OVERMUGGED O LEVEL MOCK PAPER 2021
SECONDARY 4 EXPRESS
SECONDARY 5 NORMAL ACADEMIC

PURE PHYSICS **6091/02**
PAPER 2 **September 2021**
1 hour 45 mins

INSTRUCTIONS TO CANDIDATES

Write in dark blue or black pen.
You may use an HB pencil for 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 **all** questions, the last question is in the form either/or.
Write your answers in the spaces provided on the Question Paper.

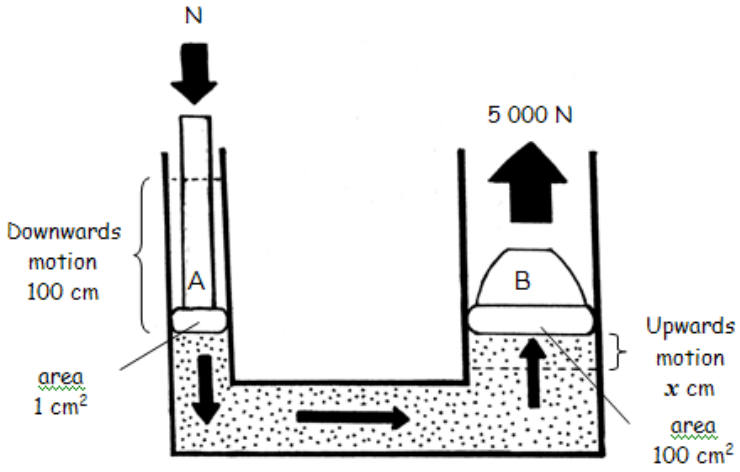
Electronic calculators may be used.

You are advised to spend no longer than one hour on Section A and no longer than 45 minutes on Section B.
The number of mark is given in brackets [ ] at the end of each question or part question.

**Questions in this mock paper may contain adapted questions from the Ten Year Series and Prelim Papers from various schools in Singapore.*

Section A

1. A hydraulic system multiplies the effort so a small effort can be used to lift a much greater load. Object B has a weight of 5000N.



a) **State 3 difference** between **mass and weight.** [2]

- Mass is defined as the amount of substance in an object/body while weight is a measure of the gravitational force acting on an object due to the gravitational field.
- Unit for mass is kg while unit for weight is N.
- Mass is a scalar quantity while weight is a vector quantity.
- Mass is constant & is not affected by gravity while weight is dependent on the gravitational field.
- Mass is measured using a beam balance, lever balance, electronic balance while weight is measured using a spring balance

b) **Calculate the force acting on A.** [2]

$$P = \frac{F_1}{A_1} = \frac{F_2}{A_2}$$

$F_A / A_A = F_B / A_B \rightarrow F_A = 50N$

c) **Calculate distance x.** [2]

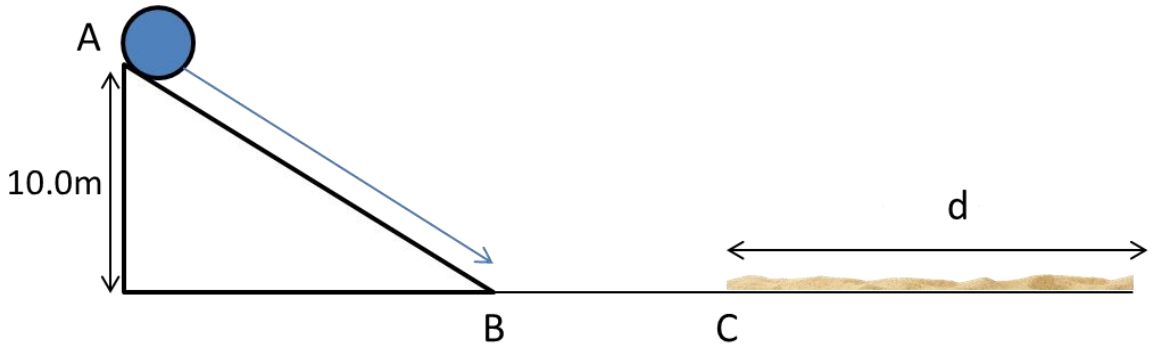
$$WD = F_1 d_1 = F_2 d_2$$

$F_A d_A = F_B d_x \rightarrow d_x = 1.0cm$

d) Assuming that there were bubbles inside the fluid, **predict and explain** whether the value of x will increase, decrease or remain the same. [2]

d_x will decrease as the pressure exerted will cause the gas to be compressed; volume of the gas will decrease, causing distance x to move a shorter distance.

