SYDNEY GRAMMAR SCHOOL

2015

FORM V
EXAMINATION

Physics

1:00 pm Monday 18 MAY

Working Time: 2 hours

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 (98)

This paper has two parts: Part A and Part B

Part A
Total marks **(14)**
- Attempt ALL Questions
- Allow about 15 minutes for this Part

Part B
Total marks **(84)**
- 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 – SRW	2 – MTK	3 – PCK
4 – AAH	5 – MRW	6 – DGB

EXAMINERS: MRW/AAH/PCK/SRW/MTK

1 A white billiard ball collides with a stationary red billiard ball of the same mass. The white ball stops straight away after the collision and the red ball moves off with exactly the same velocity that the white ball initially had.

Which of the following statements about the collision between these two balls is most correct?

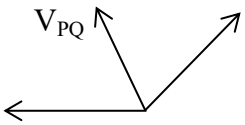
(A) The collision is elastic as both momentum and kinetic energy are conserved.
(B) As neither momentum nor kinetic energy are conserved, the collision is inelastic.
(C) Momentum is the only quantity that can ever be conserved in the collision.
(D) Due to loss of kinetic energy the collision is inelastic.

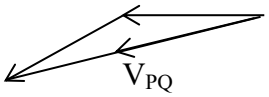
2 Air bags reduce the injury to passengers in car accidents by:

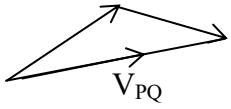
(A) Decreasing the time it takes the passengers to stop
(B) Decreasing the passengers' stopping distance
(C) Increasing the passengers' rate of change of momentum
(D) Increasing the passengers' stopping time

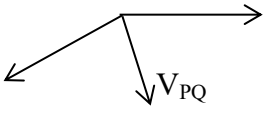
3 The vector diagram below represents the velocities of two cars P and Q.

Which of the following vector diagrams best represents the velocity of car P relative to car Q (V_{PQ})?

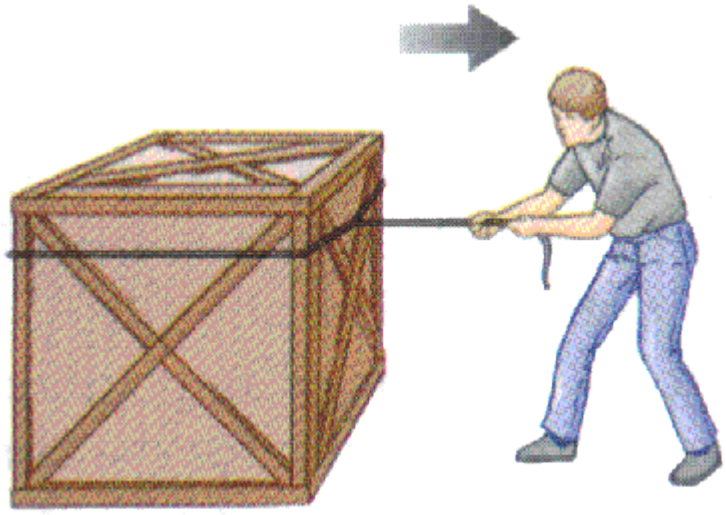
(A)


(B)


(C)


(D)


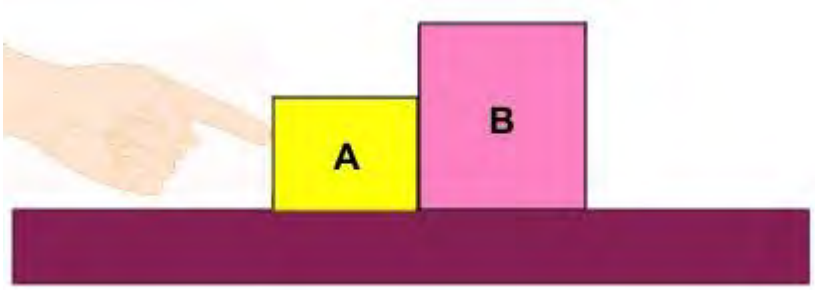
4 A 100 kg block is pulled by a man with a force of 800 N.



If the acceleration of the block is 5 ms^{-2} then the magnitude of the force of friction acting is:

(A) 0 N
(B) 100 N
(C) 300 N
(D) 800 N

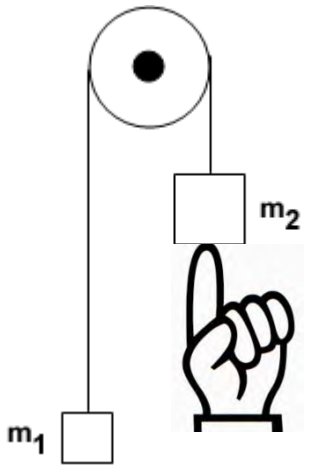
5 Two blocks, A of mass 2 kg and B of mass 3 kg, are pushed horizontally across a table with a force of 20 N pushing on A.



If no friction is acting, then the force of A on B is

(A) 5 N
(B) 8 N
(C) 10 N
(D) 12 N

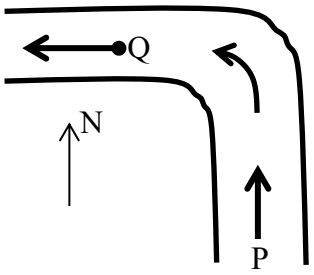
6 Two masses, m_1 of mass 4 kg and m_2 of mass 10 kg, are connected by a massless string over a fixed massless pulley as shown below.



A pupil holds m_2 so that it does not move. The magnitude of the force provided by the pupil is

(A) 4 kg
(B) 39.2 N
(C) 58.8 N
(D) 98 N

7 A car travels around a right-angle bend in the road at a constant speed of 9 ms^{-1} shown in the following diagram.



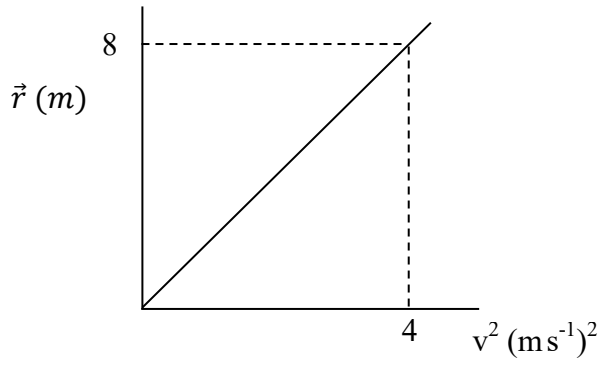
What is the total change in velocity of the car which occurs between position P and position Q?

(A) 0 ms^{-1}
(B) 9 ms^{-1} west
(C) 13 ms^{-1} south west
(D) 13 ms^{-1} north east

8 An object with a mass of 5.0 kg is moving to the left with a speed of 7.0 ms^{-1}. The momentum of the object is:

(A) 35 $kgms^{-1}$
(B) -35 Ns^{-1}
(C) 35 $kgms^{-1}$ right
(D) 35 Ns left

9 The following graph shows how the displacement of an object initially at rest varies with its velocity squared.



What is the magnitude of the acceleration of the object (in ms^{-2})?

(A) 0.25
(B) 0.5
(C) 1.0
(D) 2.0

10 A 50 g ball hits the ground at 5 ms^{-1} and rebounds at 4 ms^{-1}. Which of the following statements is true?

(A) The impulse of the ball on the ground is 450 Ns downwards
(B) The impulse of the ground on the ball is 0.45 Ns upwards
(C) The change in velocity of the ball is 9 ms^{-1} downwards
(D) The change in velocity of the ball is 1 ms^{-1} upwards

11 A vehicle with a mass (m) begins moving from rest with a constant net force (F) acting on it for a time (t). After this time it is travelling with a speed (v), which expression will give the time (t)?

(A) $\frac{mv}{F}$

(B) $\frac{mF}{v}$

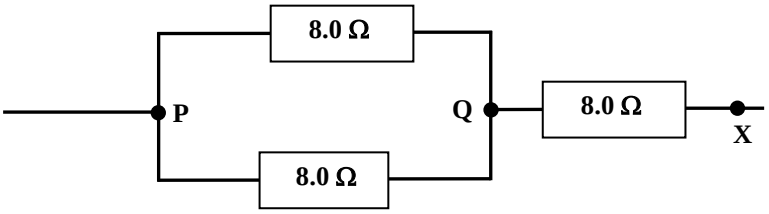
(C) $\frac{F}{mv}$

(D) $\frac{F}{\frac{1}{2}mv^2}$

12 A resistor of 6.0 Ω has a potential difference of 12.0 V across it.
How many Coulombs of charge flow through the resistor in 10.0 seconds?

(A) 0.20
(B) 2.0
(C) 20
(D) 720

13 This question refers to the following combination of resistors.
The potential difference between points Q and X is 16.0 volts.

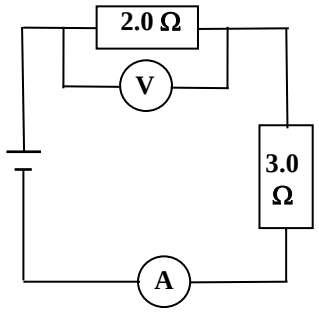


What is the potential difference between points P and Q?

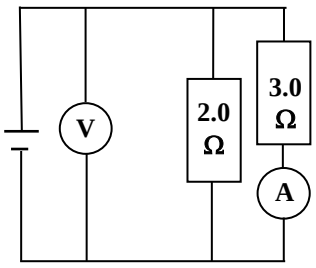
(A) 4.0 volts.
(B) 8.0 volts.
(C) 16.0 volts.
(D) 24.0 volts.

14 In which of the following circuits does the ammeter read the greatest current? The voltage from the power supply is the same in each circuit.

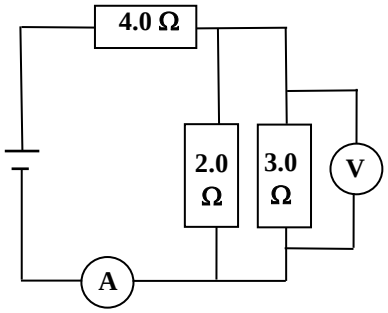
(A)



(B)



(C)



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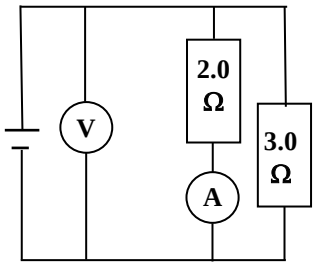

Class

Name

Part B

Total marks (84)
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 15 (5 marks) **Marks**

A car travelling East along a straight road at a constant velocity is then accelerated uniformly at 4 ms^{-2} East over a distance of 18 m. At the end of the 18 m, the car's velocity was found to be 20 ms^{-1} East.

