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PHYSICS 0625/41

Paper 4 Theory (Extended) **October/November 2024**

1 hour 15 minutes

You must answer on the question paper.

No additional materials are needed.

INSTRUCTIONS

- Answer **all** questions.
- Use a black or dark blue pen. You may use an HB pencil for any diagrams or graphs.
- Write your name, centre number and candidate number in the boxes at the top of the page.
- Write your answer to each question in the space provided.
- Do **not** use an erasable pen or correction fluid.
- Do **not** write on any bar codes.
- You may use a calculator.
- You should show all your working and use appropriate units.
- Take the weight of 1.0 kg to be 9.8 N (acceleration of free fall = 9.8 m/s^2).

INFORMATION

- The total mark for this paper is 80.
- The number of marks for each question or part question is shown in brackets [ ].

This document has **20** pages. Any blank pages are indicated.

DC (CE/CB) 336627/3

1 A spring is suspended from a clamp. Fig. 1.1 shows a pointer attached to the lower end of the spring.

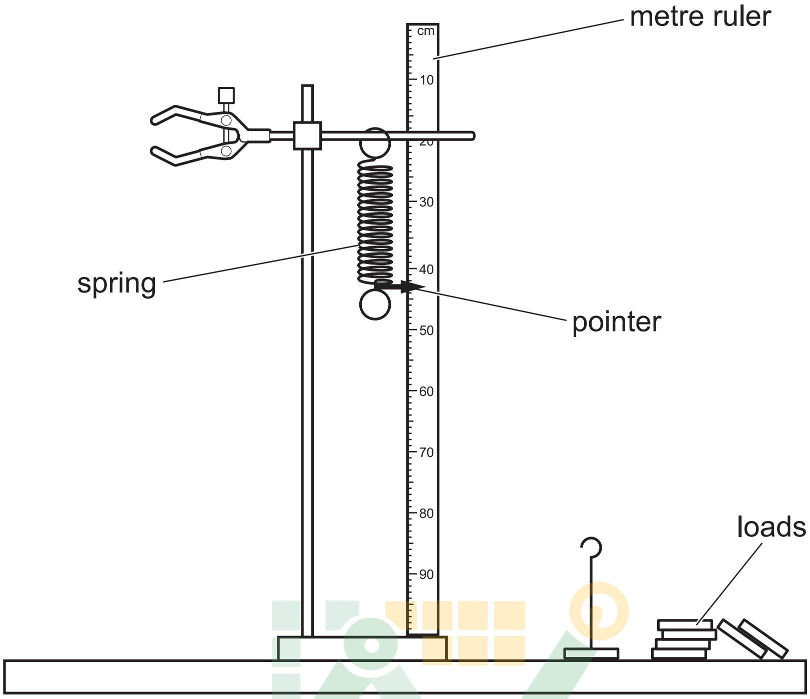


Fig. 1.1

A student suspends loads of different weights from the spring and records the readings on the metre ruler.

Fig. 1.2 is the reading–weight graph that the student obtains.

