SYDNEY GRAMMAR SCHOOL

2019
ANNUAL EXAMINATION

PHYSICS
Form V

STRUCTURE OF PAPER

- Section I: Multiple Choice (18 marks)

  Answer all questions on the Multiple-Choice Answer Sheet.

- Section II: Extended Response (78 marks)

  Answer all parts of the questions in the spaces provided in the Examination Paper.

- Board approved calculators may be used

EXAMINATION

Date: Thursday 5th September
Duration: 2 hours
Marks: 96

CHECKLIST

In the stapled bundle each boy should have the following:

- ☐ 1 Examination Paper
- ☐ 1 Data and Formula Sheet
- ☐ 1 Multiple-Choice Answer Sheet

EXAM INSTRUCTIONS

- Remove the centre staple and hand in all parts of the examination in a neat bundle.
- WRITE YOUR **CANDIDATE NUMBER** IN THE SPACE PROVIDED AT THE TOP OF EACH SEPARATE SECTION.
- There is a Data/Formula sheet included at the end of the paper.
- Responses requiring more writing space should be clearly be marked **CONTINUED**. Additional extra writing space is provided at the end of each section. When the response is continued on extra writing paper it should clearly indicate the question number.

Master in charge: MRW

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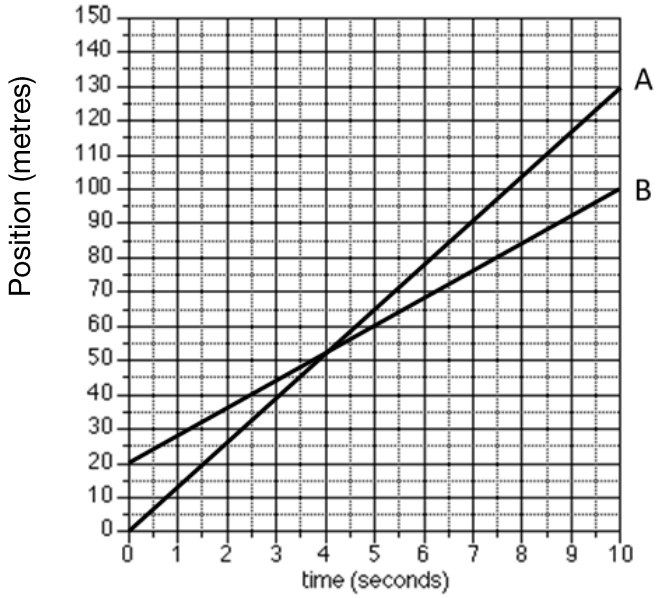
SECTION I: MULTIPLE CHOICE

Attempt ALL Questions
Use the Multiple-Choice Answer Sheet.

Questions 1 to 3 refer to the information below.

Two Go Karts, A and B, are moving along a straight track in the same direction. The graph below represents their relative positions during a 10-second time interval.



1 At what time do they have the same displacement?

(A) At 0 s

(B) At 4 s

(C) At all times in the 10 s interval.

(D) Not at any time in the 10 s interval.

2 At what time do they have the same velocity?

(A) At 0 s

(B) At 4 s

(C) At all times in the 10 s interval.

(D) Not at any time in the 10 s interval.

3 At what time do they have the same acceleration?

(A) At 0 s

(B) At 4 s

(C) At all times in the 10 s interval.

(D) Not at any time in the 10 s interval.

4 A man walks 20 m East, and then 40 m North. His displacement at the end of this walk will be:

(A) 45 m at 27° East of North

(B) 45 m at 63° East of North

(C) 60 m at 27° East of North

(D) 60 m at 63° East of North

5 A car travelling initially at 8.0 m s^{-1} West accelerates over an interval of 15 s until it reaches 10 m s^{-1} East. What is the car's average acceleration during this time?

(A) 0.13 m s^{-2} West

(B) 0.13 m s^{-2} East

(C) 1.2 m s^{-2} West

(D) 1.2 m s^{-2} East

6 An object, P, of mass m, moving with a velocity, v, collides with another object, Q, of mass $\frac{m}{2}$ moving in the same direction with velocity $\frac{v}{2}$ as shown in the following diagram.

During the collision object P exerts an average force, F, on object Q.

During the collision object Q exerts an average force on object P of magnitude:

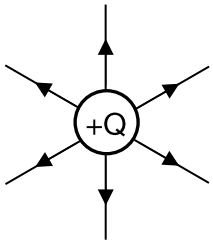
(A) $\frac{F}{2}$

(B) $\frac{F}{4}$

(C) F

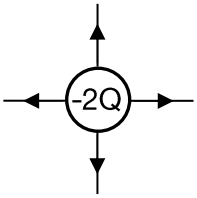
(D) $2F$

7 The following diagram shows the electric field around a single point charge, +Q.

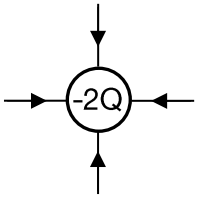


Which diagram below shows the electric field about a point charge -2Q?

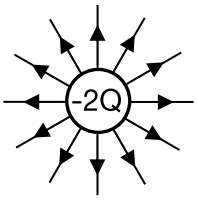
(A)



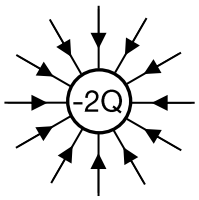
(B)



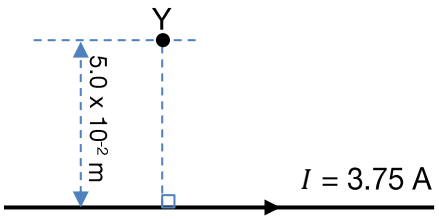
(C)



(D)



8 In the diagram below, a long, straight wire carries a current of 3.75 A as shown.



Calculate the magnitude of the magnetic field strength at point Y, which is 5.0×10^{-2} m away from the wire.

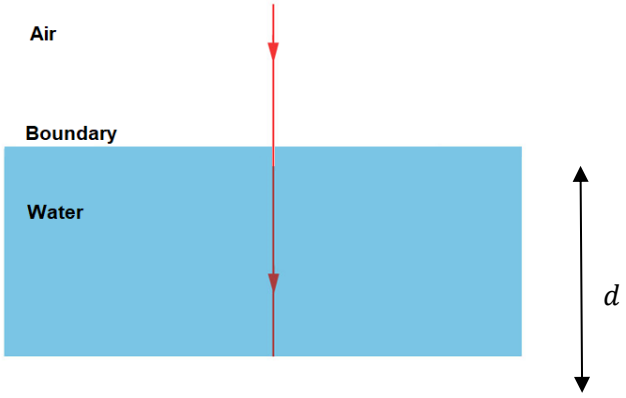
(A) 2.7×10^{-9} T

(B) 1.5×10^{-5} T

(C) 3.0×10^{-4} T

(D) 5.6×10^{-4} T

9 A light ray travels along the normal from air into water as shown in the diagram below. The speed of light in air is c.



If the refractive index of the water is n and the depth of the water is d metres, then the time taken for the light ray to travel distance, d, through the water in seconds is:

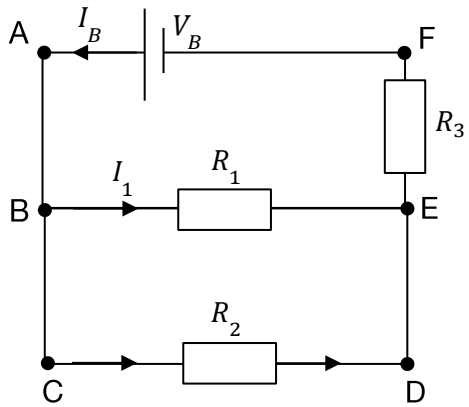
(A) $\frac{d}{n}$

(B) $\frac{cd}{n}$

(C) $\frac{cn}{d}$

(D) $\frac{dn}{c}$

10 Consider the circuit below:



Which of the following equations is a correct application of Kirchhoff's voltage law to the loop ABEFA?

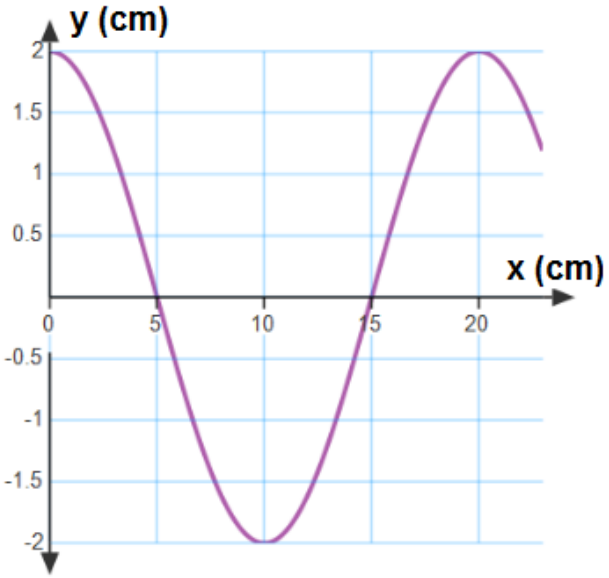
(A) $I_1R_1 + I_BR_3 - V_B = 0$

(B) $(I_B - I_1)R_1 - I_BR_3 - V_B = 0$

(C) $I_1R_1 - (I_B - I_1)R_2 = 0$

(D) $I_BR_2 + I_1R_3 - V_B = 0$

The following graph is used to answer Questions 11 and 12.



The graph above represents the vertical displacement of a wave, y, as a function of its horizontal displacement, x.

11 What is the amplitude of the wave?

(A) 2 cm

(B) 4 cm

(C) 5 cm

(D) 20 cm

12 What is the wavelength of the wave?

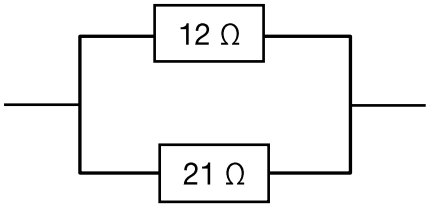
(A) 2 cm

(B) 5 cm

(C) 15 cm

(D) 20 cm

13 Consider the following arrangement of resistors.



Calculate the total resistance of this combination of resistors.

(A) 0.13 Ω

(B) 7.6 Ω

(C) 9.0 Ω

(D) 33 Ω

14 The intensity of light from a globe is 0.12 Wm^{-2} at a distance of 16 m away from it.

Calculate the intensity of the light at a distance of 5.0 m from the globe.

(A) 0.012 Wm^{-2}

(B) 0.38 Wm^{-2}

(C) 1.2 Wm^{-2}

(D) 31 Wm^{-2}

15 A +4.0 C charge placed at point X experiences an electrostatic force of 10 N. The magnitude of the electric field strength at point X is:

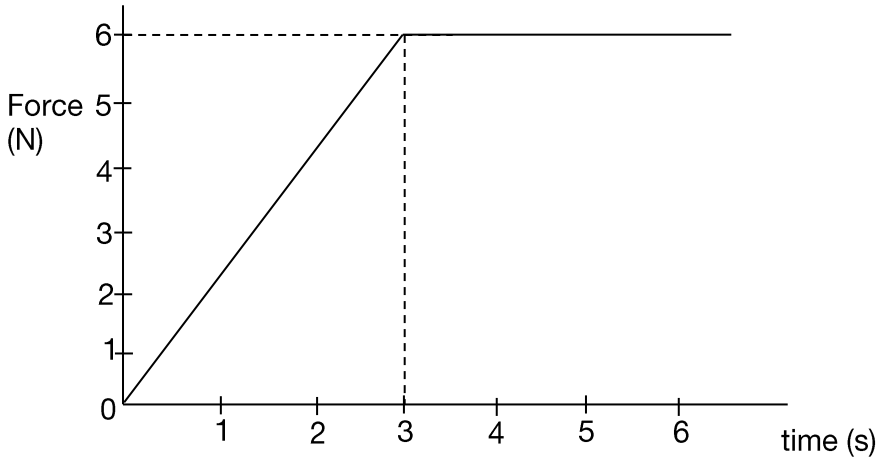
(A) 0.40 NC^{-1}

(B) 2.5 NC^{-1}

(C) 6.0 NC^{-1}

(D) 40 NC^{-1}

16 The graph below shows how the force on a 4.5 kg object varies with time.



What is the magnitude of the object's change in momentum after 6 seconds.

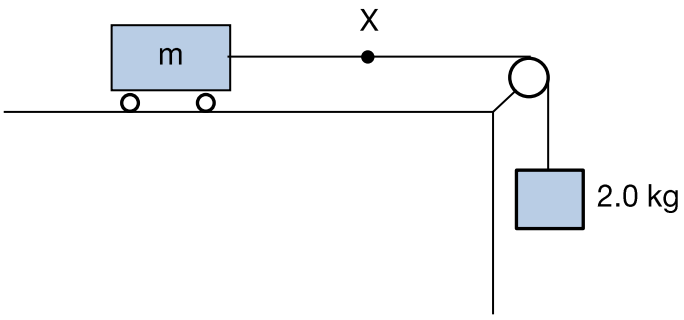
(A) 9 $kg\,m\,s^{-1}$

(B) 6 $kg\,m\,s^{-1}$

(C) 18 $kg\,m\,s^{-1}$

(D) 27 $kg\,m\,s^{-1}$

17 A trolley of unknown mass is connected by a light inextensible string over a frictionless pulley to a mass of 2.0 kg as shown below.



The trolley is on a **rough** horizontal surface and is accelerating at 2.6 $m\,s^{-2}$. Air resistance is negligible.

The tension in the string at X is closest to:

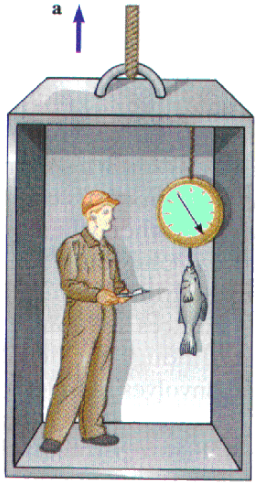
(A) 5.2 N

(B) 14 N

(C) 20 N

(D) 25 N

18 A fish of mass 3.5 kg is weighed by a man a with a spring balance inside a lift that is accelerating upwards at 2.3 $m\,s^{-2}$.



