Ch 18 (YG) Electrical Energy and Capacitance.

The list of recommended Problems.

**Potential Difference and Potential Energy**

\( W_{a\rightarrow b_{(el)}} = |F| \cdot |S| \cos \theta = -q_0 \cdot E \cdot (y_b - y_a) > 0 \)

\( W_{el} = -\Delta U = -(U_b - U_a) \)

\( U_{el} = k \frac{q_1 \cdot q_2}{r} \)

\( K_a + U_a = K_b + U_b \)

![Diagram](image)

# 5, 8 (b), 9,10
Ex.18.1, p.584
Ex18.2, p.588

## 1, 2, 3, 4, 8 (a)
Ex18.3, p.589
Ex.18.4, p.591

## 22

## 24

**Electric Potential**

\( V = \frac{PE_{el}}{q_{test}} = k \frac{Q_{source}}{r} \)

\( K_a + U_a = K_b + U_b \)

\( V_{tot} = k \left( \frac{q_1}{r_1} + \frac{q_2}{r_2} + \frac{q_3}{r_3} + \ldots \right) \)

\( W_{a-b} = (V_a - V_b) q_0 \)

## 10, 11
## 16
## 18
## 23

## 22

## 24
## 75, 78, 79, 80

### The Parallel – Plate Capacitor.

\[ C = \frac{Q}{V_{ab}} = \varepsilon_0 \frac{A}{d} \]
\[ E = \frac{\sigma}{\varepsilon_0} = \frac{Q}{\varepsilon_0 A} \]
\[ V_{ab} = E \cdot d \]

\[ 1 \text{ F} = 1 \frac{C^2}{N \cdot m} = 1 \frac{C^2}{J} \]

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### Ch 16.8. Combination of Capacitors.

(1) In Series

- \[ \frac{1}{C_{ser}} = \frac{1}{C_1} + \frac{1}{C_2} \]
- \[ V_{tot} = V_1 + V_2 \]
- \[ Q_{tot} = Q_1 = Q_2 \]

(2) In Parallel

- \[ C_{par} = C_1 + C_2 \]
- \[ V_{tot} = V_1 = V_2 \]
- \[ Q_{tot} = Q_1 + Q_2 \]

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## 41, 42, 44, 45

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## 49, 50
(3) Combination of Capacitors

### 39, Sw (Ex16.8)
Sw # 16.(40 +41) + ( V_{ab} + C_i, q_i )

Instructor’s Problems.

(Given: C –s, q_n
Find: q-s, V-s, V_{tot}, q_{tot}, C_{tot} )

### 85

Connected to the battery and then reconnected
Ch16.9 Energy Stored in the Capacitor

\[ U = \frac{V \cdot Q}{2} = \frac{Q^2}{2C} = \frac{CV^2}{2} \]

### 81 or 82 (Connected and disconnected from the battery)

### 86

Reconnection of capacitors.

Sw #16.61,
Sw #16.62

Ch.16.10. Capacitor with Dielectric.

\[ K = \frac{C}{C_0} = \frac{V_0}{V} = \frac{E_0}{E} \]

### 83, 84,
### 88, 89 ( set up)

Capacitor and Kinematics
(See Ch 17 assignment)

\[ \Delta y = v_y \Delta t + \frac{a_y \Delta t^2}{2} \]

Sw 66

#17.70
Fr-12, #21.83
### The problems.

1. (Kn, Ex29.1) A 2.0 cm *2.0 cm parallel – plate capacitor with a 2.0 mm spacing is charged to ±1.0nC. First a proton, then a electron are released from rest at the midpoint of the capacitor.

   (1) What is each particle’s change in electric potential energy from its release until it collides with one of the plates?

   (2) What is each particle’s speed as it reaches the plate? { 2.33*10^5 m/s - proton 9.96 *10^6 m/s - electron}

![Diagram of capacitor with particles](image)

2. (Kn Ex 29.7) A parallel – plate capacitor is constructed of two 2.0 cm diameter disks spaced 2.0 mm apart. It is charged to a potential difference of 500 V.

   (a) What is the electric field strength inside? (2.5 *10^5 V/m)

   (b) A proton is shot through a small hole in the negative plate with a speed of 2.0 *10^5 m/s. Does it reach the other side? If not, where is the turning point? (No it turns around at a distance of 0.84 mm before the plate, L = 1.16 mm)

![Diagram of capacitor with proton](image)

3. (Kn #29.42) A proton and α - particle (q = +2e, m = 4u) are fired directly toward each other from far away, each with an initial speed of 0.01c. What is their distance of closest approach, as measured between their centers? (Δx_{min} if \( \vec{V}_1 = \vec{V}_2 \); \( \Delta x_{min} = 1.93*10^{-14} \text{ m} \), \( v_f = 1.8*10^6 \text{ m/s} \))

![Diagram of α particle and proton](image)
4. (Kn, #29.79) The 2.0 mm diameter spheres [(2.0 g, 2.0 nC) and (1.0 g, 1.0 nC)] are released from rest when they are next to each other. What are their speed $v_C$ and $v_D$ when they are very far from each other? ($v_a = -0.0548 \text{ m/s}$, $v_b = 0.110 \text{ m/s}$)

4. (Kn, #29 #80) The 2.0 mm diameter spheres [(1.0 g, 2.0 nC) and (2.0 g, -1.0 nC)] are released from rest at a distance of 10.0 mm from each other. What are their speed $v_C$ and $v_D$ at the instant they collide? ($v_1 = -2v_2$; $v_1 = 4.9 \text{ cm/s}$, $v_2 = -9.8 \text{ cm/s}$)

5. Sw#16.(40+41)
(1) Find the equivalent capacitance between point a and b. $C_1 = 5 \mu F$, $C_2 = 10 \mu F$, $C_3 = 2 \mu F$. (6.04 $\mu F$)
(2) If $V_{ab} = 60.0 \text{ V}$, Find $q_3$? (83.6 $\mu C$)

6. (Sw #16, 57) Find the equivalent capacitance of the combination. (All capacitances are given in $\mu F$)
7. (Sw, #16.61) Capacitors $C_1 = 6.0 \ \mu F$ and $C_2 = 2.0 \ \mu F$ are charged as a parallel combination across a 250 – V battery. The capacitors are disconnected from the battery and from each other. They are then connected positive plate to negative plate and negative plate to positive plate. Calculate the resulting charge on each capacitor.

8. (Sw, #16.62) Capacitors $C_1 = 4.0 \ \mu F$ and $C_2 = 2.0 \ \mu F$ are charged as a series combination across a 100 – V battery. The capacitors are disconnected from the battery and from each other. They are then connected positive plate to positive plate and negative plate to negative plate. Calculate the resulting charge on each capacitor.