A Code: 1

PHSX 212 — Exam 1 — September 13, 2006

Student Name [redacted] **KUID** [redacted]

Important—read before you start

This exam consists of 12 problems with total of 100 points. In addition, there is one extra credit problem of 10 points. Since the exam will hand graded, please do all work on this paper and show all intermediate steps and derivations that lead to your answer. Your objective should be to show us what you know about each problem.

Please write your name and KUID at the top of each page.

For grading use:

Problem	**Score**
1	5
2	5
3	5
4	5
5	10
6	10
7	10
8	10
9	10
10	7
11	9.
12	10
Extra credit	10
Total (110 possible)	108

√+

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1. **(5 points)** You generate traveling waves on a stretched string by wiggling one end. The wave travels at speed V_0. What would you need to do in order to make the wave travels at $2V_0$?

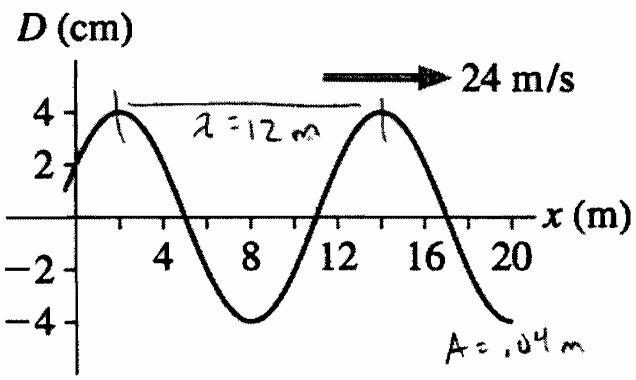
5

$V_{string} = \sqrt{\frac{T_s}{\mu}}$

$2V_{string} = \sqrt{\frac{4T_s}{\mu}} = \sqrt{\frac{T_s}{\frac{\mu}{4}}}$

You must either make the tension 4 times as much or divide the linear density by 4, or mybe double T_s and halve μ or any number of similar combinations to make $\sqrt{\frac{T}{\mu}}$ twice is for V_0

2. **(5 points)** The snapshot graph (at $t = 0$ seconds) below is of a sinusoidal traveling wave moving toward the right with a wave speed of 24 m/s. Calculate the period and initial phase of the wave.



Snapshot graph at $t = 0$ s

$V = \frac{\lambda}{T}$

$24 = \frac{12}{T}$ ✓

$\boxed{T = 0.5 \text{ sec}}$

$D(x,t) = A\sin(kx - \omega t + \phi_0)$

$D(0,0) = A\sin(\phi_0)$

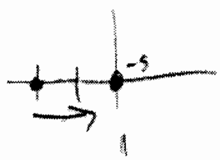
$.02 = .04\sin(\phi_0)$ ✓

$\sin\phi_0 = .5$

$\boxed{\phi_0 = 0.524 \text{ radians}}$

+5

3. **(5 points)** A point charge Q=-5 nC is placed at the origin of the coordinate system. Find the direction of the electric field at point x=-2.0 m $\bar{i}$



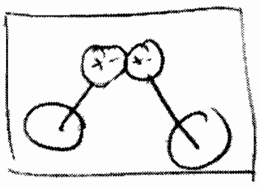
$\vec{E} = \frac{kq}{r^2}$

points toward origin, toward negative charges

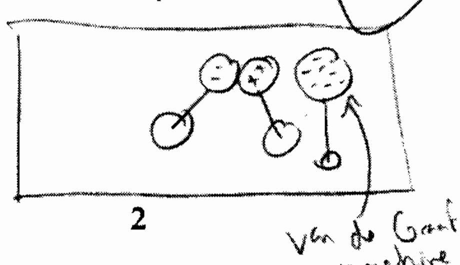
Points toward the origin in the positive i direction (to the right) w/ a magnitude of 11.25 N/C

4. **(5 points)** You have two neutral metal spheres on wooden stands. Describe using words and pictures a procedure for putting ***exactly equal and opposite*** charges on the two spheres.

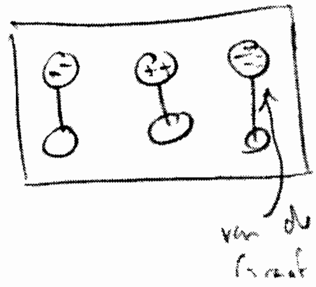
① Touch the sphere together.



② Bring them near a strong charge, with one closer than the other. This polarizes the spheres.



③ Separate them. This preserves the polarized charges on the spheres.



