Class/ Index Number /	Centre Number/ 'O' Level Index Number /	Name

新加坡海星中学

MARIS STELLA HIGH SCHOOL
PRELIMINARY EXAMINATION
SECONDARY FOUR

PHYSICS **6091/01**
Paper 1 Multiple Choice **28 August 2024**
1 hour

Additional Materials:
Optical Test Answer Sheet (OTAS) – 1 sheet

READ THESE INSTRUCTIONS FIRST

Write in soft pencil.
Do not use staples, paper clips, glue or correction fluid.
Write your class, index number, Centre number, O level index number and name in the spaces at the top of this page.

There are **forty** questions on this paper. Answer **all** questions. For each question, there are four possible answers **A**, **B**, **C** and **D**.
Choose the **one** you consider correct and record your answer in **soft pencil** on the separate Answer Sheet.

Read the instructions on the Answer Sheet very carefully.

Each correct answer will score one mark. A mark will not be deducted for a wrong answer.
Any rough working should be done in this question booklet.
The use of an approved scientific calculator is expected, where appropriate.

The total number of marks for this paper is 40.

At the end of the examination, hand in the following separately:
(1) Optical Test Answer Sheet (OTAS)
(2) Question Paper

1 A student studies some equations for his Physics Examination.

power = work done / time
force = mass x acceleration
velocity = displacement / time

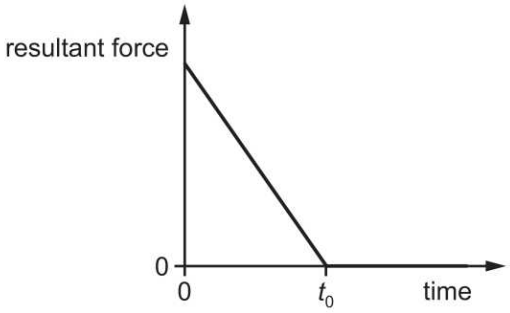
How many different scalar quantities are there in all the equations?

A 2 **B** 3 **C** 4 **D** 5

2 Which of the following equations is correct?

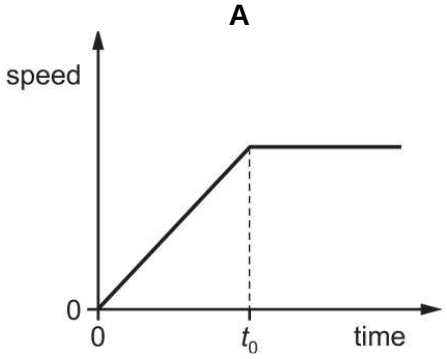
A 43 N / mm^2 = 4.3 x 10^{-2} N / m^2
B 63 Hz = 6.3 x 10^9 GHz
C 85 µm = 8.5 x 10^3 m
D 123 nA = 1.23 x 10^{-7} A

3 A resultant force acts on an object and causes it to move in a straight line. The graph shows how the resultant force varies with time.

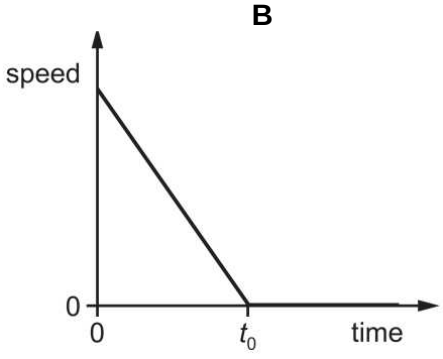


Which graph is the speed-time graph for the object?

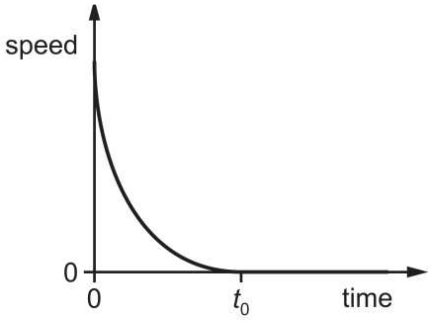
A



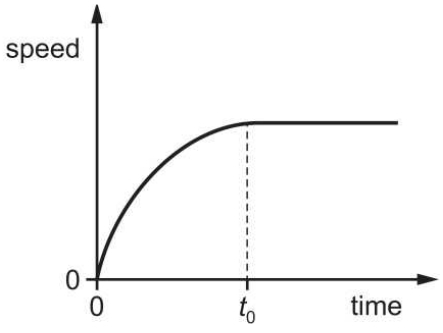
B



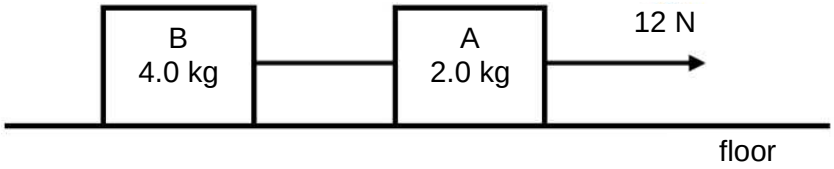
C



D



4 Block A and block B are connected by a light inextensible string. A force of 12 N acts on block A as shown.



Given that the floor is smooth, what is the tension in the string connecting block A and block B?

A 2.0 N **B** 4.0 N **C** 8.0 N **D** 12 N

5 Which of the following is **not** an example of an action-reaction pair based on Newton's laws of motion?

A A student pulling a bag forward, the bag pulling the student backwards.

B Weight of a book resting on the table, and the normal contact force the table exerts on the book.

C Driving wheel of a bicycle exerting friction on the road, and the road exerting friction on the wheel.

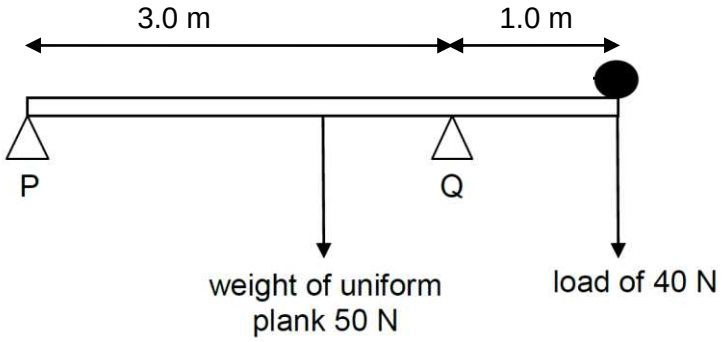
D Earth pulling a skydiver with gravitational force, and skydiver pulling Earth with a gravitational force.

6 The weight of a rock on Venus is less than its weight on Earth.

How do the mass of the rock and gravitational field strength on Venus compare with their respective values on Earth?

	mass of rock	gravitational field strength
A	smaller	smaller
B	smaller	zero
C	same	smaller
D	same	same

7 A 4.0 m long uniform plank weighing 50 N balances on two pivots P and Q when a load of 40 N is placed at one end.

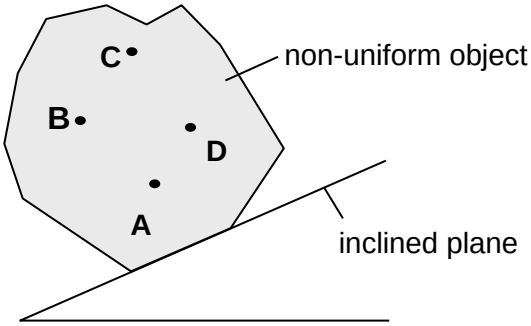


What are the normal contact forces at points P and Q?

	normal contact force at P	normal contact force at Q
A	3	87
B	20	70
C	45	45
D	67	23

8 A non-uniform object is placed on an inclined plane. The object is just about to topple.

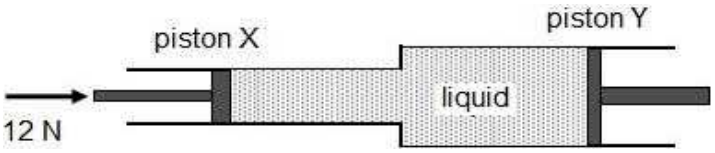
Which position is most likely to be its centre of gravity?



9 Which of the following would most likely sink into soft mud?

A a loaded truck with six wheels
B a loaded truck with four wheels
C an empty truck with six wheels
D an empty truck with four wheels

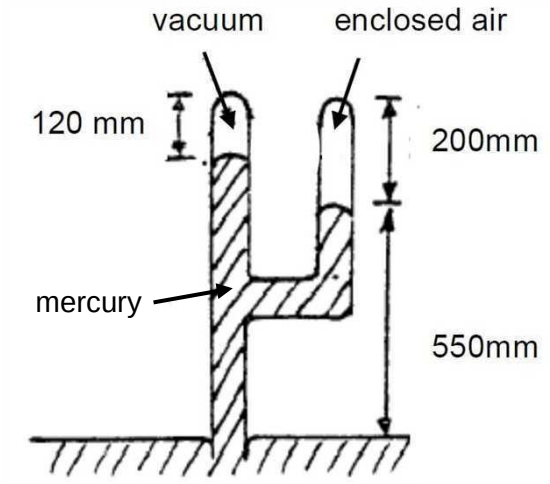
10 The diagram shows a cylinder fitted with two pistons X and Y of diameters 5.0 cm and 10.0 cm respectively. The piston X is pushed by a force of 12 N.



What is the force exerted on piston Y?

A 3.0 N **B** 6.0 N **C** 24 N **D** 48 N

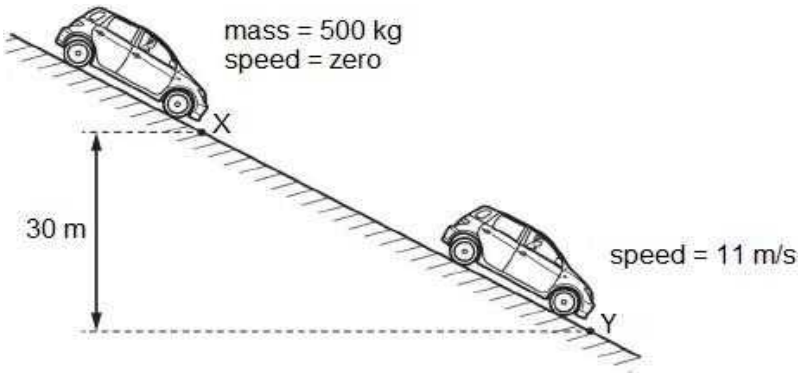
11 The diagram below shows a manometer.



What is the pressure of the enclosed air in the manometer?

A 80 mmHg **B** 120 mmHg
C 200 mmHg **D** 550 mmHg

12 A car of mass 500 kg is at rest at point X on a slope, as shown. The car's brakes are released and the car rolls down the slope with its engine switched off.



At point Y, the car has moved through a vertical height of 30 m and has a speed of 11 m/s.

What is the energy dissipated by frictional forces when the car moves from X to Y?

A 3.0×10^4 J **B** 1.2×10^5 J
C 1.5×10^5 J **D** 1.8×10^5 J

13 A 5.0 W lamp is switched on for 180 s. It transfers 600 J to the internal store (thermal) of the surroundings.

What is the efficiency of the lamp?

A 33 % **B** 43 %
C 67 % **D** 70 %

14 When smoke particles are viewed under a microscope, they can be seen moving with Brownian motion.

Which row describes and explains Brownian motion?

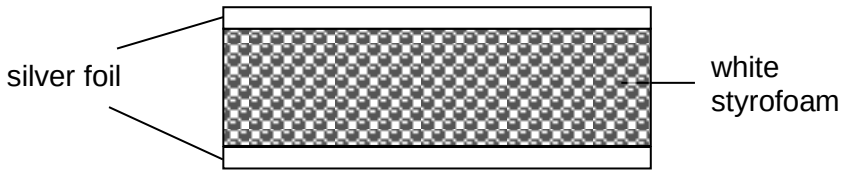
	description	explanation
A	random	air molecules bombard the smoke particles
B	random	smoke particles bombard the air molecules
C	vibration	air molecules bombard the smoke particles
D	vibration	smoke particles bombard the air molecules

15 A gas is heated in a rigid sealed container.

Which quantity does not change?

A The average speed of the gas particles.
B The average distance between the gas particles.
C The average force exerted on the walls of the container by the gas particles.
D The frequency of collisions on the walls of the container by the gas particles.

