# ELECTIRC FIELD

Challenging **MCQ** questions by The Physics Cafe


**Compiled and selected by The Physics Cafe**

1 **Fig 27** shows some equipotential lines in an electric field.

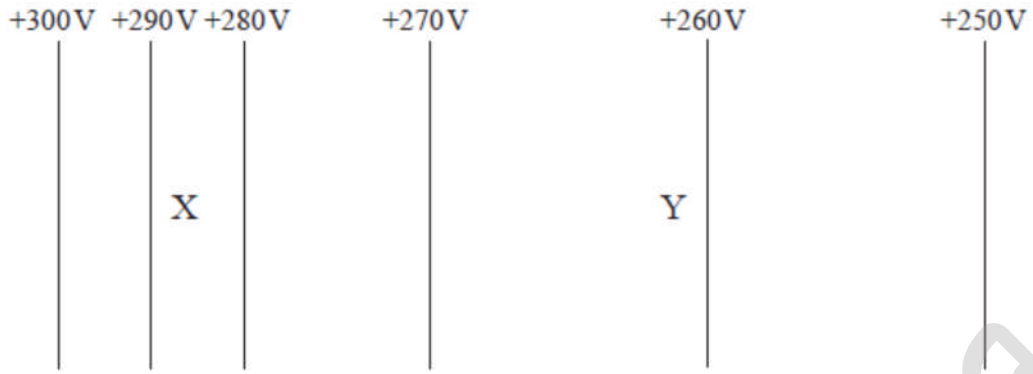



**Fig 27**

The magnitude of the electric field strength at X is $E_X$ and at Y is $E_Y$.

Which of one of the following correctly compares $E_X$ and $E_Y$ and gives the correct directions of the electric field?

| | Magnitude of electric field strength | Direction of electric field |
|---|---|---|
| **A** | $E_X > E_Y$ | X $\rightarrow$ Y |
| **B** | $E_X > E_Y$ | Y $\rightarrow$ X |
| **C** | $E_X < E_Y$ | X $\rightarrow$ Y |
| **D** | $E_X < E_Y$ | Y $\rightarrow$ X |

2 Two charged conducting spheres each of radius 1.0 cm are placed with their centres 10.0 cm apart, as shown in **Fig 28.1**.

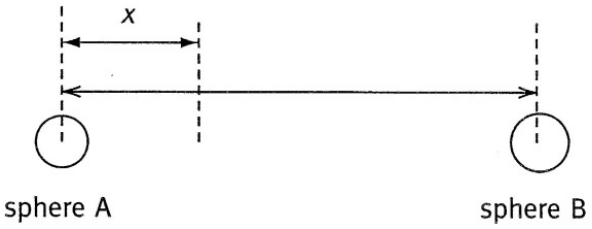



**Fig 28.1**

Sphere A carries a charge of + 2.0 x $10^{-10}$ C.

The graph in Fig 28.2 shows how the resultant electric field strength *E*, between the two spheres varies with distance *x*.

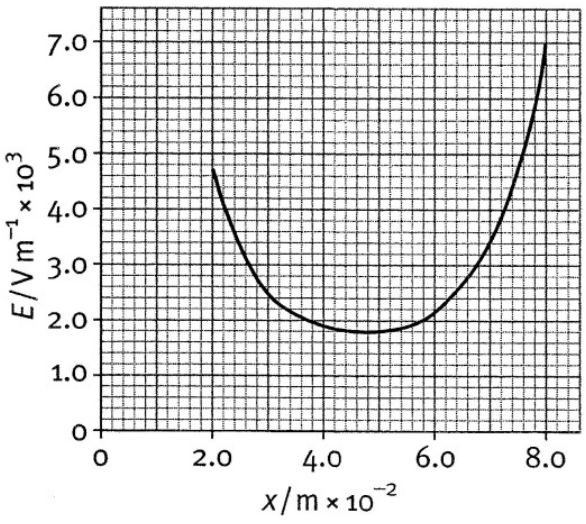



**Fig 28.2**

What is the magnitude of the electric field strength due to the charge on sphere B at the 5.0 cm mark? Identify the nature of the charge on sphere B.

| | **Magnitude of $E_B$ / $Vm^{-1}$** | **Nature of charge on sphere B** |
|---|---|---|
| **A** | 1.08 x $10^3$ | positive |
| **B** | 1.08 x $10^3$ | negative |
| **C** | 1.76 x $10^3$ | positive |
| **D** | 1.76 x $10^3$ | negative |

| | | |
|---|---|---|
| | | |

3 Which one of the following statements about the electric potential at a point is correct?

**A** The electric potential at a point due to a system of joint charges is given by the sum of the potentials at that point due to the individual charges of the system

