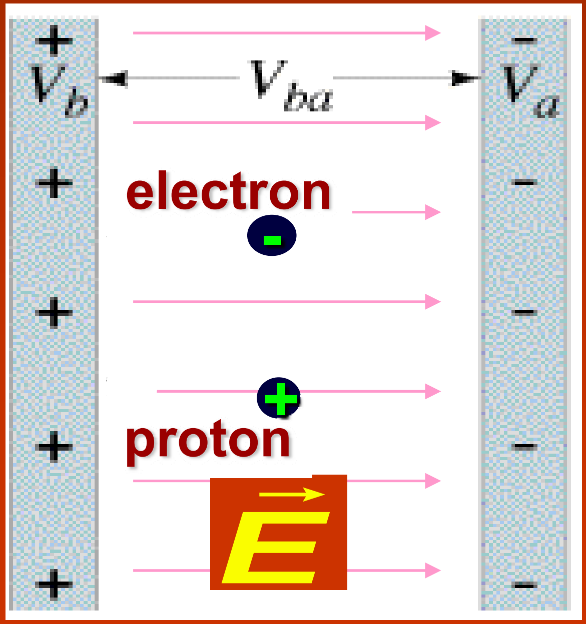
# ConcepTest 24.1a Electric Potential Energy I

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?

1) proton
2) electron
3) both feel the same force
4) neither – there is no force
5) they feel the same magnitude force but opposite direction

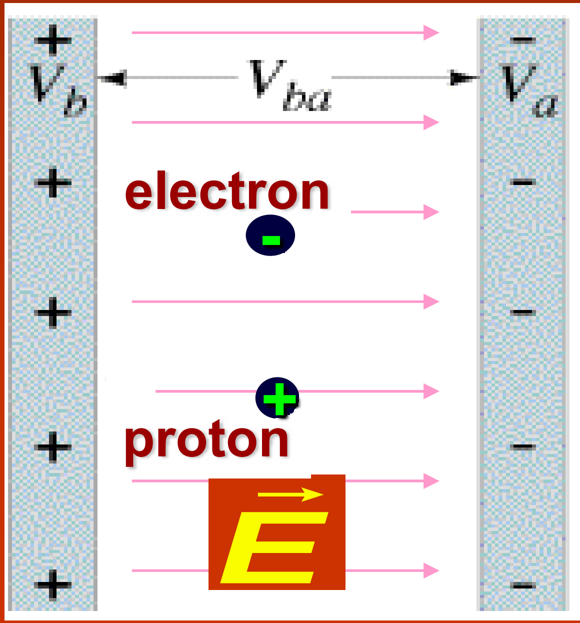


# *ConcepTest 24.1a* Electric Potential Energy I

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?

1) proton
2) electron
3) both feel the same force
4) neither – there is no force
5) they feel the same magnitude force but opposite direction

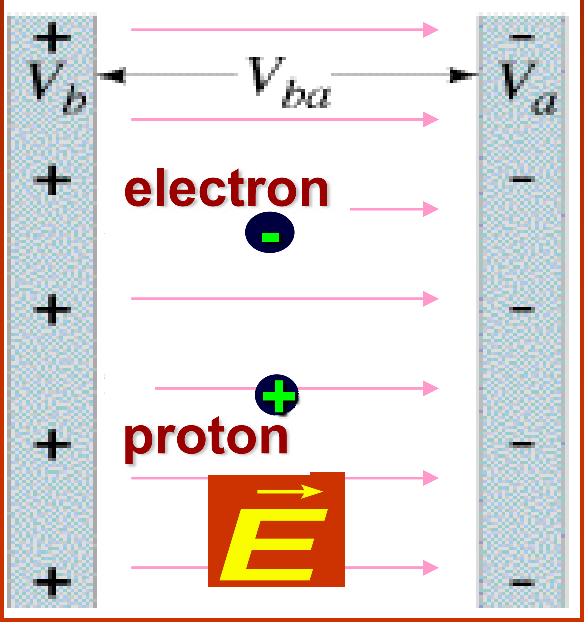
Since $F = qE$ and the proton and electron have the same charge in magnitude, they both experience the same force. However, the forces point in opposite directions because the proton and electron are oppositely charged.



# ConcepTest 24.1b 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?

1) proton
2) electron
3) both feel the same acceleration
4) neither – there is no acceleration
5) they feel the same magnitude acceleration but opposite direction

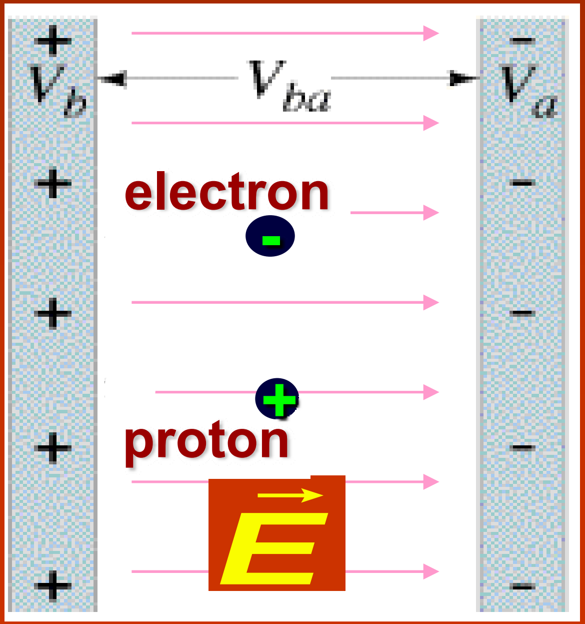


# *ConcepTest 24.1b* Electric Potential Energy II

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?

1) proton
2) electron
3) both feel the same acceleration
4) neither – there is no acceleration
5) they feel the same magnitude acceleration but opposite direction

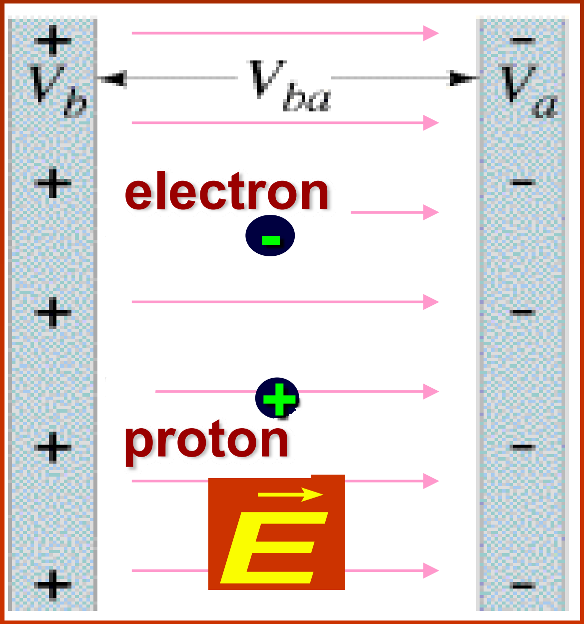
Since $F = ma$ and the electron is much less massive than the proton, then the electron experiences the larger acceleration.



# ConcepTest 24.1c 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?

1) proton
2) electron
3) both acquire the same KE
4) neither – there is no change of KE
5) they both acquire the same KE but with opposite signs

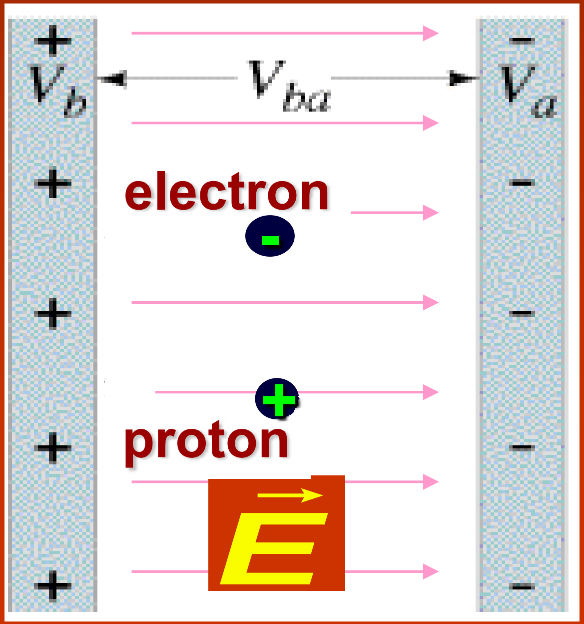


# ConcepTest 24.1c Electric Potential Energy III

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?