2. A ball with unknown mass x kg travels down a **frictionless slope**, from point A to point B.



a) **State** the '**Principle of Conservation of Energy'.** [1]

The principle of conservation of energy states that energy cannot be created or destroyed but can only change from one form to another or transferred from one body to another but the total amount of energy in the system remains constant.

b) State the conversion of energy as the ball rolls from point A to point B. [1]

GPE to KE

c) Determine the **speed of the ball** when it reaches **point B**. [2]

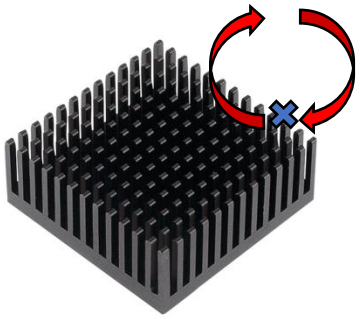
$mgh = ½ mv^2$
$v = \sqrt{2gh}$
$v = 14.1 ms^{-1}$

d) The ball then travels along a frictionless surface from B to C before entering a **sand pit with frictional force of 60N**.

Assuming the **ball travels 5.5m before coming to a stop**; determine the **mass of the ball**. [2]

$mgh = ½ mv^2$ = Work done against friction = F x d
(m)(10)(10) = 60N x 5.5m
m = 3.3kg

3. A computer processor produces heat energy that is dissipated by heat sinks with black metal fins.



a) **State two differences between conduction and convection.** [2]

Conduction occurs in solid, liquid & gas while convection only occurs in liquid & gas (fluids) only.
Conduction is faster in Solid > Liquid > Gas while Convection is faster in Gas > Liquid.

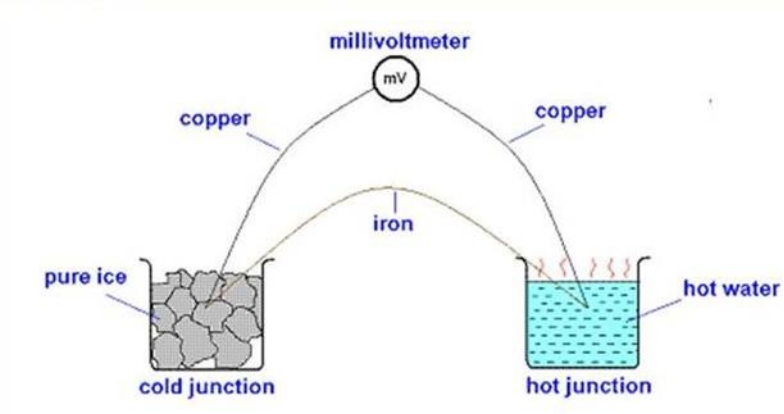
b) **State how the design of the black metal fins helps to dissipate heat efficiently.** [3]

Heat transfer	**Explanation**
Conduction	The fin is made of metal which is a good conductor of heat, hence conducting heat away efficiently.
Convection	The vertical design allows the movement of air between the fins and convection currents can be set-up, transferring more heat away.
Radiation	Black is a good emitter of radiation, hence heat energy can be emitted away faster.

c) Refer to the 'x' on the diagram above. **Draw** the **convection current** that will be formed and **explain how convection current works**. [2]

The hot air near the metal fins rises as it expands and becomes less dense, while the cooler and denser air at the top sinks. The cooler air now gets heated up and rises, resulting in a continuous convection current.

4. The following diagram shows a thermocouple.



a) **State the thermometric property used for a thermocouple.** [1]

Electromotive force

b) The thermocouple shows a reading of **2.50V** when placed in pure ice and hot boiling water. When the hot junction is taken out and placed in another solution, the reading dropped to **1.5V**. Determine the **temperature of the new solution**. [2]

