JAMES RUSE AGRICULTURAL HIGH SCHOOL

2018

PHYSICS

YEAR 11 EXAMINATION

THEORY

General Instructions

- Reading time - 5 minutes
- Working time - 120 minutes
- Board-approved calculators 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 page 9.

Total: 80 marks

PART A Theory – 20 Multiple Choice Questions **20** marks Allow about 30 minutes

PART B Theory – Extended Response Questions **60** marks Allow about 90 minutes

Part A – 20 marks

Attempt Questions 1-20

Allow about 30 minutes for this part

Use the multiple choice answer sheet on page 10.

Select the alternative A, B, C or D that best answers the question. Fill in the response oval completely.

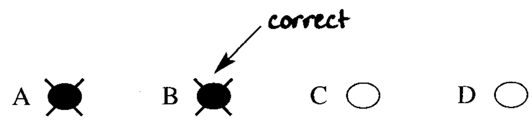
Sample: $2 + 4 =$ (A) 2 (B) 6 (C) 8 (D) 9

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 ○

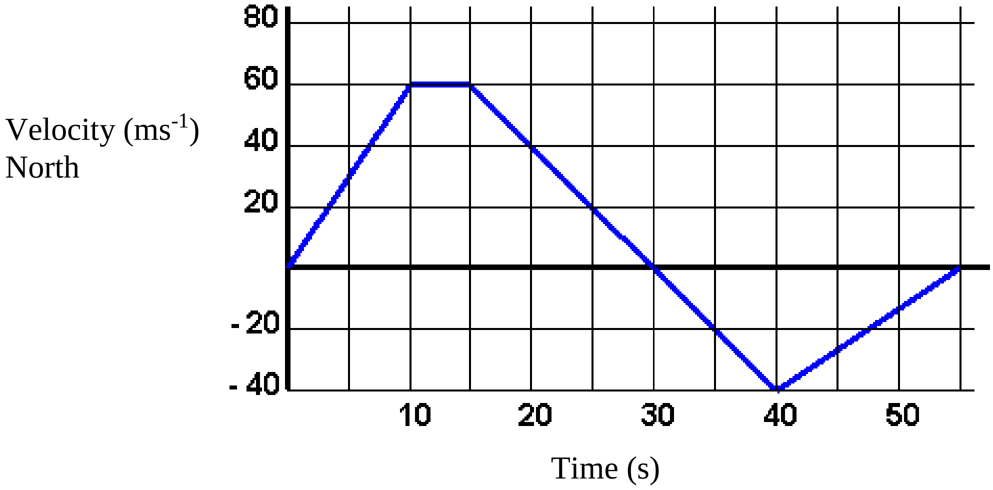
If you change your mind and have crossed out what you consider to be the correct answer, then indicate the correct answer by writing the word *correct* and drawing an arrow as follows.



PART A 20 Multiple Choice Questions 20 marks.

The information below applies to questions 1 and 2.

The graph shows the velocity-time graph for a car moving initially North.



1. Which statement best describes the motion of the car between 15 and 40 seconds?

   (A) The car slows down and then speeds up.
   (B) The car speeds up and then slows down.
   (C) The car slows down, stops and then speeds up in the opposite direction
   (D) The car is travelling from the North to the South at constant speed.

2. Determine the displacement of the car in the 15 to 40 s time interval.

   (A) 250 m, North
   (B) 650 m, South
   (C) 250 m, South
   (D) 650 m, North

3. A rock is dropped from the top of a tall tower. Half a second later another rock, twice as massive as the first, is dropped. Ignoring air resistance,

   (A) they strike the ground with the same kinetic energy.
   (B) the acceleration is greater for the more massive rock.
   (C) they strike the ground more than half a second apart.
   (D) the distance between the rocks increases while both are falling.

4. Diamond has a refractive index of 2.4. What is the speed of light in diamond?

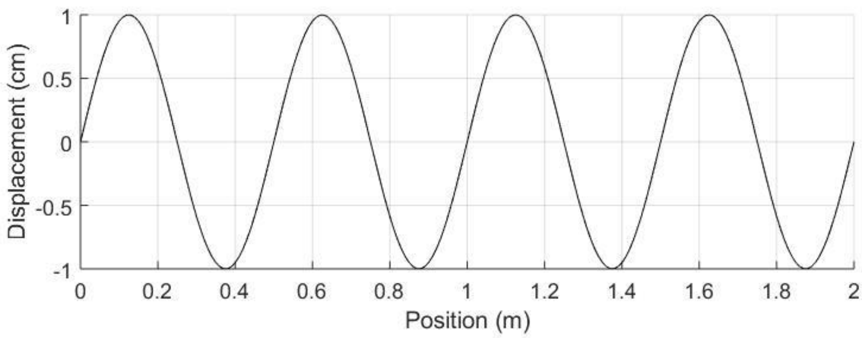
   (A) 0.6×10^8 m s^{-1}
   (B) 1.3×10^8 m s^{-1}
   (C) 3.0×10^8 m s^{-1}
   (D) 7.2×10^8 m s^{-1}

5. What is the effect of connecting additional resistors in parallel in a circuit?

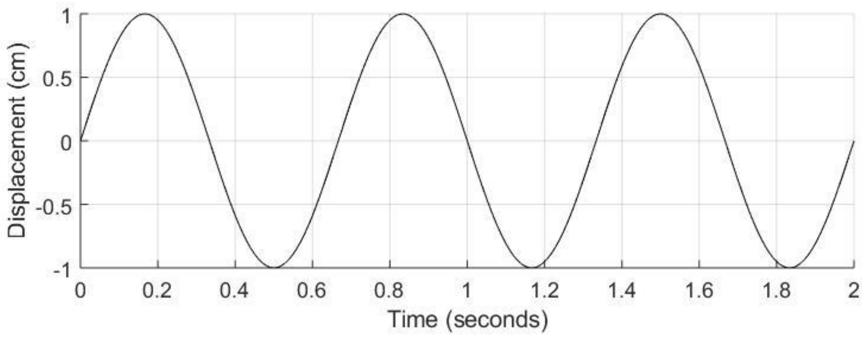
(A) To decrease the current in the circuit.
(B) To increase the total resistance in the circuit.
(C) To decrease the total resistance in the circuit.
(D) To decrease the current and the resistance in the circuit.

The information below applies to questions 6 and 7.

A wave is propagating along a string. The plots below show the displacement of the string as a function of position (Graph A) and the displacement of a particular point on the string as a function of time (Graph B).



Graph A



Graph B

6. What is the wavelength of the wave?

(A) 0.5 m
(B) 0.7 m
(C) 1.0 m
(D) 2.0 m

7. What is the velocity of the wave?

(A) $0.33\ \mathrm{ms^{-1}}$
(B) $0.66\ \mathrm{ms^{-1}}$
(C) $0.75\ \mathrm{ms^{-1}}$
(D) $1.33\ \mathrm{ms^{-1}}$

8. What is the critical angle for light travelling from glass, with refractive index 1.5, into air?

(A) 42°
(B) 41.8°
(C) 90°
(D) 90.0°

9. A ballplayer catches a ball 3.00 s after throwing it vertically upward with initial speed, u. The ball reaches a maximum height, h.

Neglecting air resistance, which row of the table, about the ball's initial speed and maximum height is correct?

	u (m s^{-1})	h (m)
(A)	29.4	44.1
(B)	14.7	44.1
(C)	29.4	11.0
(D)	14.7	11.0

10. A car travelling at a velocity of v ms^{-1} stops in a distance of X m.

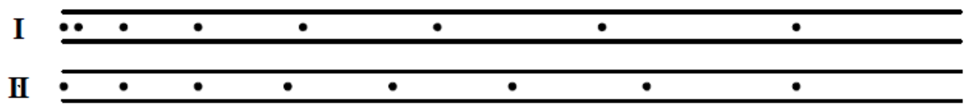
What would be the stopping distance (in m) if the car was travelling at three times this speed? (Assume the stopping force on the car is equal in each case.)

(A) $\frac{3}{2}X$
(B) $3X$
(C) $9X$
(D) $\frac{1}{3}X$

11. Which instrument is connected in parallel in an electric circuit?

(A) Ammeters because they have a low resistance
(B) Voltmeters because they have a high resistance
(C) Ammeters because they have a high resistance
(D) Voltmeters because they have a low resistance

12. The diagram 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 row of the table best compares the motion of the two objects?

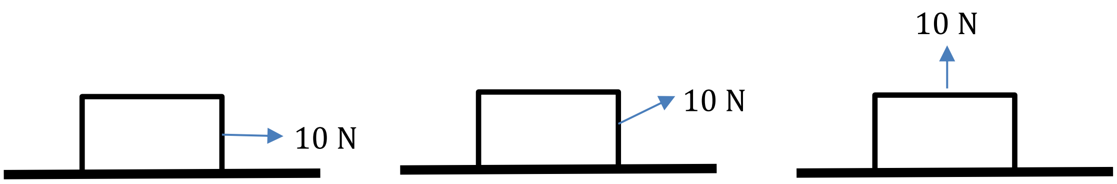
	Initial speed of object I compared to object II	*Average acceleration of object I compared to object II*
(A)	Smaller	Smaller
(B)	Smaller	Larger
(C)	Larger	Smaller
(D)	Larger	Larger

13. The siren of a stationary police car emits sound at a frequency of 1600 Hz.

What will be the apparent frequency of the siren if the police car moves at 25 ms^{-1} away from an observer?

(A) 1727 Hz
(B) 1490 Hz
(C) 1718 Hz
(D) 1482 Hz

14. A box moves to the right on a horizontal surface as a boy pulls on it with a 10-N force.



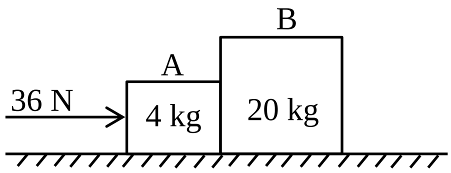
1 2 3

The displacement is the same for all cases.

Rank the situations shown above according to the work done by the 10-N force, from least to greatest.

(A) 3, 2, 1
(B) 3, 1, 2
(C) 2, 3, 1
(D) 1, 2, 3

15. Two blocks (A and B) are in contact on a horizontal frictionless surface. A 36 N constant force is applied to A as shown.



