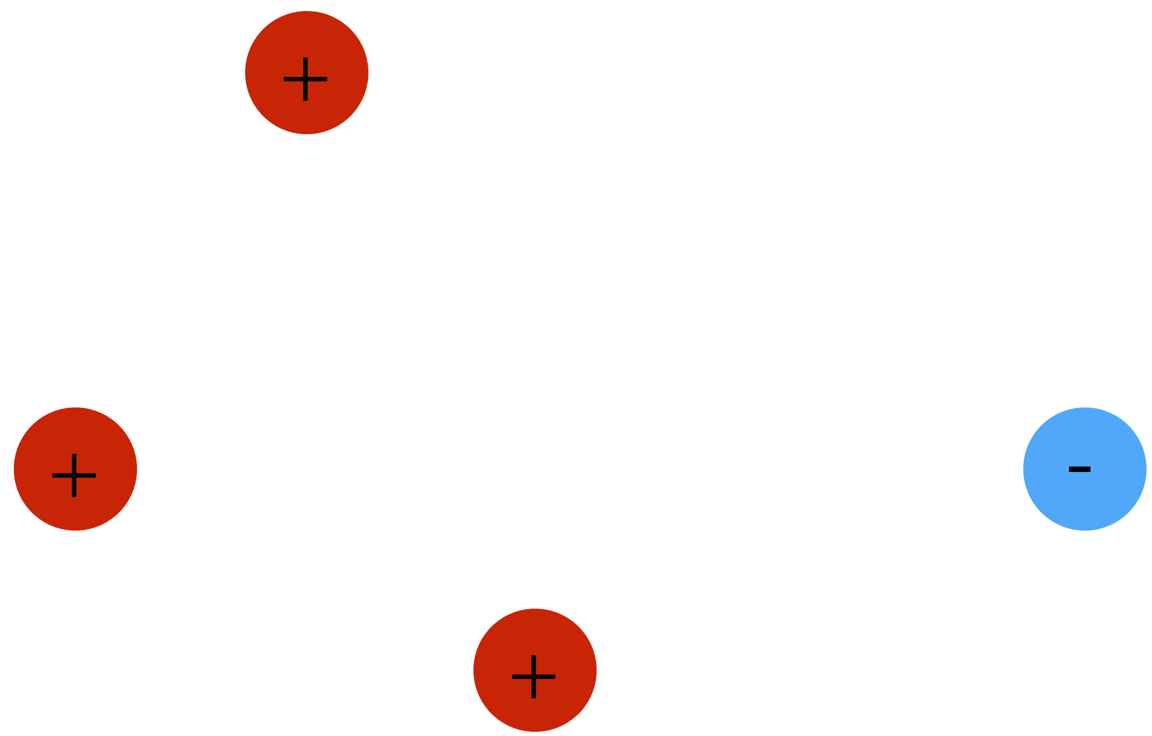
PH 220

Lance Nelson

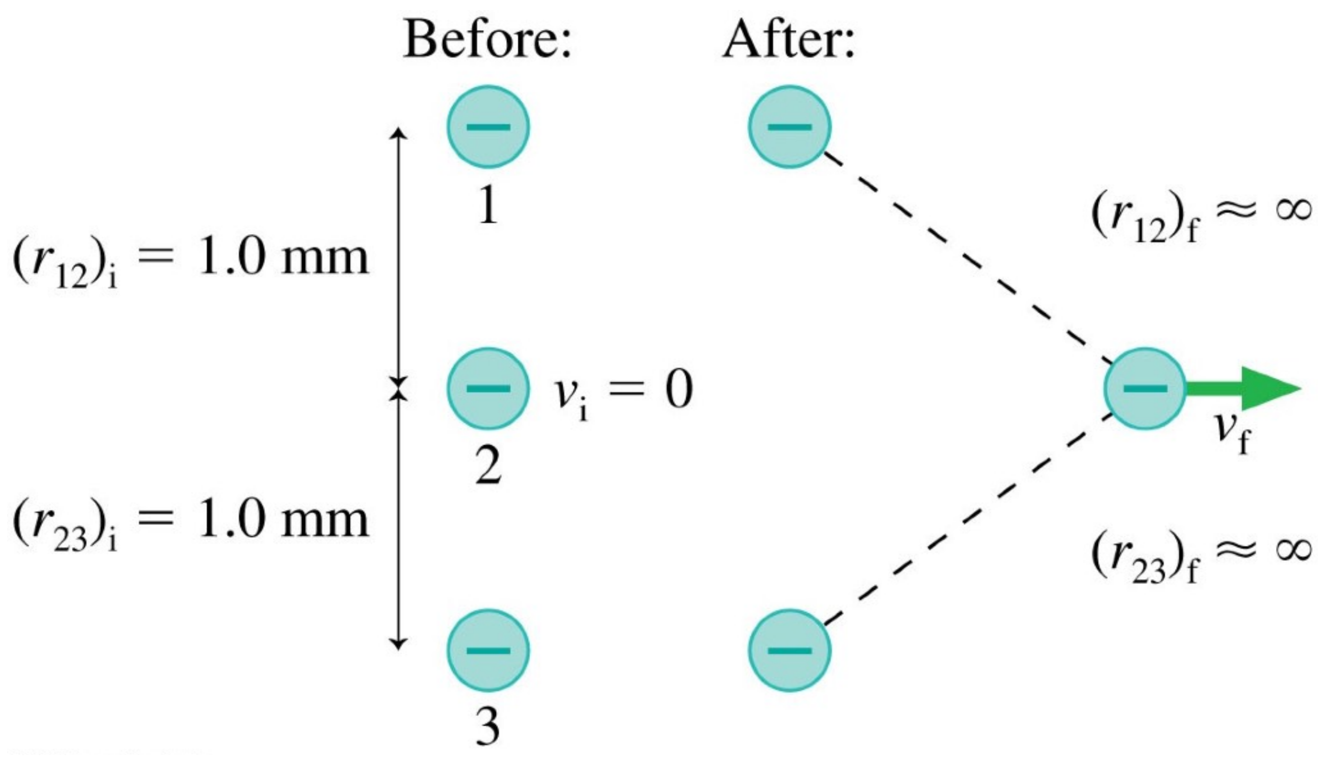
What if there are more than just two charges?



$$U = \sum_{i<j} \frac{k q_i q_j}{r_{ij}}$$

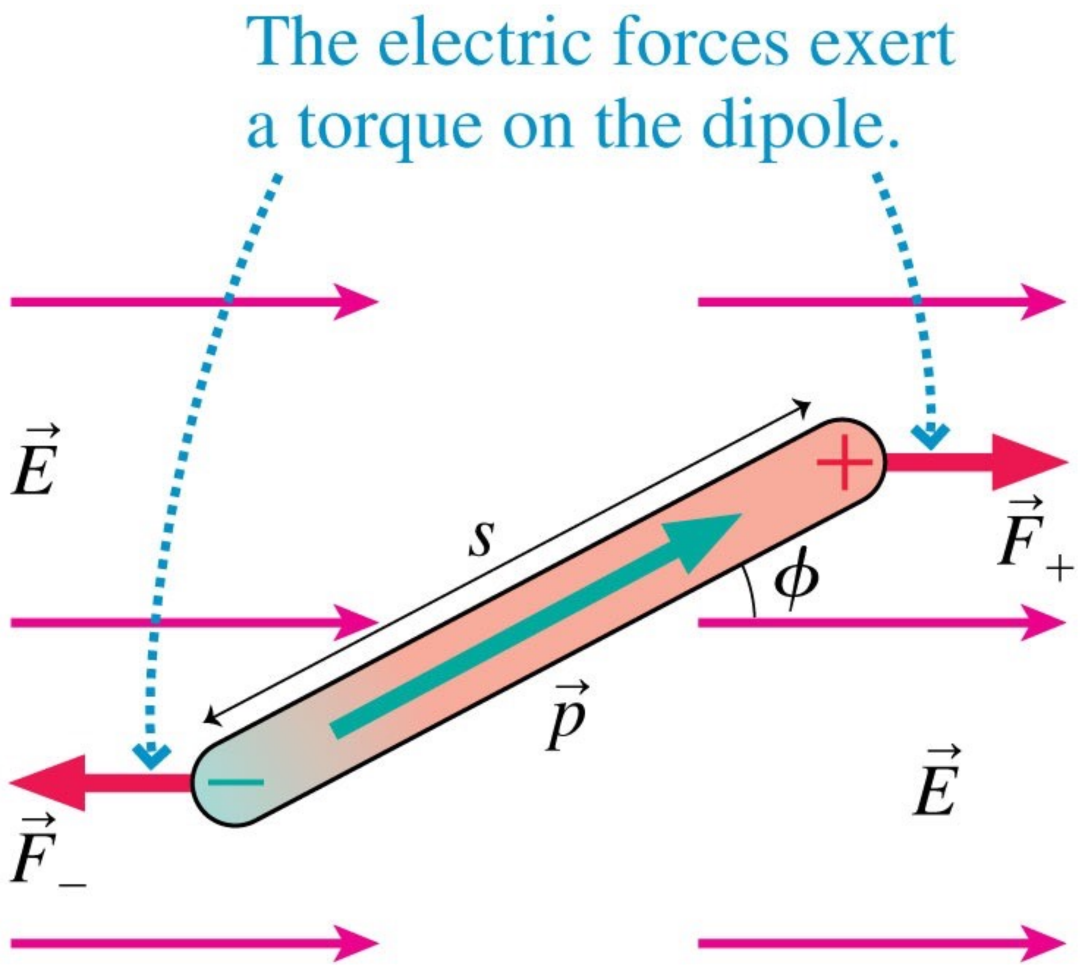
Example

Three electrons are spaced 1.0 mm apart on a vertical line. If the center electron is nudged horizontally by a very small distance, what will its speed be when it is very far away?



$$m_{\text{electron}} = 9.109 \times 10^{-31} \quad \text{kg}$$

Potential Energy of a dipole in a uniform field



linear motion

$$dW = F_s ds$$

rotational motion

$$dW = \tau d\phi$$

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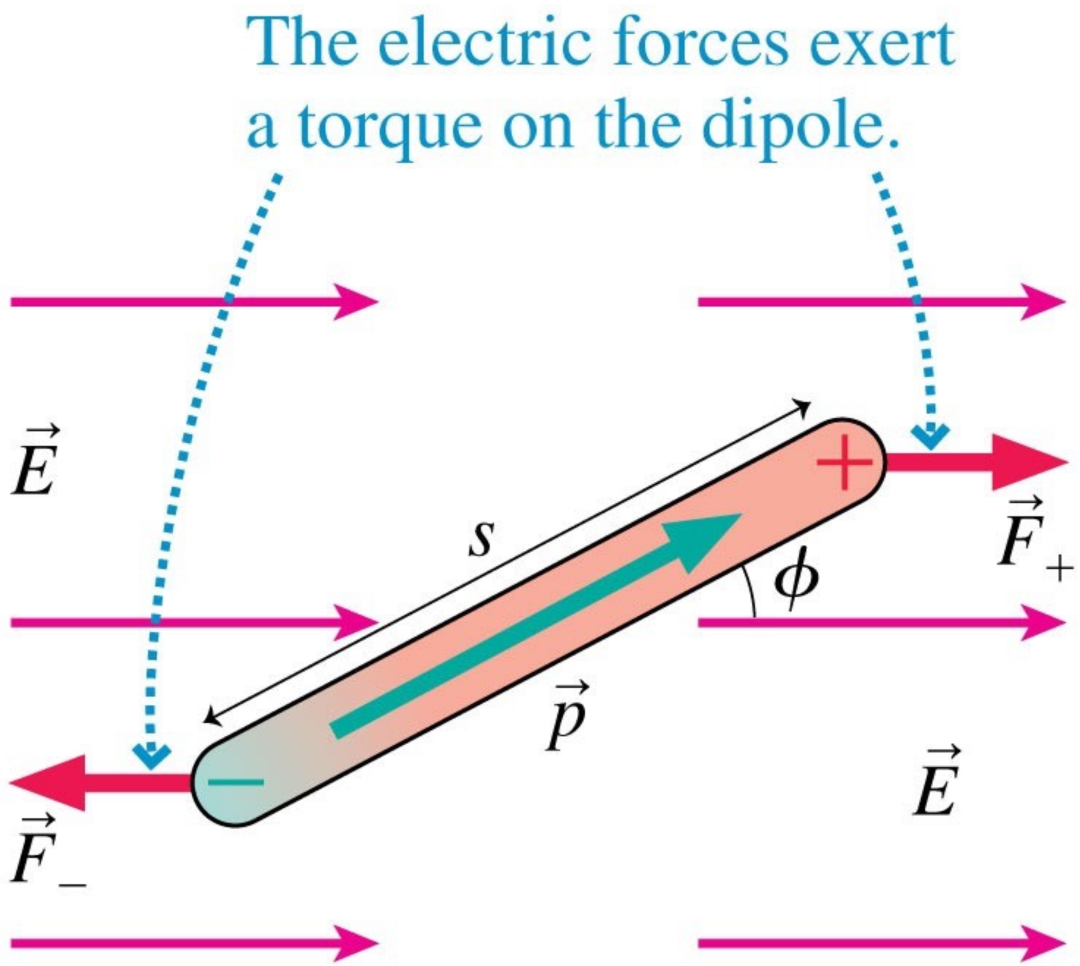

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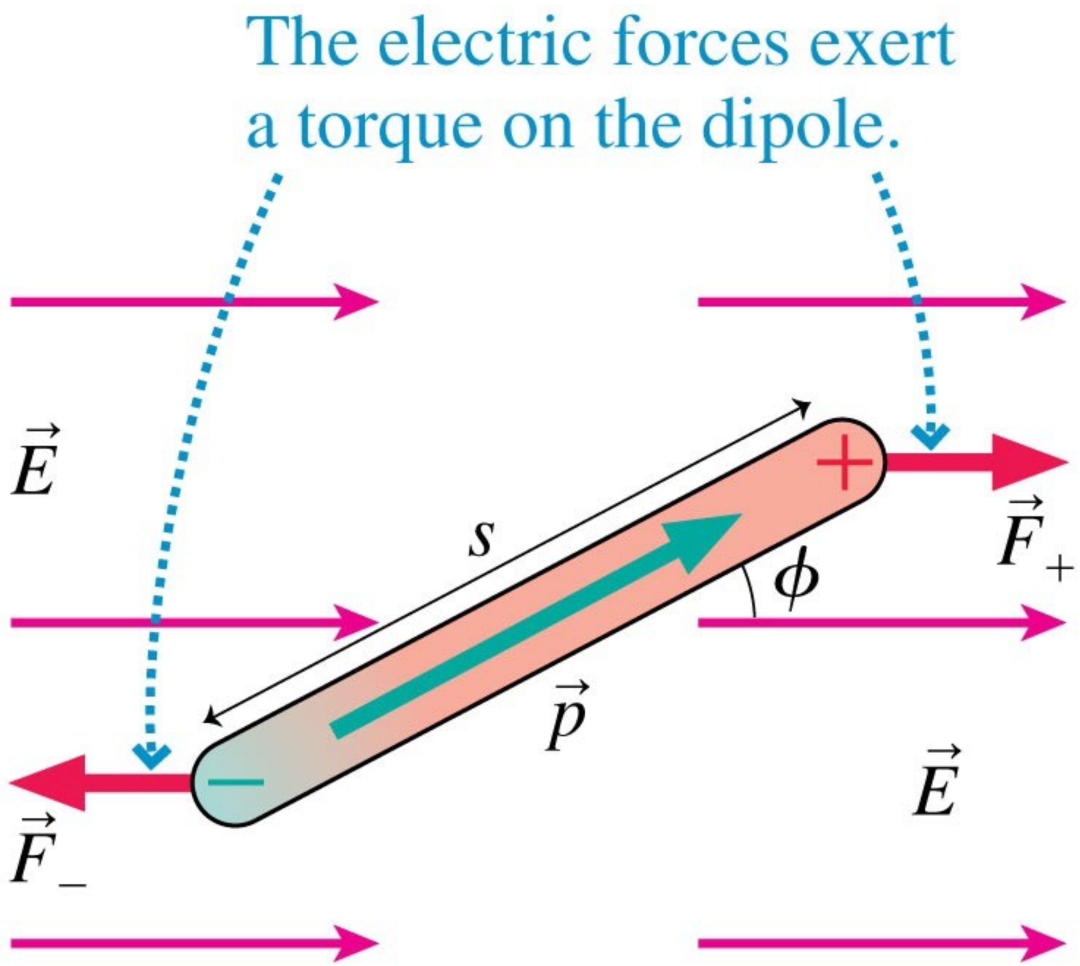

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$$W = -\int pE \sin\phi d\phi$$

