Activity 17 - Oct. 29/30, 2007
PHYS-1200 PHYSICS II EXAM 2 March 23, 2007

PART A. (40%) Each question is worth 4%. In the space provided, to the left of the question number, write the letter corresponding to the best answer to the question.

_A_ 1. A particle is in simple harmonic motion with period T. At time $t = 0$, it is at its amplitude. Which is the first later time when it is furthest from the equilibrium point?
<u>A. 0.5*T*</u> B. 0.7T C. T D. 1.4T E. 1.5T

_B_ 2. A charged capacitor and an inductor are connected at time $t = 0$. In terms of the period T of the resulting oscillations, what is the first later time at which the energy stored in the electric field of the capacitor is a maximum?
A. T/4 **<u>B. *T*/2</u>** C. 3T/4 D. T E. None of the above

_E_ 3. Which equations can be used to show that magnetic field lines form closed loops?
A. $\oint \vec{E} \cdot d\vec{a} = \frac{q}{\varepsilon_0}$
B. $\oint \vec{B} \cdot d\vec{s} = 0$
C. $\oint \vec{E} \cdot d\vec{s} = -\frac{d\Phi_B}{dt}$
D. $\oint \vec{B} \cdot d\vec{a} = \mu_0 i + \mu_0 \varepsilon_0 \frac{d\Phi_E}{dt}$
E. None of these

_C_ 4. Which of the following relationships between the acceleration a and the displacement x of a particle involve Simple Harmonic Motion?
A. $a = 0.5\,x$
B. $a = 400\,x^2$
C. $a = -20x$
D. $a = -3x^2$
E. $a = \frac{3.14}{x}$

_D_ 5. Take the speed of sound to be 340 m/s. A thunder clap is heard about three seconds after the lightning is seen. The source of both light and sound is:
A. moving overhead faster than the speed of sound.
B. emitting a much higher frequency than is heard
C. emitting a much lower frequency than is heard.
D. about 1000 m away.
E. much more than 1000 m away.

_E 6. Select the *incorrect* statement.
A. Ultraviolet light has a shorter wavelength than infrared light.
B. Blue light has a lower frequency than x rays.
C. Radio waves have longer wavelength than gamma rays.
D. Gamma rays have higher frequency than infrared waves.
E. Microwaves have higher frequency than x rays.

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_B_ 7. Which of the following represents a standing wave?

A. $y = (6.0\text{ mm})\sin[(3.0\text{ mm}^{-1})x + (2.0\text{ s}^{-1})t] - (6.0\text{ mm})\cos[(3.0\text{ mm}^{-1})x + 2.0]$

B. $y = (6.0\text{ mm})\cos[(3.0\text{ mm}^{-1})x - (2.0\text{ s}^{-1})t] + (6.0\text{ mm})\cos[(2.0\text{ s}^{-1})t + (3.0\text{ mm}^{-1})x]$

C. $y = (6.0\text{ mm})\cos[(3.0\text{ mm}^{-1})x - (2.0\text{ s}^{-1})t] - (6.0\text{ mm})\sin[(2.0\text{ s}^{-1})t - 3.0]$

D. $y = (6.0\text{ mm})\sin[(3.0\text{ mm}^{-1})x - (2.0\text{ s}^{-1})t] - (6.0\text{ mm})\cos[-(2.0\text{ s}^{-1})t + (3.0\text{ m}^{-1})x]$

E. $y = (6.0\text{ mm})\sin[(3.0\text{ mm}^{-1})x] + (6.0\text{ mm})\cos[(2.0\text{ s}^{-1})t]$

_E_ 8. Which statement concerning Electromagnetic Waves is *incorrect*:

A. The electric and magnetic fields must be perpendicular

B. The direction of propagation of the wave is perpendicular to both the electric and magnetic field

C. The electric field must be sinusoidally oscillating in time

D. $\frac{E_{\max}}{B_{\max}} = \frac{angular\_frequency}{wave\_number}$

E. E_{max} is independent of B_{max}

_B__ 9. Which of the following is *not true* for sound waves?

A. Sound waves are mechanical waves

B. Sound waves are transverse waves

C. In humans, not every frequency in the audible range is heard with the same loudness.

D. Sound waves require a medium to propagate

E. The audible range for humans is about 20 Hz to 20,000 Hz.

__A_ 10. Which of the following is *not true* for light waves?

A. Light waves are mechanical waves

B. Light waves are transverse waves

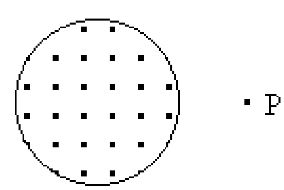
C. In humans, not every frequency is seen with the same intensity or brightness

D. Light waves do not require a medium to propagate

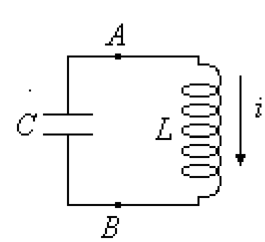
E. The visual spectrum for humans is about $4.29\text{x}10^{14}$ Hz to $7.50\text{x}10^{14}$ Hz

PART B. (20%)

1. (3%) The diagram at the right represents a circular region where an electric field is directed out of the page, and is *constant* in time. The direction of the induced magnetic field at point *P* is: (Circle the correct answer)
   <u>THERE IS NO INDUCED MAGNETIC FIELD</u>



