

PENRITH HIGH SCHOOL

2022 Preliminary Yearly

SCIENCE PRELIMINARY PHYSICS



Task Weighting: 30 %

General Instructions:

- Reading Time – 5 minutes
- Working time – 2 hours
- Write using black pen
- Draw diagrams using pencil
- Calculators approved by NESA may be used
- A data, formulae sheet, and Periodic Table are provided at the back of this paper
- Write your student number at the bottom of every answer page
- There is supplementary writing paper at the back of this booklet. Students using this supplementary space should indicate this at the relevant question

Total Marks: 75

Section I Pages 2 - 9

15 marks

- Multiple Choice
- Attempt Questions 1–15
- Allow about 25 minutes for this part

Section II Pages 2 – 18

60 marks

- Short Response
- Attempt Questions 16–26
- Allow about 1 hours and 35 minutes for this part

Total pages this exam: 32

M/C answer sheet: 1

Student Number:-----

Section I

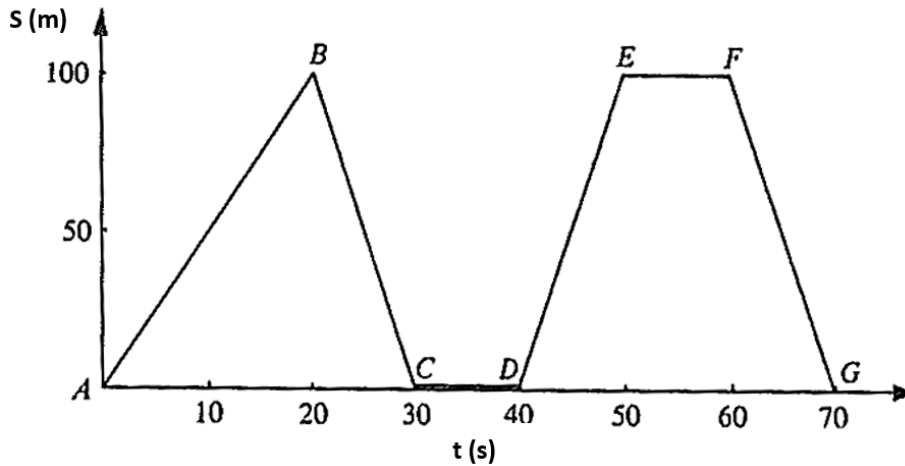
20 marks

Attempt Questions 1 – 20

Allow about 35 minutes for this section

Use the multiple-choice answer sheet for Questions 1- 20

1. A person is jogging in a straight line. A graph of their displacement data is shown below.

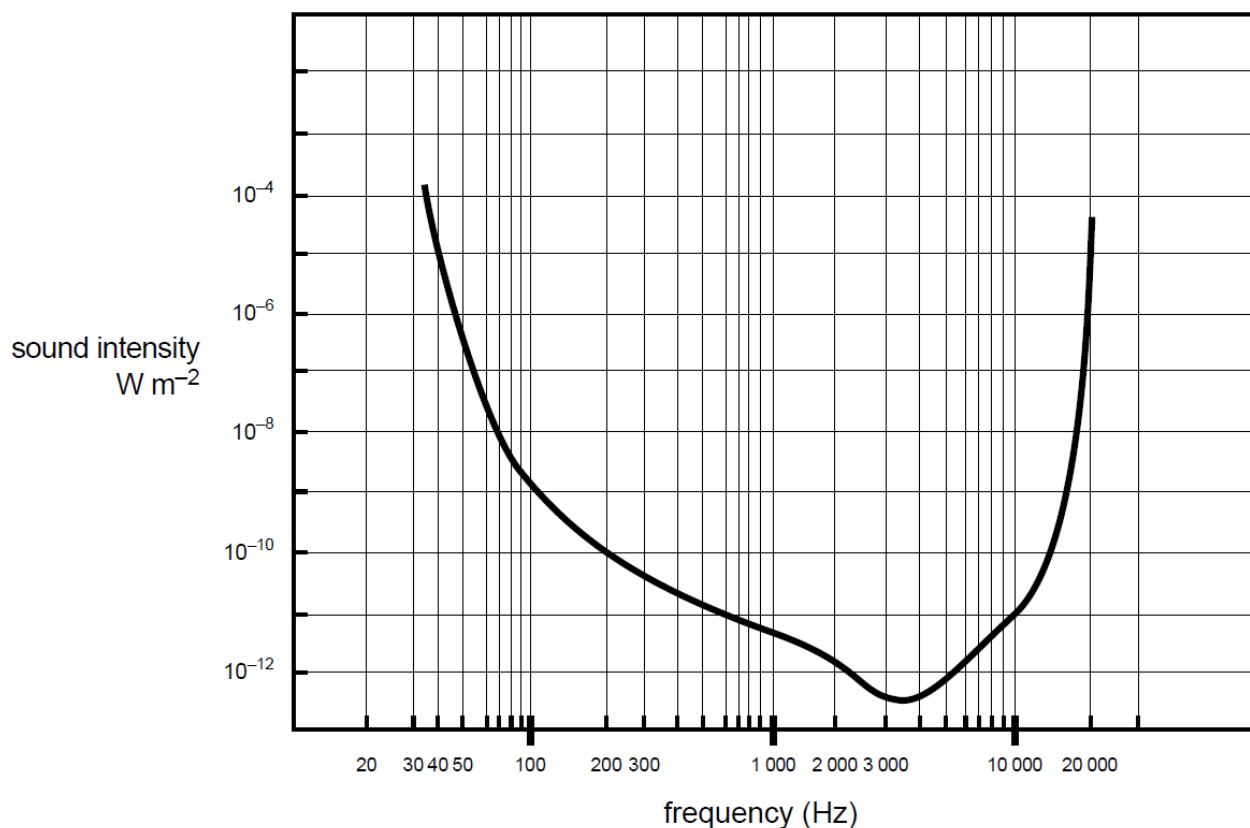


During which part of the motion did the jogger have a velocity of 5 ms^{-1} North?

- A. A-B
 - B. B-C
 - C. C-D
 - D. F-G
2. A mass of 4.2 Kg is allowed to fall 3 m from a balcony. What is its final velocity at the instant before it hits the ground?
- A. 7.7 ms^{-1}
 - B. 9.8 ms^{-1}
 - C. 23.1 ms^{-1}
 - D. 32.3 ms^{-1}

3. What are the frequency ranges heard by a person listening to a stereo at an intensity of 50 dB?

EQUATION	VARIABLES
$\beta = \left(\frac{I}{10^{-12}} \right)$	$\beta = \text{sound heard in decibels (dB)}$ $I = \text{sound intensity (Wm}^{-2}\text{)}$



- A. 35 – 20 000 Hz
- B. 45 – 19 000 Hz
- C. 55 – 17 500 Hz
- D. 100 – 17 000 Hz

4. Blue light in the visible part of the electromagnetic spectrum has a wavelength of 450 nm.

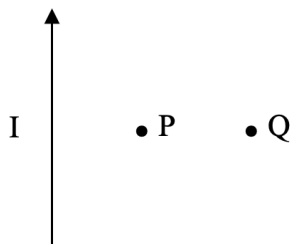
Calculate the frequency of this light.

- A. 1.5×10^{15} Hz
- B. 6.6×10^5 Hz
- C. 6.6×10^{14} Hz
- D. 6.7×10^{14} Hz

5. A worker is rolling a very heavy roller across the grass at a bowling club. He is pushing with a 150 N force at an angle of 40° . What is the effective force that pushes the roller along the ground?



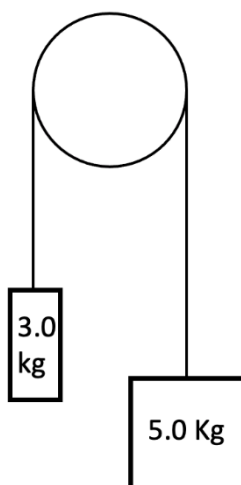
- A. 75 N
B. 115 N
C. 150 N
D. 106 N
6. The magnetic field strength, “B”, around a wire is measured at a distance of “r” at a point P. Point Q is located a distance “2r”. What is the field strength at point Q?



- A. $B/2$ out of the page
B. $B/4$ out of the page
C. $B/2$ into the page
D. $B/4$ into the page

The following scenario applies to the questions 7 and 8.

A string passes over a pulley wheel as shown in the diagram below. The pulley has a negligible mass. Two masses are attached to the pulley as shown and allowed to move freely.



7. Determine the acceleration of the system.

- A. 0.81 ms^{-2}
- B. 1.5 ms^{-2}
- C. 2.45 ms^{-2}
- D. 2.5 ms^{-2}

8. Determine the tension on the string.

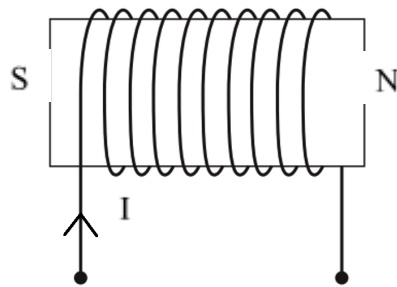
- A. 7.9 N
- B. 29.4 N
- C. 36.8 N
- D. 49 N

9. The thermal conductivity of a 0.01 m thick copper surface area is $398 \text{ Wm}^{-1}\text{K}^{-1}$. How much energy is discharged through the 1 m^2 surface when 100°C is applied on one side with the aim of increasing the temperature on the other side of the copper surface to 50°C . The time interval for this to take place is 10 seconds.

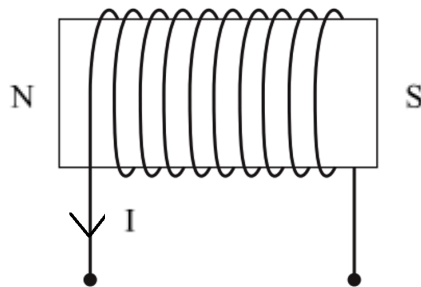
- A. $-1.99 \times 10^7 \text{ J}$
- B. $1.99 \times 10^8 \text{ J}$
- C. $-1.99 \times 10^7 \text{ J}$
- D. $1.99 \times 10^7 \text{ J}$

10. Which diagram correctly represents the magnetic field around a solenoid?

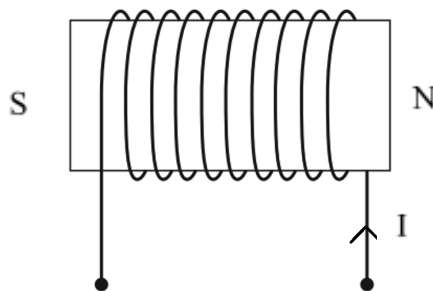
A.



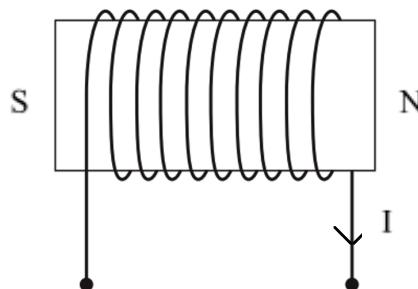
B.



