Practice Exam 1

Physics 152

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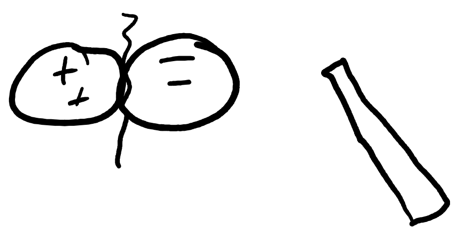
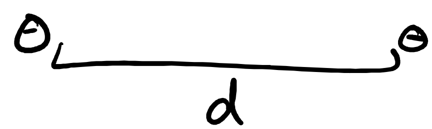
Can conductors and insulators each be charged?

- A) Conductors yes, insulators no
- B) Conductors no, insulators yes
- C) Conductors yes, insulators yes
- D) Conductors no, insulators no



Two electrons are placed a certain distance d apart. Each of the electrons experiences a force of 3E-6 Newtons. How far apart should the electrons be placed?



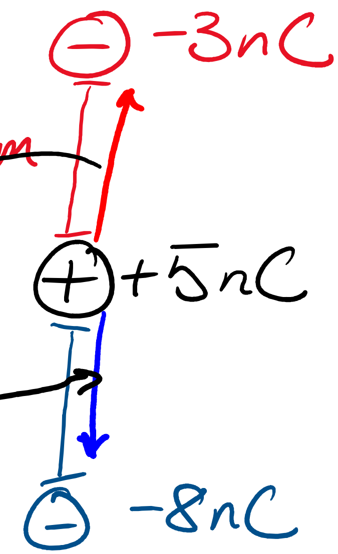
$$3E-6 = \frac{k\,(1.6E-19)^2}{r^2}$$

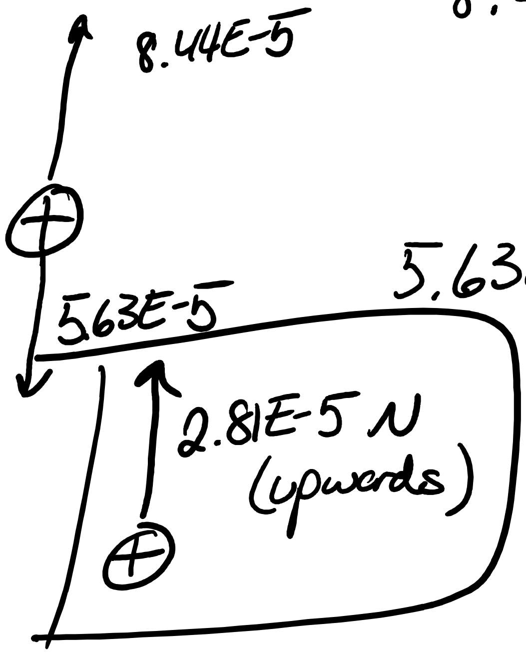
$$r = \sqrt{\frac{k\cdot(1.6E-19)^2}{3E-6}} = \boxed{8.76E-12\ m}$$

Find the net force on the middle charge (magnitude and direction).

$$8.44E\text{-}5\,N = \frac{k(3E\text{-}9)(5E\text{-}9)}{(.04)^2}$$

$$5.63E\text{-}5\,N = \frac{k\cdot(5E\text{-}9)(8E\text{-}9)}{(.08)^2}$$

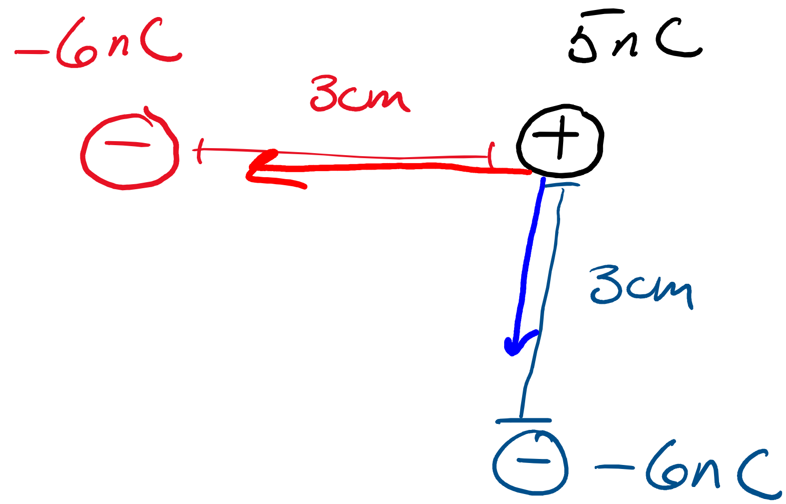


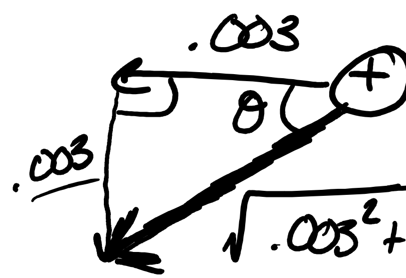


Find the direction and magnitude of the force on the black charge.

$$\frac{k\cdot(5E-9)(6E-9)}{.03^2} = .003N$$

$$\frac{k\cdot(6E-9)(5E-9)}{.03^2} = .003N$$



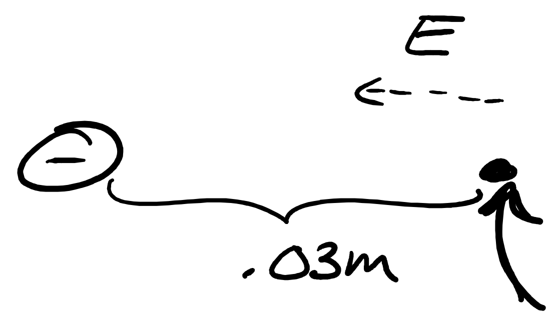


$$\sqrt{.003^2+.003^2} = \boxed{.0042N}$$

$$\theta = \tan^{-1}\left(\frac{.003}{.003}\right) = \tan^{-1}(1) = \boxed{45^\circ}$$ (below -x axis)

