Figures are on the last page.

1. If $a = 3.0$ mm, $b = 4.0$ mm, $Q_1 = 60$ nC, $Q_2 = 80$ nC, and $q = 24$ nC in the figure, what is the magnitude of the total electric force on q?
   (a) 2.7 N
   (b) 1.9 N
   (c) 2.3 N
   (d) 1.5 N
   (e) 0.52 N

2. A uniformly charge rod (length = 2.0 m, charge per unit length = 3.0 nC/m) is bent to form a semicircle. What is the magnitude of the electric field at the center of the circle?
   (a) 64 N/C
   (b) 133 N/C
   (c) 48 N/C
   (d) 85 N/C
   (e) 34 N/C

3. (Open Ended) The electron gun in a television tube accelerates electrons (mass = 9.1×10^{-31} kg, charge = 1.6×10^{-19} C) from rest to 3.0×10^7 m/s within a distance of 2.0 cm. What electric field is required?

4. A solid nonconducting sphere (radius = 12 cm) has a charge of uniform density (30 nC/m^3) distributed throughout its volume. Determine the magnitude of the electric field 15 cm from the center of the sphere.
   (a) 22 N/C
   (b) 49 N/C
   (c) 31 N/C
   (d) 87 N/C
   (e) 26 N/C

5. The axis of a long hollow metallic cylinder (inner radius = 1.0 cm, outer radius = 2.0 cm) coincides with a long wire. The wire has a linear charge density of −8.0 pC/m, and the cylinder has a net charge per unit length of −4.0 pC/m. Determine the magnitude of the electric field 3.0 cm from the axis.

   (a) 5.4 N/C
   (b) 7.2 N/C
   (c) 4.3 N/C
   (d) 3.6 N/C
   (e) 2.4 N/C

6. A point charge of 6.0 nC is placed at the center of a hollow spherical conductor (inner radius = 1.0 cm, outer radius = 2.0 cm) which has a net charge of −4.0 nC. Determine the resulting charge density on the inner surface of the conducting sphere.

   (a) $+4.8\ \mu C/m^2$
   (b) $-4.8\ \mu C/m^2$
   (c) $-9.5\ \mu C/m^2$
   (d) $+9.5\ \mu C/m^2$
   (e) $-8.0\ \mu C/m^2$

7. (Open Ended) The nucleus of lead-208, ${}^{208}_{82}Pb$, has 82 protons within a sphere of radius 6.34×10^{-15} m. Each electric charge has a value of 1.60×10^{-19} C. Calculate the electric field at the surface of the nucleus.

8. Point charges q and Q are positioned as shown. If $q = +2.0$ nC, $Q = -2.0$ nC, $a = 3.0$ m, and $b = 4.0$ m, what is the electric potential difference, $V_A - V_B$?

   (a) 8.4 V
   (b) 6.0 V
   (c) 7.2 V
   (d) 4.8 V
   (e) 0 V

9. Two particles, each having a mass of 3.0 mg and having equal but opposite charges of magnitude 5.0 nC, are released simultaneously from rest when the two are 5.0 cm apart. What is the speed of either particle at the instant when the two are separated by 2.0 cm?

   (a) 2.1 m/s
   (b) 1.5 m/s
   (c) 1.8 m/s
   (d) 2.4 m/s
   (e) 3.2 m/s

10. A linear charge of nonuniform density $\lambda = bx$, where $b = 2.1$ nC/m^2, is distributed along the x axis from $x = 2.0$ m to $x = 3.0$ m. Determine the electric potential (relative to zero at infinity) of the point $y = 4.0$ m on the y axis.

    (a) 36 V
    (b) 95 V
    (c) 10 V
    (d) 17 V
    (e) 15 V

11. Determine the equivalent capacitance of the combination shown when $C = 12$ pF.

    (a) 48 pF
    (b) 12 pF
    (c) 24 pF
    (d) 6.0 pF
    (e) 59 pF

12. Determine the equivalent capacitance of the combination shown when $C = 45$ μF.

    (a) 28 μF
    (b) 36 μF
    (c) 52 μF
    (d) 44 μF
    (e) 23 μF

13. Determine the equivalent capacitance of the combination shown when $C = 24\ \mu$F.
    (a) 20 μF
    (b) 36 μF
    (c) 16 μF
    (d) 45 μF
    (e) 27 μF
14. How much energy is stored in the 50-μF capacitor when $V_a - V_b = 22$ V?
    (a) 0.78 mJ
    (b) 0.58 mJ
    (c) 0.68 mJ
    (d) 0.48 mJ
    (e) 0.22 mJ
15. What total energy is stored in the group of capacitors shown if the potential deifference V_{ab} is equal to 50 V?
    (a) 48 mJ
    (b) 27 mJ
    (c) 37 mJ
    (d) 19 mJ
    (e) 10 mJ
16. When a capacitor has a charge of magnitude 80 μC on each plate the potential difference across the plates is 16 V. How much energy is stored in this capacitor when the potential difference across its plates is 42 V?
    (a) 1.0 mJ
    (b) 4.4 mJ
    (c) 3.2 mJ
    (d) 1.4 mJ
    (e) 1.7 mJ

17. A 30-μF capacitor is charged to 80 V and then connected across an initially uncharged capacitor of unknown capacitance C. if the final potential difference across the 30-μF capacitor is 20 V, determine C.

