Name______________________________________ **Section**____________

University of Maryland
Department of Physics

Physics 122 Dr. David Noyes: Exam 1 : Make up

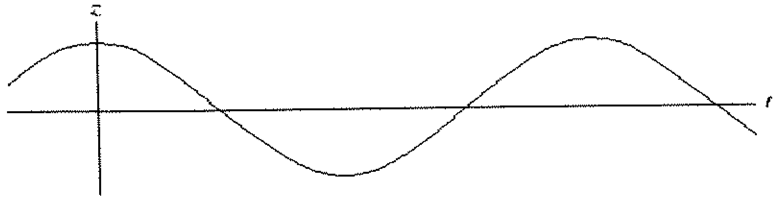
Instructions: Do not open this examination until the proctor tells you to begin. Read these instructions while waiting.

1. When the proctor tells you to begin, **write your name and section number at the top of every page.**
2. Do your work for each problem on the page for that problem. I will pass around paper so you can do your scratch work on it before starting to write out your answer on the exam. **If part of your answer is on the back, be sure to check the box on the bottom of the page so the grader knows to look on the back!**
3. Partial credit will be granted for correct steps shown, even if the final answer is wrong. So be sure to show your work.
4. Write clearly and logically so I can understand what you are doing and can give you as much partial credit as you deserve. I cannot give credit for what you are thinking — only for what you show on your paper.
5. If on a multi-step problem you can't do a particular part, don't give up. Go on to the next part anyway. If necessary, define a name for the quantity you couldn't find and express your answer in terms of it.
6. You are not permitted to have any outside information during this exam. This includes any written information and any relevant information programmed into a calculator. If you are caught using such information, you will be prosecuted and may receive a grade of XF for this course.
7. If there is a formula or constant that is not given, but you think is needed, ask me and if reasonable, I will put it on the board. However I will not tell you which equation is needed for a given problem. Also note that some of the formulas that are given only apply in certain situations, so be sure to take that into account.
8. Take a deep breath, relax, and good luck!

Name____________________________________ **Section**___________

Vibrations and Waves (28 points)

1) (**5 points**) A mass connected to a spring is oscillating back and forth on a frictionless table as indicated.



Which of the following possibilities occur?

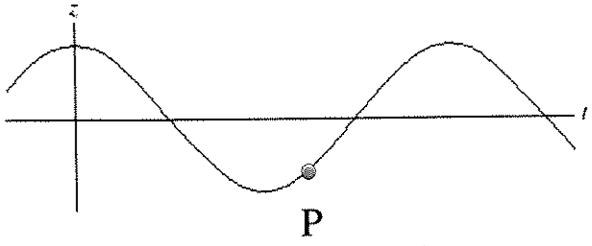
[✓ *(i)*] At some instant during the oscillation the mass has zero kinetic energy but is accelerating.

[✓ *(ii)*] At some instant during the oscillation the mass has an equal amount of kinetic and potential energy.

(iii) At some instant during the oscillation the mass has zero kinetic energy and the net force on the mass is zero.

[✓ *(iv)*] At some instant during the oscillation the mass has a positive displacement but a negative acceleration.

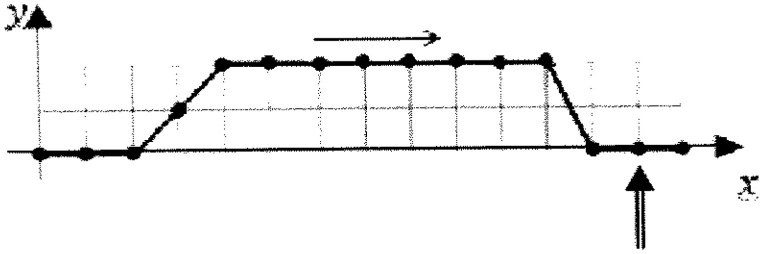
2) (**5 points**) A mass attached to a spring oscillates back and forth as indicated in the position vs. time plot below. At point *P*, the mass has:



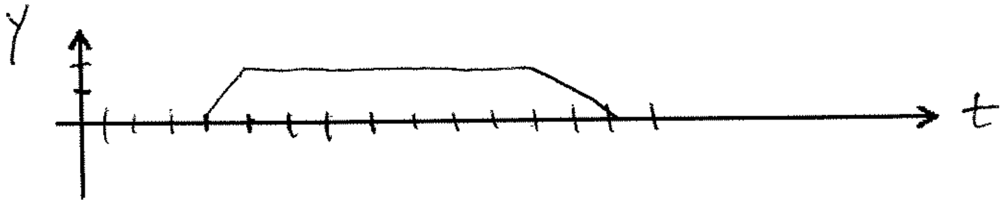
[✓ a.] Positive velocity and positive acceleration.
b. Positive velocity and negative acceleration.
c. Positive velocity and zero acceleration.
d. Negative velocity and positive acceleration.
e. Negative velocity and negative acceleration.
f. Negative velocity and zero acceleration.
g. Zero velocity but is accelerating (positively or negatively).
h. Zero velocity and zero acceleration.

Name____ **Section**____________

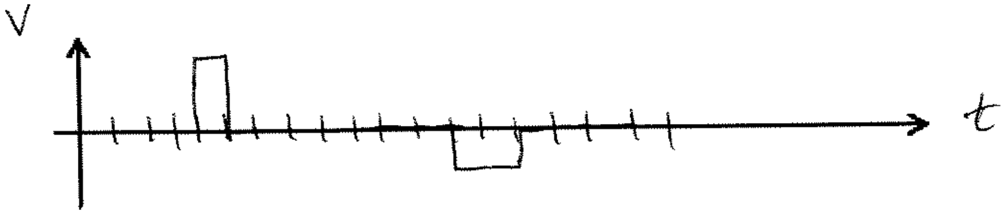
3) (**10 points**) A wave pulse is moving, as illustrated, with uniform speed v to the right along a rope.



A) (**5 points)** Draw on the axes below the graph of the y displacement vs time of the piece of rope indicated by the large arrow. Pay attention to the differing slopes, and be sure to label the axes.



B) (**5 points)** Draw on the axes below the graph of the y velocity vs time of the piece of rope indicated by the large arrow. Be sure to label the axes.

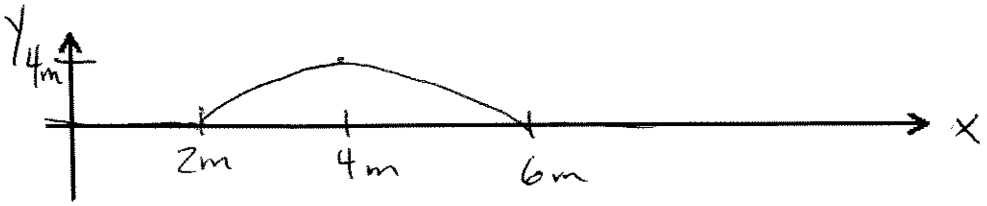


Name____ **Section**____________

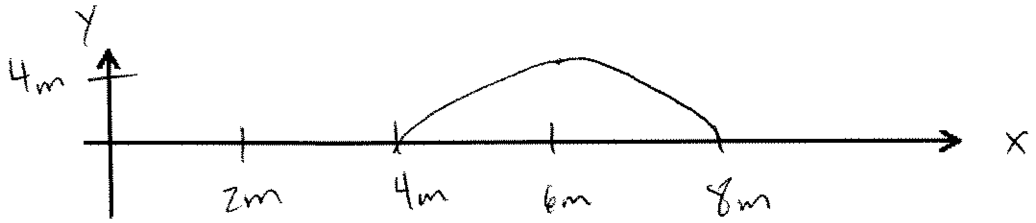
4) (**8 points**) Assume that a wave pulse traveling on a spring is described at time t = 0 as:

$y(x, t = 0) = 4 - (x - 4)^2 \quad 2m <= x <= 6m$
$y(x, t = 0) = 0 \quad$ for all other values of x

a) (**4 points**) Construct a graph below that portrays the actual shape of the spring at t = 0. Be sure to label the graph.



b) (**4 points**) If the pulse is traveling to the right with a velocity of 0.5 m/s, draw the shape of the spring at time t = 4 s. Again be sure to label everything.