Calculate the direction and size of the electric field 3cm from an electron.

$$E = \frac{k q_{source}}{r^2}$$

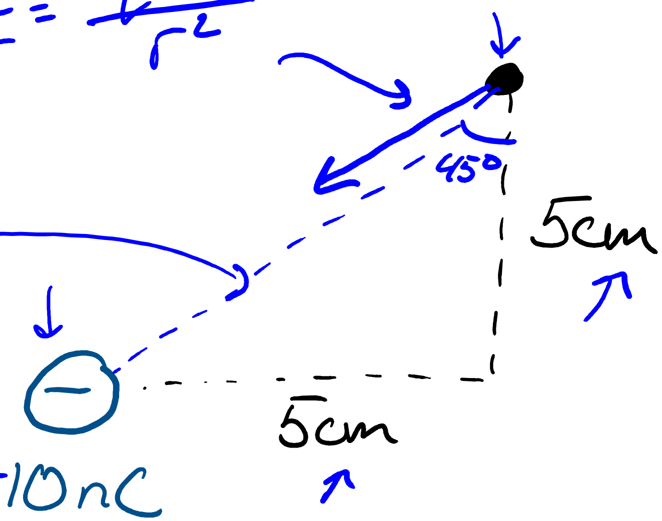


$$= \frac{k \cdot (1.6E{-}9)}{(.03)^2} = \boxed{16000\ N/c}$$

Direcxn: Towards e^-

What are the x and y components of the Electric field at the black dot?

$$E = \frac{kq_{source}}{r^2}$$



$$\sqrt{.05^2 + .05^2} = .071$$

$$\frac{k\cdot(10E-9)}{(.071)^2} = 17854 \ N/C$$

$$17854 \cos 45 = \boxed{12625 \ N/C}$$

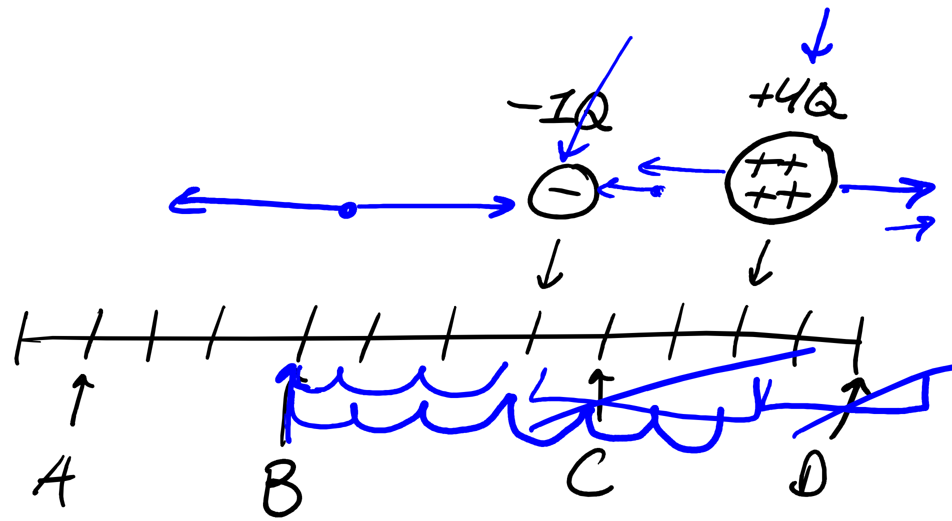
$$17854 \sin 45 = \boxed{12\,625 \ N/C}$$

$$\boxed{x: 12625 \ N/C, \ y: 12625 \ N/C}$$

At which point of the diagram below will the electric field be zero?

