SYDNEY GRAMMAR SCHOOL

2016

FORM V
EXAMINATION

Physics

Working Time: 2 hours

1:00 pm Monday 23 MAY

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 (99)

This paper has two parts: Part A and Part B

Part A
Total marks **(13)**
- Attempt ALL Questions
- Allow about 15 minutes for this Part

Part B
Total marks **(86)**
- Attempt ALL Questions
- Allow about 1 hour 45 minute for this Part

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

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

EXAMINERS: MRW/AAH/PCK/SRW/MTK

Part A

Total marks (13)
Attempt ALL Questions
Allow about 15 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

○ A ● B ○ C ○ D

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

● A ⊗ B ○ C ○ D

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.

correct

⊗ A ⊗ B ○ C ○ D

1 Which of the following lists contains three vector quantities?

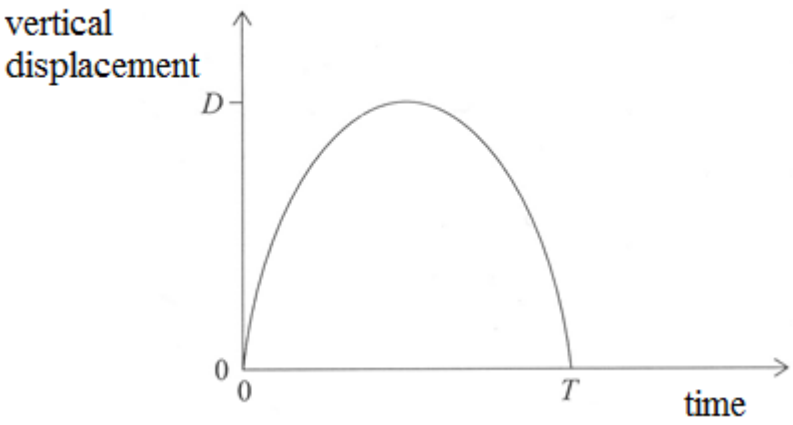
(A) Velocity, mass, acceleration
(B) Energy, velocity, time
(C) Work, displacement, velocity
(D) Acceleration, momentum, force

2 Which of the following is **always** true for an object travelling in a straight line at a constant speed?

(A) The friction is zero.
(B) No forces are acting on it.
(C) The momentum of the object is zero.
(D) No net force acts on the object.

3 A ball is thrown vertically upwards from the ground.

The graph below shows the variation of the vertical displacement of the ball with time.

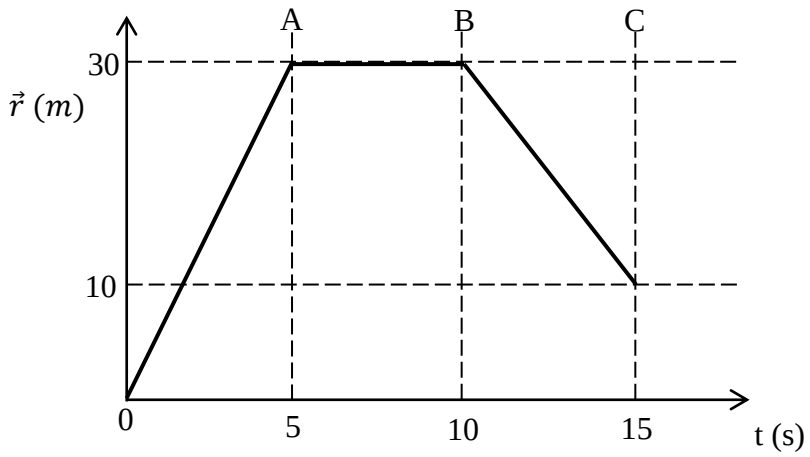


Determine which of the following is the final vertical displacement of the ball at time T and the average speed between time $t = 0$ and time T?

	Final vertical Displacement	**Average Speed**
(A)	0	0
(B)	0	2D/T
(C)	D	2D/T
(D)	2D	0

The following information applies to Questions 4 and 5:

The displacement versus time graph below shows the motion of an object along a straight line.

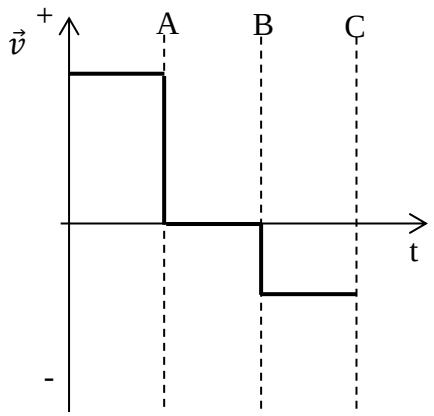


4 What is the total distance travelled by the object?

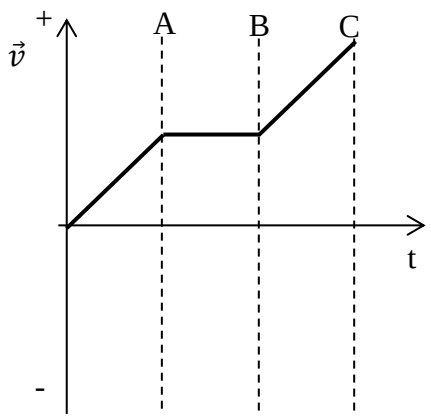
(A) 10 m
(B) 20 m
(C) 40 m
(D) 50 m

5 Which of the following graphs best represents the velocity versus time graph for the motion described in the displacement versus time graph on the previous page?

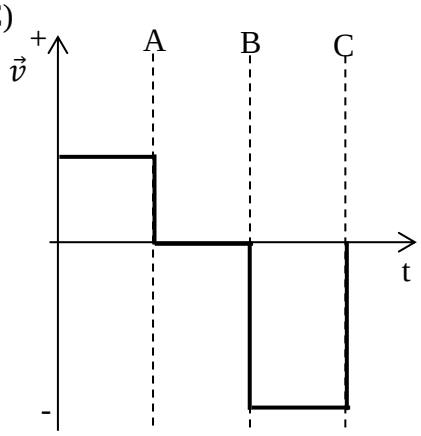
(A)



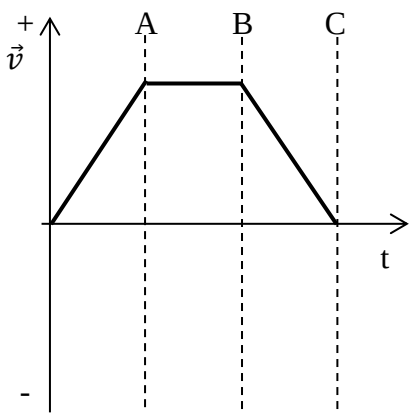
(B)



(C)



(D)

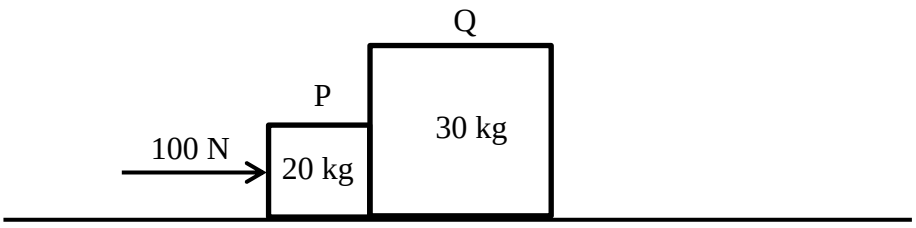


6 A 40 N force is applied horizontally to a 10 kg block which is initially at rest. After 5.0 seconds, the velocity of the block is 12 m s^{-1}.

What is the magnitude of the frictional force acting on the block?

(A) 0 N
(B) 16 N
(C) 24 N
(D) 40 N

7 Consider the following arrangement of blocks, labelled P and Q.



A constant, horizontal force of 100 N is applied to block P.

Determine the magnitude of the force block P exerts on block Q.

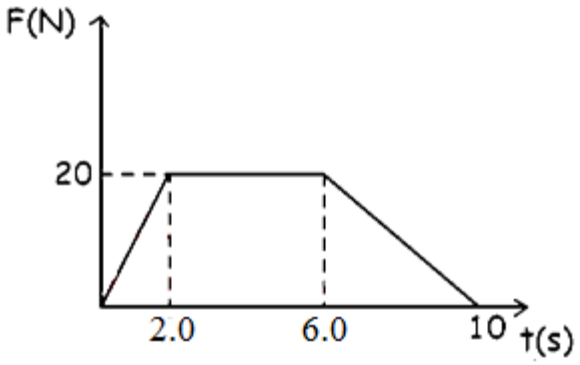
(A) 40 N
(B) 60 N
(C) 80N
(D) 100 N

8 A block moves at a speed of 10 m s^{-1} across a frictionless, horizontal surface. No net force is acting on this block.

What is the magnitude of the velocity of the block 10 seconds later?

(A) 0 m s^{-1}
(B) Less than 10 m s^{-1}
(C) 10 m s^{-1}
(D) Greater than 10 m s^{-1}

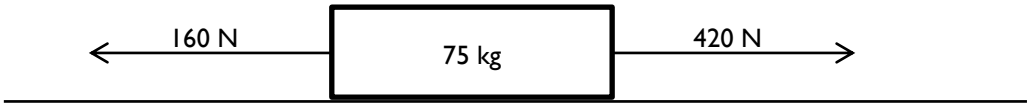
9 The following graph shows how the net force acting on a toy car varies with time.



What is the magnitude of the total change in momentum of the toy car at the end of 10 seconds?

(A) 240 kg m s^{-1}
(B) 200 kg m s^{-1}
(C) 140 kg m s^{-1}
(D) 100 kg m s^{-1}

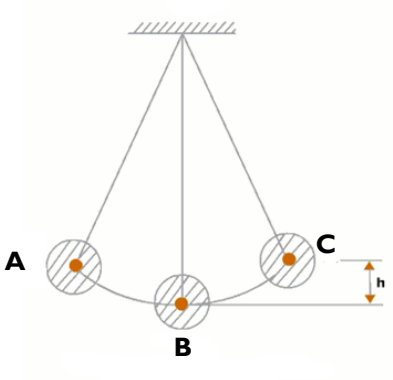
10 Consider the block shown below which is initially at rest on a frictionless horizontal surface and then acted upon by two forces simultaneously.



Determine the kinetic energy of the block when it has moved 5 metres.

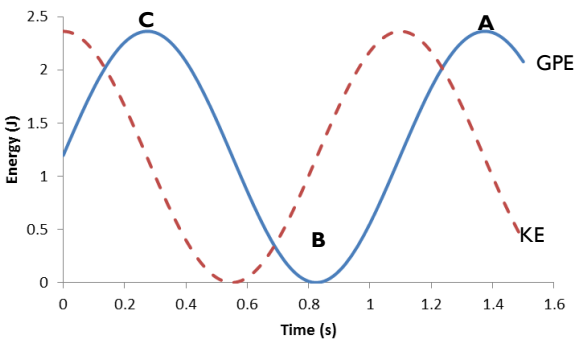
(A) 3.5 J
(B) 260 J
(C) 1300 J
(D) 2100 J

11 A pendulum swings backwards and forwards through positions A, B and C.

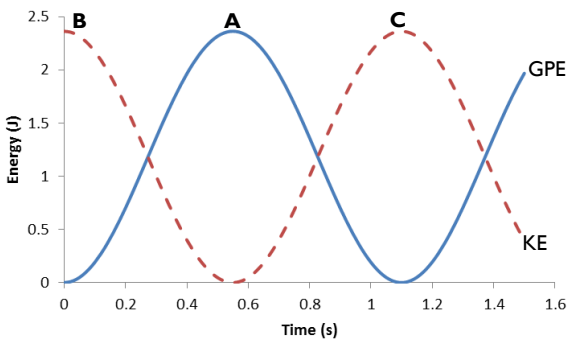


Which of the following graphs **best** represents how the gravitational potential energy (GPE) and kinetic energy (KE) vary with time?

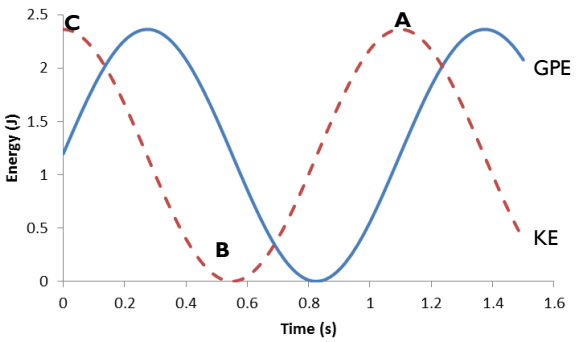
(A)



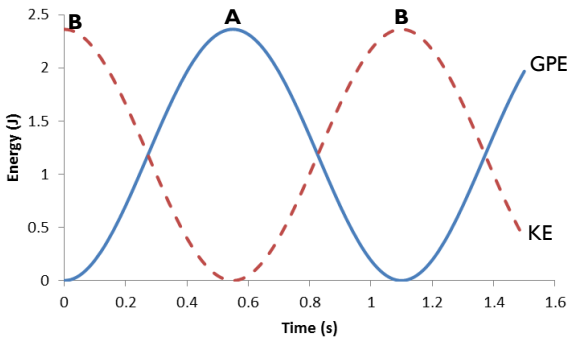
(B)



(C)



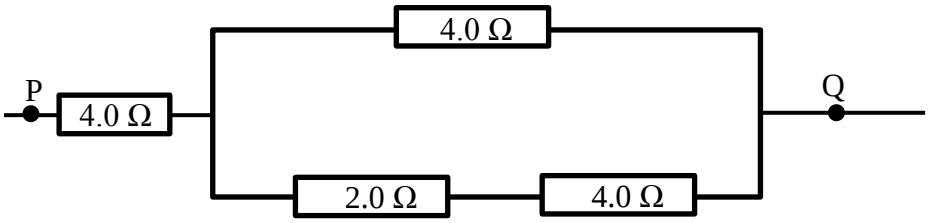
(D)



12 A resistor has a steady current of 5.0 A flowing through it in 10 s.
How many electrons pass through the resistor in 10 s?

