Electromagnetism - Transformers (Questions) A Physics MW

Formulae..

$$\frac{N_s}{N_p} = \frac{V_s}{V_p}$$

and.. $I_p V_p = I_s V_s$

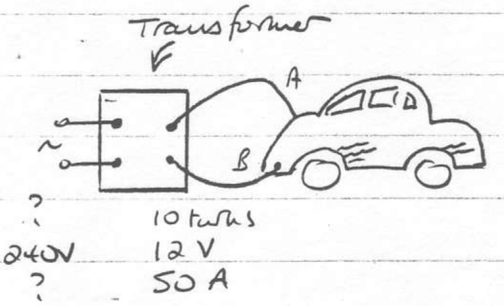
$P_{in} = P_{out}$

1. You overhear the end of a technical argument at the checkout in ASDA,... "Anyway, you ought to know that real transformer are never 100% efficient." And with that she packed the Guinness and oysters, and left. You puzzle over this...

(a) what does the statement mean? (only 1)

(b) Can you briefly describe and explain 4 ways energy is lost from a transformer (4×3 = er, 12) [13]

2. You are pursuing your hobby of welding old cars



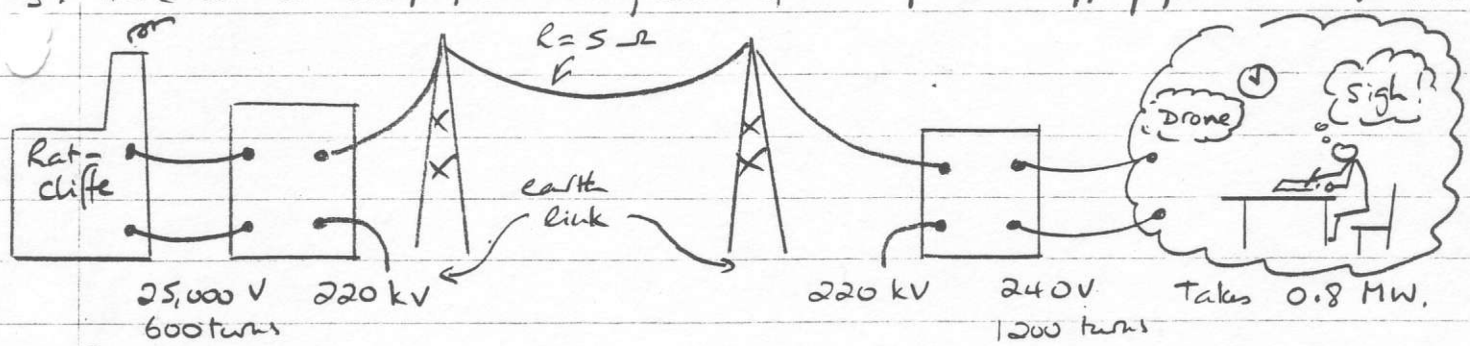
(a) What current is taken from 240V mains? (2)

(b) How many turns are on the primary coil? (2)

(c) A friend comes in and takes hold of the secondary output cables (A & B). Why isn't he killed? (2)

(d) Explain how the transformer seems to give something for nothing - ie 50A current from a small current input. (3) [7]

3. Here is a simplified diagram of the power supply for Wilsthorpe...



Calculate....

(a) the current taken by Wilsthorpe at 240 V. (2)

(b) the number of primary turns on the step down transformer (2)

(c) the number of secondary turns on the step up transformer (2)

(d) the current in the high voltage cable (2)

(e) the current supplied by the power station (2)

(f) the energy lost per second as heat from the high voltage cable (3) [15]

(g) the power output from Ratcliffe if each transformer is 90% efficient (2)

Electromagnetism – Transformers — Answers — A Physics

1. (a) less energy out than input in (1)

(b) Electrical (1) Current flowing (1) in coils, (1) against resistance → heat (1)

(2) eddy currents in iron core (1) → heat (again)

Magnetic (1) leakage of flux (1) out of the core (1) → reduced flux density

(2) energy needed to magnetise (1) the iron core (1) – keep reversing it (1) (12)

[13]

2. (a) Use Power in = $I_p V_p = I_s V_s$ (1) = Power out

so $I_p = I_s \frac{V_s}{V_p} = 50 \times \frac{12}{240} = \underline{2.5\ A}$ (1) (2)

(b) Use $\frac{N_p}{N_s} = \frac{V_p}{V_s} \longrightarrow N_p = \frac{V_p \times N_s}{V_s} = \frac{240 \times 10}{12} = \underline{200 \text{ turns}}$ (2)

rearrange to suit... N_p on top.

(c) The output is only 12V ! ... too low (1) .. produces tiny current through the body!

(d) The transformer increases current but at the expense of reduced voltage (1)

For an ideal transformer – Power (energy) in = Power (energy) out (1)

$P = IV$ (1) so current + voltage vary so the power is constant

[9]

3. (a) $P_{\text{wilsthorpe}} = 0.8 \times 10^6\ W = IV$ (1) $\longrightarrow I = 0.8 \times 10^6 / 240 = \underline{3333\ A}$ (2)

(b) $N_p/N_s = V_p/V_s$ (1) $\longrightarrow N_p = \frac{220{,}000}{240} \times 1200 = \underline{1.1 \times 10^6 \text{ turns}}$ (1) (2)

(c) for step up $N_s/N_p = V_s/V_p$ (1) $\longrightarrow N_s = \frac{220{,}000}{25{,}000} \times 600 = \underline{5280 \text{ turns}}$ (1) (2)

(d) Use the step down transformer... $I_p V_p = I_s V_s$ (1)

so I_p in cable $= 3333 \times 240 / 220{,}000 = \underline{3.64A}$ (1) (2)

(e) Now the step-up transformer...

$I_p V_p = I_s V_s$ (1) $\longrightarrow I_p$ from Ratcliffe $= 3.64 \times 220{,}000/25{,}000 = \underline{32\ A}$ (1) (2)

(f) Heat loss $= I^2_{\text{cable}} R_{\text{cable}}$ (1) $= 3.64^2 \times 5$ (1) $= \underline{66\ W}$ (1) J/s (3)

(g) Ratcliffe → step up → cable → step-down → wilsthorpe

P watts × 90/100 — Ignore small loss — × 90/100 = 800,000 W.

So Ratcliffe output $P = 800{,}000 / 0.9 \times 0.9$ (1) $= 988 \times 10^3$ (1) Watts (988 kW) (2)

[15]

TW

11.98.