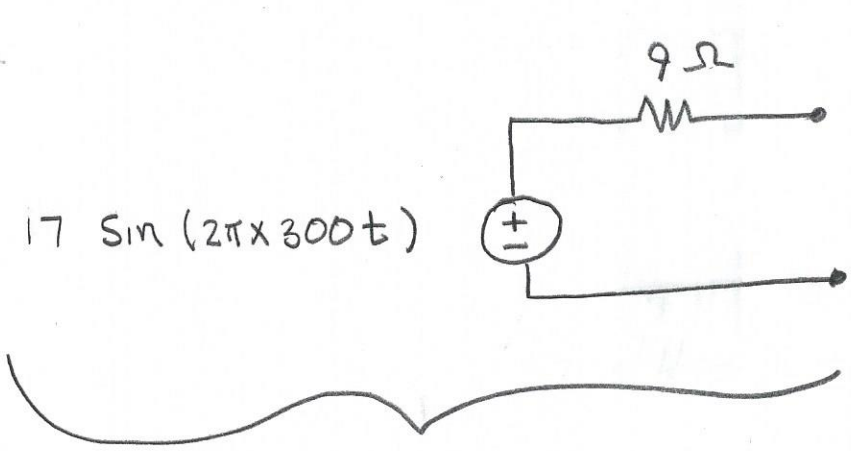
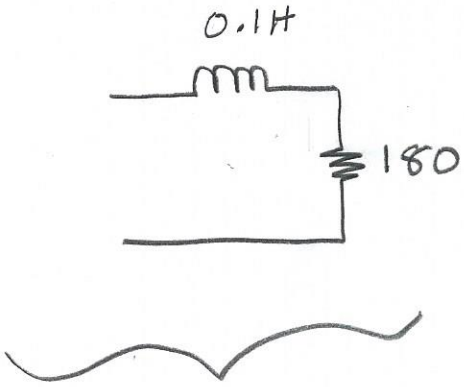
SUPPLEMENTAL PROBLEM – MAGNETIC CIRCUITS

DORR
SPRING 2017



You are given this Source



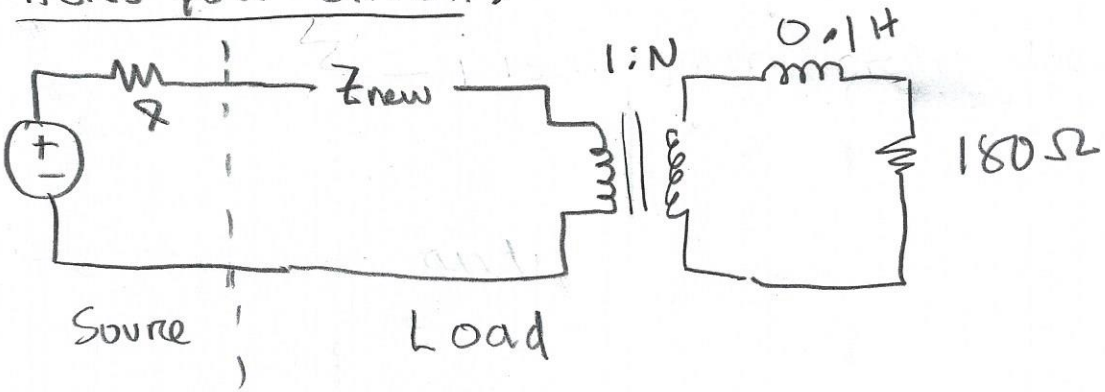
and this load

Use an ideal transformer and one additional component so the load recieves maximum power from the source.

The additional component must be placed in series with the 9 Ω source resistance. Additional component must be a capacitor or inductor. Find component value and turns ratio.