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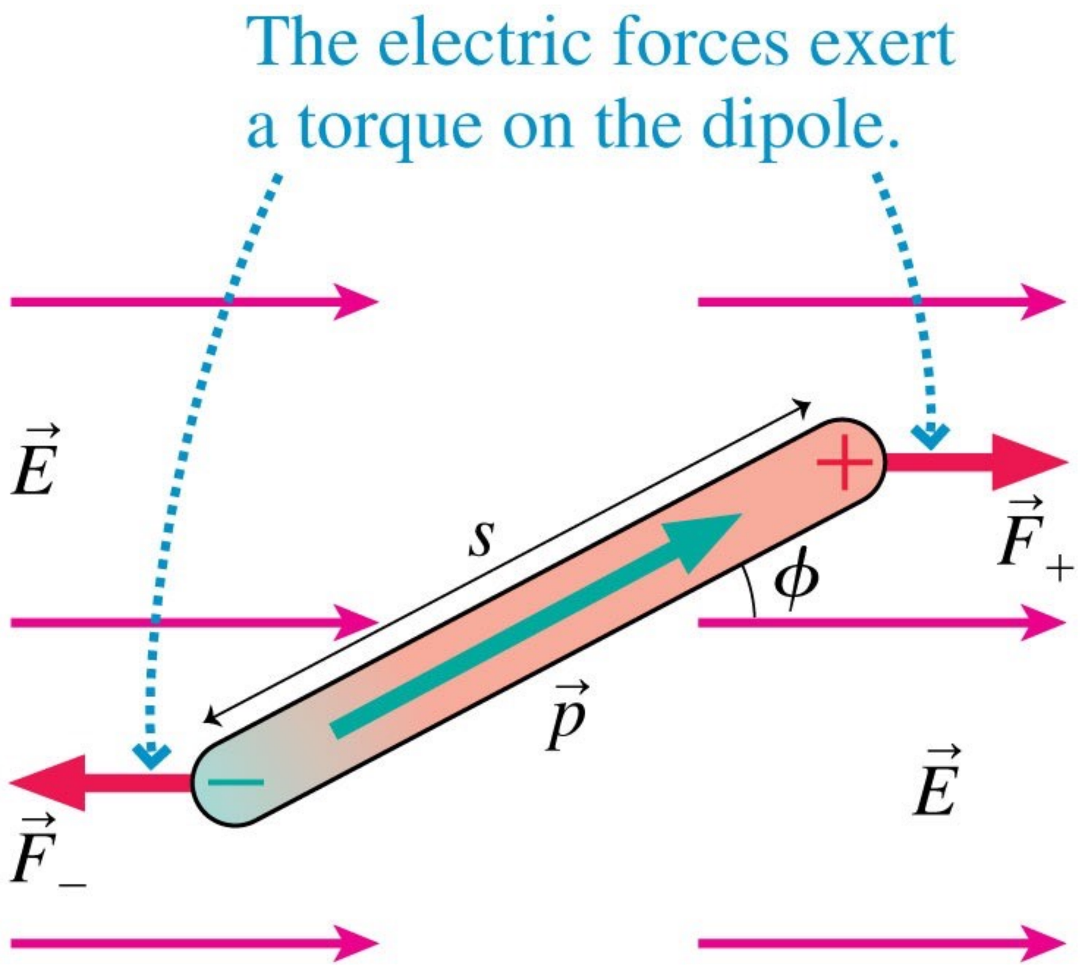

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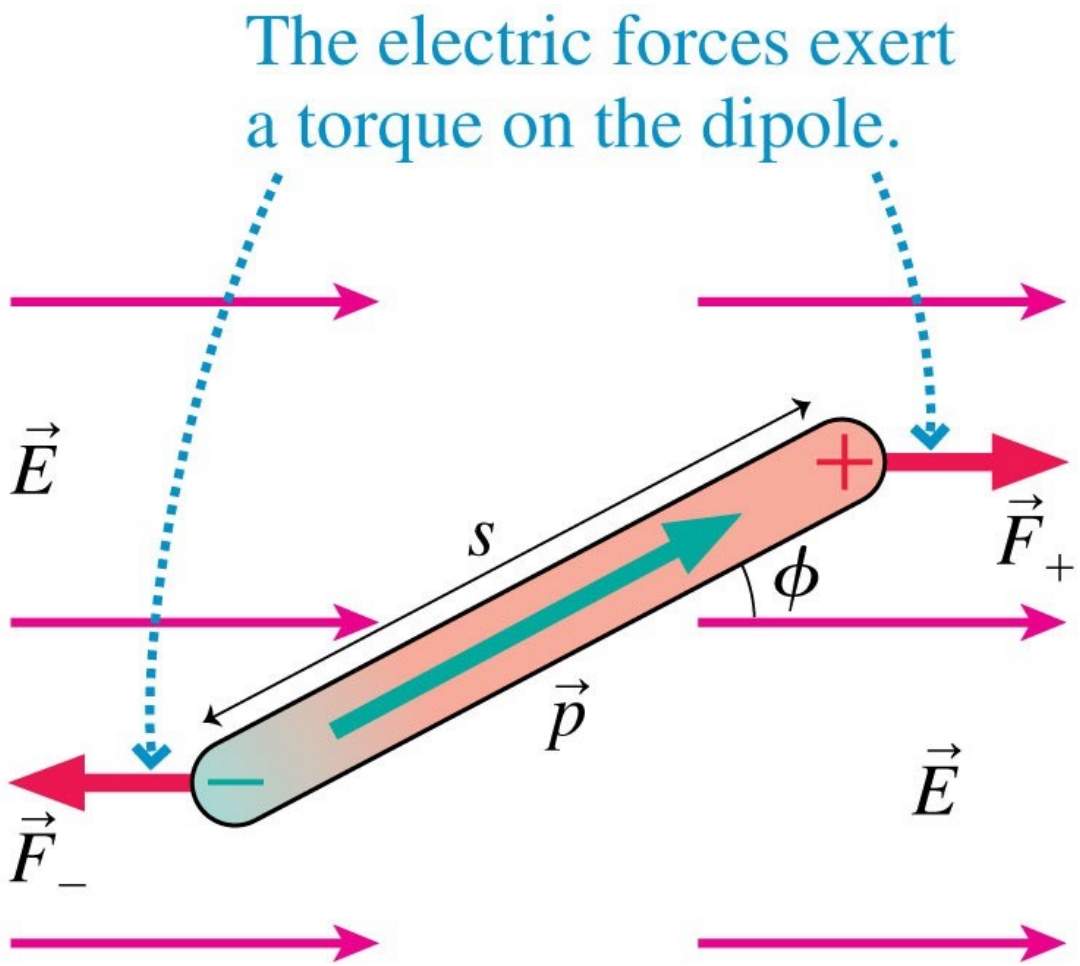

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$$= pE \cos\phi_f - pE \cos\phi_i$$

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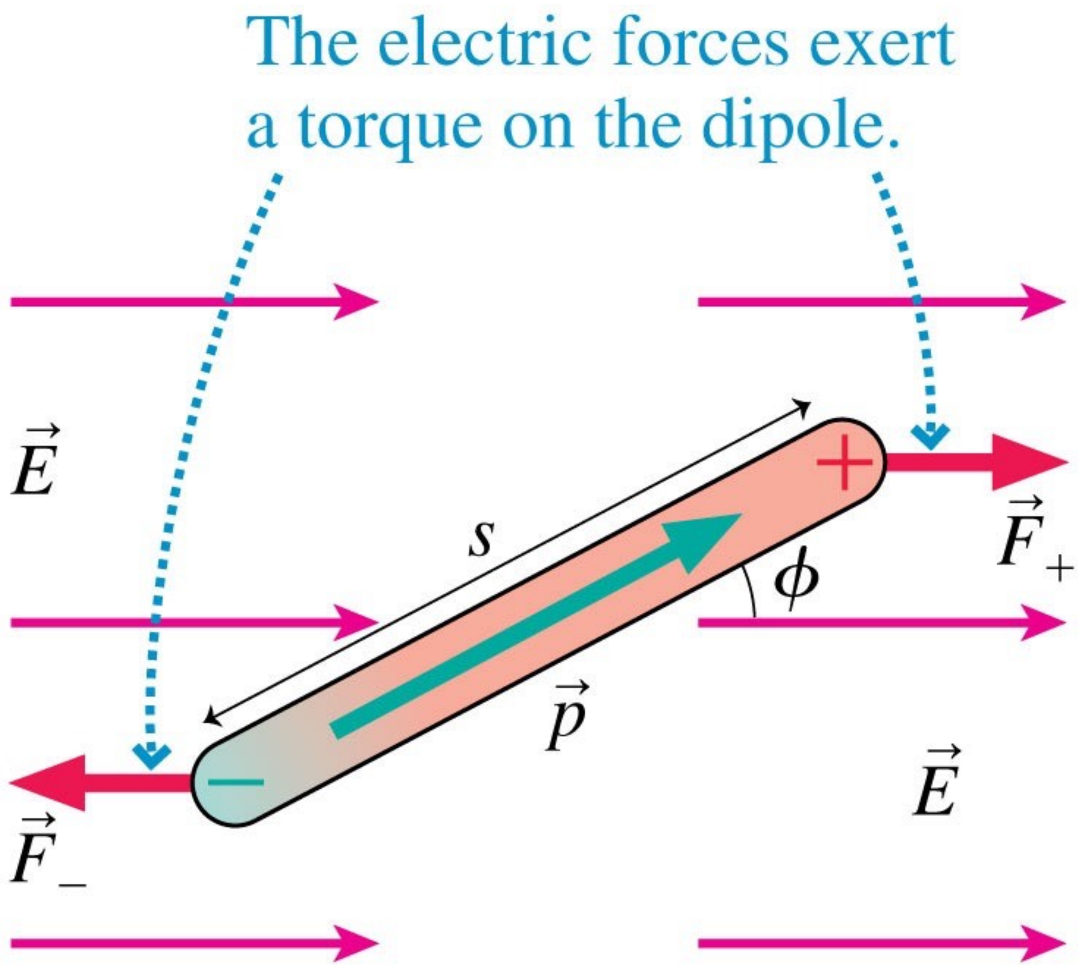

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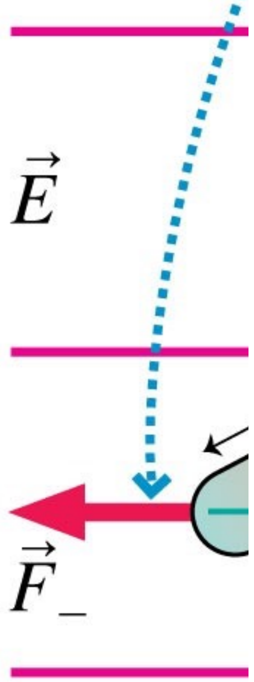
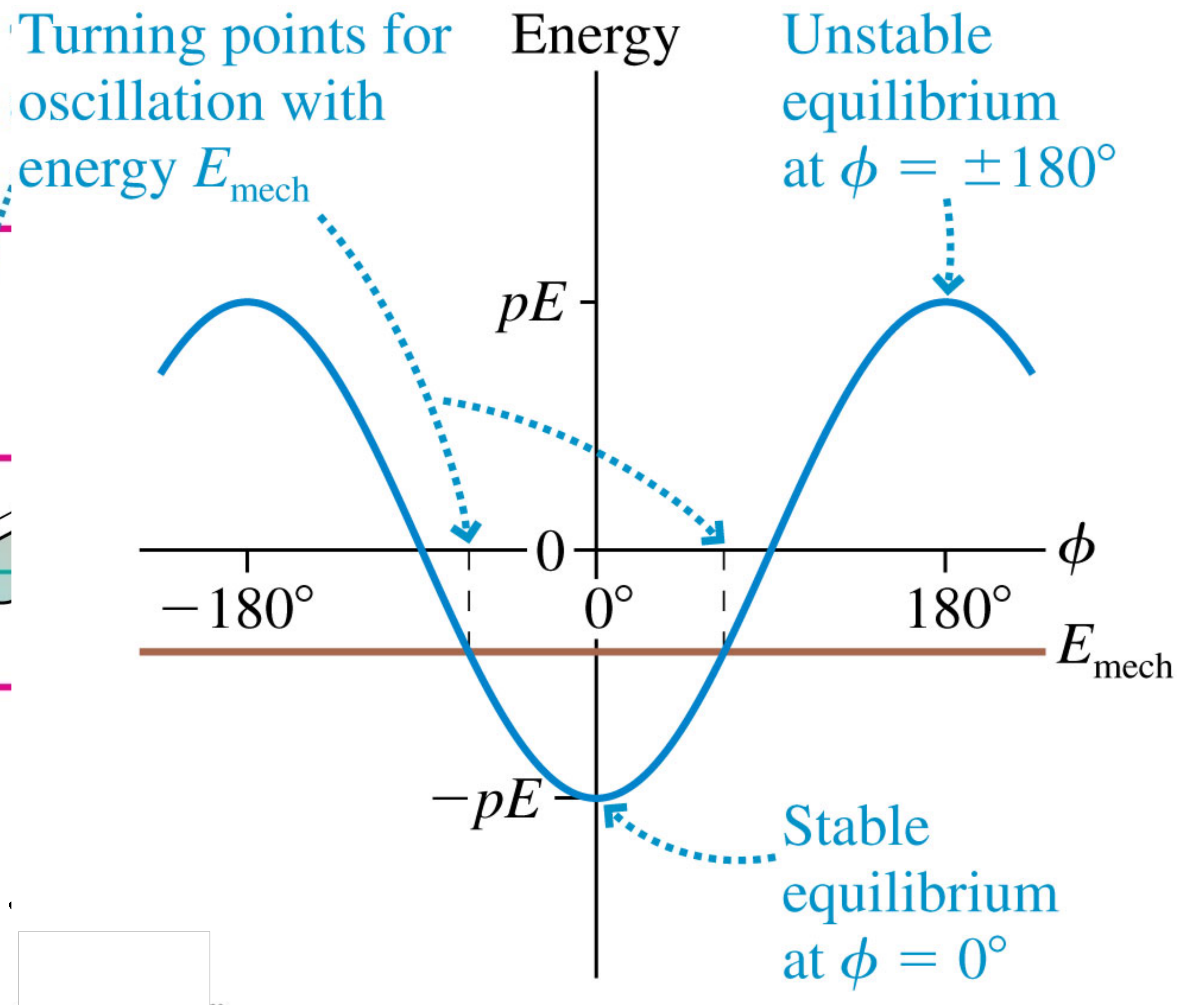
$$U_{\text{dipole}} = -\vec{p} \cdot \vec{E}$$

Potential Energy of a dipole in a uniform field





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$E \sin\phi d\phi$

$W = -$

$$= pE\cos\phi_f - pE\cos\phi_i$$

$$U_{\text{dipole}} = -\vec{p}\cdot\vec{E}$$

Potential Energy → Potential

Remember when we introduced the electric field?

Force → E - Field

$$\vec{F} = \frac{kq_1q_2}{r^2}\hat{r}$$

$$\vec{E} = \frac{kq_1}{r^2}\hat{r}$$

Potential Energy → Potential

Remember when we introduced the electric field?

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$$\vec{F} = \frac{kq_1q_2}{r^2}\hat{r}$$

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

$$\vec{E} = \frac{kq_1}{r^2}\hat{r}$$

Potential Energy → Potential

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$$U = \frac{kq_1q_2}{r} \qquad V = \frac{U}{q} \qquad V = \frac{kq_1}{r}$$

