



PHYSICS

BOOKS - CENGAGE PHYSICS

STATIC ELECTRICITY

Worked Examples

1. Two small particles of carbon, each weighing 1 mg and carrying a charge of 10^{-6} , are 1 cm

apart. Calculate the electrostatic force between them.



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2. Given the following data, calculate the electrostatic force and gravitational force between two electrons. Show that the electrostatic force is much greater than gravitational force, for the electrons separated by a certain distance.

Charge on the electron = $1.6 \times 10^{-19} \text{C}$

Mass of the electron = $9.1 \times 10^{-31} \text{kg}$

Gravitational constant

$$= 6.67 \times 10^{-11} \text{Nm}^2\text{kg}^{-2}$$



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3. Calculate the electrostatic force of attraction between a proton and an electron in a hydrogen atom. If the radius of the electron orbit is 0.05 nm and charge on the electron is $1.6 \times 10^{-19} \text{C}$.



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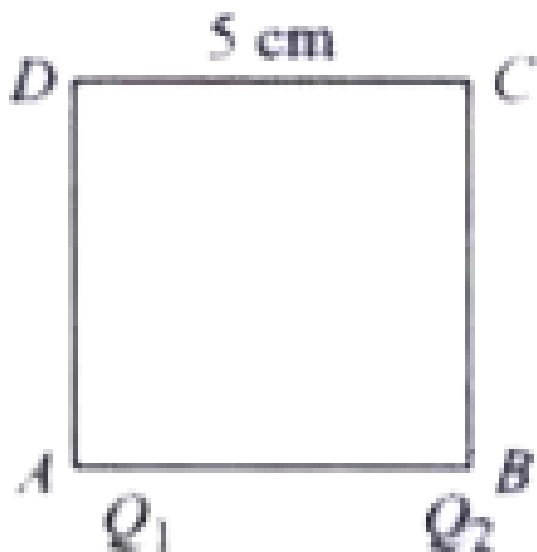
4. Three equal charges, each having a magnitude of $2 \times 10^{-6} \text{C}$, are placed at the three corners of a right-angled triangle of sides 3, 4, and 5 cm. Find the force on the charge at the right-angled corner.



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5. Charges $2 \times 10^{-6} \text{C}$ and $1 \times 10^{-6} \text{C}$ are placed at corners A and B of a square of side 5 cm as shown in the figure. How much work will

be done against the electric field in moving a charge of $1 \times 10^{-6} \text{ C}$ from C to D?



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Mandatory Exercise Exercise Set I

1. Mention a few methods of charging a body.



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2. How does a body get charged in the process of charging by friction?



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3. A glass rod is rubbed with silk. State the charge acquired by glass and silk.



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4. Name the kinds of charges present in nature.



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5. What is the smallest amount of charge available in nature?



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6. Name the constituents of an atom.



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7. Why do we say that the charge acquired by a glass rod or an ebonite rod is static?



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8. How do you use a pith ball electroscope to detect the presence of charges on a body?





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9. Mention the different methods of charging a gold leaf electroscope.



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10. What is the source of electricity and electrical phenomena?



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11. What happens during charging by conduction?



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12. If a glass rod rubbed with silk cloth is brought in contact with a neutral metallic sphere, what type charge will be gained by the sphere?



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13. How do charges behave in the presence of other charges?



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14. What are the charges acquired by an ebonite rod and fur when they are rubbed against each other?



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15. "Unchanged bodies contain no charged particles". Is the statement true? Explain.



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16. Atom as a whole is electrically neutral.

Why?



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17. Can a body contain + 10.25 e charge on it?



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18. What is conservation of charge?



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19. What are conductors? Give examples.



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20. What are insulators? Give examples.



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21. Explain why conductors have large number of free electrons.



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22. Salty water contains no free electrons but can conduct electricity. How?



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23. Can free electrons move in and out of the body?



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24. Can ions behave as charge carriers in metallic conductors?



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25. What is an electroscope?