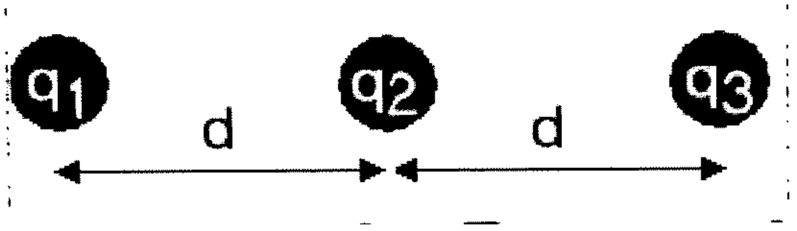
Electric Fields and Forces (26 points)

5) (**5 points**) Three pithballs are suspended from thin threads. Various objects are then rubbed against other objects (nylon against silk, glass against polyester, etc.) and each of the pithballs is charged by touching them with one of these objects. It is found that pithballs 1 and 2 attract each other and that pithballs 2 and 3 repel each other. From this we can conclude that

[✓ a.] 1 and 3 carry charges of opposite sign.
b. 1 and 3 carry charges of equal sign.
c. All three carry the charges of the same sign.
d. One of the objects carries no charge.
e. We need to do more experiments to determine the sign of the charges.

Name____________________________________ **Section**___________

6) **(6 points)** Three charges are lined up in a row as shown in the figure at the right. For each of the items below, complete the statements given with all the possible correct answers in the box at the right. If none are correct, write N.



a.) (**3** points) All the charges have the same magnitude. If we compare the force charge q_1 exerts on charge q_3 (F_{13}) to the force q_2 exerts on charge q_3 (F_{23})

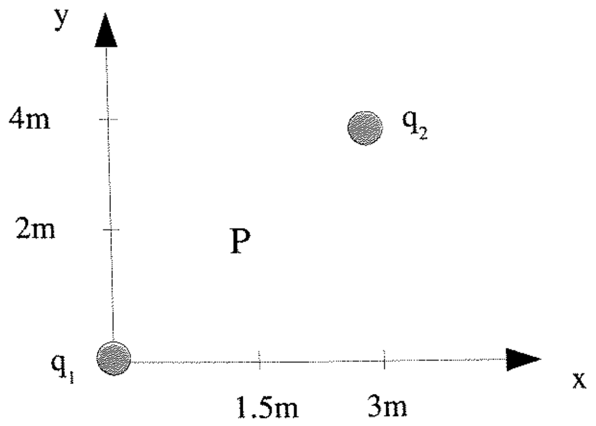
- a) F_{13} is twice as big as F_{23}.
- b) F_{13} is half as big as F_{23}.
- c) F_{13} is more than twice as big as F_{23}.
- [✓ d)] F_{13} is less than half as big as F_{23}.
- e) F_{13} doesn't affect q_3 at all since q_2 is in the way.

b.) **(3 points)** If the amount of charge in q_3 is doubled, then

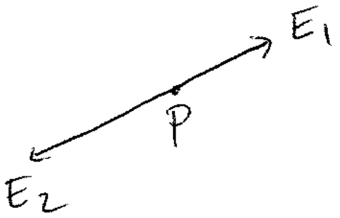
- a) F_{13} stays the same and F_{23} doubles.
- [✓ b)] F_{13} and F_{23} both double.
- c) F_{13} and F_{23} both stay the same.
- d) F_{13} is now the same as F_{12}.
- e) F_{13} is now half as big as F_{12}.

Name______________________________________ **Section**____________

7) **(15 points)** Charges q1 and q2 are fixed in place as shown below. We will consider the electric field at the point P with (x,y) = (1.5m, 2m).



a) **(3 points)**What is the magnitude of the electric field at point P due to q1 and q2, if q1 = q2 = +1μC?



$|E_1| = |E_2|$ but they point in opposite directions.

So $E_{net} = 0$

b) **(3 points)**What is the magnitude of the electric field at P due to q1 and q2 if a test charge q0 equal to 10 nC is placed at the point P?

E is independent of the test charge.

So $E = 0$ still.

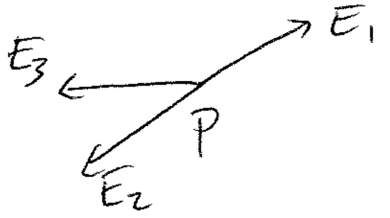
c) **(3 points)** In this case what is the net force on the test charge? Describe the motion of q0 if it is placed at P with no initial velocity.

