Name KEY

PHY 2049 Exam # 2 21 questions

MULTIPLE CHOICE. Choose the one alternative that best completes the statement or answers the question.

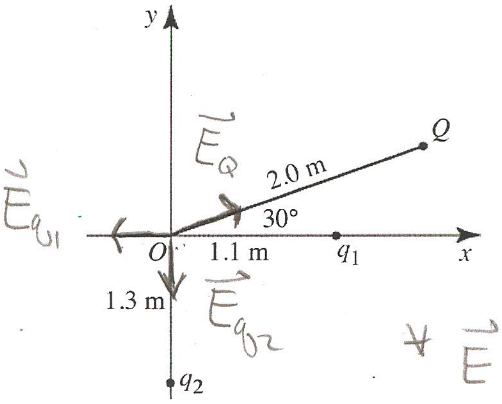
1) A point charge Q = -500 nC and two unknown point charges, q_1 and q_2, are placed as shown in the figure. The electric field at the origin O, due to charges Q, q_1 and q_2, is equal to zero. The charge q_1 is closest to

that tells us what the directions of the electric fields must be *

From diagram,

$|\vec{E}_{q_1}| = |\vec{E}_Q| \cos(30)$

$\frac{k|q_1|}{1.1^2} = \frac{k|Q|}{2^2}$

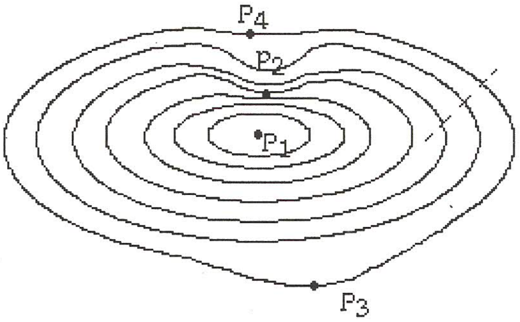


* $\vec{E}$ is radially out of positive charges,

A) 150 nC. B) -130 nC. C) -76 nC. D) 130 nC. E) 76 nC.

$\therefore |q_1| = 131 nC$

2) An electric charge distribution causes the equipotential lines that are shown in the figure. Of the four labeled points, which is at the point where the electric field is stronger than the field strength at the others?



$\vec{E} = -\nabla V$

Class notes → contour map pg 771

A) P3 B) P4 C) P2 D) P1

3) A charge q = 2.00 μC is placed at the origin in a region where there is already a uniform electric field $\vec{E} = 100\,\hat{i}$ N/C. Calculate the flux of the net electric field through a Gaussian sphere of radius R = 10.0 cm centered at the origin. ($\varepsilon_0 = 8.85 \times 10^{-12}\ C^2/N \cdot m^2$, surface area of sphere = 4*PI*r^2)

A) zero
B) $5.52 \times 10^5\ N \cdot m^2/C$
C) $2.26 \times 10^5\ N \cdot m^2/C$
D) $1.13 \times 10^5\ N \cdot m^2/C$

$\oint \vec{E} \cdot d\vec{A} = \frac{Q_{enclosed}}{\varepsilon_0}$

for sphere centered @ origin

$= \frac{2 \times 10^{-6}}{8.85 \times 10^{-12}} = 2.26 \times 10^5$

4) A metal sphere of radius 10 cm carries a charge of +2.0 μC uniformly distributed over its surface. What is the magnitude of the electric field due to this sphere at a point 5.0 cm outside the sphere's surface?
($k = 1/4\pi\varepsilon_0 = 8.99 \times 10^9\ \mathrm{N \cdot m^2/C^2}$)

$\oint \vec{E}\cdot d\vec{A} = \frac{Q_{enc}}{\varepsilon_0}$

looks just like a point charge

$E = \frac{kq}{r^2} = \frac{8.99\times10^9(2\times10^{-6})}{(0.15)^2} = 8.0\times10^6$

