

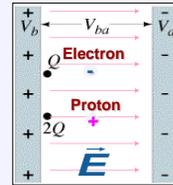
ConcepTest Clicker Questions
Chapter 20

Physics, 4th Edition
James S. Walker

Question 20.1a Electric Potential Energy I

A **proton** and an **electron** are in a constant electric field created by oppositely charged plates. You release the **proton** from the **positive** side and the **electron** from the **negative** side. Which feels the larger electric force?

- a) proton
- b) electron
- c) both feel the same force
- d) neither – there is no force
- e) they feel the same magnitude force but opposite direction

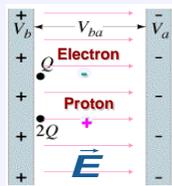


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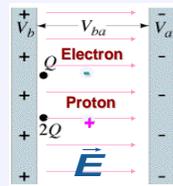
Since $F = qE$ and the proton and electron have the **same charge in magnitude**, they both experience the **same force**. However, the forces point in **opposite directions** because the proton and electron are **oppositely charged**.



Question 20.1b Electric Potential Energy II

A **proton** and an **electron** are in a constant electric field created by oppositely charged plates. You release the **proton** from the **positive** side and the **electron** from the **negative** side. Which has the larger acceleration?

- a) proton
- b) electron
- c) both feel the same acceleration
- d) neither – there is no acceleration
- e) they feel the same magnitude acceleration but opposite direction

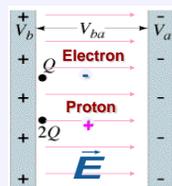


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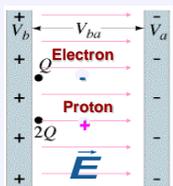
Since $F = ma$ and the **electron is much less massive** than the proton, the **electron experiences the larger acceleration**.



Question 20.1c Electric Potential Energy III

A **proton** and an **electron** are in a constant electric field created by oppositely charged plates. You release the **proton** from the **positive** side and the **electron** from the **negative** side. When it strikes the opposite plate, which one has more KE?

- a) proton
- b) electron
- c) both acquire the same KE
- d) neither – there is no change of KE
- e) they both acquire the same KE but with opposite signs

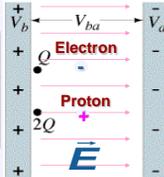


Question 20.1c Electric Potential Energy III

A proton and an electron are in a constant electric field created by oppositely charged plates. You release the proton from the positive side and the electron from the negative side. When it strikes the opposite plate, which one has more KE?

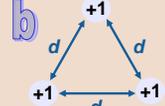
- a) proton
- b) electron
- c) both acquire the same KE
- d) neither – there is no change of KE
- e) they both acquire the same KE but with opposite signs

Since $PE = qV$ and the proton and electron have the same charge in magnitude, they both have the same electric potential energy initially. Because energy is conserved, they both must have the same kinetic energy after they reach the opposite plate.



Question 20.2 Work and Potential Energy

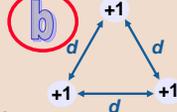
Which group of charges took more work to bring together from a very large initial distance apart?



- c Both took the same amount of work.

Question 20.2 Work and Potential Energy

Which group of charges took more work to bring together from a very large initial distance apart?



- c Both took the same amount of work.

The work needed to assemble a collection of charges is the same as the total PE of those charges:

$$PE = k \frac{Q_1 Q_2}{r} \quad \text{added over all pairs}$$

For case 1: only 1 pair

$$PE = k \frac{(+2)(+1)}{d} = k \frac{2}{d}$$

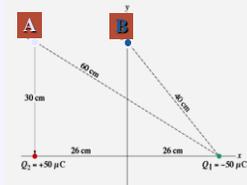
For case 2: there are 3 pairs

$$PE = 3k \frac{(+1)(+1)}{d} = 3k \frac{1}{d}$$

Question 20.3a Electric Potential I

What is the electric potential at point A?

- a) $V > 0$
- b) $V = 0$
- c) $V < 0$

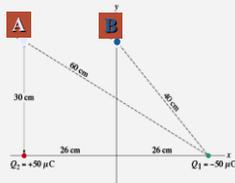


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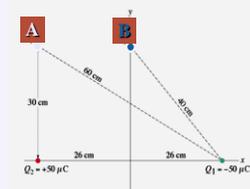
Since Q_2 (which is positive) is closer to point A than Q_1 (which is negative) and since the total potential is equal to $V_1 + V_2$, the total potential is positive.



Question 20.3b Electric Potential II

What is the electric potential at point B?

- a) $V > 0$
- b) $V = 0$
- c) $V < 0$



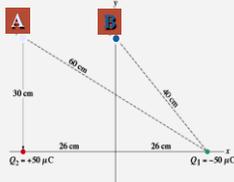
Question 20.3b Electric Potential II

What is the electric potential at point B?

