Candidate Name: _____ **Index No:** ____ **Class:** _____

ZHENGHUA SECONDARY SCHOOL
PRELIMINARY EXAMINATION 2023
SECONDARY FOUR EXPRESS
PHYSICS **6091/02**

Paper 2 Theory

25 August 2023

Candidates answer on the Question Paper.
No Additional Materials are required.

1 hour 45 minutes

READ THESE INSTRUCTIONS FIRST

Write your index number and name on all the work you hand in.
Write in dark blue or black pen.
You may use an HB pencil for any diagrams or graphs.
Do not use staples, paper clips, glue or correction fluid.

Section A
Answer **all** questions.

Section B
Answer **all** questions. Question 12 has a choice of parts to answer.

Candidates are reminded that **all** quantitative answers should include appropriate units.
The use of an approved scientific calculator is expected, where appropriate.
Candidates are advised to show all their working in a clear and orderly manner, as more marks are awarded for sound use of Physics than for correct answers.

The number of marks is given in brackets [ ] at the end of each question or part question.

The total score for this paper is 80 marks.

Name of Setter: Mr Andrew Kan

Section A

Answer **all** the questions in this section.

1 Fig. 1.1 shows how the velocity of a motorcycle varies with time.

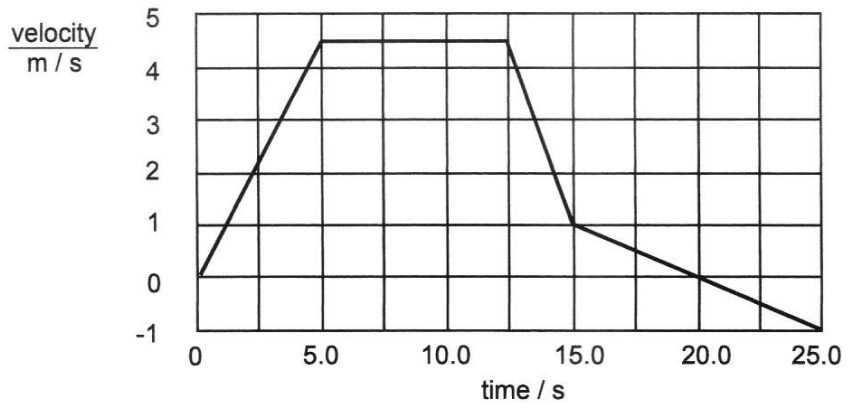


Fig. 1.1

(a) During which time interval are the forces on the motorcycle balanced?

..... [1]

(b) Explain your answer in **(a)** using Newton's laws of motion.

.....

.....

..... [2]

(c) Determine the average velocity of the motorcycle for the first 12.5 seconds.

average velocity = ... [1]

(d) Describe the motion of the motorcycle in terms of acceleration in the last 10 seconds of the journey.

.....

.....

..... [2]

2 Fig. 2.1 shows a block of wood moving at a constant speed down a slope.

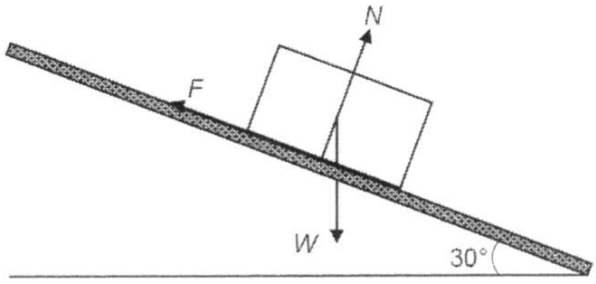


Fig. 2.1

The forces acting on the block are the weight *W* of the block, the normal reaction force *N* exerted by the slope and the friction *F* between the block and the slope.

F is 10.0 N and *N* is 17.4 N.

(a) In the space below, draw a labelled vector diagram to show the resultant of F and N.

Determine the size of the resultant force and the direction between the resultant force and the horizontal ground.

resultant force = ...

direction = ...

[3]

(b) State the weight of the block of wood.

weight = ... [1]

(c) The resultant force in **(a)** and *W* are not a Newton's Third Law action-reaction pair.

Describe the other force that is part of the action-reaction pair with *W* and state its direction.

.....

.....

..... [2]

3 Fig. 3.1 shows the empty container being tilted at an angle θ, pivoting at point P.
Its centre of gravity, C, is located at half its height from its base. The container is just about to topple.

Fig. 3.2 shows a metal weight being placed into the bottom of the container, which is then tilted about P, to the same angle θ.

