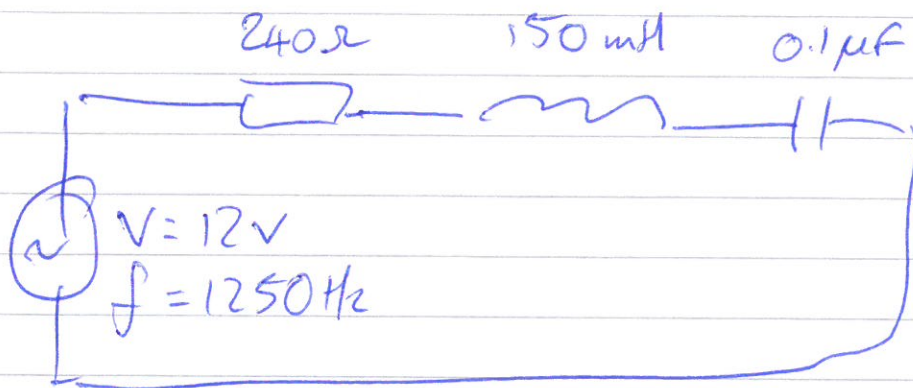


① a)



$$X_L = 2\pi fL = 2\pi \times 1250 \times 150 \times 10^{-3} = 1178.097\Omega$$

$$X_C = \frac{1}{2\pi fC} = \frac{1}{2\pi \times 1250 \times 0.1 \times 10^{-6}} = 1273.240\Omega$$

$$|Z| = \sqrt{R^2 + (X_L - X_C)^2} = \sqrt{240^2 + (1178.097 - 1273.240)^2} = 258.17\Omega$$

$$Z = 240 - j95.143\Omega$$

$$I = \frac{V}{Z} = \frac{12 + j0}{240 - j95.143}$$

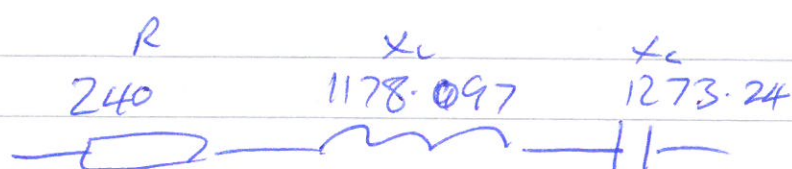
$$I = \frac{12 (240 + j95.143)}{(240 - j95.143)(240 + j95.143)}$$

$$I = \frac{2880 + j1141.716}{57600 - j^2 9052.19} = \frac{2880 + j1141.716}{66652.19} = \frac{0.043209}{j0.017129}$$

$$i) |I| = \sqrt{0.043209^2 + 0.017129^2} = 0.04648 \text{ A.}$$

$$\phi = \tan^{-1} \frac{0.017129}{0.043209} = 21.6245^\circ$$

i) a)  
ii)



Page 2.

$$V = 12$$

$$I = 0.04648 \quad \phi = 21.6245^\circ$$

$$V_R = I \times R = 0.04648 \times 240 = \underline{11.1552 \text{ V}}$$

$$V_L = I X_L = 0.04648 \times 1178.097 = 54.7579 \text{ V.}$$

$$(0.043209 + j0.017129)(j1178.097)$$

$$V_L = j50.90439327 + j^2 20.1796 = -20.1796 + j50.90439327$$

$$|V_L| = \sqrt{50.90439327^2 + 20.1796^2} = 54.758 \text{ V}$$

$$\phi = \tan^{-1} \frac{-20.1796}{50.9044} = \underline{\underline{-21.624^\circ}}$$

$$V_C = I X_C = (0.043209 + j0.017129)(-j1273.24)$$

$$V_C = -55.0154 - j^2 21.798$$

$$|V_C| = \sqrt{55.0154^2 + 21.798^2} = \underline{59.1764 \text{ V}}$$

$$\phi = \tan^{-1} \frac{-21.798}{-55.0154} = \underline{21.614^\circ}$$

①

$$a) \Rightarrow P_R = I^2 R$$

$$I = 0.043209 + j0.017129 \text{ A} \quad (0.04648 \angle 21.6245^\circ \text{ A})$$