What is the magnitude of the force of B on A?

(A) 1.5 N
(B) 6.0 N
(C) 30 N
(D) 36 N

16. When a water wave travels from deep water to shallow water, the wave slows down. This means:

(A) frequency of the wave decreases and wavelength remains the same.
(B) wavelength of the wave decreases and frequency remains the same.
(C) both wavelength and frequency decrease.
(D) wavelength and frequency remain the same.

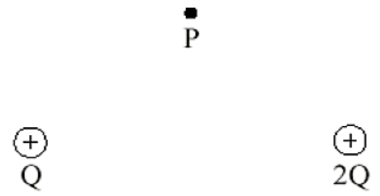
17. Object A is in thermal equilibrium with object B and object B is in thermal equilibrium with object C.

Which of the following statements are true?

(I) Object A, B and C are at the same temperature.
(II) Object A is hotter than object B.
(III) Object B is colder than object C.
(IV) Object A and C are in thermal equilibrium.

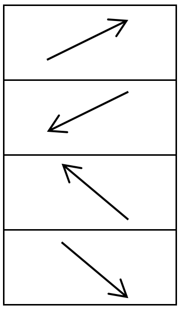
(A) (I) and (II)
(B) (I) and (III)
(C) (II) and (IV)
(D) (I) and (IV)

18. Two positive charges of magnitude Q and 2Q are equidistant from Point P.

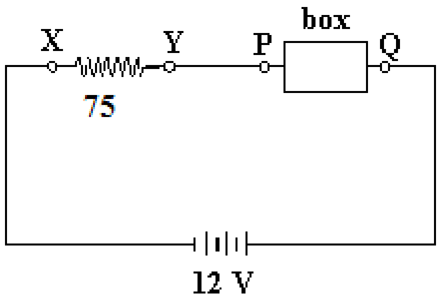


Which vector best represents the direction of the electric field at point P?

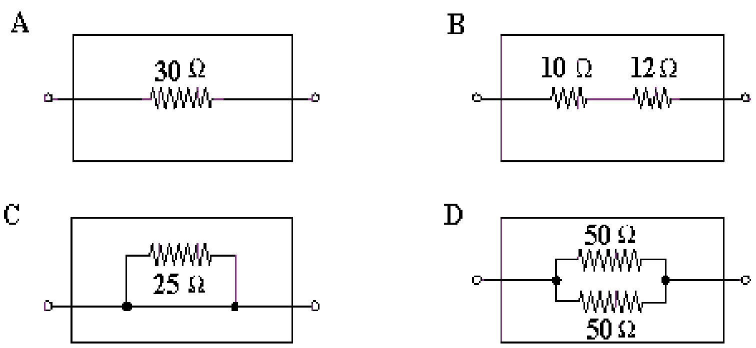
(A)
(B)
(C)
(D)



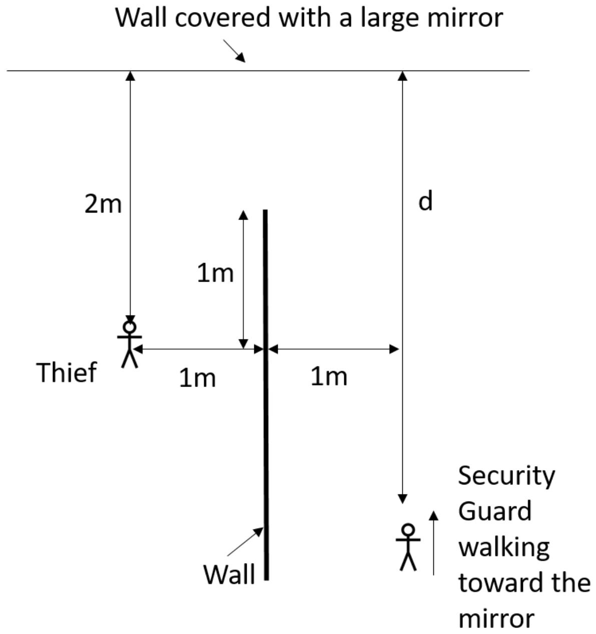
19. A student completes a circuit that includes a mystery resistance box connected between P and Q.



If the potential difference between X and Y is 9 V, which of the following boxes can be connected between P and Q?



20. A thief is in a museum trying to steal something. A security guard is walking up the corridor as shown in the diagram. The wall at the end is covered by a large mirror.



At what distance d from the mirror will the security guard be able to first see the thief?

(A) 1 m
(B) 2 m
(C) 4 m
(D) 6 m

Student No. …….....................

ANSWER BOOKLET

PART A Multiple Choice Answer Sheet **20 marks**

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

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1. A ○ B ○ C ○ D ○

2. A ○ B ○ C ○ D ○

3. A ○ B ○ C ○ D ○

4. A ○ B ○ C ○ D ○

5. A ○ B ○ C ○ D ○

6. A ○ B ○ C ○ D ○

7. A ○ B ○ C ○ D ○

8. A ○ B ○ C ○ D ○

9. A ○ B ○ C ○ D ○

10. A ○ B ○ C ○ D ○

11. A ○ B ○ C ○ D ○

12. A ○ B ○ C ○ D ○

13. A ○ B ○ C ○ D ○

14. A ○ B ○ C ○ D ○

15. A ○ B ○ C ○ D ○

16. A ○ B ○ C ○ D ○

17. A ○ B ○ C ○ D ○

18. A ○ B ○ C ○ D ○

19. A ○ B ○ C ○ D ○

20. A ○ B ○ C ○ D ○

PART B   13 questions   60 marks

Attempt questions 21-34.

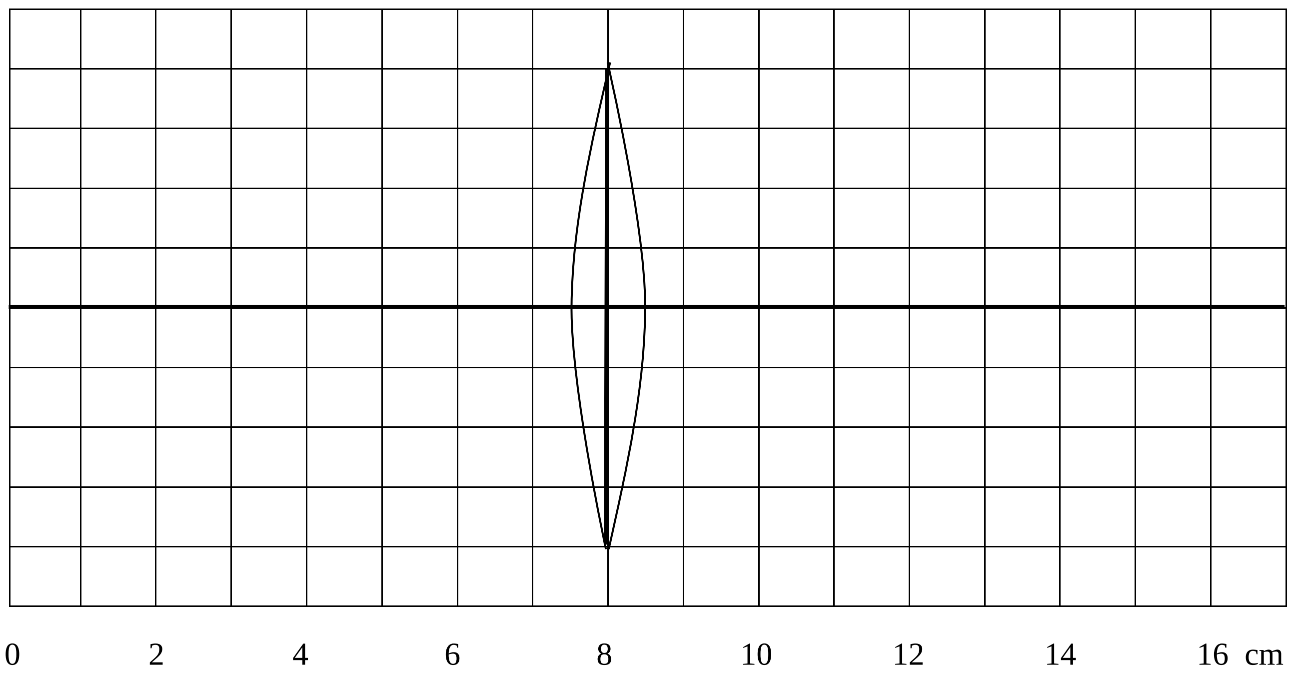
Allow about 90 minutes for this part.

Show all relevant working in questions involving calculations.

Question 21 (5 marks)

An object of height 3 cm is placed 8 cm in front of a biconvex lens of focal length 3 cm.

(a) Draw a ray diagram to show the how the image is formed. Label object and the image. **3**



(b) Is the image real or virtual? **1**

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(c) Determine the size of the image, using the ray diagram. **1**

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Question 22 (7 marks)

A world record was set for the men's 100-m dash in the 2008 Olympic Games in Beijing by Usain Bolt of Jamaica. Bolt "coasted" across the finish line with a time of 9.69 s.

Assumption: Bolt accelerates uniformly for 3.00 s to reach his maximum speed u, and maintains this speed for the rest of the race.

(a) Draw a graph of his velocity as a function of time for the duration of the race. **2**

(b) Use the graph to determine his maximum speed. **2**

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(c) What is his acceleration in the

(i) First 3 s of his motion? ____________ **1**

(ii) Last 3 s of his motion? ____________ **1**

(d) In the same Olympics, Bolt also set the world record in the 200-m dash. Use the same assumption as for the 100-m dash.