(a) Calculate the velocity of the car before it started to accelerate.

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(b) Calculate the time that the car was accelerating.

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(c) If, at the end of 18 m, brakes are then applied and the car comes to a stop in 3 seconds. Determine the distance the car travels while it is braking.

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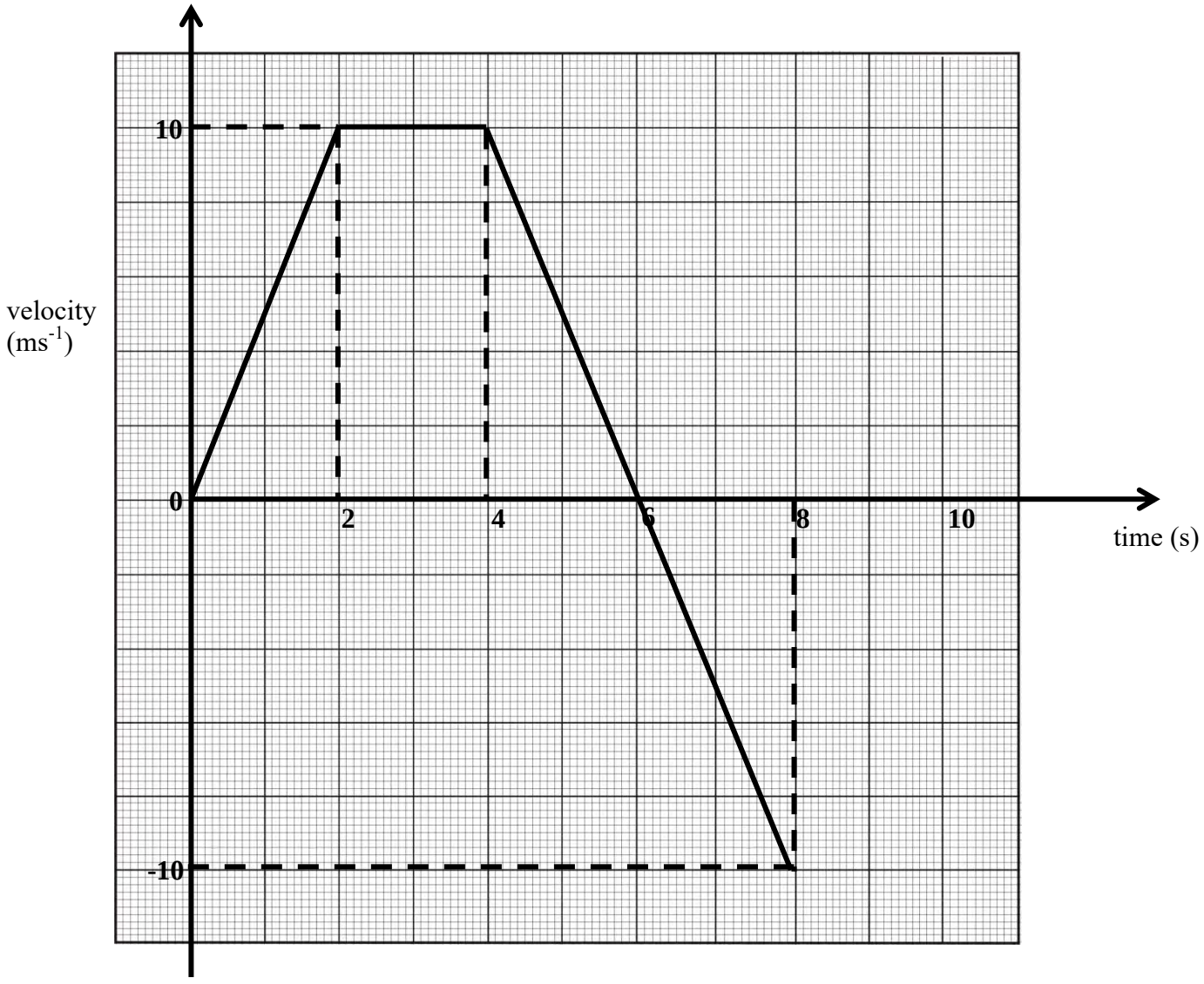
Question 16 (12 marks) **Marks**

A car of mass 2500 kg travels along a straight road as described by the following graph.



Question 16 continued on next page.

Class

Name

Question 16 continued. **Marks**

(a) Describe qualitatively (in words) the motion of the car for the 8 seconds.

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(b) Calculate the magnitude of the velocity of the car at 3 seconds.

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(c) Calculate the magnitude of the net force acting on the car at 5 seconds.

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(d) Calculate the distance travelled by the car in 8 seconds.

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(e) Calculate the magnitude of the displacement of the car for the 8 seconds.

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Question 16 continued on next page.

Question 16 continued. **Marks**

(f) Determine the magnitude of the average velocity of the car for the 8 seconds.

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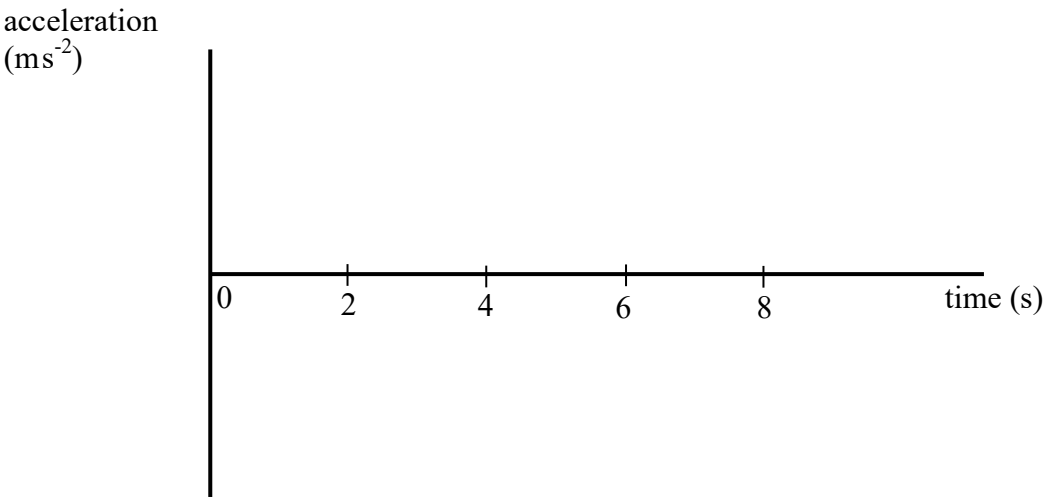
(g) Sketch an acceleration versus time graph on the axes shown below of the car for the 8 seconds.

(Include numerical values).



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Class

Name

Question 17 (4 marks) **Marks**

A car is driven East for a distance of 50 km, then North for 30 km, and then East for 40 km.

(a) Find the total distance travelled by the car.

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(b) Using a diagram, find the magnitude and direction of the displacement of the car.

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Class

Name

Question 18 (2 marks) **Marks**

A rocket of mass 10,000 kg is launched from Earth.

If the thrust provided by the rocket engines is 200,000 N, determine the magnitude of the acceleration of the rocket.

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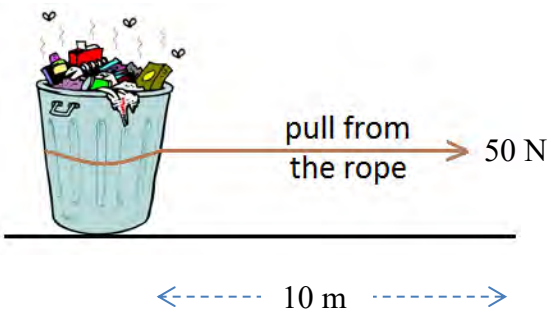
Question 19 (3 marks) **Marks**

A trash bin is too dirty to be carried outside. A rope is used to pull it out of the house. The pulling force acting on the bin has a magnitude of 50 N and is applied horizontally over 10 m.



The bin is originally at rest and is measured to have a speed of 8.5 ms^{-1} when the 10 m mark is reached. The floor creates an average friction force of 30 N.

(a) Calculate the net work done on the bin over the 10 m displacement.

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(b) Determine the mass of the bin.

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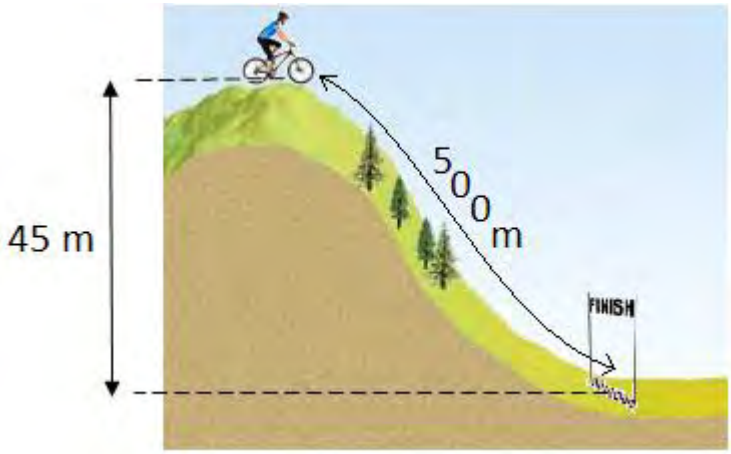
Class

Name

Question 20 (5 marks) **Marks**

A mountain biker is standing still at the top a hill. He wants to know how fast he will be going when he crosses the finish line at the bottom of the hill WITHOUT pedalling.

The track he wants to follow reaches the foot of the hill in 500 m, with a vertical drop of 45 m. The total mass of the biker and his bike is 90 kg.



NOT TO SCALE

(a) Considering that the track is ideal and does not create friction, calculate the speed of the biker as he crosses the finish line.

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(b) More realistically, the dirt track creates an average frictional force of 60 N on the bike's wheels.

Calculate the real speed of the biker as he crosses the finish line.

