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1. Which option, involving multiples and sub-multiples, is the correct representation of 1 m?

   A $1\ Gm = 1 \times 10^{6}\ m$
   B $1\ km = 1 \times 10^{5}\ cm$
   C $1\ \mu m = 1 \times 10^{-6}\ cm$
   D $1\ \eta m = 1 \times 10^{-6}\ mm$

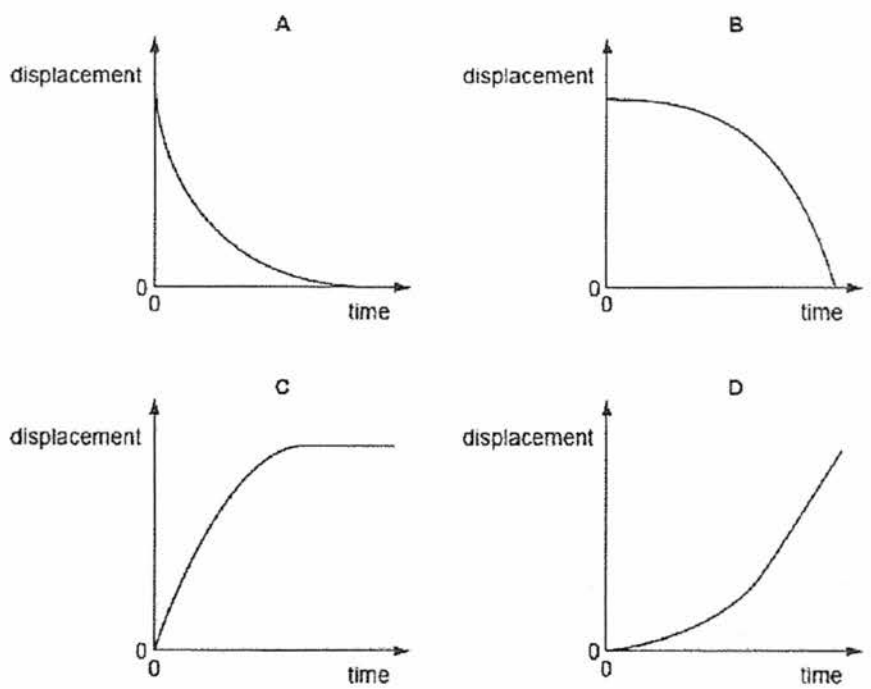
2. The speed of sound v in a gas is related to the pressure P of the gas by the expression

   $v = \sqrt{(kP)}$, where k is a constant.

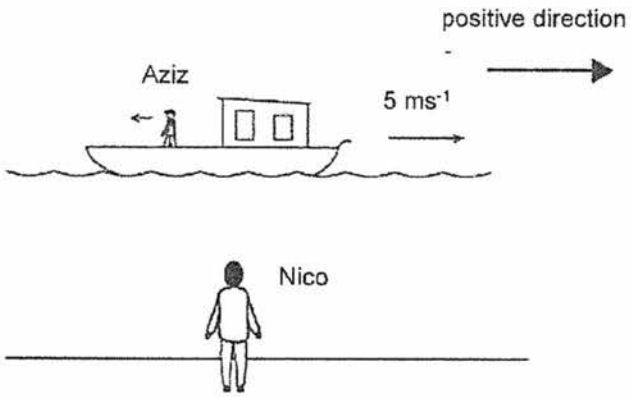
   Which variables should be plotted in order to produce a straight-line graph with the slope equal to k?

   A v^2 against P^2
   B v^2 against P
   C v against P
   D v against P

3. Which displacement-time graph best represents the motion of an falling object with constant acceleration of which eventually reduces until it begins to travel at constant terminal velocity?



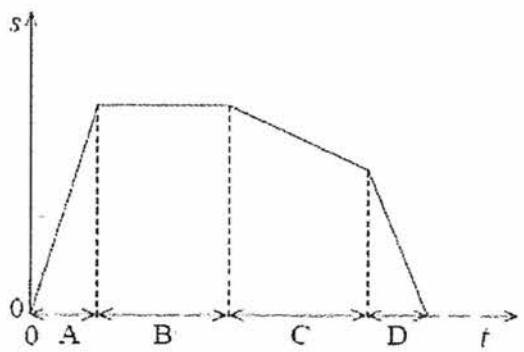
4. A boat is moving in the direction shown with a speed of 5 ms^{-1} as measured by Nico who is at rest on the beach. Aziz walks along the deck of the boat in the direction shown with a speed of 2 ms^{-1} measured relative to the boat.



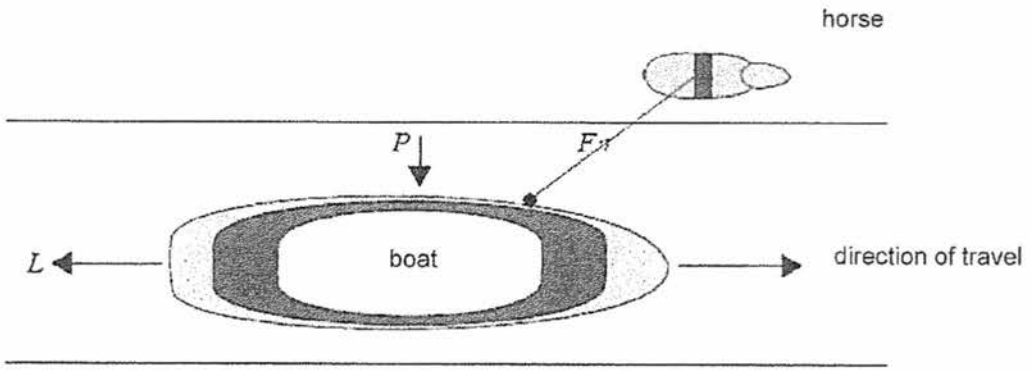
If velocity is measured as positive in the direction shown, what is the velocity of Aziz relative to Nico?

A - 7 ms^{-1}
B - 3 ms^{-1}
C 3 ms^{-1}
D 7 ms^{-1}

5. The graph below shows the variation with time t of the displacement s of a car.
In which time interval is the speed greatest?

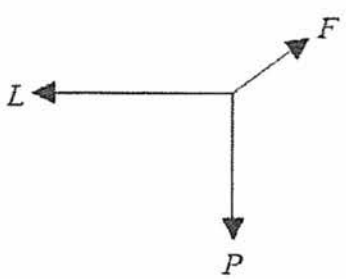


6. A horse pulls a boat along a canal at constant speed in a straight-line as shown below.

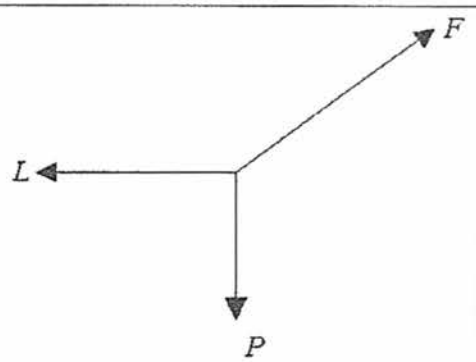


The horse exerts a constant force F on the boat. The water exerts a constant drag force L and a constant force P on the boat. The directions of F, L and P are as shown.
Which one of the following best represents a free-body diagram for the boat?

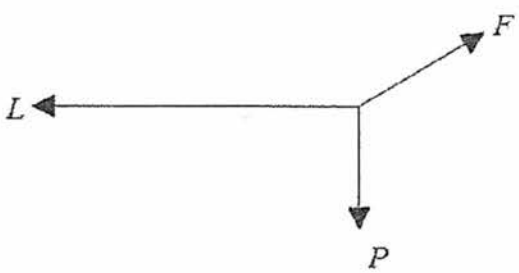
A



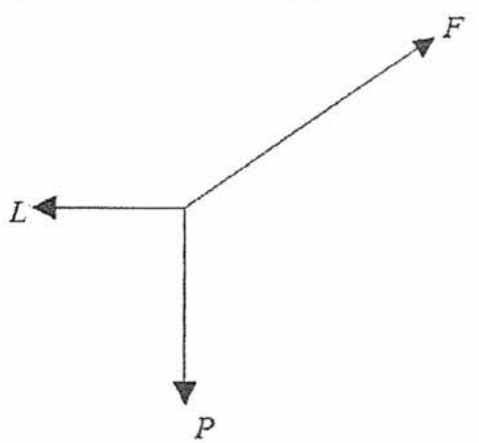
B



C



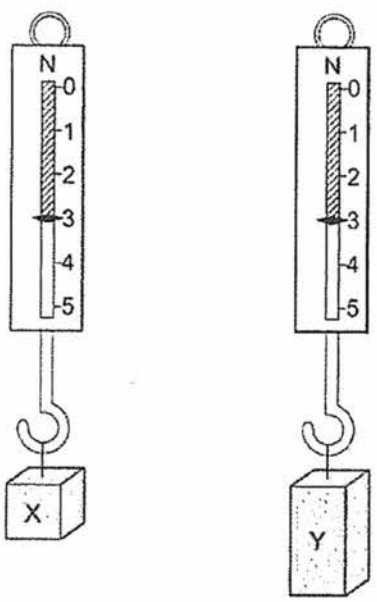
D



7. Water is pumped through a hose-pipe at a rate of 90 kg per minute. It emerges from the hose-pipe horizontally with a speed of 20 ms^{-1}.
Which force is required from a person holding the hose-pipe to prevent it moving backwards?

A 30 N
B 270 N
C 1800 N
D 10 800 N

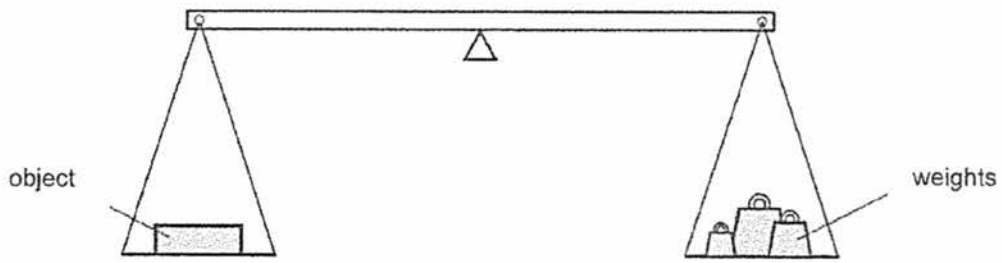
8. Two blocks of metals X and Y hang from spring balances, as shown in the diagrams.



What do the diagrams show about X and Y?

A They have the same mass and the same volume but different weights.
B They have the same mass and the same weight but different volumes.
C They have the same mass, the same volume and the same weight.
D They have the same weight and the same volume but different masses.

9. The weight of an object is found using the balance shown in the diagram. The object is put on the left-hand pan and various weights are put on the right-hand pan.



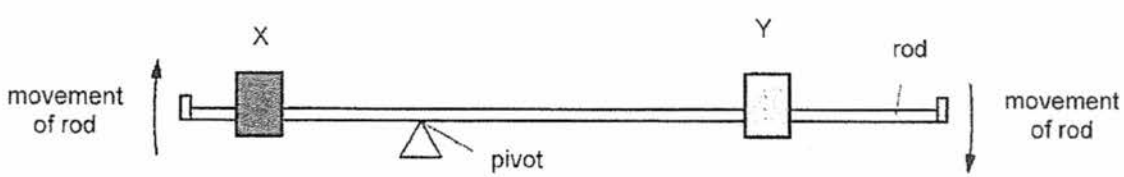
These are the results.

weights in the right-hand pan	effect
0.1 N, 0.1 N, 0.05 N, 0.02 N	balance tips down slightly on the left-hand side
0.2 N, 0.1 N, 0.01 N	balance tips down slightly on the right-hand side

What is the best estimate of the weight of the object?

A 0.27 N
B 0.29 N
C 0.31 N
D 0.58 N

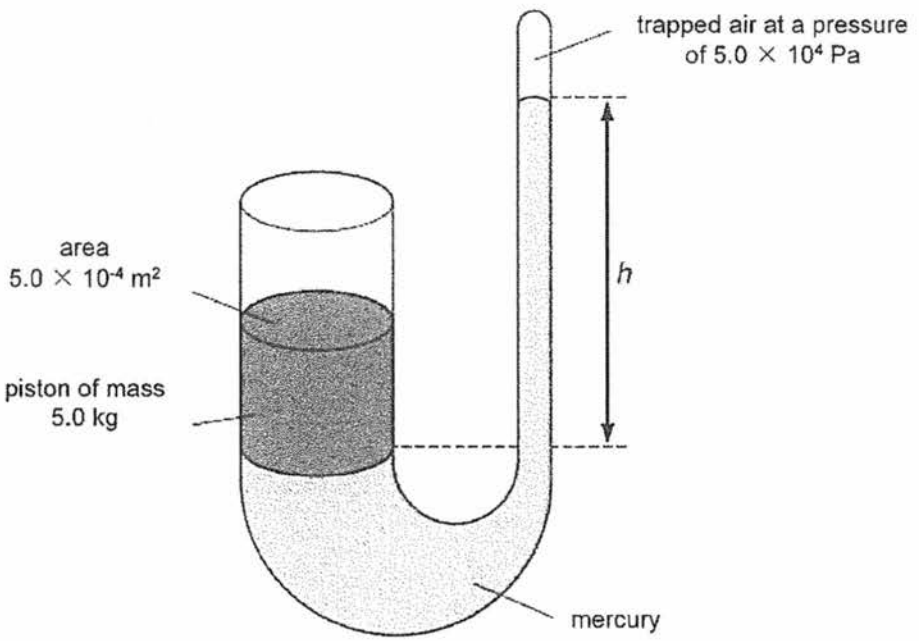
10. The diagram shows an unbalanced rod. Two loads X and Y can be moved along the rod. The rod turns in a clockwise direction as shown.