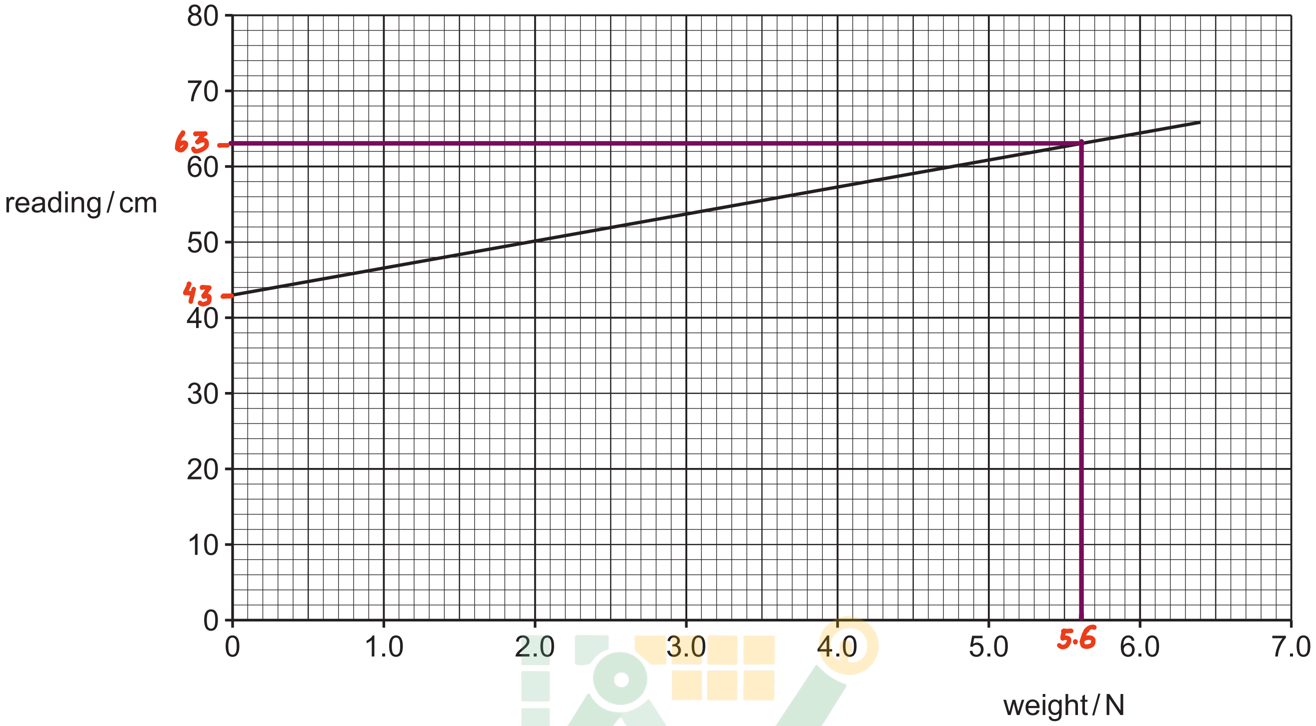


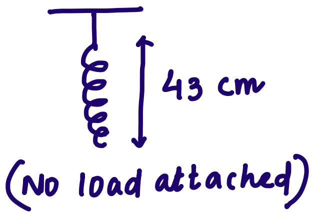
Fig. 1.2

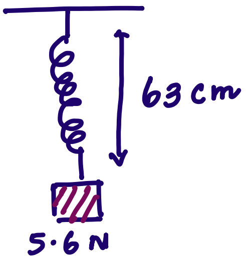
(a) **(i)** Using Fig. 1.2, determine the reading on the metre ruler when

1. no weight is attached to the spring ....43 cm........

2. a weight of 5.6 N is attached to the spring ....63 cm........ [1]

(ii) Calculate the **extension** of the spring when the weight attached is 5.6 N.





63 cm – 43 cm

extension = ...20 cm........ [1]

(b) Using the values found in **(a)**, calculate the spring constant of the spring.

Spring Constant   Extension of the string

$$F = K x$$

$$K = \frac{F}{x} = \frac{5.6\ N}{20\ cm}$$

spring constant = ...0·28 N/cm........ [2]

(c) An object of mass 0.50 kg is attached to the spring.

(i) Calculate the weight of the object.

weight →

$$W = m \times g$$

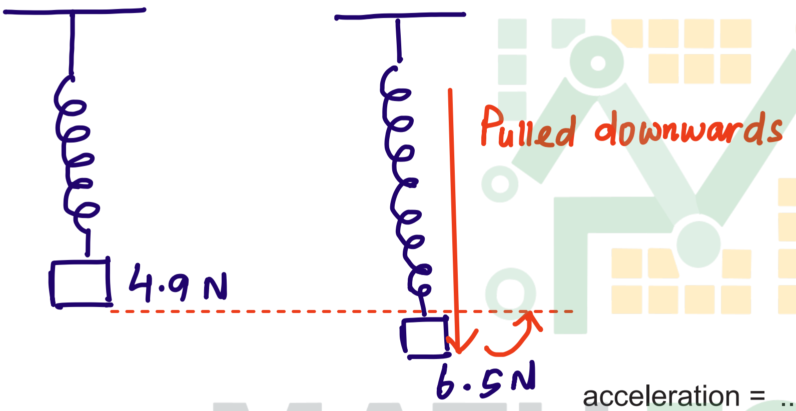
$$W = 0.5\ \text{kg} \times 9.8\ \text{m/s}^2$$

weight = ...4.9 N.... [1]

(ii) The object is pulled downwards until the tension in the spring is 6.5 N.

The object is released.

Calculate the acceleration of the object immediately after it is released.



$$F = m \times a$$

$$a = \frac{F}{m}$$

$$a = \frac{1.6\ \text{N}}{0.5\ \text{kg}}$$

acceleration = ...3.2 m/s².... [3]

[Total: 8]

Force applied to pull the string downwards: 6.5 − 4.9 = 1.6 N

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2 A drag car is a racing car that is powered by a rocket engine.

u=0

A drag car accelerates uniformly from rest until it reaches the finishing line. The engine is then switched off and a parachute opens. The car decelerates until it stops.

Fig. 2.1 shows a drag car decelerating after a race.

