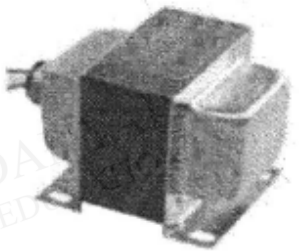
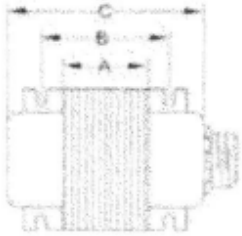
O Level Pure Physics Structured

Electromagnetic Induction Test 3.0

Q1

Fig 12.1 shows a screenshot of the specifications of a website that sells two models of transformers. Both models have an input power of 20 W (or VA).





MODEL	Pri V	PRI(VAC)	HZ	Sec V	UL MARK	CE MARK	A
2001MWSH	20	240	50/60	24	V	V	1.00"
2011MWSH	20	120	50/60	24	V	V	1.00"

Fig. 12.1

Wei Kang intends to buy a transformer that can be plugged into a typical 240 V three pin power socket. The transformer is meant to be used to power a fish pump that has an input voltage of 24 V.

(a) Explain why a transformer requires an alternating input voltage to work.

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..... [2]

(b) State the model of transformer Wei Kang should purchase and the normal operating current in the fish pump. Assume the transformer is operating at 100% efficiency.

model = _____ [1]

operating current = _____ [1]

(c) Fig 12.2 shows the representation of one of the transformers.

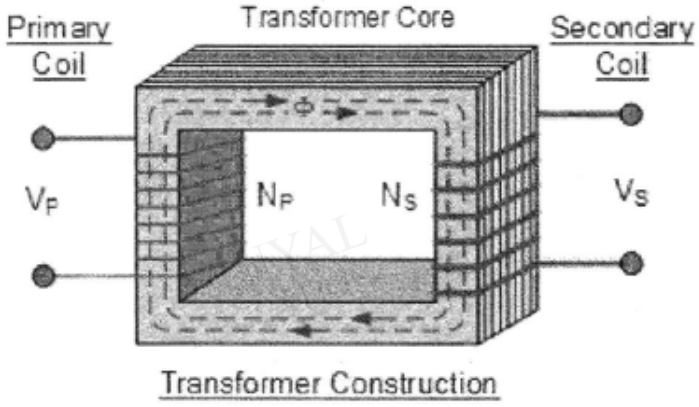

Fig 12.2

(i) Sketch the direction of the current in the primary coil that will produce the magnetic flux shown above. [1]

(ii) Sketch the direction of the current in the secondary coil in the instant shown in Fig 12.2. [1]

(iii) State two ways to increase the secondary voltage.

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_____ [2]

(d) Fig 12.3 shows how the output voltage of a transformer changes over time. The step-down transformer has a turns ratio of 0.10. The input voltage is set at 120 V, 50 Hz.

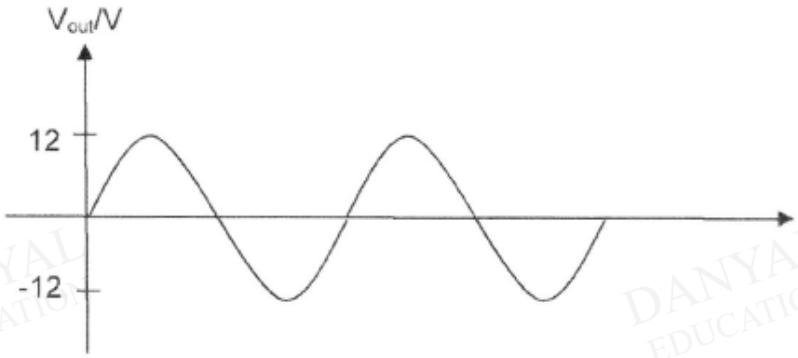

Fig 12.3

An input voltage of 240 V, 100 Hz is now applied across the input terminals of the same transformer. Sketch on Fig 12.3 the new output voltage. [2]

Q2

(a) Fig. 12.3 shows a device used to measure the flow of air. The turbine is made to rotate by the air that flows through it.

When viewed from **X**, the turbine is rotating in an anticlockwise direction.

The rim of the turbine contains small magnets.