    (a) 60 μF
    (b) 75 μF
    (c) 45 μF
    (d) 90 μF
    (e) 24 μF

    Solution

    We had some trouble with the language on this one, but understand (as I do now): when something is connected "across" something else, the two elements are *in parallel.* So the problem is solved like so: the capacitance of the second capacitor is given by

$$C_2 = \frac{Q_2}{\Delta V_2} \tag{1}$$

where ΔV_2 is the final voltage drop across the parallel combination (given as 20 V). Since no charge may be lost from the system, the amount of charge Q_2 is the difference between the amount of charge C_1 stored at its original voltage, and what it now stores at the new voltage, thus

$$C_2 = \frac{Q_{1,\mathrm{i}} - Q_{1,\mathrm{f}}}{\Delta V_2} \tag{2}$$

$$= \frac{C_1 \Delta V_\mathrm{i} - C_1 \Delta V_\mathrm{f}}{\Delta V_2} \tag{3}$$

$$= \frac{C_1(\Delta V_\mathrm{i} - \Delta V_\mathrm{f})}{\Delta V_2} \tag{4}$$

$$= \frac{(3 \times 10^{-5})(80 - 20)}{20} \tag{5}$$

$$= \boxed{90\ \mu\mathrm{F}}. \tag{6}$$

18. A parallel plate capacitor of capacitance C_0 has plates of area A with separation d between them. When it is connected to a battery of voltage V_0, it has charge of magnitude Q_0 on its plates. It is then disconnected from the battery and the space between the plates is filled with a material of dielectric constant 3. After the dielectric is added, the magnitudes of the capacitance and the potential difference between the plates are

    (a) $\frac{1}{3}C_0, \frac{1}{3}V_0$

    (b) $C_0, \frac{1}{3}V_0$

    (c) C_0, V_0

    (d) $3C_0, \frac{1}{3}V_0$

    (e) $3C_0, 3V_0$

19. A 0.16 pF parallel-plate capacitor is charged to 10 V. Then the battery is disconnected from the capacitor. When 1.00×10^7 positive charges of magnitude $|e|$ are now placed on the positive plate of the capacitor, the voltage between the plates changes by

    (a) -8.9 V

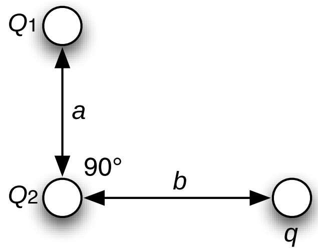
    (b) -1.1 V

    (c) 0 V

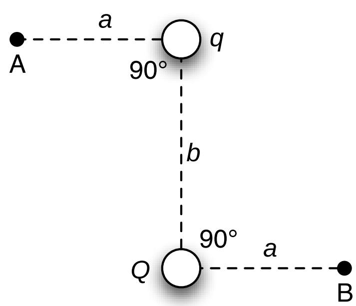
    (d) $+1.1$ V

    (e) $+8.9$ V

20. (Open Ended) Regarding the Earth and a cloud layer 800 m above the Earth as the "plates" of a capacitor, calculate the capacitance if the cloud layer has an area of 1.0 km^2. If an electric field of 2.0×10^6 N/C makes the air break down and conduct electricity (lightning), what is the maximum charge the cloud can hold?



Problem 1



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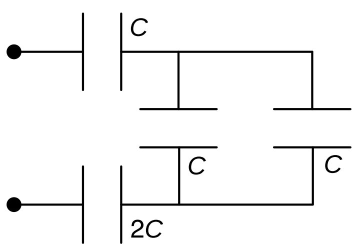

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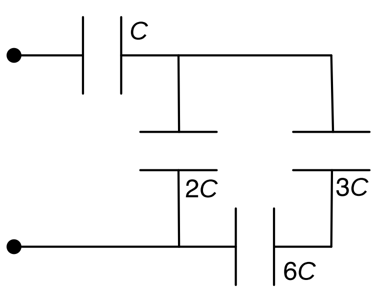

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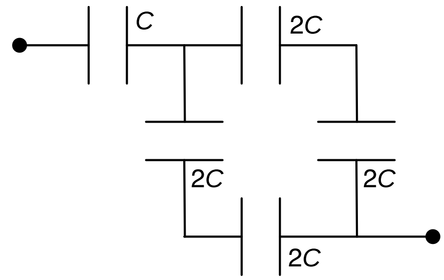

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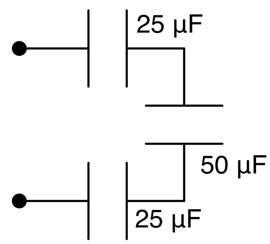
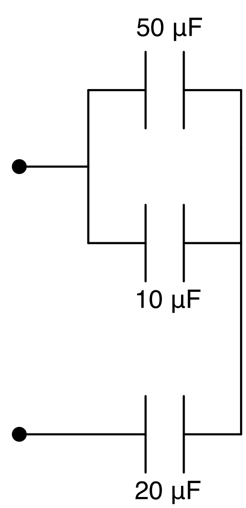


Problem 14



Problem 15