Name ____________________________________ **Student ID Number** ____________

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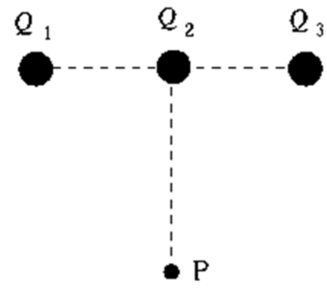
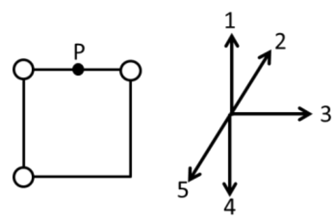
Part I. Lecture Multiple Choice (43 points total)

1. (5 pts.) Three charges Q_1, Q_2, and Q_3, each equal to 6 μC, are in a straight line. The distance between neighboring charges is 0.6 m. The magnitude of the electric field at P, which is 0.8 m from Q_2 on a line at right angles to the line between Q_1 and Q_3, is (updated with correct ans)



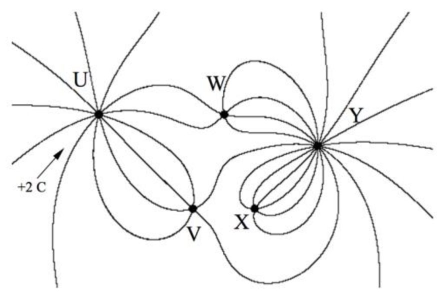
   A. 0.25×10^5 N/C
   B. 0.9×10^5 N/C
   C. 1.5×10^5 N/C
   D. 1.7×10^5 N/C
   E. 2.6×10^5 N/C

2. (3 pts) A square has equal positive charges at three of its corners, as shown. The direction of the electric field at point P is



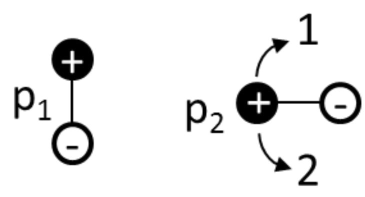
   A. 1
   B. 2
   C. 3
   D. 4
   E. 5

3. (4 pts) Five charges, labeled U through Y, and the electric field lines they create are shown in the figure. Given that the **charge on U is +2 C**, the electric charges on the others are



A.	V = +4/3C	W = +2/3C	X = -1C	Y = -2C
B.	V = -4C	W = -2C	X = +6C	Y = -6C
C.	V = -1C	W = -1C	X = -1C	Y = +3C
D.	V = +1C	W = -1C	X = -1C	Y = +3C

4. (3 pts) Two electric dipoles, p_1 and p_2, are arranged as shown. Dipole p_1 on the left is fixed. It cannot move. Dipole p_2 is placed as shown and released. It is free to move or rotate. What happens to p_2?



   A. It will translate toward p1
   B. It will translate away from p1
   C. It will rotate along the arrow 1 path
   D. It will rotate along the arrow 2 path
   E. It will remain in its current positon and orientation

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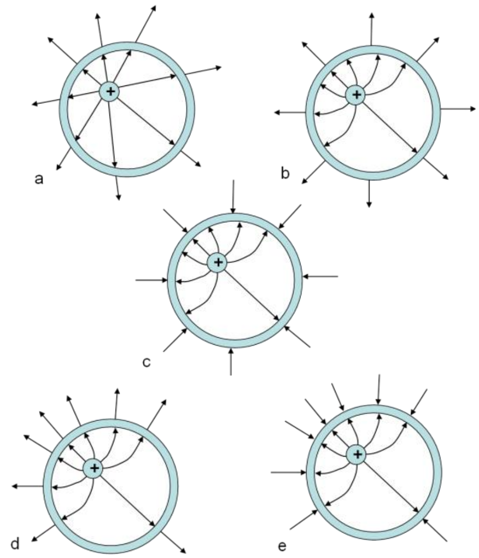
The figure to the right applies to the next two questions

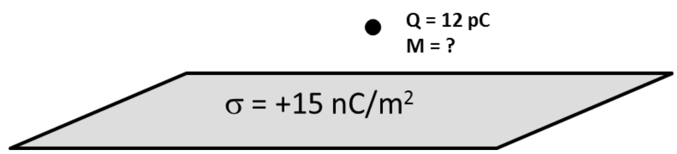


5. (3 pts) A solid conducting sphere with a net positive charge +5 μC is placed inside an <u>uncharged conducting shell</u>. Which of the diagrams most accurately depicts the electric field lines?
Pick the letter on the right and put it on your answer sheet

6. (3 pts) If the uncharged shell has inner radius R, what is the net induced charge on the inside of the shell?