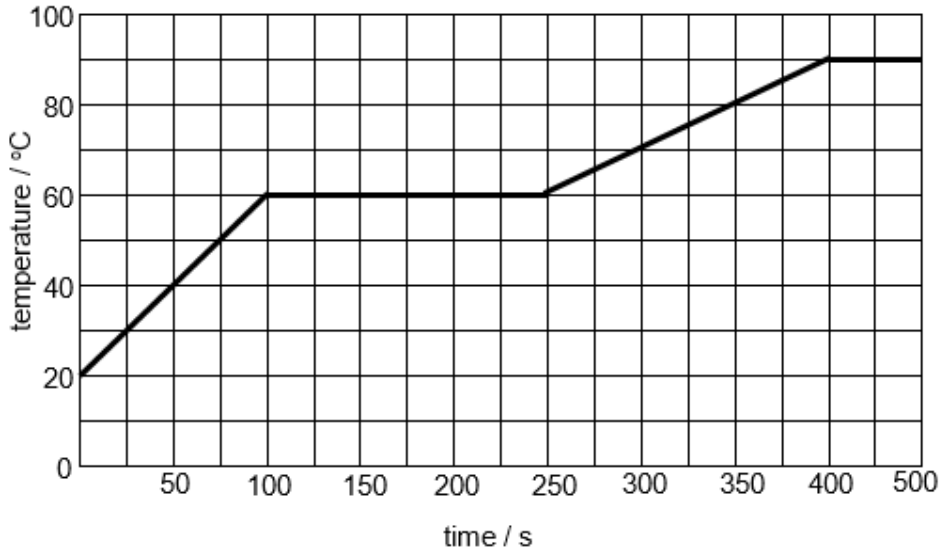
16 A type of insulation board used in the construction of houses in cold climate is shown below.



Which part of the board reduces energy transfer to the surrounding by conduction and why?

	part	reason
A	silver foil	shiny surface is a good reflector of radiation
B	silver foil	shiny surface is a poor emitter of radiation
C	styrofoam	it contains air which is a poor thermal conductor
D	styrofoam	it is white in colour which is a poor absorber of radiation

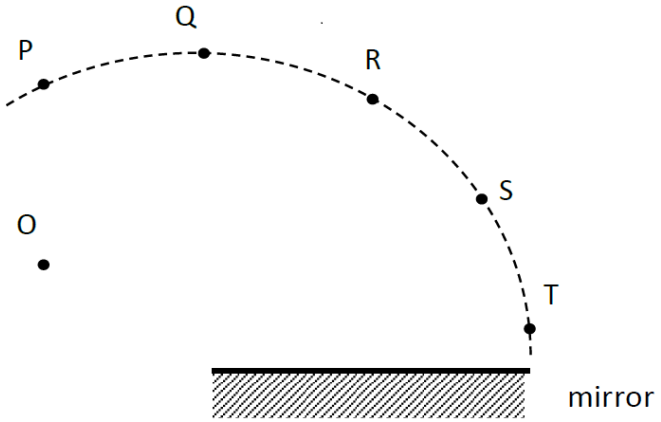
17 A solid of 2.0 kg is heated by a 2000 W heater. The graph of temperature against time for the substance is shown in the diagram.



What is the specific latent heat of fusion of the solid?

A 2.0 kJ / kg
B 30 kJ / kg
C 150 kJ / kg
D 300 kJ / kg

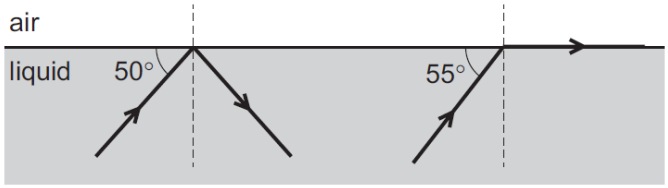
18 An object O is placed in front of a mirror.



Where must the observer position himself such that he will be able to see the image of O in the mirror?

A between S and T
B between R and S
C between Q and R
D between P and Q

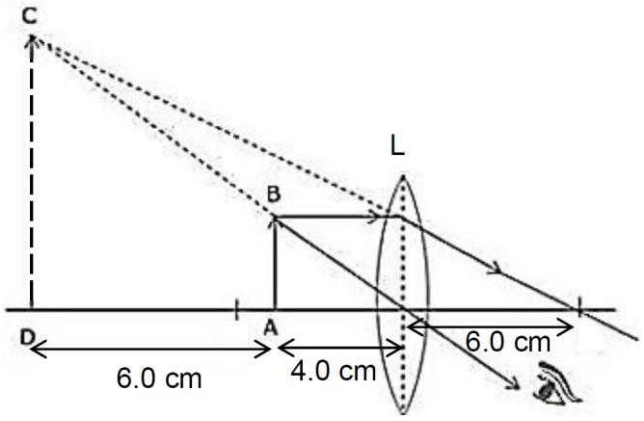
19 The diagram represents the surface of a transparent liquid. Two rays of light are travelling within the liquid. They both reach the surface. The path of each ray is shown.



What is the refractive index of this liquid?

A 1.2 **B** 1.3 **C** 1.6 **D** 1.7

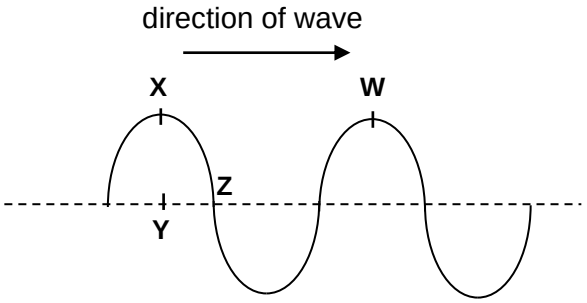
20 A converging lens L acts as a magnifying glass when an object AB is placed 4.0 cm from the centre of the lens. The image CD is 6.0 cm from A. Focal length of the lens is 6.0 cm.



What are the characteristics of the image formed when the object is placed 12.0 cm away from the centre of the lens ?

A virtual and same size as object
B real and same size as object
C virtual and diminished
D real and diminished

21 The diagram shows a water wave traveling towards the right.

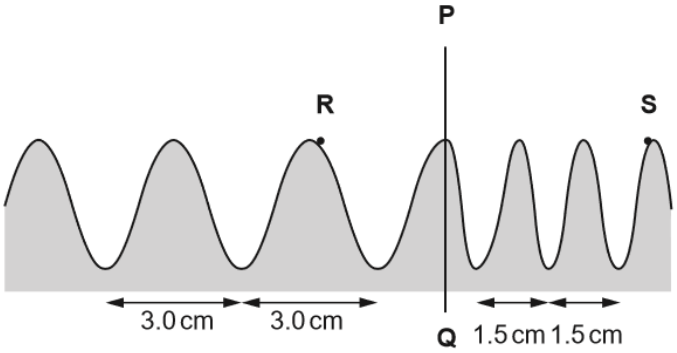


Which of the following statements are **not correct**?

I Particles at X and W are in phase.
II Particle at X will move to W after a period.
III Particle at Z will move up in the next instant.
IV Wavelength of the wave is represented by XY.

A I and III only
B II and IV only
C I, II and IV only
D all the above

22 The diagram shows a water wave in a ripple tank.



The wave has a speed of 0.15 m / s at R.

The wave crosses a boundary PQ where the distance between troughs changes from 3.0 cm to 1.5 cm.

What is the velocity of the wave at point S?

A 0.075 m / s **B** 0.15 m / s
C 0.30 m / s **D** 0.45 m / s

23 Wi-Fi is the name of a popular wireless networking technology that uses radio waves to provide wireless high speed internet and network connections.

Which statement below correctly describes the radio waves?

A The waves cannot be reflected.
B The waves are longitudinal in nature.
C The waves can travel longer distances than gamma ray.
D Speed of the waves in vacuum will be faster at higher frequency.

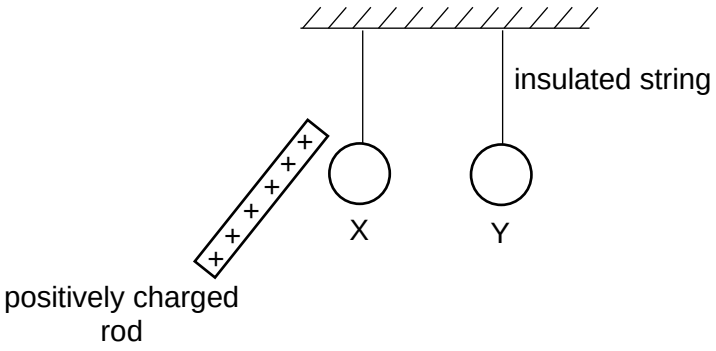
24 Which of the following shows the correct part of the electromagnetic spectrum that is being used for various applications?

	satellite communications	sterilisation of surgical equipment	telecommunications
A	microwave	ultraviolet radiation	radio wave
B	microwave	infrared radiation	radio wave
C	radio wave	infrared radiation	microwave
D	radio wave	ultraviolet radiation	microwave

25 Which list shows electromagnetic waves in order of increasing frequency?

A x-rays, gamma rays, visible light
B visible light, x-rays, gamma rays
C visible light, gamma rays, x-rays
D gamma rays, x-rays, visible light

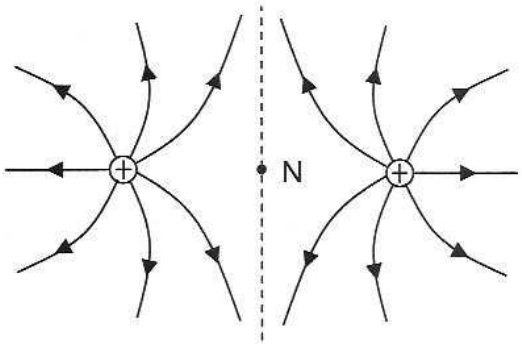
26 The diagram shows a positively-charge rod placed near two metal spheres X and Y, insulated and hung by non-conducting strings. Both spheres are initially uncharged.



What would be the charges on both spheres after sphere X is earthed?

	sphere X	sphere Y
A	negative	positive
B	negative	uncharged
C	positive	positive
D	positive	uncharged

27 An electron is placed at the point N in the electric field as shown below where point N is the centre of two identical positive charges.



What is the motion of the electron?

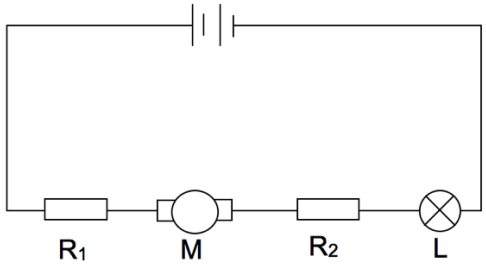
A moves out of the plane of paper

B moves downwards

C moves upwards

D does not move

28 In the circuit shown below, two resistors R_1 and R_2, a motor M and lamp L are connected to a suitable voltage supply.



The potential difference across each of the circuit component is measured and recorded as shown in the table below.

Circuit Component	R_1	M	R_2	L
Potential difference / V	6.0	10.0	3.0	1.0

Which of the following inference is **not** true?

A The resistance of R_1 is twice the resistance of R_2.

B The motor uses the greatest amount of electrical energy per unit time.

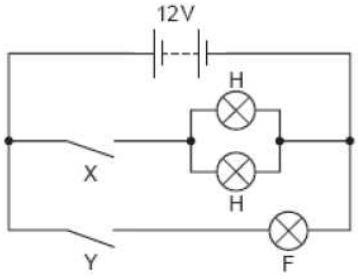
C The lamp has the least amount of current passing through compared to other components.

D If the motor is removed from the circuit and replaced with a wire, the current through each component would be two times the existing value.

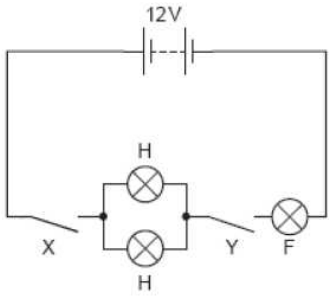
29 In a car, the identical headlamps H are controlled by switch X. The fog lamp F is controlled by switch Y and only lights up if the headlamps are also switched on. Lamps H and F have a normal working voltage of 12 V.

Which circuit would allow all the lamps to work as above at normal brightness?