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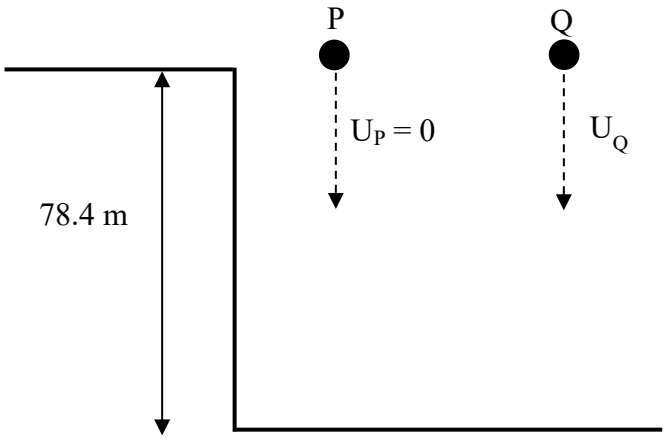
Question 21 (3 marks) **Marks**

Ball P is dropped from a height of 78.4 m. One second later, another Ball Q is thrown vertically down from the same height.



Calculate the speed Ball Q would need to be thrown so that ball's P and Q both reach the ground at the same instant.

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Class

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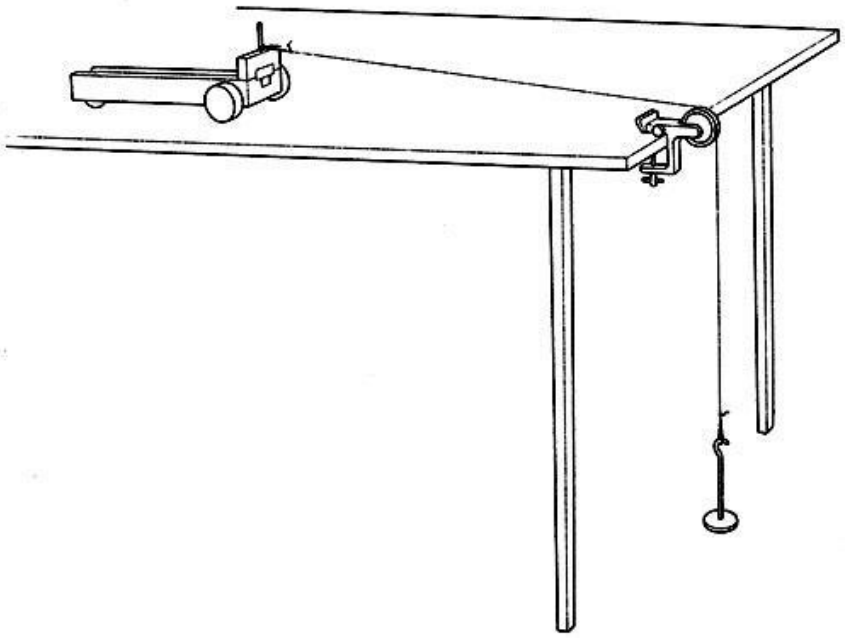
Question 22 (5 marks) **Marks**

An experiment is done to determine the acceleration of a trolley accelerated by suspended mass-carrier.



The trolley is released from rest and the time taken to travel 0.4 m is recorded on a stopwatch as taking 0.76 s. The total mass of the mass-carrier is 50 g.

(a) Determine the magnitude of acceleration of the trolley.

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(b) If there is no friction acting, determine the mass of the trolley.

..... **2**

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Question 22 continued on next page.

Question 22 continued. **Marks**

(c) Determine the magnitude of the tension in the string.

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Class

Name

Question 23 (6 marks) **Marks**

A business man is carrying his 2 kg briefcase in an elevator accelerating upwards at 3 ms^{-2}.

(a) What is the magnitude of the net force acting on the briefcase?

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(b) Determine the magnitude of the force that the man applies to the briefcase.

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(c) The man is standing with his briefcase on weighing scales inside the elevator and the scales read 1152 N.

Determine the mass of the man.

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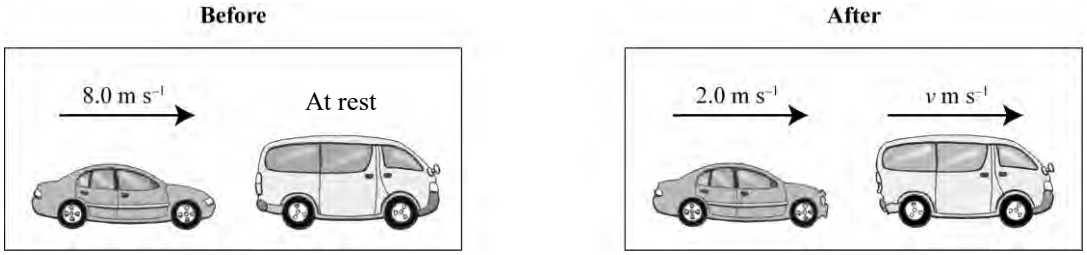
Question 24 (7 marks) **Marks**

Alfred is driving his car (850 kg) home when he collides with a stationary van (1500 kg). The car is travelling at 8.0 ms^{-1} before the collision and at 2.0 ms^{-1} immediately after the collision, as shown in the diagram.



Assume there are no outside horizontal forces acting during the collision.

(a) Determine the magnitude of the car's momentum before the collision.

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(b) Calculate the magnitude of the velocity of the van immediately after the collision.

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(c) Calculate the magnitude of the change in momentum of the car during the collision.

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Question 24 continued on next page.

Class

Name

Question 24 continued. **Marks**

(d) If the collision time between the two vehicles is 0.1 second, then;

i) Determine the magnitude of the average force that must have been applied to the car to change its velocity during the collision.

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ii) Explain why the size of the collision force slowing the car is the same size force that pushes the van forward.

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(e) Kinetic energy is lost during this collision. Explain how the law of conservation of energy still applies.

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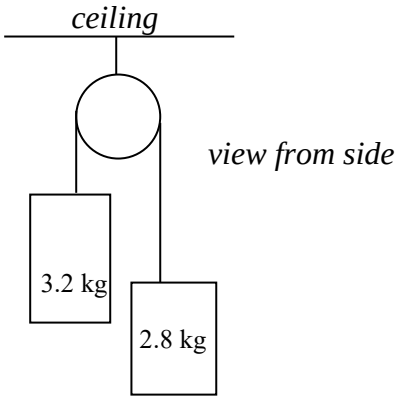
Question 25 (5 marks) **Marks**

In an experiment, two masses are connected by a massless and unstretchable string over a pulley suspended from the ceiling, as shown in the diagram below. There is no friction in the system.



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

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(b) Calculate the magnitude of the tension in the string.

..... **2**

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(c) Determine the magnitude of the net force on the 2.8 kg mass

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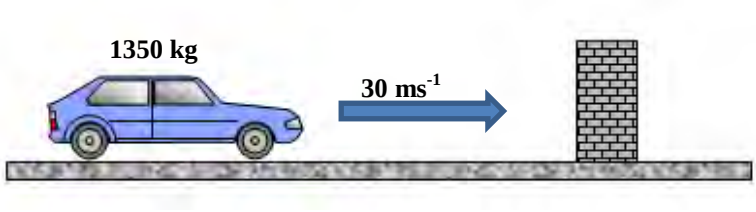
Class

Name

Question 26 (6 marks) **Marks**

A car and its contents have a mass of 1350 kg and travelling at 30 ms^{-1} collides with a wall and comes to a complete stop.



(a) A dog is unrestrained in the back seat and during the collision continues at a constant velocity until hitting the front dashboard.

i) Explain why the dog continues at a constant velocity.

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ii) Explain why the deceleration of the dog would be more damaging than to the driver who is wearing a seatbelt.

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Question 26 continued on next page.

Question 26 continued. **Marks**

(b) The modern family car has become far safer due to the application of better technology like the seatbelt, but nothing can defy the Laws of Physics.

Referring specifically to Newton's Laws of Motion, outline the use of ONE safety device implemented on cars other than the seatbelt.

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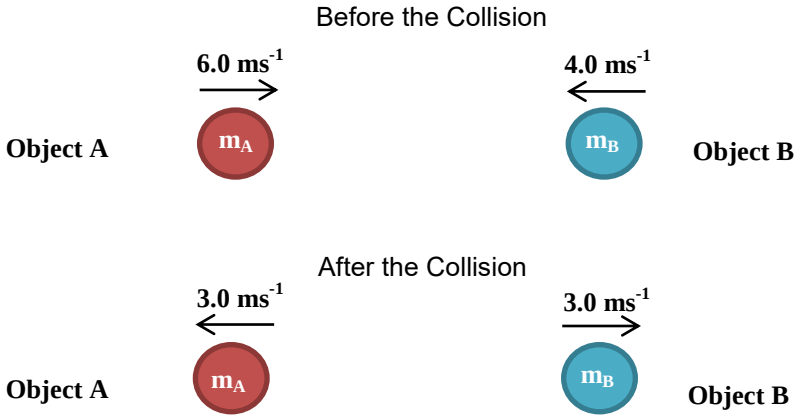
Class

Name

Question 27 (4 marks) **Marks**

An object A of mass m_A travelling at 6.0 ms^{-1} to the right collides *inelastically* with object B of mass m_B travelling left at 4.0 ms^{-1}. After the collision both objects are travelling at the same speed 3.0 ms^{-1} in opposite directions. The total amount of kinetic energy lost in the collision is 100 J.



Determine what the mass of object A (m_A) and the mass of object B (m_B) must be for this collision to occur.

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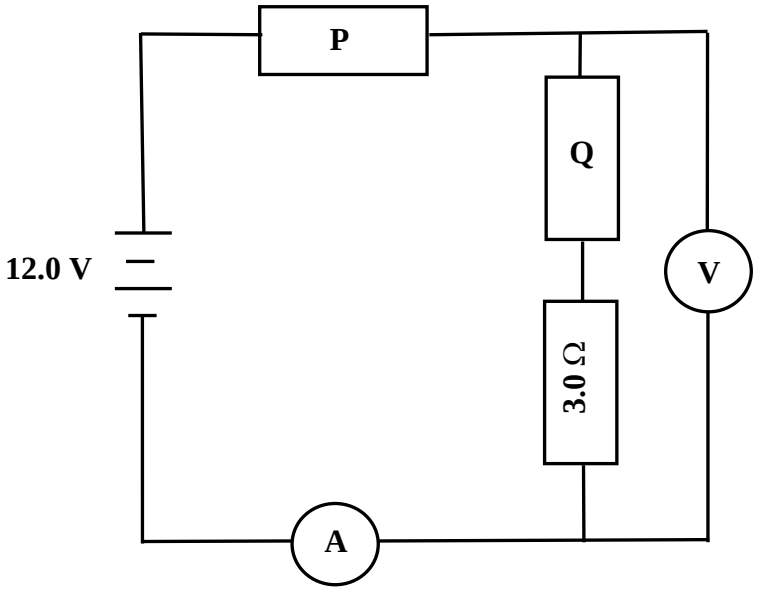
Class

Name

Question 28 (4 marks) **Marks**

Three resistors P, Q and a 3.0 Ω resistor are connected to a 12.0 volt battery.