1) proton
2) electron
3) both acquire the same KE
4) neither – there is no change of KE
5) they both acquire the same KE but with opposite signs

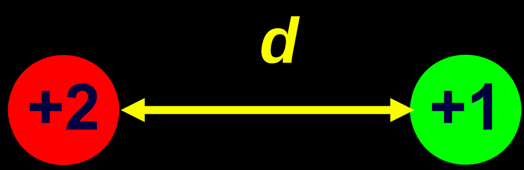
Since PE = $qV$ and the proton and electron have the same charge in magnitude, they both have the same electric potential energy initially. Because energy is conserved, they both must have the same kinetic energy after they reach the opposite plate.



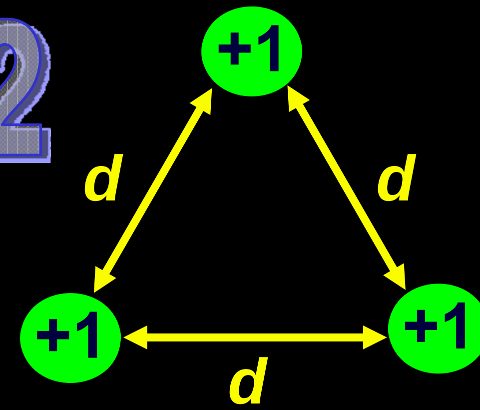
## *ConcepTest 24.2* Work and Potential Energy

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

1




2

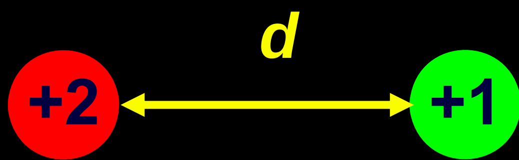



3 **Both took the same amount of work**

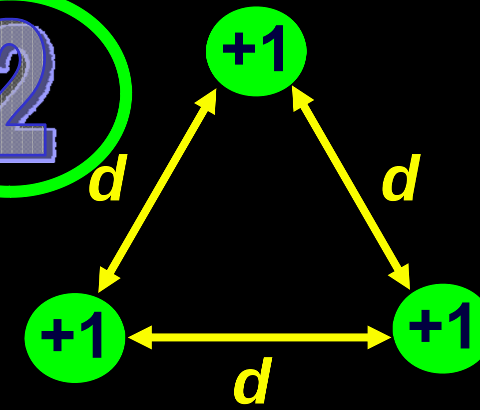
# ConcepTest 24.2 Work and Potential Energy

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

1




2




3 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:

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

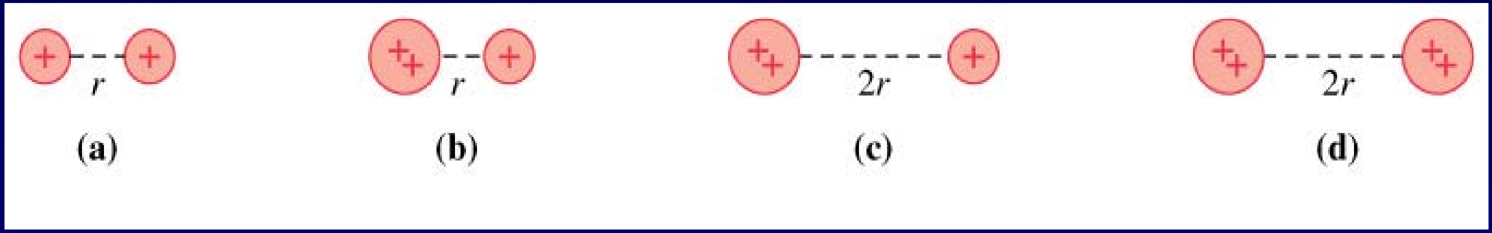
**For case 1:** only 1 pair

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

**For case 2:** there are 3 pairs

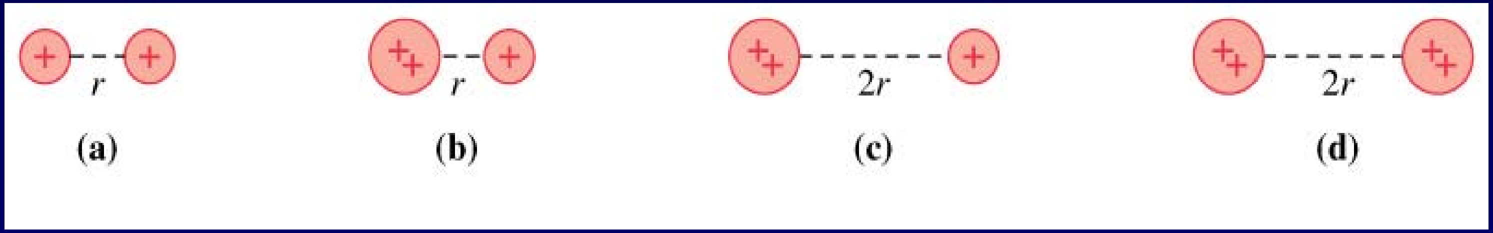
$$PE = 3k\frac{(+1)(+1)}{d} = 3k\frac{1}{d}$$

Rank in order, from largest to smallest, the potential energies $U_a$ to $U_d$ of these four pairs of charges. Each + symbol represents the same amount of charge.




A. $U_a = U_b > U_c = U_d$
B. $U_a = U_c > U_b = U_d$
C. $U_b = U_d > U_a = U_c$
D. $U_d > U_b = U_c > U_a$
E. $U_d > U_c > U_b > U_a$

Rank in order, from largest to smallest, the potential energies $U_a$ to $U_d$ of these four pairs of charges. Each + symbol represents the same amount of charge.




A. $U_a = U_b > U_c = U_d$

B. $U_a = U_c > U_b = U_d$

**C. $U_b = U_d > U_a = U_c$**

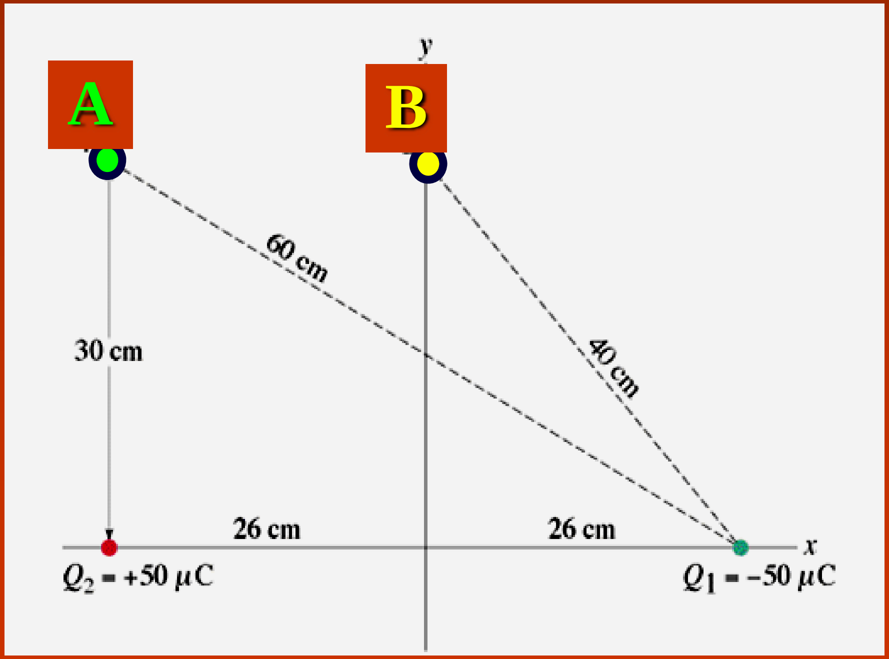
D. $U_d > U_b = U_c > U_a$

E. $U_d > U_c > U_b > U_a$

# ConcepTest 24.3a Electric Potential I

What is the electric potential at point A?