(A) 8.0×10^{-18}
(B) 3.1×10^{20}
(C) 2.5×10^{-3}
(D) 1.6×10^{20}

13 Consider the following combination of resistors.



What is the total resistance between points P and Q in the above section of an electric circuit?

(A) 2.0 Ω
(B) 4.0 Ω
(C) 6.4 Ω
(D) 11.6 Ω

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Class

Name

Part B

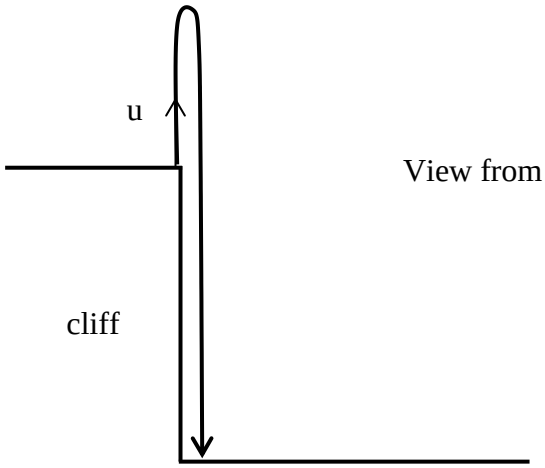
Total marks (86)
Attempt ALL Questions
Allow about 1 hour and 45 minutes for this Part

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

Question 14 (5 marks) **Marks**

A ball was thrown vertically upwards at a speed of 10.0 m s^{-1} from the top of a cliff. The time of flight for the ball to hit the sea at the bottom of the cliff was 6.92 s.

Assume no air resistance acts on the ball.



(a) Calculate the speed with which the ball hits the sea at the bottom of the cliff. **2**

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Question 14 continued on next page.

Question 14 continued. **Marks**

(b) Calculate the height of the cliff top above sea level.

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(c) What is the acceleration of the ball at the highest point?

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Class

Name

Question 15 (6 marks) **Marks**

A police motor bike is stationary by the side of a road. An L-plate driver, exceeding the speed limit, passes the police motor bike at a constant speed of 108 km h^{-1}. The police motor bike sets off to catch the L-plater just as he passes. The police motor bike accelerates uniformly at 6.5 m s^{-2} for 6.0 s and then continues at a constant speed.

(a) Convert the L-plate driver's speed to ms^{-1}.

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(b) Calculate the speed of the police motor bike at 6 s.

..... **1**

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(c) Calculate the distance travelled by police motor bike in the first 6 s.

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(d) Calculate the total time for the police motor bike to draw level with the L-plate driver.

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(e) Calculate how far the L-plate driver has travelled before the police motor bike catches up.

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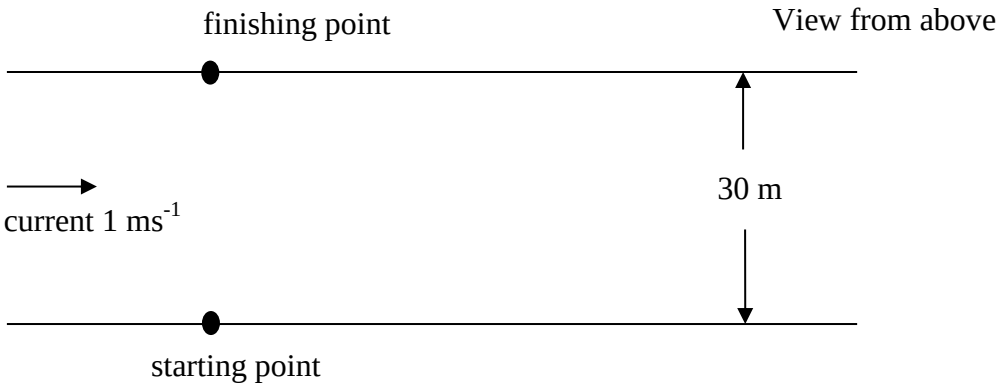
Question 16 (3 marks) **Marks**

A swimmer competes in a swimming race across a 30 m wide river which has a constant downstream current of 1.0 ms^{-1}. He swims slightly against the current so that he ends up exactly opposite the starting point as shown in the following diagram.



The swimmer can swim at 2 ms^{-1} in still water.

By drawing velocity vectors in the space provided below, determine the time it takes the swimmer to swim from the starting point to the finishing point.

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Class

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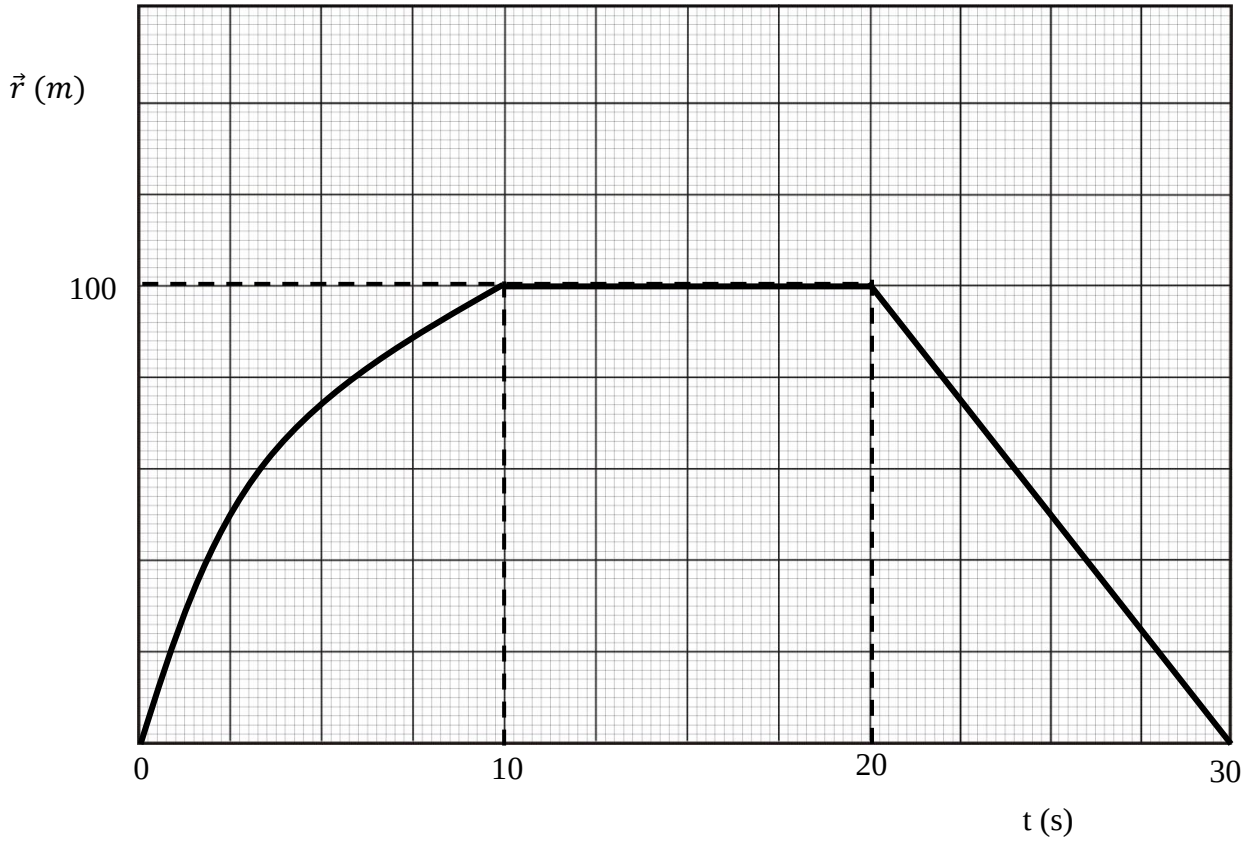
Question 17 (5 marks) **Marks**

The diagram below shows the displacement versus time graph for a car travelling along a straight road.



From the graph, determine:

(a) the average speed of the car between 0 and 30 s. **1**

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Question 17 continued on next page.

Question 17 continued. **Marks**

(b) the average velocity of the car between 20 and 30 s.

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(c) the instantaneous velocity of the car at 5 s.

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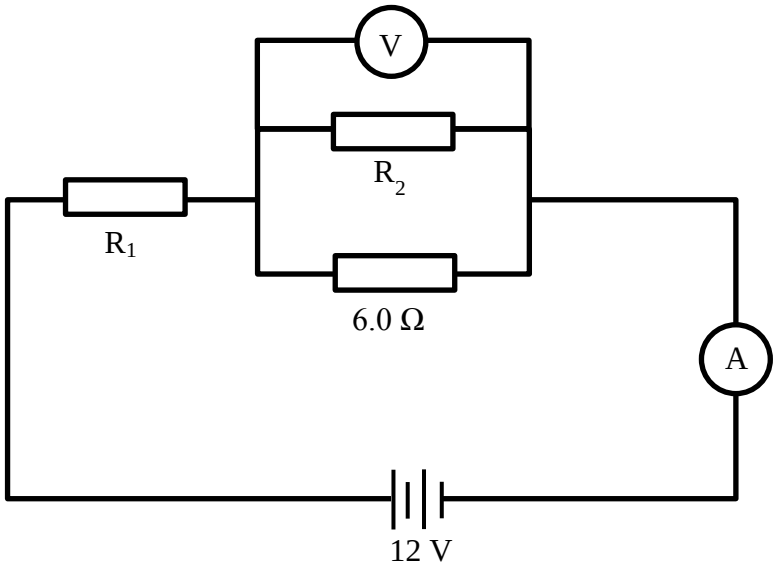
Class

Name

Question 18 (4 marks) **Marks**

This question refers to the electric circuit shown below.



The voltmeter has a reading of 4.0 V and the ammeter has a reading of 3.0 A.

(a) Calculate the voltage across the unknown resistor, R_1.

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(b) Calculate the value of the unknown resistor, R_1.

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(c) Calculate the value of the unknown resistor, R_2.

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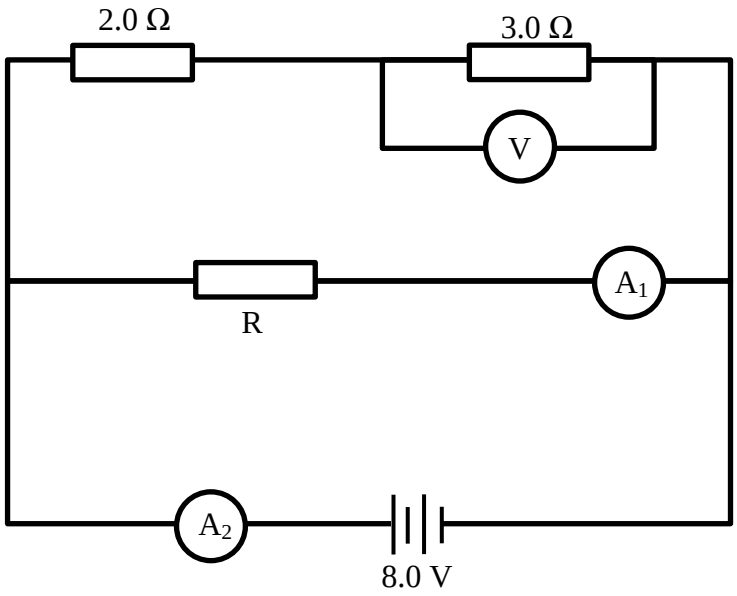
Question 19 (4 marks) **Marks**

This question refers to the electric circuit shown below.



The reading on the ammeter, A_1 is 0.80 A.

(a) Calculate the value of the unknown resistor, R.

..... **1**

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(b) Determine the reading on the voltmeter in the circuit above.

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(c) Calculate the reading on the ammeter A_2.

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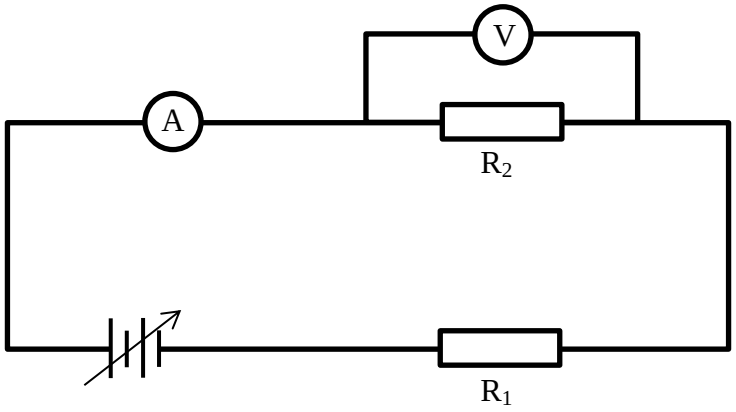
Class

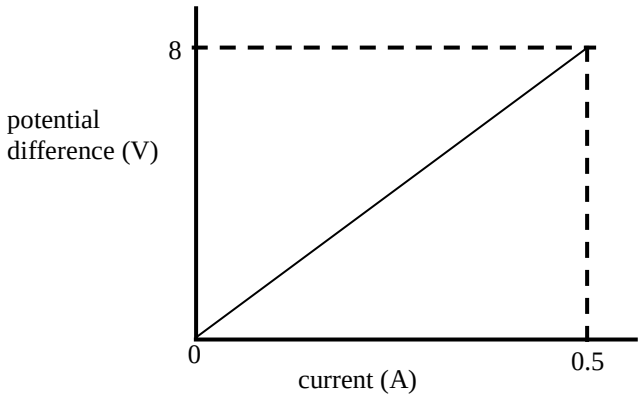
Name

Question 20 (3 marks) **Marks**

The following circuit was set up with two resistors, R_1 and R_2,and a battery.



