

University Physics 2

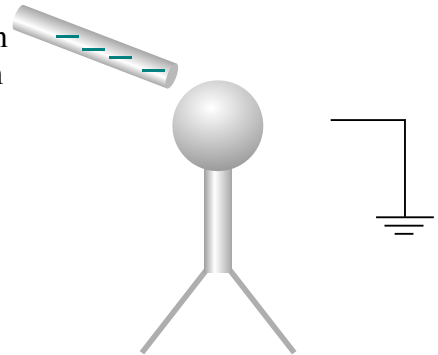
Midterm Exam 1

Name: Solutions

Multiple Choice Questions:

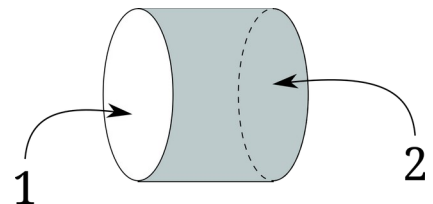
Select the best answer by circling the letter.

1. An electroscope (with zero net charge) is approached with a negatively charged rod. While holding the rod near, a connection to ground is touched to the electroscope and then removed. With the negative rod remaining in place, what is the charge on the electroscope?



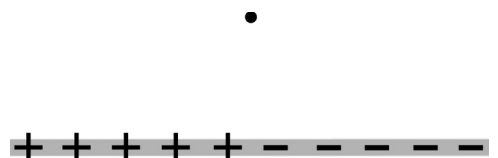
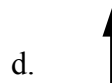
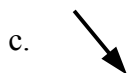
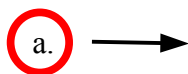
- a. negative charge on top, zero charge on the bottom leaves
- b. positive charge on top, negative charge on the bottom leaves
- c. positive charge on top, zero charge on the bottom leaves
- d. zero charge on top, zero charge on the bottom leaves

2. A cylindrical surface lies in a uniform electric field which points horizontally to the right. Surface 1 is the disk at the left end. Surface 2 is the rest of the cylinder (the right end and the curved surface). Which is a correct statement about the magnitudes of the electric flux through each surface:



- a. $\Phi_1 = \Phi_2 \neq 0$
- b. $\Phi_1 < \Phi_2$
- c. $\Phi_1 > \Phi_2$
- d. $\Phi_1 = \Phi_2 = 0$

3. A rod is charged half positive, half negative, as shown. What is the best estimate of the direction of the electric field at the dot, above the midpoint?

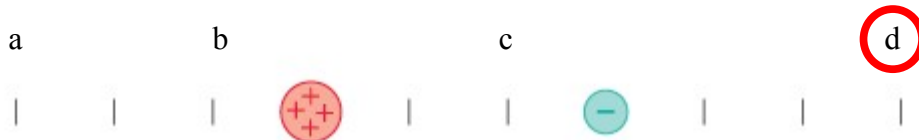


4. Metal sphere A in the figure has charge $Q_A = -4e$ and metal sphere B has charge $Q_B = +2e$. The two spheres are brought into contact. What is the final charge state of each sphere?



- a. $Q_A = -4e, Q_B = -4e$ **b.** $Q_A = -e, Q_B = -e$
 c. $Q_A = -2e, Q_B = -2e$ d. $Q_A = -4e, Q_B = +2e$




5. Charges of $+4q$ and $-1q$ are placed as shown below. Circle the letter at the location that is most likely to have zero net electric field.

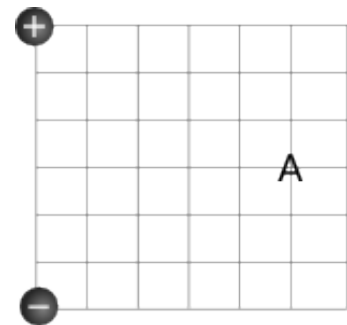


6. A positive charge is placed at $x = 0$, and a negative charge of equal magnitude is placed to the right, at $x = d$. The electric field at a point $x = \frac{1}{2}d$...

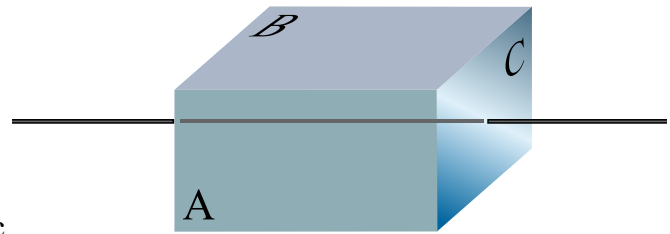
- a. is zero **b.** points to the left
 c. points in the $+y$ direction **d.** points to the right

7. A positive charge of $8.0 \mu\text{C}$ and a negative charge of $-1.0 \mu\text{C}$ are arranged as shown in the figure. What is the best estimate for the direction of the electric field at point A?