1) $V > 0$
2) $V = 0$
3) $V < 0$

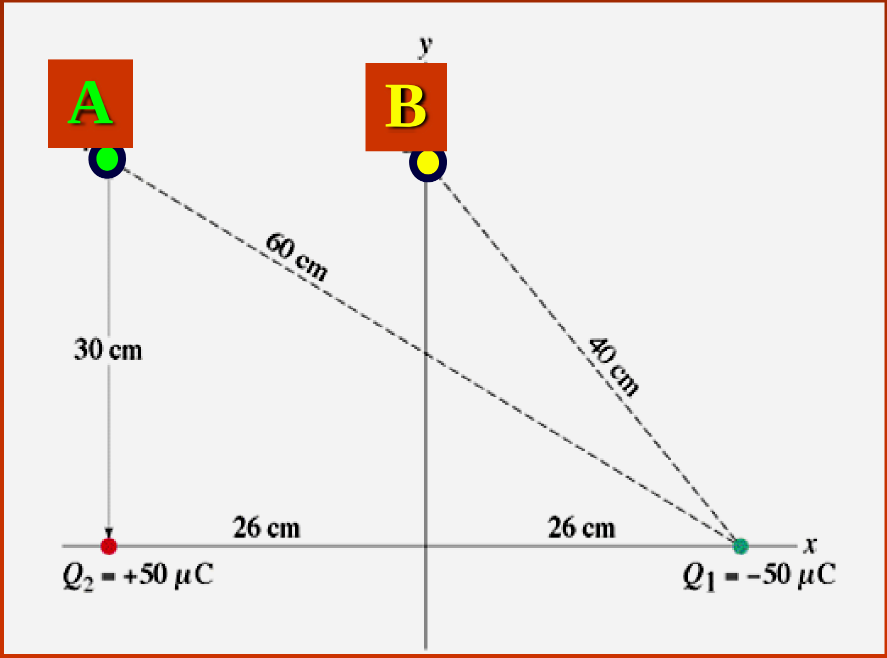


# *ConcepTest 24.3a* Electric Potential I

What is the electric potential at point A?

1) $V > 0$
2) $V = 0$
3) $V < 0$

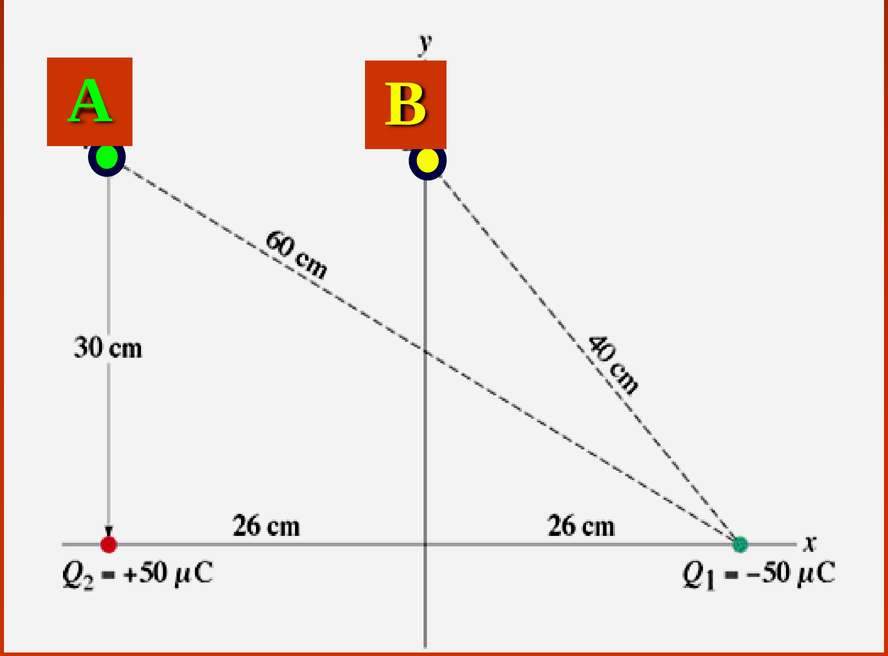
Since $Q_2$ (which is **positive**) is **closer** to point A than $Q_1$ (which is negative) and since the total potential is equal to $V_1 + V_2$, then the total potential is **positive**.



# *ConcepTest 24.3b* Electric Potential II

What is the electric potential at point B?

1) $V > 0$
2) $V = 0$
3) $V < 0$



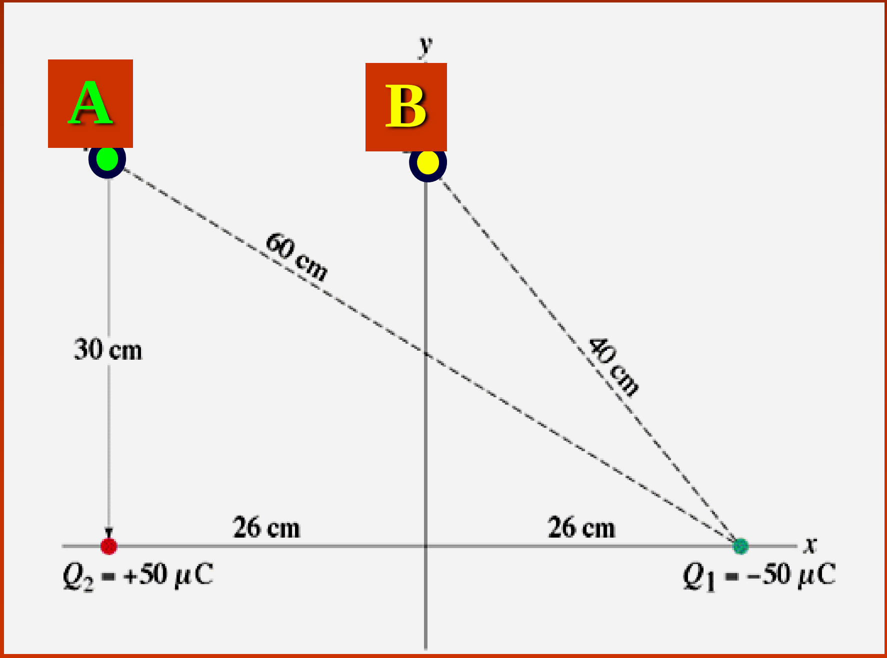
# *ConcepTest 24.3b* Electric Potential II

What is the electric potential at point B?

1) $V > 0$
2) $V = 0$
3) $V < 0$

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

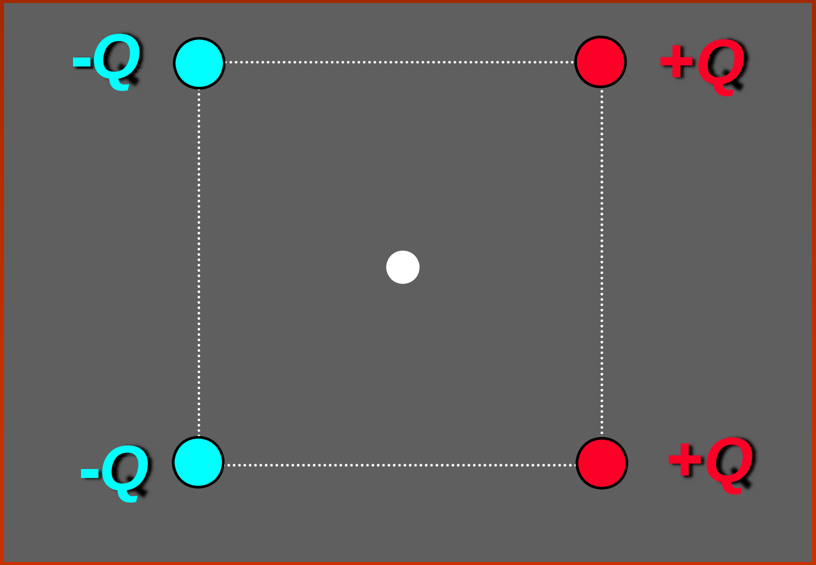
**Follow-up: What is the potential at the origin of the *x-y* axes?**



# *ConcepTest 24.4* 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**.

1) $E = 0 \quad V = 0$
2) $E = 0 \quad V \neq 0$
3) $E \neq 0 \quad V \neq 0$
4) $E \neq 0 \quad V = 0$
5) $E = V$ regardless of the value