The following graph shows how the potential difference across resistor, R_2, varies as the current through resistor, R_2, is changed.



(a) Calculate the value of the resistance of resistor, R_2.

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Question 20 continued on next page

Question 20 continued. **Marks**

(b) When the potential difference of the battery is 8.0 V, it supplies a current of 0.40 A to the circuit.

Calculate the value of the unknown resistor, R_1.

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Question 21 (2 marks)

A 100 kg man stands on a set of bathroom scales in a lift and notices that the scales read 153 kg.

Determine the acceleration of the lift.

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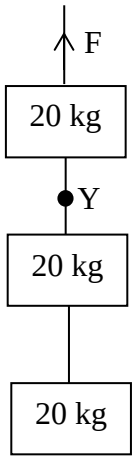
Class

Name

Question 22 (4 marks) **Marks**

Three 20 kg masses are pulled **upwards** with a constant force F such that the tension force in the rope at point Y is 500 N.



(a) Determine the magnitude of the acceleration of the masses. **2**

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(b) Determine the magnitude of the constant force, F. **2**

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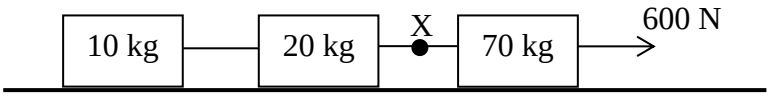
Question 23 (4 marks) **Marks**

Three masses 10 kg, 20 kg and 70 kg are connected by massless and unstretchable strings and pulled along a frictionless, horizontal surface by a constant horizontal force of 600 N as shown below.



(a) Calculate the magnitude of the acceleration of the masses.

..... **1**

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(b) Calculate the tension force in the string at X.

..... **1**

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(c) The same arrangement of three masses is now placed on a rough surface. If the frictional force which now acts on each mass is equal to 0.2 times the weight of each mass, determine the magnitude of the new acceleration of the system when the constant horizontal force of 600 N is applied.

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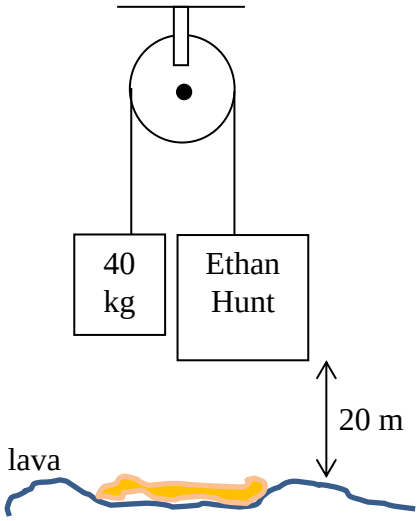
Class

Name

Question 24 (6 marks) **Marks**

In "*Mission Impossible Twelve*", Ethan Hunt of mass 80 kg finds himself attached to a 40 kg mass via a pulley above a pool of lava as shown below.



(a) Assuming the system is released from rest, what time would elapse before Ethan reaches the surface of the lava? **2**

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(b) Ethan starts to climb up the rope with an acceleration of 1.0 m s^{-2} **relative to the lava**.

(i) Determine the tension in the rope while Ethan is climbing. **2**

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Question 24 continued on next page.

Question 24 continued. **Marks**

(ii) Determine the magnitude of the acceleration of the 40 kg mass while Ethan climbs the rope.

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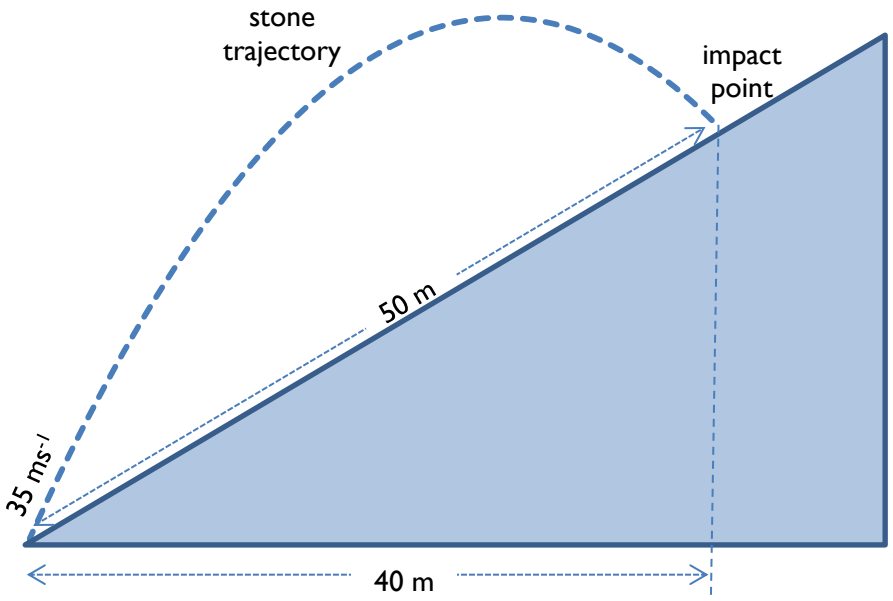
Class

Name

Question 25 (4 marks) **Marks**

A stone of mass 0.25 kg is thrown into the air with an initial speed of 35 m s^{-1} and it lands 50 m up a slope as shown in the following diagram.



(a) Determine the initial kinetic energy of the stone.

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(b) Determine the speed of the stone when it hits the slope.

..... **3**

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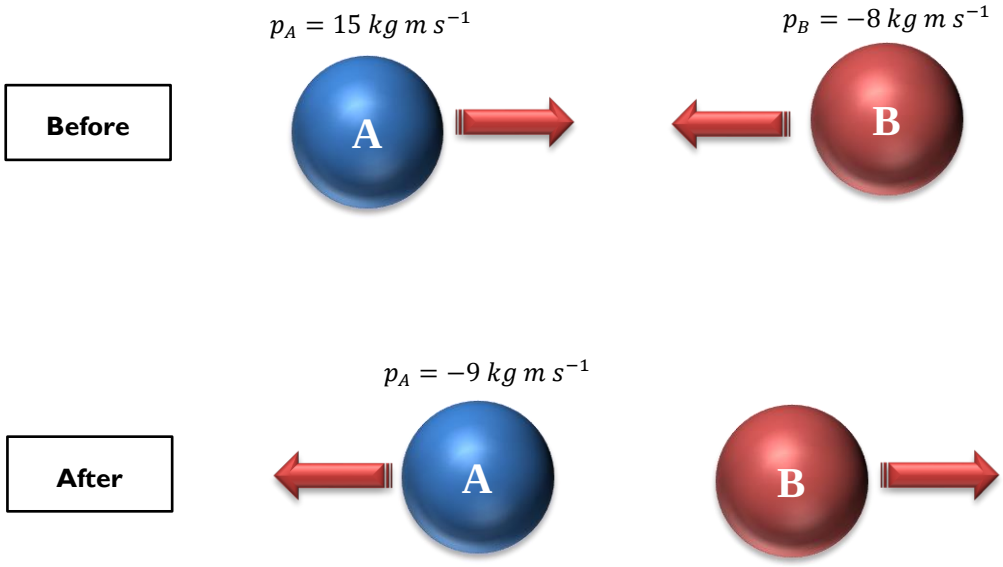
Class

Name

Question 26 (6 marks) **Marks**

Two balls, A and B (with momenta p_A and p_B), collide ***elastically*** as follows:



During the collision, ball A of mass 3 kg loses 24 joules of kinetic energy.

(a) Calculate the magnitude of the final momentum p_B of ball B after the collision.

..... **1**

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(b) Calculate the magnitude of the impulse that ball A applies to ball B during the collision.

..... **1**

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Question 26 continued on next page.

Question 26 continued. **Marks**

(c) Determine the initial velocity of ball A.

..... **1**

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(d) Determine the mass of ball B.

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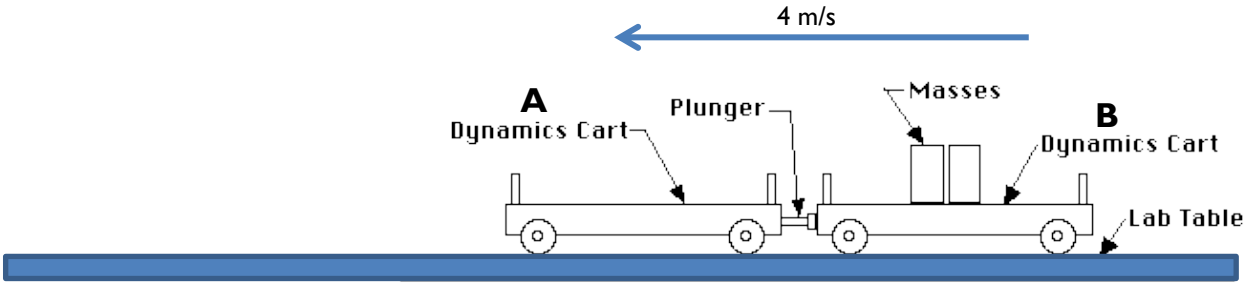
Question 27 (5 marks) **Marks**

Two dynamics trolleys, A and B, are joined together and moving to the left at 4 m s^{-1}. The spring loaded plunger is set off pushing the trolleys apart. Trolley A increases in speed while trolley B becomes stationary.



The dynamics trolleys are 3 kg each and the two added masses to trolley B are 1 kg each.

(a) Calculate the magnitude of the total momentum of trolley A and B before the plunger is set off.

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(b) Determine the speed of trolley A after the plunger is set off.

..... **1**

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(c) Show numerically whether the total kinetic energy increases, decreases or remains the same. Account for why this occurs.

..... **3**

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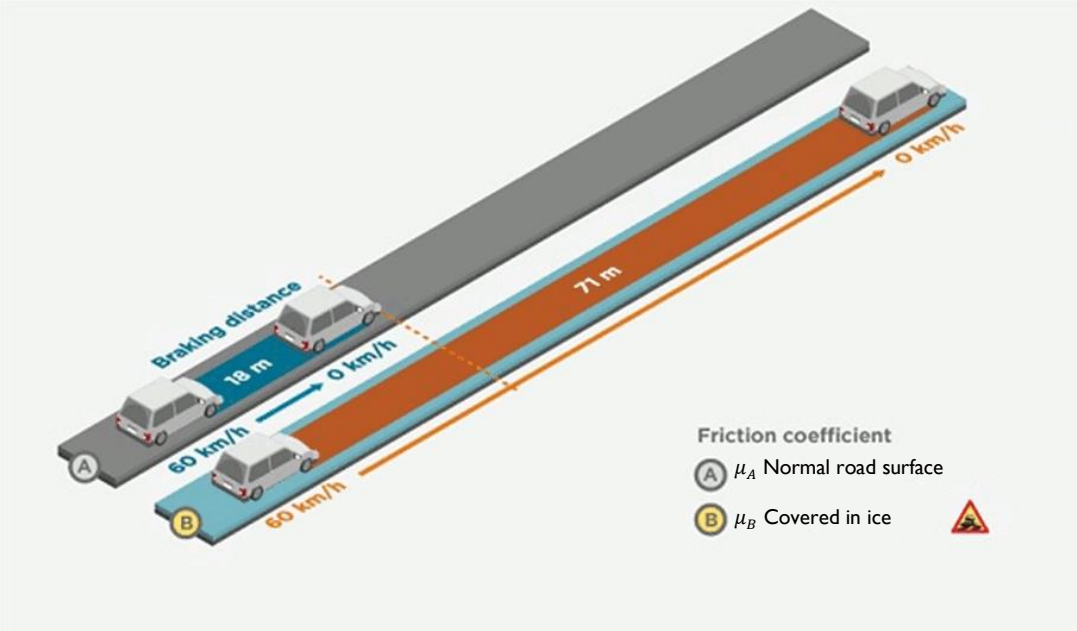
Question 28 (5 marks) **Marks**

The maximum braking force of a car is limited by the frictional force between the tyres and the road. The maximum frictional force, F, can be determined by the equation $F = \mu mg$ where μ is the coefficient of friction between the tyre and the road and mg is the weight of the car.

A car's braking distance is tested on two different road surfaces, A and B, both from an initial speed of 60 kmh^{-1} (16.67 ms^{-1}).

The braking distance on surface A was 18 m.

The braking distance on surface B was 71 m.



(a) Determine the coefficient of friction for the normal road surface A. **2**

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Question 28 continued on next page.