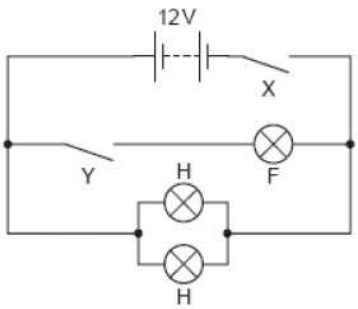
A



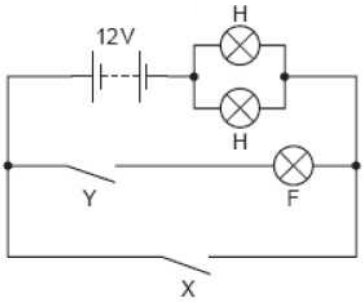
B



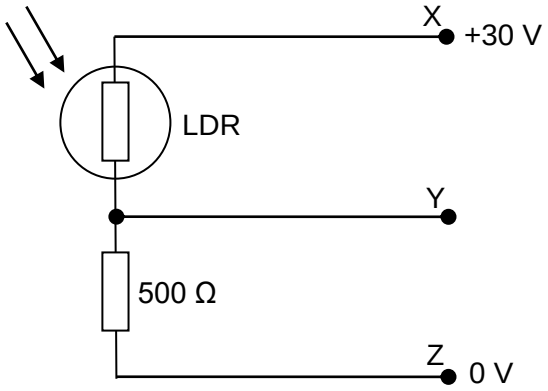
C



D



30 A light dependent resistor (LDR) and a 500 Ω resistor form a potential divider between voltage lines held at +30 V and 0 V as shown in the diagram. The resistance of the LDR is 1000 Ω in the dark but drops to 100 Ω in bright light.



What is the corresponding change of potential difference between X and Y when the LDR is placed in a dark room and then move to a bright room?

A a fall from 30 V to 5 V
B a fall from 20 V to 5 V
C a rise from 5 V to 30 V
D a rise from 5 V to 20 V

31 An electric heater which is rated '240 V, 1500 W' is connected to a 3-pin socket.

Which of the following correctly describes the current in the neutral wire and the potential difference between the earth and neutral wire during normal operation?

	current in neutral wire / A	potential difference between earth and neutral wire / V
A	0	0
B	6.25	240
C	0	240
D	6.25	0

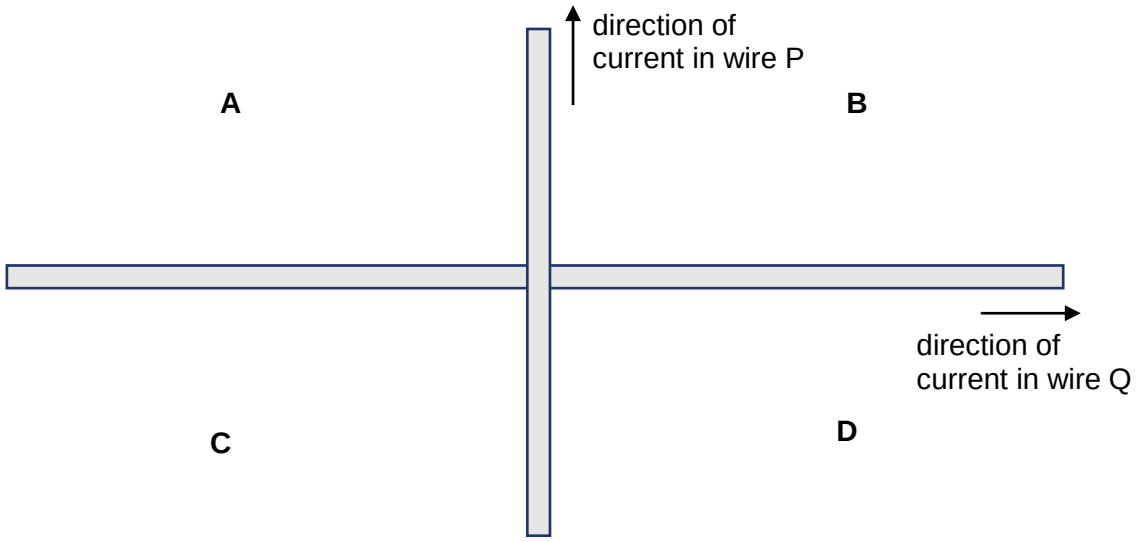
32 A 3-pin plug is connected to a heater with a rating of '200V, 1200 W'.

Which of the following is/are correct?

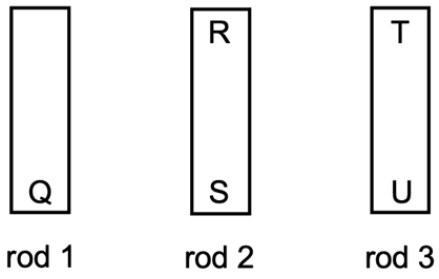
1 A 5 A fuse should be used inside the heater.
2 The fuse should be placed on the brown wire of the cable.
3 The neutral wire should be connected to the metal case of the heater.

A 2 only
B 3 only
C 1 and 2 only
D 2 and 3 only

33 The diagram shows two insulated wires, P and Q, each with the same amount of current flow. Which region **A**, **B**, **C** or **D** has the strongest magnetic field out of the paper?



34 The ends of three metal rods are tested by holding end Q of rod 1 close to each end of rods 2 and 3.



The results are as follows:

End Q attracts end R.
End Q attracts end S.
End Q attracts end T.
End Q repels end U.

Which of the metal rods is a magnet?

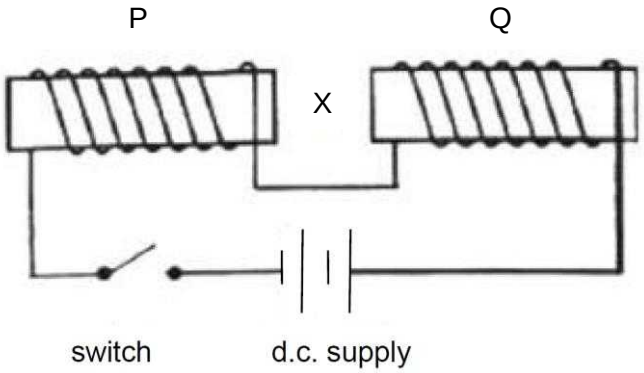
A rod 2 and rod 3 only

B rod 1 and rod 3 only

C rod 1 only

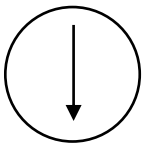
D rod 2 only

35 The figure shows an iron bar P and steel bar Q being wound by wire and connected to a d.c. supply. A compass is placed between the two metal bars at position X.

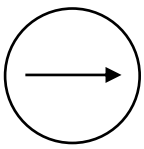


Which option shows the correct position of the compass needle when the switch is closed?

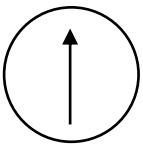
A



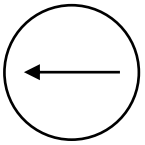
B



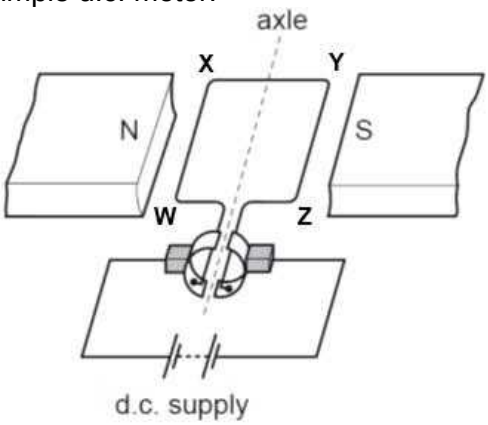
C



D



36 The diagram below shows a simple d.c. motor.

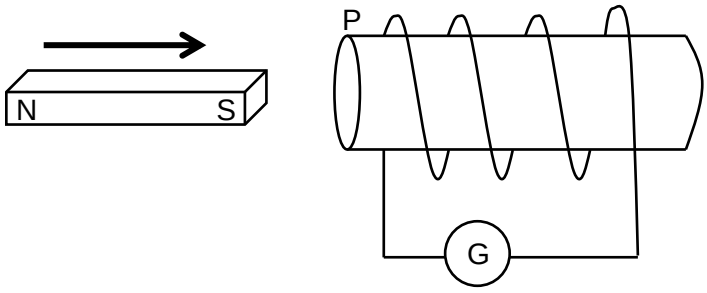


Which of the following statements is/are correct?

I A current will flow round the coil in the direction WXYZ.
II The coil will rotate in a clockwise direction about the axle.
III The split-ring commutator will reverse the direction of the current every 360°.

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

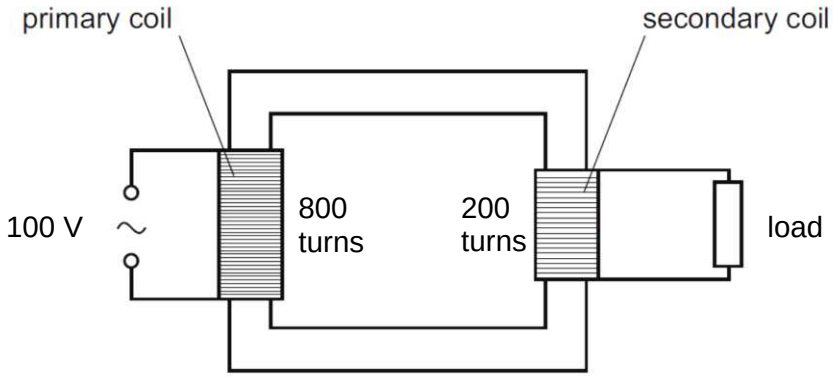
37 The diagram shows a permanent magnet approaching a solenoid at a constant speed.



What is the polarity of the solenoid at P and the direction of the deflection in the galvanometer?

	polarity of solenoid at P	direction of the deflection in galvanometer
A	north pole	to the right
B	north pole	to the left
C	south pole	to the right
D	south pole	to the left

38 The diagram shows an ideal transformer. An alternating current supply of 100 V is supplied to the primary coil and a current of 0.50 A flows through it.



What is the potential difference across the load and the current flowing through it?

	potential difference / V	current / A
A	50	2.0
B	50	1.0
C	25	2.0
D	25	1.0

39 A neutral atom of an isotope has the nuclide notation $^{84}_{36}Kr$.

Which statement is correct?

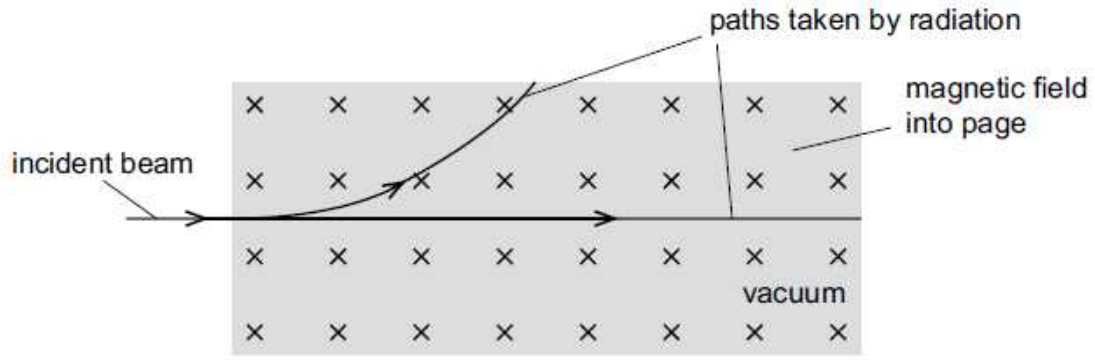
A There are 12 more neutrons than electrons in the atom.

B There are 36 electrons in the nucleus of the atom.

C There are 45 neutrons in the nucleus of the atom.

D There are 48 protons in the nucleus of the atom.

40 A beam of radiation enters a region in which there is a very strong, uniform magnetic field directed into the page. All the equipment is in a vacuum.



The beam splits and the curved path and the straight path taken by the radiation in the magnetic field are shown on the diagram.

What types of radiation are in the incident beam?

A β-particles and γ-rays only

B α-particles and γ-rays only

C α-particles and β-particles only

D α-particles, β-particles and γ-rays

End of Paper

ANSWERS

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

Class / Index Number /	Centre Number / 'O' Level Index Number /	Name

新加坡海星中学

MARIS STELLA HIGH SCHOOL

PRELIMINARY EXAMINATION

SECONDARY FOUR

PHYSICS **6091/02**

Paper 2 Structured and Free Response **22 August 2024**

1 hour 45 minutes

Candidates answer on the Question Paper.
No Additional Materials are required.

READ THESE INSTRUCTIONS FIRST

Write your class, index number and name on all the work you hand in.
Write in dark blue or black pen.
You may use an HB pencil for any diagrams or graphs.
Do not use staples, paper clips, glue or correction fluid.

Section A
Answer **all** questions.
Write your answers in the spaces provided on the question paper.

Section B
Answer one question.
Write your answers in the spaces provided. Circle your choice of question on the cover page.