- A) A
- B) B
- ~~C) C~~
- ~~D) D~~

$$E \sim \frac{kq_{source}}{r^2}$$

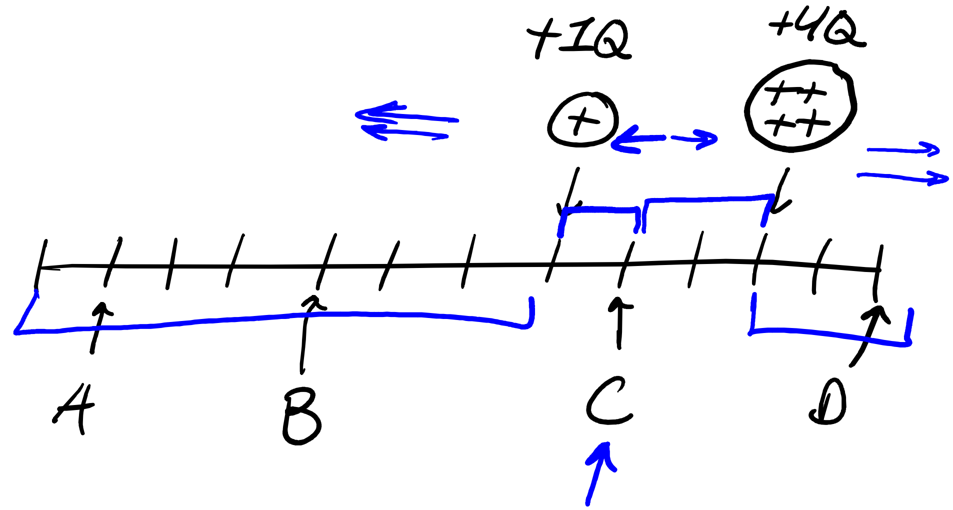


$$\frac{\cancel{4}Q}{(\cancel{2}\cdot 3)^2}$$

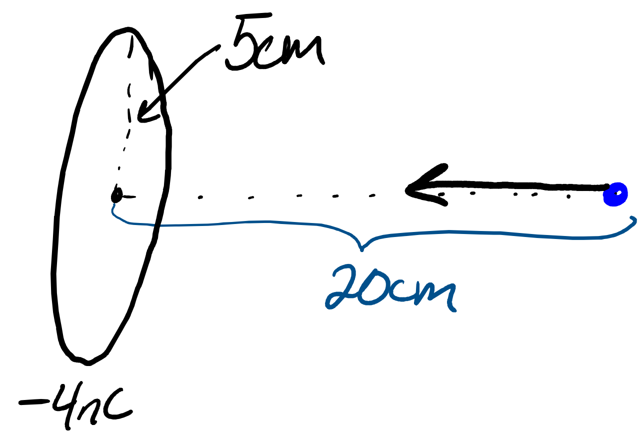
At which point of the diagram below will the electric field be zero?

- A) A
- B) B
- C) C
- D) D

$$E = \frac{k q_{source}}{r^2}$$



A thin ring (NOT a disk) of radius 5cm and total charge -4nC is shown at right. Find the E field size and direction at a point 20cm away from the ring.



4E-9

z = .2m

$$E = \frac{kQz}{(a^2+z^2)^{3/2}} = \boxed{821.8\ \text{N/C towards ring}}$$

.05

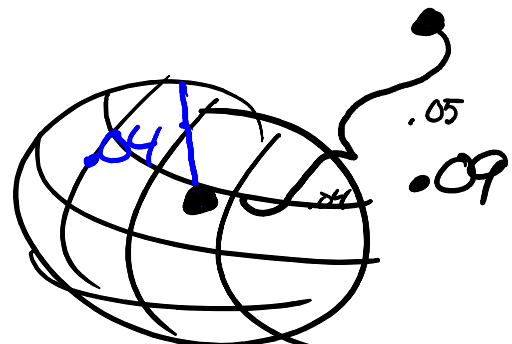
Find the E field 5cm from the SURFACE of a charged spherical shell of radius 4cm, and with surface charge density 4nC/m^2. You will need the formula for surface area of a spherical surface of radius r, which is $A = 4\pi r^2$.

$$E = \frac{k\cdot Q}{r^2} \qquad \frac{k\cdot\sigma\cdot 4\pi r_o^2}{r^2}$$

r_o of the shell

r from observation point to the center

$$= \frac{k\cdot\sigma\cdot 4\pi\cdot(.04)^2}{(.09)^2} = \boxed{89.36\ N/C}$$

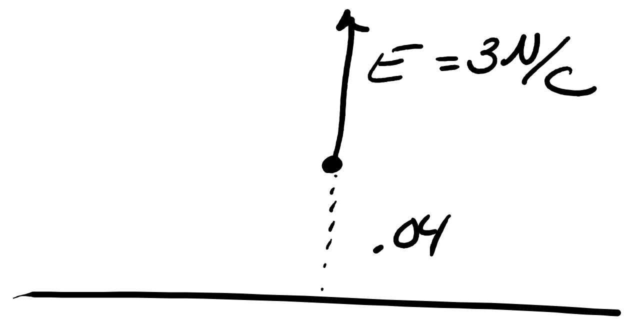


$\sigma = 4E{-}9\ C/m^2$

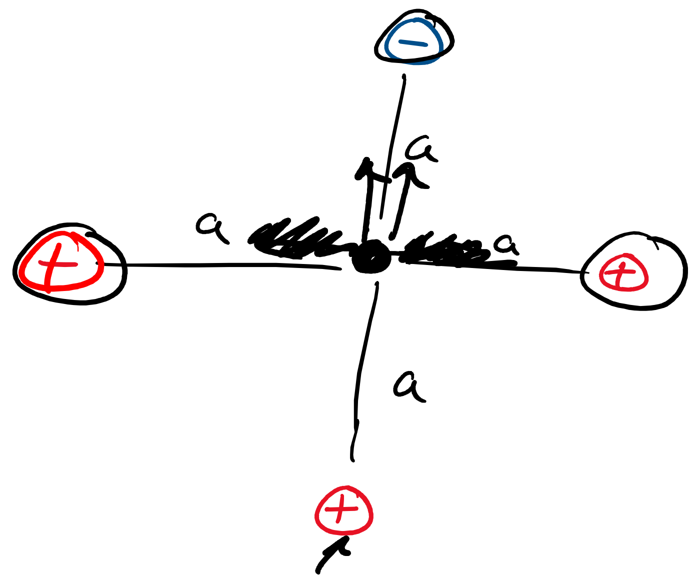
The E field 4cm away from an infinite wire of charge is 3N/C. What is the charge density of the wire?

$$3 = \frac{\lambda}{2\pi \varepsilon_0 (.04)}$$

$$\boxed{\lambda = 6.67E{-}12 \ \frac{C}{m}}$$



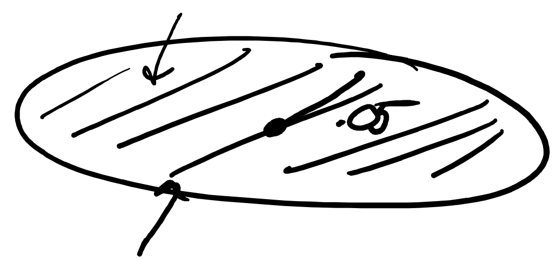
Find the direction of the electric field at the black dot.



- A) Up
- B) Down
- C) Zero
- D) Diagonally up and to the right

4C of charge are spread out across a circular disk of radius 5cm. What is the surface charge density?

$$\sigma = \frac{Q}{\text{Area}} = \frac{4}{\left(\pi \cdot (.05)^2\right)} = \boxed{509 \ C/m^2}$$



The charge density on a wire is $\lambda = 8x^2$. If the wire spans from x=1 to x=3, what is the total charge on the wire?

