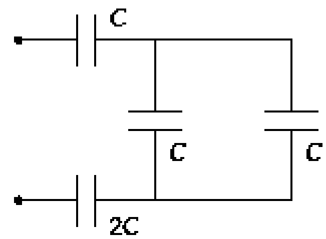
Chapter 26—Capacitance and Dielectrics

MULTIPLE CHOICES

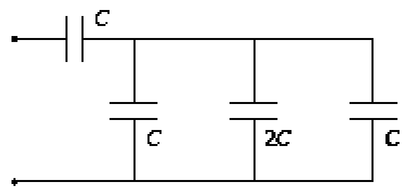
1. **Determine the equivalent capacitance of the combination shown when *C* = 12 pF.**



   a. 48 pF
   b. 12 pF
   c. 24 pF
   d. 6.0 pF
   e. 59 pF

   ANS: D

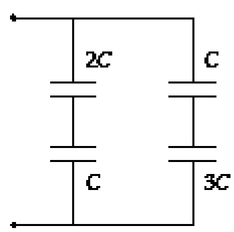
2. **Determine the equivalent capacitance of the combination shown when *C* = 15 mF.**



   a. 20 mF
   b. 16 mF
   c. 12 mF
   d. 24 mF
   e. 75 mF

   ANS: C

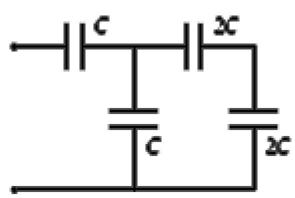
3. **Determine the equivalent capacitance of the combination shown when *C* = 12 nF.**



   a. 34 nF
   b. 17 nF
   c. 51 nF
   d. 68 nF
   e. 21 nF

   ANS: B

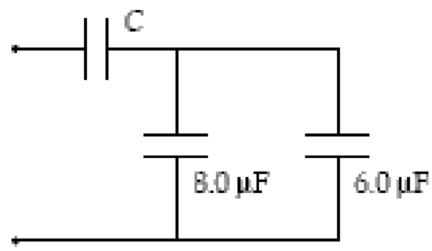
4. **Determine the equivalent capacitance of the combination shown when *C* = 45 μF.**



   a. 36 μF
   b. 32 μF
   c. 34 μF
   d. 30 μF
   e. 38 μF

   ANS: D

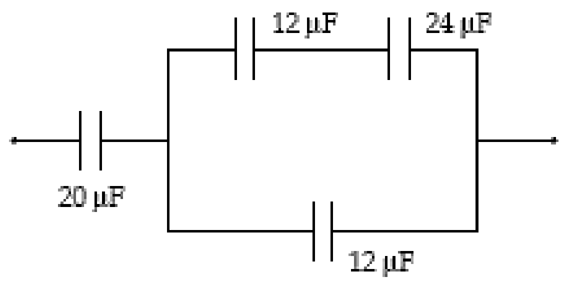
5. If $C = 10\ \mu F$, what is the equivalent capacitance for the combination shown?



a. 7.5 μF
b. 6.5 μF
c. 7.0 μF
d. 5.8 μF
e. 13 μF

ANS: D

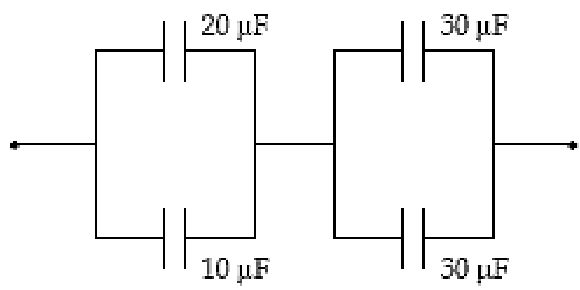
6. What is the equivalent capacitance of the combination shown?