$$R = 240 \Omega$$

$$P_R = (0.043209 + j0.017129)(0.043209 + j0.017129) 240$$

$$(\cancel{1.867 \times 10^{-3}} + j^2 293.403 \times 10^{-6}) 240$$

$$(0.44808 - \cancel{0.07043}) = 0.37765 \text{ W}$$

$$(1.867 \times 10^{-3} + j740.127 \times 10^{-6} + j740.127 \times 10^{-6} + j^2 293.403 \times 10^{-6}) 240$$

$$0.44808 + j0.35526 + j^2 0.07043$$

$$P_R = 0.37765 + j0.35526 \text{ W}$$

$$|P_R| = \sqrt{0.37765^2 + 0.35526^2} = 0.51849 \text{ W}$$

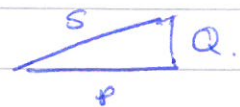
$$iv) P_{Tot} = V I$$

$$= 12 (0.043209 + j0.017129)$$

$$= 0.518508 + j0.205548 \text{ VA}$$

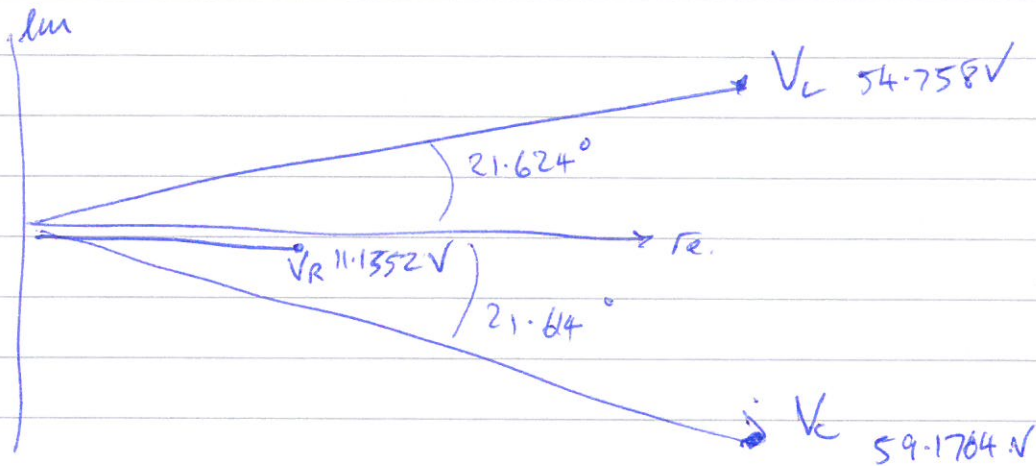
$$|P_{Tot}| = \sqrt{0.518508^2 + 0.205548^2} = 0.55776 \text{ VA}$$

$$v) S = 0.55776 \quad P = 0.51849$$



$$Q = \sqrt{0.55776^2 - 0.51849^2} = 0.20395 \text{ VAR}$$

1. b)



$$c) f_{res} = \frac{1}{2\pi\sqrt{LC}} = \frac{1}{2\pi\sqrt{150 \times 10^{-3} \times 0.1 \times 10^{-6}}} = 1299.49 \text{ Hz}$$

$$d) i) I = \frac{V}{R} = 0.05 \text{ Amps } \angle 0^\circ$$

$$ii) V_R = I \times R = 0.05 \times 240 = 12 \text{ V}$$

$$X_C = \frac{1}{2\pi f C} = \frac{1}{2\pi \times 1299.49 \times 0.1 \times 10^{-6}} = 1224.749 \Omega$$

$$V_C = I \times X_C = 0.05 \times 1224.749 = 61.23745 \text{ V}$$

$$X_L = X_C = 1224.749$$

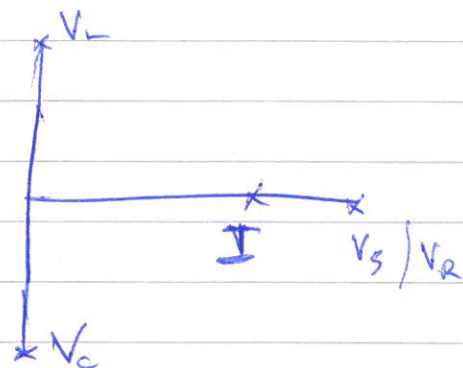
$$V_L = I \times X_L = 0.05 \times 1224.749 = 61.23745 \text{ V}$$

