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

COMBINED SCIENCE (PHYSICS) **5076/02**
PAPER 2 **September 2021**
1 hour 15 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.

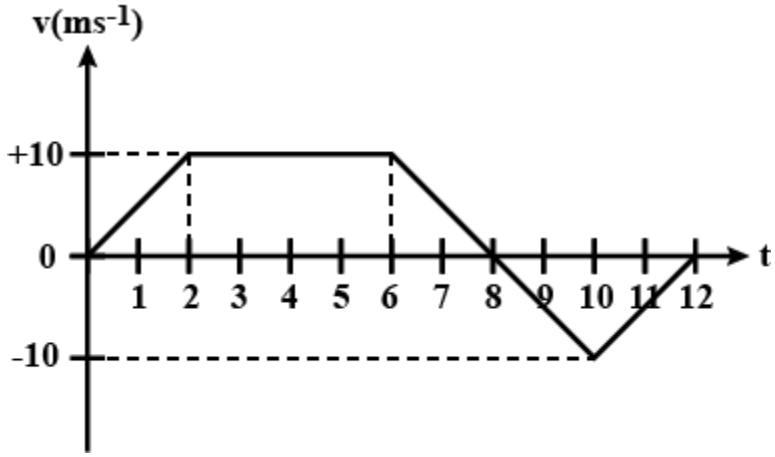
Electronic calculators may be used.

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. Refer to the velocity time graph below.



a) What is the **average speed** of the car over 12s? [2]

Total Distance = Area under graph
= (½ x 2 x 10) + (4 x 10) + (½ x 2 x 10) + (½ x 4 x 10)
= 80m

Average speed = 80m / 12s
= 6.67 ms^{-1}

b) What is the **average velocity** of the car? [2]

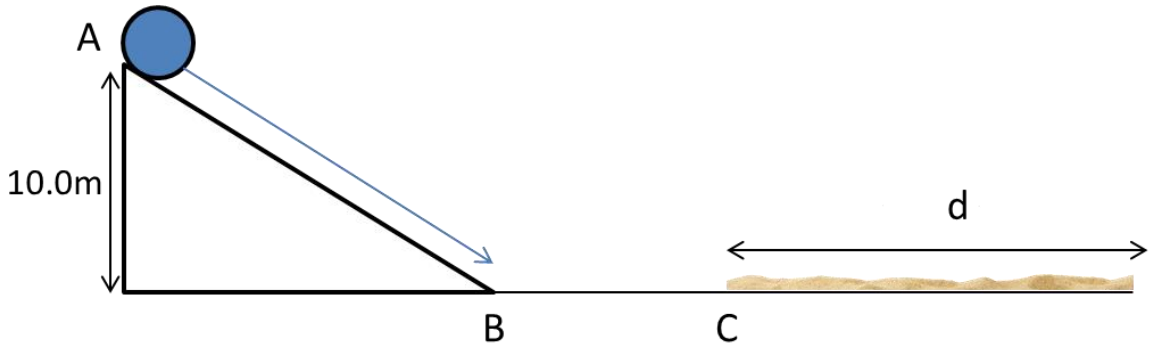
Total Displacement = area under graph
= (½ x 2 x 10) + (4 x 10) + (½ x 2 x 10) - (½ x 4 x10)
= 40m

Average velocity = 40m / 12s
= 3.33 ms^{-1}

c) What is the **instantaneous speed** of the car at 1s? [1]

The instantaneous speed of the car at 1s is 5 ms^{-1} .

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**.

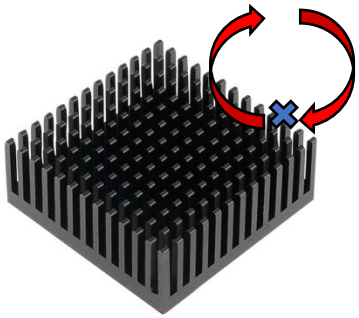
Assuming the **ball travels 5.5m before coming to a stop**; determine the **mass of the ball**. [2]

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

e) State 2 examples when **friction is useful**. [2]

- Friction between the floor & the soles of our shoes prevent us from slipping
- Friction allows us to grip objects
- Friction allows car tyres to have traction and allowing the car to move forward
- Friction allow matchsticks to generate a spark and a flame

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.

