PHYSICS

BOOKS - PSEB

ELECTRIC CHARGES AND FIELDS

Exercise

1. What is the Coulomb.s force between two small charged spheres having charges

2.0×10^{-7} C and 3.0×10^{-7} Coulomb placed 30 cm in air.

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2. The electrostatic force on a small sphere of charge $0.4 \mu C$ due to another small sphere of charge $-0.8 \mu C$ in air is 0.2 N. -What is the distance between the two spheres?

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3. The electrostatic force on a small sphere of charge $0.4\mu C$ due to another small sphere of charge $-0.8\mu C$ in air is 0.2 N. - What is the force on the second sphere due to the first?

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4. Check that the ratio $\left(ke^2\right)/Gm_em_p$ is dimensionless. Look up a Table Physical Constants and determine the value of this ratio. What does the ratio signify?

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5. Explain the meaning of the statement 'electric charge of a body is quantised'.

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6. When a glass rod is rubbed with a silk cloth, charges appear on both. A similar phenomenon is observed with many other pairs of bodies. Explain how this observation is consistent with the law of conservation of charge.

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7. Four point charges $q_A = 2\mu C, q_B = -5\mu C$. $q_c = 2\mu C$, and $q_D = -5\mu C$ are located at the corners of a square ABCD of side 10 cm. What is the force on a charge of $1\mu C$ placed at the centre of the square?

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8. An electrostatic field line is a continuous curve. That is, a field line cannot have sudden breaks. Why not?

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9. An electrostatic field line is a continuous curve. That is, a field line cannot have sudden breaks. Why not? Explain why two field lines never cross each other at any point?

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10. Two point charges $q_A = 3\mu C$ and $q_B = -3\mu C$ are located 20 cm apart in vacuum. What is the electric field at the midpoint O of the line AB joining the two charges?

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11. Two point charges $q_A = 3\mu C$ and $q_B = -3\mu C$ are located 20 cm apart in vacuum. If a negative test charge of

magnitude $1.5 \times 10^{-9} C$ is placed at this point, what is the force experienced by the test charge?

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12. A system has two charges $q_A = 2.5 \times 10^{-7}$ C and $q_B = -2.5 \times 10^{-7} C$ located at points A: (0, 0, -15 cm) and B: (0,0, +15 cm), respectively. What are the total charge and electric dipole moment of the system?

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13. An electric dipole with dipole moment 4×10^{-9} C m is aligned at 30° with the direction of a uniform electric field of magnitude 5×10^{4} N/C. Calculate the magnitude of the torque acting on the dipole.

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14. A polythene piece rubbed with wool is found to have a negative charge of

$3 \times 10^{-7}C$. Estimate the number of electrons transferred (from which to which?)

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15. A polythene piece rubbed with wool is found to have a negative charge of $3 \times 10^{-7}C$. Is there a transfer of mass from wool to polythene?

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16. Two insulated charged copper spheres A and B have their centres separated by a distance of 50 cm. What is the mutual force of electrostatic repulsion if the charge on each is $6.5 \times 10^{-7} C$? The radii of A and B are negligible compared to the distance of separation.

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17. Two insulated charged copper spheres A and B have their centres separated by a distance of 50 cm. What is the mutual force of electrostatic repulsion if the charge on each is $6.5 \times 10^{-7} C$? The radii of A and B are negligible compared to the distance of separation. What is the force of repulsion if each sphere is charged double the above amount, and the distance between them is halved?

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18. Two insulated identically sized charged copper spheres A and B have their centers separated by a distance 50 cm. Charges on each sphere is $q = 6.5 \times 10^{-7}$ C. A third sphere of the same size but uncharged is brought in contact with the first, then brought in contact with the second, and finally removed from both. What is the new force of repulsion between A and B?

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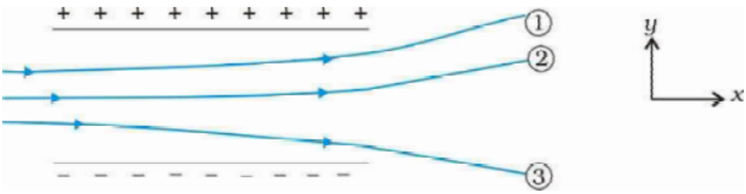
19. Figure shows tracks of three charged particles in a uniform electrostatic field. Give the signs of the three charges. Which particle has the highest charge to mass ratio?:



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20. Consider a uniform electric field $E = 3 \times 10^3 \hat{i} N/C$. - What is the flux of this field through a square of 10 cm on a side whose plane is parallel to the yz plane?

