

2020

PHYSICS

YEAR 11 EXAMINATION

General Instructions

- Reading time - 5 minutes
- Working time - 70 minutes
- Calculators approved by NESA may be used
- Write using black pen
- Draw diagrams using pencil
- A Data Sheet, Formulae Sheet and a Periodic Table are provided
- Write your Student Number in the space provided on the top of the first page of Part B.

Total: 60 marks

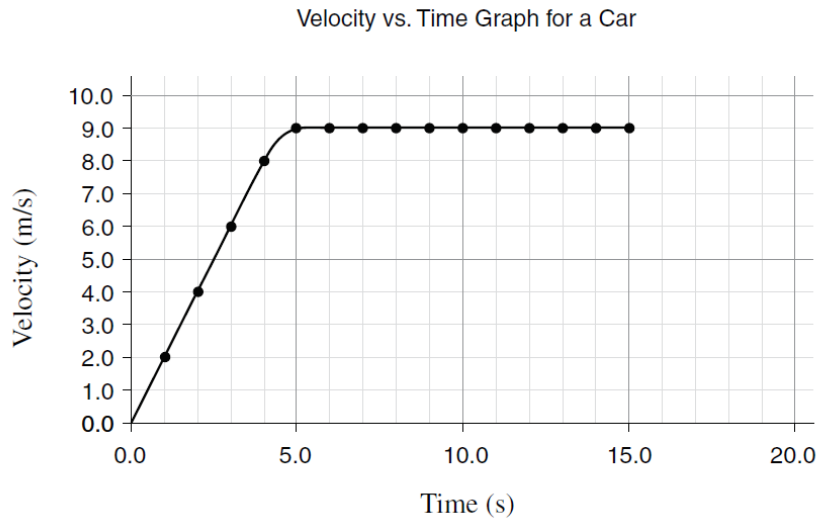
PART A 16 Multiple Choice Questions 16 marks Allow about 22 minutes

PART B Extended Response Questions 44 marks Allow about 48 minutes

PART A 16 Multiple Choice Questions

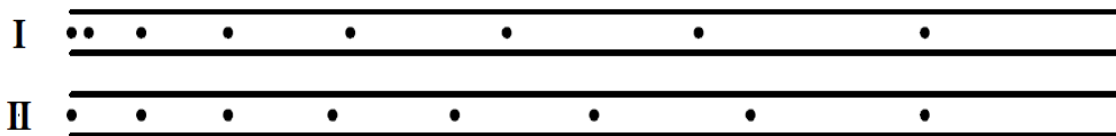
16 marks.

1. A car's motion is described by the velocity versus time graph shown below.



What is the total distance travelled by the car during its motion?

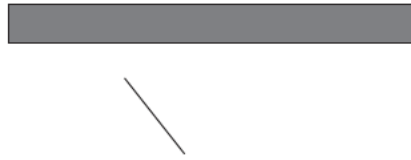
- A. 23 m
 - B. 45 m
 - C. 90 m
 - D. 113 m
2. The picture below shows the pattern of dots made on ticker tapes connected to two different moving objects, I and II. Each timer was set to make the same number of dots per second and each tape is oriented so that the first dot that was made is at the left.



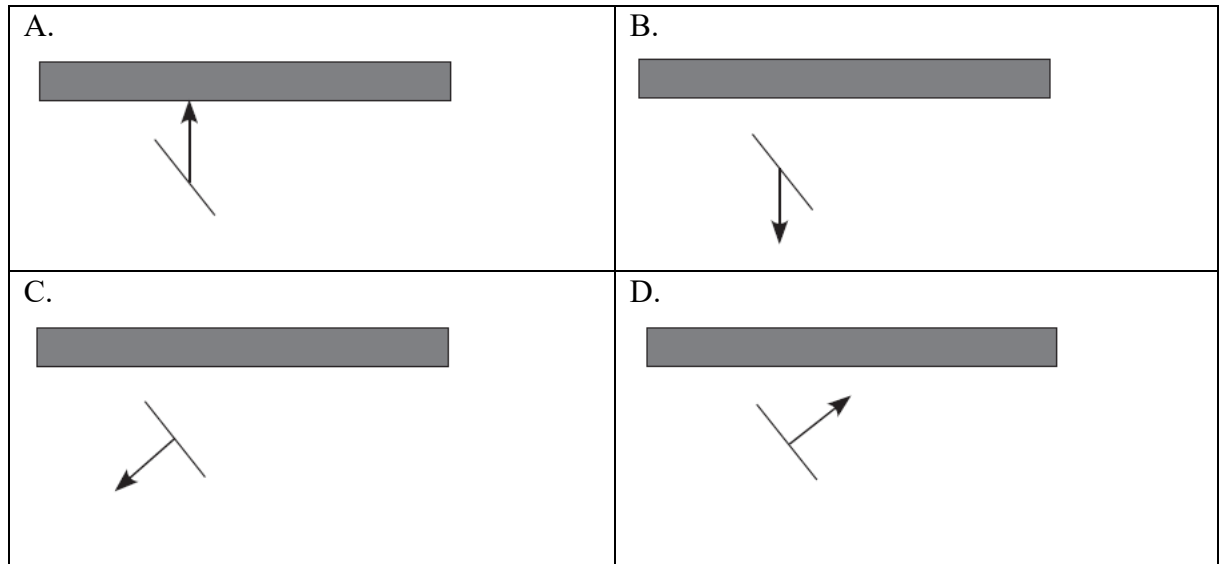
Which of the statements below best compares the motion of the two objects?

- A. Object I has a smaller initial speed than object II and object I has a smaller average acceleration than object II
- B. Object I has a smaller initial speed than object II, but object I has a larger average acceleration than object II
- C. Object I has a larger initial speed than object II, but object I has a smaller average acceleration than object II
- D. Object I has a larger initial speed than object II and object I has a larger average acceleration than object II

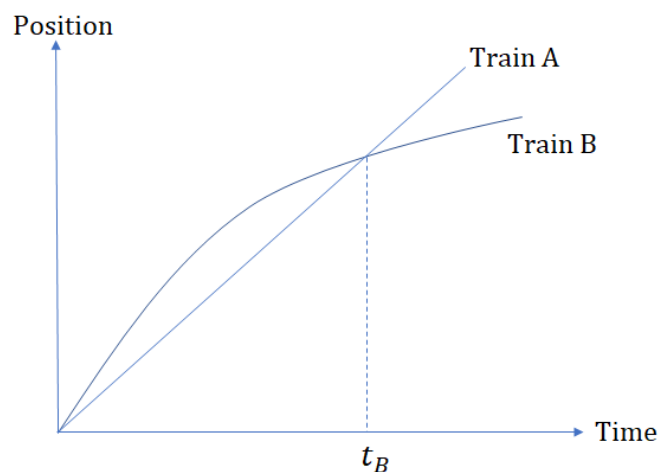
3. The diagram below shows an incident wavefront approaching a straight barrier.



Which diagram correctly shows the wave ray for the above wavefront?



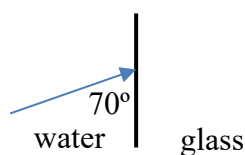
4. The graph shows the position as a function of time for two trains running on parallel tracks.



Which of the following statements is true about the trains?

- A. Both trains speed up all the time.
- B. At time t_B , both trains have the same velocity.
- C. Both trains have the same velocity at some time before t_B .
- D. Somewhere on the graph, both trains have the same acceleration.

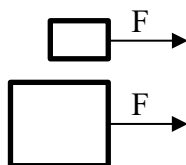
5. A ray of light, travelling through water strikes a glass wall, as shown below.



If the refractive index of water is 1.33 and that of glass 1.52, what is the angle of refraction of the light ray in the glass wall?

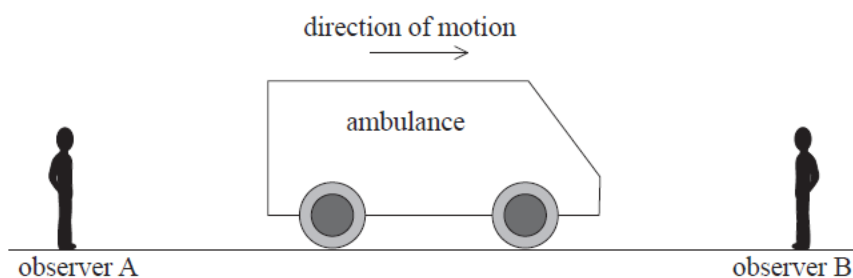
- A. 17.4°
B. 55.3°
C. 23.0°
D. 61.0°
6. Two students are discussing forces acting on objects.
- Student A: “An object falling at a steady speed will slow down if the resultant force on it is zero”.
- Student B: “If a force acts on an object it must move”
- Which of the following is true?
- A. Only student A is correct
B. Only student B is correct
C. Both student A and student B are correct
D. Neither student A nor student B are correct
7. A 10 kg block is being pulled vertically upwards by a rope at an acceleration of 5 m s^{-2} .
- What is the tension in the rope?
- A. About 50 N
B. About 100 N
C. About 150 N
D. The tension increases as the block speeds up.

8. Two blocks of different masses are pulled sideways by identical forces on a frictionless surface:



After they have been pulled the same distance, which of the following is true?

