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CANDIDATE NAME

CENTRE NUMBER

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PHYSICS **0625/41**

Paper 4 Theory (Extended) **May/June 2022**

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 10 N (acceleration of free fall = 10 m/s^2).

$g = 9.81\ m/s^2$

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 **16** pages.

DC (LK/SW) 214895/1

[Turn over

1 A car of mass *m* is travelling along a straight, horizontal road at a constant speed *v*.

At time $t = 0$, the driver of the car sees an obstruction in the road ahead of the car and applies the brakes.

The car does **not** begin to decelerate at $t = 0$.

(a) Explain what is meant by deceleration.

decrease in velocity

– change in velocity per unit time $a = \frac{v-u}{t}$

– negative acceleration. [2]

u = 10 m/s
v = 2 m/s
v − u = 2 − 10
= −8/t

(b) Suggest **one** reason why the car does **not** begin to decelerate at $t = 0$.

– There is a reaction time between seeing the

obstacle and applying the brakes. [1]

(c) Fig. 1.1 is the distance–time graph for the car from $t = 0$.

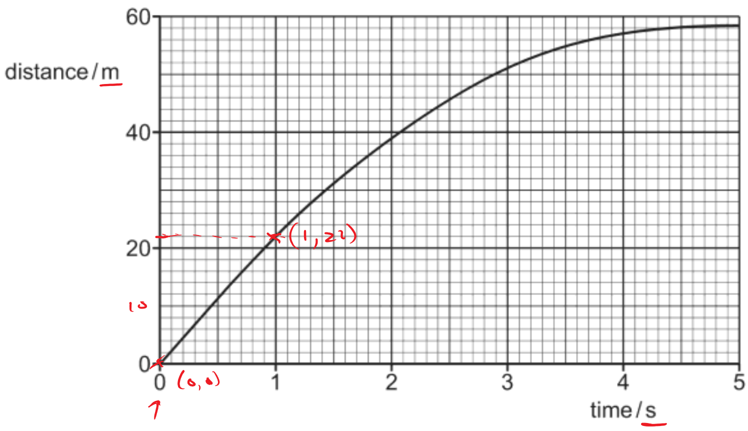


Fig. 1.1

(i) State the property of a distance–time graph that corresponds to speed.

Gradient / Slope of the graph [1]

(ii) Using Fig. 1.1, determine the initial speed *v* of the car.

Gradient $= \frac{\Delta y}{\Delta x}$

$= \frac{22-0}{1-0}$

$= \frac{22}{1}$

$= 22$ m/s

v = 22 m/s [2]

(d) When the car is decelerating, there is a constant resistive force F on the car due to the brakes.

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

The deceleration of the car is greater than $\frac{F}{m}$ and is **not** constant.

Explain why:

(i) the deceleration of the car is greater than $\frac{F}{m}$

air resistance acting on the car to oppose motion.

[1]

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

$-2\,m/s^2 \rightarrow 1.8\,m/s^2 \rightarrow 1.2\,m/s^2$

- the air resistance decreases as the speed of the car decrease
- Resistive force changes.

[2]

[Total: 9]