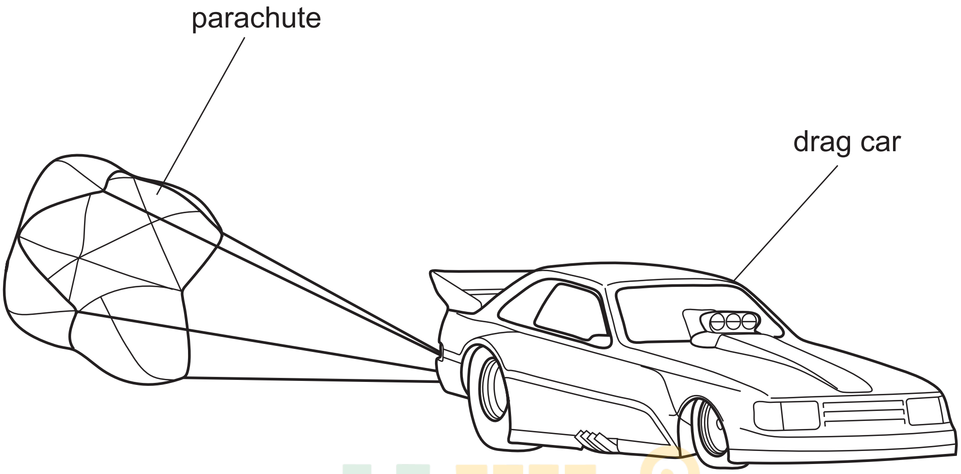


Fig. 2.1

This drag car has a mass of 1400 kg.

Fig. 2.2 is the speed–time graph for the car during a race on a straight horizontal track.

NOTE :

Gradient = Acceleration

Area = Distance Travelled

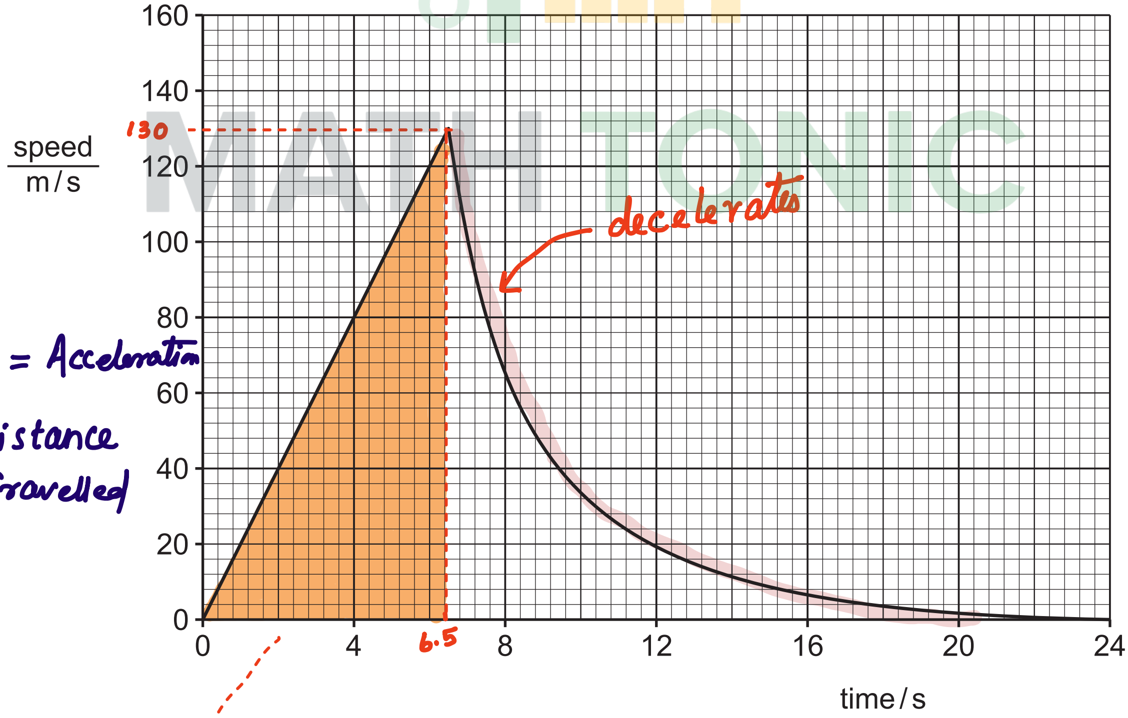


Fig. 2.2

The car reaches its maximum speed of 130 m/s at a time of 6.5 s.

To find the maximum momentum we have to take maximum velocity (mass is const.)

(a) (i) Calculate the maximum momentum of the car during the race.

$$\uparrow \underset{(\text{maximum})}{\text{Momentum}} = \text{mass} \times \underset{(\text{maximum})}{\text{Velocity}} \uparrow$$

$$= 1400\text{ kg} \times 130\text{ m/s}$$

$$\underset{(\text{max.})}{\text{momentum}} = 182000\text{ kg m/s}$$

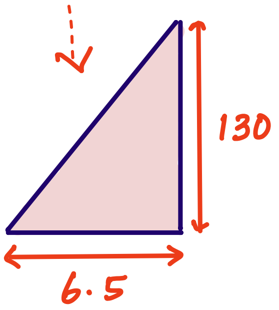
maximum momentum = 1.8×10^5 kg m/s [2]

(ii) State the feature of Fig. 2.2 that represents the distance travelled by the car.