The reading on the ammeter is 1.5 A. The reading on the voltmeter is 6.75 V.

(a) Determine the resistance of P.

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(b) Determine the resistance of Q.

..... **2**

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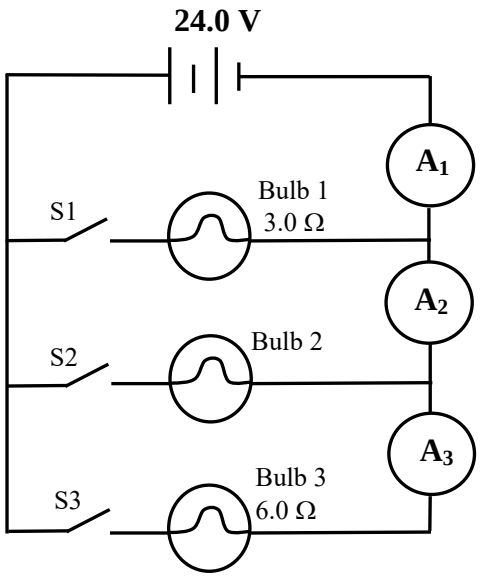
Question 29 (4 marks) **Marks**

This question refers to the following electric circuit consisting of three light bulbs connected to a 24.0 V battery. S1, S2, and S3 are switches.



Bulb 1 has a resistance of 3.0 Ω. **Bulb 3** has a resistance of 6.0 Ω.
When all three switches are closed (on), **ammeter A_1** has a reading of 18.0 A.

(a) Calculate the total resistance of the circuit.

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(b) Determine the reading on ammeter, A_3.

..... **1**

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Question 29 continued on next page.

Class

Name

Question 29 continued. **Marks**

(c) Determine the reading on ammeter, A_2.

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(d) Determine the resistance of bulb 2.

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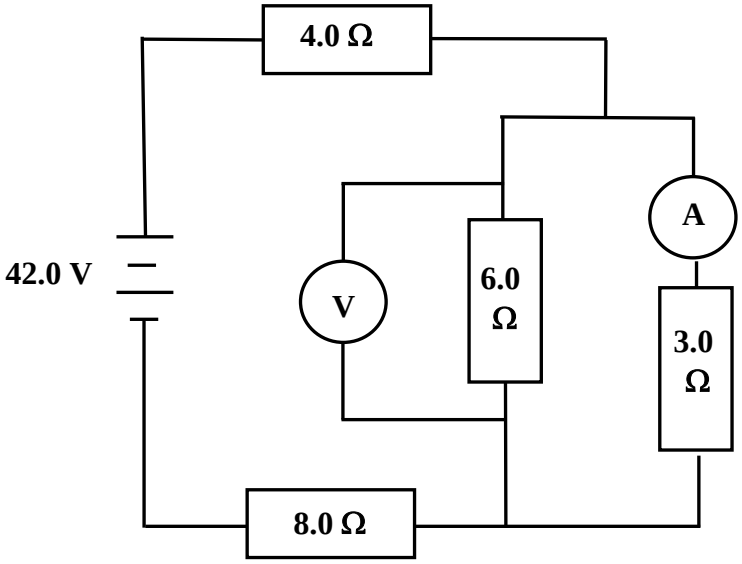
Question 30 (4 marks) **Marks**

This question refers to the circuit diagram below.



(a) Determine the total current in the circuit. **2**

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(b) Determine the reading on the voltmeter. **1**

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(c) Determine the reading on the ammeter. **1**

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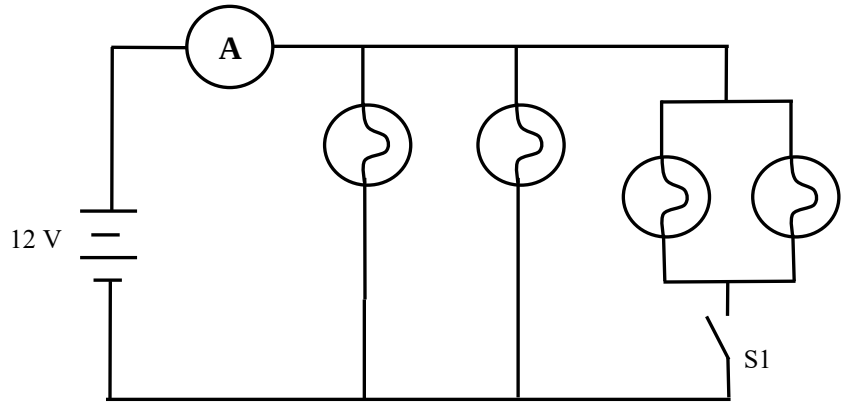
Class

Name

Question 31 (5 marks) **Marks**

A Form V boy was building a circuit. He used a 12.0 volt power supply, four light globes and one switch, S1. Each light globe has an identical resistance of 16.0 Ω.

His circuit is shown in the following diagram.



(a) In the first test of this circuit, S1 is open (off). For this first circuit test:

i) Calculate the total resistance of the circuit.

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ii) Calculate the current flowing through the ammeter.

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Question 31 continued on next page.

Question 31 continued. **Marks**

(b) In the second test of the circuit, the switch, S1, is closed (on). Calculate the total current flowing through the ammeter in this case.

..... **1**

.....

(c) The power supply used in the circuit was equipped with an internal circuit breaker that will turn off the power if the current exceeds 5.0 A. In the third test of the circuit, the boy decided to add more 16.0 Ω light globes in parallel with the four already shown.

What is the maximum total number of light globes that can be wired in parallel without activating the circuit breaker?

..... **2**

.....

.....

.....

.....

Physics

Data Sheet

Charge on the electron, q_e	-1.602×10^{-19} C
Mass of electron, m_e	9.109×10^{-31} kg
Mass of neutron, m_n	1.675×10^{-27} kg
Mass of proton, m_p	1.673×10^{-27} kg
Speed of sound in air	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	1.661×10^{-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

CREB
Class

Multiple Choice
Name

PHYSICS
Form V
May 2015
Monday 18th MAY 1.00 PM

Multiple Choice ANSWER SHEET

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

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.

Mark

CRIB
Class

Name

Part B
Total marks (84)
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 15 (5 marks) **Marks**

A car travelling East along a straight road at a constant velocity is then accelerated uniformly at 4 ms^{-2} East over a distance of 18 m. At the end of the 18 m, the car's velocity was found to be 20 ms^{-1} East.

(a) Calculate the velocity of the car before it started to accelerate. 2

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

$20^2 = u^2 + 2 \times 4 \times 18$ ✓①mk correct substitution into correct formula.

$u^2 = 256$

$u = 16 ms^{-1}$ East. ✓①mk direction

(b) Calculate the time that the car was accelerating. 1

$v = u + at$. [$20 = \overset{Ans\ (a)}{} + 4t$]

$20 = 16 + 4 \times t$

$t = 1s$ ✓①mk.

(c) If, at the end of 18 m, brakes are then applied and the car comes to a stop in 3 seconds. Determine the distance the car travels while it is braking. 2

$r = \left(\frac{u+v}{2}\right)t$ or $v^2 = u^2 + 2ar$

$r = \left(\frac{20+0}{2}\right)3$ $0^2 = 20^2 + 2 \times \left(\frac{0-20}{3}\right)r$

$= 30m$ $r = 30m$.

or $v = u + at$ * −1mk for each mistake identified in the substitution

$0 = 20 + a3$ ✓①mk.

