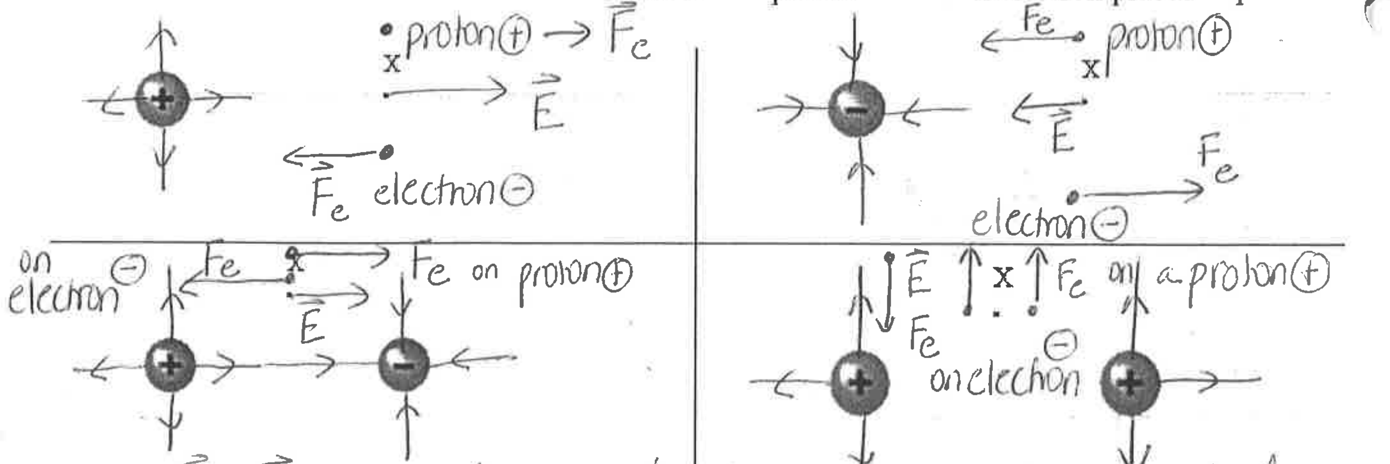
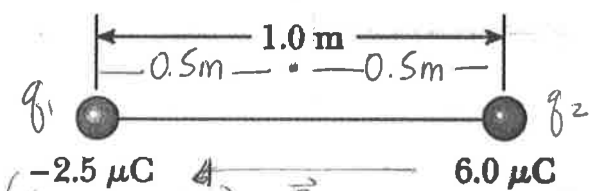
Comparing Forces and Fields

1. In each case below, compare the direction of the electric field at point X produced by the charged object with the direction of the electrostatic forces exerted on a proton and on an electron placed at point X.



Conclusion $\vec{F}$ & $\vec{E}$ are in the same direction on a positive test charge but in opposite directions on a negative test charge.

2. a) Find the magnitude and direction of the net electric field halfway between the two charges shown below.



$\vec{E} = \left|\frac{Kq_1}{r^2}\right| + \left|\frac{Kq_2}{r^2}\right|$

$\vec{E} = \frac{8.99\times10^9 \frac{Nm^2}{C^2}(2.5\times10^{-6}C)}{(0.5m)^2} + \frac{8.99\times10^9 \frac{Nm^2}{C^2}(\cancel{6.0\times10^{-6}}C)}{(0.5m)^2} = \boxed{3.1\times10^5 \frac{N}{C}}$

b) Determine the electric force on a proton placed at this spot.

$F_e = q\vec{E} = (1.6\times10^{-19}C)(3.1\times10^5 \frac{N}{C}) = \boxed{4.9\times10^{-14}N}$

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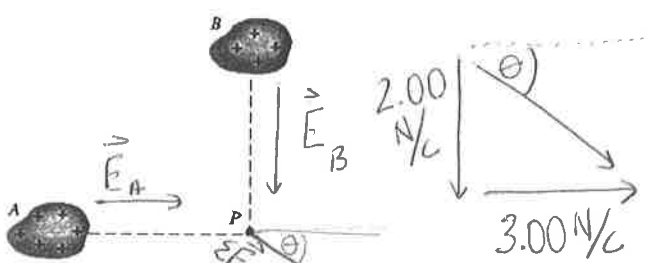
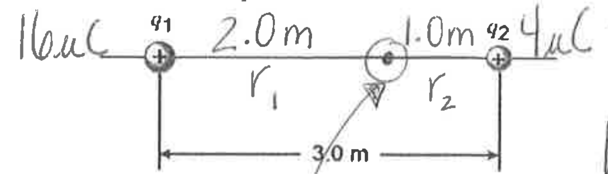
3. Two charged objects, *A* and *B*, each contribute as follows to the net electric field at point *P*: $\mathbf{E_A}$ = 3.00 N/C directed to the right, and $\mathbf{E_B}$ = 2.00 N/C directed downward. What is the net electric field at *P*?



$\Sigma\vec{E} = \sqrt{(\vec{E}_A)^2 + (\vec{E}_B)^2} = \boxed{3.61 \frac{N}{C}}$

$\tan^{-1}\left(\frac{2}{3}\right) = \boxed{33.7°}$ below horizontal.

6. a) Two positive point charges, $q1 = +16$ μC and $q2 = +4.0$ μC, are separated in a vacuum by a distance of 3.0 m. Find the spot on the line between the charges where the net electric field is zero.