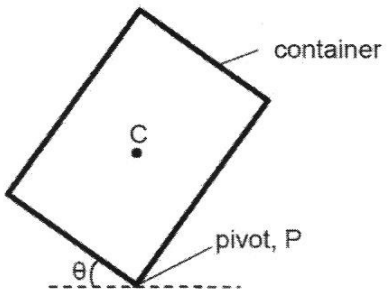


Fig. 3.1

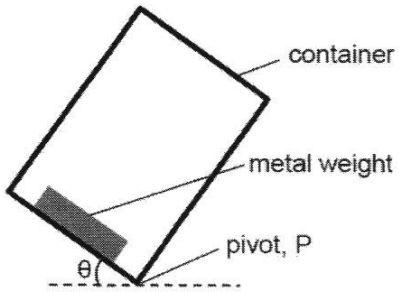


Fig. 3.2

Explain why the container in Fig. 3.2 can now be tilted to a larger angle before it topples.

.....

.....

.....

..... [2]

4 **(a)** An illuminated object is placed 30 cm in front of a convex lens and a sharp image is formed on a screen on the other side of the lens. The image is of the same size as the object.

(i) Is the image real or virtual? Explain your answer.

.....

..... [2]

(ii) Draw a ray diagram to show how the image of the illuminated object is formed. [3]

(iii) Hence, or otherwise, determine the focal length of the lens.

focal length = ... [1]

(b) A ray of light in air strikes a liquid surface at an angle of incidence 30°.The angle of refraction is 22.6°.

Given that the speed of light in vacuum is 3.0×10^8 m/s, calculate the speed of light as it travels through the liquid

speed of light =..... [2]

5 Fig. 5.1 shows a filament lamp. As current passes through the thin filament wire, the wire heats up and glows brightly.

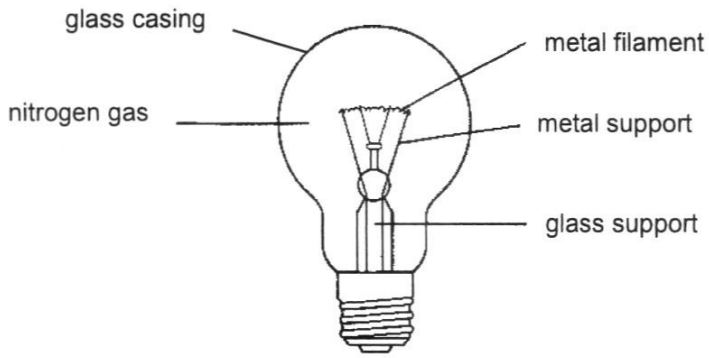


Fig. 5.1

(a) The glass casing is found to be hot after the lamp is used for several minutes. Briefly explain how heat from the filament wire reaches the glass casing.

.....

.....

.....

.....

..... [3]

(b) The filament lamp is found to be emitting electromagnetic waves.

(i) List two such electromagnetic waves emitted by the lamp.

..... [2]

(ii) State a property of electromagnetic waves that distinguishes them from all other type of waves.

..... [1]

6 Fig. 6.1 shows a torch that does not use batteries.

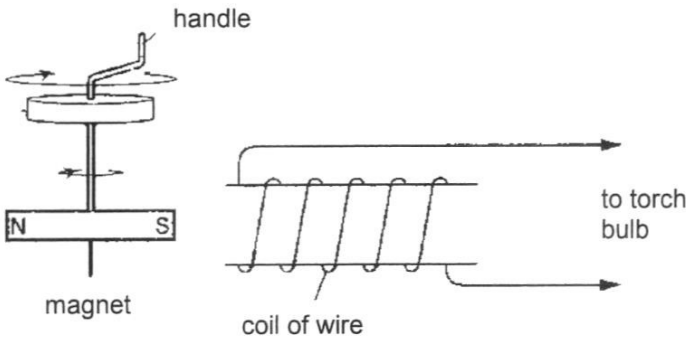


Fig. 6.1

To use the torch, the handle is turned to rotate a magnet near a coil of wire. This will illuminate the torch bulb.

(a) Explain why the torch bulb is illuminated when the magnet rotates.

.....

.....

.....

.....

.....

..... [3]

(b) The magnet takes 0.20 s to make one complete revolution.

Sketch a voltage-time graph on Fig. 6.2 to show how the induced e.m.f varies with time when the magnet is rotated through one revolution.

Label the period of the waveform in Fig. 6.2.