Show that the time for the 200-m dash as determined from the adjusted graph is 17.88 s. **1**

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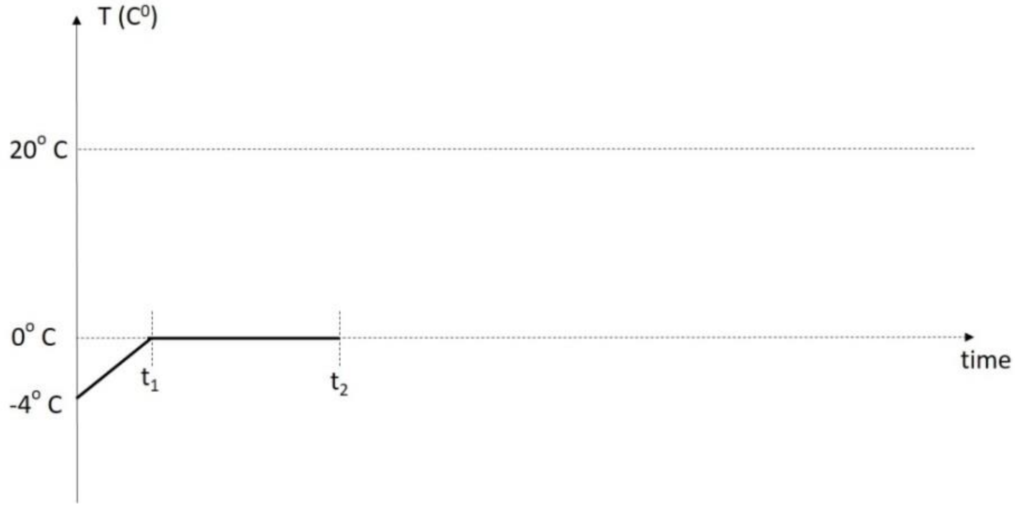
Question 23 (3 Marks)

An icy pole is taken from the freezer at 4^0 C, and placed on a bench in a room at 20^0 C.

A graph of the temperature of the icy pole over time is shown below.



(a) Explain the shape of the graph from

(i) $t = 0$ to $t = t_1$ seconds. **1**

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(ii) $t = t_1$ to $t = t_2$ seconds. **1**

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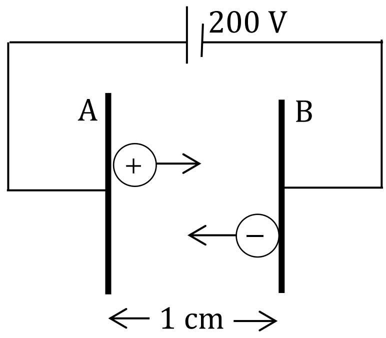
(b) Show on the graph how the temperature of the icy pole changes with time between $T = 0^0$ and $T = 20^0$. **1**

Question 24 (5 marks)

Two parallel plates, 1 cm apart are connected to a 200 volt DC source.

A proton and an electron placed in between the plates and released from rest, were observed to move towards plates B and A respectively.



(a) Find the magnitude and direction of the electric field between the plates. **2**

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(b) Find the final speed of the electron as it lands on plate A. **3**
Show all working.

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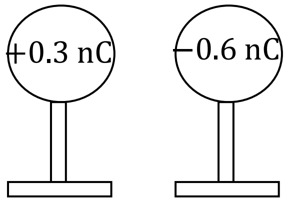
Question 25 (4 Marks)

Two identical spheres on insulating stands, 45 cm apart, carry charges of $+0.3\ nC$ and $-0.6\ nC$.



(a) Calculate the magnitude and direction of the force between the charged spheres at this distance. **3**

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(b) The two spheres are then touched and separated 30 cm apart.

What is the charge on each sphere now? **1**

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Question 26 (4 Marks)

Using a labelled diagram, describe an investigation you performed in class to demonstrate charging by the process of induction. **4**

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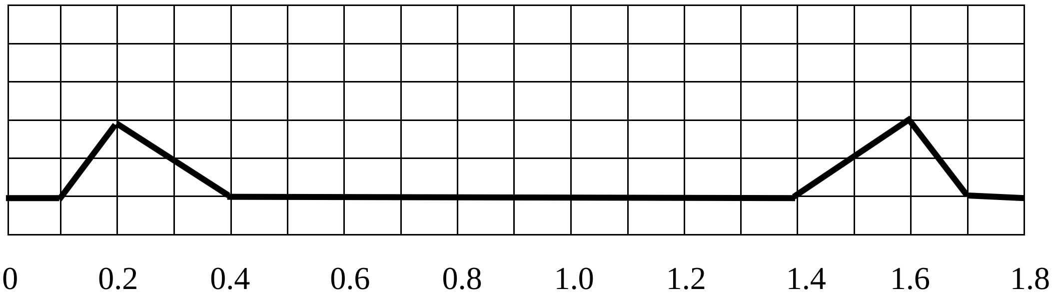
Question 27 (2 marks)

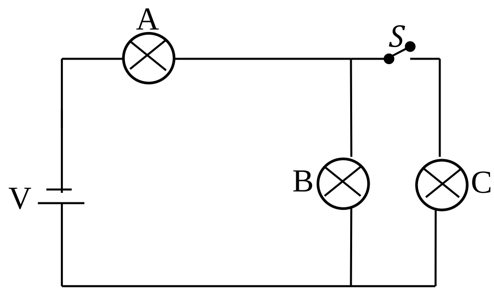
Two wave pulses are travelling toward each other at a speed of $10\ \text{ms}^{-1}$ on a long string, as shown in the figure below. The horizontal displacements are in metres.



On the above grid, sketch the shape of the string at time $t = 0.06$ s.

Question 28 (5 Marks)

The circuit below consists of 3 identical light bulbs, A, B and C connected to a DC voltage source, V and a switch S.



(a) Compare the brightness of bulbs A, B and C when S is open. **2**

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(b) Compare quantitatively the brightness of bulbs A, B and C when S is closed. **3**

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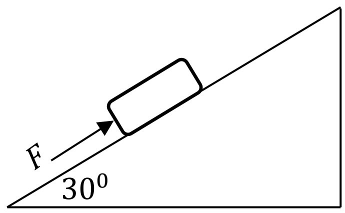
Question 29 (5 marks)

A 1 kg box is being pushed up a rough 30^0 incline by a constant force F. The frictional force between the box and the inclined plane is 15 N.



(a) On the diagram, draw and label all the forces acting on the box while it is pushed up the plane. **3**

(b) Determine the magnitude of F that would accelerate the box up the plane at1.0 ms^{-2}. **2**

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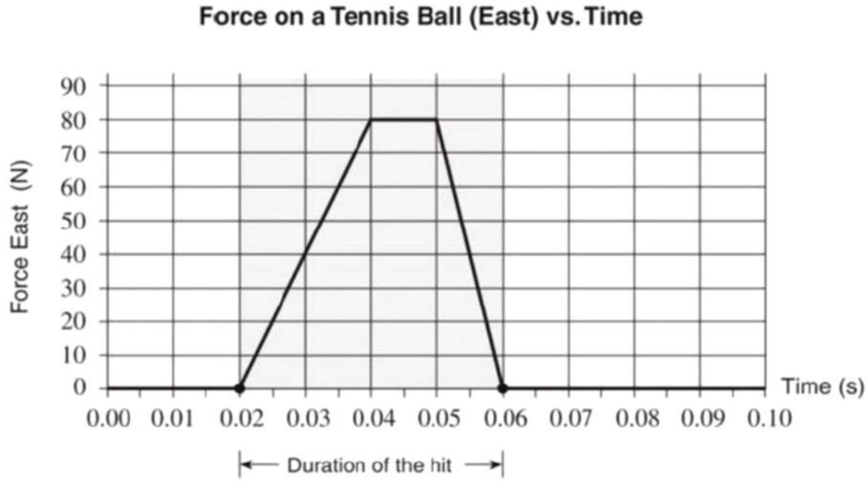
Question 30 (3 marks)

A plane was flying horizontally at 200 ms^{-1} relative to the air around it, heading due north according to its onboard compass. A wind was blowing towards the west at 50 ms^{-1} relative to the ground.

Determine the resultant velocity of the plane with the aid of a scale vector diagram.

Question 31 (4 marks)

A 0.057 kg tennis ball moving West at 24 ms^{-1} is hit in the opposite direction (East) with a tennis racket. The force acting on the ball during the hit is shown in the graph below.



(a) Calculate the impulse imparted to the tennis ball. **2**

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(b) What is the magnitude of the final momentum of the ball? Show all working. **2**

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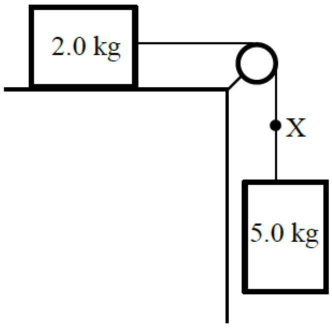
Question 32 (3 marks)

Consider the system shown in the diagram below.



The blocks are connected by a light, inextensible string over a frictionless pulley.
The 2.0 kg block is resting on a smooth horizontal surface.

(a) Calculate the magnitude of the tension force in the string at X. **2**

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(b) Calculate the acceleration of the system. **1**

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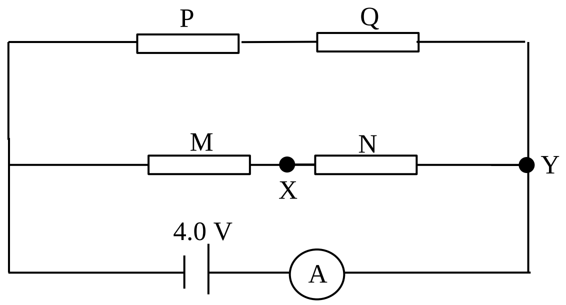
Question 33 (5 marks)

Four resistors, P, Q, M and N are connected to a 4.0 V power supply.



The current flowing through the ammeter is 2.0 A, and the resistance of P, M and N are 3.0 Ω, 1.0 Ω and 2.0 Ω respectively. The resistance of Q is unknown.

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

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(b) Calculate the resistance of resistor Q. **2**

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(c) Calculate the voltage drop across X and Y. **2**

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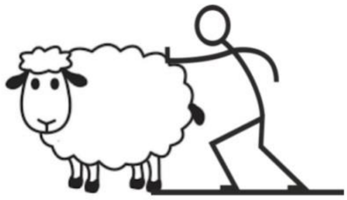
Question 34 (5 Marks)

Ms Ashurst is trying to push Millie the lamb into her pen, but she is big now and resists. Having been at James Ruse for a while Millie has been learning some physics, but hasn't understood a number of important ideas correctly.