a. 29 μF
b. 10 μF
c. 40 μF
d. 25 μF
e. 6.0 μF

ANS: B

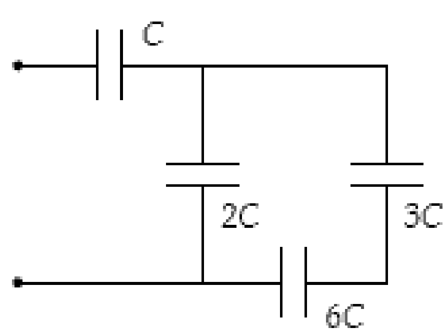
7. What is the equivalent capacitance of the combination shown?



a. 20 μF
b. 90 μF
c. 22 μF
d. 4.6 μF
e. 67 μF

ANS: A

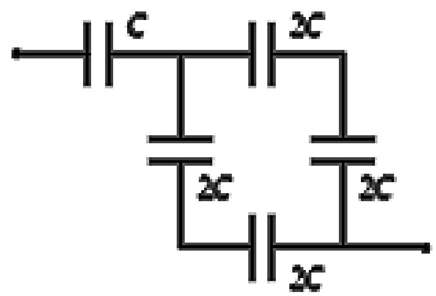
8. Determine the equivalent capacitance of the combination shown when $C = 45\ \mu F$.



a. 28 μF
b. 36 μF
c. 52 μF
d. 44 μF
e. 23 μF

ANS: B

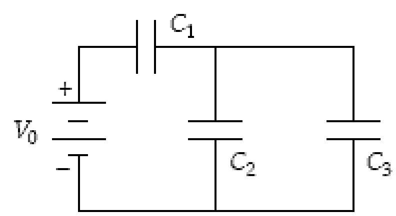
9.Determine the equivalent capacitance of the combination shown when $C = 24\ \mu\text{F}$.



a. 20 μF
b. 36 μF
c. 16 μF
d. 45 μF
e. 27 μF

ANS: C

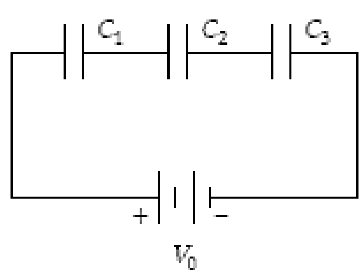
10. Determine the energy stored in C_2 when $C_1 = 15\ \mu\text{F}$, $C_2 = 10\ \mu\text{F}$, $C_3 = 20\ \mu\text{F}$, and $V_0 = 18$ V.



a. 0.72 mJ
b. 0.32 mJ
c. 0.50 mJ
d. 0.18 mJ
e. 1.60 mJ

ANS: D

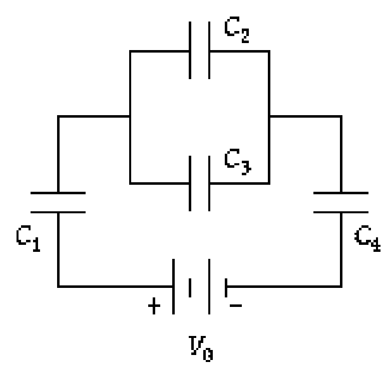
11. Determine the energy stored in C_1 when $C_1 = 10\ \mu\text{F}$, $C_2 = 12\ \mu\text{F}$, $C_3 = 15\ \mu\text{F}$, and $V_0 = 70$ V.



a. 6.5 mJ
b. 5.1 mJ
c. 3.9 mJ
d. 8.0 mJ
e. 9.8 mJ

ANS: C

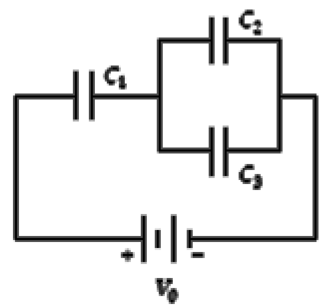
12. Determine the energy stored by C_4 when $C_1 = 20\ \mu\text{F}$, $C_2 = 10\ \mu\text{F}$, $C_3 = 14\ \mu\text{F}$, $C_4 = 30\ \mu\text{F}$, and $V_0 = 45$ V.