Which action could make the rod balance?

A moving X to the left
B moving X to the right
C moving Y to the right
D moving the pivot to the left

11. A U-tube closed at one end contains mercury. Air at a pressure of 5.0×10^4 Pa is trapped at the closed end. The other end is open to the atmosphere and is fitted with a piston of mass 5.0 kg and cross-sectional area 5.0×10^{-4} m^2.



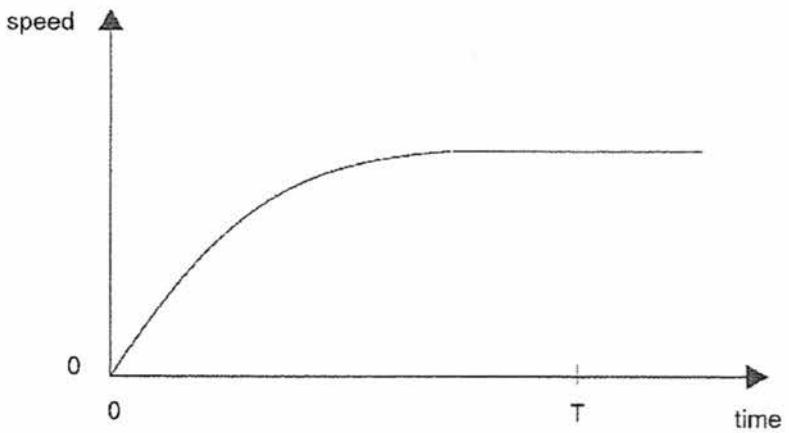
The density of mercury is 13 600 kgm^{-3} and atmospheric pressure is 1.01×10^5 Pa.
What is the height h of the mercury column?

A 37 cm
B 44 cm
C 74 cm
D 110 cm

12. Two stones, X and Y, of different mass are dropped from the top of a cliff. Stone Y is dropped a short time after stone X. Air resistance is negligible.
Which statement correctly describes how the distance between the stones would change?

A decrease if the mass of Y is greater than the mass of X
B increase if the mass of X is greater than the mass of Y
C decrease whether the mass of X is greater or less than the mass of Y
D increase whether the mass of X is greater or less than the mass of Y

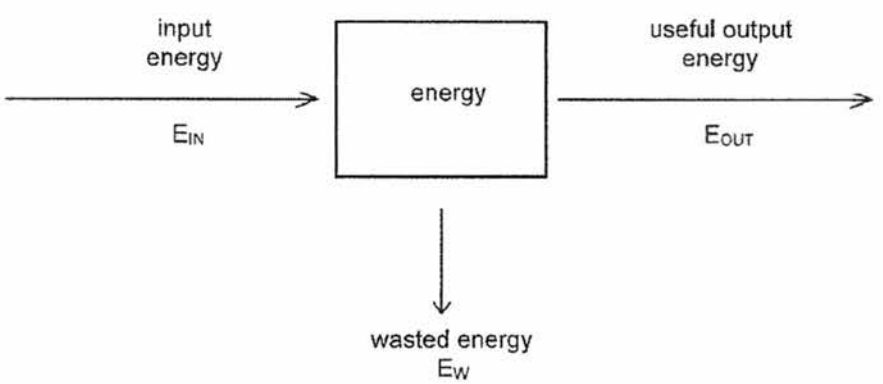
13. The variation with time of the vertical speed of a ball falling in air is shown below.



During the time from 0 to T, the ball gains kinetic energy and loses gravitational potential energy ΔEp. Which of the following statements is true?

A ΔEp is equal to the gain in kinetic energy.
B ΔEp is greater than the gain in kinetic energy.
C ΔEp is equal to the work done against air resistance.
D ΔEp is less than the work done against air resistance.

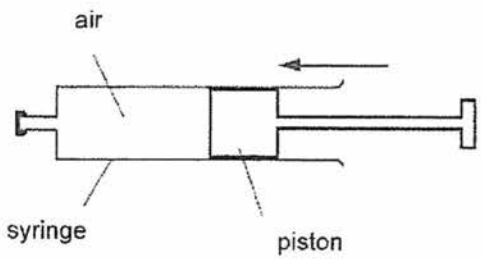
14. The diagram below represents energy transfers in an engine.



Which expression gives the efficiency of the engine?

A $E_W \div E_{IN}$
B $E_W \div E_{OUT}$
C $E_{OUT} \div E_{IN}$
D $E_{OUT} \div E_W$

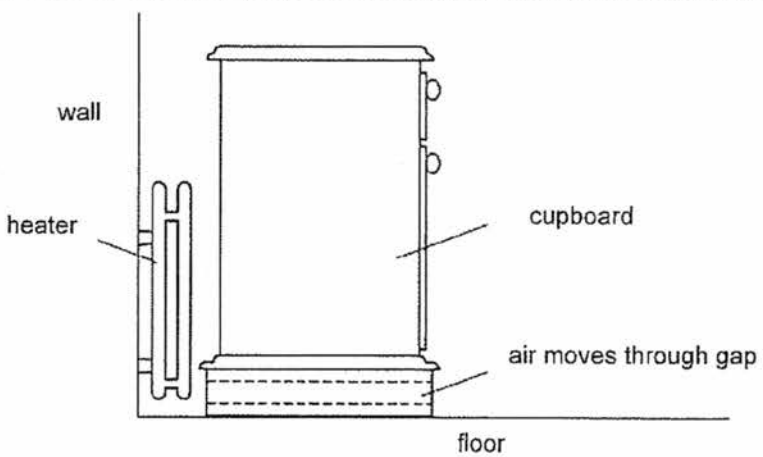
15. Air in a sealed syringe is slowly compressed by moving the piston. The temperature of the air stays the same.



Which statement about the air is correct?

A The pressure of the air decreases because its molecules now travel more slowly.
B The pressure of the air decreases because the area of the syringe walls is now smaller.
C The pressure of the air increases because its molecules now hit the syringe walls more frequently.
D The pressure of the air increases because its molecules now travel more quickly.

16. A cupboard is placed in front of a heater. Air can move through a gap under the cupboard.



Which option correctly describes the temperature, and the direction of movement of the air in the gap?

	air temperature	**air direction**
A	cool	away from heater
B	cool	toward the heater
C	warm	away from heater
D	warm	toward the heater

17. Which quantity gives the *thermal capacity* of a solid object?

A the energy lost by radiation from the object in 1.0 s
B the energy needed to melt the object
C the energy needed to raise the temperature of the object by 1.0 °C
D the total amount of thermal energy in the object

18. A temperature scale is to be constructed using the property X of a substance.
Which of the following must be a characteristic of the property X?

A The value of the property must be zero at 0K.
B The property must increase with increase of temperature.
C The property must have a different value at each temperature to be measured.
D The value of the property must vary linearly with the temperature measured in Kelvin.

19. Two ideal gases X and Y, are contained in a cylinder at constant temperature. The mass of the atoms of X is m and of Y is 4m.
Which one of the following is the correct value of the ratio of

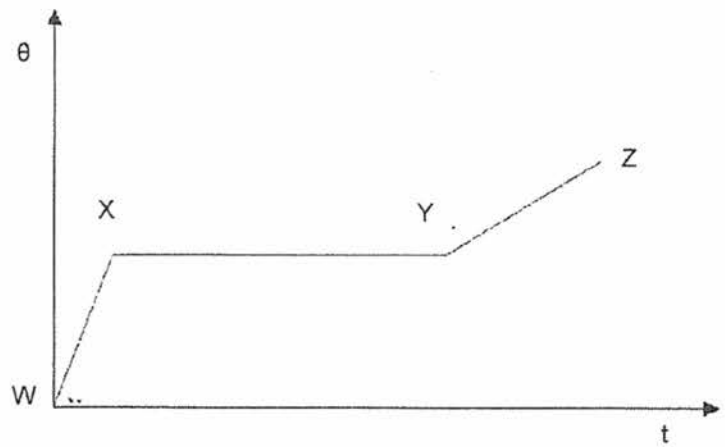
$$\frac{average\ kinetic\ energy\ of\ atoms\ of\ Y}{average\ kinetic\ energy\ of\ atoms\ of\ X}\ ?$$

A 1
B 2
C 4
D 16

20. Which of the following correctly shows the changes, if any, in the potential energy and in the kinetic energy of the molecules of a solid as it melts?

	Potential Energy	Chemical Energy
A	decrease	increase
B	increase	stay the same
C	stay the same	decrease
D	stay the same	stay the same

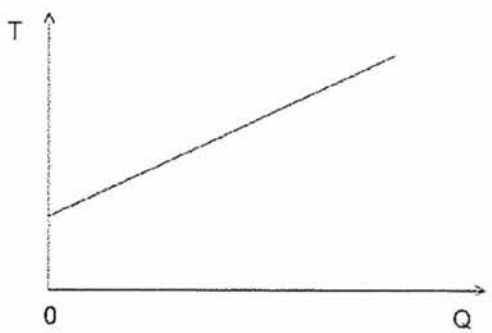
21. A substance is heated at a constant rate. The sketch graph shows the variation with time t of the temperature θ of the substance.



In which region or regions of the graph must there be more than one state of the substance present?

A WX and YZ
B WX only
C WX, XY and YZ
D XY only

22. The specific heat capacity c of a solid block of mass m is determined by heating the block and measuring its temperature. The graph below shows the variation of the temperature T of the block with the thermal energy Q transferred to the block.



What does the gradient of the line represent?

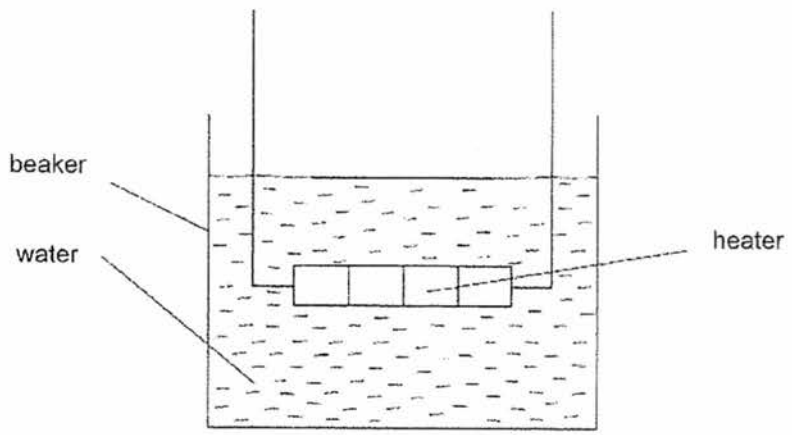
A $\frac{c}{m}$

B $\frac{m}{c}$

C mc

D $\frac{1}{mc}$

23. As part of an experiment to determine the latent heat of vaporisation of water, a student boils some water in a beaker using an electric heater as shown below.



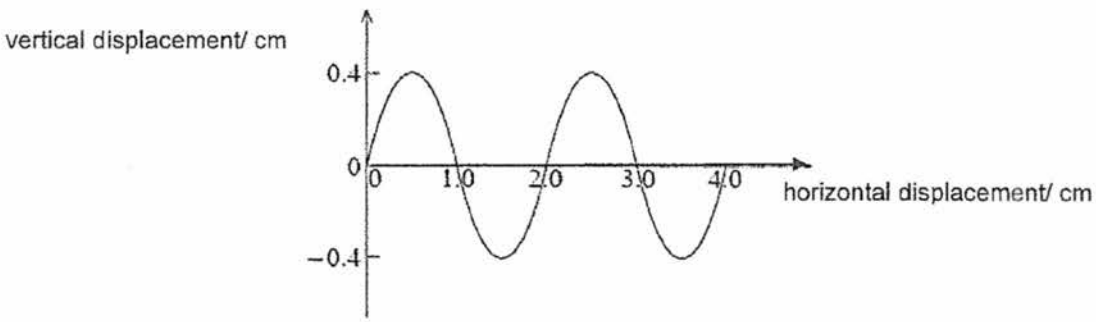
The student notes two sources of error.

Error 1: thermal energy is lost from the sides of the beaker
Error 2: as the water is boiling, water splashes out of the beaker

Which of the following gives the correct effects of these two errors on the calculated value for the specific latent heat?

	Error 1	Error 2
A	increase	decrease
B	increase	stay the same
C	decrease	increase
D	decrease	stay the same

24. A source produces water waves of frequency 10 Hz. The graph shows the variation with horizontal position of the vertical displacement of the surface of water at one instant in time.



What is the speed of the water waves?

A $0.20\ cms^{-1}$
B $4.0\ cms^{-1}$
C $10\ cms^{-1}$
D $20\ cms^{-1}$

25. Diagram 1 below shows the displacement of part of a medium through which a wave is travelling at time t = 0. Diagram 2 shows the displacement at a later time t = 4.0 s in which the wave has moved forward 10 cm. In this time, the point P on the wave has moved from a crest through zero displacement to a trough.