2 Fig. 2.1 shows water stored in a reservoir behind a hydroelectric dam.

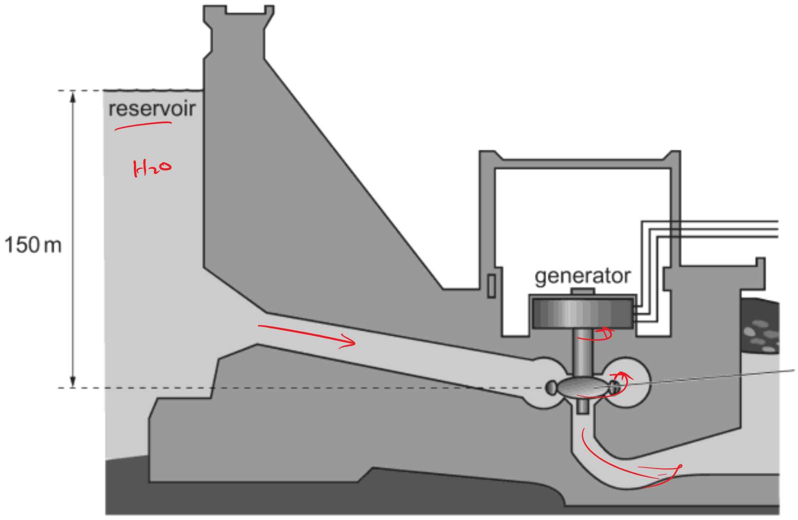


Fig. 2.1 (not to scale)

(a) State the form of the energy stored in the water in the reservoir that is used to generate electricity.

g.p.e .... [1]

(b) The turbine is 150 m below the level of the water in the reservoir.

Atmospheric pressure is 1.0×10^5 Pa. The density of water is 1000 kg/m^3.

(i) Calculate the total pressure in the water at the turbine.

P_T = atm. pressure + $\rho g h$

$= (1.0 \times 10^5) + (1000 \times 10 \times 150)$

= 100,000 Pa + 1500,000

= 1600,000 Pa

$= 1.6 \times 10^6$ Pa

pressure = 1.6×10^6 Pa .... [3]

(ii) The turbine has a cross-sectional area of $3.5\,m^2$.

Calculate the force exerted on the turbine by the water.

$P = \frac{F}{A}$

$F = P \times A$

$= 1.6 \times 10^6 \frac{N}{m^2} \times 3.5\,m^2$

$= 5600000\,N$

$5.6 \times 10^6\,N$

force = $5.6 \times 10^6\,N$ [2]

(c) The water flows to the turbine through a pipe of constant cross-sectional area.

Explain why the kinetic energy of the water in the pipe remains constant as it flows through the pipe.

$K.E = \frac{1}{2}mv^2$

– Speed of water remains constant

– Amount of water entering the pipe is also

the amount leaving the pipe at time [2]

[Total: 8]

3 During a picnic on a warm, dry day, a metal can of lemonade is wrapped in a damp cloth.

Evaporation cools the water in the cloth.

(a) Explain, in terms of molecules, how evaporation cools the water in the cloth.

– Faster, more energetic molecules escape into air.
– Molecules left behind have less K.E
– Less K.E means less temperature and so has a cooling effect [3]

(b) As the water in the cloth cools, so does the lemonade.

Explain how electrons transfer thermal energy through the metal of the can.

– Vibrating atoms hit electrons propell them through the metal can.
– The distant atoms will be hit the moving electrons [3]

[Total: 6]

4 A thermocouple is a device that is used as a thermometer.

(a) Fig. 4.1 shows a beaker that contains molten sulfur at an initial temperature greater than 400 °C.

(i) On Fig. 4.1, sketch and label a diagram of a thermocouple that is used to determine the temperature of the sulfur as it cools to room temperature.

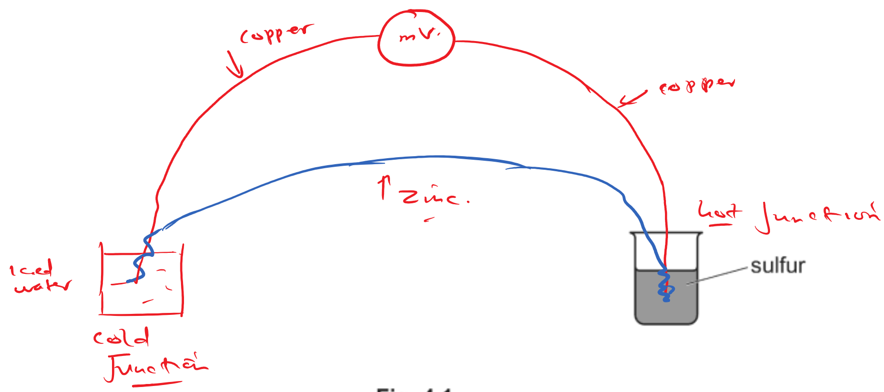


Fig. 4.1

[4]

(ii) Describe briefly how the temperature of the sulfur in the beaker is deduced.