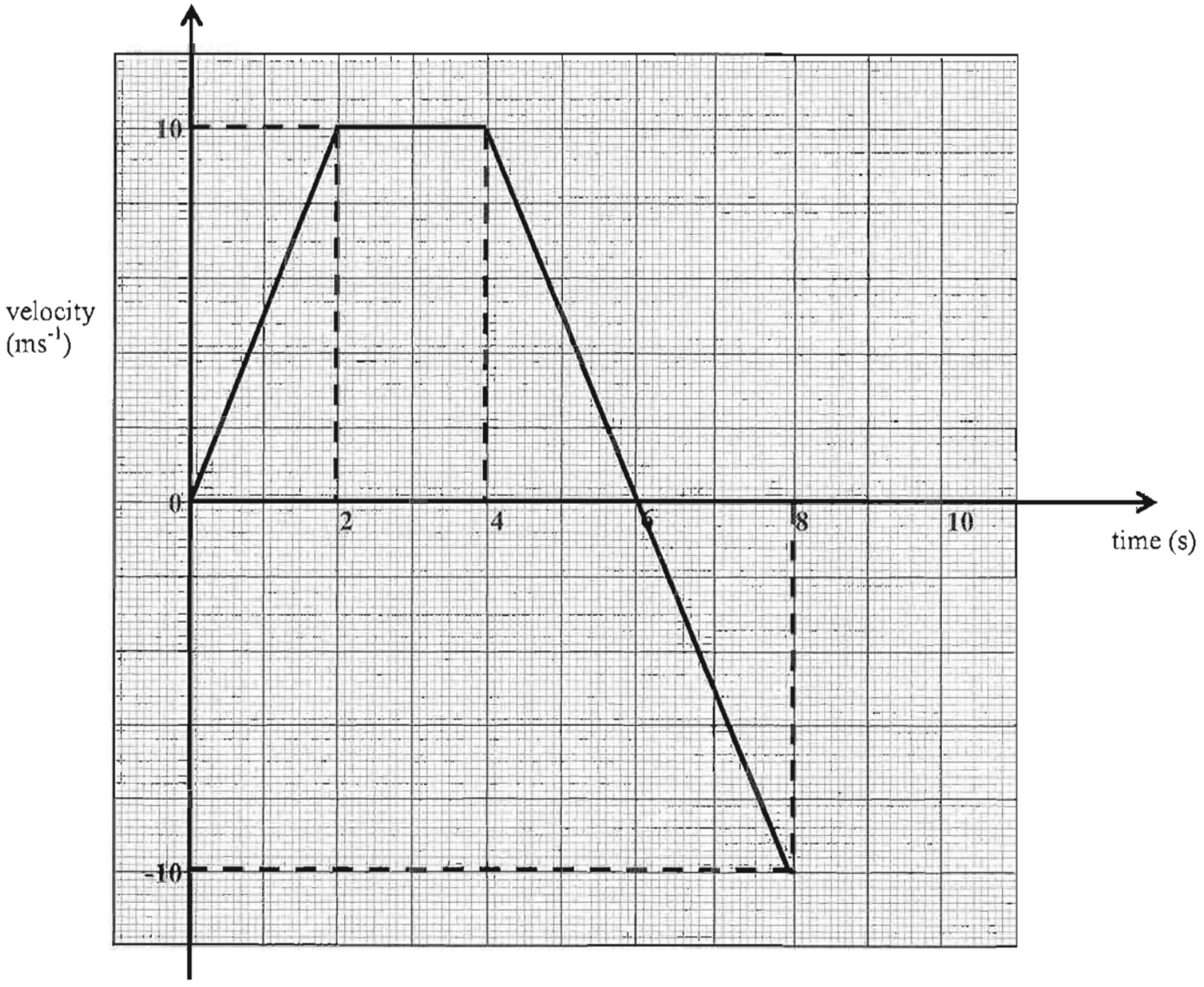
$a = -6\frac{2}{3} ms^{-2}$

$r = 20 \times 3 + \frac{1}{2} \times (-6\frac{2}{3}) 3^2$

$= 30m$. ✓①mk.

Question 16 (12 marks) **Marks**

A car of mass 2500 kg travels along a straight road as described by the following graph.



Question 16 continued on next page.

Class

Name

Question 16 continued. **Marks**

(a) Describe qualitatively (in words) the motion of the car for the 8 seconds.

correct description for each section. 3

$0 < t < 2s$ uniform acceleration ✓①mk

$2 < t < 4s$ constant velocity ✓①mk

$4 < t < 8s$ uniform negative acceleration. ✓①mk.

Note: some candidate descriptions only described $4 < t < 8s$. i.e. did not describe the 6-8s section :- 1mk.

(b) Calculate the magnitude of the velocity of the car at 3 seconds.

$10 ms^{-1}$ ✓①mk ignore direction ignore unit 1

(c) Calculate the magnitude of the net force acting on the car at 5 seconds.

$a = \frac{v-u}{t} = \frac{0-10}{2} = -5 ms^{-2}$ 1

$F = (2500 \times -5) = (-)12500N$

✓①mk. for correct substitution. (ignore answer)

(d) Calculate the distance travelled by the car in 8 seconds.

distance = area under curve ✓①mk. $= \frac{1}{2} \times 10 \times 2 + 2 \times 10 + \frac{1}{2} \times 10 \times 2$

$+ + (\frac{1}{2} \times 2 \times 10)$

$= 10 + 20 + 10 + 10$

$= 50m.$ ✓①mk

-1 mk for any mistake. for correct substitution. (ignore answer)

(e) Calculate the magnitude of the displacement of the car for the 8 seconds.

displacement $= \frac{1}{2} \times 2 \times 10 + 2 \times 10 + \frac{1}{2} \times 2 \times 10$ 1

$- \frac{1}{2} \times 10 \times 2$

$= (10 + 20 + 10) - 10$

$= 40 - 10 = 30m.$ ✓①mk.

Note: $r = 10 + 10 - 10$

$= 10m.$

Question 16 continued on next page.

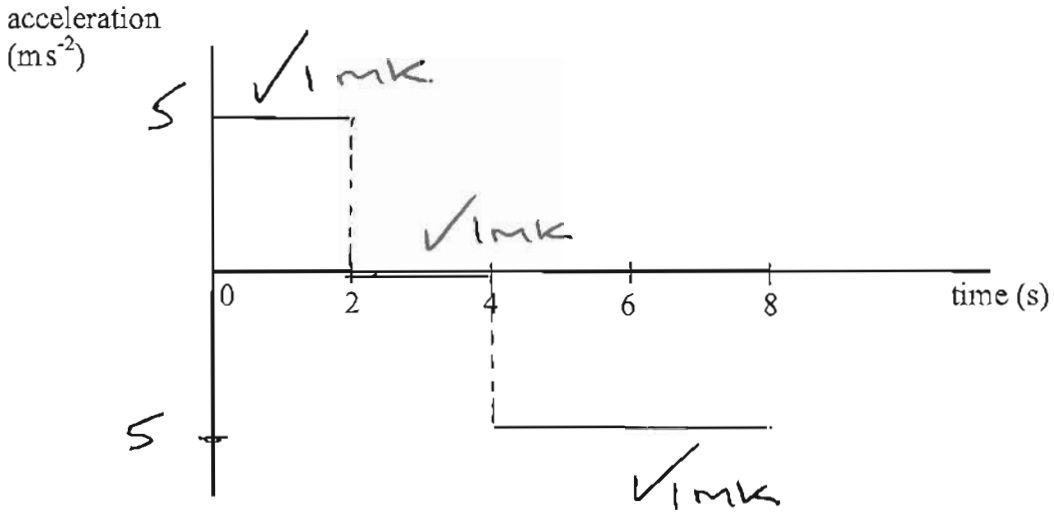
Question 16 continued. **Marks**

(f) Determine the magnitude of the average velocity of the car for the 8 seconds.

$\vec{v}_{av} = \frac{\text{Ans.(e)}}{8} = 30/8 = 3.75\,ms^{-1}$ **1**

(g) Sketch an acceleration versus time graph on the axes shown below of the car for the 8 seconds.

(Include numerical values).



3

-1 mk if numerical values are not included.

Class

Name

Question 17 (4 marks) **Marks**

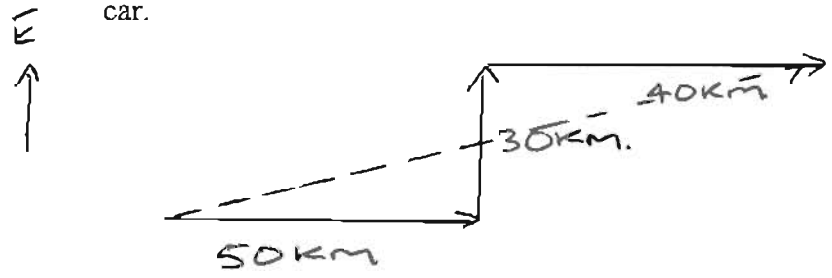
A car is driven East for a distance of 50 km, then North for 30 km, and then East for 40 km.

(a) Find the total distance travelled by the car.

$50 + 30 + 40 = 120\,km$ ✓1mk. 1

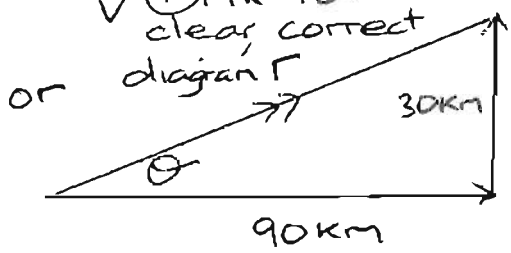
ignore units

(b) Using a diagram, find the magnitude and direction of the displacement of the car.



✓1mk for clear correct diagram

or



3

$r = \sqrt{90^2 + 30^2}$ ✓1mk.

$= 94.87\,Km$ at an angle of.

$E18.43^\circ N$

$N71.57^\circ E$ ✓1mk. direction

Class

Name SKW

CRIB

Question 18 (2 marks) **Marks**

A rocket of mass 10,000 kg is launched from Earth.

If the thrust provided by the rocket engines is 200,000 N, determine the magnitude of the acceleration of the rocket.

$200000 - 100000 = 10000a$ (1)

$a = 10 \cdot 2 \text{ m/s}^2$ (1) **2**

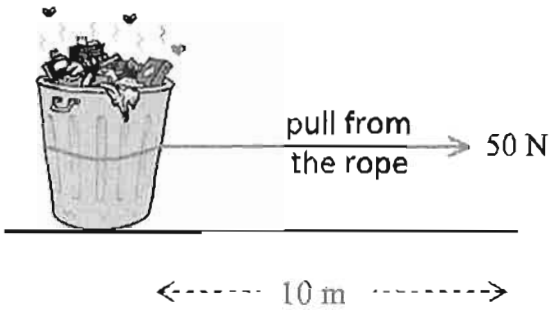
(If you left out Weight = mg, a = 20 m/s² (1))

common error!

SRW

Question 19 (3 marks) **Marks**

A trash bin is too dirty to be carried outside. A rope is used to pull it out of the house. The pulling force acting on the bin has a magnitude of 50 N and is applied horizontally over 10 m.



The bin is originally at rest and is measured to have a speed of 8.5 ms^{-1} when the 10 m mark is reached. The floor creates an average friction force of 30 N.

(a) Calculate the net work done on the bin over the 10 m displacement.

$F_{Net} \times d = 20 \times 10 = 200\ J$ **1**

(b) Determine the mass of the bin.

$200J = \frac{1}{2} m \times 8.5^2$ ①

$m = 5.54\ kg$ ①

2

or $20 = ma$, $8.5^2 = 2a \times 10$ ①

$a = 3.6125\ m/s^2$

$m = \frac{20}{3.6125} = 5.54\ kg$ ①

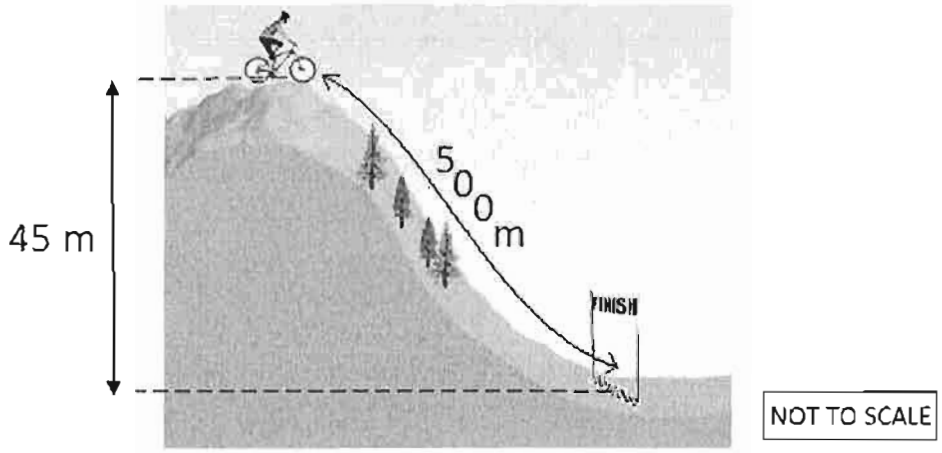
Class

Name

Question 20 (5 marks) **Marks**

A mountain biker is standing still at the top a hill. He wants to know how fast he will be going when he crosses the finish line at the bottom of the hill WITHOUT pedalling.