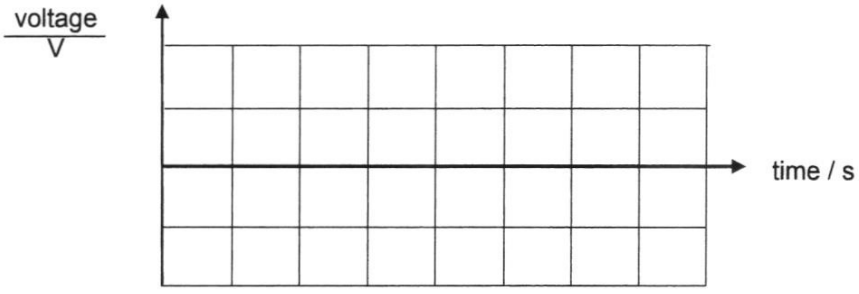


Fig. 6.2

[2]

(c) State the effects on the amplitude and frequency of the induced e.m.f when the magnet is rotated faster.

Amplitude: .....

Frequency: .....

[2]

(d) When the handle is turned, a force is induced that acts against the rotation of the magnet. Explain why there is an induced force and how it acts against the rotation of the magnet.

.....

.....

.....

..... [2]

7 Fig. 7.1 shows a table lamp made from plastic. It has only two wires in the cable. The lamp has a power rating of 100 W and is used on a 230 V supply.

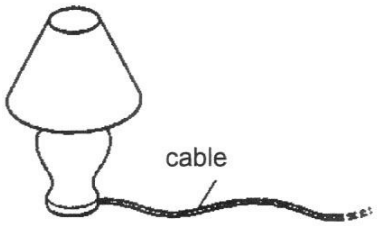


Fig. 7.1

(a) **(i)** State the wire which is not needed in the cable for the table lamp.

..... [1]

(ii) Explain why the lamp is safe to use even though it has only two wires.

.....

.....

..... [2]

(b) **(i)** Explain what is meant by "The lamp has a power rating of 100 W."

.....

.....

..... [1]

(ii) Calculate the current flowing in the lamp.

current =..... [1]

(iii) Hence or otherwise, suggest a value of the fuse rating that should be used in the plug for this table lamp.

fuse rating =..... [1]

8 Fig. 8.1 shows a simple experimental set-up to study the motion of a motor. AB and CD are solenoids connected to a battery. F and G are connected to an external d.c. voltage supply.

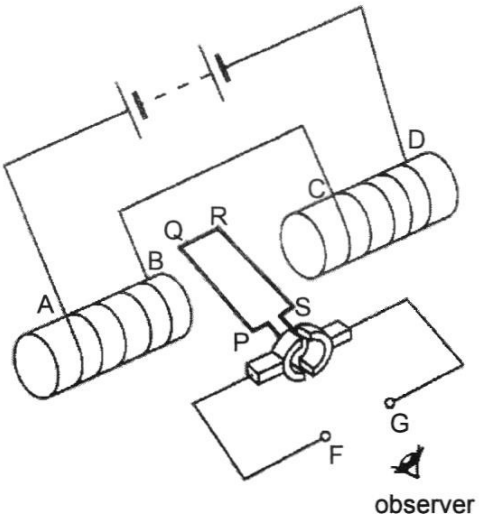


Fig. 8.1

(a) State the polarity of the solenoids

(i) at B .....[1]

(ii) at C .....[1]

(b) If the direction of rotation of the coil PQRS as seen by the observer is in the clockwise direction, state whether F or G is connected to a positive terminal.

..... [1]

(c) Suggest two ways that can be done to have the coil PQRS turn in the anti-clockwise direction.

.....

.....

.....

..... [2]

(d) The coil rotates continuously when the split-ring commutator is used. Explain why.

.....

.....

.....

..... [2]

Section B

Answer **all** the questions in this section.
Answer only one of the two alternative questions in **Question 12**.

9 A cross-section of a coffee-maker is shown in Fig 9.1. The working principles of the coffee maker are described below.

1. When you pour in cold water, it flows from the reservoir through the hole to the one-way valve.
2. Then the water flows through the one-way valve, into the aluminium tube in the heating element and then partially up through the aluminium tube. This all happens naturally because of gravity.
3. When you turn on the switch, the heating element starts heating the aluminium tube and eventually the water in the tube boils.
4. Steam bubbles upwards in the delivery tube during boiling. The delivery tube is small enough, and the bubbles are big enough that a column of water can ride upward on top of the bubbles.
5. As steam rises to the top, it condenses into water that cooled to a temperature less than boiling point of water. This is when it drips out of the machine and onto the ground coffee.
6. The hot water flows through the ground coffee beans, picking up their oil essence on the way down into the coffee pot.