Determine the mass that the spring balance will measure while the lift is accelerating.

(A) 2.7 kg

(B) 3.7 kg

(C) 4.3 kg

(D) 5.8 kg

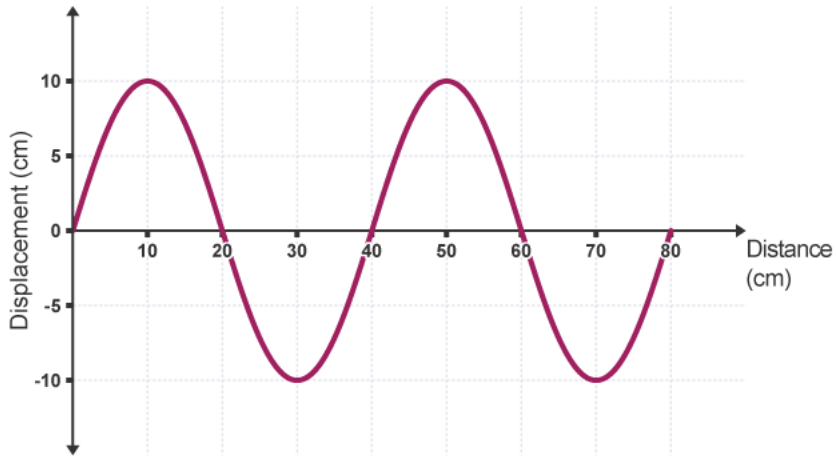
SECTION II: Part A (17 Marks)

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

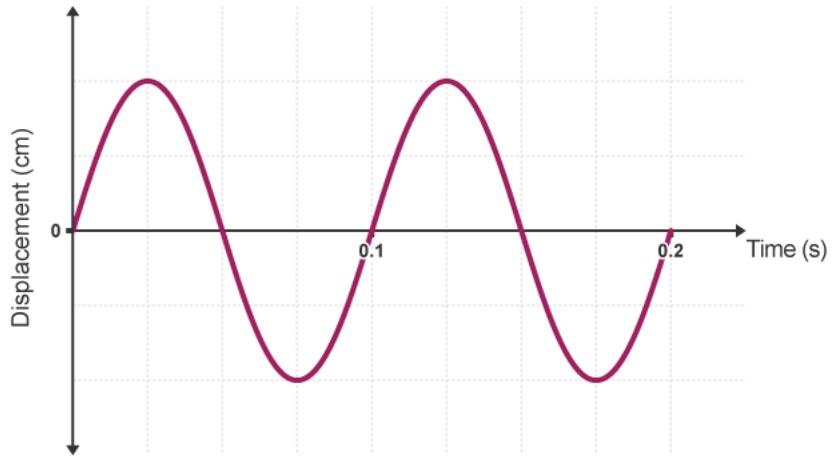
CANDIDATE NUMBER							

Question 19 (3 marks) **Marks**

The graph below shows a vertical displacement versus horizontal distance graph for a wave travelling to the right.



The graph below shows the vertical displacement versus time of a point in the medium.



(a) Determine the frequency of the wave.

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(b) Determine the velocity of the wave.

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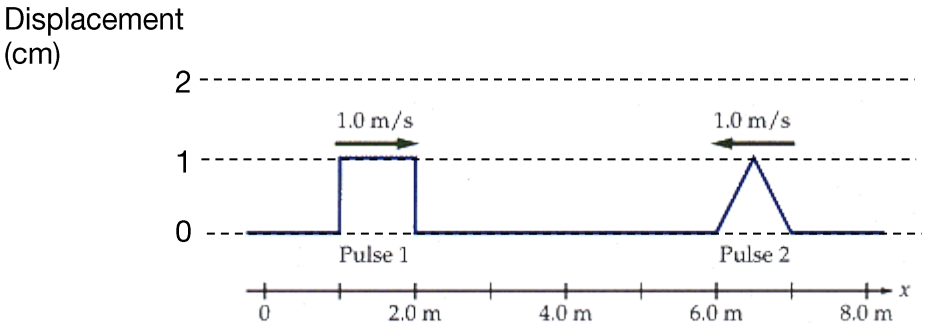
Question 20 (3 marks) **Marks**

The diagram below shows two wave pulses approaching each other on a stretched string at time t = 0 s. Both pulses have a speed of 1.0 m s^{-1}.



(a) Determine the time when the leading edge of each pulse first meets.

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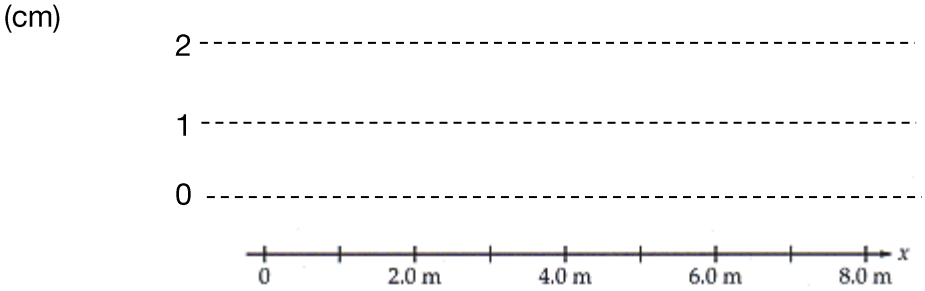
(b) Draw the shape of the string due to the two pulses at t = 2.5 s later on the empty graph below.



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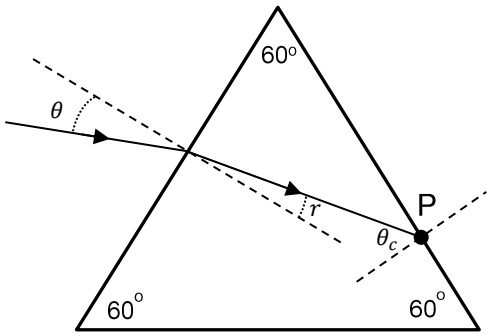
Question 21 (4 marks) **Marks**

The diagram below shows a light ray passing from air into a triangular glass block, with a refractive index of 1.5.



(a) Calculate the critical angle, θ_c, of the ray at point P. **1**

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(b) **Calculate the smallest** angle, θ, at which the ray does not undergo total internal reflection when it hits the second surface at point P. **3**

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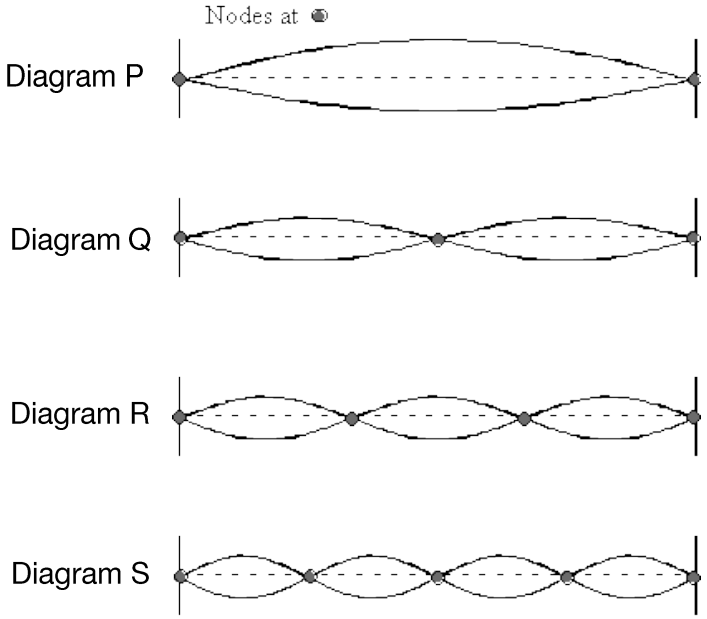
Question 22 (4 marks) **Marks**

A series of standing waves is produced in a string as shown below. The fundamental mode of vibration is shown in diagram P and diagram S was produced when the string was driven by an oscillator of frequency 120 Hz. The length of the string is 4 m.



(a) Determine the wavelength of the wave shown in diagram S.

..... **1**

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(b) Determine the speed of the wave in the string.

..... **1**

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(c) Determine the fundamental frequency of the wave.

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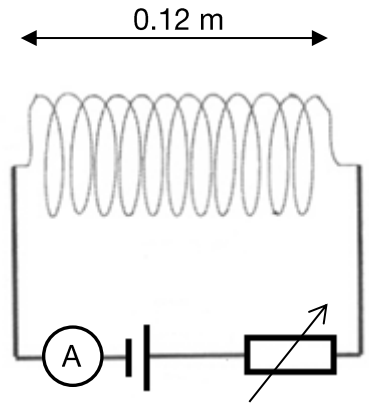
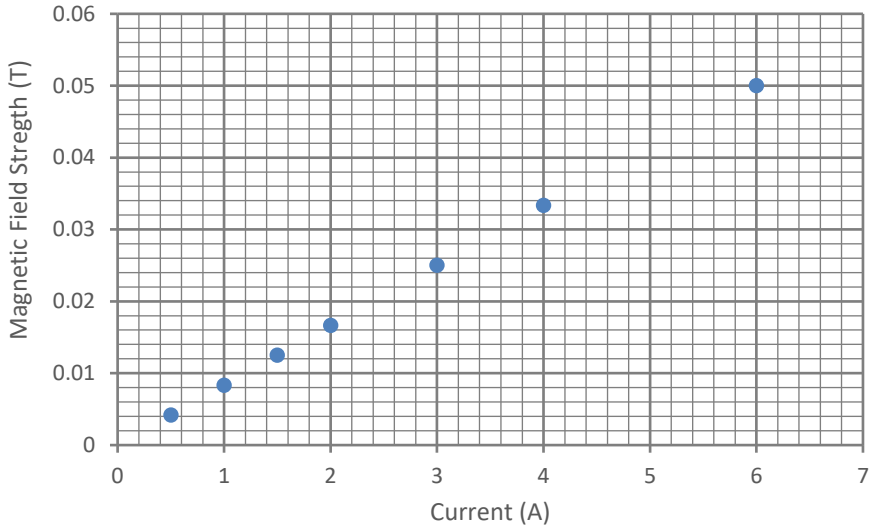
Question 23 (3 marks) **Marks**

The diagram below shows a solenoid of length 0.12 m connected to a power source.



The current through the solenoid is varied and the magnetic field strength within the solenoid is measured. This information is plotted in the graph shown below.



Using the graph, determine the number of turns of wire in the solenoid. **3**

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Section II extra writing space

If you use this space, clearly indicate which question you are answering.

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SECTION II: Part B (16 Marks)

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

CANDIDATE NUMBER							

Question 24 (6 marks) **Marks**

In the spaces below, draw diagrams to represent:

(a) the electric field around the two point charges shown.

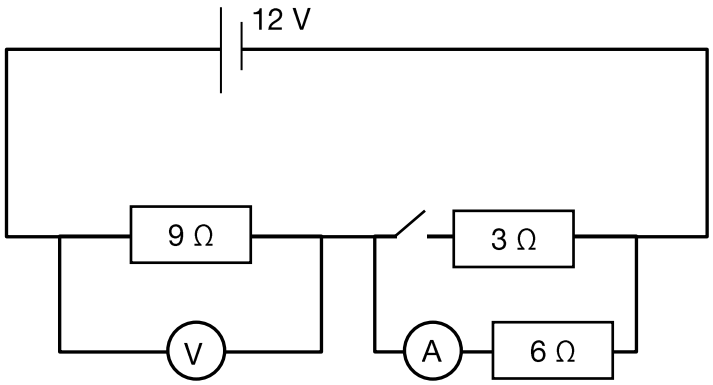
3

(b) the magnetic field around the current-carrying wire shown.

3

Question 25 (6 marks) **Marks**

Consider the circuit shown below.



Calculate the readings on the ammeter and voltmeter when:

(a) the switch is open.

i. Ammeter reading

..... **1**

ii. Voltmeter reading

..... **1**

(b) the switch is closed.

i. Ammeter reading

..... **2**

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ii. Voltmeter reading

..... **2**

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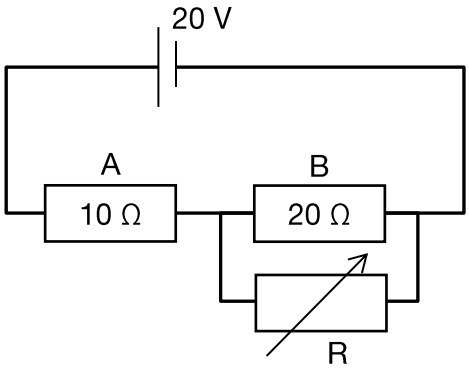
Question 26 (4 marks) **Marks**

Consider the circuit shown below.



To what resistance must the variable resistor, R, be set to ensure that the power dissipated by resistor A is equal to the power dissipated by resistor B? **4**

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Section II extra writing space

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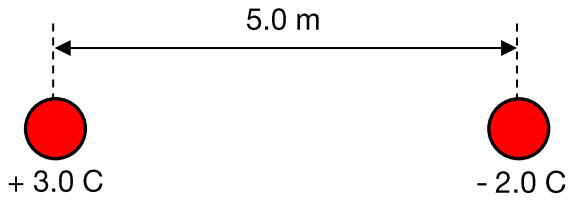
SECTION II: Part C (17 Marks)

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

CANDIDATE NUMBER							

Question 27 (2 marks) **Marks**

The diagram below shows two charges separated by a distance of 5.0 m.



Calculate the electrostatic force on the -2.0 C charge.