A) 4.2×10^6 N/C
B) 4.0×10^5 N/C
C) 4.0×10^7 N/C
D) 8.0×10^7 N/C
E) 8.0×10^5 N/C ✓

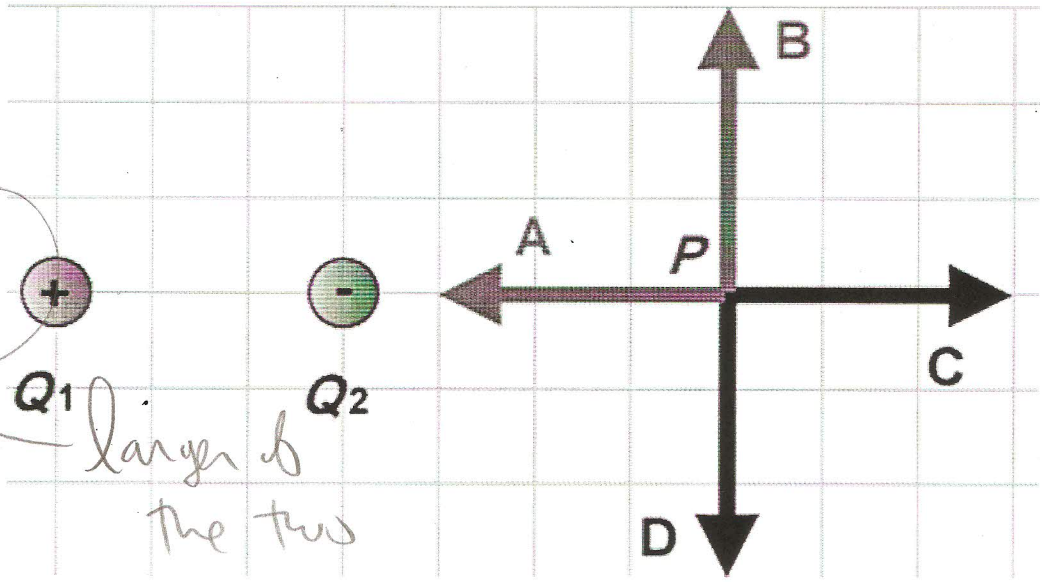
5) For a charged conductor in electrostatic equilibrium, the electric field just outside the surface ___________.

A) is always zero because the electric field is zero inside conductors.
B) can have nonzero components perpendicular to and parallel to the surface of the conductor.
C) is always perpendicular to the surface of the conductor. SEE NOTES. If not ⊥, then charges would move.
D) is perpendicular to the surface of the conductor only if it is a sphere, a cylinder, or a flat sheet.
E) is always parallel to the surface.

6) Two point charges Q_1 and Q_2 of equal magnitudes and opposite signs are positioned as shown in the figure. Which of the arrows best represents the net electric field at point P due to these two charges?

$\frac{kQ_1}{r_1^2}\hat{i}$

$-\frac{kQ_2}{r_2^2}\hat{i}$



larger of the two

A) A ✓
B) B
C) C
D) D
E) The field is equal to zero at point P.

7) A 4.0 μF and a 15.0 μF capacitor are connected in series, and the series arrangement is connected in parallel to a 20.0 μF capacitor. How much capacitance would a single capacitor need to replace the three capacitors?

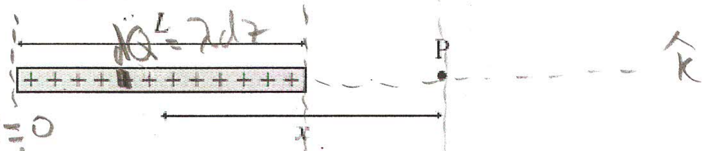
A) 18 μF B) 23 μF ✓ C) 13 μF D) 31 μF

Point charge NEGATIVE *

8) The electric field 1.5 cm from a very small charged object points toward the object with a magnitude of 180,000 N/C. What is the charge on the object? ($k = 1/4\pi\varepsilon_0 = 8.99 \times 10^9$ N · m^2/C^2)

