Physics 161

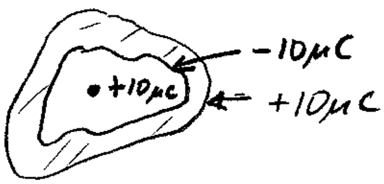
Test 2 Spring 2008, Dr. Morrison

Solutions

(1) (D) $V = \text{constant}$ inside a static conductor

(2) (B) $W = \int \vec{F}\cdot d\vec{\ell} < 0$, $\Delta V = -\int \vec{E}\cdot d\vec{\ell} > 0$

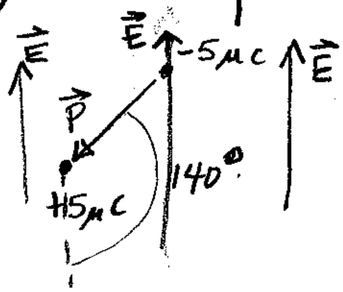
(3)



(D)

(4) (D)

(5) $\vec{\tau} = \vec{p} \times \vec{E}$ so $|\vec{\tau}| = \tau = pE\sin\theta$



$= qdE\sin\theta$

$\tau = (5.00\,\mu C)(1.20\,mm)(525\,\frac{N}{C})\sin(180° - 140°)$

$\tau = (5.00\times10^{-6}\,C)(1.20\times10^{-3}\,m)(525\,\frac{N}{C})\sin 40°$

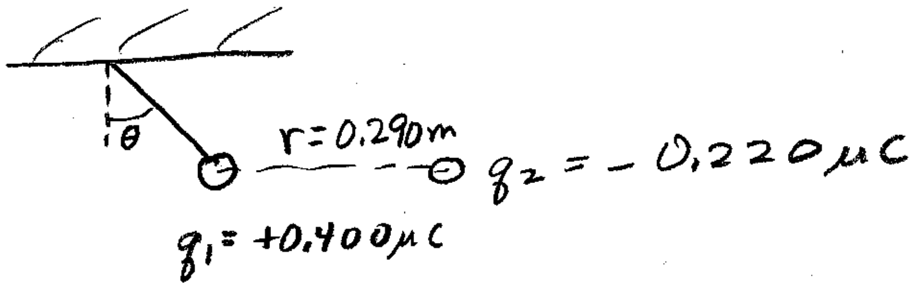
$\underline{\tau = 2.02\times10^{-6}\,N\cdot m}$ (D)

(6) $\Delta V = -\int \vec{E}\cdot d\vec{\ell} = E\cdot d$

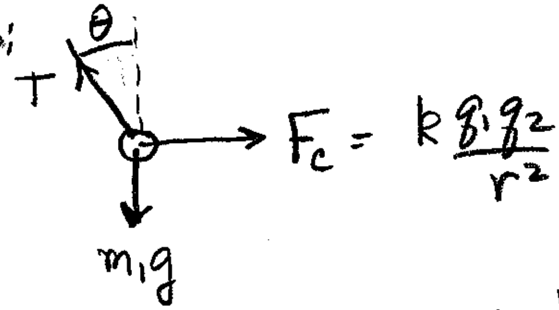
$= (9.3\times10^{6}\,\frac{V}{m})(0.030\times10^{-3}\,m)$

$\underline{\Delta V = 279\,V}$ (A)

(7)



Force diagram:



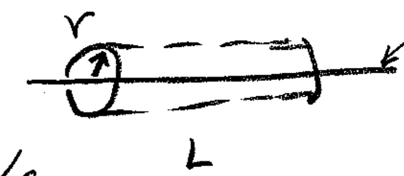
So $\left.\begin{aligned} T\sin\theta &= kq_1q_2/r^2 \\ T\cos\theta &= m_1 g \end{aligned}\right\}$ divide: $\sin\theta = \dfrac{kq_1q_2}{m_1 g r^2}$

$\Rightarrow \underline{\theta = 0.917^\circ}$ (E)