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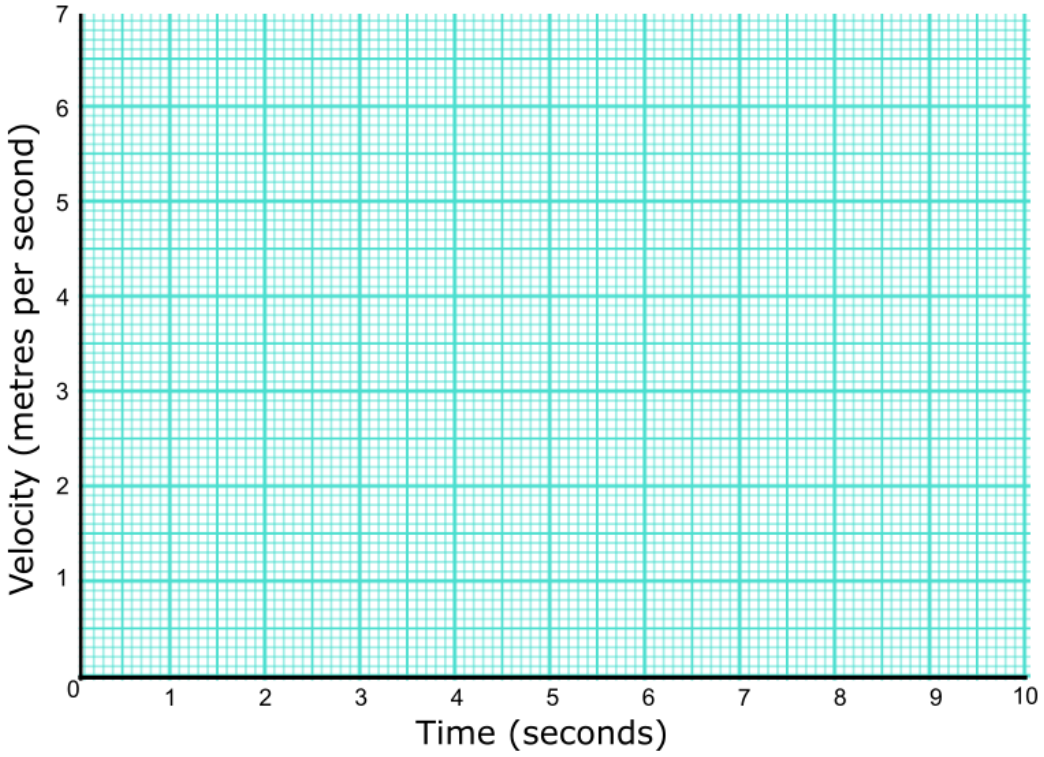
Question 28 (8 marks) **Marks**

A model train is placed on a length of straight track.

- It starts from rest with a constant acceleration for 5 s, reaching a velocity of 6 m s^{-1}.
- It then has a constant velocity for the next 2 seconds.
- It then slows down with constant acceleration, coming to a complete stop after a further 3 s.

(a) Plot a corresponding graph of velocity versus time of this motion on the axes below.



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Question 28 continued on next page.

Question 28 continued. **Marks**

(b) Use your graph, or otherwise, to calculate:

i. the magnitude of the acceleration of the train between 0 and 5 s.

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ii. the total distance travelled by the train.

..... **2**

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iii. the average speed of the train for the 10 s of its motion.

..... **1**

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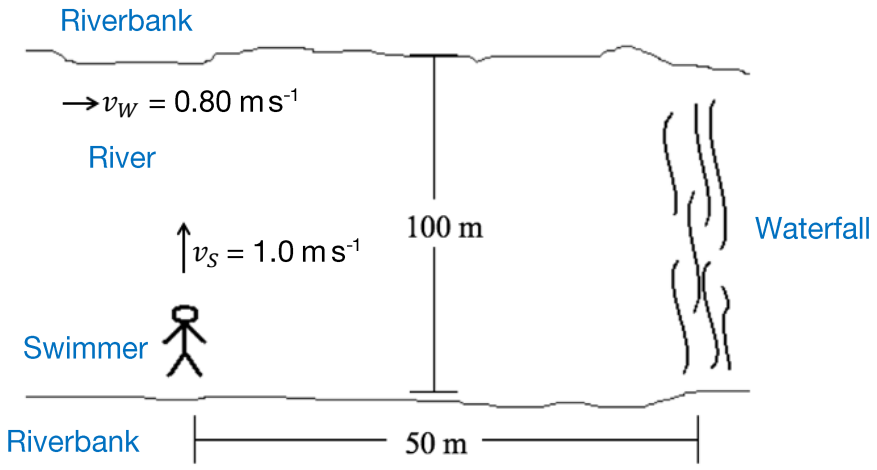
Question 29 (7 marks) **Marks**

A swimmer is trying to swim across a 100 m wide river. A dangerous waterfall which is 50.0 m down the river from his starting point is threatening to drown any unsuspecting swimmers. The swimmer can swim at a speed of v_S = 1.0 m s^{-1} relative to the water and the speed of the water is v_W = 0.80 m s^{-1}. He assesses two strategies to cross the river.

(a) The swimmer's first strategy is to start out by aiming himself straight for the other bank, always perpendicular to the edge of the river as depicted in the following diagram.



i. How long will it take him to reach the far riverbank this way?

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ii. What distance downstream would the swimmer arrive on the opposite riverbank?

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Question 29 continued on next page.

Question 29 continued. **Marks**

(b) The swimmer is cautious and decides to investigate a second strategy where he swims at the same speed but at an angle so that he will end up landing directly opposite his starting point (i.e. his v_S velocity is the same magnitude but a different direction).

i. Sketch a vector diagram showing the velocity of the swimmer, v_S, relative to the water, the velocity of the water, v_W, relative to the riverbank, and the velocity of the swimmer relative to the riverbank (label v_R) that will achieve this aim.

3

ii. How long will it take him to reach the opposite shore using this new strategy?

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Section II extra writing space

If you use this space, clearly indicate which question you are answering.

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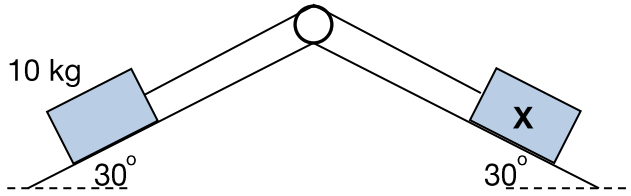
SECTION II: Part D (15 Marks)

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

CANDIDATE NUMBER							

Question 30 (2 marks) **Marks**

Two objects on two frictionless inclined planes are connected by a light inextensible string over a pulley as shown in the diagram below.



The acceleration of object X was 0.8 m s^{-2} down the plane.

Calculate the mass of object X.

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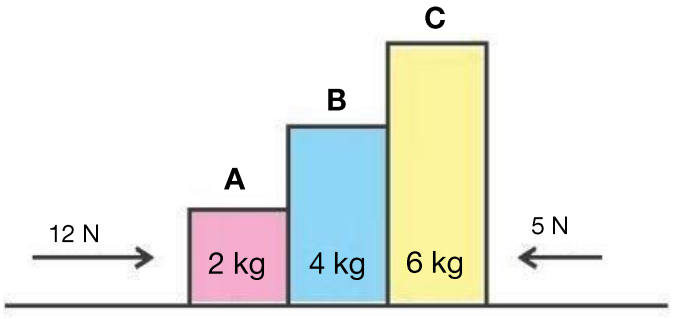
Question 31 (4 marks) **Marks**

Three blocks, A, B and C, are on a frictionless surface pushed by two forces as depicted in the diagram.



(a) Calculate the magnitude of the acceleration of the three blocks. **1**

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(b) Calculate the magnitude of the net force on box B. **1**

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(c) Determine the magnitude of the force that block C is applying to block B. **2**

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Question 32 (7 marks) **Marks**

A ball is launched vertically upwards from ground level at a speed of 15 $m\,s^{-1}$.

(a) If the ball falls back to ground level, calculate the time of flight.

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(b) Calculate the maximum height reached by the ball.

..... **2**

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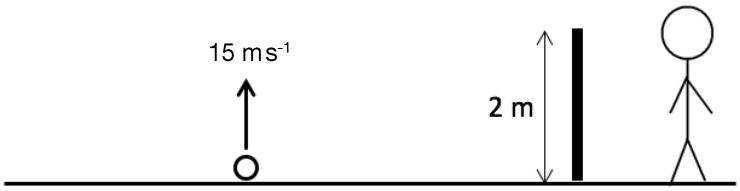
(c) A man is watching the ball's flight from over a fence so that he can only see it when it is at least 2 m above the ground. For what length of time is the ball visible to the man? (*ignore parallax issues*)



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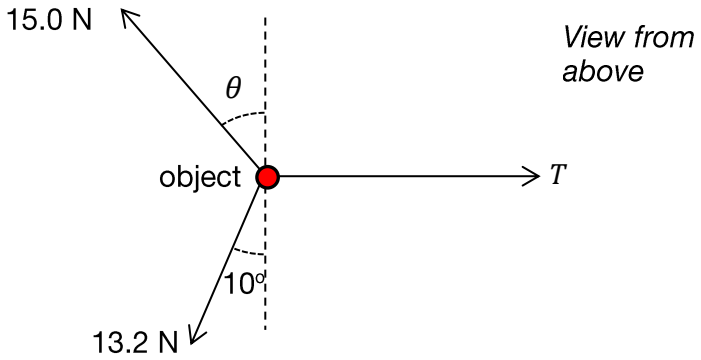
Question 33 (2 marks) **Marks**

An object is on a horizontal frictionless surface. It is **held in equilibrium** by three horizontal strings with different tensions, as shown in the diagram below. The diagram is not drawn to scale.



(a) Determine the angle, θ.

..... **1**

.....

.....

(b) Calculate the magnitude of the tension, T.

..... **1**

.....

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Section II extra writing space

If you use this space, clearly indicate which question you are answering.

Do NOT write in this area.

Section II extra writing space

If you use this space, clearly indicate which question you are answering.

Do NOT write in this area.

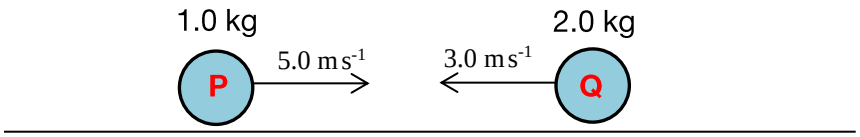
SECTION II: Part E (13 Marks)

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

CANDIDATE NUMBER							

Question 34 (3 marks) **Marks**

Two balls collide on a frictionless horizontal surface as shown in the diagram below. Ball P of mass 1.0 kg is initially travelling with a speed of 5.0 m s^{-1} when it collides with ball Q of mass 2.0 kg which is travelling at 3.0 m s^{-1} towards P.



The balls make a perfectly elastic collision.

Calculate the velocities of ball P and ball Q immediately after the collision (v_P and v_Q respectively).

3

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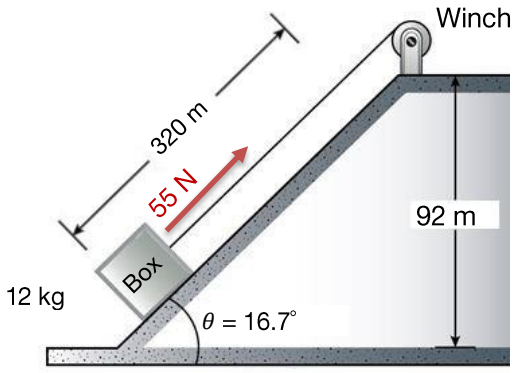
Question 35 (6 marks) **Marks**

A box is pulled 320 m up a rough ramp at a constant speed by means of an electrically powered winch. The tension force in the cable pulling the box is 55 N. The box is raised through a vertical height of 92 m. The mass of the box is 12 kg. The angle of the ramp is $\theta = 16.7^{\circ}$.



(a) Calculate the work done by the cable in pulling the box up the ramp.

..... **1**

.....

(b) Calculate the gain in gravitational potential energy in moving the box up the ramp (i.e. 92 m vertically).

..... **1**

.....

(c) Calculate the energy lost due to friction.

..... **1**

.....

Question 35 continued on next page.

Question 35 continued. **Marks**

(d) Calculate the magnitude of the frictional force on the box as it moves up the ramp.

..... **1**

.....

.....

(e) Calculate the magnitude of the normal force on the box.

..... **1**

.....

.....

(f) Calculate the co-efficient of kinetic friction between the box and the ramp (μ_k).

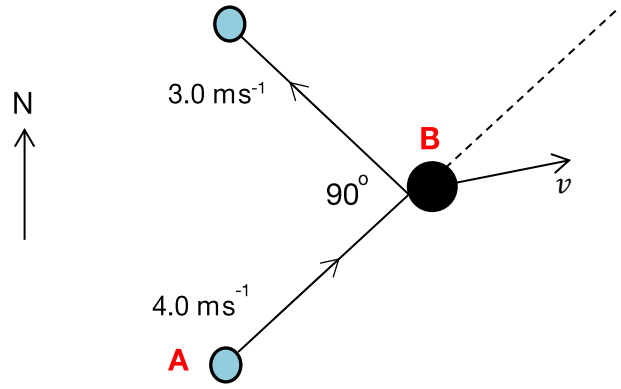
..... **1**

.....

.....

Question 36 (4 marks) **Marks**

A small ball A of mass 1.2 kg travelling North-East at 4.0 m s^{-1} strikes a stationary ball B of mass 4.8 kg. It bounces off at 90° to its original direction (or North-West) travelling at 3.0 m s^{-1} as shown in the following diagram. Ball B is travelling at velocity v after the collision.



(a) Determine the magnitude of the change in momentum of ball A caused by the collision with ball B. **2**

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(b) If the impact with the lasts 2.5×10^{-4} s what was the magnitude of the average force exerted by ball A on ball B during the impact? **1**

.....

.....

(c) Determine the magnitude of the velocity, v, of ball B after the collision. **1**

.....

.....

END OF EXAMINATION

Section II extra writing space

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Office Use Only – Do NOT write anything, or make any marks below this line.

Section II extra writing space

If you use this space, clearly indicate which question you are answering.

Do NOT write in this area.