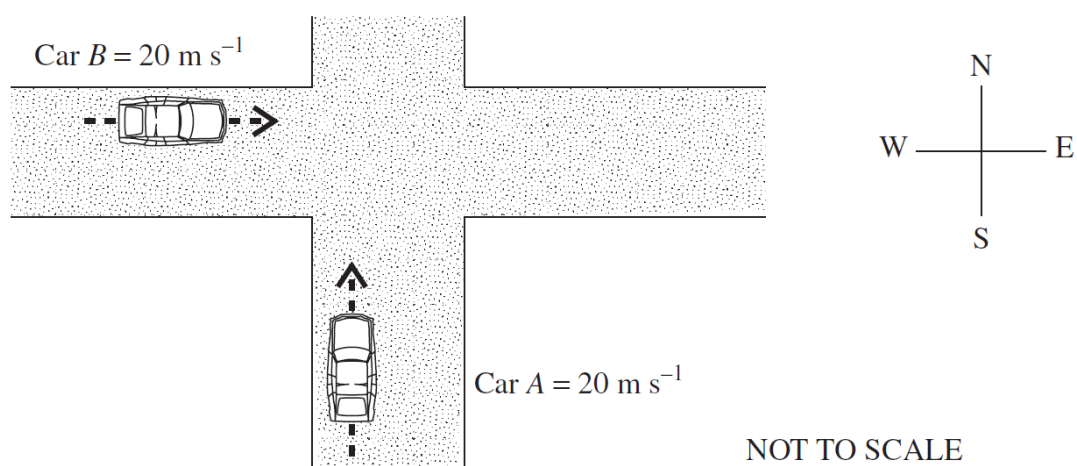
- A. The momentum of the smaller mass is higher.
 - B. The kinetic energy of the smaller mass is higher.
 - C. The power delivered to the smaller mass is higher.
 - D. The impulse delivered to the smaller mass is higher.
9. An ambulance emits a sound of frequency f as it travels along a straight road between stationary observers A and B.



Which of the following shows how the frequency of the sound heard by each observer compares with f ?

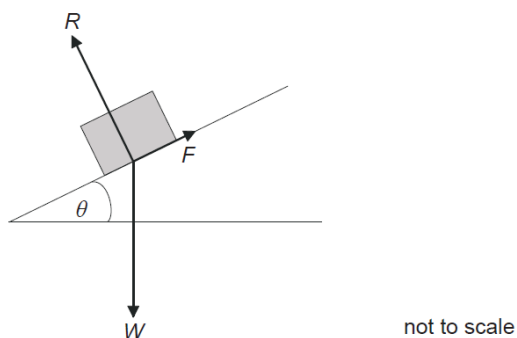
| | <i>Observer A</i> | <i>Observer B</i> |
|----|-------------------|-------------------|
| A. | less than f | greater than f |
| B. | greater than f | less than f |
| C. | greater than f | greater than f |
| D. | less than f | less than f |

10. Car *A* and Car *B* approach an intersection as shown.



What is the approximate velocity of Car *B* relative to Car *A*?

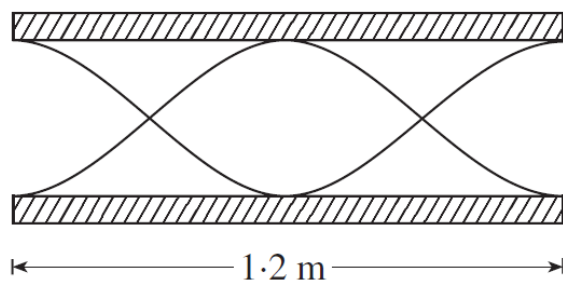
- A. 28 m s^{-1} SE
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11. The diagram shows the forces acting on a block resting on an inclined plane. The angle θ is adjusted until the block is just at the point of sliding. *R* is the normal reaction, *W* the weight of the block and *F* the maximum frictional force.



What is the maximum coefficient of static friction between the block and the plane?

- A. $\sin \theta$
 B. $\cos \theta$
 C. $\tan \theta$
 D. 1

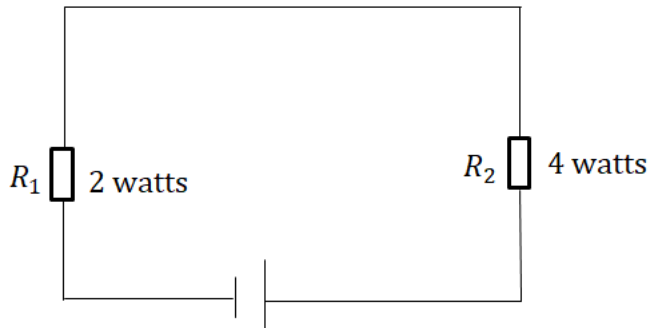
12. An organ is constructed so that it has open pipes. A note produced by one of these pipes has a frequency of 280 Hz. The length of this pipe is 1.2 m. A representation of a standing wave corresponding to this note is shown.



What is the frequency and wavelength of the fundamental resonance for this pipe?

| | <i>Frequency (Hz)</i> | <i>Wavelength (m)</i> |
|----|-----------------------|-----------------------|
| A. | 140 | 1.2 |
| B. | 140 | 2.4 |
| C. | 560 | 1.2 |
| D. | 560 | 2.4 |

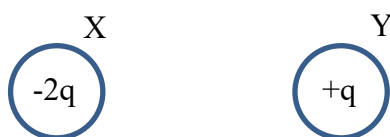
13. The power produced by two resistors in the following circuit is shown.



Which row of the table is consistent with the information provided?

| | $\frac{\text{Current through } R_1}{\text{Current through } R_2}$ | $\frac{\text{Resistance of } R_1}{\text{Resistance of } R_2}$ |
|----|---|---|
| A. | 2 | 0.5 |
| B. | 2 | 2 |
| C. | 1 | 0.5 |
| D. | 1 | 2 |

14. Two charged particles X and Y have the same mass. They are in a vacuum and their centres are aligned horizontally. They are released from rest from the positions shown.

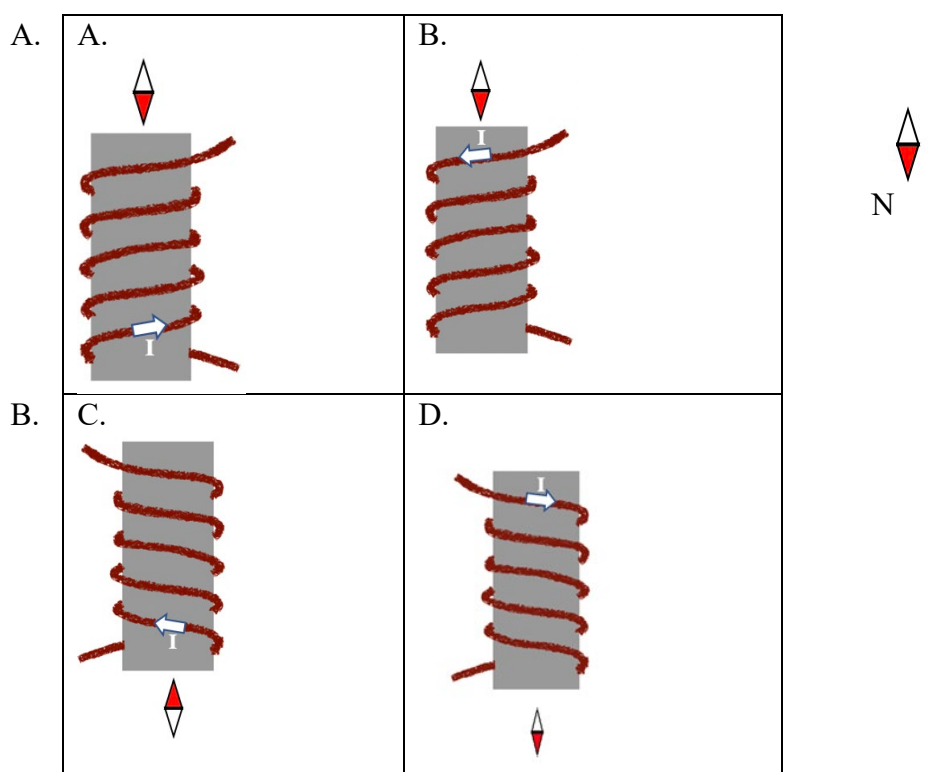


Which statement correctly compares the accelerations of X and Y?

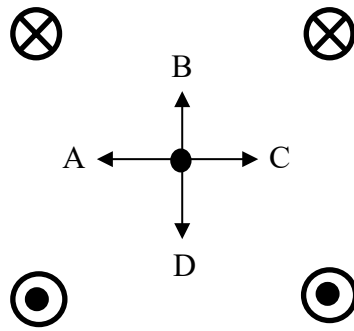
- A. The magnitude of the acceleration X is the same as that of Y and it will decrease as the particles move.
- B. The magnitude of the acceleration X is the double that of Y and it will decrease as the particles move.
- C. The magnitude of the acceleration X is the double that of Y and it will increase as the particles move.
- D. The magnitude of the acceleration X is the same as that of Y and it will increase as the particles move.
15. The diagram of a magnetic compass that could be used to investigate the effects of the current in the solenoid is shown when there is no current in the solenoid.

The long axis of the solenoids in the options is parallel to the compass needle shown in the diagram of the magnetic compass.

In which of the following diagrams can the orientation of the compass needle adjacent to the end of the solenoid be accounted for as being due ONLY to the effects of the current in the solenoid?



16. Four parallel current-carrying conductors are placed at the corners of a square as shown below.



If the magnitudes of the currents in the four conductors are the same, what is the direction of the net magnetic field at the centre of the square?

- A. A
- B. B
- C. C
- D. D

ANSWER BOOKLET

Student No.

PART A Multiple Choice Answer Sheet

16 marks

Choose the most appropriate answer and fill in the response oval completely.

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 ○

Attempt questions 17-29.

Allow about 48 minutes for this part.

Show all relevant working in questions involving calculations.

