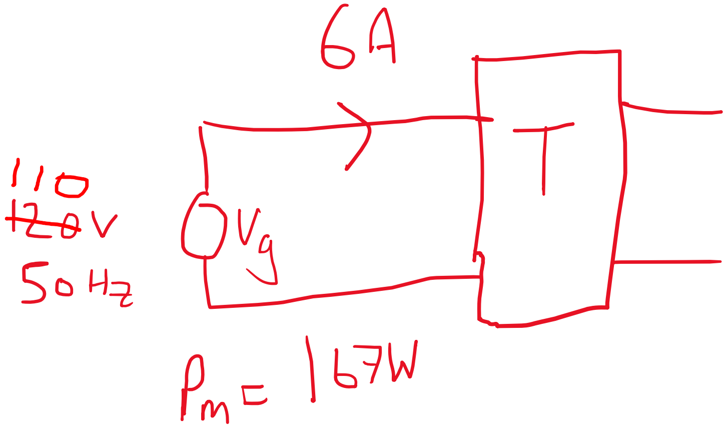
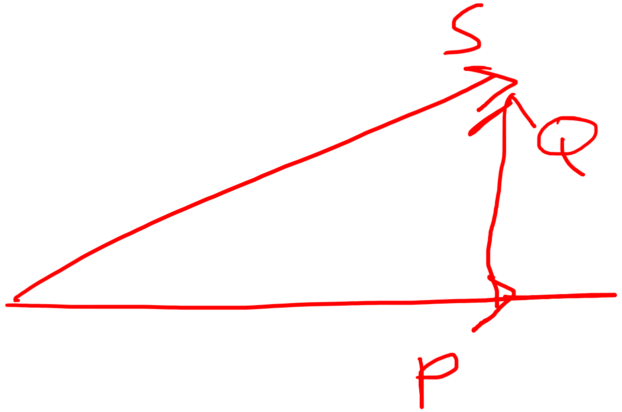
Transformers Example

26th October 2021

Q1





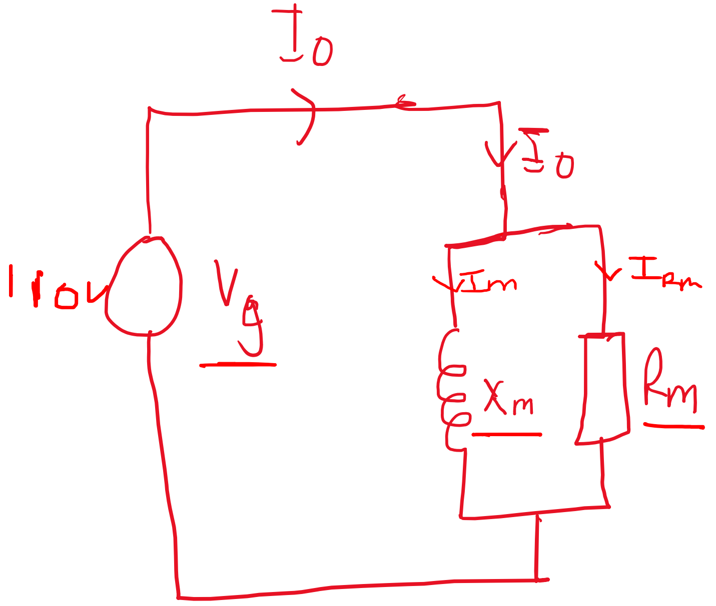
Apparent power supplied to core:

$S_m = V_g I_o = 110 \times 6 = 660\ VA$

Iron Losses = $P_m = 167\ \text{W}$

VAR

$\therefore$ Reactive power absorbed by core = $Q_m = \sqrt{S_m^2 - P_m^2} = \sqrt{660^2 - 167^2} = 638.5\ \text{VAr}$



For part (b) and (c) we need to find X_m and R_m

$$R_m = \frac{V_g^2}{P_m} = \frac{110^2}{167} = 72.5\Omega$$

(c) $$X_m = \frac{V_g^2}{Q_m} = \frac{110^2}{638.5} = 18.95\Omega$$

(b) $$Z_m = R_m // X_m = \frac{72.5 \times j18.95}{72.5 + j18.95} = \frac{1373.9\angle 90^o}{74.94\angle 14.65^o} = 18.3\angle 75.35^o\,\Omega$$