Millie argues:
"*You can't move me, because Newton's third law states that the force you apply to me is the same as the force I apply back to you*."

Ms Ashurst is still pushing, so Millie makes yet another claim:
"The law of conservation of momentum says that if my momentum is zero, it must remain zero!"



Explain what misunderstandings Millie has about Newton's 3rd law and the law of conservation of momentum, and use physics principles to explain how Ms Ashurst can in fact push Millie into her pen.

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END OF EXAMINATION ☺

JAMES RUSE AGRICULTURAL HIGH SCHOOL

2018

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YEAR 11 EXAMINATION

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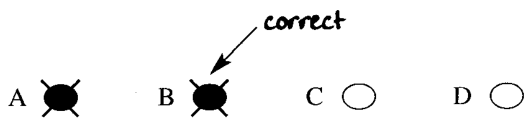
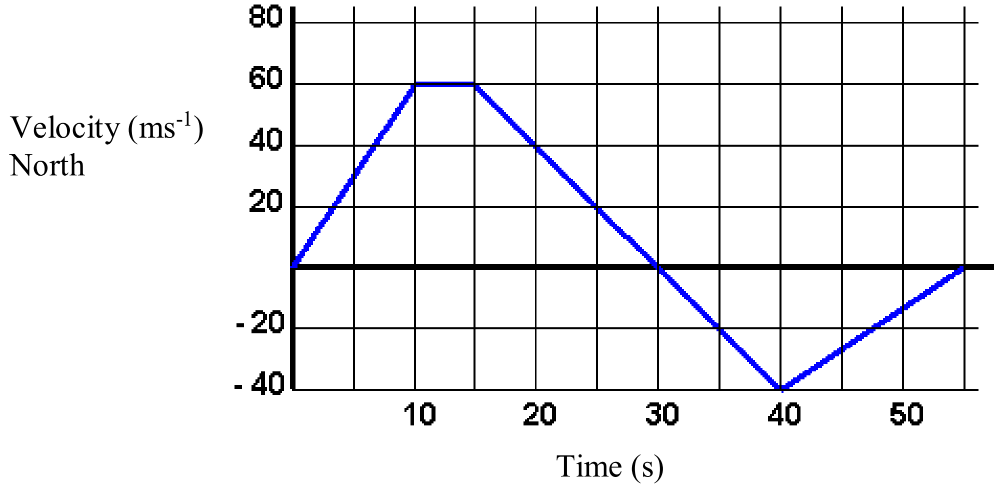


PART A 20 Multiple Choice Questions 20 marks.

The information below applies to questions 1 and 2.

The graph shows the velocity-time graph for a car moving initially North.



1. Which statement best describes the motion of the car between 15 and 40 seconds?

(A) The car slows down and then speeds up.
(B) The car speeds up and then slows down.
(C) The car slows down, stops and then speeds up in the opposite direction
(D) The car is travelling from the North to the South at constant speed.

2. Determine the displacement of the car in the 15 to 40 s time interval.

(A) 250 m, North
(B) 650 m, South
(C) 250 m, South
(D) 650 m, North

3. A rock is dropped from the top of a tall tower. Half a second later another rock, twice as massive as the first, is dropped. Ignoring air resistance,

(A) they strike the ground with the same kinetic energy.
(B) the acceleration is greater for the more massive rock.
(C) they strike the ground more than half a second apart.
(D) the distance between the rocks increases while both are falling.

4. Diamond has a refractive index of 2.4. What is the speed of light in diamond?

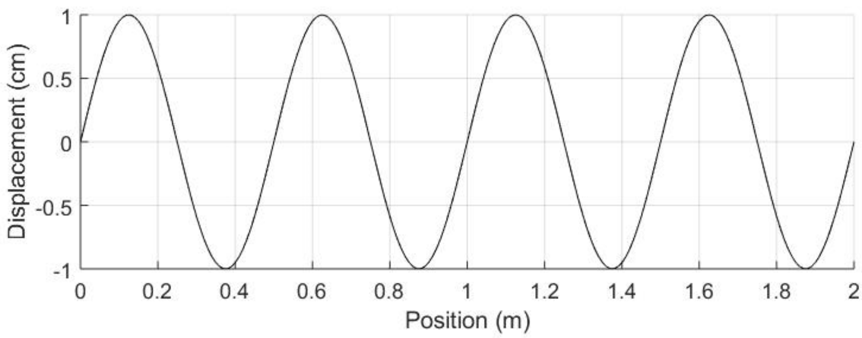
(A) 0.6×10^8 m s^{-1}
(B) 1.3×10^8 m s^{-1}
(C) 3.0×10^8 m s^{-1}
(D) 7.2×10^8 m s^{-1}

5. What is the effect of connecting additional resistors in parallel in a circuit?

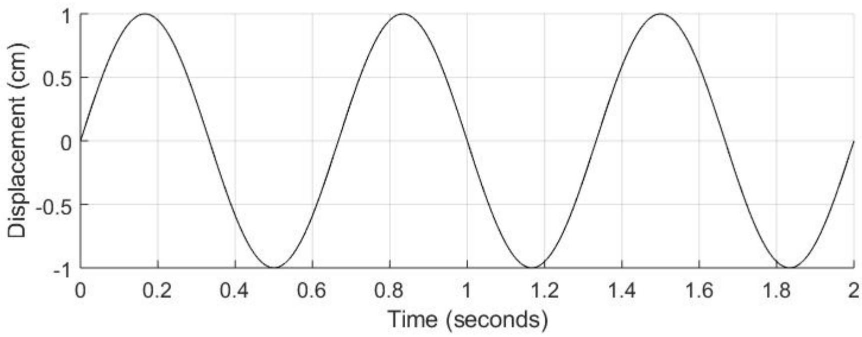
(A) To decrease the current in the circuit.
(B) To increase the total resistance in the circuit.
(C) To decrease the total resistance in the circuit.
(D) To decrease the current and the resistance in the circuit.

The information below applies to questions 6 and 7.

A wave is propagating along a string. The plots below show the displacement of the string as a function of position (Graph A) and the displacement of a particular point on the string as a function of time (Graph B).



Graph A



Graph B

6. What is the wavelength of the wave?

(A) 0.5 m
(B) 0.7 m
(C) 1.0 m
(D) 2.0 m

7. What is the velocity of the wave?

(A) 0.33 ms^{-1}
(B) 0.66 ms^{-1}
(C) 0.75 ms^{-1}
(D) 1.33 ms^{-1}

8. What is the critical angle for light travelling from glass, with refractive index 1.5, into air?

(A) 42°
(B) 41.8°
(C) 90°
(D) 90.0°

9. A ballplayer catches a ball 3.00 s after throwing it vertically upward with initial speed, u. The ball reaches a maximum height, h.

Neglecting air resistance, which row of the table, about the ball's initial speed and maximum height is correct?

	u (m s^{-1})	h (m)
(A)	29.4	44.1
(B)	14.7	44.1
(C)	29.4	11.0
(D)	14.7	11.0

10. A car travelling at a velocity of v ms^{-1} stops in a distance of X m.

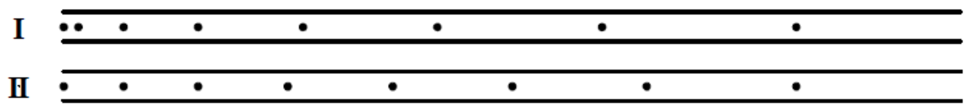
What would be the stopping distance (in m) if the car was travelling at three times this speed? (Assume the stopping force on the car is equal in each case.)

(A) $\frac{3}{2}X$
(B) $3X$
(C) $9X$
(D) $\frac{1}{3}X$

11. Which instrument is connected in parallel in an electric circuit?

(A) Ammeters because they have a low resistance
(B) Voltmeters because they have a high resistance
(C) Ammeters because they have a high resistance
(D) Voltmeters because they have a low resistance

12. The diagram 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 row of the table best compares the motion of the two objects?

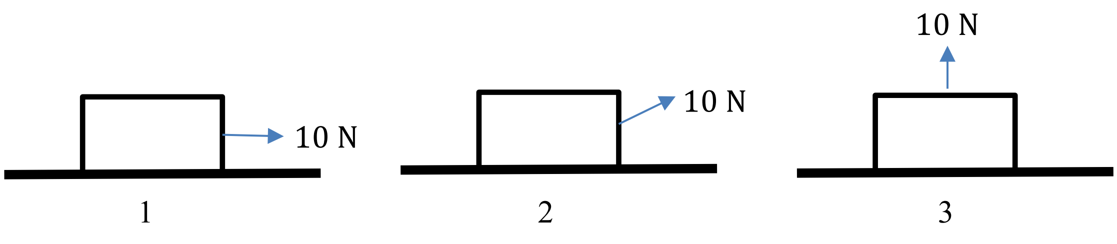
	Initial speed of object I compared to object II	*Average acceleration of object I compared to object II*
(A)	Smaller	Smaller
(B)	Smaller	Larger
(C)	Larger	Smaller
(D)	Larger	Larger

13. The siren of a stationary police car emits sound at a frequency of 1600 Hz.

What will be the apparent frequency of the siren if the police car moves at 25 ms^{-1} away from an observer?

(A) 1727 Hz
(B) 1490 Hz
(C) 1718 Hz
(D) 1482 Hz

14. A box moves to the right on a horizontal surface as a boy pulls on it with a 10-N force.

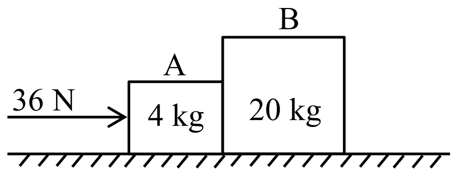


The displacement is the same for all cases.

Rank the situations shown above according to the work done by the 10-N force, from least to greatest.

(A) 3, 2, 1
(B) 3, 1, 2
(C) 2, 3, 1
(D) 1, 2, 3

15. Two blocks (A and B) are in contact on a horizontal frictionless surface. A 36 N constant force is applied to A as shown.



What is the magnitude of the force of B on A?