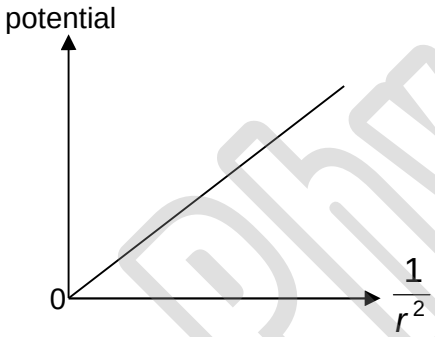
**B** The electric potential is given by the rate of change of electric field intensity with distance

**C** The unit of electric potential is either the joule or the volt

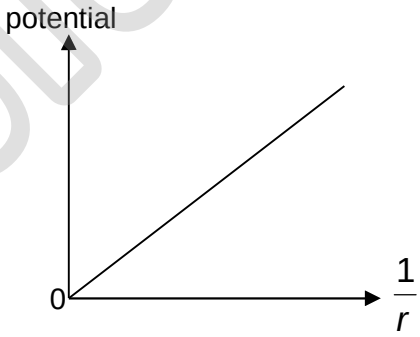
**D** Two points in an electric field are at the same potential only when a unit positive charge placed anywhere on the line joining them remains stationary.

4 Which graph correctly relates the electric potential in the field of a negative point charge with distance *r* from the charge?

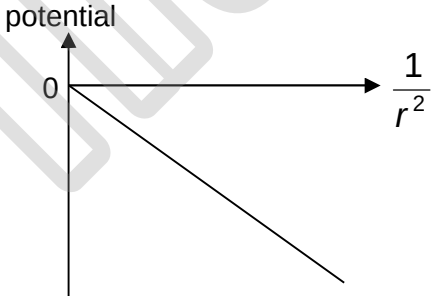
**A**



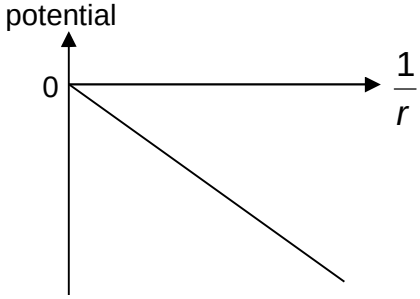

**B**



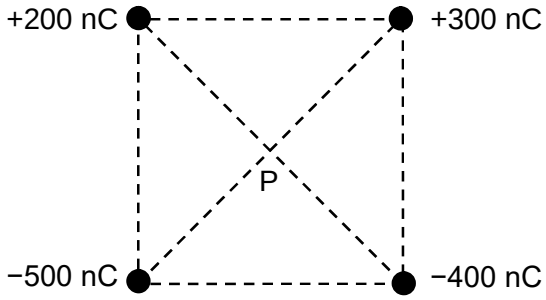

**C**




**D**



5 Four charges are arranged at the corners of a square as shown. Point P is located at the centre of the square. The diagonal of the square is 8.0 cm.




How much work is done by the field in bringing a −3.0 nC charge from infinity to point P without any change in its kinetic energy?

**A** −270 $\mu$J **B** −135 $\mu$J **C** +135 $\mu$J **D** +270 $\mu$J

6 Which of the following statements about an electric field is incorrect?

**A** The electric field strength at a point is a measure of the potential gradient at that point.

**B** Electric field strength is a vector quantity.

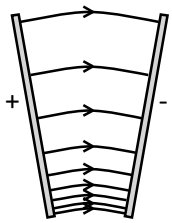
**C** The electric field strength at a point is the force per unit positive charge experienced by a small test charge placed at that point.

**D** The electric field strength is zero at all points where the potential is zero.

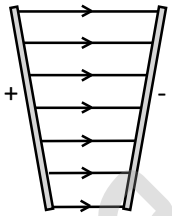
7 A potential difference is applied between two metal plates that are **not** parallel.

Which diagram shows the electric field between the plates?