a. 3.8 mJ
b. 2.7 mJ
c. 3.2 mJ
d. 2.2 mJ
e. 8.1 mJ

ANS: D

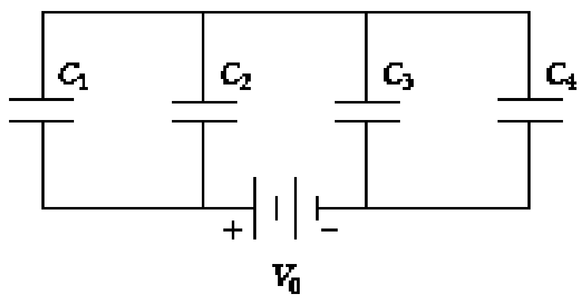
13. Determine the charge stored by C_1 when $C_1 = 20\ \mu F$, $C_2 = 10\ \mu F$, $C_3 = 30\ \mu F$, and $V_0 = 18$ V.



a. 0.37 mC
b. 0.24 mC
c. 0.32 mC
d. 0.40 mC
e. 0.50 mC

ANS: B

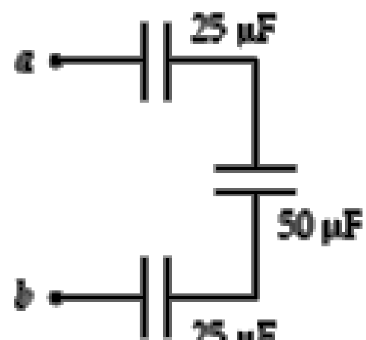
14. What is the total energy stored by C_3 when $C_1 = 50\ \mu F$, $C_2 = 30\ \mu F$, $C_3 = 36\ \mu F$, $C_4 = 12\ \mu F$, and $V_0 = 30$ V?



a. 6.3 mJ
b. 25 mJ
c. 57 mJ
d. 1.6 mJ
e. 14 mJ

ANS: A

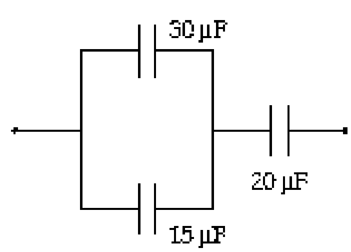
15. How much energy is stored in the 50-μF capacitor when $V_a - V_b = 22V$?



a. 0.78 mJ
b. 0.58 mJ
c. 0.68 mJ
d. 0.48 mJ
e. 0.22 mJ

ANS: D

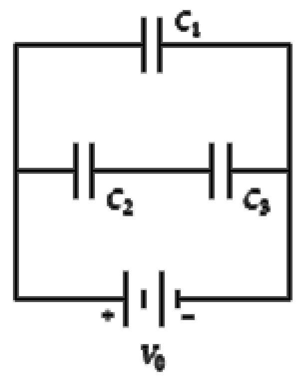
16. What is the total energy stored in the group of capacitors shown if the charge on the 30-μF capacitor is 0.90 mC?



a. 29 mJ
b. 61 mJ
c. 21 mJ
d. 66 mJ
e. 32 mJ

ANS: D

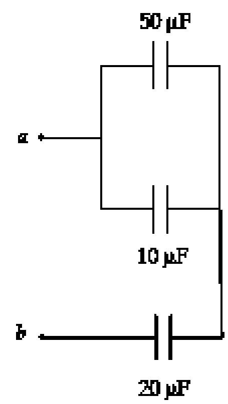
17. What is the potential difference across C_2 when $C_1 = 5.0\ \mu F$, $C_2 = 15\ \mu F$, $C_3 = 30\ \mu F$, and $V_0 = 24$ V?



a. 21 V
b. 19 V
c. 16 V
d. 24 V
e. 8.0 V

ANS: C

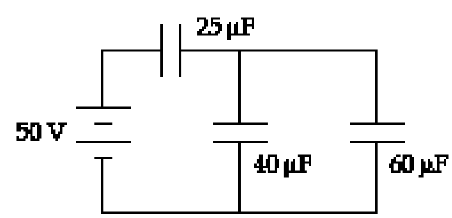
18. What total energy is stored in the group of capacitors shown if the potential difference V_{ab} is equal to 50 V?



