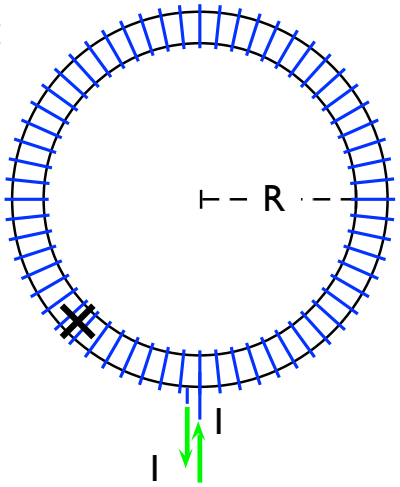
Lecture 38

Discussion of Ch24.Hw1.001

Set-up:



$E^{ext} = uniform \quad \otimes$, increasing

Apply Ampere-Maxwell Law:

$$2\pi R B_p = \mu_0 \left[I_{path} + I_{DC} \right]$$

(1) (2)

$$\epsilon_0 \frac{d\Phi_E}{dt}$$

Caution, check contributions of:

$$(1) \begin{cases} CW \\ CCW \end{cases} \quad (2) \begin{cases} CW \\ CCW \end{cases}$$

Clicker 1:

	Contrib. of (1)	Contrib. of (2)
1)	CW	CW
2)	CCW	CW
3)	CW	CCW
4)	CCW	CCW

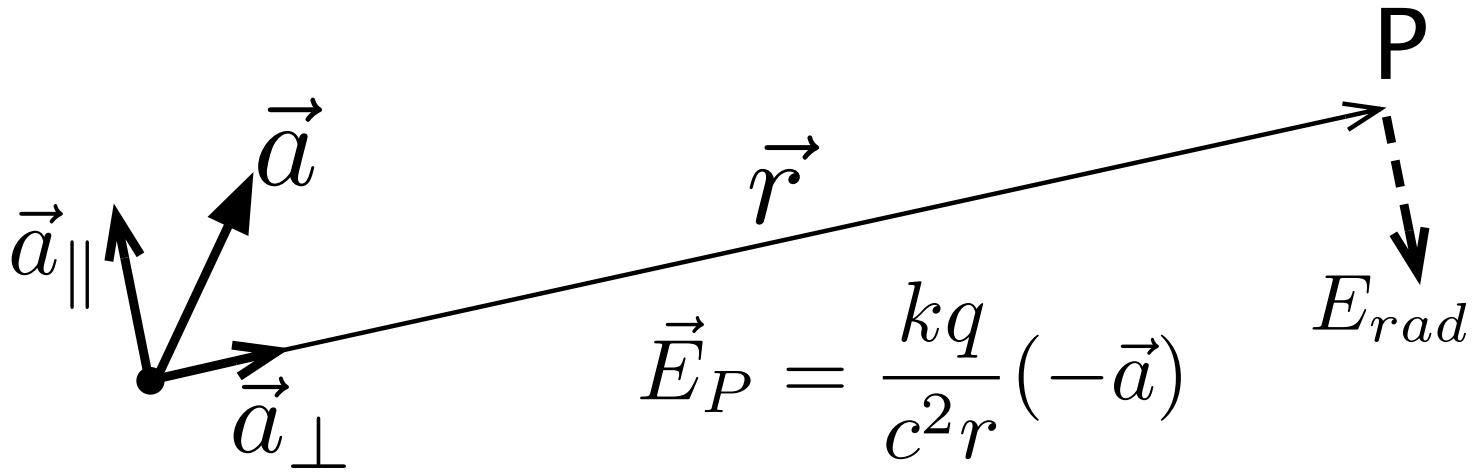
correct

Exercise: Check various cases:

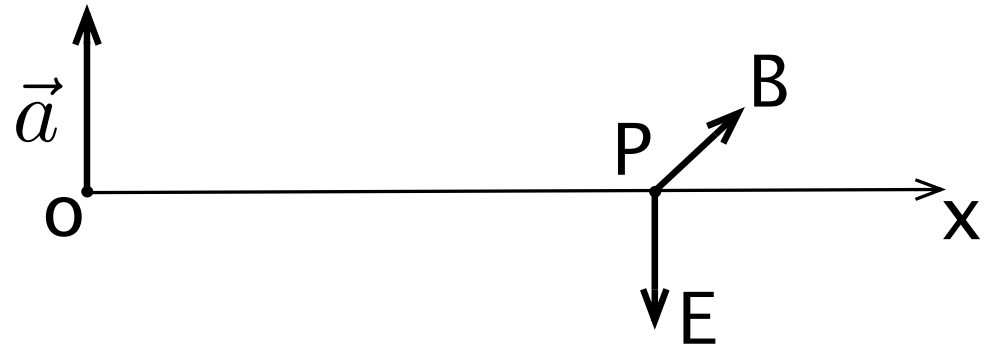
$$\vec{E} \otimes \begin{cases} CW \\ CCW \end{cases}$$

$$\vec{E} \odot \begin{cases} CW \\ CCW \end{cases}$$

Application of E-radiation formula due to acceleration of a point charge:



For 1D-plane wave case – simple case: (Assume q > 0)

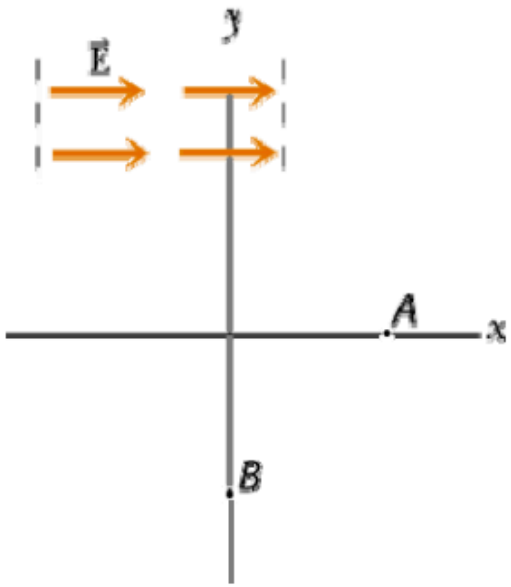


$at\ P,\ \vec{E} \downarrow$

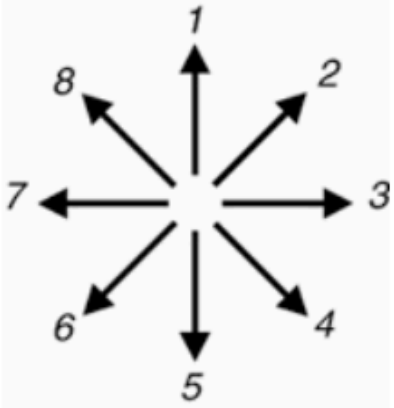
(Source is a current sheet)

For point charge case, notice only a-perp contributes.
As is convenient, do the vector decompositions as indicated.
At P the direction of E-rad detected is indicated by the dashed vector.

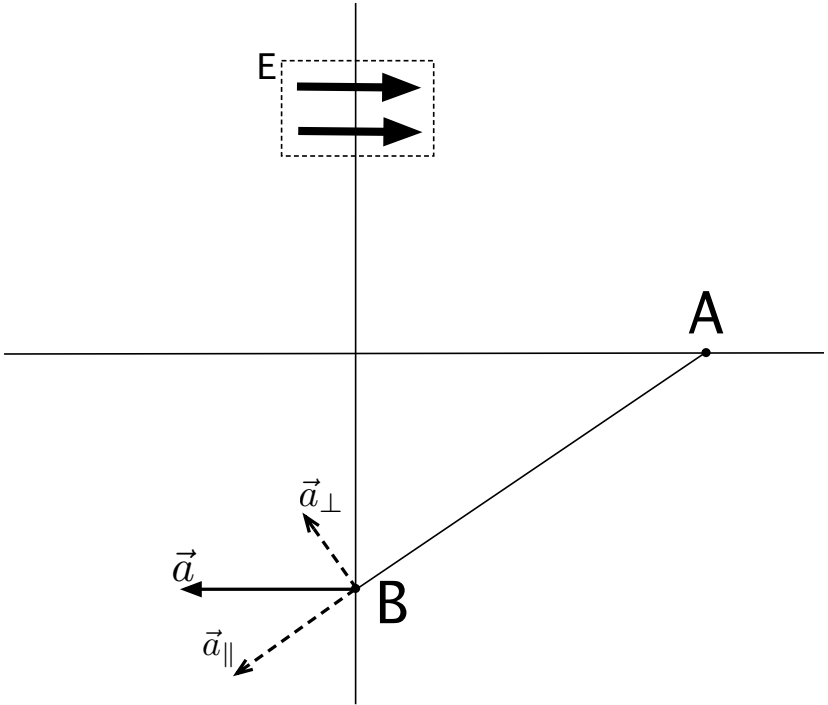
Q23.5a



A narrow collimated pulse of radiation propagates in the –y direction. There is a proton at location B. What is the direction of the radiative electric field detected at location A?



Hint:



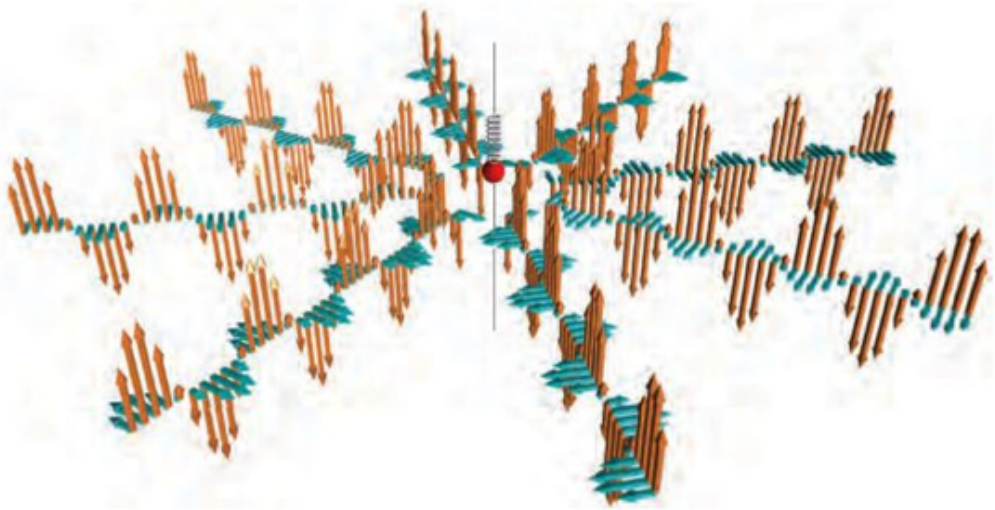
Radiation Field Due to Sinusoidal Oscillation of a Point Charge