Potential Energy → Potential

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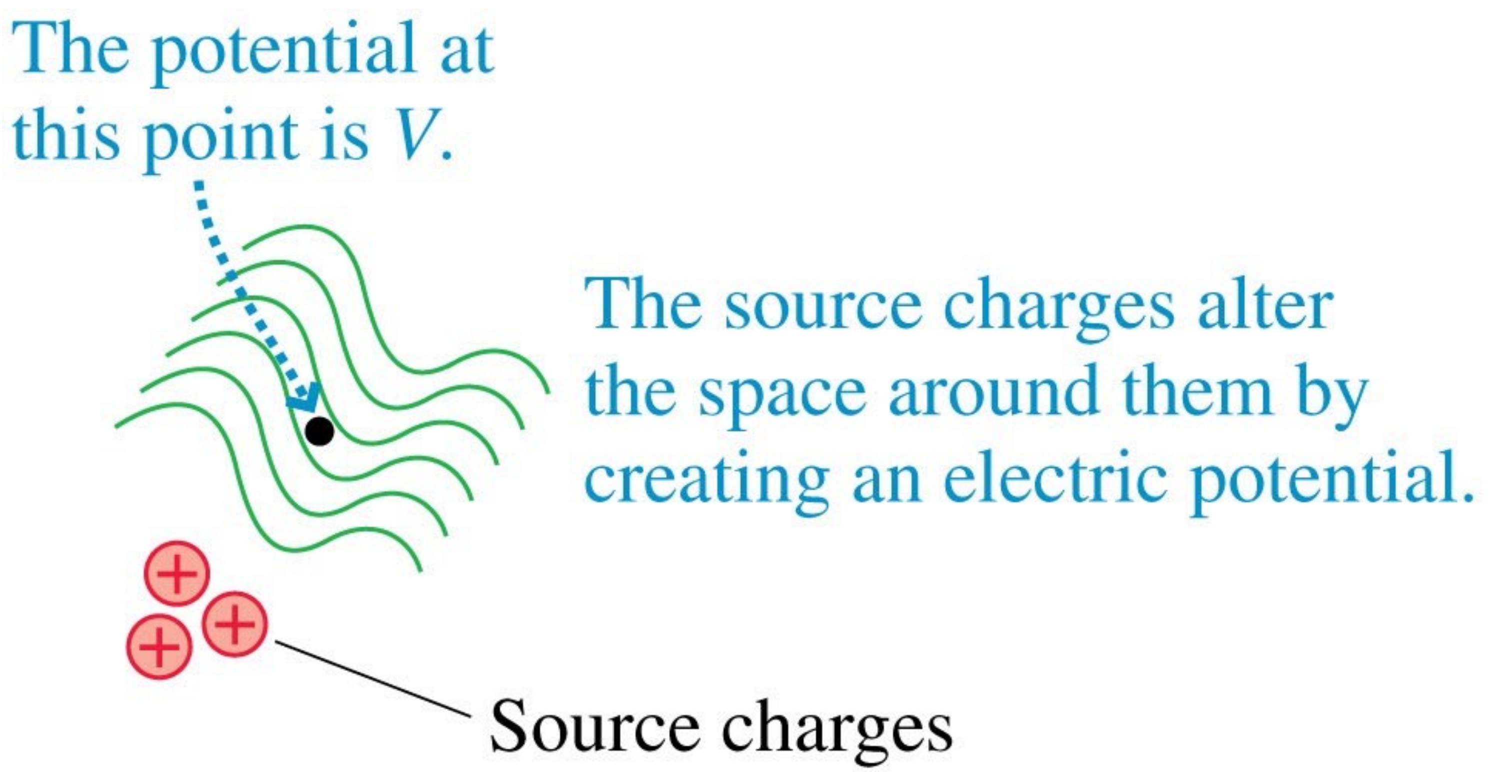
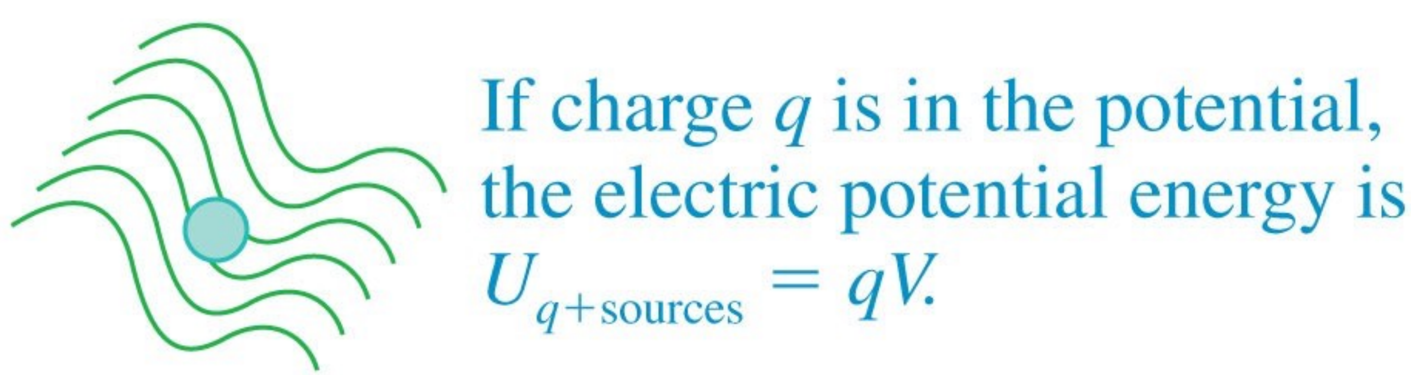
Potential Energy → Potential

units??

$$1 \text{ volt} = 1 \text{ V} \equiv 1 \text{ J/C}$$

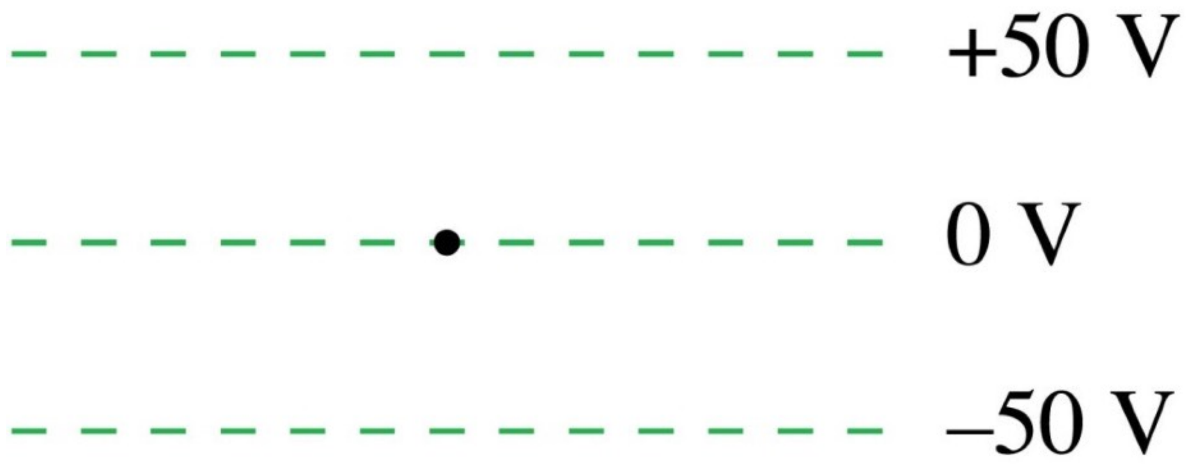
- Test charge q is used as a probe to determine the electric potential, but the value of V is *independent of q*.
- **The electric potential, like the electric field, is a property of the source charges.**





Question #15

A proton is released from rest at the dot. Afterward, the proton



A. Moves downward with an increasing speed.
B. Moves upward with steady speed.
C. Moves upward with an increasing speed.
D. Moves downward with a steady speed.
E. Remains at the dot.

Question #15

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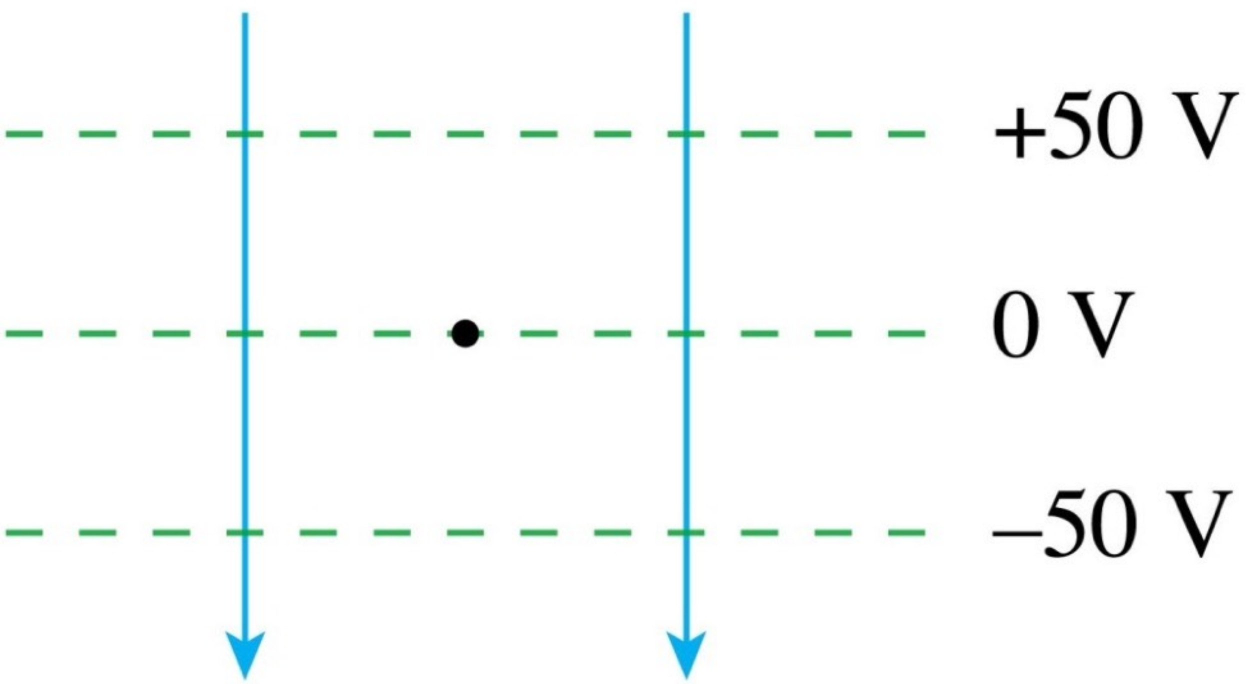


A. Moves downward with an increasing speed.
B. Moves upward with steady speed.
C. Moves upward with an increasing speed.
D. Moves downward with a steady speed.
E. Remains at the dot.

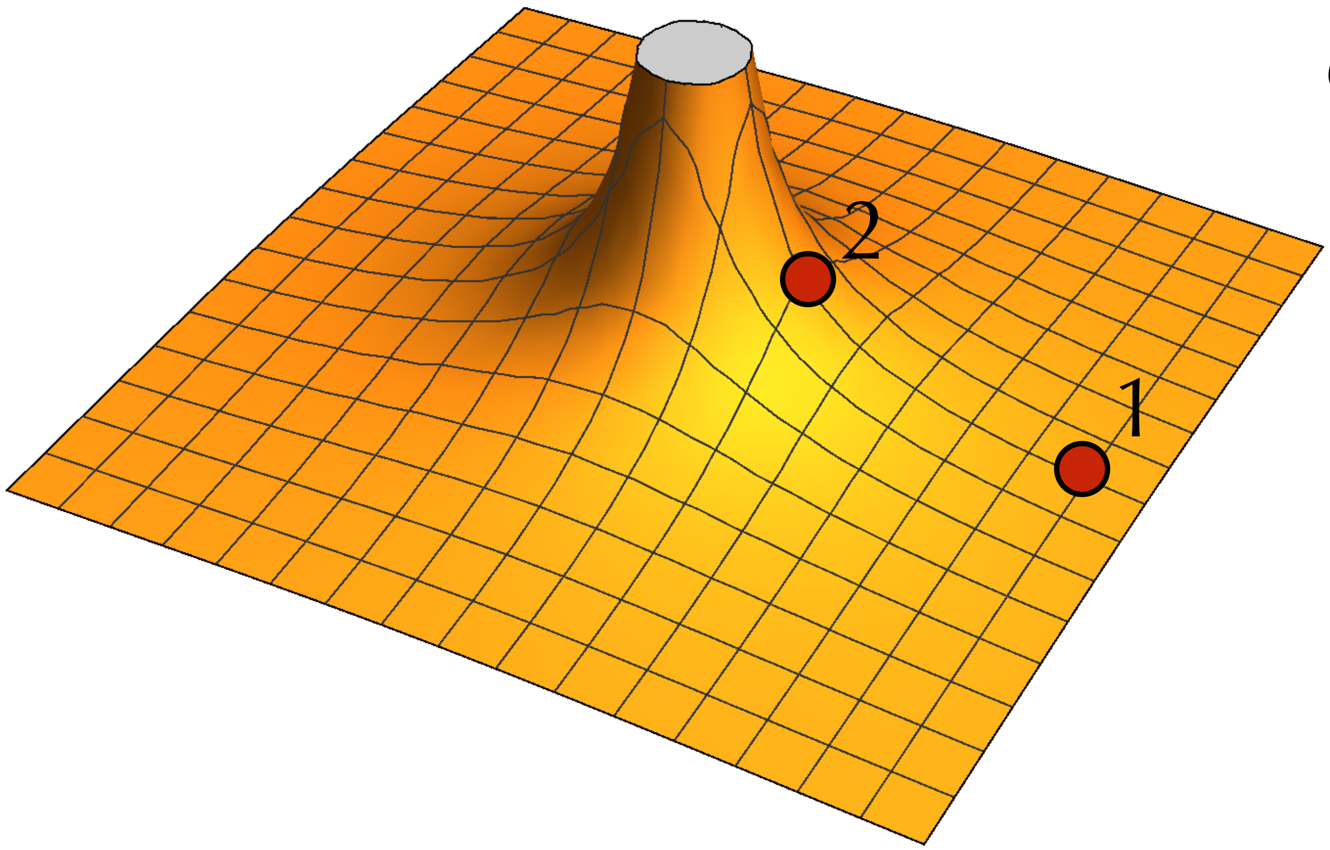
Question #16

If a positive charge is released from rest, it moves in the direction of

A. A stronger electric field.
B. Lower electric potential.
C. Higher electric potential.
D. A weaker electric field.
E. Both B and D.

Electric potential due to a point charge

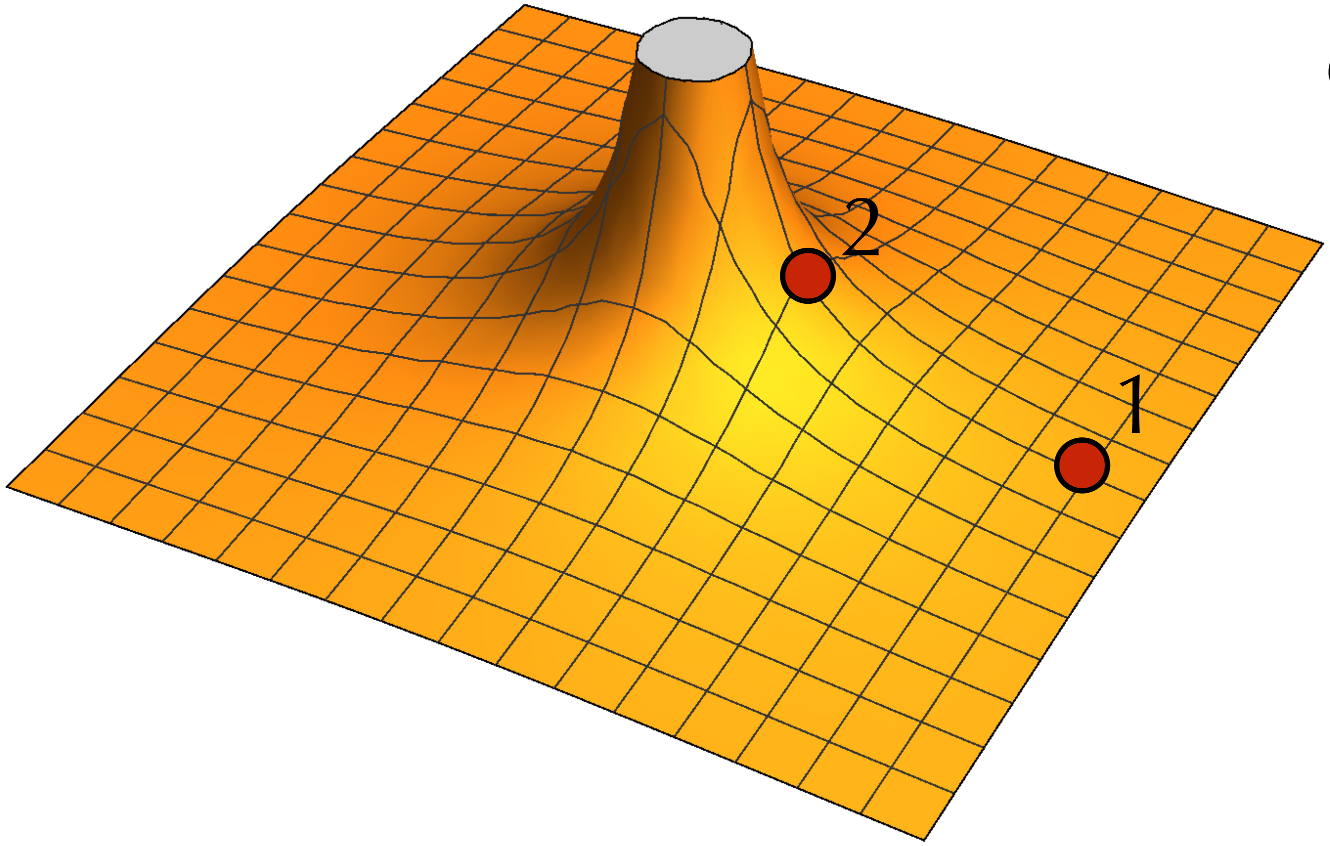
$$V = \frac{kq}{r}$$



If an electron/proton were to move from point 1 to point 2, would its energy increase or decrease.