HIGHER SCHOOL CERTIFICATE
EXAMINATION

Physics

DATA SHEET

Charge on 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	$340\ \text{m s}^{-1}$
Earth's gravitational acceleration, g	$9.8\ \text{m s}^{-2}$
Speed of light, c	$3.00 \times 10^{8}\ \text{m s}^{-1}$
Electric permittivity constant, ε_0	$8.854 \times 10^{-12}\ \text{A}^2\,\text{s}^4\,\text{kg}^{-1}\,\text{m}^{-3}$
Magnetic permeability constant, μ_0	$4\pi \times 10^{-7}\ \text{N A}^{-2}$
Universal gravitational constant, G	$6.67 \times 10^{-11}\ \text{N m}^2\,\text{kg}^{-2}$
Mass of Earth, M_E	6.0×10^{24} kg
Radius of Earth, r_E	6.371×10^{6} m
Planck constant, h	6.626×10^{-34} J s
Rydberg constant, R (hydrogen)	$1.097 \times 10^{7}\ \text{m}^{-1}$
Atomic mass unit, u	1.661×10^{-27} kg $931.5\ \text{MeV}/c^2$
1 eV	1.602×10^{-19} J
Density of water, ρ	$1.00 \times 10^{3}\ \text{kg m}^{-3}$
Specific heat capacity of water	$4.18 \times 10^{3}\ \text{J kg}^{-1}\,\text{K}^{-1}$
Wein's displacement constant, b	$2.898 \times 10^{-3}\ \text{m K}$

FORMULAE SHEET

Motion, forces and gravity

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

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

$$\Delta U = mg\Delta h$$

$$P = \frac{\Delta E}{\Delta t}$$

$$\sum \frac{1}{2}mv^2_{\text{before}} = \sum \frac{1}{2}mv^2_{\text{after}}$$

$$\Delta \vec{p} = \vec{F}_{\text{net}}\Delta t$$

$$\omega = \frac{\Delta \theta}{t}$$

$$\tau = r_{\perp}F = rF\sin\theta$$

$$v = \frac{2\pi r}{T}$$

$$U = -\frac{GMm}{r}$$

$$v = u + at$$

$$\vec{F}_{\text{net}} = m\vec{a}$$

$$W = F_{\parallel}s = Fs\cos\theta$$

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

$$P = F_{\parallel}v = Fv\cos\theta$$

$$\sum m\vec{v}_{\text{before}} = \sum m\vec{v}_{\text{after}}$$

$$a_{\text{c}} = \frac{v^2}{r}$$

$$F_{\text{c}} = \frac{mv^2}{r}$$

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

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

Waves and thermodynamics

$$v = f\lambda$$

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

$$d\sin\theta = m\lambda$$

$$n_{\text{x}} = \frac{c}{v_{\text{x}}}$$

$$I = I_{\max}\cos^2\theta$$

$$Q = mc\Delta T$$

$$f_{\text{beat}} = \left| f_2 - f_1 \right|$$

$$f' = f\frac{\left(v_{\text{wave}} + v_{\text{observer}}\right)}{\left(v_{\text{wave}} - v_{\text{source}}\right)}$$

$$n_1\sin\theta_1 = n_2\sin\theta_2$$

$$\sin\theta_{\text{c}} = \frac{n_2}{n_1}$$

$$I_1r_1^2 = I_2r_2^2$$

$$\frac{Q}{t} = \frac{kA\Delta T}{d}$$

Electricity and magnetism

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

$$V = \frac{\Delta U}{q}$$

$$W = qV$$

$$W = qEd$$

$$B = \frac{\mu_0 I}{2\pi r}$$

$$B = \frac{\mu_0 NI}{L}$$

$$\Phi = B_{||}A = BA\cos\theta$$

$$\varepsilon = -N\frac{\Delta\Phi}{\Delta t}$$

$$\frac{V_\mathrm{p}}{V_\mathrm{s}} = \frac{N_\mathrm{p}}{N_\mathrm{s}}$$

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

$$F = \frac{1}{4\pi\varepsilon_0}\frac{q_1 q_2}{r^2}$$

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

$$V = IR$$

$$F = qv_\perp B = qvB\sin\theta$$

$$F = lI_\perp B = lIB\sin\theta$$

$$\frac{F}{l} = \frac{\mu_0}{2\pi}\frac{I_1 I_2}{r}$$

$$\tau = nIA_\perp B = nIAB\sin\theta$$

$$V_\mathrm{p} I_\mathrm{p} = V_\mathrm{s} I_\mathrm{s}$$

Quantum, special relativity and nuclear

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

$$K_\mathrm{max} = hf - \phi$$

$$\lambda_\mathrm{max} = \frac{b}{T}$$

$$E = mc^2$$

$$E = hf$$

$$\frac{1}{\lambda} = R\left(\frac{1}{n_\mathrm{f}^2} - \frac{1}{n_\mathrm{i}^2}\right)$$

$$t = \frac{t_0}{\sqrt{\left(1 - \frac{v^2}{c^2}\right)}}$$

$$l = l_0\sqrt{\left(1 - \frac{v^2}{c^2}\right)}$$

$$p_\mathrm{v} = \frac{m_0 v}{\sqrt{\left(1 - \frac{v^2}{c^2}\right)}}$$

$$N_\mathrm{t} = N_0 e^{-\lambda t}$$

$$\lambda = \frac{\ln 2}{t_{\frac{1}{2}}}$$

PERIODIC TABLE OF THE ELEMENTS

KEY	
Atomic Number	79
Symbol	Au
Standard Atomic Weight	197.0
Name	Gold

1 H 1.008 Hydrogen																	2 He 4.003 Helium
3 Li 6.941 Lithium	4 Be 9.012 Beryllium											5 B 10.81 Boron	6 C 12.01 Carbon	7 N 14.01 Nitrogen	8 O 16.00 Oxygen	9 F 19.00 Fluorine	10 Ne 20.18 Neon
11 Na 22.99 Sodium	12 Mg 24.31 Magnesium											13 Al 26.98 Aluminium	14 Si 28.09 Silicon	15 P 30.97 Phosphorus	16 S 32.07 Sulfur	17 Cl 35.45 Chlorine	18 Ar 39.95 Argon
19 K 39.10 Potassium	20 Ca 40.08 Calcium	21 Sc 44.96 Scandium	22 Ti 47.87 Titanium	23 V 50.94 Vanadium	24 Cr 52.00 Chromium	25 Mn 54.94 Manganese	26 Fe 55.85 Iron	27 Co 58.93 Cobalt	28 Ni 58.69 Nickel	29 Cu 63.55 Copper	30 Zn 65.38 Zinc	31 Ga 69.72 Gallium	32 Ge 72.64 Germanium	33 As 74.92 Arsenic	34 Se 78.96 Selenium	35 Br 79.90 Bromine	36 Kr 83.80 Krypton
37 Rb 85.47 Rubidium	38 Sr 87.61 Strontium	39 Y 88.91 Yttrium	40 Zr 91.22 Zirconium	41 Nb 92.91 Niobium	42 Mo 95.96 Molybdenum	43 Tc Technetium	44 Ru 101.1 Ruthenium	45 Rh 102.9 Rhodium	46 Pd 106.4 Palladium	47 Ag 107.9 Silver	48 Cd 112.4 Cadmium	49 In 114.8 Indium	50 Sn 118.7 Tin	51 Sb 121.8 Antimony	52 Te 127.6 Tellurium	53 I 126.9 Iodine	54 Xe 131.3 Xenon
55 Cs 132.9 Caesium	56 Ba 137.3 Barium	57–71 Lanthanoids	72 Hf 178.5 Hafnium	73 Ta 180.9 Tantalum	74 W 183.9 Tungsten	75 Re 186.2 Rhenium	76 Os 190.2 Osmium	77 Ir 192.2 Iridium	78 Pt 195.1 Platinum	79 Au 197.0 Gold	80 Hg 200.6 Mercury	81 Tl 204.4 Thallium	82 Pb 207.2 Lead	83 Bi 209.0 Bismuth	84 Po Polonium	85 At Astatine	86 Rn Radon
87 Fr Francium	88 Ra Radium	89–103 Actinoids	104 Rf Rutherfordium	105 Db Dubnium	106 Sg Seaborgium	107 Bh Bohrium	108 Hs Hassium	109 Mt Meitnerium	110 Ds Darmstadtium	111 Rg Roentgenium	112 Cn Copernicium	113 Nh Nihonium	114 Fl Flerovium	115 Mc Moscovium	116 Lv Livermorium	117 Ts Tennessine	118 Og Oganesson

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

Standard atomic weights are abridged to four significant figures.

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

Information on elements with atomic numbers 113 and above is sourced from the International Union of Pure and Applied Chemistry Periodic Table of the Elements (November 2016 version).

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

SYDNEY GRAMMAR SCHOOL

CANDIDATE NUMBER

2019 FORM V ANNUAL EXAMINATION

Physics

Section I - Multiple Choice

Select the alternative A, B, C or D that best answers the question. Fill in the response oval 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 the correct answer by writing the word ~~correct~~ and drawing an arrow as follows.

correct

A ✗ B ✗ C ○ D ○

Start Here →

1.	A ○	B ○	C ○	D ○
2.	A ○	B ○	C ○	D ○
3.	A ○	B ○	C ○	D ○
4.	A ○	B ○	C ○	D ○
5.	A ○	B ○	C ○	D ○
6.	A ○	B ○	C ○	D ○
7.	A ○	B ○	C ○	D ○
8.	A ○	B ○	C ○	D ○
9.	A ○	B ○	C ○	D ○
10.	A ○	B ○	C ○	D ○
11.	A ○	B ○	C ○	D ○
12.	A ○	B ○	C ○	D ○
13.	A ○	B ○	C ○	D ○
14.	A ○	B ○	C ○	D ○
15.	A ○	B ○	C ○	D ○
16.	A ○	B ○	C ○	D ○
17.	A ○	B ○	C ○	D ○
18.	A ○	B ○	C ○	D ○

SYDNEY GRAMMAR SCHOOL

2019
ANNUAL EXAMINATION

PHYSICS CRIB
Form V

STRUCTURE OF PAPER

- Section I: Multiple Choice (18 marks)

  Answer all questions on the Multiple-Choice Answer Sheet.

- Section II: Extended Response (78 marks)

  Answer all parts of the questions in the spaces provided in the Examination Paper.

- Board approved calculators may be used

EXAMINATION

Date: Thursday 5th September
Duration: 2 hours
Marks: 96

CHECKLIST

In the stapled bundle each boy should have the following:

- ☐ 1 Examination Paper
- ☐ 1 Data and Formula Sheet
- ☐ 1 Multiple-Choice Answer Sheet

EXAM INSTRUCTIONS

- Remove the centre staple and hand in all parts of the examination in a neat bundle.
- WRITE YOUR **CANDIDATE NUMBER** IN THE SPACE PROVIDED AT THE TOP OF EACH SEPARATE SECTION.
- There is a Data/Formula sheet included at the end of the paper.
- Responses requiring more writing space should be clearly be marked **CONTINUED**. Additional extra writing space is provided at the end of each section. When the response is continued on extra writing paper it should clearly indicate the question number.

Master in charge: MRW

Form Average for Multiple Choice

15/18

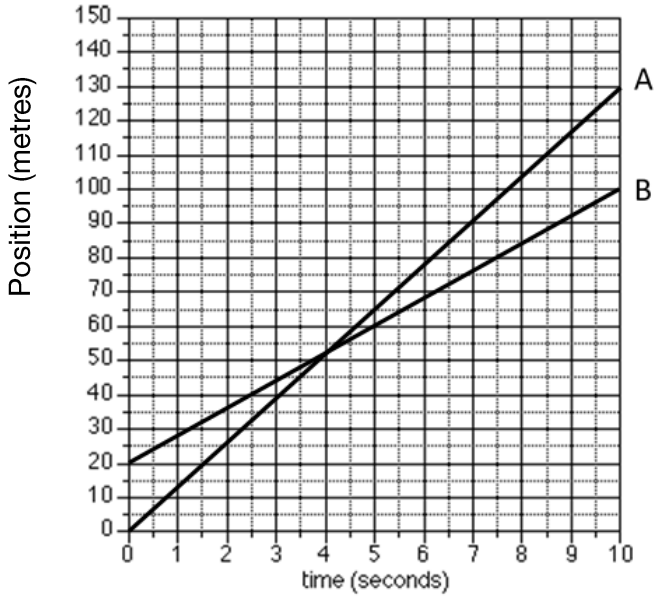
Question	Answer	A	B	C	D
1	**B**	16%	83%	0%	1%
2	**D**	10%	8%	0%	82%
3	**C**	5%	1%	74%	21%
4	**A**	77%	21%	1%	1%
5	**D**	1%	10%	3%	86%
6	**C**	10%	19%	69%	3%
7	**D**	0%	2%	2%	96%
8	**B**	4%	88%	8%	0%
9	**D**	1%	14%	5%	80%
10	**A**	66%	7%	25%	1%
11	**A**	100%	0%	0%	0%
12	**D**	0%	0%	1%	99%
13	**B**	2%	98%	0%	0%
14	**C**	3%	7%	90%	0%
15	**B**	3%	94%	2%	0%
16	**D**	12%	5%	9%	75%
17	**B**	14%	65%	11%	11%
18	**C**	10%	2%	80%	8%

SECTION I: MULTIPLE CHOICE

Attempt ALL Questions
Use the Multiple-Choice Answer Sheet.

Questions 1 to 3 refer to the information below.

Two Go Karts, A and B, are moving along a straight track in the same direction. The graph below represents their relative positions during a 10-second time interval.



1 At what time do they have the same displacement?

(A) At 0 s

(B) At 4 s

(C) At all times in the 10 s interval.

(D) Not at any time in the 10 s interval.

2 At what time do they have the same velocity?

(A) At 0 s

(B) At 4 s

(C) At all times in the 10 s interval.

(D) Not at any time in the 10 s interval.

3 At what time do they have the same acceleration?

(A) At 0 s

(B) At 4 s

(C) At all times in the 10 s interval.

(D) Not at any time in the 10 s interval.