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21. Consider a uniform electric field $E = 3 \times 10^{3} \hat{i} N / C$. - What is the flux through the square of 10 cm if the normal to its plane makes a 60° angle with the x-axis?

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22. What is the net flux of the uniform electric field through a cube of side 20 cm oriented so that its faces are parallel to the coordinate planes?

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23. Careful measurement of the electric field at the surface of a black box indicates that the net outward flux through the surface of the box is $8.0 \times 10^3 Nm^2 / C$. What is the net charge inside the box?

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24. Careful measurement of the electric field at the surface of a black box indicates that the net outward flux through the surface of the box is $8.0 \times 10^3 Nm^2 / C$. If the net outward flux through the surface of the box were zero, could you conclude that there were no charges inside the box? Why or Why not?

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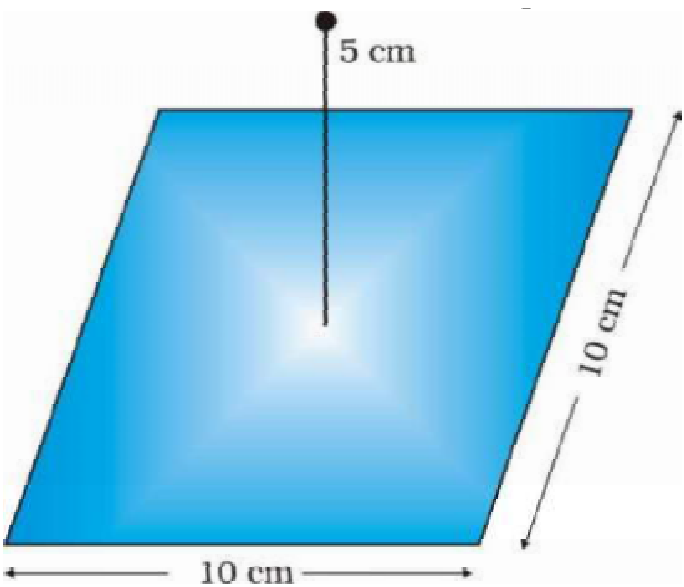
25. A point charge $+10\mu C$ is a distance 5 cm directly above the centre of a square of side 10 cm, as shown in Fig. What is the magnitude of the electric flux through the square? :



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26. A point charge of $2.0\mu C$ is at the centre of a cubic Gaussian surface 9.0 cm on edge. What is the net electric flux through the surface?

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27. A point charge causes an electric flux of $-1.0 \times 10^3 Nm^2 / C$ to pass through a spherical Gaussian surface of 10.0 cm radius centred on the charge - If the radius of the

Gaussian surface were doubled, how much flux would pass through the surface?

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28. A point charge causes an electric flux of $-1.0 \times 10^3 Nm^2 / C$ to pass through a spherical Gaussian surface of 10.0 cm radius centred on the charge - What is the value of the point charge?

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29. A conducting sphere of radius 10 cm has an unknown charge. If the electric field 20 cm from the centre of the sphere is $1.5 \times 10^3 N/C$ and points radially inward, what is the net charge on the sphere?

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30. A uniformly charged conducting sphere of 2.4 m diameter has a surface charge density of $80.0 \mu C/m^2$ - Find the charge on the sphere.

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31. A uniformly charged conducting sphere of 2.4 m diameter has a surface charge density of $80.0\mu C/m^2$ - What is the total electric flux leaving the surface of the sphere?

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32. An infinite line charge produces a field of $9 \times 10^4 N/C$ at a distance of 2 cm. Calculate the linear charge density.

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33. Two large, thin metal plates are parallel and close to each other. On their inner faces, the plates have surface charge densities of opposite signs and of magnitude $17.0 \times 10^{-22} C/m^2$. What is E: in the outer region of the first plate?

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34. Two large, thin metal plates are parallel and close to each other. On their inner faces, the plates have surface charge densities of opposite signs and of magnitude $17.0 \times 10^{-22} C / m^2$. What is E: in the outer region of the second plate?

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35. Two large, thin metal plates are parallel and close to each other. On their inner faces, the plates have surface charge densities of opposite signs and of magnitude $17.0 \times 10^{-22} C / m^2$. What is E: between the plates?

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36. An oil drop of 12 excess electrons is held stationary under a constant electric field of $2.55 \times 10^4 NC^{-1}$ in Millikan's oil drop experiment. The density of the oil is

$1.26gcm^{-3}$. Estimate the radius of the drop. $(g = 9.81ms^{-2}, e = 1.60 \times 10^{-19}C)$.

