Section A [30 marks]

Four possible answers **A**, **B**, **C** and **D** are given for each question. Choose the **most appropriate answer** and shade your answers in pencil on the OTAS answer sheet provided.

1 Which quantity is a base quantity?

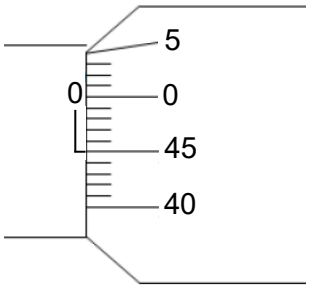
A length

B heat

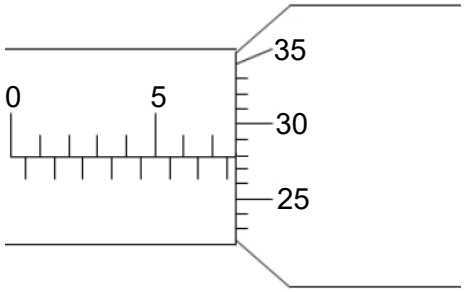
C weight

D potential difference

2 The diagrams below show the readings of a micrometer screw gauge when it is closed fully and when it is measuring the diameter of a marble.



fully closed



measuring diameter of marble

What is the diameter of this marble?

A 7.33 mm **B** 7.73 mm **C** 7.83 mm **D** 8.23 mm

3 A student carries out an experiment to investigate how the length of a pendulum will affect the period of oscillation of the pendulum bob. Throughout the experiment, the student realises that there are some steps that may result in errors in his results.

A brief description of these steps are as follows:

Step P: The length of pendulum is measured from a blunt edge of a metre rule.

Step Q: The time taken for the oscillation of pendulum bob is recorded using a handheld stopwatch.

Step R: He starts timing the period of oscillation immediately upon the release of the pendulum.

Step S: The size of the pendulum bob is measured using a micrometer screw gauge with an initial reading of 0.01 mm when fully closed without any measurement.

Which of the following shows the correct classification of the errors identified?

	systematic error(s)	random error(s)
A	Step R, Step S	Step P, Step Q
B	Step P, Step S	Step Q, Step R
C	Step S	Step P, Step Q, Step R
D	Step P, Step R, Step S	Step Q

4 At the 9 km mark, a runner records an initial velocity of 2.00 m / s. Assume that at the last kilometre (from 9 km mark to the 10 km mark), the runner accelerates at an uniform rate of 0.0100 m / s^2.

How long does the runner take to travel the last kilometre?

A 290 s **B** 500 s **C** 690 s **D** 2710 s

5 An object is thrown vertically upwards with an initial velocity, v_o, and it returns to the same initial position in the absence of air resistance.

If the same experiment is carried out in the presence of air resistance, which statement is false?

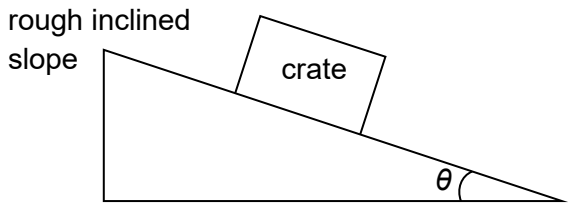
A The time taken for the object to reach zero velocity is smaller.

B The total distance travelled by the object is shorter.

C The velocity when the object lands back at the initial position is smaller than v_o.

D The net acceleration is the same throughout the motion.

6 A crate of mass 5.00 kg, is placed on a rough slope inclined at angle, θ. It experiences a constant frictional force of 12.0 N along the slope.



What is the minimum inclined angle of tilt θ before the crate starts to slide down the slope?

A 0.245° **B** 13.9° **C** 14.2° **D** 75.8°

7 Which statement about mass and weight is true?

A Weight changes with the planet's gravitational field strength.

B Mass changes with the planet's gravitational field strength.

C Mass is a vector quantity.

D Weight is a scalar quantity.

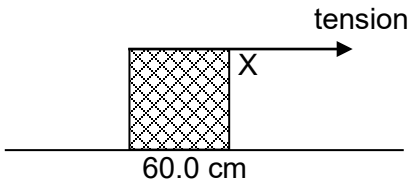
8 A block of mass 2.10 kg is attached to a light inextensible string. A constant force of 6.00 N is applied to the string in order to accelerate the block at 0.100 m / s^2 along a rough horizontal surface.

The string broke off from the block and the block continues to move through a distance before coming to a stop.

If the frictional force is constant, what is the acceleration of the block when the string broke?

A 0 m / s^2 **B** –0.10 m / s^2 **C** –2.76 m / s^2 **D** –5.79 m / s^2

9 A wooden cube of mass 100 kg is at rest on a rough horizontal surface. The length of each side of the cube is 60.0 cm. The tension of the rope attached to corner X, is gradually increased in the horizontal direction.



What is the minimum tension needed to tilt the cube?

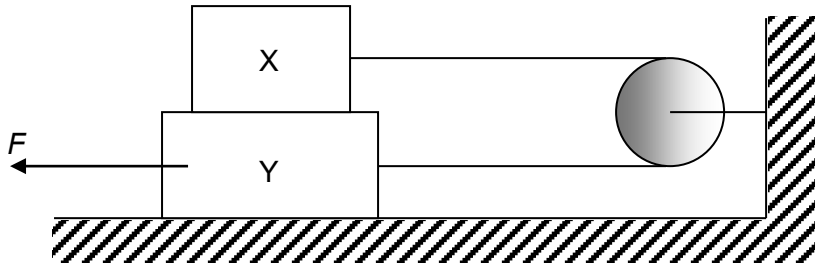
A 50.0 N

B 100 N

C 491 N

D 981 N

10 Two stationary blocks X and Y are connected by a string which passes over a smooth, fixed pulley as shown in the diagram.



Assume that the friction between any two surfaces is 2.0 N. If a horizontal force *F* is applied to block Y, what is the minimum work done by force *F* to move block Y over a distance of 0.50 cm?

A 1.0×10^{-2} J

B 2.0×10^{-2} J

C 3.0×10^{-2} J

D 4.0×10^{-2} J

11 The kinetic energy of a toy car decreases from 8.0 J to 5.0 J over a period of 10.0 s.

What is the average power loss of the toy car?

