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**PHYS 122** **EXAM I** **October 3, 2008**
**Prof. S. M. Bhagat**

Name:

(Sign in ink, print in pencil) SOLUTION

Notes

1) There are four (4) problems in this exam. Please make sure that your copy has all of them.

2) Please show your work indicating clearly what formula you used and what the symbols mean. Just writing the answer will not get you full credit. In stating vectors give both magnitude and direction.

3) Write your answers on the sheets provided.

4) Do not forget to write the units.

5) Do not hesitate to ask for clarification at any time during the exam. You may buy a formula at the cost of one point.

Take Care! God Bless You!

$$k_e = 9\times10^9\,\frac{N\cdot m^2}{C^2},\ \mu_0 = 4\pi x10^{-7}\,\frac{T-m}{A}$$

$$\varepsilon_0 = 9\times10^{-12}\,F/m$$

Mass of proton $m_p = 1.6\times10^{-27}\,kg$

Mass of electron $m_e = 9\times10^{-31}\,kg$

Elementary Charge $e = 1.6\times10^{-19}\,C$

**Problem 1a**

What is a traveling wave? (5)

A Deviation (D) from equilibrium which is a function of both $x$ and $t$ such that $x$ and $t$ appear in the form

$$(x \mp vt)$$

will travel as a wave with velocity $\vec{v} = \pm v\hat{x}$

**Problem 1b**

What factors are missing in the equation $D =$ *sin* $(x\text{-}vt)$?
Fill in the blanks and explain their meanings. (10)

$$D = A \sin \frac{2\pi}{\lambda}(x - vt)$$

A is needed because D has dimensions/units and the sine function has none. Indeed, units of A tell us the nature of the wave.

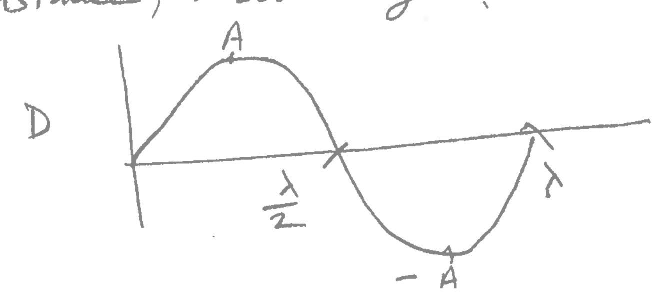
$\lambda$, a length, is necessary because argument of sine function cannot have dimensions.

$2\pi$ is put in to explicitly state that sine repeats every $2\pi$

A = amplitude, measures maximum value of D

$\lambda$ = repeat distance, wave length.

Example $t=0$



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Problem 1c

What is the difference between a longitudinal wave and a transverse wave? (5)

Consider a Sine wave

$$\vec{D} = \vec{A} \sin \frac{2\pi(x-vt)}{\lambda}$$

Longitudinal: $\vec{A} \parallel \hat{x}$

Transverse $\vec{A} \perp \hat{x}$

Problem 1d

If 2m is the wavelength and 20Hz the frequency, what is the speed of the wave? (5)

$$V = \lambda f$$

$$= 2 \times 20 = 40 \text{ m/s}$$

Problem 2a

Is it possible for the following wave to exist

$$D= 10N/m^2 - 11N/m^2 \cos(6.28n + 12.56t)?$$

Justify your answer. (5)

This is a pressure wave
Pressure can never be negative.
So this wave cannot exist because
when Cos ( ) becomes +1,
D becomes -ive.

Problem 2b

In a stretched string a periodic wave transports the power

$$\eta = \frac{1}{2} A^2 w^2 \frac{F}{v}$$

Where $A$= amplitude, $w$= angular frequency, $F$= tension in string, $v$= speed of wave. By what factor would $\eta$ change if you

i) Double $w$ or
ii) Double $v$ or
iii) Double $F$ or
iv) Reduce $A$ by a factor of 4?

Justify your answers. (20)

i) $\eta \propto w^2$ so $w \to 2w$ $\eta \to 4\eta$

ii) $\eta \propto \frac{1}{V}$ $V \to 2V$ $\eta \to \frac{\eta}{2}$

(iii) $\eta \propto \frac{F}{V}$, $V = \sqrt{\frac{F}{\mu}}$ so $F \to 2F$, $V \to \sqrt{2}V$
and $\eta \to \frac{2}{\sqrt{2}}\eta = \sqrt{2}\eta$

(iv) $\eta \propto A^2$, $A \to \frac{A}{4}$ $\eta \to \frac{\eta}{16}$

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Problem 3a

What is sound? (5)

Any mechanical wave whose frequency lies between 20Hz and 20kHz. We call it SOUND because our Ears detect it.