$$iii) P_R = 0.05^2 \times 240 = 0.06 \text{ W}$$

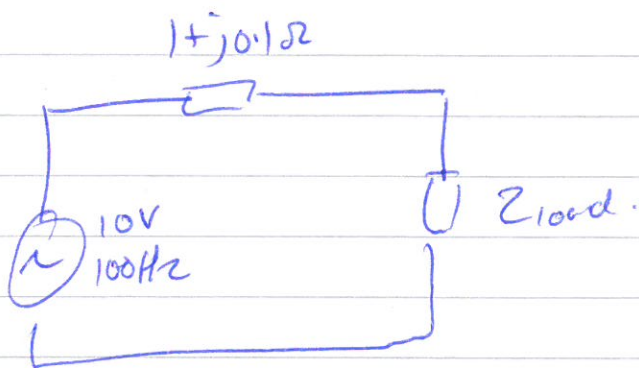
$$iv) 0.06 \text{ W}$$

$$v) 0 \text{ W}$$

e)



2.



a)  $Z_{load} = 10 - j0.5 \Omega$  power in load.

$$Z_{TOTAL} = 1 + j0.1 + 10 - j0.5$$

$$Z_T = 11 - j0.4 \Omega$$

$$I = \frac{V}{Z_T} = \frac{10}{11 - j0.4}$$

$$\frac{10(11 + j0.4)}{(11 - j0.4)(11 + j0.4)} = \frac{110 + j4}{121 - j^2 0.16} = \frac{110 + j4}{121.16}$$

$$I = 0.90789 + j0.033 \text{ A}$$

$$P_{LOAD} = I^2 Z = (0.90789 + j0.033)(0.90789 + j0.033)(10 - j0.5) \text{ VA.}$$

$$(0.82464 + j0.02996 + j0.02996 + j^2 0.001689)(10 - j0.5)$$

$$(0.822951 + j0.05992)(10 - j0.5)$$

$$8.22951 - j0.4114755 + j0.5992 - j^2 0.02996$$

$$P_{LOAD} = 8.25947 + j0.18772$$

$$|P| = \sqrt{8.25947^2 + 0.18772^2} = 8.2616 \text{ VA.}$$

$$\phi = \tan^{-1} \frac{0.18772}{8.25947} = 1.2985^\circ$$

2.

$$b). \quad I = 0.90789 + j0.033$$

$$V_{Z_{LOAD}} = I Z_{LOAD} = (0.90789 + j0.033)(10 - j0.5)$$

$$9.0789 - j0.453945 + j0.33 - j^2 0.0165$$

$$V_{Z_{LOAD}} = 9.0954 - j0.123945 \quad V$$

$$|V_{Z_{LOAD}}| = \sqrt{9.0954^2 + 0.123945^2} = 9.09624$$

$$\phi = \tan^{-1} \frac{0.123945}{9.0954} = 0.7807^\circ$$

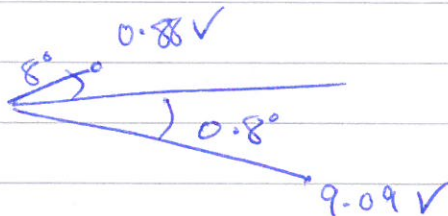
$$V_{Z_{SRC}} = I Z_{SRC} = (0.90789 + j0.033)(1 + j0.1)$$

