Assignment 1

February 4, 2023 1:17 AM

Assignment-1

1 Assignment Prepared By (Individual Work)

Assignment Due: February 7, 2023 – 11:59 pm
Please submit on Blackboard / email

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2 Questions

Q1 [Textbook 22.33] [20 pts]

T A charged cork ball of mass 1.00 g is suspended on a light string in the presence of a uniform electric field as shown in Figure P22.33. When $\vec{\mathbf{E}} = (3.00\hat{\mathbf{i}} + 5.00\hat{\mathbf{j}}) \times 10^5$ N/C, the ball is in equilibrium at $\theta = 37.0°$. Find

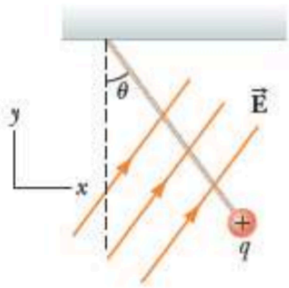
(a) the charge on the ball and

(b) the tension in the string.

$\sum F = T + qE + mg$

$E_x = 3.00\hat{i} \cdot 10^5$ N/C

$E_y = 5.00\hat{j} \cdot 10^5$ N/C



Applying Newton's second law or the first condition for equilibrium in the x & y directions,

$\sum F_x = qE_x - T\sin 37° = 0$ [Eq1]

$\sum F_y = qE_y + T\cos 37° - mg = 0$ [Eq2]

Figure [22.33]: A charged ball suspended on a string.

a) Solve for T from eq1

$T = \frac{qE_x}{\sin 37°}$

$q = \frac{mg}{E_y + \frac{E_x}{\tan 37°}}$

$= \frac{(1.00 \cdot 10^{-3}\ kg)(9.80\ m/s^2)}{5 \cdot 10^5\ N/C + \left(\frac{3 \cdot 10^5\ N/C}{\tan 37°}\right)}$

$\boxed{q = 1.09 \cdot 10^{-8}\ C}$

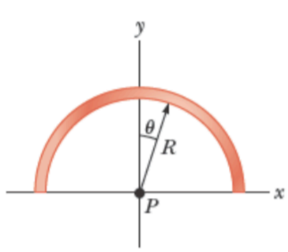
b) $T = \frac{qE_x}{\sin 37°}$

$= \frac{(1.09 \cdot 10^{-8}\ C)(3 \cdot 10^5\ N/C)}{\sin 37°}$

$\boxed{T = 5.44 \cdot 10^{-3}\ N}$

Q2 [Textbook 23.41] [20 pts]

A line of positive charge is formed into a semicircle of radius $R = 60.0$ cm as shown in Figure P23.41. The charge per unit length along the semicircle is given by the expression $\lambda = \lambda_0 \cos\theta$. The total charge on the semicircle is 12.0 μC. Calculate the total force on a charge of 3.00 μC placed at the center of curvature P.



$\lambda_0 = \frac{Q}{2R}$

$= \frac{12 \cdot 10^{-6}}{2(0.6)}$

$= 1 \cdot 10^{-5}\ C$

Figure [23.41]: Electric force due to continuous charge distribution.

$F_e = qE$

$= -\frac{\pi K_e \lambda_0 q}{2R}$

$$F_e = -\frac{\pi(8.988\,10^{9})(1\,10^{-5})(3\,10^{-6})}{2(0.6)}$$

$$= -706\,10^{-3}\,N$$

(−) Indicates that the total force is directed in the negative direction

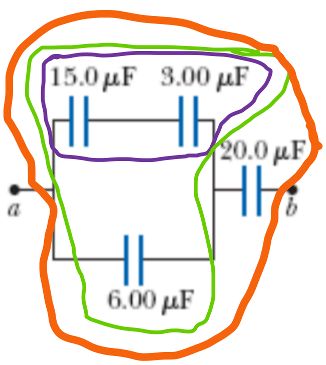
$$F_e = -(706\,10^{-3}\,N)\,J$$

Q3 [Textbook 25.11] [20 pts]

Four capacitors are connected as shown in Figure P25.11.

(a) Find the equivalent capacitance between points a and b.

(b) Calculate the charge on each capacitor, taking $\Delta V_{ab} = 15.0$ V.



a)

$$\frac{1}{C_s} = \frac{1}{15.0} + \frac{1}{3.00}$$

$$\frac{1}{C_s} = \frac{1}{0.4}$$

$$C_s = 2.50\,\mu F$$

$$C_p = 2.50\,\mu F + 6.00\,\mu F$$

$$C_p = 8.50\,\mu F$$

$$C_{eq} = \frac{1}{\left(\frac{1}{8.50} + \frac{1}{20.0}\right)}$$

$$C_{eq} = \frac{1}{\frac{57}{340}}$$

$$C_{eq} = 5.96\,\mu F$$

Figure [25.11]: Capacitor combination.