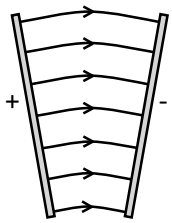
**A**



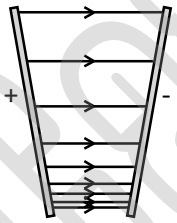

**B**




**C**




**D**

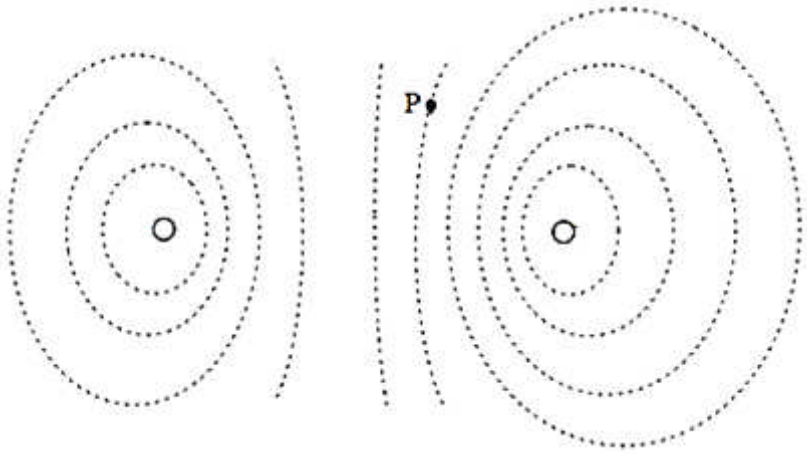



8 The electron beam current in a cathode-ray oscilloscope is 40 μA. The time-base of the oscilloscope is set at 20 ms $cm^{-1}$.

What is the number of electrons arriving at the screen in two centimetre length of the horizontal trace?

**A** $10^{10}$ **B** $10^{13}$ **C** $10^{16}$ **D** $10^{19}$

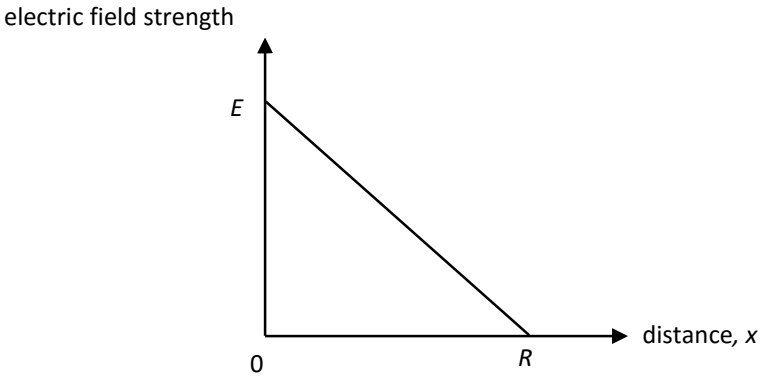
9 The diagram below shows equipotential lines in the vicinity of two unequal charges.




Which of the arrows below best represents the direction of the force that would act on a small positive test charge placed at point P?

**A**  **B**  **C**  **D** 

10 The graph below shows how the electric field strength varies with distance *x*.




Determine the work done to move a positive test charge *q* from *x* = 0 to *x* = *R*.

**A** *qER* **B** *- qER* **C** *½ qER* **D** *- ½ qER*

11 Diagram 1 and 2 show possible paths for a beam of electron directed into an electric field and deflected by it. All paths are in the plane of the paper.

Diagram 1 represents an electric field in the plane of the paper.

Diagram 2 represents an electric field perpendicular to the plane of the paper.

Which line **A**, **B**, **C** or **D** best represents the path taken by the beam of electron?