Electric potential due to a point charge

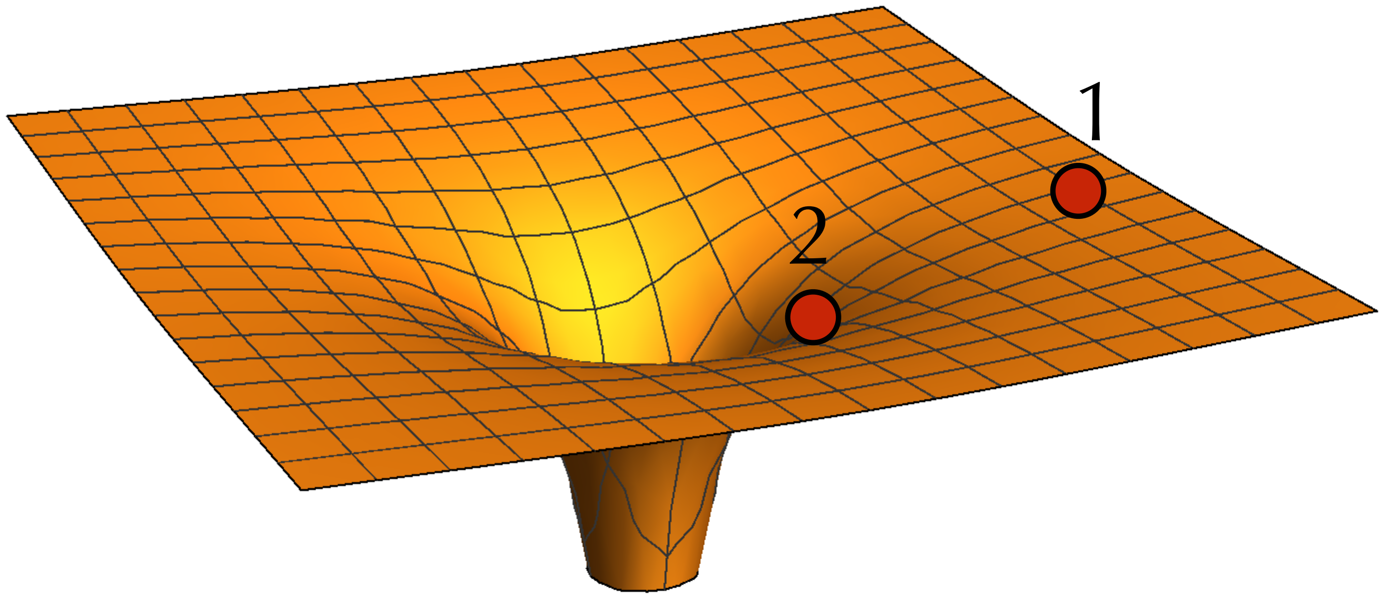
$$V = \frac{kq}{r}$$



If an electron/proton were to move from point 1 to point 2, would its energy increase or decrease.

$$U = qV$$

$$V = \frac{kq}{r}$$



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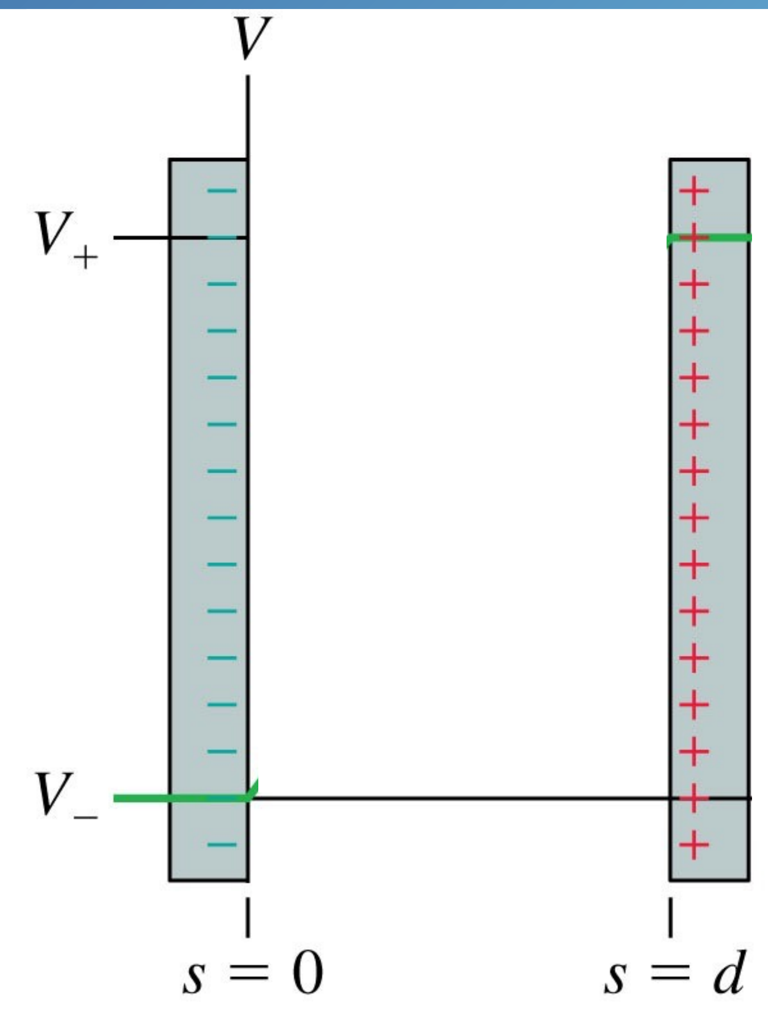
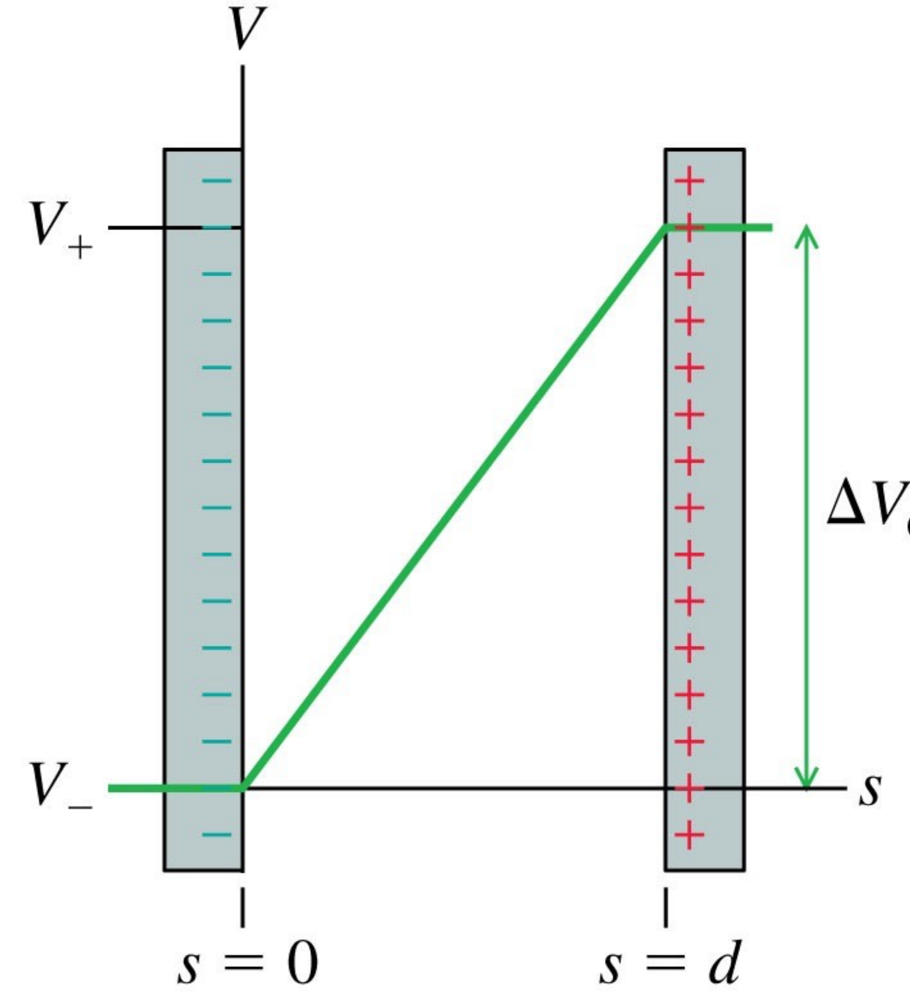
Parallel-plate capacitor

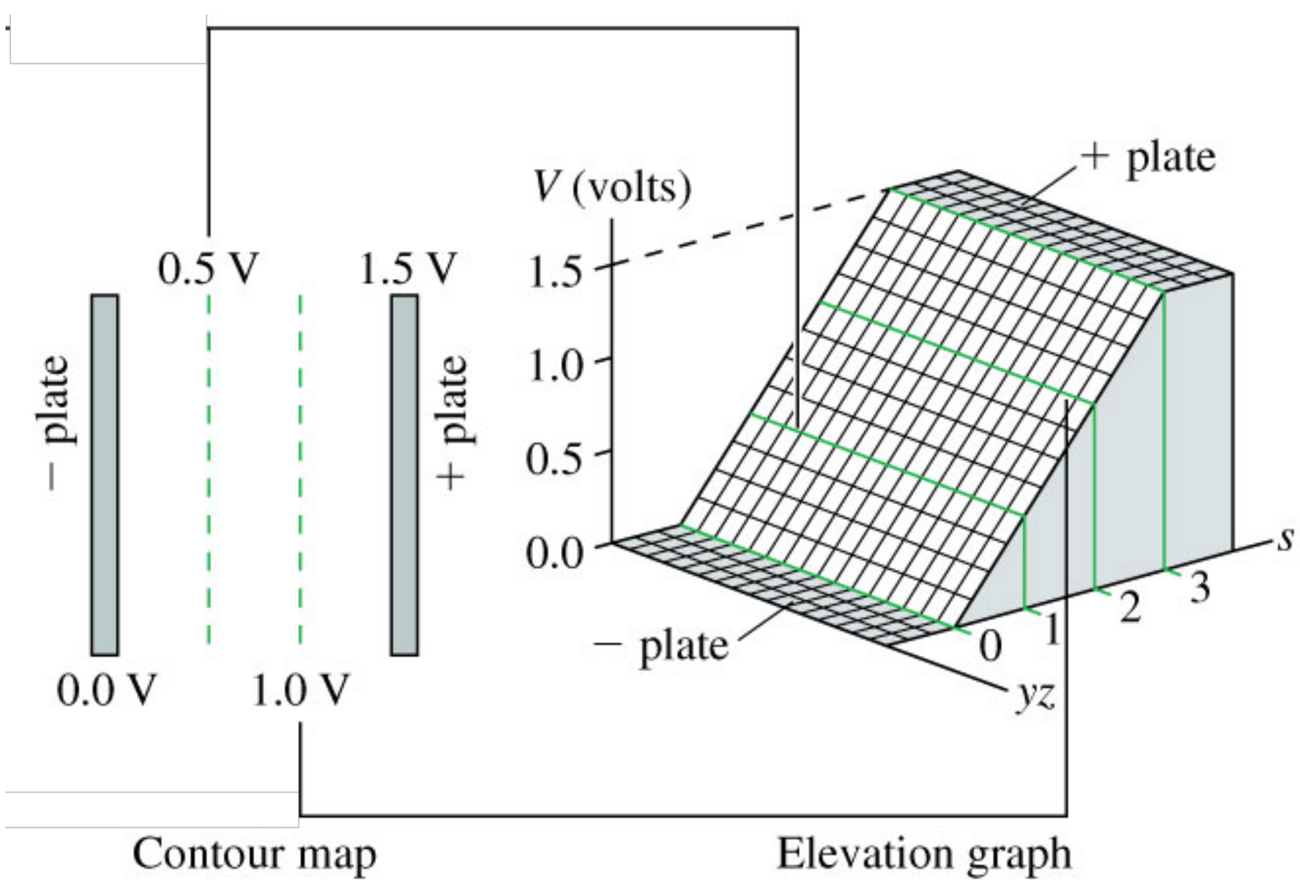


What would you expect the potential due to the oppositely charged plates to be?

Parallel-plate capacitor

$$V = Es$$





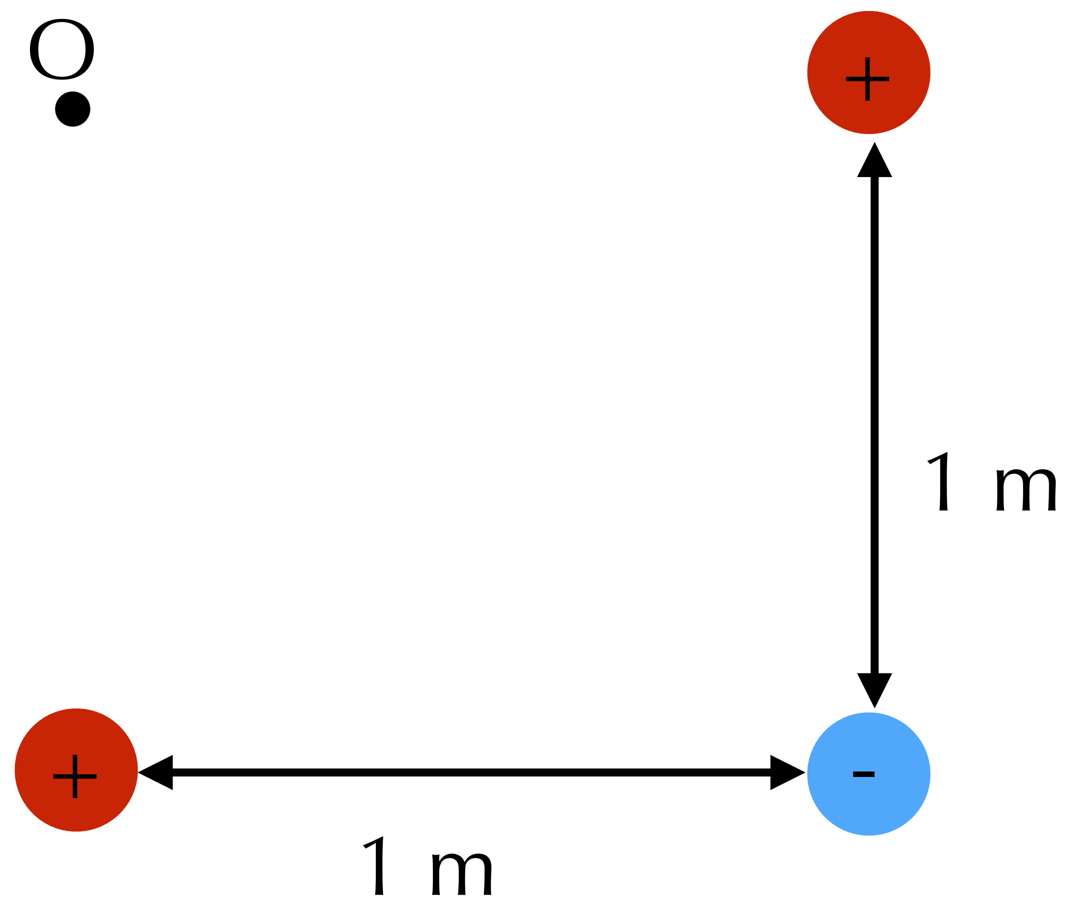
What would you expect the potential due to the oppositely charged plates to be?

Electric Potential of Point charge

Make a sketch of the electric potential of these three point charges

$$U_{\text{elec}} = \frac{Kq_1 q_2}{x}$$

$$V = \frac{kq}{r}$$



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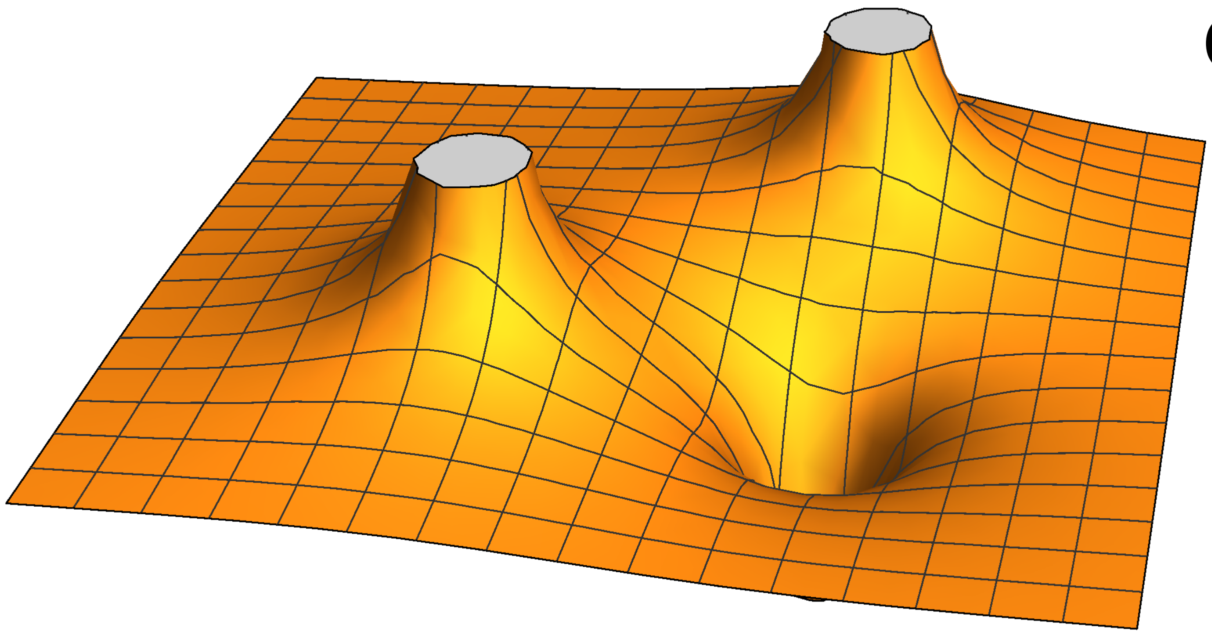

