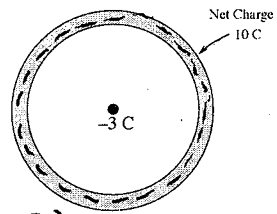
1. In Fig. 5, a net charge of +10 C is placed on the spherical conducting shell. A −3 C point charge is placed at the center of the cavity. The charge on the inner surface of the shell is:



a) −7 C
b) −3 C
c) 0
d) +3 C
e) +7 C

Charge enclosed inside dotted surface = 0 (by Gauss law because $E=0$ everywhere on surface so $\Phi = 0$)
To balance −3C point charge, need +3C on inner surface

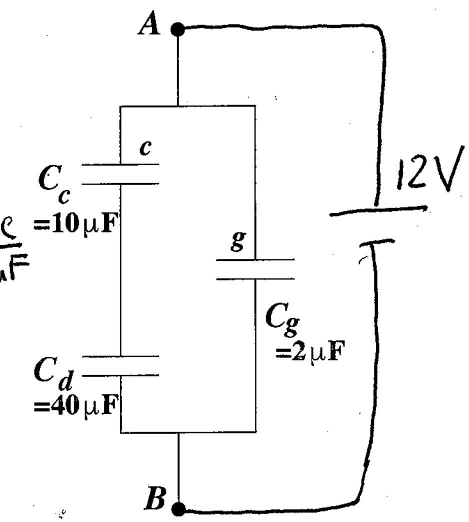
2. An infinitely large horizontal plane carries a uniform charge density of $+10.0\mu C/m^2$. What is the vertical component of the electric field a distance of 20.0 cm above the plane?

a) $(+5.65 \times 10^5)$ N/C
b) $(+1.13 \times 10^6)$ N/C
c) (-1.13×10^6) N/C
d) (-5.65×10^5) N/C
e) (-2.81×10^6) N/C

Electric field due to uniform charge density σ on a plane is $\frac{\sigma}{2\epsilon_0}$ away from the plane.

$$E = \frac{10.0 \times 10^{-6}}{2 \times 8.85 \times 10^{-12}} \frac{N}{C} = +5.65 \times 10^5 \frac{N}{C}$$

3. Three capacitors are connected by conducting wires as shown. Suppose A is connected to the positive terminal of a 12 V battery and B is connected to the negative terminal of that battery. What are the charges present at the plates c and g of the two capacitors, as shown

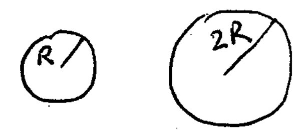


Voltage across g is 12V
$Q_g = C_g \cdot 12V = +24\mu C$
Q_c is positive so get (a) by elimination
check − $V_c + V_d = \frac{96\mu C}{10\mu F} + \frac{96\mu C}{40\mu F} = 12V$ ✓

a) $Q_c = +96\,\mu C$, $Q_g = +24\,\mu C$
b) $Q_c = +120\,\mu C$, $Q_g = +24\,\mu C$
c) $Q_c = +120\,\mu C$, $Q_g = -24\,\mu C$
d) $Q_c = -24\,\mu C$, $Q_g = +24\,\mu C$
e) $Q_c = 0$, $Q_g = -24\,\mu C$

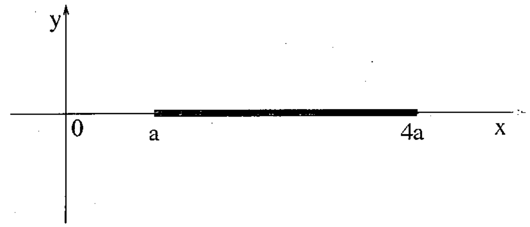
4. A charge Q is distributed uniformly on the surface of a conducting sphere. If the radius of the sphere is increased by a factor of 2, the magnitude of the electric field at the surface is:

a) Increased by a factor of 4.
b) Increased by a factor of 2.
c) Unchanged.
d) Decreased by a factor of 2.
e) Decreased by a factor of 4.



$E_1 = \frac{kQ}{R^2}$ $E_2 = \frac{kQ}{(2R)^2} = \frac{E_1}{4}$

5. A line charge with linear charge density λ extends along the x-axis from $x = a$ to $x = 4a$ as shown in the figure. What is the potential at the origin?



a) $k\lambda\, ln(4)$
b) $\frac{3}{4}\frac{k\lambda}{a}$
c) $3k\lambda a$
d) $-k\lambda\, ln(4)$
e) $-\frac{3}{4}\frac{k\lambda}{a}$

$$\phi(x=0) = \int_{x=a}^{x=4a} \frac{k\lambda dx}{x} = k\lambda \ln\left(\frac{4a}{a}\right) = k\lambda \ln 4$$

