O Level Pure Physics Structured

Electromagnetic Induction Test 1.0

Q1

Two coils, A and B, are placed one on top of the other, as shown in Fig. 10.1. Coil A is connected in series with a battery and a switch. A millivoltmeter is connected across the terminals of coil B.

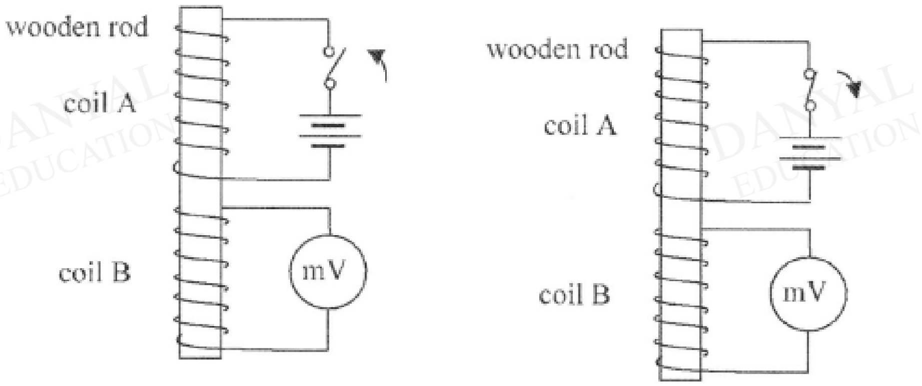

Fig. 10.1 Fig. 10.2

(a) Explain why, when the current in coil A in Fig 10.1 is switched on, the millivoltmeter indicates an induced e.m.f. for a short period of time and then reduces to zero rapidly.

....

....

.... [2]

(b) **(i)** On Fig. 10.2, draw an arrow on coil B to show the direction of the induced current in coil B when the switch was just opened. [1]

(ii) Explain the direction drawn in **(b)(i)**.

....

....

....

.... [2]

Fig. 10.3 shows two coils of insulated wire wound on an iron core to make a transformer. One coil is connected to a 16 V a.c. supply. The other coil is connected to a lamp, which is rated 12 V, 24 W.

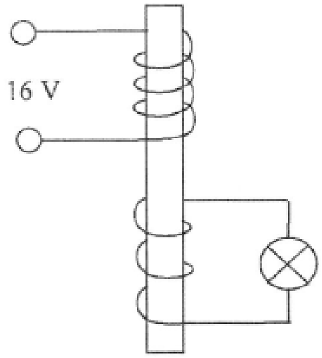

Fig. 10.3

(c) The lamp is operating at its correct rating.
Calculate the minimum current drawn from the 16 V supply.

current = ... [2]

(d) The current drawn from the supply is found to be 1.7 A instead. Caculate

(i) the input power to the transformer,

power = ... [1]

(ii) the energy lost by the transformer each second.

energy = ... [1]

(e) Explain why the thermal energy lost in the wire is lower if the wire is thicker.

....

.... [1]

Q2

A town is supplied with electrical energy from a power station some distance away by power cables as shown in Fig. 10.2.

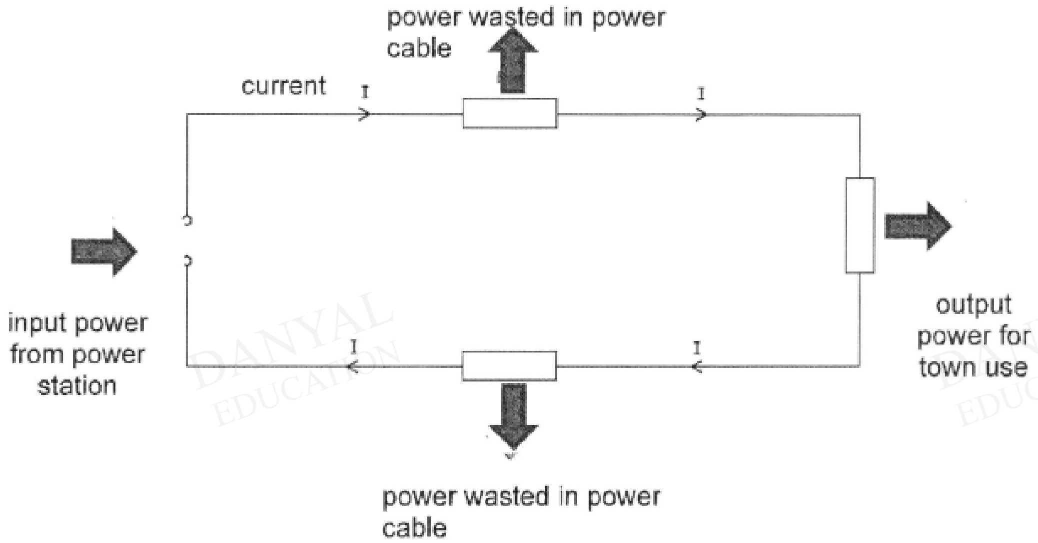

Fig. 10.2

(a) The input power from the power station is 100 kW, at 20 kV. The total resistance of the cables is 5.0 Ω. Calculate

