Phys 25100 Sample Test 1

Please print your name_____

This test contains four problems. You may choose to solve any three. Please indicate which three problems you would like us to grade.

Questions (5 points each) Please blacken the letter of the best answer for each question.

Q1 A 50 μF capacitor stores 0.01 Joules of energy. A second capacitor of value 20 μF carries the same voltage as the first. Please find the charge on the second capacitor.

a) 2×10^{-4} C
b) 4×10^{-4} C
c) 6×10^{-4} C
d) 8×10^{-4} C
e) None of the above

Q2 Identical positive charges Q are placed at the corners of a square of side L. Assume we use the convention that V = 0 at infinity. E is the magnitude of the electric field, V is the electric potential. Please indicate which of the following statements is true at the center of the square.

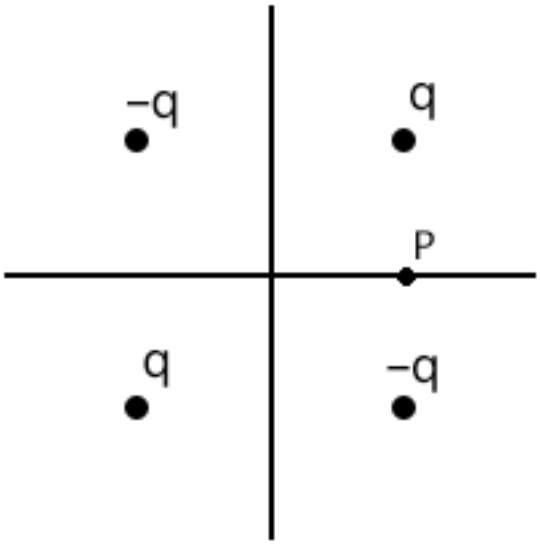
b) $E > 0, V > 0$
c) $E > 0, V = 0$
c) $E > 0, V < 0$
d) $E = 0, V > 0$
e) $E = 0, V = 0$
f) $E = 0, V < 0$
g) None of the above

Problems (30 points each). Please show your work and circle your answers. Missing or incorrect reasoning will earn no credit.

P1 A proton is released from rest in a uniform electric field of magnitude 75,000 V/m. Please find

a) The electric force on the proton.
b) The proton's kinetic energy after it has traveled 5 cm.
c) The surface charge density σ that must be placed on a infinite plane to produce the field.

P2 Two positive charges and two negative charges, all of magnitude 4 μC, are placed at four corners of a square with side 2 m centered at the origin. The situation is shown in the figure.



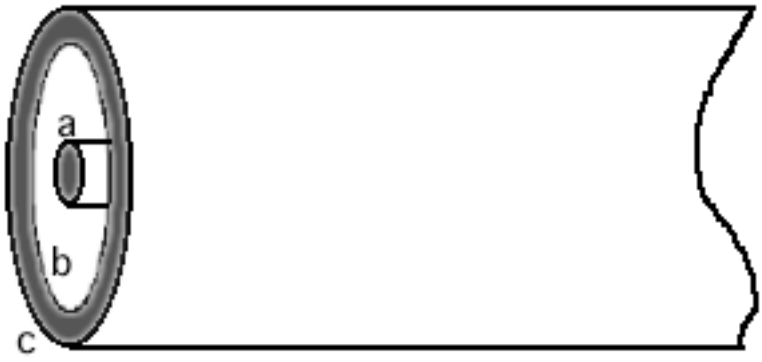
Please answer each of the following questions.

a) What is the direction of the electric field at point P located 1 m from the origin on the positive *x*-axis?

b) What is the total potential energy of the system of four charges?

c) A charge Q =1 μC is placed at point P. What is the net force on Q?

P3 A long conducting wire of radius a is surrounded by a conducting coaxial cylinder of inner radius b and outer radius c. The wire carries a net linear charge density λ and the cylinder carries a net linear charge density 2λ.

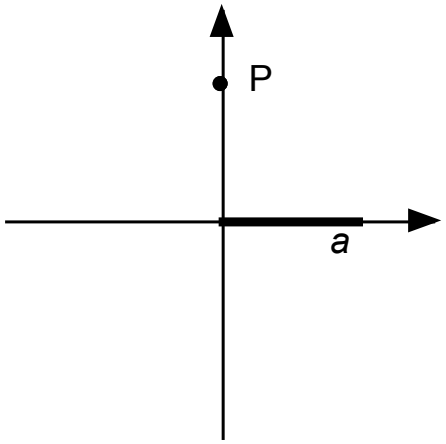


Please answer each of the following questions.

a) What is the linear charge density on each of the following surfaces?
   (i) $r = a$
   (ii) $r = b$
   (iii) $r = c$

b) What is the magnitude of the electric field in each of the following regions?
   (i) $r < a$
   (ii) $b < r < c$
   (iii) $r > c$

P4 Charge Q is distributed uniformly over a thin rod of length a, which lies along the positive x-axis as shown.



Please answer each of the following questions.

a) Is the rod an insulator or a conductor?

b) What is the linear charge density on the rod?

c) Draw an arrow on the figure indicating the approximate direction of the electric field at point P located at $(0, y)$.

d) Determine the x-component of the electric field at point P. You should find one of these integrals useful:

$$\int \frac{x\,dx}{\left(x^2+b^2\right)^{\frac{3}{2}}} = -\frac{1}{\sqrt{x^2+b^2}} \qquad \int \frac{dx}{\left(x^2+b^2\right)^{\frac{3}{2}}} = \frac{1}{b^2}\frac{x}{\sqrt{x^2+b^2}}$$

$$\int \frac{dx}{x^2+b^2} = \frac{1}{b}\arctan\left(\frac{x}{b}\right)$$

NOTE: This sample exam is intended to give a sense of how the test is structured, and how difficult the problems may be. It does not indicate that the problems on the test will be "similar" to these problems. Other possibilities include

- A statics problem with electrical forces involved
- A problem with a circuit including multiple capacitors
- A problem in which you must find the capacitance
- A problem with charge uniformly distributed over a circular arc