a. 48 mJ
b. 27 mJ
c. 37 mJ
d. 19 mJ
e. 10 mJ

ANS: D

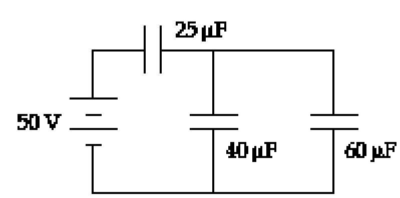
19. Determine the energy stored in the 60-μF capacitor.



a. 2.4 mJ
b. 3.0 mJ
c. 3.6 mJ
d. 4.3 mJ
e. 6.0 mJ

ANS: B

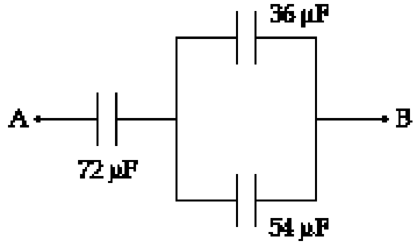
20. Determine the energy stored in the 40-μF capacitor.



a. 2.4 mJ
b. 1.6 mJ
c. 2.0 mJ
d. 2.9 mJ
e. 4.0 mJ

ANS: C

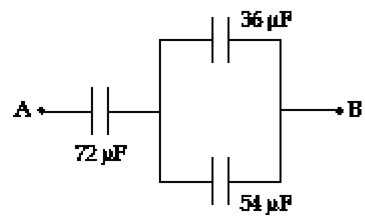
21. If V_A - V_B = 50 V, how much energy is stored in the 36-μF capacitor?



a. 50 mJ
b. 28 mJ
c. 13 mJ
d. 8.9 mJ
e. 17 mJ

ANS: D

22. If $V_A - V_B = 50$ V, how much energy is stored in the 54-μF capacitor?



a. 50 mJ
b. 13 mJ
c. 28 mJ
d. 8.9 mJ
e. 17 mJ

ANS: B

23. 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

ANS: B

24. A 15-μF capacitor and a 30-μF capacitor are connected in series, and charged to a potential difference of 50 V. What is the resulting charge on the 30-μF capacitor?

a. 0.70 mC
b. 0.80 mC
c. 0.50 mC
d. 0.60 mC
e. 0.40 mC

ANS: C

25. A 15-μF capacitor and a 25-μF capacitor are connected in parallel, and charged to a potential difference of 60 V. How much energy is then stored in this capacitor combination?

a. 50 mJ
b. 18 mJ
c. 32 mJ
d. 72 mJ
e. 45 mJ

ANS: D

26. 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 plates are pulled apart to a separation 2d without discharging them. After the plates are 2d apart, the magnitude of the charge on the plates and the potential difference between them are

a. $\frac{1}{2}Q_0$, $\frac{1}{2}V_0$

b. Q_0, $\frac{1}{2}V_0$

c. Q_0, V_0

d. Q_0, $2V_0$

e. $2Q_0$, $2V_0$

ANS: D

27. 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 plates are pulled apart to a separation 2d without discharging them. After the plates are 2d apart, the new capacitance and the potential difference between the plates are

a. $\frac{1}{2}C_0$, $\frac{1}{2}V_0$

b. $\frac{1}{2}C_0$, V_0

c. $\frac{1}{2}C_0$, $2V_0$

d. C_0, $2V_0$

e. $2C_0$, $2V_0$

ANS: C

28. 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. The plates are pulled apart to a separation 2d while the capacitor remains connected to the battery. After the plates are 2d apart, the magnitude of the charge on the plates and the potential difference between them are

a. $\frac{1}{2}Q_0$, $\frac{1}{2}V_0$

b. $\frac{1}{2}Q_0$, V_0

c. Q_0, V_0

d. $2Q_0$, V_0

e. $2Q_0$, $2V_0$

ANS: B

29. 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. The plates are pulled apart to a separation $2d$ while the capacitor remains connected to the battery. After the plates are $2d$ apart, the capacitance of the capacitor and the magnitude of the charge on the plates are

