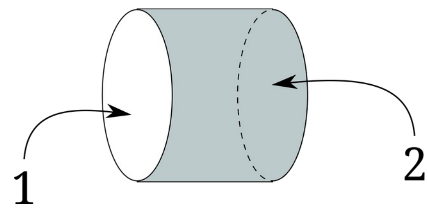
University Physics 2
Midterm Exam 1

Name: ______________________________

Multiple Choice Questions:

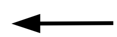
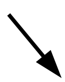
Select the best answer by circling the letter.

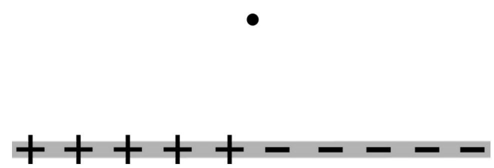
1. A cylindrical surface lies in a uniform electric field which points horizontally to the right. Surface 1 is the disk at the left end. Surface 2 is the rest of the cylinder (the right end and the curved surface). Which is a correct statement about the magnitudes of the electric flux through each surface:



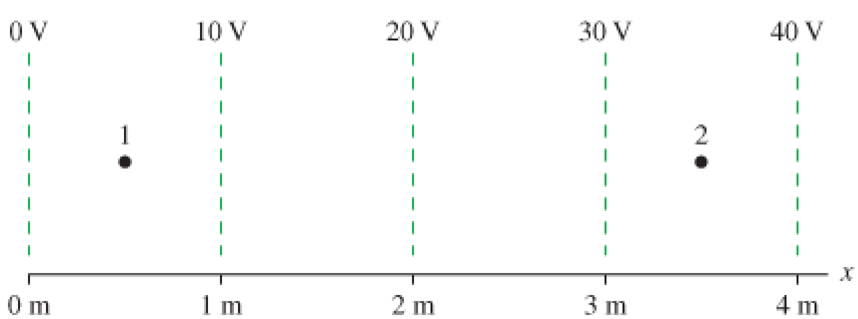
a. $\Phi_1 = \Phi_2 \neq 0$
b. $\Phi_1 < \Phi_2$
c. $\Phi_1 > \Phi_2$
d. $\Phi_1 = \Phi_2 = 0$

2. 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?

a. 
b. 
c. 
d. 



3. Equipotential surfaces are shown in the figure as dotted lines. What can be said about the electric field at points 1 and 2?



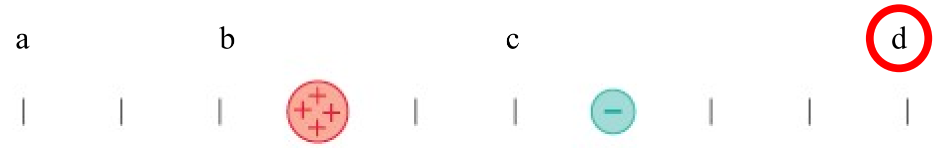
a. the field at both points is toward the right
b. the field at 2 is stronger than the field at 1
c. the field at 1 is the same strength as the field at 2
d. the electric field is zero at both points

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.

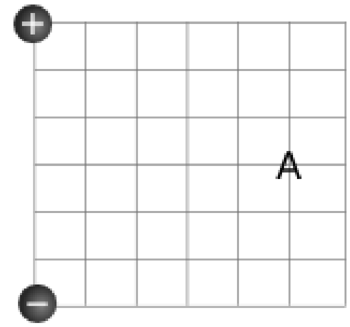


6. A positive charge is placed at $x = 0$, and a negative charge of equal magnitude is placed to the right, at $x = d$. The electric field at a point $x = \frac{1}{2}d$ …

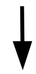
a. is zero b. points to the left

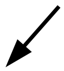
c. points in the $+y$ direction d. points to the right

7. A positive charge of 8.0μC and a negative charge of −1.0μC are arranged as shown in the figure. What is the best estimate for the direction of the electric field at point A?



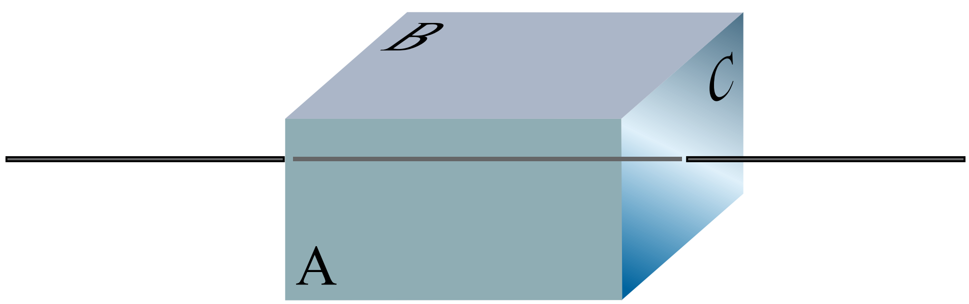
a. 

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. $\Phi_A = +$ $\quad\Phi_B = +$ $\quad\Phi_C = +$

b. $\Phi_A = -$ $\quad\Phi_B = -$ $\quad\Phi_C = -$

c. $\Phi_A = 0$ $\quad\Phi_B = 0$ $\quad\Phi_C = 0$

d. $\Phi_A = -$ $\quad\Phi_B = -$ $\quad\Phi_C = 0$

Long Answer Problems:

Correct units must be included with every answer.