Candidates are reminded that **all** quantitative answers should include appropriate units.
The use of an approved scientific calculator is expected, where appropriate.
Candidates are advised to show all their working in a clear and orderly manner, as more marks are awarded for sound use of Physics than for correct answers.

The number of marks is given in brackets [ ] at the end of each question or part question.
The total number of marks for this paper (sections A and B) is 80.

For Examiner's Use	
Section A	70
Section B (12 / 13)	10
Total	80

This document consists of **23** printed pages inclusive of this cover page.

Section A

Answer **all** questions in this section.

1 Fig. 1.1 shows a man cycling forward on a straight road surface P. After cycling for 10 s, he enters a road surface Q. Throughout the entire journey, the man exerts a constant forward driving force of 600 N.

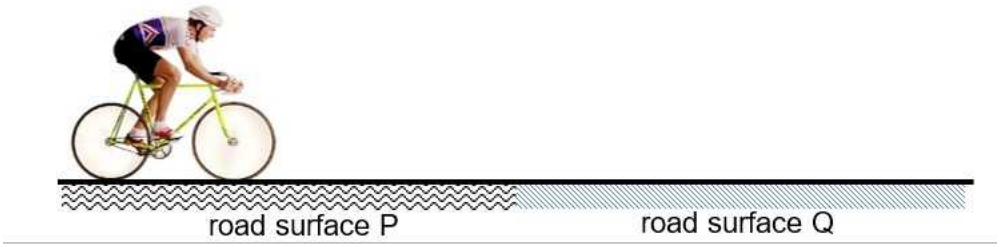


Fig. 1.1

Fig. 1.2 shows a graph of the resistive force acting on the bicycle against time.

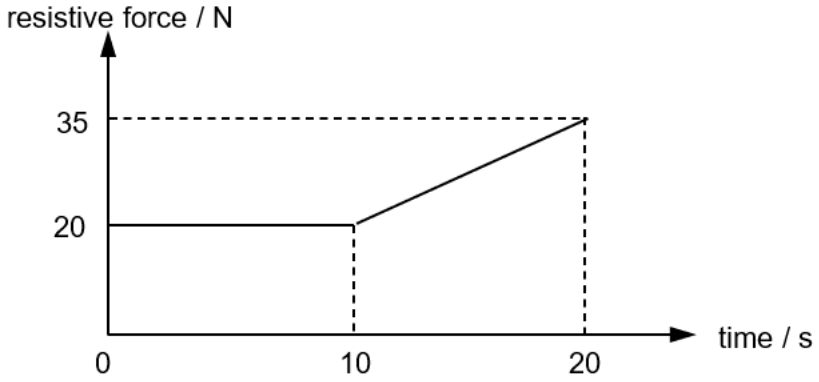


Fig. 1.2

The man and his bicycle have a combined mass of 150 kg. His initial speed is 2.0 m/s.

(a) Calculate the acceleration of the man and his bicycle at t = 5 s.

acceleration = ……[2]

(b) Calculate the speed of the bicycle at t = 10 s.

speed = ……..……[2]

(c) Describe the velocity and acceleration of the cyclist from 10 s to 20 s.

……..

……..

…….[1]

2 Fig. 2.1 shows an archer shooting an arrow at a target during a competition.

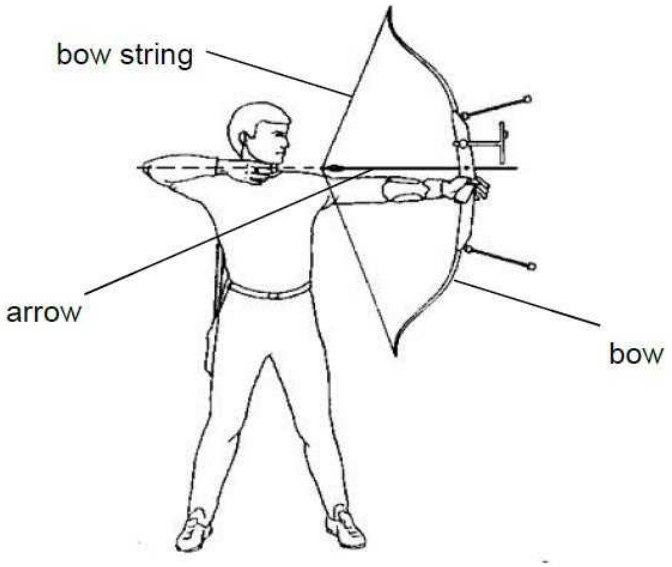


Fig. 2.1

(a) The arrow has a mass of 0.025 kg and is initially at rest. The arrow leaves the bow 0.013 s after the bow string is released. When it leaves the bow, the velocity of the arrow is 86 m/s.

Calculate

(i) the average force exerted on the arrow during the 0.013 s.

average force = …….[2]

(ii) The magnitude of the force exerted on the arrow by the bow string is not consistent during the 0.013 s. Suggest why this is so.

……

……

……

……[2]

(b) On Fig. 2.2, sketch a possible speed-time graph for the arrow after the bow string is released. [2]

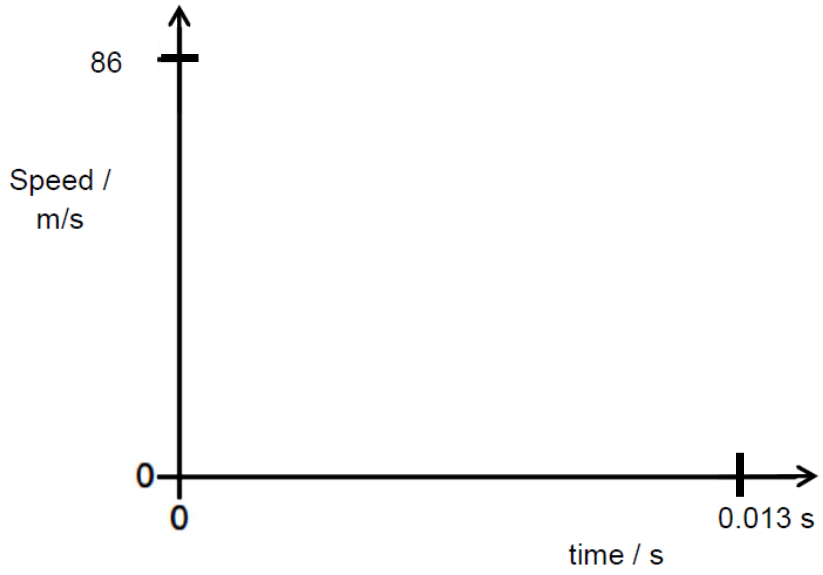


Fig. 2.2

3 A mass, hanging on the end of a string, is pulled horizontally sideways to the right so that the string makes an angle of 30° with the vertical as shown in Fig. 3.1. In this position, the tension in the string is 8.0 N.

By means of a scale diagram, determine the weight of the mass.

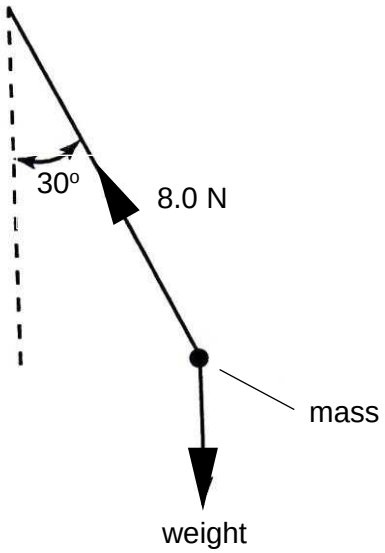


Fig. 3.1

weight of mass = ……[4]

4 Fig. 4.1 shows a door and an automatic door-closer viewed from above.

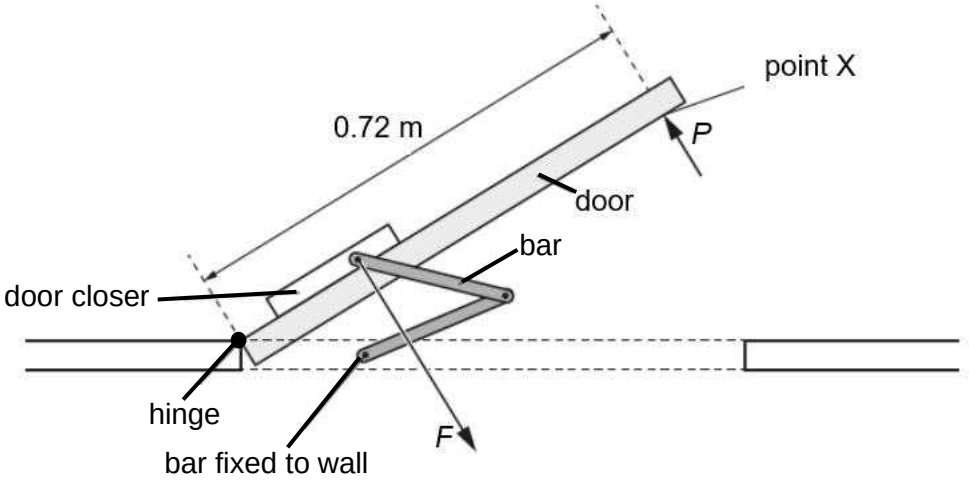


Fig. 4.1

When the door opens and closes, the hinge acts as a pivot.

A girl opens the door by exerting a force *P* at point X.

Force *P* is perpendicular to the surface of the door.

(a) Fig. 4.1 shows that point X is at a distance of 0.72 m along the front of the door from the hinge. The force *P* is 25 N.

(i) Calculate the moment of force *P* about the hinge.

moment of force = ……[1]

(ii) The door rotates about the hinge by 90º. As it rotates, the force *P* remains perpendicular to the surface of the door. The circumference of a circle of radius 0.72 m is 4.5 m.

Calculate the work done on the door by force *P*.

work done = ……[2]

(b) As the door opens, there is a force *F* on the door in the direction shown in Fig. 4.1. Although force *F* is larger than force *P*, the door rotates about the hinge.

Explain why.

……..

……..

……..

……..[2]

5 **(a)** Fig. 5.1 shows an electric circuit powered by a 12.0 V battery of negligible internal resistance.

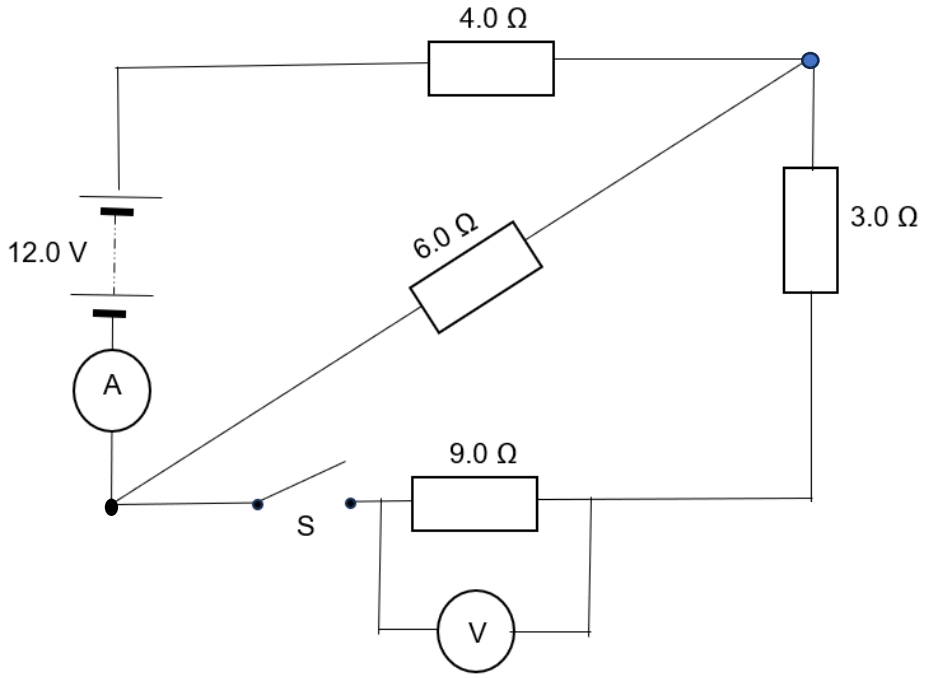


Fig. 5.1

When switch S is closed, calculate

(i) the total resistance of the circuit,

total resistance = ……..[2]

(ii) the current flowing through the ammeter.

current = ……[1]

(b) Describe the effect on the reading of the ammeter when the switch S is opened.

……..