A) −5.0 nC $180000 = \frac{kq}{(0.015)^2}$ $\therefore q = 4.5 \times 10^{-9}$ * B) +4.5 nC C) +5.0 nC D) −4.5 nC

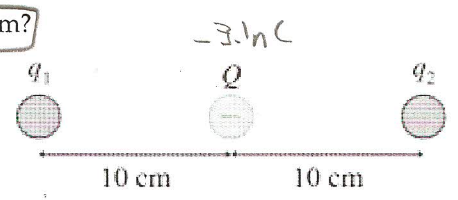
9) The figure shows a thin rod of length L = 5.0 cm with total charge Q = 8.4 nC. What is the magnitude of the electric field E at x = 3.0 cm? NOTE: The origin as shown is at the middle of the rod. That places the point P a distance of 0.5 cm from one end of the rod. You can set up and perform the integration using whatever coordinates you wish. Your result will be the same.



A) 1.8×10^5 N/C B) 2.7×10^5 N/C C) 8.4×10^4 N/C D) 3.7×10^5 N/C

z = 5cm z = 0.5cm

10) In the figure, all the charges are point charges and the charge in the middle is Q = −3.1 nC. For what charge q_1 will charge q_2 be in static equilibrium?



$|\vec{F}_{q_1 q_2}| = |\vec{F}_{q_2 Q}|$

$\frac{k q_1 q_2}{(0.2)^2} = \frac{k q_2 Q}{(0.1)^2}$

A) 12 nC ✓ B) 6.2 nC C) 3.1 nC D) 25 nC

$\therefore q_1 = 12.4 \times 10^{-9}$ C

→ A Tough exam question (that is in your classnotes ☺)

$\int dE = \int \frac{k\,dQ}{r^2}$

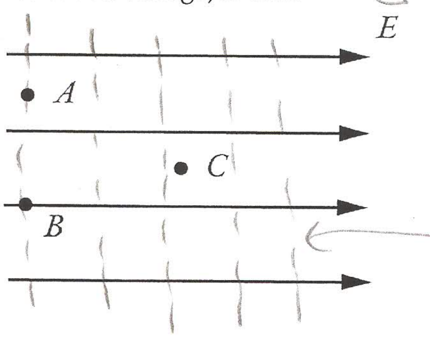
$E = \int_0^{0.05} \frac{k\,dQ}{(0.055 - z)^2} = \int_0^{0.05} \frac{k\lambda\,dz}{(0.055-z)^2} = +k\lambda\left(\frac{1}{(5\times10^{-3})} - \frac{1}{(0.055)}\right) = 2.7\times10^5$

$\lambda = \frac{8.4\times10^{-9}}{0.05}$

in $+\hat{k}$ "away from positive"

OVER

11) Suppose a region of space has a $\boxed{\text{uniform electric field}}$, directed towards the right, as shown in the figure. Which statement about the electric potential (also called voltage) is true?



$\vec{E}$ from high voltage to low voltage

Equipotential Surfaces

A) The potential at points A and B are equal, and the potential at point C is higher than the potential at point A.

B) The potential at point A is the highest, the potential at point B is the second highest, and the potential at point C is the lowest.

C) The potential at points A and B are equal, and the potential at point C is lower than the potential at point A.

D) The potential at all three locations (A, B, C) is the same because the field is uniform.

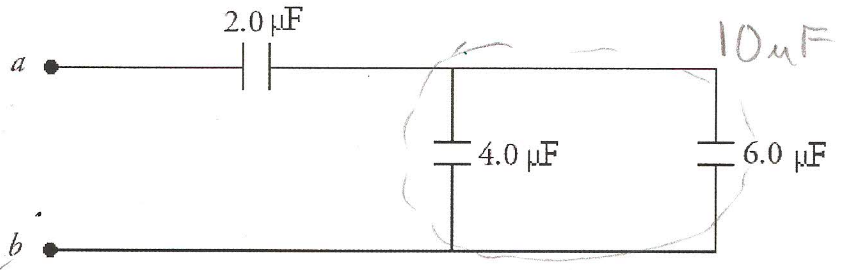
PE xfrmd to K.E.