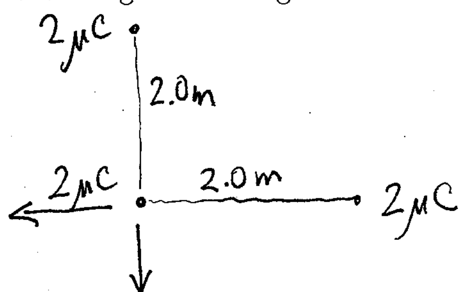
6. The potential in a certain region between x=0 and x=5.0 m is $V = ax + bx^2$ where $a=$ 10V/m and $b =$ 4.0V/m^2. What are the magnitude and direction of the electric field at x = 2.0 m?

a) 18 V/m, **i**
b) 26 V/m, -**i**
c) 18 V/m, -**i**
d) 36 V/m, **i**
e) none of the other answers is correct

$$E(x) = -\frac{dV}{dx} = -(a + 2bx)$$
$$E(x=2.0m) = -\left(10\frac{V}{m} + 2\cdot\frac{4.0V}{m^2}\cdot 2m\right)$$

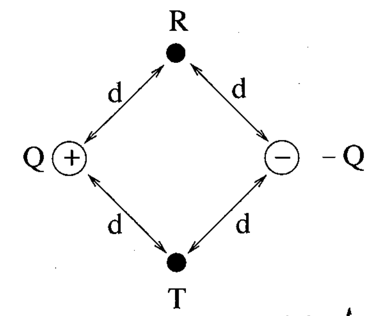
7. A 2.0 μC charge is placed at the origin, an identical charge is placed 2.0 m from the origin on the x axis, and a third identical charge is placed 2.0 m from the origin on the y axis. The magnitude of the force on the charge at the origin is:

a) 9.0 x 10^{-3} N
b) 6.4 x 10^{-3} N
c) 1.3 x 10^{-2} N
d) 1.8 x 10^{-2} N
e) 3.6 x 10^{-2} N



Vector sum : $k \cdot 10^{-12} \cdot \left(\frac{2\cdot 2}{2^2}\right) \cdot \sqrt{2} = 9\times10^{-3} \cdot \sqrt{2}$ N

8. Points R and T are each a distance d from each of two equal and opposite charges as shown. The work required to move a negative charge q from R to T is:



a) 0
b) kqQ/d^2
c) kqQ/d
d) $kqQ/(\sqrt{2}d)$
e) $kQq/(2d)$

the potential at R is $\frac{kQ}{d} + \frac{k(-Q)}{d} = 0$
the potential at T is the same

so work done = change × potential diff = 0

9. A uniform charge density of 0.500 μC/m^3 is distributed throughout a spherical volume (radius = 16.0 cm). Consider a cubical (4.00 cm along the edge) surface completely inside the sphere. Determine the electric flux through this surface.

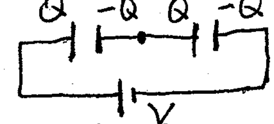
a) 0.281 N·m^2/C
b) 3.62 N·m^2/C
c) 90.4 N·m^2/C
d) 2.81 × 10^6N · m^2/C
e) depends on where within the sphere the cube is located.

charge inside cubical surface = $0.500\frac{\mu C}{m^2}\cdot(4\times10^{-2})^3$

$\Phi = \frac{\text{charge enc}}{\epsilon_0} = 3.62\ Nm^2/C$

10. Which of the following statements is **false**?

a) If the electric field is zero in a region of space the electric potential is also zero in that region. No - the electric potential is constant
b) The electric field points in the direction of decreasing electric potential.
c) Electric field lines cannot cross at a point in space. tangent to line is direction of field
d) The electric field within a conductor in electrostatic equilibrium is zero.
e) Excess charge on an isolated conductor is, in electrostatic equilibrium, entirely on its surface.



sum of potential diff across the capacitors $= V$

11. A parallel-plate vacuum capacitor has 10.0 J of energy stored in it. The separation between the plates is 2.0 mm. After the plates are disconnected from the potential source, the plate separation is decreased to 1.0 mm. What is the energy now stored in the capacitor?