When a small magnet goes near and then away from the coil (wound on a soft-iron core), a trace (which looks like a sine curve) is formed on the graph of induced e.m.f. against time (see Fig. 12.4). This trace is due to an alternating e.m.f. being induced in the coil.

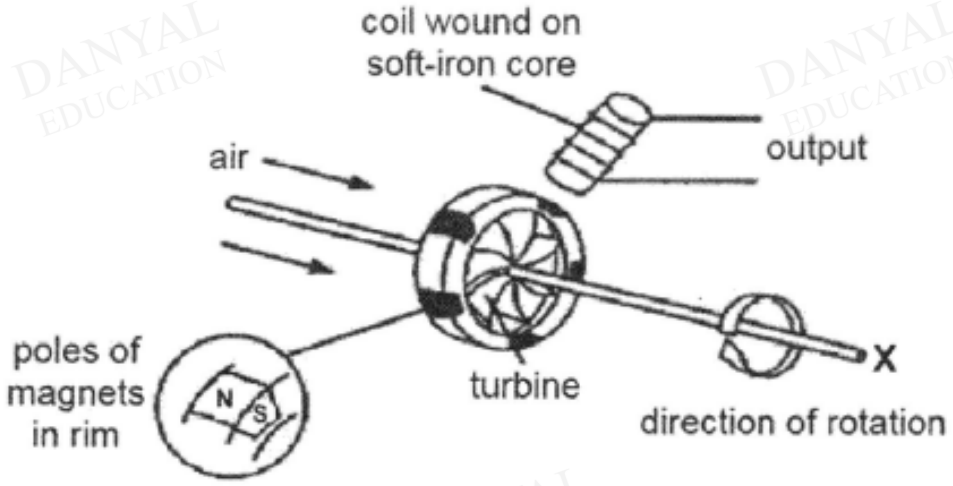

Fig. 12.3

(i) Explain why an alternating e.m.f. is induced in the coil.

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..... [3]

(ii) The traces (two separate sine curves) on Fig. 12.4 show how the induced e.m.f. varies with time when the turbine rotates at a steady speed.

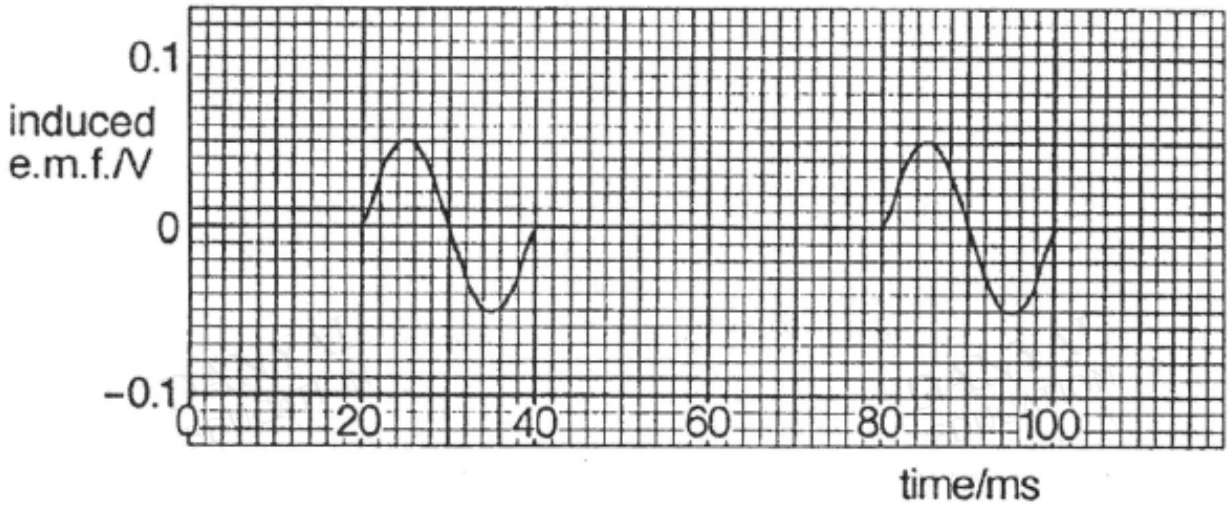

Fig. 12.4

The turbine now rotates twice as fast.

Draw on Fig. 12.4 the new traces to show how the induced e.m.f. varies with time. [3]

(b) Fig. 12.5 shows high voltage cables used to transmit electrical energy.