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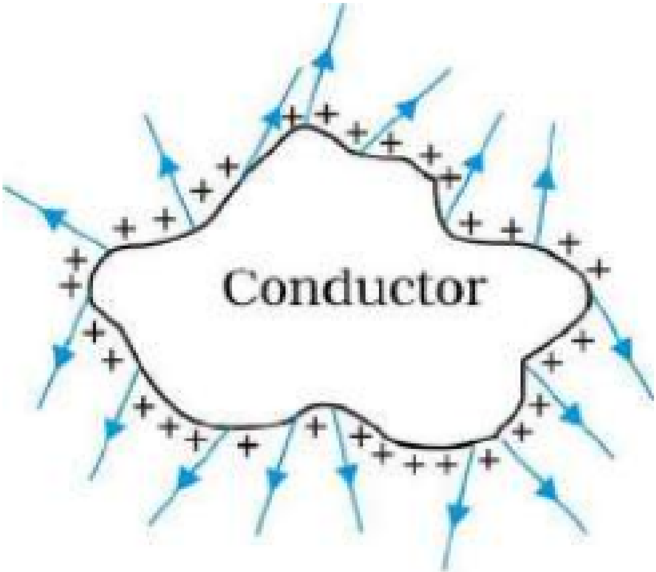
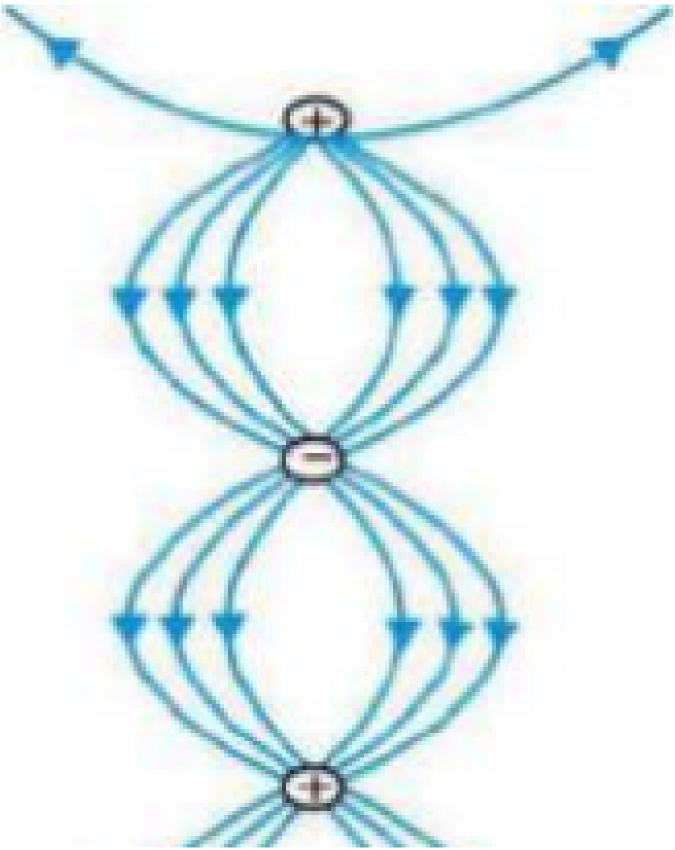
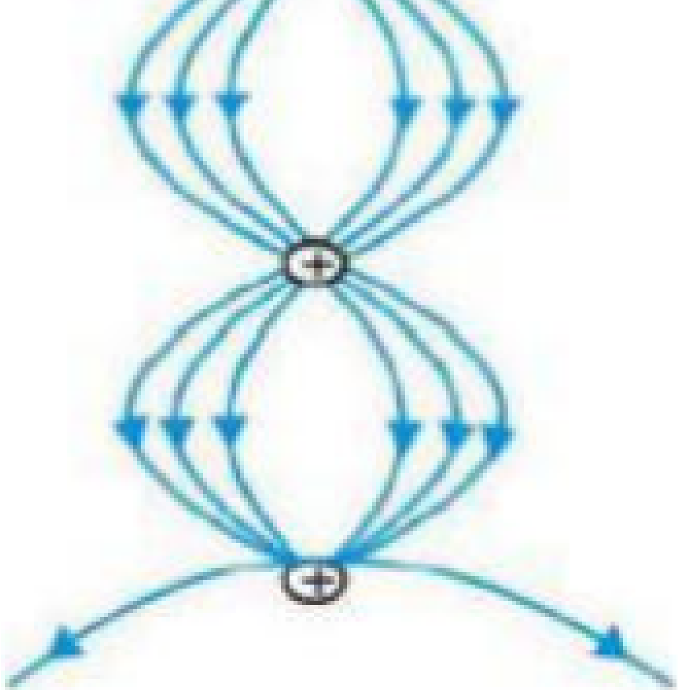
