NAME

PHYS-1200 PHYSICS II QUIZ 2 MARCH 29, 2006

SOLUTIONS

PART A.

1. D
2. B
3. D
4. B
5. C
6. A
7. B
8. B

PART B.

1. **TO THE BOTTOM OF THE PAGE**
   The current in the wire produces a decreasing magnetic flux within the wire loop. According to Lenz's law, the induced electric field would be in a direction to oppose that decrease. It must be counterclockwise about the loop, so at *P*, it is toward the bottom of the page.

2. a) **TO THE LEFT** The same direction as the current in the wires.

   b) **OUT OF THE PAGE** Based on the direction of the current and the right hand rule.

3. a) $v = \frac{\Delta x}{\Delta t} = \frac{1.0\text{ m}}{0.04\ s}$ <u>v = 25 m/s</u>

   b) The wavelength can be read directly from the graph. <u>λ = 4.0 m</u>

   c) $f = \frac{v}{\lambda} = \frac{25\text{ m/s}}{4.0\text{ m}}$ <u>f = 6.2 Hz</u>

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PART C.

1. a) $f = \frac{1}{2\pi\sqrt{LC}} = \frac{1}{2\pi\sqrt{(2.0\times10^{-3}\ \text{H})(4.0\times10^{-7}\ \text{F})}}$ <u>$f = 5.6\times10^3$ Hz = 5600 Hz</u>

b) $|\mathcal{E}| = L\left|\frac{di}{dt}\right|$. The easy way to get this is $L\frac{di}{dt} + \frac{q}{C} = 0$, so $L\frac{di}{dt} = -\frac{q}{C}$. Then, just after the switch is closed, $|\mathcal{E}| = L\left|\frac{di}{dt}\right| = \frac{|q|}{C} = \frac{Q}{C}$, so $|\mathcal{E}| = \frac{1.5\times10^{-6}\ \text{C}}{4.0\times10^{-7}\ \text{F}}$ <u>$|\mathcal{E}| = 3.8$ V</u>

Another approach is $q = Q\cos\omega t$, so $i = \frac{dq}{dt} = -\omega Q\sin\omega t$, and $\frac{di}{dt} = -\omega^2 Q\cos\omega t$.

$|\mathcal{E}| = L\left|\frac{di}{dt}\right| = L\omega^2 Q|\cos\omega t|$. When the switch is closed, $t = 0$, so $\cos\omega t = 1$ and $|\mathcal{E}| = L\omega^2 Q$.

Since $\omega^2 = \frac{1}{LC}$, this becomes $|\mathcal{E}| = \frac{LQ}{LC} = \frac{Q}{C}$, as before. However, we could calculate ω^2 and use $|\mathcal{E}| = L\omega^2 Q$ directly. Then $\omega^2 = \frac{1}{LC} = \frac{1}{(2.0\times10^{-3}\ \text{H})(4.0\times10^{-7}\ \text{F})} = 1.25\times10^9\ s^{-1}$

Finally $|\mathcal{E}| = L\omega^2 Q = (2.0\times10^{-3}\ \text{H})(1.25\times10^9\ \text{s}^{-1})(1.5\times10^{-6}\ \text{C}) = 3.8$ V, as before.

c) The total energy in the circuit is equal to $U_0 = \frac{Q^2}{2C}$, which is the energy in the capacitor before the switch is closed. When the charge is $\frac{Q}{2}$, the energy in the capacitor is

$U_E = \frac{(Q/2)^2}{2C} = \frac{1}{4}\left(\frac{Q^2}{2C}\right) = \frac{U_0}{4}$. Energy is conserved, so the energy in the inductor is

$U_B = \frac{3}{4}U_0 = \frac{3}{4}\left(\frac{Q^2}{2C}\right) = \frac{3}{4}\left(\frac{(1.5\times10^{-6}\ \text{C})^2}{2(4.0\times10^{-7}\ \text{F})}\right) = \frac{3}{4}(2.8\times10^{-6}\ \text{J})$ <u>$U_B = 2.1\times10^{-6}$ J</u>

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2. a) $f_{beat} = \Delta f = 330\text{ Hz} - 300\text{ Hz}$ $\underline{f_{beat} = 30\text{ Hz}}$

   b) At the fundamental frequency, $L_{string} = \dfrac{\lambda}{2} = \dfrac{v}{2f} = \dfrac{600\text{ m/s}}{2(300\text{ Hz})}$ $\underline{L_{string} = 1.0\text{ m}}$

   c) At the fundamental frequency, $L_{pipe} = \dfrac{\lambda}{2} = \dfrac{v}{2f} = \dfrac{343\text{ m/s}}{2(330\text{ Hz})}$ $\underline{L_{pipe} = 0.52\text{ m}}$

   d) **AWAY FROM THE ORGAN PIPE** The detector must move away from the source to result in a lower frequency.

   e) For a moving detector $f' = f\dfrac{v - v_{mic}}{v}$. Then, $\dfrac{f'}{f}v = v - v_{mic}$, and

   $$v_{mic} = \left(1 - \frac{f'}{f}\right)v = \left(1 - \frac{300\text{ Hz}}{330\text{ Hz}}\right)(343\text{ m/s})$$ $\underline{v_{mic} = 31\text{ m/s}}$

   f) **IT WILL DETECT BEATS** The frequencies detected from both sources will be lowered, so they will still be different, and beats will result.