$$V_{Z_{SRC}} = 0.90789 + j0.090789 + j0.033 + j^2 0.0033$$

$$V_{Z_{SRC}} = 0.87489 + j0.123789 \quad V$$

$$|V_{Z_{SRC}}| = \sqrt{0.87489^2 + 0.123789^2} = 0.8836 \quad V$$

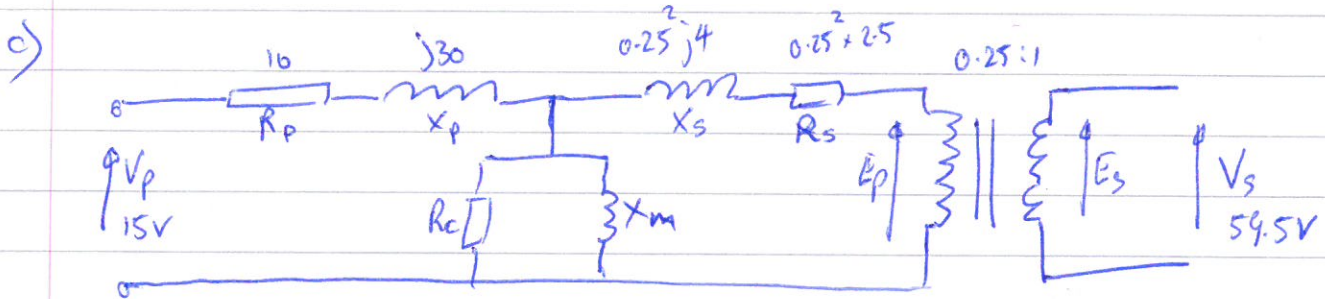
$$\phi = \tan^{-1} \frac{0.123789}{0.87489} = 8.053^\circ$$



(3)

- a) Hysteresis in transformer core  
 Eddy currents in transformer core  
 Copper losses in primary + Secondary coils  
 Flux linkage / Flux leakage between coils + core

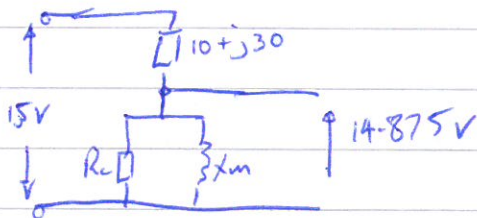
- b) Eddy currents can be reduced by laminating the core. This increases the electrical resistance of the core impeding the eddy currents.



$$E_s = V_s = 59.5V$$

$$E_p = a E_s = 0.25 \times 59.5 = 14.875V$$

No current in secondary - No need to include  $X_s$  or  $R_s$



$$14.875 = 15 \times \frac{R_c + jX_m}{10 + j30 + R_c + jX_m}$$

$$\frac{14.875}{15} = \frac{R_c + jX_m}{10 + j30 + R_c + jX_m}$$

$$0.99166 = \frac{R_c + jX_m}{10 + j30 + R_c + jX_m}$$

$$1.00841 = \frac{10 + j30 + R_c + jX_m}{R_c + jX_m}$$

$$1.00841 = \frac{10 + j30}{R_c + jX_m} + 1$$

$$1.00841 - 1 = \frac{10 + j30}{R_c + jX_m}$$

$$0.00841 = \frac{10 + j30}{R_c + jX_m}$$

$$\frac{10 + j30}{0.00841} = R_c + jX_m$$

$$1189.06 + j3567.18 = R_c + jX_m$$

$$R_c = 1189.06 \, \Omega$$

$$X_m = j3567.18 \, \Omega$$

d) Flux present in core is given by

$$\Phi_{\max} = \frac{E_{\text{rms}}}{4.44 f N}$$

Where  $E_{\text{rms}}$  is the voltage across the primary coil,  $f$  is frequency and  $N$  is number of turns

$$E_p = I_p Z_p = 10 (10 + j30) = 100 + j300 \, \text{V}$$

$$|E_p| = \sqrt{100^2 + 300^2} = 316.2278 \, \text{V}_{\text{peak}}$$

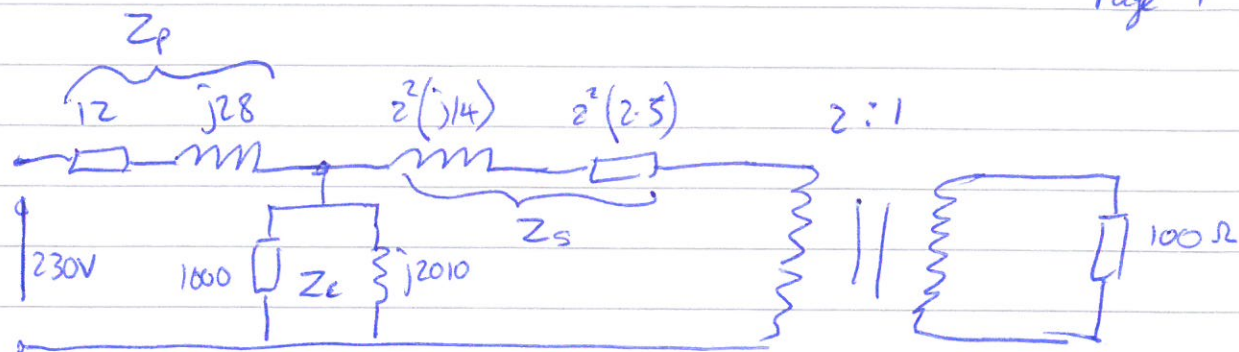
$$E_{\text{rms}} = \frac{E_p}{\sqrt{2}} = \frac{316.2278}{\sqrt{2}} = 223.607 \, \text{V}$$