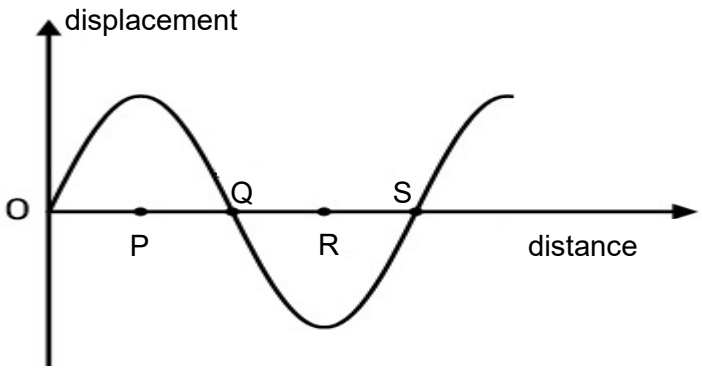
A 0.10 W **B** 0.30 W **C** 0.50 W **D** 0.80 W

12 Transverse sinusoidal waves of wavelength λ are progressing along a horizontal rope. P and Q are points on the rope 0.75λ apart and the waves are travelling from P to Q.

Which one of the following correctly describes Q at an instant when P is displaced downwards but moving upwards?

	displacement of Q	movement of Q
A	upwards	upwards
B	upwards	downwards
C	downwards	upwards
D	downwards	downwards

13 The diagram shows the displacement–distance graph of air molecules at a particular instant when a sound wave passes through air. The displacement to the right is taken to be positive.



Which point shows a centre of rarefaction at this instant?

A point P

B point Q

C point R

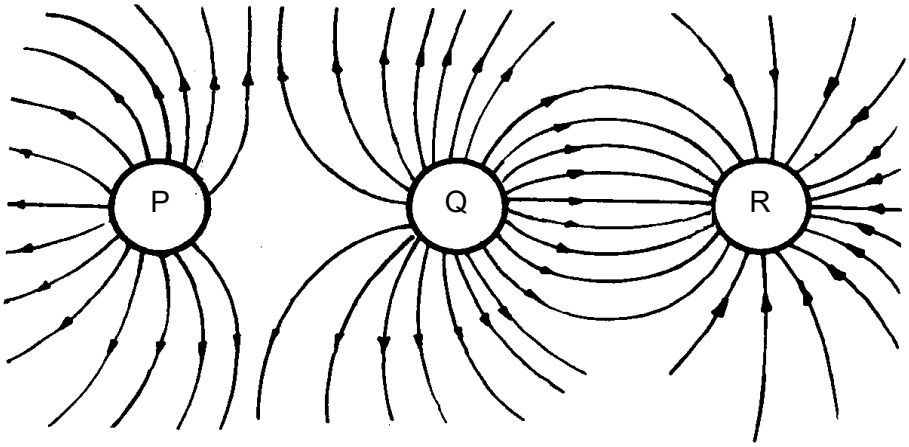
D point S

14 Solid cubes X and Y are made of the same material, but the length of one side of X is twice that of Y.

Given that twice the amount of thermal energy was supplied to X as compared to Y, what is the ratio of the heat capacity of X to Y? Assume no heat loss to the surroundings.

A 0.5 **B** 1.0 **C** 2.0 **D** 8.0

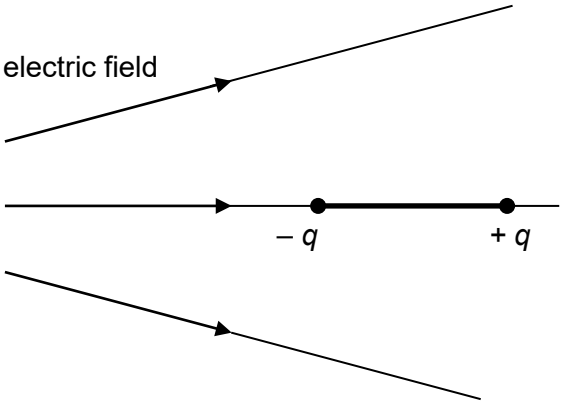
15 The diagram shows the pattern of electric field produced by three charged spheres P, Q and R.



What could be the charge of the three charged spheres?

	charge of P	charge of Q	charge of R
A	negative	negative	positive
B	negative	positive	positive
C	positive	negative	negative
D	positive	positive	negative

16 The diagram shows an electric dipole (a positive and negative charge of equal magnitude connected by a rigid rod) placed in an electric field.



Which statement is correct?

A The dipole will experience no net force.

B The dipole will experience a net force towards the left.

C The dipole will experience a net force towards the right.

D The dipole will experience a net force upwards.

17 The potential difference between the ends of a conductor is 6.0 V.
How much electrical energy is converted to other forms of energy in the conductor when 60 C of charge flows through it?

A 0.010 J

B 10 J

C 66 J

D 360 J

18 Wires P and Q are made of the same material. The ratio of the mass of wire P to the mass of wire Q is 0.250. The ratio of the length of wire P to the length of wire Q is 1.25.

What is the ratio of the resistance of wire P to the resistance of wire Q?

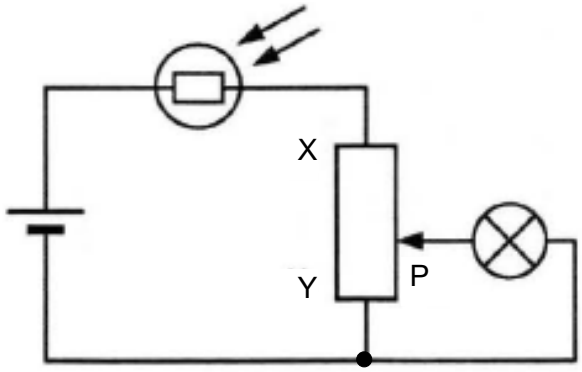
A 0.200

B 1.56

C 5.00

D 6.25

19 The diagram shows a potential divider circuit consisting of a cell, light dependent resistor (LDR), potentiometer and a light bulb. The circuit is used to vary the potential difference across a light bulb.



The light bulb is brightest when

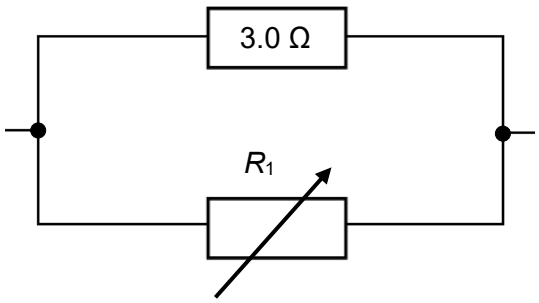
A light is incident on the LDR and P is moved to X.

B light is incident on the LDR and P is moved to Y.

C the LDR is covered and P is moved to X.