12) A very small object carrying $-6.0\ \mu C$ of charge is attracted to a large, well-anchored, positively charged object. How much kinetic energy does the negatively charged object gain if the voltage through which it moves is 3.0 mV? ($k = 1/4\pi\varepsilon_0 = 8.99 \times 10^9\ N \cdot m^2/C^2$)

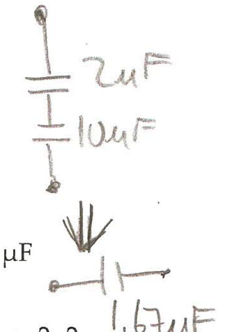
$\Delta PE = q\Delta V = 6\times10^{-6} * 3\times10^{-3} = 18\times10^{-9}\ J$

A) 18 nJ
B) 0.50 kJ
C) 0.50 J
D) 6.0 μJ

13) Three capacitors are connected as shown in the figure. What is the equivalent capacitance between points a and b?



10 μF



A) 1.7 μF
B) 12 μF
C) 7.1 μF
D) 4.0 μF
E) 8.0 μF

14) In a certain region, the electric potential due to a charge distribution is given by the equation $V(x,y,z) = 3x^2y^2 + yz^3 - 2z^3x$, where x, y, and z are measured in meters and V is in volts. Calculate the magnitude of the electric field vector at the position $(x,y,z) = (1.0, 1.0, 1.0)$.

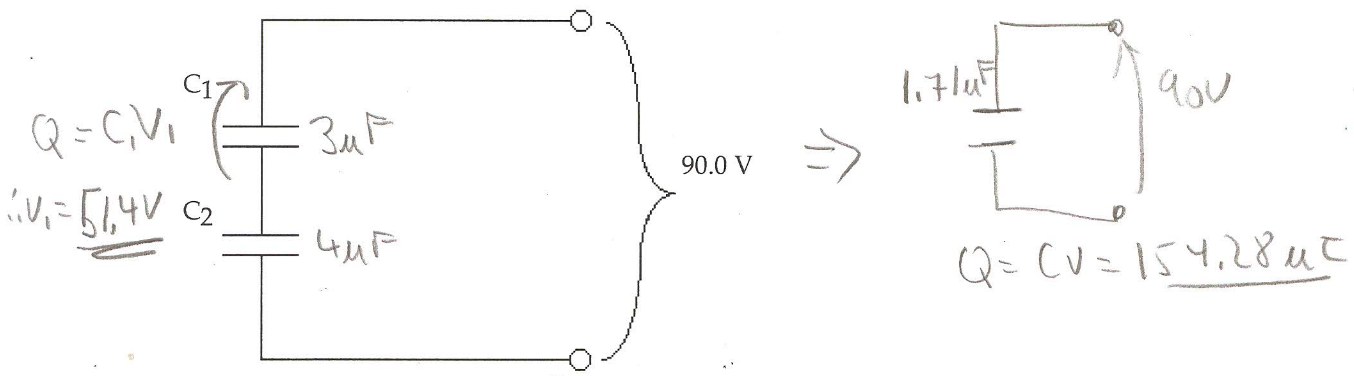
A) 2.0 V/m
B) -8.1 V/m
C) 8.6 V/m
D) 4.3 V/m
E) 74 V/m

$$\vec{E} = -\nabla V = -[6y^2x - 2z^3]\hat{i} - [6x^2y + z^3]\hat{j} - [3yz^2 - 6xz^2]\hat{k}$$

$$\vec{E}(1,1,1) = -4\hat{i} - 7\hat{j} + 3\hat{k}$$

$$|\vec{E}(1,1,1)| = \sqrt{16+49+9} = 8.6\ V/m$$

15) Two capacitors, one a 3.0 μF capacitor, C_1, and the other a 4.0 μF capacitor, C_2, are connected in series. If a 90.0 V voltage source is applied to the capacitors, as shown, find the voltage across the 3.0 μF capacitor.