Diagram 1

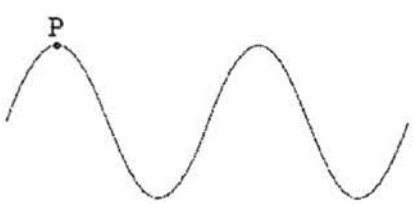
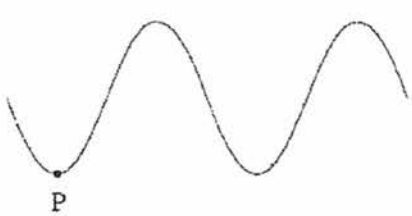


Diagram 2



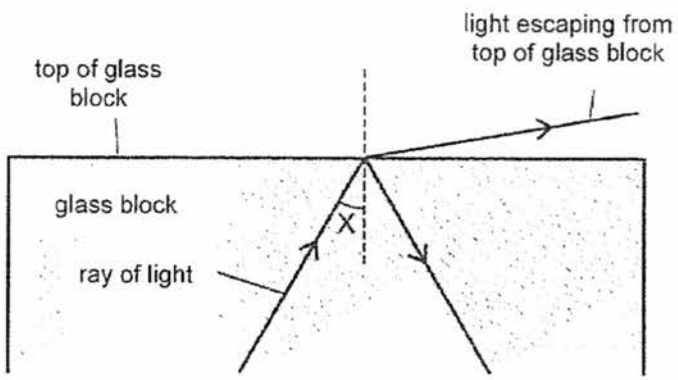
What is the wavelength of the wave?

A 5.0 cm
B 10 cm
C 20 cm
D 40 cm

26. A wave travels from one medium to another.
Which of the following is true about its frequency and wavelength?

	Frequency	Wavelength
A	no change	no change
B	change	no change
C	no change	change
D	change	change

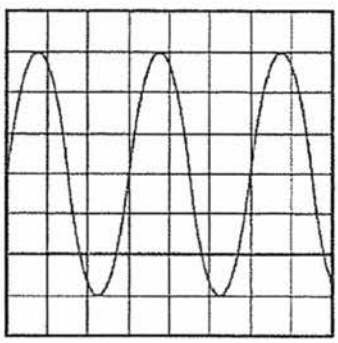
27. A scientist tries to direct a ray of light in a glass block so that no light escapes from the top of the block.



However, some light does escape.
The scientist changes angle X and stops the light escaping from the top. Which option correctly describes the change to angle X and the name of the effect produced?

	change to angle X	name of effect produced
A	decrease	total internal reflection
B	decrease	total internal refraction
C	increase	total internal reflection
D	increase	total internal refraction

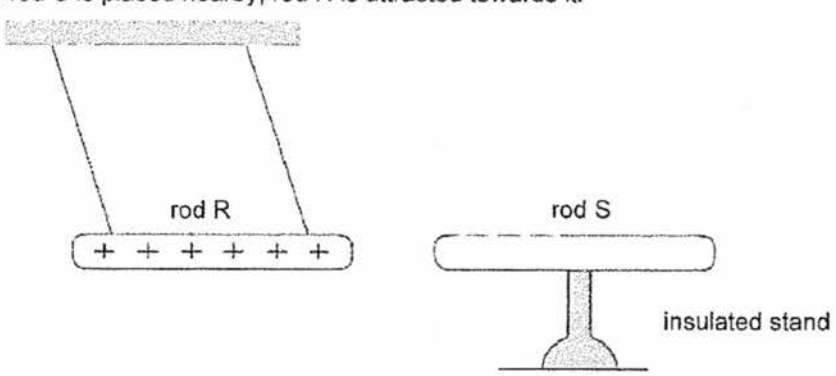
28. A sound wave is displayed on the screen of a cathode-ray oscilloscope, as shown.



The time-base setting is 0.50 ms per division.
What is the frequency of the sound wave?

A 250 Hz
B 500 Hz
C 670 Hz
D 1300 Hz

29. The diagram below shows a charged rod R suspended by insulating strings. When a stationary rod S is placed nearby, rod R is attracted towards it.



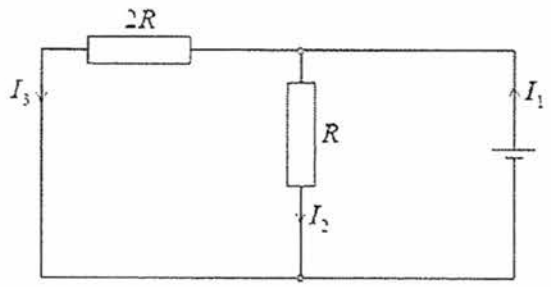
Consider the following statements regarding the possible nature of the rod S.

I. Rod S is charged
II. Rod S is an uncharged insulator.
III. Rod S is an uncharged conductor.

Which statement(s) can explain the attraction of rod R to rod S?

A I only
B II only
C III only
D I and III only

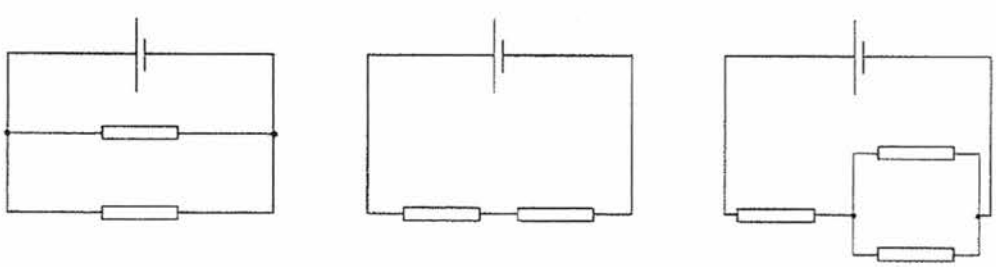
30. In the circuit shown below, the cell has negligible internal resistance.



Which of the following equations is correct?

A $I_1 = 2I_2$
B $I_1 = 2I_3$
C $I_2 = 2I_3$
D $I_3 = 2I_1$

31. In the circuits below, the cells each have the same e.m.f. and zero internal resistance. All the resistors have the same resistance.



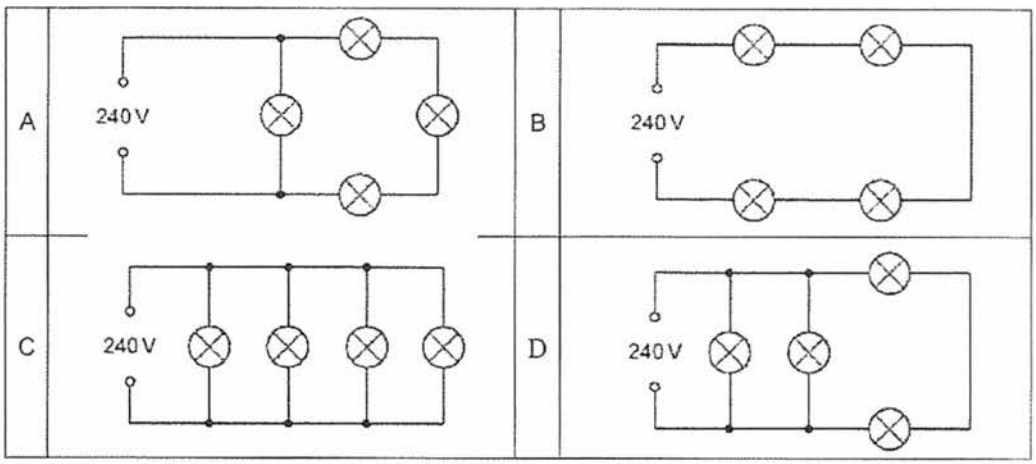
circuit X circuit Y circuit Z

Which of the following gives the current through the cells in order of increasing magnitude?

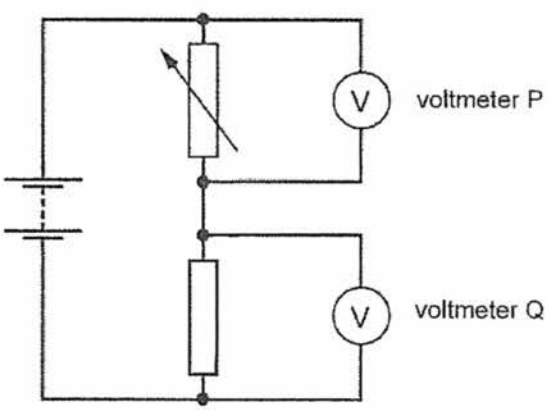
	lowest current	⟶	**highest current**
A	X	Y	Z
B	Z	X	Y
C	Y	Z	X
D	Y	X	Z

32. Four lamps are each labelled 240 V.

In which circuit do all four lamps have normal brightness?



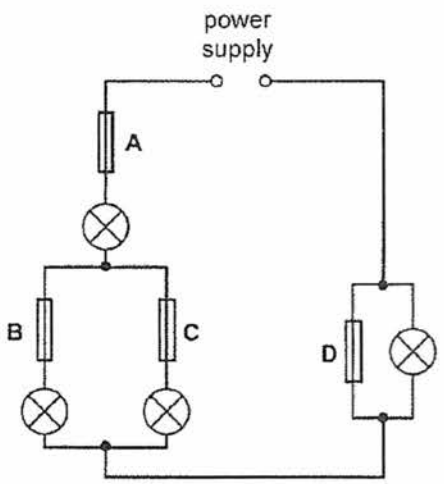
33. The diagram shows a potential divider connected to two voltmeters P and Q.



The resistance of the variable resistor is decreased.
Which option shows what happens to the reading on each voltmeter?

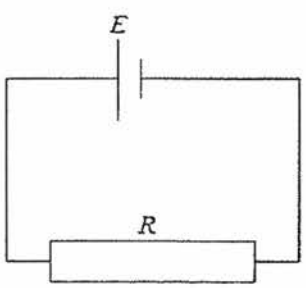
	reading on Voltmeter P	reading on Voltmeter Q
A	decreases	decreases
B	decreases	increases
C	increases	decreases
D	increases	increases

34. In the circuit shown, only one of the fuses has blown, but none of the lamps is lit.
Which fuse has blown?

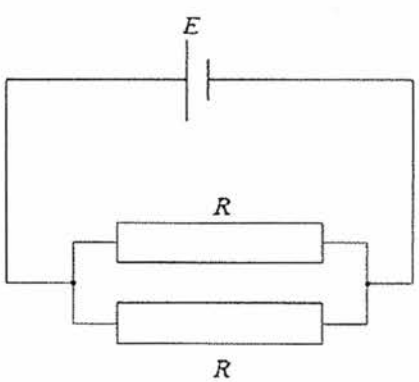


35. In the two circuits X and Y below, each cell has an e.m.f. E and negligible internal resistance.
Each resistor has a resistance R.

circuit X



circuit Y



The power dissipated in circuit X is P.
What is the best estimate for the power dissipated in circuit Y?

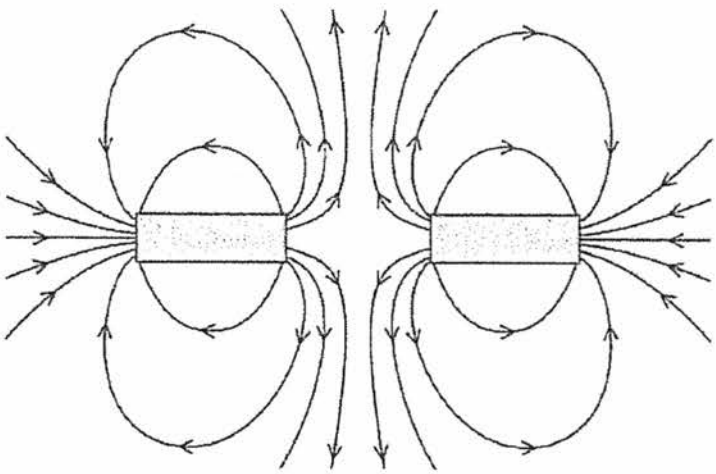
A $\frac{P}{4}$

B $\frac{P}{2}$

C 2P

D 4P

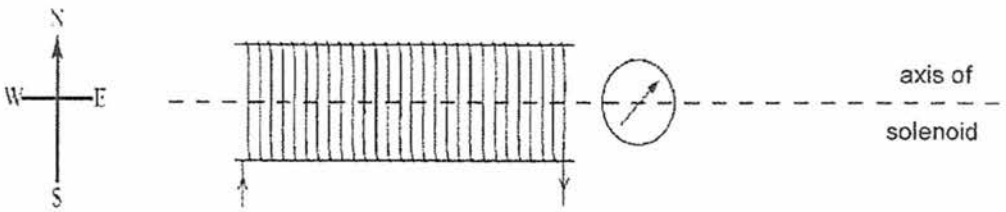
36. The diagram shows the magnetic field around two bar magnets.



Which diagram shows the poles of the magnets?

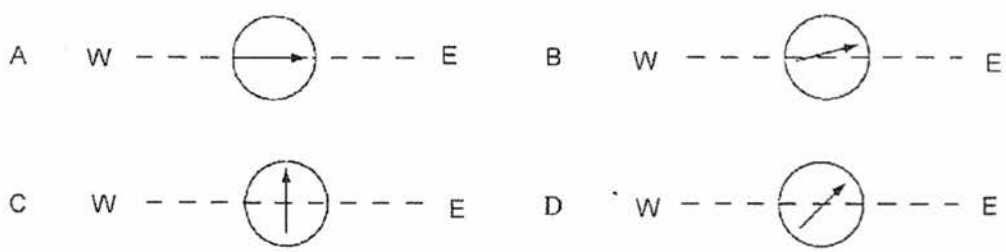
A	N S	N S
B	N S	S N
C	S N	N S
D	S N	S N

37. A current-carrying solenoid is placed with its axis pointing east-west as shown below. A small compass is situated near one end of the solenoid.