Area under the graph

[1]

(iii) Determine the distance travelled by the car in the first 6.5 s.



$$\text{Area} = \tfrac{1}{2} \times \text{base} \times \text{height}$$

$$= \tfrac{1}{2} \times 6.5 \times 130$$

$$= 422.5\text{ m}$$

distance = 422.5 m ≃ 420 m (2 sf) [2]

(b) The parachute opens at 6.5 s and the car decelerates.

Describe how Fig. 2.2 shows that, after 6.5 s:

(i) the car decelerates

Negative gradient

[1]

(ii) the deceleration of the car is **not** constant.

Gradient is changing.

[1]

(c) Describe the energy transfer that takes place as the car slows down.

Kinetic energy decreases and transfers to thermal Energy.

[2]

(Hence usually the tyre and the car remain hot)

[Total: 9]

3 **(a)** Define the moment of a force and describe the effect that it measures.

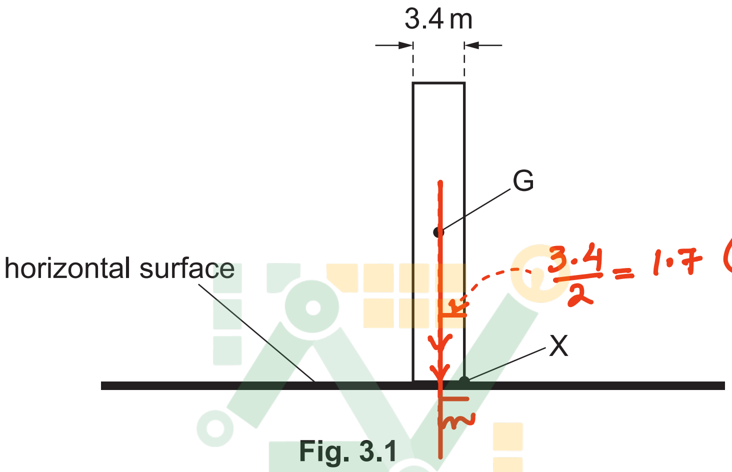
Moment of a force = force × Perpendicular distance from pivot.

It measures its turning effect

[3]

Please check 1.5.2 (Turning effect of forces) – 1, 2

(b) A large rectangular block of stone has a square base of side 3.4 m. Fig. 3.1 shows the block at rest on a horizontal surface.



$\frac{3.4}{2} = 1.7$ (Perpendicular distance from Pivot)

Fig. 3.1

The block is of uniform density and the centre of gravity G is at its centre.

(i) Explain what is meant by centre of gravity.

It is the point on an object where its weight appears to act through

[1]

(ii) The weight of the block is 1.3×10^7 N.

Calculate the moment of the weight of the block about corner X.

moment = force × Perpendicular distance from Pivot

$= 1.3 \times 10^7$ N × 1.7 m
(weight)

= 22 100 000 Nm

moment of weight = 2.21×10^7 Nm [2]

(c) The block shown in Fig. 3.1 is in equilibrium.

State the **two** different conditions that apply when an object is in equilibrium.

1 No resultant force

2 No resultant moment

[2]

Please check: 1.5.2 Turning effect of forces - 4

[Total: 8]

4 **(a)** Describe an experiment to determine the specific heat capacity of aluminium. You may draw a diagram.

Include in your answer:

- the measurements made
- any equations needed.

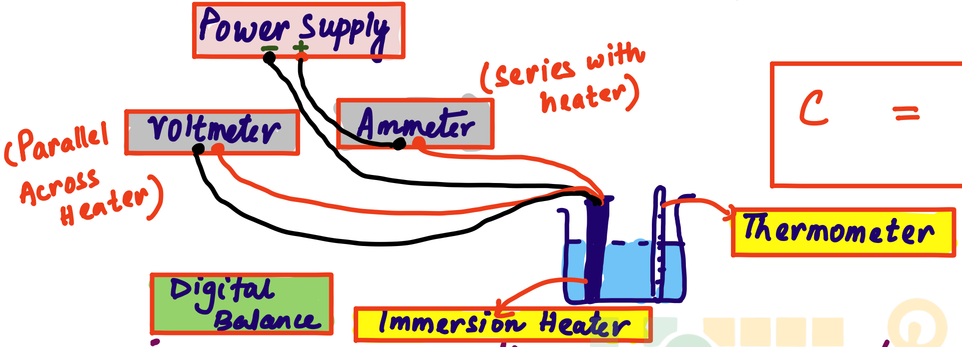
$E = \text{mass} \times \text{Specific heat capacity} \times \text{Change in Temperature}$

(Energy)

$$\text{Specific heat Capacity } (c) = \frac{\text{Energy } (E)}{\text{mass } (m) \times \text{Change in Temp. } (\theta)}$$

$$\boxed{c = \frac{E}{m\theta}}$$

Diagram (Optional)



i. Measure the mass of the aluminium block

ii. Record the initial and final temperature of water for 10 minutes.

iii. Calculate the Energy transfer by using: $E = V \times I \times t$

iv. Now use the formula: $c = \frac{E}{m\theta}$ to calculate specific heat capacity. [4]

(b) An aluminium dish is initially at room temperature. Boiling water is poured into the aluminium dish as shown in Fig. 4.1.