(A) 1.5 N
(B) 6.0 N
(C) 30 N
(D) 36 N

16. When a water wave travels from deep water to shallow water, the wave slows down.
This means:

(A) frequency of the wave decreases and wavelength remains the same.
(B) wavelength of the wave decreases and frequency remains the same.
(C) both wavelength and frequency decrease.
(D) wavelength and frequency remain the same.

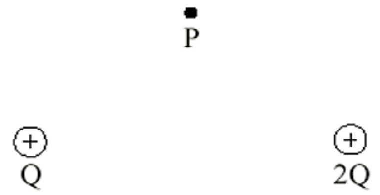
17. Object A is in thermal equilibrium with object B and object B is in thermal equilibrium with object C.

Which of the following statements are true?

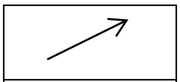
(I) Object A, B and C are at the same temperature.
(II) Object A is hotter than object B.
(III) Object B is colder than object C.
(IV) Object A and C are in thermal equilibrium.

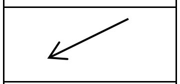
(A) (I) and (II)
(B) (I) and (III)
(C) (II) and (IV)
(D) (I) and (IV)

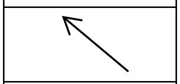
18. Two positive charges of magnitude Q and 2Q are equidistant from Point P.

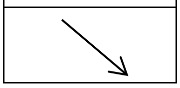


Which vector best represents the direction of the electric field at point P?

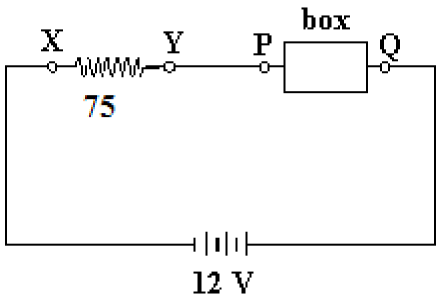
(A) 

(B) 

(C) 

(D) 

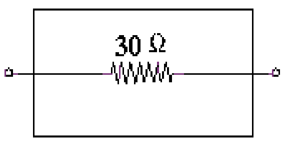
19. A student completes a circuit that includes a mystery resistance box connected between P and Q.



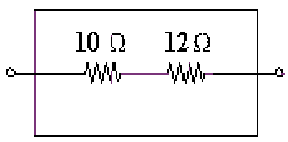
Answer: D

If the potential difference between X and Y is 9 V, which of the following boxes can be connected between P and Q?

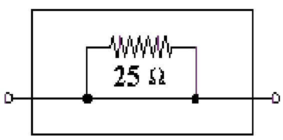
A



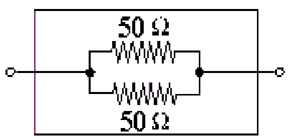
B



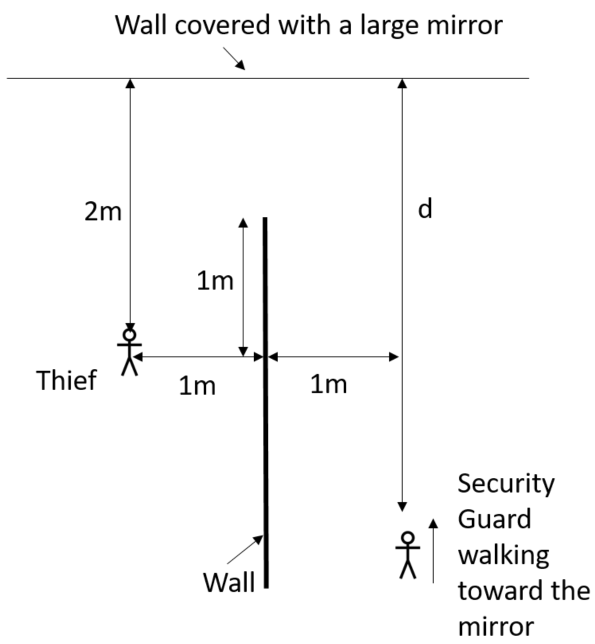
C



D



20. A thief is in a museum trying to steal something. A security guard is walking up the corridor as shown in the diagram. The wall at the end is covered by a large mirror.



At what distance d from the mirror will the security guard be able to first see the thief?

(A) 1 m
(B) 2 m
(C) 4 m
(D) 6 m

Student No. ……......................

ANSWER BOOKLET

PART A Multiple Choice Answer Sheet **20 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 ○

17. A ○ B ○ C ○ D ○

18. A ○ B ○ C ○ D ○

19. A ○ B ○ C ○ D ○

20. A ○ B ○ C ○ D ○

PART B 13 questions 60 marks

Attempt questions 21-34.

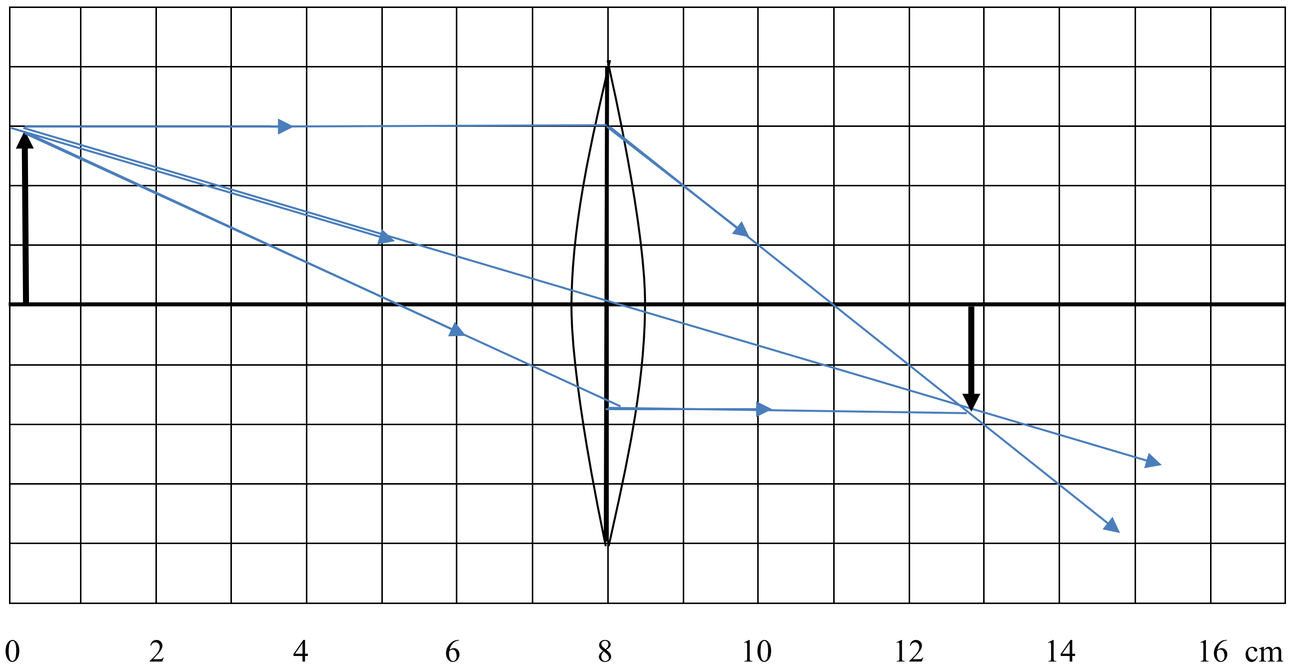
Allow about 90 minutes for this part.

Show all relevant working in questions involving calculations.

Question 21 (5 marks)

An object of height 3 cm is placed 8 cm in front of a biconvex lens of focal length 3 cm.

(a) Draw a ray diagram to show the how the image is formed. Label object and the image. **3**



Marking Scheme

(a) 1 mark each for two principal rays
1 mark locating image at position where rays cross (with the object and image labelled)

(b) Is the image real or virtual? **1**

Real

(c) Determine the size of the image, using the ray diagram. **1**

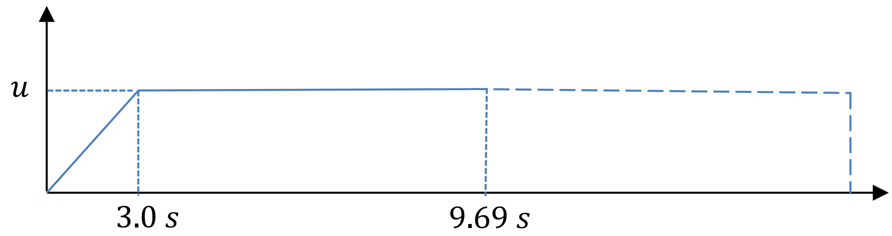
$1.8\ cm$

Question 22 (7 marks)

A world record was set for the men's 100-m dash in the 2008 Olympic Games in Beijing by Usain Bolt of Jamaica. Bolt "coasted" across the finish line with a time of 9.69 s.

Assumption: Bolt accelerates uniformly for 3.00 s to reach his maximum speed u, and maintains this speed for the rest of the race.

(a) Draw a graph of his velocity as a function of time for the duration of the race. **2**



(b) Use the graph to determine his maximum speed. **2**

Criteria	Mark
Equates area under graph to displacement and correctly determines maximum speed	2
Provides some relevant information	

Sample Answer:

Area under v-t graph gives displacement

Hence $\frac{1}{2}(9.69 + 6.60)u = 100$

$\therefore u = 12.21\ m\ s^{-1}$ is the maximum speed.

(c) What is his acceleration in the

(i) First 3 s of his motion? $a = \frac{12.21}{3} = 4.07\ m\ s^{-2}$ **1**

(ii) Last 3 s of his motion? $a = 0$ **1**

(d) In the same Olympics, Bolt also set the world record in the 200-m dash. Use the same assumption as for the 100-m dash.