(8) $C_2 = 2C_1$, $Q_2 = Q_1$

Since $U = Q^2/2C \Rightarrow \dfrac{U_2}{U_1} = \dfrac{Q_2^2/2C_2}{Q_1^2/2C_1} = \dfrac{C_1}{C_2}$

or $\underline{\dfrac{U_2}{U_1} = \dfrac{C_1}{2C_1} = \dfrac{1}{2}}$ (D)

(9) For infinite line charge 

Gauss' Law: $\oint \vec{E} \cdot d\vec{A} = q/\epsilon_0$

$$E\, 2\pi r L = \lambda L/\epsilon_0$$

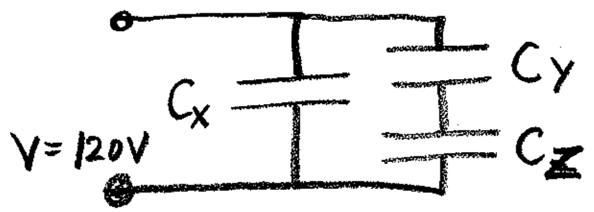
or $r = \dfrac{\lambda}{2\pi\epsilon_0 E}$ so $\dfrac{r_2}{r_1} = \dfrac{\lambda/2\pi\epsilon_0 E_2}{\lambda/2\pi\epsilon_0 E_1} = \dfrac{E_1}{E_2}$

so $r_2 = \dfrac{E_1}{E_2} r_1 = \dfrac{1000\, N/c}{2000\, N/c} r_1 = \dfrac{r_1}{2}$ (B)

(10) With 2 very large parallel sheets of charge $\pm\sigma$, the electric field between is $E = \sigma/\epsilon_0$ and is independent of distance to plate. Thus the force on a test charge between the plates is independent of where it is,

$F = q_0 E$ (D)

(11) When S_1 is closed and S_2 is open:



To find charge on C_Y,

ie $q_Y = C_Y V_Y$

But $q_Y = q_Z$ and $V = V_Y + V_Z$

ie, $V = \frac{q_Y}{C_Y} + \frac{q_Z}{C_Z} = q_Y\left(\frac{1}{C_Y} + \frac{1}{C_Z}\right)$

or $q_Y = \frac{V}{\frac{1}{C_Y} + \frac{1}{C_Z}} = \frac{120V}{\frac{1}{5\mu F} + \frac{1}{8\mu F}} = \boxed{370\mu C}$

ie (B)

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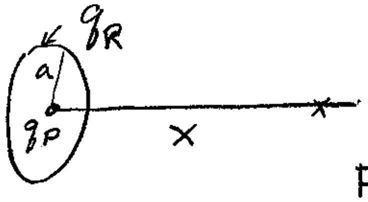

For point charge $V_P(x) = kq_P/x$

For ring: $V_R(x) = k\, q_R/\sqrt{x^2+a^2}$

If $V = V_R + V_P = 0 = k\left(\dfrac{q_P}{x} + \dfrac{q_R}{\sqrt{x^2+a^2}}\right)$

Notice: Can have $V=0$ iff $q_P q_R < 0$ which is true.

Solve for x: $\Rightarrow$ $\dfrac{q_P}{x} = -\dfrac{q_R}{\sqrt{x^2+a^2}}$, square both sides:

$$\frac{q_P^2}{x^2} = \frac{q_R^2}{x^2+a^2} \quad \text{or} \quad \left(\frac{q_R}{q_P}\right)^2 x^2 = x^2+a^2$$

$$x = \pm\frac{a}{\sqrt{(q_R/q_P)^2-1}} = \pm\frac{2.4\text{ m}}{\sqrt{\left(\frac{520}{360}\right)^2-1}}$$

$\underline{x = 2.3\text{ m}}$ (D)

13 If battery remains connected, V remains same, but the charge increases,

$\underline{q_2 = K q_1 \quad \text{(A)}}$