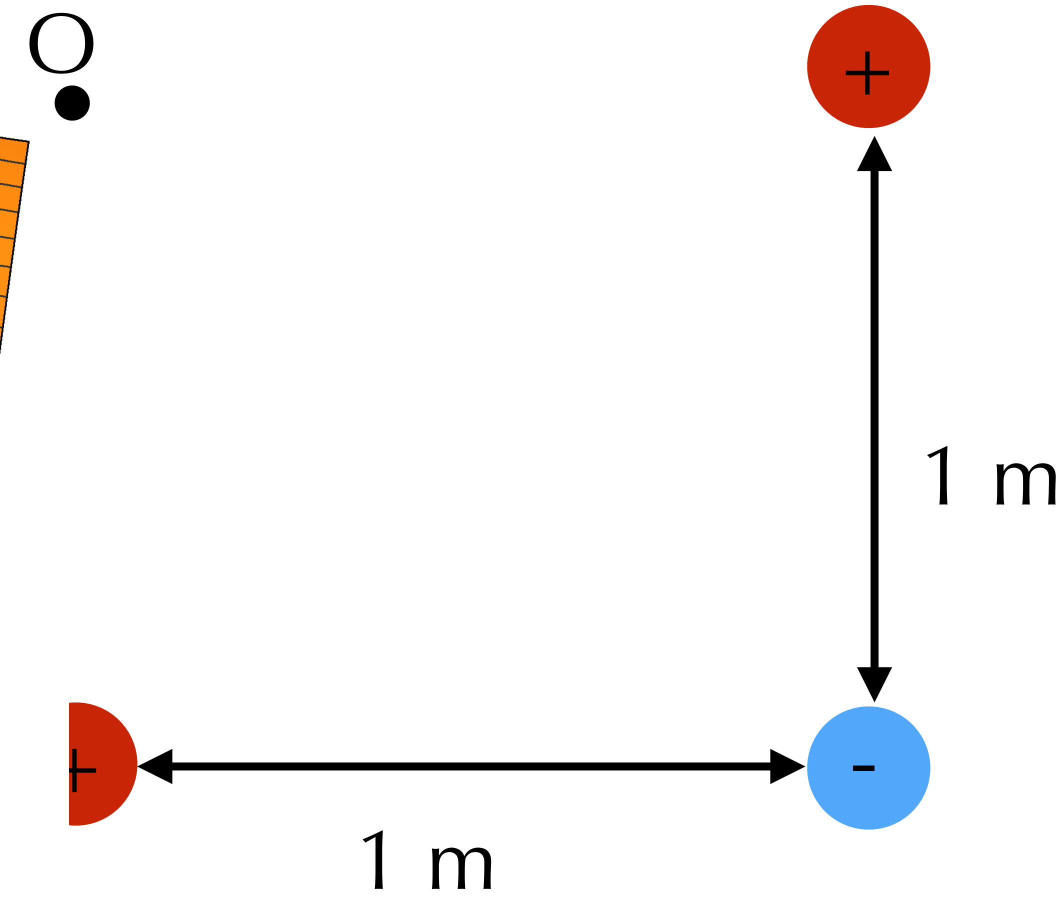

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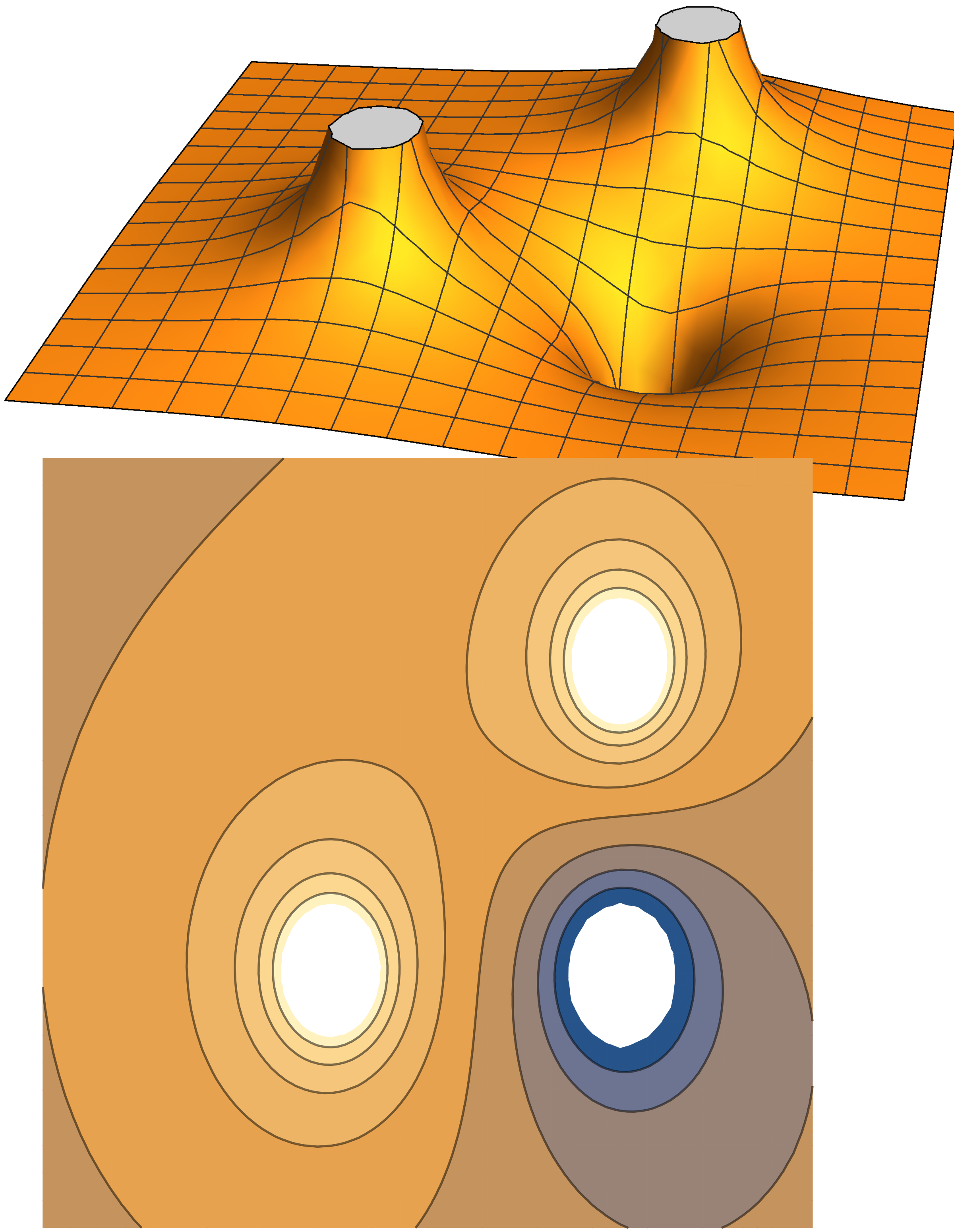

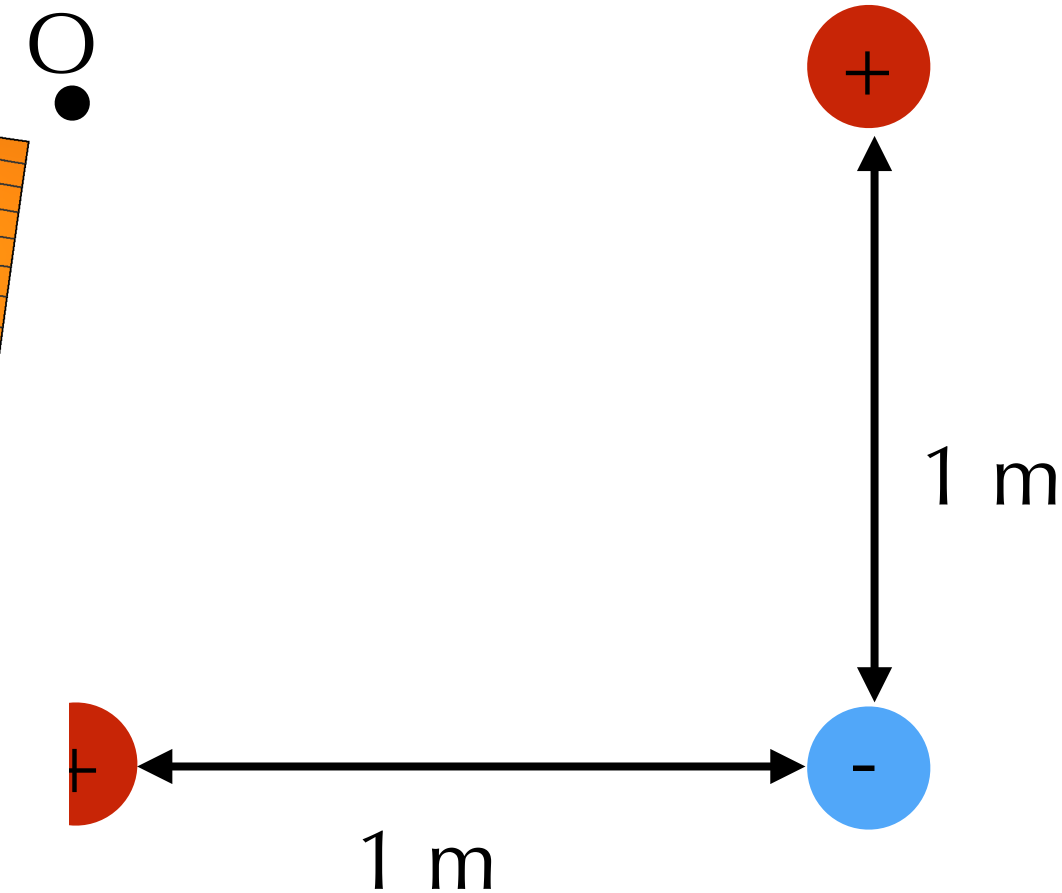

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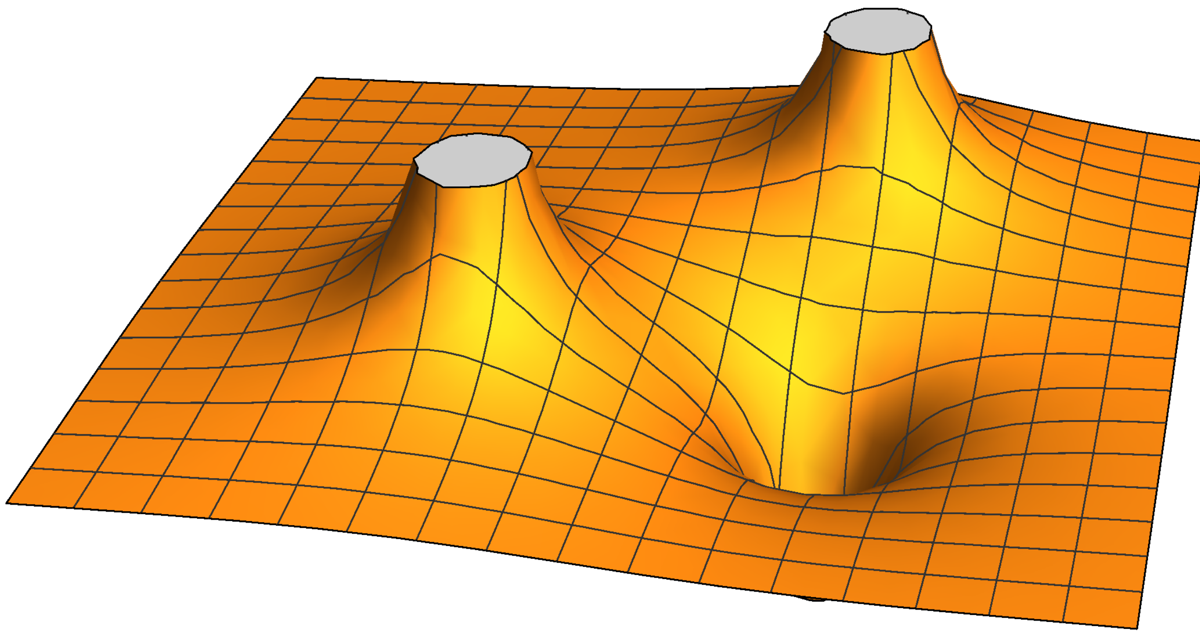
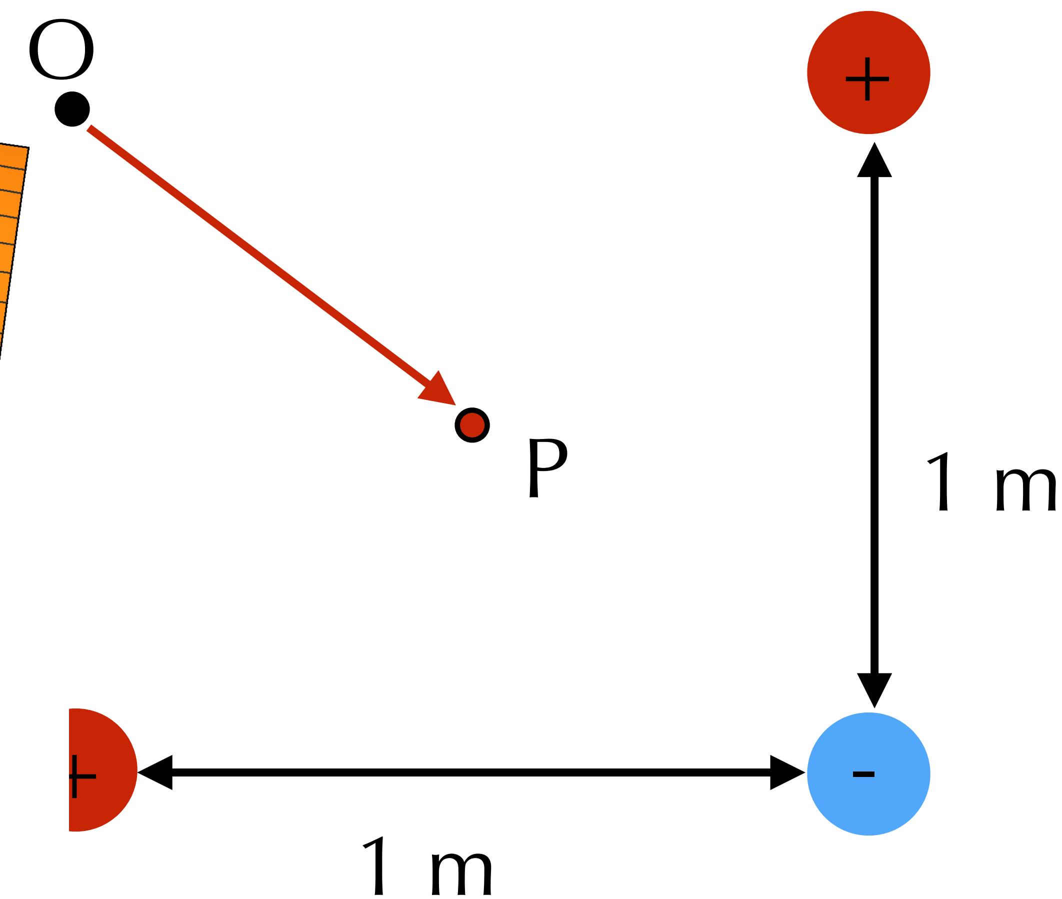
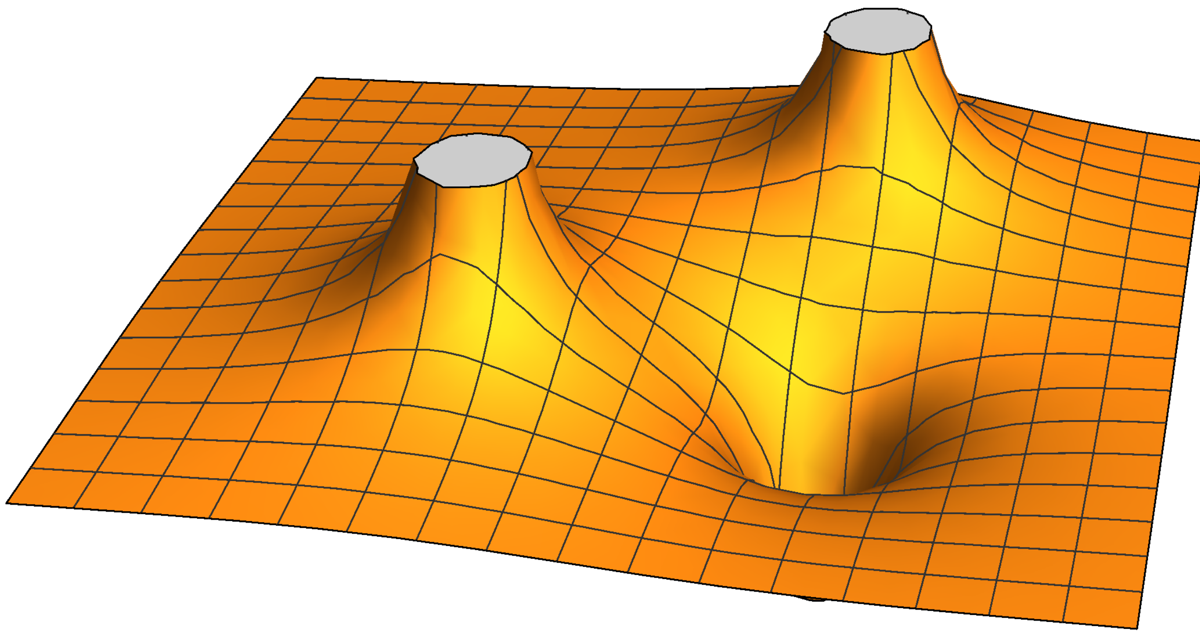