D the LDR is covered and P is moved to Y.

20 The diagram shows a 3.0 Ω resistor connected in parallel to a variable resistor R_1, where $R_1 > 3.0\ \Omega$.



Which is true about the effective resistance R?

A $R > 3.0\ \Omega$

B $R < 3.0\ \Omega$

C $R > R_1$

D $3.0\ \Omega < R < R_1$

21 Which of the following is not a safety feature in an electrical system?

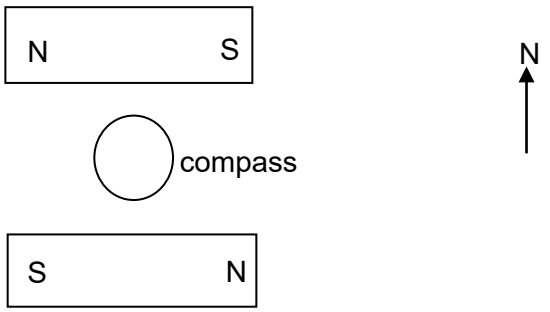
A circuit breaker

B double insulation

C fuse

D transformer

22 Two equally strong bar magnets are placed side by side on a table as shown in the diagram. A compass is placed exactly midway between the magnets. The North pole of the compass is shown by an arrow-head and the direction of earth's magnetic field is given below.



Which direction will the compass point?

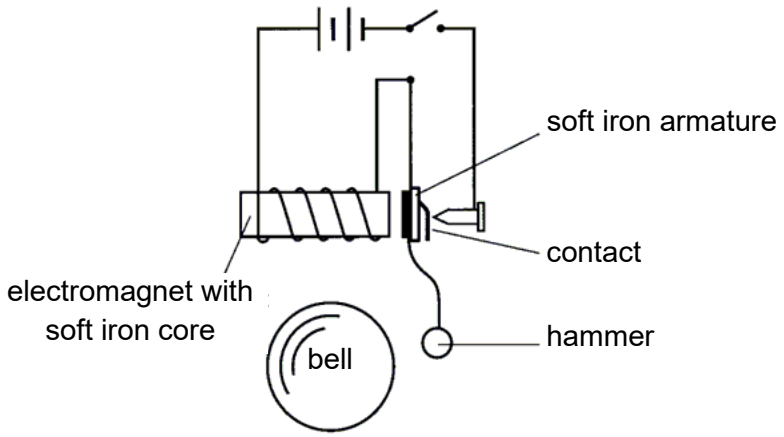
A 

B 

C 

D 

23 The diagram shows a simple electric bell.



Which of the following will result in the hammer striking the bell at a higher frequency?

A reduce the number of coils for the electromagnet

B add a resistor in the main circuit

C replace the soft iron core of electromagnet with steel core

D shift the soft iron armature and contact closer to the electromagnet

24 Which part of a simple d.c. motor reverses the direction of current through the coil every half-cycle?

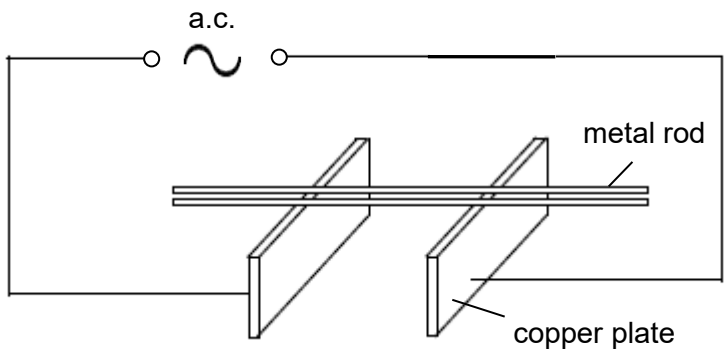
A carbon brushes

B permanent magnets

C split-ring commutator

D slip-rings

25 Two light metal rods are placed horizontally above the two copper plates as shown.



What happens to the metal rods when a low frequency a.c. source is connected to the copper plates?

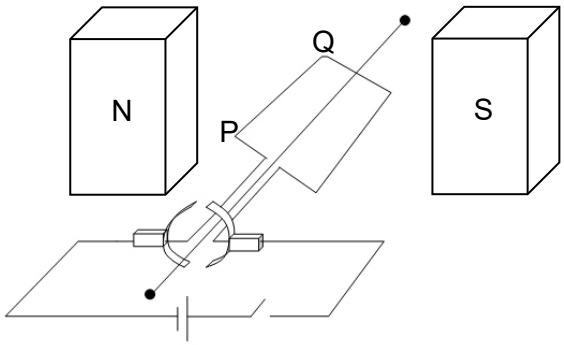
A They will repel and attract in a periodic manner.

B They will repel each other.

C They will attract each other.

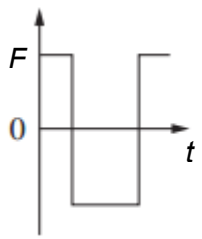
D Nothing happens.

26 The diagram shows a simple d.c. motor with a split-ring commutator. A force *F* acts on the wire PQ when the switch is closed.

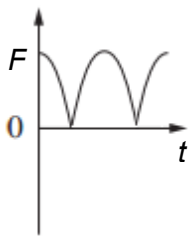


Which graph best describes the variation of force *F* with time *t* over one period?