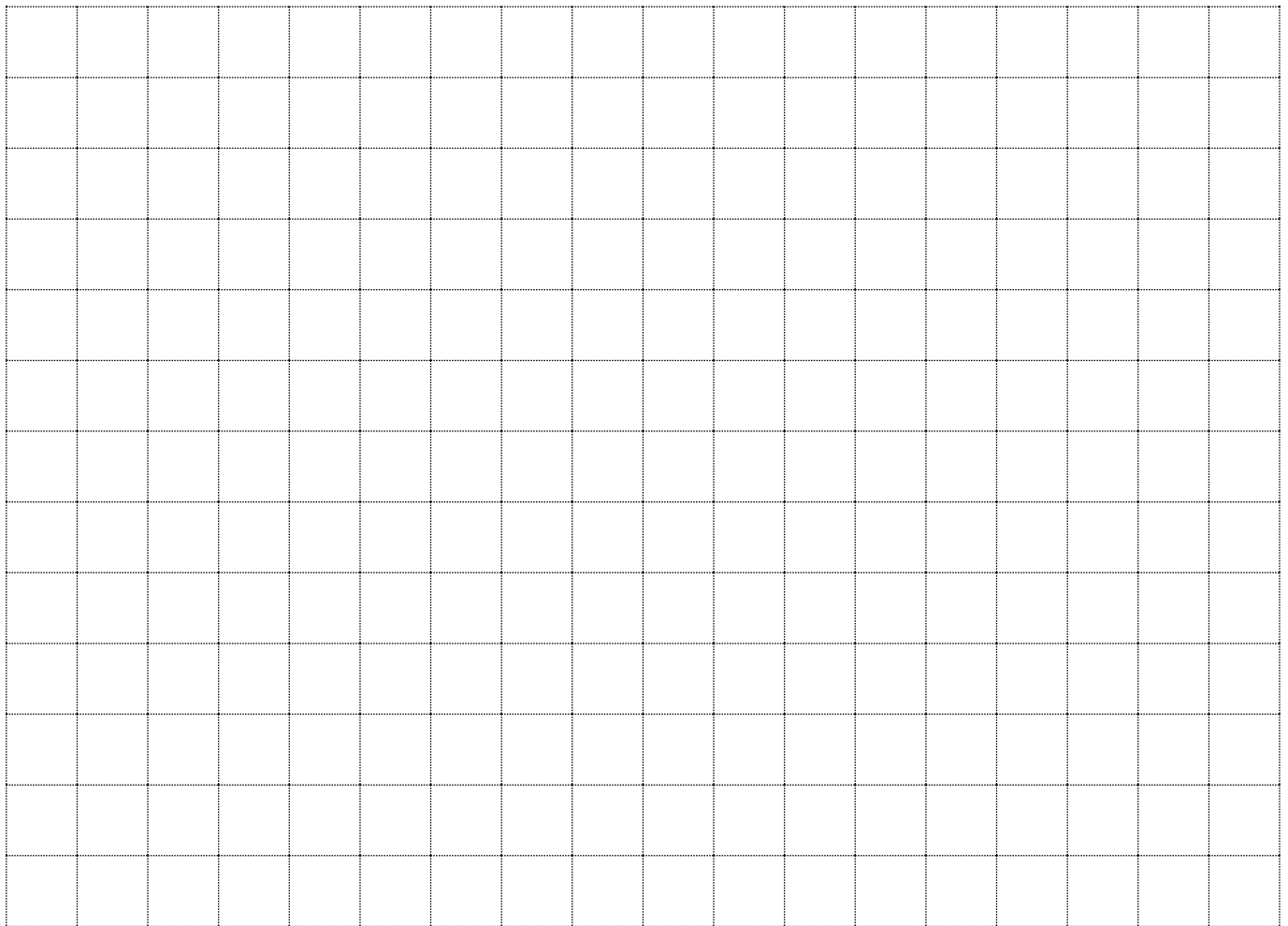
Question 17 (4 marks)

An explorer is caught in a whiteout (in which the snowfall is so thick that the ground cannot be distinguished from the sky) while returning to base camp. He was supposed to travel due north for 4.5 km , but when the snow clears, he discovers that he actually travelled 7.8 km at E 50° N.

4

By drawing an accurate vector diagram to scale (1 cm \equiv 1 km), determine how far and in what direction must he now travel to reach base camp?

NOTE: No marks will be awarded if algebraic techniques are used.



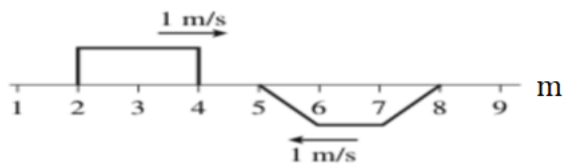
How Far: _____

What Direction: _____

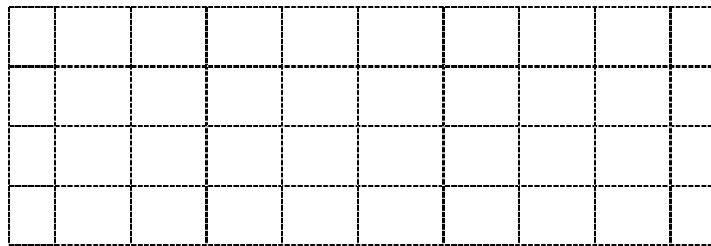
Question 18 (3 marks)

Two waves on a string, at $t = 0$, are moving towards each other at a speed of 1 m s^{-1} , as shown below.

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Draw the appearance of the string at $t = 2 \text{ s}$.



Question 19 (4 Marks)

(a) With reference to magnetic domains (moments), outline the difference between an unmagnetised magnetic material and a magnetised material.

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(b) Sketch a graph that clearly shows the relationship between the distance from a long current-carrying conductor and the magnitude of the magnetic field around the wire as a function of distance.

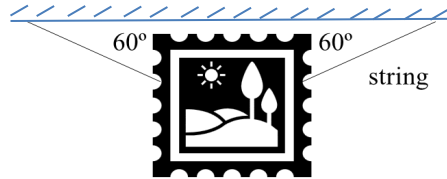
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Question 20 (3 marks)

A 1.5 kg picture frame is hanging on the wall by massless and inextensible strings as shown:

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By drawing a free body diagram of the forces acting on the frame, find the tension, T in the string.

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Question 21 (2 Marks)

A rubber ball is dropped from a height of 1 m and rebounds to the same height. Which of momentum and/or kinetic energy is conserved in the collision with the ground?

2

Justify your answer using physics principles.

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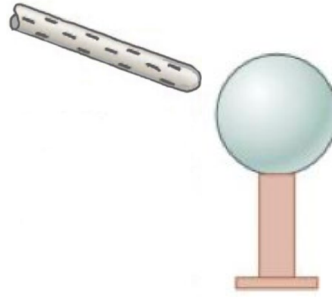
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Question 22 (2 Marks)

Explain the charge on the metal sphere if it was initially neutral and it was charged by induction using the negatively charged rod.



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Question 23 (3 Marks)

Two trains, one of which is stationary, emit 424 Hz whistles. A passenger on the stationary train hears a 3 Hz beat frequency when the other train approaches.

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Calculate the speed of the moving train.

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Question 24 (6 Marks)

A driver of a car going 90 km h^{-1} suddenly sees the lights of a barrier 40.0 m ahead. It takes the driver 0.75 s before he applies the brakes. Once he does begin to brake, he slows down at a rate of 10 m s^{-1} every second.

- a) Does he hit the barrier? Justify your answer by means of calculations. **3**

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- b) What would be the maximum speed at which the car could travel and not hit the barrier 40.0 m ahead? Assume the same reaction time and braking rate. **3**

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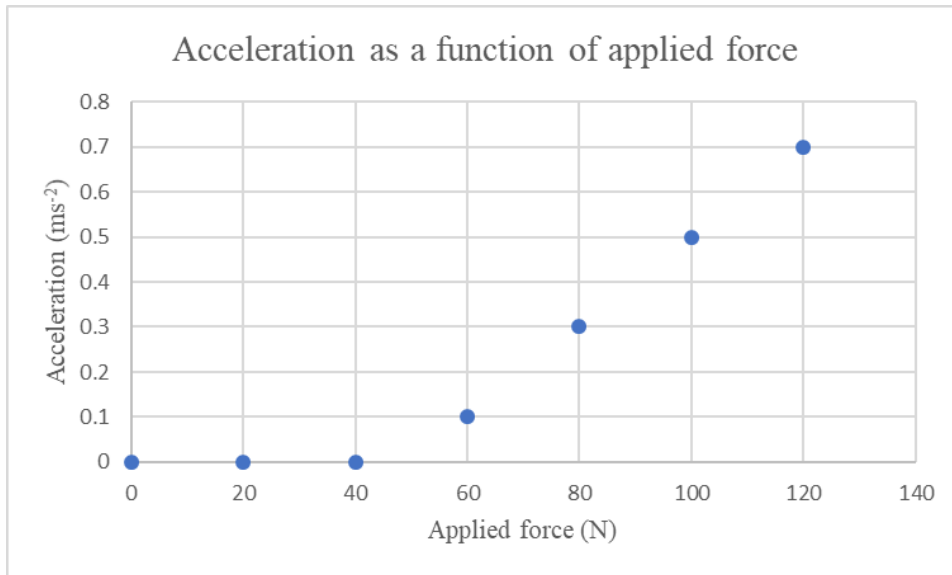
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Question 25 (3 Marks)

A 100 kg box is pushed with varying forces on a lubricated rough surface and the corresponding 3 accelerations measured.



The graph below shows the acceleration of the box as a function of the applied force.



Use the graph to determine the coefficient of dynamic (kinetic) friction.