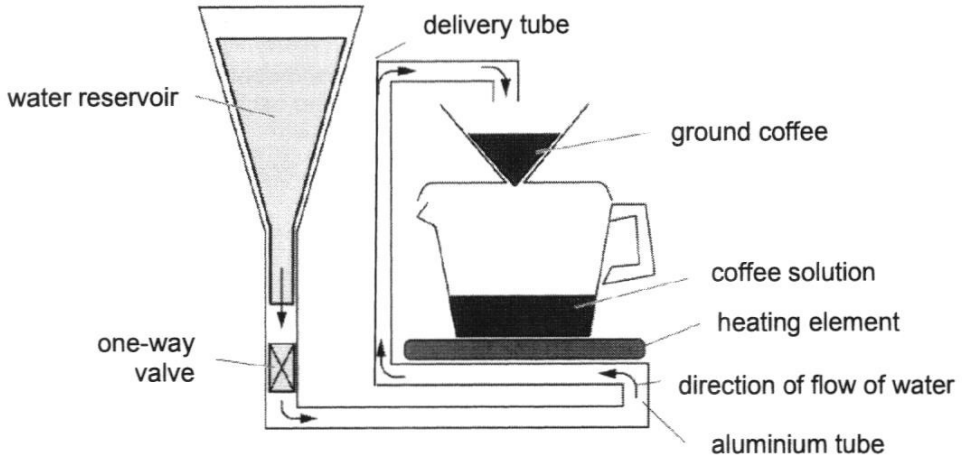


Fig. 9.1

(a) Describe, using kinetic model of matter, how the alumimium tube get heated quickly by the heating element.

.....

.....

.....

.....

.....

..... [2]

(b) The specifications of the coffee maker are shown in Table 9.2

Table 9.2

Voltage	230V
Current	9 A
Specific heat capacity of water	4200 J/kg°C
Specific latent heat of vaporisation of water	2260 000 J/kg
Initial temperature of water in the water reservoir	30°C
Boiling point of water	100°C
Temperature of water as it drips over the ground coffee	93°C

(i) Calculate the power rating of the heating element.

power rating = ... [1]

(ii) By considering the energy provided in one second for the heating element to boil the water in the aluminium tube, calculate the estimated mass of water flowing in the aluminium tube in one second.

mass of water flowing in one second = ... [3]

(c) Electrical heating equipment frequently contains a device to prevent the heating element from becoming too hot. A bimetallic strip made of two different metals **X** and **Y** that are joined together is placed in the circuit near to the heating element.

Fig 9.3 shows the device when the temperature is in the normal operating range for the equipment.

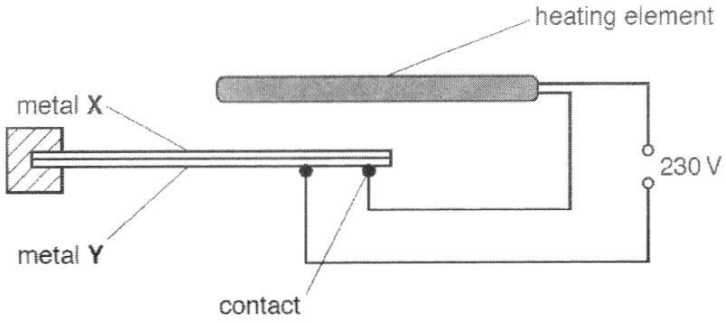


Fig. 9.3 (temperature in operating range)

Fig 9.4 shows the device when the temperature is too high for the equipment.

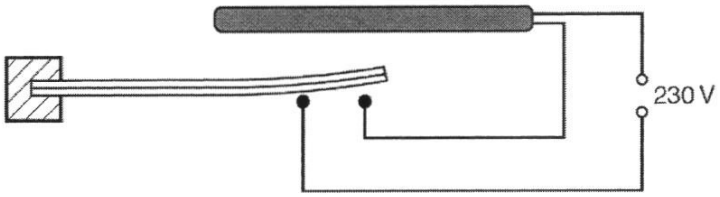


Fig. 9.4 (temperature too high)

For the same volume of metal **X** and **Y**, these two metals expand to different volumes when subjected to the same temperature rise.

With reference to the expanded volume of metal **X** and **Y**, explain how the bimetallic strip prevents the temperature required in the heating equipment from becoming too high.

.....

.....

.....

.....

..... [2]

10 Fig. 10.1 shows an uncharged metal sphere, P hanging from a string. It is placed near a positively charged metal sphere, Q, supported on an insulating stand. P is attracted to Q but both spheres are not in contact.

