ÇANKAYA UNIVERSITY

PHYS 132 – PHYSICS II

CHAPTER 25

CAPACITANCE

PROBLEM SET

1) *** The charge on a capacitor increases by 26 μC when the voltage across it increases from 28 V to 78 V. What is the capacitance of the capacitor?
[Answer: 0,52 µF]

2) Assume a 1200-F ultracapacitor is initially charged to 12.0V by a battery and is then disconnected from the battery. If charge is then drawn off the plates of this capacitor at a rate of 1.0 mC/s, how long (in days) will it take for the potential difference across this capacitor to drop to 6.0 V? **[Answer: 83 days]**

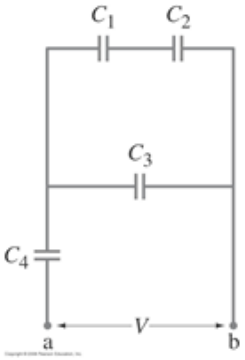
3) Dry air will break down if the electric field exceeds about $3.0 \times 10^6\ V/m$. What amount of charge can be placed on a capacitor if the area of each plate is 6.8 cm^2 ?
[Answer: $\mathbf{1.8 \times 10^{-8}}$ C]

4) Given three capacitors, $C_1 = 2.0$ µF, $C_2 = 1.5$ µF and $C_3 = 3.0$ µF, what arrangement of parallel and series connections with a 12-V battery will give the minimum voltage drop across the $2.0 -$ µF capacitor? What is the minimum voltage drop?
[Answer: 2.8 V]

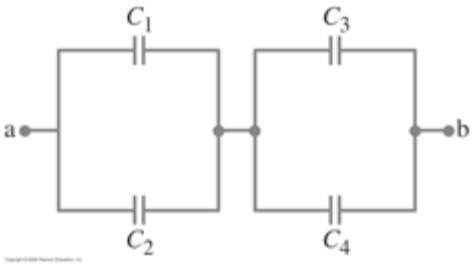
5) In Fig. 24–23, suppose $C_1 = C_2 = C_3 = C_4 = C$. (*a*) Determine the equivalent capacitance between points a and b. (*b*) Determine the charge on each capacitor and the potential difference across each in terms of *V*. **[Answer: a)** $\frac{3}{5}C$**, b) below**

$Q_1 = Q_2 = \frac{1}{5}CV \;;\; Q_3 = \frac{2}{5}CV \;;\; Q_4 = \frac{3}{5}CV$

$V_1 = V_2 = \frac{1}{5}V \;;\; V_3 = \frac{2}{5}V \;;\; V_4 = \frac{3}{5}V$ **]**



6) *** In Fig. 24–25, $C_1 = C_3 = 8.0\ \mu\text{F}$, $C_2 = C_4 = 16\ \mu\text{F}$, and $Q_3 = 23\ \mu\text{C}$ Determine (*a*) the charge on each of the other capacitors, (*b*) the voltage across each capacitor, and (*c*) the voltage V_{ba} across the combination.**[Answer: a)** $Q_1 = 23\ \mu\text{C}$, $Q_2 = 46\ \mu\text{C}$, $Q_4 = 46\ \mu\text{C}$ **b)** $V_1 = V_2 = V_3 = V_4 = 2.9\ \text{V}$ **c)** $V_{ba} = 5.8\ V$ **]**



7) (*a*) Show that each plate of a parallel-plate capacitor exerts a force

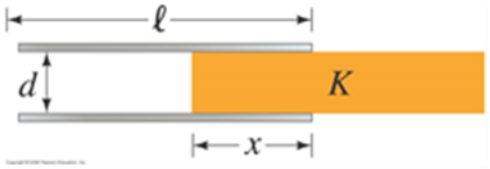
$$F = \frac{1}{2}\frac{Q^2}{\varepsilon_0 A}$$

on the other, by calculating *dW*/*dx* where *dW* is the work needed to increase the separation by *dx*. (*b*) Why does using $F = QE$, with *E* being the electric field between the plates, give the wrong answer? **[Answer: b) Because the electric field is due to both plates, and charge cannot put a force on itself by the field it creates. By the symmetry of the geometry, the electric field at one plate, due to just the other plate, is** $\frac{1}{2}E$**.]**

8) When two capacitors are connected in parallel and then connected to a battery, the total stored energy is 5.0 times greater than when they are connected in series and then connected to the same battery. What is the ratio of the two capacitances? (Before the battery is connected in each case, the capacitors are fully discharged.)

[Answer: $\frac{C_1}{C_2} = 2.62$ *or* $\frac{C_1}{C_2} = 0.382$]

9) A slab of width d and dielectric constant K is inserted a distance x into the space between the square parallel plates (of side $\boldsymbol{l}$) of a capacitor as shown in Fig. 24–32. Determine, as a function of x, (*a*) the capacitance, (*b*) the energy stored if the potential difference is V_0, and (*c*) the magnitude and direction of the force exerted on the slab (assume V_0 is constant).**[Answer: below]**



a) $\varepsilon_0 \frac{\ell^2}{d}\left[1+(K-1)\frac{x}{\ell}\right]$

b) $\varepsilon_0 \frac{\ell^2}{2d}\left[1+(K-1)\frac{x}{\ell}\right]V_0^2$

c) $\frac{V_0^2 \varepsilon_0 \ell}{2d}(K-1)$, left

10) *** The capacitor shown in Fig. 24–34 is connected to a 90.0-V battery. Calculate (and sketch) the electric field everywhere between the capacitor plates. Find both the free charge on the capacitor plate and the induced charge on the faces of the glass dielectric plate.

[Answer: $Q_{plate} = 3.45 \times 10^{-7}\ C$, $Q_{ind} = 2.86 \times 10^{-7}\ C$]