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26. Name two different types of electroscopes.



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27. What is the drawback of pith ball electroscopes?



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28. Explain the setup of a gold leaf electroscope with a neat labeled diagram



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29. What is the difference between charging by conduction and charging by induction?



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30. State the Coulomb's Law. Write down its mathematical form.



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31. True or false: The columbic force of attraction or repulsion between two charges is an action reaction pair according to Newton's third law.



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32. What is 1 coulomb?



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33. What is a point charge? Can point charge actually exist?



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34. How can we define intensity of electric field?





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35. What is the convention for direction of an electric field?'



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36. What are electric field lines?



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37. How can we find the direction of electric field from electric field lines?



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38. How do electric field lines give us idea about electric field intensity at different points?



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39. Can electric field lines intersect each other?

Why or why not?



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40. Draw the electric field lines due to two equal and opposite point charges.



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41. Draw the electric field lines due to two equal and same point charges.



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42. True or False:

The direction of force on a charge in electric field is always along the direction of electric field.



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43. What is potential energy for a system of charges?



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44. How can we define electric potential at any point?



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45. What is a potential difference ?





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46. What is 1 volt potential difference?



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47. How are sparks produced?



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48. How is lightning produced?





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49. Why are lightning and thunder experienced at different time although they are produced simultaneously?



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50. Explain how lightning conductors work.



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51. True or False: The accumulation of charges is directly proportional to the radius of curvature of a curved surface.



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52. Explain the working of a photocopier and the importance of static electricity in its working.



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Mandatory Exercise Exercise Set I Multiple Choice Questions With One Correct Answer

1. When a plastic comb rubbed on hair is brought near bits of paper, it attracts them because

- A. the comb and the paper get similarly charged
- B. they get oppositely charged
- C. the paper bits are very light
- D. none of these

Answer: B



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2. Two uncharged bodies when rubbed against each other get charged. This is known as

- A. charging by conduction
- B. charging by friction
- C. charging by induction
- D. none of the above

Answer: B



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3. When a glass rod is rubbed with silk, it is said to be positively charged. Which of the following statements is true?

- A. Electrons move from silk to glass.
- B. Electrons move from glass to silk.
- C. Protons move from silk to glass.
- D. Protons move from glass to silk.

Answer: B



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4. You have two bodies A and B. A is positively charged. If A and B are conductors and A touches B, then

A. B gets positively charged

B. B gets negatively charged

C. A and B will have equal amounts of charge

D. A and B both have positive charges

Answer: C



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5. The rod or stem of a gold leaf electroscope is made of

A. wood

B. brass

C. glass

D. ebonite

Answer: B



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6. If a charge is placed on a conductor having a pointed end, then

A. the charges get accumulated at the points

B. the charges get distributed around the conductor

C. the charges collect inside the conductor

D. none of the above

Answer: A



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7. The process of making copies in a photocopier is known as

A. photography

B. xerography

C. videography

D. all of these

Answer: B



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8. Which of the following is a photo conducting material?

A. Copper

B. Poly vinyl chloride

C. Selenium

D. Aluminum

Answer: C



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9. What is the atmospheric temperature at a height of 6-7 km?

A. 20°C

B. 0°C

C. -10°C

D. -20°C

Answer: D



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10. The potential difference between two points also called

A. voltage

B. work

C. electric power

D. rating

Answer: A



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11. If 8 field lines come out of + 1 C charge, how many field lines will end at -2C charge?

A. 0

B. 8

C. 16

D. 32

Answer: C



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12. The relative permittivity of a medium is also known as

A. Boltzmann constant

B. Planck's constant

C. Stefan's constant

D. Dielectric constant

Answer: D



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13. Nylon is an example of

A. insulator

B. conductor

C. semiconductor

D. none of these

Answer: A



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Mandatory Exercise Exercise Set II

1. Lightning conductors are made of

A. copper

B. glass

C. ebonite

D. fur

Answer: A



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2. Where do charges reside in the case of a charged conductor?