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5. **(10 points)** What are the speed *and* direction of a traveling wave whose displacement is given by the following equation: $D(x,t) = 5\sin(3.5x - 7.0t)$? (Assume that x is measured in meters and t in seconds).

k ω

$\omega = 2\pi f = 7.0$

$f = 1.11$ Hz

$k = \frac{2\pi}{\lambda} = 3.5$

$\lambda = 1.80$ m

10

$v = \lambda \cdot f = (1.11 \cdot \frac{1}{s})(1.80\ m)$

$\boxed{v = 2.0\ m/s}$

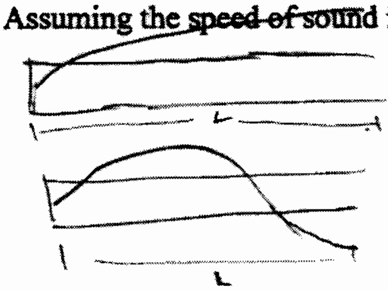
$\boxed{\omega > 0 \Rightarrow \text{traveling to the right}}$

6. **(10 points)** An organ pipe with one end open and the other end close is to resonate in its 3rd harmonic frequency at 210 Hz. Assuming the ~~speed of sound~~ in air is 343 m/s, calculate the required length for this pipe.

$v = \lambda f$

$343\ m/s = \lambda \cdot 210/s$

$\lambda = 1.633$ m



fundamental: λ: $4L$ $f: \frac{v}{\lambda} = \frac{v}{4L}$

3rd $\lambda = \frac{4}{3}L$ $f: \frac{v}{\lambda} = \frac{3v}{4L}$

$\frac{3v}{4L}$ = 3 times the fundamental frequ

$\lambda = \frac{4}{3}L = 1.633$ m

$\boxed{L = 1.23\ m}$

✓

7. **(10 points)** A tornado warning siren on top of a tall pole radiates sound waves of power 15 Watts uniformly in all directions. (a) Calculate the intensity of the wave at 10 m away from the siren. (b) By how many times does the sound intensity level drop when you move ten times as far away from the siren?

a) $I = \frac{\text{Power}}{\text{area}} = \frac{\text{Watts}}{4\pi r^2} = \frac{(15)}{4\pi(10)^2}$

$\boxed{I = 0.0119\ \frac{W}{m^2}}$ ✓

b) I decreases by a factor of r^2, so if you multiply r by 10, I will decrease by a factor of 10^2 or 100

✓

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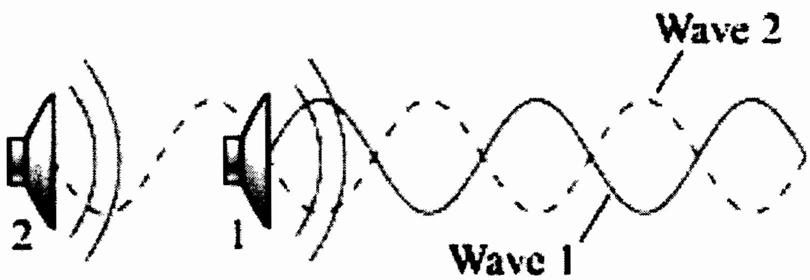
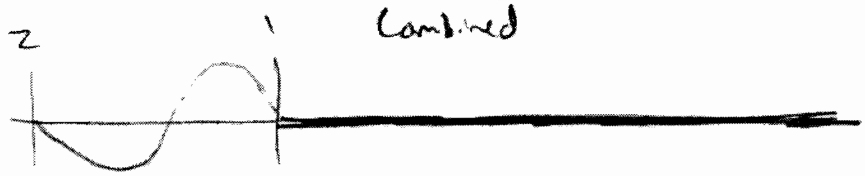
8. **(10 points)** (a) Draw a picture of and describe in words the interference of wave 1 and wave 2 (pictured below).

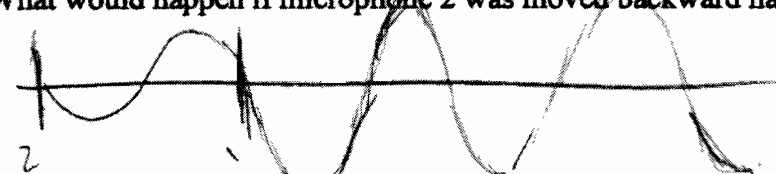




+10

When wave 1 is at its crest, wave 2 is at its trough. As the two waves have the same f and λ, their phase difference is $\Delta\phi = \pi$ and they destructively interfere, causing no sound to be heard to the right of speaker 1.