Hints

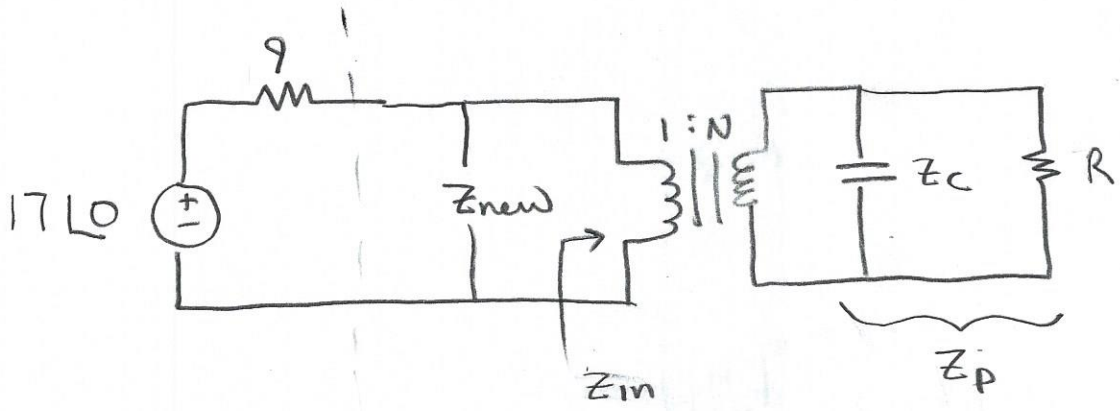
1) Here's your circuit:



2) Compute turns ratio to match 9 Ω, then find the reactive component.

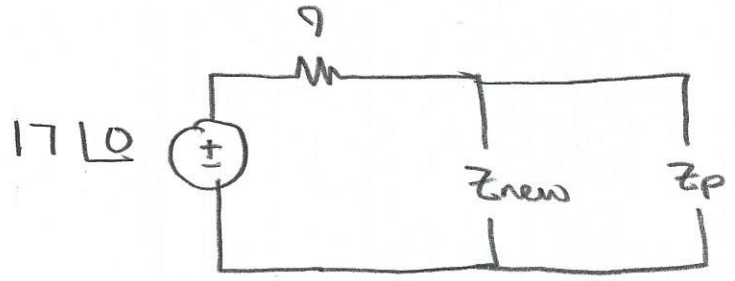
3) The example on the next several pages shows how to do the problem for shunt components

Example problem for subblement



$$Z_p = \frac{Z_c Z_R}{Z_c + Z_R}$$

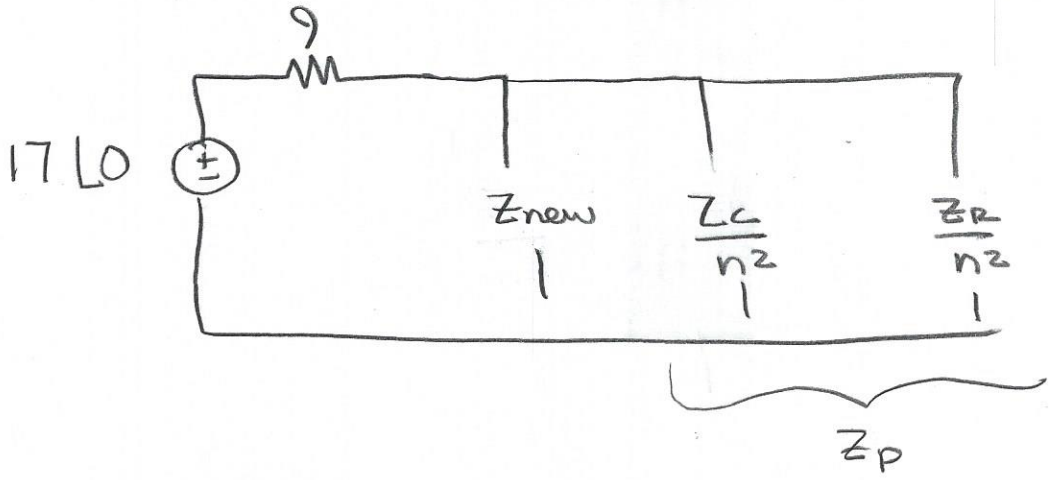
$$Z_{in} = \frac{Z_p}{n^2}$$



$$\frac{Z_p}{n^2} = \frac{Z_c Z_R}{Z_c + Z_R} \times \frac{1}{n^2} = \frac{\frac{Z_c}{n^2} \times \frac{Z_R}{n^2}}{\frac{Z_c}{n^2} + \frac{Z_R}{n^2}} = \frac{Z_c Z_R}{Z_c + Z_R} \times \frac{\frac{1}{n^4}}{1/n^2}$$