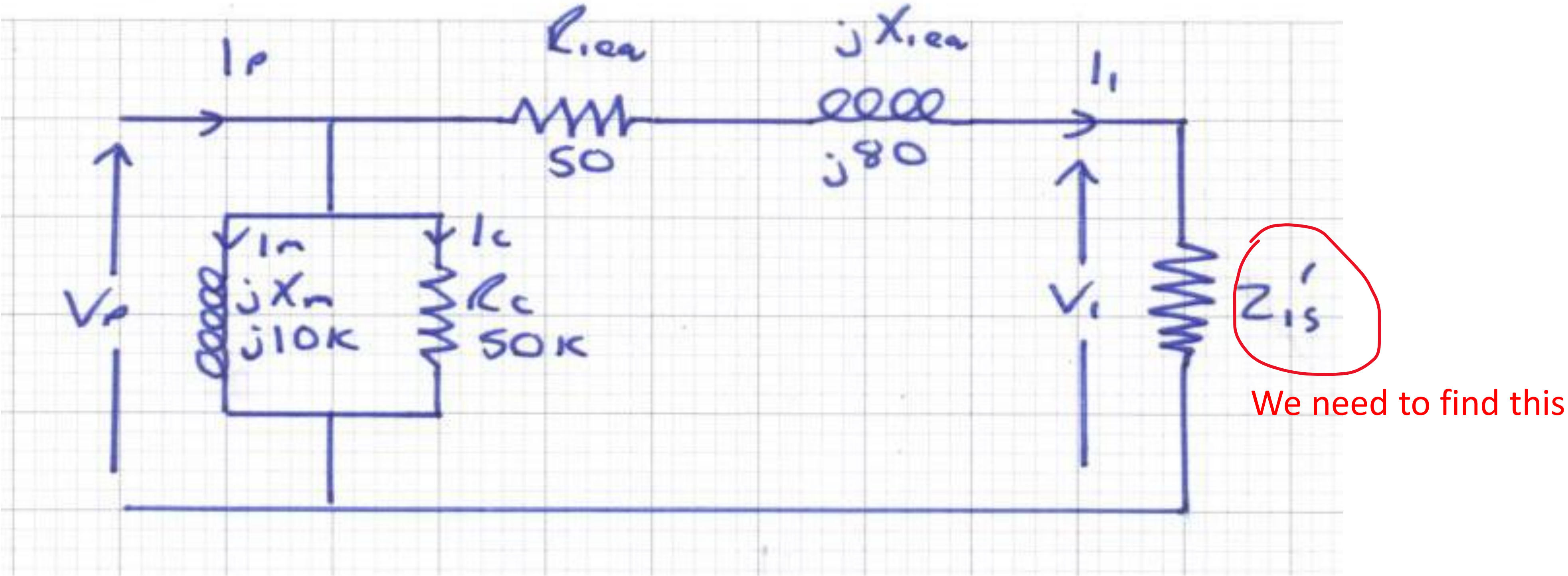
Magnetizing Current:

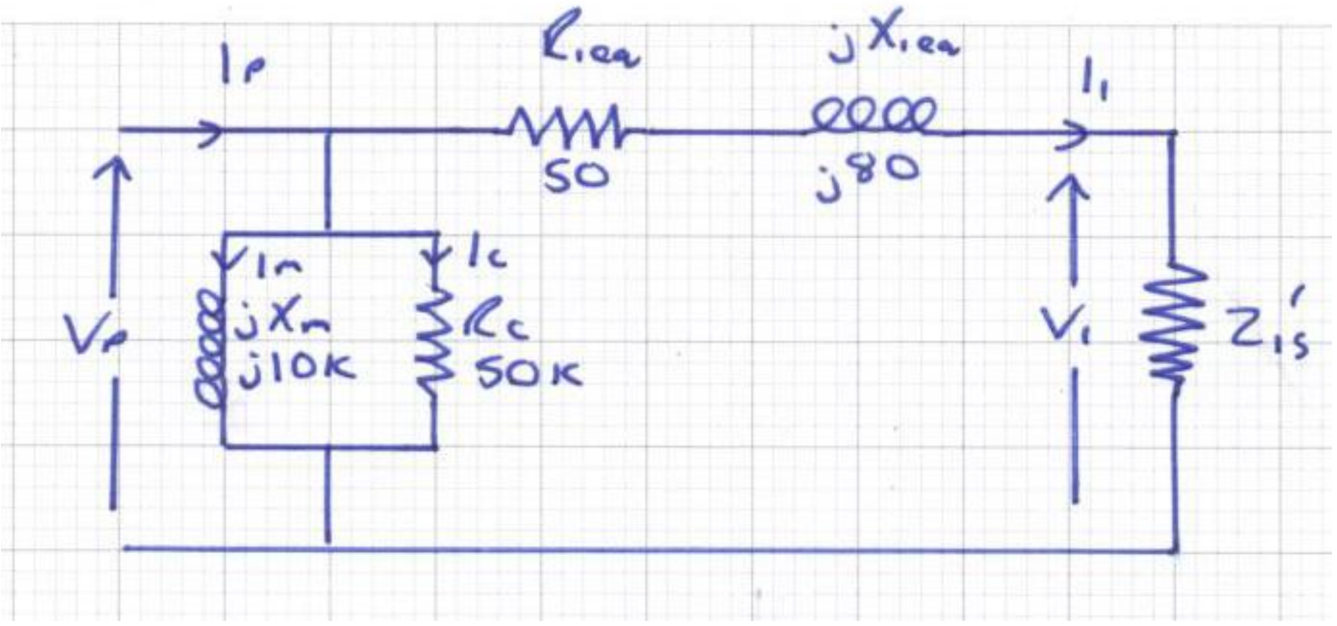
$$I_m = \frac{V_g}{jX_m} = \frac{110}{18.95\angle 90^\circ} = 5.8A$$

$$\underline{5.8\angle -90^\circ\ A}$$

Q2

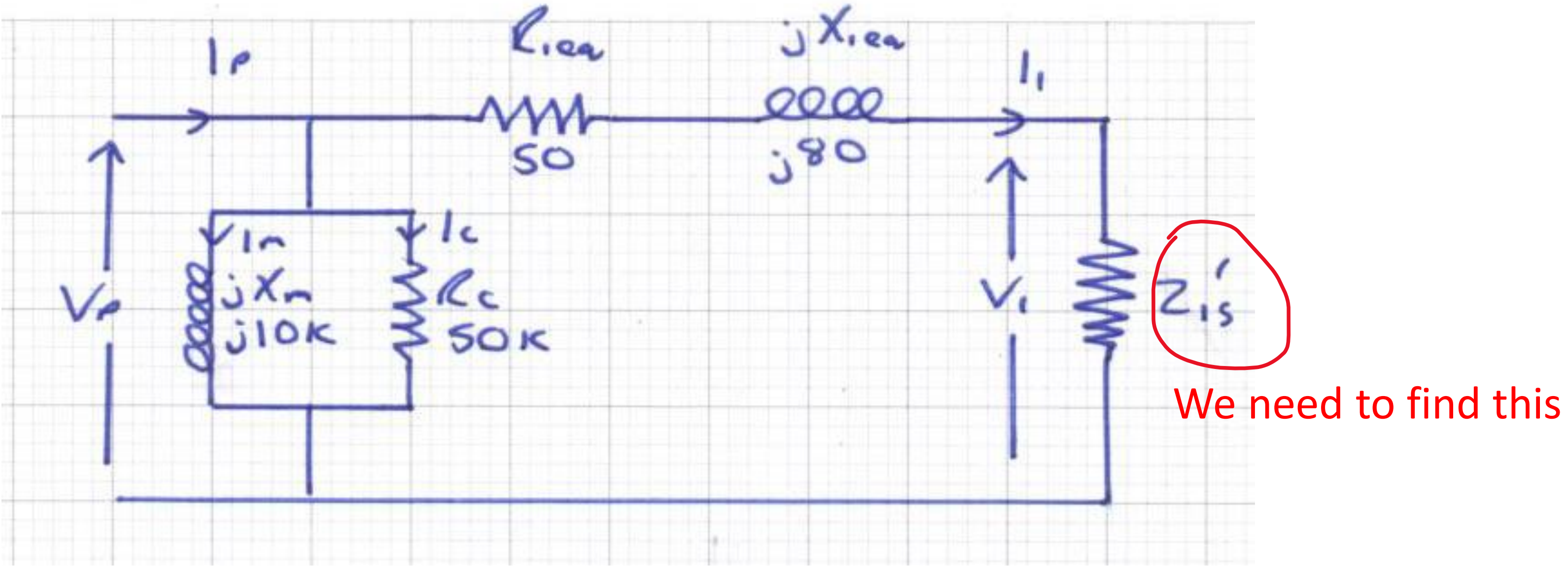
Remember: Draw diagrams when solving problems. It makes it easier to see what you are doing (and easier to give better marks !)