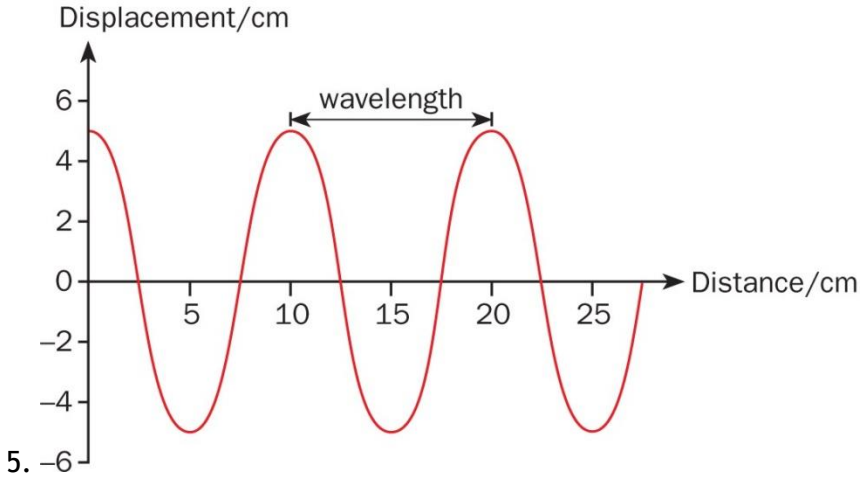
b) **State how the design of the black metal fins helps to dissipate heat efficiently.** [3]

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. Refer to the graph below for wave A.



5.

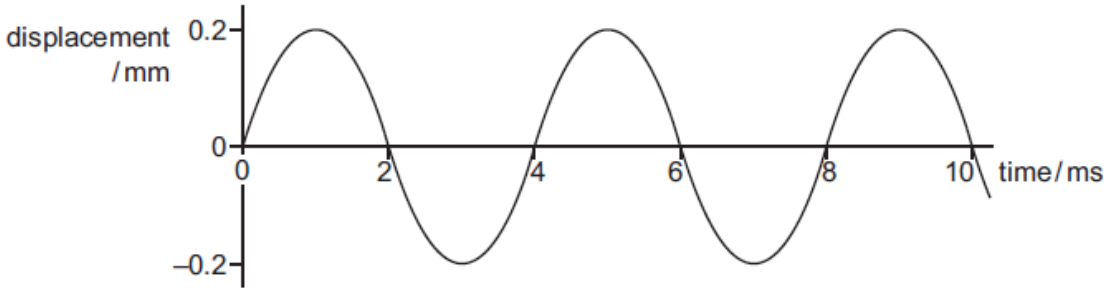
a) What is the **amplitude of wave A?** [1]

Amplitude: **5.0 cm**

b) What is the **wavelength of wave A?** [1]

Wavelength, **λ** = 10 cm

Refer to the graph of wave B.



c) Determine **the period, T, of wave B.** [1]

2.5 waves completed.
Period, **T** = 10ms / 2.5
= **4 ms**

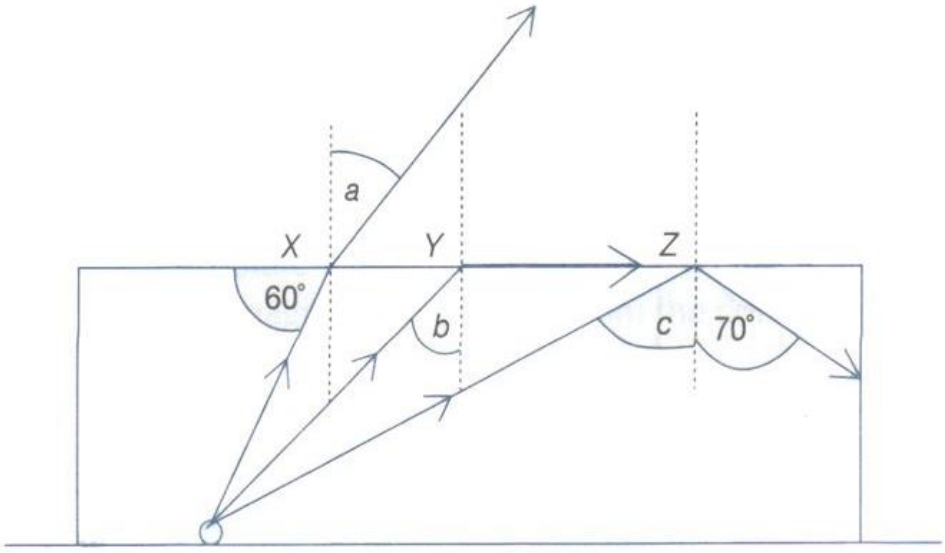
d) Determine **frequency** of **wave B.** [1]

f = 1 / T
= 1 / 4 ms = **250 Hz**

e) Assuming that **wave A's wavelength is twice that of wave B**, determine the **speed of wave B.** [2]

v = fλ; v = 250Hz x (0.1/2) = 12.5m/s

5. 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.