……..[1]

6 Fig. 6.1 shows how the resistance of a thermistor, *R,* varies with temperature.

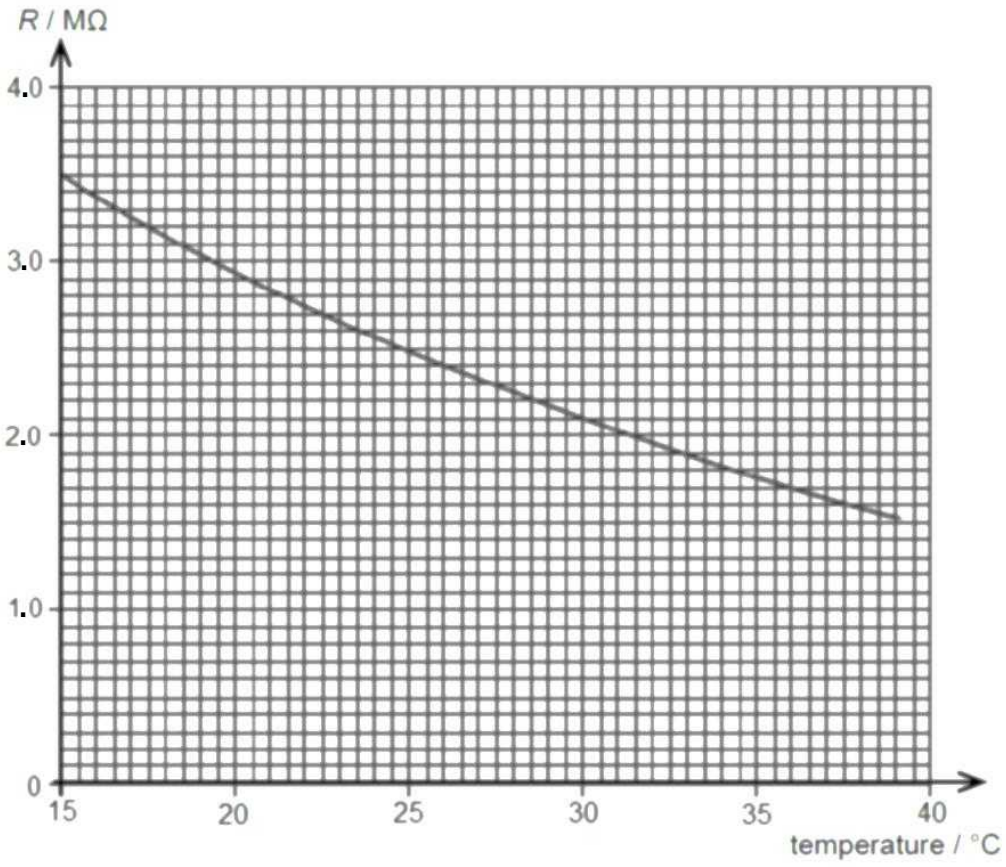


Fig. 6.1

The thermistor is connected to the circuit in Fig. 6.2.

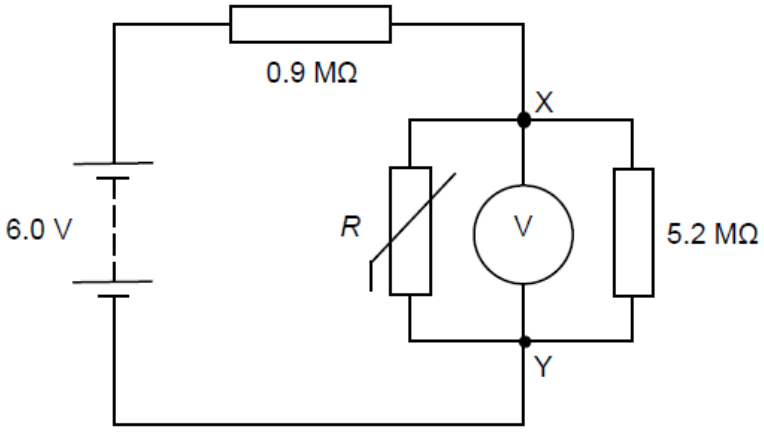


Fig. 6.2

The battery has an electromotive force (e.m.f.) of 6.0 V.

The voltmeter reads 4.0 V.

(a) Determine

(i) the total resistance between points X and Y,

total resistance between points X and Y = ……..……..[2]

(ii) the temperature of the thermistor using Fig. 6.1.

temperature = ……..….[2]

(b) A student suggests that the circuit in Fig. 6.2 could be calibrated to measure temperature.

Suggest a disadvantage of using the thermistor for the measurement of temperature.

……..

……..[1]

7 Fig. 7.1 shows a d.c. generator.

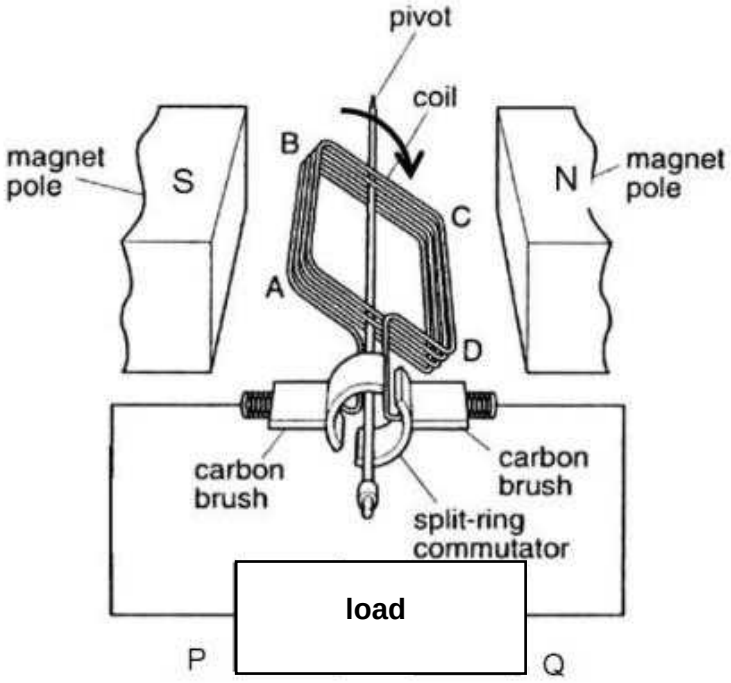


Fig. 7.1

(a) Coil ABCD rotates clockwise. Using arrows, draw the directions of the induced currents on the sides AB and CD of the coil on Fig. 7.1. [1]

(b) Sketch on Fig. 7.2, the graph of the induced e.m.f. against time when the coil is rotated. [3]

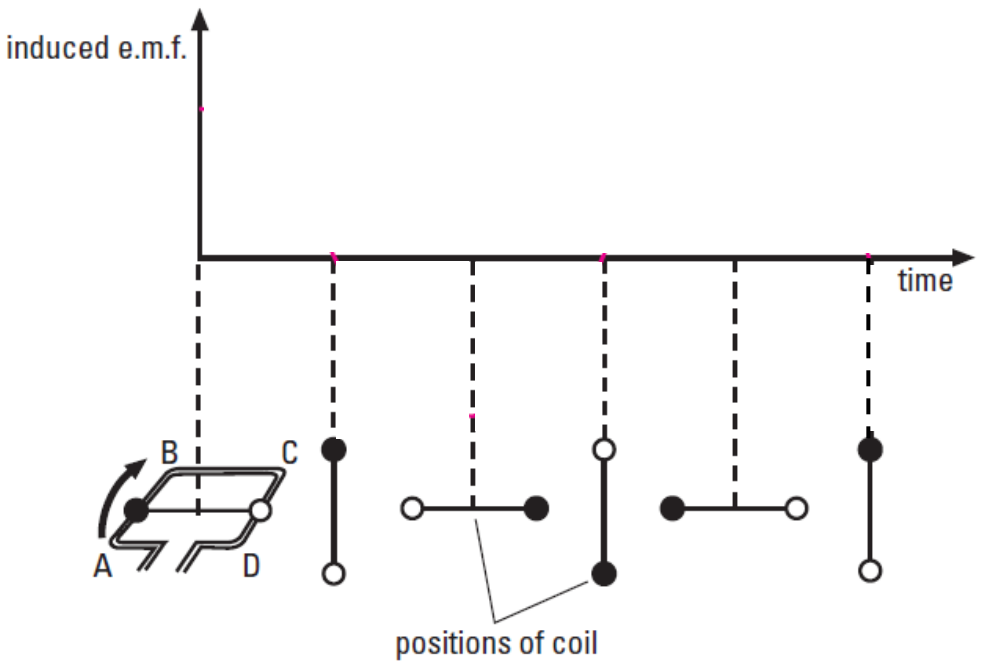


Fig. 7.2

(c) Explain why a motor can also be used as a generator.

……..

……..

……..[1]

8 Fig. 8.1 shows the structure of a transformer which is used in the transmission of electrical power through the cables.

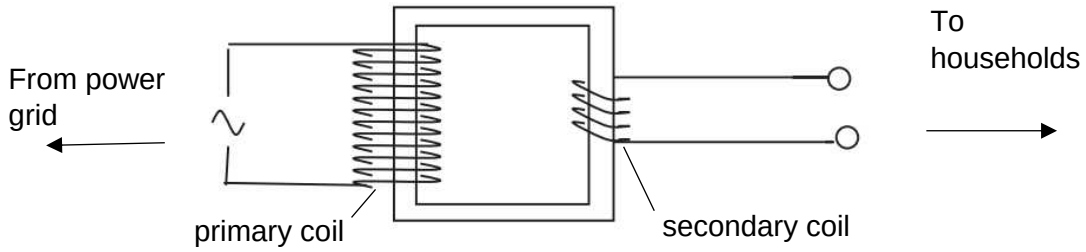


Fig. 8.1

An engineer is assigned to build a step-down transformer for stepping down the voltage from 3.3 kV to 220 V in the substation of a housing estate. He has the choice of using four types of coils with different number of turns as shown in Table 8.2 below.

coil	number of turns
J	50
K	100
L	1 000
M	1 500

Table 8.2

(a) Based on Table 8.2, select the most suitable pair of coils for making the primary coil and secondary coil of the transformer.

Explain your choice.

……..

……..

……..

……..[2]

(b) Assuming that the transformer is 75 % efficient and the power output is 15 kW, calculate the current flowing in the primary coil.

current = ……[2]

(c) Describe one feature of the transformer that improves its efficiency.

……

……

……

……[2]

9 The nuclide sodium-24 ($^{24}_{11}Na$) undergoes radioactive decay to become magnesium-24 ($^{24}_{12}Mg$). A radioactive sample contains N_o atoms of sodium-24 and zero atoms of magnesium-24 at time t = 0. Fig. 9.1 shows the variation of number of sodium-24 atoms (N) with time t.

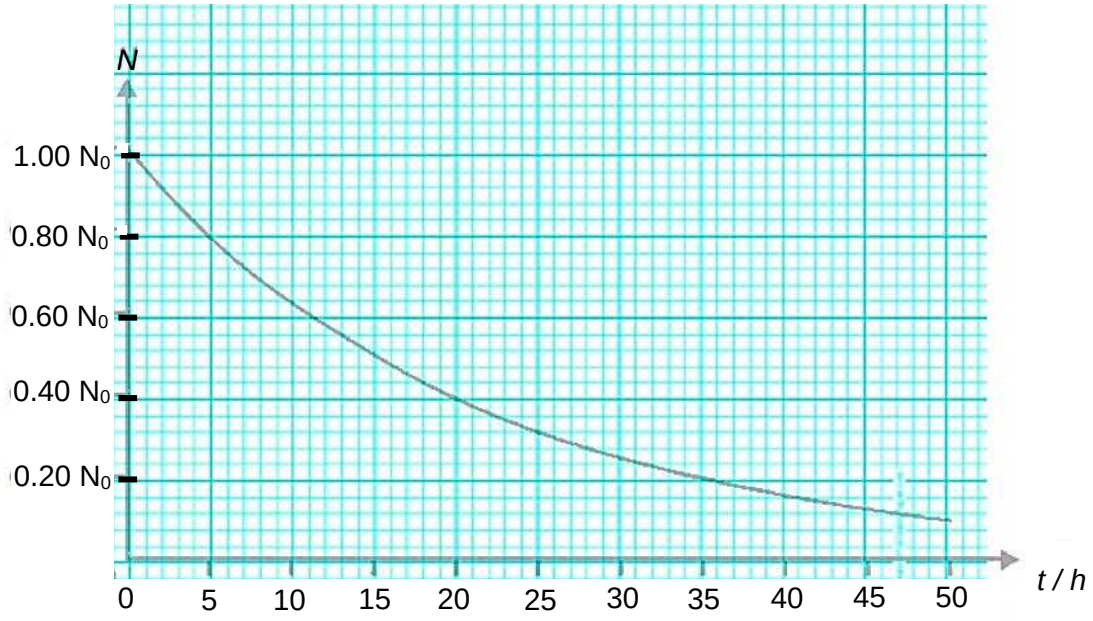


Fig. 9.1

(a) **(i)** Write the nuclide equation to represent sodium-24 decay to magnesium-24.