Class

Name

Question 28 continued. **Marks**

(b) Determine the maximum initial speed that should be travelled on road surface B to have the same stopping distance as surface A. **3**

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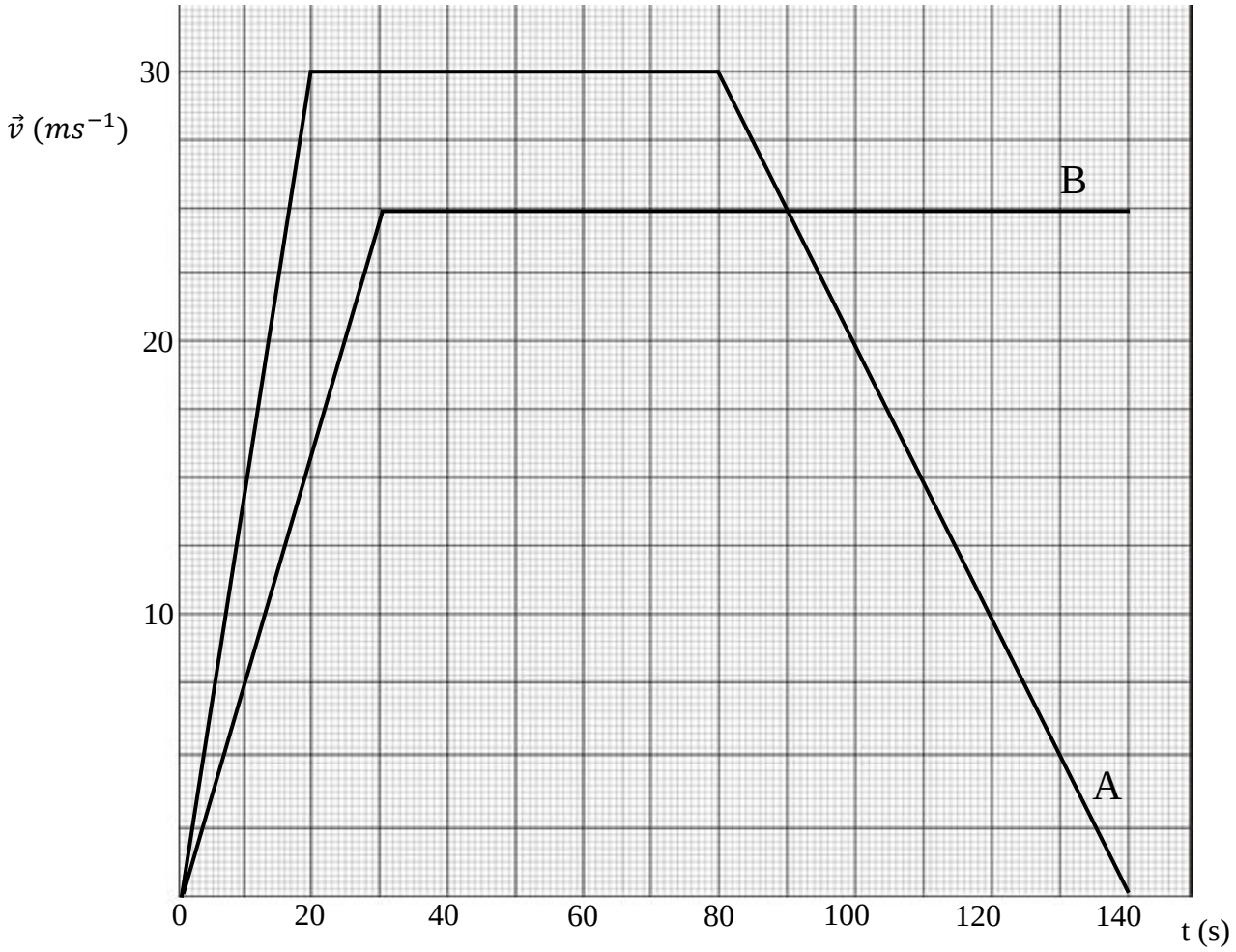
Name

Question 29 (6 marks) **Marks**

The velocity versus time graphs below show two underground trains, A and B, travelling from the same station on parallel, straight tracks. At time t = 0 s, both trains are alongside each other at rest.



Question 29 continued on next page.

Question 29 continued. **Marks**

Using the graphs, or otherwise, determine:

(a) the maximum speed of train B.

..... **1**

(b) the magnitude of the acceleration of train A between 80 and 140 s.

..... **2**

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(c) the time at which train A and train B are alongside each other again.

..... **3**

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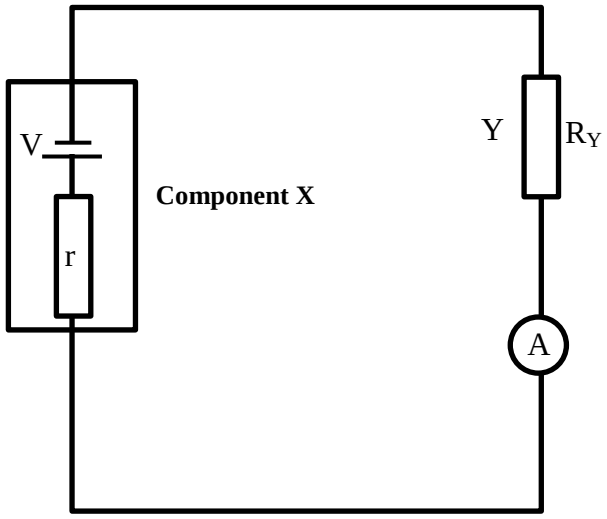
Class

Name

Question 30 (4 marks) **Marks**

A physics student sets up the following circuit in an attempt to determine the electrical characteristics of component X.



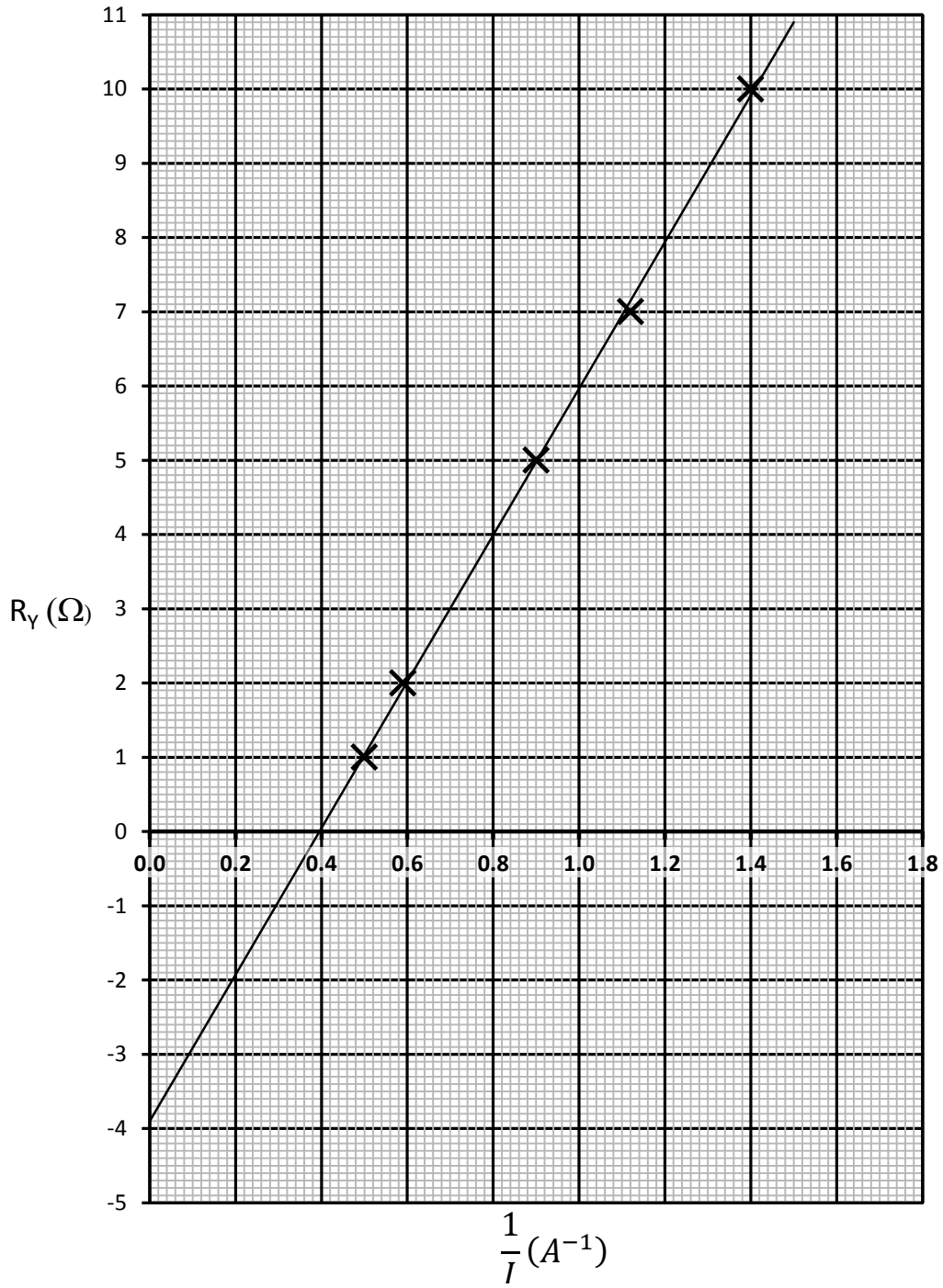
Component X consists of a battery of potential difference, V and a resistor, r, in series.

Various resistors, R_Y, are placed in the circuit at Y and the current flowing through the ammeter is recorded each time.

Question 30 continued on next page.

Question 30 continued. **Marks**

The following graph is a plot of R_Y (on the y-axis) versus $\frac{1}{I}$ using the experimental results obtained.



Question 30 continued on next page.

Class

Name

Question 30 continued. **Marks**

(a) Use the graph to find the value of the resistor, r, within component X.

..... **2**

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(b) Use the graph to find the value of the potential difference, V, of the battery within component X.

..... **2**

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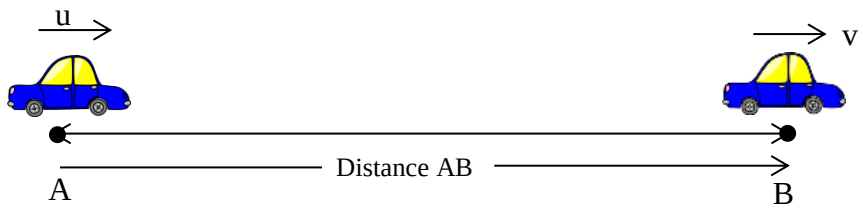
Question 31 (10 marks) **Marks**

In an engine test, a car accelerates uniformly between two points (from the same starting velocity) on a straight road, and its final velocity is recorded.



The data obtained is included in the table on the following page.

Distance AB (m)	**Final Velocity, *v* (ms^{-1})**			**Average *v* (ms^{-1})***	***Average* v^2 (m^2s^{-2})***
	1	**2**	**3**		
50	20.6	21.4	21.2	21.1	445
100	27.2	27.2	27.0	27.1	734
150	32.7	33.4	32.8	33.0	1090
200	37.3	37.5	37.1	37.3	1390
250	40.4	40.9	40.8		
300	44.2	44.6	44.8	44.5	1980

(* to 3 significant figures, with v^2 based on v to 3 significant figures)

(a) Complete the table above by adding in the missing values. **2**

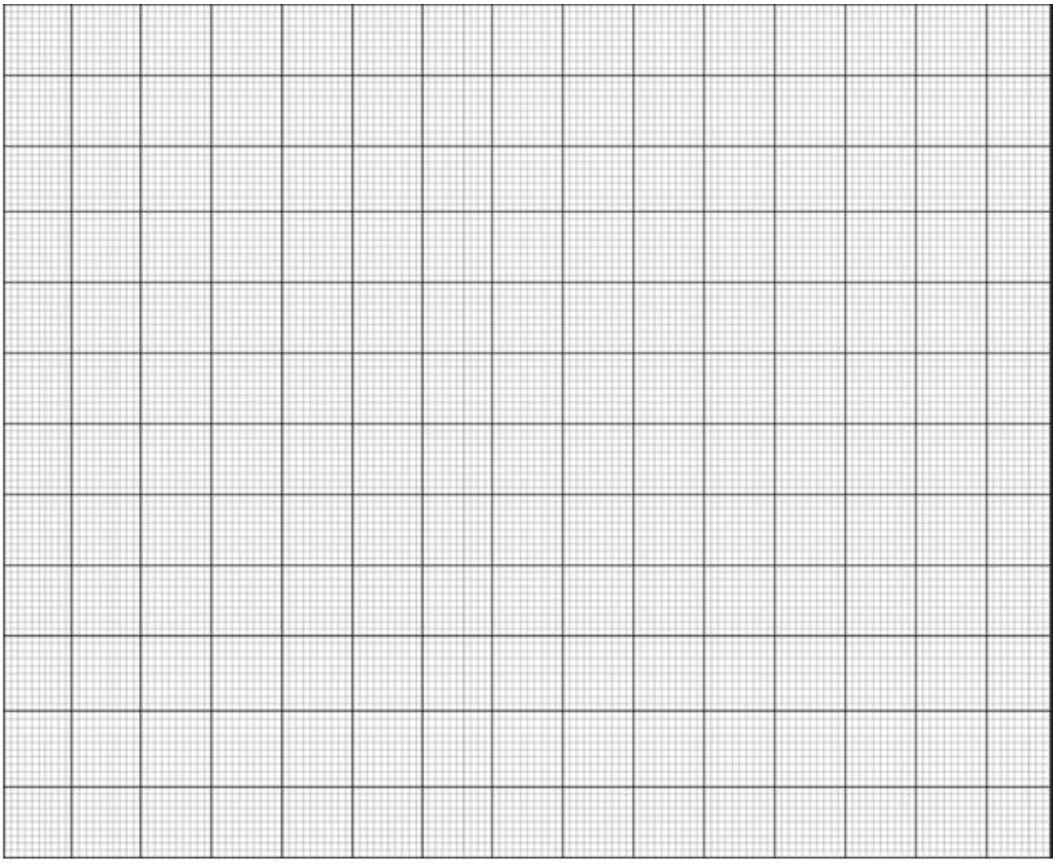
Question 31 continued on next page.

Class

Name

Question 31 continued. **Marks**

(b) Plot a graph of velocity squared (on the y-axis) against distance.



4

Question 31 continued on next page.

Question 31 continued. **Marks**

(c) Using your graph, or otherwise, determine:

(i) the initial velocity of the car.

..... **2**

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.....

(ii) the acceleration of the car.

..... **2**

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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	340 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 x 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}

FORMULAE SHEET FORM V ONLY

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

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

$$v = u + at$$

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

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

$$\sum F = ma$$

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

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

$$E_p = mgh$$

$$W = Fr$$

$$p = mv$$

$$\Delta p = F_n t$$

$$F = mg$$

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

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

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

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

$$P = VI$$

$$Energy = VIt$$

$$v = f\lambda$$

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

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

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

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

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

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

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

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

$$E = mc^2$$

FORMULAE SHEET

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

$$F = BIl\sin\theta$$

$$\tau = Fd$$

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

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

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

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

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

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

$$F = qvB\sin\theta$$

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

$$E = hf$$

$$c = f\lambda$$

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

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

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

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

$$Z = \rho v$$

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

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

Class

Name

PHYSICS
Form V
May 2016
Monday 23rd MAY 1.00 PM

General Instructions

- Write your class and Candidate Number in the space provided.
- Attempt all questions
- Use a blue or black pen
- Select the alternative A, B, C, or D that best answers the question.
- Fill in the response oval completely.