2.5V = k(100-0)
k = 0.025
1.5V = 0.025 (x-0)
x = 60°C

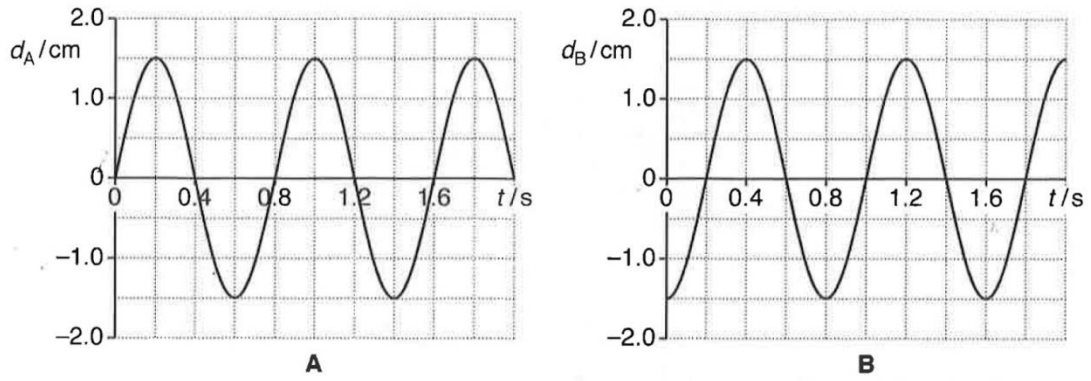
c) The hot junction is now placed back into the boiling hot water and the **cold junction** is moved to **another liquid at -150°C**. **Determine** the **new reading** on the thermocouple. [2]

x = 0.025 [100-(-150)]
x = 6.25V

d) State **two advantages** of a thermocouple. [2]

- Measure over a wide range of temperatures from -200°C to 1700°C
- Able to measure the temperature at a point as the wire junctions is small
- Able to measure rapid changes due to its quick response (small mass and low heat capacity)

5. A wave travels along a rope from left to right. Two points on the rope, point A and point B displayed the following waveforms.



a) **State** the **amplitude** of the wave in its **SI unit**. [1]

0.015m

b) **Define** the term '**period of a wave**'. [1]

Time taken for any given point on the wave to move a distance of one wavelength; the time taken to generate one complete wave.

c) Determine the **frequency** of the wave. [1]

f = 1/0.8s = 1.25 Hz

d) **Point B** is **50 cm** to the right of **Point A**.

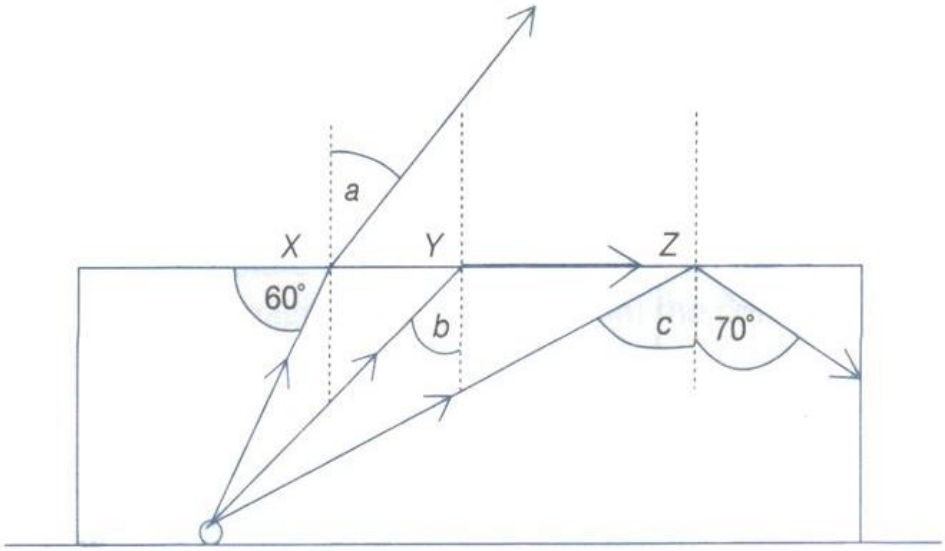
Explain, with working clearly shown, why the **speed of the wave is 250 cm/s**. [2]

Based on the diagram, point A and B are ¼ wavelength apart.
Hence, one wavelength = 50cm x 4 = 200cm
speed = frequency x wavelength = 200 x 1.25 = 250cm /s

e) **Explain** why the speed of the waves could be **other values** as well, not just 250 cm/s. [1]

Besides T/4, it can be 1.25T or 2.25 T etc. Hence the speed can be other values.