……[1]

(ii) Explain the meaning of *half-life* of a radioactive nuclide.

……..

……[1]

(iii) Using Fig. 9.1 to determine the half-life of sodium-24.

half-life = ……[1]

(iv) Suggest an application for the radioactive products of sodium-24.

……...

……..[1]

(b) In a separate experiment, a different radioactive source is used. The background count rate is 20 counts / minute.

When the radiation detector is placed near the source, the count rate is 800 counts / minute.

The half-life of the source is 5 minutes.

(i) State what is background radiation.

……

……..[1]

(ii) Determine the count rate on the detector at the end of 10 minutes.

count rate = ……[2]

(iii) Calculate how long it will take for the count rate on the detector to decrease to 118 counts / minute.

time = ……[2]

(iv) Radioisotopes are used to treat cancer. Internal radionuclide therapy is administered by injecting a small radiation source by mouth as a pill or injected into a vein.

Explain why the radioisotope should have a short half-life.

……

……

……..[1]

10 Fig. 10.1 shows a cooling system used to cool a motor car engine by circulating water through it. The radiator is a heat exchanger where the hot water transfers its thermal energy to the air.

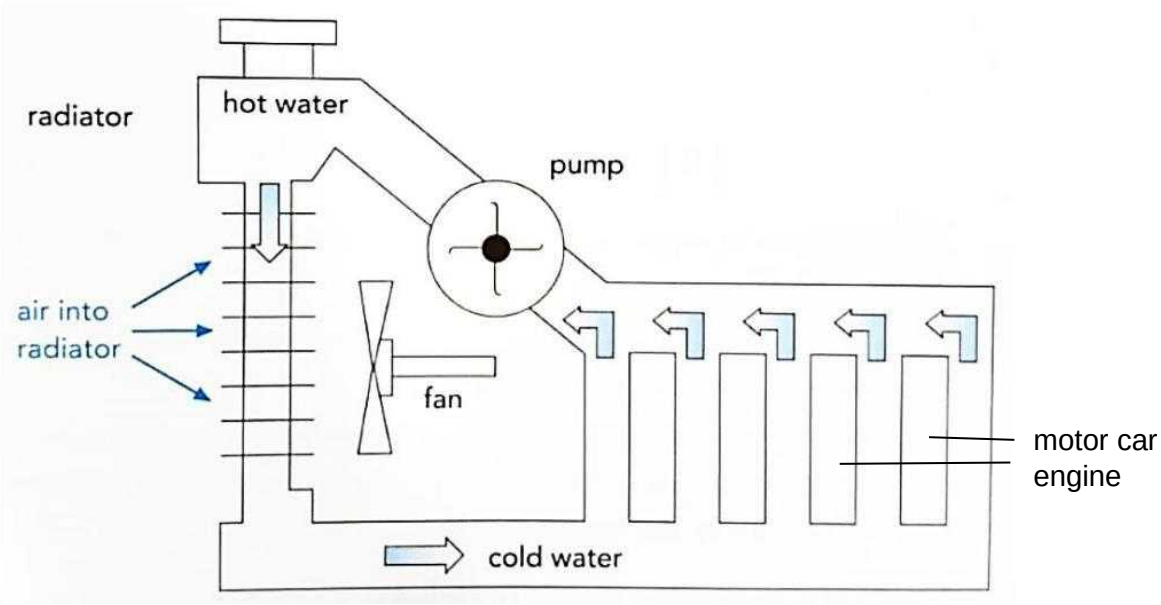


Fig. 10.1

A number of test runs are carried out to investigate the cooling system. Table 10.2 shows the data from one test run and the specific heat capacities of some substances.

Duration of test / min	4.0
Energy available from fuel used / J kg^{-1}	5.0×10^7
Fuel consumed / kg	0.80
initial temperature of air / ^oC	20.0
initial temperature of cold water / ^oC	30.0
final temperature of hot water / ^oC	80.0
rate of flow of water / kg s^{-1}	0.22
rate of flow of air over radiator fins / kg s^{-1}	1.25
specific heat capacity of castor oil / J kg^{-1} $^oC^{-1}$	1800
specific heat capacity of glycerine / J kg^{-1} $^oC^{-1}$	2430
specific heat capacity of water / J kg^{-1} $^oC^{-1}$	4200
specific heat capacity of air/ J kg^{-1} $^oC^{-1}$	760

Table 10.2

Fig. 10.3 shows an expanded view of the cross-section of the radiator.

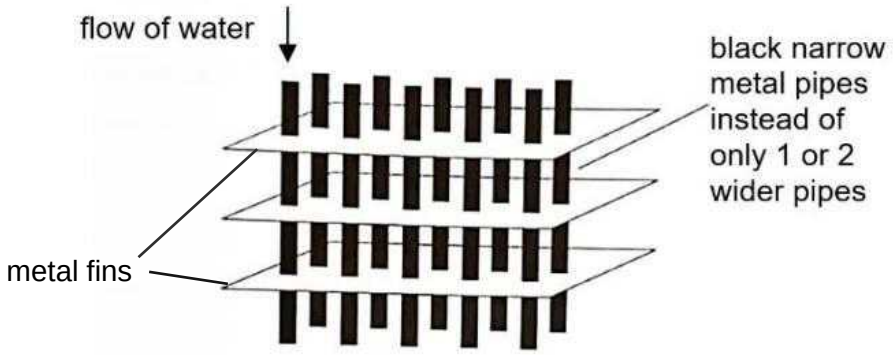


Fig. 10.3

(a) Explain why water is used as a coolant in the radiator of a motor car engine instead of the other fluids given in the table in Table 10.2.

……..

……..

……..

…….[2]

(b) The manufacturer claims that 20% of the energy from the fuel is transferred into useful mechanical energy.

(i) Calculate the amount of thermal energy removed from the hot water in the test run based on the manufacturer's claim.

energy = ……..…….[1]

(ii) Calculate the actual amount of thermal energy removed from the hot water during the test run.

energy = ……...….[1]

(iii) Suggest a reason for the difference between the values in **(i)** and **(ii)**.

……

……..….[1]

(c) Using Fig. 10.3, explain the features of the radiator that allow thermal energy to be transferred easily away from the hot water which flows through the tubes.

……..

……..

……..

……..

……..

…….[3]

(d) Assuming that there is no heat loss by the cooling water as it flows from the engine to the radiator, calculate the average final temperature of air leaving the radiator in the test run.

average final temperature = ……..……[2]

11 Two metal cans A and B are filled with equal masses of the same liquid at a temperature of 75°C as shown in Fig. 11.1.

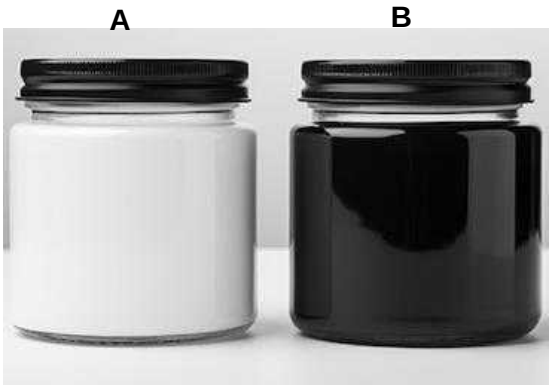


Fig. 11.1

The cans are identical except that can A has a polished silver surface and can B has a dull black surface.

Both cans are placed on a table and the temperature of each can is measured every minute.

The variation with time of the temperature of the liquid in can A is shown in Fig. 11.2.

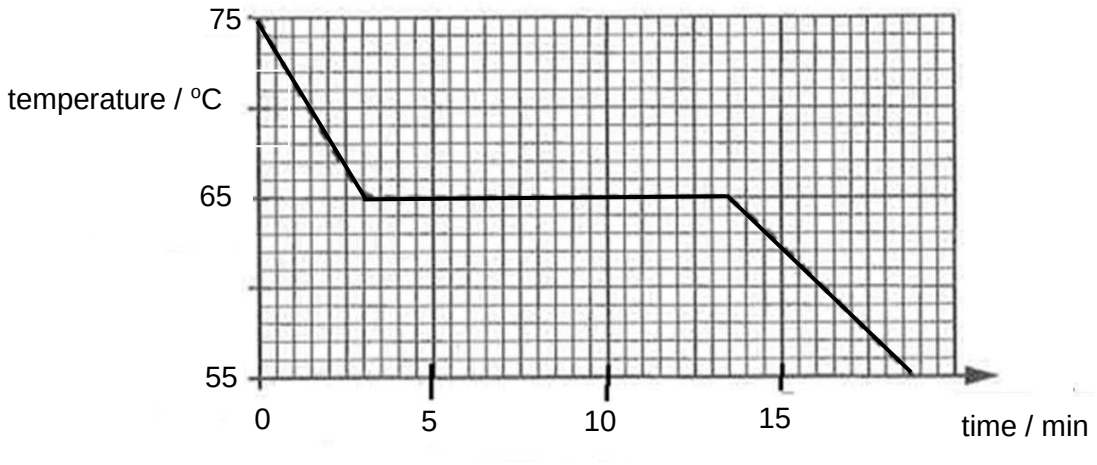


Fig. 11.2

(a) Describe how thermal energy is transferred from the liquid to the surroundings.

……..

……..

……..

……..[2]

(b) Determine the initial rate of fall in temperature, giving your answer in °C/min.

initial rate of fall in temperature = …...……...……[1]

(c) The mass of liquid in can A is 50 g. The specific heat capacity of liquid is 4.2 J/(g°C).

Calculate the average energy lost by the liquid per minute in the first 3.0 min.

average energy lost = ……[2]

(d) After some time, the temperature remains constant, even though heat is still being transferred by the liquid to the surroundings. Explain why.

……

……

……

……..[2]

(e) On Fig. 11.2, sketch the variation with time of the temperature of the liquid in can B for the temperature change from 75°C to 55°C. [2]

(f) Explain why your graph for can B is different from the graph for can A.

……

……

……..[1]

Section B

Answer **one** question in this section.

12 Fig. 12.1 shows an electrical wiring in a water heater. It consists of a heater coil rated '240 V, 2500 W' and an exhaust fan rated '240 V, 300 W'. The mains supply 240 V to the water heater.

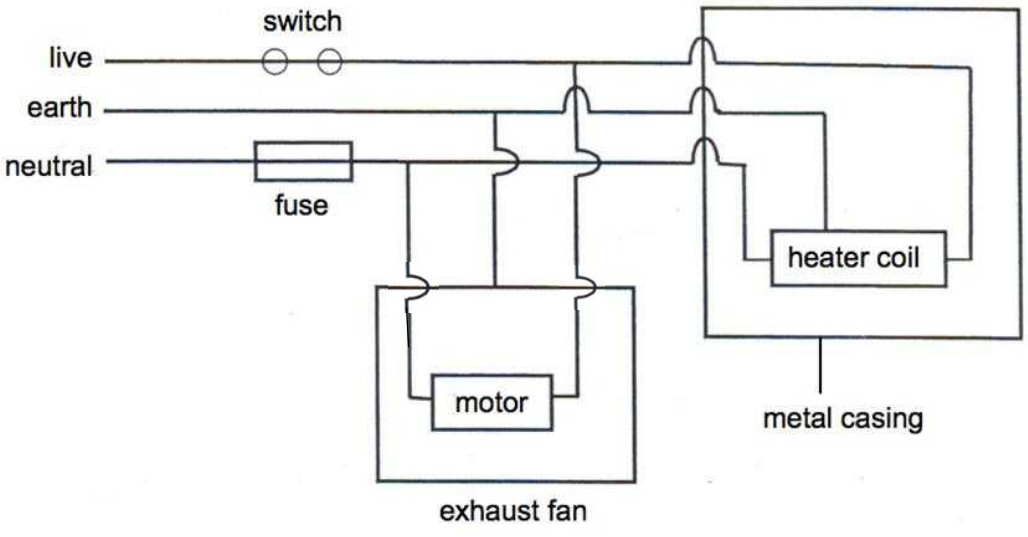


Fig. 12.1

(a) **(i)** The fuse rating in Fig. 12.1 is 11 A. Explain, with clear calculation, why the fuse rating is not suitable.

……

……

……[2]

(ii) Identify two other faults in Fig. 12.1 and describe how they should be corrected.