diagram 1

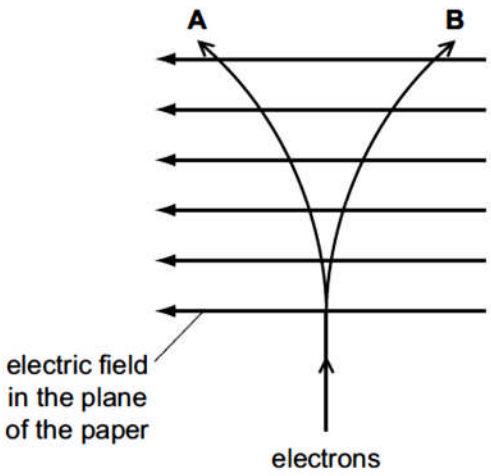
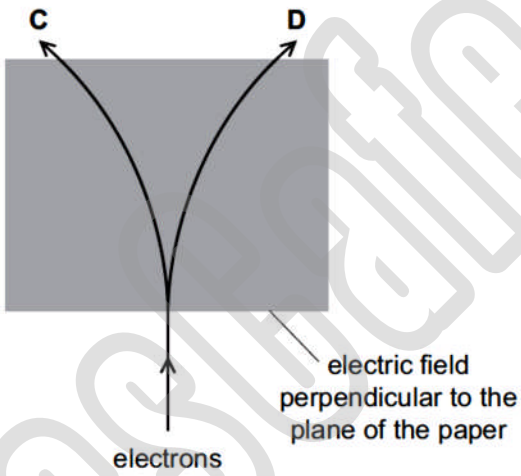
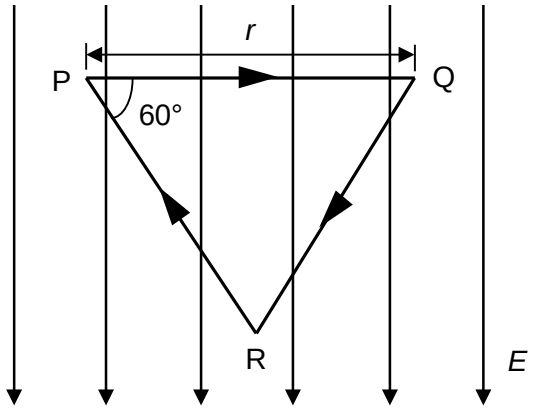



diagram 2



12 The diagram below shows three points P, Q and R forming an equilateral triangle of side *r* in a uniform electric field of strength *E*. An electron of charge *e* is moved from P to Q to R and back to P.




Which of the following correctly gives the work done against electrical forces in moving the electron along various parts of its path?

| | P to Q | Q to R | R to P |
|---|---|---|---|
| **A** | + *Eer* | - *Eer* sin 60° | + *Eer* sin 60° |
| **B** | 0 | + *Eer* sin 60° | - *Eer* sin 60° |
| **C** | + *Eer* | + *Eer* sin 60° | - *Eer* sin 60° |
| **D** | 0 | + *Eer* cos 60° | - *Eer* cos 60° |

13 What physical quantity would be the result of multiplying a potential difference with an electric charge?

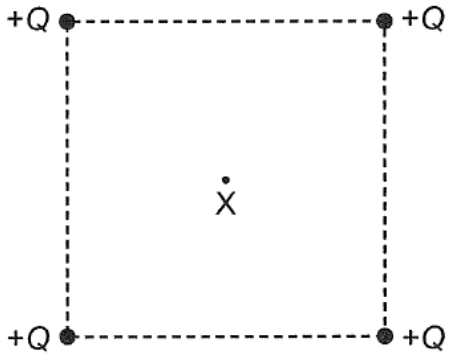
**A** Electric power

**B** Electric current

**C** Electric potential energy

**D** Electromotive force

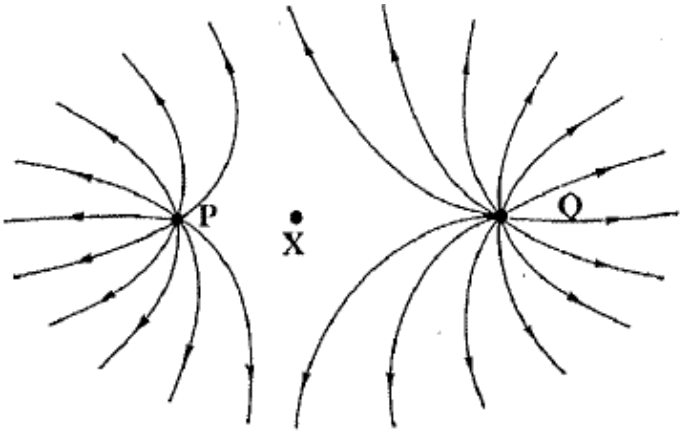
14 Four charges are arranged at the corners of a square as shown.




Which of the following statements is true about the electric field strength *E* and the electric potential *V* at the centre X of the square?

| | ***E*** | ***V*** |
|---|---|---|
| **A** | not zero | zero |
| **B** | not zero | not zero |
| **C** | zero | not zero |
| **D** | zero | zero |

15 The diagram shows electric field lines around two isolated point charges **P** and **Q**. At **X**, the electric field strength is zero.




Which of the following statements is true?

**A** The electric potential at **X** is zero.

**B** **P** is a larger charge than **Q** because **X** is closer to **P** than **Q**.

**C** The electric field lines show that both charges are positive.

**D** Electric field strength at **X** due to **P** is stronger than that due to **Q**.

# ELECTRIC FIELD WORKED SOLUTIONS

Challenging **MCQ** questions by The Physics Cafe



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1 Ans: **A**

Electric field strength is the –ve of the electric potential gradient which is the change in electric potential per unit distance hence $E_X > E_Y$

Direction of field always in direction of decreasing potentials.