(i) the current I in the cables, [1]

(ii) the power loss in the cables, [1]

(iii) the voltage supplied to the town. [2]

(b) Fig. 10.3 shows another way of supplying electrical energy to the town using transformers.

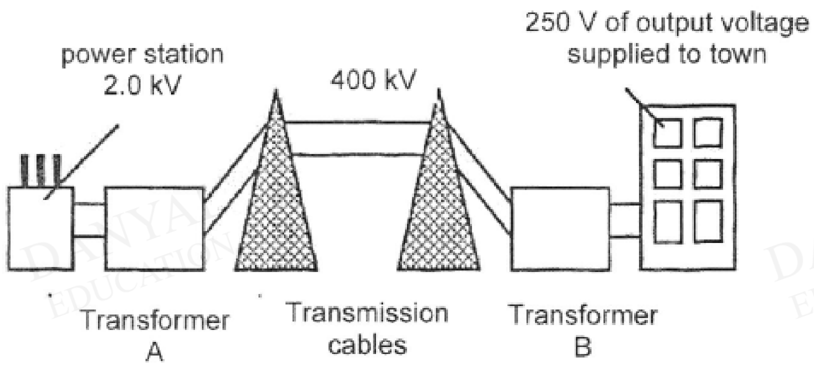

Fig. 10.3

(i) Name the types of transformers used for transformer A and transformer B. [1]

(ii) Explain why transformer A is necessary for the transmission. [2]

(iii) Explain why the transmission cables used have to be quite thick. [1]

(iv) Calculate the turn ratio for transformer B. [2]

Q3

Fig. 12.4 shows two towers that support a single cable of total length 20.0 km, which links a factory to the electrical grid. The voltage at the tower A is at 6000 V while the voltage at the factory is at 5500 V.

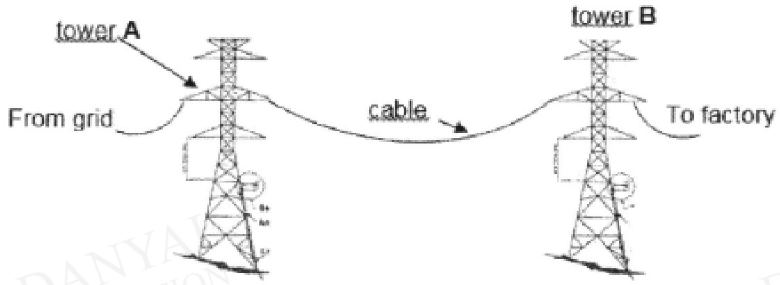

Fig. 12.4

The cable used is made from aluminium which has a resistance of 3.6 Ω per 1.0 km.
Calculate the

(i) power loss in the cable. **[2]**

(ii) cost of the power loss for a day given that 1 kWh costs $0.15. **[2]**

Q4

(a) Fig. 12.5 shows an experimental set-up where a copper ring is fitted loosely over an iron core that has been placed inside a solenoid that is connected to a D.C supply.

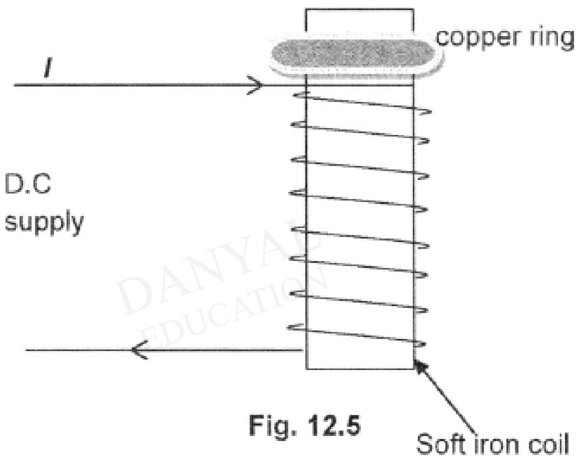

Fig. 12.5

Fig. 12.6

(i) At the instant when the switch is closed, state what happen to the ring. **[1]**

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(ii) Explain the observation stated in (a)(i). **[3]**

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(iii) State what will happen to the copper ring at the instant when the switch is closed if the current flows in the opposite direction in the coil. **[1]**

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(iv) State what will happen if the solid copper ring is now replaced with a slit copper ring as shown in Fig.12.6 at the instant the switch is closed. **[1]**

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(b) Fig 12.7 shows an ideal transformer connected to an a.c. input voltage of 240 V. The transformer has 2000 turns in Primary coil and 100 turns in Secondary coil. A current of 8.0 A flows in the secondary coil.