– measure the p.d

– convert the p.d to temperature, by use of

callibration graph. [2]

(b) State **one** advantage of using a thermocouple to measure temperature rather than using a liquid-in-glass thermometer.

– measures high temperature

– rapid response [1]

– direct input to computer

[Total: 7]

5 Fig. 5.1 shows a kitchen tap that supplies instant boiling water.

Fig. 5.1

Cold water passes over an electric immersion heater inside the tap.

The boiling point of water is 100 °C.

(a) State what is meant by boiling point.

temperature at which a liquid changes to gas ....

.... [2]

(b) The immersion heater is powered by the mains at a voltage of 230 V. When the tap is opened, the heater switches on and the current in the heater is 13 A.

(i) Calculate the thermal energy produced by the heater in 60 s.

$E = V \times I \times t$

$= 230 \times 13 \times 60$

$= 179\,400\ J$

$\approx 180\,000\ J$

$= 1.8 \times 10^5\ J$

thermal energy = ... 1.8×10^5 J ...... [2]

(ii) The specific heat capacity of water is 4200 J / (kg °C). The cold water that enters the tap is at 22 °C.

Calculate the rate at which water at its boiling point emerges from the tap.

kg/s

$\Delta T = 100 - 22$

$= 78\ °C$

$E = m C \Delta T$

$m = \frac{E}{c\ \Delta T}$

$m = \frac{1.8 \times 10^5}{4200 \times 78}$

$= 0.54945\ kg$

rate $= \frac{0.54945\ kg}{60\ s}$

$= 0.0091575\ kg/s$

$= 9.2 \times 10^{-3}\ kg/s$

rate = ... 9.2×10^{-3} kg/s ...... [4]

(c) The metal tap is earthed and there is a fuse in the cable that connects the heater to the mains.

1. Explain how the earth wire protects the user.

- If the tap becomes live, the current will be chanelled to Earth by the Earth wire

2. Explain how the fuse protects the circuit.

the large current will in the live through the fuse, and so the fuse melt, disconnecting the circuit

[3]

[Total: 11]

6 Fig. 6.1 shows a road next to the sea.

Fig. 6.1

– conduction
– convection
– radiation

(a) On a sunny day, the Sun warms the road.

Describe how energy from the Sun reaches the Earth and warms the road.

– Energy is transferred through radiation

– The road absorb the radiant energy

– Radiation is by Infrared, EM wave.

.... [3]

(b) The temperature of the road is greater than the temperature of the sea.

The surface of the road is black.

Suggest **one** reason why the temperature of the road is greater than that of the sea.

– Black is a good absorber of radiant heat

– Sea is poor absorber of radiation. [1]

(c) The air above the road is heated by the warm road.

(i) Describe how this affects the molecules of the air.

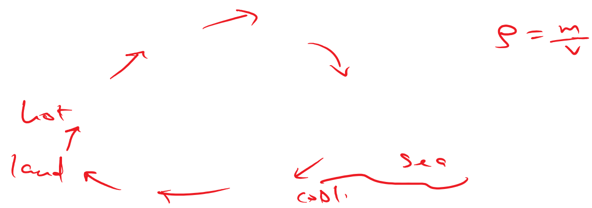
– Molecules gain heat and K.E increases. This will

increase the Speed of the molecules

– They will move further apart due expansion. [2]

(ii) A cyclist travelling along the road notices that a cool breeze is blowing from the sea to the land.

Explain how convection produces this breeze. You may include a diagram if it helps your answer.