Show that the time for the 200-m dash as determined from the adjusted graph is 17.88 s. **1**

Criteria	Mark
Correctly shows that the time taken is 17.88 s or that the distance covered in 17.88 s is 200 m	1

Sample answer:

With same assumptions, his maximum speed is $12.21\ m/s$,

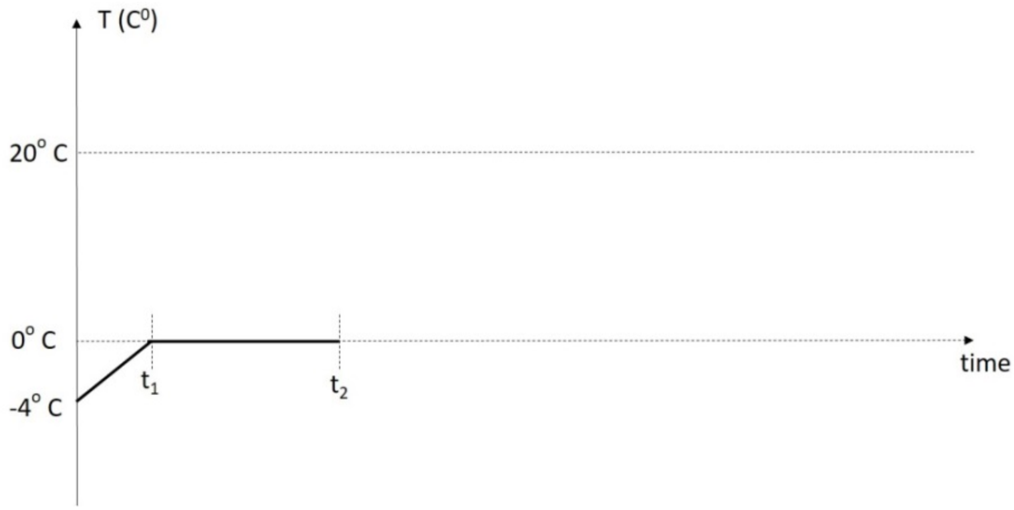
Hence $\frac{1}{2}(t - 3 + t)12.21 = 200$

$$\therefore t = 17.88\ s$$

Question 23 (3 Marks)

An icy pole is taken from the freezer at 4^0 C, and placed on a bench in a room at 20^0 C.

A graph of the temperature of the icy pole over time is shown below.



(a) Explain the shape of the graph from

(i) $t = 0$ to $t = t_1$ seconds. **1**

Explanation for each (not just description, temperature increases or temp remaining the same)

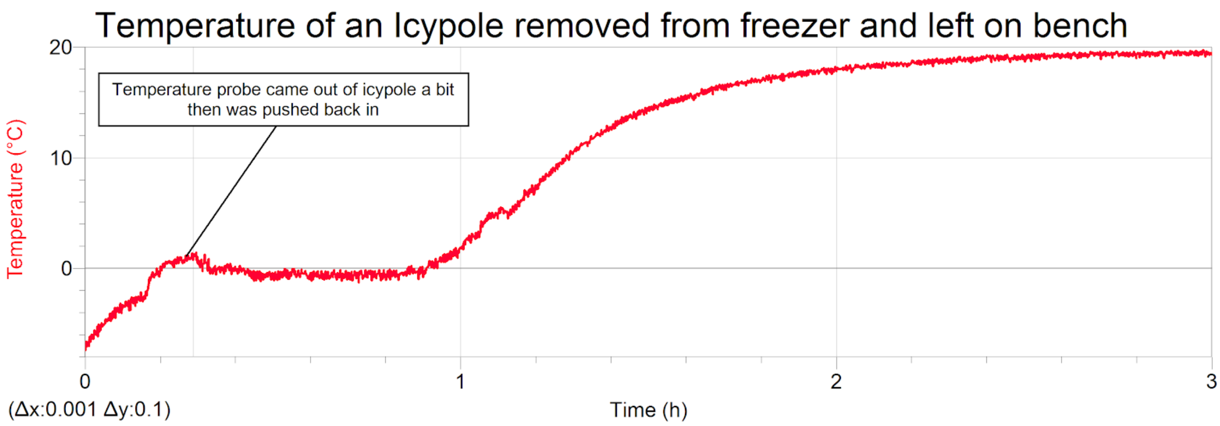
As there is a temperature difference between the icypole and the bench, heat flows from the bench (and the surrounding air) to the icypole, increasing its temperature.

(ii) $t = t_1$ to $t = t_2$ seconds. **1**

Heat is continuously transferred to the icypole from the environment due to the difference in temperature. This heat provides the latent heat to break the intermolecular bonds between the water molecules as it undergoes a phase change from solid to liquid.

(b) Show on the graph how the temperature of the icy pole changes with time between $T = 0^0$ and $T = 20^0$. **1**

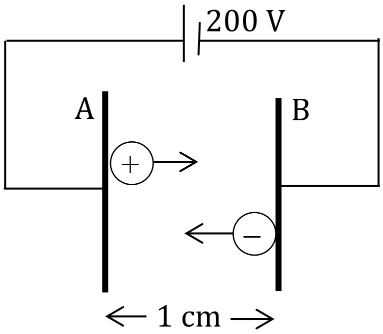
Draws a concave down curve that approaches 20C asymptotically, as shown in the data below.



Question 24 (5 marks)

Two parallel plates, 1 cm apart are connected to a 200 volt DC source.

A proton and an electron placed in between the plates and released from rest, were observed to move towards plates B and A respectively.



(a) Find the magnitude and direction of the electric field between the plates. **2**

Criteria	Mark
Correctly finds the magnitude and direction of the electric field	2
Correctly finds either the magnitude OR the direction of the electric field and or omits the units or has incorrect units OR Provides some relevant information	1

Sample Answer

$E = \frac{V}{d} = \frac{200}{0.01}$

$= 2 \times 10^4\ Vm^{-1}\ or\ NC^{-1}$, towards plate B, or from positive plate to negative plate

(b) Find the final speed of the electron as it lands on plate A. **3**
Show all working.

Criteria	Mark
Uses work done equal change in kinetic energy, relates work done to voltage and charge, and correctly calculates the speed OR Find F, then a, then v	3
Uses work done equal change in kinetic energy, relates work done to voltage and charge, but substitutes incorrectly, obtaining incorrect speed OR Any two of F, a, or v	2
Provides some relevant information	1

Sample Answer:

$$
\begin{aligned}
& W = \Delta E_k \\
\Rightarrow & VQ = E_k^f - E_k^i \\
& = \frac{1}{2}mv^2 - 0 \\
\Rightarrow & v = \sqrt{\frac{2VQ}{m}} \\
& = \sqrt{\frac{2\times200\times1.602\times10^{-19}}{9.109\times10^{-31}}} \\
& = 8.39\times10^6\ m\ s^{-1}
\end{aligned}
$$

OR Uses $F = EQ = ma$

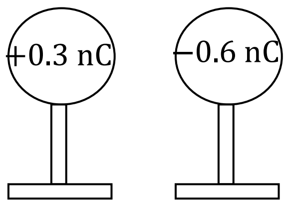
And hence finds acceleration: $a = \frac{EQ}{m} = \frac{20000\times1.602\times10^{-19}}{9.109\times10^{-31}} = 3.52\times10^{15}\ m\ s^{-2}$

Then uses $v^2 = u^2 - 2as$

$$
\begin{aligned}
& \therefore v^2 = 0 - 2\times3.52\times10^{15}\times(-0.01) \\
& \Rightarrow v = 8.39\times10^6\ m\ s^{-1}
\end{aligned}
$$

Question 25 (4 Marks)

Two identical spheres on insulating stands, 45 cm apart, carry charges of $+0.3\ nC$ and $-0.6\ nC$.



(a) Calculate the magnitude and direction of the force between the charged spheres at this distance. **3**

Criteria	Mark
Correctly substitutes into correct formula and computes the magnitude and direction of force	3
Any two of the above, with nano-coulomb incorrect, or electric permittivity incorrect	2
Provides some relevant information	1

Sample Answer:

$$
\begin{aligned}
F &= \frac{1}{4\pi\varepsilon_0}\frac{Q_1Q_2}{r^2} \\
&= \frac{1}{4\pi\times8.854\times10^{-12}}\frac{0.3\times10^{-9}\times0.6\times10^{-9}}{(0.45)^2} \\
&= 7.99\times10^{-9}\ N \text{ , towards each other}
\end{aligned}
$$

Lose 1 mark if nanocoulomb incorrect and everything else correct – follow on error

Lose 1 mark if k incorrect and everything else correct – follow on error

Lose 1 mark if direction incorrect or not given, everything else correct – follow on error

(b) The two spheres are then touched and separated 30 cm apart.

What is the charge on each sphere now? **1**

Criteria	Mark
Correct charge or correct process	1

Sample answer:

$$Q = \frac{(0.6+(-0.3))}{2} nC = 0.15\ nC$$

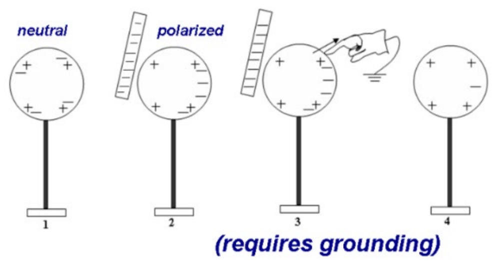
Question 26 (4 Marks)

Using a labelled diagram, describe an investigation you performed in class to demonstrate charging by the process of induction. **4**

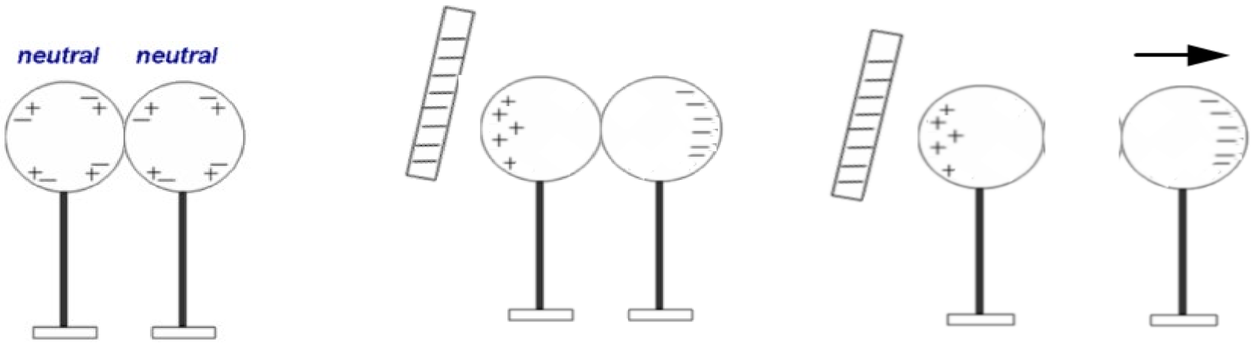
Criteria	Mark
Correct use of labelled diagram (1st mark) Describes how charge obtained (use of Van der Graaf Generator or by rubbing rod with material etc) (2nd Mark) Demonstrates the induction process (3rd mark) Communication mark	1 1 1 1
Any three of the above	3
Any two of the above	2
Some relevant information	1

Sample Answer:

Method 1: Polarise and then ground



Method 2: Polarise and then separate



Method 3:

Charge up the Vander Graaf Generator, bring an electroscope close to the dome of the generator, without touching, then remove. Charge will be retained on electroscope.

