2026 S4 Assignment 19B

Transformers - Answers

Note:
- State any formulae used.
- Upper case ‘i’ (e.g. current) to write as I
- Use suitable subscripts to differentiate between similar physical quantities in different parts of the power transmission circuit, e.g. V_p, V_s

1(a) Mutual induction or Electromagnetic induction

(b) When the switch is closed, current flows in coil P to produce a north pole on its right end.

By Lenz’s Law, a momentary current is induced in the coil Q to set up a north pole on its left end to oppose the strengthening magnetic field set up by the coil P, when the switch is first closed.
Using right hand grip rule, the current induced in Q will flow from left to right.

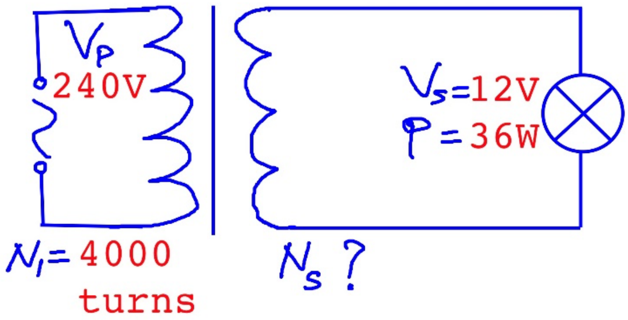
(c) The two coils have north poles facing each other.
Since like poles repel, the coils will move away from each other.

(d) A momentary deflection is observed in the galvanometer in a direction opposite to that in part (c) when the switch is closed.
The two coils will move slightly towards each other.

Note: *This because coil Q will have an induced e.m.f that sets up a magnetic field in the same direction to oppose the decreasing magnetic flux of coil P. Explanation not required.*

2(a) $\frac{N_s}{N_p} = \frac{V_s}{V_p} \Rightarrow$ 4000 : N_s = 240: 12 $\Rightarrow$ N_s = 200 turns

Assume the transformer is ideal / 100% efficiency / has no power loss.



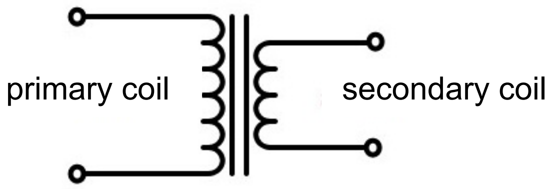
(b) $I_p V_p = I_s V_s \Rightarrow I_p \times 240\text{ V} = 36\text{ V} \rightarrow I_p = 0.15\text{ A}$

(c) Energy = Pt = 36 W x 300 s = 10 800 J
= 0.0030 kWh

3(a) (i) Combined resistance = 5.00 km x (1000 m / 1.00 km) x 0.00120 Ω/m x 2 = 12.0 Ω

(ii) Power loss = $I^2R = (40.0\text{ A})^2 \times 12.0\ \Omega$ = 19 200 W

(b)



A step-down transformer (from 6000 V to 240 V)

Note: Sketch a diagram of the circuit to help in understanding it.

4(a)(i) P=IV ➔ $I = P / V = 40\,000 \text{ W} / 5000 \text{ V} = 8.0 \text{ A}$

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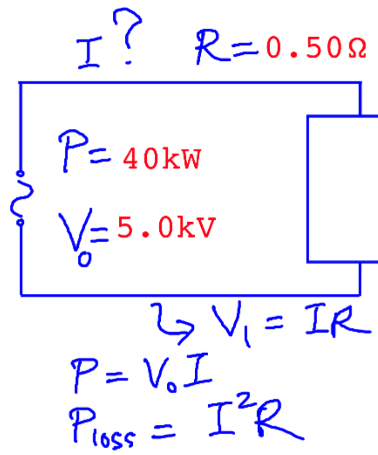

(ii) voltage drop, V $= IR = 8.0 \text{ A} \times 0.50\ \Omega = 4.0 \text{ V}$

(iii) Power loss in the cables, $P = I^2R = (8.0 \text{ A})^2 \times 0.50\ \Omega = 32 \text{ W}$
OR $P = IV = 8.0 \text{ A} \times 4.0 \text{ V} = 32 \text{ W}$

(b) The power loss is converted to thermal energy produced per unit time in the cables and lost to the surroundings.

(c) Power loss, $P = I^2R = (20 \times 8.0 \text{ A})^2 \times (0.50\ \Omega) = 12\,800 \text{ W}$

(OR use $I = P / V = 40\,000 \text{ W} / 250 \text{ V} = 160 \text{ A}$)

Note:

	High voltage transmission	**Low voltage transmission**
Voltage input to the cables, V_i where $P = V_i I$	*5000 V or 5.0 kV* *Higher voltage*	*250 V*
Current in the cables, I where $I = P/V_i$	*8.0 A* *Lower current*	*160 A*
Power loss in the cables where $P_{loss} = I^2R$	*32 W* *Much lower power loss*	*12 800 W*

- *(a)(iii) and (b) show that <u>power loss in the cables is much lower in a high voltage transmission</u>.*
- *Hence, voltage output at a power generator is usually stepped up to a high voltage before transmission into the power grid.*

- *If V_i is higher* ➔ *$I = P/V_i$ is lower*
  ➔ *$P_{loss} = I^2R$ is also lower*