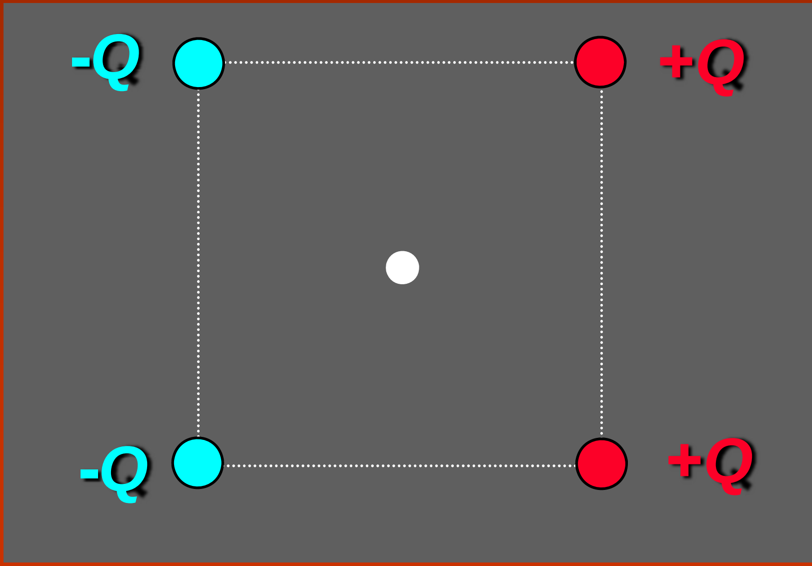
# ConcepTest 24.4 Hollywood Square

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.

1) $E = 0$ $V = 0$
2) $E = 0$ $V \neq 0$
3) $E \neq 0$ $V \neq 0$
4) $E \neq 0$ $V = 0$
5) $E = V$ regardless of the value

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).

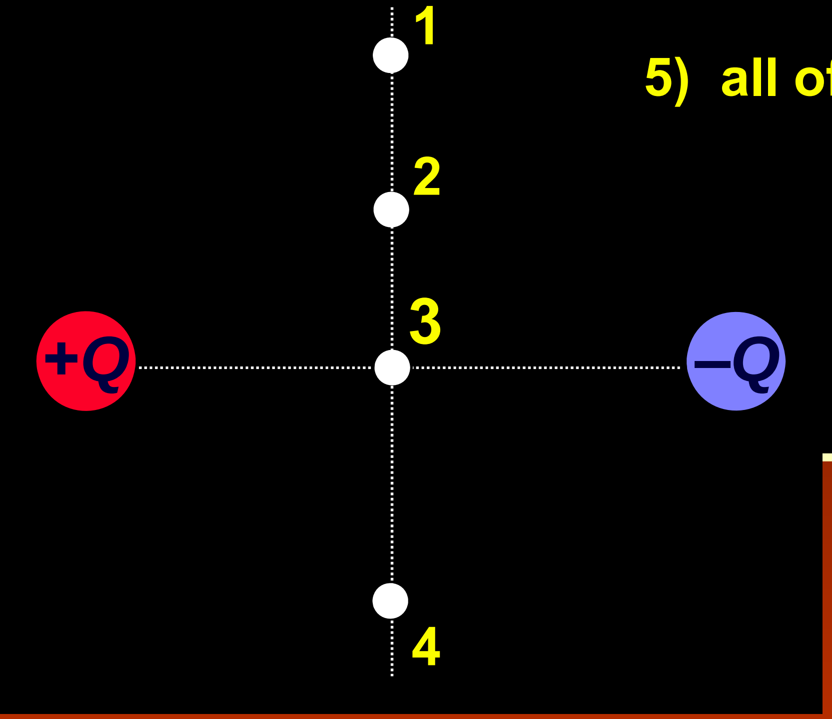



**Follow-up: What is the direction of the electric field at the center?**

# *ConcepTest 24.5a* Equipotential Surfaces I

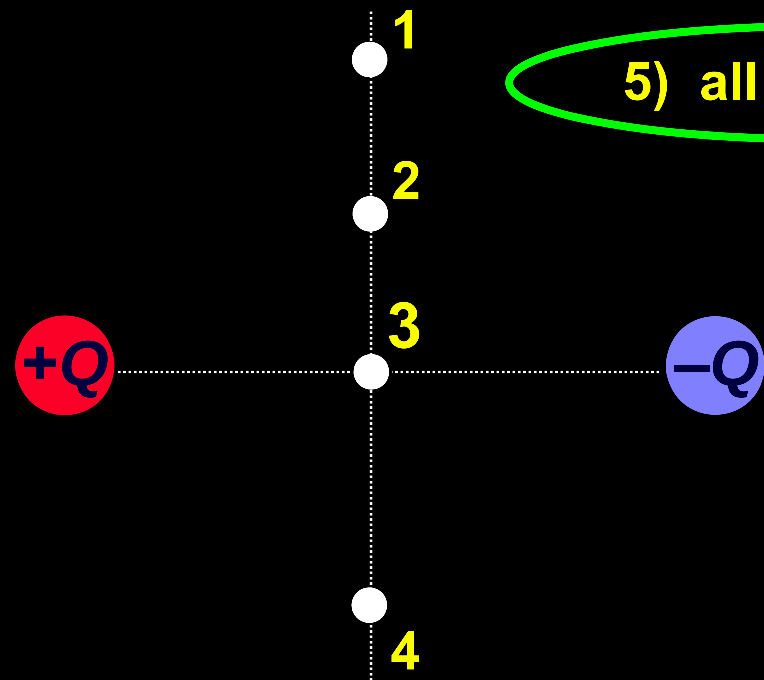
At which point does $V = 0$?

5) all of them



# ConcepTest 24.5a Equipotential Surfaces I

At which point does $V = 0$?