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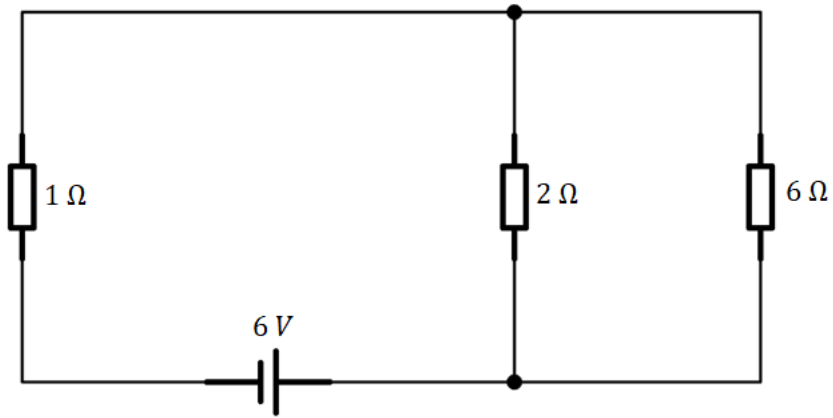
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Question 26 (3 Marks)

Calculate the current that flows through the $6\ \Omega$ resistor in the circuit shown.



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Question 27 (3 marks)

At what distance apart should a $6 \mu\text{C}$ charge be placed from a $-8 \mu\text{C}$ charge so that they experience an attractive force of 1.11 N ?

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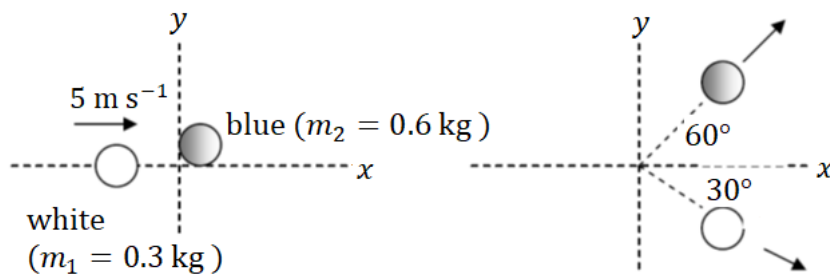
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Question 28 (4 marks)

The diagram below shows a collision between a 0.3 kg white ball moving at 5 m s^{-1} horizontally and a 0.6 kg blue ball which is initially at rest. The collision is not head-on, so the balls bounce off of each other at the angles shown.

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Find the final speed of each ball after the collision.
(Let the speed of the blue ball be v_2 and the white ball be v_1 .)

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Question 29 (4 Marks)

Dr Sendt recently acquired a lamp, like the one shown below, to help her cross stitch at night. A biconvex lens is surrounded by a circle of lights, equivalent to the light output of the overhead ceiling light in the room.



Using relevant Physics principles, explain why this tool will help Dr Sendt to see her stitches.

4

Use appropriate diagrams to support your answer.

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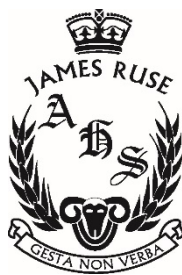
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END OF EXAMINATION ☺



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Total: 60 marks

PART A 16 Multiple Choice Questions 16 marks Allow about 22 minutes

PART B Extended Response Questions 44 marks Allow about 48 minutes

Part A – 16 marks

Attempt Questions 1-16

Allow about 22 minutes for this part

Use the multiple choice answer sheet on page 11.

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

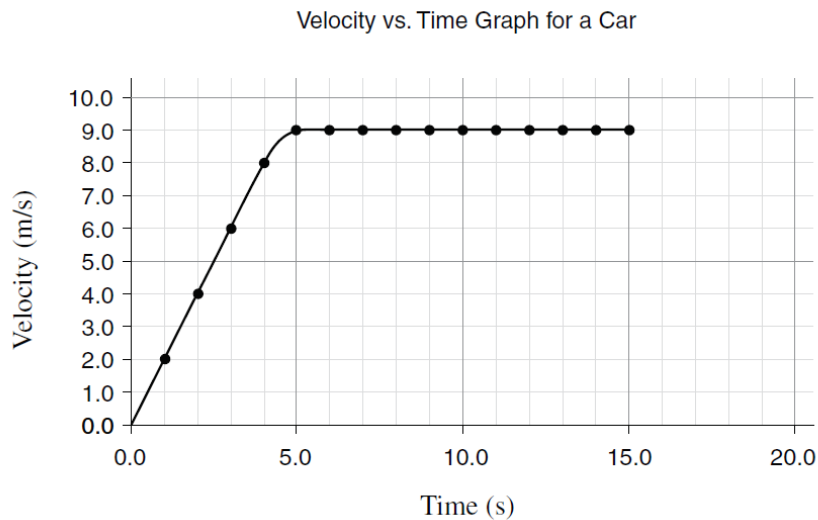
If you change your mind and have crossed out what you consider to be the correct answer, then indicate the correct answer by writing the word **correct** and drawing an arrow as follows.

A B C D
correct ↙

PART A 16 Multiple Choice Questions

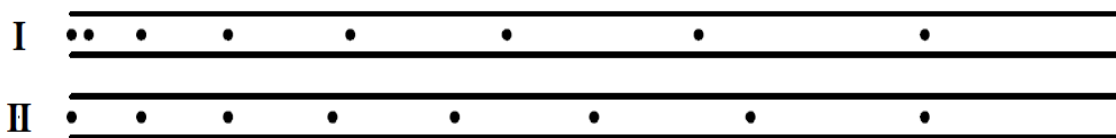
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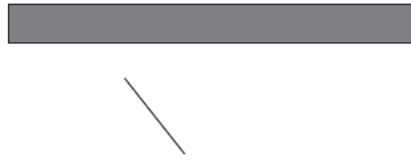
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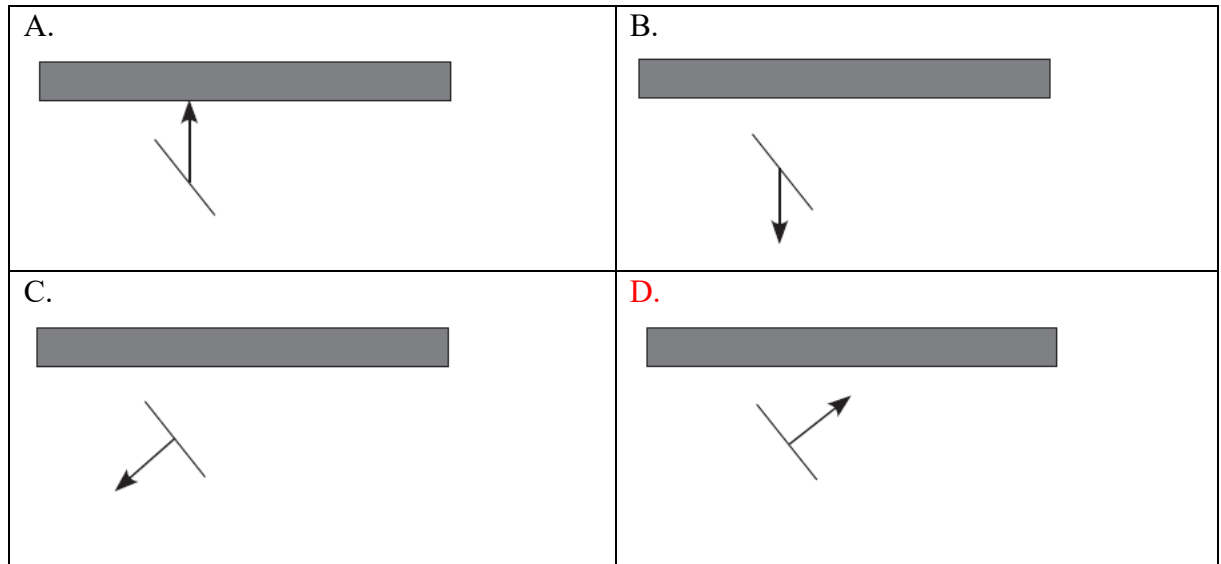
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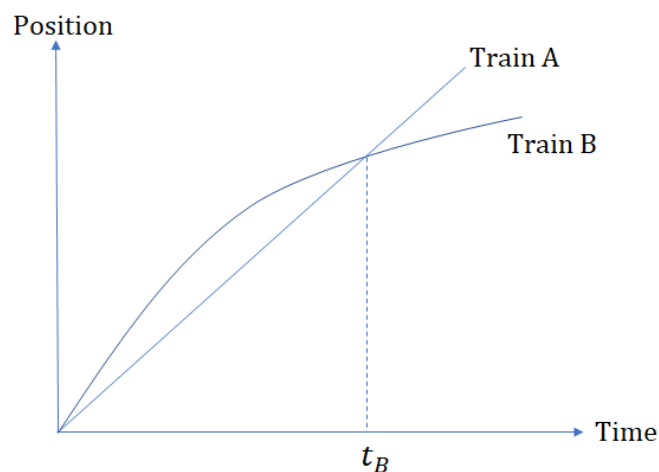
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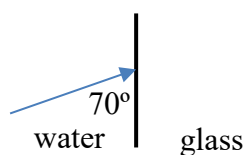
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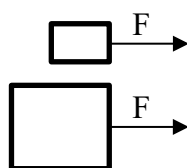
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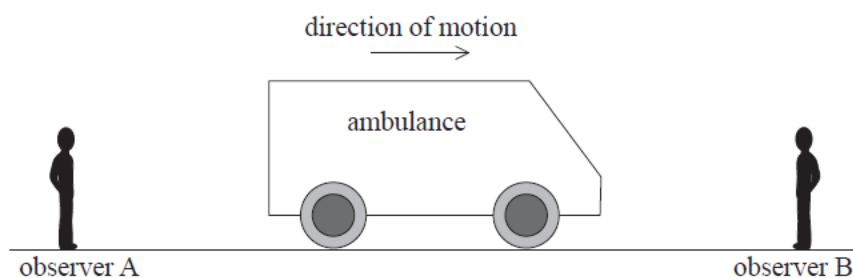
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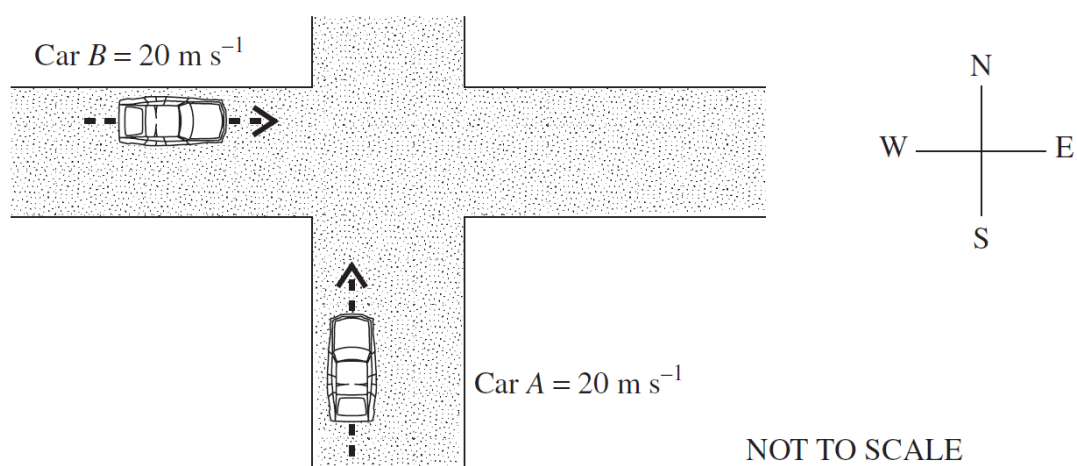
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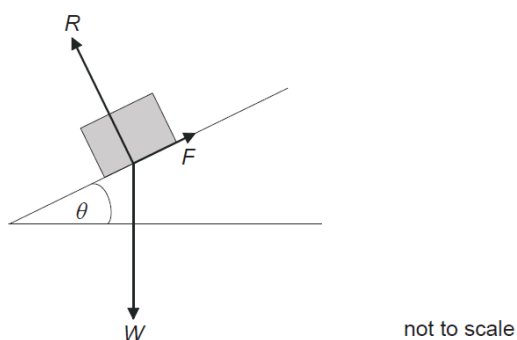
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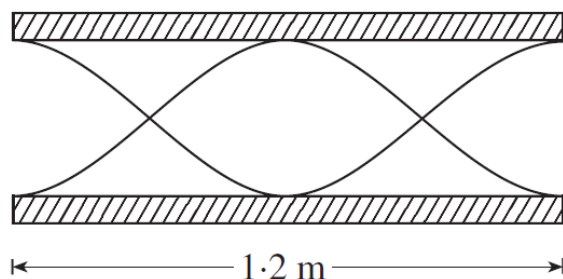
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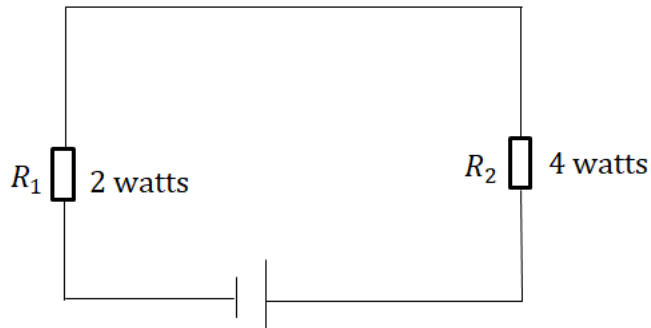
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| B. | 140 | 2.4 |
| C. | 560 | 1.2 |
| D. | 560 | 2.4 |