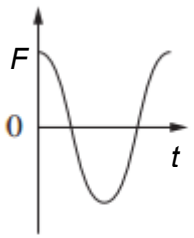
A



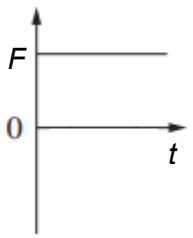
B



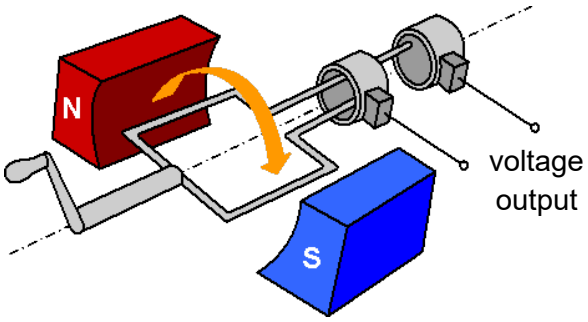
C



D

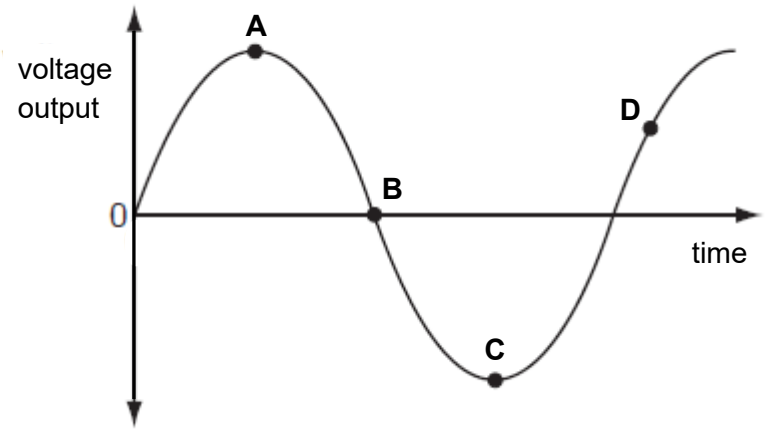


27 The diagram shows part of an a.c. generator.

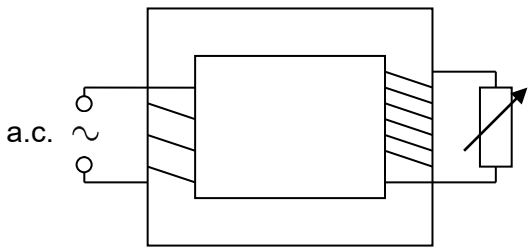


The a.c. generator is used in an experiment and the graph shows the voltage output plotted against time.

Which point on the graph shows the voltage output when the coil is in a vertical position?



28 The primary coil of a transformer is connected to an alternating voltage supply. The secondary coil is connected across a variable resistor.



Which change will cause a decrease in the potential difference across the variable resistor?

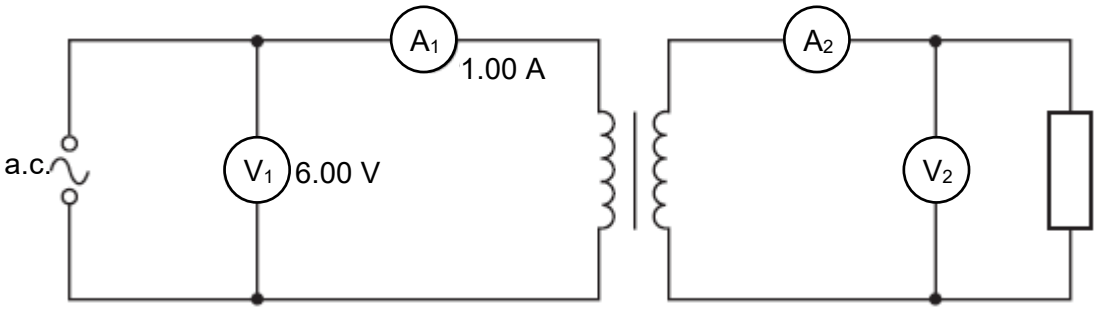
A increasing the thickness of the wire of the secondary coil

B increasing the voltage of the a.c. supply in the primary coil

C increasing the number of turns of the primary coil

D decreasing the resistance of the variable resistor

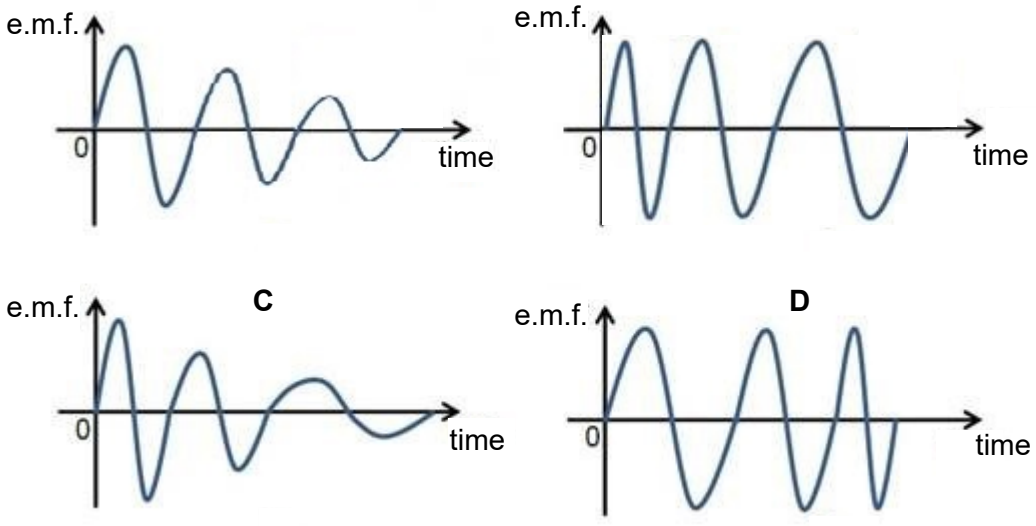
29 The diagram shows an ideal step-up transformer.



Which pair of readings are possible on meters V_2 and A_2?

	V_2 / V	A_2 / A
A	0.60	0.10
B	0.60	10.00
C	60.00	0.10
D	60.00	10.00

30 Which graph shows the relationship of induced e.m.f. with time if the speed of rotation of the coil in a generator decreases gradually after each round of rotation?



Section B [50 marks]

Write your **answers to Questions 31 to 41 in the spaces provided in each question**. Show your workings clearly where necessary. All quantitative answers should include appropriate units and be quoted to a suitable number of significant figures.

Question 31(e) indicated with an * is optional and will count towards your total marks. Your total marks will remain limited to a maximum of **80 marks**.