Multiple Choice ANSWER SHEET

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

Mark

MTK.
Class

CRIB.
Name

Part B

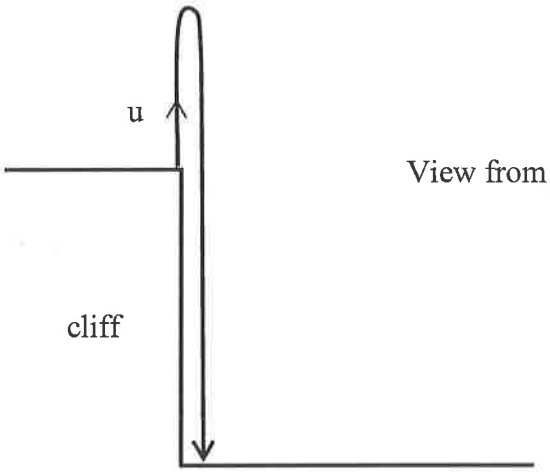
Total marks (86)
Attempt ALL Questions
Allow about 1 hour and 45 minutes for this Part

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

Question 14 (5 marks) **Marks**

A ball was thrown vertically upwards at a speed of 10.0 m s^{-1} from the top of a cliff. The time of flight for the ball to hit the sea at the bottom of the cliff was 6.92 s.

Assume no air resistance acts on the ball.



View from side

(a) Calculate the speed with which the ball hits the sea at the bottom of the cliff. **2**

$V = u + at$

$= 10 + -9.8 \times 6.92$

$= 57.8 \text{ ms}^{-1} \downarrow$

Question 14 continued on next page.

Question 14 continued. **Marks**

(b) Calculate the height of the cliff top above sea level.

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

$= 10 \times 6.92 + \frac{1}{2} \times -9.8 \times 6.92^2$

$= 165.4$ m

(c) What is the acceleration of the ball at the highest point?

$-9.8\ ms^{-2} \downarrow$ **1**

Class

Name

Question 15 (6 marks) **Marks**

A police motor bike is stationary by the side of a road. An L-plate driver, exceeding the speed limit, passes the police motor bike at a constant speed of 108 km h^{-1}. The police motor bike sets off to catch the L-plater just as he passes. The police motor bike accelerates uniformly at 6.5 m s^{-2} for 6.0 s and then continues at a constant speed.

(a) Convert the L-plate driver's speed to ms^{-1}.

$108/3.6 = 30\ ms^{-1}$ **1**

(b) Calculate the speed of the police motor bike at 6 s.

$v = u + at = 0 + 6.5 \times 6 = 39\ ms^{-1}$ **1**

(c) Calculate the distance travelled by police motor bike in the first 6 s.

$r = ut + \frac{1}{2}at^2 = 0 + \frac{1}{2} \times 6.5 \times 6^2 = 117\ m$ **1**

(d) Calculate the total time for the police motor bike to draw level with the L-plate driver.

Car in 6s $6 \times 30 = 180\ m$ ∴ must be after 6s. **2**

(1) $30t = 117 + 39 \times (t - 6)$

(1) $t = 13\ s$

(OR) (1) $180 - 117 = 63$ $39 - 30 = 9$ $63/9 = 7\ s$.

(1) total $= 6 + 7 = 13\ s$

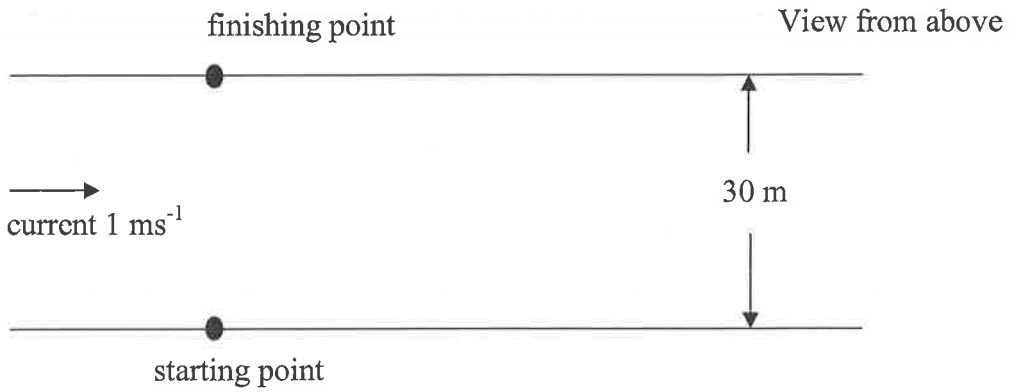
(e) Calculate how far the L-plate driver has travelled before the police motor bike catches up.

$r = ut = 30 \times 13 = 390\ m$ **1**

or Ans (d)

Question 16 (3 marks) **Marks**

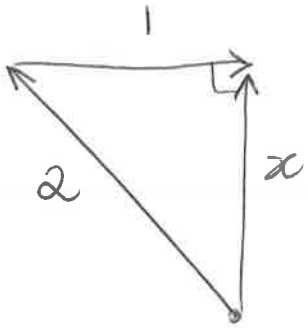
A swimmer competes in a swimming race across a 30 m wide river which has a constant downstream current of 1.0 ms^{-1}. He swims slightly against the current so that he ends up exactly opposite the starting point as shown in the following diagram.



The swimmer can swim at 2 ms^{-1} in still water.

By drawing velocity vectors in the space provided below, determine the time it takes the swimmer to swim from the starting point to the finishing point.

(1)



(1) $1^2 + x^2 = 2^2$

$x = \sqrt{3}$ ms^{-1} **3**

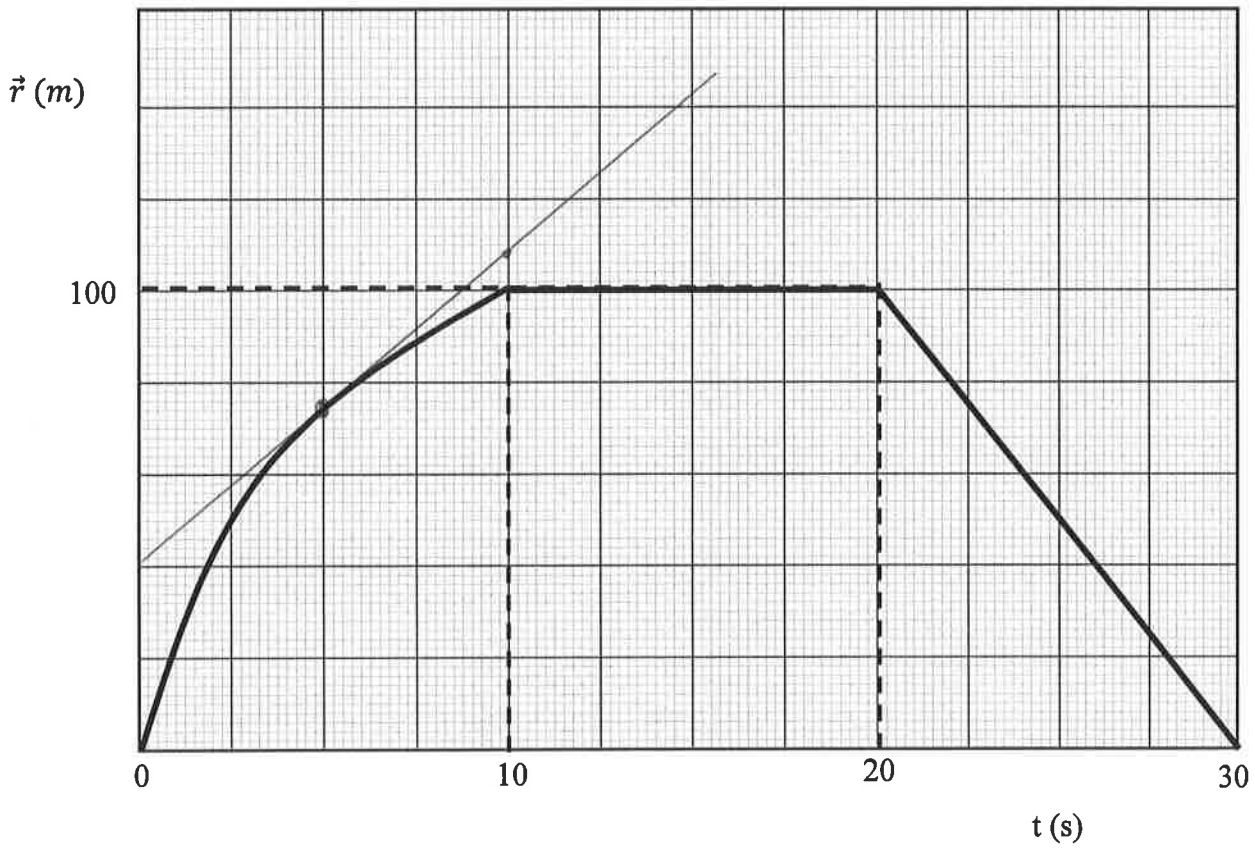
(1) $t = d/v = 30/\sqrt{3} = 17.3\,s$

Class

Name

Question 17 (5 marks) **Marks**

The diagram below shows the displacement versus time graph for a car travelling along a straight road.



From the graph, determine:

(a) the average speed of the car between 0 and 30 s. **1**

speed = d/t = (100+100)/30

= 6.7 ms^{-1}

Question 17 continued on next page.

Question 17 continued. **Marks**

(b) the average velocity of the car between 20 and 30 s.

$V_{AV} = r/t$ **2**

$= \frac{0-100}{10}$

$= -10\ ms^{-1}$

(1) (1).

OR backwards

(c) the instantaneous velocity of the car at 5 s.

(1) – recognising tangent required. **2**

(1) – calculating gradient of tangent.

$V = \frac{106-40}{10} = 6.6\ ms^{-1}$

* paid a wide range of answers as long as it matched the tangent drawn.

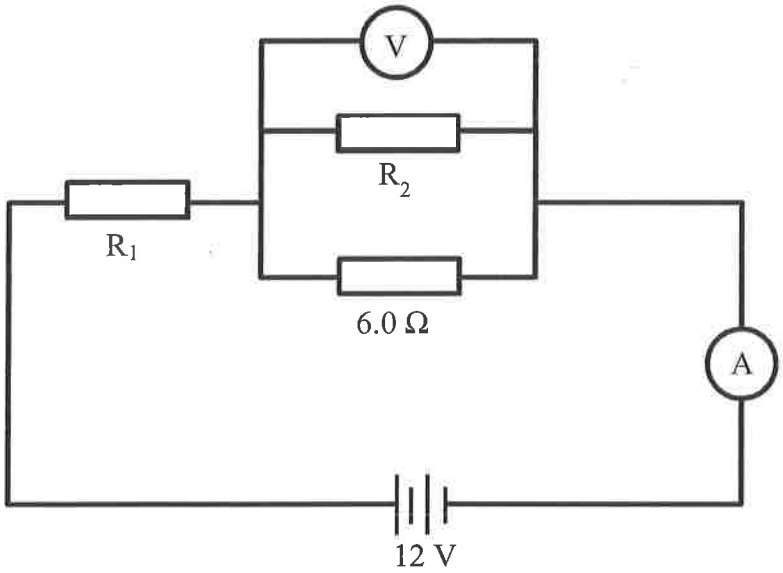
(1) only for $V_{AV} = \frac{74}{5} = 14.8\ ms^{-1}$.

Class

Name

Question 18 (4 marks) **Marks**

This question refers to the electric circuit shown below.



The voltmeter has a reading of 4.0 V and the ammeter has a reading of 3.0 A.

(a) Calculate the voltage across the unknown resistor, R_1.

$V_T = V_{R_1} + V_{11}$

$12 = V_{R_1} + 4$

$V_{R_1} = 8\,V$

✓ 0mk for correct method. 1

(b) Calculate the value of the unknown resistor, R_1.

$R_1 = \frac{V_{R_1}}{I} = \frac{Ans(a)}{3} = 8/3 = 2.67\,\Omega$

✓ 0mk 1

(c) Calculate the value of the unknown resistor, R_2.

Step 1: $V = IR$

$12 = 3R$

$R_T = 4\,\Omega$

Step 2: $\therefore R_T = R_1 + R_{11}$

$4 = Ans(a) + R_{11}$

$4 = 2.67 + R_{11}$

$R_{11} = 1.33\,\Omega$

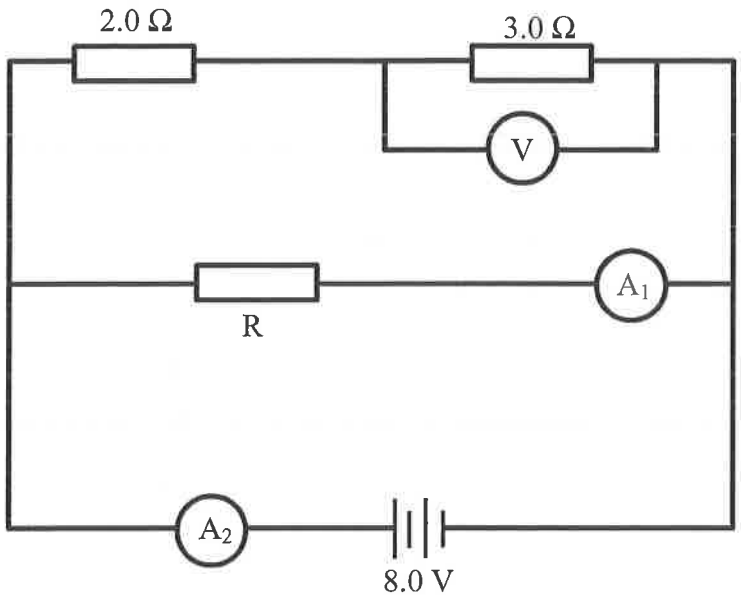
Step 3: $\frac{1}{1.33} = \frac{1}{6} + \frac{1}{R_2}$

$R_2 = 1.71\,\Omega$ ✓✓ 2mks.