13. The power produced by two resistors in the following circuit is shown.



Which row of the table is consistent with the information provided?

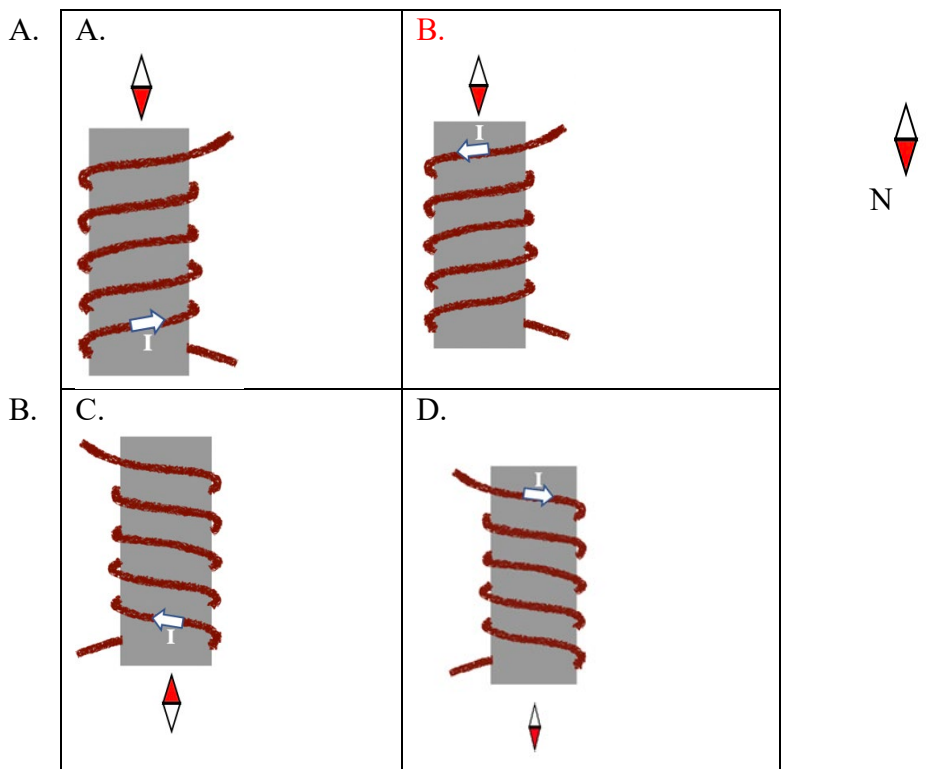
| | $\frac{\text{Current through } R_1}{\text{Current through } R_2}$ | $\frac{\text{Resistance of } R_1}{\text{Resistance of } R_2}$ |
|----|---|---|
| A. | 2 | 0.5 |
| B. | 2 | 2 |
| C. | 1 | 0.5 |
| D. | 1 | 2 |

14. Two charged particles X and Y have the same mass. They are in a vacuum and their centres are aligned horizontally. They are released from rest from the positions shown.

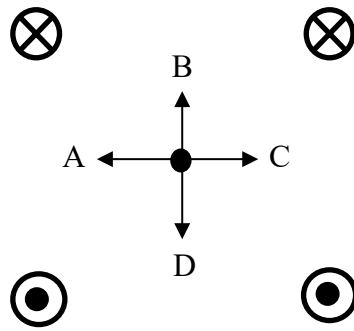


Which statement correctly compares the accelerations of X and Y?

- A. The magnitude of the acceleration X is the same as that of Y and it will decrease as the particles move.
- B. The magnitude of the acceleration X is the double that of Y and it will decrease as the particles move.
- C. The magnitude of the acceleration X is the double that of Y and it will increase as the particles move.
- D. The magnitude of the acceleration X is the same as that of Y and it will increase as the particles move.**
15. The diagram of a magnetic compass that could be used to investigate the effects of the current in the solenoid is shown when there is no current in the solenoid.
- The long axis of the solenoids in the options is parallel to the compass needle shown in the diagram of the magnetic compass.
- In which of the following diagrams can the orientation of the compass needle adjacent to the end of the solenoid be accounted for as being due ONLY to the effects of the current in the solenoid?



16. Four parallel current-carrying conductors are placed at the corners of a square as shown below.



If the magnitudes of the currents in the four conductors are the same, what is the direction of the net magnetic field at the centre of the square?

- A. A
- B. B
- C. C
- D. D

ANSWER BOOKLET

Student No.

PART A Multiple Choice Answer Sheet

16 marks

Choose the most appropriate answer and fill in the response oval completely.

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 ○

Attempt questions 17-29.

Allow about 48 minutes for this part.

Show all relevant working in questions involving calculations.