4 A man walks 20 m East, and then 40 m North. His displacement at the end of this walk will be:

(A) 45 m at 27° East of North

(B) 45 m at 63° East of North

(C) 60 m at 27° East of North

(D) 60 m at 63° East of North

5 A car travelling initially at 8.0 m s^{-1} West accelerates over an interval of 15 s until it reaches 10 m s^{-1} East. What is the car's average acceleration during this time?

(A) 0.13 m s^{-2} West

(B) 0.13 m s^{-2} East

(C) 1.2 m s^{-2} West

(D) 1.2 m s^{-2} East

6 An object, P, of mass m, moving with a velocity, v, collides with another object, Q, of mass $\frac{m}{2}$ moving in the same direction with velocity $\frac{v}{2}$ as shown in the following diagram.

During the collision object P exerts an average force, F, on object Q.

During the collision object Q exerts an average force on object P of magnitude:

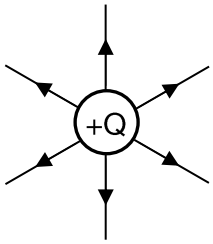
(A) $\frac{F}{2}$

(B) $\frac{F}{4}$

(C) F

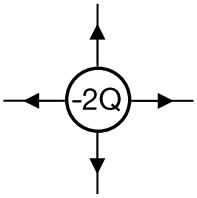
(D) $2F$

7 The following diagram shows the electric field around a single point charge, +Q.

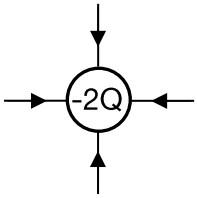


Which diagram below shows the electric field about a point charge -2Q?

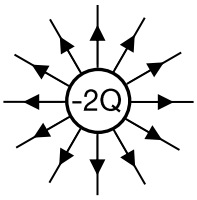
(A)



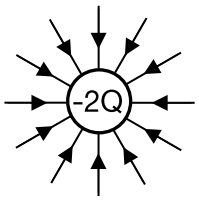
(B)



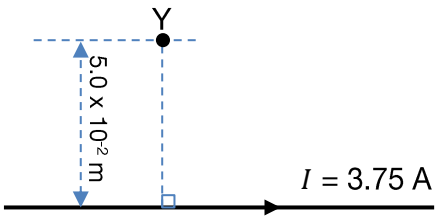
(C)



(D)



8 In the diagram below, a long, straight wire carries a current of 3.75 A as shown.



Calculate the magnitude of the magnetic field strength at point Y, which is 5.0×10^{-2} m away from the wire.

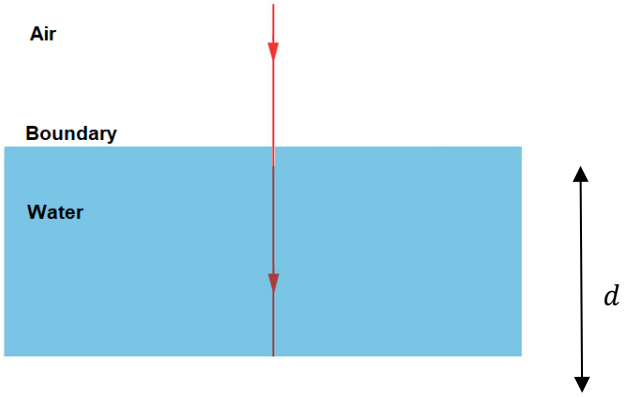
(A) 2.7×10^{-9} T

(B) 1.5×10^{-5} T

(C) 3.0×10^{-4} T

(D) 5.6×10^{-4} T

9 A light ray travels along the normal from air into water as shown in the diagram below. The speed of light in air is c.



If the refractive index of the water is n and the depth of the water is d metres, then the time taken for the light ray to travel distance, d, through the water in seconds is:

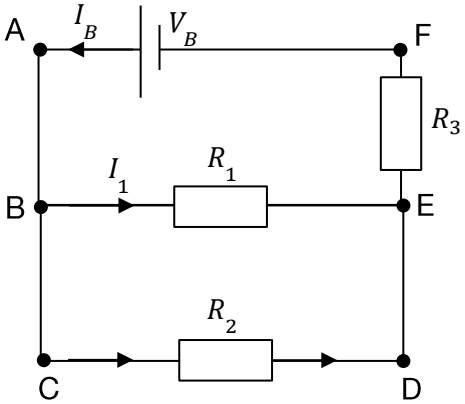
(A) $\frac{d}{n}$

(B) $\frac{cd}{n}$

(C) $\frac{cn}{d}$

(D) $\frac{dn}{c}$

10 Consider the circuit below:



Which of the following equations is a correct application of Kirchhoff's voltage law to the loop ABEFA?

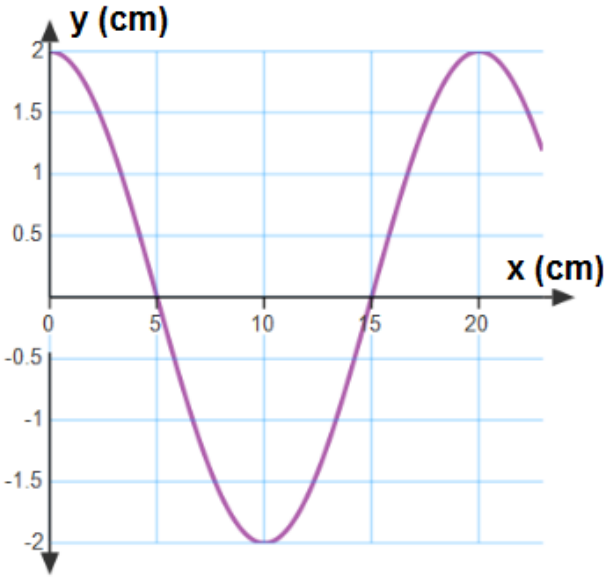
(A) $I_1R_1 + I_BR_3 - V_B = 0$

(B) $(I_B - I_1)R_1 - I_BR_3 - V_B = 0$

(C) $I_1R_1 - (I_B - I_1)R_2 = 0$

(D) $I_BR_2 + I_1R_3 - V_B = 0$

The following graph is used to answer Questions 11 and 12.



The graph above represents the vertical displacement of a wave, y, as a function of its horizontal displacement, x.

11 What is the amplitude of the wave?

(A) 2 cm

(B) 4 cm

(C) 5 cm

(D) 20 cm

12 What is the wavelength of the wave?

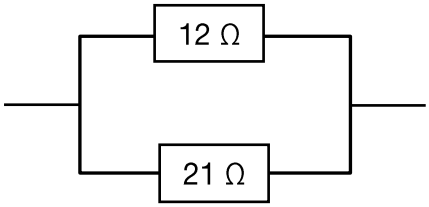
(A) 2 cm

(B) 5 cm

(C) 15 cm

(D) 20 cm

13 Consider the following arrangement of resistors.



Calculate the total resistance of this combination of resistors.

(A) 0.13 Ω

(B) 7.6 Ω

(C) 9.0 Ω

(D) 33 Ω

14 The intensity of light from a globe is 0.12 Wm^{-2} at a distance of 16 m away from it.

Calculate the intensity of the light at a distance of 5.0 m from the globe.

(A) 0.012 Wm^{-2}

(B) 0.38 Wm^{-2}

(C) 1.2 Wm^{-2}

(D) 31 Wm^{-2}

15 A +4.0 C charge placed at point X experiences an electrostatic force of 10 N. The magnitude of the electric field strength at point X is:

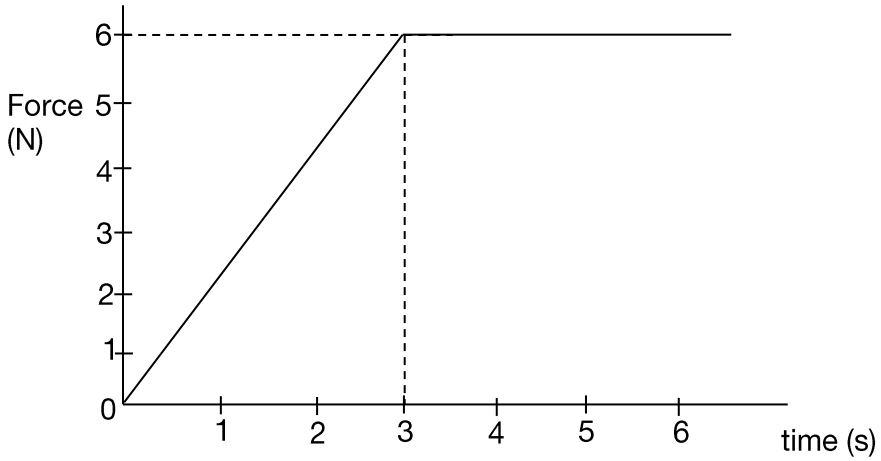
(A) 0.40 NC^{-1}

(B) 2.5 NC^{-1}

(C) 6.0 NC^{-1}

(D) 40 NC^{-1}

16 The graph below shows how the force on a 4.5 kg object varies with time.



What is the magnitude of the object's change in momentum after 6 seconds.

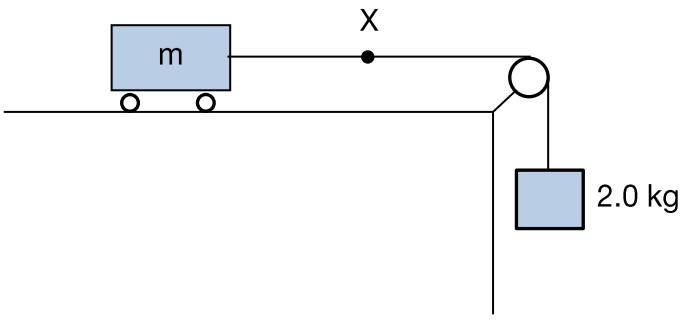
(A) 9 $kg\,m\,s^{-1}$

(B) 6 $kg\,m\,s^{-1}$

(C) 18 $kg\,m\,s^{-1}$

(D) 27 $kg\,m\,s^{-1}$

17 A trolley of unknown mass is connected by a light inextensible string over a frictionless pulley to a mass of 2.0 kg as shown below.



The trolley is on a **rough** horizontal surface and is accelerating at 2.6 $m\,s^{-2}$. Air resistance is negligible.

The tension in the string at X is closest to:

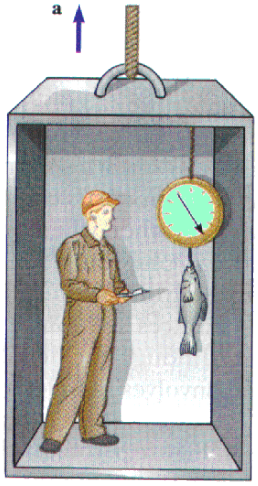
(A) 5.2 N

(B) 14 N

(C) 20 N

(D) 25 N

18 A fish of mass 3.5 kg is weighed by a man a with a spring balance inside a lift that is accelerating upwards at 2.3 $m\,s^{-2}$.



Determine the mass that the spring balance will measure while the lift is accelerating.

(A) 2.7 kg

(B) 3.7 kg

(C) 4.3 kg

(D) 5.8 kg

SECTION II: Part A (17 Marks)

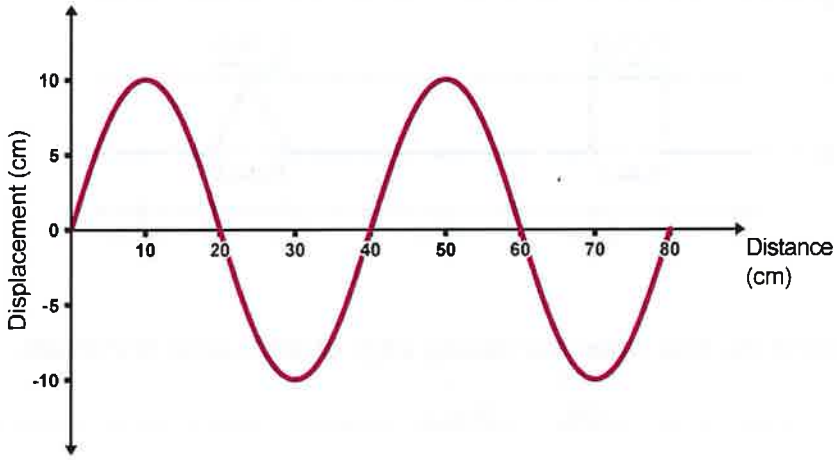
SHW

CANDIDATE NUMBER

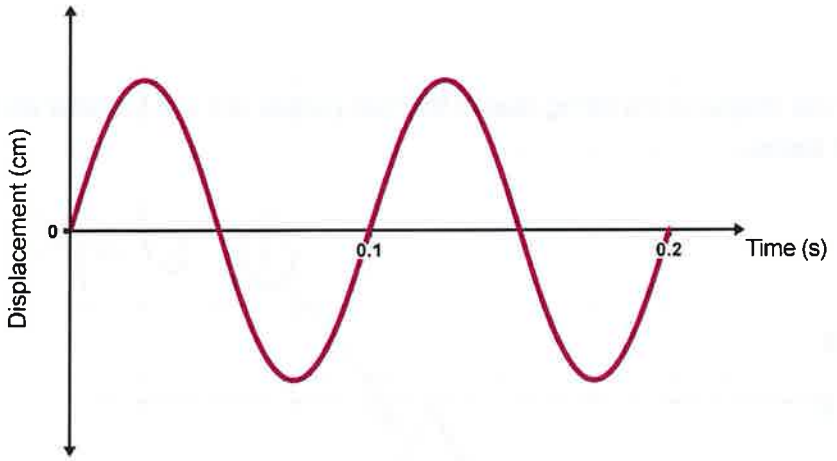
Answer the questions in the spaces provided.
Show all relevant working in questions involving calculations.

Question 19 (3 marks) **Marks**

The graph below shows a vertical displacement versus horizontal distance graph for a wave travelling to the right.



The graph below shows the vertical displacement versus time of a point in the medium.



(a) Determine the frequency of the wave.

