Lecture38 iq33

Radiation fields, traveling (or running) waves and polarization of em waves.

1. Ch24.h1: 001 and beyond.
2. The radiation field formula due to the acceleration of a point charge.
   Clicker questions: Q23.2h, Q23.3a; Q23.3d, Q23.5a.
3. Radiation field due to sinusoidal oscillations
4. Running waves: Wavelength, period, speed, EM spectrum.
5. Direction of polarization is the direction along which the E-field is oscillating.

Announcement:

Please take a look at the updated lesson plan (see the top line on our homepage)

The lecture video link is in our homepage. The video is now available for viewing. Keep in mind it is an experimental project. Your feedback is welcome.

Application of the LA position is now available. For those of you who do well in this course are encouraged to apply. LAs are playing an important part in helping students through their interaction with students. If you are interested in this job opportunity please contact Lisa Gentry*.

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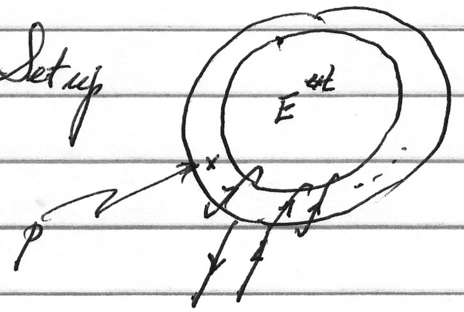
iq 33

1. Digression on HW: 06

Setup



E^{ext} : Uniform

⊗, increasing

Apply Amp-Maxwell law

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

I_{path} ← ①

I_{DC} ← $\epsilon_0 \frac{d\Phi_E}{dt}\Big|_{path}$: ②

Caution: Check contrib. of ① { CW / CCW

Contrib. of ② { CW / CCW

Clicker 1

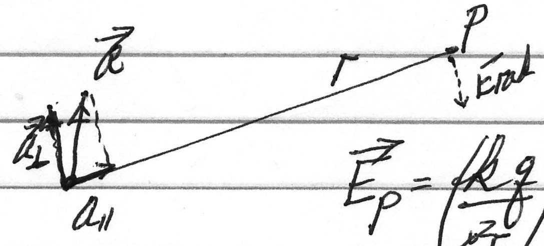
	contrib. of ①	contrib. of ②
1)	CW	CW
2)	CCW	CW
3)	CW	CCW
4)	CCW	CCW

Ans = 1 By inspection.

Exersis: Please check various cases of ②

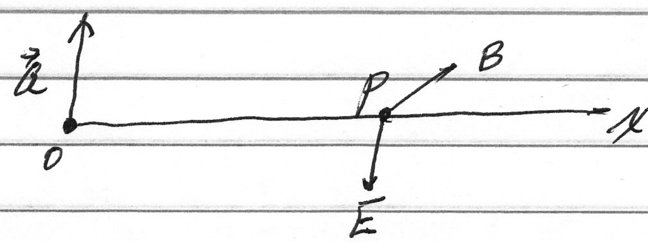
E ⊗ { inc. / dec. } ; E ⊙ { inc. / dec. }

2. Application on E radiation formula due to acceleration of point charge.



$$\vec{E}_P = \left(\frac{k q}{c^2 r}\right)(-\vec{a}_\perp)$$

For 1d-plane wave case - Simpler case (Assume $q>0$)



At P, $\vec{E}\downarrow$.

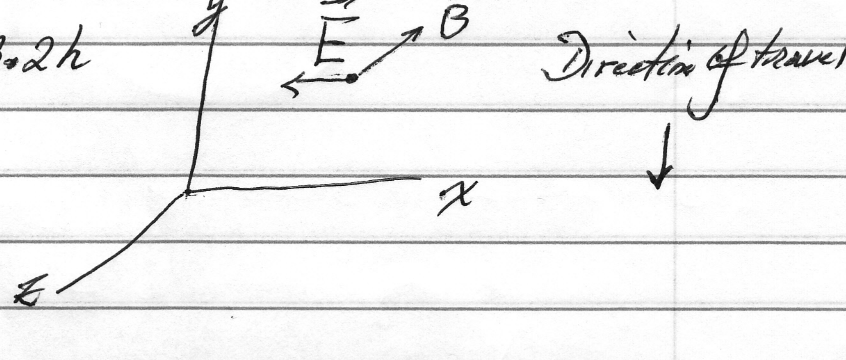
Source is a current sheet,

For point charge case, notice only $a_\perp$ contributes,

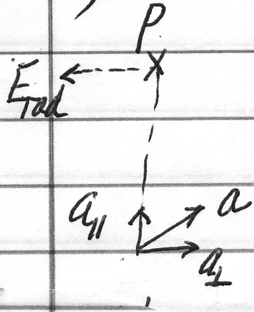
It is convenient do the vector decomposition as indicate.

