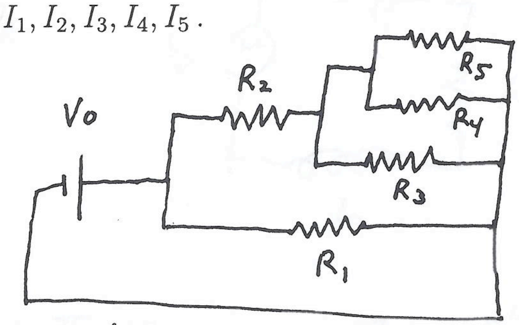
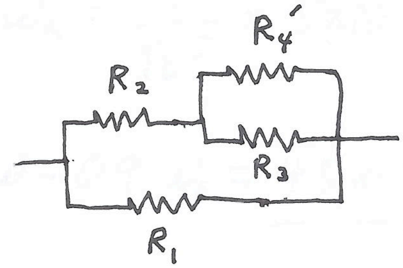
SMU Physics 1308 : Spring 2009

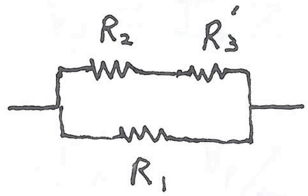
Final Exam

Problem 1 : The figure below shows a circuit with the corresponding resistances $R_1 = 3\Omega$, $R_2 = 5\Omega$, $R_3 = 2\Omega$, $R_4 = 7\Omega$, $R_5 = 4\Omega$. If the battery has the voltage $V_0 = 5\text{V}$, find the currents I_1, I_2, I_3, I_4, I_5 .

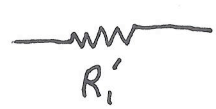




$R_4' = 28/11$



$R_3' = 28/25$



$$\frac{1}{R_1'} = \frac{1}{R_1} + \frac{1}{R_2 + R_3'}$$

$$R_1' = \frac{159}{128}$$

$$I_1 = V_0/R_1 = 1.67\text{ A}$$

$$I_2 = \frac{V_0}{(R_2 + R_3')} = 0.82\text{ A}$$

$$V_3' = V_0 - I_2 R_2 = 0.92\text{ V}$$

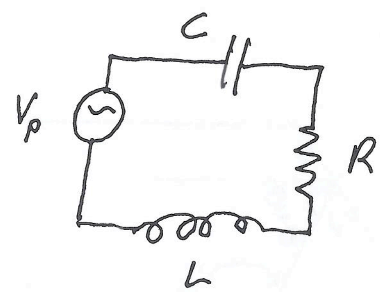
$$I_3 = V_3'/R_3 = 0.46\text{A}$$

$$I_4 = V_3'/R_4 = 0.13\text{ A}$$

$$I_5 = V_3'/R_5 = 0.23\text{ A}$$

Problem 2 : An RLC circuit has $R = 12\Omega$, $C = 1.0 \times 10^{-6}$ F, and $L = 4.0 \times 10^{-2}$ H. If it is being driven by an oscillating source of peak voltage $V_p = 5$ V which is operating at 90% of the resonant frequency of the circuit, what is the peak voltage across the resistor (V_{pR}), the inductor (V_{pL}), and the capacitor (V_{pC})?

$w = 0.9 w_R$



$w_R = \frac{1}{\sqrt{LC}} = 5 \times 10^3 \, s^{-1}$

$w = 0.9 \, w_R = 4.5 \times 10^3 \, s^{-1}$

$V_p = I_p Z$

$Z = (R^2 + (wL - 1/wC)^2)^{1/2} = 43.9 \, \Omega$

$I_p = V_p / Z = 0.114 \, A$

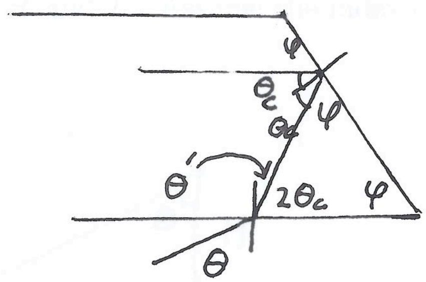
$V_{pR} = I_p R = 1.37 \, V$

$V_{pC} = I_p / wC = 25.31 \, V$

$V_{pL} = I_p w L = 20.50 \, V$

Problem 3 : The figure below shows a piece of glass of refractive index $n = 1.8$ which is cut at an angle φ such that the ray shown strikes the glass-air interface an infinitesimal amount beyond the critical angle θ_c. That is assume the angle shown below is the critical angle, but a reflection takes place as shown. Find the angle φ, and the angle θ that the ray emerges from the glass.

$n = 1.8$



$\sin\theta_c = \frac{1}{n}$

$\theta_c = 33.75^\circ$

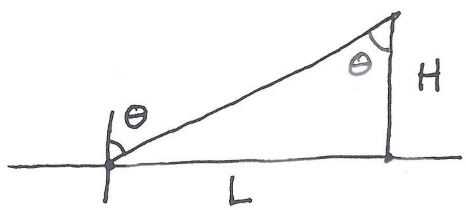
$\varphi = 90^\circ - \theta_c = 56.25^\circ$

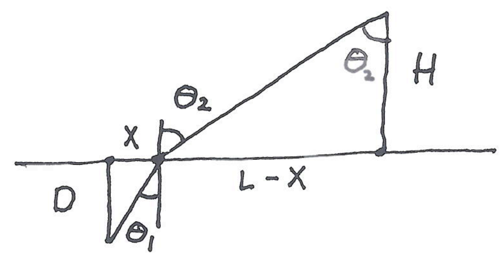
$\theta' = 90^\circ - 2\theta_c = 22.50^\circ$

$n \sin\theta' = \sin\theta$

$\theta = 43.54^\circ$

Problem 4 : The first figure below depicts a small submarine at the surface of the water. The submarine is looking at a lighthouse of height H which is a horizontal distance L away. The angle from the vertical that the submarine sees the lighthouse is $\theta = 75°$. The second figure shows the submarine submerged at a depth $D = 20\,\text{m}$ at the same horizontal distance L from the lighthouse. The angle from the vertical that the submarine sees the lighthouse when submerged is $\theta_1 = 46°$. Find the height of the lighthouse H and the horizontal distance L. The distance x and the angle θ_2 in the figure below will have to be eliminated (or solved for) in order to find H and L. Assume the index of refraction of air is $n_2 = 1$ and that of water is $n_1 = 1.33$.





$$\tan\theta = \frac{L}{H} = 3.73$$

$$\tan\theta_1 = \frac{X}{D} = 1.04$$

$$n_1 \sin\theta_1 = n_2 \sin\theta_2$$

$$\tan\theta_2 = \frac{L-X}{H} = 3.29$$

$$\sin\theta_2 = 1.33 \sin\theta_1$$

$$X = D\tan\theta_1 = 20.71$$

$$\theta_2 = 73.1°$$

$$\tan\theta_2 = \frac{\tan\theta\, H - D\tan\theta_1}{H}$$

$$H = \frac{D\tan\theta_1}{\tan\theta - \tan\theta_2} = 46.60\,\text{m}$$

$$L = H\tan\theta = 173.93\,\text{m}$$