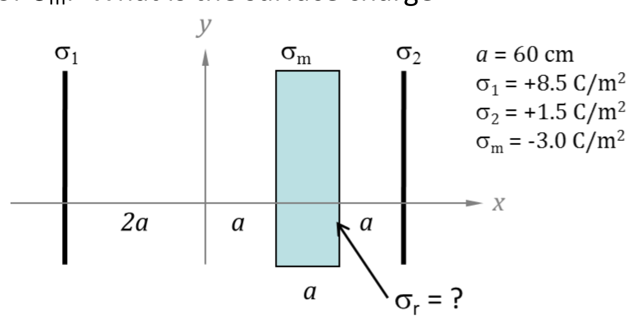
A. 0
B. -5 μC
C. +5 μC
D. $-5\ \mu C/4\pi R^2$
E. $+5\ \mu C/4\pi R^2$

7. (5 pts) A small dust particle is given a net positive charge of q = +12 pC (1 pC = 10^{-12} C). It is positioned and floats above a very large sheet (approximate as an infinite plane), with a surface charge density of σ = +15 nC/m^2. What is the particle mass M? (recall: g = 9.8 m/s^2)



A. 1.5×10^{-19} kg
B. 16.5×10^{-12} kg
C. 1.04×10^{-9} kg
D. 2.08×10^{-9} kg
E. It cannot be determined from the information given

8. (5 pts) Two infinite, thin sheets of charge are placed perpendicular to the x-axis with surface charge densities σ_1 and σ_2. A thick <u>conducting metal</u> plate of infinite area is placed between these charged sheets. It has a net charge per unit area of σ_m. What is the surface charge density σ_R induced on the <u>*right-hand* surface</u> of the conducting plate?



A. $\sigma_R = 1.5$ C/m^2
B. $\sigma_R = 2.0$ C/m^2
C. $\sigma_R = 4.0$ C/m^2
D. $\sigma_R = 5.0$ C/m^2
E. $\sigma_R = 7.0$ C/m^2

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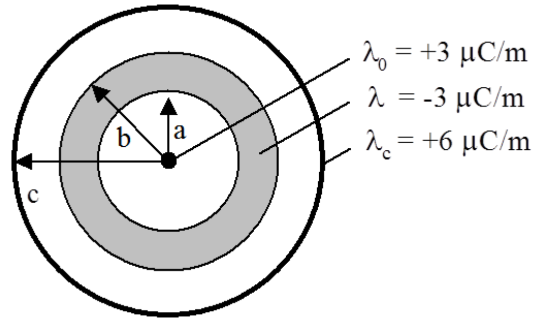
The figure to the right applies to the next three questions

An infinite line of charge pointing **into the page** has charge density λ_0 = +3 μC/m (black dot). Concentric with the line is a thick-walled hollow cylinder (shaded), made of **conducting** material. The hollow cylinder has a charge per unit length of λ = -3 μC/m. Finally, a **thin nonconducting** cylindrical shell is concentric with the other two objects, and carries a charge per unit length of λ_c = +6 μC/m. The dimensions of the objects are shown in the figure; all three have infinite length.