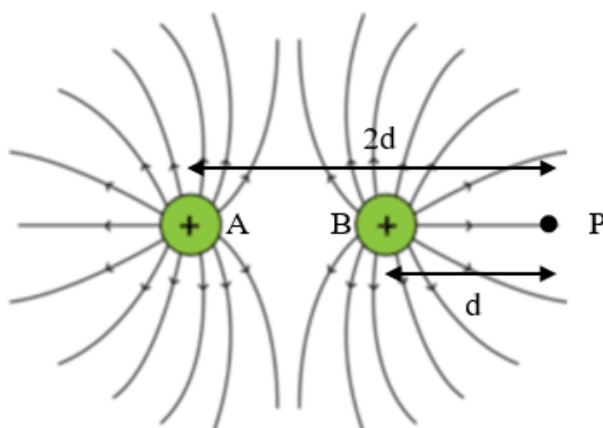
C.



D.

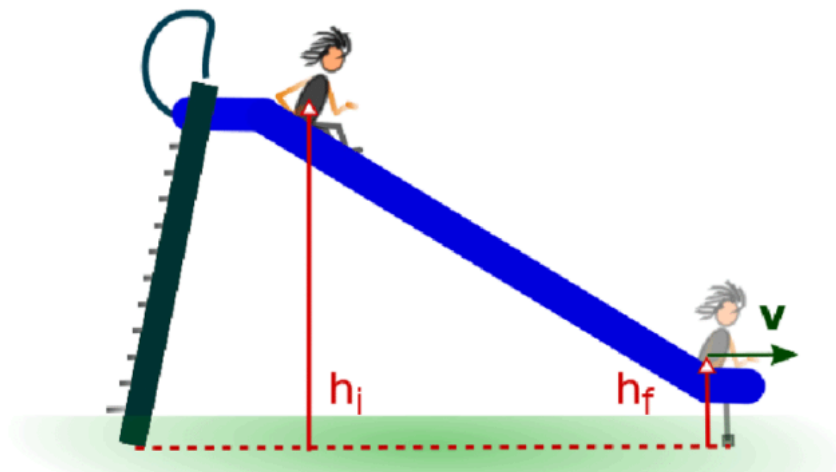


The following scenario applies to questions 11 and 12. Two identical charges, A and B, are placed in close proximity to each other. The electric field diagram is as follows. The following questions both refer to the diagram.



11. Calculate the force between charges A and B if they are separated by a distance of 2 cm and each have a magnitude of 0.5 C.
- A. 1.12×10^{11} N
 - B. 5.61×10^{12} N
 - C. 5.61×10^8 N
 - D. 12.12×10^8 N
12. An electron is placed to the right of charge B at a distance twice that of charge A. Calculate the acceleration acting on the electron.
- A. 1.48×10^{24} ms^{-2} left
 - B. 1.48×10^{24} ms^{-2} right
 - C. 2.47×10^{24} ms^{-2} left
 - D. 2.47×10^{24} ms^{-2} right

The following scenario applies to questions 13 and 14. A boy slides from rest down an angled slide. The slide is shown below.



The initial height of the slide, h_i , is 2.8 m and the final height, h_f , is 40 cm. The slide is at an angle of 35° to the horizontal.

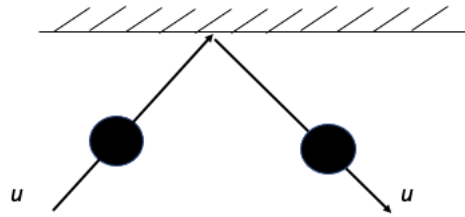
13. Calculate the final velocity, v , of the boy if there is no friction between the boy and the slide.

- A. 3.4 ms^{-1}
- B. 6.9 ms^{-1}
- C. 7.4 ms^{-1}
- D. 47 ms^{-1}

14. How long will the boy take to reach the bottom point of the incline?

- A. 0.75 s
- B. 0.86 s
- C. 1.22 s
- D. 1.43 s

15. . A pool ball travelling at speed u is struck against the side of a pool table. It rebounds with the same speed as shown in the diagram.



What is the direction of the change in velocity of the ball?

A.



C.



B.



D.



END OF MULTIPLE CHOICE

2022 TRIAL HSC EXAMINATION

Multiple Choice – Answer Sheet

Student Number.....

- | | | | | | | | | |
|-----|---|-----------------------|---|-----------------------|---|-----------------------|---|-----------------------|
| 1. | A | <input type="radio"/> | B | <input type="radio"/> | C | <input type="radio"/> | D | <input type="radio"/> |
| 2. | A | <input type="radio"/> | B | <input type="radio"/> | C | <input type="radio"/> | D | <input type="radio"/> |
| 3. | A | <input type="radio"/> | B | <input type="radio"/> | C | <input type="radio"/> | D | <input type="radio"/> |
| 4. | A | <input type="radio"/> | B | <input type="radio"/> | C | <input type="radio"/> | D | <input type="radio"/> |
| 5. | A | <input type="radio"/> | B | <input type="radio"/> | C | <input type="radio"/> | D | <input type="radio"/> |
| 6. | A | <input type="radio"/> | B | <input type="radio"/> | C | <input type="radio"/> | D | <input type="radio"/> |
| 7. | A | <input type="radio"/> | B | <input type="radio"/> | C | <input type="radio"/> | D | <input type="radio"/> |
| 8. | A | <input type="radio"/> | B | <input type="radio"/> | C | <input type="radio"/> | D | <input type="radio"/> |
| 9. | A | <input type="radio"/> | B | <input type="radio"/> | C | <input type="radio"/> | D | <input type="radio"/> |
| 10. | A | <input type="radio"/> | B | <input type="radio"/> | C | <input type="radio"/> | D | <input type="radio"/> |
| 11. | A | <input type="radio"/> | B | <input type="radio"/> | C | <input type="radio"/> | D | <input type="radio"/> |
| 12. | A | <input type="radio"/> | B | <input type="radio"/> | C | <input type="radio"/> | D | <input type="radio"/> |
| 13. | A | <input type="radio"/> | B | <input type="radio"/> | C | <input type="radio"/> | D | <input type="radio"/> |
| 14. | A | <input type="radio"/> | B | <input type="radio"/> | C | <input type="radio"/> | D | <input type="radio"/> |
| 15. | A | <input type="radio"/> | B | <input type="radio"/> | C | <input type="radio"/> | D | <input type="radio"/> |

See overleaf for instructions

Student Number

Physics
Section II Answer Booklet

60 marks

Attempt Questions 16 – 26

Allow about 1 hours and 35 minutes for this section

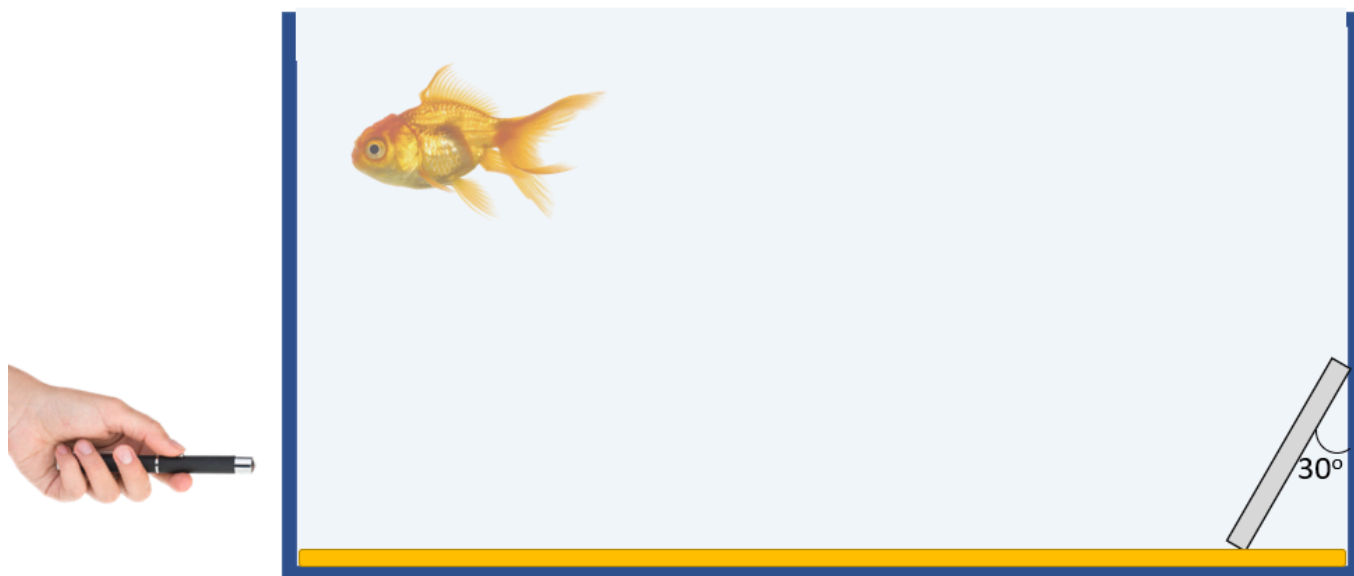
Instructions

- Write your Student Number at the top of this page
 - Answer the questions in the spaces provided.
 - Show all relevant working in questions involving calculations
 - Extra writing space is provided at the back of this booklet. If you use this space, clearly indicate which question you are answering.
-

Question 16 (6 marks)

A laser beam is flashed through a glass rectangular fish tank wall. The tank is filled to the top with water and has no glass lid over it. A small mirror is placed inside the tank at an angle of 30° to the wall it rests on.

- (A) Trace out the path from the laser pointer to the mirror, along with the path it traces out of the tank. Take the refractive index of air to be 1, water 1.3 and glass 1.5. **(4 marks)**