(b) What would happen if microphone 2 was moved backward half a wavelength.



The phase difference would become 0 or 2π, causing wave 1 and wave 2's crests and troughs to occur concurrently. Thus, the waves constructively interfere, giving the same λ and f, but double the amplitude.

9. **(10 points)** A positive charge 0.6 μC exerts an attractive force with a magnitude of 0.500 N on an unknown charge 0.25 m away. What is the unknown charge (magnitude and sign)?

10

$$F = \frac{k q_1 q_2}{r^2}$$

$$.500 = \frac{(9E9)(.6E-6)\cdot q_2}{(.25)^2}$$

$$.500 = 8.64E4\, q_2$$

$$|q_2| = 5.79\cdot 10^{-6}$$

Because the forces are attractive, the charges must be opposite. q_1 is positive, so q_2 must be negative.

$$\boxed{\begin{gathered} q_2 = -5.79\cdot 10^{-6}\ C \\ q_2 = -5.79\ \mu C \end{gathered}}$$

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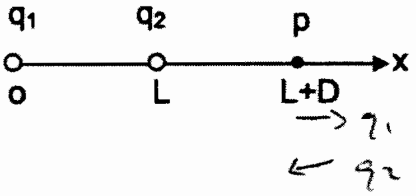
10. **(10 points)** Two charges q_1 and q_2 are placed a distance L apart on the x-axis (see Figure). What must be the value of q_1 in terms of q_2 (including sign), L and D to ensure that the electric field is zero at point P on the x-axis a distance D from q_2 and $D+L$ from q_1?

$\vec{E}_{q_2} = \frac{kq_2}{D^2}$ $\quad \vec{E}_{q_1} = \frac{kq_1}{(L+D)^2}$ $\quad$ 7



$\vec{E}_{q_1} + \vec{E}_{q_2} = 0$

$q_1 = -\frac{q_2(L+D)^2}{D^2}$

$\frac{kq_1}{D_2} + \frac{kq_2}{(L+D)^2} = 0$

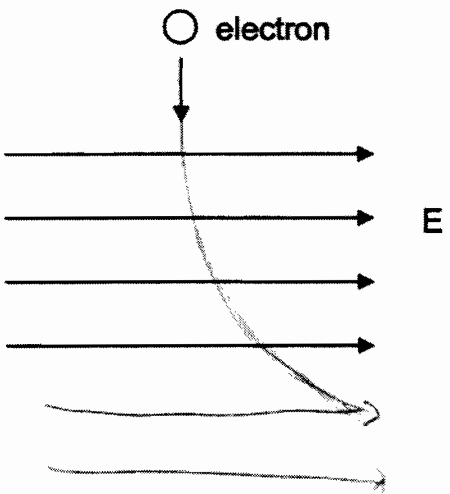
They must be opposite signs in order to cancel each other.

$\frac{\cancel{k}q_1}{D^2} = \frac{-\cancel{k}q_2}{(L+D)^2} \longrightarrow \boxed{q_1 = \frac{-q_2 \cdot D^2}{(L+D)^2}}$

11. **(10 points)** An electron enters a uniform electric field $\mathbf{E} = 4\text{x}10^{-2}$ N/C $\vec{i}$. (a) Find the magnitude and direction of the acceleration after the electron enters the E field. (The mass of the electron is $9.11\text{x}10^{-31}$kg). (b) Sketch the trajectory of the electron after it enters the electrical field (you may ignore gravity).

$F = ma = \vec{E} q_e$

$1 e^- = 1.6 \cdot 10^{-19}$ C



$F = \vec{E} \cdot q = (.04\ N/C) \cdot (1.6E{-19}\ C)$

$F = 6.4E{-21}$ N

$F = ma = 6.4E{-21}\ \frac{kg\text{-}m}{s^2}$

$m_e = 9.11E{-31}$ kg

$6.4E{-21}\ \frac{\cancel{kg}\text{-}m}{s^2} = (9.11E{-31}\ \cancel{kg}) \cdot a$