- a.  b. 
 c.  **d.** 



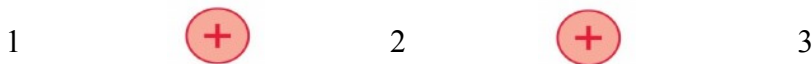
8. The figure below shows an infinitely long wire with a uniform line of negative charge. A closed rectangular box surrounds a portion of the wire, with its left and right faces perpendicular to the wire.



Determine the sign (+, −, or 0) of the electric flux through surface A, B and C.

- a. $\Phi_A = +$ $\Phi_B = +$ $\Phi_C = +$
 b. $\Phi_A = -$ $\Phi_B = -$ $\Phi_C = -$
 c. $\Phi_A = 0$ $\Phi_B = 0$ $\Phi_C = 0$
 d. $\Phi_A = -$ $\Phi_B = -$ $\Phi_C = 0$

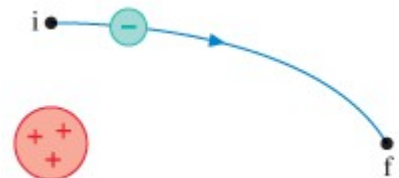
9. What is the correct relation among the electric potentials at points 1, 2 and 3 below? Assume the points and charges are equally spaced.



- a. $V_1 = V_2 = V_3$
 b. $V_2 > V_1 = V_3$
 c. $V_1 < V_2 < V_3$
 d. $V_2 < V_1 = V_3$

10. An electron moves along the trajectory shown from *i* to *f*. What happens to the value of the electric potential at the electron?

- a. increases
 b. decreases
 c. remains constant
 d. increases then decreases



Long Answer Problems:

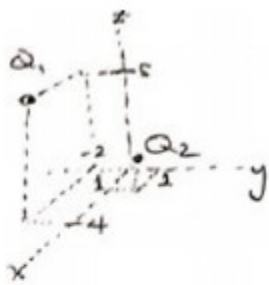
Correct units must be included with every answer.

Give vector answers in $\hat{i} \hat{j} \hat{k}$ notation.

Answers should be written on the blank provided, and work that you want credit for must be done in the box. If you need more space, indicate in writing that the work is continued in another area.

1. Point charges $Q_1 = 1.0 \mu\text{C}$ and $Q_2 = -2.0 \mu\text{C}$ are located at $\vec{r}_1 = (4.0\hat{i} - 2.0\hat{j} + 5.0\hat{k}) \text{ m}$ and $\vec{r}_2 = (1.0\hat{i} + 1.0\hat{j} + 1.0\hat{k}) \text{ m}$. What is the electric force on Q_1 ?

answer: $\vec{F} = (-2.72\hat{i} + 2.72\hat{j} - 3.63\hat{k}) \times 10^{-4} \text{ N}$



$$\vec{r}_{21} = (3\hat{i} - 3\hat{j} + 4\hat{k}) \text{ m}$$

points from 2 \rightarrow 1

$$r = \sqrt{3^2 + 3^2 + 4^2} = \sqrt{34}$$

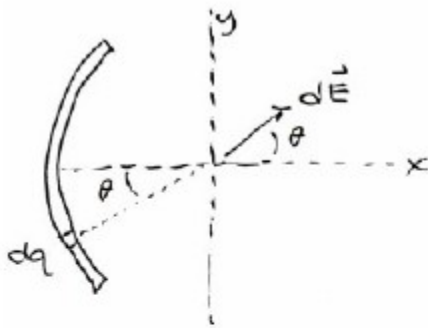
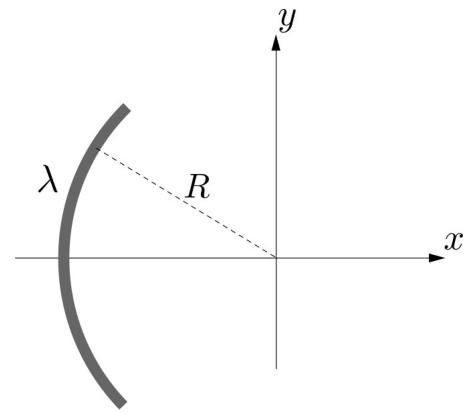
$$\hat{u} = \frac{\vec{r}_{21}}{r}$$

$$\vec{F} = \frac{kQ_1Q_2}{r^2} \hat{u} = (9.0 \times 10^9) \frac{(-2 \times 10^{-12})}{r^2} (3\hat{i} - 3\hat{j} + 4\hat{k})$$

$$= (-0.272\hat{i} + 0.272\hat{j} - 0.363\hat{k}) \text{ mN}$$

2. The charge per unit length on the thin quarter-circle of wire shown is λ . The quarter-circle has its center at the origin and radius R . What is the electric field at the origin?