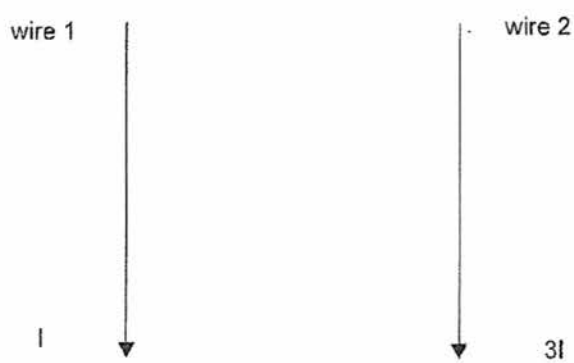


The axis of the needle of the compass is approximately 45° to the axis of the solenoid. The current in the solenoid is then doubled.

Which of the following diagrams best shows the new position of the compass needle?



38. The currents in two parallel wires are I and I in the directions shown in the diagram below.



The magnetic force on wire 2 due to the current in wire 1 is F.
What is the magnitude of the force on wire 1 due to the current in wire 2?

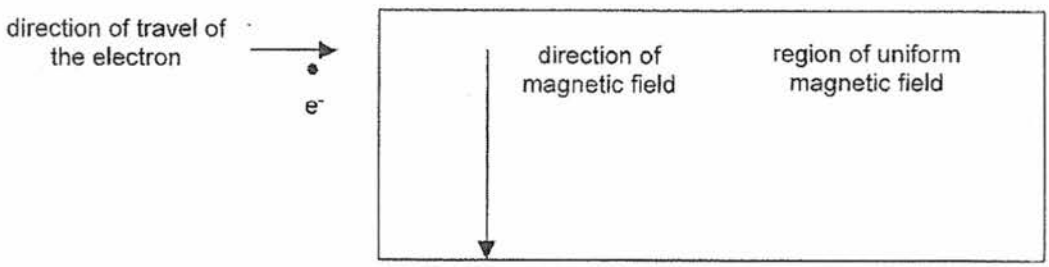
A $\frac{F}{3}$

B $\frac{F}{2}$

C F

D 3F

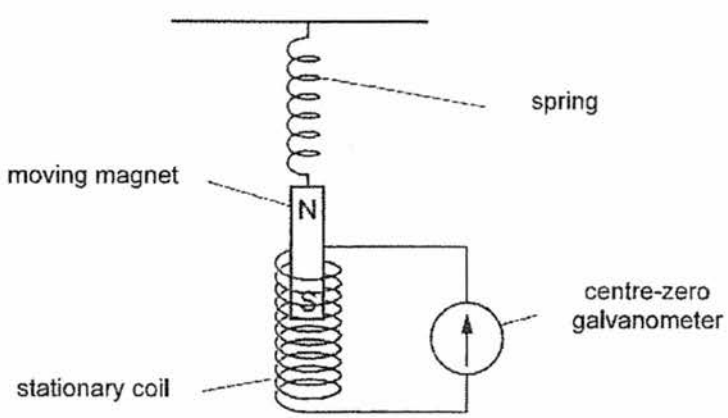
39. An electron is travelling in the direction shown and enters a region of uniform magnetic field.



What is the direction of the force acting on the electron after it enters the region of magnetic field?

A into the plane of the paper
B out of the plane of the paper
C towards the top of the page
D towards the bottom of the page

40. A magnet is suspended from a spring so that it can move freely inside a stationary coil. The coil is connected to a sensitive centre-zero galvanometer.



The magnet repeatedly moves slowly up and down.
What does the galvanometer show?

A a constantly changing reading
B a steady reading to the left
C a steady reading to the right
D a steady reading of zero

END OF PAPER

Section A

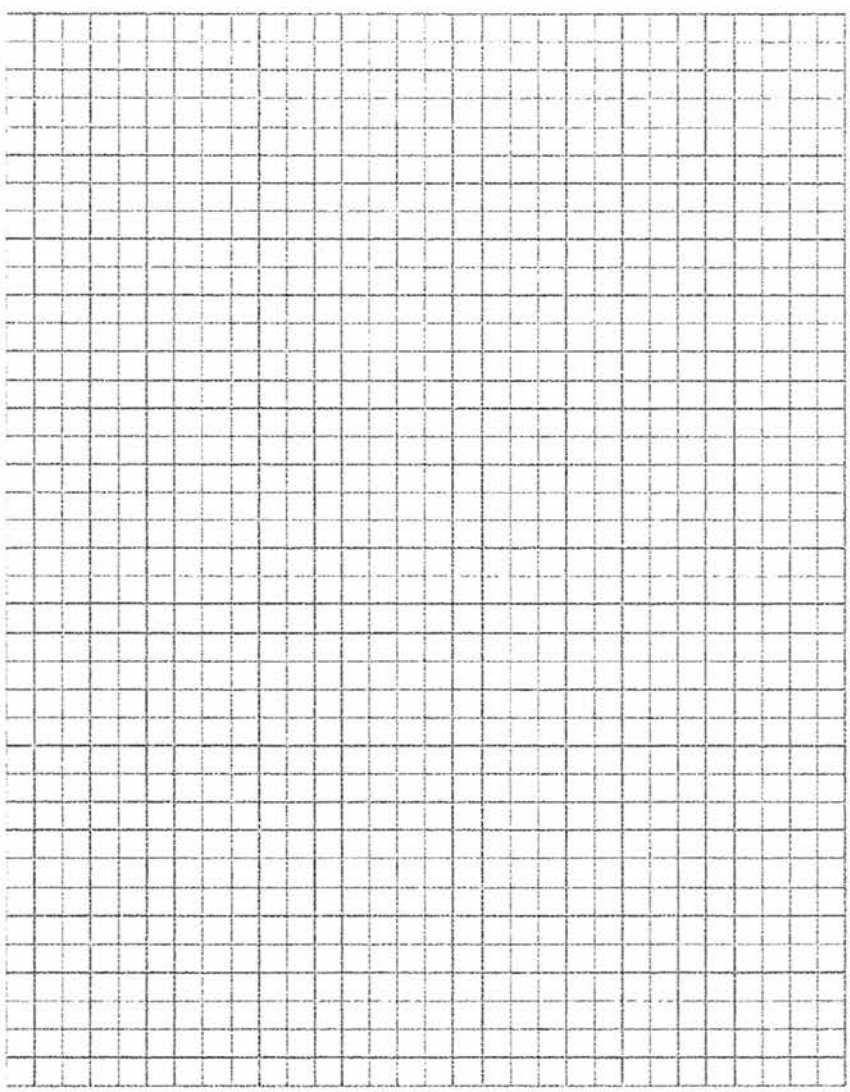
Answer **all** the questions in this section.
The total mark for this section is 50.

1. The following data is collected in a kinematics experiment using a toy car.

t/s	0.20	0.30	0.40	0.50	0.60	0.70	0.80	0.90
v/(ms^{-1})	0.35	0.46	0.59	0.70	0.83	0.94	1.10	1.18

a. Plot the graph of v vs. t with the data and extend your line back to t = 0.

[2]



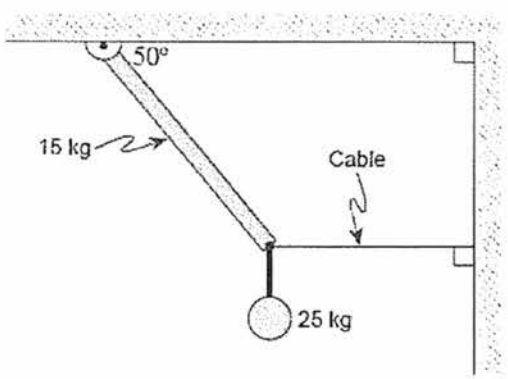
b. What is the displacement of the toy car from t = 0 to t = 0.90 s?

[2]

c. What does the y-intercept of the graph represent?

[1]

2. A 4.0 m long uniform pole with a mass of 15 kg is pivoted at one end and held in position by a horizontal cable at the other end. A 25 kg mass is suspended from the end of the pole as shown in the figure below.



a. Calculate the weight of the uniform pole.

[1]

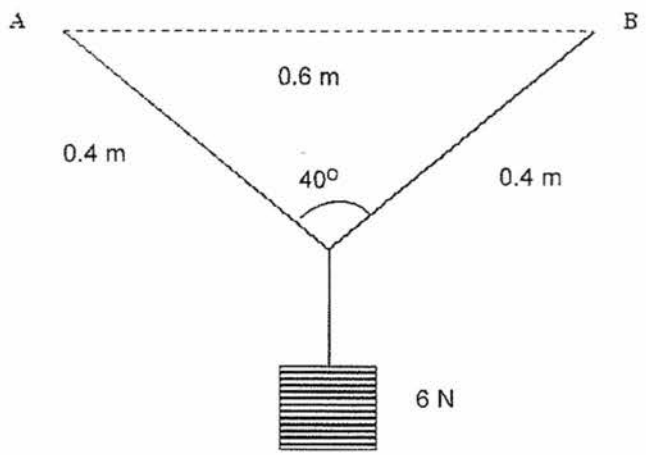
b. Mark out clearly, on the figure, the position where all the weight of the pole seems to be acting.

[1]

c. Determine the tension in the horizontal cable.

[2]

3. A 6.0 N weight is attached to a light string which is then tied to the midpoint of a second string of length 0.8 m. This string is suspended from two fixed points which are on the same horizontal line 0.60 m apart. The arrangement is shown below:



What is the tension in each string?

[3]

4. A container of mass 2000 kg is hoisted by an electrically operated crane as shown in Figure 1, in order for it to be loaded onto a ship. Initially the container is accelerated upwards briefly, after which it is hoisted at a constant speed.

Physical System

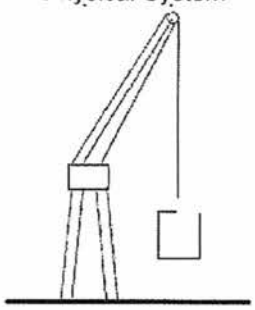


Figure 1

Free Body Diagram

accelerating upwards

Figure 2

Free Body Diagram

moving upwards at constant speed

Figure 3

a. On Figures 2 and 3 above, draw free-body force diagrams showing and labelling the forces acting on the container during the stages of acceleration and constant velocity. Use longer vectors for greater forces.

[2]

b. The safety limit for the tension in the cable is 25000 N.
Determine the maximum permissible upward acceleration of the container if the limit is not to be exceeded.

[2]

c. After the initial acceleration, the crane continues hoisting the container at a constant upward speed of 0.5 ms^{-1}.

i. Calculate the power output of the crane during this stage.

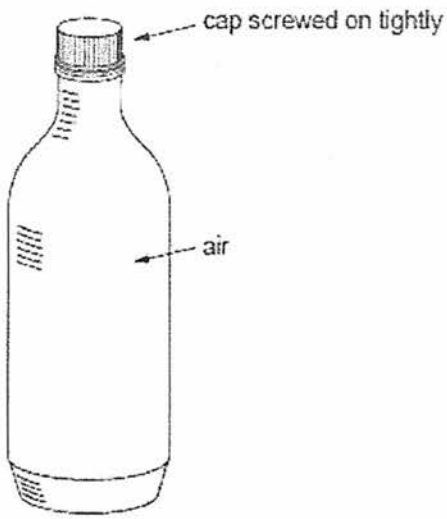
[2]

ii. The crane's electric motor operates at 400 V.
Assuming no power losses, calculate the current drawn by the motor during hoisting.

[2]

iii. Eventually the container reaches a height sufficient for loading onto the ship.
To what energy has the electrical energy supplied to the motor be converted into?
[1]

5a. On a hot day, a child drinks all the water in a plastic bottle. She then screws the cap back tightly on the bottle, so that the bottle contains only air.

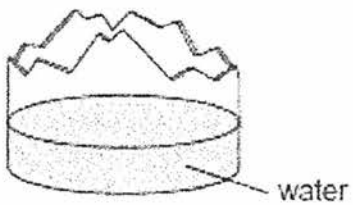


She throws the bottle into a waste basket, where the sun shines on it. After a while in the sun's rays, the air in the bottle is much hotter than before.

i. State and explain what has happened to the pressure of the air in the bottle.
[1]

ii. In terms of the behaviour of the air molecules, explain your answer to (a)(i).
[1]

b. A broken glass bottle containing a small quantity of water was found in the waste basket, as shown in the figure below.



As the sun shines on it, the volume of water slowly decreases.

i. State the name of the process causing this decrease.

[1]

ii. In terms of the effect of the sun's rays on the water molecules, explain your answer to (b)(i).

[1]

6. 2 kg of ice from a freezer at −15 °C is mixed with 10 kg of water at 30 °C.

   a. Determine the final temperature of the mixture after equilibrium is reached. Energy losses to the environment are negligible. You may make use of the data provided below.

   [3]

   Data:
   Specific heat capacity of ice: 2.1×10^3 J kg^{-1} °C^{-1}
   Specific heat capacity of water: 4.2×10^3 J kg^{-1} °C^{-1}
   Specific latent heat of melting of ice: 3.4×10^5 kg^{-1} °C^{-1}

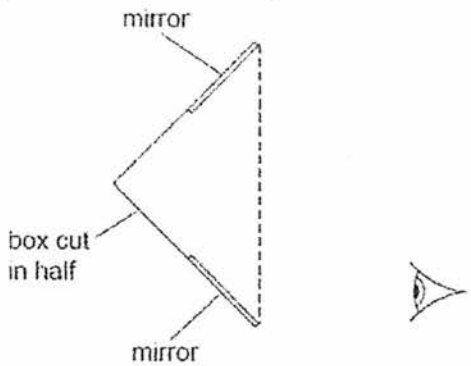
   b. During the process when the ice is melting, it absorbs energy but its temperature does not increase. Explain, from the molecular point of view, how this can be possible.