31 The velocity-time graph of a car travelling along an expressway is plotted in Fig. 31.1.

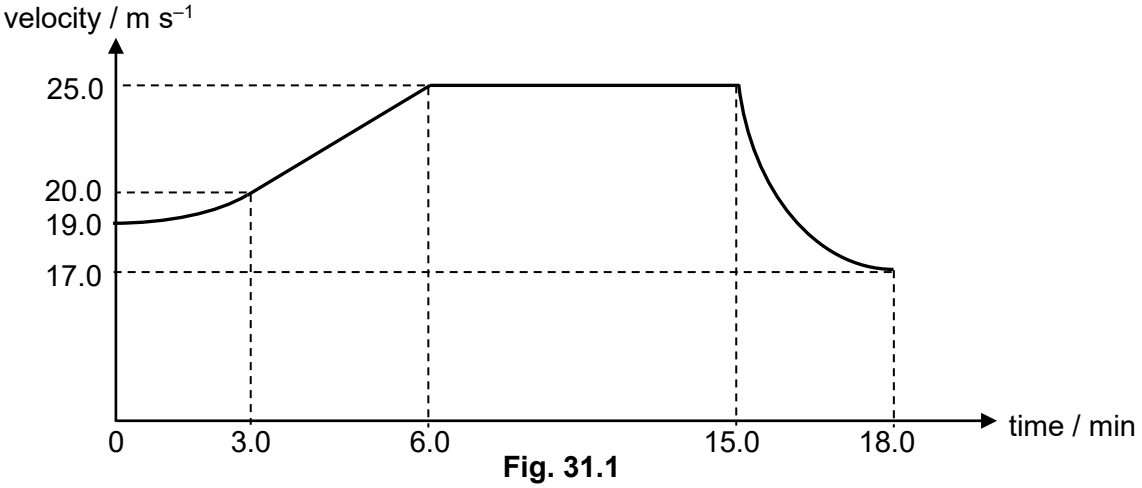


Fig. 31.1

(a) Explain what is meant by "*a velocity of 19.0 m s–1*".

.....

..... [1]

(b) Calculate the acceleration of the car at time = 5.0 min.

acceleration = ... [2]

(c) Describe the motion of the car between time = 15.0 min and time = 18.0 min.

.....

..... [1]

(d) The mass of the car is 1800 kg and it experiences both frictional force and air resistance as it travels along the expressway. The air resistance is directly proportional to the square of its velocity, and the car experiences a constant frictional force of 200 N throughout the journey. At time = 3.0 min, the driving force is 1.05 kN.

Calculate the magnitude of the air resistance at time = 3.0 min.

air resistance = ... [2]

***(e)** Fig. 31.2 shows the driving force-time graph between time = 0 min and time = 18.0 min.

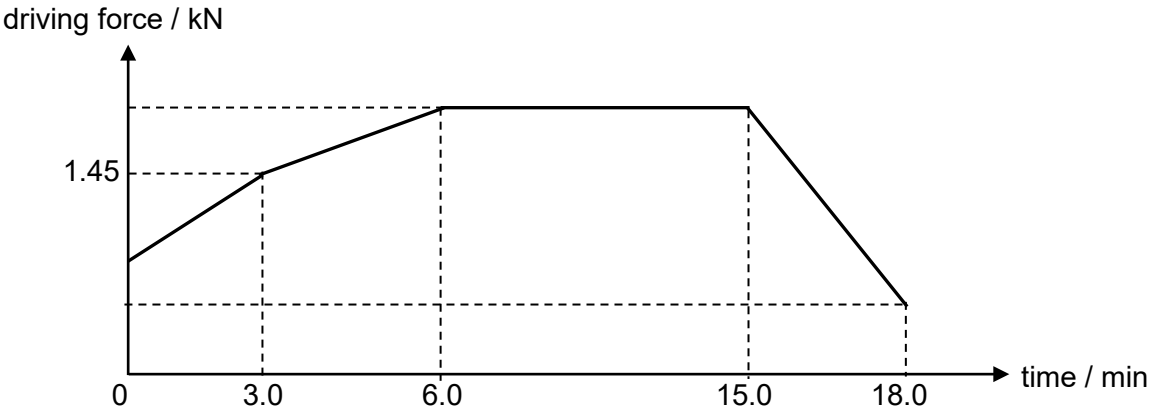


Fig. 31.2

In Fig. 31.3, sketch the air resistance-velocity graph of the car between time = 3.0 min and time = 15.0 min.

Fig. 31.3

[3]

32 Fig. 32.1 shows a student flying a kite with a light string on a windy day. The weight of the kite is 1.30 N.

The string makes an angle of 50.0° to the vertical and the tension in the string is 5.00 N.

Using a labelled vector diagram or otherwise, determine the force of the wind when the kite remains stationary. State the scale, if a vector diagram is used.

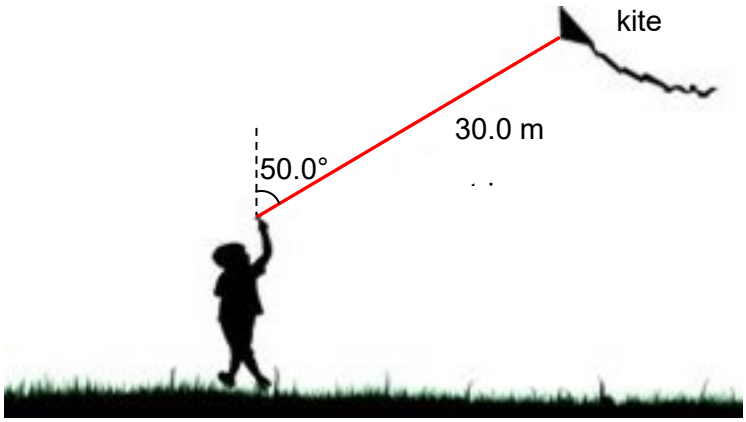


Fig. 32.1

magnitude = ...

direction = ... [3]

33 Fig. 33.1 shows a hammer, with the centre of gravity (c.g.) labelled as X.

Fig. 33.1

(a) State and explain, using the concept of moments, the type of equilibrium when the hammer is suspended at X.

.....

.....

..... [2]

(b) The hammer of mass 0.20 kg is thrown vertically upwards so that its c.g. reaches a maximum height of 3.0 m above the point of projection.

Calculate the kinetic energy of the hammer when its c.g. is 2.0 m above the point of projection, assuming that there is no air resistance.

kinetic energy = ... [2]

34 Fig. 34.1 shows a displacement-time graph of a water wave.

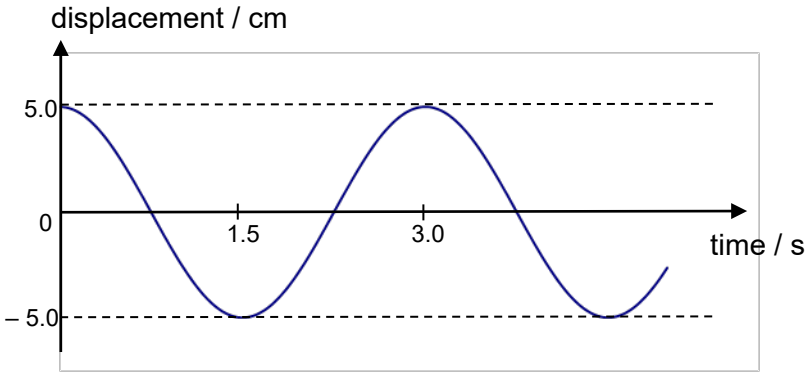


Fig. 34.1

(a) Calculate the speed of the wave if its wavelength is 2.0 cm.

speed = ... [1]

(b) Describe the change in frequency and wavelength of the wave when the wave enters a shallow region.