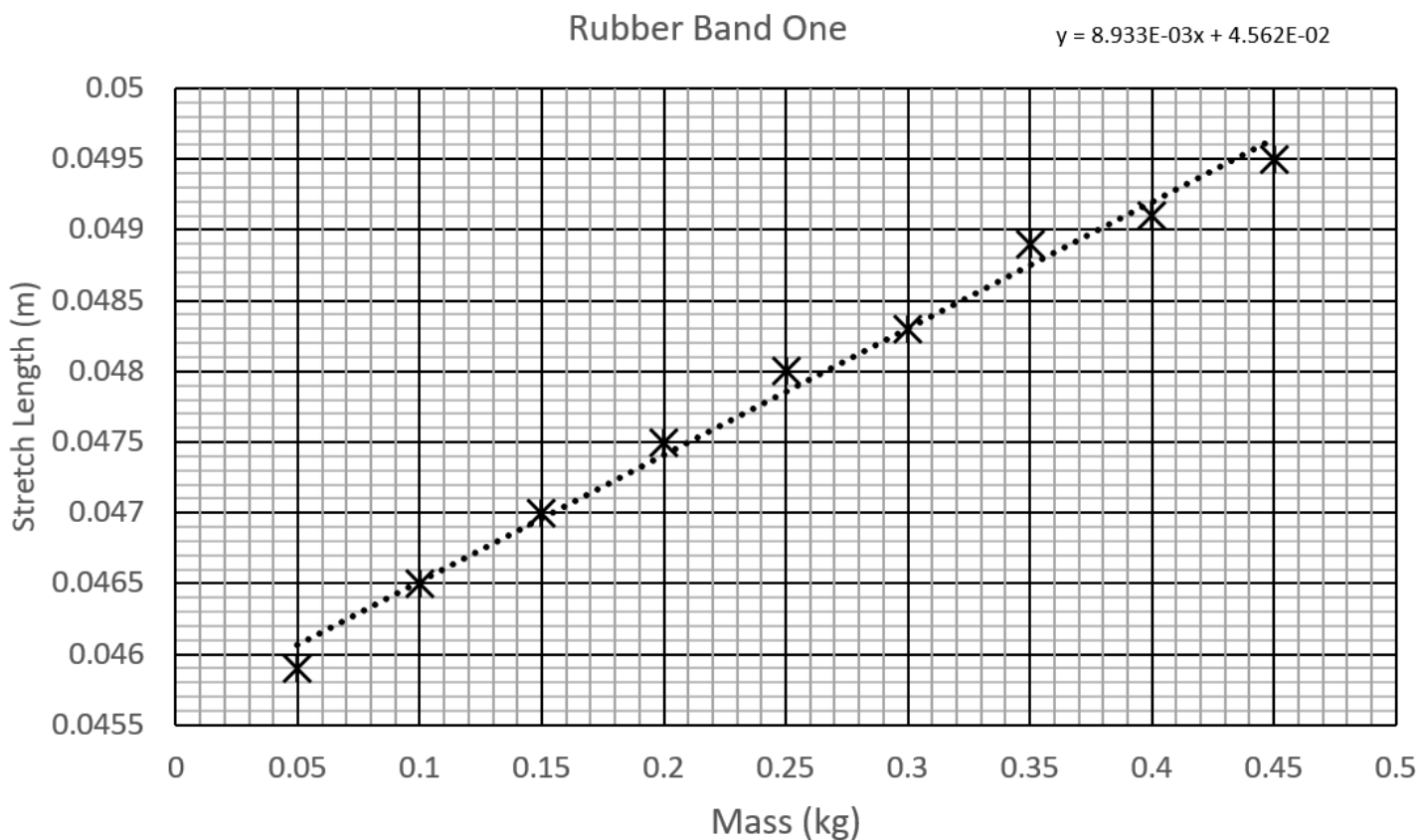
- (B) Calculate the critical angle at the water air boundary. **(2 marks)**

Question 17 (9 marks)

One objective for scientists is to find patterns in nature. By looking at how variables relate. To do this they often use experimental data.

A physics student explored the relationship between the stretch length of rubber bands with respect to loads added to them.

The student collected data for one rubber band and presented it in a graph.



Some values obtained from the graph are provided.

$$\text{Gradient} = 8.933 \times 10^{-3} \text{ m.kg}^{-1}$$

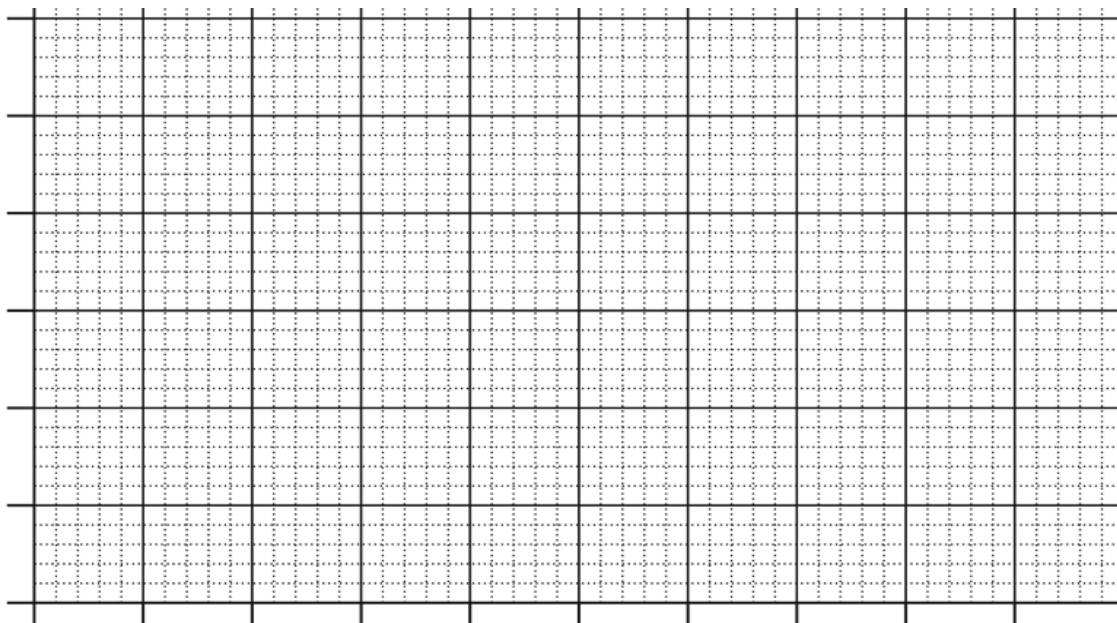
$$\text{Y-intercept} = 4.562 \times 10^{-2} \text{ m}$$

(A) What physical characteristics of the rubber band is demonstrated with the y-intercept in this data?
(1 mark)

The student gathered some more data on a different rubber band. Presented below, is the mass loaded on to the mass which was recorded in kilogram (kg), while the stretch length of the rubber band was recorded in meters (m).

Mass loaded (kg)	Stretch length of the rubber band (m)
0.00	0.07
0.10	0.12
0.25	0.19
0.40	0.26
0.45	0.28

(B) Graph the data and create a line of best fit. (3 marks)

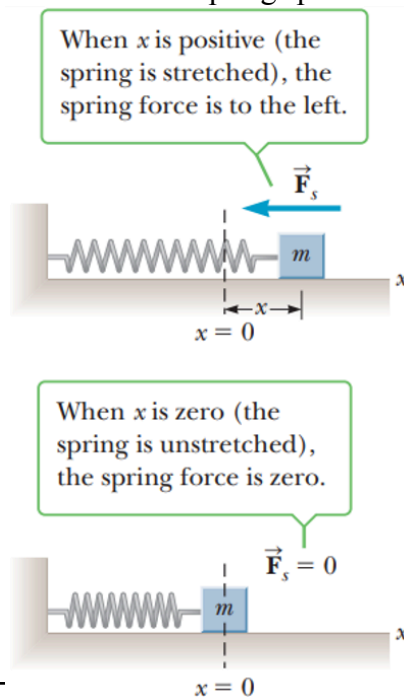


(C) Calculate the gradient for the data gathered for the second rubber band. (2 marks)

Discovered in 1660 by Robert Hooke, Hooke’s Law considers the stiffness which springs possess. Stiffness is a property which considers the amount of force that must be applied in order for the spring to be stretched or compressed.

Hooke deduced that all springs stretched or compressed from their rest state (or equilibrium point) must have a force applied to them, incidentally this force has a direct impact on the amount of elongation or contraction that the spring experiences.

Hooke concluded that all springs must have a spring constant “k”. The spring constant is an empirically tested quantity which considers the stiffness of a spring. The spring constant allows for the prediction of the force yielded by a spring as a function of the distance which the spring is stretched or compressed from its equilibrium point.



EQUATION	VARIABLES
$F = kx$	$F =$ Force yielded by spring (N) $x =$ displacement of spring from equilibrium point (m) $k =$ Spring constant = Gradient of a Stretch Length vs Force graph (Nm^{-1})

(D) Gradients of graphs are quantities which describe the rate of change in studied phenomena.
Use Hooke's Law to account for the difference in the gradient values experienced by Rubber Band One and Rubber Band Two. **(3 marks)**

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Question 18 (4 marks)

A boat is travelling across the Nepean River. The river is flowing downstream with a strong current of 2.4 ms^{-1} . The boat has a maximum speed of 8 ms^{-1} . At the crossing point, the river is 220 m wide.

(A) Determine the velocity of the boat relative to the East side river bank if it crosses directly from West to East. (At what upstream angle must the boat head) **(2 marks)**

(B) How long will the boat take to cross the river at this point? **(2 marks)**

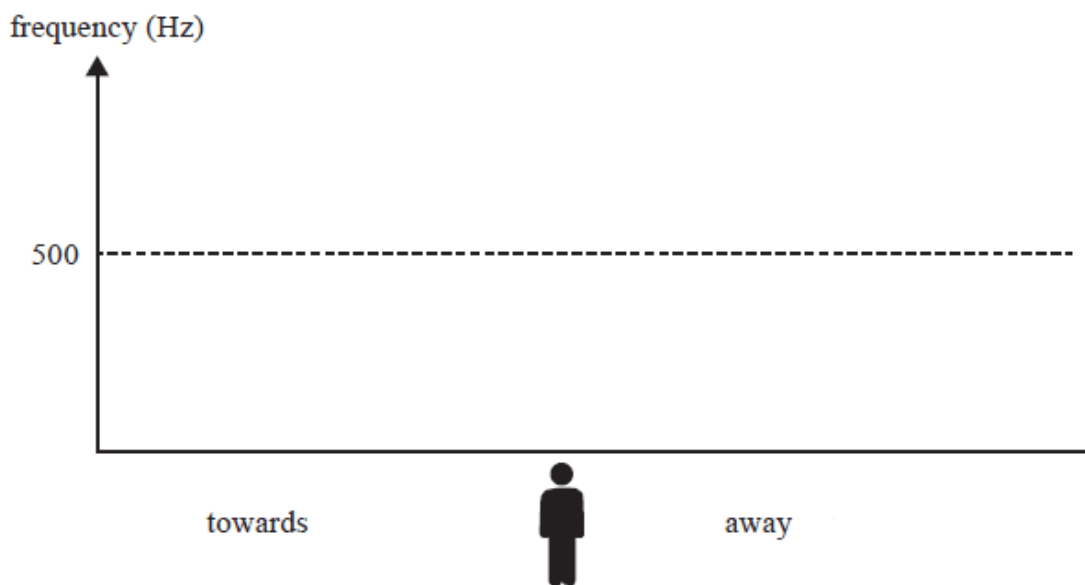
Question 19 (3 marks)

A distant fire truck travelling at 20 m s^{-1} to a fire has its siren emitting sound at a constant frequency of 500 Hz.

An observer is standing on the edge of the road. Assume that the fire truck is travelling directly towards him as it approaches and directly away from him as it goes past. The arrangement is shown below;

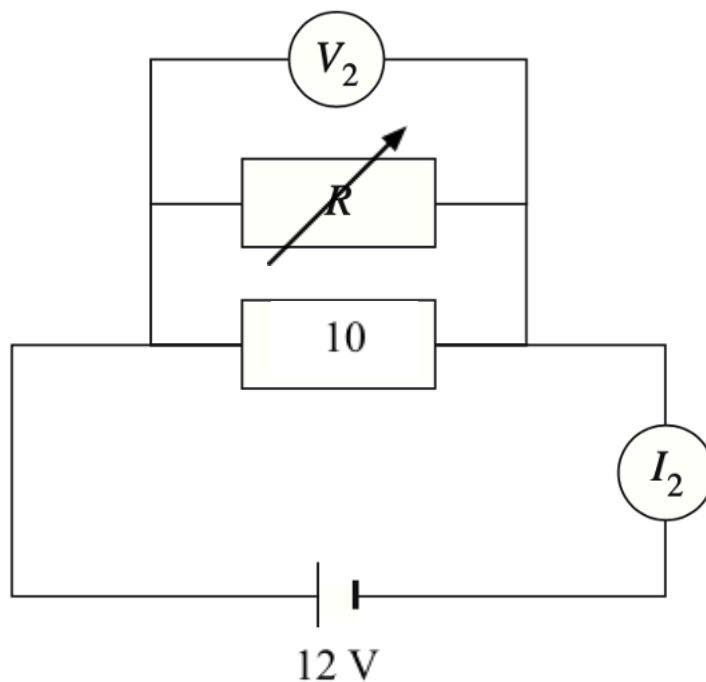


On the diagram below, sketch a curve to depict the frequency that the observer will hear as the truck moves towards him and then moves away from him. The 500 Hz siren signal is shown as a dotted line for reference. Consider the speed of sound as 340 m s^{-1} . Include all relevant calculations.