Method based on finding total R, then R_{11} then $\frac{1}{R_{11}} = \frac{1}{R_2} + \frac{1}{6}$. but answer incorrect ✓× 1mk. 2

Question 19 (4 marks) **Marks**

This question refers to the electric circuit shown below.



The reading on the ammeter, A_1 is 0.80 A.

(a) Calculate the value of the unknown resistor, R. **1**

$R = V/I = 8/0.8$ ✓ (1) mk correct substitution into correct formula

$= 10\ \Omega$

(b) Determine the reading on the voltmeter in the circuit above. **2**

$I_{3\Omega} = \frac{V}{R} = 8/5 = 1.6\ A$ ✓ (1) mk.

$V_{3\Omega} = 3 \times 1.6$
$= 4.8V$ } ✓ (1) mk i.e $V = 3 \times I$

↑ correct or incorrect current.

(c) Calculate the reading on the ammeter A_2. **1**

$I_2 = I_1 + I_{3\Omega}$

$= 0.8 +$ Answer for I used in (b) $= 2.4A$

OR/ $\frac{V_T}{R_T} = I_T = A_2$.

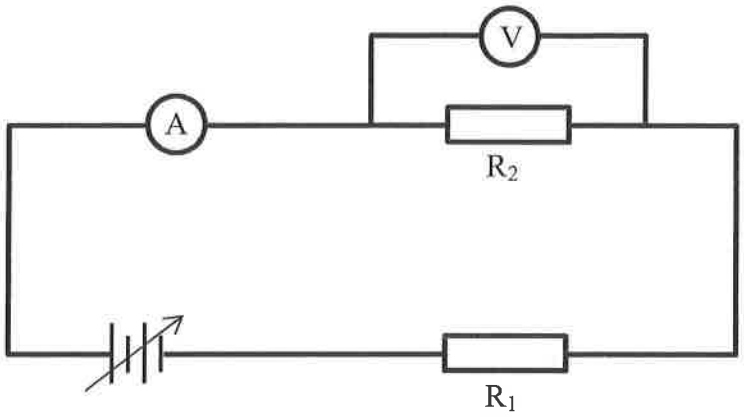
← use values from (a) and question to calculate R_T correctly

Class

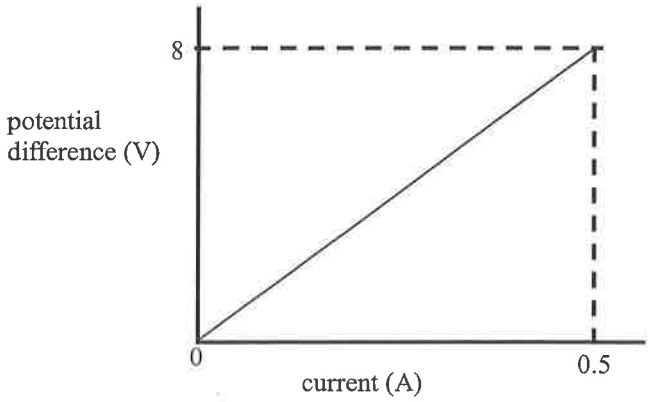
Name

Question 20 (3 marks) **Marks**

The following circuit was set up with two resistors, R_1 and R_2,and a battery.



The following graph shows how the potential difference across resistor, R_2, varies as the current through resistor, R_2, is changed.



(a) Calculate the value of the resistance of resistor, R_2.

$R = V/I = 8/0.5$ ✓1mk for substitution into correct formula.

$= 16\,\Omega$ 1

Question 20 continued on next page

Question 20 continued. **Marks**

(b) When the potential difference of the battery is 8.0 V, it supplies a current of 0.40 A to the circuit.

Calculate the value of the unknown resistor, R_1.

$R_T = 8/0.4 = 20\,\Omega$ ✓ ①mk if calculated total resistance only **2**

$R_T = R_1 + R_2$

$20 = Ans(a) + R_2$ ✓ ①mk $R_2 = 20 - Ans(a)$

$R_2 = 4\,\Omega$

OR/ $8 = (16 + R_1) \times 0.40$ ✓✓ 2mks

OR/ calculate V across R_1 ✓ ①mk.

$V = 0.4 \times Ans(a)$. ✓①mk.

Question 21 (2 marks) $V_{R_1} = 8 - 6.4$ then $V_{R_1} = R \times 0.4$.

A 100 kg man stands on a set of bathroom scales in a lift and notices that the scales read 153 kg.

Determine the acceleration of the lift.

$\Sigma F = ma$. ✓①mk **2**

$153 \times 9.8 - 100 \times 9.8 = 100a$

$a = 5.2\ ms^{-2}$ ✓①mk

OR/ $153 \times 9.8 = 100a$ $a = 14.99 ms^{-2}$ weight not included ✓x 1mk

OR/ $153 - 100 \times 9.8 = 100a$ R not converted to newtons ✓x 1mk

OR/ $153 \times 9.8 - 100 \times 9.8 = 153a$ ✓1mk

OR/ $153 \times 9.8 = 100a$ ✓x 1mk.

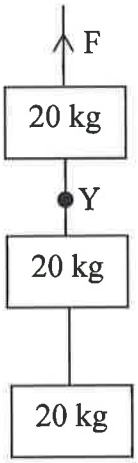
Class

SRW

Name

Question 22 (4 marks) **Marks**

Three 20 kg masses are pulled **upwards** with a constant force F such that the tension force in the rope at point Y is 500 N.



Many boys left out gravity
Maximum marks = 2/4

(a) Determine the magnitude of the acceleration of the masses. **2**

$500 - 40g = 40a$ (1)

$a = 2.7\ m/s^2$ (1)

(b) Determine the magnitude of the constant force, F. **2**

$F - 60g = 60a$ (1)

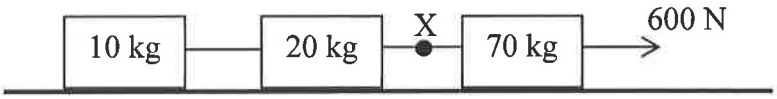
$F = 60(a+g)$

$= 750\ N$ (1)

Many boys got 750 N even though they ignored gravity. They only got a maximum of 2/4 marks

Question 23 (4 marks) **Marks**

Three masses 10 kg, 20 kg and 70 kg are connected by massless and unstretchable strings and pulled along a frictionless, horizontal surface by a constant horizontal force of 600 N as shown below.



(a) Calculate the magnitude of the acceleration of the masses.

$a = \frac{600}{100} = 6\ m/s^2$ (1) **1**

(b) Calculate the tension force in the string at X.

$T = 30a = 180\ N$ (1) **1**

(c) The same arrangement of three masses is now placed on a rough surface. If the frictional force which now acts on each mass is equal to 0.2 times the weight of each mass, determine the magnitude of the new acceleration of the system when the constant horizontal force of 600 N is applied.

$600 - 0.2 \times 100 \times g = 100a$ (1) **2**

$a = 4.04\ m/s^2$ (1)

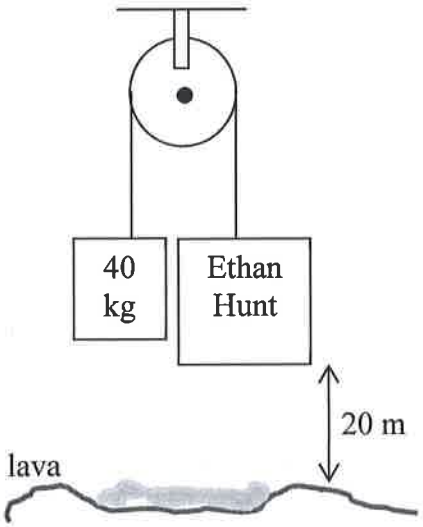
Many boys forgot "g" I took off 1 mark

Class

Name

Question 24 (6 marks) **Marks**

In "*Mission Impossible Twelve*", Ethan Hunt of mass 80 kg finds himself attached to a 40 kg mass via a pulley above a pool of lava as shown below.



(a) Assuming the system is released from rest, what time would elapse before Ethan reaches the surface of the lava? **2**

$a = \frac{40g}{120} = 3.26\dot{} \text{ m/s}^2$ down (1)

$s = \frac{1}{2}at^2 \quad \therefore t = \sqrt{\frac{2\times 20}{3.26\dot{}}} = 3.5$ sec (1)

(allowed carry through error)

(b) Ethan starts to climb up the rope with an acceleration of 1.0 m s^{-2} **relative to the lava**.

(i) Determine the tension in the rope while Ethan is climbing. **2**

$T - 80g = 80a$ (1)

$T = 80(g+1) = 864 \text{ N}$ (1)

Question 24 continued on next page.

Question 24 continued. **Marks**

(ii) Determine the magnitude of the acceleration of the 40 kg mass while Ethan climbs the rope. **2**

$T - 40g = 40a$ (1)

$\therefore a = \frac{864 - 40g}{40} = 11.8 m/s^2$ (1)

← From part (i)

$a = \frac{T - 40g}{40}$

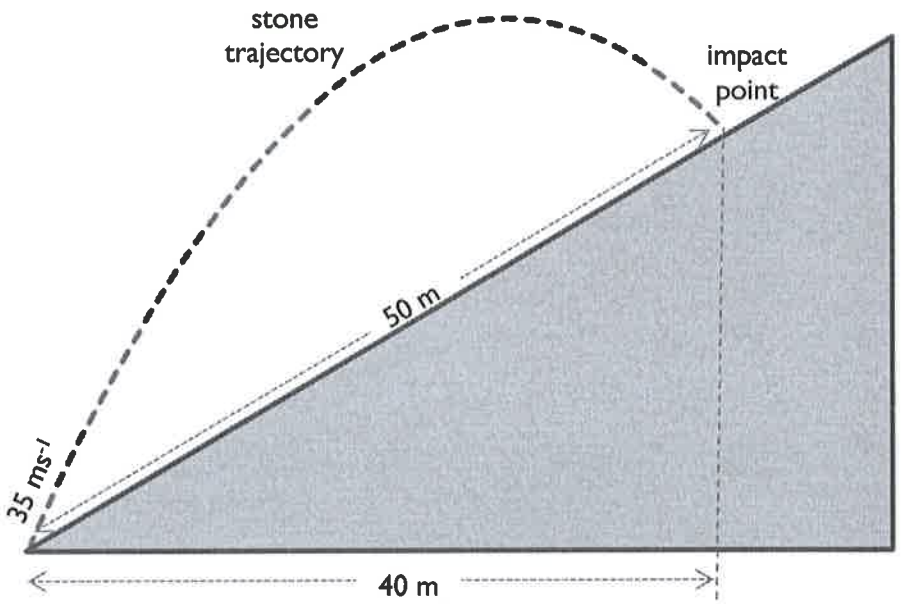
Carry through error allowed.

Class

Name

Question 25 (4 marks) **Marks**

A stone of mass 0.25 kg is thrown into the air with an initial speed of 35 m s^{-1} and it lands 50 m up a slope as shown in the following diagram.



(a) Determine the initial kinetic energy of the stone.

$\frac{1}{2}mv^2 = \frac{1}{2} \times 0.25 \times 35^2 = 153.125$ J. (1) **1**

(b) Determine the speed of the stone when it hits the slope.

Final Energy = GPE + KE **3**

153.125 = 73.5 + KE (1)

$\therefore$ KE = 79.625

$\therefore \frac{1}{2}mv^2 = 79.625$ (1)

$\therefore v = \sqrt{637} = 25.2$ m/s (1)

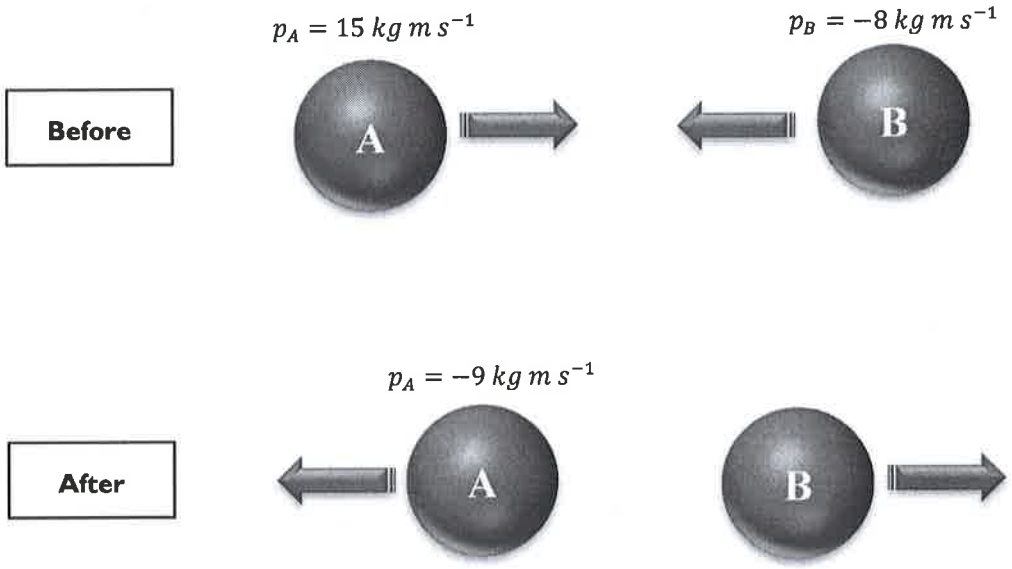
Many boys used a weird method where they assumed the initial vertical velocity was 35 m/s. I only gave (2) marks for this wrong physics

CRIB
Class

PCK
Name

Question 26 (6 marks) **Marks**

Two balls, A and B (with momenta p_A and p_B), collide ***elastically*** as follows:



During the collision, ball A of mass 3 kg loses 24 joules of kinetic energy.