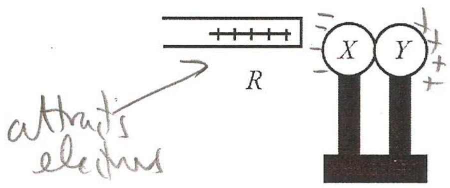
A) 68 V B) 51 V ✓ C) 39 V D) 9.0 V

16) If the potential in a region is given by $V(x,y,z) = xy - 3z^{-2}$, then the y component of the electric field in that region is

A) $x + y - 6z^{-3}$. B) $-y$. C) $x + y$. D) $-x$. ✓

$E_y = -\frac{\partial}{\partial y} V = -x$

17) X and Y are two uncharged metal spheres on insulating stands, and are in contact with each other. A positively charged rod R is brought close to X as shown in Figure (a).



"induced polarization"

Figure (a)

Sphere Y is now moved away from X, as in Figure (b).

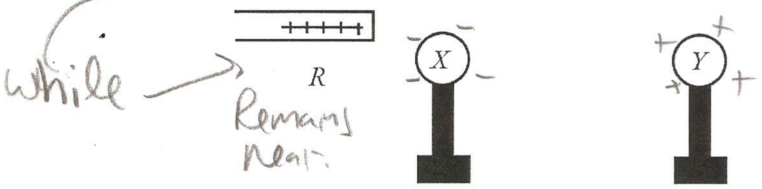


Figure (b)

What are the final charge states of X and Y?

A) X is negative and Y is positive.

B) X is positive and Y is neutral.

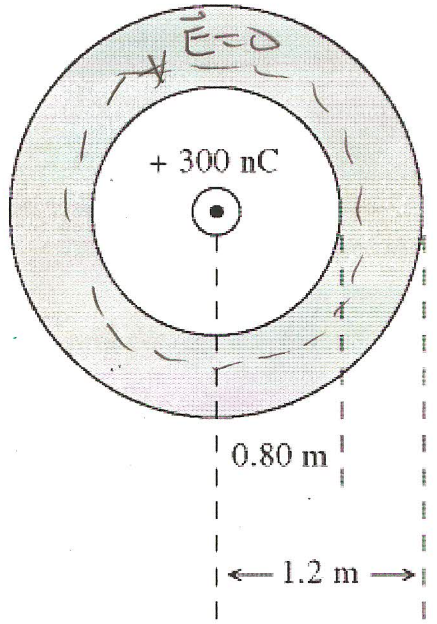
C) X is neutral and Y is positive.

D) Both X and Y are negative.

E) Both X and Y are neutral.

Very much like the foils that I brought to class to introduce electric charge.

18) A hollow conducting spherical shell has radii of 0.80 m and 1.20 m, as shown in the figure. The sphere carries an excess charge of –500 nC. A point charge of +300 nC is present at the center. The surface charge density on the inner spherical surface is closest to ____________.(surface area of sphere = 4*PI*r2)



Gauss ⇒ $q_{\text{inner surface}} = -300\,nC$

$\sigma_{\text{inner surface}} = \dfrac{-300 \times 10^{-9}}{4\pi (0.8)^2}$

$= -3.7 \times 10^{-8}\ C/m^2$

A) zero.

B) +4.0 × 10^{-8} C/m2.

C) -6.0 × 10^{-8} C/ m2.

D) +6.0 × 10^{-8} C/ m2.

E) -4.0 × 10^{-8} C/ m2.