a = 4 cm

b = 5 cm

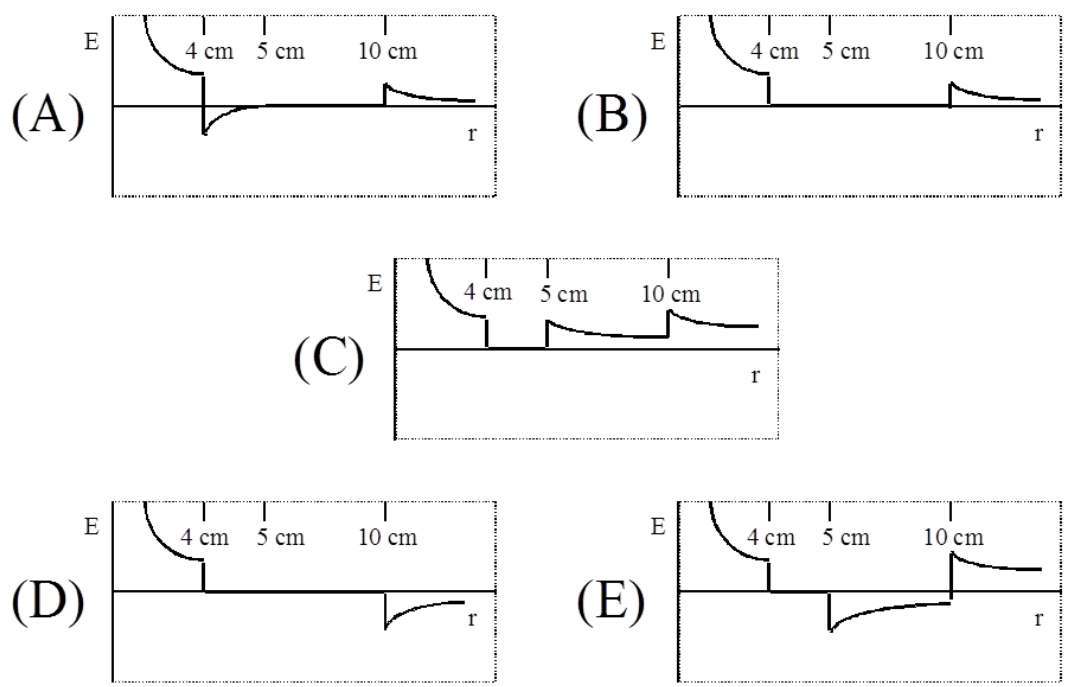
c = 10 cm



9. (3 pts) What is the surface charge density σ_b on the outer surface of the thick conducting shell?
   - A. $\sigma_b > 0$
   - B. $\sigma_b = 0$
   - C. $\sigma_b < 0$

10. (5 pts) What is the magnitude of the electric field at a radius r = 20 cm?
   - A. E = 0.54 x10^6 N/C
   - B. E = 1.23 x10^6 N/C
   - C. E = 3.15 x10^6 N/C
   - D. E = 5.57 x10^6 N/C
   - E. E = 7.14 x10^6 N/C

11. (4 pts) Which graph best represents the radial dependence of the electric field E?



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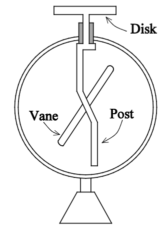
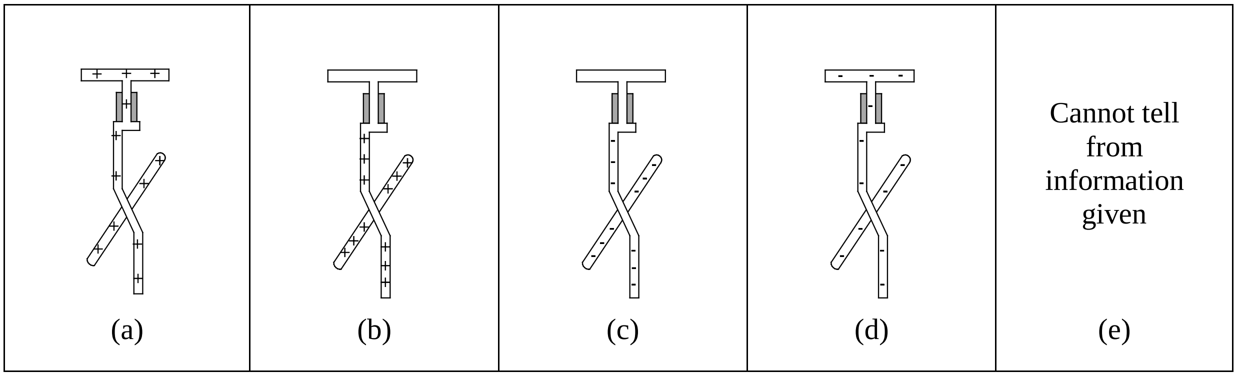
II. Lab questions [12 pts]

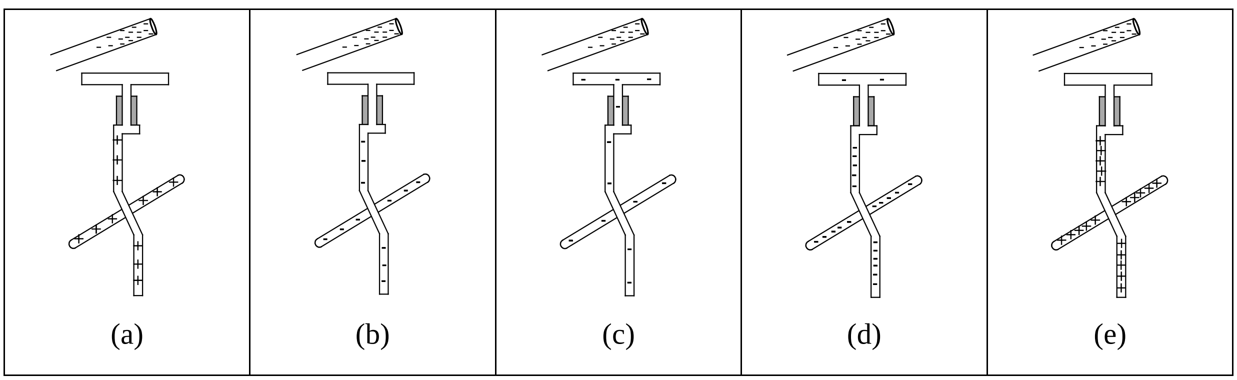


Initially, an electroscope's vane is **open**, as shown at right. Then a **Teflon** rod is rubbed with a wool cloth, giving it a **negative charge**. The rod is held *near* the electroscope disk (but does not touch and no sparks jump), and it is observed that the vane **opens further**.