Method 4

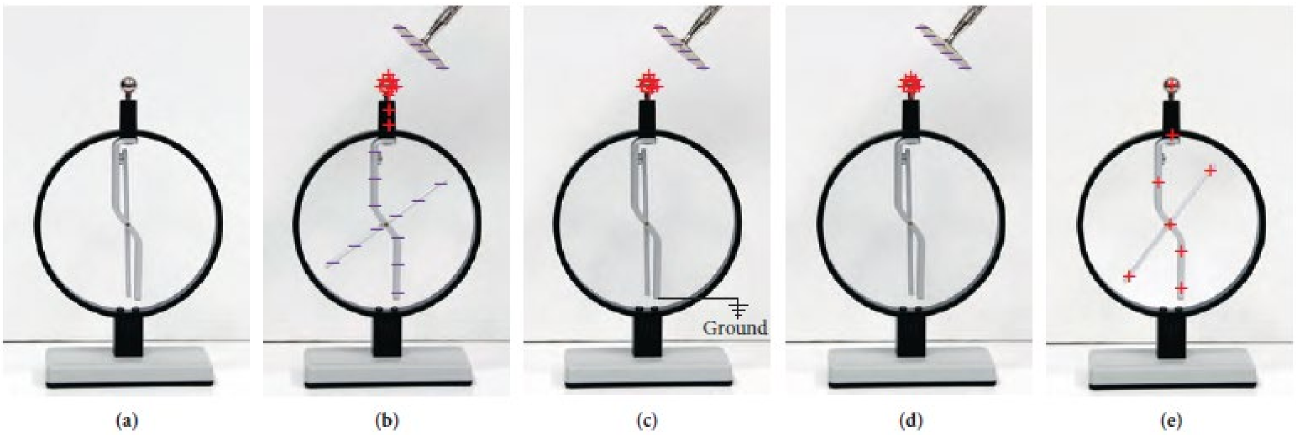
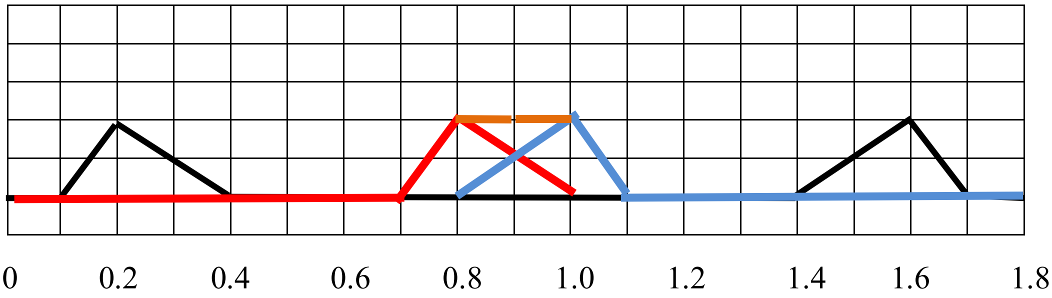


FIGURE 21.11 Charging by induction: (a) An uncharged electroscope. (b) A negatively charged paddle is brought close to the electroscope. (c) A ground is connected to the electroscope. (d) The connection to the ground is removed. (e) The negatively charged paddle is taken away, leaving the electroscope positively charged.

Question 27 (2 marks)

Two wave pulses are travelling toward each other at a speed of $10\ ms^{-1}$ on a long string, as shown in the figure below. The horizontal displacements are in metres.

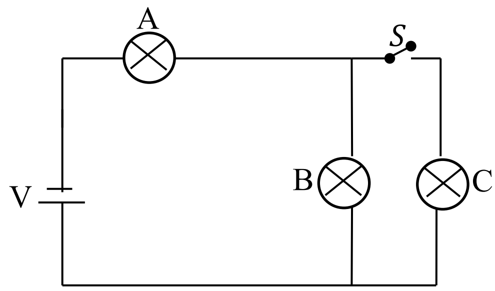


On the above grid, sketch the shape of the string at time $t = 0.06$ s.

Criteria	Mark
Shows evidence of peak of left wave travelling 0.6 m to to 0.8 right and Peak of right wave travelling from 1.6 to 1.0	1
Shows superposition of waves at position drawn	1

Question 28 (5 Marks)

The circuit below consists of 3 identical light bulbs, A, B and C connected to a DC voltage source, V and a switch S.



(a) Compare the brightness of bulbs A, B and C when S is open. **2**

Criteria	Mark
For using relevant equations ($P = I^2R$ or $P = \frac{V^2}{R}$), and arriving and B having equal brightness and C unlit (no brightness)	2
Provides some relevant information	1

Sample Answer:

A and B are in series, have equal resistance and the current through each is the same.

Hence from $P = I^2R$, the power dissipated in each is the same. Hence A and B have the same brightness.

OR

Since the bulbs are in series, and the resistances are equal, then the voltage drop is the same, then from $P = \frac{V^2}{R}$, the power dissipated is the same, hence the brightness is the same.

Bulb C will not light up

(b) Compare quantitatively the brightness of bulbs A, B and C when S is closed. **3**

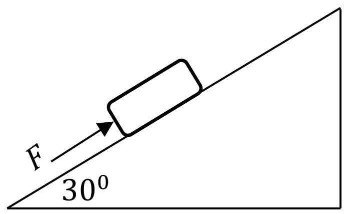
Sample Answer

The voltage drop across B and C are the same, and since the resistance is the same, the brightness of B and C will be the same. However the voltage drop across A is twice that across B and C combined. Hence from $P = \frac{V^2}{R}$, the power dissipated in A is four times larger than B or C. Hence the brightness of A will be four times that of B or C.

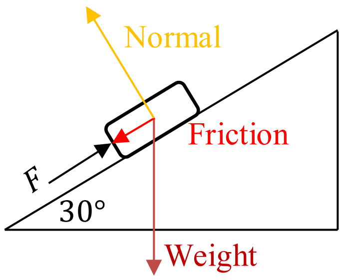
Criteria	Mark
For using relevant equations ($P = I^2R$ or $P = \frac{V^2}{R}$), and arriving at B and C having equal brightness and A being four times bright than B or C	3
For using relevant equations ($P = I^2R$ or $P = \frac{V^2}{R}$), and arriving at B and C having equal brightness and A being brighter than B or C (without the factor 4)	2
Provides some relevant information	1

Question 29 (5 marks)

A 1 kg box is being pushed up a rough 30^0 incline by a constant force F. The frictional force between the box and the inclined plane is 15 N.



(a) On the diagram, draw and label all the forces acting on the box while it is pushed up the plane. **3**



Marking Criteria	*Mark(s)*
• Correct direction and label for EACH force.	3

(b) Determine the magnitude of F that would accelerate the box up the plane at 1.0 ms^{-2}. **2**

Component of weight action on the same axis as F $= mg\sin 30°$
$= 1 \times 9.81 \times \sin 30°$
$= 4.905\ N$

Since $F_{Net} = m \times 1 = 1 \times 1 = 1\ N$,

Then $F_{Net} = F - 15 - 4.905 = 1$, *given frictional force* $= 15\ N$

Thus, $F = 20.905\ N$ *or* $20\ N$

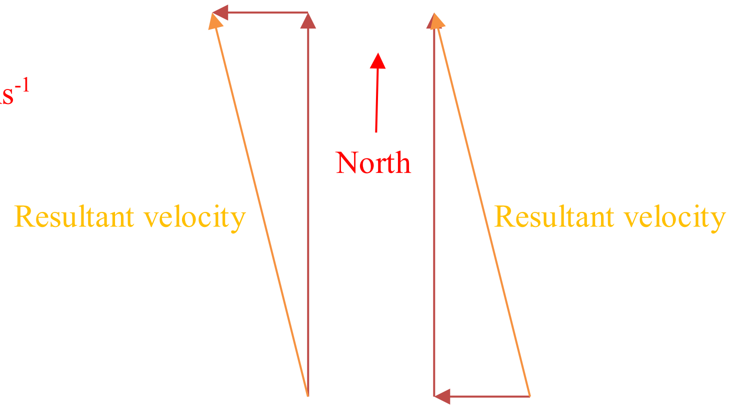
Marking Criteria	*Mark(s)*
• Correctly calculates the component of weight acting against the applied force (F). AND Correctly identifies that the net force acting on the block. • Correctly calculates the value of F.	2
• Correctly calculates the component of weight acting against the applied force (F). OR Correctly identifies that the net force acting on the block.	1

Question 30 (3 marks)

A plane was flying horizontally at 200 ms^{-1} relative to the air around it, heading due north according to its onboard compass. A wind was blowing towards the west at 50 ms^{-1} relative to the ground.

Determine the resultant velocity of the plane with the aid of a scale vector diagram.