At P the direction of $\vec{E}_{rad}$ detected is indicated by the dashed vector.

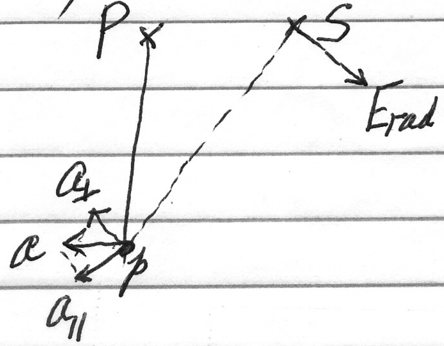
Clicker: Q23.2h



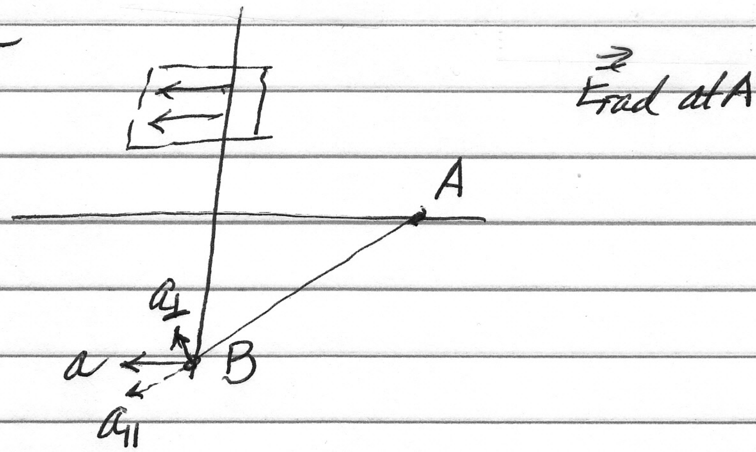
Q23.3a



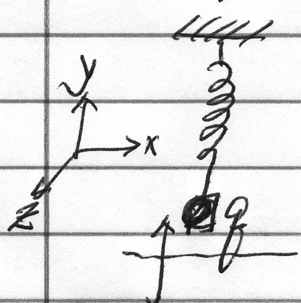
Q23.3d



Q23.5a



3. Radiation field due to sinusoidal oscillation of a point charge

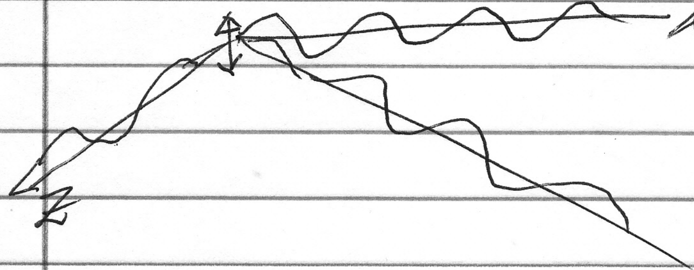


$$y = y_{max} \sin \omega t$$

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

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

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

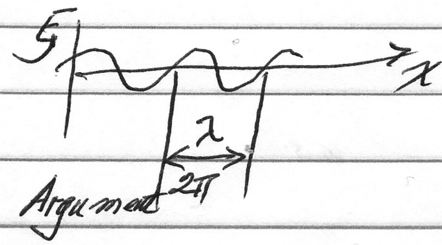


Along X : $E_y = E_{y\,max} \sin(\omega t - kx + \phi)$
(or more generally along r)

Initial phase angle in the oscillation.

fix $t = t_1$; $E_y \approx \sin(\omega t_1 - kx + \phi)$

Sinusoidal in x



$k\lambda = 2\pi$, $k = \frac{2\pi}{\lambda}$ conversion factor from x-scale to angle-scale.

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

Fix phase: Define the speed the fixed shape travels.

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

$kx = \omega t + \phi - \text{const}$

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

em waves in vacuum is specified by 1 parameter

λ or f_0

EM wave spectrum: e.g. radio — microwaves — visible light

x-ray.

KLBJ: 590 KHz ~ $600 \times 10^3 \frac{1}{sec}$.

$$\lambda = \frac{c}{f} = \frac{3\times10^8}{6\times10^5} \approx 500m$$

Spectrum of EM waves —

	λ	
Radio AM	stadium	$10^3 m$
microwaves	bean size	$10^{-2} m$
visible light	micron	$0.6\mu = 600 nm$
x-ray	atomic size	$10^{-10} m$ Angstrom