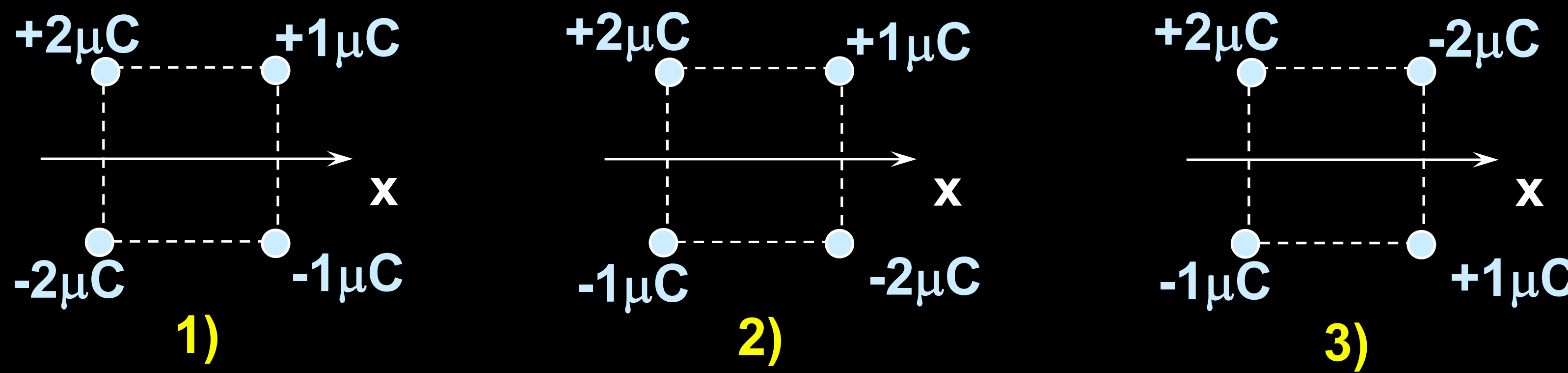

5) all of them

**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?

# ConcepTest 24.5b Equipotential Surfaces II

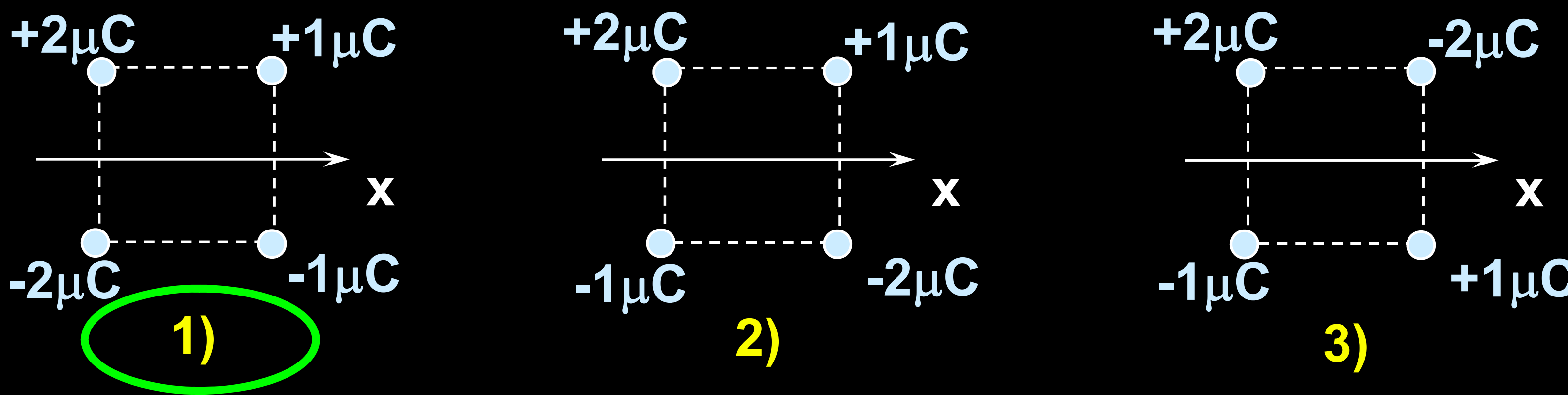
**Which of these configurations gives $V = 0$ at all points on the $x$-axis?**




4) all of the above    5) none of the above

# *ConcepTest 24.5b* Equipotential Surfaces II

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

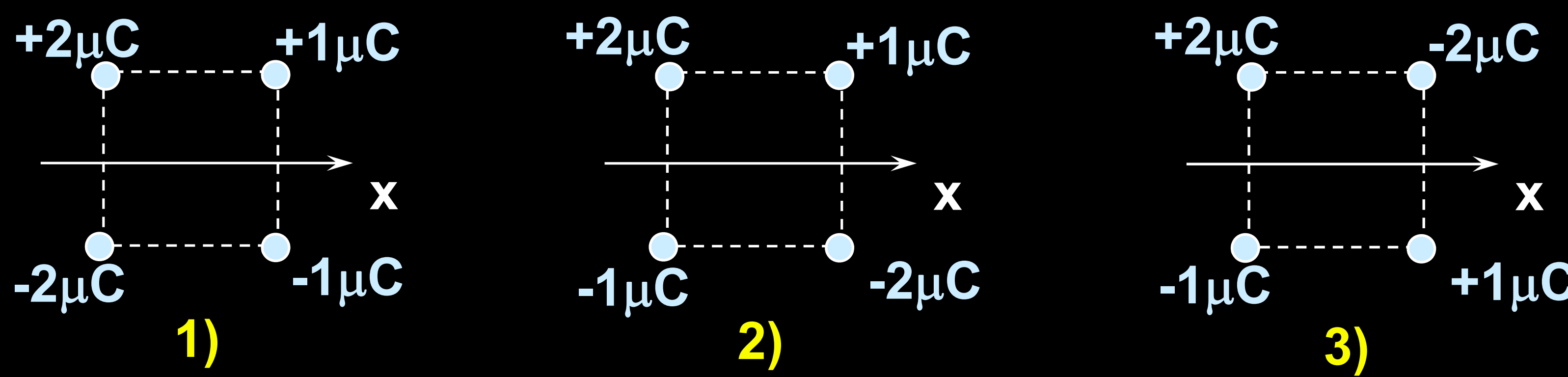



**4) all of the above** **5) none of the above**

**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.**

# ConcepTest 24.5c Equipotential Surfaces III

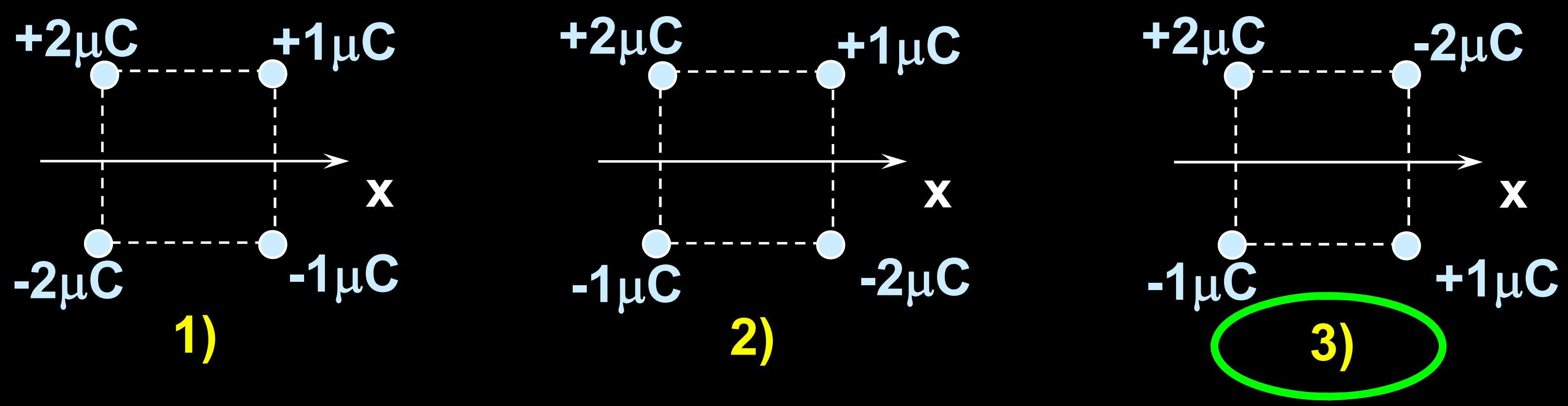
Which of these configurations gives *V* = 0 at all points on the *y*-axis?




4) all of the above 5) none of the above

# ConcepTest 24.5c Equipotential Surfaces III

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




**4) all of the above** **5) none of the above**

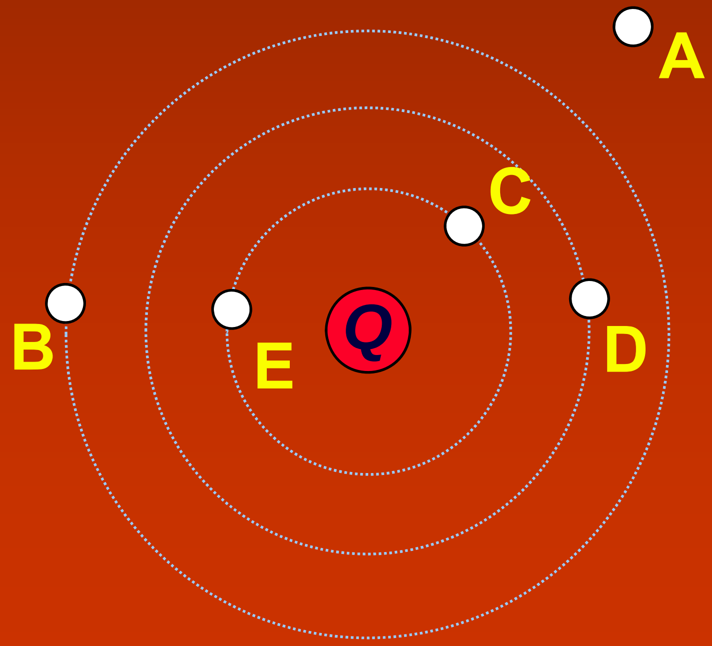
**Only in case (3), where opposite charges lie directly across the *y*-axis from each other, do the potentials from the two charges above the *y*-axis cancel the ones below the *y*-axis.**

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

# *ConcepTest 24.6* Equipotential of Point Charge

Which two points have the **same** potential?

1) A and C
2) B and E
3) B and D
4) C and E
5) no pair



# ConcepTest 24.6 Equipotential of Point Charge

Which two points have the same potential?