   [2]

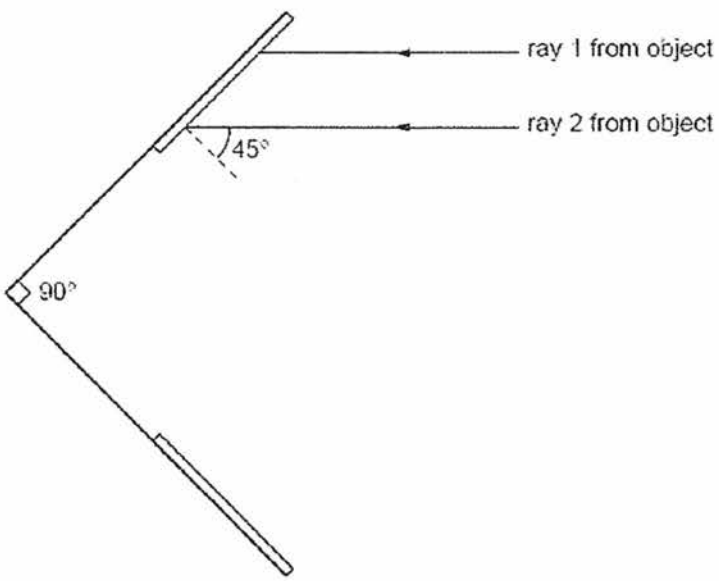
   c. Using the principle of conservation of energy, state the energy conversion that has taken place.

   [1]

7. An inventor is trying to make a device to enable him to see objects behind him. He cuts a square box in half diagonally and sticks two plane mirrors on the inside of the box.
A side view of the arrangement is shown in the figure below.



A second figure below shows the arrangement that is drawn with a larger view. Two parallel rays from two different points on a distant object behind the man are drawn in the figure below.



a. Continue the two rays to show how the rays of light will enter the eyes of the inventor.
[2]

b. What can be said about the image seen by the inventor?
[1]

_____

_____

8. A hammer is used to strike one end of a 900 m long hollow metal pipe. A data logger connected with a sensitive sound detector at the other end registers two sounds at an interval of 2.3 s between them. (Take speed of sound in air = 330 ms^{-1})

   a. Explain why there are two sounds registered at an interval of 2.3 s apart.

   [1]

   _____

   _____

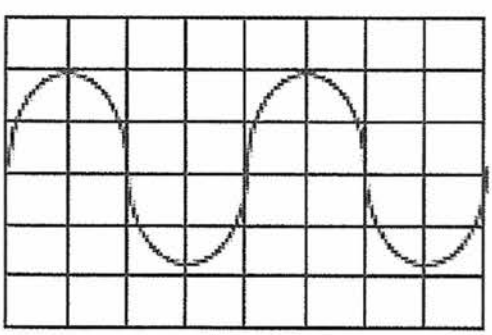
   b. Calculate the time taken for sound to travel 900 m in air.

   [1]

   c. Calculate the speed of sound in the metal pipe.

   [2]

   d. The hammer is then used to hit the pipe again. The figure below shows the waveform that is registered by the data logger. The waveform represents the sound in the metal pipe.



   On the figure above, draw a new waveform to represent the new sound wave that is formed when the hammer is now hitting the pipe with **more** force.

   [2]

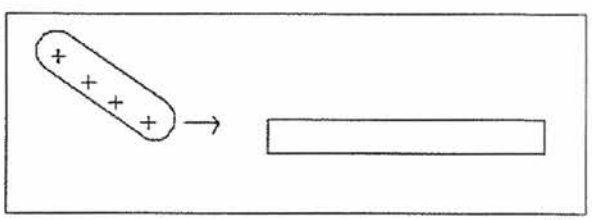
9. Two electrostatic charging processes are illustrated below.

a. A rubber rod R is originally uncharged. When rubbed with fur, the rod becomes positively charged.
Explain briefly how the net positive charge arises on the rod.

[2]

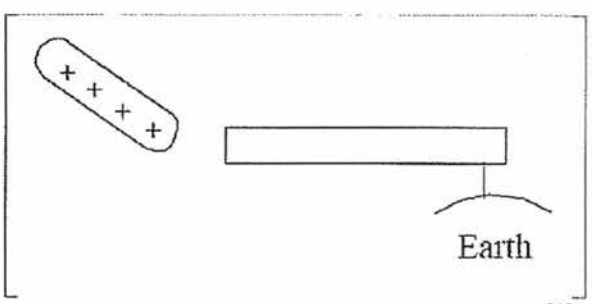
b. A positively charged rubber rod is used to charge a metal rod by electrostatic induction. The diagrams below show the steps in the process.
For each step, draw the charge distribution in the metal rod.

i. The charged rubber rod is brought close to the metal rod.



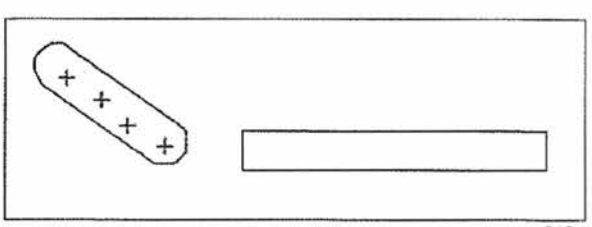
[1]

ii. The metal rod is connected to earth.



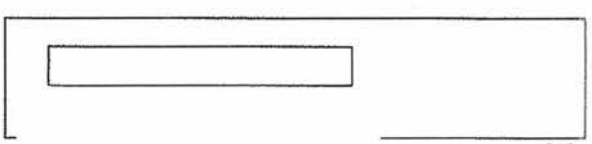
[1]

iii. The earth connection is removed.



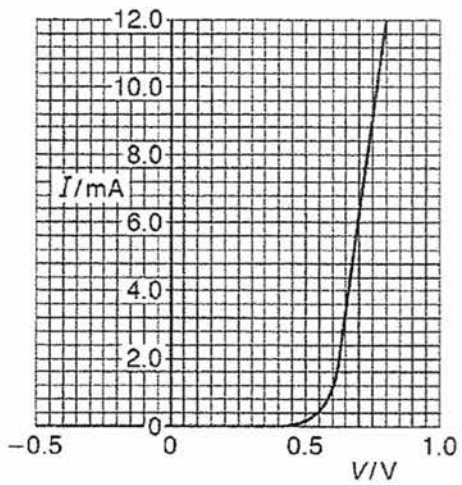
[1]

iv. The rubber rod is removed.



[1]

10. The variation with potential difference (p.d.) V of current I for a semiconductor diode is shown in the figure below.

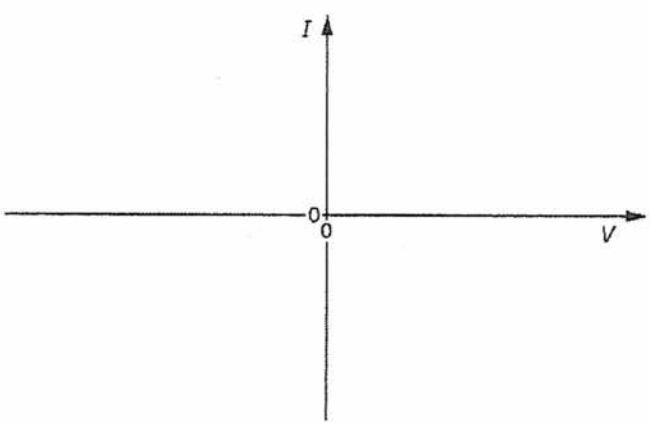


a. Use the figure provided to describe the variation of the resistance of the diode between V = - 0.5 V and V = 0.8 V.

[2]

b. On the figure below, sketch the variation with p.d. V of current I for a filament lamp. Numerical values are not required.

[1]



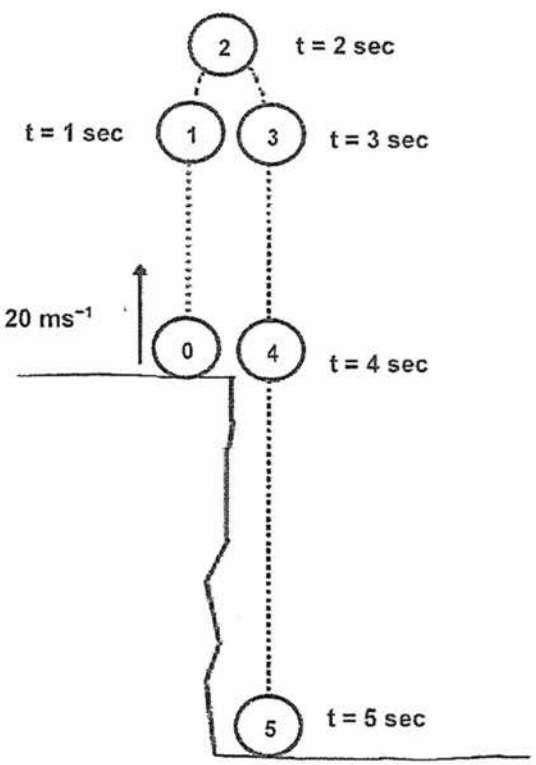
c. What is the name given to such an electrical conductor as described in (b)?

[1]

Section B

Answer **all** the questions in this section in the spaces provided.
Question 13 is in the form either/or
and only **one** of the alternatives should be attempted.
The total mark for this section is 30.

11. A stone is projected almost vertically upwards at 20 ms^{-1} from the edge of a cliff as shown. It finally lands on the ground at the base of the cliff. The sequence diagram below shows the position of the stone at one-second intervals. Image 0 is just after projection, and Image 5 is just before landing. Gravitational acceleration is taken as 10 ms^{-2} and air resistance is ignored.



a. State whether the acceleration of the stone is upward, downward or zero in each of the following cases:

i. when the stone is on its way up, _____ [1]

ii. when the stone is on its way down, _____ [1]

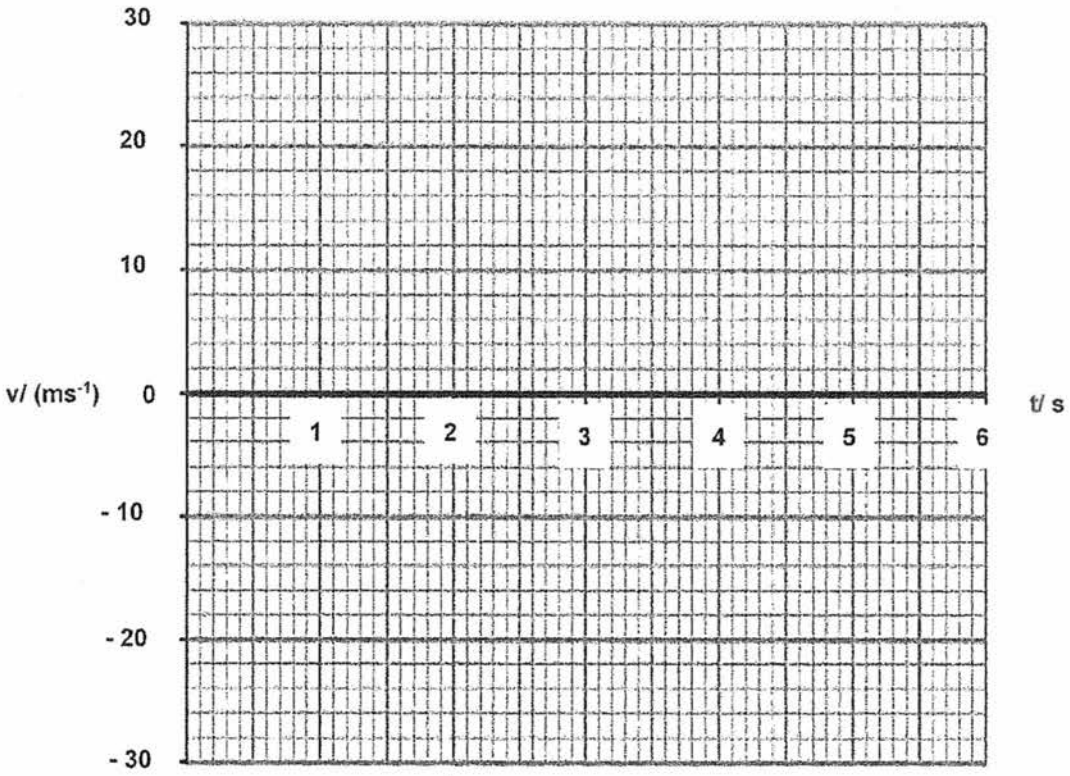
iii. when the stone is at the top of its path. _____ [1]

b. Next to each of the six images, draw in a vector to represent the instantaneous velocity at that stage of the motion. The vector at image 0 has been drawn in for you. Show clearly the direction and relative lengths of the vectors, and label them with their magnitudes in ms^{-1}.

[3]

c. In the grid below, draw a velocity–time graph to represent the motion of the stone. On the graph label the stages representing upward motion and downward motion, and label the topmost point of the motion.