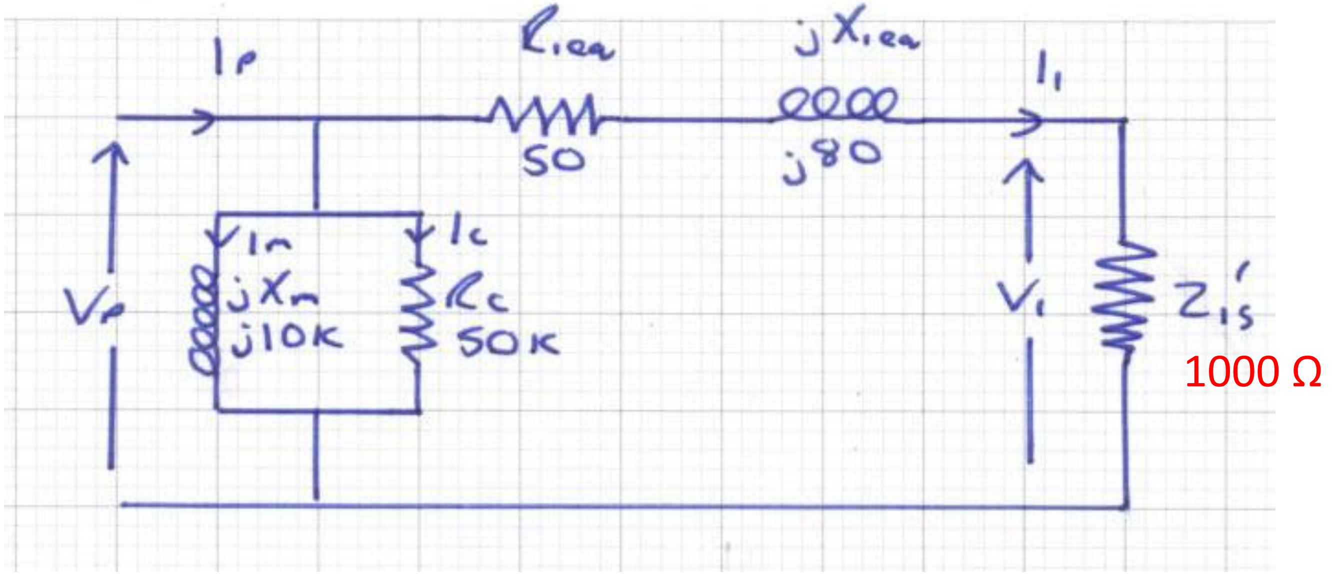
A resistive load of 1.6Ω is connected across the secondary terminals of a 10kV/400V transformer.

$$\text{Turns Ratio} = \frac{V_P}{V_{Soc}} = \frac{10000}{400} = 25$$



$$Z_{1s}^{'} = (\text{Turns Ratio})^2 \times Z_s = 25^2 \times 1.6 = 1000\ \Omega$$

The output current (I_S)