$F = qE = (10nC) * 0 = 0$

q0 remains at rest.

Name____________________________________ **Section**___________

d) **(3 points)** What is the magnitude and direction of the electric field at the point P if we now place an additional fixed charge q3 = -1μC at the point (*x,y*) = (0m, 2m)?



$E_1 + E_2$ still cancel, So

$$|E_{net}| = |E_3| = \frac{k|q_3|}{r_3^2} = \frac{(9\times10^9)(|-1\times10^{-6}C}{(2m)^2}$$

= 2250 N/C to the left.

e) **(3 points)** In this case what is the net force on the test charge? Describe the motion of q0 if it is placed at P with no initial velocity.

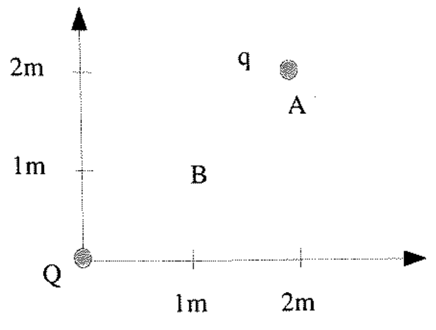
$$F = qE = (10nC)(2250N/C) = (10\times10^{-9}C)(2250N/C$$

$= 2.25\times10^{-5}N$ to the left.

q0 will initially move towards q3.

Electric Potential Energy, Electric Potential, and Capacitance (27 points)

9) (**8 points**) A fixed charge Q sits at the origin as shown below. A test charge q is moved from point A at (*x,y*) = (2m, 2m) to point B at (*x,y*) = (1m, 1m). Let Q = 100nC.



a.) **(2 points)**If q = 1nC. In moving from A to B, the potential energy of the system:

[✓ a.] Increases.

b. Decreases.

c. Stays the same.

Name____________________________________ **Section**___________

b.) **(2 points)** Relative to the electric potential at point A, the electric potential at point B is:
a.) Smaller.
[✓ b.)] Larger.
c.) The same.

c.) **(2 points)** If q = -1nC. In moving from A to B, the potential energy of the system:
a. Increases.
[✓ b.] Decreases.
c. Stays the same.

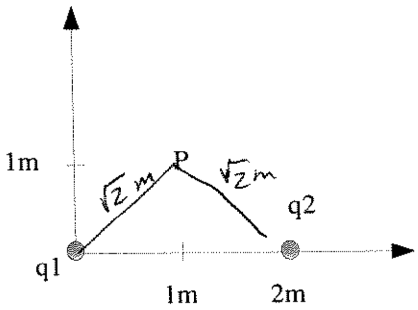
d.) **(2 points)** Now with q = -1nC, relative to the electric potential at point A, the electric potential at point B is:
a.) Smaller.
[✓ b.)] Larger.
c.) The same.

11) **(5 points)** You are given 2 parallel plate capacitors each with a capacitance of 1 nF when there is only air between the two plates. You also have a piece of dielectric material which can be inserted between the plates. The dielectric constant of this material is κ = 5. Which way of connecting the capacitors has the highest equivalent capacitance?

a. The two capacitors connected in series with only air between the plates.
b. One capacitor with air between the plates, connected in series to the other capacitor with the dielectric between its plates.
c. The two capacitors connected in parallel with only air between the plates.
[✓ d.] One capacitor with air between the plates, connected in parallel to the other capacitor with the dielectric between its plates.
e. The equivalent capacitance is the same in each case.

Name____ **Section**____________

12) **(14 points)** Charges q1 = -10nC and q2 = -10nC are fixed as shown below.



a.) **(3 points)** Calculate the electric potential at the point P.

$$V_p = V_1 + V_2 = \frac{kq_1}{r} + \frac{kq_2}{r} = \left(9\times10^9 \frac{N\cdot m^2}{C^2}\right)\left[\frac{-10\times10^{-9}C}{\sqrt{2}m} + \frac{-10\times10^{-9}C}{\sqrt{2}\ m}\right.$$

$$= -90\left(\frac{2}{\sqrt{2}}\right)V = -127.3V$$

b.) **(3 points)** If a charge q = 1nC is brought to the point P from infinity, calculate the change in potential energy of the system.

$$\Delta PE = q\Delta V = (1\times10^{-9}C)(V_p - V_\infty) = 10^{-9}C(-127.3-0)$$

$$= -1.273\times10^{-7}J$$

c.) **(3 points)** If the charge q has an initial velocity of 10 m/s when it starts from infinity, what is its velocity at the point P?