(a) Calculate the magnitude of the final momentum p_B of ball B after the collision. **1**

$\Sigma p_i = 17 - 8 = 7\ kgm/s$

$\Sigma p_f = -9 + p_B = 7 \quad p_B = 16\ kgm/s$

(b) Calculate the magnitude of the impulse that ball A applies to ball B during the collision. **1**

$I = \Delta p_B = p_B(final) - p_B(initial) = 16 - (-8)$

Impulse is the change in momentum $= 24\ Ns$

The Impulse on ball B is the change of momentum of ball B.

Question 26 continued on next page.

Question 26 continued. **Marks**

(c) Determine the initial velocity of ball A.

given $m_A = 3kg$ $p_{A(initial)} = m_A u_A = 15$, $u_A = \frac{15}{3}$ **1**

$u_A = 5 m/s$

(positive, or to the right direction)

(d) Determine the mass of ball B.

For an elastic collision $\Sigma KE_i = \Sigma KE_f$ **3**

Similar to c) final velocity of ball A can be found $v_A = \frac{p_{A(final)}}{3} = -3 m/s$.

Since m_B is unknown, but momenta are $u_B = \frac{-8}{m_B}$, $v_B = \frac{16}{m_B}$

Kinetic Energy can also be written $KE_B = \frac{1}{2}\left(\frac{p_B}{m_B}\right)^2 m_B = \frac{1}{2m_B} p_B^2$

Method 1. use ΣKE with v_A

No. (A) Before (B) (A) After (B)

$\frac{1}{2}$ $3(5)^2 + \frac{1}{m_B}(-8)^2 = 3(-3)^2 + \frac{1}{m_B}(16)^2$

$75 + \frac{64}{m_B} = 27 + \frac{256}{m_B}$

$\frac{1}{m_B}(256 - 64) = 75 - 27$

$m_B = \frac{192}{48}$

$m_B = 4kg$

Method 3 Relative velocities.

In elastic collision

$v_B - v_A = u_A - u_B$

$\frac{16}{m_B} - (-3) = 5 - \left(\frac{-8}{m_B}\right)$

$\frac{8}{m_B} = 2$

$m_B = 4kg$

Method 2 use $\Delta KE = 24J$

$\frac{1}{2}3(5)^2 + \frac{1}{2m_B}(-8)^2 = \left[\frac{1}{2}3(5)^2 - 25\right] + \frac{1}{2m_B}(16)^2$

$37.5 + \frac{32}{m_B} = 13.5 + \frac{128}{m_B}$

$\frac{1}{m_B}(128 - 32) = 24$

$m_B = \frac{96}{24} = 4kg$

Method 4. Centre of mass

$v_{cm} = \frac{\Sigma p}{\Sigma m} = \frac{7}{3 + m_B}$

$v_A = 2(v_{cm}) - u_A$

$-3 = \frac{14}{3 + m_B} - 5$

$\frac{14}{3 + m_B} = 2$, $m_B + 3 = 14(\frac{1}{2}) = 7$

$m_B = 7 - 3 = 4kg$

ALL SOLUTIONS		A	B
Before	momentum	15	-8
	velocity	5	-2
	KE	37.5	8
After	momentum	-9	16
	velocity	-3	4
	KE	13.5	32
	ΔKE	-24	+24

Only 15% of form could solve

Marking

(1) Uses relations between mass, momentum and velocity. $\Sigma KE_i = \Sigma KE_f$ solvable equation

(1) Valid method

(1) Correct answer

Class

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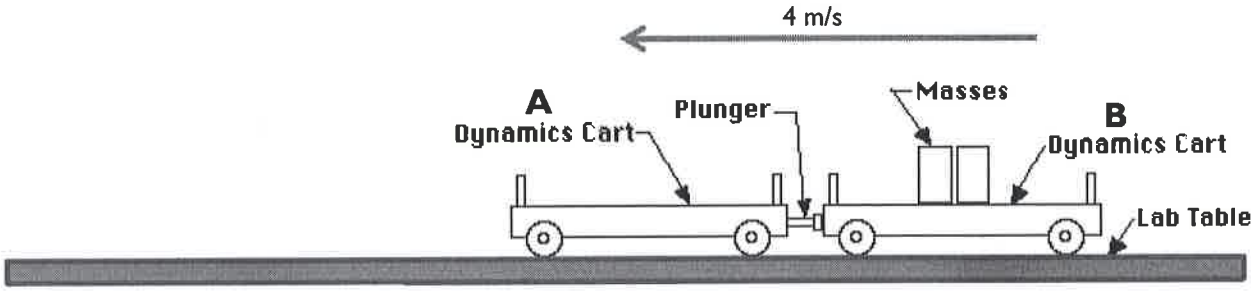
Question 27 (5 marks) **Marks**

Two dynamics trolleys, A and B, are joined together and moving to the left at 4 m s^{-1}. The spring loaded plunger is set off pushing the trolleys apart. Trolley A increases in speed while trolley B becomes stationary.



The dynamics trolleys are 3 kg each and the two added masses to trolley B are 1 kg each.

(a) Calculate the magnitude of the total momentum of trolley A and B before the plunger is set off. **1**

$\Sigma p_i = m_A u_A + m_B u_B = u(m_A + m_B) = -4(3+5)$

$= -32$ kg m/s

32 kg m/s

(b) Determine the speed of trolley A after the plunger is set off. **1**

$v_B = 0$, $\Sigma p_f = m_A v_A = 32$

$v_A = \frac{32}{3} = 10.7$ m/s

(3 sig fig) (11 m/s to 2 sig fig)

(c) Show numerically whether the total kinetic energy increases, decreases or remains the same. Account for why this occurs. **3**

$\Sigma KE_i = \frac{1}{2} 8(4)^2 = 64$ J || $\Sigma KE_f = \frac{1}{2}(3)(10.67)^2 = 171$ J

① mark for KE_i, KE_f both correct

total KE increase. ① must state & explicitly

total KE increases because there is stored potential energy in the spring that does work when released.

① Identifies that additional energy is coming from the spring

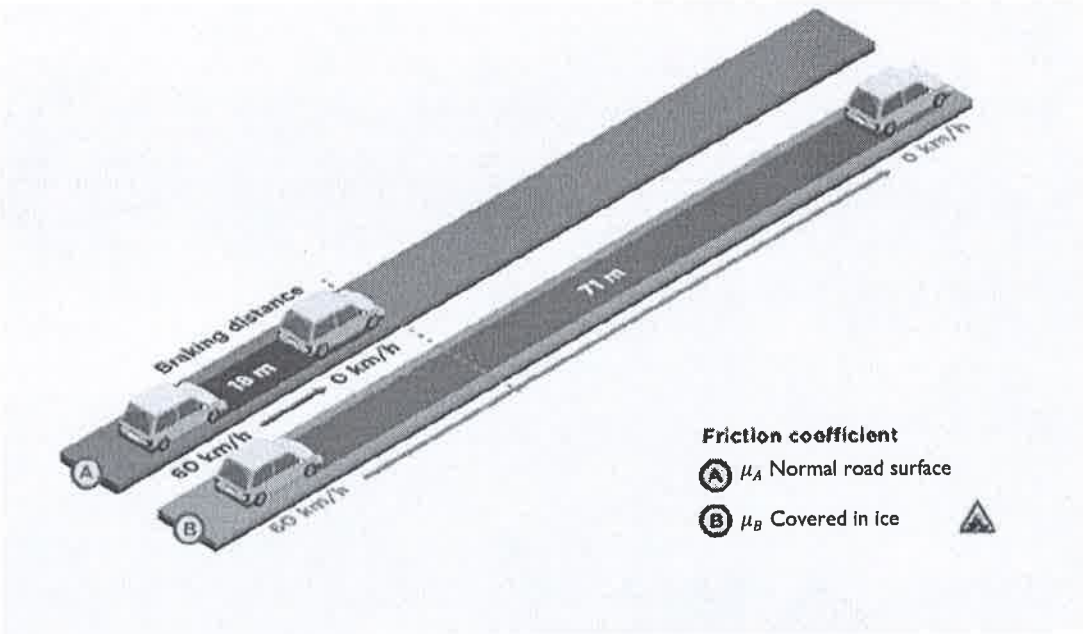
Question 28 (5 marks) **Marks**

The maximum braking force of a car is limited by the frictional force between the tyres and the road. The maximum frictional force, F, can be determined by the equation $F = \mu mg$ where μ is the coefficient of friction between the tyre and the road and mg is the weight of the car.

A car's braking distance is tested on two different road surfaces, A and B, both from an initial speed of 60 kmh^{-1} (16.67 ms^{-1}).

The braking distance on surface A was 18 m.

The braking distance on surface B was 71 m.



(a) Determine the coefficient of friction for the normal road surface A. **2**

Method 1. Energy

$F d_A = (\mu_A mg) d_A = \frac{1}{2} m u^2$, $\mu_A = \frac{u^2}{2g d_A} = \frac{(16.67)^2}{2 \times 9.8 \times 18}$

① equates energy

Method 2. Forces

Find $a = \frac{v^2 - u^2}{2s} = \frac{-u^2}{2s}$ $(-2.72 m/s^2)$, $F = ma = \mu_A mg$, $\mu_A = \frac{a}{g} = \frac{u^2}{2g d_A}$

OR [① acceleration. or ① equates forces.]

coefficient of friction.

$\mu_A = 0.79$ or 0.8

(Units not needed) and ① mark - correct co-efficient

Question 28 continued on next page.

Class

Name

Question 28 continued. **Marks**

(b) Determine the maximum initial speed that should be travelled on road surface B to have the same stopping distance as surface A.

Method 1.

Find μ_B on ice.

$\mu_B = \frac{(16.67)^2}{2 \times 9.8 \times 71}$ $\mu = 0.2$ coefficient of friction on ice road. (1) finds μ_B 3

now use $d = 18m$ (1) $u^2 = 2gd\mu_B$

$u = \sqrt{2 \times 9.8 \times 18 \times 0.2} = 8.4 m/s$ (2 sig fig) or ($\sim 30 km/h$). (1)

Method 2

deceleration

Find max deceleration on ice. $a = \frac{-u^2}{2s_B} = -\frac{(16.67)^2}{2 \times 71} = -1.956 m/s^2$. (1)

Find initial speed at this deceleration to stop in 18m. use 18m (1)

$u = \sqrt{v^2 - 2as_A} = \sqrt{-2as}$

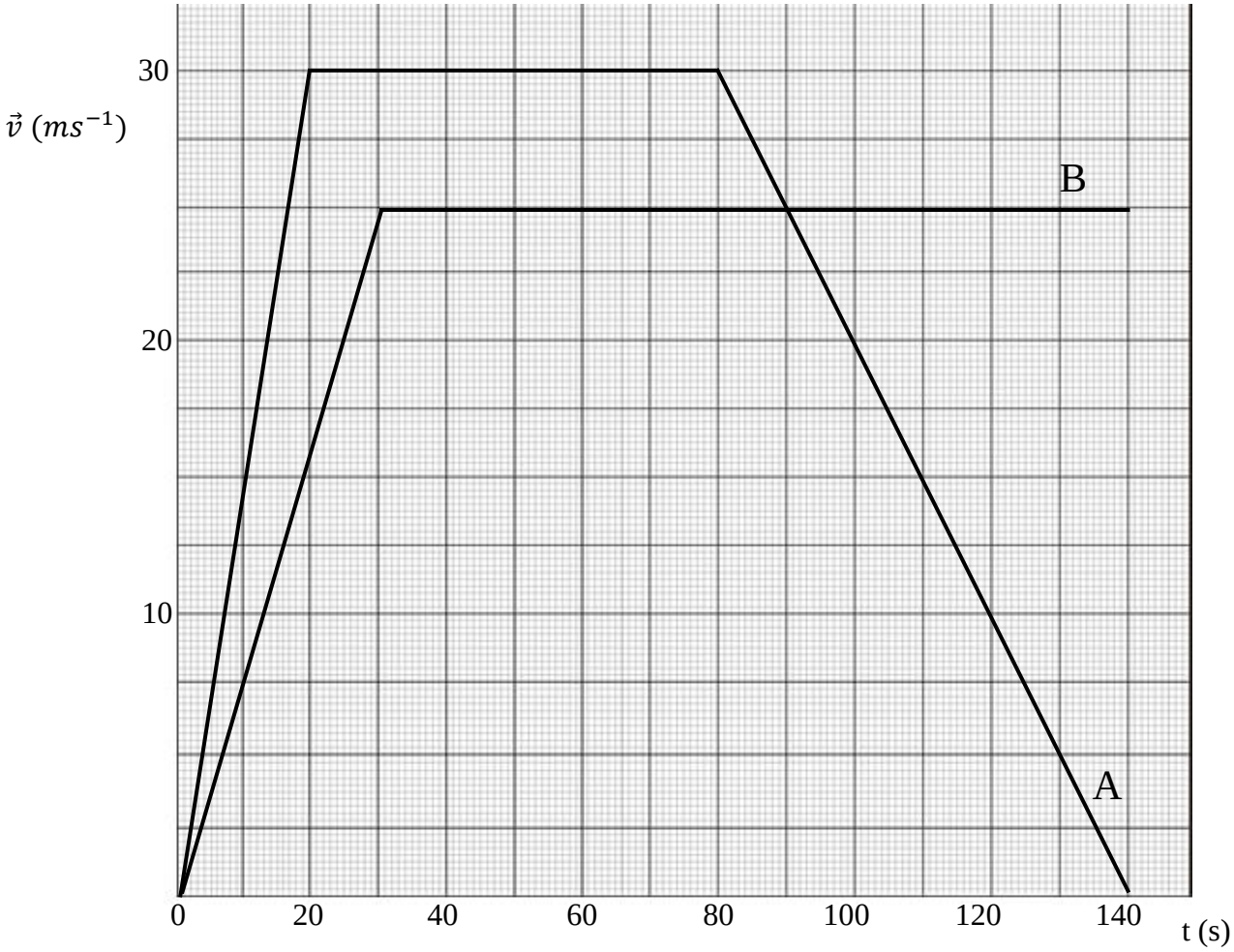
$= \sqrt{-2\left(\frac{-u^2}{2 \times 71}\right) \times 18}$

$= \sqrt{(16.67)^2 \times \frac{18}{71}} = 8.4 m/s.$ (1) correct answer

AAH - CRIB

Question 29 (6 marks) **Marks**

The velocity versus time graphs below show two underground trains, A and B, travelling from the same station on parallel, straight tracks. At time t = 0 s, both trains are alongside each other at rest.