2 Ans: **B**

Resultant field strength **E** = $\mathbf{E_A}$ + $\mathbf{E_B}$

Calculate $\mathbf{E_A}$ by applying E = $\frac{Q}{4\pi\varepsilon_0 r^2}$ = 0.72 x$10^3$ $Vm^{-1}$

From the graph at x = 5 cm = 5.0 x $10^{-2}$ m

the magnitude of resultant field is 1.8 x$10^3$ $Vm^{-1}$

hence $\mathbf{E_B}$ = 1.08 x$10^3$ $Vm^{-1}$; and

$Q_B$ is a negative charge as its direction is towards +ve x direction; so the resultant field is greater than that due to $Q_A$.

if candidate gave $\mathbf{E_B}$ = 1.76 x$10^3$ $Vm^{-1}$, they must have use V = $\frac{Q}{4\pi\varepsilon_0 r}$ instead

3 Ans: **A**

The electrical potential at a point due to a system of joints charges is given by the sum of the potentials at that point due to the individual charges of the system.

(C) Unit of potential cannot be Joule,

(B) $V \neq \frac{dE}{dr}$

+ve charge may not remain stationary if there is presence of lower potential in the field.

4 Ans: **D**

Electric potential at a point is defined as the work done per unit charge by an external agent to bring a positive test charge from infinity to that point without any change in KE.

$V = \frac{Q}{4\pi\varepsilon_0 r}$

since the point charge is negative in this case, the potential must be negative as well, i.e.

$V \propto -\frac{1}{r}$

5 Ans: **A**

the potential at point P, $V_P = \frac{Q_1}{4\pi\varepsilon_o r_1} + \frac{Q_2}{4\pi\varepsilon_o r_2} + \frac{Q_3}{4\pi\varepsilon_o r_3} + \frac{Q_4}{4\pi\varepsilon_o r_4}$

since $r_1 = r_2 = r_3 = r_4 = \frac{8.0}{2}$ = 4.0 cm,

$V_P = \frac{1}{4\pi\varepsilon_o r_1}(Q_1 + Q_2 + Q_3 + Q_4)$

The work done by **<u>external agent</u>** in bringing the −3.0 nC charge to point P without any change in KE

= EPE = $V_P$ x $q$.

The work done **<u>by the field</u>** = − EPE

$$= -\left[\frac{1}{4\pi\varepsilon_o r_1}(Q_1 + Q_2 + Q_3 + Q_4)\right]q$$

$$= -\left[\frac{9\times10^9}{4.0\times10^{-2}}(200 + 300 - 400 - 500)\times10^{-9}\right]\left(-3.0\times10^{-9}\right)$$

$$= -2.7\times10^{-4}\ \text{C}$$

= −270 $M$j

6 Ans: **D**

7 Ans: **A**

8 Ans: **B**

9 Ans: **B**

10 Ans: **D**

11 Ans: **B**

Electric field points from a region of high polarity to a region of low polarity. Hence, an electron will be attracted towards the region of high polarity. All electron paths are on the plane of the paper.

12 Ans: **B**

*Work done against electrical forces acting on an electron is positive when it is moved in the direction of the E. Field and vice versa.*
*Hence, work done against the field,*
*From P to Q = 0*
*From Q to R = +eΔV*
*= +Eer* sin *60°*
*From R to P = -eΔV*
*= -Eer* sin *60°*

13 Ans: **C**

By definition of potential difference, multiplying p.d. with charge will yield an energy quantity.

14 Ans: **A**

At the centre of the square, the magnitude of the electric field strength due to each of the charge is the same. Since electric field strength is **vector**, the electric field strength due to the top right corner will **add** to that due to the bottom left corner as their directions are the **same**, and that due to the top left corner will **add** to that due to the bottom right corner as their directions are **same**, thus giving **non-zero** resultant electric field strength toward right horizontally at the centre of the square ⇒ Option **A** or Option **B**.
At the centre of the square, the electric potential due to each of the charge has the **same magnitude but different polarity**. Since electric potential is **scalar**, the electric potential at the centre of the square will be the **sum** of the electric potential due to each of the charge thus it will be a **zero** value ⇒ Option **A** is the only correct option

15 Ans: **C**

Only the statement “the electric field lines show that both charges are positive” is true.