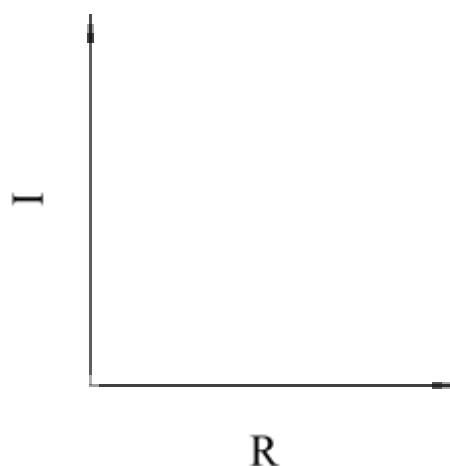
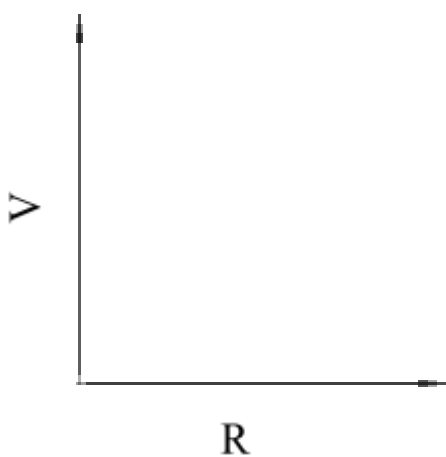


Question 20 (8 marks)

A circuit is set up as shown. R is a variable resistor.



(A) The resistance of R is gradually increased. On the graph below, sketch and label TWO graphs for what would happen to the readings of voltmeter V_2 and ammeter I_2 as this happens (3 marks)

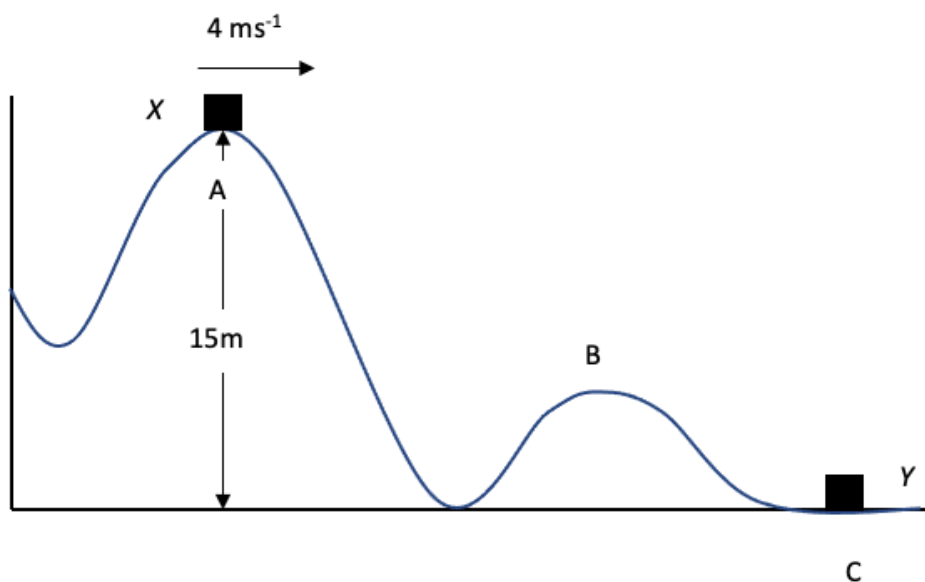


(B) The value of I_2 is measured to be 2 A. Calculate the resistance at which this would occur.
(3 marks)

(C) Calculate the smallest total current that is possible in the circuit **(2 marks)**.

Question 21 (4 marks)

A roller coaster has a section shaped like the one in the diagram. The X and Y are trolleys that travel freely on wheels over the ride carrying passengers. The mass of X is 1000 kg and it is travelling at 4 ms^{-1} at position A . At position C it connects and remains connected to trolley Y which is without passengers and has a mass of 300 Kg .



(A) Calculate the speed of trolley X just before the collision. (2 marks).

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(B) Calculate the combined speed of X and Y just after the collision. (2 marks).

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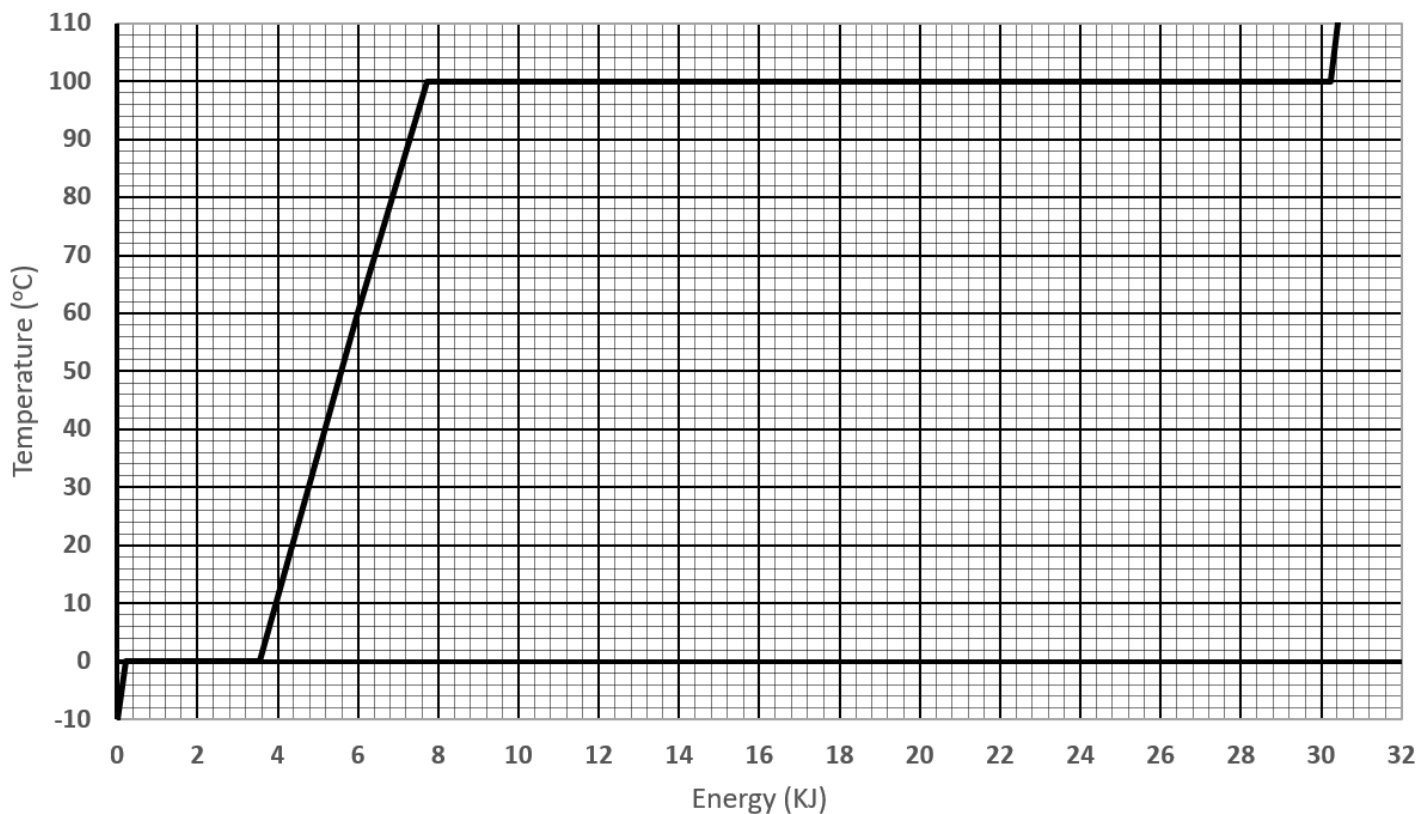
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Question 22 (4 marks)

The following data illustrates the heating curve of water. Here, as energy (KJ) is added to the water, the temperature increases (°C)

Water



(A) Describe where in the graph the substance is being heated up, and where it is undergoing phase change. **(2 marks)**

(B) Use the graph to calculate the quantity of water heated up. (2 marks)

Question 23 (4 Marks)

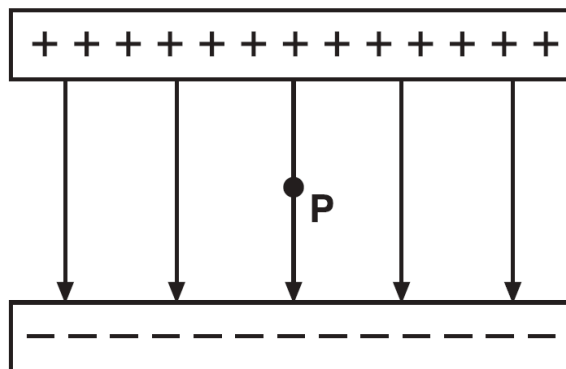
Two students are kneeling on rolling office chairs. They are facing each other and can touch their hands together. One student has a mass of 43 Kg and the other has a mass of 49 Kg.



Use physics principles to describe the motion of the 43 kg student if they push the 49 kg student away with an equal and opposite force.

Question 24 (9 marks)

An electric field is established between a set of parallel plates as shown in the diagram below. The potential difference between the plates is 10 V and the plates are separated by a distance of 0.1 m. A particle “P” is placed exactly halfway between the two plates. Ignore the effects of gravity.



- (A) If the particle were an electron, calculate the force that the particle P experiences in the field. **(2 marks).**

- (B) If the electron is released from rest, calculate the kinetic energy of the electron once it reaches one of the electric plates. **(3 marks)**

(C) The electron is replaced with a proton at the exact same position. If the proton was also released from rest, compare the velocity at which the proton hits the plate with that of the electron. **(4 marks)**

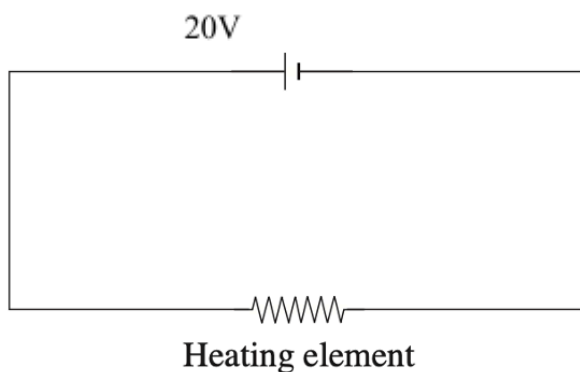
Question 25 (2 marks)

The intensity of electromagnetic waves from the sun is 1400 Wm^{-2} just above the earth's atmosphere. Only eighty percent of this reaches the Earth's surface at noon on a clear summer day.