– density of hot decreases, so it rises up.
– air above the road is hot, less density, so it rises. The air above the sea is cool more dense and therefore takes place of the rising hot air.
[3]

[Total: 9]

7 Fig. 7.1 is a full-scale diagram of a small nail N in front of a thin converging lens. The line L represents the lens.

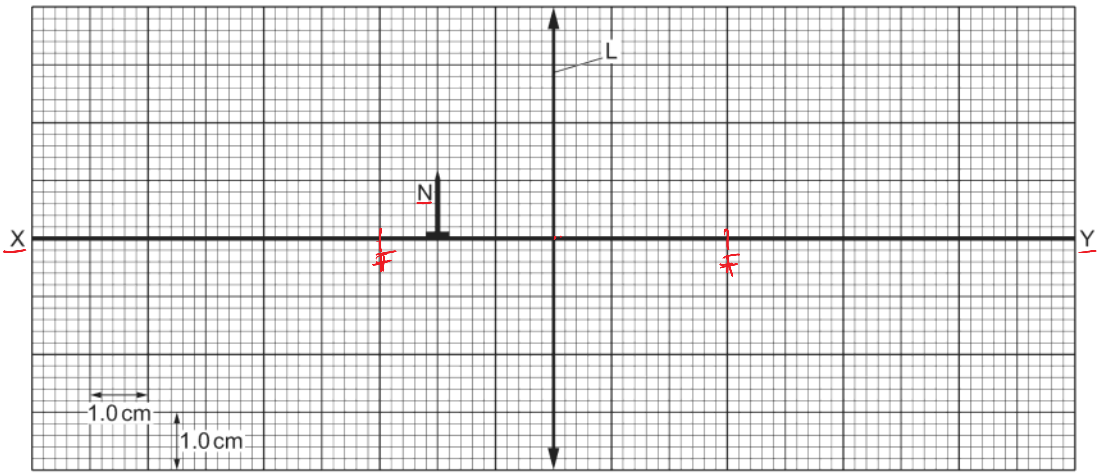


Fig. 7.1 (full scale)

The focal length of the lens is 3.0 cm.

(a) Rays of light, parallel to XY, are travelling towards the lens.

Describe what happens to the light after it passes through the lens.

— All the rays will converge at the focal point

— Then will appear to spread out from the

focal point.

.... [3]

(b) On Fig. 7.1, mark and label with an F each of the **two** principal focuses of the lens. [1]

(c) The small nail N, of height 1.2 cm, is positioned 2.0 cm to the left of the lens.

(i) By drawing on Fig. 7.1, find the position of the image I of N and add image I to the diagram. [3]

(ii) State and explain whether I is a real or a virtual image.

— Virtual Image.

— No real rays intersect to form image [1]

(iii) State the name given to a lens when it is used in this way.

Magnifying ~~Lense~~ glass. [1]

[Total: 9]

8 Fig. 8.1 shows two vertical, cylindrical tubes and a cylindrical magnet all held in a vacuum.

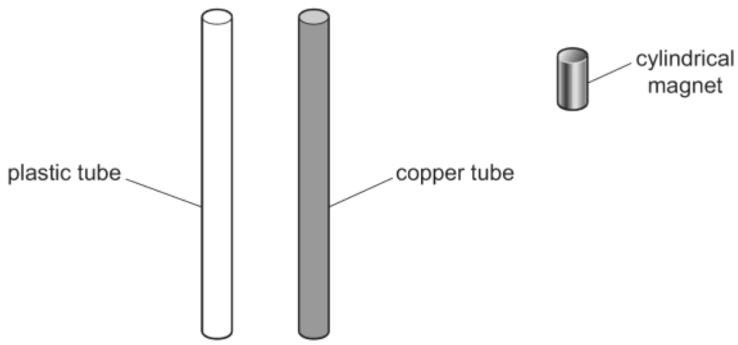


Fig. 8.1 (not to scale)

One tube is made of plastic and the other tube is made of copper. The two cylindrical tubes have identical dimensions.

The magnetic field of the small, cylindrical magnet is extremely strong.

Initially, the magnet is at rest at the top of the plastic tube.

The magnet is released and it falls through the plastic tube without experiencing a resistive force. The magnet takes 0.67 s to fall to the lower end of the plastic tube.

