2021 S4 Assignment 19B Transformers

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)

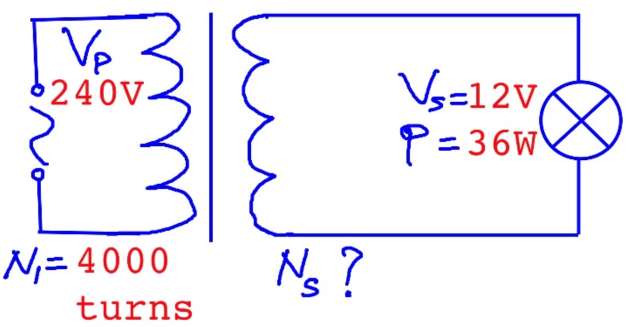
(b) When the switch is closed, current flows in coil P to produce a north pole on the right end.
By Lenz's Law, the current induced in the coil Q will produce a north pole on its left end to oppose the magnetic field caused by the coil P.
Using right hand grip rule, current induced in Q will flow in the direction shown on above diagram.

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

(d) A short-lived deflection is observed in the galvanometer in the opposite direction 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 rate of 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.



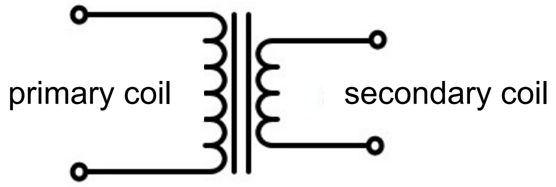
(b) $I_p V_p = I_s V_s \Rightarrow I_p \times 240 = 36 \rightarrow I_p = 0.15$ A

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

3(a)(i) Combined resistance = 5.00 x 1000 m x 0.00120 Ω/m x 2 = 12 Ω

(ii) Power loss = I^2R = (40.0^2) x 12 = 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 / 5000 = 8.0 A

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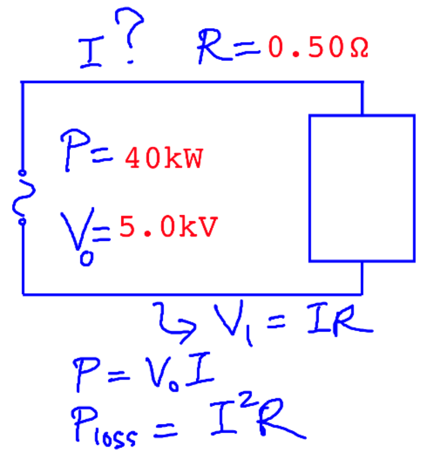

(ii) voltage drop, V = IR = 8.0 A x 0.50 Ω = 4.0 V

(iii) Power loss in the cables, P = I^2R = 8.0^2 x 0.5 = 32 W
OR P= IV = 8.0 x 4 = 32 W

(b) The lost energy is converted to thermal energy and lost to the surroundings.

(c) Power loss, P= I^2R = $(20 \times 8)^2$ x (0.5)
=12 800 W

(OR I = P / V = 40 000 / 250 = 160 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 power loss in the cables is much lower in a high voltage transmission.
- 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