Suppose you think of your back as a $0.3 \text{ m} \times 0.5 \text{ m}$ rectangular area. How many joules of solar energy fall on your back as you work on your tan for 1 h? **(2 marks)**

Question 26 (7 marks)

A simple heating circuit is set up as shown in the diagram below.



The current through the heating element is measured to be 3.5 A.

(A) Calculate the power of the heating element. **(1 mark)**

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(B) The heating element is left on to run for a total of 5 minutes. Calculate the total energy dissipated by the heating element during this time (you may assume 100% efficiency). **(2 marks)**

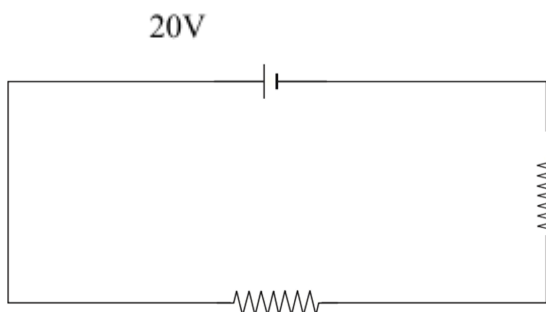
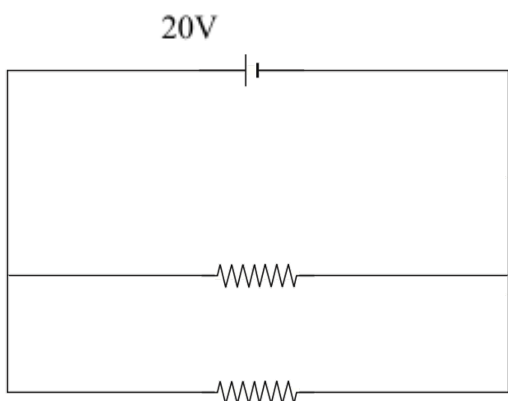
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(C) An additional identical heating element is added to the circuit as demonstrated below.
Compare the total power output of the power supply if the heating element was added in parallel to if it was added in series.
(4 marks)



End of Paper

PENRITH HIGH SCHOOL

2022 Preliminary Yearly

SCIENCE PRELIMINARY PHYSICS



Multiple Choice:

Question	Answer
1	A
2	A
3	C
4	D
5	B
6	C
7	C
8	C
9	D
10	C

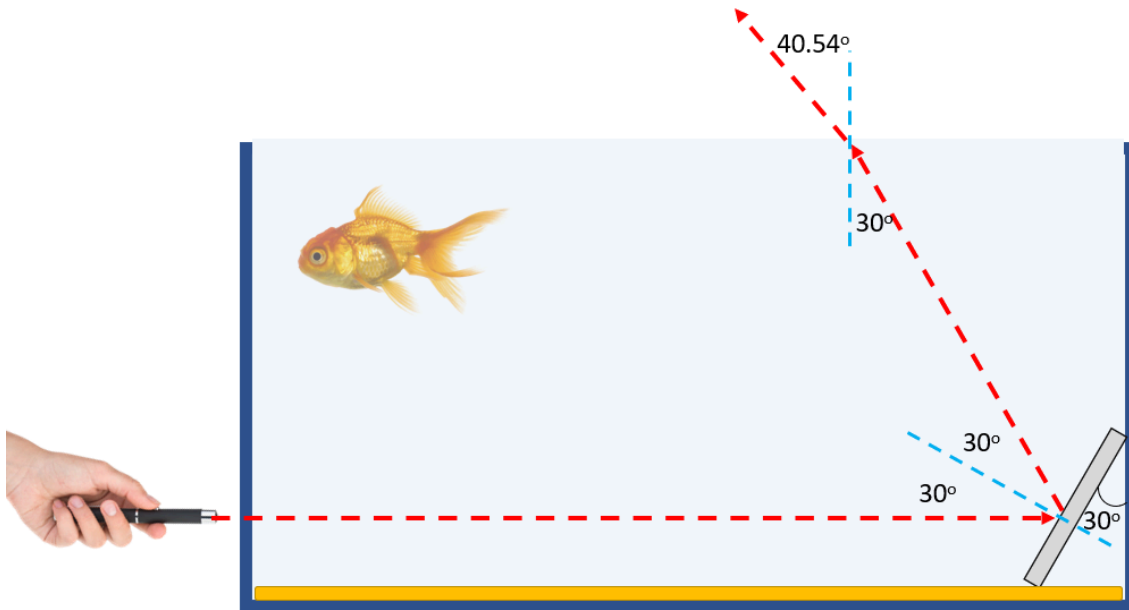
Question	Answer
11	B
12	C
13	B
14	C
15	C

Question 16 (6 marks)

A laser beam is flashed through a glass rectangular fish tank wall. The tank is filled to the top with water and has no glass lid over it. A small mirror is placed inside the tank at an angle of 30° to the wall it rests on.

(A) Trace out the path from the laser pointer to the mirror, along with the path it traces out of the tank. Take the refractive index of air to be 1, water 1.3 and glass 1.5. **(4 marks)**

Sample answer :



Criteria	Marks
<ul style="list-style-type: none"> All four angles where the light changes direction are marked and drawn to scale with a protractor. The drawn ray clearly compliments the inscribed angles. 	4
<ul style="list-style-type: none"> All correct angles are included, but angles are not drawn to scale 	3
<ul style="list-style-type: none"> May provided correct calculation for reflective angles Or Refraction of ray out of the water air boundary 	2
<ul style="list-style-type: none"> Students demonstrates an understanding about the nature of ray diagrams and how they model reflection and or refraction. 	1

Marker’s feedback:

Students were assessed on their ability to apply the law of reflection and refraction in this question. By students using the law of reflection they should have been able to trace out the first three angles. The last angle requiring the light to exist out of the water considered the light bending away from the normal. Students who performed poorly in this question are encouraged to review module three and the principles behind ray diagrams.

(B) Calculate the critical angle at the water air boundary. (2 marks)

Sample answer :

$$\begin{aligned}n_1 \sin \theta_1 &= n_2 \sin \theta_2 \\1.3 \sin \theta_c &= 1 \sin (90) \\ \theta_c &= \left(\frac{1}{1.3}\right) \\ \theta_c &= 50.28^\circ\end{aligned}$$

Criteria	Marks
• Correct equation, with answer	2
• Correct equation	1

Marker’s feedback:

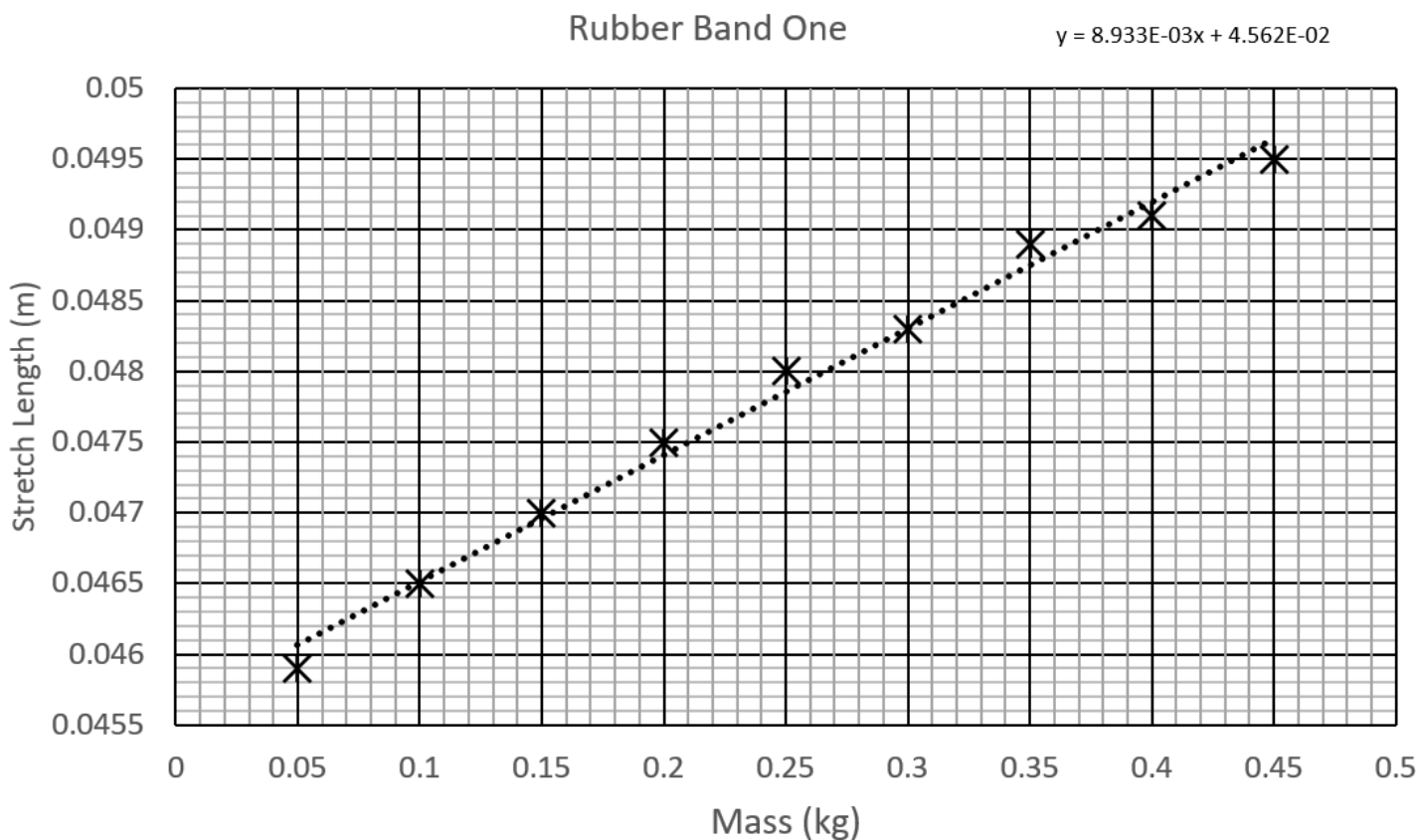
This question was accessible to the majority of the cohort. This equation is provided in the data sheet and required the students to correctly select the refractive index between the water and air boundary. The critical angle is the limit where the light ray passing through a dense medium into a less dense medium results in the light being refracted parallel to the boundary. Any angle greater than this results in total internal reflection.

Question 17 (9 marks)

One objective for scientists is to find patterns in nature. In doing this they look at how variables relate. To do this they often use experimental data.

A physics student explored the relationship between the stretch length of rubber bands with respect to loads added to them.

The student collected data for one rubber band and presented it in a graph.