$$y = y_{max} \sin \omega t$$

$$\frac{dy}{dt} = y_{max}\omega \cos \omega t$$

$$\frac{d^2y}{dt^2} = y_{max}\omega^2(-\sin \omega t)$$

$$= -y^2 t$$



$$E_y = \frac{kq}{c^2 r}(-\vec{a}_\perp) = \frac{kq}{c^2 r} y_{max}\omega^2 \sin \omega t = E_{y,max} \sin \omega t$$

Along x (or more generally, along r):

$$E_y = E_{y,max} \sin(\omega t - kx + \phi)$$

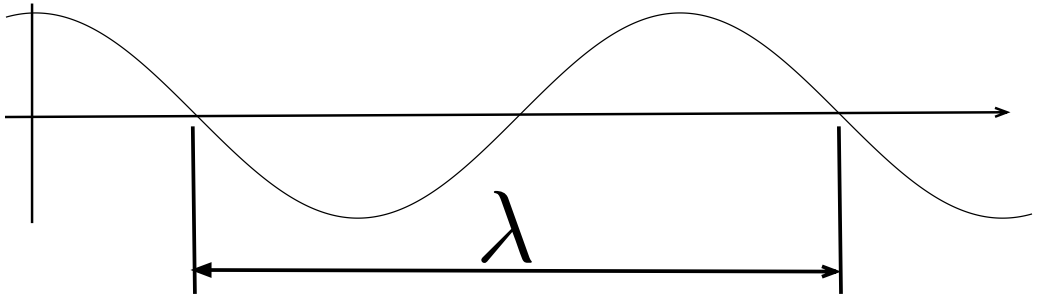
Φ is the initial phase angle of the oscillation

Fix $t = t_0$:

$$E_y \approx \sin(\omega t_0 - kx + \phi)$$

$$E_y \approx \sin(\omega t_0 - kx + \phi)$$

Sinusoidal in x:



$$k\lambda = 2\pi,\ k = \frac{2\pi}{\lambda}$$

λ is a conversion factor from x-scale to angle-scale

Period: $\omega T = 2\pi,\ \omega = \frac{2\pi}{T} = 2\pi f$

Fix phase: Defines the speed the fixed shape travels

$$v = \left.\frac{dx}{dt}\right|_{fixed\,phase} ;\ \omega t - kx + \phi = const.$$

$$kx = \omega t + \phi - const.$$

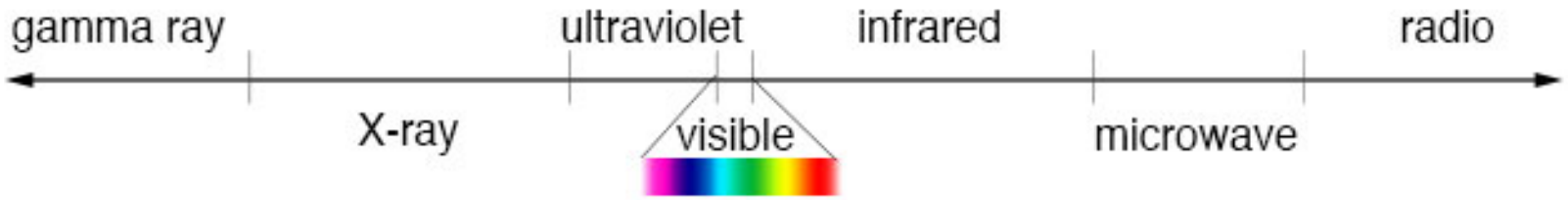
$$\therefore \frac{dx}{dt} = \frac{\omega}{k} = \left(\frac{2\pi}{T}\right) \Big/ \left(\frac{2\pi}{\lambda}\right) = \frac{\lambda}{T} = \lambda f = c$$

EM Waves

EM waves in a vacuum are specified by one thing:

$$\lambda \; or \; f$$

EM wave spectrum:



Radio Station KLBJ

$$590\ kHz \approx 600 \times 10^3\ \frac{1}{sec} \longrightarrow \lambda = \frac{c}{f} = \frac{3 \times 10^8}{6 \times 10^5} \approx 500\ m$$

Spectrum of EM waves:

Radio AM	stadium	10^3 m
Microwaves	Bean size	10^2 m
Visible Light	Micrometer	600 nm
X-Ray	Atomi size	10^{-10} m