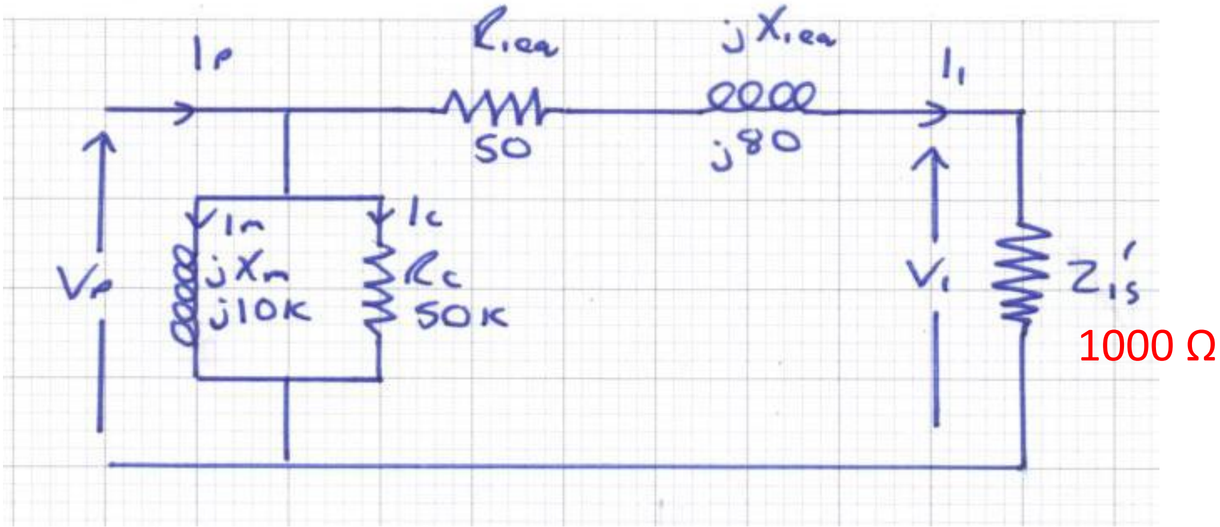


$$V_P = I_1(R_{1eq} + jX_{1eq} + Z'_{1s})$$

$$\therefore I_1 = \frac{V_P}{R_{1eq} + jX_{1eq} + Z'_{1s}} = \frac{10000}{1050 + j80} = \frac{10000\angle 0^o}{1053\angle 4.35^o} = 9.5\angle -4.35^o \text{ A}$$

$$I_s = \left(\frac{n_p}{n_s}\right) I_1 = 25 \times 9.5\angle -4.35^o = 237.5\angle -4.35^o \text{ A}$$

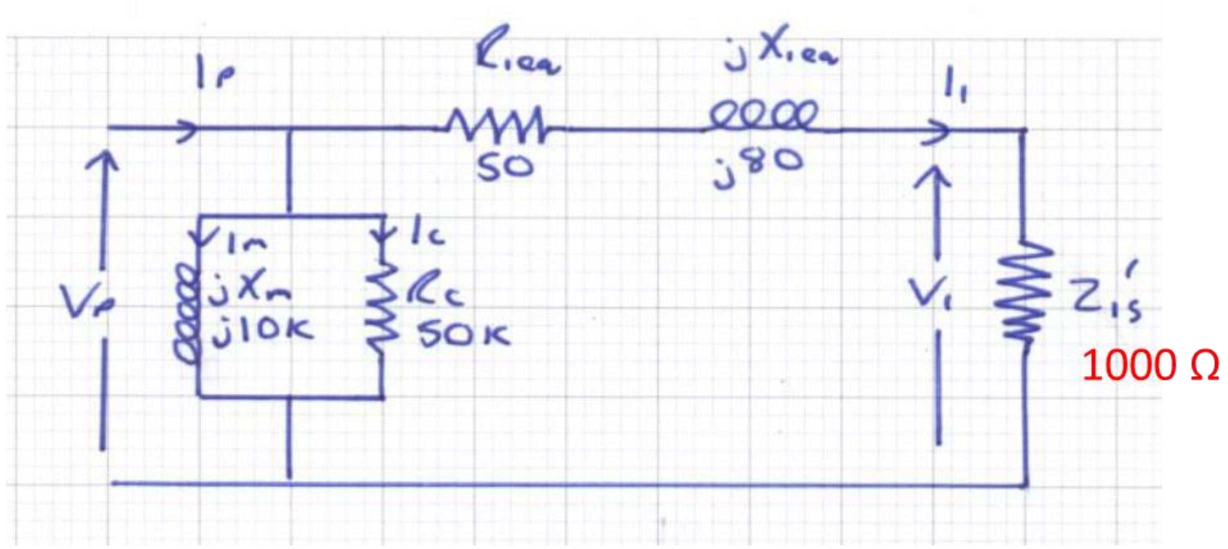
The output voltage under load (V_S)



$$V_1 = I_1 Z_{1s}^{'} = 9.5\angle -4.35^o \times 1000\angle 0^o = 9500\angle -4.35^o \text{ V}$$

$$V_s = \left(\frac{n_s}{n_p}\right) V_1 = \frac{1}{25} \times 9500\angle -4.35^o = 380\angle -4.35^o \text{ V}$$