~~"$Q = \lambda \cdot L$"~~

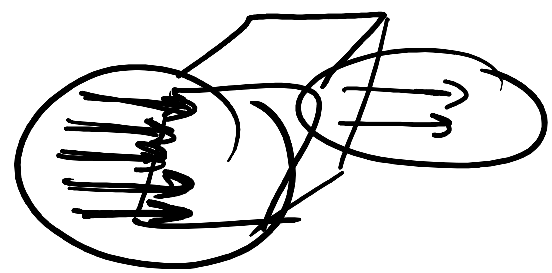
$$Q = \int_1^3 8x^2\,dx$$

$$= \frac{8}{3}\left(x^3\Big|_1^3\right)$$

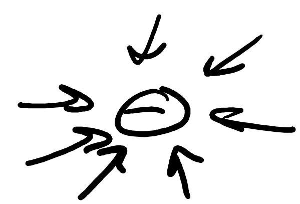
$$= \frac{8}{3}(27-1) = \frac{8}{3}\cdot 26 = \boxed{69.3\,C}$$

5 Nm^2/C of flux is going into one side of a box, and 2 Nm^2/C is going out of the other side of the box. There are no other fluxes going into/out of the box. What is the charge enclosed in the box?

$$\phi = \frac{Q_{enc}}{\varepsilon_0}$$

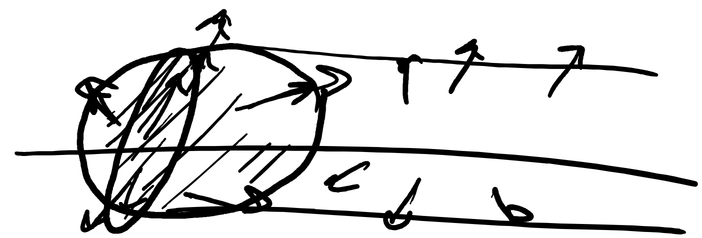


$$-3 = \frac{Q_{enc}}{\varepsilon_0}$$



$$\boxed{Q_{enc} = -3\varepsilon_0}$$

In order to derive the electric field near a long charged wire, we drew a Gaussian surface. What shape was the shape of the Gaussian surface?



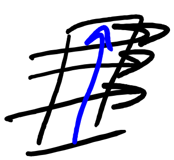
- A) Spherical shell
- B) Cylindrical shell
- C) Box
- D) Gauss' Law cannot be used to derive the formula

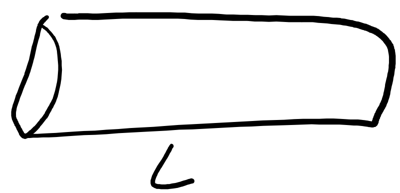
What is the value of the electric flux through the circular “caps” of the cylindrical Gaussian surface surrounding a charged wire, and why?

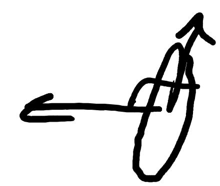
- A) $\pi r^2 E$, since flux is always E*A
- B) 0, since the E field was at an angle of 90 degrees to the surface normal
- C) 0, since the E field on the caps is magnitude zero
- D) 0, since our cylinder was so long that we ignored the caps

$EA\cos\theta \to 0$

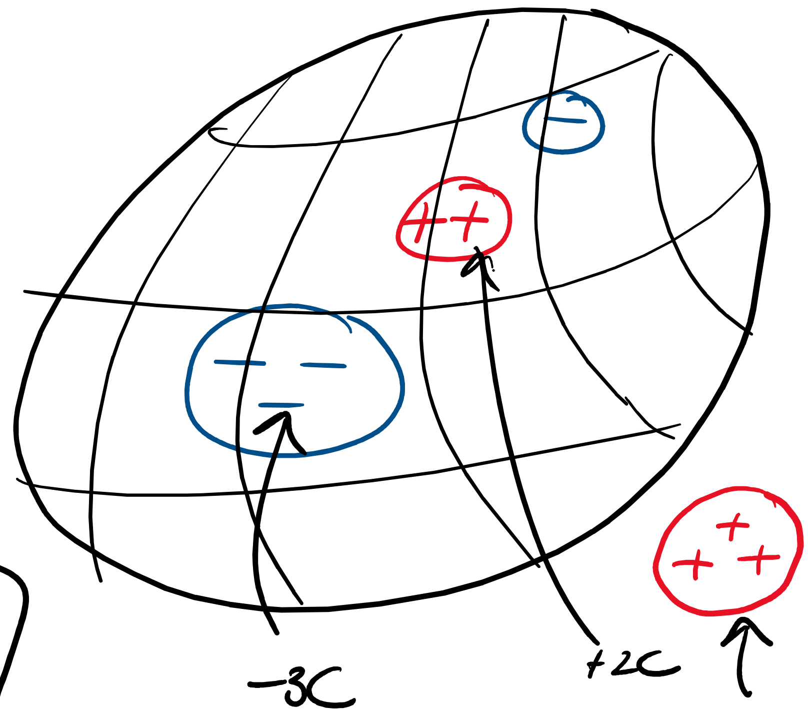
$\measuredangle$ b/t E and surface $\perp$





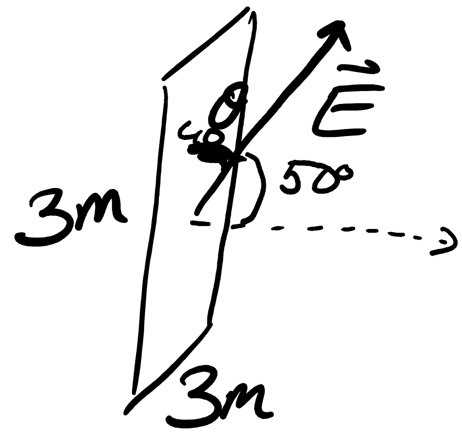


Find the electric flux leaving the black surface drawn at right. (The surface is like a spherical shell, and it wraps around the three charges inside it in the picture, but not around the one outside.)



$$\phi = \frac{Q_{enc}}{\varepsilon_0} = \boxed{\frac{-2}{\varepsilon_0}}$$

Find the magnitude of the electric flux through the square surface shown at the right.