.....

..... [1]

35 An electrical heater, operating at a constant power, is used to heat a liquid of mass M placed in a metal container. Fig. 35.1 shows the temperature-time graph of the heating process. t_1 is the time taken for the liquid to reach boiling point, and t_2 is the time taken for all the liquid to boil away.

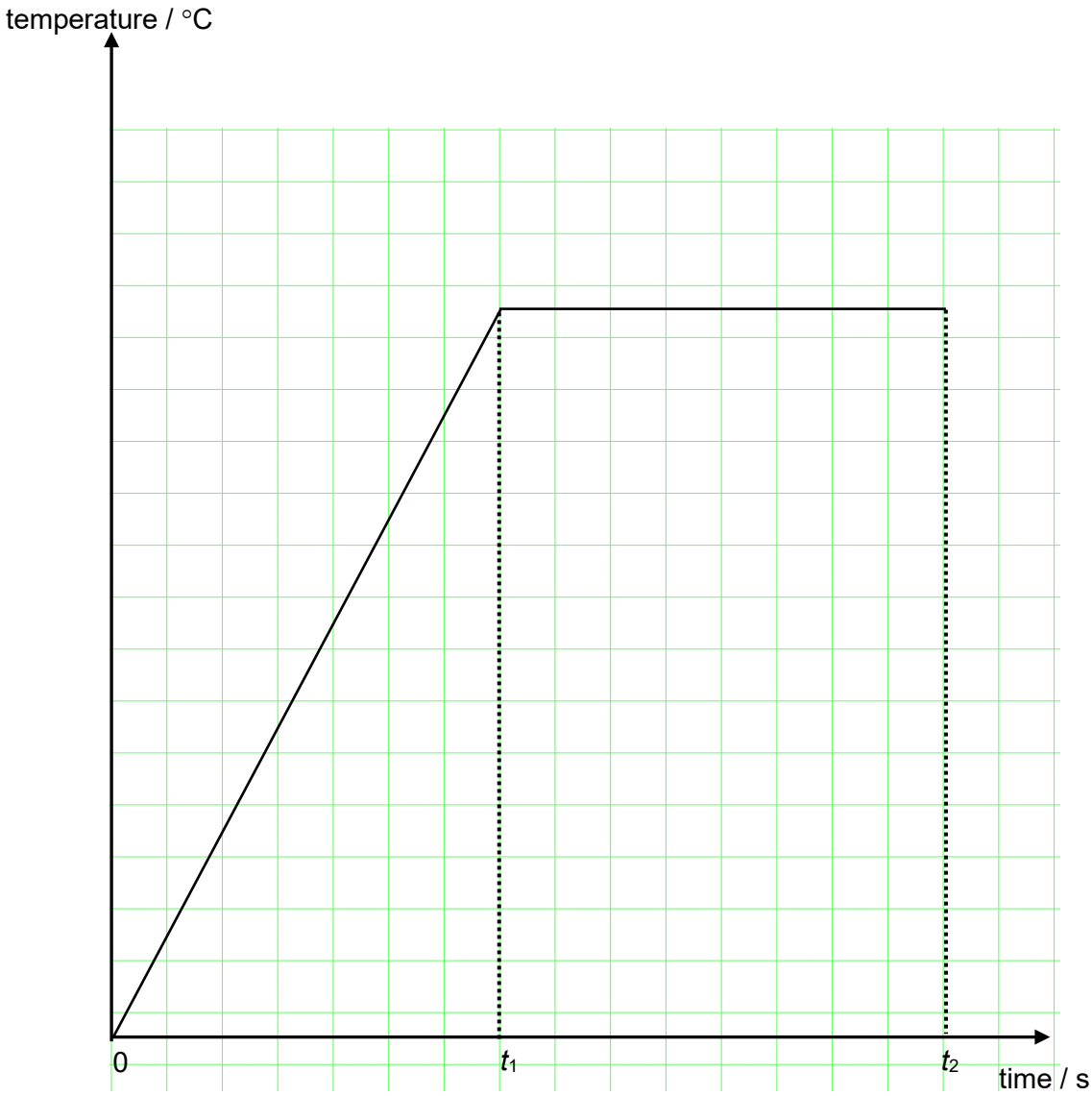


Fig. 35.1

The experiment is repeated using half the amount of the same type of liquid in another container of a lower specific heat capacity. The mass of the containers, the initial temperatures of the liquids and the power supplied are the same.

Assuming that no heat is lost to the surrounding, sketch the temperature-time graph for the new experiment and label the new t_1' and t_2' on Fig. 35.1. [3]

36 Fig. 36.1 shows an uncharged metal rod being held by an insulating handle and a negatively charged sphere being suspended by a nylon thread.

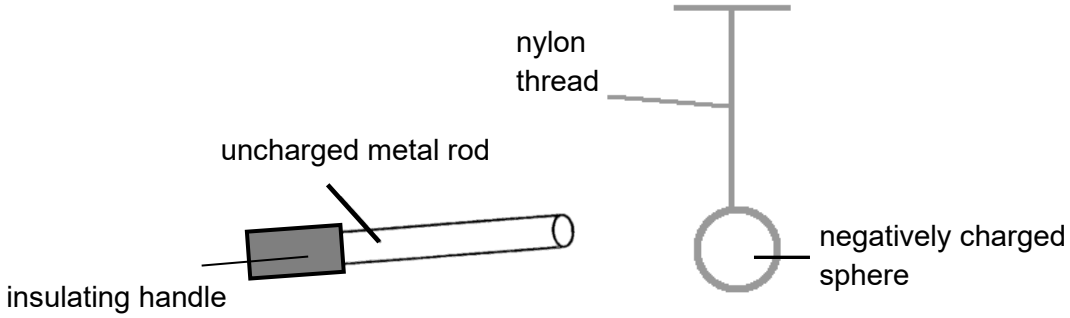


Fig. 36.1

When the rod is brought towards the sphere, the sphere experiences an electric force and is attracted towards the rod.

Explain this observation in terms of the movement of charges.

.....

.....