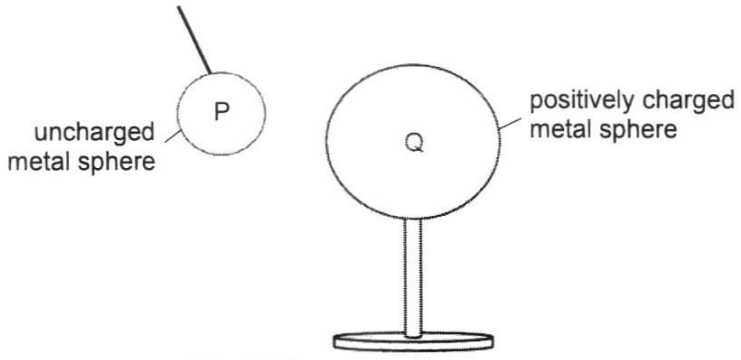


Fig. 10.1

(a) (i) On Fig. 10.1, draw the charge distribution in sphere P. [1]

(ii) Hence or otherwise, explain why sphere P is attracted towards sphere Q, even though there are like charges on the right side of sphere P.

.....

.....

.....

.....

.....

..... [3]

(b) (i) Sphere Q is moved towards the left until it makes contact with sphere P.

Describe and explain what happens to sphere P.

.....

.....

.....

.....

.....

..... [3]

(ii) When sphere P is earthed, 20 C of charges flow to the sphere in 25 s.

Calculate the current flowing in the earth wire.

current = ... [2]

11 Fig. 11.1 shows a circuit breaker that could be used in domestic circuits.

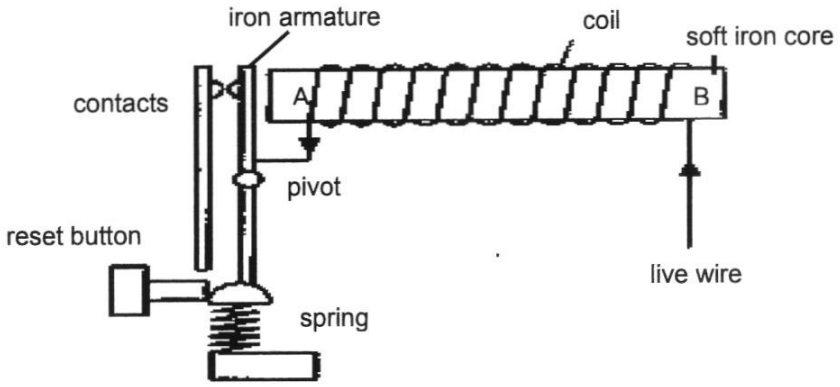


Fig. 11.1

Explain how the circuit breaker operates as a safety feature when the current flowing through its coil exceeds a certain value.

.....

.....

.....

.....

.....

..... [3]

12 EITHER

Fig. 12.1 shows a regular hexagonal glass piece of refractive index 1.42. A ray of light enters the glass piece at side AB, at an angle parallel to its top surface.

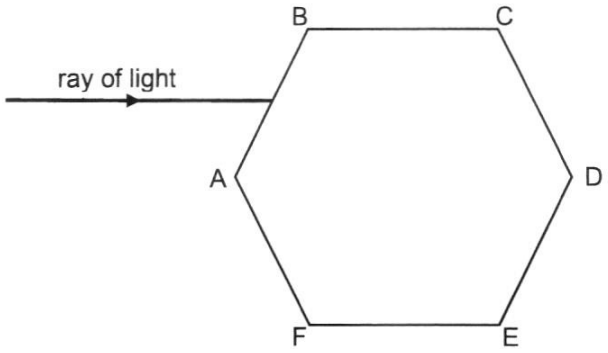


Fig. 12.1 (not to scale)

(a) Determine

(i) the critical angle of the glass,

critical angle = ... [2]

(ii) the angle of refraction of the ray of light at side AB.

angle of reflection = ... [2]

(b) Given that the ray of light continues to travel and meet side CD at an incident angle of 39.4°, on Fig. 12.1, complete the path of the ray of light after it meets side CD. [2]

(c) **(i)** State two conditions of total internal reflection.

.....

.....

..... [2]

(ii) Explain if the light ray undergoes total internal reflection in the glass piece.

.....

.....

..... [2]

12 OR

Fig. 12.2 shows how electrical power is transmitted from a power station to different users via high voltage transmission wires.

