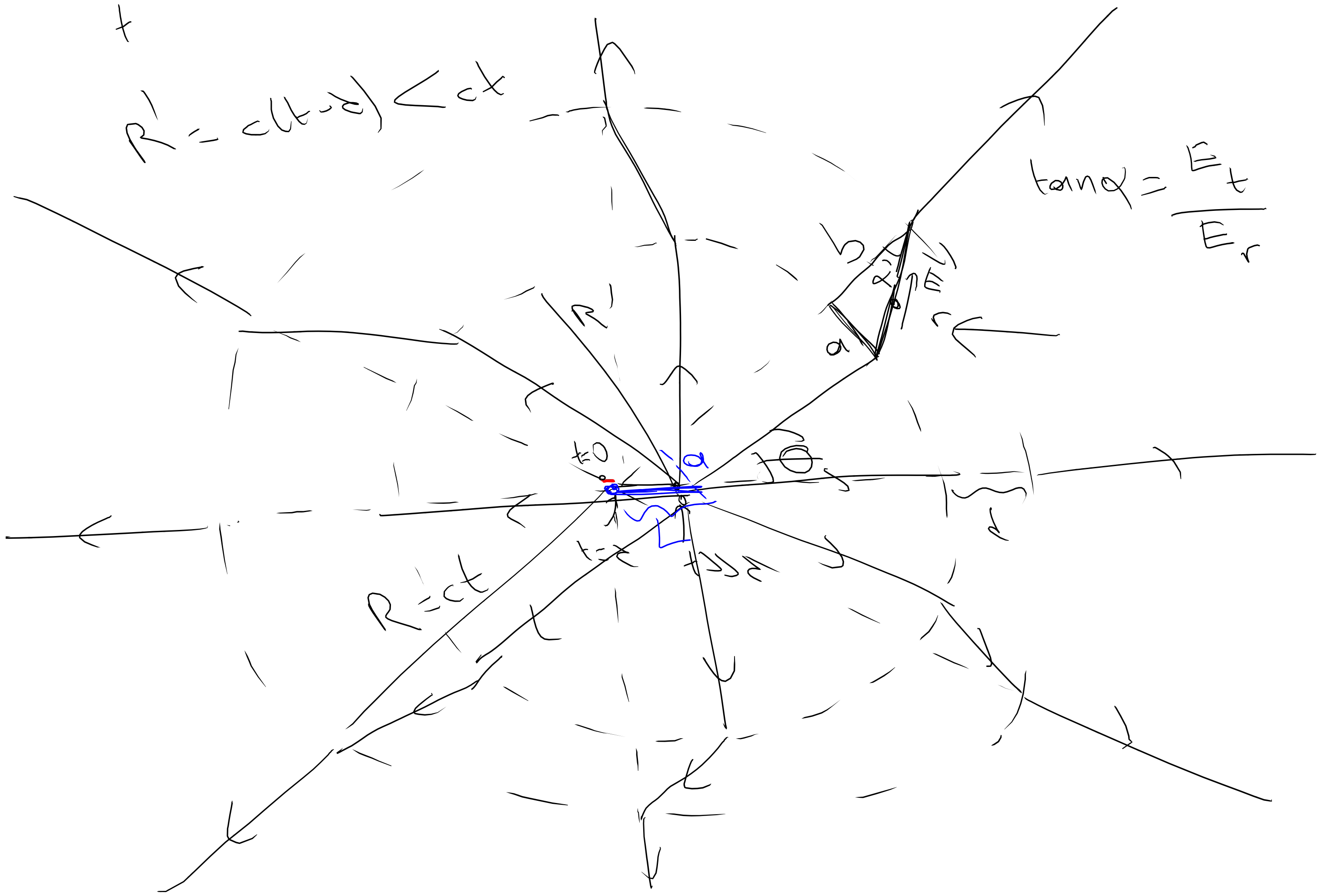
$$\vec{p} = q\vec{r}(t)$$

$$\vec{a}(t) = \begin{cases} a & 0 < t < \tau \\ 0 & \text{otherwise.} \end{cases}$$

t

$R' = c(t-\tau) < ct$



$$\tan\alpha = \frac{E_t}{E_r}$$

$$E_t = E_r \tan\alpha = \frac{q}{4\pi\varepsilon_0}\frac{1}{r^2}\tan\alpha$$

$$\boxed{d = R - R' - (a\tau)(t-\tau) > 0}$$

$$\tan\alpha = \frac{a}{b}$$

$$\frac{a}{L} = \sin\theta \Rightarrow a = L\sin\theta$$

$$b = R - R' = ct - c(t-\tau) = c\tau$$

$$\tan\alpha = \frac{L\sin\theta}{c\tau}$$

$$E_t = \frac{q}{4\pi\varepsilon_0}\frac{1}{r^2}\frac{L\sin\theta}{c\,\tau}$$

$$= \frac{q}{4\pi\varepsilon_0}\frac{1}{r^2}\frac{v t \sin\theta}{c\,\tau}$$

$$= \frac{q}{4\pi\varepsilon_0}\frac{1}{r^2}\frac{a}{\tau}\frac{t}{c}\sin\theta$$