B)

$$Q = C\Delta V = (5.96\,\mu F)(15V)$$

$$= 89.5\,\mu C \text{ on } 20\,\mu F$$

$$\Delta V = \frac{Q}{C} = \frac{89.5\,\mu C}{20.0\,\mu F} = 4.47V$$

$$15V - 4.47V = 10.53V$$

$$Q = C\Delta V = (6\,\mu F)(10.53V)$$

$$= 63.2\,\mu C \text{ on } 6\,\mu F$$

$$89.5 - 63.2 = 26.3\,\mu C \text{ on } 15\,\mu F \,\&\, 3\,\mu F$$

Q4 [Textbook 26.30] [20 pts]

An 11.0-W energy-efficient fluorescent lightbulb is designed to produce the same illumination as a conventional 40.0-W incandescent lightbulb. Assuming a cost of $0.110/kWh for energy from the electric company, how much money does the user of the energy-efficient bulb save during 100 h of use?

Bulb 1 = Power → 11.0W
Bulb 2 = Power → 40W

Cost / energy = $0.110/KWH

$t = 100$ hours

$E = P \cdot t$

$E_{B1} = \frac{11 \cdot 100}{1000}$

$= 1.1\ KWH$

$E_{B2} = \frac{40 \cdot 100}{1000}$

$= 4\ KWH$

$(4 - 1.1) \cdot 0.110$

$= 2.9 \cdot 0.110$

$= 0.319$

total money saved would be $0.319

Q5 [Textbook 27.22] [20 pts]

GP Q|C For the circuit shown in Figure P27.22, we wish to find the currents I_1, I_2, and I_3. Use Kirchhoff's rules to obtain equations for

(a) the upper loop,

(b) the lower loop, and

(c) the junction on the left side. In each case, suppress units for clarity and simplify, combining the terms.

a) $\begin{bmatrix} -(11\Omega) I_2 + 12V - (7\Omega) I_2 \\ -(5\Omega) I_1 + 18V - (8\Omega) I_1 \end{bmatrix} = 0$

$(13\Omega) I_1 + (18\Omega) I_2 = 30V$ 1

B) $\begin{bmatrix} -(5\Omega) I_3 + 36V + (7\Omega) I_2 \\ -12V + (11\Omega) I_2 \end{bmatrix} = 0$

$(18\Omega) I_2 - (5\Omega) I_3 = -24V$ 2

(d) Solve the junction equation for I_3.

(e) Using the equation found in part (d), eliminate I_3 from the equation found in part (b).

(f) Solve the equations found in parts (a) and (e) simultaneously for the two unknowns I_1 and I_3.

(g) Substitute the answers found in part (f) into the junction equation found in part (d), solving for I_3.

(h) What is the significance of the negative answer for I_2?

C) $I_1 - I_2 - I_3 = 0$ (3)

d) $I_3 = I_1 - I_2$

e) $(18\Omega)I_2 - (5\Omega)(I_1 - I_2) = -24V$

$(18\Omega)I_2 - (5\Omega)I_1 + (5\Omega)I_2 = -24V$ (4)

$(5\Omega)I_1 - (23\Omega)I_2 = 24V$

f) $(5\Omega)I_1 - (23\Omega)I_2 = 24V$

$I_1 = \dfrac{24V + (23\Omega)I_2}{5\Omega}$ (5)

$(13\Omega)I_1 + (18\Omega)I_2 = 30V$

$(13\Omega)\left(\dfrac{24V + 23\Omega}{5\Omega}\right) + (18\Omega)I_2 = 30V$

$13\Omega((24V + 23\Omega)I_2) + (5\Omega)(18\Omega)I_2 = 30V \cdot 5\Omega$

$312\,\Omega V + (299\Omega^2)I_2 + (90\Omega^2)I_2 = 150\,\Omega V$

$(389\Omega^2)I_2 = -162\,\Omega V$

$I_2 = \dfrac{-162\,\Omega V}{(389\Omega^2)}$

$I_2 = -0.416\,A$

$I_1 = \dfrac{24V + (23\Omega)(-0.416A)}{5\Omega}$

$I_1 = 2.88A$

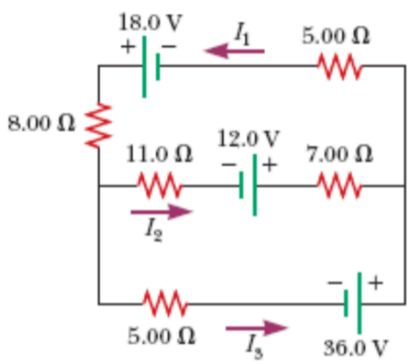


Figure [27.22]: Circuit diagram.

G) $I_3 = I_1 - I_2$

$I_3 = 2.88 - (-0.416)$

$I_3 = 3.29A$

H) It means that the current flows in the opposite direction.