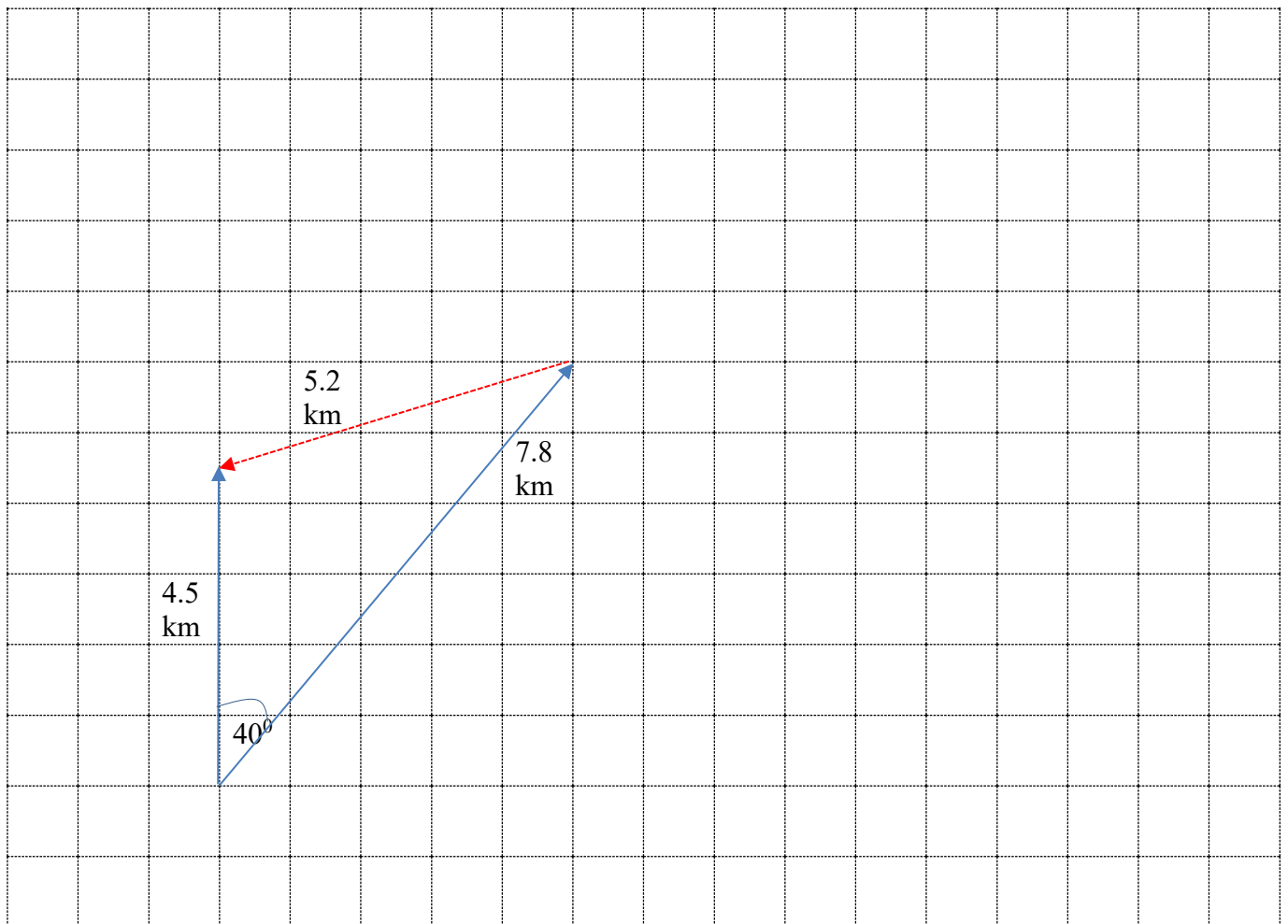
Question 17 (4 marks)

An explorer is caught in a whiteout (in which the snowfall is so thick that the ground cannot be distinguished from the sky) while returning to base camp. He was supposed to travel due north for 4.5 km, but when the snow clears, he discovers that he actually travelled 7.8 km at E 50° N.

4

By drawing an accurate vector diagram to scale (1 cm \equiv 1 km), determine how far and in what direction must he now travel to reach base camp?

NOTE: No marks will be awarded if algebraic techniques are used.



How Far: **5.2 km**

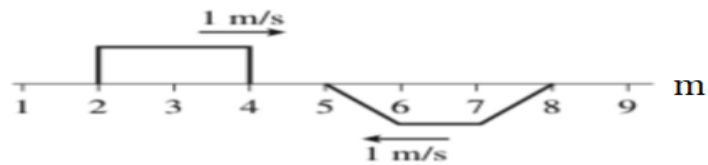
What Direction: **W17°S**

| Marking Criteria | Mark |
|--|------|
| Correctly constructing the 4.5 km vector (1), the 7.8 km vector (1), determining how far the explorer is (1) and in what direction (1), by construction. | 4 |
| Any three of the above | 3 |
| Any two of the above | 2 |
| Some relevant information | 1 |

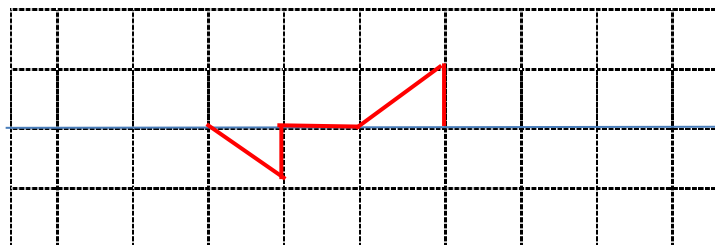
Question 18 (3 marks)

Two waves on a string, at $t = 0$, are moving towards each other at a speed of 1 m s^{-1} , as shown below.

3



Draw the appearance of the string at $t = 2 \text{ s}$.

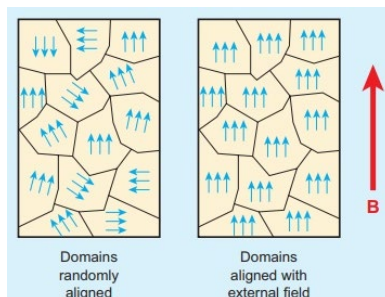


| Marking Criteria | Mark |
|--------------------------------------|------|
| For each correct resultant amplitude | 3 |
| Two/One of the above | 2/1 |

Question 19 (4 Marks)

- (a) With reference to magnetic domains (moments), outline the difference between an unmagnetised magnetic material and a magnetised material. 2

Sample answer:

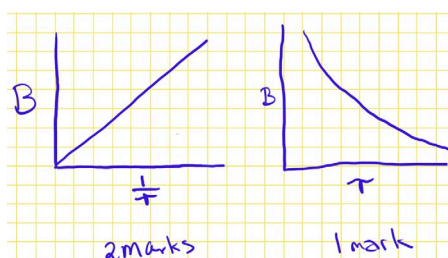
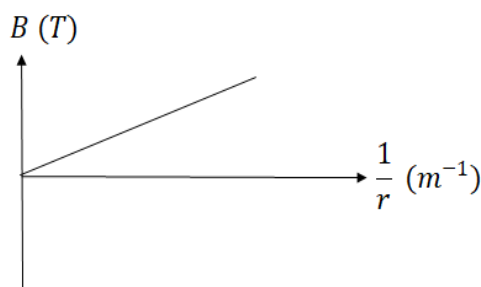


In an unmagnetised material, the magnetic field produced by individual domains has random directions and magnitudes such that the net field is zero.

A magnetised material possesses a net magnetic field because the sum of the individual domain effects is non-zero.

| Marking Criteria | Mark |
|---|------|
| Outlines the difference between magnetised and unmagnetized materials | 2 |
| One of the above | 1 |

- (b) Sketch a graph that clearly shows the relationship between the distance from a long current-carrying conductor and the magnitude of the magnetic field around the wire as a function of distance. 2



NOTE: The graph on the right does not show the relationship clearly since it cannot be deduced what the shape of the graph is ... it could be a parabola or any one of an infinite number of curves with a similar shape that do not show inverse proportionality.

| Marking Criteria | Mark |
|--|------|
| Correctly depicts that $B \propto \frac{1}{r}$, graphically | 2 |
| Shows $B \propto r$, graphically | 1 |

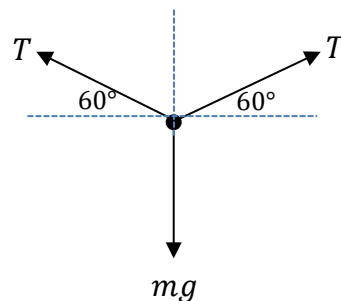
Question 20 (3 marks)

A 1.5 kg picture frame is hanging on the wall by massless and inextensible strings as shown:

3



By drawing a free body diagram of the forces acting on the frame, find the tension, T in the string.



$$\Sigma F_x = 0$$

$$T \cos 30^\circ - T \cos 30^\circ = 0$$

$$\Sigma F_y = 0$$

$$T \sin 30^\circ + T \sin 30^\circ = mg$$

$$2T \sin 30^\circ = 1.5 \times 9.8$$

$$T = \frac{1.5 \times 9.8}{2 \sin 30} = 14.7 \text{ N}$$

| Marking Criteria | Marks |
|--|-------|
| Draws correct free body diagram Correctly resolves forces Correctly calculates T | 3 |
| Two of the above OR Makes one mistake in calculation. Shows relevant working | 2 |
| Shows relevant working | 1 |

Note: Some students were confused about which angle the 60° referred to, so if they used it as the angle between the horizontal and the string that was also marked correct.

Comments: the question required the drawing of a free body diagram as part of the answer. Some students were confused about what to do with the two strings.

Question 21 (2 Marks)

A rubber ball is dropped from a height of 1 m and rebounds to the same height. Which of momentum and/or kinetic energy is conserved in the collision with the ground?

2

Justify your answer using physics principles.

Sample answer:

Immediately prior to the collision, the ball has converted mgh ($h=1$) of potential energy into KE. As it returns to the same height, the KE immediately after the collision must equal mgh ($h=1$). Therefore the kinetic energy is conserved in the collision, and hence the speed of the ball is the same.
The direction of the velocity of the ball has changed, and hence the momentum of the ball has changed.

However, if we consider the system to contain the Earth and ball, then there is no change in momentum of the system as the change in momentum of the ball is exactly equal in size but opposite in magnitude to the change in the momentum of the Earth as there is not net force acting on the system.

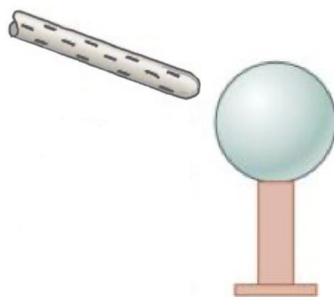
| Marking Criteria | Mark |
|--|------|
| Provides correct justification for conservation of kinetic energy and not momentum OR | 2 |

| | |
|---|---|
| Provides correct justification for conservation of kinetic energy and momentum by identifying system as containing Earth and ball | |
| Provides correct justification for conservation of kinetic energy OR not momentum | 1 |

Comments: Some students did not address the question with regards to the collision, the very short time that the ball and the ground are in contact. Some students stated that the collision was elastic, without using information from the question to justify why. Some students applied the conservation of momentum, which only applies to a closed system in the absence of an external force; if they did this, they needed to identify what the closed or isolated system contained.

Question 22 (2 Marks)

Explain the charge on the metal sphere if it was initially neutral and it was charged by induction using the negatively charged rod.