$E = 8\ N/C$

$\theta = 40°$

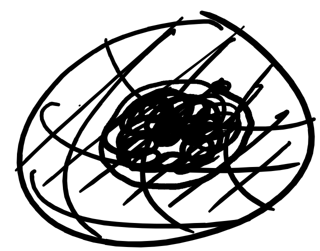
$\phi = E \cdot A \cdot \cos\theta$

$\angle$ btwn E and $\perp$

$= 8 \cdot 9 \cdot \cos(50) = \boxed{46.3\ \frac{Nm^2}{C}}$

Find the E field 3cm away from the center of a solid charged ball of radius 8cm, given that its volume charge density is $\rho = 3nC$ per meter cubed.

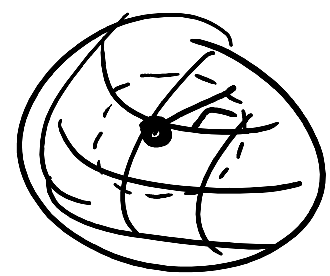
$$E = \frac{kQ_{enc}}{r^2}$$ at or below inspection radius



$$= \frac{k \cdot \rho \cdot V_{enc}}{r^2} = \frac{k(3E\text{-}9)\,\frac{4}{3}\pi(.03)^3}{(.03)^2} = \boxed{34\,N/C}$$

Extra credit: A spherical ball has NON-UNIFORM charge density $\rho(r) = \rho_0 r^2$. Find the expression for the charge enclosed at or below a radius “r”, valid for radii within the ball. You will need to use $dV_{sphere} = 4\pi r^2 dr$

$$Q_{enc} = \int \rho\, dV$$



$$Q_{enc} = \underbrace{\int_0^{r} \rho_0 r'^2 4\pi r'^2 dr'}$$

$$= 4\pi\rho_0 \int_0^{r} r'^4 dr' = 4\pi\rho_0 \left(\frac{r'^5}{5} \Bigg|_0^{r} \right) = \boxed{\frac{4\pi\rho_0 r^5}{5}}$$

a) Find the expression for the electric field outside the shown charge distribution that is valid for 0<r<a.

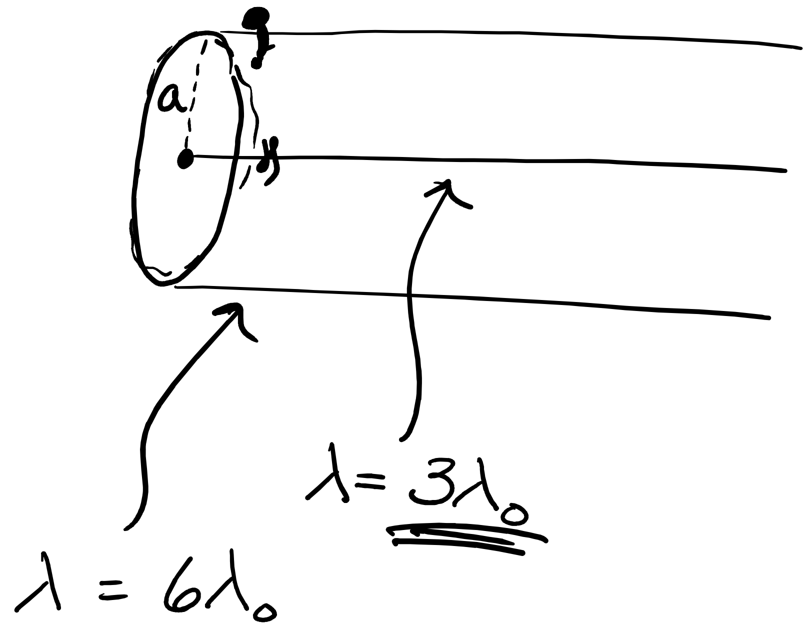
b) B) Next, find the expression valid for r>a. λ_0 is a constant.

(Note: The outer shell is hollow, not a solid cylinder.)

like $E = \frac{kQ_{enc}}{r^2}$

$$E = \frac{\lambda_{\text{enclosed}}}{2\pi\varepsilon_0 r}$$

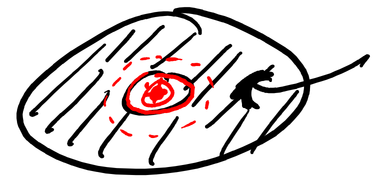
below radii of inspection



$$\boxed{\begin{aligned} E &= \frac{3\lambda_0}{2\pi\varepsilon_0 r} \quad r<a \\ E &= \frac{9\lambda_0}{2\pi\varepsilon_0 r} \quad r>a \end{aligned}}$$

The surface charge density on a region of conducting surface is 3C/m^2. Find the E field ~~1cm~~ outside the surface of the conductor. (Assume that 1cm is small enough that the conductor still appears flat, so our equation from class for E field near conductors is still valid.)