$m = 1kg$

$$\Delta PE + \Delta KE = 0 = -1.273\times10^{-7}J + \frac{1}{2}m(V_f^2 - V_i^2)$$

$$\frac{1}{2}(1kg)(V_f^2 - 10^2) = 1.273\times10^{-7}$$

$$V_f = \sqrt{(1.273\times10^{-7})\times2+100} = 10.000000013\ m/s$$

we shoul
have used
a smalle
mass

d.) **(5 points)** Answer parts a, b, and c if instead, q1 =10nC and q2 = -10nC.

if $q_1 = -q_2$ $V_p = (9\times10^9)(10\times10^{-9}C)\left(\frac{1}{\sqrt{2}} - \frac{1}{\sqrt{2}}\right) = 0$

ⓐ $V_p = 0$

ⓑ $\Delta PE = q\Delta V = q(V_p - V_\infty) = 0$

ⓒ $\Delta PE + \Delta KE = 0 \rightarrow 0 + \Delta KE = 0 \quad \Delta KE = 0 \rightarrow V_f = V_i$

Name_____________________________________ **Section**___________

Current and Resistance (19 points)

13) **(5 points)**The resistance of a conducting wire **decreases** with: (*circle all that are true)*

a. Temperature.
b. Length of wire.
[✓ c.] Cross sectional area of wire.
[✓ d.] Conductivity.
e. Number of impurities in the metal used to make the wire.
f. The current flowing in the wire (assuming that the temperature does not change with current).
g. The potential difference across the wire.

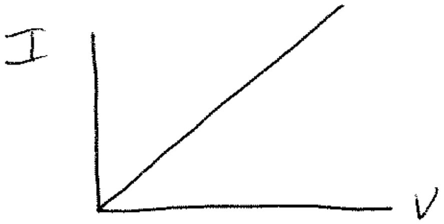
14) **(4 points)** Imagine you are setting up a home theater system. The cables that you use to connect your amplifier to your speakers can have an effect on the amount of power delivered to your speakers. When you go to the store to buy these cables you notice that they have some that are quite a bit more expensive than others. These expensive cables are 1) larger in diameter and 2) have gold plated connectors. Given that the resistivity of gold is less than that of copper (the typical connector material) explain why the expensive cables would be more desirable.

Power consumed by cable is higher if the resistance of the cable is higher. This means less power for the speaker. The expensive cables have a lower resistance since $R = \rho \frac{L}{A}$, gold has a lower resistivity (ρ) + $A = \pi r^2 = \pi (d/2)^2 \rightarrow$ larger diameter = larger area.

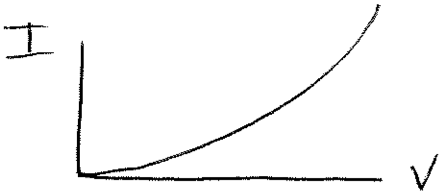
Name____ **Section**____________

15) **(10 points)** Ohmic vs non-ohmic materials.

a.) **(5 points)** Draw an example of the current versus voltage graph for an ohmic device.



b.) **(5 points)** Draw an example of the current versus voltage graph for a non-ohmic device.



Extra Credit (5 points)

Estimate the weight of solid garbage thrown away by American families each year.

# of US families: 300million people $\frac{1 \text{ family}}{3 \text{ people}}$

= 100 million families = 1×10^8 families

pounds of trash per family in 1wk: 10 – 100 pounds

min: 1×10^8 families $*$ $10\,\frac{\text{lbs}}{\text{wk}}$ $*$ $52\,\frac{\text{wks}}{\text{yr}}$ = $5.2\times10^{10}\,\frac{\text{lbs}}{\text{yr}}$

max 1×10^8 families$*$ $100\,\frac{\text{lbs}}{\text{wk}}$ $*$ $52\,\frac{\text{wks}}{\text{yr}}$ = $5.2\times10^{11}\,\frac{\text{lbs}}{\text{yr}}$

→ between ~50 and 500 billion pounds per year!