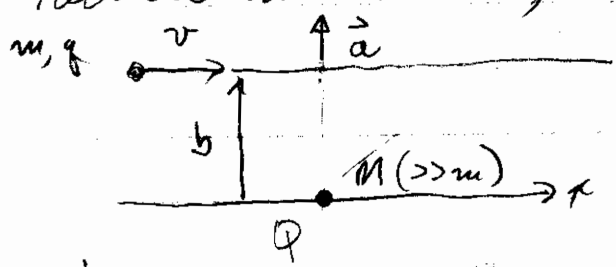
PS 8

2) Particle moves at v, b:



a) $$\vec{E}_{rad} = \frac{q}{4\pi\varepsilon_0 c^2}\left[\frac{a_\perp}{R}\right] = \frac{q}{4\pi\varepsilon_0}\,\frac{a}{R}\sin\theta\ \hat{\theta}$$

$\vec{a}$ is f'n of time, but we approximate it by $a_{max}\,\hat{y} = \dfrac{qQ}{4\pi\varepsilon_0 b^2 m}\,\hat{y}$

so $$\vec{E}_{rad} = \frac{q}{4\pi\varepsilon_0 R c^2}\left(\frac{qQ}{4\pi\varepsilon_0 b^2 m}\right)\sin\theta\ \hat{\theta}$$

b) This causes $\vec{B} = \frac{1}{c}E\,\hat{\phi}$ or

$$\vec{S} = \frac{\vec{E}\times\vec{B}}{\mu_0} = c\varepsilon_0 E^2\hat{R} = c\varepsilon_0 E^2 \hat{R}.$$

$$\hat{S} = c\varepsilon_0\left[\frac{q^2 Q}{(4\pi\varepsilon_0)^2 c^2 b^2 m}\right]^2 \frac{1}{R^2}\ \sin^2\theta\ \hat{R}$$

c) $P = \int S\ R^2\,d\Omega$, $d\Omega = 2\pi\sin\theta\,d\theta$, so

$$P = [\ \sim\ ]\,2\pi\underbrace{\int_0^\pi \sin^3\theta\,d\theta}_{2/3}$$

The energy radiated during $\tau = 2b/v$ is

$W = 2b/v \times P$

$$W = \left(\frac{q^2}{4\pi\varepsilon_0 b}\right)^2\left(\frac{Q^2}{4\pi\varepsilon_0 b}\right)\left(\frac{1}{m^2c^4}\right)\left(\frac{c}{v}\right)$$

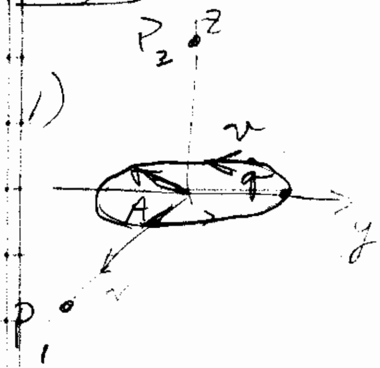
d) Set $W = \alpha\,(mv^2/2) = \left(\frac{q^2}{4\pi\varepsilon_0 b}\right)^2 \left(\frac{q^2}{4\pi\varepsilon_0 b}\right)\left(\frac{1}{m^2c^4}\right)\left(\frac{a}{v}\right)$,

solve for $b = 2.7(-13)/\alpha^{1/3} = \underline{5.9(-13)\,m}$.

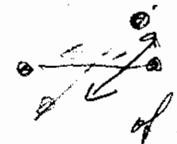
for $\alpha = 0.1$. Quite unrealistic.

PS 8

1)



$\Rightarrow$



Maximum acceleration of radio oscillator $= v^2/A$

$t_r = t - x/c$ or $t_r = t - z/c$

a) $E = \frac{q}{4\pi\varepsilon_0 c^2}\left[\frac{a_\perp}{R}\right]$ If $v \ll c$ $R \approx x$ or z

$a = \frac{v^2}{A}$, directed inwards; let $\omega = v/R$

at x, $E_1 = \frac{q}{4\pi\varepsilon_0 c^2}\left(\frac{v^2}{A}\right)\frac{\sin(\omega t_r)}{x}\hat{y}$ linear

at z, $E_2 = \frac{q}{4\pi\varepsilon_0 c^2}\left(\frac{v^2}{A}\right)\frac{1}{z}\left(\hat{x}\cos\omega t_r + \hat{y}\sin\omega t_r\right)$ circular

b) $S_1 = \frac{EB}{\mu_0} = \varepsilon_0 E^2 c = \left[\left(\frac{q}{4\pi\varepsilon_0 c^2}\right)\left(\frac{v^2}{A}\right)\right]^2 \varepsilon_0 c \,\frac{\sin^2\omega t}{x}$

$S_2 = \left(\left(\frac{q}{4\pi\varepsilon_0 c^2}\right)\frac{v^2}{A}\right)^2 \varepsilon_0 c\,\underbrace{\left(\cos^2\omega t + \sin^2\omega t\right)}_{1}$

c) For single oscillator $P = \frac{\mu_0 p_0^2 \omega^4}{12\pi c}$ where $p_0 = qA$

For this case get __double__ this, since have 2 oscillators

d) H-atom has $v = 3(8)$ m/s$/137 = 2.29(8)$ m/s, $A = .53(-10)$ m
or $\omega = 4.13 \times 10^{16}$ rad/s; $p_0 = 1.6(-19)A = 8.5(-30)$ C-m
$\mu_0 = 4\pi(-7)$; so
$P \overset{1.25(-6)}{=} 4.65(-8)$ W $= 2.9(-11)$ eV/sec
If $T = 27$ eV, $\tau = T/P = 0.9(-10)$ sec

PS 8

11.10 acceleration is g,

radiates $P = \frac{\mu_0 q^2 a^2}{6\pi c}$ (class notes)

$\mu_0 = 1.25(-6)$; $q = 1.6(-19)$; $a = 9.8$; $c = 3(8)$

$P = 5.43(-52)\,W$

To fall 1 cm takes $t = \sqrt{2s/a} = .045$ sec

Radiates $2.45(-53)$ J.

Loses PE of $mgh = 8.9(-32)$ J

$\Big\}$ Fraction radiated $= \underline{2.7 \times 10^{-22}}$.

Not much.