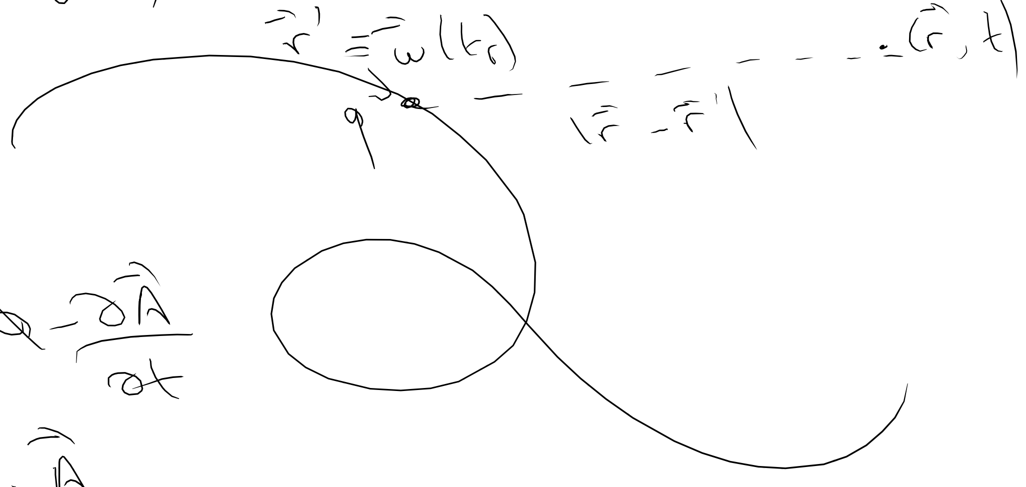
$$\vec{r} = \vec{w}(t) \qquad t_r = t - \frac{|\vec{r} - \vec{r}'|}{c}$$



$$\vec{E} = -\vec{\nabla}\phi - \frac{\partial \vec{A}}{\partial t}$$

$$\vec{B} = \vec{\nabla} \times \vec{A}$$

$$\phi^{(L)}(\vec{r}, t) = \frac{1}{4\pi\varepsilon_0} \frac{q}{\left| \vec{r} - \vec{w}(t_r) - (\vec{r} - \vec{w}(t_r)) \cdot \frac{\vec{v}(t_r)}{c} \right|}$$

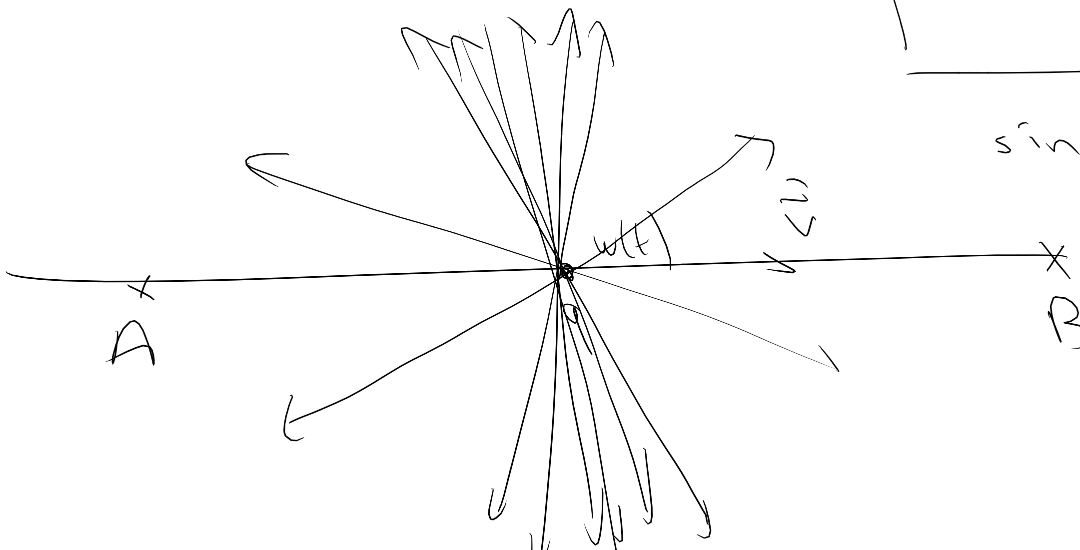
$$\vec{A}(\vec{r}, t) = \frac{\vec{v}(t_r)}{c^2}\phi$$