$$r = ct \Rightarrow t = \frac{r}{c}$$

$$E_t = \frac{q}{4\pi\varepsilon_0}\frac{1}{r^{\cancel{2}}}\,a\,\frac{\cancel{r}}{c^2}\sin\theta$$

$$= \frac{q}{4\pi\cancel{\varepsilon_0}}\,a\,\mu_0\cancel{\varepsilon_0}\left(\frac{\sin\theta}{r}\right)$$

$$\boxed{E_t = \frac{\mu_0}{4\pi}\left(q\,a\left(t-\frac{r}{c}\right)\right)\left(\frac{\sin\theta}{r}\right)}$$

$$q a = q\frac{d^2 r}{dt^2} = \frac{d^2}{dt^2}(q r) = \frac{d^2}{dt^2}p = \ddot{p}$$

$$\boxed{E_t = \frac{\mu_0}{4\pi}\ddot{p}\left(\frac{\sin\theta}{r}\right)}$$

$$\boxed{\nabla^2\phi = \frac{\rho}{\varepsilon_0}}$$

$$\left(-\frac{\hbar^2}{2m}\nabla^2 + V(\vec r)\right)\psi = E\psi$$

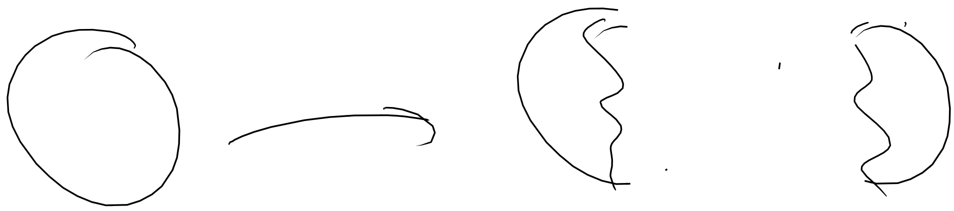
$$\left[\frac{1}{2m}\left(\frac{\hbar}{i}\vec\nabla - \frac{q}{c}\vec A\right)^2 + \phi\right]\psi = E\psi$$

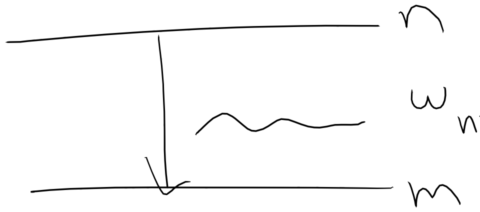
$$\vec A \to \vec A' = \vec A + \nabla\Lambda$$

$$\phi \to \phi' = \phi - \frac{\partial\Lambda}{\partial t}$$

$$\left[\frac{1}{2m}\left(\frac{\hbar}{i}\vec\nabla - \frac{q}{c}\vec A'\right)^2 + \phi'\right]\psi' = E\psi'$$

$$\boxed{\psi' = e^{\frac{iq}{c\hbar}\Lambda}\psi}$$





$$\omega_{nm} = \frac{E_n - E_n}{\hbar}$$

$$\psi(\vec r, t=0) = a\,\psi_n(\vec r) + b\,\psi_m(\vec r)$$

$$\psi(\vec r, t) = a\,e^{-\frac{i}{\hbar}E_n t}\psi_n(\vec r) + b\,e^{-\frac{i}{\hbar}E_m t}\psi_m(\vec r)$$

$$\langle \vec r\rangle = \int d^3r\, \psi^*(\vec r, t)\,\vec r\,\psi(\vec r, t)$$

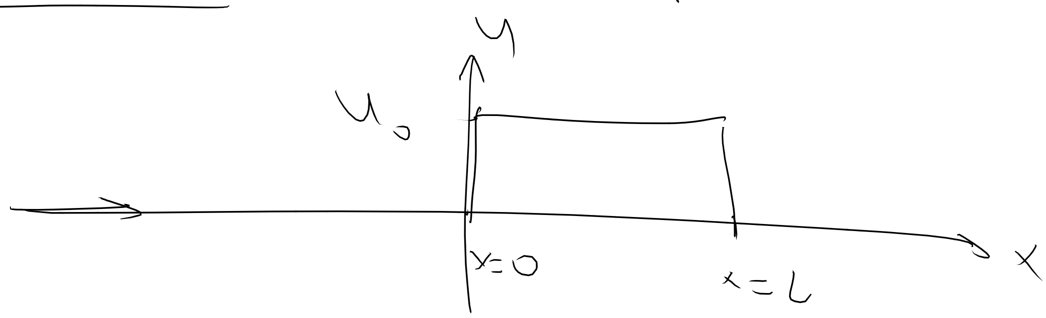
$$= |a|^2\langle \vec r\rangle_n + |b|^2\langle \vec r\rangle_m + 2\mathrm{Re}\, a^* b\, \vec r_{nm}\, e^{\frac{i}{\hbar}(E_n - E_m)t}$$