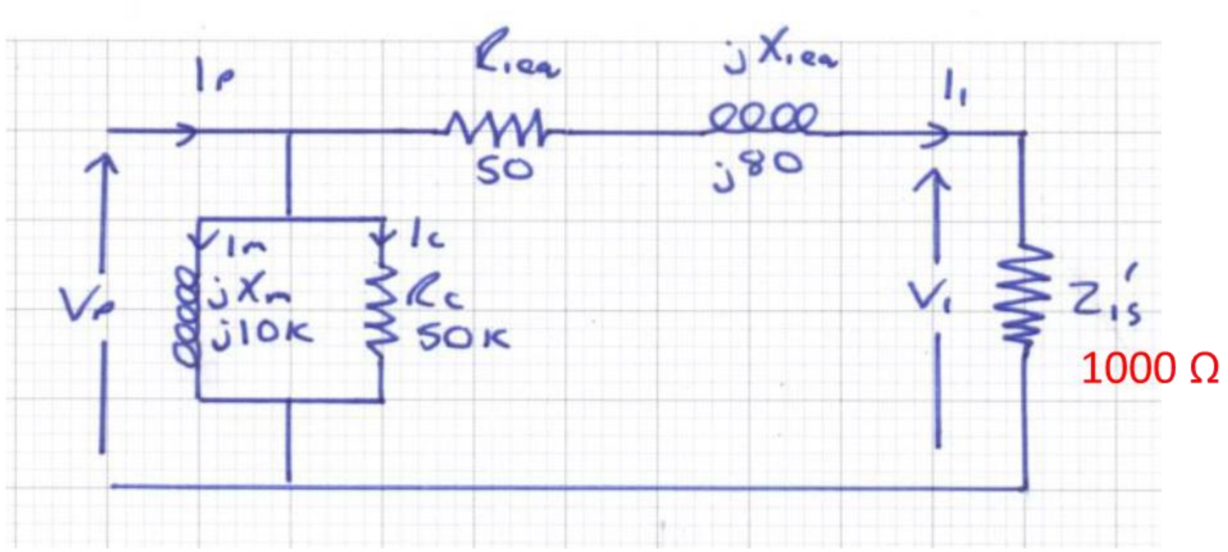
The iron and copper loss



$$\text{Iron Loss } P_{iron} = \frac{V_p^2}{R_c} = \frac{10000^2}{50000} = 2 \text{ kW}$$

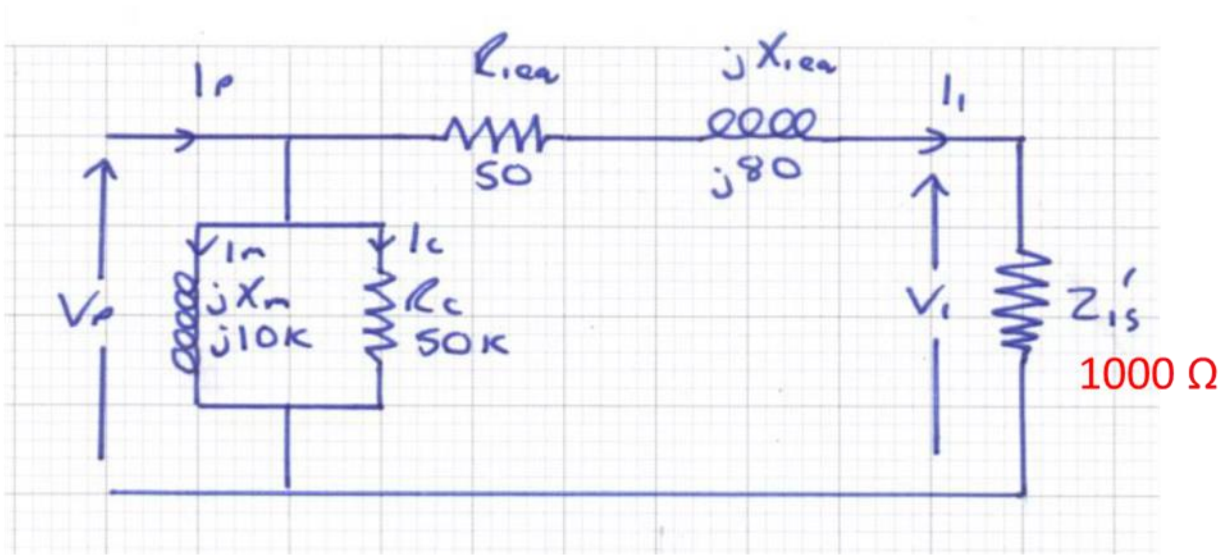
$$\text{Copper Loss } P_{Cu} = I_1^{\,2} R_{1eq} = 9.5^2 \times 50 = 4.51 \text{ kW}$$