(a) The mass of the magnet is 0.012 kg.

Calculate the kinetic energy of the magnet when it reaches the lower end of the plastic tube.

kinetic energy = ...0·27 J.......... [4]

(b) The magnet is then held at the top of the copper tube and released. As it falls through the copper tube, an electric current is generated in the copper.

(i) Explain why there is a current in the copper.

– There is a changing magnetic field in copper tube

– This induces e.m.f in copper tube

.... [2]

Lenzs law

(ii) The current in the copper produces a magnetic field of its own in the tube.

The magnet falls much more slowly in the copper tube than in the plastic tube.

Explain why the magnet falls more slowly in the copper tube.

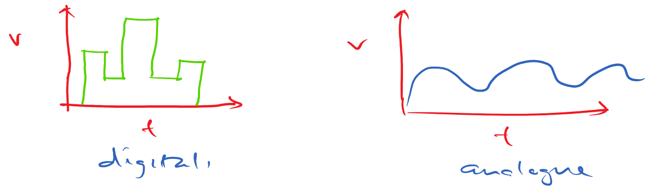
– An upward force is produced by the magnetic field due to current. This force opposes the magnet – and slows it down.

[2]

[Total: 8]

9 Combinations of logic gates are used when digital signals are processed.

(a) Describe the difference between a digital signal and an analogue signal. You may include a diagram if it helps your answer.



- A digital signal consists of 1's and 0's (high value - 1, low value - 0)

- Analogue is continuously variation in magnitude

.... [2]

(b) Fig. 9.1 is the truth table for a logic gate X.

input A	input B	output
0	0	1
0	1	0
1	0	0
1	1	0

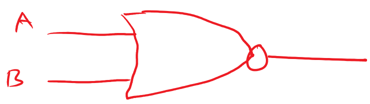
NOR gate

Fig. 9.1

State the name of logic gate X and draw the symbol that represents it.

name NOR gate

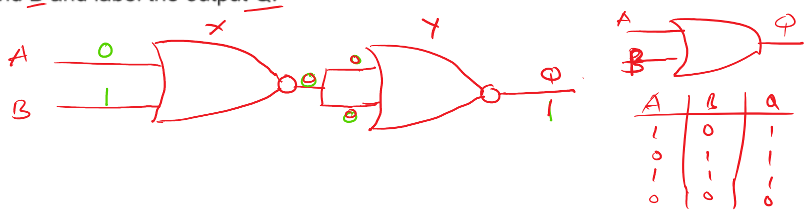
symbol



[1]

(c) Logic gate Y is identical to logic gate X.

Draw a combination of logic gates X and Y that behaves like an OR gate. Label the inputs A and B and label the output Q.



[2]

[Total: 5]

10 Two of the isotopes of hydrogen are hydrogen-2 ($^{2}_{1}H$) and hydrogen-3 ($^{3}_{1}H$).

(a) **(i)** State **one** similarity in the composition of their nuclei.

Both have only 1 proton. .... [1]

(ii) Describe how a nucleus of hydrogen-3 differs from a nucleus of hydrogen-2.

— H-3 has 2 neutrons while H-2 has ....

only one neutron. .... [2]

(b) In a nuclear fusion reactor, a nucleus of hydrogen-2 fuses with a nucleus of hydrogen-3 at an extremely high temperature. This fusion reaction produces an isotope of element X and releases a neutron.

(i) Explain why an extremely high temperature is needed when forcing these two nuclei together.

proton — +ve   +ve + +ve → repel.

— High temp will increase the K.E of nuclei

and increase the ability to overcome the

repulsion of two protons in the ~~new~~ nuclei

— Like charge repel .... [3]

(ii) Using nuclide notation, complete the equation for this reaction.

$$^{2}_{1}H + ^{3}_{1}H \longrightarrow ^{4}_{2}X + ^{1}_{0}n$$

[2]

$^{4}_{2}He$

[Total: 8]