6. The diagram below shows how light bends went it goes through a block of glass. The **refractive index of the glass is 1.5**.



a) Calculate the value of **a**. [1]

n = sin i / sin r
1.5 = sin a / sin 30 = 48.6°

b) Calculate the value of **b**. [1]

n = 1 / sin c
c = 41.8 °

c) State the **two conditions** for the ray to behave in such a manner at point Z. [2]

Light ray must be travelling from optically denser medium to an optically less dense medium and angle of incidence must be greater than the critical angle.

d) State the value of c. [1]

70 °

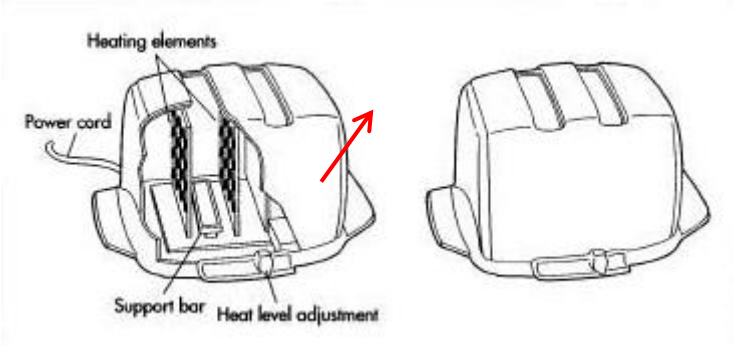
e) Diamond has a **higher refractive index** than glass. Predict how the **value of b** will change. [1]

Value of b will lower.

f) Name **one application** of the phenomenon at point Z and **explain how it works**. [2]

Optic fibres are made of glass and transmit light from one point to another. The light ray entering the pipe does not exit but is constantly undergoing total internal reflection until it reaches the other end of the fibre.

7. A toaster is used to make bread taste crispier. It typically contains a heating element.



The appliance is set up with a fuse and **other safety precautions** as well.

a) Name **two other safety features** the toaster should have and how it protects the user. [2]

Three pin plug/ earth wire. Prevents electric shock in case the live wire touches the metal case - providing a path for charges to travel from the metal casing to the ground.

Insulation casing (made of plastic for eg), to prevent current carrying wire & metal parts from being in direct contact with users.

b) The toaster has a **power rating of 900W** and is connected to a 240V main supply. Calculate the **current it draws**. [1]

P = VI
I = 3.75A

c) Suggest a **suitable fuse rating** and **explain** how the fuse works. [2]

5A. When **current slightly above fuse rating** passes through, fuse **melts and breaks** the circuit.

d) The toaster also experiences power loss in the form of thermal energy when current flows through the wire.

Assuming the power loss has to be capped at 40W, what is the **maximum resistance** the wire can be? [1]

$P = I^2R \rightarrow R = 40 / (3.75)^2 = 2.84\ \Omega$

e) Two toasters are used for 5 minutes daily for 30 days. **Calculate the cost** if one unit of electricity is 15 cents. [2]

Electricity used (per kWh) = 2 x 0.9 x (5/60) x 30 = 4.5kWh
Cost = 4.5 x $0.15 = $0.68 (2sf)

Section B

8. Refer to the extract from an online article below:

The northern lights, or Aurora Borealis, the spectacular cosmic shimmer is caused by powerful electromagnetic waves.

Auroras are in fact caused by interactions between energetic particles from the Sun and the Earth's magnetic field.

Electromagnetic waves transfer energy to electrons, which then hitch a ride toward Earth.

The electrons eventually collide with atoms and molecules in a brilliant light show — the aurora.

a) **Substantiating using information** found in the article, state **two properties of EM waves**. [2]

Transfer energy from one place to another (Electromagnetic waves transfer energy to electrons)
EM waves can travel through vacuum (hitch a ride toward Earth).

b) Deduce a **possible explanation** why the northern lights **appears in a variety of colours** when seen by the human eye. [1]

When the electrons collide with the atoms and molecules, the energy transfer may vary, causing the visible light spectrum to produce colours of differing frequency/wavelength, hence appearing as different colours to the human eye.

c) State **two other EM waves** with **higher frequency** than **visible light**. [1]