$$\langle \vec{r} \rangle = |a|^2 \langle \vec{r} \rangle_n + |b|^2 \langle \vec{r} \rangle_m + 2\mathrm{Re}\, a^* b \langle \vec{r} \rangle_{nm} e^{i\omega_{mn} t}$$

$$\langle \vec{r} \rangle_{nm} = \int \psi_n^*(\vec{r})\, \vec{r}\, \psi_m(\vec{r})\, d^3 r$$

$$\langle \ddot{\vec{r}} \rangle = -\omega_{mn}^2 \left(2\mathrm{Re}\, a^* b \langle \vec{r} \rangle_{nm} e^{i\omega_{mn} t} \right)$$

Q32 A charged particle, traveling . . .



$$ma = m\tau \dot{a} + F(x)$$

$$\boxed{ma = m\tau \dot{a} + U_0 \left[-\delta(x) + \delta(x-L) \right]}$$

$$\boxed{ma = m\tau \dot{a} + F(t)}$$

$$\dot{a} - \frac{a}{\tau} = -\frac{F(t)}{m\tau}$$

$$\frac{d}{dt}(fa) = \dot{f} a + \dot{a} f$$

$$e^{-\frac{t}{\tau}} \dot{a} - \frac{1}{\tau} e^{-\frac{t}{\tau}} a = -\frac{F(t)}{m\tau} e^{-\frac{t}{\tau}}$$

$$\frac{d}{dt}\left(e^{-\frac{t}{\tau}} a \right) = -\frac{F(t)}{m\tau} e^{-\frac{t}{\tau}}$$

$$e^{-\frac{t}{\tau}} a = -\int_{t_0}^{t} \frac{F(t')}{m\tau} e^{-\frac{t'}{\tau}}$$

$$\boxed{a(t) = -\int_{t_0}^{t} \frac{F(t')}{m\tau} e^{\frac{(t-t')}{\tau}} dt'}$$

$$\boxed{ma = m\tau\dot{a} + U_0\left[-\delta(x) + \delta(x-L)\right]}$$

$x<0$ or $0<x<L$ or $x>L$

$$\cancel{m}a = \cancel{m}\tau\dot{a} \Rightarrow \dot{a} = \frac{a}{\tau} \Rightarrow a(t) = Ce^{\frac{t}{\tau}}$$

$$v(t) = C\tau e^{\frac{t}{\tau}} + D$$

$$\boxed{x(t) = C\tau^2 e^{\frac{t}{\tau}} + Dt + E}$$

$t=0 \qquad x(t=0) = 0$

$t<0$

$$x(t) = C_0\tau^2 e^{\frac{t}{\tau}} + D_0 t + E_0$$

$$x(t=0) = C_0\tau^2 + E_0 = 0 \Rightarrow E_0 = -C_0\tau^2$$

$$\boxed{x_0(t) = C_0\tau^2\left(e^{\frac{t}{\tau}} - 1\right) + D_0 t}$$

$$x(t_1) = L$$

$$0 < t < t_1$$

$$\boxed{x_1(t) = C_1 \tau^2 \left(e^{\frac{t}{\tau}} - 1\right) + D_1 t}$$

$$t > t_1$$

$$x_2(t) = C_2 \tau^2 e^{\frac{t}{\tau}} + D_2 t + E_2$$

$$\boxed{x_1(t_1) = x_2(t_1) = L}$$

$$\int_{0^-}^{0^+} \frac{dx}{v} \left\{ ma = m\tau \dot{a} + U_0 \left[-\delta(x) + \delta(x-L) \right] \right\}$$

$$0 = m\tau \int_{0^-}^{0^+} \frac{dx}{\cancel{v}} \frac{da}{dx} \cancel{\frac{dx}{dt}} - U_0$$

$$m\tau \int_{0^-}^{0^+} dx \frac{da}{dx} = U_0 \Rightarrow \boxed{a(x=0^+) - a(x=0^-) = \frac{U_0}{m\tau v(0)}}$$

$$\boxed{a(x=L^+) - a(x=L^-) = \frac{-U_0}{m\tau v(x=L)}}$$

$$\boxed{\begin{gathered} v_0(t=0) = v_1(t=0) \\ v_1(t=t_1) = v_2(t=t_1) \end{gathered}}$$