Physics 1B HW#7

22.37)

a) $a > r > b$

$E = \frac{1}{2\pi\varepsilon_0}\frac{\lambda}{r}$

$\boxed{E = \frac{1}{2\pi\varepsilon_0}\frac{\lambda}{r}}$

b) radially out

c) $\lambda_{in} = -\lambda$

$\lambda_{out} = \lambda$

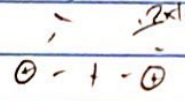
$\boxed{E = \frac{1}{2\pi\varepsilon_0}\frac{\lambda}{r}}$

d) radially out

c) $\boxed{\lambda_{in} = -\lambda}$

$\boxed{\lambda_{out} = \lambda}$

23.3)



$W_{a\to b} = U_a - U_b$

$U = q \cdot E_r$

$U = \frac{1}{4\pi\varepsilon_0}\varepsilon\frac{q_1}{r_1}$

$U = \frac{e}{4\pi\varepsilon_0}\left(\frac{2e}{r}\right)$

$U = \frac{2e^2}{4\pi\varepsilon_0 r}$

$U = 3.456\times10^{-13}\,J$

$W = U/q = \boxed{2.16\,MeV}$

23.7) $E_{tot} = K + U$

$E_{tot} = K_i = (1.67\times10^{-27}kg)(2.1\times10^{5}\frac{m}{s})^2$

$E_{tot} = 7.36\times10^{-17}\,J$

$7.36\times10^{-17}\,J = k\frac{e^2}{r}$

$r = 3.13\times10^{-12}\,m$

$F = k\frac{q_1 q_2}{r^2} = k\frac{q^2}{r^2}$

$\boxed{F = 2.35\times10^{-5}\,N}$

23.11) $E_y = \alpha + \frac{\beta}{y^2}$

$\alpha = 600\frac{N}{C}$

$\beta = 5.00\,N\frac{m^2}{C}$

$a \to y = 2.00\,cm \to 0.02m$

$b \to y = 3.00\,cm \to 0.03m$

a) $V = \frac{U}{q_0}$

$V_a - V_b = \frac{U_a}{q_0} - \frac{U_b}{q_0}$

$V_a - V_b = \int_a^b E\cos\phi\,dl$

$= \int_{0.02m}^{0.03m}\left(\alpha + \frac{\beta}{y^2}\right)dy$

$= \left[\alpha y - \frac{\beta}{y}\right]_{0.02}^{0.03}$

$= -148.67\,V - (-238\,V)$

$= \boxed{89.33\,V}$

b) $V_a - V_b > 0 \to$ $\boxed{a \text{ is higher}}$

23.29) $r = 14.0\,cm = 0.14m$

$q = 22.0\,nC = 22\times10^{-9}\,C$

$r_c = 28.0\,cm = 0.28m$

a) not SHM $\to F \sim \frac{1}{r^2}$, not $F \sim r$

opposite signs $\to$ attracted

b) $V = \frac{kq}{\sqrt{x^2+r^2}}$

$V = \frac{kQ}{\sqrt{r^2+r_c^2}}$

$V = \frac{U}{q_0}$

$V_i = 632.49\,V$

$U = 2.0\,V$

$U_i = -1.01\times10^{-16}\,J$

$V_f = 1414.29\,V$

$U_f = -2.26\times10^{-16}\,J$

$U_i = U_f + K_f$

$-1.01\times10^{-16}\,J = -2.26\times10^{-16}\,J + \frac{1}{2}mv^2$

$\boxed{v = 1.66\times10^{7}\frac{m}{s}}$

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23.37) $r_{cyl} = 6.40cm = 0.064m$

$\lambda = 8.70nC/m = 8.7\times10^{-6}\frac{C}{m}$

$V = \frac{\lambda}{2\pi\varepsilon_0}\ln\left(\frac{r_b}{r}\right)$

a) $r_b = 0.064m$

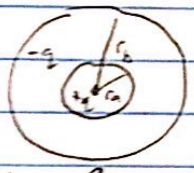
$r = 0.064m + 0.045m = 0.107m$

$V = 81.47kV = \boxed{81467.11V}$

b) V in cylinder r = V at surface

$\boxed{0V}$

23.41



a) $\Phi_E = \frac{q}{\varepsilon_0} = EA$

$\frac{q_{encl}}{\varepsilon_0} = E_a(A)$

$E_a = \frac{q_{encl}}{\varepsilon_0 4\pi r_a^2} = \frac{q}{\varepsilon_0 4\pi r_a^2}$