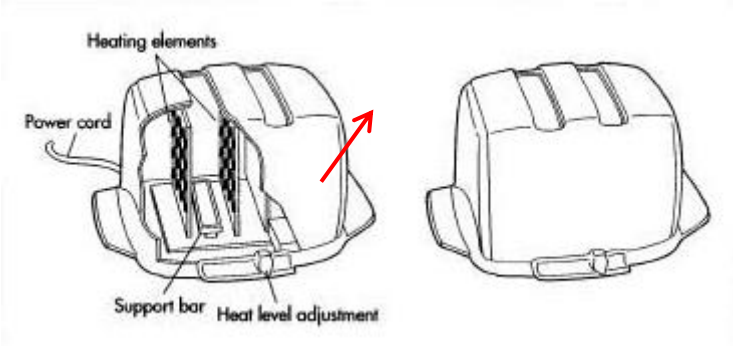
d) State the value of c. [1]

70 °

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

Value of b will lower.

6. 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 the case where 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 = $0.67 (2sf)

Section B

7. 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]

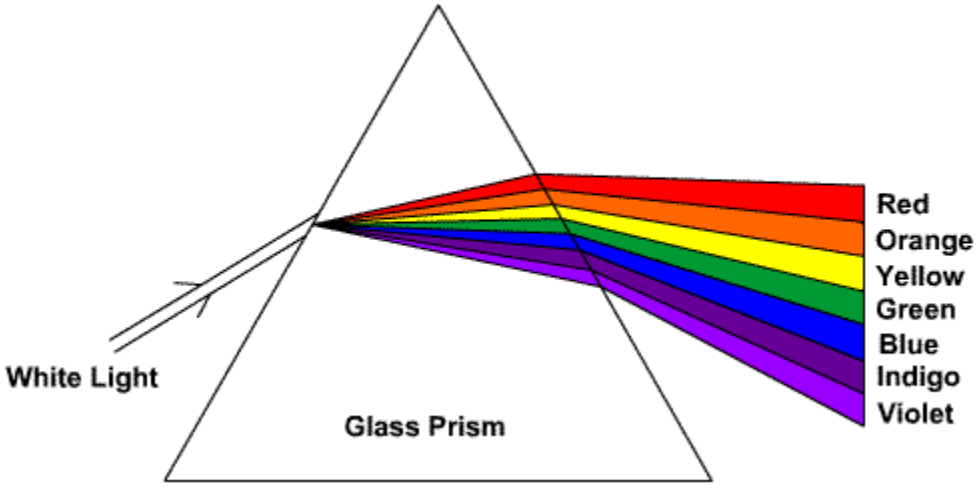
Ultraviolet Ray / X-rays / Gamma rays

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]

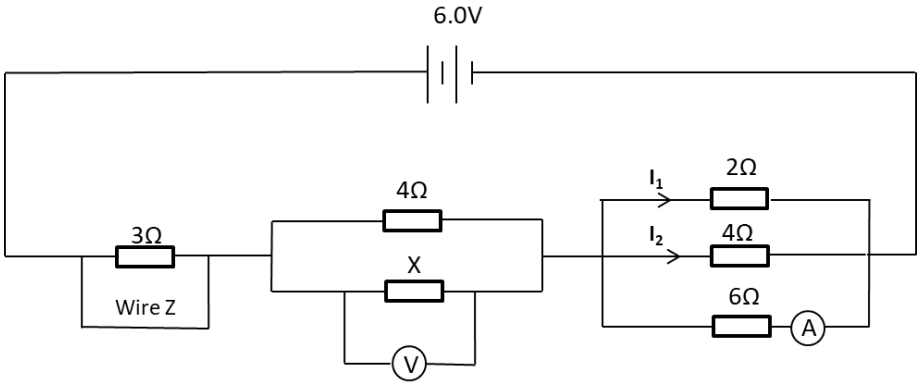
Since $v = f\lambda$, when a colour of smaller wavelength enters the glass prism, the speed of the wave decreases.

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.

8. Refer to the circuit diagram below.



a) Define **current**. [1]

Current is the rate of flow of charges in a circuit.

b) 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

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

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

d) 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.

e) 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

f) Wire Z is now removed. Explain what happens to the current flow in the circuit. [1]

The current in the circuit will now have to pass through the 3 Ω resistor.

g) 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