a. $\frac{1}{2}C_0$, $\frac{1}{2}Q_0$

b. $\frac{1}{2}C_0$, Q_0

c. C_0, Q_0

d. $2C_0$, Q_0

e. $2C_0$, $2Q_0$

ANS: A

30. 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. While it is connected to the battery the space between the plates is filled with a material of dielectric constant 3. After the dielectric is added, the magnitude of the charge on the plates and the potential difference between them are

a. $\frac{1}{3}Q_0$, $\frac{1}{3}V_0$

b. Q_0, $\frac{1}{3}V_0$

c. Q_0, V_0

d. $3Q_0$, V_0

e. $3Q_0$, $3V_0$

ANS: D

31. 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. While it is connected to the battery, the space between the plates is filled with a material of dielectric constant 3. After the dielectric is added, the magnitude of the charge on the plates and the new capacitance are

a. $\frac{1}{3}Q_0$, $\frac{1}{3}C_0$

b. Q_0, $\frac{1}{3}C_0$

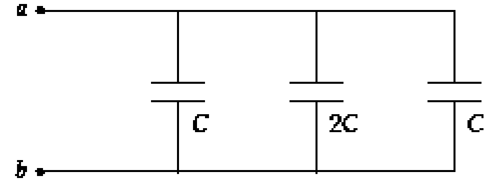
c. Q_0, C_0

d. $3Q_0$, C_0

e. $3Q_0$, $3C_0$

ANS: E

32.The equivalent capacitance of the circuit shown below is



a. 0.2 C.
b. 0.4 C.
c. 1 C.
d. 4 C.
e. 5 C.

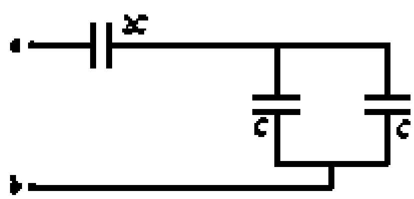
ANS: D

33. The equivalent capacitance of the circuit shown below is

a. 0.2 C.
b. 0.4 C.
c. 1 C.
d. 4 C.
e. 5 C.

ANS: B

34. The equivalent capacitance of the circuit shown below is



a. 0.50 C.
b. 1.0 C.
c. 1.5 C.
d. 2.0 C.
e. 2.5 C.

ANS: B

35. Which of the following is not a capacitance?

a. $\frac{\varepsilon_0 A}{d}$
b. $\frac{\kappa \varepsilon_0 A}{d}$
c. $\frac{ab}{k_e(b-a)}$
d. $\frac{k_e \varepsilon_0 A}{d}$

ANS: d

36.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 charge on the plates and the potential difference between them are

a. $\frac{1}{3}Q_0$, $\frac{1}{3}V_0$.

b. Q_0, $\frac{1}{3}V_0$.

c. Q_0, V_0.

d. Q_0, $3V_0$.

e. $3Q_0$, $3V_0$.

ANS: B

37. 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. $3C_0$, $3V_0$.

ANS: D

38. An initially uncharged parallel plate capacitor of capacitance C is charged to potential V by a battery. The battery is then disconnected. Which statement is correct?

a. There is no charge on either plate of the capacitor.

b. The capacitor can be discharged by grounding any one of its two plates.

c. Charge is distributed evenly over both the inner and outer surfaces of the plates.

d. The magnitude of the electric field outside the space between the plates is approximately zero.

e. The capacitance increases when the distance between the plates increases.

ANS: D

39. A 0.120 pF parallel-plate capacitor is charged to a potential difference of 10.0 V and then disconnected from the battery. A cosmic ray burst creates 1.00×10^6 electrons and 1.00×10^6 positive charges between the plates. If the charges do not recombine, but reach the oppositely charged plates, by how much is the potential difference between the capacitor plates reduced?
    a. 1.33 V
    b. 7.34 V
    c. 8.67 V
    d. 1,330 V
    e. 8,670 V

    ANS: A

40. 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 electrons are now placed on the negative plate of the capacitor, the voltage between the plates changes by
    a. –5.0 V.
    b. –1.1 V.
    c. 0 V.
    d. +1.1 V.
    e. +5.0 V.