Some values obtained from the graph are provided.

$$\text{Gradient} = 8.933 \times 10^{-3} \text{ m.kg}^{-1}$$

$$\text{Y-intercept} = 4.562 \times 10^{-2} \text{ m}$$

(A) What physical characteristics of the rubber band is demonstrated with the y-intercept in this data?
(1 mark)

Sample answer :

The resting length of the rubber band

Criteria	Marks
● Correct response	1

Marker's feedback:

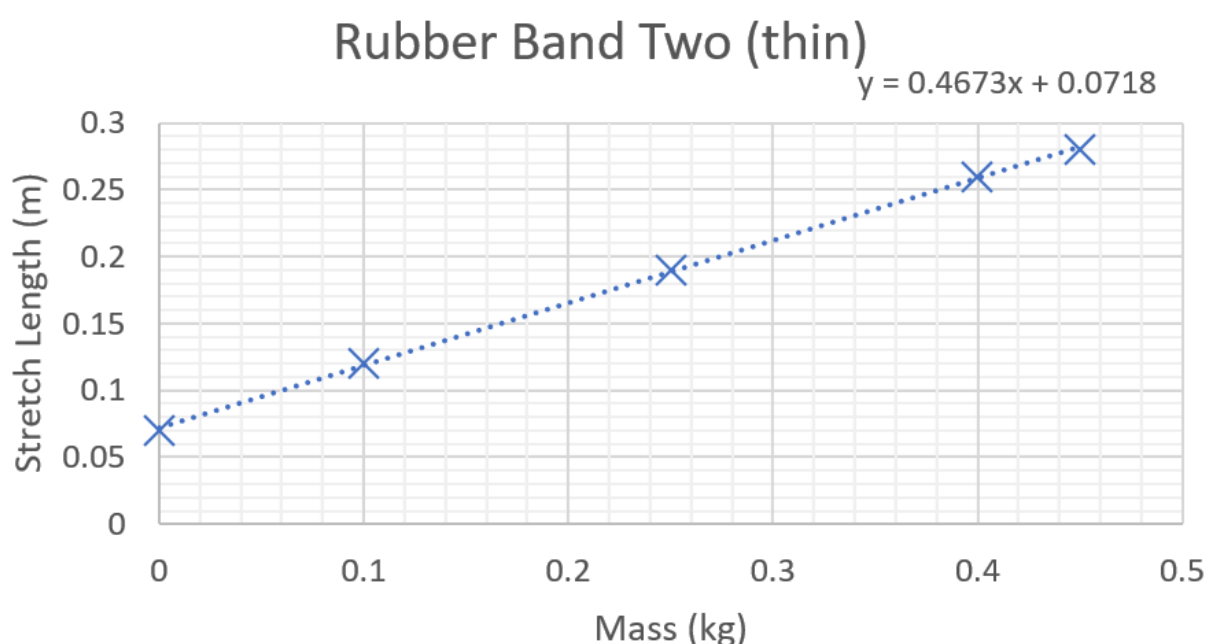
Responses were generally correct. Student were expected to think critically about the data at hand.

The student gathered some more data on a different rubber band. Presented below, is the mass loaded on to the mass which was recorded in kilogram (kg), while the stretch length of the rubber band was recorded in meters (m).

Mass loaded (kg)	Stretch length of the rubber band (m)
0.00	0.07
0.10	0.12
0.25	0.19
0.40	0.26
0.45	0.28

(B) Graph the data and create a line of best fit. (3 marks)

Sample answer :



Criteria	Marks
<ul style="list-style-type: none"> ● Meets the following criteria <ul style="list-style-type: none"> ● Suitable scale is provided for axis – along with headings ● Points are correctly aligned and made with crosses ● Appropriate line of best fit is administered 	3
<ul style="list-style-type: none"> ● Two of the ideal answer 	2
<ul style="list-style-type: none"> ● One from the ideal answer 	1

Marker's feedback:

Students demonstrated strength in developing an appropriate graph with suitable labels, scales and line of best fit.

(C) Calculate the gradient for the data gathered for the second rubber band. (2 marks)

Sample answer :

$$\frac{\Delta y}{\Delta x} = \frac{0.19-0.12}{0.25-0.1} = 0.467 \text{ m.kg}^{-1}$$

Criteria	Marks
<ul style="list-style-type: none"> • Uses points on the line to provide a correct calculation. 	2
<ul style="list-style-type: none"> • Correctly attempts the question 	1

Marker’s feedback:

Students must be critical about the values the assigning to points in a graph and are intending to use for a gradient calculation. Some students either got confused by their own selection of points or did not use their appropriate values in their calculations. This was intended as an easier question which more students were expected to get correctly. Students must revise the data processing and analysing skills.

(D) Gradients of graphs are quantities which describe the rate of change in studied phenomena. Use Hooke’s Law to **account** for the difference in the gradient values experienced by Rubber Band One and Rubber Band Two. (3 marks)

Sample answer :

The data provided considered how the rubber band stretched with an increase in load added to it. The first rubber band had a gradient value of 0.008933 m.kg⁻¹, while the second rubber band has a gradient value of 0.4673 m.kg⁻¹. The first rubber band was less flexible, stretching to 4.9cm under a load of 450g, while the second rubber band was more flexible – stretching to 28 cm under a load of 450g. Hooke’s law is a mathematical model that can also be applied to rubber bands. Here the spring constant relates to the stiffness of the rubber band, being that the unit of stretch length per mass added to rubber band increases proportionally by this constant. The stretch length of each rubber band behaves in a predictable manner as per the constant provided in the gradient. Taking the inverse for the value of the gradients for the data provided would support these findings.

Criteria	Marks
<ul style="list-style-type: none"> • Meets the following criteria <ul style="list-style-type: none"> • Provides a comparison between the gradients of separate graphs • Accounts for the for the different properties of the rubber band. • Develops a correct argument about the property of the rubber bands using Hooke’s law. 	3
<ul style="list-style-type: none"> • Two of the ideal answer 	2
<ul style="list-style-type: none"> • One from the ideal answer 	1

Marker’s feedback:

Students were assessed on their ability to analyse stimulus, problem solve and communicate their understanding about the trend found in the data. The question revealed that the cohort dissect the question thoroughly, with some students failing to consider a comparison between the gradients of the two data sets. Most students attempted to make a connection between the values of the gradient and the stiffness constant “k” of Hooke’s Law. The area where the cohort had the greatest difficulty was in building a correct argument to account for the differences in the rubber band.

Question 18 (4 marks)

A boat is travelling across the Nepean River. The river is flowing downstream with a strong current of 2.4 ms^{-1} . The boat has a maximum speed of 8 ms^{-1} . At the crossing point, the river is 220 m wide.

(A) Determine the velocity of the boat relative to the East side river bank if it crosses directly from West to East. **(2 marks)**

Sample answer :

$v^2 = v_x^2 + v_y^2$ $v_x \sqrt{v^2 - v_y^2}$ $v_x = \sqrt{8^2 - 2.4^2}$ $v_x = 7.63 \text{ m/s}$	$\frac{v_y}{v} = \sin \theta$ $\frac{2.4}{8} = \theta$ $17.45^\circ = \theta$ <p style="text-align: center;">N073E</p>
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Criteria	Marks
<ul style="list-style-type: none"> ● Correct approach and answer. ● Correct angle 	2
<ul style="list-style-type: none"> ● One from the ideal answer 	1

Marker's feedback:

Large portion of students did this calculation wrong. Some students attempted to use SUVAT equations even though relative velocity assumes constant velocity. All vector quantities must include directions.

(B) How long will the boat take to cross the river at this point? **(2 marks)**

Sample answer :

$$t = \frac{s}{v}$$

$$t = \frac{220}{7.63}$$

$$t = 28.83 \text{ m/s}$$

Criteria	Marks
<ul style="list-style-type: none"> ● Substitutes appropriate velocity from previous calculation and the correct displacement value. ● Solves the question correctly 	2
<ul style="list-style-type: none"> ● Substituted values are correct with respect to criteria, but calculation may demonstrate a minor error. 	1

Marker's feedback:

Most of cohort attempted this question in an appropriate manner.

Question 19 (3 marks)

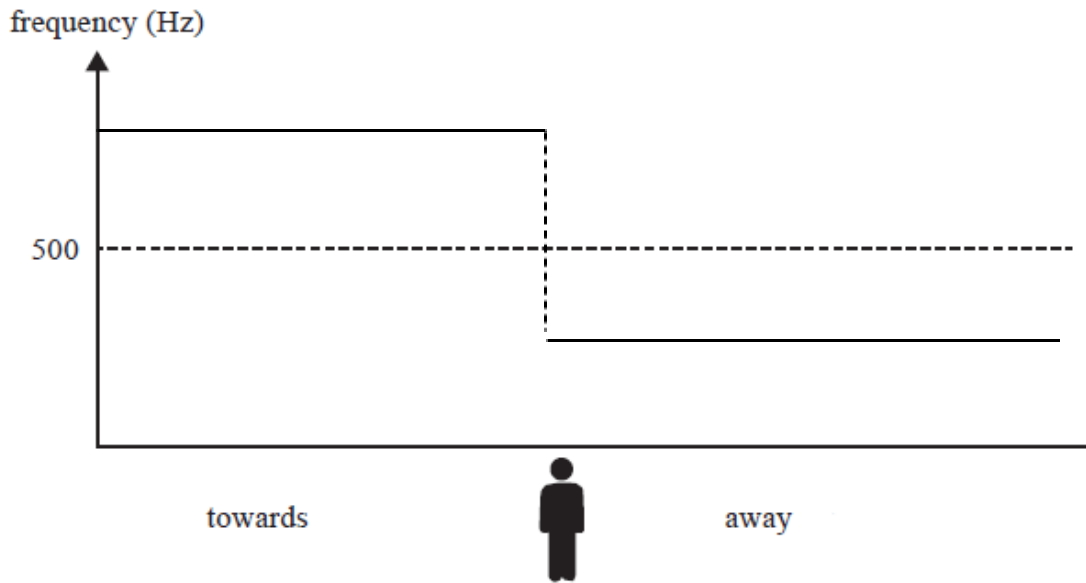
A distant fire truck travelling at 20 m s^{-1} to a fire has its siren emitting sound at a constant frequency of 500 Hz.

An observer is standing on the edge of the road. Assume that the fire truck is travelling directly towards him as it approaches and directly away from him as it goes past. The arrangement is shown below;



On the diagram below, sketch a curve to depict the frequency that the observer will hear as the truck moves towards him and then moves away from him. The 500 Hz siren signal is shown as a dotted line for reference. Consider the speed of sound as 340 ms^{-1} , Include all relevant calculations.

Sample answer :



$$f' = f_0 \left(\frac{v_w + v_o}{v_w - v_s} \right)$$

$$f^{\text{approaching}} = 500 \left(\frac{340+0}{340-20} \right) = 531 \text{ Hz}$$

$$f^{\text{receding}} = 500 \left(\frac{340+0}{340+20} \right) = 472 \text{ Hz}$$

Criteria	Marks
<ul style="list-style-type: none"> Two correct calculations and a graph that shows apparent frequency > 500 Hz before the observer and apparent frequency < 500 Hz after the receiver 	3
<ul style="list-style-type: none"> Two of the ideal answer 	2
<ul style="list-style-type: none"> One from the ideal answer 	1

Marker's feedback:

Responses demonstrated some understanding of the changes to frequency due to the doppler effect but limited skill in constructing a graph to represent this. Most students could calculate the values and most could not draw the graph.