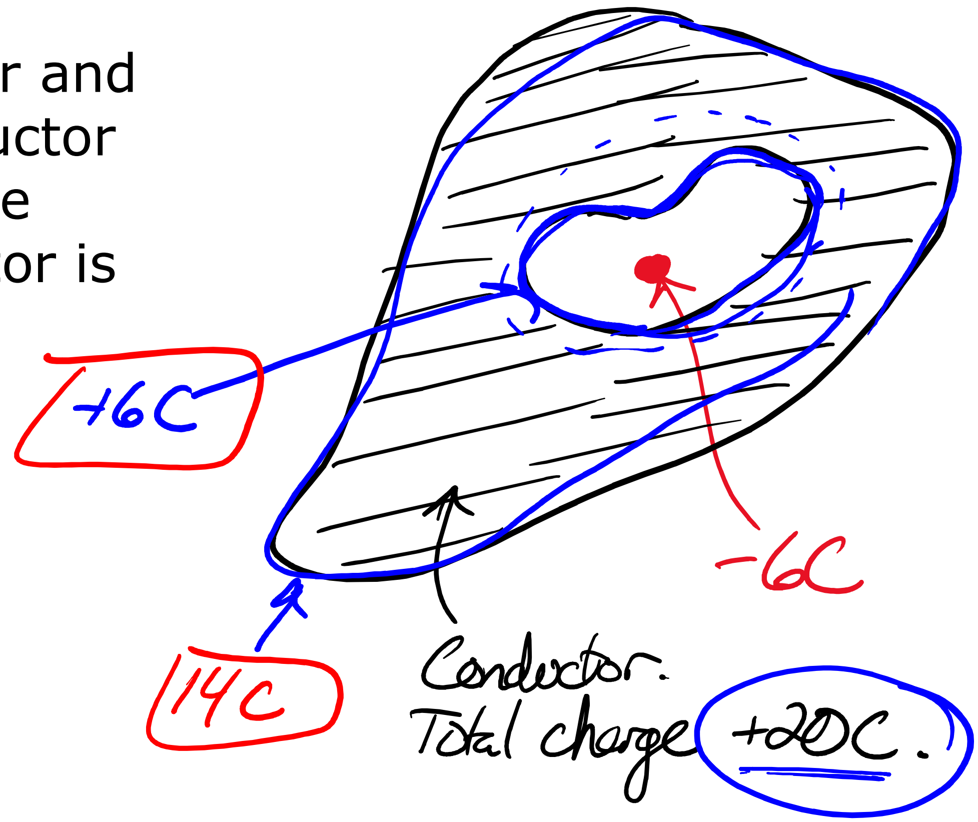
$$E_{conductor} = \frac{\sigma}{\varepsilon_0} = \boxed{\frac{3}{\varepsilon_0}}$$



What is true about the electric field inside each region of a cavity conductor (a conductor, with an air hole in the middle)?

- A) The E field inside both the conductor material itself and the air pocket must be zero.
- B) The E field inside both the conductor material itself and the air pocket must be nonzero.
- C) The E field inside the conductor material may be nonzero, but the E field inside the air pocket must be zero.
- D) The E field inside of the conductor material itself must be zero, but inside the air pocket it can be nonzero.

What are the charges on the inner and outer surfaces of the cavity conductor shown in the figure, given that the overall net charge on the conductor is +20C?



Find the E field strength within a parallel plate capacitor, given that each plate is 2 meters by 2 meters, and the total charge on each plate is plus minus .01 coulombs.

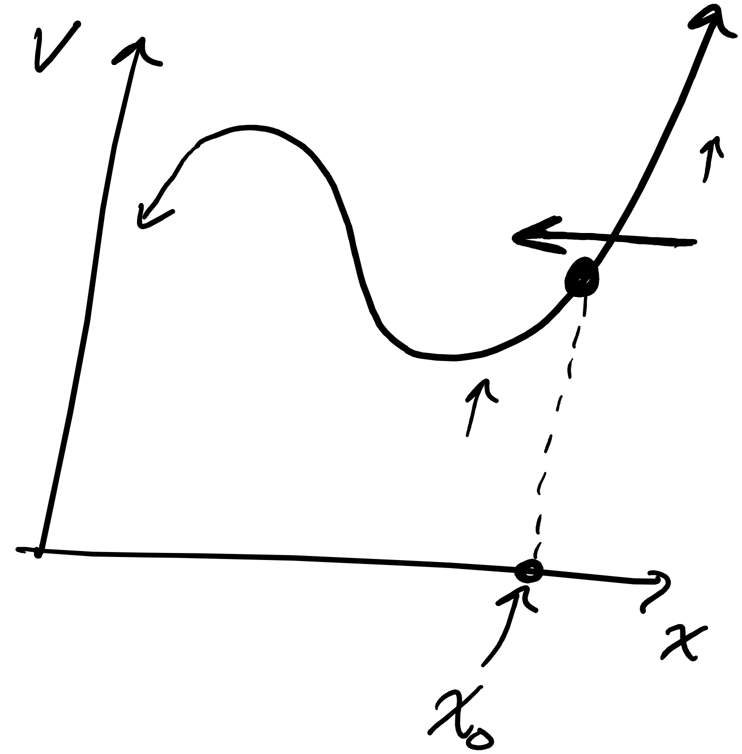
$$\frac{.01}{4}$$

$$E = \frac{\sigma}{\varepsilon_0} = \boxed{\frac{.0025}{\varepsilon_0} \ \frac{N}{C}}$$

A voltage graph is shown. What is the direction of the E field at the indicated x value?

- A) Left
- B) Right
- C) Zero
- D) Not enough information

$$E = -\frac{dV}{dx}$$



Find the voltage 2cm away from a Helium nucleus (charge +2e).

$$V = \frac{k\, q_{source}}{r_{\text{source to obs. point}}} = \frac{k \cdot 2 \cdot 1.6E\text{-}19}{.02} = \boxed{1.44E\text{-}7 \text{ Volts}}$$