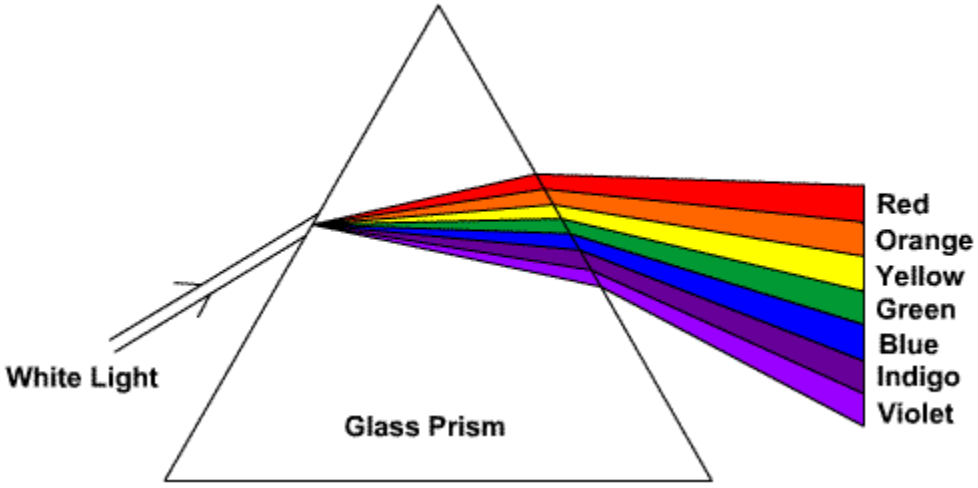
Ultraviolet Ray / X-rays / Gamma rays

d) State the **two uses of the EM waves** mentioned in part c. [2]

Sun lamps & sun beds or Sterilise surgical instruments / Diagnostic tool in medicine and dentistry / Used to kill cancerous cells and sterilise hospital equipment/ Check for flaws in metals

When white light passes through a glass prism, a spectrum of colours can be seen as shown in the diagram below.

This separation of visible light into its different colors is known as '**dispersion of light**'.



e) State and explain how the dispersion of light is achieved. [1]

Light undergoes refraction as they bends as it travels from one medium to another.

f) **Deduce** and **explain** whether **red light or violet light has a greater wavelength**. [3]

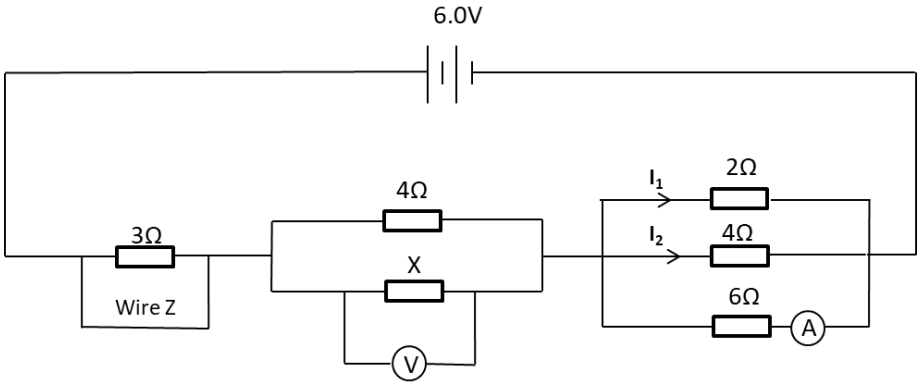
Since $v = f\lambda$, when a colour of smaller wavelength enters the glass prism, the speed of the wave decreases.

Since 'n = speed of light in vacuum / speed of light in medium', the angle of refraction will increases as the wavelength of light decreases,

Shorter wavelengths of light (violet and blue) are slowed down more and consequently experience more bending than do the longer wavelengths (orange and red).

Hence, red light has longer wavelengths.

9. Refer to the circuit diagram below.



a) The ammeter registered a reading of 0.5A. Determine the I_1 & I_2. [2]

V = IR = 6 x 0.5 = 3V
Since voltage is constant in each parallel branch,
I_1 = V/R = 3/2 = 1.5A
I_2 = V/R = 3/4 = 0.75A

b) Find the **total current** of the circuit. [1]

I_{total} = 1.5 + 0.75 + 0.5 = 2.75A

c) Find the **reading on the voltmeter**. [1]

2 parallel circuits in series arrangement. 6V – 3V = 3V
Parallel branches with 4 Ω and X will experience constant voltage of 3V.