Question 20 (8 marks)

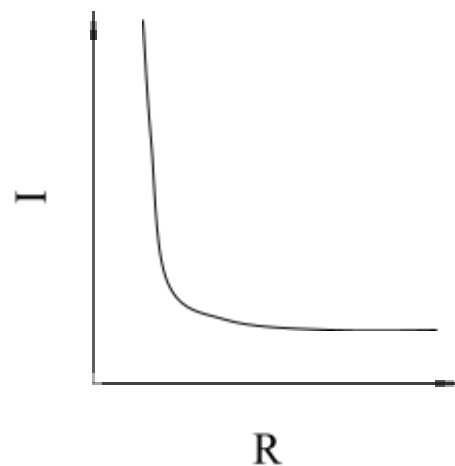
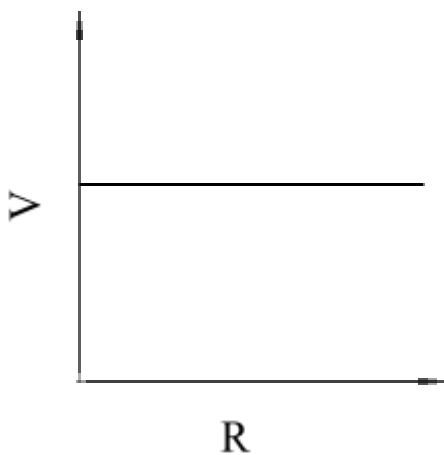
A circuit is set up as shown. R is a variable resistor.

(A) The resistance of R is gradually increased. On the graph below, sketch and label TWO graphs for what would happen to the readings of voltmeter V_2 and ammeter I_2 as this happens (**3 marks**)

Sample answer :

V_2 is the voltage across the resistors which is in parallel to the source and invariant.

R	R_T	I
0	Creates a short circuit so 0	infinite
1	1.1	10.9
10	5	2.4
100	9.1	1.3
1000	9.9	1.2
10000	9.99	1.2



Criteria	Marks
<ul style="list-style-type: none"> One mark for the correct V vs R graph Two marks for the correct I vs R graph 	3
<ul style="list-style-type: none"> Two of the ideal answer I vs R graph may show decreasing I with increasing R but not the correct shape for 1 mark out of 2. 	2
<ul style="list-style-type: none"> One from the ideal answer 	1

Marker's feedback:

Student responses were often correct but also often showed limited skill in representing physical phenomenon graphically. Any data can be represented graphically. Students are encouraged to construct a sample data analysis such as that shown in the sample to help them to think about the data to be graphed before graphing.

(B) The value of I_2 is measured to be 2 A. Calculate the resistance at which this would occur.
(3 marks)

Sample answer :

$V=IR$
 $I=2$
 $R_T=6\Omega$

$$\frac{1}{6} = \frac{1}{10} + \frac{1}{R}$$

$$R = 15\Omega$$

Criteria	Marks
<ul style="list-style-type: none"> Correct calculation of total resistance for one mark Correct calculation of R for two marks 	3
<ul style="list-style-type: none"> Two of the ideal answer 	2
<ul style="list-style-type: none"> One from the ideal answer 	1

Marker's feedback:

Students could typically calculate the total resistance but often found it difficult to determine the unknown resistance.

(B) Calculate the smallest possible total current that is possible in the circuit (2 marks).

Sample answer :

Resistance is smallest when $R \square 10\Omega$
 $V=IR$
 $I = 12/10$
 $I = 1.2 \text{ A}$

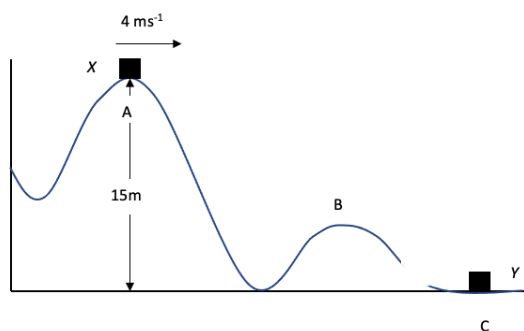
Criteria	Marks
<ul style="list-style-type: none"> Valid analysis of the scenario 	2
<ul style="list-style-type: none"> A relevant analysis of the scenario 	1

Marker's feedback:

Responses were often incomplete and demonstrated inability to recognise how the variable resistor would effect the circuit.

Question 21 (4 marks)

A roller coaster has a section shaped like the one in the diagram. The *X* and *Y* are trolleys that travel freely on wheels over the ride carrying passengers. The mass of *X* is 1000 kg and it is travelling at 4 ms⁻¹ at position A. At position C it connects and remains connected to trolley *Y* which is without passengers and has a mass of 300 Kg.



(A) Calculate the speed of trolley *X* just before the collision. (2 marks).

Sample answer :

Total energy = GPE + KE

$$E_T = mgh + \frac{1}{2} mv^2 = \text{energy at the start} = \text{energy at the finish}$$

$$= 1000 \times 9.8 \times 15 + \frac{1}{2} 1000 \times 4^2$$

$$= 155000J$$

If all energy is in the form of kinetic energy just before the collision then:

$$KE = \frac{1}{2} mv^2 = 155000$$

$$V = (2 \times 155000)^{1/2}$$

$$V = 17.6 \text{ ms}^{-1}$$

Criteria	Marks
<ul style="list-style-type: none"> Correct calculation of total energy Correct calculation of final velocity based on energy conversion 	3
<ul style="list-style-type: none"> Two of the ideal answer 	2
<ul style="list-style-type: none"> One from the ideal answer 	1

Marker’s feedback:

Some students correctly answered this question. Others omitted the initial kinetic energy from the analysis.

Some students incorrectly attempted to answer this using the equations of motion because they ignored the 2D aspect of this question.

(B) Calculate the combined speed of *X* and *Y* just after the collision. (2 marks).

Sample answer :

$$\Sigma p_i = \Sigma p_f$$

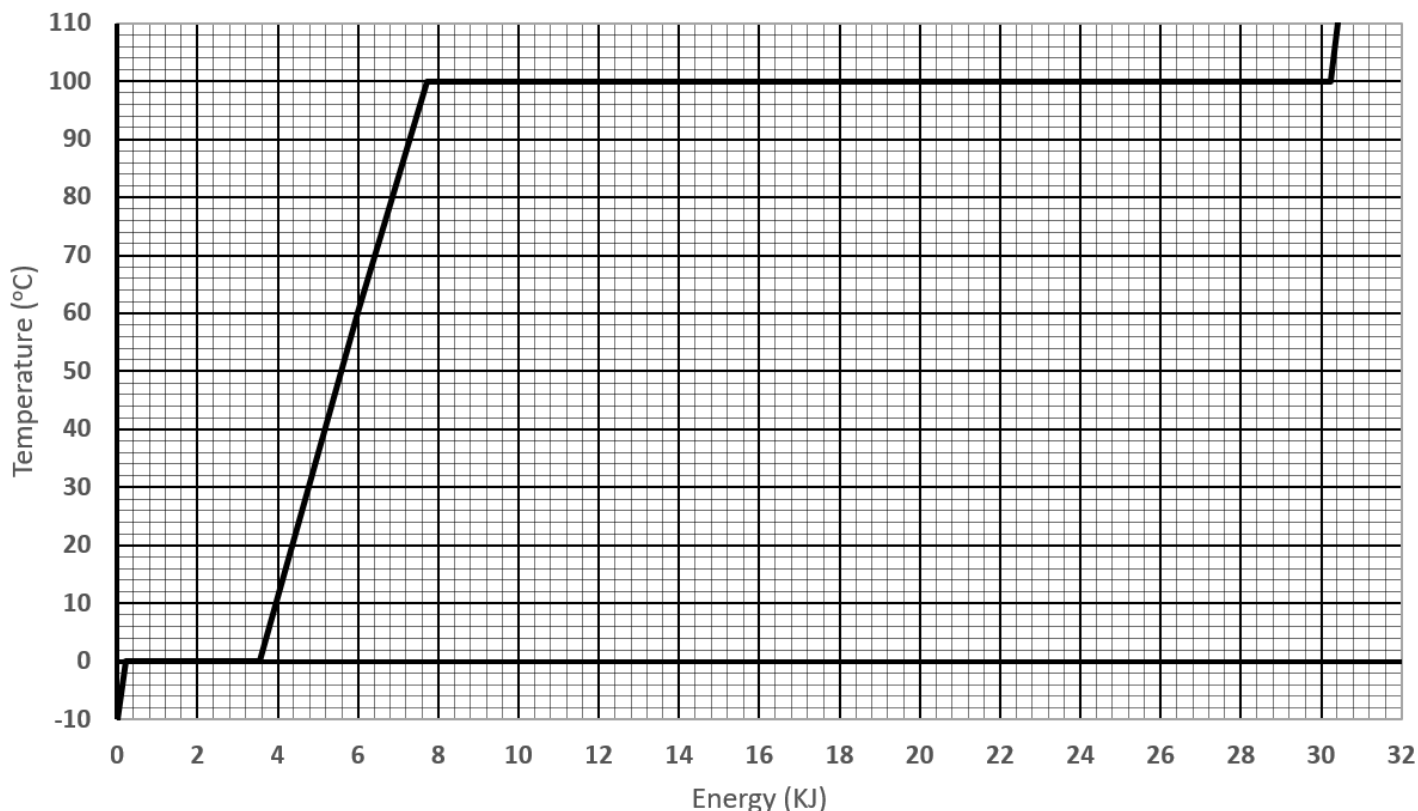
$$M_1u_1 + m_2u_2 = (m_1 + m_2) v$$

$$1000 \times 17.6 + 0 = 1300v$$

$$V = 13.5 \text{ ms}^{-1}$$

Criteria	Marks
<ul style="list-style-type: none"> Students validly used the velocity from question (a) to find final velocity. Students used the law of conservation of momentum to analyse this scenario 	3

Water



<ul style="list-style-type: none"> Two of the ideal answer 	2
<ul style="list-style-type: none"> One from the ideal answer 	1

Marker's feedback:

This question required students to use the law of conservation of momentum. Conservation of kinetic energy is not valid as it cannot be assumed and the masses become connected.

Question 22 (4 marks)

The following data illustrates the heating curve of water. Here, as energy (KJ) is added to the water, the temperature increases (°C)

(A) Describe where in the graph the substance is being heated up, and where it is undergoing phase change. **(2 marks)**

Sample answer :

Heating from -10 degrees to 0 degrees, from 0 degrees to 100 degrees and from 100 degrees upward. Phase change while the temperature does not change at 0 degrees and at 100 degrees.

Criteria	Marks
<ul style="list-style-type: none"> Identify 3 heating sections and 2 phase change sections 	2

• Less than the required number listed in a full mark answer	1
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Marker's feedback:

Students need to be clear and specific with their responses.