10Hz (1) 1

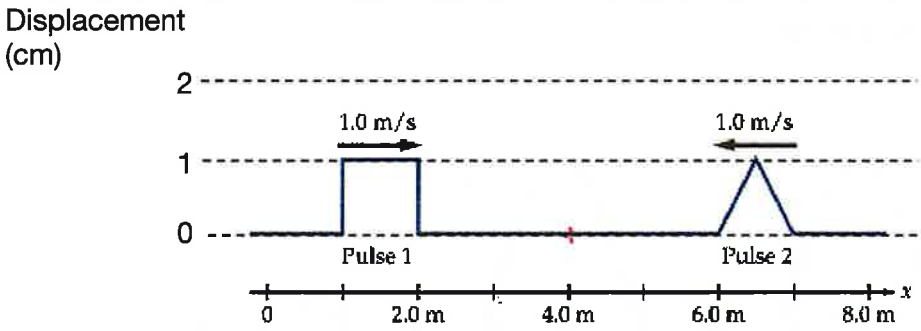
(b) Determine the velocity of the wave.

$V = f\lambda = 10 \times 0.4$ (1)

$= 4\ m/s$ (1) 2

Question 20 (3 marks) **Marks**

The diagram below shows two wave pulses approaching each other on a stretched string at time t = 0 s. Both pulses have a speed of 1.0 m s^{-1}.



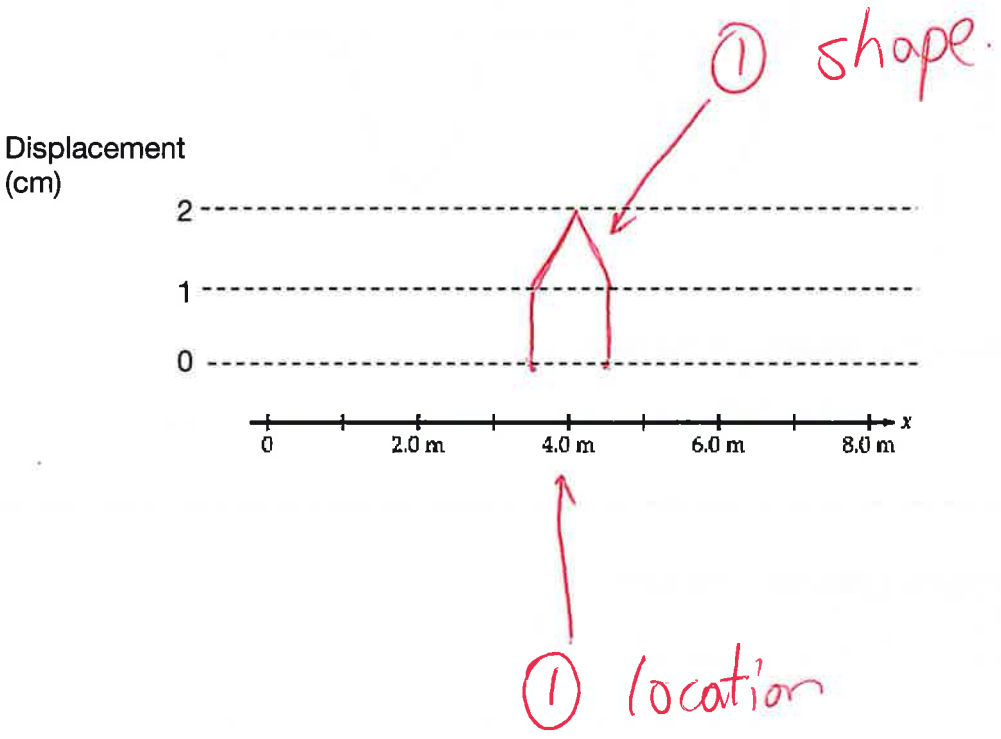
(a) Determine the time when the leading edge of each pulse first meets.

2 sec **1**

.....

.....

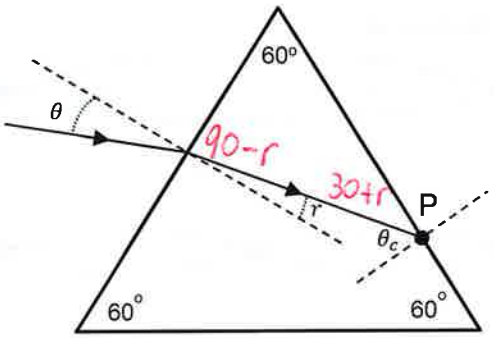
(b) Draw the shape of the string due to the two pulses at t = 2.5 s later on the empty graph below.



2

Question 21 (4 marks) **Marks**

The diagram below shows a light ray passing from air into a triangular glass block, with a refractive index of 1.5.



(a) Calculate the critical angle, θ_c, of the ray at point P. **1**

$\sin\theta_c = \frac{1}{1.5}$

$\theta_c = 41.8°$ (1)

(b) **Calculate the smallest** angle, θ, at which the ray does not undergo total internal reflection when it hits the second surface at point P. **3**

From Δ $\therefore 30+r = 90-(a)$

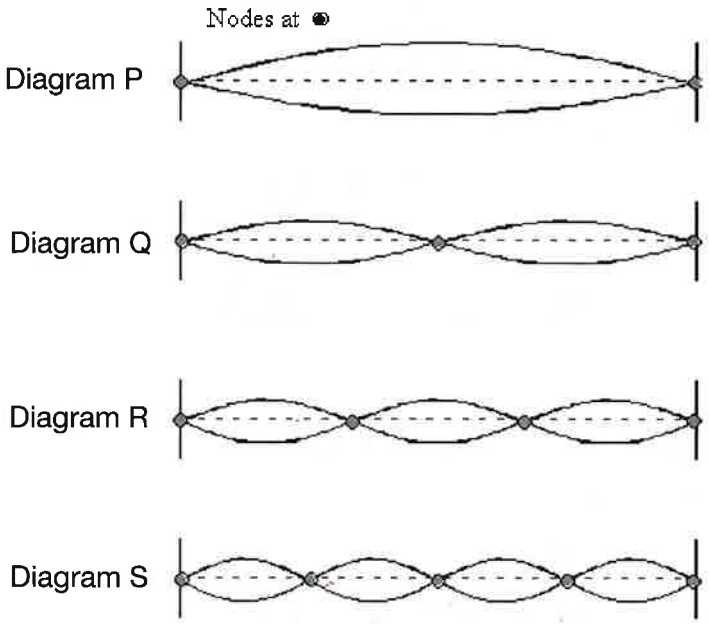
$\therefore r = 18.2°$ (1)

$\frac{\sin\theta}{\sin 18.2} = \frac{1.5}{1}$ $\therefore \theta = 27.9°$ (1)

(1)

Question 22 (4 marks) **Marks**

A series of standing waves is produced in a string as shown below. The fundamental mode of vibration is shown in diagram P and diagram S was produced when the string was driven by an oscillator of frequency 120 Hz. The length of the string is 4 m.



(a) Determine the wavelength of the wave shown in diagram S.

2m

1

(b) Determine the speed of the wave in the string.

$V = f\lambda = 120 \times 2 = 240$ m/s

1

(c) Determine the fundamental frequency of the wave.

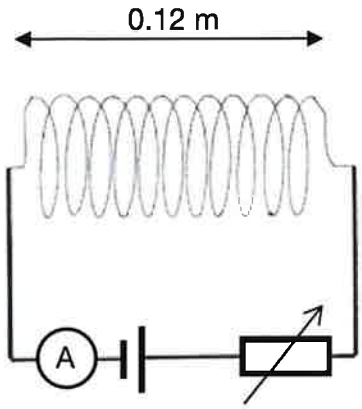
$\frac{120}{4} = 30$ Hz ②

or $f = \frac{V}{\lambda} = \frac{240}{8} = 30$ Hz. ②

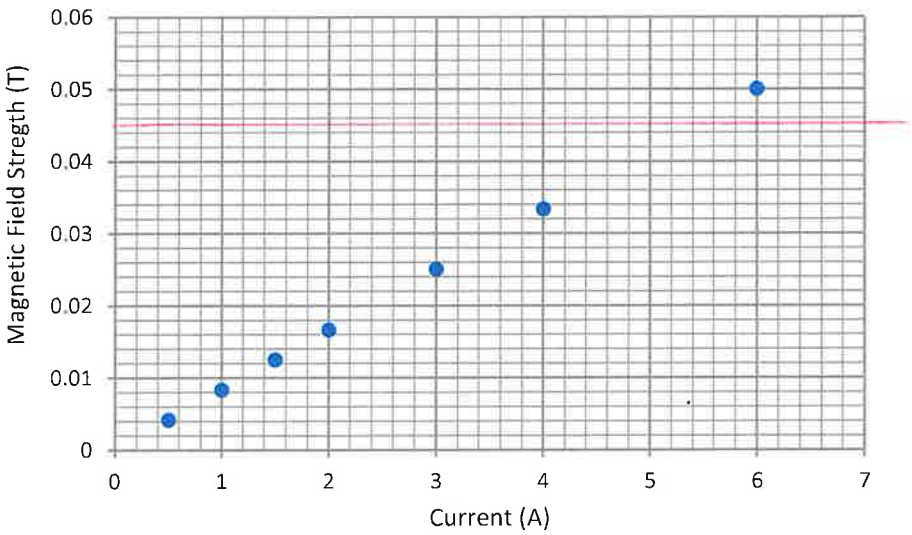
2

Question 23 (3 marks) **Marks**

The diagram below shows a solenoid of length 0.12 m connected to a power source.



The current through the solenoid is varied and the magnetic field strength within the solenoid is measured. This information is plotted in the graph shown below.



Using the graph, determine the number of turns of wire in the solenoid.

3

$B = \mu_0 \frac{NI}{L}$

$\therefore \text{gradient} = \frac{\mu_0 N}{L} = \frac{0.05}{6} = 8.3 \times 10^{-3}$ (1)

$N = \frac{L \times \text{gradient}}{\mu_0} = 796 \text{ turns}$ (1)

$\pm 5\%$

$N = 9.55 \times 10^{4} \times \text{gradient}$ (1) $= 756 \rightarrow 836$

accepted in this range.

Section II extra writing space

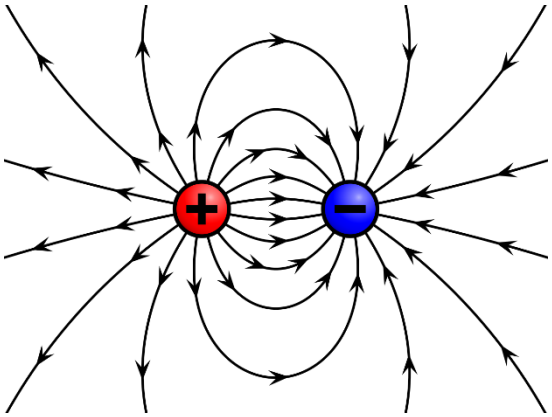
If you use this space, clearly indicate which question you are answering.

Do NOT write in this area.

Question 24 (6 marks) **Marks**

In the spaces below, draw diagrams to represent:

(a) the electric field around the two point charges shown.



*For **3 Marks** I expected something similar to this, with the following details:*

Correct direction of field lines.

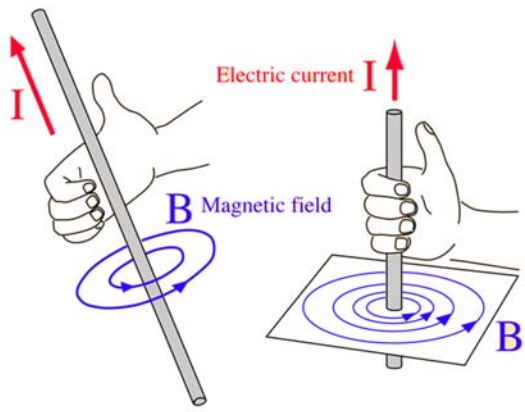
Broadly correct shape both between charges and outside them.

Field lines show symmetry.

Field lines show field getting weaker at large distances.

3

(b) the magnetic field around the current-carrying wire shown.



*For **3 Marks**, I expected something like this (2D version is fine), with the following details:*

Field lines are circular and concentric on the wire.

Field lines point in the correct direction.

Field lines get further apart as the distance from the wire increases.

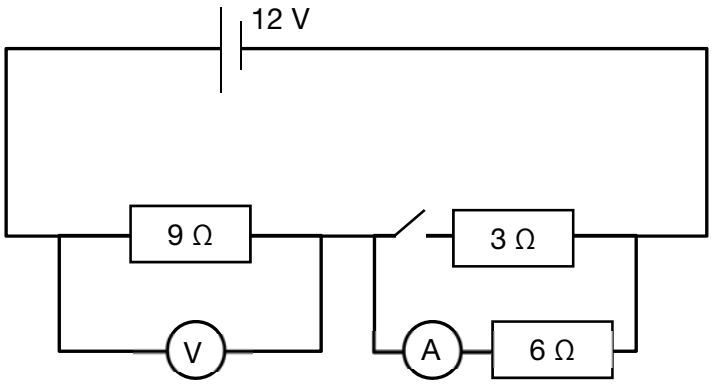
3

NB 1: I was pretty generous about interpreting these criteria!

NB 2: In general, beyond a certain minimum, the more field lines you drew, the less likely you were to get full marks! Keep it simple…

Question 25 (6 marks) **Marks**

Consider the circuit shown below.



Calculate the readings on the ammeter and voltmeter when:

(a) the switch is open.

i. Ammeter reading

=12/15 ***= 0.8 A*** **1**

ii. Voltmeter reading

=0.8 x 9 ***= 7.2 V*** . **1**

(b) the switch is closed.

i. Ammeter reading

R_{TOT} *= 9 + 2 =* ***11 Ω****, so* I_{TOT} *= 12/11 =* ***1.09 A***
(one for either of these if final answer is incorrect) .