Assuming  $f = 50 \, \text{Hz}$  and  $N = 1000$  turns

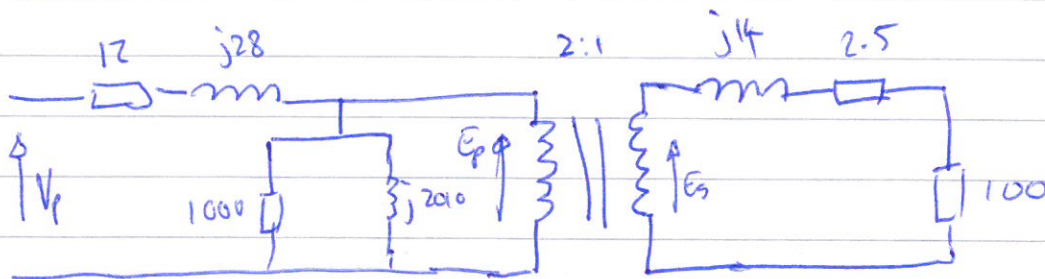
$$\Phi_{\max} = \frac{223.607}{4.44 \times 50 \times 1000} = 1.007 \times 10^{-3} \, \text{Wb}$$

③

e)



Redraw:-



$$E_p = V_p \times \frac{Z_c}{Z_p + Z_c}$$

$$E_p = 230 \times \frac{1000 + j2010}{1012 + j2038}$$

$$E_p = 230 \times \frac{(1000 + j2010)(1012 - j2038)}{(1012 + j2038)(1012 - j2038)}$$

$$E_p = 230 \times \frac{1012000 - j2038000 + j2034120 - j^2 4096380}{1024144 - j^2 4153444}$$

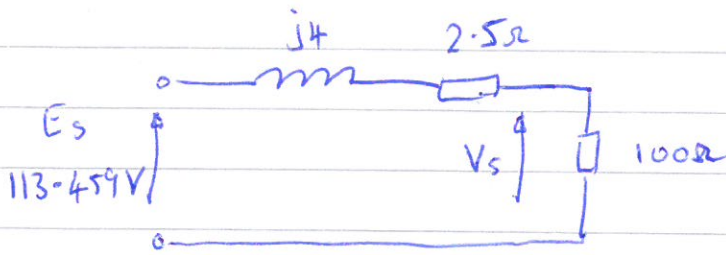
$$E_p = 230 \times \frac{5108380 - j3880}{5177588} = 230 \times \frac{0.9}{0.9866} - j749.38 \times 10^{-6}$$

$$E_p = 226.918 - j0.17238$$

$$|E_p| = \sqrt{226.918^2 + 0.17238^2} = 226.918 \text{ V}$$

$$E_s = \frac{E_p}{a} = \frac{226.918}{2} = 113.459 \text{ V}$$

③ e) cont:



$$V_s = E_s \times \frac{100}{2.5 + j4 + 100}$$

$$V_s = 113.459 \times \frac{100}{102.5 + j4}$$

$$V_s = 113.459 \times \frac{100(102.5 - j4)}{(102.5 + j4)(102.5 - j4)}$$

$$V_s = 113.459 \times \frac{10250 - j400}{10506.25 - j^2 16}$$

$$V_s = 113.459 \times \frac{10250 - j400}{10522.25}$$

$$V_s = 113.459 \times (0.974126 - j0.038)$$

$$V_s = 110.523 - j4.3114$$

$$|V_s| = \sqrt{110.523^2 + 4.3114^2} = 110.607 \text{ V}$$