Sample Answer

The metal sphere becomes positively charged because electrons in it are repelled when the rod is brought near the sphere and when the sphere is earthed, electrons are conducted away from the sphere so that when the earth is removed, the sphere is left with a positive charge.

| Marking Criteria | Mark |
|---|------|
| Correct cause and effect provided (negative charge migration, grounding, positively charged sphere) | 2 |
| One of the above | 1 |

Question 23 (3 Marks)

Two trains, one of which is stationary, emit 424 Hz whistles. A passenger on the stationary train hears a 3 Hz beat frequency when the other train approaches.

3

Calculate the speed of the moving train.

Sample answer:

$$f_{beat} = |f_1 - f_2|$$

$$f = 427 \text{ Hz or } 421 \text{ Hz}$$

Approaching train implies that $f = 427 \text{ Hz}$

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

$$427 = 424 \left(\frac{340 + 0}{340 - v_{train}} \right)$$

$$340 - v_{train} = 340 \times \frac{424}{427}$$

$$v_{train} = 340 - 340 \times \frac{424}{427}$$

$$= 2.39 \text{ m s}^{-1}$$

$$= 8.60 \text{ km h}^{-1}$$

| Marking Criteria | Mark |
|--|------|
| For correctly finding the doppler shifted frequency (1) For correctly substituting into correct formula For correctly obtaining the speed of the train | 3 |
| Any two of the above | 2 |
| Any one of the above | 1 |

NOTE: (a) If $v_w = 343$, maximum 2

(b) Must show justification for $f' = 427 \text{ Hz}$

(c) If $f' = 3$, then maximum 1

Question 24 (6 Marks)

A driver of a car going 90 km h^{-1} suddenly sees the lights of a barrier 40.0 m ahead. It takes the driver 0.75 s before he applies the brakes. Once he does begin to brake, he slows down at a rate of 10 m s^{-1} every second.

a) Does he hit the barrier? Justify your answer by means of calculations.

3

Sample answer:

Reaction distance:

$$s = vt = \frac{90}{3.6} \times 0.75 = 18.75 \text{ m}$$

Braking distance:

$$v^2 = u^2 + 2as$$
$$0 = \left(\frac{90}{3.6}\right)^2 + 2(-10)s$$
$$s = \frac{\left(\frac{90}{3.6}\right)^2}{20} = 31.25 \text{ m}$$

$$\text{Net distance} = 18.75 + 31.25 = 50 \text{ m} > 40 \text{ m}$$

Hence the car will not stop in time, hitting the barrier in the process.

OR

Braking time: $t = \frac{v-u}{a} = \frac{0-25}{-10} = 2.5 \text{ s}$

Distance covered in 2.5 s : $s = ut + \frac{1}{2}at^2 = 25 \times 2.5 - \frac{1}{2} \times 10 \times 2.5^2 = 31.25$ which is more than $40 - 18.75 = 21.25$, hence the car hits the barrier.

| Marking Criteria | Mark |
|--|------|
| Correctly determines the reaction distance and braking distance, and draws the appropriate conclusion. | 3 |
| Correctly determines the reaction distance OR braking distance, and draws the appropriate conclusion. | 2 |
| Provides some relevant conclusion | 1 |

(b) What would be the maximum speed at which the car could travel and not hit the barrier 40.0 m ahead? Assume the same reaction time and braking rate.

3

Sample Answer

$$\text{reaction distance } s = u \times 0.75$$

$$\text{braking distance:} \quad v^2 = u^2 + 2as$$

$$0 = u^2 + 2(-10)(40 - 0.75u)$$

$$u^2 = 20(40 - 0.75u)$$

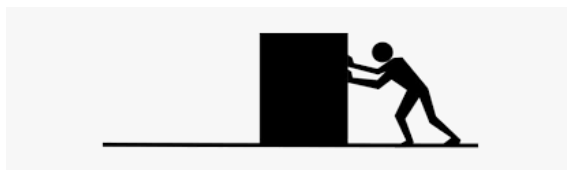
$$u^2 + 15u - 800 = 0$$

$$u = \frac{-15 \pm \sqrt{3425}}{2} = 21.8 \text{ m s}^{-1} = 78.3 \text{ km h}^{-1}$$

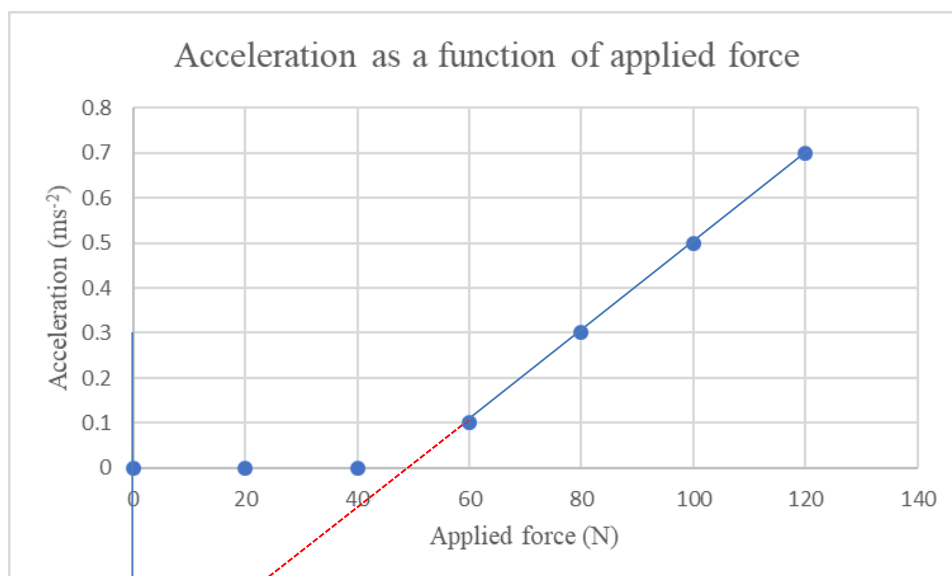
| Marking Criteria | Mark |
|--|------|
| Correctly obtains expressions for reaction and braking distances and computes maximum speed. | 3 |
| Correctly obtains expressions for reaction OR braking distances and computes maximum speed. | 2 |
| Provides some relevant information | 1 |

Question 25 (3 Marks)

A 100 kg box is pushed with varying forces on a lubricated rough surface and the corresponding 3 accelerations measured.



The graph below shows the acceleration of the box as a function of the applied force.



Use the graph to determine the coefficient of dynamic (kinetic) friction.

Sample Answer:

Method 1:

$$F_{net} = ma$$

$$\Rightarrow F_{applied} - f_k = ma$$

When $a = 0$, $F_{applied} = 50 \text{ N}$

from graph

$$\therefore f_k = 50 \text{ N}$$

$$\mu_k N = 50$$

$$\mu_k = \frac{50}{100 \times 9.8} = 0.05$$

Method 2:

From N(II),

$$F_{net} = ma$$

$$\Rightarrow F_{applied} - f_k = ma$$

$$\Rightarrow a = \frac{1}{m}F_{applied} - \frac{\mu_k N}{m}$$

$$\Rightarrow a = \frac{1}{m}F_{applied} - \mu_k g$$

This means that the y-intercept equates to $\mu_k g$

i. e. $\mu_k g \sim 0.45$

$$\mu_k \sim 0.05$$

Method 3:

Substitute one point on the curve into

$$a = \frac{1}{m}F_{applied} - \mu_k g$$

And solve:

$$0.3 = \frac{1}{100} \times 80 - \mu_k \times 9.8$$

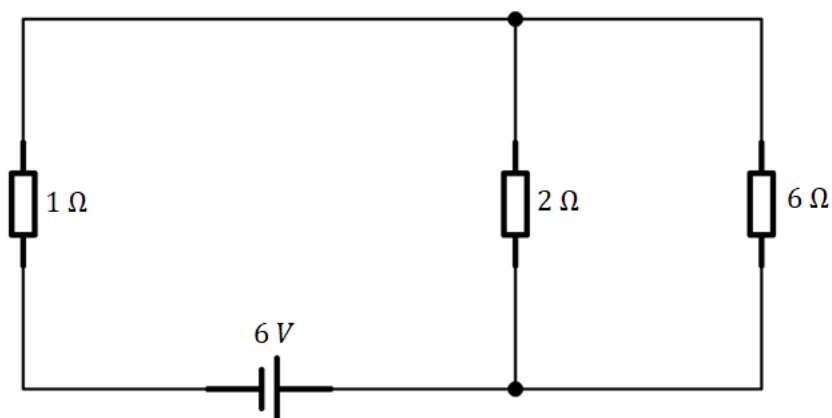
$$\therefore \mu_k = 0.05$$

| Marking Criteria | Mark |
|--|------|
| Correctly determines the coefficient of friction Makes relevant use of graph | 3 |
| Demonstrates relationship between weight and co-efficient of friction Uses graph to determine net force on box at or above 50N or y-intercept | 2 |
| Uses graph to determine when applied force and frictional force balance OR Demonstrates relationship between weight and co-efficient of friction | 1 |

Comments: The information provided does not allow the determination of the coefficient of static friction. Assuming that the force was increase in a monotonically increasing manner, it must be between 50 and 60 N, but no more can be deduced.

Question 26 (3 Marks)

Calculate the current that flows through the 6 Ω resistor in the circuit shown.



Sample answer:

$$\begin{aligned} I_m &= \frac{V}{R_{eq}} \\ &= \frac{6}{1 + \left(\frac{2 \times 6}{2 + 6}\right)} \\ &= 2.4 \text{ A} \\ V_6 &= 6 - V_1 \\ &= 6 - 1 \times 2.4 \\ &= 3.6 \text{ V} \\ \therefore I_6 &= \frac{3.6}{6} \\ &= 0.6 \text{ A} \end{aligned}$$

| Marking Criteria | Mark |
|---|------|
| Correctly computes the equivalent resistance of the circuit, the main current in the circuit and then the current in the 6 ohm resistor | 3 |
| Any two of the above | 2 |
| Any one of the above | 1 |

Question 27 (3 marks)

At what distance apart should a $6 \mu\text{C}$ charge be placed from a $-8 \mu\text{C}$ charge so that they experience an attractive force of 1.11 N ?