$\boxed{a = 7.03 \cdot 10^9\ m/s^2}$

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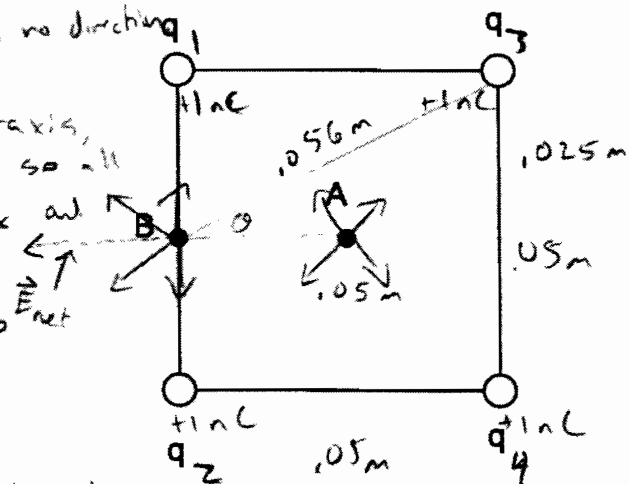
12. **(10 points)** Four charges each has q=1nC are arranged at the corners of a square of side 5cm. What is the magnitude and direction of the Electric Field at (a) Point A, the center of the square and (b) Point B, midway up the left hand side.

a) $\vec{E}_A = 0$, the field has no magnitude at this point due to symmetry thus no direction



b) Symmetry cancels movement in the y-axis, and q_1 and q_2 cancel each other, so all we need to worry about is q_{3x} and q_{4x}, or $2q_{3x}$

$\theta = \tan^{-1}\left(\frac{.025}{.05}\right) = \tan^{-1}\left(\frac{1}{2}\right) = 26.57°$

$\vec{E}_{q_3} = \frac{k q_3}{r^2}$

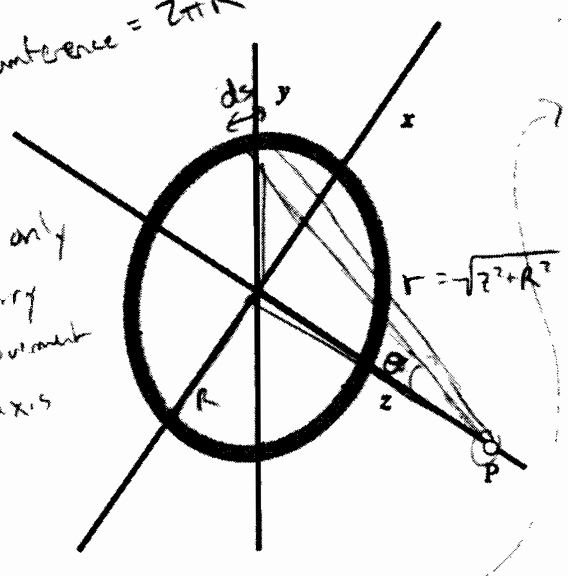
$2\vec{E}_{q_{3x}} = \frac{2kq_3}{r^2} \cdot \cos(26.57°) = \frac{2(9E9)(1E-9)}{(.056)^2} \cdot \cos(26.57°)$ 10

$\boxed{|\vec{E}_B| = 5133.6\ N/C, \text{ to the left or } -\hat{i} \text{ direction}}$

Extra Credit (10 points)

A ring of radius R has a charge Q uniformly distributed over its perimeter. ~~Calculate~~ Derive the field at a point P a distance z from the center along the axis of the disk. Check your answer by consider the two limits, Z=0 and Z very much greater than R.

Circumference = $2\pi R$



Symetry, only need to worry about movement along Z-axis

~~angular charge density~~ $= \frac{Q}{2\pi}$ ~~radians~~

linear charge density $= \frac{Q}{2\pi R}$

$$d\vec{E} = \frac{k\,\Delta Q}{r^2} = \frac{k \cdot \frac{Q}{2\pi R}\,ds}{\left(\sqrt{R^2+Z^2}\right)^2} \cdot \cos\theta$$

$\cos\theta = \frac{Z}{r}$

$\cos\theta = \frac{Z}{\sqrt{R^2+Z^2}}$

$$\vec{E} = \int_0^{2\pi R} \frac{k \cdot \frac{Q}{2\pi R}}{R^2+Z^2} \cdot \frac{Z}{\sqrt{R^2+Z^2}}\,ds$$

$$\vec{E} = \frac{k\frac{Q}{2\pi r}Z}{\sqrt{R^2+Z^2}\cdot(R^2+Z^2)} \int_0^{2\pi R} ds$$

$\Rightarrow$ integral will equal $2\pi R$

$$\boxed{\vec{E} = \frac{kQZ}{\sqrt{R^2+Z^2}\cdot(R^2+Z^2)}}$$

10

At $Z=0$, $\vec{E}=0$; it fits symmetry cancels out, r

At $Z \gg R$, R disappears to leave