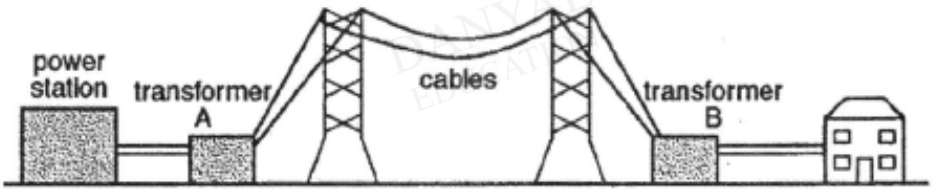

Fig. 12.5

(i) State the purpose of transformer B.

..... [1]

(ii) Explain why high voltages are used to transmit electrical power.

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..... [1]

(iii) Fig. 12.6 shows how the loss of thermal energy from a cable varies with the thickness of the cable.

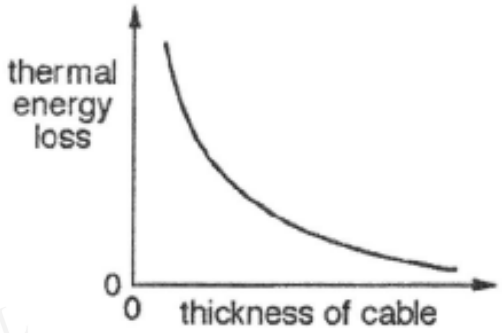

Fig. 12.6

Explain why the loss of thermal energy is less if the cable is thicker.

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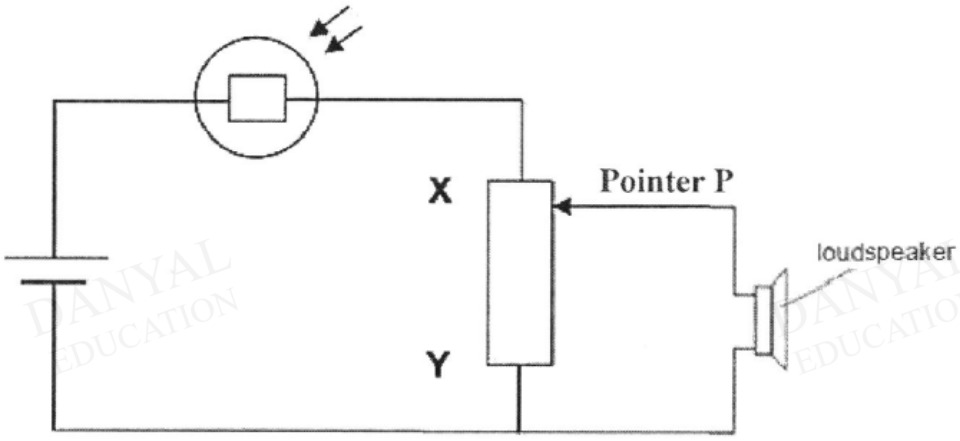
..... [2]

Q3

The diagram shows a circuit consists of a light dependent resistor (LDR), a potentiometer **XY** and a loudspeaker.



When little light falls on the LDR, its resistance is 3000 Ω. When the light of strong intensity falls on the LDR, its resistance is 500 Ω.

The Y-plates of a cathode-ray oscilloscope (CRO) are connected to the input voltage of the loudspeaker. The Y-gain of the CRO is set at 2.0 V/ division and the time-base is set at 0.01 s/division.

Given that the amplitude of the input voltage is 4.0 V and its frequency is 25 Hz, draw the trace on the screen of the CRO in **Fig. 7.1.**

Draw **at least** 2 complete waves. [2]

