B

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	2
4	5
5	10
6	2
7	9
8	10
9	10
10	10
11	9
12	10
Extra credit	2
Total (110 possible)	89

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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 $2V_0$?

$V_s = \sqrt{\frac{T_s}{\mu}}$ → Increase the tension by 4 times

$\mu = \frac{M}{L}$ or Increase the length by 4 times

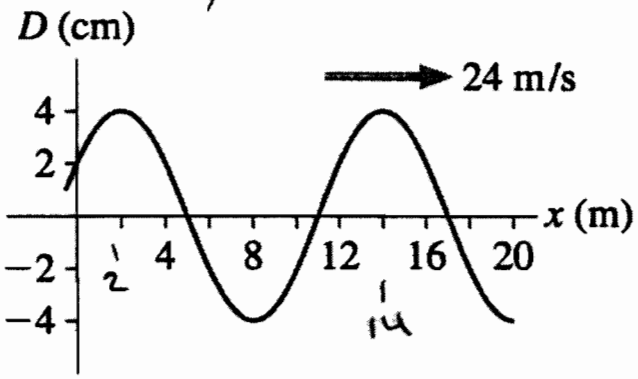
or decrease the mass by 4 times

5

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.

$\lambda = 14 - 2 = 12$

$D(0,0) = a\sin(kx - \omega t + \phi_0)$



Snapshot graph at $t = 0$ s

$D(0,0) = 2$

$a = 4$

$2 = 4\sin(\phi_0)$

$\frac{1}{2} = \sin\phi_0$

$\phi_0 = \sin^{-1}(\frac{1}{2}) = 30°$

$v = \lambda \cdot f$

$v = \lambda \cdot \frac{1}{T}$

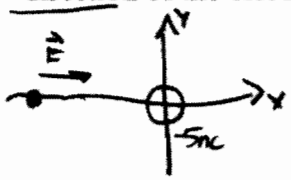
$vT = \lambda$

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

$= \frac{12\text{ m}}{24\text{ m/s}}$

$T = .5\text{ s}$ ✓

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 $\vec{i}$



$E = k\frac{Q}{r^2}$

$r^2 = 4\text{ m}^2$

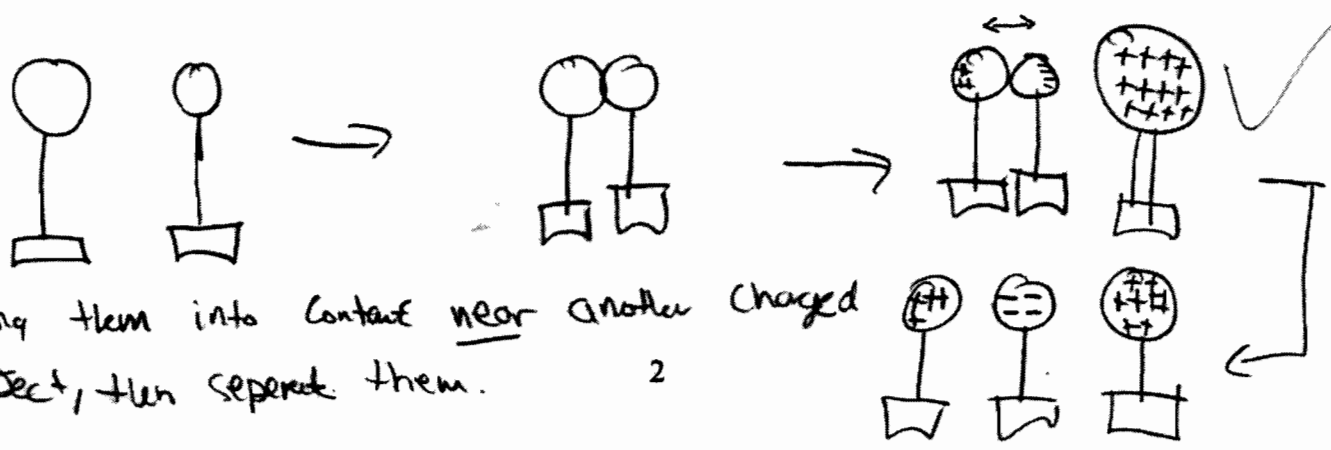
$Q = 5\times10^{-9}\text{ C}$

$k = 9\times10^9\ \frac{Nm^2}{C^2}$

$E = 9\times10^9\ \frac{Nm^2}{C^2} \cdot \frac{5\times10^{-9}\text{ C}}{4\text{ m}^2}$

$\vec{E} = -11.25\,\hat{i}\ \frac{N}{C}$

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.



Bring them into contact near another charged object, then seperate them.

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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).