$$= \frac{Z_c Z_R}{Z_c + Z_R} \times \frac{1}{n^2}$$

So I can represent reflected impedance as shown on the next page



So strategy is to set n^2 so $\frac{Z_R}{n^2} = 9$

Then set Z_{new} so $Z_{new} \| \frac{Z_C}{n^2} = \infty$

$$n = \sqrt{\frac{Z_R}{9}} = \sqrt{\frac{R}{9}}$$

so $$\frac{Z_C}{n^2} = \frac{Z_C}{R/9} = \frac{9Z_C}{R}$$

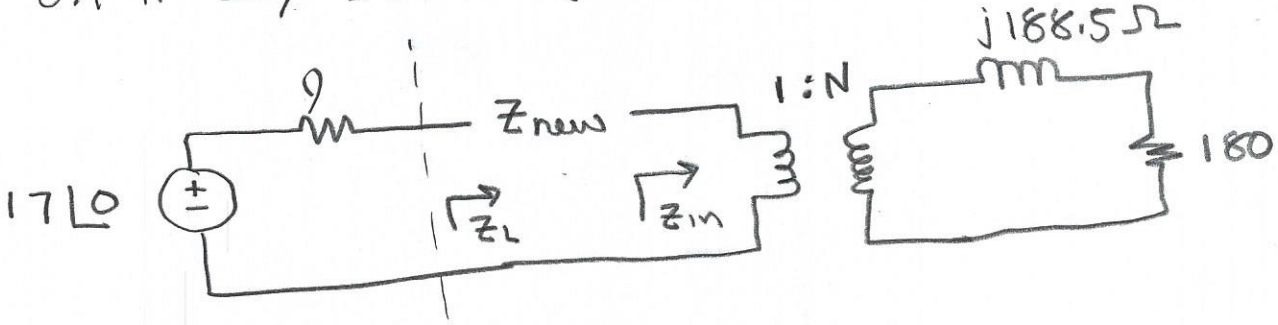
and $Z_{new} \| \frac{9Z_C}{R} = \infty$

$$\frac{Z_{new} \times \frac{9Z_C}{R}}{Z_{new} + \frac{9Z_C}{R}} = \infty \quad \text{so} \quad Z_{new} + \frac{9Z_C}{R} = 0$$

or $$\boxed{Z_{new} = -\frac{9Z_C}{R}}$$

SUPPLEMENTAL PROBLEM SOLUTION
MAGNETIC CIRCUITS

0.1 H $\Rightarrow$ $2\pi f L = j\omega L = j\,2\pi \cdot 300 \times 0.1 = j188.5\,\Omega$

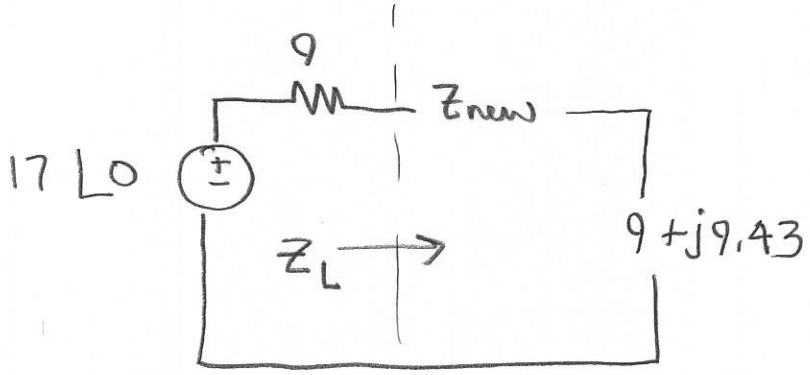


Reflect load to primary

$$Z_{in} = \frac{Z_L}{n^2} = \frac{180 + j188.5}{n^2}$$

Set n so $\mathrm{Re}(Z_{in}) = 9\,\Omega$ or $\frac{180}{n^2} = 9$ $\therefore n = 4.47$

Now $Z_{in} = \frac{180 + j188.5}{4.47^2} = 9 + j9.43$



so for $Z_L = Z_{Th}^*$, $Z_L = 9$

so $Z_{new} + 9 + j9.43 = 9$ or $Z_{new} = -j9.43\,\Omega$

Z_{new} must be a capacitor because $Z_{new} = -j9.43$

$$Z_C = -j9.43 = \frac{1}{j2\pi \times 300 \cdot C}$$

$$C = \frac{1}{2\pi \times 300 \times 9.43} = 56.25\ \mu f$$