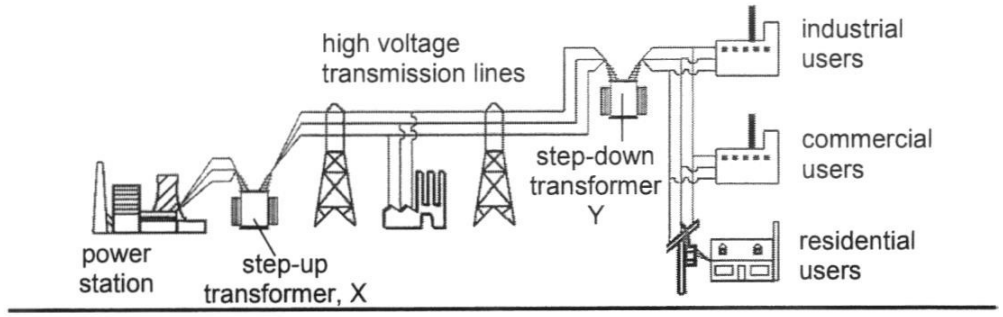


Fig. 12.2

Fig. 12.3 shows a simplified version of the transformers, X and Y, involved.

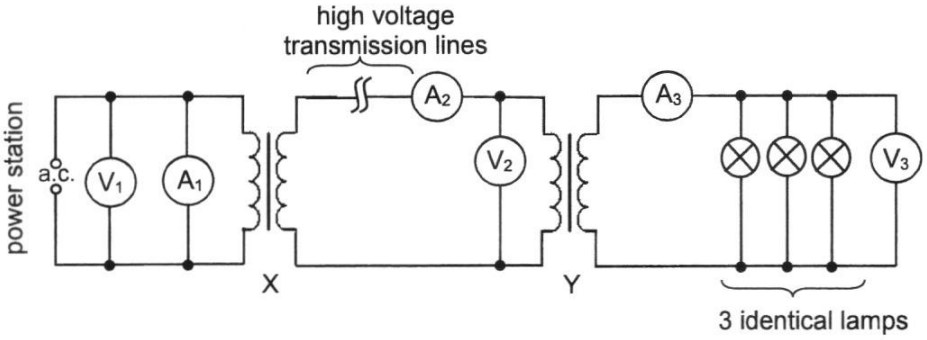


Fig. 12.3

The electrical power runs three identical lamps, each of rating "240 V, 60 W", in the residential household. Transformers X and Y are considered to be ideal and all the three lamps are operating normally.

(a) All the three lamps are switched on. Determine the current flowing through each lamp.

current = ... [2]

(b) **(i)** Transformer Y has 4000 turns in the primary coil and 50 turns in the secondary coil. The voltage in the secondary coil is 240 V. Assuming the transformer is 100 % efficient, calculate the reading in voltmeter V_2.

voltage = ... [2]

(ii) Explain how a current in the primary coil produces an output voltage in the secondary coil.

.....

..... [1]

(iii) State the purpose of the soft-iron core.

.....

..... [1]

(c) In reality, there is loss of power in the transmission and distribution of electricity from power stations to households and industries. The high voltage transmission wire has a resistance of 20 Ω. The reading in ammeter A_2 is 9.4 mA.

(i) Determine the power loss in the transmission wire.

power loss = ... [2]

(ii) State two way of reducing power loss due to Joule heating when transmiting electrical power.

.....

.....

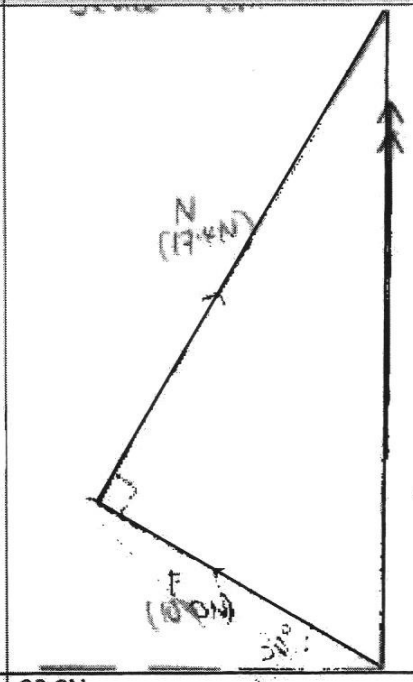
.....