I_6 *= 12/11 * 1/3* ***= 0.364 A*** . **2**

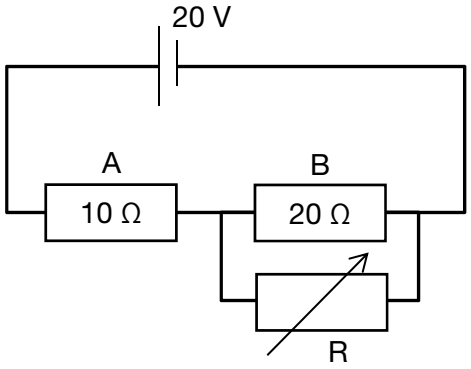
ii. Voltmeter reading

= 1.09 x 9 ***= 9.8 V*** . **2**

NB: The average mark on this question was very high.

Question 26 (4 marks) **Marks**

Consider the circuit shown below.



To what resistance must the variable resistor, R, be set to ensure that the power dissipated by resistor A is equal to the power dissipated by resistor B?

Lots of approaches were possible here; e.g.:

$P_A=P_B \quad \therefore I_A^2.R_A = I_B^2.R_B$ - **1 Mark** *(for a power equation correctly applied to the circuit)*

But $R_B=2R_A \quad \therefore \boldsymbol{I_A=\sqrt{2}I_B}$ **– 2 Marks**

Let X stand for the parallel element:

$V_X = I_A.R_X = 20.I_B \quad \therefore R_X = 20.I_B/I_A =$ $\boldsymbol{20/\sqrt{2}}$ **– 3 Marks**

$$\frac{1}{R}+\frac{1}{20}=\frac{\sqrt{2}}{20}$$

R=48.3 Ω **- 4 Marks**

For incorrect answers, marks were awarded for making some progress towards the final answer. Common things awarded marks included:

- *Calculating the voltage across A:* ***V_A=8.3 V*** *–* ***2 Marks*** *(assuming no errors)*
- *A trial and error approach that correctly calculated P_A and P_B (up to* ***2 Marks****, depending on how close you came)*

No marks *were awarded:*

- *For rambling equations over several lines or pages that attempted to find an algebraic expression for the total resistance but which never went anywhere!*
- *When I had no idea what you were doing – often because you used* ***P*** *and* $\boldsymbol{R_1}$ *and* $\boldsymbol{I_1}$ *and* ***y*** *in long expressions, but didn't define what they were.*

NB: a handful of pupils misinterpreted the question to mean that the ***whole parallel element*** *produced the same power as A, which gives (easily) R=20 Ω – a maximum of* ***1 Mark*** *was given for this.*

ELM

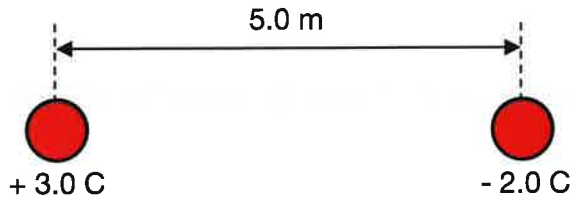
SECTION II: Part C (17 Marks)

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

CANDIDATE NUMBER

Question 27 (2 marks) **Marks**

The diagram below shows two charges separated by a distance of 5.0 m.



Calculate the electrostatic force on the -2.0 C charge.

2

$F = \frac{1}{4\pi\varepsilon_0}\frac{q_1 q_2}{r^2}$

$= \frac{9.0 \times 10^9 \times 3 \times 2}{25}$

$= 2.2 \times 10^9$ N left

1 for correct numerical answer
1 for correct direction

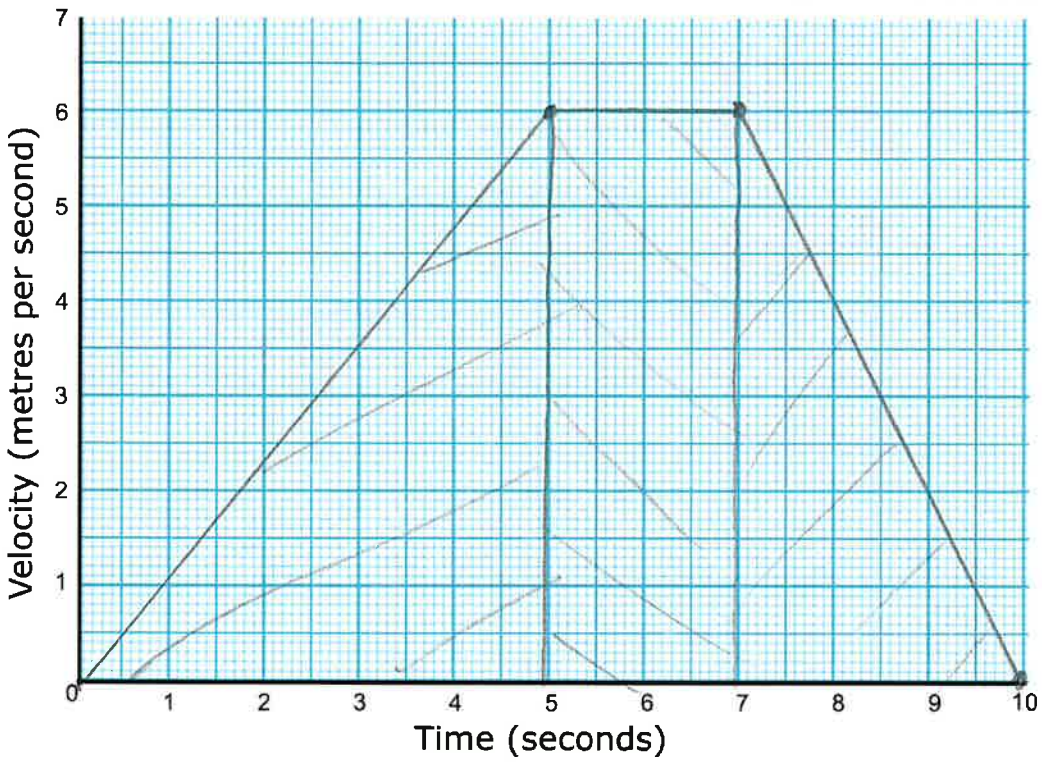
minus sign not counted as direction without reference frame

Question 28 (8 marks) **Marks**

A model train is placed on a length of straight track.

- It starts from rest with a constant acceleration for 5 s, reaching a velocity of 6 m s^{-1}.
- It then has a constant velocity for the next 2 seconds.
- It then slows down with constant acceleration, coming to a complete stop after a further 3 s.

(a) Plot a corresponding graph of velocity versus time of this motion on the axes below.



3

- correct shape −1
- correct time intervals −2

Question 28 continued on next page.

Question 28 continued. **Marks**

(b) Use your graph, or otherwise, to calculate:

i. the magnitude of the acceleration of the train between 0 and 5 s. **2**

$a = \frac{v-u}{t} = \frac{6}{5} = 1{\cdot}2\ ms^{-2}$

ii. the total distance travelled by the train. **2**

$A = \frac{1}{2} \times 6 \times 5 + 6 \times 2 + \frac{1}{2} \times 6 \times 3$

$= 15 + 12 + 9$

$= 36m$

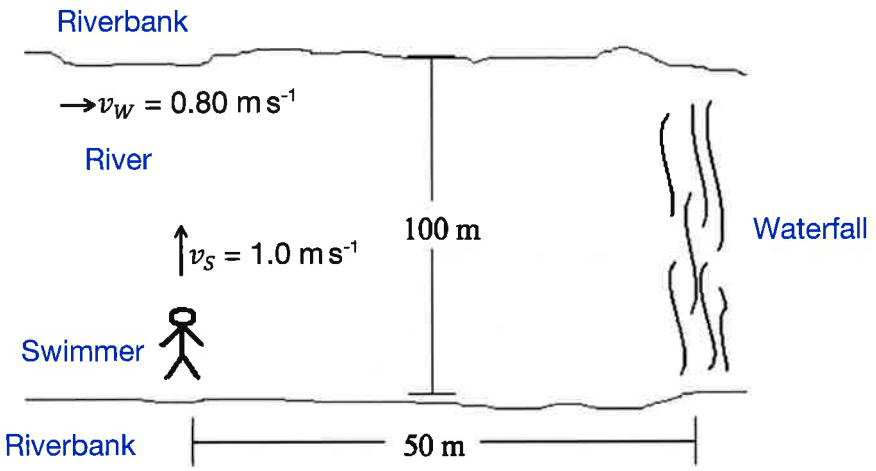
iii. the average speed of the train for the 10 s of its motion. **1**

$v_{av} = \frac{36}{10} = 3{\cdot}6\ ms^{-1}$

Question 29 (7 marks) **Marks**

A swimmer is trying to swim across a 100 m wide river. A dangerous waterfall which is 50.0 m down the river from his starting point is threatening to drown any unsuspecting swimmers. The swimmer can swim at a speed of v_S = 1.0 m s^{-1} relative to the water and the speed of the water is v_W = 0.80 m s^{-1}. He assesses two strategies to cross the river.

(a) The swimmer's first strategy is to start out by aiming himself straight for the other bank, always perpendicular to the edge of the river as depicted in the following diagram.



i. How long will it take him to reach the far riverbank this way?

$V_{across\ stream} = 1.0\ ms^{-1}$

$t = \frac{d}{v} = \frac{100\ m}{1.0\ ms^{-1}} = 100\ s$ **1**

ii. What distance downstream would the swimmer arrive on the opposite riverbank?

$d_{downstream} = 0.8\ ms^{-1} \times 100\ s$

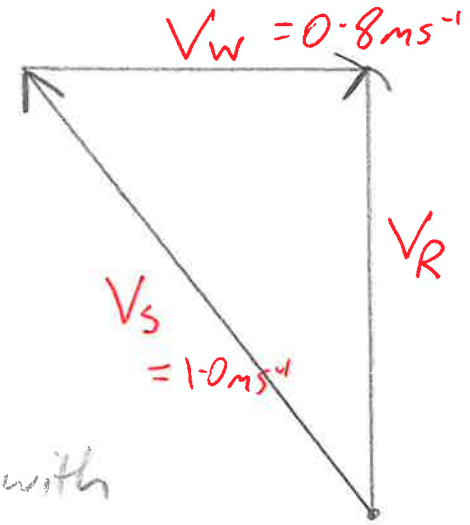
$= 80\ m$ **1**

Question 29 continued on next page.

Question 29 continued. **Marks**

(b) The swimmer is cautious and decides to investigate a second strategy where he swims at the same speed but at an angle so that he will end up landing directly opposite his starting point (i.e. his v_S velocity is the same magnitude but a different direction).

i. Sketch a vector diagram showing the velocity of the swimmer, v_S, relative to the water, the velocity of the water, v_W, relative to the riverbank, and the velocity of the swimmer relative to the riverbank (label v_R) that will achieve this aim.



- Three correct arrows with labels. (A triangle doesn't count as a vector diagram)
- Arrows consistent with $\vec{V_S} + \vec{V_W} = \vec{V_R}$

3

ii. How long will it take him to reach the opposite shore using this new strategy?

$|V_R| = \sqrt{1^2 - 0.8^2}$

$= 0.6 ms^{-1}$

$t = \frac{100m}{0.6 ms^{-1}} = 167 s$

2

correct value for V_R - 1

OR t consistent with calculated V and d - 1

LDO CRIB.

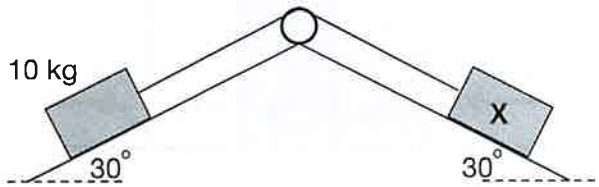
SECTION II: Part D (15 Marks)

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

CANDIDATE NUMBER							

Question 30 (2 marks) **Marks**

Two objects on two frictionless inclined planes are connected by a light inextensible string over a pulley as shown in the diagram below.



The acceleration of object X was 0.8 m s^{-2} down the plane.

Calculate the mass of object X.

$F_{net} = Xg \sin 30 - 10g \sin 30 = (10 + X)\,0.8$ — (1) **2**

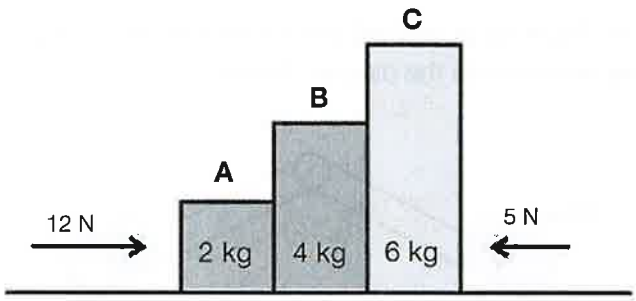
$4.9X - 49 = 8 + 0.8X$

$4.1X = 57$

$X = 13.9$ kg — (2)

Question 31 (4 marks) **Marks**

Three blocks, A, B and C, are on a frictionless surface pushed by two forces as depicted in the diagram.



(a) Calculate the magnitude of the acceleration of the three blocks. **1**

$12 - 5 = (6 + 4 + 2)a$

$7 = 12a$

$a = 0.58\ ms^{-2}$ — (1)

(b) Calculate the magnitude of the net force on box B. **1**

$F_{net} = 4 \times 0.58$

$= 2.32\ N$ — (1)

(c) Determine the magnitude of the force that block C is applying to block B. **2**

$F_{C \to B} = F_{B \to C}$ $F - 5 = 6 \times 0.58$ — (1)

$F = 8.48\ N.$ — (2)

(1) mark allowed if net force calculated

eg. $F = 6 \times 0.583$

$= 3.5\ N.$

Question 32 (7 marks) **Marks**

A ball is launched vertically upwards from ground level at a speed of 15 m s^{-1}.