Give vector answers in $\hat{\imath}\ \hat{\jmath}\ \hat{k}$ 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.

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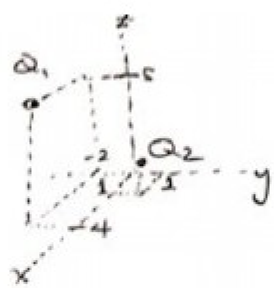
1. Point charges $Q_1 = 1.0\ \mu C$ and $Q_2 = -2.0\ \mu C$ are located at $\vec{r}_1 = \left(4.0\hat{\imath} - 2.0\hat{\jmath} + 5.0\hat{k}\right)$ m and $\vec{r}_2 = \left(1.0\hat{\imath} + 1.0\hat{\jmath} + 1.0\hat{k}\right)$ m . What is the electric force on Q_1 ?

answer: $\vec{F} = \left(-2.72\,\hat{\imath} + 2.72\,\hat{\jmath} - 3.63\,\hat{k}\right) \times 10^{-4}$ N



$\vec{r}_{21} = \left(3\hat{\imath} - 3\hat{\jmath} + 4\hat{k}\right)$ m

points from 2 → 1

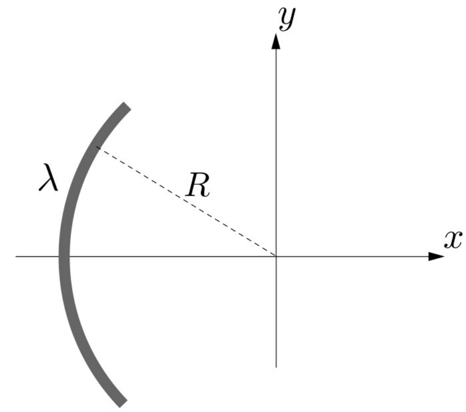
$r = \sqrt{3^2 + 3^2 + 4^2} = \sqrt{34}$

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

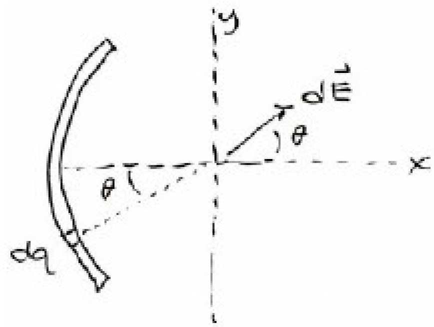
$\vec{F} = \dfrac{kQ_1Q_2}{r^2}\hat{u} = \left(9.0\times10^{9}\right)\dfrac{\left(-2\times10^{-12}\right)}{r^3}\left(3\hat{\imath} - 3\hat{\jmath} + 4\hat{k}\right)$

$= \left(-0.272\hat{\imath} + 0.272\hat{\jmath} - 0.363\hat{k}\right)$ 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:

$$E_x = \int dE_x = \frac{k\lambda}{R}\int_{-\pi/4}^{+\pi/4}\cos\theta\,d\theta = \frac{k\lambda}{R}\underbrace{\sin\theta\Big|_{-\pi/4}^{+\pi/4}}_{\frac{1}{\sqrt{2}}-\left(-\frac{1}{\sqrt{2}}\right)}$$

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

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

3. A point charge of q = +20.0 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 cm, r_2 = 8.0 cm, and r_3 = 15.0 cm
   b. What are the charges induced on the inner and outer surfaces of the shell?

answers:

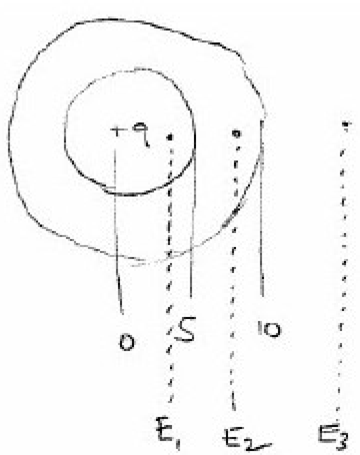
a. E_1 = 112 kV/m

E_2 = 0

E_3 = 7.99 kV/m

b. Q_{in} = − 20 nC

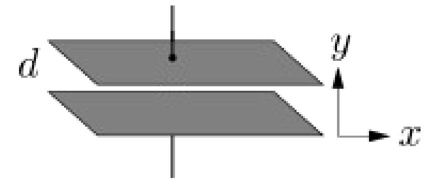
Q_{out} = + 20 nC



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

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

4. The two neutral conducting plates with area A are separated by distance d. They may be approximated as infinite.



A charge of $+Q$ is moved from the lower plate to the upper plate. Determine the following in terms of the variables and coordinates given (and any physical constants).

a. The electric field between the plates.
b. The electric potential as a function of y (the vertical distance from the lower plate), assuming $V = 0$ at the lower plate.

answers:

a. $\vec{E} = -\frac{Q}{\epsilon_0 A}\hat{j}$

b. $V(y) = \frac{Q}{\epsilon_0 A}\cdot y$

3.5

$$\vec{E} = \frac{\sigma}{\epsilon_0}(-\hat{j}) = -\frac{Q}{\epsilon_0 A}\hat{j}$$

$$\Delta V = -\int_0^y \vec{E}\cdot d\vec{s} = \frac{Q}{\epsilon_0 A}\int_0^y ds = \frac{Q}{\epsilon_0 A}\cdot y$$