2. (6%) The picture shows an ideal oscillating *LC* circuit (resistance is zero)



   a) (3%) At the instant shown in the picture, the current in the inductor is decreasing. What is the direction of the displacement current between the plates of the capacitor is? (Circle the correct answer)

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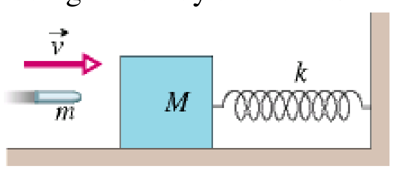
b) (3%) At the instant shown in the picture, suppose the current in the inductor is at a maximum. At which point, *A* or *B*, is the voltage higher? (Circle the correct answer)
VOLTAGE AT *A* = VOLTAGE AT *B*

3. (11%) State all four of Maxwell's Equations and explain in your own words what they mean. ***Write neatly and legibly, and give your explanation concisely !!*** *(ie. using few words)*
a) Ampere/Maxwell: The integral of the magnetic field around a closed loop is proportional to the current passing through the loop. This current can be real (moving charge) or displacement (change of electric flux through the loop.)
b) Faraday: The integral of the electric field around a closed loop is proportional to the rate of change of magnetic flux through the loop.
c) Gauss: The normal component of the electric field passing through a closed surface is proportional to the net electric charge enclosed.
d) Magnetic Gauss: The normal component of the electric field passing through a closed surface is proportional to the net magnetic charge enclosed. Since there are no monopoles, the integral is zero.

PART C. (40%) You must show all of your work or state your reasoning in order to receive credit.

1. (20%) A block of mass $M = 2.0$ kg, at rest on a horizontal frictionless table, is attached to a rigid support by a spring of spring constant $k = 500$ N/m. A bullet of mass $m = 0.50$ kg and velocity $v = 15$ m/s strikes the block, as shown in the picture, and bounces off the block in a perfectly elastic collision. Immediately after being struck by the bullet, before the spring has started to compress, the speed of the block is $V = 3.0$ m/s. The mass-spring system goes into simple harmonic motion after being struck by the bullet.



a) (5%) Find the amplitude of the simple harmonic motion.

$$\frac{1}{2}kx_{\max}^2 = \frac{1}{2}MV^2$$

$$x_{\max} = \sqrt{\frac{MV^2}{k}} = \sqrt{\frac{18}{500}}m$$

b) (5%) Find the period of the simple harmonic motion.

$$T = 2\pi\sqrt{\frac{M}{k}} = 2\pi\sqrt{\frac{2}{500}}s \text{ so } \omega = \frac{2\pi}{T} = \sqrt{\frac{k}{M}} = \sqrt{\frac{500}{2}} \cong 15.9 rad/s$$

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An experimenter wishes to make an electrical circuit that will duplicate the performance of the mechanical oscillator. The electromagnetic oscillator will consist of a capacitor and an inductor. It is to have a period identical to the block in part b) above. The capacitor used in the circuit is $C = 1.0 \times 10^{-6}$ F.

c) (5%) Find the value of the inductor that is used in the circuit.

$$\omega = \frac{1}{\sqrt{LC}} \text{ so } L = \frac{1}{\omega^2 C} = \frac{1}{250 \times 1E-6} H = 4000H$$

d) (5%) The electrical L-C circuit will radiate electromagnetic waves from an antenna using the values of C and L from above. When this circuit is oscillating, what is the numerical value of the ratio of the amplitudes of the electric to magnetic fields of the radiated wave?

E/B=c=3×10^8 m/s

2. (20%) A musician wishes to tune the "A" string on his violin to 440 Hz, but it is vibrating at only 400 Hz. He is tuning by listening to a pitch pipe, which is a small tube open at both ends.

a) (4%) The fundamental frequency of the string can be increased by adjusting the tension in the string. To increase the fundamental frequency, the tension should be: (Circle the correct answer.)

INCREASED

b) (4%) How long does the pitch pipe, open at both ends, need to be to produce a frequency of 440 Hz?

$$L = \lambda / 2 \text{ and } \lambda = v / f = \frac{343 m/s}{440 Hz} \text{ so } L = \frac{343}{880} m \sim 0.4\text{m}$$

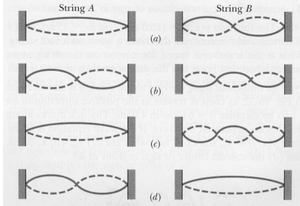
c) (4%) Suppose instead he has a pitch pipe that has one open end and one closed end. How long would this pitch pipe need to be to produce a frequency of 440 Hz?

$$L = \frac{\lambda}{4} \text{ so } L = \frac{343}{440 \times 4} m \sim 0.2\text{m}$$

d) (4%) The violinist can make a different note by touching the string in the exact center, midway between the two fixed ends. If the original frequency is 440 Hz, what frequency is this new note?

f = _*880 Hz*

e) (4%) Two violins are playing together, using similar instruments and identically made strings. The violin playing String A, however, has his strings under considerably greater tension than the other violin, playing string B. Each violinist is playing the same string and can touch the string to change the vibrational mode of the string like in part d) above. The situation is illustrated here:



In which situation, (a), (b), (c) or (d) is there a possibility that strings A and B are playing the same note?

a, b, and c