(a) If the ball falls back to ground level, calculate the time of flight. **2**

$V = u + at$

$15 = 0 + 9.81t$

$t = 1.53\text{s} \times 2 = 3.1\text{ s}$

(1) (2)

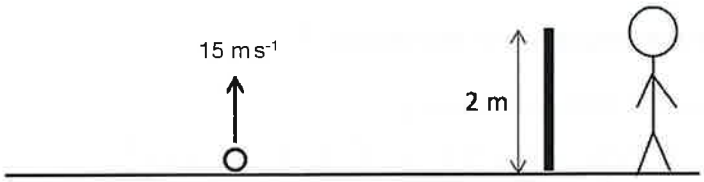
(b) Calculate the maximum height reached by the ball. **2**

$V^2 = u^2 + 2as$

$0 = 15^2 + (2 \times -9.8 \times S)$ —(1)

$S = 11.5\text{m}$. —(2)

(c) A man is watching the ball's flight from over a fence so that he can only see it when it is at least 2 m above the ground. For what length of time is the ball visible to the man? (*ignore parallax issues*)



3

$V^2 = u^2 + 2as$

$V^2 = 15^2 - (2 \times 9.8 \times 2)$

(1) $V = 13.63\text{ ms}^{-1}$

$S = \frac{1}{2}(u+v)t$

$19 = 13.63t$

(2) $t = 1.4\text{ s}$

$t_{tot} = 1.4 \times 2$

(3) $= 2.8\text{ s}$

or

$V = u + at$

$-13.63 = 13.63 + (-9.8t)$

$9.8t = 27.26$

$t = 2.78$ (2)

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

$2 = 15t - 4.9t^2$ —(1)

$4.9t^2 - 15t + 2 = 0$

$\frac{+15 \pm \sqrt{225 - 39.2}}{9.8}$

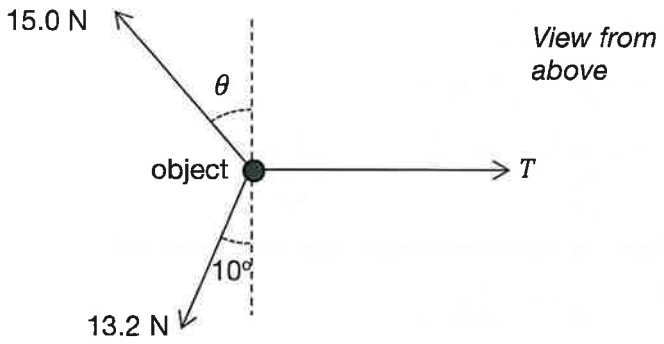
$t = 2.925$ $t = 0.1397$ —(2)

$t = 2.9215 - 0.1397$

$= 2.78\text{ s}$ —(3)

Question 33 (2 marks) **Marks**

An object is on a horizontal frictionless surface. It is **held in equilibrium** by three horizontal strings with different tensions, as shown in the diagram below. The diagram is not drawn to scale.



(a) Determine the angle, θ. **1**

Resolving vertically –

$15\cos\theta = 13{\cdot}2\cos 10$

$\theta = 29{\cdot}9^\circ$ — ①

(b) Calculate the magnitude of the tension, T. **1**

Resolving horizontally

$T = (15\sin 29{\cdot}9) + (13{\cdot}2\sin 10)$

$T = 9{\cdot}78\,N.$ — ①

[Allowed e.c.f from incorrect angle with correct working shown.]

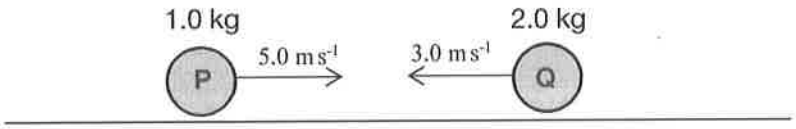
SECTION II: Part E (13 Marks)

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

D	r		W	A	R	D	
CANDIDATE NUMBER							

Question 34 (3 marks) **Marks**

Two balls collide on a frictionless horizontal surface as shown in the diagram below. Ball P of mass 1.0 kg is initially travelling with a speed of 5.0 m s^{-1} when it collides with ball Q of mass 2.0 kg which is travelling at 3.0 m s^{-1} towards P.



The balls make a perfectly elastic collision.

Calculate the velocities of ball P and ball Q immediately after the collision (v_P and v_Q respectively).

Regardless of method: 3

* 1 mark for each correct equation formed x 2 = 2mks ✓✓

* 1 mark for solving these equations to find both the velocity of ball P and ball Q = 1mk ✓

See the following pages for solutions:

Using Law of Conservation of momentum

$$m_P u_P + m_Q u_Q = m_P v_P + m_Q v_Q$$

for an inelastic collision

$$\tfrac{1}{2} m_P u_P^2 + \tfrac{1}{2} m_Q u_Q^2 = \tfrac{1}{2} m_P v_P^2 + \tfrac{1}{2} m_Q v_Q^2$$

Solving these equations gives

$$v_P = \left(\frac{m_P - m_Q}{m_P + m_Q}\right) u_P + \left(\frac{2m_Q}{m_P + m_Q}\right) u_Q$$

$$= \left(\frac{1-2}{1+2}\right) 5 + \left(\frac{2 \times 2}{1+2}\right) \times -3$$

$$= \left(\frac{-1}{3}\right) 5 + \frac{4}{3} \times -3$$

$$= -5/3 - 12/3 = \underline{-17/3 \text{ ms}^{-1}}$$

$$= -5.67 \text{ ms}^{-1}.$$

$$v_Q = \left(\frac{2m_P}{m_P + m_Q}\right) u_P + \left(\frac{m_Q - m_P}{m_P + m_Q}\right) u_Q$$

$$= \left(\frac{2 \times 1}{1+2}\right) 5 + \left(\frac{2-1}{3}\right) \times -3$$

$$= 2/3 \times 5 + 1/3 \times -3$$

$$= 10/3 - 1$$

$$= 3.33 - 1 \quad = 2.33 = \underline{7/3 \text{ ms}^{-1}}$$

OR/ Make Q stationary

$$u_P' = u_P - u_Q = 5 - (-3) = 8 \text{ ms}^{-1}$$

$$v_P' = \frac{1-2}{1+2} \times 8 = -\frac{8}{3} = -2.67 \text{ ms}^{-1}$$

$$v_P = -2.67 - 3 = -5.67 \text{ ms}^{-1}$$

$$v_Q' = \frac{2 \times 1}{1+2} \times 8 = 16/3 = 5.33 \text{ ms}^{-1}$$

Centre of Mass

$$v_{cm} = \frac{\Sigma p}{\Sigma m} = \frac{1 \times 5 + 2 \times -3}{1+2} = -1/3$$

$$v_p = 2v_{cm} - u_p$$
$$= \underline{2(-1/3) - 5} = -17/3 \text{ ms}^{-1} = -5.66 \text{ ms}^{-1}$$

$$v_Q = 2v_{cm} - u_Q$$
$$= \underline{2 \times (-1/3) - (-3)} = 7/3 \text{ ms}^{-1} = 2.33 \text{ ms}^{-1}$$

Relative velocity

$$v_Q - v_p = u_p - u_Q$$

$$v_Q - v_p = 5 - (-3) = 8$$

$$\boxed{v_Q = 8 + v_p} \quad - (1)$$

Conservation of momentum:

$$\Sigma p_{before} = \Sigma p_{after}$$

$$1 \times 5 + 2 \times -3 = 1v_p + 2v_Q$$

$$\boxed{v_p + 2v_Q = -1} \quad - (2)$$

Substitute (1) into (2)

$$v_p + 2(8 + v_p) = -1$$
$$v_p + 16 + 2v_p = -1$$
$$3v_p = -17$$
$$v_p = -17/3 \text{ ms}^{-1} = -5.66 \text{ ms}^{-1}$$
$$v_Q = (+5.66 - 1)/2 = 2.33 \text{ ms}^{-1}$$

Momentum and Kinetic Energy Method.

$$\Sigma p_i = \Sigma p_f$$

$$m_p u_p + m_Q u_Q = m_p v_p + m_Q v_Q.$$

$$1 \times 5 + 2x - 3 = 1 \times v_p + 2 \times v_Q.$$

$$\boxed{-1 = v_p + 2v_Q} \quad (1)$$

elastic collision

$$\tfrac{1}{2} m_p u_p^2 + \tfrac{1}{2} m_Q u_Q^2 = \tfrac{1}{2} m_p v_p^2 + \tfrac{1}{2} m_Q v_Q^2$$

$$m_p u_p^2 + m_Q u_Q^2 = m_p v_p^2 + m_Q v_Q^2$$

$$1 \times 5^2 + 2 \times 3^2 = v_p^2 + 2 v_Q^2$$

$$\boxed{43 = v_p^2 + 2v_Q^2} \quad (2)$$

using (1)

$$v_p = -2v_Q - 1 \quad (3)$$

Substitute (3) into (2)

$$(-1-2v_Q)^2 + 2v_Q^2 = 43$$

$$(1 + 4v_Q + 4v_Q^2) + 2v_Q^2 = 43$$

$$6v_Q^2 + 4v_Q - 42 = 0$$

$$6v_Q^2 + 18v_Q - 14v_Q - 42 = 0$$

$$6v_Q(v_Q + 3) - 14(v_Q + 3) = 0$$

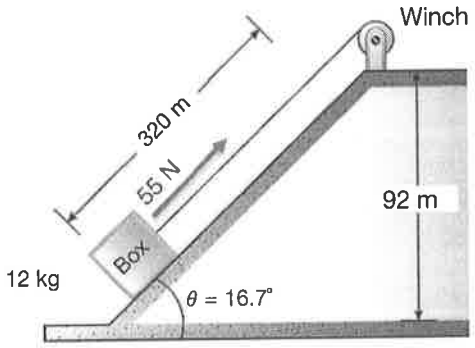
$$(6v_Q - 14)(v_Q + 3) = 0$$

$v_Q = 2.3 ms^{-1}$ / $v_p = -1 - (2 \times 2.3) = -5.6 ms^{-1}$ ✓

or $v_Q = -3 ms^{-1}$ × $v_p = -1 + 6 = 5 ms^{-1}$ ×

Question 35 (6 marks) **Marks**

A box is pulled 320 m up a rough ramp at a constant speed by means of an electrically powered winch. The tension force in the cable pulling the box is 55 N. The box is raised through a vertical height of 92 m. The mass of the box is 12 kg. The angle of the ramp is $\theta = 16.7°$.



(a) Calculate the work done by the cable in pulling the box up the ramp.

$W = Fs$ ✓①mk for correct substitution 1

$= 55 \times 320 = 17600\,J$

[common mistake, $W = 55 \times 320 \times \cos 16.7° = 16857.68\,J$

(b) Calculate the gain in gravitational potential energy in moving the box up the ramp (i.e. 90 m vertically).

$\Delta E_p = mgh$ ✓①mk for correct substitution 1

$= 12 \times 9.8 \times 92 = 10819.2\,J$

(or $12 \times 9.8 \times 90 = 10584.5\,J$)

(c) Calculate the energy lost due to friction.

$KE_i + GPE_i + W_{winch} - W_{friction} = KE_f + GPE_f$

$0 + 17600 - W_f = 10819.2$

$W_f = 6780.8\,J$ ✓①mk

i.e. [Answer (a) − answer (b)]

Question 35 continued on next page.

or $16857.68 - 10584.5 = 6274\,J$ ✓①mk

Question 35 continued. **Marks**

(d) Calculate the magnitude of the frictional force on the box as it moves up the ramp. 1

$W = fs$

$6780.8 = f \times 320$

$f = 21.19\,N$

[f = Ans(c)/320] ✓1mk

(e) Calculate the magnitude of the normal force on the box. 1

$N = mg\cos 16.7^\circ$

$= 12 \times 9.8 \cos 16.7^\circ$

$= 112.6\,N$ ✓1mk

(f) Calculate the co-efficient of kinetic friction between the box and the ramp (μ_k). 1

$f = \mu_k N$

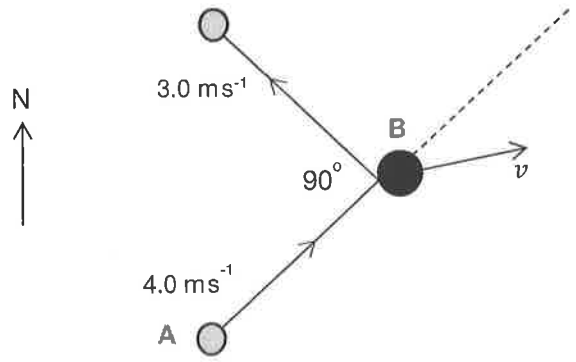
$21.19 = \mu_k \times 112.6$

$\mu_k = 0.19$

$\mu_k = \left[\frac{\text{Ans(a)}}{\text{Ans(e)}}\right]$ ✓1mk.

Question 36 (4 marks) **Marks**

A small ball A of mass 1.2 kg travelling North-East at 4.0 m s^{-1} strikes a stationary ball B of mass 4.8 kg. It bounces off at 90° to its original direction (or North-West) travelling at 3.0 m s^{-1} as shown in the following diagram. Ball B is travelling at velocity v after the collision.



(a) Determine the magnitude of the change in momentum of ball A caused by the collision with ball B. **2**

$\Delta p = p_f - p_i$

$= 1.2 \times 3 \uparrow - 1.2 \times 4 \rightarrow$

$= 3.6 \uparrow + 4.8 \leftarrow$ ✓① mk for correctly calculating both momenta.

$= 4.8 \swarrow 3.6 \uparrow$

6 kgms^{-1} ✓① mk for correct addition to give 6 kgms^{-1}.

if subtract as 1D ① mk
$1.2 \times 3 - 1.2 \times 4 = -1.2 \text{ kgms}^{-1}$ ✓x

(b) If the impact with the lasts 2.5×10^{-4} s what was the magnitude of the average force exerted by ball A on ball B during the impact? **1**

$F \times 2.5 \times 10^{-4} = 6$

$\therefore F = 24000 \text{ N}$ ✓① mk.

[F = Ans(a) / 2.5×10^{-4}]

(c) Determine the magnitude of the velocity, v, of ball B after the collision. **1**

$\Delta p = m \Delta v$

$\Delta p / m = v - 0 \quad \therefore 6/4.8 = 1.25 \text{ ms}^{-1}$

END OF EXAMINATION

$v = \frac{\text{Ans(a)}}{4.8}$ ✓① mk.

Note:
if (a) 1.2 kgms^{-1} x
then (b) 4800 N ✓ C.T = carry through
then (c) 0.25 ms^{-1} ✓ C.T = carry through.