A. Inside the conductor

B. On the outer surface of the conductor

C. On the inner surface of the conductor

D. Anywhere outside the conductor

Answer: B



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3. Two point charges 3 C and -6 C are 3 m apart.

Find the force between them. State the nature of the force.



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4. Two point charges q and $10q$ repel each other with a force of 3.6×10^{-5} N when they are 0.02 m apart. Find the charges.



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5. Calculate the force between two electrons that are 0.1 nm apart.



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6. Find the magnitude of force on a $10 \mu\text{C}$ charge placed in an electric field of 1×10^6 N/C.



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7. Find the minimum electrostatic force that can exist between two charges separated by distance 1m.



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8. Find the number of excess electrons in a body having charge of -5 C.



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9. A charge of -20 C is placed in an electric field given by $\vec{E} = (5\hat{i} - 3\hat{j} + 4\hat{k})$ N/C. Find the force on the charge.



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10. Three charges in an isolated system have initial charges of $+2\text{ C}$, -3 C and $+4\text{ C}$. After some interaction their final charges become -5 C , $+1\text{ C}$ and $X\text{ C}$ respectively. Find X .



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11. Find the work done by external force in bring two charges of $+10\text{ C}$ each from infinity to a separation of 2 meters .



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12. What is the electric field at a distance of 5 meters from a point charge of $+0.2\text{ C}$?



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13. What is the work done in moving a charge of $-10e$ across a potential difference of 20 V from higher potential to lower potential?



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Consolidated Exercise

1. What is the acceleration of the positive charge q ? Is it in uniform acceleration?



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2. What will be the final velocity of the charge after having a displacement x ?



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3. What will be the kinetic energy of the charge after it has moved a distance x ?



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4. Match the following:

A	B
(1) Electric force	(a) $\vec{E} = \frac{kQ}{r^2}$
(2) Natural behaviour of two charged bodies	(b) Work done in moving unit positive charge from one point to another
(3) $q = ne$	(c) $\epsilon_0 = 8.8542 \times 10^{-12} \text{ C}^2 / \text{N} - \text{m}^2$
(4) Law of conservation of charges	(d) The force of interaction between charged bodies
(5) Conductors	(e) $U = -\frac{kq_1q_2}{r}$
(6) Electroscopes	(f) The sphere of influence around a charge
(7) Coulomb's law	(g) $\vec{F} = q\vec{E}$
(8) Permittivity of free space	(h) Quantisation of charge
(9) Electric field	(i) Like charges repel and unlike charges attract each other
(10) Electric field intensity at a distance r from a charge Q	(j) Materials which have free charge carriers
(11) Force on a point charge in an electric field	(k) Charges can neither be created nor be destroyed, but can be transferred from one body to another
(12) Potential energy of a system of two charges separated by a distance r	(l) Device used to test the presence and nature of charge on a body
(13) Potential difference between two points in an electric field	(m) $F = \frac{kq_1q_2}{r^2}$



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Consolidated Exercise Multiple Choice Questions With One Or More Than One Correct Answer

1. Which of the following is/are conductors?

A. Copper

B. Aluminum

C. Glass

D. Wood

Answer: (A) and (B)



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2. Which of the following is/are insulators?

A. Iron

B. Steel

C. Plastic

D. Glass

Answer: (C) and (D)



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3. Electrification of a body can be achieved by charging by

A. friction

B. conduction

C. induction

D. rotation

Answer: (A), (B), and (C)



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4. Which of the following is/are applications of static electricity?