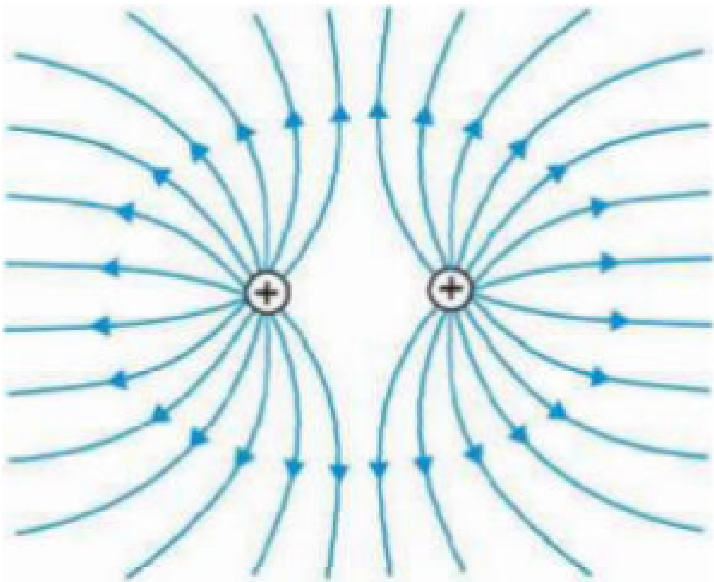
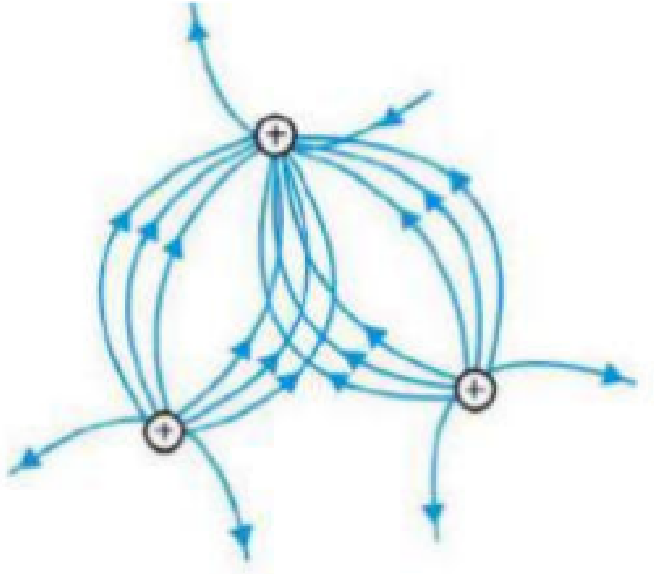
37. Which among the curves shown in Fig. cannot possibly represent electrostatic field lines? :