- a) $V > 0$
- b) $V = 0$
- c) $V < 0$

Since Q_2 and Q_1 are equidistant from point B, and since they have equal and opposite charges, the total potential is **zero**.

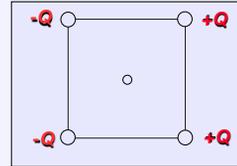
Follow-up: What is the potential at the origin of the $x y$ axes?



Question 20.4 Hollywood Square

Four point charges are arranged at the corners of a square. Find the electric field E and the potential V at the center of the square.

- a) $E = 0$ $V = 0$
- b) $E = 0$ $V \neq 0$
- c) $E \neq 0$ $V \neq 0$
- d) $E \neq 0$ $V = 0$
- e) $E = V$ regardless of the value



Question 20.4 Hollywood Square

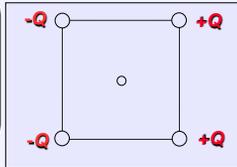
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The **potential is zero**: the scalar contributions from the two positive charges cancel the two minus charges.

However, the contributions from the electric field add up as vectors, and they do not cancel (so **it is non-zero**).

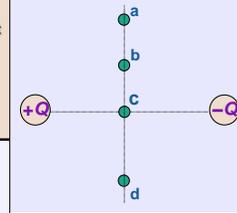
Follow-up: What is the direction of the electric field at the center?



Question 20.5a Equipotential Surfaces I

At which point does $V = 0$?

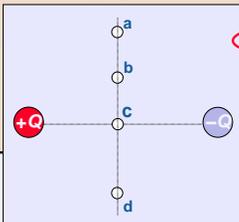
- e) all of them



Question 20.5a Equipotential Surfaces I

At which point does $V = 0$?

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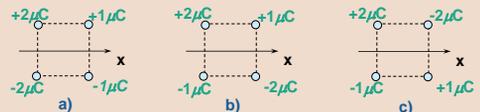


All of the points are equidistant from both charges. Since the charges are equal and opposite, their contributions to the potential **cancel out everywhere** along the mid-plane between the charges.

Follow-up: What is the direction of the electric field at all 4 points?

Question 20.5b Equipotential Surfaces II

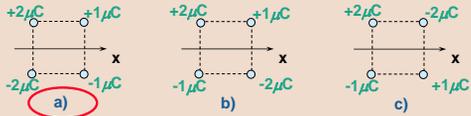
Which of these configurations gives $V = 0$ at all points on the x axis?



- d) all of the above
- e) none of the above

Question 20.5b Equipotential Surfaces II

Which of these configurations gives $V = 0$ at all points on the x axis?

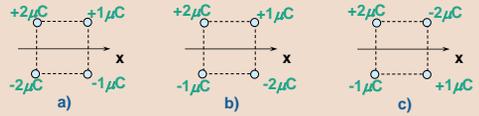


- d) all of the above e) none of the above

Only in case (1), where opposite charges lie directly across the x axis from each other, do the potentials from the two charges above the x axis cancel the ones below the x axis.

Question 20.5c Equipotential Surfaces III

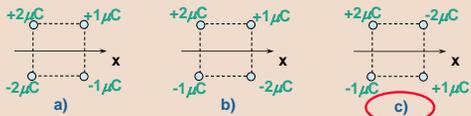
Which of these configurations gives $V = 0$ at all points on the y axis?



- d) all of the above e) none of the above

Question 20.5c Equipotential Surfaces III

Which of these configurations gives $V = 0$ at all points on the y axis?



- d) all of the above e) none of the above

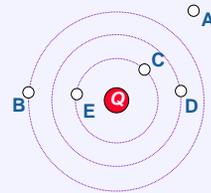
Only in case (3), where opposite charges lie directly across the y axis from each other, do the potentials from the two charges above the y axis cancel the ones below the y axis.

Follow-up: Where is $V = 0$ for configuration #2?

Question 20.6 Equipotential of Point Charge

Which two points have the same potential?

- a) A and C
b) B and E
c) B and D
d) C and E
e) no pair



Question 20.6 Equipotential of Point Charge

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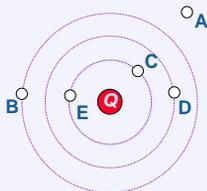
- a) A and C
b) B and E
c) B and D
d) C and E
e) no pair

Since the potential of a point charge is:

$$V = k \frac{Q}{r}$$

only points that are at the same distance from charge Q are at the same potential. This is true for points C and E.

They lie on an equipotential surface.

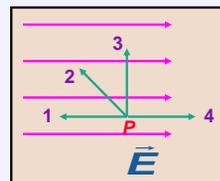


Follow-up: Which point has the smallest potential?

Question 20.7a Work and Electric Potential

Which requires the *most work*, to move a **positive charge** from P to points 1, 2, 3 or 4? All points are the same distance from P .