The magnetising current (I_m)



$$\text{Magnetizing Current } I_m = \frac{V_p}{jX_n} = \frac{10000\angle 0^o}{10000\angle 90^o} = 1\angle -90^o \text{ A}$$

The Input Current (I_P)



$$I_p = I_1 + I_m + I_c$$

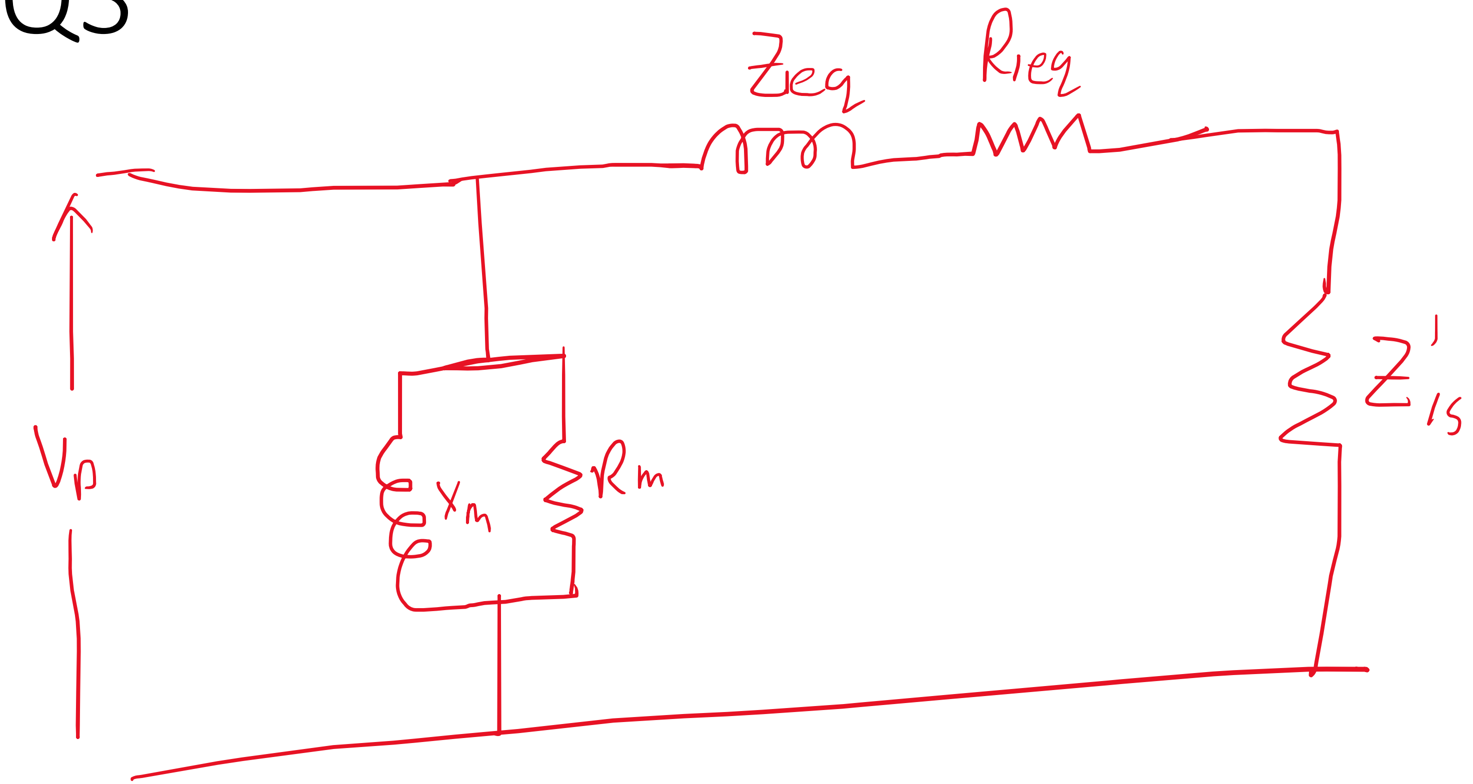
$$I_1 = 9.5\angle -4.35^o = 9.47 - j0.75 \text{ A}$$