A. Lightning conductor

B. Photocopier

C. Electromagnet

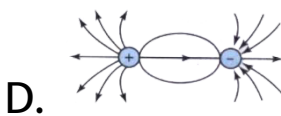
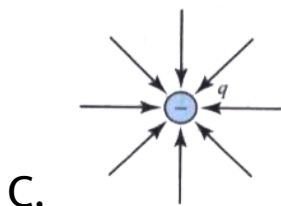
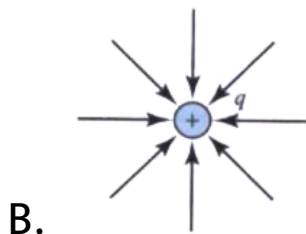
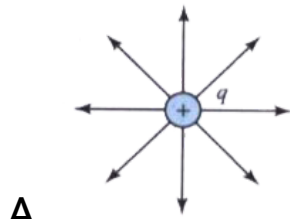
D. Microphone

Answer: (A) and (D)



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5. Which of the following represent electric field lines?



Answer: (A), (C), and (D)



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Challenging Exercise

1. Two equal charges repel each other with a force of $4 \times 10^{-5} \text{ N}$. when they are 0.03 m apart in air. Find the magnitude of the charges. What will be the force if the distance between them is doubled?



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2. Force between two charges is 36×10^{-6} N when separated by a certain distance. On increasing the separation by 5 m, the force reduces to 25×10^{-6} N. If one charge is ten times the other, find the initial separation and magnitude of charges.



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3. Two charges of 9 and 16 μC are placed 0.7 m apart. Find the position of the null point (A point where the net field is zero) on the line joining the two charges.



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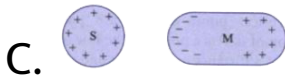
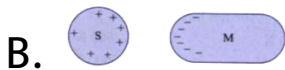
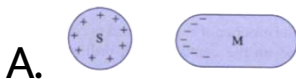
4. Two fixed charges of $+2C$ and $-2C$ are kept at $(1, 0)$ and $(0, -1)$ respectively. Find the electric field at the point $(1, -1)$.



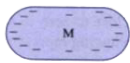
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Olympiad And Ntse Level Exercises

1. An uncharged metal object M is insulated from its surroundings. A positively charged metal sphere S is then brought near to M . Which diagram best illustrates the resultant distributions of charge on S and M ?



D.



Answer: B



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2. A glass rod rubbed with silk is used to charge a gold leaf electroscope and the leaves are observed to diverge. The electroscope thus charged is exposed to X -rays for a short period. Then

A. the divergence of leaves will not be affected

B. the leaves will diverge further

C. the leaves will collapse

D. the leaves will melt

Answer: B



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3. Given are four arrangements of three fixed electric charges. In each arrangement, a point labelled P is also identified - test charge, $+q$, is placed at point P . All of the charges are of the same magnitude Q , but they can be either positive or negative as indicated. The charges and point P all lie on a straight line. The distances between adjacent items, either between two charges or between a charge and point P , are all the same.



Correct order of choices in a decreasing order of magnitude of force on P is

A. $II > I > III > IV$

B. $I > II > III > IV$

C. $II > I > IV > III$

D. $III > IV > I > II$

Answer: C



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4. Point charges $+4q$, $-q$ are kept on the x -axis at points $x = 0$, $x = a$ and $X = 2a$ respectively, then

A. Only q is in stable equilibrium

B. None of the charges are in equilibrium

C. All the charges are in unstable equilibrium

D. All the charges are in stable equilibrium

Answer: C





5. An infinite number of charges, each of charge $1\mu C$ are placed on the x -axis with coordinates $x = 1, 2, 4, 8, \dots, \infty$. If a charge of $1C$ is kept at the origin, then what is the net force action on $1C$ charge

A. 9000 N

B. 12000 N

C. 24000 N

D. 36000 N

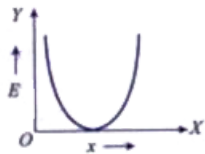
Answer: B



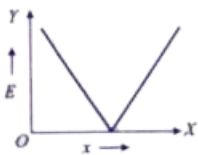
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6. Two identical point charges are placed at a separation of d . P is a point on the line joining the charges, at a distance x from any one charge. The field at P is E , E is plotted against x for value of x from close to zero to slightly less than d . Which of the following represents the resulting curve

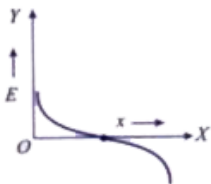
A.