(B) Use the graph to calculate the quantity of water heated up. (2 marks)

Sample answer :

$$\begin{aligned} \Delta T &= 100^{\circ}\text{C} & c &= 4.18 \times 10^3 & Q &= 4 \times 10^3 \text{ J} \\ Q &= mc\Delta T \\ 4.0 \times 10^3 &= m \times 4.18 \times 10^3 \times 100 \\ m &= 0.01 \text{ Kg} \end{aligned}$$

Criteria	Marks
• Correct analysis of the question and data for a correct answer	2
• A small error in the analysis	1

Marker's feedback:

Students generally did well but there was some difficulty in choosing data to utilise from the graph and the use of scientific notation, prefixes and units.

Question 23 (4 Marks)

Two students are kneeling on rolling office chairs. They are facing each other and can touch their hands together. One student has a mass of 43 Kg and the other has a mass of 49 Kg.



Use physics principles to describe the motion of the 43 kg student if they push the 49 kg student away with an equal and opposite force.

Criteria	Marks
<ul style="list-style-type: none"> Correct analysis of motion with the relevant physics principles, including quantitative aspects 	4
<ul style="list-style-type: none"> Correctly describes the motion of the students with the application of the law of conservation of momentum or Newton’s second law 	3
<ul style="list-style-type: none"> States that the 43 kg student will move faster than the 49 kg student and makes some reference to the conservation of momentum or Newton’s second law 	2
<ul style="list-style-type: none"> Provides some relevant information 	1

Sample answer: The 43 kg student would move back at an initial velocity that is faster than the 49 kg student. This is due to the law of conservation of momentum which states that the sum of the initial momentum is equal to the sum of the final momentum of a system.

$$0 = (43)v_1 + (49)v_2$$

$$43(v_1) = -49(v_2)$$

$$v_1 = -49/43 (v_2)$$

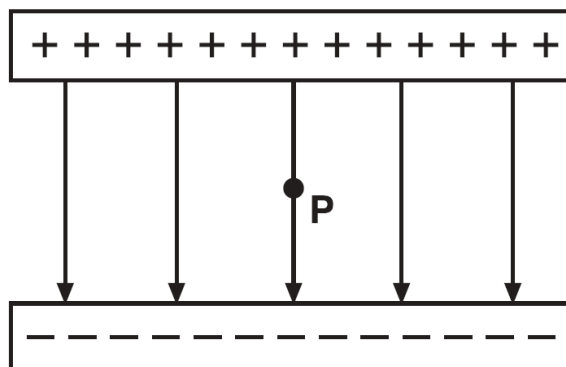
Marker’s feedback:

Many students did not consider the quantitative aspect of the question. Students are advised that if numbers (such as mass) are given in a question, then you are expected to do some sort of quantitative

analysis. Many students also restated many aspects of the stimulus which does not contribute to any marks.

Question 24 (9 marks)

An electric field is established between a set of parallel plates as shown in the diagram below. The potential difference between the plates is 10 V and the plates are separated by a distance of 0.1 m. A particle “P” is placed exactly halfway between the two plates. Ignore the effects of gravity.



(A) If the particle were an electron, calculate the force that the particle P experiences in the field. (2 marks).

Criteria	Marks
<ul style="list-style-type: none"> Correctly calculates the force acting on the electron 	2
<ul style="list-style-type: none"> Provides some relevant information 	1

Sample answer :

$$E = \frac{V}{d} \qquad F = qE$$

$$= \frac{10}{0.1} \qquad = 1.602 \times 10^{-19} \times 100$$

$$= 100 \text{ V.m}^{-1} \qquad = 1.602 \times 10^{-17} \text{ N}$$

Marker’s feedback: Some students were confused as to whether to use 0.1 or 0.05 as the distance.

(B) If the electron is released from rest, calculate the kinetic energy of the electron once it reaches one of the electric plates. (3 marks)

Criteria	Marks
<ul style="list-style-type: none"> Correctly calculates the kinetic energy of the electron, including correct units and sign (must be positive) 	3
<ul style="list-style-type: none"> Provides some progress towards the correct answer 	2
<ul style="list-style-type: none"> Provides some relevant information 	1

Sample answer:

$$W = FS$$

$$= (1.602 \times 10^{-17}) (0.05)$$

$$= 8.01 \times 10^{-19} \text{ J}$$

$$W = \Delta KE$$

$$W = KE_F - KE_I$$

$$8.01 \times 10^{-19} = KE_F - 0$$

$$KE_F = 8.01 \times 10^{-19} \text{ J}$$

Marker's feedback: There are several ways to approach this problem, but the quickest way is to use the work-energy theorem. Many students also omitted units and included a negative sign (which is not possible in this situation).

(C) The electron is replaced with a proton at the exact same position. If the proton was also released from rest, compare the velocity at which the proton hits the plate with that of the electron.

(4 marks)

Criteria	Marks
<ul style="list-style-type: none"> Provides an analysis of the two particles that compares their velocities as well as direction. 	4
<ul style="list-style-type: none"> Provides a complete response with one minor error or omission 	3
<ul style="list-style-type: none"> Provides some progress towards determining the properties of both particles 	2
<ul style="list-style-type: none"> Provides some relevant information 	1

Sample answer:

Electron:

$$\frac{1}{2}mv^2 = 8.01 \times 10^{-19} \text{ J}$$

$$v = \sqrt{\frac{2 \times 8.01 \times 10^{-19}}{9.109 \times 10^{-31}}}$$

$$= 1.33 \times 10^6 \text{ m/s up}$$

Proton:

$$F_{net} = ma$$

$$1.602 \times 10^{-17} = 1.673 \times 10^{-27} \times a$$

$$a = 9.58 \times 10^9 \text{ m/s}^2$$

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

$$v = \sqrt{2 \times (9.58 \times 10^9) (0.05)}$$

$$= 3.09 \times 10^4 \text{ m/s}$$

The electron moves up and hits the plate at a speed that is approximately 42 times greater than the proton, which moves in the opposite direction downwards.

Marker's feedback: Overall, this question was done quite poorly. Many students did not provide a ratio for the basis of comparison (or even a comparative statement). In this case, the marking criteria was generous and did not require a ratio but still required a comparative statement. Most students failed to account for the difference in direction of the two particles.

Question 25 (2 marks)

The intensity of electromagnetic waves from the sun is 1400 Wm^{-2} just above the earth's atmosphere. Only eighty percent of this reaches the Earth's surface at noon on a clear summer day.

Suppose you think of your back as a $0.3 \text{ m} \times 0.5 \text{ m}$ rectangular area. How many joules of solar energy fall on your back as you work on your tan for 1 h? (2 marks)

Criteria	Marks
<ul style="list-style-type: none"> Correctly calculates the amount of solar energy 	2
<ul style="list-style-type: none"> Provides some relevant information 	1

Sample answer:

$$I = 1400 \times 0.8$$

$$= 1120 \text{ W}$$

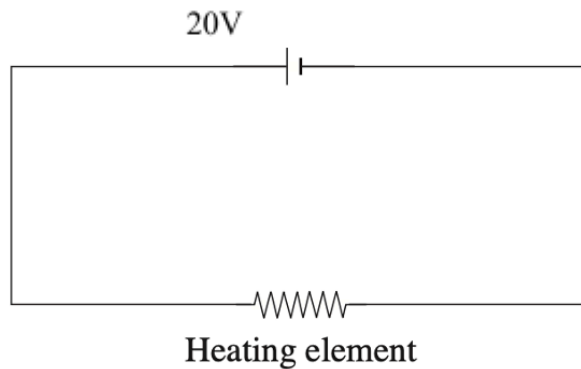
$$E = 1120 \times 0.3 \times 0.5 = 3600$$

$$= 6.04 \times 10^5 \text{ J}$$

Marker's feedback: Students are encouraged to review the definition of intensity and how it relates to total energy. It was clear that many students did not understand the scenario.

Question 26 (7 marks)

A simple heating circuit is set up as shown in the diagram below.



The current through the heating element is measured to be 3.5 A.

(A) Calculate the power of the heating element. **(1 mark)**

Criteria	Marks
<ul style="list-style-type: none"> Correctly calculates power 	1

Sample answer:

$$P = VI$$

$$= 20 \times 3.5$$

$$= 70 \text{ W}$$

Marker's feedback: No major issues

(B) The heating element is left on to run for a total of 5 minutes. Calculate the total energy dissipated by the heating element during this time (you may assume 100% efficiency). **(2 marks)**

Criteria	Marks
<ul style="list-style-type: none"> Correctly calculates total energy 	2

- | | |
|--------------------------------------|---|
| • Provides some relevant information | 1 |
|--------------------------------------|---|

Sample answer:

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

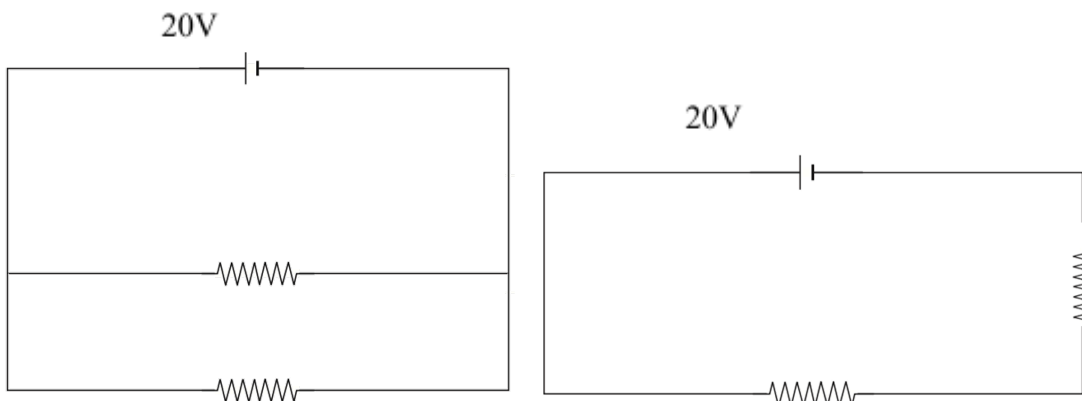
$$E = Pt$$

$$= 70 \times 5 + 60$$

$$= 2.1 \times 10^4 \text{ J}$$

Marker's feedback: Students are advised to review the relationship between and energy and power.

(C) An additional identical heating element is added to the circuit as demonstrated below.
 Compare the total power output of the power supply if the heating element was added in parallel to if it was added in series.
(4 marks)



Criteria	Marks
• Quantitatively compares the power of both circuits (including a ratio)	4
• Compares the power of both circuits with one minor error or omission	3
• Demonstrates progress to determining the power of both circuits	2
• Provides some relevant information	1

Sample answer:

$$R = \frac{V}{I} = \frac{20}{3.5} = 5.7 \Omega$$

Parallel:

$$\frac{1}{R_T} = \frac{1}{5.7} + \frac{1}{5.7}$$

$$R_T = 2.85 \Omega$$

$$P = \frac{V^2}{R} = \frac{20^2}{2.85} = 140W$$

Series:

$$R_T = 5.7 + 5.7 = 11.4 \Omega$$

$$P = \frac{V^2}{R} = \frac{20^2}{11.4} = 35W$$

The total power of the parallel circuit is FOUR times greater than the total power of the series circuit.

Marker's feedback: Most students did not understand how power/voltage/current changes as a circuit is modified – the only thing that stays the same is the resistance of each identical heating element.