if $r < r_a$, $V(r) = V(r_a)$

$V = \frac{U}{q_0} = \frac{kq}{r}$

$V(r) = \frac{kq}{r_a} + \frac{-kq}{r_b}$

$\boxed{V(r) = kq\left(\frac{1}{r_a} - \frac{1}{r_b}\right)}$

b) V(r) for $r_a < r < r_b$

$V_b(r) = V_b(r_b)$

$V_b(r) = \frac{-kq}{r_b}$

$V_a(r) = \frac{kq}{r}$

$\boxed{V(r) = kq\left(\frac{1}{r} - \frac{1}{r_b}\right)}$

c) V(r) for $r > r_b$

$V_b(r) = \frac{-kq}{r}$

$V_a(r) = \frac{kq}{r}$

$V(r) = \frac{kq}{r} - \frac{kq}{r}$

$\boxed{V(r) = 0V}$

d) $V_{ab} = V_a - V_b$

$V_a = \frac{kq}{r_a}$ $V_b = \frac{kq}{r_b}$

$\boxed{kq\left(\frac{1}{r_a} - \frac{1}{r_b}\right) = V_{ab}}$

e) $E_r = -\frac{\partial V}{\partial r}$

$\frac{\partial}{\partial r}\left(kq\left(\frac{1}{r} - \frac{1}{r_b}\right)\right)$

$kq\left[\left(\frac{\partial}{\partial r}\frac{1}{r}\right) - \left(\frac{\partial}{\partial r}\frac{1}{r_b}\right)\right]$

$kq\left[-\frac{1}{r^2}\right]$

$\boxed{+\frac{kq}{r^2}}$

f) $\frac{\partial}{\partial r}(0) = \boxed{0}$

g) $V_{ab} = V_a - V_b$ ✗

$V_a = \frac{kq}{r}$ $V_b = \frac{kq}{r_b}$

$\boxed{V_{ab} = k\left(\frac{q}{r_a} - \frac{q}{r_b}\right)}$

b) $E_r = -\frac{\partial V}{\partial r}$

$V_b(r) = V_b(r_b)$

$V_b(r) = \frac{-kq}{r_b}$

$V_a = \frac{kq}{r}$

$V(r) = k\left(\frac{q}{r} - \frac{Q}{r_b}\right)$

$k\frac{\partial}{\partial r}\left(\frac{q}{r} - \frac{Q}{r_b}\right)$

$= \boxed{\frac{kq}{r^2}}$

i) $V_b(r) = \frac{-kQ}{r}$

$V_a(r) = \frac{kq}{r}$

$V(r) = k\left(\frac{q}{r} - \frac{Q}{r}\right)$

$E_r = -\frac{\partial V}{\partial r}$

$-k\frac{\partial}{\partial r}\left(\frac{q}{r} - \frac{Q}{r}\right)$

$-k\left[-\frac{q}{r^2} + \frac{Q}{r^2}\right]$

$\boxed{-\frac{k}{r^2}[Q-q]}$

23.50) $m = 5\times10^{-7}kg$

$q = 6.00nC = 8\times10^{-6}C$

$d = 0.500m$

$\sigma = 8pC/m^2 = 8\times10^{-12}\frac{C}{m^2}$

$U = qEr$

$E = \frac{\sigma}{2\varepsilon_0} = 0.452\frac{N}{C}$

$U = 8\times10^{-6}C \times 0.452\frac{N}{C} \times 0.5m$

$U = 1.8\times10^{-6}J$

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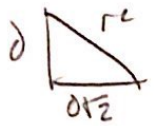


$d^2 + 2d^2 = r^2$

$d\sqrt{3}$

$U_i = 1.81 \times 10^{-6}\ J$

$U_i = K_i + U_f$

$U_f = qEr_f$

$U_f = 3.61 \times 10^{-7}$

$K_f = 1.45 \times 10^{-6}\ J$

$K = \frac{1}{2}mv^2$

$v = 2.41 \frac{m}{s}$

$U_{gi} + U_{ei} = K_f + U_{ef} + U_{gf}$

$qEr_i + mgh_i = K_i + qEr_f + mgh_f$

$qE(r_i - r_f) + mg(h_i - h_f) = K_f$

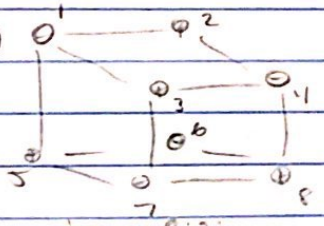
$(0.400m)(qE + mg) = K_f$

$(0.400m)(3.62 \times 10^{-6}N + 4.9 \times 10^{-4}N) = K_f$

$K_f = 3.41 \times 10^{-6}\ J$

$v = 3.69 \frac{m}{s}$

23.57)