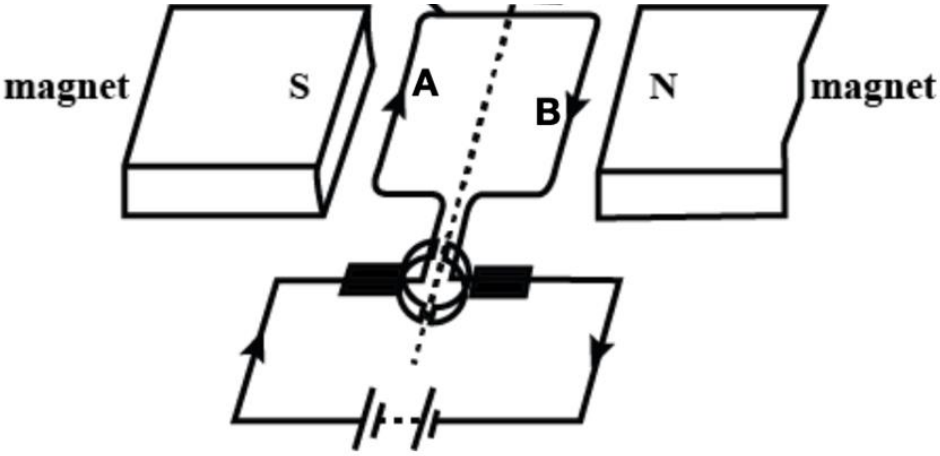
d) Determine the **resistance of X**. [2]

Resistance = 3/2.75 = 12/11 Ω
R_{eff} = 12/11 → 1/ R_{eff} = 11/12 = 1/4 + 1/X
X = 1.5 Ω

e) Wire Z is now removed. Calculate the **new reading in the ammeter**. [2]

Total resistance = 3 + (12/11) x 2 = 5.18 Ω
Total current = 6 / 5.18 = 1.16A
Current in ammeter = 1.16 / (3+1.5+1) = 0.21A

10. The diagram below shows a simple D.C. motor.



a) **Explain** why a **split ring commutator** is required in a D.C motor set-up? [2]

The split ring commutator **allows direction of current to be reversed every half a rotation** to ensure that the coil will continue its **clockwise moment**.

b) **State** and **explain** what is happening at point A and B respectively. [3]

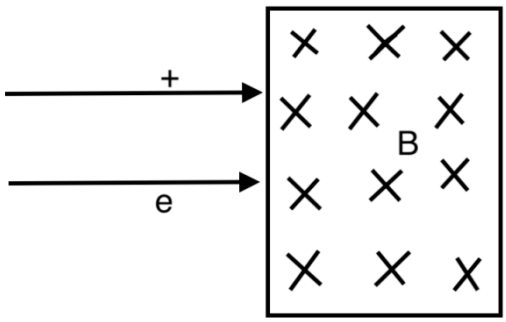
The coil will experience an upward force at A and a downward force at B.

Using Fleming's left hand rule, the **left side of the coil** experiences an **upward force** while the **right hand side of the coil** experiences an equal **downward force**.
Fleming's left hand rule states that if the index finger, middle finger and the thumb of left hand are stretched to be perpendicular to each other, with the **index finger representing the magnetic field**, the **middle finger in the direction of current**, the **thumb will point in the direction of force** experienced by the conductor.

c) **Explain** why the coil does not stop rotating at the vertical point. [1]

The current will be cut off when the coil is not in contact with the split ring commutator but the momentum of the coil will carry it slightly beyond the vertical position.

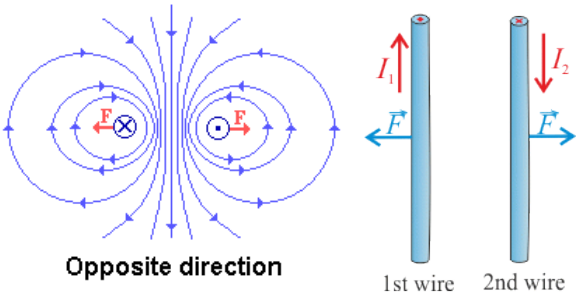
Two streams of parallel positive and negatively charged particles move into the magnetic field as shown in the diagram below.



d) **Describe** what will happen to the **2 stream of particles before** and **after** entering the magnetic field. [2]

Before entering, they will **move away from each other** as two parallel current conductors will experience repulsion if the current is in opposite directions.

After entering, the magnetic field, based on Fleming's left hand rule, the **positively charged stream of particles will deflect to the top** while the **negatively charged stream of particles will deflect to the bottom.**



e) **Draw** the path of the stream of charges if the direction of magnetic field is **reversed.** [2]