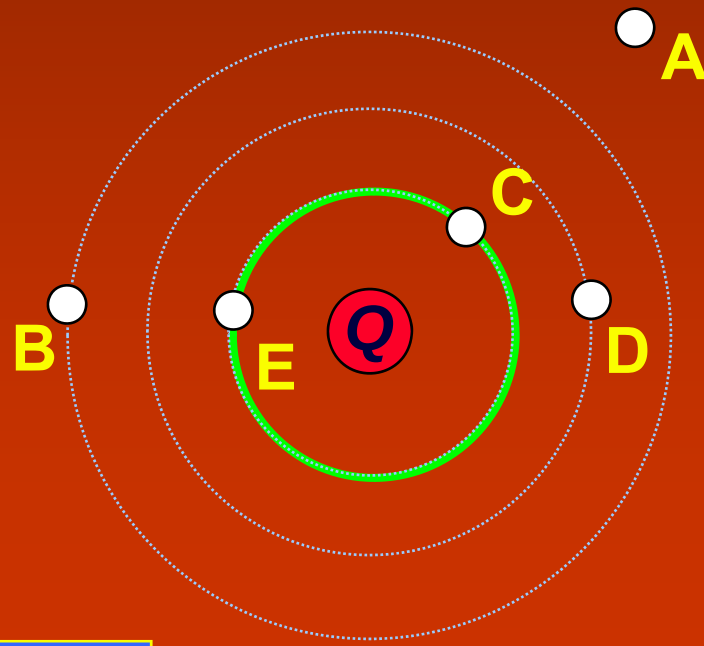
1) A and C
2) B and E
3) B and D
4) C and E
5) no pair

Since the potential of a point charge is:

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

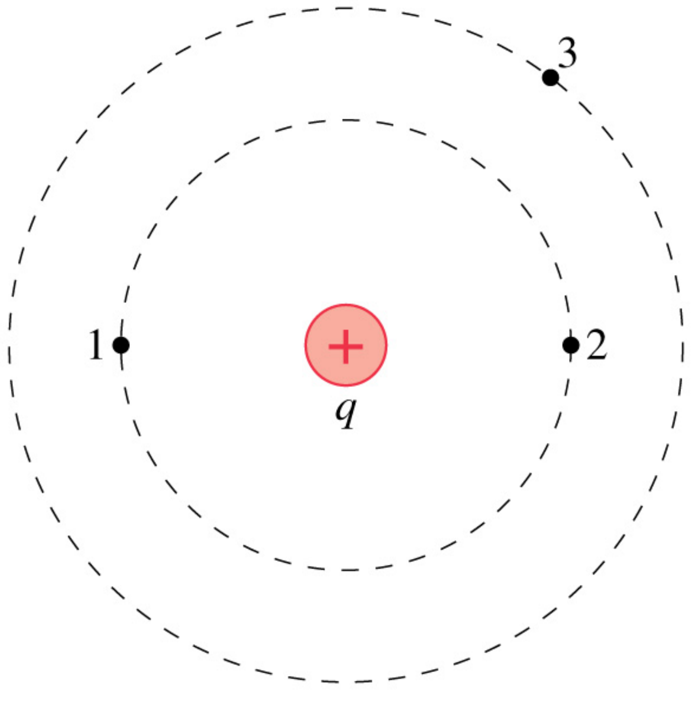
only points that are at the same distance from charge Q are at the same potential. This is true for points C and E.

They lie on an ***Equipotential Surface***.




**Follow-up: Which point has the smallest potential?**

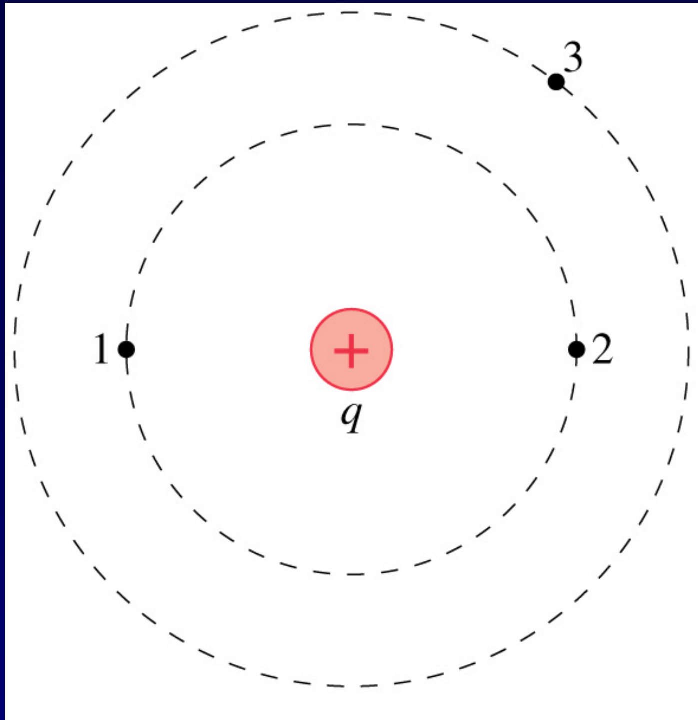
Rank in order, from largest to smallest, the potential differences $\Delta V_{12}$, $\Delta V_{13}$, and $\Delta V_{23}$ between points 1 and 2, points 1 and 3, and points 2 and 3.





A. $\Delta V_{12} > \Delta V_{13} = \Delta V_{23}$
B. $\Delta V_{13} > \Delta V_{12} > \Delta V_{23}$
C. $\Delta V_{13} > \Delta V_{23} > \Delta V_{12}$
D. $\Delta V_{13} = \Delta V_{23} > \Delta V_{12}$
E. $\Delta V_{23} > \Delta V_{12} > \Delta V_{13}$

Rank in order, from largest to smallest, the potential differences $\Delta V_{12}$, $\Delta V_{13}$, and $\Delta V_{23}$ between points 1 and 2, points 1 and 3, and points 2 and 3.



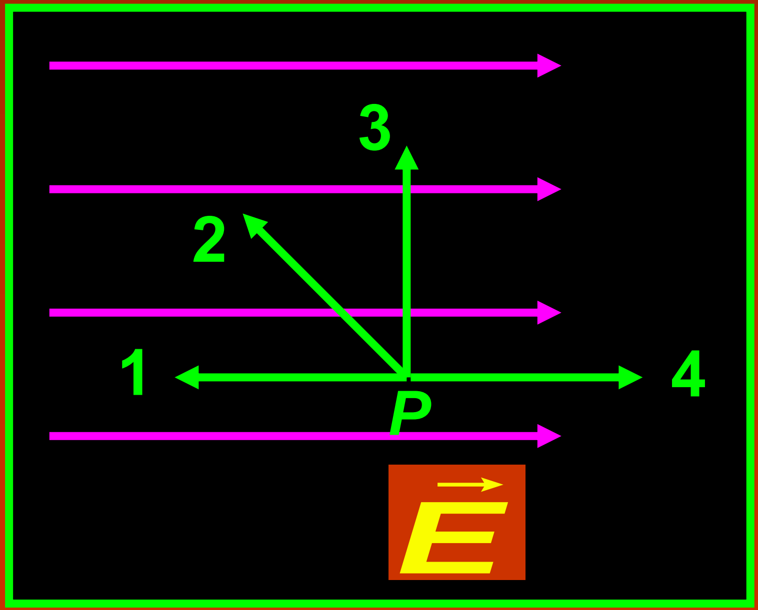


A. $\Delta V_{12} > \Delta V_{13} = \Delta V_{23}$
B. $\Delta V_{13} > \Delta V_{12} > \Delta V_{23}$
C. $\Delta V_{13} > \Delta V_{23} > \Delta V_{12}$
✔ **D. $\Delta V_{13} = \Delta V_{23} > \Delta V_{12}$**
E. $\Delta V_{23} > \Delta V_{12} > \Delta V_{13}$

# *ConcepTest 24.7a* 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***.

1) $P \rightarrow 1$
2) $P \rightarrow 2$
3) $P \rightarrow 3$
4) $P \rightarrow 4$
5) all require the same amount of work

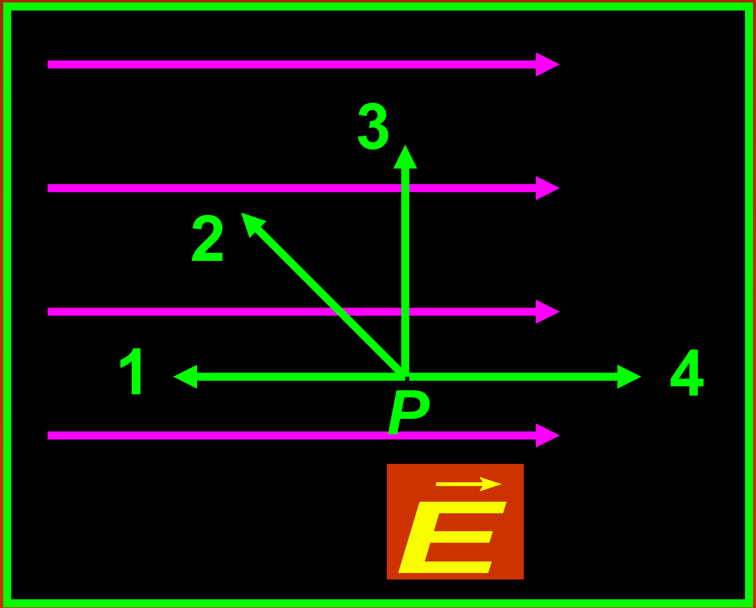


# *ConcepTest 24.7a* Work and Electric Potential I

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*.