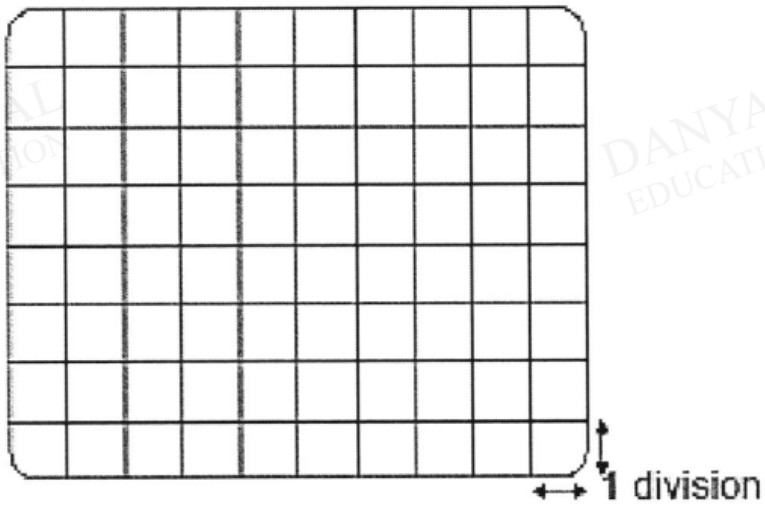


Fig 7.1

Q4

Fig. 8.1 shows an anemometer, a device for measuring wind speed. When the wind blows, the spindle rotates and there is a deflection on the a.c. voltmeter.

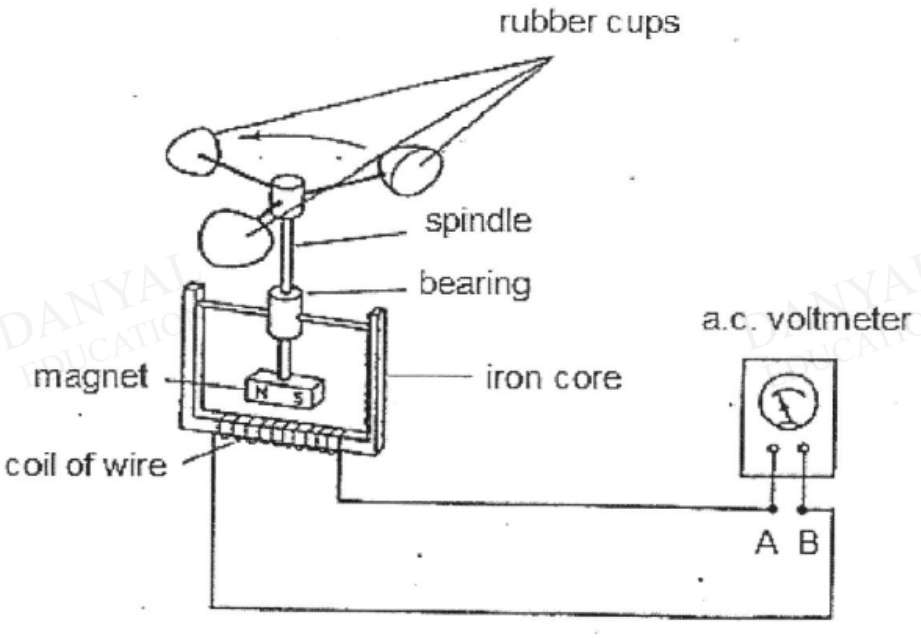


Fig 8.1

Explain how the rotating spindle causes an alternating deflection on the voltmeter. [4]

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Q5

(i) A wind turbine produces an alternating voltage of 600 V to the primary input of a transformer.

Explain how a transformer works. [3]

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(ii) Electric cables connect the secondary coil of the transformer to houses some distance away. Energy is wasted within the cable.

State and explain one method to reduce the amount of energy that is wasted. [1]