The track he wants to follow reaches the foot of the hill in 500 m, with a vertical drop of 45 m. The total mass of the biker and his bike is 90 kg.



(a) Considering that the track is ideal and does not create friction, calculate the speed of the biker as he crosses the finish line.

$v^2 = 2 \times 9.8 \times 45$ ① or $\left(mgh = \frac{1}{2}mv^2\right)$ **2**

$v = 29.7$ m/s ①

(b) More realistically, the dirt track creates an average frictional force of 60 N on the bike's wheels.

Calculate the real speed of the biker as he crosses the finish line.

BEST METHOD

Heat $= 60 \times 500$ ①

$90 \times 9.8 \times 45 = \frac{1}{2} \times 90 \times v^2 + 30000$ ① or

$v = 14.7$ m/s ①

BAD METHOD

$v^2 = u^2 + 2as$ **3**

$a = 0.882$ m/s

$\therefore F_{Net\,friction} = 90a = 79.38$ N ①

$F_{Net(with\,friction)} = 79.38 - 60$ ①

$\therefore a = \frac{19.38}{90} = 0.215$ m/s² ①

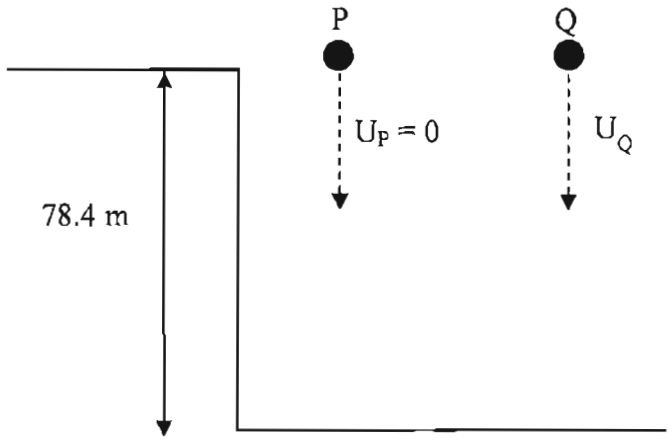
$v^2 = u^2 + 2as$

$= 14.7$ m/s ①

SRW

Question 21 (3 marks) **Marks**

Ball P is dropped from a height of 78.4 m. One second later, another Ball Q is thrown vertically down from the same height.



Calculate the speed Ball Q would need to be thrown so that ball's P and Q both reach the ground at the same instant.

$r = 4.9t^2$

$t = \sqrt{\frac{78.4}{4.9}}$

$= 4$ sec (1)

$r = u \times 3 + 4.9 \times 3^2$ (1)

$u = \frac{78.4 - 4.9 \times 3^2}{3}$

$= 11.43$ m/s (1)

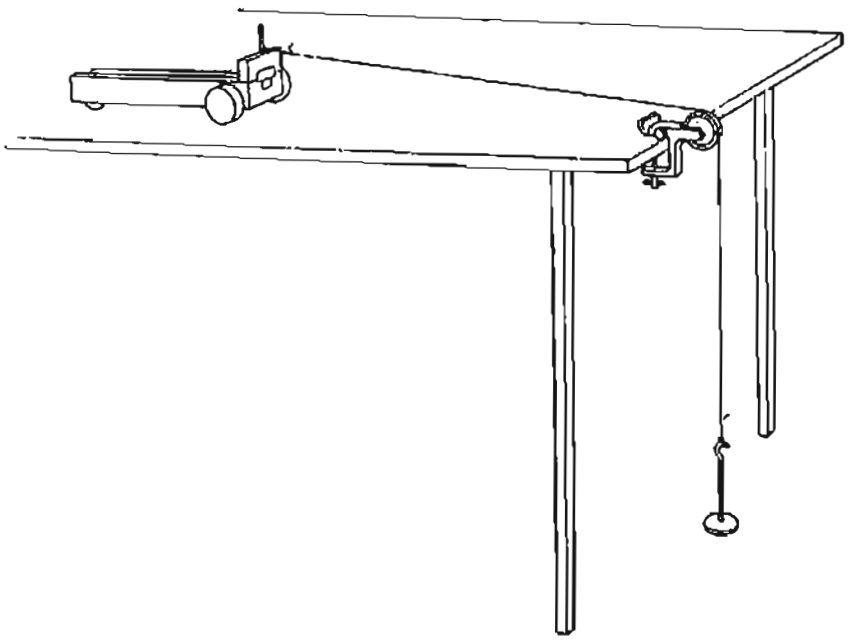
3

SKW Class

Name

Question 22 (5 marks) **Marks**

An experiment is done to determine the acceleration of a trolley accelerated by suspended mass-carrier.



The trolley is released from rest and the time taken to travel 0.4 m is recorded on a stopwatch as taking 0.76 s. The total mass of the mass-carrier is 50 g.

(a) Determine the magnitude of acceleration of the trolley.

$s = \frac{1}{2}at^2$ $a = 1.385\ m/s^2$ **1**

(b) If there is no friction acting, determine the mass of the trolley.

$m = 0.49 - 0.05$ (1) **2**

(a)

$m = 0.304\ kg$ (1)

common error!!

$m_{carrier}g = m_{trolley}a$

$0.05g = m_{trolley}a$

Question 22 continued on next page.

SRW

Question 22 continued. **Marks**

(c) Determine the magnitude of the tension in the string. **2**

$T = (a) \times (b)$ ①

$= 0.42\ N$ ①

or $mg - T = ma$ ①

$T = mg - ma$

$= 0.42\ N$

General comments

- ✓ Too many boys only wrote the result of their calculations without explaining where it comes from with the appropriate equations/formulae.
- ✓ Units were generally stated at the end of calculations: please continue!
- ✓ Do not refrain from drawing diagrams to be sure you understand the problem (e.g. direction of forces) and/or to clarify an explanation.
- ✓ Do not use repeaters or fractions like you would in Maths: approximate your results to the correct number of sig.fig. or d.p., e.g. write 9.67 $m.s^{-1}$ and not $9.66\dot{6}$ $m.s^{-1}$ or $\frac{29}{3}$ $m.s^{-1}$.

Question 23

(a)

Criteria	Marks	%
• Correct result.	1	*73*
	0	*27*

Sample answer:

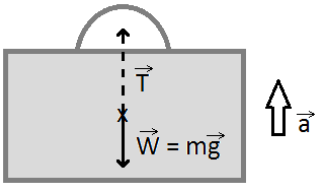
Net force F_{net} = ma = 2 x 3 = 6 N

(b)

Criteria	Marks	%
• Correct equation. AND • Correct result.	2	*59*
• Correct equation. OR • Correct result without justification.	1	*11*
	0	*30*

Sample answer:

T = force applied by the man on the briefcase.
F_{net} = ma = 6N with $F_{net} = T - mg$ (because T and a are in the same direction)
Thus, $T = F_{net} + mg = 6 + 2 \times 9.8 = 25.6$ N



Marker's comments:

- *A lot of boys still used F_{net} (or ∑F) to describe the force applied by the man on the briefcase. Therefore, their equation "$T = F_{net} + mg$" was actually written "$\sum F = ma + mg$" which is wrong physically: $\sum F = ma$ (N2L)so "$\sum F = ma + mg$" means that "mg" = 0, either because $m = 0$ or because $g = 0$ (neither of those hypothesis is true here)*
  Choose the notation of the forces wisely!
- *A lot of boys stated Newton's Third Law (N3L) to justify that the force of the man on the briefcase was the net force calculated in the previous question: this is also very wrong and show a poor understanding of the concept of net force, especially in the context of an accelerating system (if $F_{man\ on\ briefcase} = F_{net}$, then either m=0 or g=0, as the weight of the briefcase has to be 0…).*

(c)

Criteria	Marks	%
• Correct force equation with appropriate signs (expression of the net force). AND • Correct expression of the mass of the system "man + briefcase". AND • Correct result for the mass of the man.	3	*65*
• TWO of the above.	2	*15*
• ONE of the above.	1	*9*
	0	*11*

Sample answer:

$\underline{F_{net} = (m_{man} + m_{briefcase}) \times a}$ and $\underline{F_{net}}$ also equals to $F_{scale} - W_{man + briefcase} = \underline{F_{scale} - (m_{man} + m_{briefcase}) \times g}$

Thus,

$F_{scale} = (m_{man} + m_{briefcase}) \times (g+a)$ => $m_{man} = \frac{F_{scale}}{g+a} - m_{briefcase} = = \frac{1152}{9.8+3} - 2 = \underline{88 \text{ kg}}$

Marker's comments:

- *Most of the boys who got 2 out of 3 found the correct mass of the system "man + briefcase" but stopped there and did not find the mass of the man.*
- *Most of the boys who only had 1 out 3 made a mistake in the signs when writing the force equation, mainly because they try to substitute values straight away without really understanding the situation: a diagram should help those boys visualise the forces and therefore use the correct signs when substituting.*

Question 24

(a)

Criteria	Marks	%
• Correct result for the magnitude of the car's initial momentum.	1	*100*
	0	*0*

Sample answer:

$p_{car} = m_{car} \times u_{car} = 580 \times 8.0 = 6800 \text{ kg.m.s}^{-1}$

Marker's comments:

Many boys added a direction to the results but only the momentum's magnitude was asked.