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

$k = \frac{2\pi}{\lambda}$ $\omega = 2\pi f$

$3.5 = \frac{2\pi}{\lambda}$ $\omega = 7.0$

$\lambda = \frac{2\pi}{3.5}$ $\frac{7.0}{2\pi} = f$

$\lambda = 1.795\,m$ $f = 1.114\,Hz = 1.114\,s^{-1}$

$v = \lambda \cdot f$

$= 1.795\,m \cdot 1.114\,s^{-1} = 2\,m/s$

10

$2\,m/s$ in the Posative x Direc

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.

$f = 210\,Hz = 210\,s^{-1}$

$v_s = 343\,m/s$

3rd harmonic

For open – Close Instrument, they work in odd number harmonics, so

$n = 1, 3, 5, 7 \cdots$

$f_n = \frac{nv}{4L}$ $L = \frac{nv}{4f_n} = \frac{3 \cdot 343\,m/s}{4 \cdot 210\,s^{-1}} = 257\,m$

8

9 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?

$P = 15\,W$

$I = \frac{P}{A} = \frac{15\,\frac{kg}{s}}{100\pi\,m^2}$

$A = 4\pi r^2 = .0477\,\frac{N}{m \cdot s}$

$r = 10\,m$

$A = 4\pi 100\,m^2$

$J = N \cdot m$

$N = \frac{kg\,m}{s^2}$

At ten times the Distan

$10 \cdot 10 = 100\,m$ ✓

$100^2 =$

10,000 times weaker

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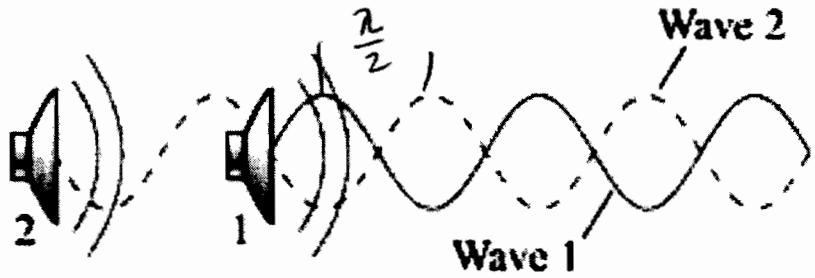
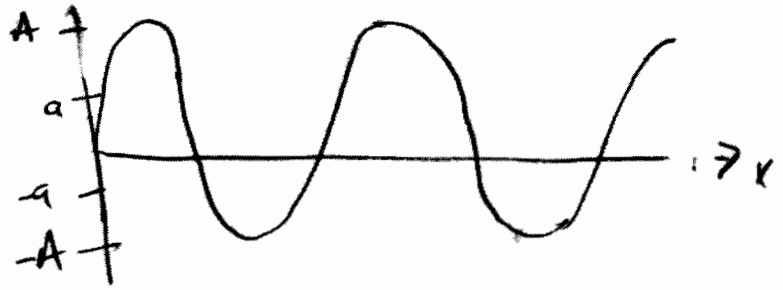
8. **(10 points)** (a) Draw a picture of and describe in words the interference of wave 1 and wave 2 (pictured below).



Perfect Destruction = no Standing Wave

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

Perfect Construction



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)?

C
Cent 10^{-3}
micro 10^{-6}
Nan 10^{-9}

$F = .500\,N \quad q_1 = 6 \times 10^{-7}\,C \quad r = .25\,m \quad q_2 =$ negative Charg

$F = k\frac{q_1 q_2}{r^2} \quad k = 9 \times 10^9 \frac{N m^2}{C^2}$

10

$\frac{F r^2}{k q_1} = q_2 = \frac{.500\,N \cdot (.25\,m)^2}{9 \times 10^9 \frac{N m^2}{C^2} \cdot 6 \times 10^{-7}\,C} \rightarrow q_2 = -5.79 \times 10^{-6}\,C$

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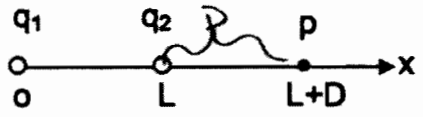
10. **(10 points)** Two charges q_1 and q_2 are placed a distance L apart on the x-axis (see Figure). What must be the value of q_1 in terms of q_2 (including sign), L and D to ensure that the electric field is zero at point P on the x-axis a distance D from q_2 and $D+L$ from q_1?