[1]



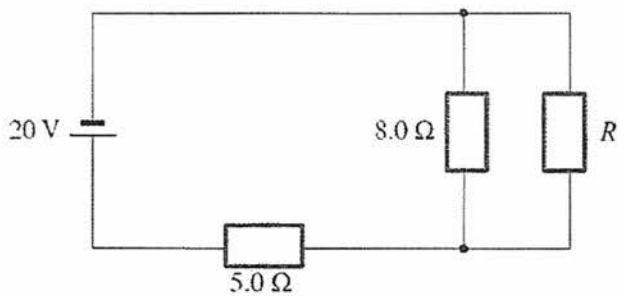
d. What does the gradient of the graph represent?

[1]

e. Determine the height of the cliff.

[2]

12. The 8.0 Ω resistor in the circuit shown below dissipates 45 J of heat energy in 5.0 s.



a. Calculate the potential difference across the 8.0 Ω resistor.

[2]

b. Calculate the current flowing through the 5.0 Ω resistor.

[3]

c. Calculate the total resistance of the circuit.

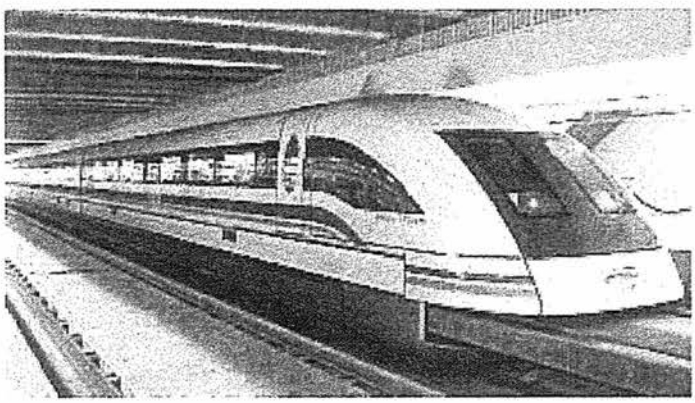
[2]

d. Determine the value of the resistor R.

[3]

Either

13. A Maglev or magnetically levitated train, shown in the figure below, uses magnetism to hover above the ground thus allowing it to travel faster than a regular train.



Maglev train uses superconducting electromagnets which are cooled to extremely cold temperature so they can conduct electricity with zero resistance. The magnets are placed at the bottom of the train. As the train moves, current is induced in the wire coils placed in the guideway or train tracks. The magnetic force between the magnets and the induced currents lifts the train. A medium-sized MagLev has a mass of 30 000 kg. With an energy consumption of 1.7 kW per tonne, the train is able to travel at 500 km/h.

a. Using the principles of electromagnetic induction, explain how the magnetic force between the magnets and the induced currents can be used to lift the train.

[2]

b. Convert 500 km/h to m/s.

[1]

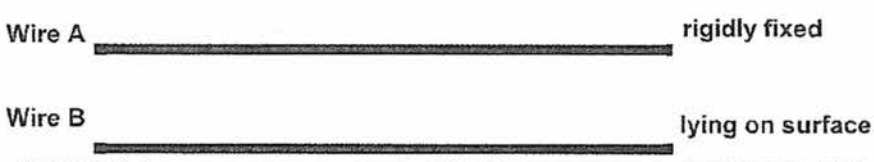
c. Suggest a reason why MagLev is able to travel at such a speed.

[1]

d. The distance from Pudong Airport in Shanghai to Shanghai city is 30 km. What is the energy consumption, in joules, of a medium-sized MagLev travelling from the airport to the city in a single-trip if it travels at 500 km/h throughout the journey?

[3]

e. A similar levitation system, which is shown in the figure below, has are two horizontal wires A and B of the same length. Wire A is rigidly fixed a distance 5 mm vertically above wire B. Wire B lies on a surface with light flexible connecting wires attached to it.



A fixed current flows in wire A. The current in wire B is gradually increased until B just starts to lift off the surface.

i. Explain why wire B lift off the surface as current in the wire is gradually increased.

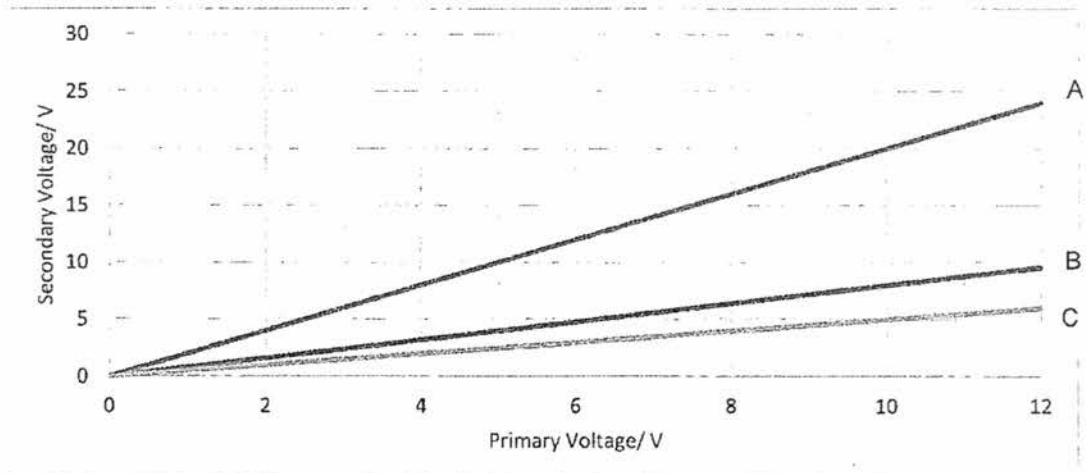
[2]

ii. For wire B to experience a lift, in which direction should the currents in A and B be flowing?

[1]

Or

13. A student is given 3 transformers labeled A, B and C.



The primary coil of each transformer has 250 turns of copper wire. The student is asked to investigate the relationship between the primary voltage V_1 and secondary voltage V_2 of each transformer.

The student applies various input voltages V_1 to the primary coil and measures the output voltages V_2 from the secondary coil of each transformer.

The results of his investigations are shown in the graph below.

a. Based on the graph shown,

i. state the relationship between V_2 and V_1.

[1]

_____

_____

ii. indicate with a tick, the type of transformer for each case in the table below.

[1]

Transformer	Step-Up Transformer	Step-Down Transformer
A		
B		
C		

iii. Assuming that all the transformers are 100% efficient, fill in the missing results in the table below.

[3]

Transformer	Primary voltage, V_1/V	Secondary voltage, V_2/V	Number of primary turns	Number of secondary turns
A	12		250	
B	6		250	
C		4	250	

b. Explain the working principle of a transformer.

[2]

c. The efficiency of transformer A is given as:

Efficiency = 0.39 m x 100%

where m = gradient of graph A.

Calculate the efficiency of transformer A.

[2]

d. Suggest a reason why the efficiency of a transformer is less than 100%.

[1]

_____

_____

_____

END OF PAPER

Paper 1

1	D	11	D	21	D	31	C
2	B	12	D	22	D	32	C
3	D	13	B	23	A	33	B
4	C	14	C	24	D	34	A
5	A	15	C	25	C	35	C
6	B	16	B	26	C	36	C
7	A	17	C	27	C	37	A
8	B	18	D	28	C	38	D
9	B	19	C	29	D	39	B
10	A	20	B	30	C	40	A

Section A

Answer **all** the questions in this section.
The total mark for this section is 50.

1. The following data is collected in a kinematics experiment using a toy car.

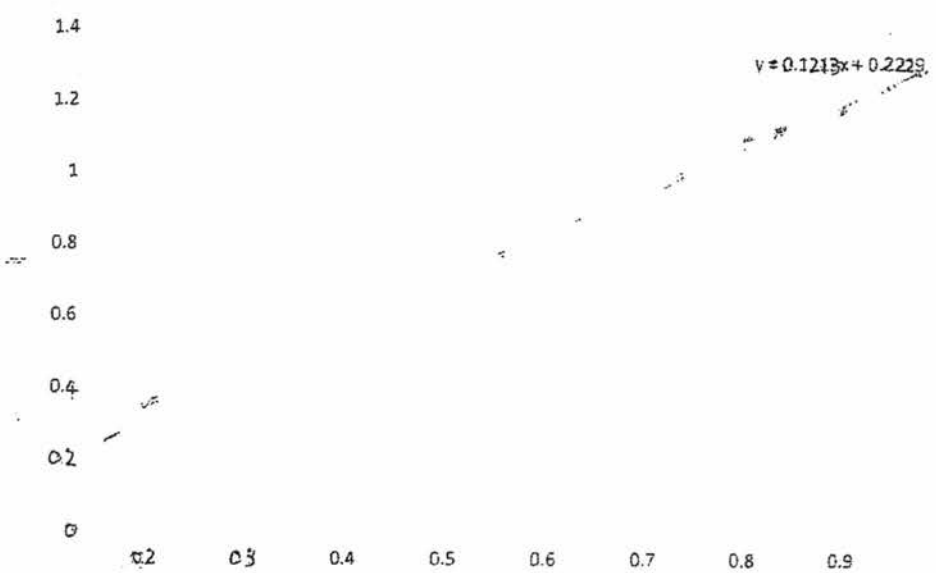
t/s	0.20	0.30	0.40	0.50	0.60	0.70	0.80	0.90
v/(ms^{-1})	0.35	0.46	0.59	0.70	0.83	0.94	1.10	1.18

a. Plot the graph of on v vs. t with the data and extend your line back to t = 0.

[2]

All points correctly plotted *A1*

Line of Best Fit extended to vertical axis *A1*



b. What is the displacement of the toy car from t = 0 to t = 0.90 s?

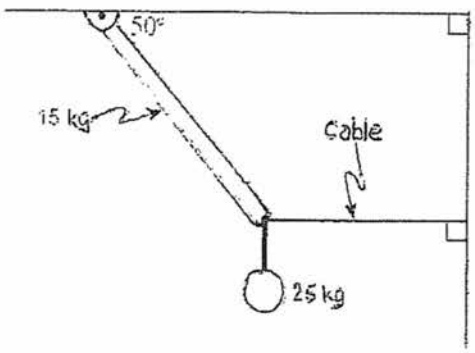
[2]

c. What does the y-intercept of the graph represent?

[1]

Instantaneous speed of the toy car at the start of experiment. *A1*

2. A 4.0 m long uniform pole with a mass of 15 kg is pivoted at one end and held in position by a horizontal cable at the other end. A 25 kg mass is suspended from the end of the pole as shown in the figure below.



a. Calculate the weight of the uniform pole.

[1]

$W = mg$

$W = 15 \times 10$

$W = 150\ N$ *A1*

b. Mark out clearly, on the figure, the position where all the weight of the pole seem to be acting.

[1]

c. Determine the tension in the horizontal cable.

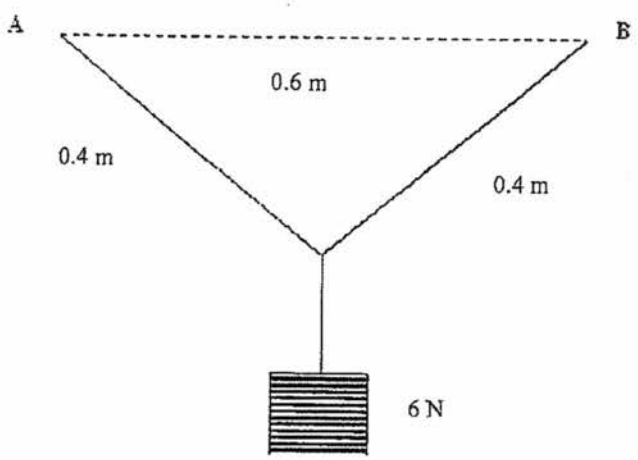
[2]

Using Principle of Moments

$T \times 4 \cos 40^0 = 250 \times 4 \sin 40^0 + 150 \times 2 \sin 40^0$ *A1*

$T = 272\ N$ *A1*

3. A 6.0 N weight is attached to a light string which is then tied to the midpoint of a second string of length 0.8 m. This string is suspended from two fixed points which are on the same horizontal line 0.60 m apart. The arrangement is shown below:



What is the tension in each string?

[3]

4. A container of mass 2000 kg is hoisted by an electrically operated crane as shown in Figure 1. In order to be loaded onto a ship. Initially the container is accelerated upwards briefly, after which it is hoisted at a constant speed.

Physical System

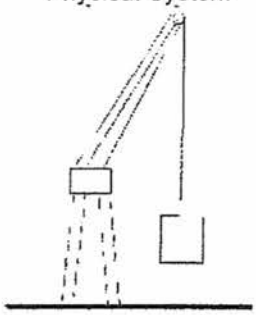


Figure 1

Free Body Diagram

accelerating upwards

Figure 2

Free Body Diagram

moving upwards at constant speed

Figure 3

a. On Figures 2 and 3 above, draw free-body force diagrams showing and labelling the forces acting on the container during the acceleration and constant velocity stages. Use longer vectors for greater forces.

[2]

b. The safety limit for the tension in the cable is 25000 N. Determine the maximum permissible upward acceleration of the container if the limit is not to be exceeded.

[2]

$F = ma$

$25\,000 - 20\,000 = 2\,000 \times a$ A1

$a = 2.5\ ms^{-2}$ A1

c. After the initial acceleration, the crane continues hoisting the container at a constant upward speed of 0.5 ms^{-1}.

i. Calculate the power output of the crane during this stage.

[2]

$Power = Work \div Time = F \times velocity$

$P = F \times v$ A1

$P = 12\,500\ w$ A1

ii. The crane's electric motor operates at 400 V. Assuming no power losses, calculate the current drawn by the motor during hoisting.