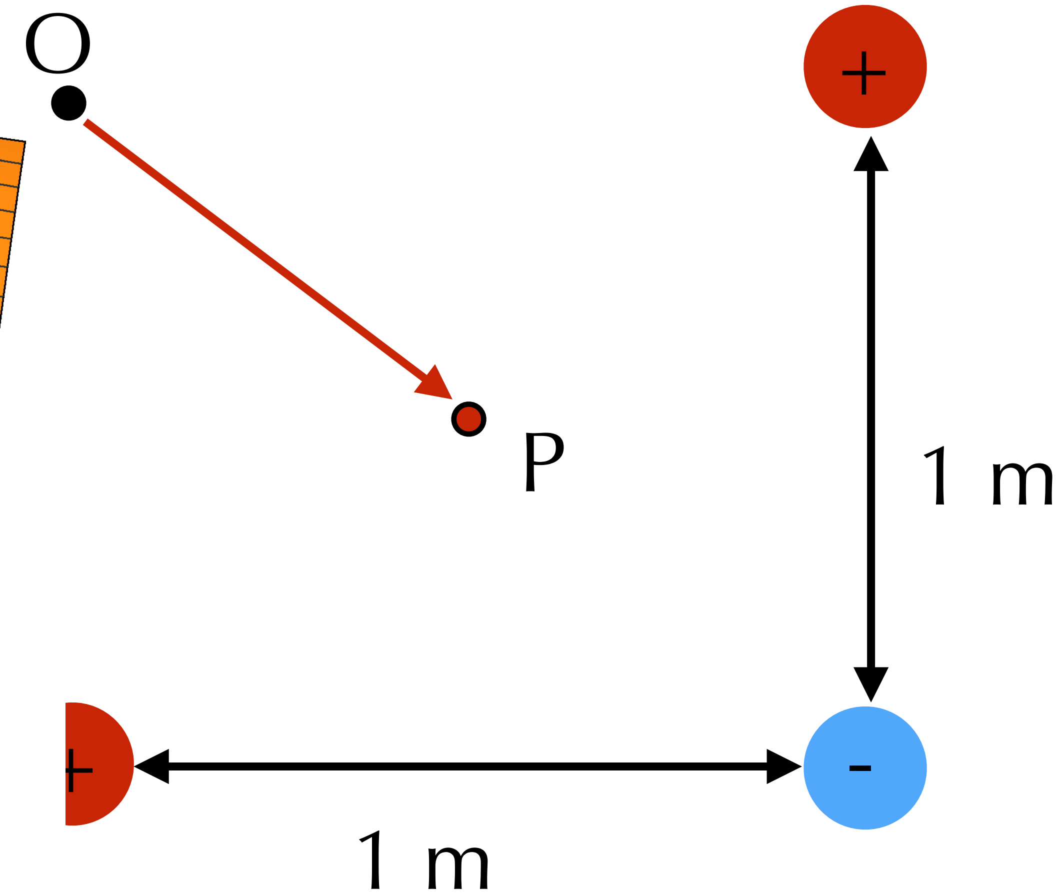


Find the potential difference between point O and point P.

Electric Potential of Point charge

Make a sketch of the electric potential of these three point charges



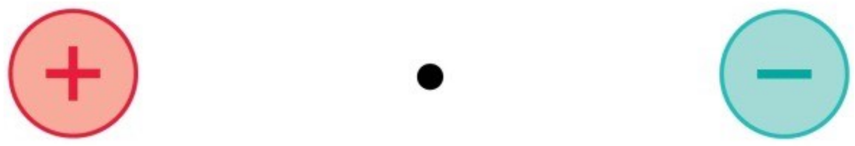


Find the potential difference between point O and point P.

If an electron is placed at O and released, how fast will it be going when it reaches point P?

Question #17

At the midpoint between these two equal but opposite charges,



A. $E = 0$; $V = 0$.

B. $E = 0$; $V > 0$.

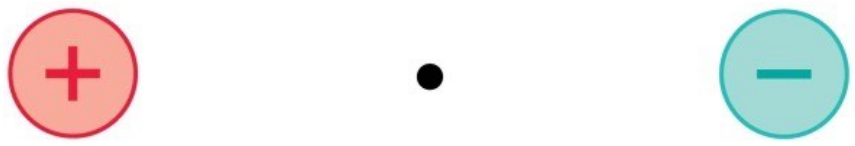
C. $E = 0$; $V < 0$.

D. E points left; $V = 0$.

E. E points right; $V = 0$.

Question #17

At the midpoint between these two equal but opposite charges,



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D. E points left; $V = 0$.

E. E points right; $V = 0$.

Does an electric potential of zero mean anything?

Question #18

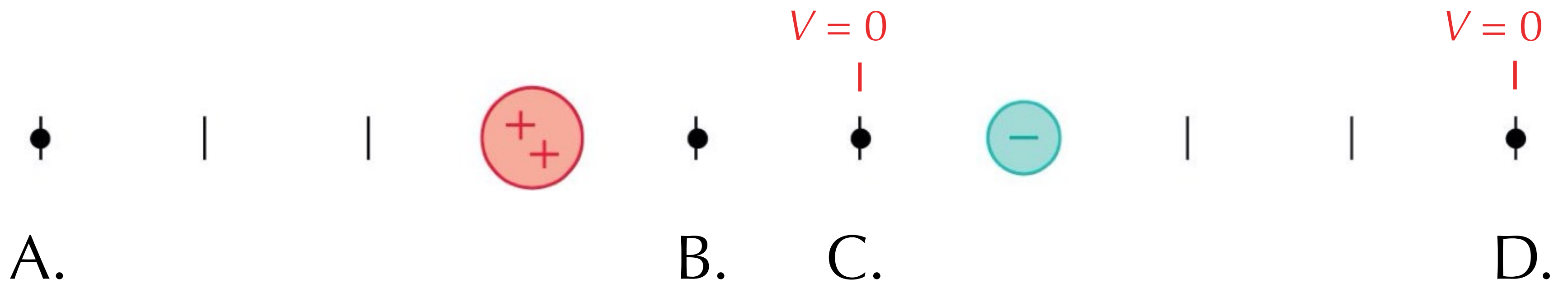
At which point or points is the electric potential zero?

A. B. C. D.

E. More than one of these.

Question #18

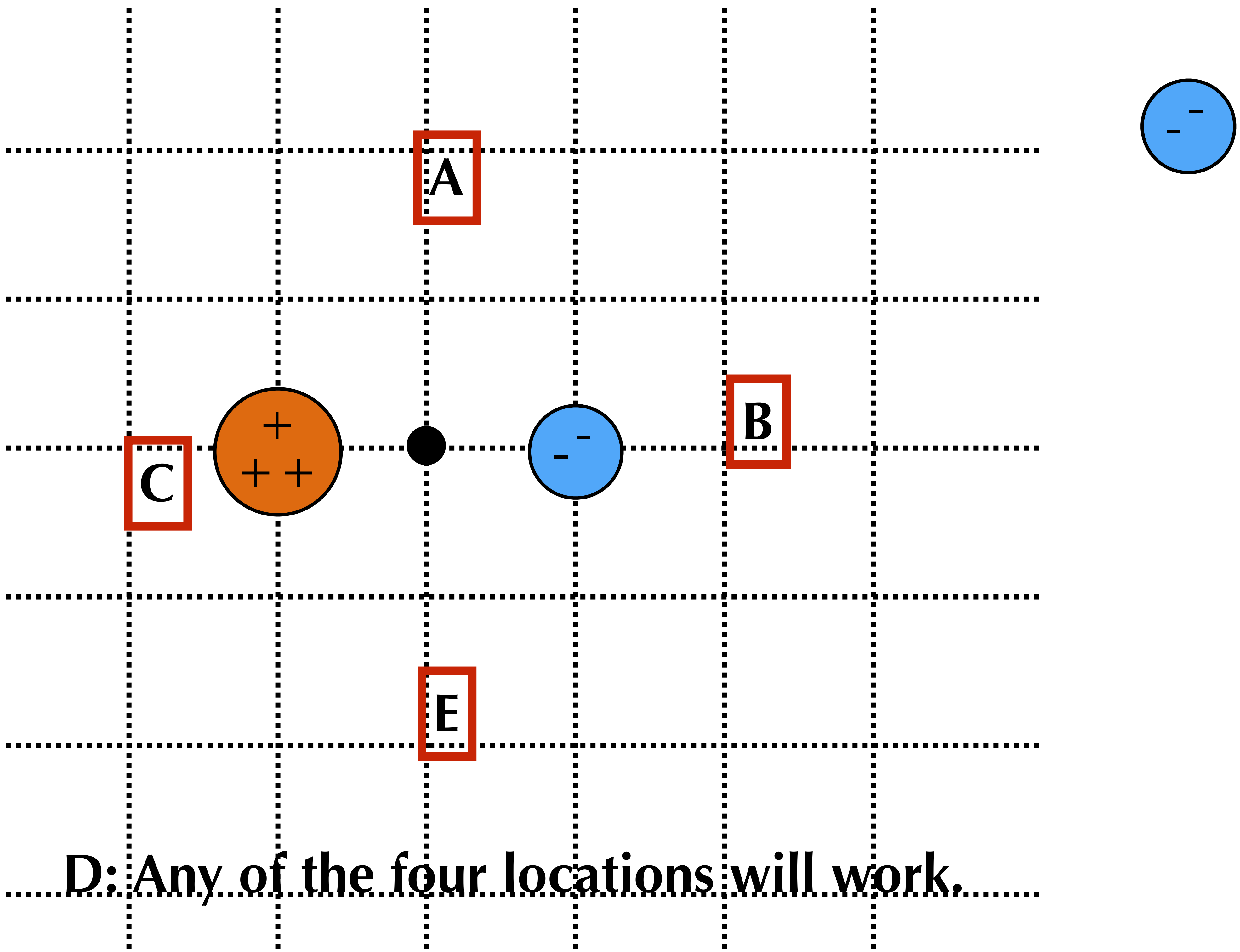
At which point or points is the electric potential zero?



E. More than one of these.

Question #19

Where should I place this charge so that the electric potential at the dot is zero?



D: Any of the four locations will work.

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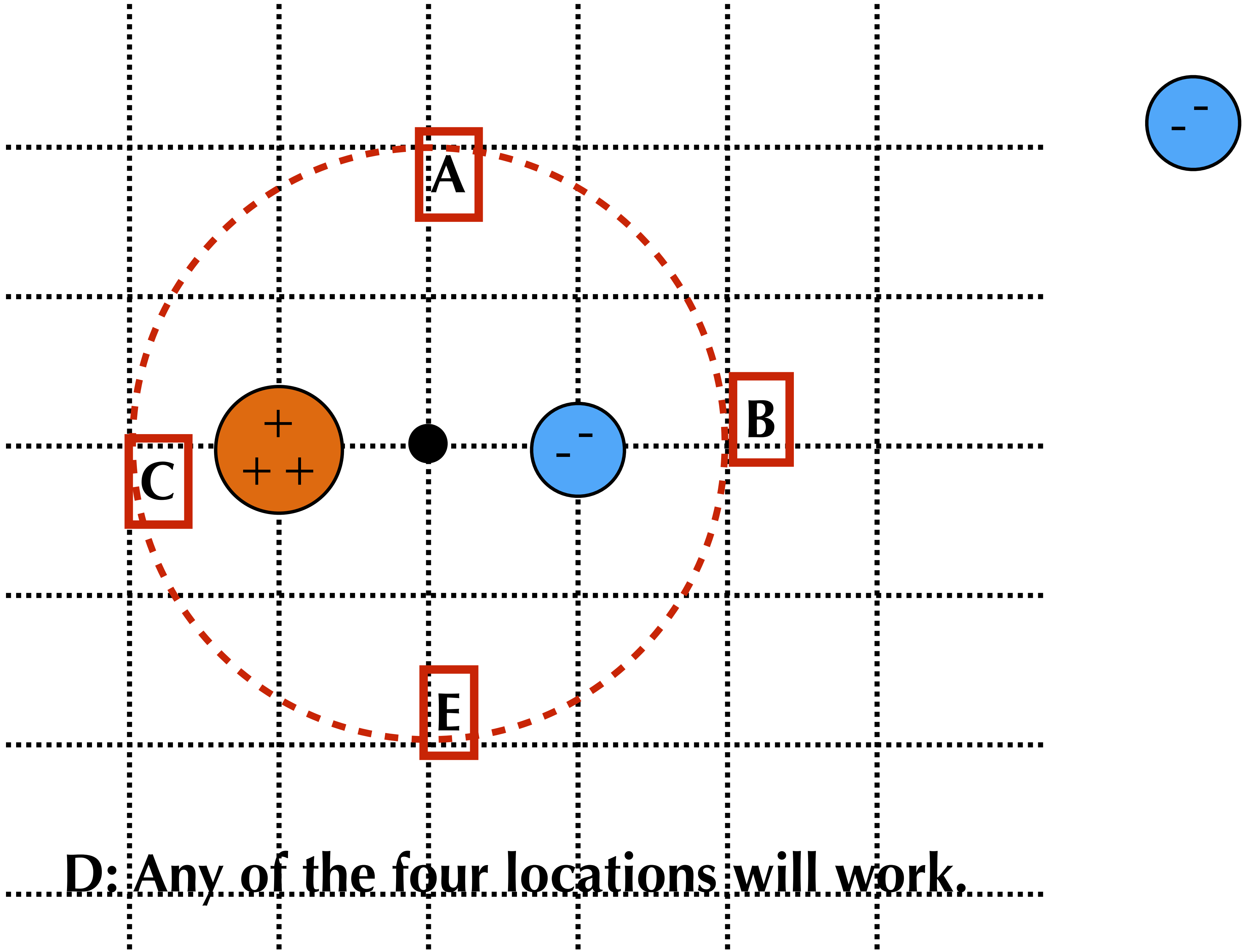
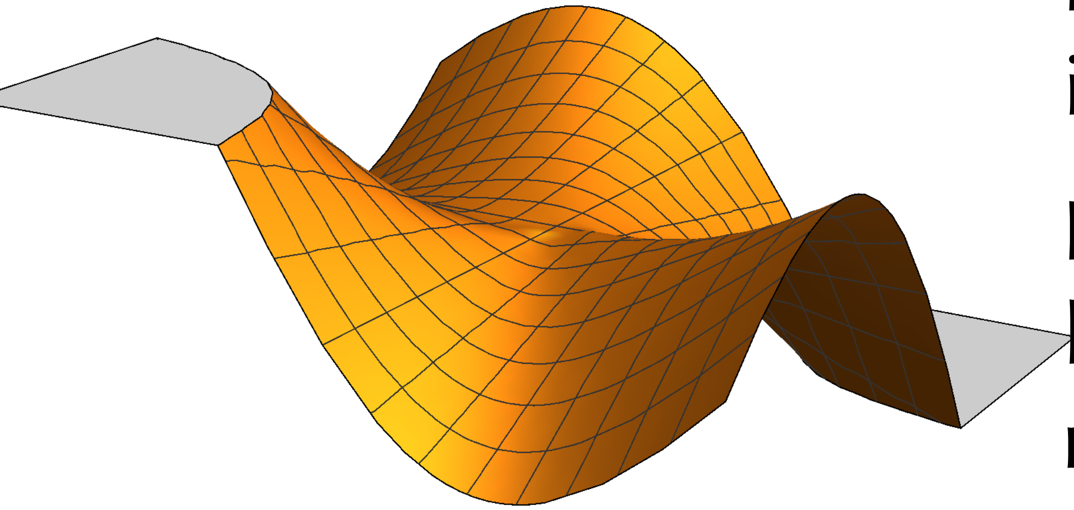
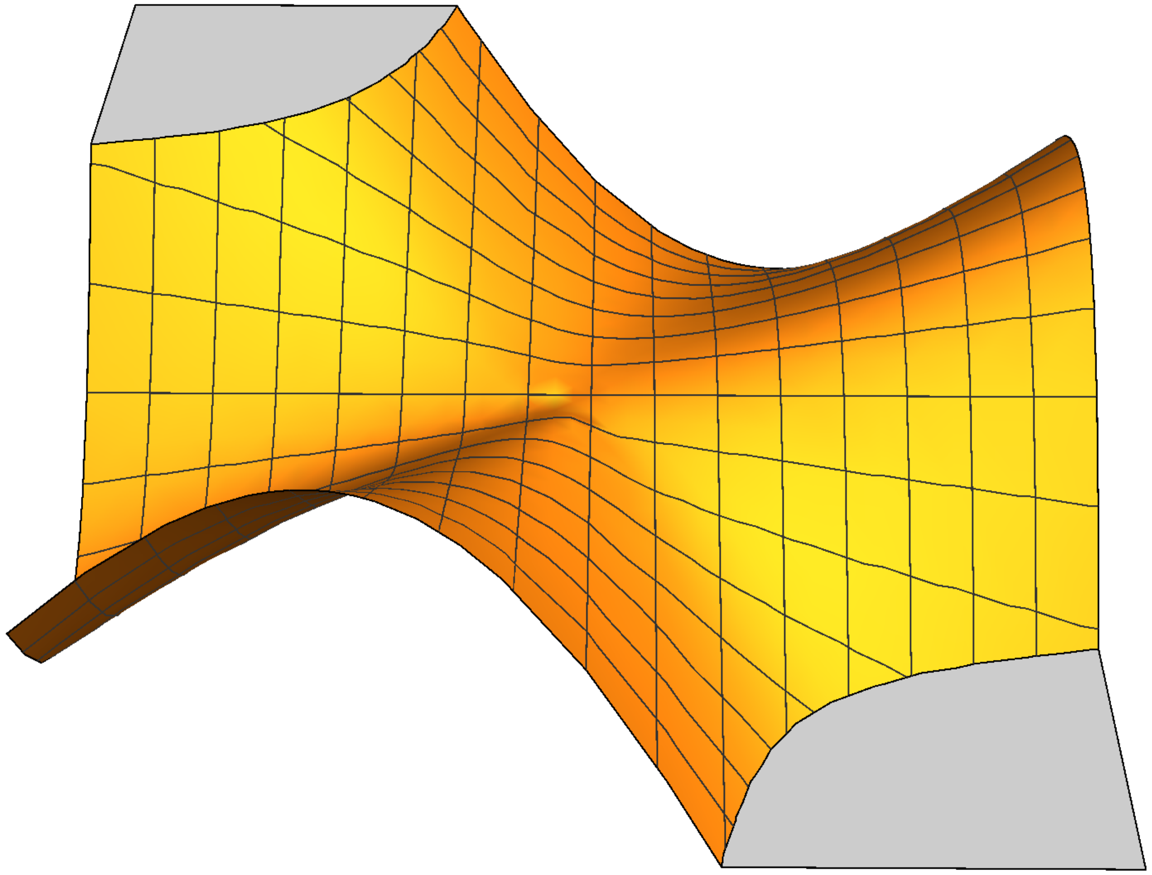
Where should I place this charge so that the electric potential at the dot is zero?