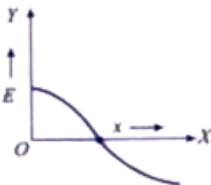
B.



C.



D.

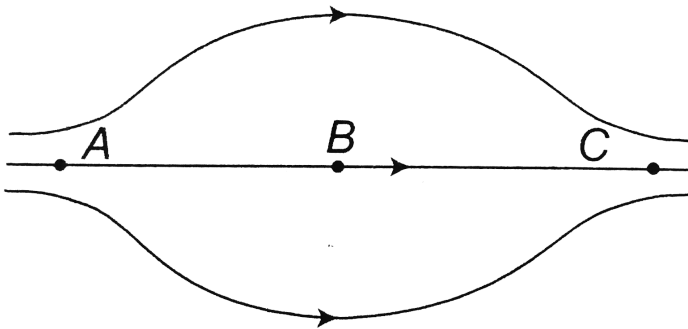


Answer: D



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7. The figure shows some of the electric field lines corresponding to an electric field. The figure suggests



A. $E_A > E_B > E_C$

B. $E_A = E_B = E_C$

C. $E_A = E_C > E_B$

D. $E_A > E_C < E_B$

Answer: C



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8. A charged particle of mass m and charge q is released from rest in an electric field of constant magnitude E . The kinetic energy of the particle after time t is

A. $\frac{2E^2t^2}{mq}$

B. $\frac{E^2q^2r^2}{2m}$

C. $\frac{Eq^2m}{2t^2}$

D. $\frac{Eqm}{2t}$

Answer: B



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9. Read the assertion and reason carefully to mark the correct option.

Assertion: A small metal ball is suspended in a uniform electric field with the help of an insulated thread. When a high energy X rays beam falls on the ball. Then the ball will be

deflected in the direction of electric field.

Reason: The ball will oscillate in the field.

A. If both Assertion and Reason are true and the Reason is correct explanation of the Assertion.

B. If both Assertion and Reason are true but Reason is not the correct explanation of Assertion.

C. If Assertion is true, but the Reason is false.

D. If both Assertion and Reason are false.

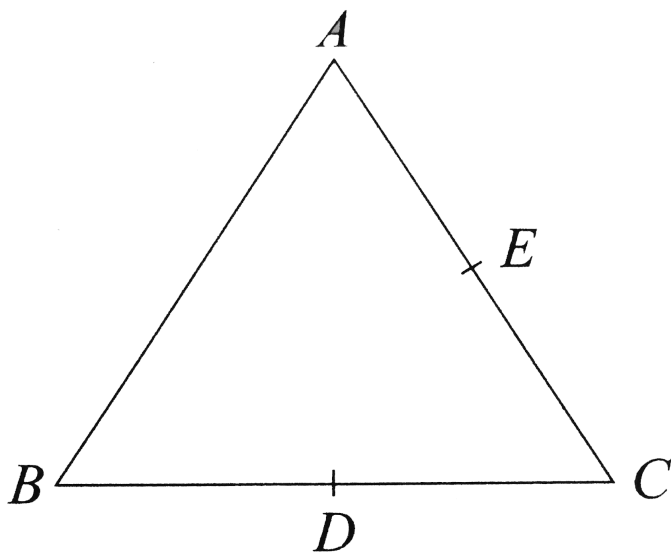
Answer: C



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10. Three charges each $+q$, are placed at the corners of an isosceles triangle ABC of sides BC and AC , $2a$, D and E are the mid-points of BC and CA . The work done in taking a

charge Q from D to E is



A. $\frac{eqQ}{4\pi\epsilon_0 a}$

B. $\frac{qQ}{4\pi\epsilon_0 a}$

C. zero

D. $\frac{3qQ}{4\pi\epsilon_0 a}$

Answer: C



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