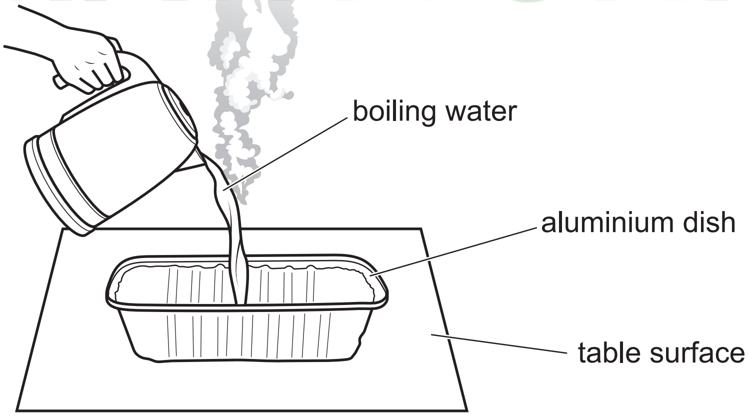


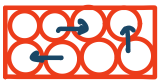
Fig. 4.1

(i) Explain why, after a short time, the dish and the water are the same temperature.

There is transfer of energy from the boiling water (higher temperature) to the dish (lower temperature) by Conduction until net transfer of energy is zero.

[3]

(ii) Explain, in terms of its particles, why the aluminium expands as the boiling water is poured into the dish.



solid particles are tightly packed.

The particles gains Kinetic energy when temperature increases. Therefore, the particles start to move further from each other.

[2]

(iii) The water in the dish evaporates.

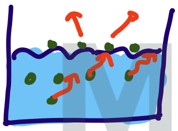
Explain, in terms of the water molecules, what is meant by evaporation.

The particles with more energy escapes the Surface of the liquid.

[2]

Please check 2.2.3 Melting Boiling Evaporation - 4.

[Total: 11]



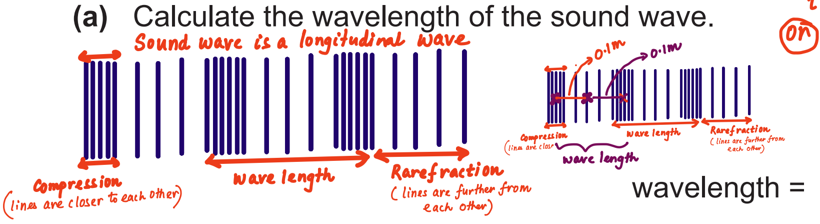
NOTE:

Evaporation is when particles in the liquid which has more energy will rise up to the surface. with enough energy they will escape the Surface to become gas.

5 A loudspeaker produces a sound wave in air. The distance between the centre of a compression and the centre of a neighbouring rarefaction is 0.10 m.

A complete wave length is distance between two compression.
or
from a Centre of rarefraction to next Centre of rarefraction.
$0.1 \times 2 = 0.2\,m$

(a) Calculate the wavelength of the sound wave.



wavelength = 0.2 m [1]

(b) State a typical value for the speed of sound in air.

330 m/s ~ 350 m/s [1]

Please check 3.4 Sound - 5

(c) **(i)** Calculate the frequency of the sound from the loudspeaker.

Speed = frequeny x wave length

$$v = f \times \lambda$$

$$f = \frac{v}{\lambda} = \frac{330\,m/s}{0.2\,m} = 1650\,Hz$$

frequency = 1650 Hz ~ 1700 Hz (2sf) [2]

(ii) Explain whether the sound from the loudspeaker is audible to a human with normal hearing.

Yes as it is within the audible range of 20 Hz to 20000 Hz.

[1]

Please Check 3.4 Sound - 3.

(d) Another loudspeaker produces a sound of wavelength 0.40 m. Sound from the loudspeaker reaches a sound absorbing surface with a gap of width 0.80 m at the centre.

Fig. 5.1 shows the arrangement.