answer: $\vec{E} = \frac{k\lambda}{R} \sqrt{2} \hat{i}$



$$d\vec{E} = \frac{k dq}{R^2} = \frac{k \lambda R d\theta}{R^2}$$

x-component only:

$$dE_x = \frac{k\lambda}{R} \cos\theta d\theta$$

total x-component of \vec{E} at origin:

$$E_x = \int dE_x = \frac{k\lambda}{R} \int_{-\pi/4}^{+\pi/4} \cos\theta d\theta = \frac{k\lambda}{R} \sin\theta \Big|_{-\pi/4}^{+\pi/4}$$

$\frac{1}{\sqrt{2}} - (-\frac{1}{\sqrt{2}})$

$$E_x = \frac{2k\lambda}{\sqrt{2}R} = \frac{k\lambda}{R} \sqrt{2}$$

$$\vec{E} = \frac{k\lambda}{R} \sqrt{2} \hat{i}$$

3. A point charge of $q = +20.0 \text{ nC}$ is placed at the center of an uncharged spherical conducting shell of inner radius 5.0 cm and outer radius 10.0 cm .

- a. Find the magnitudes of the electric field at radii $r_1 = 4.0 \text{ cm}$, $r_2 = 8.0 \text{ cm}$, and $r_3 = 15.0 \text{ cm}$
 b. What are the charges induced on the inner and outer surfaces of the shell?

answers:

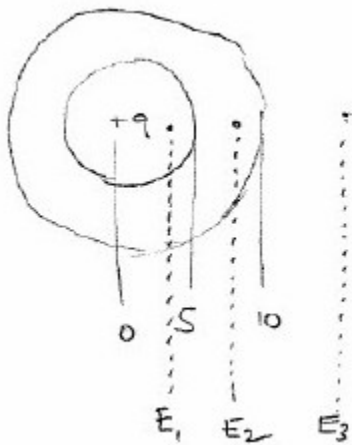
a. $E_1 = \underline{112 \text{ kV/m}}$

$E_2 = \underline{0}$

$E_3 = \underline{7.99 \text{ kV/m}}$

b. $Q_{\text{in}} = \underline{-20 \text{ nC}}$

$Q_{\text{out}} = \underline{+20 \text{ nC}}$



$$E_1 = \frac{kq}{(0.04)^2} = 112 \frac{\text{kV}}{\text{m}}$$

$$E_3 = \frac{kq}{(0.15)^2} = 7990 \frac{\text{V}}{\text{m}}$$

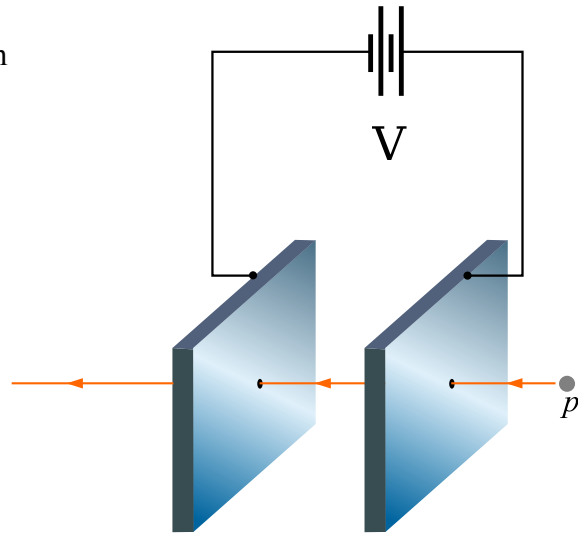
4. Two metal plates, 2.0 cm apart, are held at a potential difference of $V = 1000\text{V}$. A proton (p) enters the region from the right at a speed of $3.0 \times 10^4 \text{ m/s}$.

What is the proton's speed when it emerges from the left side?

answer:

$$v = \underline{4.4 \times 10^5 \text{ m/s}}$$

(mass of proton = $1.67 \times 10^{-27} \text{ kg}$)



$$K_1 + U_1 = K_2 + U_2$$

$$\frac{1}{2} m v_1^2 + 0 = \frac{1}{2} m v_2^2 + qV$$

$$v_2 = \sqrt{v_1^2 + \frac{2}{m} qV}$$

$$= \sqrt{(3.0 \times 10^4)^2 + \left(\frac{2}{1.67 \times 10^{-27}}\right) (1.6 \times 10^{-19}) (1000)}$$

$$= 4.39 \times 10^5 \text{ m/s}$$