……

……

……

……

……

……[2]

(b) Fig. 12.2 shows two coils, A and B, with currents flowing through them in the directions indicated.
A is suspended from a spring balance while B is fixed.

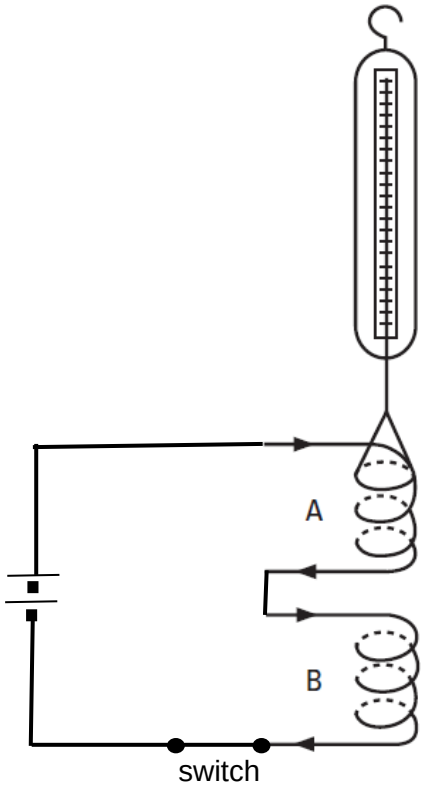


Fig. 12.2

(i) Mark at each end of A and B, the magnetic poles due to the current flowing through the coils. [1]

(ii) State the effect the coils will have on each other.

……...[1]

(iii) Describe how this effect will change the reading on the spring balance.

……....[1]

(iv) If the direction of current in both coils is opposite to that shown in Fig.12.2, describe the effect on the reading on the spring balance.

……...[1]

(v) State and explain the effect on the spring balance when the switch is just opened.

……...

……..

……..

……...[2]

13 **(a)** The displacement-distance graph of a wave in a string at an instant in time is shown in Fig. 13.1.

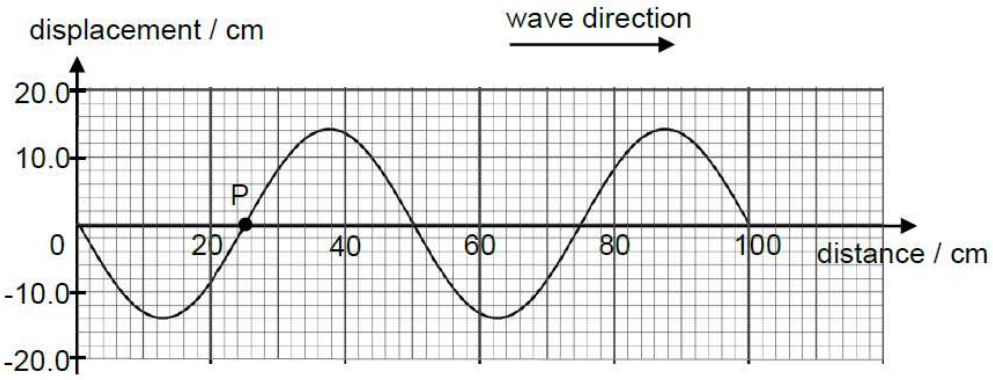


Fig. 13.1

(i) Determine the wavelength of the wave.

wavelength = ……...…[1]

(ii) The wave has a frequency of 2.0 Hz.

Calculate the distance travelled by the wave in 0.060 s.

distance travelled = ……[2]

(iii) Draw on Fig. 13.1 to show how the wave will appear after 0.060 s. [1]

(iv) Estimate the displacement of particle P after 0.060 s.

displacement = ……..……[1]

(b) Fig. 13.2 shows an ultrasound transmitter and receiver placed in close contact with the skin.

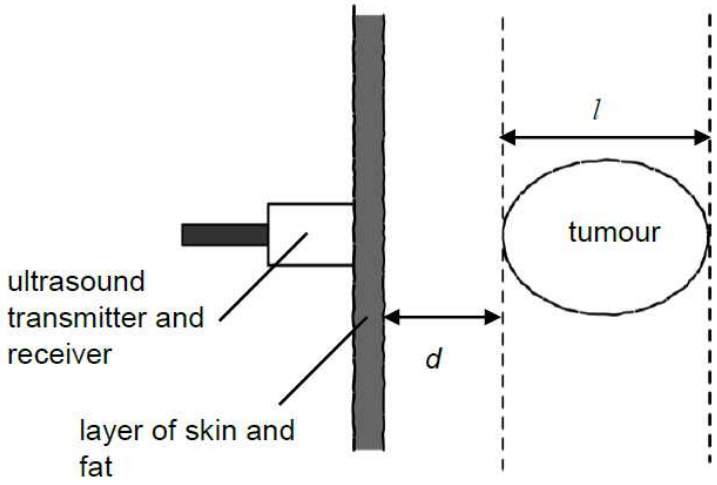


Fig. 13.2

The scan can determine the depth, *d* of a tumour below the skin and the length of the tumour, *l*.

On Fig. 13.3, the strength of the reflected ultrasound pulses A, B, C and D is plotted against time *t* where *t* is the time taken for the ultrasound receiver to receive the pulse after being transmitted. The ultrasound pulses are reflected at the different interfaces.

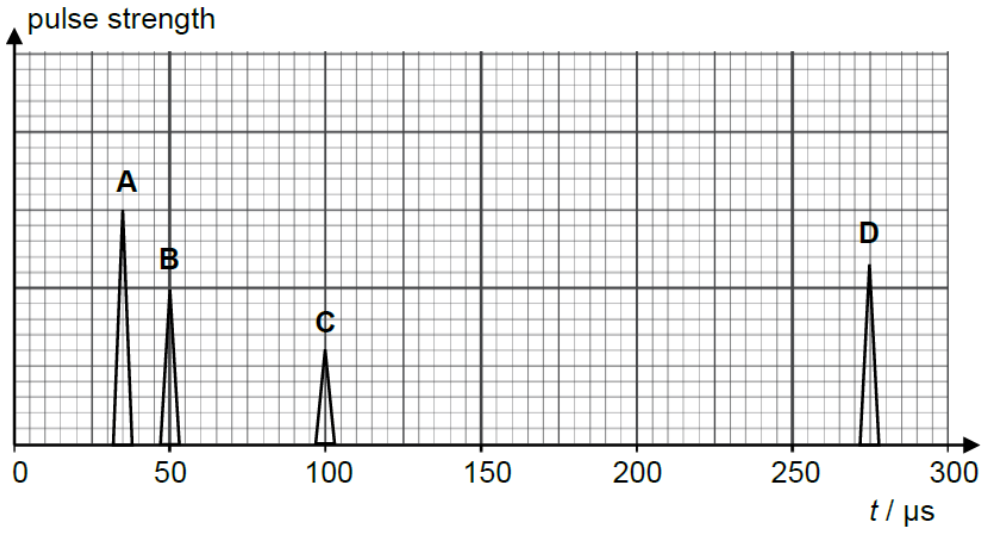


Fig. 13.3

(i) Suggest a reason why a layer of gel is applied between the ultrasound transmitter/receiver and the skin during the scan.

……..……

……...[1]

(ii) Indicate with a cross **X** on Fig. 13.2 the origin of the reflected pulse D. [1]

(iii) The average speed of the ultrasound in human tissue and muscle is 1.5×10^3 m/s.

Using Fig. 13.3, determine length l of the tumour.

l = ……..[2]

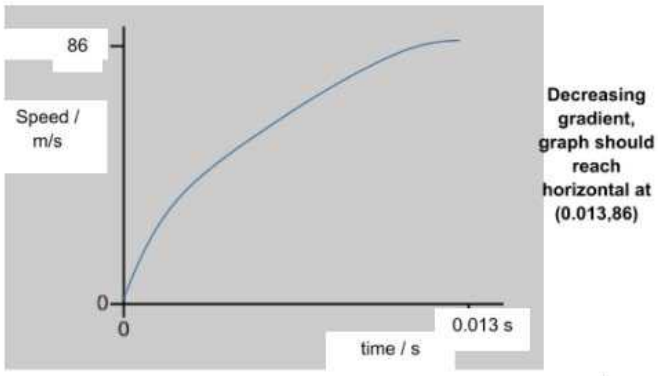
(iv) State one advantage of using ultrasound as opposed to using X-rays in medical diagnosis.

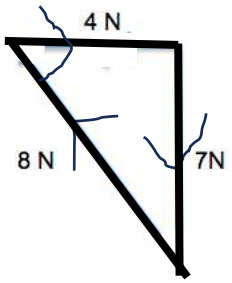
……

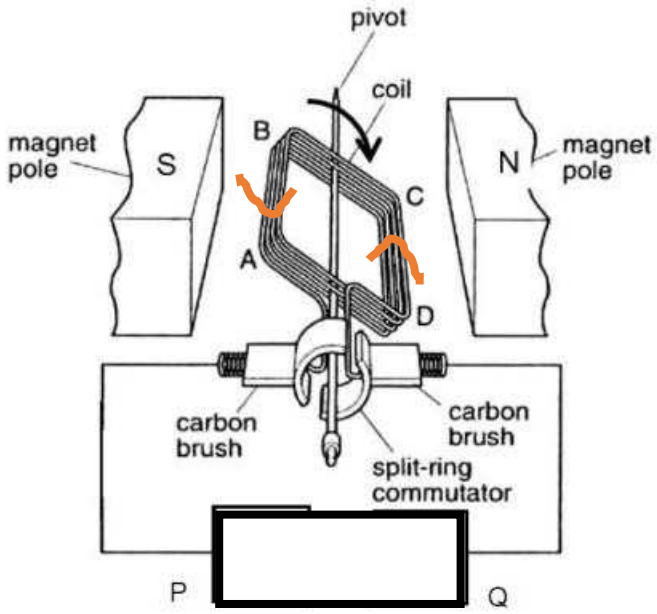
……..……[1]

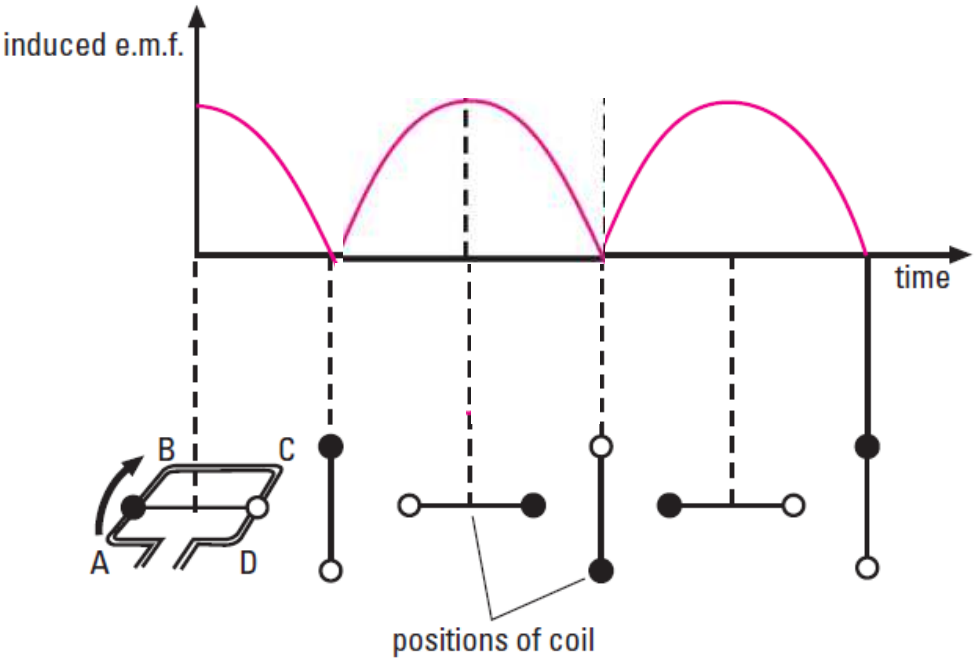
END OF PAPER

Answer Scheme:

1	a	F = ma 600 – 20 = (150)(a) [M1] a = 3.87 m/s^2 [A1]	
	b	a= (v-u)/t 3.87 = $\frac{V-2}{10}$ [M1] v = 40.7 m/s [A1]	
	c	The <u>velocity of the cyclist increases</u> uniformly, whilst his <u>acceleration decreases at a uniform rate.</u> [A1]	
2	ai	a = v – u / t = 86 – 0 / 0.013 = 6600 m/s^2 [C1] F = ma = 6600 x 0.025 = 165 N = 170 N (2sf) [A1]	
	ii	As the bow string is released, the arrow <u>experiences the highest force as it is stretched the most initially.</u> (more elastic energy is transferred per second to the arrow) This force will <u>decrease until zero</u> when the arrow leaves the bow. Alternative accepted answers: <u>Work done to overcome air resistance</u>/ resistive forces of arrow during motion, force on arrow <u>decreases</u>. <u>Acceleration of arrow changes</u>,as air resistance increases with its speed. Since F = ma so force changes.	B1 B1 B1 B1 Max [2]
	b	 1 mark – decreasing gradient 1 mark – reach horizontal line at 0.013, 86	
3			