$\Sigma E_{net} = \emptyset \frac{N}{C}$

$E_1 = E_2$

$\frac{Kq_1}{r_1^2} = \frac{Kq_2}{r_2^2}$

$\frac{q_1}{q_2} = \frac{r_1^2}{r_2^2}$

$\sqrt{4r_2^2} = \sqrt{r_1^2}$

$\frac{16\mu C}{4\mu C} = \frac{4}{1} = \frac{r_1^2}{r_2^2}$

$r_2 + r_1 = 3.0m$

$2r_2 = 8r_1$

$2(1.0m) = 2.0m$

Electric Potential Energy and Potential

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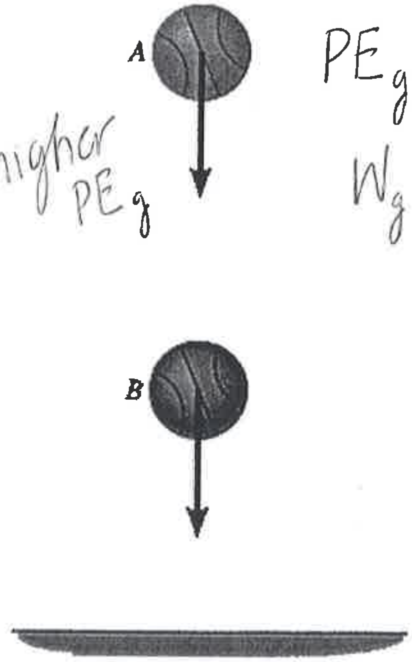
Formula:

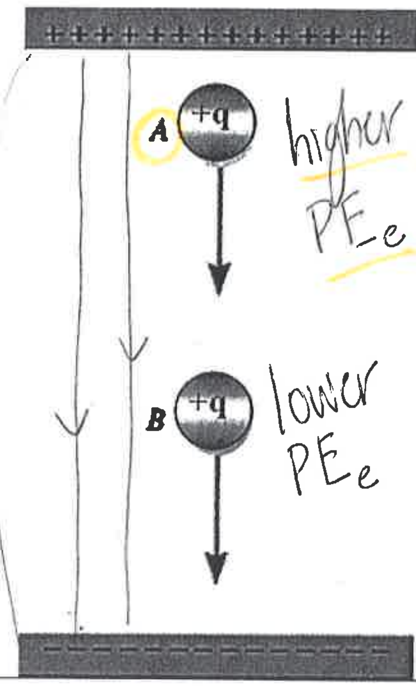


higher PE_g

$PE_g = mgh$

$W_g = F_g \cdot d$

$h = \emptyset$



Known also as

higher PE_e

$PE_e = E_p$

$PE_e = (q\vec{E})d$

lower PE_e

$PE_e = F_e \cdot d$

Electric potential energy: energy due to a change in position in an electric field

Symbol: Units: [J] Joules

1. In the diagram above, at which spot, A or B, will the test charge have more electric potential energy?

Electric potential (voltage): amount of electric potential energy per unit charge

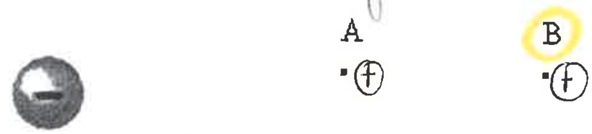
same Symbol: V as Units: [V] or $\left[\frac{J}{C}\right]$

$\frac{PE_e}{q} = \frac{\cancel{q}\vec{E}d}{\cancel{q}}$ $\quad \boxed{V = \vec{E}d}$

$\frac{PE_e}{q} = \frac{F_e \cdot d}{q}$

2. In the diagram above, which spot, A or B, is at a higher electric potential?

3. Which spot, A or B, is at a higher electric potential?



Farther to travel in $\vec{E}$

larger "d"

4. Which spot, A or B, is at a higher electric potential?

greater F_e at A than B

Conclusion: A spot where a positive test charge has more potential energy is at a higher electric potential or voltage.

Formula:

$PE_e = \vec{F}_e \cdot d$

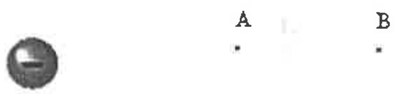
$PE_e = q(\vec{E} \cdot d)$

$PE_e = qV$

W or (E_p)

Variable:	PE_e or W	q	V
Quantity:	electric potential energy	charge	Voltage or electric potential
Units:	J	C	$\frac{J}{C} = V$
Type:	scalar	scalar	scalar

1. How much work is done in moving +5.0 C of charge through a potential difference of 12 volts?



$PE_e = qV \quad (5.0\,\cancel{C})(12\,\frac{J}{\cancel{C}}) =$

$\boxed{60.\ J}$

2. An electron gains 4.8 x 10^{-17} joule of energy moving between two points in an electric field. What is the electric potential difference between these two points?

$V = \frac{PE_e}{q} = \frac{4.8\times10^{-17}\ J}{1.6\times10^{-19}\ C} =$

$\boxed{3.0\times10^{2}\ V}$

Electronvolt: "MINI-JOULE" The amount of energy gained moving one electron through a potential difference of one volt.

3. Determine the conversion factor between joules and electronvolts.

one electron volt (e.v.) $= (1.6\times10^{-19}\ C)(1\ V) = 1.6\times10^{-19}\ J$

amount of work

or electric potential energy

4. An external force does 4.0 eV of work moving an electron between two points in an electric field. How much energy in joules does the electron gain?

$(4.0\ \cancel{eV}) \times \frac{1.6\times10^{-19}\ J}{1\ \cancel{eV}} = \boxed{6.4\times10^{-19}\ J}$

5. A proton falls through a potential difference of 30. volts. How much kinetic energy does the proton gain? Express your answer in both joules and electronvolts.

$1\ e.c. \times 30V = \boxed{30\ eV}$

$30\ \cancel{eV} \times \frac{1.6\times10^{-19}\ J}{1\ \cancel{eV}} = \boxed{4.8\times10^{-18}\ J}$