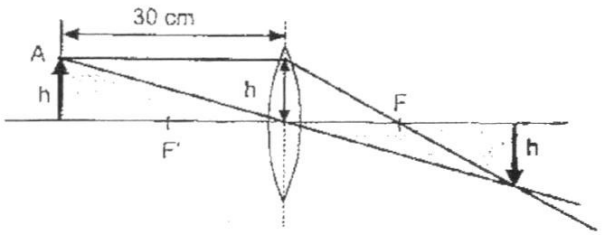
..... [2]

ZHENGHUA SECONDARY SCHOOL
PRELIMINARY EXAMINATION 2023
SEC 4E PURE PHYSICS 6091 PAPER 2

MARKING SCHEME

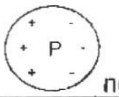
Paper 2 Section A [50 marks]

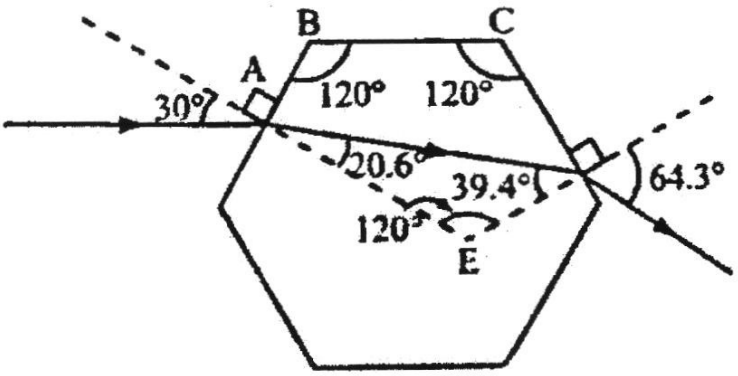
1a	From t=5s to t=12.5s	[1]
1b	Motorcycle is moving at zero acceleration, Based on N2L/F=ma, the net force acting on it is zero, and the forces are balanced. (rejected: constant velocity, lack accuracy for F=ma concept)	[1] [1]
1c	Ave velocity = total displacement/time =(0.5x5x4.5 +4.5x7.5)/12.5 = 3.6 m/s	[1]
1d	constant deceleration from t=15s to t=20s, then constant acceleration in negative direction from t=20s to t=25s (precision of time segment, accuracy of deceleration and negative acceleration)	[1] [1]
2a	 - Correct drawing of vectors 400 N (F) and 600 N (N) with direction [1] - Correct drawing of resultant force with direction (18N – 22N) [1] - Direction of resultant force 90° to to the ground [1] Deduct 1 mark for no labels / wrong labels	[3]
(b)	20.0N *Allow ecf from (a)*	[1]
(c)	Force by the block of wood on Earth. Acting upwards	[2]
	total	[6]
3	When the metal weight is added, the **overall/new CG** of the object **is further to the left of the pivot.** The object needs to be tilted to a larger angle before the line of action of the CG is beyond the base and produces a moment that causes it to topple over	[1] [1]
	total	[2]

4(a) i	The image is **real** as it is **formed on a screen** on the other side of the lens.	[1] [1]
4(a) ii	 - ray passing through optical centre with direction [1] - ray parallel to principal axis and pass through focal point with direction [1] - correct drawing of image [1]	[3]
4(a) iii	From the figure, focal length is found to be 15 cm.	[1]
4(b)	$n = \frac{sin30°}{sin22.6°}$ $= 1.30$ $1.30 = \frac{3.0 \times 10^8}{speed}$ $speed = 2.31 \times 10^8\ m/s$	[1] [1]
	total	[8]
5a	The glass casing gains heat by infrared radiation from the filament wire. The filament wire heats up the nitrogen gas, which expands and rises due to it becoming less dense. The cooler surrounding gas cools, forming convection currents. The hot gas in contact with the glass casing heats it up by conduction.	[1] [1] [1]
5bi	Visible light and infrared radiation	[2]
5bii	Travel at speed of light ($3x10^8$ m/s)/ do not require a medium to propagate.	[1]
	total	[6]
6a	When the **magnet rotates, there is a change in magnetic flux linkage** in the coil. Using **Faraday's Law,** there will be an **induced emf in the coil** **and hence an induced current flows in the coil.**	[1] [1] [1]
6b	correct shape (zero voltage at first position, sine graph) correct periodic time (0.20 s)	[1] [1]
6c	Larger amplitude Higher frequency	[1] [1]
d	The interaction of the magnetic field of the induced current and the magnet will induce the force (or the induced current in the coil will set up a magnetic field that will exert a force on the magnet). The direction of the induced force will oppose rotation of the magnet in accordance to Lenz's Law (a like pole will be induced when the magnet is moving towards the coil and an unlike pole will be induced when the magnet is moving away from it).	[1] [1]
	total	[9]