D: Any of the four locations will work.

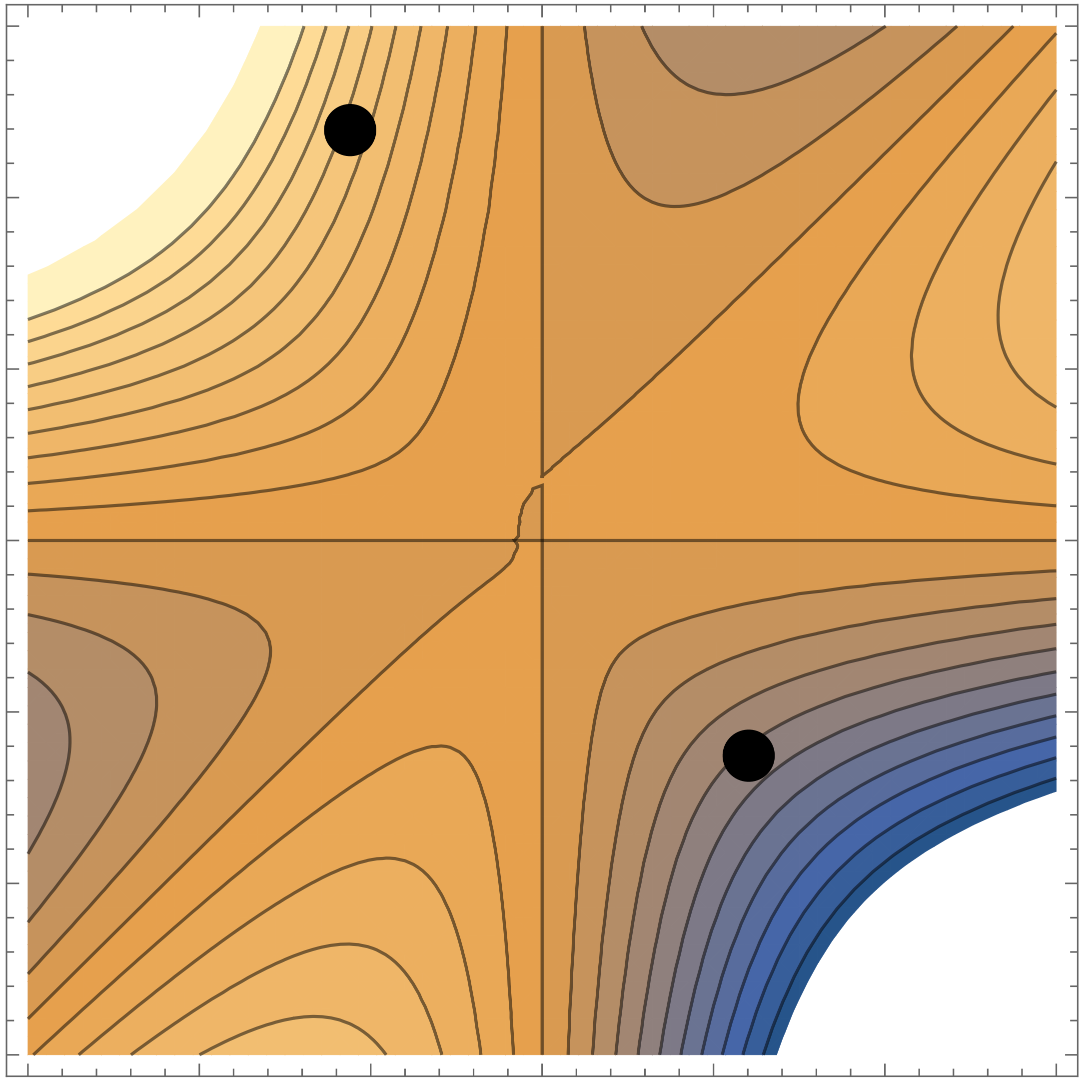
Electric Potential





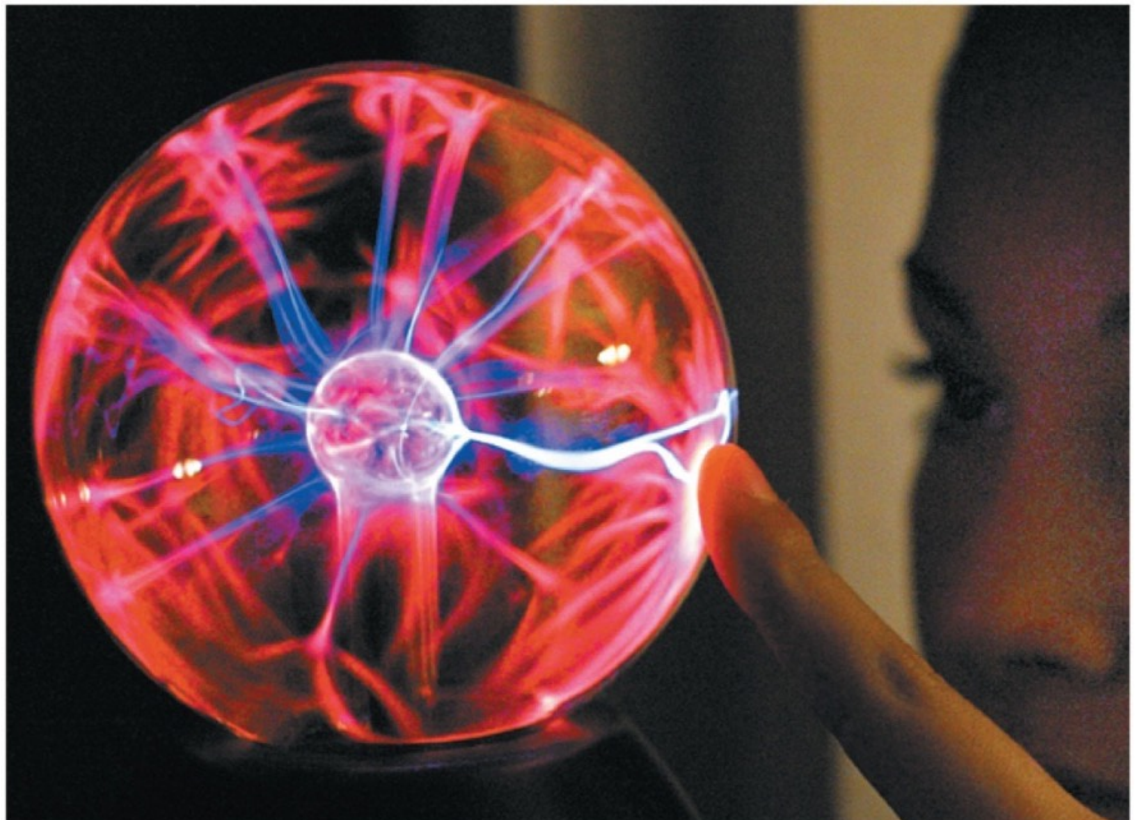
If a proton were placed at these locations, in which direction would it move?

If an electron were placed at these locations, in which direction would it move?



Electric Potential of sphere of charge

$$V = \frac{1}{4\pi\epsilon_0}\frac{Q}{r} \quad \text{outside}$$



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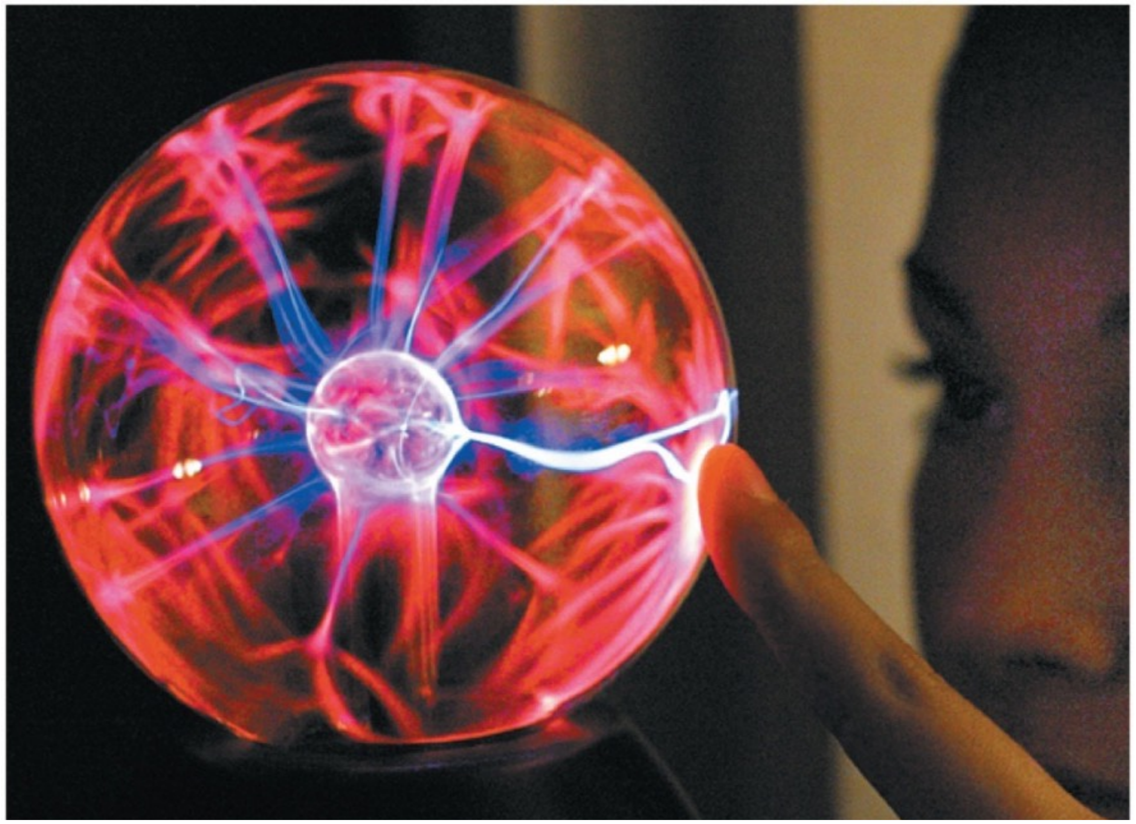
$$V_0 = \frac{1}{4\pi\epsilon_0}\frac{Q}{R}$$



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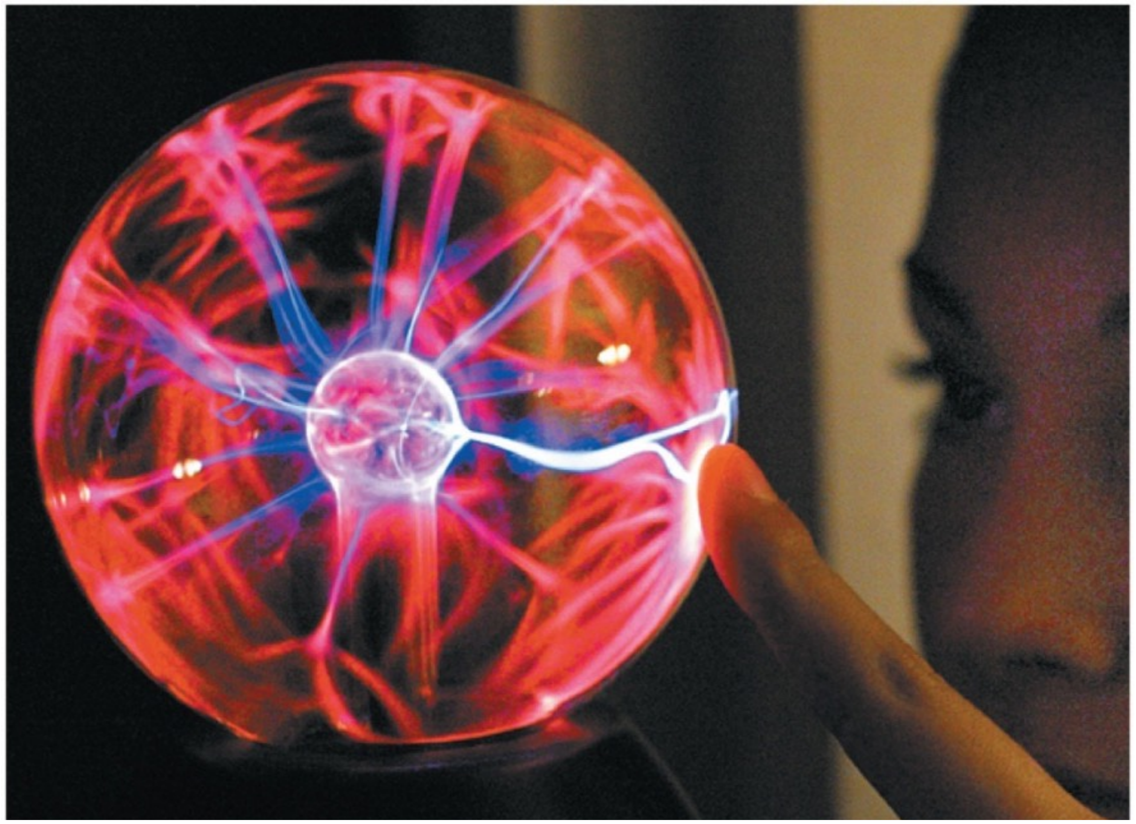