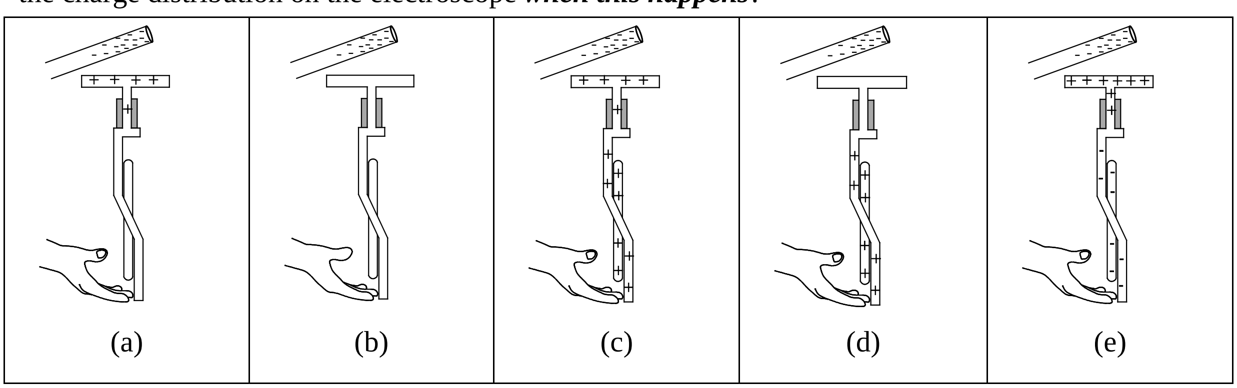
12. [4 pts] Which picture below shows the charge distribution on the electroscope ***before*** the Teflon rod is brought near the disk?



13. [4 pts] Which picture below shows the charge distribution on the electroscope ***while*** the Teflon rod is held near the disk?



14. [4 pts] Next, the experimenter continues to hold the rod in one hand **near** the electroscope's disk, and **touches the bottom end of the post with a finger on the other hand.** Which picture below shows the charge distribution on the electroscope ***when this happens***?



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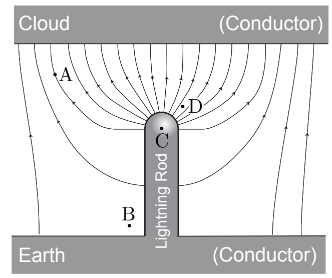
The next three problems are related.



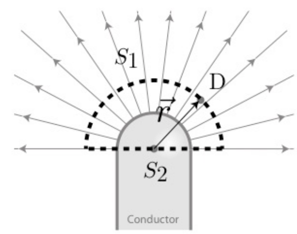
A lightning rod in a storm. Study the field lines and answer the following questions.

X. (5 pts) **Rank** the **magnitude** of the **force** on a negative charge at points A, B, C and D from smallest to largest. (If the electric field at any two points is equal, state so explicitly.)

$$F\_ < F\_ < F\_ < F\_$$

X. (5 pts) Why?

Assume the E field outside the top cap of the lightning rod is well **approximated** by the field generated by a charged spherical conductor, as shown. Consider the **Gaussian surface** S constructed from the half sphere S_1 and circular end cap S_2, as shown.

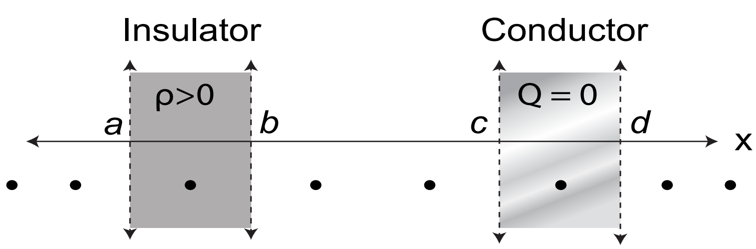


X. (5 pts) If charge Q is enclosed by the **Gaussian surface** S, what is the **electric field vector** at point D in terms of Q, $\vec{r}$ and ε_0?

The next two problems are related.

E field from an infinite slab: Consider an infinite **insulating slab** with charge density $\rho > 0$ and an infinite **conducting slab** with no net charge ($Q = 0$) for the next two questions.

X. (5 pts) **Sketch** the E field **by drawing an E field vector at each black point**. If the E field is zero, leave the point blank.



X. (5 pts) **Sketch** the x component of the E field (E_x) as a function of the x position **on the plot to the right**.