1) $P \rightarrow 1$
2) $P \rightarrow 2$
3) $P \rightarrow 3$
4) $P \rightarrow 4$
5) all require the same amount of work

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.



# *ConcepTest 24.7b* 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*.

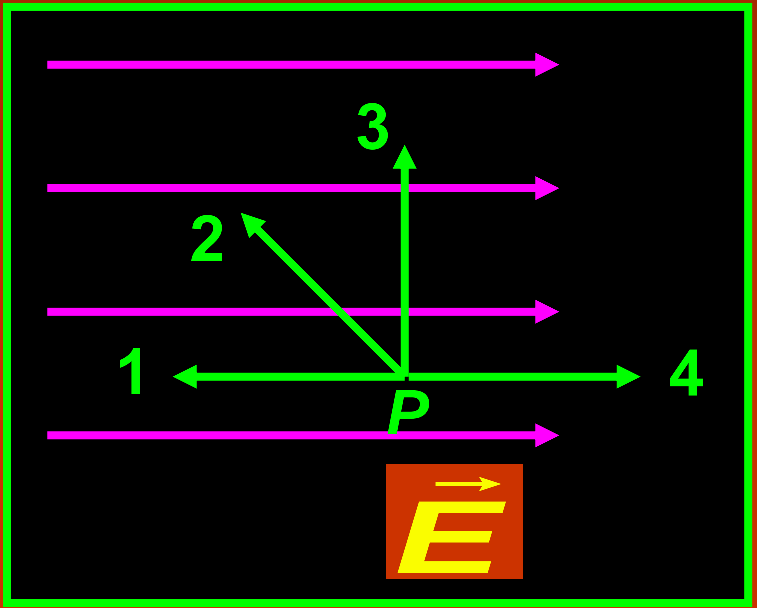
1) $P \rightarrow 1$

2) $P \rightarrow 2$

3) $P \rightarrow 3$

4) $P \rightarrow 4$

5) all require the same amount of work

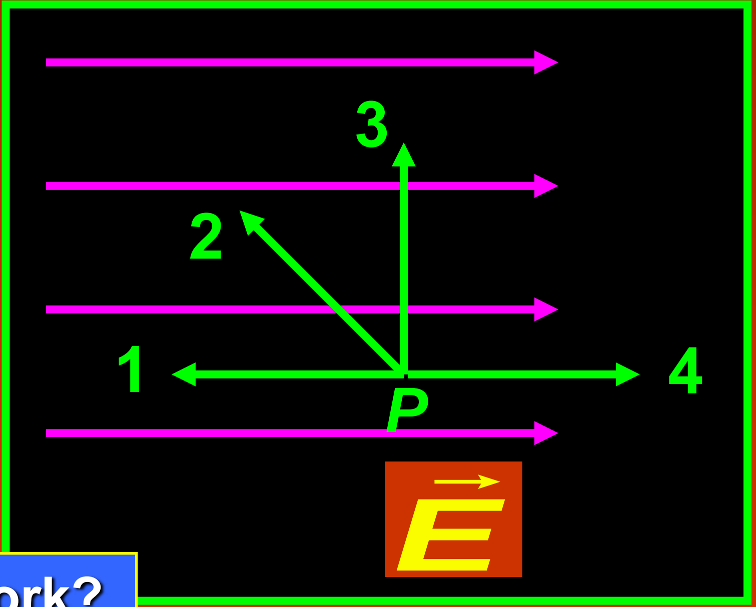


# ConcepTest 24.7b Work and Electric Potential II

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*.

1) $P \rightarrow 1$
2) $P \rightarrow 2$
3) $P \rightarrow 3$
4) $P \rightarrow 4$
5) all require the same amount of work

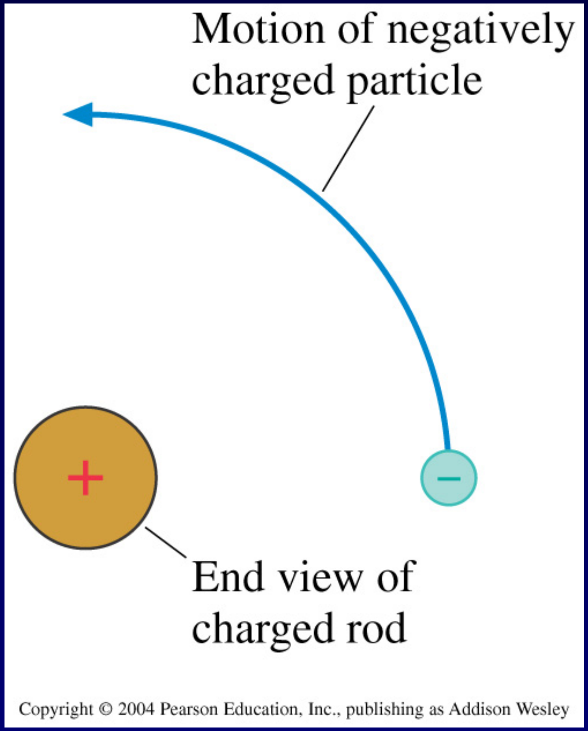
For path #3, you are moving in a direction perpendicular to the field lines. This means you are moving along an equipotential, which requires no work (by definition).




**Follow-up:** Which path requires the least work?

The positive charge is the end view of a positively charged glass rod. A negatively charged particle moves in a circular arc around the glass rod. Is the work done on the charged particle by the rod's electric field positive, negative or zero?

A. Positive
B. Negative
C. Zero

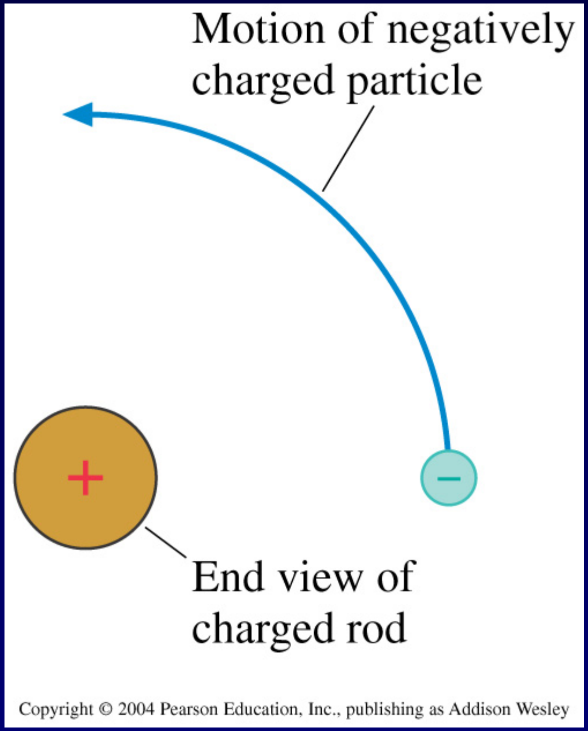


The positive charge is the end view of a positively charged glass rod. A negatively charged particle moves in a circular arc around the glass rod. Is the work done on the charged particle by the rod's electric field positive, negative or zero?