Particle moving at constant velocity

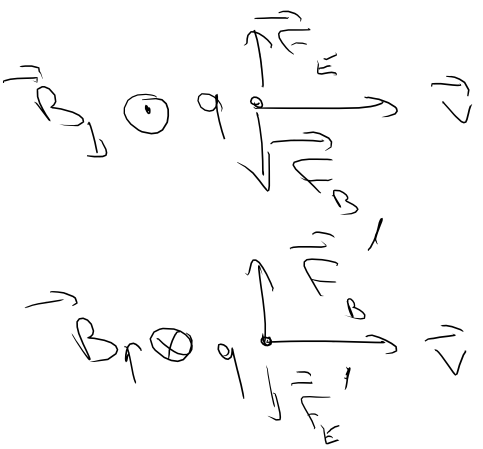
$$\vec{E}(\vec{r}, t) = \frac{q}{4\pi\varepsilon_0} \frac{\hat{R}}{R^2} \frac{1 - v^2/c^2}{1 - \frac{v^2}{c^2}\sin^2\theta}$$

$$\vec{R} = \vec{r} - \vec{w}(t) \qquad \boxed{\vec{B} = \frac{1}{c^2}\vec{v} \times \vec{E}}$$

$$\sin\theta = \sin(\pi - \theta)$$



reference frame 1



reference frame 2

$$\frac{d\vec{p}}{dt} = \vec{F} = q\left[\vec{E}(\vec{r}(t),t) + \vec{v}(t)\times\vec{B}(\vec{r}(t),t)\right]$$

$$\frac{d}{dt} f(\vec{r}(t),t) = \frac{\partial f}{\partial t} + \frac{\partial f}{\partial x_i}\frac{dx_i}{dt}$$

$$\boxed{\frac{df}{dt} = \frac{\partial f}{\partial t} + \vec{v}\cdot\vec{\nabla} f}$$

$$\frac{d\vec{p}}{dt} = q\left[\overbrace{-\vec{\nabla}\phi - \frac{\partial\vec{A}}{\partial t}}^{\vec{E}} + \vec{v}\times\overbrace{(\vec{\nabla}\times\vec{A})}^{\vec{B}}\right]$$

$$\begin{aligned}
\left[\vec{v}\times(\vec{\nabla}\times\vec{A})\right]_i &= \varepsilon_{ijk} v_j (\vec{\nabla}\times\vec{A})_k \\
&= \varepsilon_{ijk} v_j \varepsilon_{klm}\partial_l A_m \\
&= (\delta_{il}\delta_{jm} - \delta_{im}\delta_{jl}) v_j \partial_l A_m \\
&= v_j \partial_i A_j - v_j \partial_j A_i
\end{aligned}$$

$$\vec{v} \times (\vec{\nabla} \times \vec{A}) = \vec{\nabla}(\vec{v} \cdot \vec{A}) - (\vec{v} \cdot \vec{\nabla}) \vec{A}$$

$$\frac{d\vec{p}}{dt} = q\left[-\vec{\nabla}\phi - \frac{\partial \vec{A}}{\partial t} + \vec{v} \times (\vec{\nabla} \times \vec{A})\right]$$

$$= q\left[-\vec{\nabla}\phi \underbrace{- \frac{\partial \vec{A}}{\partial t} - (\vec{v} \cdot \vec{\nabla})\vec{A}}_{\frac{d\vec{A}}{dt}} + \vec{\nabla}(\vec{v} \cdot \vec{A})\right]$$

$$\frac{d}{dt}(\vec{p} + q\vec{A}) = q\left[-\vec{\nabla}\phi + \vec{\nabla}(\vec{v} \cdot \vec{A})\right]$$

$$\frac{d}{dt}\underbrace{(\vec{p} + q\vec{A})}_{\vec{P}} = -\vec{\nabla}\underbrace{(q\phi - q\vec{v} \cdot \vec{A})}_{U_{vel}}$$

$$\frac{d\vec{P}}{dt} = -\vec{\nabla} U_{vel}$$