERCEPT OF GRAPH.

(a) the friction acting on the wooden block. 1

$= 0.8 \times 9.8$ (MUST RECOGNISE THAT FRICTION

(1) ← [$= 7.84$ N] $=$ X-INTERCEPT $\times g$).

(b) the mass of the wooden block. 2

USING, e.g. $M_W = 6.0$ kg :

[$(6.0 \times 9.8 - 7.84) = (6.0 + M_B) . 4.6$] (1)

→ [$M_B = 5.1$ kg] (2)

ie VALID SUBSTITUTION USING TWO CORRECT VALUES

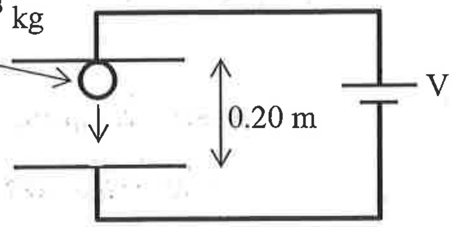
NB: The data is CLEARLY NOT A STRAIGHT LINE (But this was not penalised in the context of an otherwise correct answer.).

Class

Name

Question 33 (6 marks) **Marks**

In the experiment below, a charged sphere of mass 2.5×10^{-3} kg is allowed to fall through an electric field, as shown.



The voltage between the plates is varied, and the velocity of the sphere as it hits the lower plate is measured.

Theoretically, the relationship between the voltage, V, across the plates and the velocity, v, of the sphere is found by conserving energy, and is given by:

$$v^2 = 2gd + 2Vq/m \qquad \textbf{(Equation 1)}$$

where: d is the separation of the plates
g is the acceleration due to gravity
q is the charge on the sphere and
m is its mass.

The results obtained in the experiment are shown below:

Voltage (V)	Velocity (ms^{-1})	v^2 $((ms^{-1})^2)$	
100	2.14	4.58	
200	2.30	5.29	
400	2.58	6.66	
600	2.83	8.01	
800	3.06	9.36	
1000	3.27	10.69	

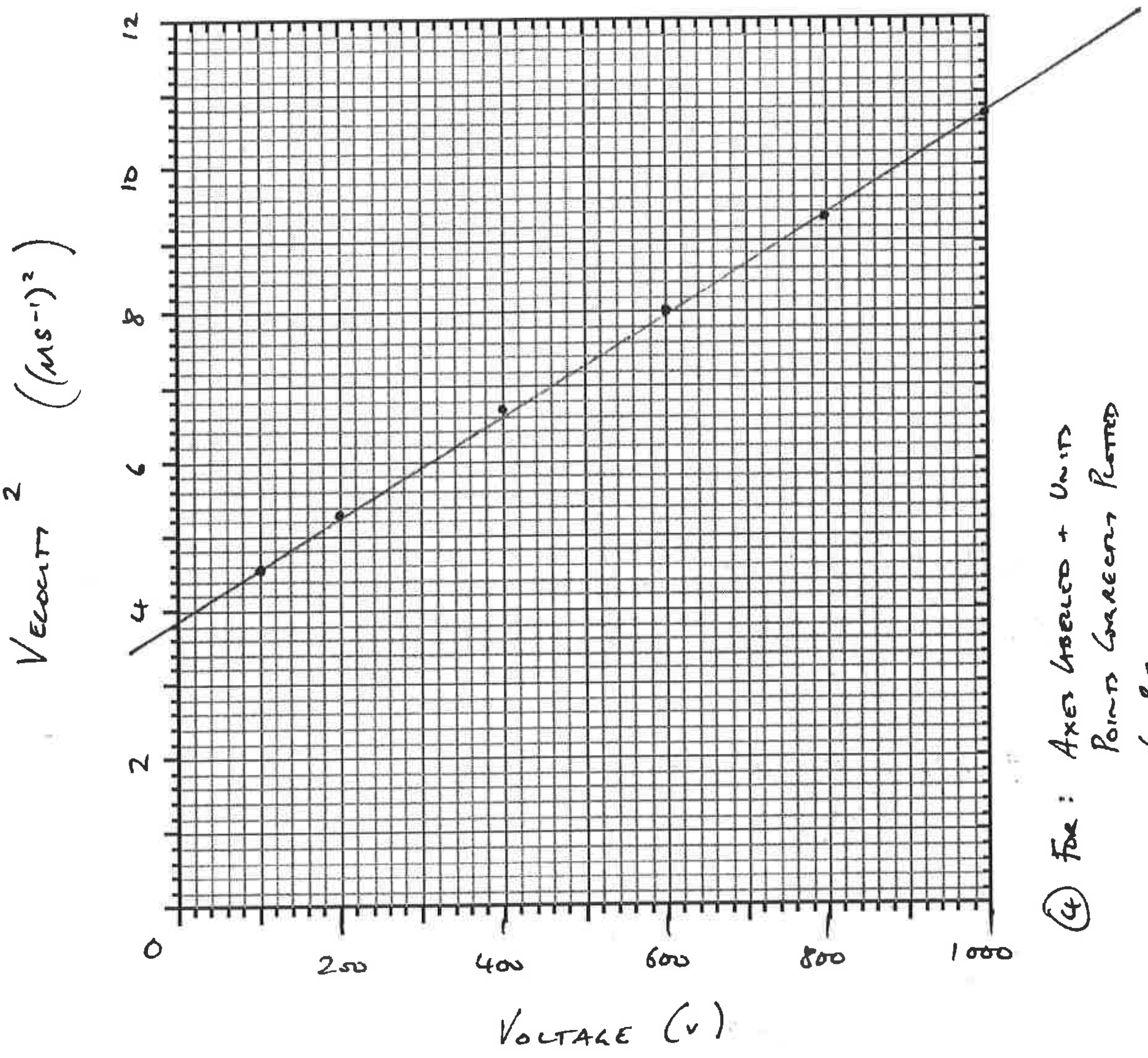
Question 33 continued on next page.