(b)

Criteria	Marks	%
• State that the TOTAL momentum is conserved ($p_{before} = p_{after}$ or any relevant expression of this equation). AND • Correct result for the final speed of the van.	2	*86*
• ONE of the above.	1	*5*
	0	*9*

Sample answer:

Conservation of total momentum: $p_{before} = p_{after} \iff 6800 + 0 = 850 \times 2 + 1500v_{van}$.
Thus, $v_{van} = 3.4 \text{ m.s}^{-1}$

Marker's comments:

- *Most of the boys who didn't get full marks here only considered the conservation of momentum for the van only and forgot the car after the collision. That's why it is better to refer to the "conservation of* total *momentum" rather than simply to the" conservation of momentum".*
- *Quite a few boys had the correct reasoning but made a calculation error and couldn't find the correct result for v.*

(c)

Criteria	Marks	%
• Correct result for the magnitude of the change in the car's momentum.	1	*90*
	0	*10*

Sample answer:

$\Delta p = p_{final} - p_{initial} = m_{car} (\Delta v_{car})$ because m_{car} doesn't change during the collision.
Thus, $\Delta p = 850 (2.0 - 8.0) = -5100 \text{ kg.m.s}^{-1} \Rightarrow |\Delta p| = 5100 \text{ kg.m.s}^{-1}$

Marker's comments:

Most of the boys could easily answer this question but many got confused with the sign they ended up with: please be sure that you write that $\Delta p = p_{final} - p_{initial}$ (and not the opposite!).
Here, it gives you a negative value so the magnitude of the change will be given by the absolute value *of Δp (i.e. $|\Delta p|$).*

(d) i)

Criteria	Marks	%
• Correct result for the magnitude of the average force on the car.	1	*82*
	0	*18*

Sample answer:

- Δp =impulse = $F_{av}t$ => $\underline{F_{av}} = \frac{\Delta p}{t} = \frac{5100}{0.1} = \underline{51000\ N}$.

OR

- $F_{av} = m\ |a| = m\frac{|v-u|}{t} = 850\frac{|2.0-8.0|}{0.1}$ = 51000N (absolute value because you want the magnitude here)

Marker's comments:

- *Many boys got confused with the sign of the acceleration they found (here it's negative as the car is decelerating).*
- *Out of the 82 boys who got that question right, 2/3 went for the first method (preferred one, as it shows their good grasp on Mechanics) and 1/3 for the second method (those boys showed they could find a way to get to the result with other tools available, well done!).*

ii)

Criteria	Marks	%
• State Newton's Third Law to explain why the two forces have the same magnitude. OR • State the Law of Conservation of Total Momentum AND make a direct and clear link between momentum and the forces involved in the collision.	1	*74*
	0	*26*

Sample answer:

N3L states that if the car acts on the van, then the van is also acting on the car with the same strength: therefore, the two forces have the same magnitude (but opposite directions).

Marker's comments:

A lot of boys only mentioned the conservation of (total) momentum without making the link between momentum and forces: no mark was awarded for such vague statements.

(e)

Criteria	Marks	%
• State that the kinetic energy of the car does not disappear but is converted / transformed / changed into other forms of energy (heat, sound, potential energy of deformation…)	1	*92*
	0	*8*

Sample answer:

The total energy is indeed conserved: the decrease in the car's kinetic energy is balanced by the release of heat energy, sound energy and potential energy of deformation during the collision.

Marker's comments:

Many boys still mix up "transfer of energy" and "transformation of energy"…

Question 25

(a)

Criteria	Marks	%
• State and use the correct equation (or derive it properly). AND • Correct result for the magnitude of the acceleration of the system.	2	*86*
• ONE of the above.	1	*11*
	0	*3*

Sample answer:

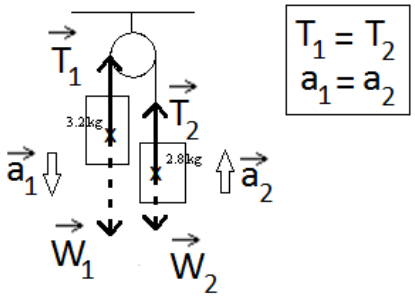
$\underline{a} = \frac{|m_2 - m_1|}{m_2 + m_1} \times g = \frac{|2.8-3.2|}{2.8+3.2} \times 9.8 = \underline{0.65\ m.s^{-2}}$.

(b)

Criteria	Marks	%
• State and use the correct expression of the net force on one of the masses. AND • Correct result for the magnitude of the tension in the string.	2	*80*
• ONE of the above.	1	*7*
	0	*13*

Sample answer:

Mass 1 (on the left):
T and a have opposite directions, a and W_1 are in the same direction.
$F_{net} = W_1 - T = m_1a$ <=> $T = W_1 - m_1a$ <=> $T = m_1(g-a)$
<=> $\underline{T} = 3.2 \times (9.8-0.65) = \underline{29.3\ N}$



Marker's comments:

- *Use the diagram to get the directions of the forces right.*
- *A lot of boys made calculation errors!*

(c)

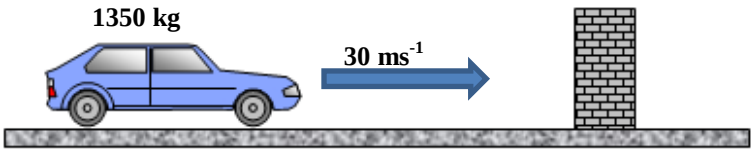
Criteria	Marks	%
• Correct result for the net force on the 2.8 kg mass.	1	*81*
	0	*19*

Sample answer:

Mass 2 (on the right): $\underline{F_{net}} = m_2a = 2.8 \times 0.65 = \underline{1.82\ N}$.

Question 26 (6 marks) **Marks**

A car and its contents have a mass of 1350 kg and travelling at 30 ms^{-1} collides with a wall and comes to a complete stop.



(a) A dog is unrestrained in the back seat and during the collision continues at a constant velocity until hitting the front dashboard.

i) Explain why the dog continues at a constant velocity.

Answer:

The unrestrained dog has no **net force** applied to it. (The frictional force with the seat is negligible) therefore according to Newton's 1st law if there is no net force on an object then it will continue with constant velocity (or remain at rest)

Marking Scheme

Criteria	*Marks*	*%*
Answers must be justify the dogs constant velocity by some correct expression of Newton's 1st law. The law must be stated	1	61%
Answers without references to Newton's 1st law or simply assume the 1st law without reference to it	0	39%

ii) Explain why the deceleration of the dog would be more damaging than to the driver who is wearing a seatbelt.

Answer:

Both driver and dog change their velocity from 30 m s^{-1} to 0 m s^{-1}. Because $a = \frac{v-u}{t}$, and $\sum F = ma$, both the acceleration and collision force are reduced if the collision time is extended.

The seatbelt restrains the driver so that they slow down at the same rate as the car. This time is extended by the crumple zone of the car.

The dog continues at a constant velocity until it hits the now/near stationary dashboard or window. This deceleration occurs over a much shorter time making the acceleration and impact force much greater on the dog (leading to more damage).

Marking Scheme

Criteria	*Marks*	*%*
A clear description of how, • Time of deceleration of the dog is shorter. • Time of deceleration of the driver is longer And a clear use of the principles of physics about how this links to a more damaging deceleration or impact force for the dog	2	57%
Not a clear use of physics concepts that justify the statements made e.g. "decelerating faster causes more damage"	1	27%
Answers that provide no justification for the outcome OR have too many incorrect conceptions about collisions OR misuse physics terminology or have imprecise phrasing.	0	16%

Notes

- The dog's collision time is not instantaneous or instant. (implies infinite acceleration)
- It is not the seatbelts elasticity particularly that increases the stopping time, but because the person is restrained to slow at the same rate as the car.
- The change in momentum or impulse for driver and dog are not the same as they have different masses.
- It is difficult to generalise about the pressure causes by the contact with different surface areas, without further detail.
- All uses of the word 'inertia' were incorrect and made answers worse. Inertia is a property of an object, it does not 'do' anything or make anything happen.
- Forces cause accelerations (acceleration does not cause forces)

Question 26 continued on next page.

Question 26 continued. **Marks**

(b) The modern family car has become far safer due to the application of better technology like the seatbelt, but nothing can defy the Laws of Physics.

Referring specifically to Newton's Laws of Motion, outline the use of ONE safety device implemented on cars other than the seatbelt.

Answer:

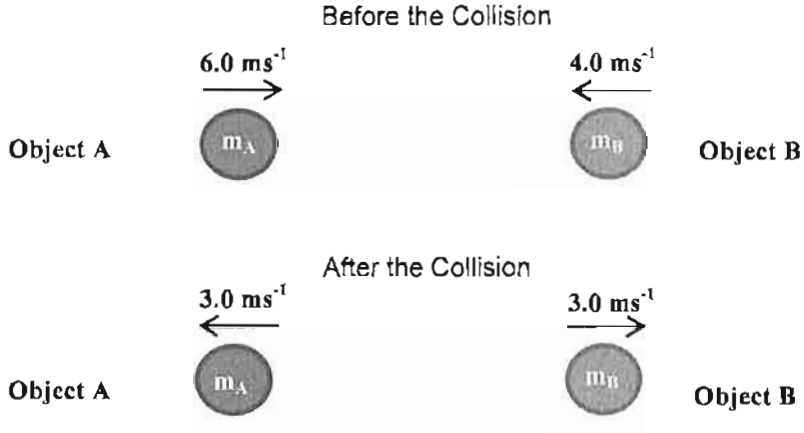
{depends on technology chosen}

Marking Scheme

Criteria	*Marks*	*%*
A well-structured answer that • clearly identifies and *describes* one safety device only (not a seatbelt) AND • Explains the concepts of physics that would reduce the injury (or improve the safety) of a person AND • Correctly links their explanation to a specifically stated Newton's law of motion *that applies to the operation of the safety device*, not simply some aspect of a collision or moving car.	3	18%
TWO of the above	2	49%
ONE of the above	1	27%
Identifies a safety device only	0	6%

Question 27 (4 marks) **Marks**

An object A of mass m_A travelling at 6.0 ms^{-1} to the right collides *inelastically* with object B of mass m_B travelling left at 4.0 ms^{-1}. After the collision both objects are travelling at the same speed 3.0 ms^{-1} in opposite directions. The total amount of kinetic energy lost in the collision is 100 J.



Determine what the mass of object A (m_A) and the mass of object B (m_B) must be for this collision to occur.

Momentum is conserved $6m_A - 4m_B = -3m_A + 3m_B$ **4**

$9m_A = 7m_B$ or $m_A = \frac{7}{9}m_B$ — (1)

KE lost $\Delta KE = -100J$, $KE_f - KE_i = -100$, $KE_i = KE_f + 100$, $2KE_i = 2KE_f + 200$

$m_A 6^2 + m_B 4^2 = 3^2(m_A + m_B) + 200$

(2) — $27m_A + 7m_B = 200$ (or $13\frac{1}{2}m_A + 3\frac{1}{2}m_B = 100$).