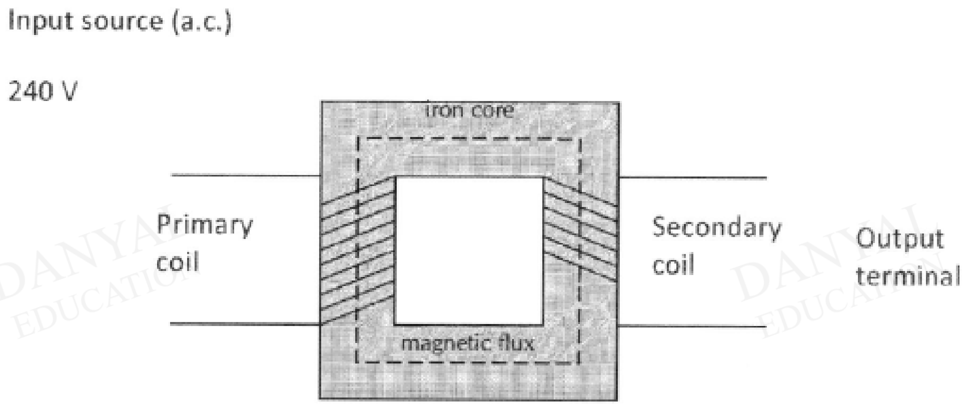

Fig. 12.7

(i) State what is meant by an ideal transformer. **[1]**

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(ii) Calculate the output voltage and input current. **[2]**

(iii) It is recommended to have laminated iron sheets instead of iron core. Suggest a reason why is this so. **[1]**

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Q5

Fig. 8.1 shows a transformer designed to operate a 1000 V motor in a machine.

The primary coil has 500 turns and the voltage supply is 200 V a.c.

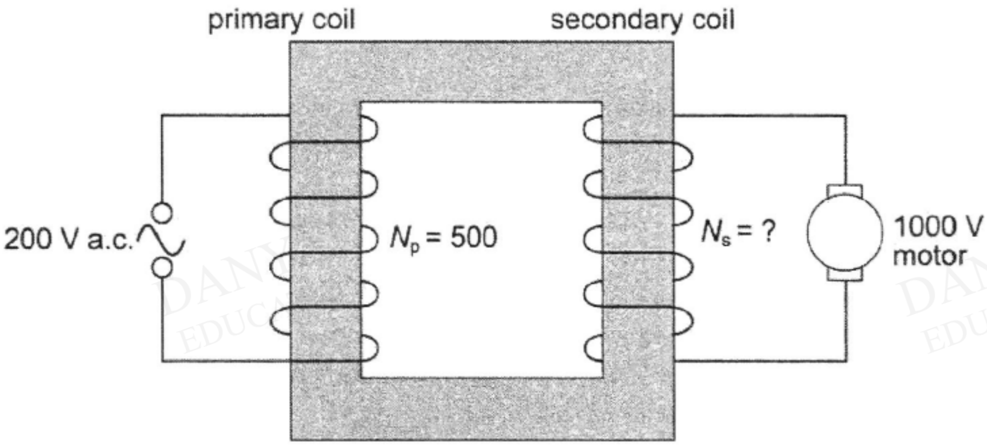

Fig. 8.1

(a) Find the number of turns (N_s) in the secondary coil.

N_s = ... [2]

(b) If the frequency of the voltage supply is 50 Hz, what is the frequency of the output voltage of the transformer?

frequency = ... [1]

(c) The current in the primary coil is 1 A. Find the current in the secondary coil if the efficiency of the transformer is 90%.

current = ... [2]

(d) Account for the energy loss in the transformer.

....