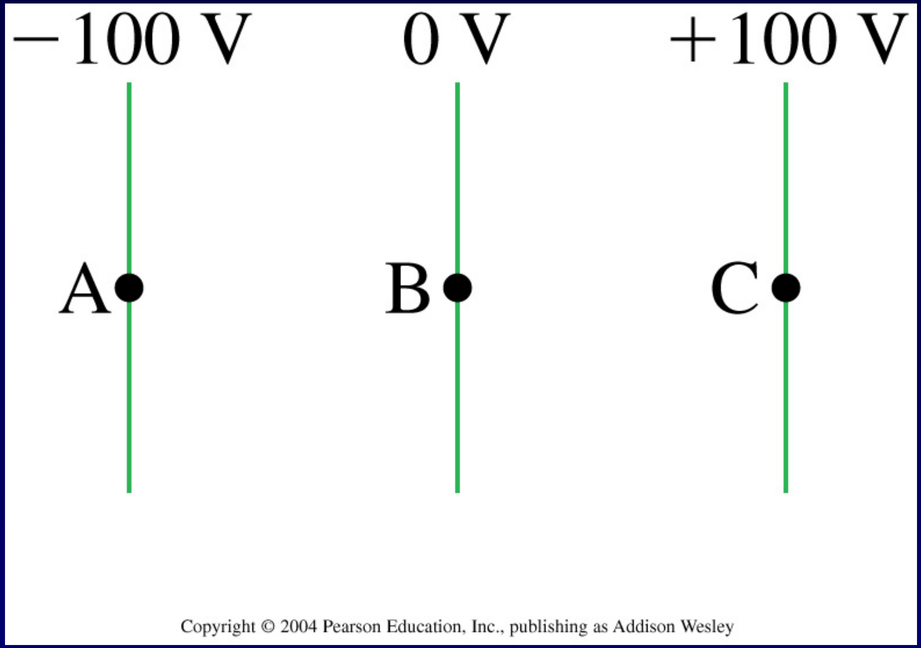
A. Positive

B. Negative

✔ **C. Zero**

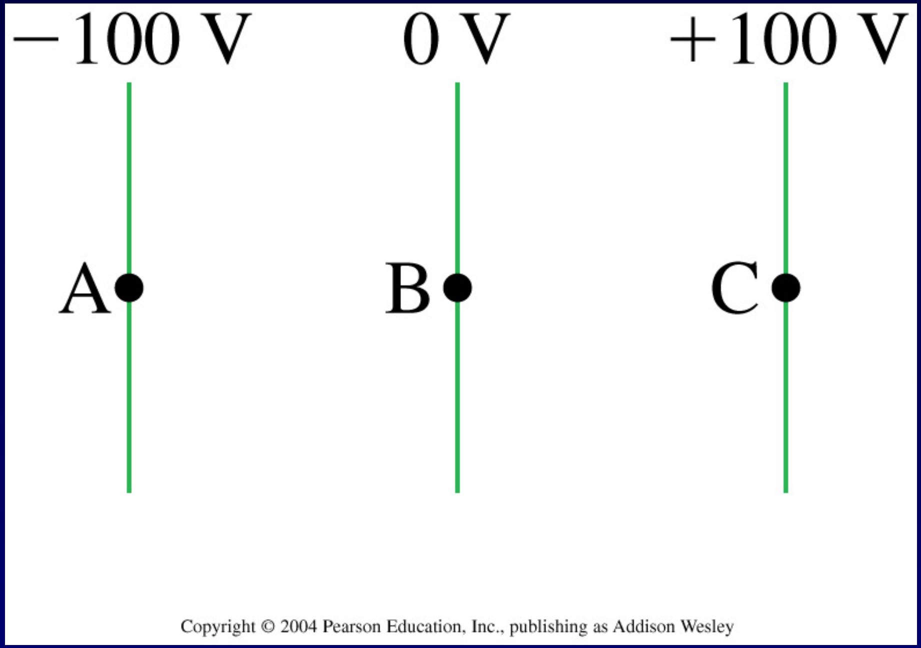


A proton is released from rest at point B, where the potential is 0 V. Afterward, the proton




A. moves toward A with an increasing speed.
B. moves toward A with a steady speed.
C. remains at rest at B.
D. moves toward C with a steady speed.
E. moves toward C with an increasing speed.

A proton is released from rest at point B, where the potential is 0 V. Afterward, the proton




**A. moves toward A with an increasing speed.** ✔

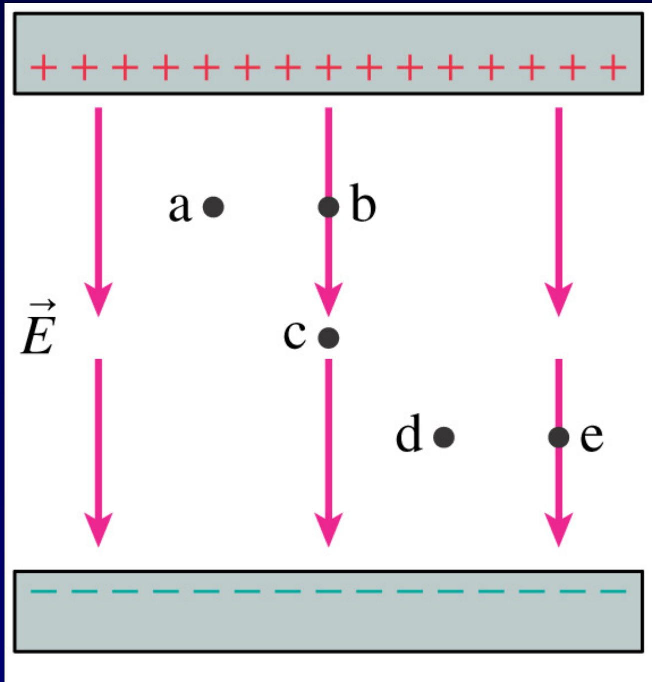
B. moves toward A with a steady speed.

C. remains at rest at B.

D. moves toward C with a steady speed.

E. moves toward C with an increasing speed.

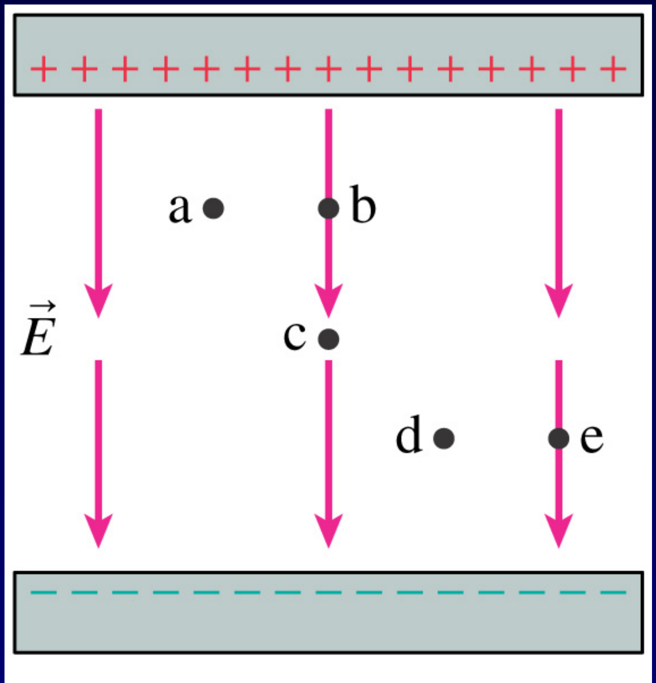
Rank in order, from largest to smallest, the potentials $V_a$ to $V_e$ at the points a to e.





A. $V_a = V_b = V_c = V_d = V_e$
B. $V_a = V_b > V_c > V_d = V_e$
C. $V_d = V_e > V_c > V_a = V_b$
D. $V_b = V_c = V_e > V_a = V_d$
E. $V_a = V_b = V_d = V_e > V_c$

Rank in order, from largest to smallest, the potentials $V_a$ to $V_e$ at the points a to e.





A. $V_a = V_b = V_c = V_d = V_e$

**B. $V_a = V_b > V_c > V_d = V_e$** ✔

C. $V_d = V_e > V_c > V_a = V_b$

D. $V_b = V_c = V_e > V_a = V_d$

E. $V_a = V_b = V_d = V_e > V_c$