[2]

$P = IV$

$12\,500 = I \times 400$ A1

$I = 31.25\ A$ A1

iii. Eventually the container reaches a height sufficient for loading onto the ship. To what energy has the electrical energy supplied to the motor be converted into?

[1]

Electrical Energy to Gravitation Potential Energy *A1*

5.

a. On a hot day, a child drinks all the water in a plastic bottle. She then screws the cap back tightly on the bottle, so that the bottle contains only air.

She throws the bottle into a waste basket, where the Sun shines on it. After a while in the Sun's rays, the air in the bottle is much hotter than before.

i. State and explain what has happened to the pressure of the air in the bottle.

[1]

The direct sun light will case the temperature of air to increase *A1/2*

When temperature increases, the pressure will increase *A1/2*

ii. In terms of the behaviour of the air molecules, explain your answer to (a)(i).

[1]

When the temperature of the air is increased, it will case the air particles to move faster.
The particles will now hit against the side wall with a greater impact force. *A1/2*
The frequency of collision with the side wall will also be increased. *A1/2*
Since Pressure is the force acting per unit area, the pressure will increased as a result.

b. A broken glass bottle containing a small quantity of water was found in the waste basket, as shown in the figure below.

As the Sun shines on it, the volume of water slowly decreases.

i. State the name of the process causing this decrease.

[1]

evaporation *A1*

ii. In terms of the effect of the Sun's rays on the water molecules, explain your answer to (b)(i).

[1]

When the water molecules at the surface of the water gain sufficient amount of kinetic energy, *A1/2*
They will be able to break the intermolecular forces and escape into the surrounding as air particles. *A1/2*

6. 2 kg of ice from a freezer at −15 ^{0}C is mixed with 10 kg of water at 30 ^{0}C.

a. Determine the final temperature of the mixture after equilibrium is reached. Energy losses to the environment are negligible. You may make use of the data provided below.

[3]

Data:
Specific heat capacity of ice: 2.1×10^3 J kg^{-1} ^{0}C^{-1}
Specific heat capacity of water: 4.2×10^3 J kg^{-1} ^{0}C^{-1}
Specific latent heat of melting of ice: 3.4×10^5 kg^{-1} ^{0}C^{-1}

Heat gained by ice + Heat gained during melting + Heat gained by melted ice = Heat lost by water *A1*

$2 \times 2.1 \times 10^3 \times (15) + 2 \times 3.4 \times 10^5 + 2 \times 4.2 \times 10^3 \times (T) = 10 \times 4.2 \times 10^3 \times (30 - T)$ *A1*

$T = 10.3$ ^{0}C *A1*

b. In the stage of the process while the ice is melting, it absorbs energy but its temperature does not increase. Explain, from the molecular point of view, how this can be possible.

[2]

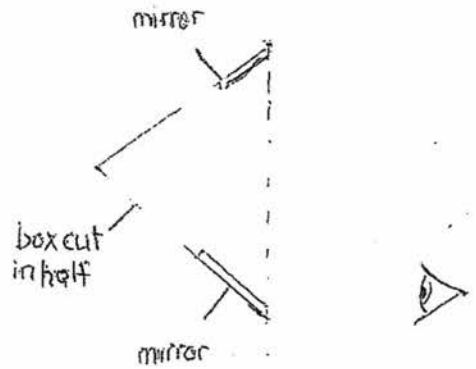
During melting, the thermal energy is used to modify the molecular forces such that the particles can slides across each other instead if vibrating about their mean positions. *A1*
The kinetic energy of the particles remain unchanged and thus the temperature is constant during melting. *A1*

c. Using the principle of conservation of energy, state the energy conversion that has taken place.

[1]

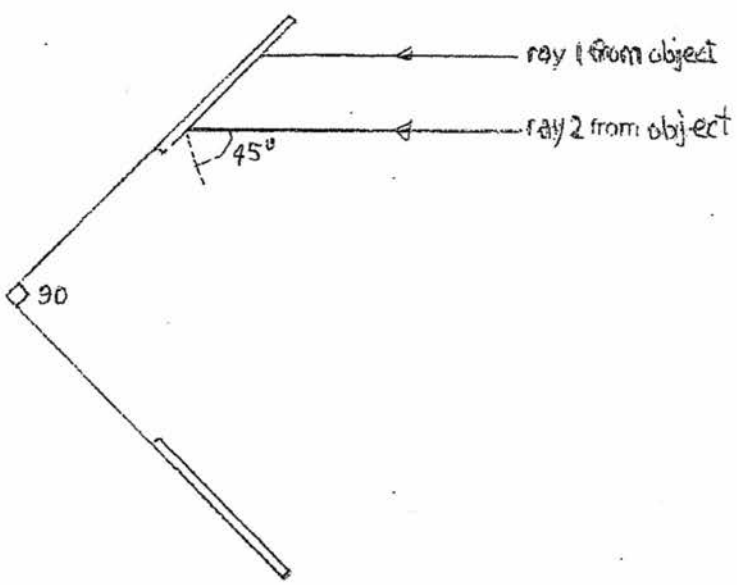
Thermal energy is converted to Internal Energy of the particles *A1*

7. An inventor is trying to make a device to enable him to see objects behind him. He cuts a square box in half diagonally and sticks two plane mirrors on the inside of the box.



A side view of the arrangement is shown in the figure above.

A second figure below shows the arrangement that is drawn with a larger view. Two parallel rays from two different points on a distant object behind the man are drawn in the figure



a. Continue the two rays to show how the rays of light will enter the eyes of the inventor.

[2]

b. What can be said about the image seen by the inventor?

[1]

The image will be inverted *A1*

8. A hammer is used to strike one end of a 900 m long hollow metal pipe. A data logger connected with a sensitive sound detector at the other end registers two sounds at an interval of 2.3 s between them. (Take speed of sound in air = 330 ms^{-1})

a. Explain why there are two sounds registered at an interval of 2.3 s apart?

[1]

One sound is from travelling through the air. *A1/2*

The second sound is from travelling through the metal pipe. *A1/2*

b. Calculate the time taken for sound to travel 900 m in air.

[1]

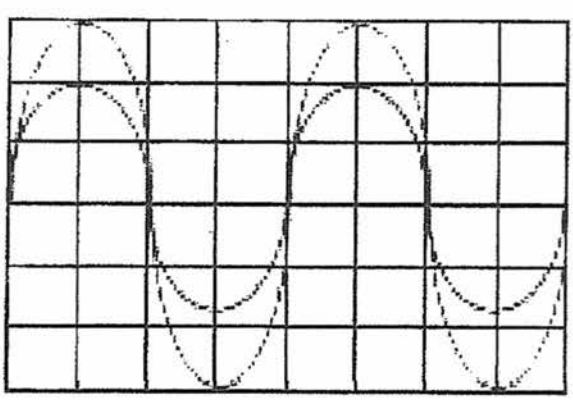
t = Distance ÷ Speed = 900 / 330
t = 900 / 330
t = 2.73 s. *A1*

c. Calculate the speed of sound in the metal pipe.

[2]

Time taken = 2.73 – 2.3
Time taken = 0.43 s *A1*
Speed = 900 / 0.43
Speed = 2093 m/s *A1*

d. The hammer is then used to hit the pipe again. Figure 6.1 shows the waveform that is registered by the data logger. The waveform represents the sound in the metal pipe.



On the figure above, draw a new waveform to represent the new sound wave that is formed when the hammer is now hitting the pipe with ***more*** force.

[2]

Larger amplitude *A1*
Same frequency *A1*

9. Two electrostatic charging processes are illustrated below.

a. A rubber rod R is originally uncharged. When rubbed with fur, the rod becomes positively charged. Explain briefly how the net positive charge arises on the rod.

[2]

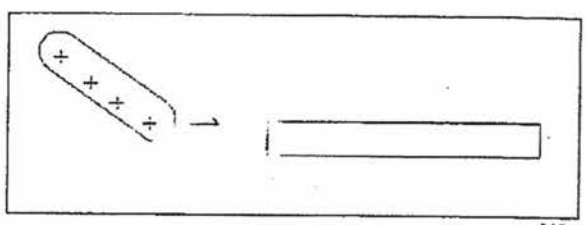
The rod was initially uncharged (same number of positive and negative charges) *A1/2*

The electrons from the rod will move over to the fur upon rubbing. *A1*

There is a net positive charge left on the rod as a result of the movement of electrons. *A1/2*

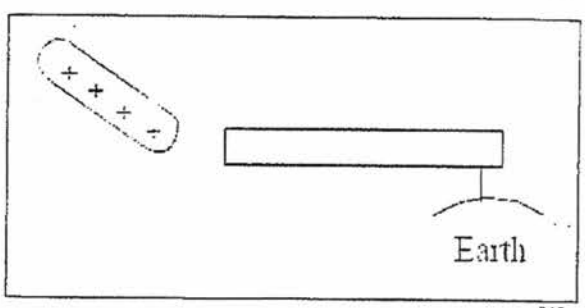
b. We now wish to use the positively charged rubber rod to charge a metal rod by electrostatic induction. The diagrams below show the steps in the process. For each step, draw the charge distribution in the metal rod.

i. The charged rubber rod is brought close to the metal rod.



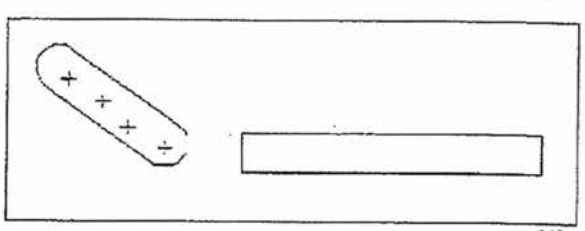
[1]

ii. The metal rod is connected to earth.



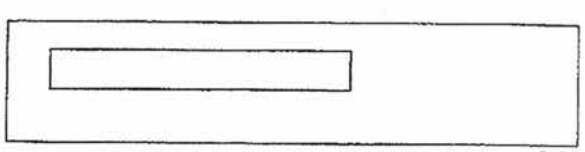
[1]

iii. The earth connection is removed.



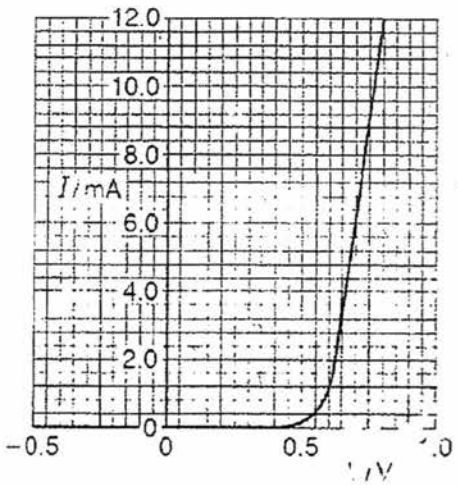
[1]

iv. The rubber rod is removed.



[1]

10. The variation with potential difference (p.d.) V of current I for a semiconductor diode is shown in the figure below.



a. Use the figure provided to describe the variation of the resistance of the diode between V = - 0.5 V and V = 0.8 V.

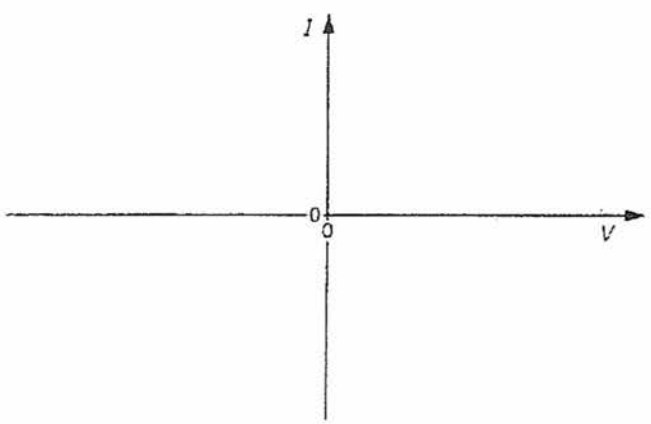
[2]

From -0.5 V to 0.4 V, the resistance of the diode is very high and no current can flow. *A1*

From V = 0.4 V onwards, the resistance of the diode decreases significantly and large amount of current can now flow. *A1*

b. On the figure below, sketch the variation with p.d. V of current I for a filament lamp. Numerical values are not required.

[1]



c. What is the name given to such an electrical conductor as described in (b)?

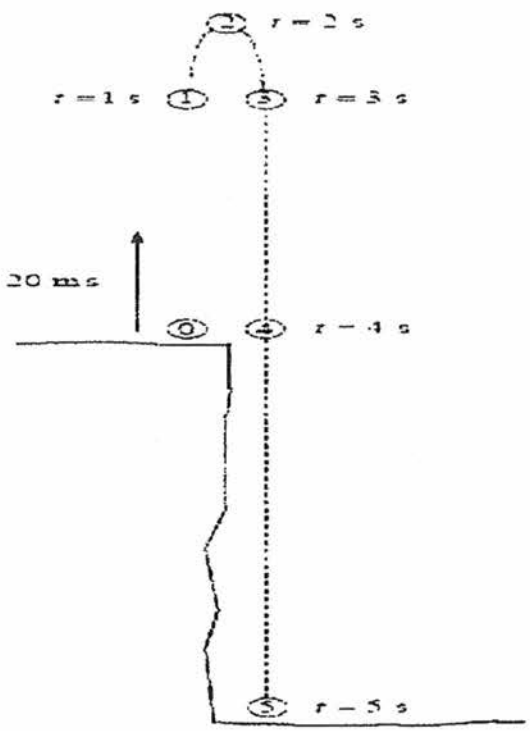
[1]

Non Ohmic Conductor *A1*

Section B

Answer **all** the questions in this section in the spaces provided.
Question 11 is in the form either/or
and only **one** of the alternatives should be attempted.
The total mark for this section is 30.