Substitute (1) into (2)

$27(\frac{7}{9}m_B) + 7m_B = 200$

$21m_B + 7m_B = 200$

$28m_B = 200$

$m_B = \frac{200}{28} = \frac{50}{7} = 7\frac{1}{7} = 7.14\,kg$

sub into (1) $m_A = \frac{7}{9}(\frac{50}{7}) = \frac{50}{9} = 5\frac{5}{9} = 5.56\,kg$

1 mark – correct equation from conservation of momentum.
1 mark – correct equation from conservation of energy
1 mark – correctly substituting correct formulas together.
1 mark – correctly determining masses of m_A and m_B.

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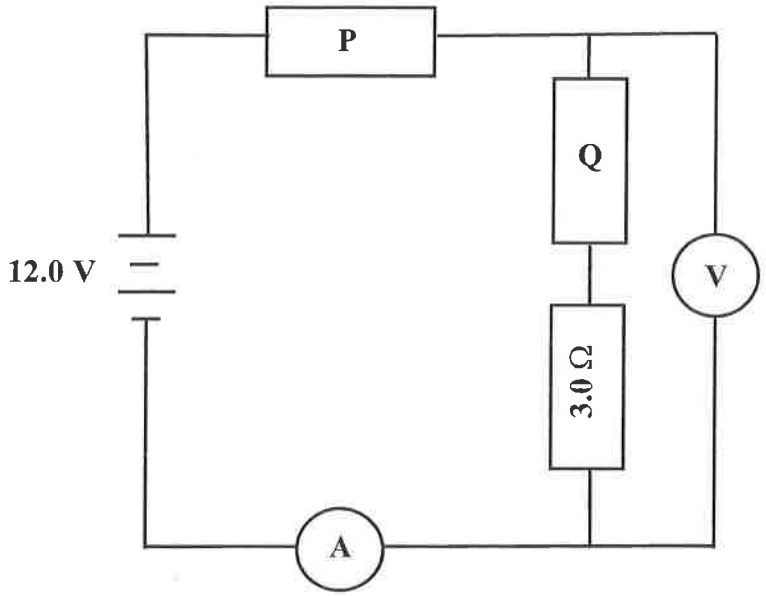
Question 28 (4 marks) **Marks**

Three resistors P, Q and a 3.0 Ω resistor are connected to a 12.0 volt battery.



The reading on the ammeter is 1.5 A. The reading on the voltmeter is 6.75 V.

(a) Determine the resistance of P. **2**

$V_P = 12 - 6.75 = 5.25$ v

$\therefore R_P = \frac{5.25}{1.5} = 3.5\ \Omega$

(b) Determine the resistance of Q. **2**

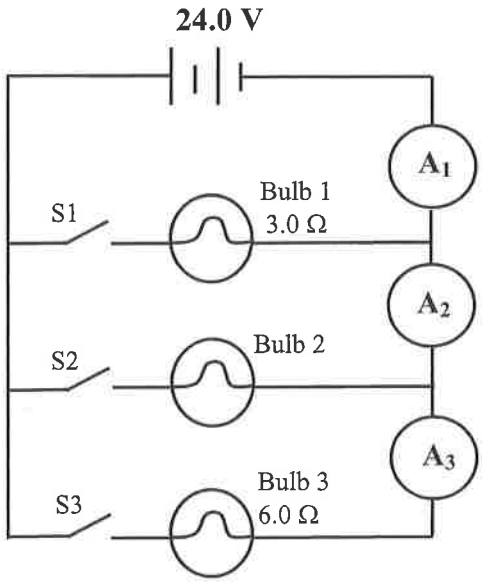
$R_{TOT} = \frac{12}{1.5} = 8\ \Omega$

$\therefore R_Q = 8 - (3 + 3.5) = 1.5\ \Omega$

NB – In this whole section, carry through marks were awarded where possible, but only in the workings were clear and obvious.

Question 29 (4 marks) **Marks**

This question refers to the following electric circuit consisting of three light bulbs connected to a 24.0 V battery. S1, S2, and S3 are switches.



Bulb 1 has a resistance of 3.0 Ω. **Bulb 3** has a resistance of 6.0 Ω.
When all three switches are closed (on), **ammeter A_1** has a reading of 18.0 A.

(a) Calculate the total resistance of the circuit. **1**

$R_{tot} = \frac{24}{18} = 1.33\ \Omega$

(b) Determine the reading on ammeter, A_3. **1**

$I_3 = \frac{24}{6} = 4\ A$

Question 29 continued on next page.

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Question 29 continued. **Marks**

(c) Determine the reading on ammeter, A_2.

$I_2 = 18 - \left(\frac{24}{3}\right)$ $= 10_A$ * **1**

(d) Determine the resistance of bulb 2.

$R_2 = \frac{24}{6}$ $= 4\Omega$ **1**

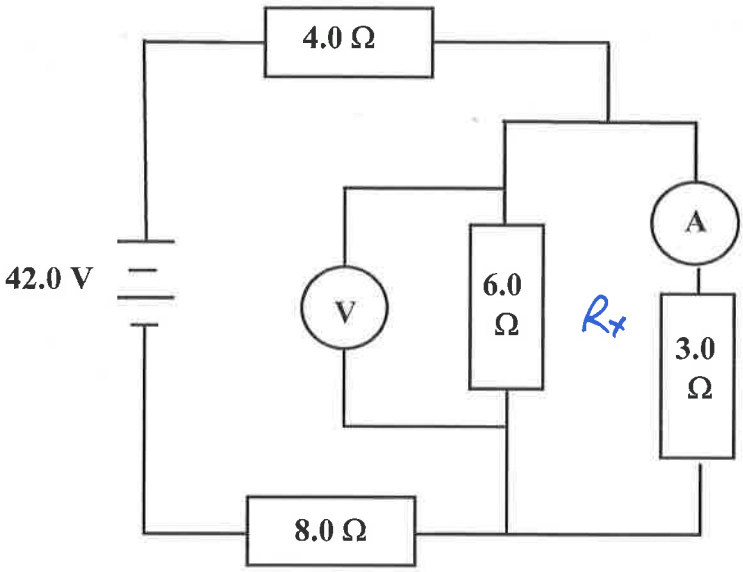
which is $I_2 - I_3$ (= 10 − 4)

* NB$_1$ – Many Boys Are Calculating The Current Through Bulb 2, which is 6A.
A_2 Measures The Current Through Bulb 2 Plus Bulb 3 !! (= 6A + 4A)

NB$_2$ – if (d) = $\frac{24}{(c)}$ → 0 Marks !!

Question 30 (4 marks) **Marks**

This question refers to the circuit diagram below.



(a) Determine the total current in the circuit.

$\frac{1}{R_x} = \frac{1}{6} + \frac{1}{3} \rightarrow R_x = 2\Omega$ (1)

$\therefore I = \frac{42}{2+4+8} \rightarrow R_{TOT} = 14\Omega$ (1)

OR (if answer wrong) $I = 3A$ (2) **2**

(b) Determine the reading on the voltmeter.

$V = IR = 3 \times 2 = 6V$ **1**

(c) Determine the reading on the ammeter.

$= \frac{6}{3} = 2A$ **1**

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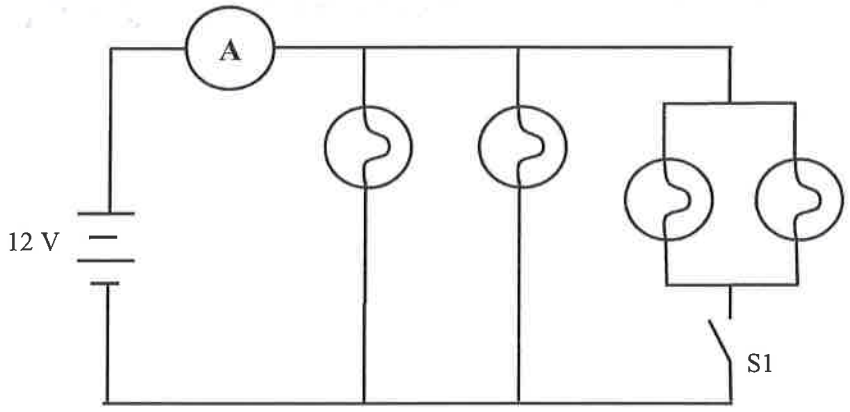
Question 31 (5 marks) **Marks**

A Form V boy was building a circuit. He used a 12.0 volt power supply, four light globes and one switch, S1. Each light globe has an identical resistance of 16.0 Ω.

His circuit is shown in the following diagram.



(a) In the first test of this circuit, S1 is open (off). For this first circuit test:

i) Calculate the total resistance of the circuit.

$R_{TOT} = \frac{16}{2} = 8\,\Omega$ **1**

ii) Calculate the current flowing through the ammeter.

$I = \frac{V}{R} = \frac{12}{8} = 1.5\,A$ **1**

Question 31 continued on next page.

Question 31 continued. **Marks**

(b) In the second test of the circuit, the switch, S1, is closed (on). Calculate the total current flowing through the ammeter in this case.

$R_{TOT} = 4\Omega$ $\therefore I_{TOT} = \frac{12}{4} = 3A$ **1**

(c) The power supply used in the circuit was equipped with an internal circuit breaker that will turn off the power if the current exceeds 5.0 A. In the third test of the circuit, the boy decided to add more 16.0 Ω light globes in parallel with the four already shown.

What is the maximum total number of light globes that can be wired in parallel without activating the circuit breaker?

$R_{TOT} = \frac{16}{n}$ $I = \frac{V}{R} = \frac{12}{16/n} = \frac{12n}{16}$ **2**

$\therefore \frac{12n}{16} < 5A$ $\therefore n < 6.7$ (2)

$n = 6$ BULBS.

NB1 "2 MORE BULBS" ACCEPTED WITH SUPPORTING CALCULATIONS.

NB2 ANY SUITABLE METHOD – INCLUDING "TRIAL AND ERROR" – ACCEPTED.

NB3 BOYS TENDED TO EITHER GET THIS QUESTION RIGHT, OR COMPLETELY WRONG (IE. ZERO MARKS). BOYS COULD GET 1 MARK FOR SOMETHING INTELLIGENT, E.G. WORKING OUT THAT $R_{MAX} = 12/5 = 2.4\Omega$ ETC.