7ai	Earth wire	[1]
7aii	The lamp is doubly insulated. The cable is insulated from the internal components of the lamp, and the casing of the lamp is made of plastic, which is an insulator. OR The cable has a layer of insulation and the casing of the lamp is made of plastic, which is an insulator.	[1] [1]
7bi	The lamp converts electrical energy to heat and light energy at a rate of 100 J per second	[1]
7bii	I = P/V = 100/230 = 0.435 A (3 s.f.)	[1]
7biii	Fuse rating = 1 A	[1]
	total	[6]
8ai	B is north pole.	[1]
8aii	C is south pole.	[1]
8b	G is connected to the positive terminal.	[1]
8c	1. reverse the terminals/polarities of the battery connected to A and D 2. wind the solenoids differently to give a S pole at B and N pole at C 3. reverse the terminals/polarities of dc supply connected to F and G Any correct 2 ways – 1 mark each ecf from 8ai, 8aii & 8b Reject swap/flip solenoids / battery	[2]
8d	The split-ring commutator reverses the direction of the current in the coil every half a revolution. By Fleming's Left Hand Rule, an upward force always acts on the side of the coil next to the N-pole and a downward force always acts on the side of the coil next to the S-pole. This allows the coil to rotate continuously in one direction. (Accept direction of force acting on each side of the coil PQ and RS to reverse every half a revolution)	[1] [1]
	total	[7]

Paper 2 Section B [30 marks + 10 marks]

9a	The internal average KE of theparticles at hot end of aluminium tube increases and vibrate more vigorously. The free moving electrons from the warmer region gain kinetic energy and move to the cooler region at greater speeds. They collide into their neighbour and pass on the energy making them vibrate more vigorously.	[1] [1]
9b i	P=IV P=9 X 230 = 2070 W	[1]
9 bii	In 1s, E for warming water = mcθ = m (4200) (100-30) = 294 000 m E for boiling water = ml_v = 2 260 000 m Total energy = 2 554 000 m E = Pt 2554000 m = 2070 x1s m = 0.000810 kg	 [1] [1] [1]
9c	**Y expands more** than X and bends **upwards** when temperature is too high. This **creates a break in the circuit** / open circuit where the heating element will stop heating, thus temperature will lower.	[1] [1]
	total	[8]
10ai	 no of –ve = no of +ve	[1]
ii	The law of electrostatics states that like charges repel and unlike charges attract. Since the negatively charged region in sphere P is nearer to sphere Q, the force of attraction is greater than the force of repulsion with the positively charged region of (at the left side of) sphere P, resulting in an overall force of attraction to sphere Q.	[1] [1] [1]
bi	The electrons in P will be attracted by the positive charged Q. They will move into Q until both spheres are equally positive charged. P swings away from Q because like charges repel.	[1] [1] [1]
bii	current = Q / t = 20 C / 25 s = 0.80A	 [1] [1]
	total	[8]
11	When there is a surge in current due to an electrical fault, current flows into the coil, and it induces a stronger magnetic force. The iron piece/armature is attracted to it. This breaks the contact and stops current from flowing.	[1] [1] [1]
	total	[3]

EITHER		
12ai	$sinc = \frac{1}{n}$ $= \frac{1}{1.42}$	[1]
	Critical angle = 44.8°	[1]
12aii	$n = \frac{sini}{sinr}$	
	$sinr = \frac{\sin(120-90)^\circ}{1.42}$	[1]
	= 20.6°	[1]
12b		
	- marking 39.4° to normal at face CD - continuing ray out of CD and away from normal (angle not required)	[1] [1]
12ci	Light ray is travelling from a region of higher optical density to a region of lower optical density. The angle of incidence is greater than the critical angle.	[1] [1]
12c	No, since the angle of incidence on the other side of the glass piece is less than the critical angle, the light ray does not undergo total internal reflection	[1] [1]
	total	[10]

OR		
12a	$I = \frac{P}{V} = \frac{60}{240}$ = 0.25 A	[1] [1]
12bi	Since $\frac{V_s}{V_p} = \frac{N_s}{N_p}$, $\frac{240}{V_2} = \frac{50}{4\,000}$ [1] $\therefore V_2 = \frac{240 \times 4\,000}{50}$ V = 19 200 V [1]	 [1] [1]
12bii	The alternating current in primary coil sets up a changing magnetic flux linking the secondary coil. This induces an e.m.f. in the secondary coil.	[1]
12biii	Soft iron is used to ensure a better magnetic flux linkage between the primary coil and secondary coil / concentrates the magnetic field lines as they are directed to the secondary coil.	[1]
12ci	$I_2 = 9.4\ mA = 9.4 \times 10^{-3}\ A$ $P = I^2R = (9.4 \times 10^{-3})^2 \times 20$ = 0.00 177 W (3 sf)	 [1] [1]
12cii	Use thicker transmission wires/larger cross section area. Transmit at high voltage.	[1] [1]
	total	[10]