    ANS: E

41. 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. –5.0 V.
    b. –1.1 V.
    c. 0 V.
    d. +1.1 V.
    e. +5.0 V.

    ANS: E

42. A parallel plate capacitor is charged to voltage *V* and then disconnected from the battery. Leopold says that the voltage will decrease if the plates are pulled apart. Gerhardt says that the voltage will remain the same. Which one, if either, is correct, and why?
    a. Gerhardt, because the maximum voltage is determined by the battery.
    b. Gerhardt, because the charge per unit area on the plates does not change.
    c. Leopold, because charge is transferred from one plate to the other when the plates are separated.
    d. Leopold, because the force each plate exerts on the other decreases when the plates are pulled apart.
    e. Neither, because the voltage increases when the plates are pulled apart.

    ANS: E

43. **Addition of a metal slab of thickness *a* between the plates of a parallel plate capacitor of plate separation *d* is equivalent to introducing a dielectric with dielectric constant *k* between the plates. The value of *k* is**
   a. $\frac{d-a}{d}$.
   b. ***d*.**
   c. ***d* - *a*.**
   d. $\frac{d}{d-a}$.
   e. $\frac{d}{a}$.

   ANS: D

44. **A parallel plate capacitor is connected to a battery and charged to voltage *V*. Leah says that the charge on the plates will decrease if the distance between the plates is increased while they are still connected to the battery. Gertie says that the charge will remain the same. Which one, if either, is correct, and why?**
   a. **Gertie, because the maximum voltage is determined by the battery.**
   b. **Gertie, because the capacitance of the capacitor does not change.**
   c. **Leah, because the capacitance decreases when the plate separation is increased.**
   d. **Leah, because the capacitance increases when the plate separation is increased.**
   e. **Neither, because the charge increases when the plate separation is increased.**

   ANS: C

45. **Two spheres are made of conducting material. Sphere #2 has twice the radius of Sphere #1. What is the ratio of the capacitance of Sphere #2 to the capacitance of sphere #1?**
   a. **1, since all conducting spheres have the same capacitance.**
   b. **2**
   c. **4**
   d. **8**
   e. **A single sphere has no capacitance since a second concentric spherical shell is necessary to make a spherical capacitor. Thus, none of the answers above is correct.**

   ANS: B

46. **Into the gap between the plates of a parallel plate capacitor of capacitance C_0 a slab of metal is inserted halfway between the plates filling one fourth of the gap between the plates. What is the resulting new capacitance?**
   a. $\frac{3}{4}C_0$
   b. $\frac{4}{3}C_0$
   c. $\frac{9}{16}C_0$
   d. $\frac{16}{9}C_0$
   e. $\frac{5}{4}C_0$

   ANS: B

PROBLEMS

1. Is it feasible to construct an air-filled parallel-plate capacitor that has its two plates separated by 0.10 mm and has a capacitance of 1.0 F? Why or why not?

   ANS:

   No. Each plate would have an area of 1.1×10^7 m^2

2. An electron is released from rest at the negative plate of a parallel plate capacitor. If the distance between the plates is 5 mm and the potential difference across the plates is 5 V, with what velocity does the electron hit the positive plate? ($m_e = 9.1 \times 10^{-31}$ kg, $q_e = 1.6 \times 10^{-19}$ C.)

   ANS:

   1.33×10^6 m/s

3. A 200-volt battery is connected to a 0.50-microfarad parallel-plate, air-filled capacitor. Now the battery is disconnected, with care taken not to discharge the plates. Some Pyrex glass is then inserted between the plates, completely filling up the space. What is the final potential difference between the plates? (The dielectric constant for Pyrex is $\kappa = 5.6$.)

   ANS:

   36 V