		Scale : Let 1 cm represent 1 N  Weight of mass = 7.0 N (1 mark for scale 1 mark for correct orientation 1 mark for correct arrows 1 mark for correct magnitude)	
4	ai	M = Fd Moment = 25 x 0.72 = 18 Nm [A1]	
	aii	Work done = 25 x $\frac{2\pi \times 0.72}{4}$ [M1] = 28. 3 J (3 sf) [A1] Or Work done = 25 x $\frac{4.5}{4}$ = 28. 1 J	
	b	The perpendicular distance of the line of action of P to hinge is greater than that of F, to the extent that M =Fd for P is greater than that of F, so that the door can rotate. [B1] The moment of force P about hinge is greater than the moment of force F about the same hinge. [B1]	
5	ai	$\frac{1}{R_T} = 4.0 + (\frac{1}{6} + \frac{1}{3+9})^{-1}$ R_T = 8.0 Ω [A1]	
	aii	I = V / R = 12 / 8 [C1] = 1.5 A [A1]	

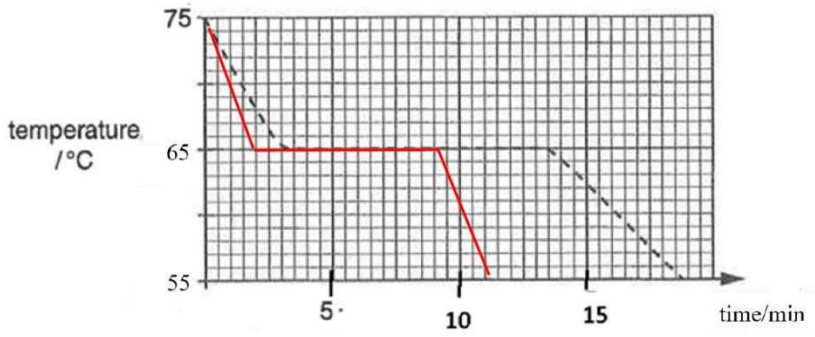
	b	The ammeter reading decreases. [A1] As the overall resistance increases.	
6	**(a)** **(i)**	2 V across 0.9 MΩ 4 V across the voltmeter will be twice the resistance according to potential divider principle, [C1] total resistance across points X and Y = 0.9 × 2 = 1.8 MΩ [A1]	
	(ii)	Resistance across the thermistor, R 1/1.8= 1/R+ 1/5.2 [M1] R = 2.75 MΩ From Fig. 6.1, the temperature of the thermistor = 22.0 °C [A1]	
	(b)	It is not accurate. It's response is non-linear at high temperatures. It has a limited temperature range. It is self-heating. It Is fragile. Any one.	[1]
7	(a)	 2 arrow correct – 1 mark	
	(b)		

		 1 mark – each curve at correct position	
	(c)	When a motor is rotated, there is a change in magnetic flux linked to the coil. This induces an emf and a current in the coil. Therefore, the motor can become a generator. [1]	
8	a	Comparing the voltages of primary coil to secondary coil: Step down ratio = 3 300 : 220 = 15 : 1 [C1] Hence the coils must be step down to the same ratio of 15 : 1 Comparing the turn ratio i.e Coil M : Coil K [A1] = 1 500 : 100 = 15 : 1	
	b	Input power = 100 / 75 x 15 kW = 20 kW [M1] I = P / V = 20 000 / 3 300 = 6.1 A [A1]	
	c	Feature [1] Explanation [1] (Any one)	

		Laminating the iron core reduces the eddy currents / power loss due to heat produced by induced current in the core itself. Using low resistance (primary and secondary) coils will minimize the amount of heat produced in the coils. To increase the magnetic flux linkage between the primary and secondary coils by using a soft magnetic material (iron core) to link	
	9(ai)	$^{24}_{11}Na \longrightarrow {}^{24}_{12}Mg + {}^{0}_{-1}e$ [A1]	
	9(aii)	A half-life of a radioactive nuclide is the time taken for half the nuclei of the nuclide in any sample to decay. [A1]	
	9(aiii)	1 N_o ⟶ 0.5 N_o Takes 15 hours [A1]	
	9(aiv)	Measure thickness of thin materials in the industry. Find leaks in pipes, Treatment of thyroid disorder/ leukemia/liver and brain tumours Locate obstructions to the flow of blood. [Any one]	
	9(bi)	Background radiation refers to nuclear radiation in an environment where no radioactive source has been deliberately introduced. [A1]	
	9(b)(ii)	780 counts/min ⟶ 390 counts/min ⟶ 195 counts/min [M1] Add background count: 195 + 20 = 215 counts / min [A1]	
	9(b)(iii)	780 counts/min ⟶ 390 counts/min ⟶ 195 counts/min ⟶ 97.5 counts /min [M1] Add background count: 97.5 + 20 = 117.5 = 118 counts/ min Total time = 5 + 5 +5 = 15 min [A1]	
	9(biv)	So that the amount remaining in the body is low after a few days and non-target organs will not be harmed. [A1]	

10	**a**	Water is used as a coolant because of its very high specific heat capacity. [B1] It can take in a large amount of thermal energy with only a small rise in its temperature. [B1]
	bi	Thermal energy required to be removed as claimed by manufacturer = (0.8 x 5.0 X 10^7) x 80%

		= 3.2 x 10^7 J [1]
	ii	Actual amount of thermal energy removed Q = mcΔΘ□ = (0.22 x 4 x 60) (4200)(80-30) = 1.1088 x 10^7 J = 1.1 x 10^7 J [1]
	iii	Some thermal energy is lost to the surroundings, apart from it being absorbed by the cooling water. [1]
	c	Metal pipes are used as they <u>are good conductors of heat</u> [1] and allows heat to be conducted faster away from the hot water to the external wall of the pipe. The metal pipes being <u>coloured in black are good emitters of radiation</u> [1] and therefore radiates heat to the surrounding air at a higher rate. Using <u>narrow pipes increase the surface area</u> [1] to facilitate a higher rate of emission of heat to the surrounding air.
	d	Energy absorbed by air = 1.1088 x 10^7 J (allow for e.c.f.) (1.25 x 4 x 60)(760)(Θ - 20) = 1.1088 x 10^7 J [M1] □ Θ = 68.6 ^oC Or 69 ^oC [A1]
11	**(a)**	The thermal energy in the liquid is transferred to the surroundings through radiation in the form of <u>infra-red radiation</u>. [1]. Thermal energy is also transferred to the surroundings <u>through conduction</u>, where particles in the can nearest to the liquid will gain energy from the liquid, vibrate faster, collide and pass on energy to the neighbouring particles. [1]
	(b)	Initial rate of fall in temp = (75 – 65) / 3.0 (accept t = 3.0 - 3.5 s) = 3.3^{o}C / min [1]
	(c)	average energy lost by the liquid per minute = (mc△ø□) / t = 50 x 4.2 x 3.33 [1] = 700 J/min [1]
	(d)	Liquid is solidifying. Thermal energy is released as the particles move closer together. The PE decreases and this energy is lost to the surroundings. [1] Since the average kinetic energy of the molecules remains unchanged, temperature is constant. [1]

		Or Thermal energy is released as intermolecular bonds are formed between the liquid molecules, and this thermal energy is lost to the surroundings. Since the average kinetic energy of the molecules remains unchanged, temperature is constant. [1]
	(e)	 **1st and last section: steeper line** **Middle portion: shorter line.**
	(f)	Can B (dull black) is a better emitter of radiation than can A, and this increases the rate of heat loss to the surrounding by radiation, hence rate of temperature fall for can B is greater.

12(ai) Show operating current of fan = 1.25 A P = VI I = P / V = 300 / 240 = 1.25 A Show operating current of heater = 10.4 A P = V/I I = 2500 / 240 = 10.4 I Total current = 1.25 + 10.41 = 11.66 A [1]

The 11 A Fuse will blow under normal operating condition because the total current exceeds the fuse rating. [1]

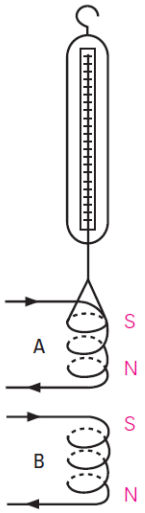
(only award if there is calculation)

12(aii) The fuse is wrongly connected to the neutral wire. A fuse should be connected to the live wire. [1]

The earth wire is wrongly connected to the heater coil . The earth wire should be connected to the metal casing of the heater coil (must mention the heater coil)

[1]

12(bi)



All poles correct - [1]

12(bii) They will attract each other. [1]

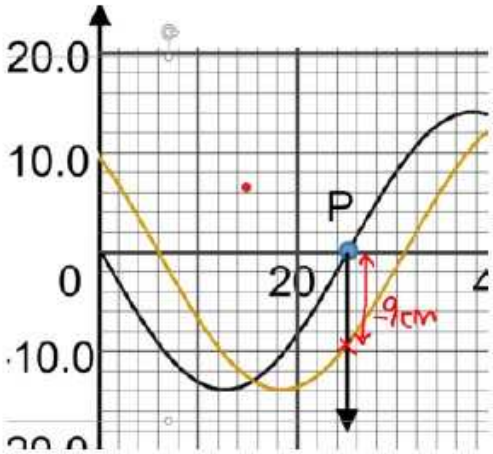
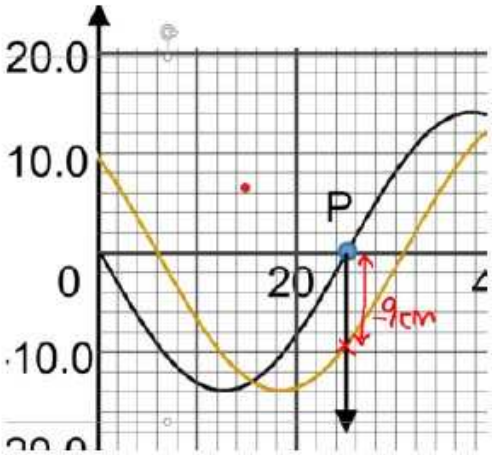
12(biii) The reading on the spring balance will increase. [1]

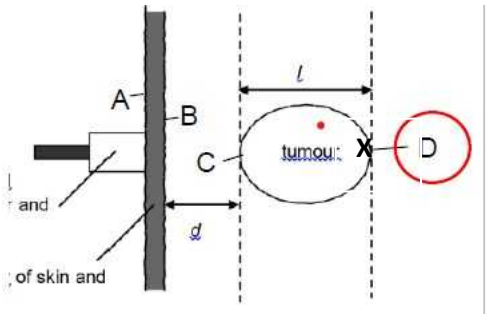
12(biv) The effect is still an attraction and the reading of the spring balance will increase. [1]

12b (v) When the switch is opened, the ends of the coil of A and B which are facing each other will be of opposite poles and still attract each other. [1]

When the switch is opened, the current is cut off and the magnetic fields diminish. When the magnetic fields withdraw from the other coil, the polarity of the magnetic fields will be such as to attract each other. This is according to Lenz's Law. [1]

Or

13(a) (i)	wavelength = 50 cm [1]	
13(a) (ii)	v = fλ = (2.0) x 50 = 100 cm/s [1] d = s x t = 100 x 0.06 = 6.0 cm [1]	
13(a) (iii)	 Sketch for the first 1 ½ cycle. The rest of the wave is repeated. [1] full ecf based on student answer from (ii)	
13(a) (iv)	-9.0 cm (-7 to 11 cm) [1] full ecf based on student answer from (ii) 	

13(b) (i)	To ensure that no air is trapped between transmitter and skin, otherwise nearly all the transmitted pulse will be reflected at the surface of the skin. [1]	
13(b) (ii)	*[1] for correct marking of X.*  	
13(b) (iii)	Pulse take 275 – 100 = 175 μs to travel 2*l* 2 *l* = s x t = 1.5 x 10^3 x175 x 10^{-6} [1] l = 0.131 m [1]	
13(b) (iv)	Ultrasound is non-ionising, hence it not dangerous compared to using X-rays as it doesn't damage human cells. [1]	