10

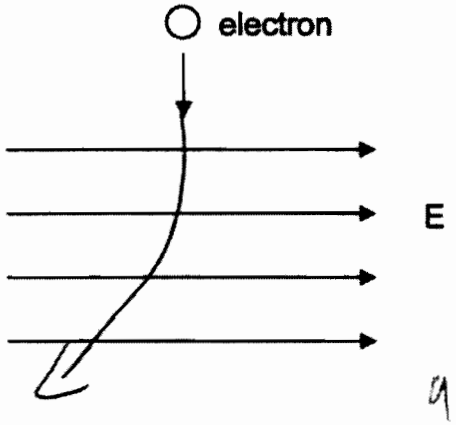
$E_{net} = E_1 + E_2 = 0$

$\frac{kQ_1}{r^2} + \frac{kQ_2}{r^2} = 0$

$\frac{kQ_1}{(L+D)^2} = -\frac{kQ_2}{(D)^2}$

$Q_1 = -\frac{Q_2 (L+D)^2}{D^2}$

11. **(10 points)** An electron enters a uniform electric field $\mathbf{E} = 4\times10^{-2}$ N/C $\hat{i}$. (a) Find the magnitude and direction of the acceleration after the electron enters the E field. (The mass of the electron is 9.11×10^{-31}kg). (b) Sketch the trajectory of the electron after it enters the electrical field (you may ignore gravity).



$F = M \cdot A$

$A = \frac{F}{M}$

$F = qE$

$q = 1.6 \times 10^{-19}$ C

$A = \frac{qE}{M}$

$A = \frac{1.6\times10^{-19}\,\text{C} \cdot .4\times10^{-2}\,\frac{N}{C}}{9.11\times10^{-31}\,kg}$

$A = 7.025\times10^{-19}\,\frac{N}{52}$ $\frac{N}{52}$

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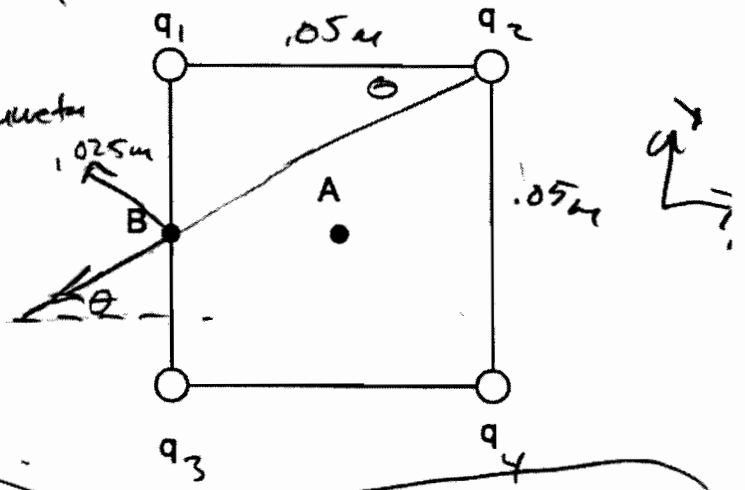
12. **(10 points)** Four charges each has q=1nC are arranged at the corners of a square of side 5cm. What is the magnitude and direction of the Electric Field at (a) Point A, the center of the square and (b) Point B, midway up the left hand side.

Point A $E_{net} = 0$ by symmetry

Point B $E_{net} = 2E_{2x}$ by symmetry



$E_{2x} = E_2 \cdot \cos\theta$

$= \frac{kQ_2}{r^2}$

$= 9\cdot10^9 \frac{N\,m^2}{C^2} \cdot 1\times10^{-9} C$

$(.0559\,m)^2$

$\theta = \tan^{-1}\frac{.025}{.05} = 26.565°$

$\sqrt{.05^2 + .025^2} = .0559\,m$

$E_{2x} = 2880 \frac{N}{C}$

$\cos\theta = .894427$

$E_{2x} = 2576$

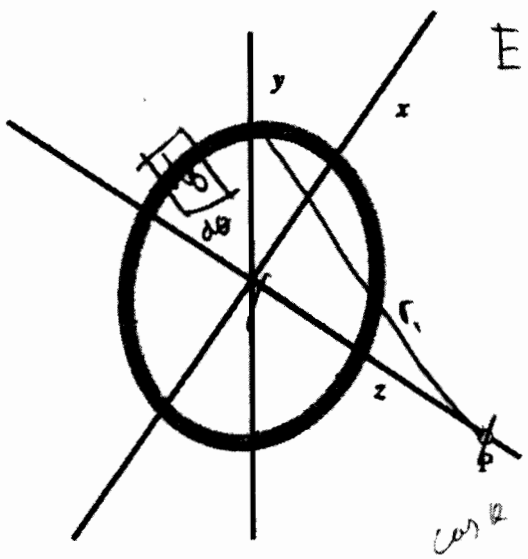
$2E_{2x} = E_{net}$

$E_{net} = -5152\hat{i}\,\frac{N}{C}$

Point B ✓

Extra Credit (10 points)

A ring of radius R has a charge Q uniformly distributed over its perimeter. Calculate 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.



$E = \int \frac{k\,dq}{r_1^2}$ 2

$dq = \frac{Q}{2\pi R}\,d\theta$

$r_1 = \sqrt{R^2 + z^2}$

$E = \int_0^{2\pi} \frac{kQ}{2\pi R(R^2+z^2)}\,d\theta$

$\cos\theta$