11. A stone is projected almost vertically upwards at 20 ms^{-1} from the edge of a cliff as shown. It finally lands on the ground at the base of the cliff. The sequence diagram below shows the position of the stone at one-second intervals. Image 0 is just after projection, and Image 5 is just before landing. Gravitational acceleration is taken as 10 ms^{-2} and air resistance is ignored.



a. State whether the stone's acceleration is upward, downward or zero in each of the following cases:

i. when the stone is on its way up [1]

downwards *A1*

ii. when the stone is on its way down [1]

downwards *A1*

iii. when the stone is at the top of its path [1]

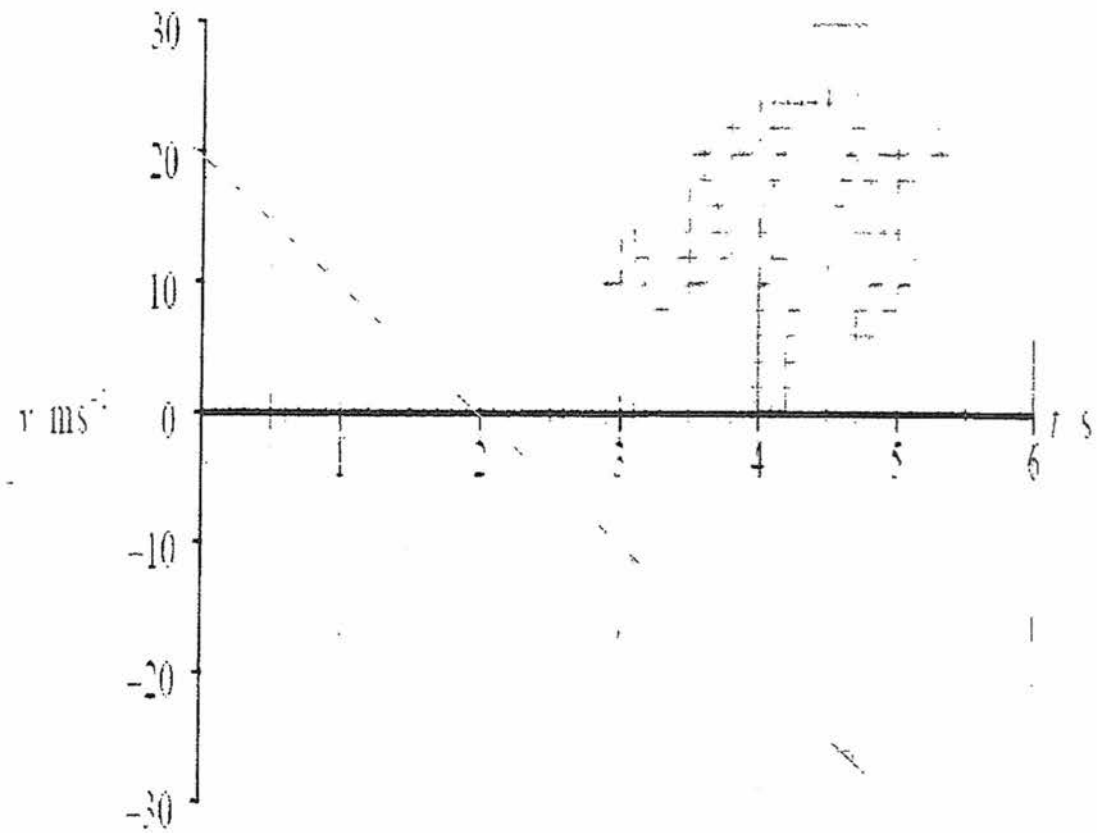
downwards *A1*

b. Next to each of the six images draw in a vector to represent the instantaneous velocity at that stage of the motion. The vector at image 0 has been drawn in for you. Show clearly the direction and relative lengths of the vectors, and label them with their magnitudes in ms^{-1}.

[3]

c. Draw a velocity–time graph to represent the motion of the stone. On the graph label the stages representing upwards motion and downwards motion, and label the topmost point of the motion.

[1]



d. What does the gradient of the graph represent?

[1]

acceleration *A1*

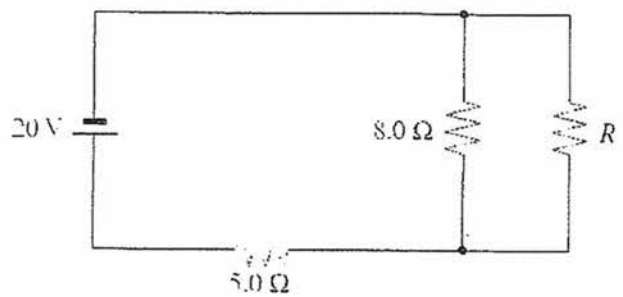
e. Determine the height of the cliff.

[2]

Height = Area under graph

Height = ½ x 3 x 30 – ½ x 2 x 20 *A1*
Height = 25 m *A1*

12. The 8.0 Ω resistor in the circuit shown below dissipates 45 J of heat energy in 5.0 s.



a. Calculate the potential difference across the 8.0 Ω resistor. [2]

Power = $V^2 \div R$

$45 \div 5 = V^2 \div 8$ A1
$V = 8.49$ V A1

b. Calculate the current flowing through the 5.0 Ω resistor. [3]

EMF = V1 + V2

20 = 8.485 + V2
V2 = 11.51 V A1

V = IR

11.51 = I x 5 A1
I = 2.30 A A1

c. Calculate the total resistance of the circuit. [2]

EMF = IR

20 = 2.302 x R A1
R = 8.69 Ω A1

d. Determine the value of the resistor R. [3]

Total R = R1 + R2

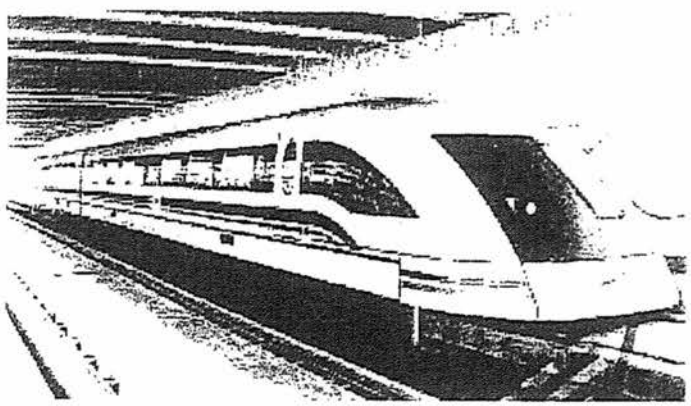
8.688 = 5 + R2
R2 = 3.688 A1

R2 = (8 x R) ÷ (8 + R)

3.688 = (8 x R) ÷ (8 + R) A1
R = 6.84 A1

Either

13. A Maglev or magnetically levitated train, shown in the figure below, uses magnetism to hover above the ground thus allowing it to travel faster than a regular train.



Maglev train uses superconducting electromagnets which are cooled to extremely cold temperature so they can conduct electricity with zero resistance.

The magnets are placed at the bottom of the train. As the train moves, current is induced in the wire coils placed in the guideway or train tracks.

The magnetic force between the magnets and the induced currents lifts the train.

A medium-sized MagLev has a mass of 30000 kg. With an energy consumption of 1.7 kW per tonne, the train is able to travel at 500 km/h.

a. Using the principles of electromagnetic induction, explain how the magnetic force between the magnets and the induced currents lifts the train.

[2]

Superconducting electromagnets produces magnetic field which changes as the train moves. *A1*

This changing the magnetic field links with the coils on tracks where there is induced current. By Lenz law, the direction of induced current always opposed the change the produces it, so the train and the track repel. *A1*

b. Convert 500 km/h to m/s.

[1]

500 km/h = 139 m/s *A1*

c. Suggest a reason why MagLev can travel at such speed.

[1]

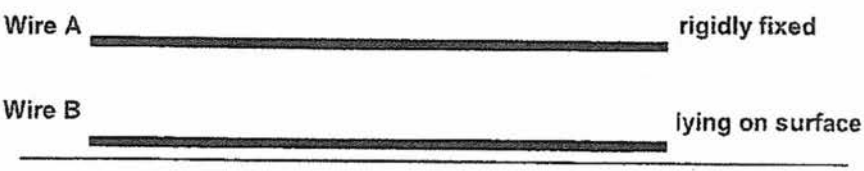
no friction as train is levitated *A1*

d. The distance from Pudong Airport in Shanghai to Shanghai city is 30 km. What is the energy consumption, in joules, of a medium-sized MagLev travelling from the airport to the city in a single-trip if it travels at 500 km/h throughout the journey?

[3]

Energy consumption for train per sec = 1.7 kW x 30 = 5.1 kW *A1*
Time of travel = 30 / 500 = 0.06 h = 216 s *A1*
Total energy consumption = 5100 x 216 = 1101600 J = 1.10 x 10^6 J *A1*

e. A similar levitation system, which is shown in the figure below, has are two horizontal wires A and B of the same length. Wire A is rigidly fixed a distance 5 mm vertically above wire B. Wire B lies on a surface with light flexible connecting wires attached to it.



A fixed current flows in wire A. The current in wire B is gradually increased until B just starts to lift off the surface.

i. Explain why wire B lift off the surface as current in the wire is gradually increased.

[2]

parallel current-carrying wire exert attractive force between them, *A1*
As the current increases, the force increases until it is more than the weight of the wire *A1*

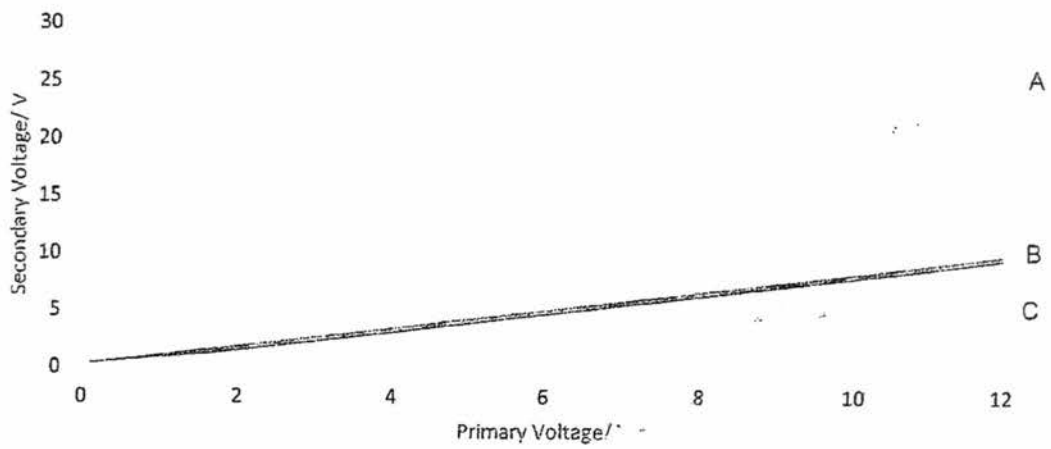
ii. For wire B to experience a lift, in which direction should the currents in A and B be flowing?

[1]

Same direction *A1*

Or

13. A student is given 3 transformers labeled A, B and C.



The primary coil of each transformer has 250 turns of copper wire. The student is asked to investigate the relationship between the primary voltage V_1 and secondary voltage V_2 of each transformer.

The student applies various input voltages V_1 to the primary coil and measures the output voltages V_2 from the secondary coil of each transformer.

The results of his investigations are shown in the graph below.

a. Based on the graph shown,

i. state the relationship between V_2 and V_1. [1]

secondary voltage, V2 is directly proportional to the primary voltage, V1 *A1*

ii. indicate, with a tick, the type of transformer for each case in the table below. [1]

Transformer	Step-Up Transformer	Step-Down Transformer
A	√	
B		√
C		√

iii. Assuming that all the transformers are 100% efficient, fill in the missing results in the table below.

[3]

Transformer	Primary voltage, V_1/V	Secondary voltage, V_2/V	Number of primary turns	Number of secondary turns
A	12	**24**	250	**500**
B	6	**4.8**	250	**200**
C	**8**	4	250	**125**

b. Explain the working principle of a transformer.

[2]

An alternating current supply is provided to the primary coil *A1*
As the current changes direction, this will change the magnetic field.
According to Faraday's Law, an induced emf will be created in the secondary coil. *A1*
The magnetic core will provide the link between the primary and the secondary coil

c. The efficiency of transformer A is given as:

Efficiency = 0.39 m x 100%

where m = gradient of graph A.

Calculate the efficiency of transformer A.

[2]

m = 20/10 = 2 (derived from graph) *A1*
Efficiency = 0.39 (2) x 100% = 78% *A1*

d. Suggest a reason why the efficiency of a transformer is less than 100%.

[1]

Power loss due to heat loss bec of resistance of the coils
OR
Power loss due to leakage of magnetic field lines between the pri and sec coils
OR
Power loss due to heat loss bec of eddy currents induced in the soft iron core
OR *A1*
Power loss due to hysteresis loss caused by the flipping of magnetic dipoles in the iron core due to a.c. (i.e. magnetizing and demagnetizing of the soft iron core)