PHYS 102: General Physics 2 **KOÇ UNIVERSITY** **Fall Semester 2015**

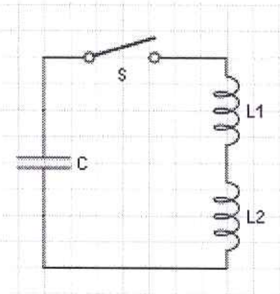
College of Arts and Sciences

Section **Quiz** **December 11, 2015**

Closed book. No calculators are to be used for this quiz.
Quiz duration: 10 minutes

Name: **Student ID:** **Signature:**

Two inductors ($L_1 = L,\ L_2 = L/2$) in series with zero current are connected through a switch to a capacitor with initial charge Q and the switch is closed at $t = 0$. Calculate the maximum voltage occuring across the inductor L_1.
(Hint: First find the equivalent inductance of two inductors in series. Then, for a simple LC circuit (one inductor – one capacitor) $-L\frac{di}{dt} - \frac{q}{C} = 0$ and $q = Q\cos(\omega t + \varphi)$. In this problem, take $\varphi = 0$)



$$L_{eq} = L_1 + L_2 = L + \frac{L}{2} = \frac{3L}{2}$$

$$-L_{eq}\frac{di}{dt} = \frac{q}{C} = V = V_{L1} + V_{L2}$$

$$-\frac{3L}{2}\frac{di}{dt} = \frac{Q\cos(wt)}{C}$$

$$V_{L1} = -L\frac{di}{dt} = \frac{2Q\cos(wt)}{3C}$$

Maximum value cosine can take is 1. Therefore:

$$(V_{L1})_{max} = \frac{2Q}{3C}$$

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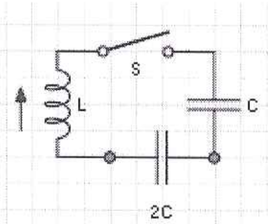
Name: Vahdet Ünal **Student ID:** **Signature:**

An inductor with initial current I (indicated by the arrow) is connected through a switch to two capacitors in series with zero initial charge and the switch is closed at $t = 0$. Calculate the maximum voltage across the capacitor with capacitance $2C$. (Hint: For a simple LC circuit (one inductor – one capacitor) $-L\frac{di}{dt} - \frac{q}{C} = 0$ and $q = Q\cos(\omega t + \varphi)$. Be careful about the value of φ you have use in this problem)



We need to find φ and Q using initial conditions.

$$q(t=0) = 0 = Q\cos(\varphi) \Rightarrow \varphi = \pi/2$$

$$i = \frac{dq}{dt} = -Q\omega\sin(\omega t + \pi/2)$$

$$i(t=0) = I = -Q\omega\sin(\pi/2) \Rightarrow Q = -\frac{I}{\omega}$$

Now we can find the voltage across capacitors.

$$V = \frac{q}{C_{eq}} = \frac{-\frac{I}{\omega}\cos(\omega t + \pi/2)}{\frac{2C}{3}} = -\frac{3I\cos(\omega t + \pi/2)}{2\omega C}$$

$$C_{eq} = \frac{C_1C_2}{C_1+C_2} = \frac{2C^2}{3C} = \frac{2C}{3}$$

$$V = V_1 + V_2 = \frac{q_1}{C} + \frac{q_2}{2C}$$

$q_1 = q_2$ since capacitors are connected in series.

$$V = \frac{q_2}{C} + \frac{q_2}{2C} = 2V_2 + V_2 = 3V_2 \Rightarrow V_2 = \frac{V}{3} = -\frac{I\cos(\omega t + \pi/2)}{2\omega C}$$

$V_{2\,max} = \frac{I}{2\omega C}$. Solution is not over yet. We need to find ω too.

$$\omega = \frac{1}{\sqrt{LC_{eq}}} = \frac{1}{\sqrt{L\frac{2C}{3}}} = \sqrt{\frac{3}{2LC}}$$

$$V_{2\,max} = \frac{I}{2\sqrt{\frac{3}{2LC}}\,C} = \frac{I}{\sqrt{\frac{6C}{L}}} = I\sqrt{\frac{L}{6C}}$$

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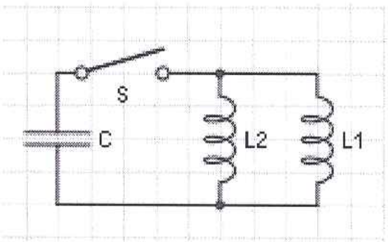
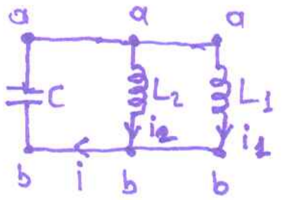
(Hint: First find the equivalent inductance of two inductors in parallel. Then, for a simple LC circuit (one inductor – one capacitor) $-L\frac{di}{dt} - \frac{q}{C} = 0$ and $q = Q\cos(\omega t + \varphi)$. In this problem, take $\varphi = 0$)





$$V_{ab} = V_C = V_{L1} = V_{L2} = \frac{q}{C}$$

$$V_{L1} = -L_1\frac{di_1}{dt} = \frac{q}{C}$$

$$V_{L1} = -L\frac{di_1}{dt} = \frac{Q\cos(wt)}{C} \Rightarrow \frac{di_1}{dt} = -\frac{Q\cos(wt)}{LC}$$

$$\int di_1 = -\frac{Q}{LC}\int \cos(wt)\,dt \Rightarrow i_1 = -\frac{Q}{LCw}\sin(wt) + \text{const.}$$

Integration constant should be 0 since $i_1(t=0) = 0$.

$(i_1)_{max} = \frac{Q}{LCw}$ since maximum value for $-\sin(wt)$ is 1.

$$w = \frac{1}{\sqrt{L_{eq}C}} = \frac{1}{\sqrt{\left(\frac{1}{L_1}+\frac{1}{L_2}\right)^{-1}C}} = \frac{1}{\sqrt{\frac{LC}{3}}} = \sqrt{\frac{3}{LC}}$$

$$(i_1)_{max} = \frac{Q}{LC\sqrt{\frac{3}{LC}}} = \frac{Q}{\sqrt{3LC}}$$