Gap < wave length
More difraction

Here Gap = 0.80 m
wave length = 0.40 m
So, Gap > wavelength
(0.8) (0.4)
Less difraction

Gap > wavelength
Less diffraction

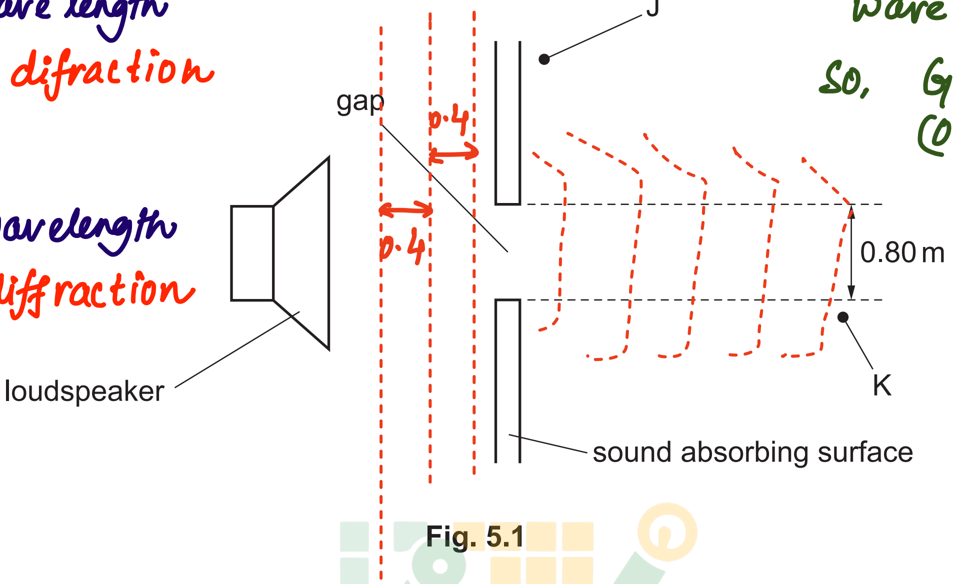


Fig. 5.1

Explain whether it is possible to detect sound from the loudspeaker at either point J or at point K.

point J No sound heard because gap is larger than wavelength, hence less diffraction and point J is far away.

point K Sound detected as the wave length is smaller than gap, hence due to less difraction and point K is very much closer.

[4]

[Total: 9]

6 A potential divider is made by connecting a light-dependent resistor (LDR) and a thermistor in series. Fig. 6.1 shows the potential divider, a voltmeter and a direct current (d.c.) power supply connected into a circuit.

	Series	Parallel
Current	Same	Split
Voltage	Split	Same

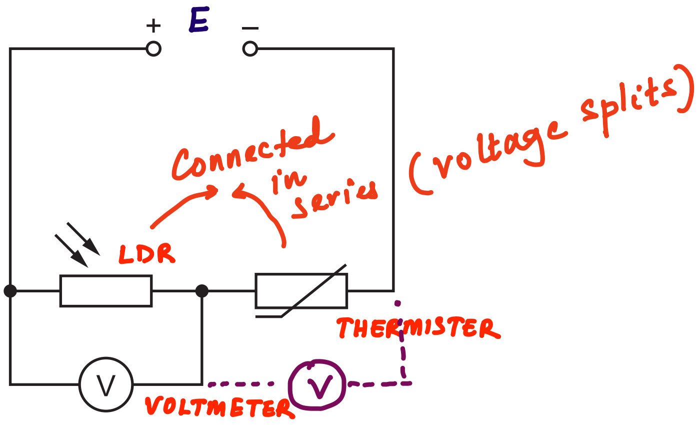


Fig. 6.1

The voltmeter measures the potential difference (p.d.) across the LDR.

(a) Define potential difference (p.d.).

The work done by a unit charge passing through a component.

[2]

Please check 4.2.3 → 3

(b) The electromotive force (e.m.f.) of the supply is *E*.

Describe how the p.d. across the thermistor can be determined using the reading on the voltmeter.

E — voltmeter reading of LDR

[1]

(c) The resistance of the LDR decreases and the resistance of the thermistor increases.

(i) State what has happened to the light intensity incident on the LDR and the temperature of the thermistor.

intensity of incident light on LDR: Increased

temperature of thermistor: Decreased

[1]

(ii) Explain what happens to the reading on the voltmeter.

According to formula of Potential divider:

$$\boxed{\frac{R_{LDR}}{R_{Total}} = \frac{V_{LDR}}{V_{total}}}$$

EMf is constant. If the Resistance of LDR decreases it will have Smaller proportion from the total resistance of the Circuit producing a smaller proportion of emf.

[3]

[Total: 7]

Notes:

4 types of resistor

1. fixed Resistor (fixed Resistance)
2. Variable Resistor (Resistance can vary)
3. Thermistor (A variable resistor, which resistance changes according to heat)
4. LDR (Light Dependent Resistor)

(A varaible resistor, resistance changes according to light)

Light intensity (↑) R (↓)

Light intensity (↓) R (↑)

Light intensity inversly Propotinal to R in LDR

LDR receives light, it doesnot emit light.

Temp (↑) R (↓)

Temp (↓) R (↑)

Ⓣ Inversely Proportinal to Ⓡ for Thermistor

7 A solid bar is inside a copper solenoid. Fig. 7.1 shows that the copper solenoid is connected in series with a battery and a variable resistor.