Question 29 continued on next page.

Question 29 continued. **Marks**

Using the graphs, or otherwise, determine:

(a) the maximum speed of train B.

From the Graph: = **25 ms^{-1}** **(1 mk)**

(b) the magnitude of the acceleration of train A between 80 and 140 s.

= Gradient of Graph A from 80 – 140 s (1 mk for valid substituion)

= 30/60 = **0.5 ms^{-2}** **(2 mks)**

(c) the time at which train A and train B are alongside each other again.

Start from t = 80s: at this time **r_A= 2100 m** and **r_B =1625 m**
so B is 475 m behind A. - (1 mk)

$r_B = 25.t$ $r_A = 30.t - t^2/4$

they meet when $r_B = r_A + 475$

i.e. when $25t = 30t - t^2/4 + 475$ - (2 mks)

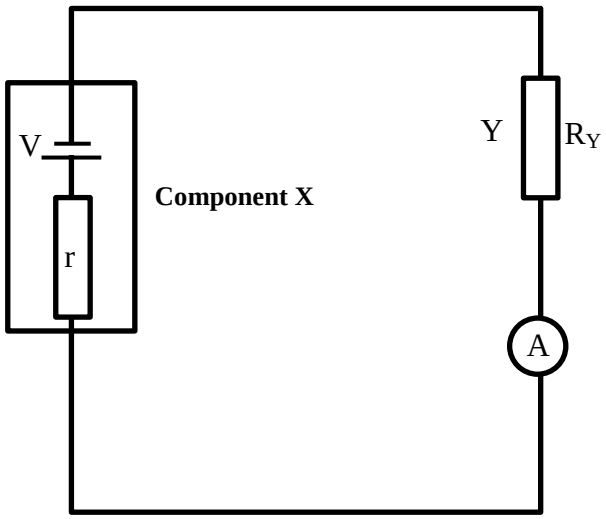
solution: t = 54.7 s **- (3 mks)**

so, **t_{TOTAL} = 134.7 s.**

NB: (1 mk) for any valid measurement of distance at any *stated* time

Question 30 (4 marks) **Marks**

A physics student sets up the following circuit in an attempt to determine the electrical characteristics of component X.



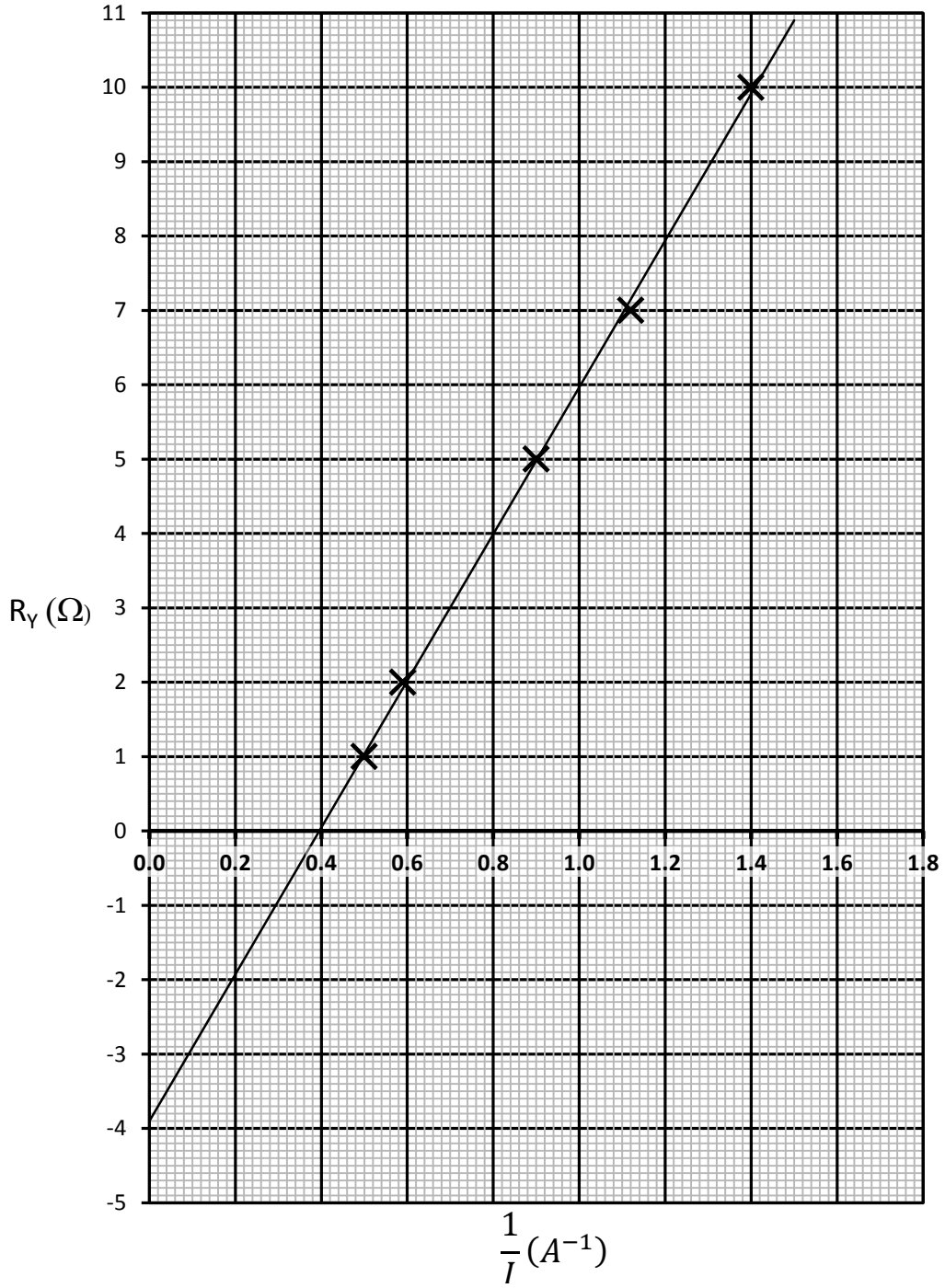
Component X consists of a battery of potential difference, V and a resistor, r, in series.

Various resistors, R_Y, are placed in the circuit at Y and the current flowing through the ammeter is recorded each time.

Question 30 continued on next page.

Question 30 continued. **Marks**

The following graph is a plot of R_Y (on the y-axis) versus $\frac{1}{I}$ using the experimental results obtained.



Question 30 continued on next page.

Question 30 continued. **Marks**

(a) Use the graph to find the value of the resistor, r, within component X.

NB circuit analysis gives:

$V = I (R_Y = r)$ so $\mathbf{R_Y = V/I - r}$

r is the negative intercept of the graph (1 mk)

= **3.9 Ω** (accept 4 Ω) **(2 mks)**

(b) Use the graph to find the value of the potential difference, V, of the battery within component X.

From above, V = Gradient of graph

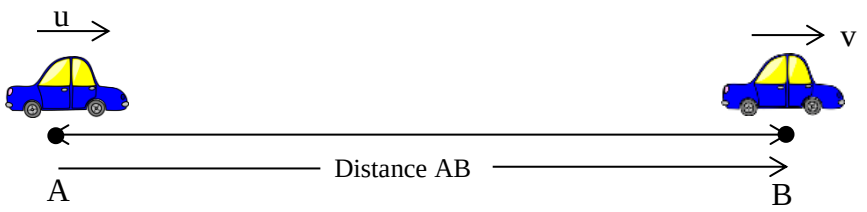
= (10 - 0)/(1.4 - 0.4) (1 mk)

= **10 V** **(2 mks)**

NB: carry through marks awarded only if the method was clear (e.g. if it was obvious where the numerical values used came from).

Question 31 (10 marks) **Marks**

In an engine test, a car accelerates uniformly between two points (from the same starting velocity) on a straight road, and its final velocity is recorded.



The data obtained is included in the table on the following page.

Distance AB (m)	Final Velocity, *v* (ms^{-1})			Average *v* (ms^{-1})*	*Average* v^2 (m^2s^{-2})*
	1	2	3		
50	20.6	21.4	21.2	21.1	445
100	27.2	27.2	27.0	27.1	734
150	32.7	33.4	32.8	33.0	1090
200	37.3	37.5	37.1	37.3	1390
250	40.4	40.9	40.8	**40.7**	**1660***
300	44.2	44.6	44.8	44.5	1980

(* to 3 significant figures, with v^2 based on v to 3 significant figures)

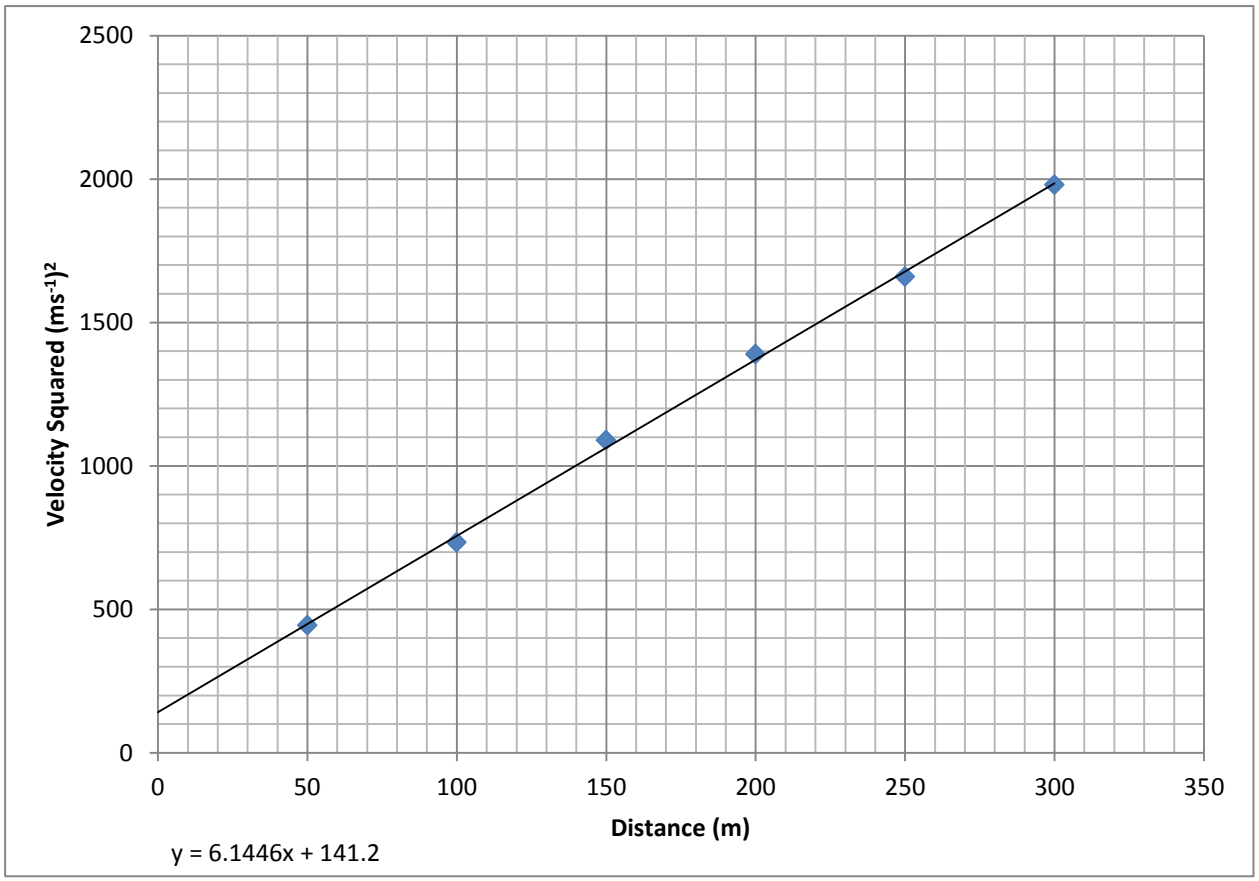
*** sig figs not penalised here!**

(a) Complete the table above by adding in the missing values.

2

Question 31 continued on next page.

(b) Plot a graph of velocity squared (on the y-axis) against distance.



- Points Correctly Plotted
- Axes Labelled
- Correct Units
- Appropriate Scale
- Line of Best Fit (which does NOT go through origin)
- Clarity

Minus 1 mk for any of the above missing

Question 31 continued on next page.

(c) Using your graph, or otherwise, determine:

(i) the initial velocity of the car.

Intercept of the graph = $u^2 = 140$

So **$u = 11.8\ ms^{-1}$**

(accepted 11.0 – 13.5 for **2 mks**, with a wider range for 1 mk)

(ii) the acceleration of the car.

$v^2 = u^2 = 2ar$, so gradient of graph = 2a

so, 2a = 6.1

$a = 3\ ms^{-2}$

(I accepted 2.7 – 3.3 for **2 mks** – but was much more generous if the mark had already been lost in part (i))

NB: carry through mark awarded for part (ii) where possible, as long as the method was clear