An electron-volt (eV) is a unit of

- A) Charge
- B) Voltage
- C) Energy
- D) Momentum

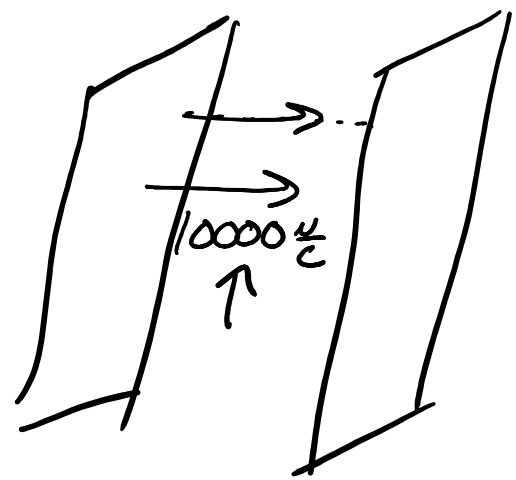
1.6E-19 Joules

Find the voltage drop between the plates of a parallel plate capacitor, given a spacing of 2mm and an electric field strength of 10 kN/C.

$$\Delta V = E \cdot \Delta d$$

$$= 10000 \cdot 2E{-}3$$

$$= \boxed{20V}$$



A proton starts at rest at a voltage of 0V. It moves to an area of voltage -10V. What is its final speed?

$$= KE_f + U_f$$

$$U_f = q \cdot V_f$$

$$KE_f = |\Delta U|$$

$$0 = \frac{1}{2}(1.67E{-27})v_f^2 \quad (1.6E{-19})(-10)$$

$$1.6E{-19} \cdot 10 = \frac{1.67E{-27}}{2} v_f^2$$

$$1.6E{-18} = 8.35E{-28}\, v_f^2$$

$$1.9E9 = v_f^2$$

$$\boxed{v_f = 43774 \text{ m/s}}$$

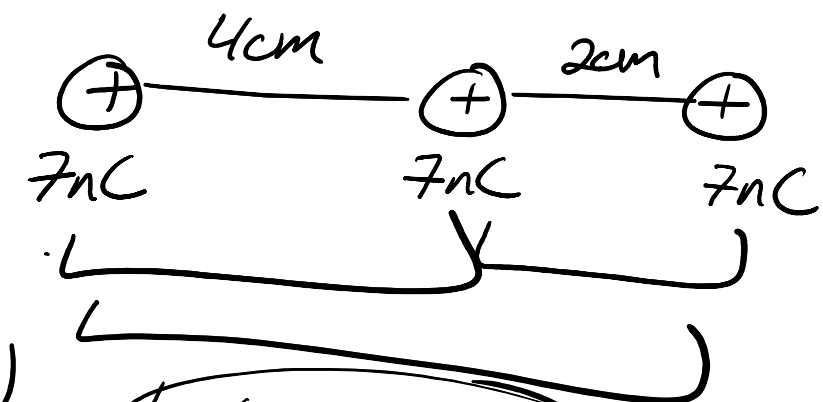
Find the potential energy of the red charge, due to the E field created by the black charge.

$$U = q_{exp\,(red)} \cdot V_{source\,(black)} = \frac{kqq}{r}$$

we do use −

$$= \frac{k \cdot (3E{-}9)(-6E{-}9)}{.04} = \boxed{-4E{-}6\ \text{J}}$$

Find the energy required to assemble the shown charge distribution.



$$W_{assembly} = \sum_{pairs} \frac{k q_i q_j}{r}$$

$$\frac{k\cdot(7E\text{-}9)(7E\text{-}9)}{.04} + \frac{k\cdot(7E\text{-}9)(7E\text{-}9)}{.02} + \frac{k\cdot(7E\text{-}9)(7E\text{-}9)}{.06}$$

$$k\cdot(7E\text{-}9)^2\left(\frac{1}{.04}+\frac{1}{.02}+\frac{1}{.06}\right) = 4E\text{-}5 \text{ Joules}$$

A moving electron is brought to rest using an electric field. Did it move into a region of higher voltage or lower voltage?

Protons like low voltage,
so e^- hate low voltage

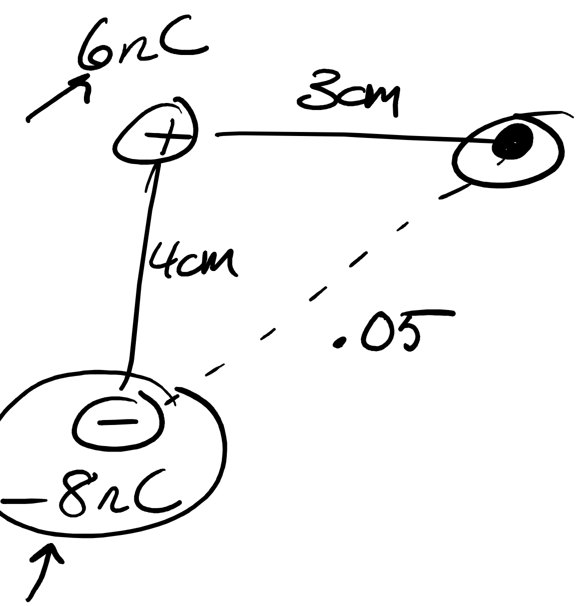
- A) Higher
- B) Lower
- C) No change
- D) Impossible to determine