$$I_m = 1\angle -90^o = 0 - j1 \text{ A}$$

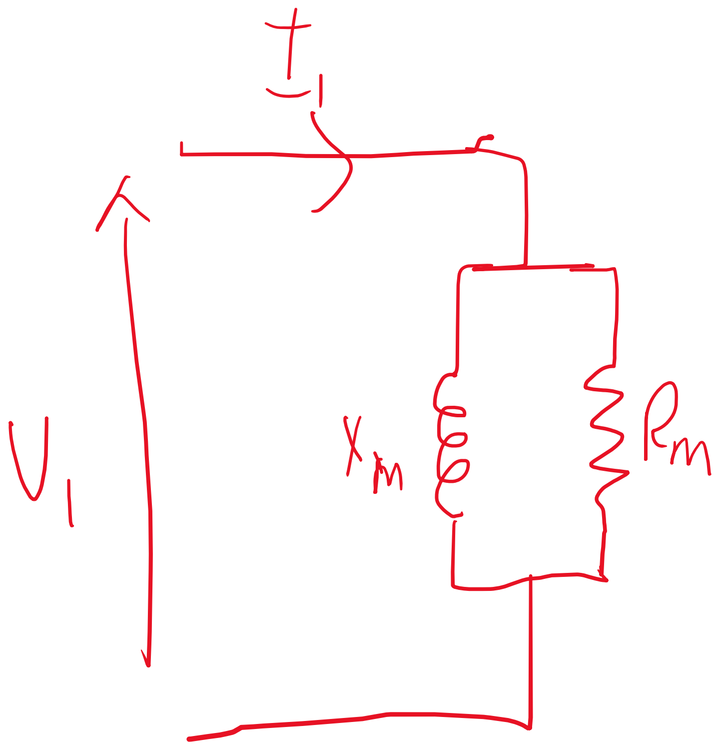
$$I_c = \frac{V_P}{R_C} = \frac{10000\angle 0^o}{50000\angle 0^o} = 0.2\angle 0^o = 0.2 + j0 \text{ A}$$

$$\therefore I_P = 9.47 - j0.75 - j1 + 0.2 = 9.67 - j1.75 = 9.83\angle -10.3^o \text{ A}$$

Q3



Open Circuit Test



$$\text{Turns Ratio} = \frac{230}{110} = 2.1$$

$$R_m = \frac{V_1^2}{Pin} = \frac{230^2}{30} = 1763.3\Omega$$

$$S_P = V_1 I_1 = 230 \times 2 = 460VA$$

$$Q_P = \sqrt{S_p^2 - P_{in}^2} = 459VA_r$$

$$X_m = \frac{V_1^2}{Q_P} = \frac{230^2}{459} = 115.3\Omega$$

Short Circuit Test

$$R_{1eq} = \frac{Pin}{I_1^2} = \frac{200}{22^2} = 0.413\ \Omega$$

$$S_{sc} = V_1 I_1 = 40 \times 22 = 880\ \text{VA}$$

$$Q_{sc} = \sqrt{S^2 - P^2} = \sqrt{880^2 - 200^2} = 857\ \text{VAr}$$

$$X_{1eq} = \frac{Q_{SC}}{I_1^2} = \frac{857}{22^2} = 1.77\ \Omega$$