Class

Name

Question 33 continued. **Marks**

(a) Using the data given on the previous page, plot a **straight line graph** that will allow you to verify Equation 1 for this data. (NOTE: extra columns have been provided in the table, should you need them.)



④ For: Axes labelled + Units
Points correctly plotted
LoBF
Scale + Clarity
Straight line graph (ie v^2 v V) — other equivalents accepted
→ V v V (!) — Max ③
(−1) For any omissions.

4

(b) Calculate the charge on the sphere. 2

From Equation 1 Gradient = $\frac{2.q}{m} = \frac{10.7 - 3.8}{1000}$ — ①

→ $q = 8.6 \times 10^{-6}$ C — ②

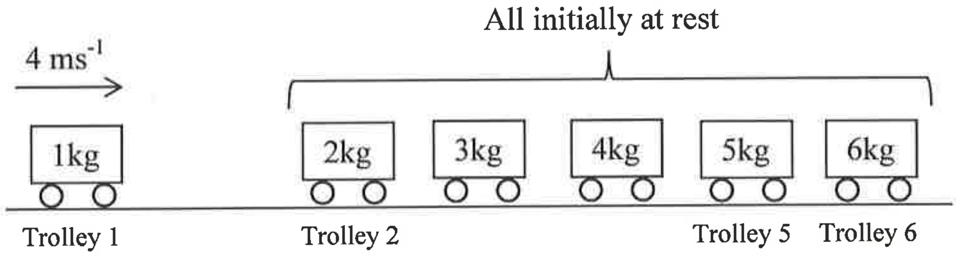
(or ① for a correct substitution into Equation 1 – with incorrect q –)

AM1
Class

CRIB
Name

Question 34 (6 marks) **Marks**

The diagram below shows a series of trolleys on a frictionless surface.



Initially, Trolley 1 is travelling at a speed of 4 ms^{-1}, and the other trolleys are stationary. The trolleys are not connected, and are set up so that, when they collide, they do so elastically.

(a) Calculate the velocity of Trolley 2, immediately after it collides with Trolley 1. **3**

(See later for worked solution)

* Valid momentum equation : $4 = V_1 + 2V_2$
* Valid KE equation : $8 = \frac{1}{2}.1.V_1^2 + \frac{1}{2}.2.V_2^2$
* Valid rel. velocity eqn : $V_2 - V_1 = 4$

} Any 2 × ① each

→ $V_2 = 8/3$ — ③

NB: Calculates $P_0 = 4$ kg m/s and $KE_0 = 8$ J — ①

Question 34 continued on next page.

Class

Name

Question 34 continued. **Marks**

(b) Calculate the velocity of Trolley 6, immediately after it collides with Trolley 5. **3**

* VALID MOMENTUM AND KE EQUATIONS FOR SECOND COLLISION ——— (1)

(OR EQUIVALENT)

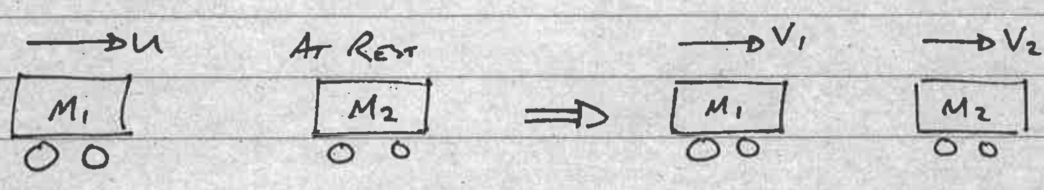
* CALCULATES $V_3 = \frac{32}{15} = 2.133\ ms^{-1}$ ——— (2)

* CALCULATES $V_6 = 1.48\ ms^{-1}$ ——— (3)

SEE NEXT PAGE FOR WORKINGS.

Q34 WORKED SOLUTION ...

* NB SOLVE ALGEBRAICALLY FOR PART a) FIRST, THEN APPLY TO b).



MOMENTUM : $M_1 u = M_1 V_1 + M_2 V_2$

REL VELOCITY : $V_2 - V_1 = u$ (OR =) $\frac{1}{2} M_1 u^2 = \frac{1}{2} M_1 V_1^2 + \frac{1}{2} M_2 V_2^2$ KE

⟶ SEVERAL LINES OF ALGEBRA...

$$\left[V_2 = 2\left(\frac{M_1}{M_1 + M_2}\right) u \right] \quad \text{(A)}$$

FOR PART a) SUB IN $u = 4\,ms^{-1}$ $M_1 = 1\,kg$ $M_2 = 2\,kg$

$$\longrightarrow V_2 = \frac{8}{3}\,ms^{-1}$$

PART b) FROM (A) $V_3 = 2\left(\frac{2}{2+3}\right) V_2 = 2\left(\frac{2}{2+3}\right) \cdot 2\left(\frac{1}{1+2}\right) 4$

etc etc

$$\longrightarrow V_6 = 2^5 \left(\frac{5 \times 4 \times 3 \times 2 \times 1}{11 \times 9 \times 7 \times 5 \times 3}\right) \cdot 4$$

$$V_6 = 1.48\,ms^{-1}$$