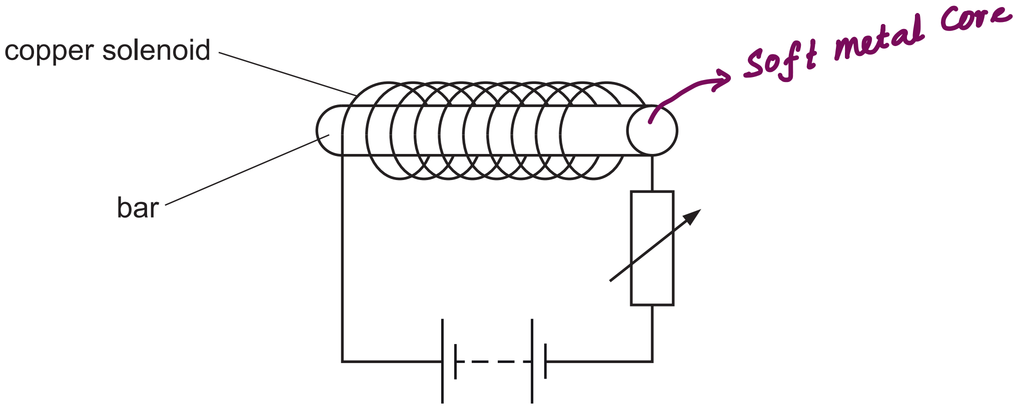


Fig. 7.1

The device shown in Fig. 7.1 is an electromagnet.

(a) Suggest a suitable material for the bar.

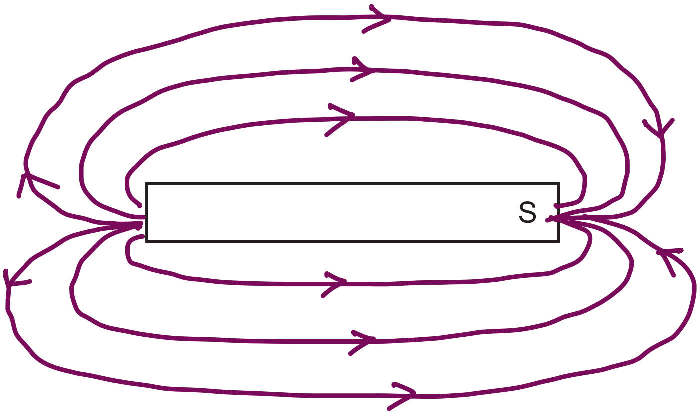
Soft Iron (As it is a temporary magnet, it can loose magnetism easily) [1]

(b) The right-hand end of the bar is the S pole.

(i) Fig. 7.2 shows the bar viewed from above.

On Fig. 7.2, draw at least six field lines to show the pattern and direction of the magnetic field surrounding the bar.

magnetic field lines always travel out of the North pole and Enters the South pole.



You should not have any lines overlapping each other.

Fig. 7.2

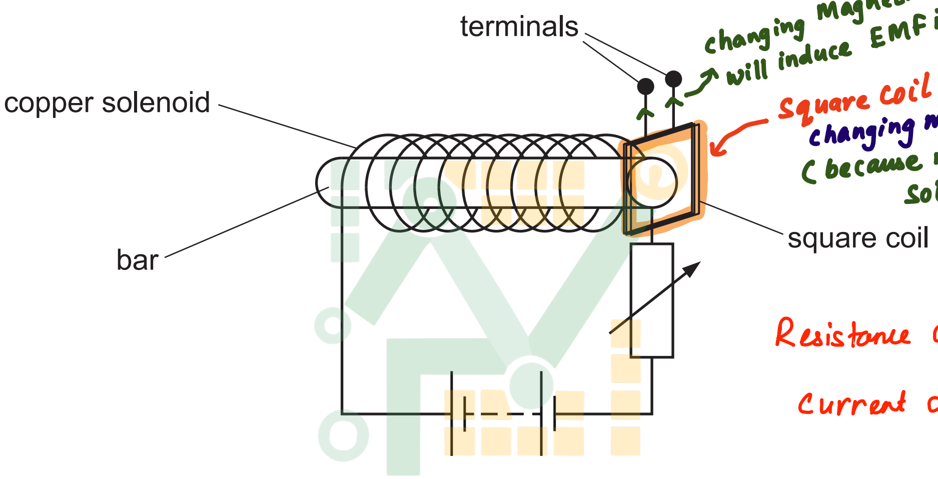
[3]

(ii) The resistance of the variable resistor increases.

Explain what happens to the magnetic field surrounding the bar and state how the pattern of field lines that represents the field changes.