..... [2]

37 Fig. 37.1 shows the *I*-*V* characteristics of resistors L and M.

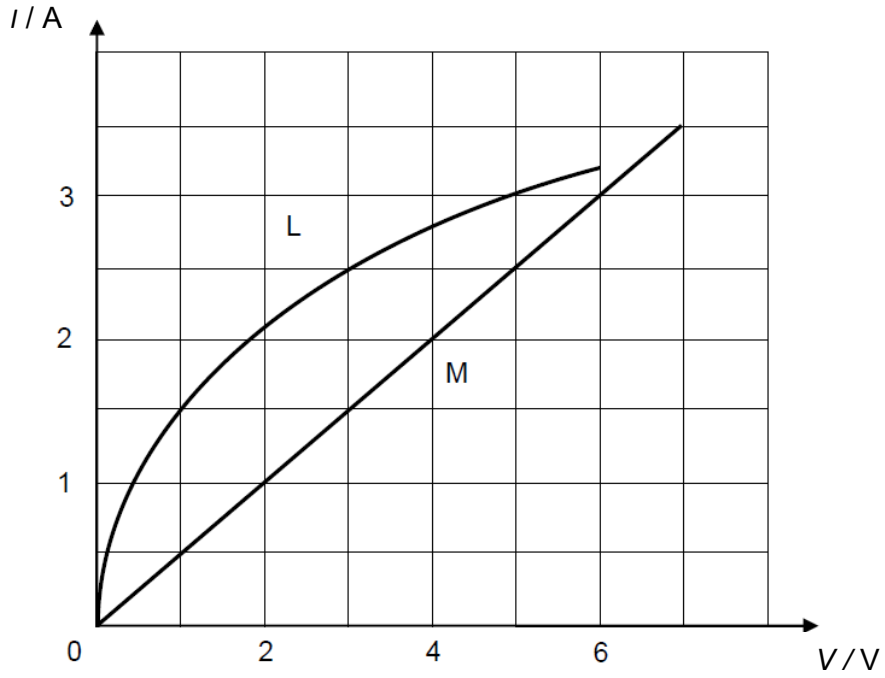


Fig. 37.1

(a) Determine the resistance of resistor L when the current through it is 2.50 A.

resistance = ... [2]

(b) Fig. 37.2 shows the resistors L and M connected in series to a 4.0 V cell. The cell has negligible internal resistance.

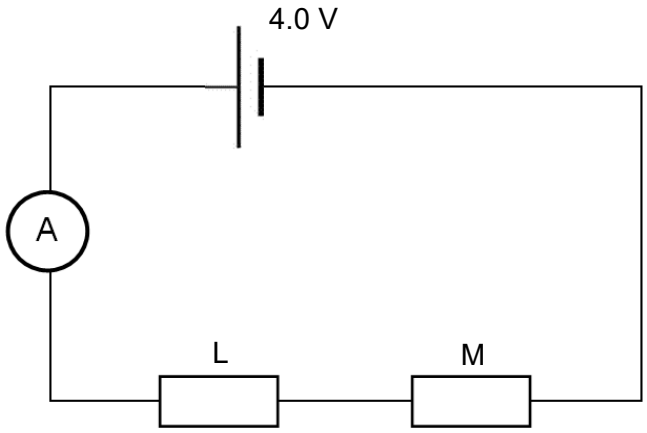


Fig. 37.2

State the current through resistor M.

current = ... [1]

38 The circuit in Fig. 38.1 consists of a cell, a fuse and four bulbs L_1, L_2, L_3 and L_4. The cell has an e.m.f. of 12 V and negligible internal resistance. Bulbs L_1, L_2 and L_3 are of rating 24 W, 12 V. Bulb L_4 has a resistance of 2.0 Ω. The ammeter shows a reading of 2.0 A.

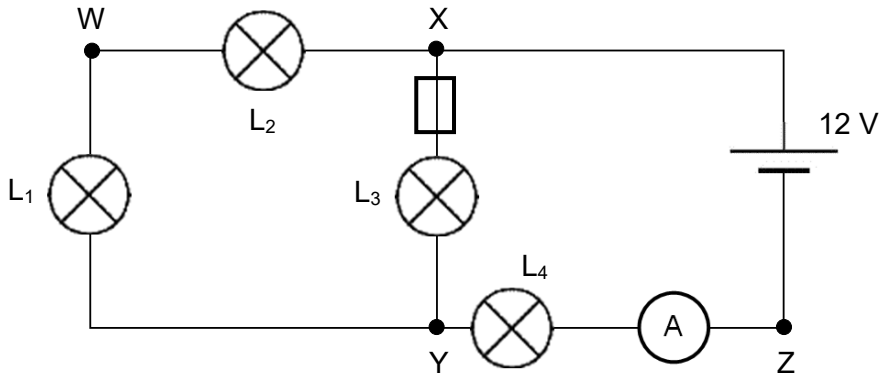


Fig. 38.1

(a) Calculate the resistance of bulb L_1.

resistance = ... [1]

(b) Calculate the current through bulb L_3.

Hence, suggest a suitable fuse rating used in the circuit.

current = ... [2]

fuse rating = ... [1]

(c) Calculate the power dissipation of bulb L_4.

power dissipation = ... [1]

(d) Arrange the brightness of the three bulbs L_2, L_3 and L_4 from the dimmest to the brightest.

..... [1]

(e) Another bulb L_5 has a resistance much lower than bulbs L_1, L_2, L_3 and L_4.

Suggest between which two points (W, X, Y, Z) the bulb L_5 can be added, so that bulb L_1 will shine more brightly.

..... [1]

39 Fig. 39.1 shows a magnet, a solenoid with an iron core, and two compasses P and Q. Both compasses are placed along the central axis of the magnet and solenoid. The effect of Earth's magnetic field can be neglected and the needles of the two compasses P and Q point in the directions shown.