Problem 3b

What is the speed of sound on the moon? (5)

There is no Sound on the moon because the moon has no atmosphere

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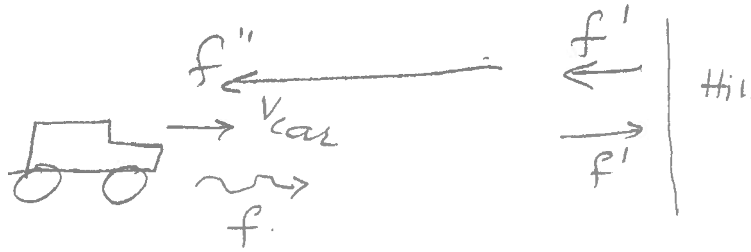
## Problem 3c

What is the Doppler Effect? (5)

If either the source or the detector is moving, the perceived frequency is not equal to the emitted frequency.

## Problem 3d

You are driving toward a hill at a speed of 15mph (about 6*m/s*). If you sound a horn at 500Hz what will be the frequency of the wave you receive after reflection from the hill? (Take speed of sound to be 330 *m/s*) (10)




outward journey of sound, car is moving source so f' received by hill is

$$\frac{f'}{f} = \frac{1}{1 - \frac{V_{car}}{V_s}}$$

$V_s$ = speed of sound.

Reflected wave starts with f' but now car is moving detector so

$$\frac{f''}{f'} = 1 + \frac{V_{car}}{V_s}$$

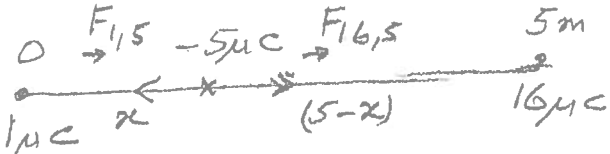
$$\frac{f''}{f'} \cdot \frac{f'}{f} = \frac{1 + \frac{V_{car}}{V_s}}{1 - \frac{V_{car}}{V_s}} = \frac{1 + \frac{6}{330}}{1 - \frac{6}{330}} \simeq 1 + \frac{12}{330} \sim 1.04$$

so $f'' = 500 \cdot 1.04 = 520\,Hz$

## Problem 4a

A charge of 1 $\mu C$ is located at $x$=0 and a charge of 16 $\mu C$ is located at $x$=5$m$. At what point would a charge of -5 $\mu C$ experience no force? Why? (20)

In order to be able to cancel the two forces $-5\mu C$ must be located on x-axis between $1\mu C$ and $16\mu C$ charge. Let us put it at $x$.




Then $\vec{F}_{1,5} = -k_e \frac{1\times 5\times 10^{6}\times 10^{-6}}{x^2}\hat{x}$

$\vec{F}_{16,5} = +k_e \frac{16\times 5\times 10^{-12}}{(5-x)^2}\hat{x}$ and we want $\vec{F}_{1,5}+\vec{F}_{16,5}=0$

$$-\frac{\cancel{k_e}\times \cancel{5}\times \cancel{10^{-12}}}{x^2} + \frac{\cancel{k_e}\times 16\times \cancel{5}\times \cancel{10^{-12}}}{(5-x)^2} = 0$$

$\frac{1}{x^2} = \frac{16}{(5-x)^2}$ or $\frac{1}{x} = \frac{4}{5-x}$ giving $x = 1m$

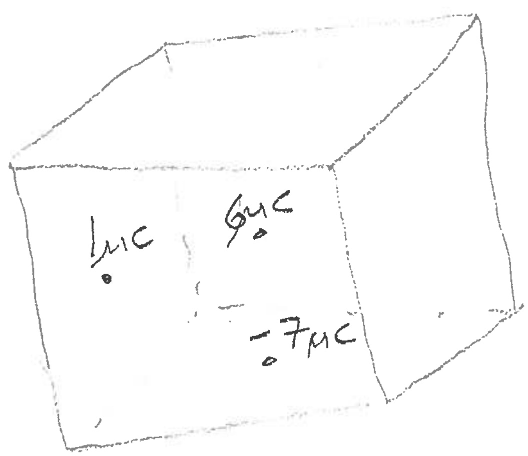
## Problem 4b

Charges of 1 $\mu C$, 6 $\mu C$ and -7 $\mu C$ located inside a closed cubical surface. What is the total flux of the $\vec{E}$ - field through the six faces of the cube? Why? (5)

Gauss's law

$\sum_c \vec{E}\cdot\Delta\vec{A} = \frac{1}{\varepsilon_0}\sum Q_i$

Total flux of $\vec{E}$ through a closed surface is determined solely by sum of enclosed charges.




Here

$\sum Q_i = \Sigma(1+6-7)\mu C = 0$

so $\sum_c \vec{E}\cdot\Delta A = 0$