Sample Answer:

$$F = \frac{1}{4\pi\epsilon_0} \frac{q_1 q_2}{r^2}$$
$$r^2 = \frac{1}{4\pi \times 8.854 \times 10^{-12}} \frac{6 \times 10^{-6} \cdot 8 \times 10^{-6}}{1.11}$$
$$= 48 \times 10^{-2}$$
$$\therefore r = 0.69 \text{ m}$$

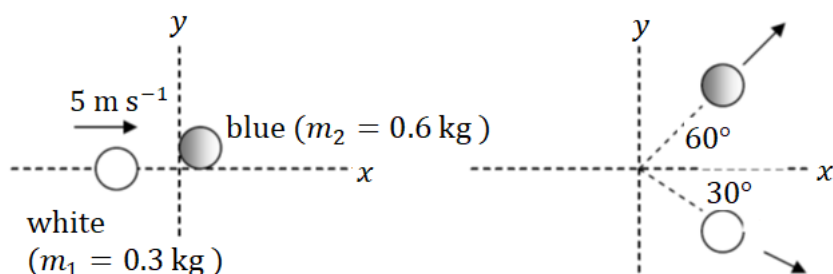
| Marking Criteria | Mark |
|---|------|
| Correctly substitutes into correct formula, and computes the distance between the charges | 3 |
| Any two of the above | 2 |
| Provides some relevant information | 1 |

Note: If $q_1 = 6, q_2 = 8$, then maximum 2, i.e. $r = 626252 \text{ m}!!!!!!$

Question 28 (4 marks)

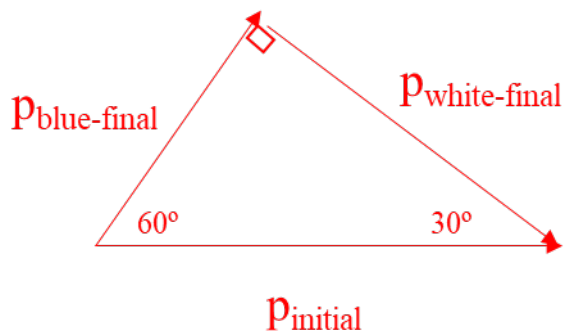
The diagram below shows a collision between a 0.3 kg white ball moving at 5 m s^{-1} horizontally and a 0.6 kg blue ball which is initially at rest. The collision is not head-on, so the balls bounce off of each other at the angles shown.

4



Find the final speed of each ball after the collision.
(Let the speed of the blue ball be v_2 and the white ball be v_1 .)

Sample Answer1:



$$\vec{p}_{\text{initial}} = m_1\mathbf{u}_1 + m_2\mathbf{u}_2 = 0.3 \times 5 + 0.6 \times 0 = 1.5 \text{ kg ms}^{-1}$$

$$\cos(60^\circ) = p_{\text{blue-final}}/p_{\text{initial}}$$

$$P_{\text{blue-final}} = \cos(60^\circ) \times p_{\text{initial}} = 0.5 \times 1.5 = 0.75 \text{ kg ms}^{-1}$$

$$V_{\text{blue-final}} = p_{\text{blue-final}}/m_{\text{blue}} = 0.75/0.6 = 1.25 \text{ ms}^{-1}$$

$$\cos(30^\circ) = p_{\text{white-final}}/p_{\text{initial}}$$

$$P_{\text{white-final}} = \cos(30^\circ) \times p_{\text{initial}} = \sqrt{3}/2 \times 1.5 = 1.3 \text{ kg ms}^{-1}$$

$$V_{\text{white-final}} = p_{\text{white-final}}/m_{\text{white}} = 1.3/0.3 = 4.33 \text{ ms}^{-1}$$

Sample Answer2:

$$x \text{ -direction: } \sum p_x^{\text{before}} = \sum p_x^{\text{after}}$$

$$0.3 \times 5 + 0 = 0.6 \times v_1 \times \cos 60 + 0.3 \times v_2 \times \cos 30$$

$$1.5 = 0.3 v_1 + 0.15\sqrt{3} v_2$$

$$5 = v_1 + \sqrt{3}v_2/2$$

$$y \text{ -direction: } \sum p_y^{\text{before}} = \sum p_y^{\text{after}}$$

$$0 = 0.6 v_1 \sin 60 - 0.3v_2 \sin 30$$

$$0 = \sqrt{3}v_1 - 0.5 v_2$$

$$v_2 = 2\sqrt{3}v_1$$

Substitute into

$$5 = v_1 + \sqrt{3}v_2/2$$

i.e. $5 = v_1 + 3 v_1 \Rightarrow v_1 = 1.25 \text{ m s}^{-1}$

$$\Rightarrow v_2 = 2\sqrt{3} \times \frac{5}{4} = 4.33 \text{ m s}^{-1}$$

| Marking Criteria | Mark |
|--|------|
| Correctly applies conservation of momentum Correctly solves for each speed | 4 |
| Applies conservation of momentum in the horizontal direction Applies conservation of momentum in the vertical direction Solves for each speed with one type of mistake | 3 |
| Applies conservation of momentum in the horizontal AND vertical directions | 2 |
| Applies conservation of momentum in the horizontal OR vertical directions OR provides some relevant information | 1 |

Comments: Very few students managed to solve this problem. Common mistakes included forgetting the masses in the conservation of momentum (particularly the vertical direction), mixing up cos and sin, not realising that the vertical velocities had different directions, trying to apply conservation of energy.

Question 29 (4 Marks)

Dr Sendt recently acquired a lamp, like the one shown below, to help her cross stitch at night. A biconvex lens is surrounded by a circle of lights, equivalent to the light output of the overhead ceiling light in the room.



Using relevant Physics principles, explain why this tool will help Dr Sendt to see her stitches.

4

Use appropriate diagrams to support your answer.

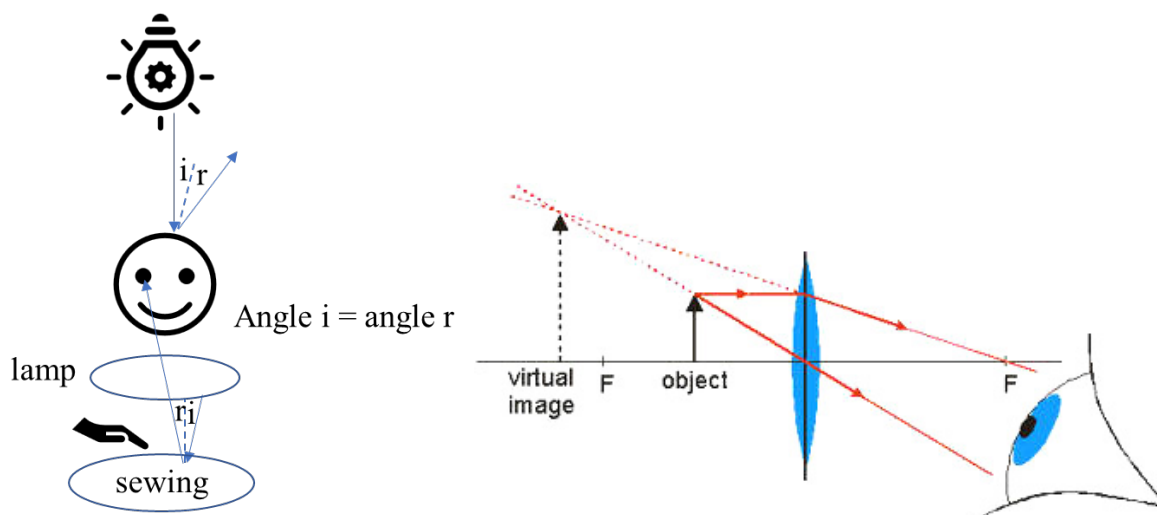
| Marking Criteria | Mark |
|--|------|
| Demonstrates relevant knowledge of refraction Demonstrates relevant knowledge of reflection Demonstrates relevant knowledge of effect of distance on intensity. Uses correct lens diagram to support answer | 4 |
| Three of the above | 3 |
| Demonstrates an understanding of refraction, reflection and/or effect of light on intensity Draws correct ray diagram of biconvex lens (may not be relevant) | 2 |
| Demonstrates an understanding of refraction, reflection and/or effect of light on intensity OR Draws correct ray diagram of biconvex lens (may not be relevant) | 1 |

Sample Answer:

The lamp is about 20cm from the cross stitch, while the ceiling is approximately 2m from the cross stitch. Using the inverse square law, this means that the light striking the cross stitch from the lamp will be 100 times brighter than that from the ceiling light.

The light is then reflected from the surface of the cross stitch (although some is absorbed), through the lens, to Dr Sendt's eyes so she can see. Without the lamp, some of the light from the ceiling light would reflect from the top of Dr Sendt's head, creating a shadow. The circle of lights means that shadows are less likely, even when she puts her hand over the sewing.

The biconcave lens, if it placed close to the sewing, will act to magnify the image, as shown below. The lamp needs to be closer to the sewing than the focal length of the lens in order to make an enlarged, upright image, which will help Dr Sendt see the stitches more clearly.



Comments: Students had an opportunity to discuss all aspects of the ray model of light. Since the sewing is not luminous, the only reason that Dr Sendt can see it is due to reflected light, either from the ceiling light or the lamp. The light from the lamp does not go through the lens, as many students indicated, rather it reflects off the stitching before going through the lens. Contrary to popular opinion, it is not easier to sew with an inverted image, Dr Sendt would prefer that the image is magnified and upright.

END OF EXAMINATION 😊