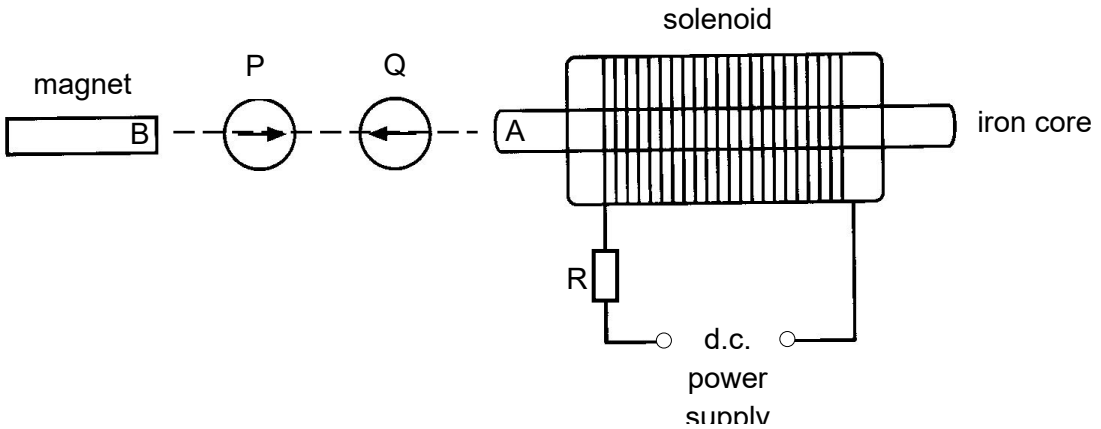


Fig. 39.1

(a) State the polarities of A and B.

polarity of A = ...

polarity of B = ... [1]

(b) On Fig. 39.1, indicate

(i) the null point using a cross 'X', [1]

(ii) the direction of current passing through the resistor R. [1]

(c) State and explain what happens to the position of the null point when the iron core is removed.

.....

.....

[2]

40 A student carries out an experiment using a solenoid and a magnet. He connects the solenoid to a cathode ray oscilloscope (c.r.o.). A magnet is dropped through the solenoid as shown in Fig. 40.1.

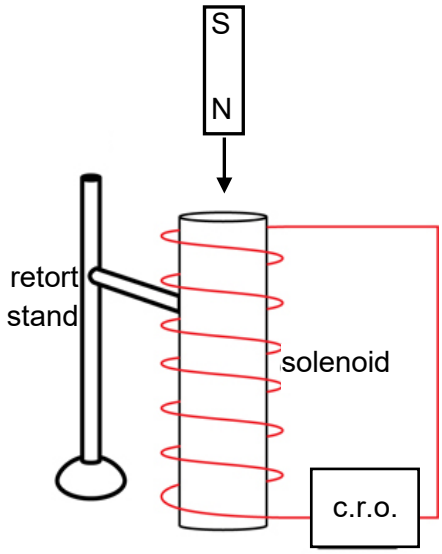


Fig. 40.1

(a) Explain why an e.m.f. is induced across the solenoid.

.....

.....

[1]

(b) State one way to increase the amplitude of the induced e.m.f. across the solenoid.

.....

.....

[1]

(c) On Fig. 40.2, sketch the variation of the induced e.m.f. with time as the magnet falls through the solenoid.

Fig. 40.2 [3]

41 In metallurgy industries, it is a common practice to detect flaws in metals using a non-destructive testing (NDT) method. Fig. 41.1 shows one such NDT method which makes use of ultrasound to detect the flaws in a steel sample by echo sounding. The source and the detector are located at the surface of the steel sample.

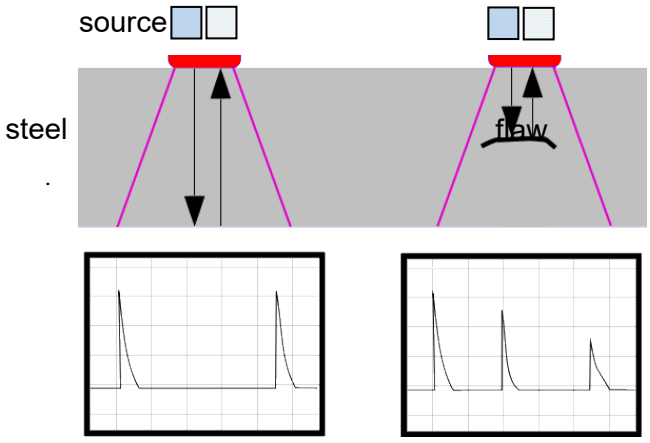


Fig. 41.1

A short pulse of ultrasound of frequency 3.0 x 10^6 Hz is generated at the surface of the steel sample. The velocity v of the pulse in this sample is related to the Young modulus E and the density ρ of the sample by the equation:

$$v = \sqrt{\frac{E}{\rho}}$$

The Young modulus refers to a material constant, and the velocity of ultrasound in steel is 5.0 km s^{-1}.

(a) Deduce the S.I. base unit for the Young modulus E.

S.I. base unit = ... [1]

(b) Given that the density of steel is 8.0×10^3 kg m^{-3}, calculate the

(i) Young modulus E of steel,

E = ... [2]

(ii) wavelength of the ultrasound.

wavelength = ... [2]

(c) Multiple flaws detected using this NDT method can be displayed on a cathode ray oscilloscope (c.r.o.). These peaks displayed on the c.r.o. indicate reflections from flaws or surfaces at different depths in the steel sample, as shown in Fig. 41.2.

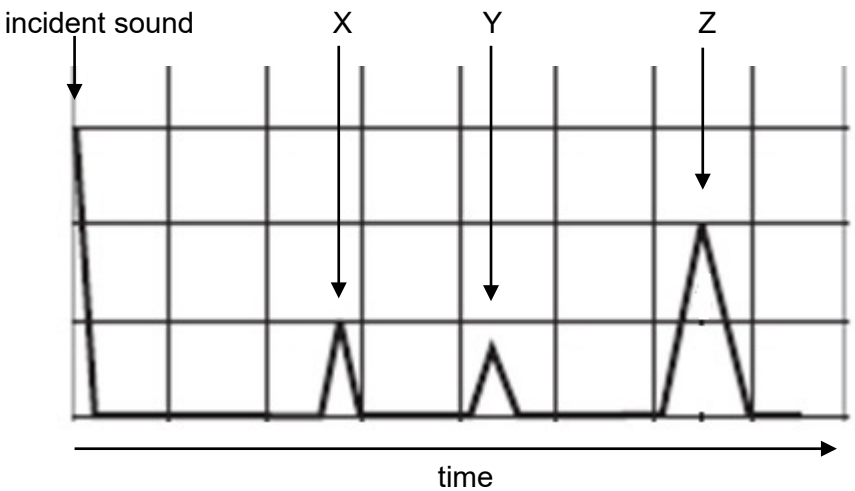


Fig. 41.2

(i) Given that peak Z corresponds to the reflection of the ultrasound at the end of the steel sample and the time-base of the c.r.o. is 0.50 μs / div, calculate the thickness of the steel sample.

thickness = ... [2]

(ii) Describe two changes that can make peaks X and Y taller.

.....

..... [2]

(d) Fig. 41.3 shows another steel sample to be examined.

If a highly penetrative source is used instead of ultrasound, sketch and label on Fig. 41.3 the position of

(i) the source,

(ii) the detector. [1]

Fig. 41.3

END OF PAPER