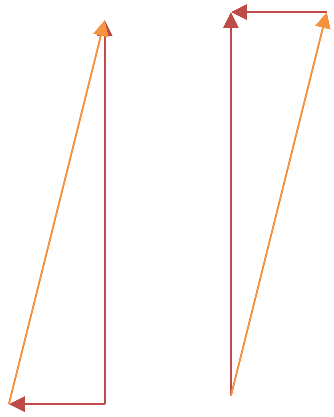
Scale
1 cm = 25 ms^{-1}



Resultant velocity $= \sqrt{200^2 + 50^2}$

$= 206.15 \ m\,s^{-1}$ *N 14° W*

If the plane was flying horizontally at 200 m s^{-1} relative to the ground below it, heading due north…



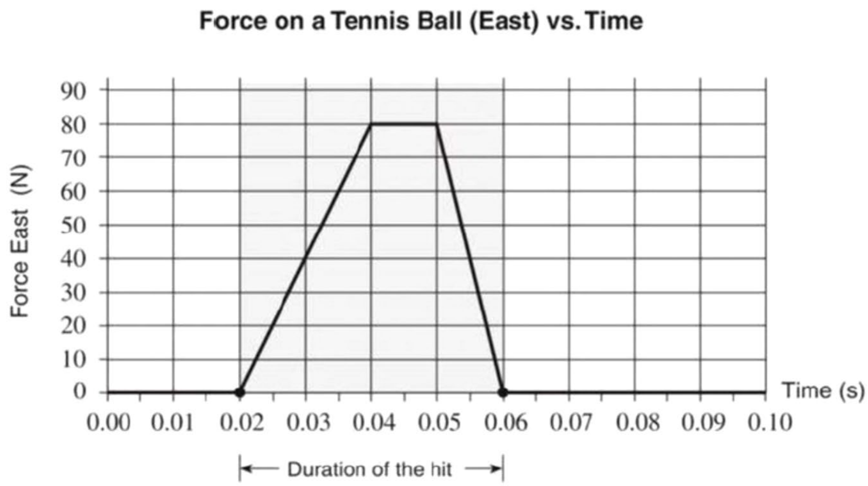
Resultant velocity $= \sqrt{200^2 + 50^2}$

$= 206.15 \ m\,s^{-1}$ *N 14° E*

Marking Criteria	*Mark(s)*
• The diagram is to scale (includes a conversion scale). • The initial vectors are placed correctly. • Correctly calculates the velocity INCLUDING correct angle.	3

Question 31 (4 marks)

A 0.057 kg tennis ball moving West at 24 ms^{-1} is hit in the opposite direction (East) with a tennis racket. The force acting on the ball during the hit is shown in the graph below.



(a) Calculate the impulse imparted to the tennis ball. **2**

Impulse = (0.5 × 0.02 × 80) + (0.01 × 80) + (0.5 × 0.01 × 80)
= 2 N s East or 2 kg m s^{-1} East

Marking Criteria	*Mark(s)*
• Correctly calculates the area between the black line and the x axis. • Provides a correct direction.	2
• Correctly calculates the area between the black line and the x axis. OR • Provides a correct direction.	1

(b) What is the magnitude of the final momentum of the ball? Show all working. **2**

Impulse = the change in momentum = final momentum – initial momentum

Thus, final momentum – (0.057 × -24) = 2

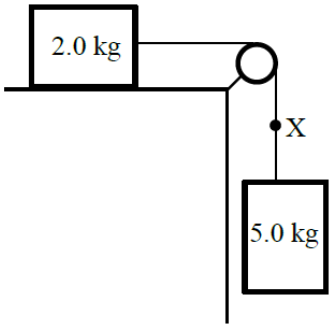
Final momentum = 0.632 East or 0.63 East

Marking Criteria	*Mark(s)*
• Identifies that the initial velocity is towards the West. • Correctly calculates the final momentum.	2

• Identifies that the initial velocity is towards the West.	1

Question 32 (3 marks)

Consider the system shown in the diagram below.



The blocks are connected by a light, inextensible string over a frictionless pulley.
The 2.0 kg block is resting on a smooth horizontal surface.

(a) Calculate the magnitude of the tension force in the string at X. **2**

$F_{net} = 2.0 \times a_{sys} = T$

Thus, $T = 14\ N$

Marking Criteria	*Mark(s)*
• Correctly calculates tension.	2

(b) Calculate the acceleration of the system. **1**

$F_{net} = 2.0 \times a_{sys} = T$

$F_{net} = 5.0 \times a_{sys} = 5.0 \times 9.81 - T$

Thus, $5.0 \times a_{sys} = 5.0 \times 9.81 - 2.0 \times a_{sys}$
$5.0 \times a_{sys} + 2.0 \times a_{sys} = 5.0 \times 9.81$
$(5.0 + 2.0) \times a_{sys} = 5.0 \times 9.81$
$a_{sys} = (5.0 \times 9.81) / (5.0 + 2.0)$

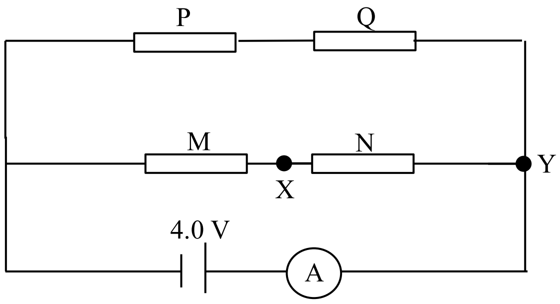
$a_{sys} = 7.0\ m\ s^{-2}$

Marking Criteria	*Mark(s)*

• Correctly calculates acceleration.	1

Question 33 (5 marks)

Four resistors, P, Q, M and N are connected to a 4.0 V power supply.



The current flowing through the ammeter is 2.0 A, and the resistance of P, M and N are 3.0 Ω, 1.0 Ω and 2.0 Ω respectively. The resistance of Q is unknown.

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

Sample Answer:

$$R = \frac{V}{I}$$
$$= \frac{4}{2}$$
$$= 2\ \Omega$$

Marking Criteria	*Mark(s)*
• Correctly calculates the resistance	1

(b) Calculate the resistance of resistor Q. **2**

Marking Criteria	*Mark(s)*
• Correctly calculates the resistance	2
• Provides some relevant information	1

Sample Answer:

$$\left(\frac{1}{1+2}+\frac{1}{3+R}\right)^{-1} = 2$$
$$\left(\frac{1}{1+2}+\frac{1}{3+R}\right) = \frac{1}{2}$$

$$\therefore R_Q = 3\ \Omega$$

(c) Calculate the voltage drop across X and Y. **2**

Marking Criteria	*Mark(s)*
• Correctly calculates the voltage drop across X and Y	2
• Provides some relevant information	1

Sample Answer:

Voltage drop across M and N is 4 V.

$V_M : V_N = 1:2$

$\therefore V_N = \frac{2}{3} \times 4 \sim 2.7\ \Omega$

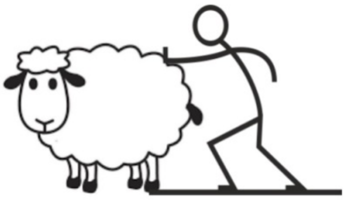
Question 34 (5 Marks)

Ms Ashurst is trying to push Millie the lamb into her pen, but she is big now and resists. Having been at James Ruse for a while Millie has been learning some physics, but hasn't understood a number of important ideas correctly.

Millie argues:
"*You can't move me, because Newton's third law states that the force you apply to me is the same as the force I apply back to you.*"

Ms Ashurst is still pushing, so Millie makes yet another claim:

"The law of conservation of momentum says that if my momentum is zero, it must remain zero!"



Explain what misunderstandings Millie has about Newton's 3rd law and the law of conservation of momentum, and use physics principles to explain how Ms Ashurst can in fact push Millie into her pen.

Newton's 3rd law:
The action and reaction forces in Newton's 3rd law do not cancel out, as they always act on different objects. In this case one force acts on Millie the sheep, and an equal and opposite force acts on Ms Ashurst. Millie's motion depends upon the vector sum of all the forces acting on Millie via Newton's 2nd law.

Conservation of Momentum:
Momentum is conserved in a closed system, i.e. one on which no net external force acts. If we consider Millie as our system, then if a net force acts on her, then her momentum will change (impulse eqn here - this is equivalent to Newton's 2nd law)

The physics of sheep pushing…

Whether Millie begins to move (i.e. whether she accelerates) depends on the net force that acts on her. In this case it is the vector sum of the force Ms Ashurst applies to her, and the force the earth applies to her hooves in the opposite direction (i.e. the frictional force acting on Millie).

Free body diagram of Millie here...

If the force that Ms Ashurst applies is greater than the frictional force that acts on Millie, then she will accelerate according to (Newton's 2nd law).

The force that Ms Ashurst can apply to Millie can be made larger if Ms Ashurst can dig her feet into the ground and exert a larger backward force on the ground via friction, so that the force the ground exerts on Ms Ashurst due to friction is larger than the force that Millie exerts on Ms Ashurst.

Free body diagrams of Millie and Ms Ashurst in the case Millie succeeds in resisting and in the case she gets pushed in.

Marking scheme
5 marks if answer contains all of the following AND no incorrect statements. 4 marks if missing one and so on.

A. Pairs of forces that are equal and opposite in Newton's 3rd law always act on different objects (any statement to this effect or a free body diagram for Millie and Ms Ashurst indicating this)

B. The momentum of any object or any group of objects is conserved if there is no external forces acting on the object/system of objects. (E.g. the momentum of any 'isolated' system is conserved).

C. The 'system' of Ms Ashurst AND Millie is not a 'closed' system, so their momentum is not conserved
OR
Millie on her own is a not a closed system, so momentum is not conserved.

<u>Reasoning</u>: If we take Millie as the system, then there is an external force acting on her due to Ms Ashurst as well as an external force from the earth via friction.
If we take both Millie and Ms Ashurst as the system then the earth exerts an external force on them via friction.

D. If the net force acting on an object is non-zero then it accelerates according to Newton's 2nd law
OR
If the net force acting on an object is non-zero then the momentum changes with time according to (Impulse equation)
OR
If an object experiences a net force then its change in kinetic energy is equal to the net work done (Work-energy theorem)

E. The net force on Millie is the sum of the force that Ms Ashurst applies and the force of friction between her hooves and the ground. Millie will accelerate (and so can be pushed into her pen) if these forces are unbalanced.

Misconceptions:

- The the object applying the force is more massive than another object then it can apply a larger force to an object that it applies back
- That the momentum of any two body system remains constant (i.e. when one object exerts a force on another) regardless of external forces
- Need to overcome 'weight force' (as well as friction) to push her.
- The reaction force acting on Ms Ashurst actually acts on the ground around her

END OF EXAMINATION ☺