$U = \frac{1}{2}\frac{Q^2}{C}$ $\quad 10.0\,\text{J} = \frac{1}{2}\frac{Q^2}{\epsilon_0 A} \cdot d$

a) 5.0J
b) 20J
c) 10J
d) 40J
e) 2.5J

Q and A don't change
d decreases by a factor of 2
So energy decreases by factor of 2
to 5.0 J

12. A parallel plate capacitor filled with dielectric ($\kappa = 2.0$) has spacing between the plates of 0.50 cm and capacitance 3.0 nF. The area of the plates is

a) 0.85 m^2
b) 1.7 m^2
c) 3.4 m^2
d) 1.2 m^2
e) 0.30 m^2

$$C = \frac{K\epsilon_0 A}{d} \Rightarrow A = \frac{dC}{K\epsilon_0}$$
$$= \frac{5\times10^{-3}\,m \cdot 3\times10^{-9}\,F}{2 \cdot 8.85\times10^{-12}\,C^2/(Nm^2)}$$

13. Three charges $Q_1 = 10\ \mu C$, $Q_2 = -2.5\ \mu C$ and $Q_3 = 10\ \mu C$ are initially at rest infinitely far apart. How much work is required to put the three charges together at rest along a line with Q_1 at x = -0.50 m, Q_2 at x = 0.0m, and Q_3 at x = 0.50 m?

a) 0.0 J
b) -0.90 J
c) -1.8 J
d) 0.90 J
e) 1.8 J

10μC -2.5μC 10μC
0.5m 0.5m

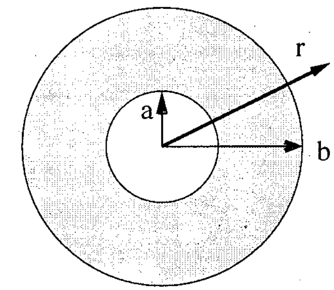
$$U = k\times10^{-12}\left(\frac{10\cdot(-2.5)}{(0.5)} + \frac{10(-2.5)}{(0.5)} + \frac{10\cdot10}{1}\right)$$

not squared!

14. A battery is used to charge a series combination of two identical capacitors. If the potential difference across the battery terminals is V and total charge Q flows through the battery during the charging process then:

a) the charge on each capacitor is $Q/2$ and the potential difference across each capacitor is $V/2$
b) the charge on each capacitor is Q and the potential difference across each capacitor is V
c) the charge on each capacitor is $Q/2$ and the potential difference across each capacitor is V
d) the charge on each capacitor is Q and the potential difference across each capacitor is $V/2$
e) the charge on each capacitor is Q and the potential difference across each capacitor is $2V$

15. A hollow cylinder of an insulating material has a uniform charge density ρ, inner radius a, and outer radius b, as shown. What is the magnitude of the electric field outside the cylinder, at a radius $r > b$?



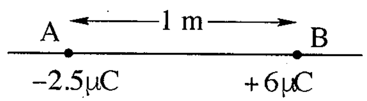
a) $E = \rho(b^2 - a^2)/2\epsilon_0 r$
b) $E = \rho b^2/2\epsilon_0 r$
c) $E = \rho b^2/2\epsilon_0 r^2$
d) $E = \rho a^2/2\epsilon_0 r$
e) $E = 0$

Same as if all charge inside recollapsed to a line on the axis.

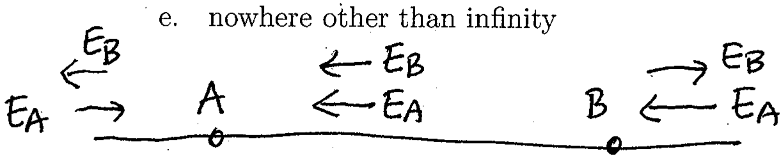
$$\lambda = \frac{(\pi b^2 - \pi a^2)\cancel{L}\rho}{\cancel{L}} \quad \left(\frac{\text{charge in piece of length } L}{\text{length } L}\right)$$

$$\text{E of a wire} = \frac{\lambda}{2\pi\epsilon_0 r} = \frac{\cancel{\pi}(b^2-a^2)\rho}{2\cancel{\pi}\epsilon_0 r}$$

16. Two point charges are separated by 1 m as shown in the figure. The point where the total electric field is zero (other than infinity) is



a. on the line AB, to the right of B
b. on the line AB, between A and B
c. on the line AB, to the left of A
d. above AB
e. nowhere other than infinity



by signs, either to left of A or to right of B.

since $|Q_A| < |Q_B|$, need to be closer to A.

$\Rightarrow$ to left of A

REFERENCE PAGE:
Useful Information

c = speed of light = 3.00×10^8 m/s
$q_e = -e$ = charge on an electron = -1.602×10^{-19} Coulombs
$q_p = +e$ = charge on a proton = $+1.602 \times 10^{-19}$ Coulombs
m_e = electron mass = 9.11×10^{-31} kg
m_p = proton mass = 1.67×10^{-27} kg
$k = 9 \times 10^9$ N m^2/C^2
$\epsilon_0 = 8.85 \times 10^{-12}$ C^2/(Nm^2)
$g = 9.80$ m/s^2
1 $eV = 1.602 \times 10^{-19}$ J
1 mC = 10^{-3} C   1 μC = 10^{-6} C
1 nC = 10^{-9} C   1 pC = 10^{-12} C