Find the voltage at the black dot

$$V = \frac{k \cdot 6E\text{-}9}{.03} + \frac{k \cdot (-8E\text{-}9)}{.05}$$

$$= \boxed{-1440 \text{ Volts}}$$

$$V_{point} = \frac{kq}{r}$$



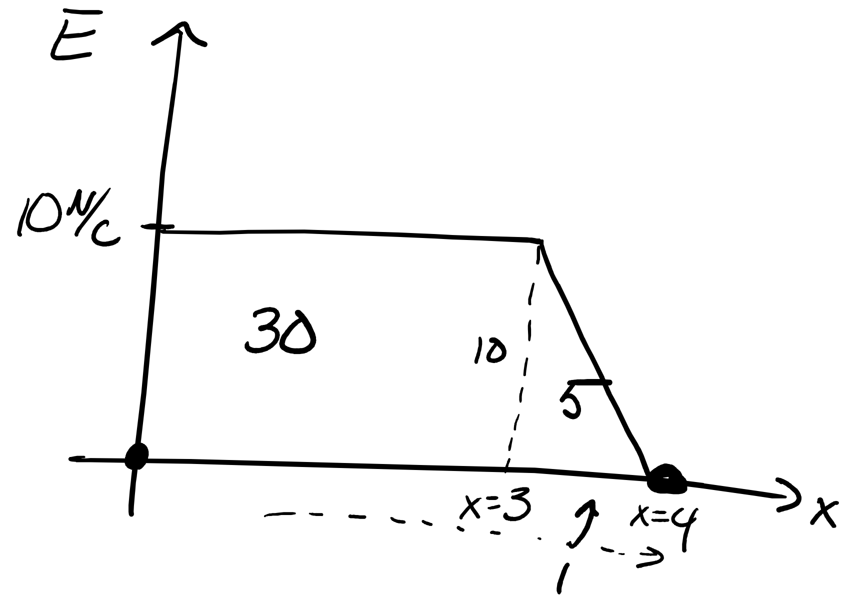
A graph of the electric field is shown. What is the voltage at x=4m, assuming the initial voltage at the origin x=0 was V=-16V? Be very careful with your signs.

$$\Delta V = V_f - V_i = -\int \vec{E} \cdot dx$$

$$V_f - (-16) = -35$$

$$V_f + 16 = -35 \quad -16$$

$$\boxed{V_f = -51V}$$



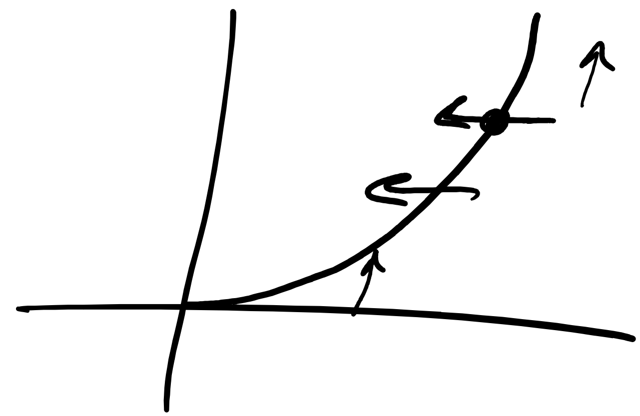
A voltage profile has the equation V=3x^2. Find:

a) The equation of the electric field as a function of x.

b) The E field size AND direction at x=3

$$E = -\frac{dV}{dx} = \boxed{-6x \ (N/C)}$$

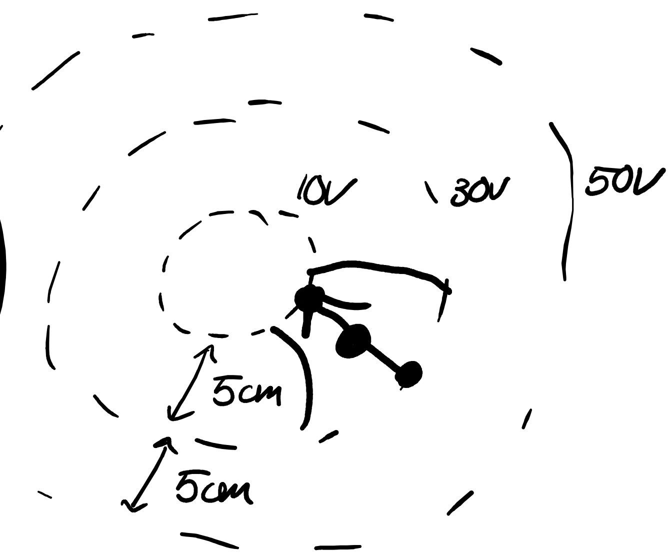
$$\boxed{E = -18 \ N/C}$$



Estimate the E field at the black dot using the equipotential graph shown. The black dashed lines are the equipotentials, at the voltages written on the diagram.

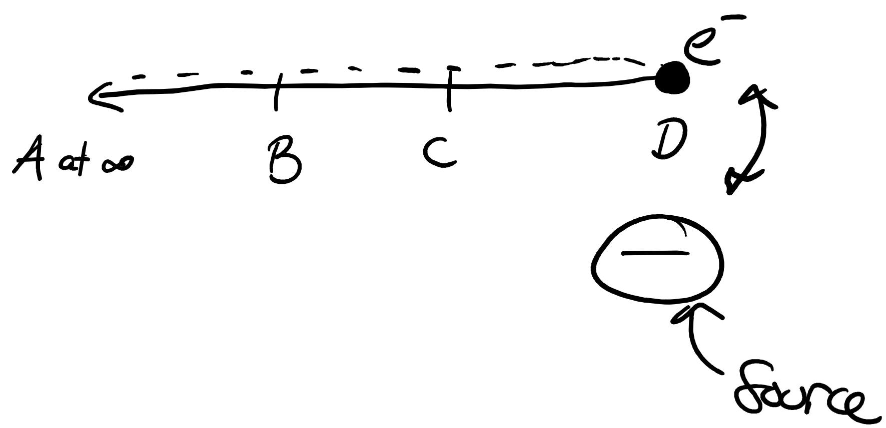
$$E \approx (-)\frac{\Delta V}{\Delta x} = \frac{20V}{.05} = \boxed{400\left(\frac{N}{C} \text{ or } \frac{V}{m}\right) \text{ towards center}}$$

communicates direction



At which point on the path shown is the electron's KE greatest? Choice A is to be read as "far away at infinity". The source charge is negative.

- A) A
- B) B
- C) C
- D) D



Choice A is to be read as "far away at infinity". The source charge is negative.

1) At which point on the path traveled by the electron the voltage the greatest?

- A) A
- B) B
- C) C
- D) D

2) At what point is it the least?

- A) A
- B) B
- C) C
- D) D