$$V_0 = \frac{1}{4\pi\epsilon_0}\frac{Q}{R}$$

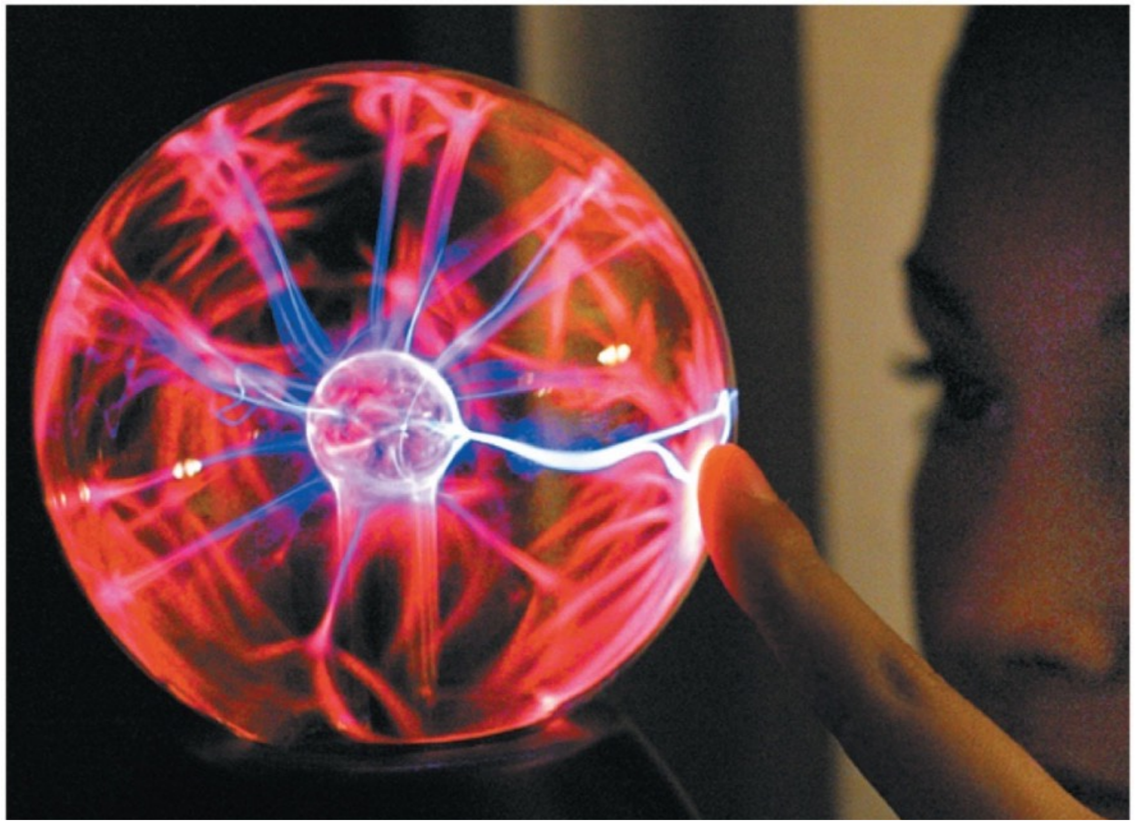
$$Q = V_0 4\pi\epsilon_0 R$$

Electric Potential of sphere of charge

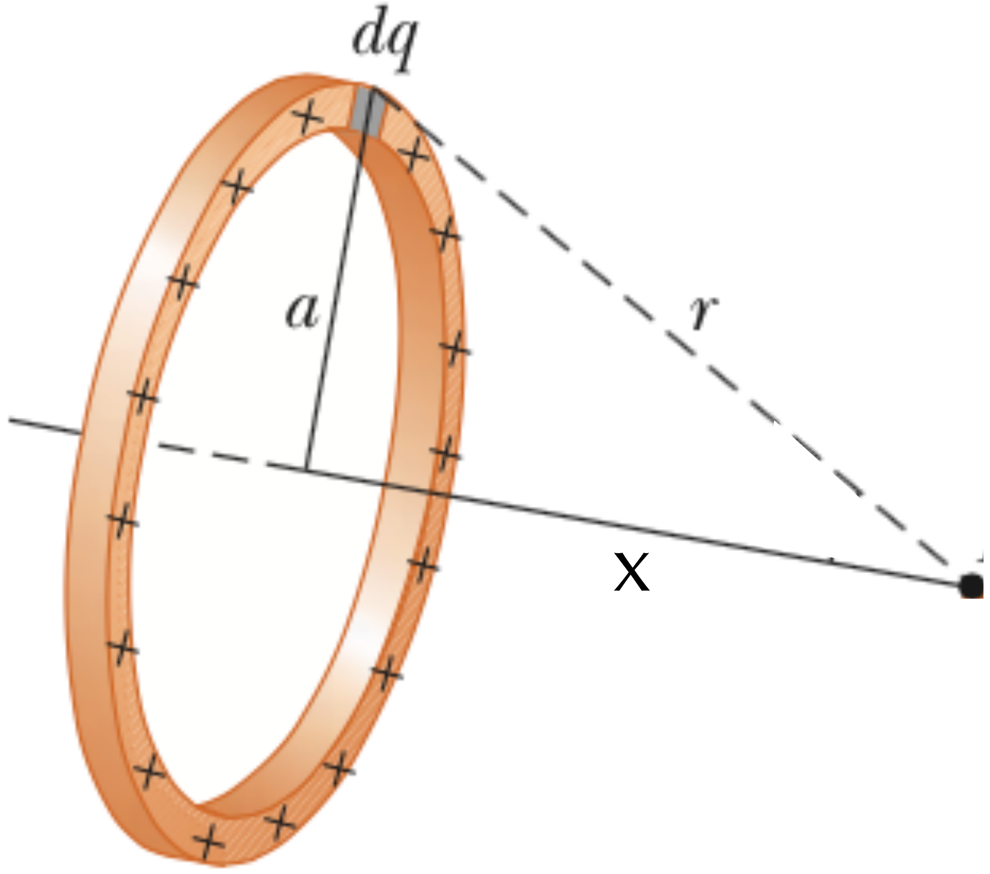
$$V = \frac{1}{4\pi\epsilon_0}\frac{Q}{r}$$ outside

$$V_0 = \frac{1}{4\pi\epsilon_0}\frac{Q}{R}$$

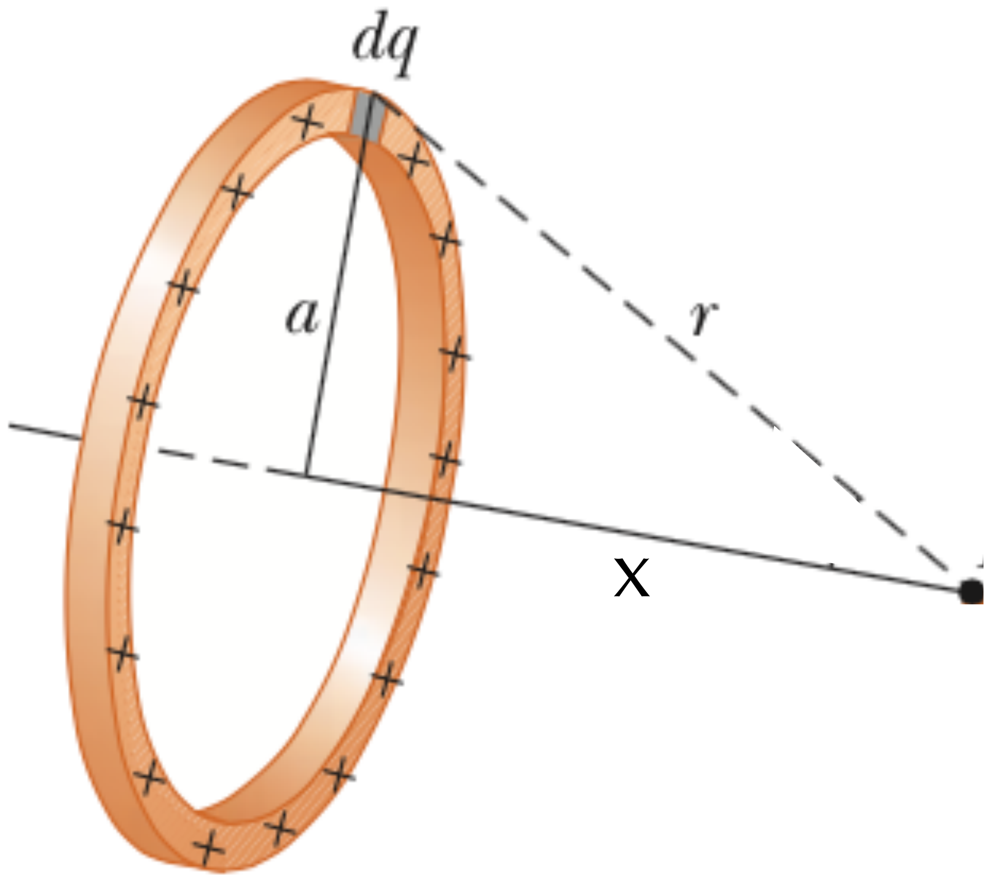
$$Q = V_0 4\pi\epsilon_0 R$$



$$V = \frac{R}{r}V_0$$ potential of a charged sphere



Can you calculate the electric potential due to this ring of charge?



Can you calculate the electric potential due to this ring of charge?

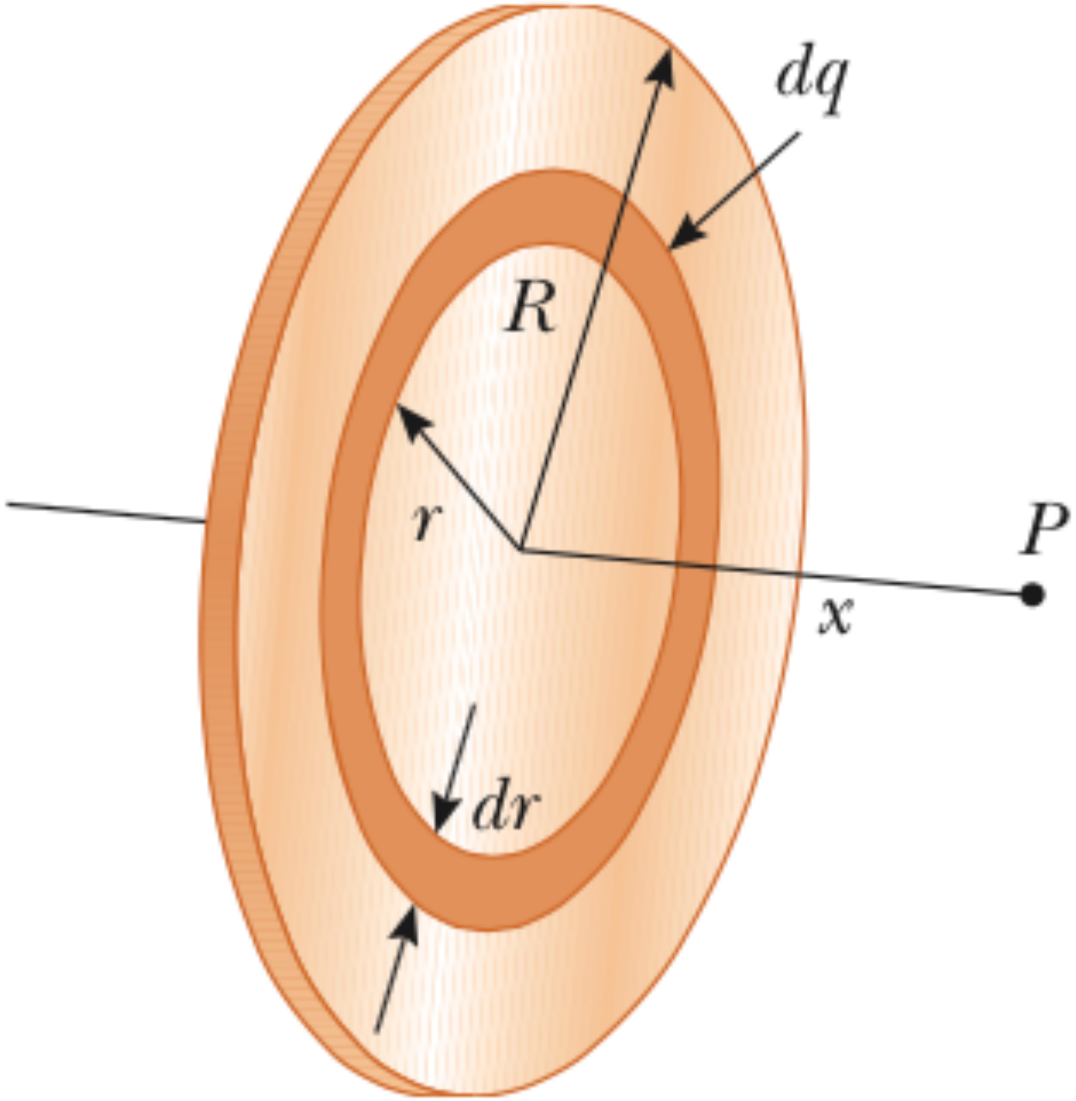
$$V = \frac{kq}{\sqrt{x^2 + a^2}}$$

$R = 17.5$ mm

$Q = +\,5.00$ nC

Find the potential of this disk at x ?

Evaluate at x=0 and x = 1.00 cm.



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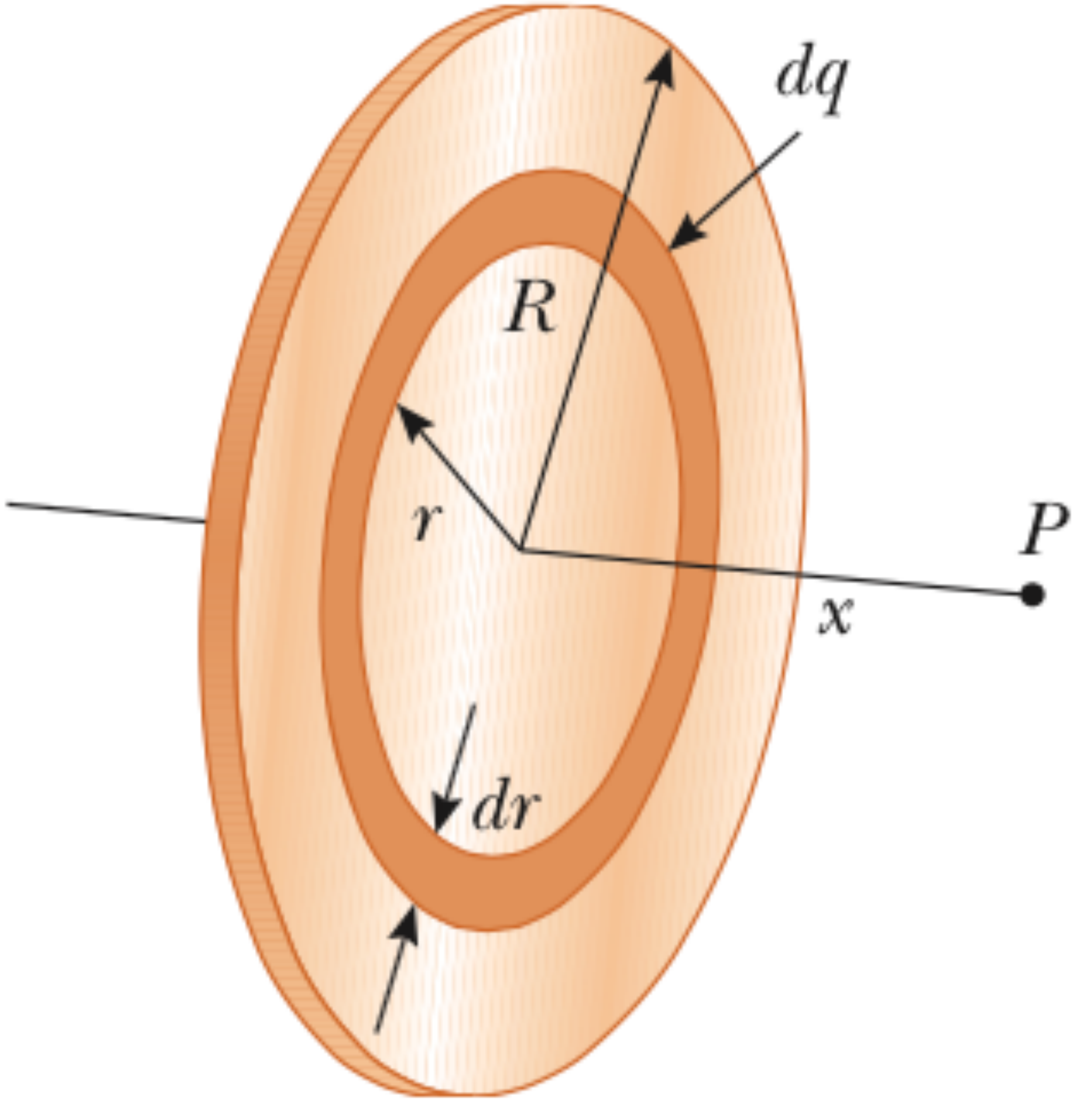

Evaluate at x=0 and x = 1.00 cm.

$$V = \frac{Q}{2\pi\epsilon_0 R^2}(\sqrt{R^2 + x^2} - x)$$

$$\rho = \frac{Q}{V} \qquad \lambda = \frac{Q}{L}$$

$$\int \vec{E} \cdot d\vec{A} = \frac{q_{\mathrm{in}}}{\epsilon_0}$$

$$\vec{E} = \frac{kq}{r^2}\hat{r}$$

$$\Phi_e = \int \vec{E} \cdot d\vec{A}$$

$$U = \frac{kq_1 q_2}{r}$$

$$U = Vq$$

$$V = \frac{kq}{r}$$

$$dV = \frac{kdq}{r}$$

$$\vec{\tau} = \vec{p} \times \vec{E}$$

$$\eta = \frac{Q}{A}$$

$$U = -\vec{p} \cdot \vec{E}$$

$$dE = \frac{kdq}{r^2}$$

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

$\boxed{9}$ $$\int \vec{E} \cdot d\vec{A} = \frac{q_{\text{in}}}{\epsilon_0}$$

$\boxed{2}$ $$\rho = \frac{Q}{V}$$

$$\lambda = \frac{Q}{L}$$ $\boxed{5}$

$$\vec{E} = \frac{kq}{r^2}\hat{r}$$ $\boxed{14}$

$\boxed{11}$ $$\Phi_e = \int \vec{E} \cdot d\vec{A}$$

$$U = \frac{kq_1 q_2}{r}$$ $\boxed{1}$

$$U = Vq$$ $\boxed{13}$

$\boxed{6}$ $$\vec{\tau} = \vec{p} \times \vec{E}$$

$$V = \frac{kq}{r}$$ $\boxed{10}$

$$dV = \frac{kdq}{r}$$ $\boxed{8}$

$\boxed{3}$ $$dE = \frac{kdq}{r^2}$$

$$\eta = \frac{Q}{A}$$ $\boxed{7}$

$$U = -\vec{p} \cdot \vec{E}$$ $\boxed{4}$

$$\vec{F} = \vec{E}q$$ $\boxed{12}$