- a) $P \rightarrow 1$
b) $P \rightarrow 2$
c) $P \rightarrow 3$
d) $P \rightarrow 4$
e) all require the same amount of work

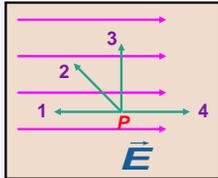


Question 20.7a Work and Electric Potential I

Which requires the **most work**, to move a **positive charge** from **P** to points **1, 2, 3 or 4**? All points are the same distance from **P**.

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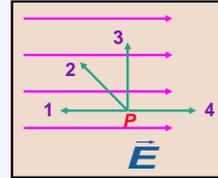
For **path #1**, you have to push the positive charge **against** the **E** field, which is **hard to do**. By contrast, path #4 is the easiest, since the field does all the work.



Question 20.7b Work and Electric Potential II

Which requires **zero work**, to move a **positive charge** from **P** to points **1, 2, 3 or 4**? All points are the same distance from **P**.

- a) $P \rightarrow 1$
- b) $P \rightarrow 2$
- c) $P \rightarrow 3$
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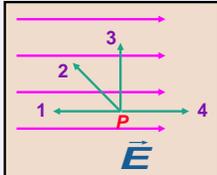


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- c) $P \rightarrow 3$
- d) $P \rightarrow 4$
- e) all require the same amount of work

For **path #3**, you are moving in a direction perpendicular to the field lines. This means you are moving along an equipotential, which requires no work (by definition).



Follow-up: Which path requires the least work?

Question 20.8 Capacitors

Capacitor C_1 is connected across a battery of **5 V**. An identical capacitor C_2 is connected across a battery of **10 V**. Which one has more charge?

- a) C_1
- b) C_2
- c) both have the same charge
- d) it depends on other factors

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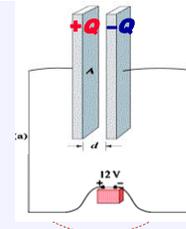
- a) C_1
- b) C_2
- c) both have the same charge
- d) it depends on other factors

Since $Q = CV$ and the two capacitors are identical, the one that is connected to the **greater voltage** has more **charge**, which is C_2 in this case.

Question 20.9a Varying Capacitance I

What must be done to a capacitor in order to increase the amount of charge it can hold (for a constant voltage)?

- a) increase the area of the plates
- b) decrease separation between the plates
- c) decrease the area of the plates
- d) either a) or b)
- e) either b) or c)

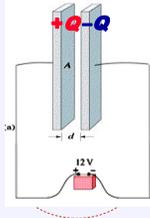


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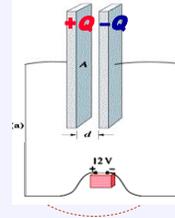
Since $Q = C\Delta V$ in order to increase the charge that a capacitor can hold at constant voltage, one has to **increase its capacitance**. Since the capacitance is given by $C = \epsilon_0 \frac{A}{d}$, that can be done by either **increasing A** or **decreasing d**.



Question 20.9b Varying Capacitance II

A parallel-plate capacitor initially has a voltage of 400 V and **stays connected to the battery**. If the plate spacing is now **doubled**, what happens?

- a) the voltage decreases
- b) the voltage increases
- c) the charge decreases
- d) the charge increases
- e) both voltage and charge change

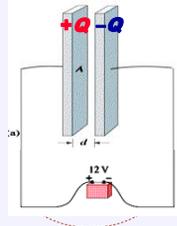


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- b) the voltage increases
- c) the charge decreases**
- d) the charge increases
- e) both voltage and charge change

Since the battery stays connected, the **voltage must remain constant!** Since $C = \epsilon_0 \frac{A}{d}$, when the spacing d is doubled, the capacitance C is halved. And since $Q = C\Delta V$, that means the **charge must decrease**.

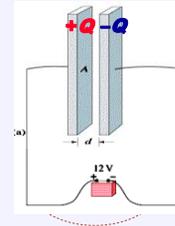


Follow-up: How do you increase the charge?

Question 20.9c Varying Capacitance III

A parallel-plate capacitor initially has a potential difference of 400 V and is then disconnected from the charging battery. If the plate spacing is now **doubled** (without changing Q), what is the new value of the voltage?

- a) 100 V
- b) 200 V
- c) 400 V
- d) 800 V
- e) 1600 V



Question 20.9c Varying Capacitance III

A parallel-plate capacitor initially has a potential difference of 400 V and is then disconnected from the charging battery. If the plate spacing is now **doubled** (without changing Q), what is the new value of the voltage?

- a) 100 V
- b) 200 V
- c) 400 V
- d) 800 V**
- e) 1600 V

Once the battery is disconnected, Q has to remain constant, since no charge can flow either to or from the battery. Since $C = \epsilon_0 \frac{A}{d}$, when the spacing d is doubled, the capacitance C is halved. And since $Q = C\Delta V$ that means the **voltage must double**.