$$U = 4\pi\varepsilon_0 \sum \frac{q_i q_j}{r_{ij}}$$

$$= \frac{1}{4\pi\varepsilon_0}\left[\frac{-q^2}{d} + \frac{-q^2}{d} + \frac{q^2}{d\sqrt{2}} + \frac{-q^2}{d} + \frac{q^2}{d\sqrt{2}} + \frac{q^2}{d\sqrt{2}} + \frac{-q^2}{d\sqrt{3}}\right]$$
$$+ \frac{1}{4\pi\varepsilon_0}\left[\frac{q^2}{d\sqrt{2}} + \frac{-q^2}{d} + \frac{q^2}{d\sqrt{2}} + \frac{-q^2}{d} + \frac{q^2}{d\sqrt{2}} + \frac{q^2}{d\sqrt{2}}\right]$$
$$+ \frac{1}{4\pi\varepsilon_0}\left[\frac{-q^2}{d} + \frac{q^2}{d\sqrt{2}} + \frac{-q^2}{d\sqrt{3}} + \frac{-q^2}{d} + \frac{q^2}{d\sqrt{2}}\right]$$
$$+ \frac{1}{4\pi\varepsilon_0}\left[\frac{-q^2}{d\sqrt{3}} + \frac{q^2}{d\sqrt{2}} + \frac{q^2}{d\sqrt{2}} + \frac{-q^2}{d}\right]$$
$$+ \frac{1}{4\pi\varepsilon_0}\left[\frac{-q^2}{d} + \frac{-q^2}{d} + \frac{q^2}{d\sqrt{2}}\right]$$
$$+ \frac{1}{4\pi\varepsilon_0}\left[\frac{q^2}{d\sqrt{2}} + \frac{-q^2}{d}\right]$$
$$+ \frac{1}{4\pi\varepsilon_0}\left[\frac{-q^2}{d}\right]$$
$$= \frac{1}{4\pi\varepsilon_0}\left[\frac{-12q^2}{d} + \frac{12q^2}{d\sqrt{2}} - \frac{4q^2}{d\sqrt{3}}\right]$$
$$= \frac{1}{4\pi\varepsilon_0}\left[\frac{-12\sqrt{2}q^2}{d\sqrt{2}} + \frac{12\sqrt{3}q^2}{d\sqrt{6}} - \frac{4\sqrt{2}q^2}{d\sqrt{6}}\right]$$
$$= \frac{1}{4\pi\varepsilon_0}\left[\frac{(12\sqrt{3} - 12\sqrt{2} - 4\sqrt{2})q^2}{d\sqrt{6}}\right]$$

23.67) $U = qV$

$dU = V\,dq$

$V(r) = \frac{kq}{r}$

$q = \rho V = \frac{4}{3}\pi r^3 \rho$

$V(r) = \frac{4\pi r^3 \rho k}{3r} = \frac{4\pi r^2 \rho k}{3}$

$dq = \frac{\partial}{\partial r}(\rho V) = 4\pi r^2 \rho\, dr$

$dU = \frac{4}{3}\pi r^2 \rho k\,(4\pi r^2 \rho\, dr)$

$\int dU = \frac{16\pi^2 \rho^2 k}{3}\int r^4\, dr$

$U = \frac{16\pi^2\rho^2 k}{3} \cdot \frac{1}{5}r^5$

$Q = \rho V_{bi}$

$V_{bi} = \frac{4}{3}\pi r^3$

$U = \frac{4^2(3)\pi^2\rho^2 k \pi^2}{(3)^2 5R}$

$\left(\frac{4}{3}\pi R^3\right)^2 \rho^2 \left(\frac{3k}{5R}\right)$

$\frac{3Qk}{5R}$

$k = \frac{1}{4\pi\varepsilon_0}$

$$\boxed{\frac{3Q^2}{20\pi\varepsilon_0 R}}$$

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