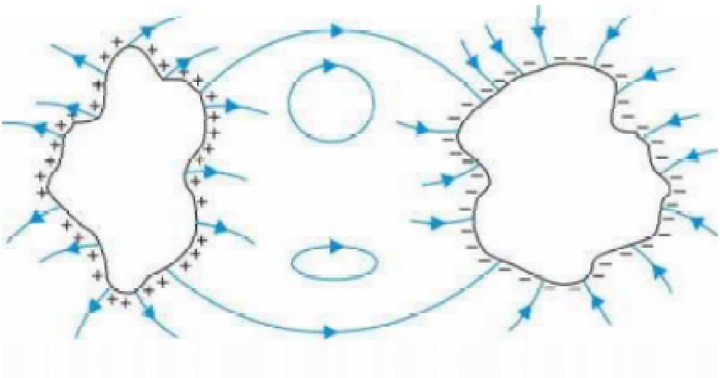

Conductor











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38. In a certain region of space, electric field is along the z-direction throughout. The magnitude of electric field is, however, not constant but increases uniformly along the positive z-direction. at the rate of $10^5 NC^{-1}$ per metre. What are the force and torque experienced by a system having a total dipole moment equal to $10^{-7} Cm$ in the negative z-direction ?

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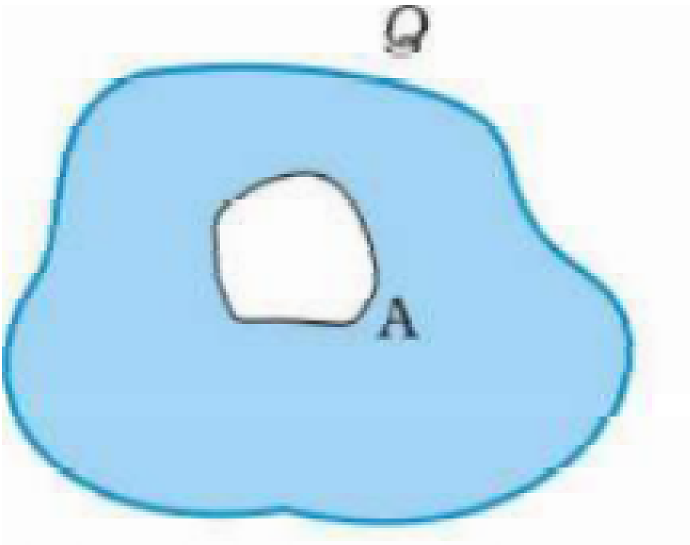
39. A conductor A with a cavity as shown in Fig. 1.36(a) is given a charge Q. Show that the entire charge must appear on the outer surface of the conductor.:



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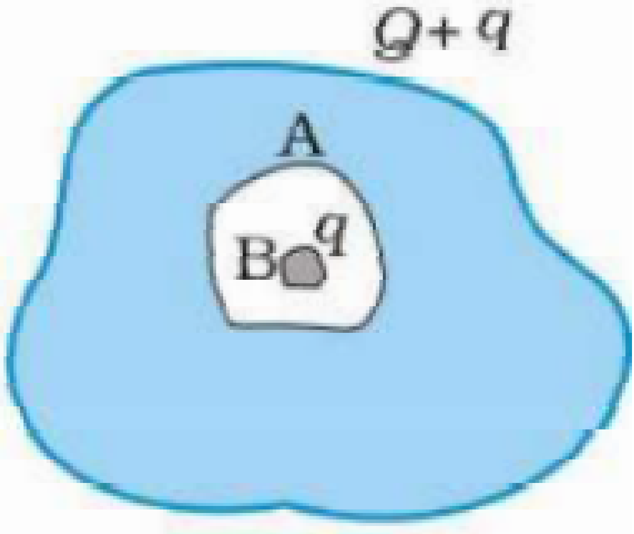
40. A conductor A with a cavity as shown in Fig. is given a charge Q.. Another conductor B with charge q is inserted into the cavity keeping B insulated from A. Show that the total charge on the outside surface of A is Q + q .



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41. A sensitive instrument is to be shielded from the strong electrostatic fields in its environment. Suggest a possible way.

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42. A hollow charged conductor has a tiny hole cut into its surface. Show that the electric field in the hole is $(\sigma / 2\varepsilon_0)\ \hat{n}$, where $\hat{n}$ is the unit

vector in the outward normal direction, and σ is the surface charge density near the hole.

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43. Obtain the formula for the electric field due to a long thin wire of uniform linear charge density λ without using Gauss's law.

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44. It is now believed that protons and neutrons (which constitute nuclei of ordinary matter) are themselves built out of more elementary units called quarks. A proton and a neutron consist of three quarks each. Two types of quarks, the so called 'up' quark (denoted by u) of charge + $(2/3)$ e, and the 'down' quark (denoted by d) of charge $(-1/3)$ e, together with electrons build up ordinary matter. (Quarks of other types have also been found which give rise to different unusual varieties of matter.) Suggest a possible quark composition of a proton and neutron.

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45. Consider an arbitrary electrostatic field configuration. A small test charge is placed at a null point (i.e., where E = 0) of the configuration. Show that the equilibrium of the test charge is necessarily unstable.

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46. Consider an arbitrary electrostatic field configuration. A small test charge is placed at a null point (i.e., where E = 0) of the configuration. Show that the equilibrium of the test charge is necessarily unstable. Verify this result for the simple configuration of two charges of the same magnitude and sign placed a certain distance apart.

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47. A particle of mass m and charge (-q) enters the region between the two charged plates initially moving along x-axis with speed v_x. The length of plate is L and an uniform electric field E is maintained between the plates. Show that the vertical deflection of the particle at the far edge of the plate is $qEL^2 / \left(2mv_x^2\right)$.

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48. Suppose that the particle is an electron projected with velocity $v_x = 2.0 \times 10^6 ms^{-1}$. If E between the plates separated by 0.5 cm is $9.1 \times 10^2 N/C$, where will the electron strike the upper plate? `(|e| =1.6 xx 10^-19 C, m_e=9.1 xx 10^-31 kg.)

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