Current in the Coil decreases, therefore the magnetic field strength decreases. Field lines appear further from each other. (because of weak magnetic field strength) [3]

(c) A square coil of many turns is placed close to the bar. Fig. 7.3 shows the plane of the square coil parallel to the flat circular surface at the right-hand end of the bar.



changing magnetic flux will induce EMF in square coil

square coil will experience a changing magnetic flux (because magnetic field in copper solenoid changes)

Resistance $\propto \frac{1}{\text{current}}$

current $\propto$ magnetic field strength

R ↑ I ↓ mf ↓

R ↓ I ↑ mf ↑

Fig. 7.3

The resistance of the variable resistor is alternately increased and decreased.

Explain what happens in the wires of the square coil.

changing resistance causes current to change through Solenoid. Therefore the magnetic field around the Solenoid changes too. The square coil experiences a changing magnetic flux that can induce Electromotive force (EMF) [3]

[Total: 10]

8 The nuclide notation for the radioactive isotope carbon-14 is $^{14}_{6}C$.

(a) Using the symbols shown in Fig. 8.1, draw a diagram to show the number of electrons, neutrons and protons in a neutral atom of carbon-14 and how they are arranged.

$^{14}_{6}C$ = 6 protons, 6 electrons

8 neutrons

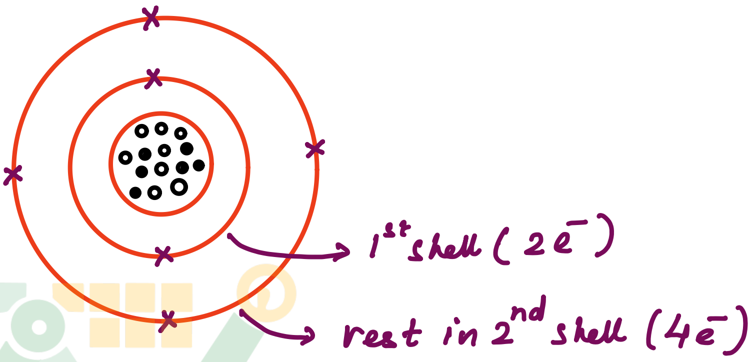
14−6 = 8

symbols:

electron ×

neutron ○

proton ●



Nucleon = Proton + Neutron } Inside nucleus

$^{14}_{6}C$

Proton

Fig. 8.1

[3]

(b) Describe how the composition of a neutral atom of carbon-14 is different from the composition of a neutral atom of nitrogen-14 ($^{14}_{7}N$).

Carbon has one more neutron and nitrogen has one more proton. [2]

	Proton	Neutron
$^{14}_{6}C$	6	8 (14−6)
$^{14}_{7}N$	7	7 (14−7)

(c) Carbon-14 decays by beta (β) emission.

$^{-1}_{0}\beta$

(i) State the name of a particle that is identical to a beta-particle.

Electron [1]

(ii) Describe the change that takes place in carbon-14 as a beta-particle is emitted.

A neutron changes into proton and electron

[1]

(d) The half-life of carbon-14 is 5700 years.

A very old object is made of wood. It contains 1.2×10^{11} atoms of carbon-14. When it was manufactured, it contained 9.6×10^{11} atoms of carbon-14.

Determine the time that has passed since it was manufactured.

$$\boxed{9.6 \times 10^{11} \text{ atoms}} \xrightarrow{①} \boxed{4.8 \times 10^{11} \text{ atoms}} \xrightarrow{②} \boxed{2.4 \times 10^{11} \text{ atoms}} \xrightarrow{③} \boxed{1.2 \times 10^{11} \text{ atoms}}$$

5700 years × 3 = 17100 years

time passed = 17000 years (2 sf) [3]

[Total: 10]

9 The Milky Way is the galaxy in which the Solar System is located.

(a) State what a galaxy is.

Group of billions of stars [1]

Please check 6.2.2 → 1

(b) The Milky Way has a diameter that is approximately equal to 100 000 light-years.

Determine this distance in kilometres (km).

1 Light Year = 9.5×10^{15} m

100 000 Light Years = $9.5 \times 10^{15} \times 10^{5}$ m

= 9.5×10^{20} m

9.5×10^{20} m

9.5×10^{17} km) ÷ 1000

distance = 9.5×10^{17} km [2]

(c) Astronomers determine the speed and distance from the Earth of a far galaxy that is moving away from the Earth.

(i) State **one** observation that allows the speed at which a galaxy is moving away to be determined.

The increase in wavelength of Electromagnetic radiation emmited by a galaxy. [1]

(ii) State **one** different observation that is used to determine the distance to a far galaxy.

Brightness of Supernova [1]

(iii) State how the speeds of galaxies and their distances from the Earth are related.

The farther the galaxy is, the faster the speed is
(Speed and distance are directly proportional) [1]

(iv) The best estimate for the Hubble constant H_0 is 2.2×10^{-18} per second.

Use this value to calculate an estimate for the age of the Universe.

formula: Age of universe $= \frac{1}{H_0} = \frac{1}{2.2 \times 10^{-18}}$

age of the Universe = 4.5×10^{17} s [2]

[Total: 8]