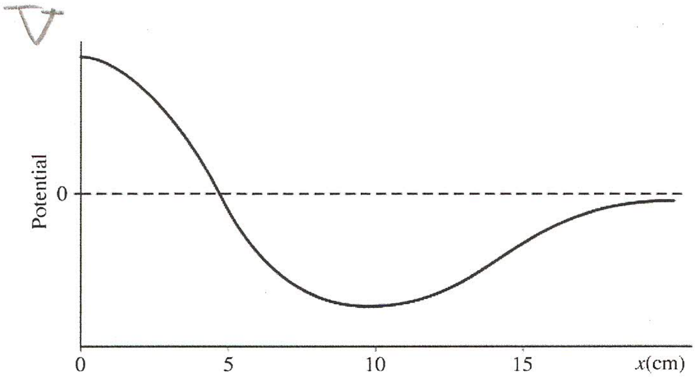
OVER →

19) The potential as a function of position x is shown in the graph in the figure. Which statement about the electric field is true?

In 1-4

$E = -\frac{d}{dx}(V)$

$\frac{dV}{dx}$ is slope of tangent line



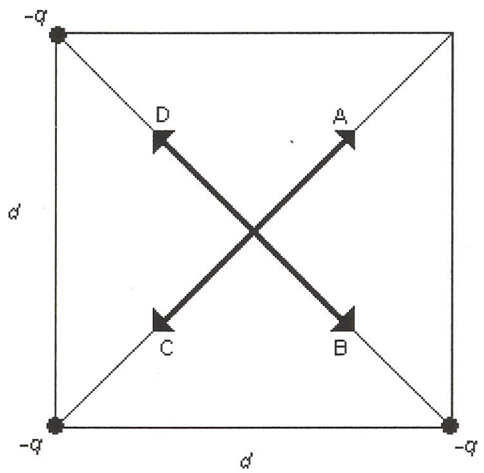
A) The electric field is zero at $x = 5$ cm, its magnitude is at a maximum at $x = 0$, and the field is directed to the right there.

B) The electric field is zero at $x = 0$, its magnitude is at a maximum at $x = 5$ cm, and the field is directed to the right there.

C) The electric field is zero at $x = 0$, its magnitude is at a maximum at $x = 15$ cm, and the field is directed to the left there.

D) The electric field is zero at $x = 10$ cm, its magnitude is at a maximum at $x = 5$ cm, and the field is directed to the left there.

20) Three equal negative point charges are placed at three of the corners of a square of side d as shown in the figure. Which of the arrows represents the direction of the net electric field at the center of the square?



A) A

B) B

C) C

D) D

E) The field is equal to zero at point P.

$\vec{E}$ is radially into negative charges

OVER

21) A negative charge, if free, will tend to move ________________.

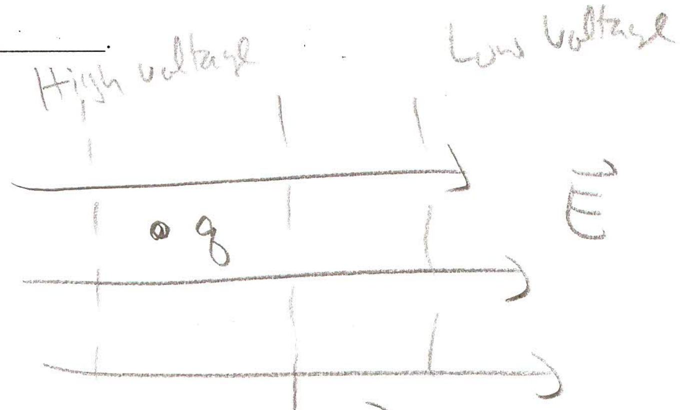
A) away from infinity.

B) toward infinity.

C) from high voltage to low voltage.

D) in the direction of the electric field.

E) from low voltage to high voltage.



Nature moves charges "downhill", but that is different for + and - charges. SEE NOTES!

$$\vec{F}_E = q\vec{E}$$

Negative sign puts $\vec{F}$ in opposite direction of $\vec{E}$