....[1]

Answers

Electromagnetic Induction Test 1.0

Q1

a	The induced e.m.f in coil B is due to a change in the magnetic flux linkage created by coil A on coil B when current flows in coil A making it an electromagnet. [B1] When the current is steady, there is no change in magnetic flux linkage between the two coils although there is magnetic flux linkage between the 2 coils. Zero change results in no emf induced according to Faraday's law of electromagnetic induction. [B1]
bi	Direction of current in the outer coil of B is to the right [B1]
bii	By Lenz's Law, the induced current must be in such a direction as to oppose the change in magnetic flux in coil B. [B1] The induced current thus produces a North pole at the end of coil B that is facing coil A to oppose the weakening or moving away south pole at the bottom of coil A. [B1]
c	P=VI, I=P/V = I_S = 24/12 = 2.0 A [B1] $I_P/I_S = V_S/V_P$ I_P =(12/16) x 2.0 = 1.5 A [B1]
di	Input Power = IV = 1.7 x 16 = 27.2 W [B1]
dii	Lost power = 27.2 – 24 = 3.2 W [B1]
e	As resistance is inversely related to the cross-sectional area, thicker wires will result in a decrease of resistance. Since $P = I^2R$, [A1] thus power loss in the cables decreases as resistance of cable decreases.

Q2

(ai)	P = VI => 100 000 = 20000 x I => I = 5.0 A	[1]
(ii)	Power loss = I^2R = 5.0^2 x 5.0 = 125 W	[1]
(iii)	Voltage drop = IR = 5.0 x 5.0 = 25 V Voltage supplied to town = 20000 – 25 = 19975 V = 20000 V (3 sig fig) Alternatively, Useful power = 100 000 – 125 = 99875 W Voltage supplied to town, V = P / I = 99875 / 5.0 = 19975 V = 20000 V (3 sig fig)	[1] [1]
(bi)	Step-up transformer (A) and Step-down transformer (B)	[1]
(ii)	Transformer A steps up the voltage. Since Power = Voltage x Current, when a high voltage is used, electrical current transmitted will be lower. This results in less electrical power loss from the cables since power loss = $(\text{current})^2$ x resistance of the cables.	[1] [1]
(iii)	Thick cables have lower resistance than thinner cables, and can carry large amount of current with less heat loss.	[1]
(iv)	Ns/Np = Vs/Vp = 250 / 400000 Ns:Np = 1:1600 Also accept Np:Ns = 1600:1	[1] [1]

Q3

(i)	Resistance of the wire = 1000 x 3.6 = 3600 Ω Power loss = p.d. ^{2} / R $=500^2/3600$ =69.4 W Note that the power loss is related to the drop in potential across the length of wire. In other words, the difference in potential between the 2 points.	M1 A1
(ii)	$\frac{69.4}{1000} \times 0.15 \times 24$ = $ 0.249 = $ 0.25	M1 A1

Q4

(i)	The copper ring will jump upwards	B1
(ii)	At the instant when the switch is closed, current starts to flow through the solenoid, causing a magnetic field to be build up in the solenoid forming a North pole adjacent to the copper ring. During the building up of magnetism in the solenoid, an increase in the rate of change of magnetic flux linkage occurs thus inducing an electromotive force (e.m.f.) in the copper ring according to Faraday's law. According to Lenz's Law, as the copper ring has a closed loop, an induced current will flow to form a North pole in the lower half of the copper ring to oppose the change in magnetic flux in it. Thus the copper ring is repelled and moves upwards. Note that copper is not a magnetic object but a good electrical conductor.	B1 B1 B1
(iii)	The copper ring will still do the same as (i) (note that this time a South pole is formed at the lower half o the copper ring to oppose the South pole formed in the solenoid nearer to the copper ring)	B1
(iv)	It will not move from this position or there is no change from its rest position.	B1

	(as it is impossible to have an induced current flowing across the broken ring to form a magnetic pole)	
(b) (i)	In an ideal transformer, there will be no power loss between the primary and the secondary coil	B1
(ii).	2000 / 100 = 240 / output voltage Output voltage = 12 V 8.0 x 12 V = 240 x I I = 0.40 A	A1 A1
(iii)	To reduce formation of eddy currents so that there will be minimum power lose due to eddy current.... (note: there is no way to prevent formation of eddy currents in the soft iron core)	B1

Q5

8(a)	Np/Ns = Vp/Vs 500/Ns = 200/1000 Ns = 2500	[1] [1]
MC	This question is very well-done	
8(b)	50 Hz	[1]
MC	Quite a number of students got this wrong because they thought that the frequency would be step up but it remains constant.	
8(c)	P_{output} = P_{input} x 90% (1000V)(Is) = (0.9)(200V)(1 A) Is = 0.18 A	[1] [1]
MC	Majority were able to calculate this correctly.	
8(d)	Heat loss in the wire. Heat loss due to induced current in the core. Energy used for magnetisation of the core.	[1] Anyone on the stated list.
MC	Quite a number of students did not receive any credit because they did not explain clearly what causes the energy loss. It is insufficient to just mentioned that energy is loss as heat in the transformer without specifying clearly that heat is loss due to the resistance of the wire.	