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Answers

Electromagnetic Induction Test 3.0

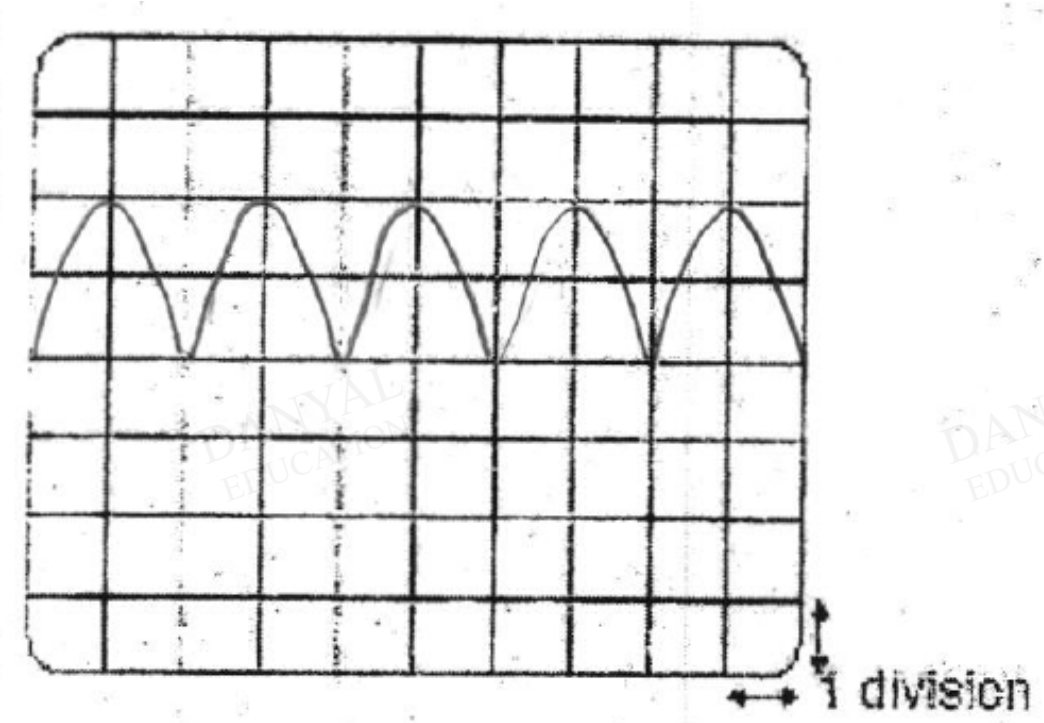
Q1

2a	A changing magnetic flux produced by an alternating voltage is needed for a transformer to change voltage/ so that an emf can be induced in the secondary coil	1 1
2b	Model 2001 (it uses 240 V) Current I = P/V = 20/24 =0.83 A	1 1
2ci	Current flowing right in primary coil (N pole at top pf primary coil using Right Hand Grip Rule)	1
2cii	Current flowing right (Right hand grip rule, produce A N pole at top to oppose pri coil magnetic field)	1
2ciii	Increase V_p, increase N_S, decrease N_p (any 2)	2
2d	V_p (120 V to 240 V) is doubled, hence V_s is doubled. When frequency is doubled (50 Hz to 100 Hz), Vs is doubled and frequency of Vs is also doubled. Overall, Vs is X 4 (V_{out} = 48 V) and frequency is doubled.	 1 1

Q2

12(O) (a)(i)	• Relative motion between magnet(ic field) and (conducting) coil leads to a change in magnetic flux linking the coil per second (or: rate of change of magnetic flux linking the coil) and this induces an e.m.f. [1] • As magnetic field is brought near the coil, there is an increase in magnetic flux linking the coil per second. This causes a peak in the alternating signal. [1] • As magnetic field is brought away from the coil, there is a decrease in magnetic flux linking the coil per second. By Lenz's Law. this causes a trough in the alternating signal. [1]	
12(O) (a)(ii)	• Each new signal has twice the amplitude (0.1V) and [1] • half the period (10 ms) as old signal. [1] • Start of new signals at t = 20 ms, 50 ms and 80 ms [1]	
12(O) (b)(i)	Transformer B is used to step down voltage.	[1]
12(O) (b)(ii)	Electric current flowing in the cables will be low (when high voltages are used). Hence the power loss (I^2R) would then be minimised.	[1]
12(O) (b)(iii)	• Thick wires have large cross-sectional areas A, and thus low resistance because resistance R inversely proportional to cross-sectional area A. [1] • Since power loss (P) = I^2R, less resistance would mean less power loss. [1]	

Q3



Q4

a) According to Faraday's law, an emf is induced and shown on the voltmeter when the coil of wire experiences a rate of change of magnetic field lines due to the spinning of the magnet above.	A2
According to Lenz's law, the direction of induced EMF and current opposes the change causing it. Hence, the coil experiences alternating polarity as a polarity of the magnet approaches it or leaves, causing an alternating deflection on the voltmeter.	A2

Q5

(i) The alternating voltage supply produces an alternating current in the primary coil. This produces an alternating magnetic field around the iron core. This alternating magnetic field cuts the secondary coil and induces an EMF in the secondary coil.	A1 A1 A1
(ii) By transmitting the power at high voltages [1] with the help of a step up transformer, the current flowing in the cable will be smaller [1] and thus the power loss due to the resistance of the cable will be reduced.	