VE230 Recitation Class 7

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2017/11/23

Short Review

E-M induction

- Motional emf
- Flux rule for motional emf
- current generators (slidewire, disk dynamo, alternator)
- Lenz’s rule

E-M induction

- induced (transformer) emf
- Faraday's law
- Induced electric field

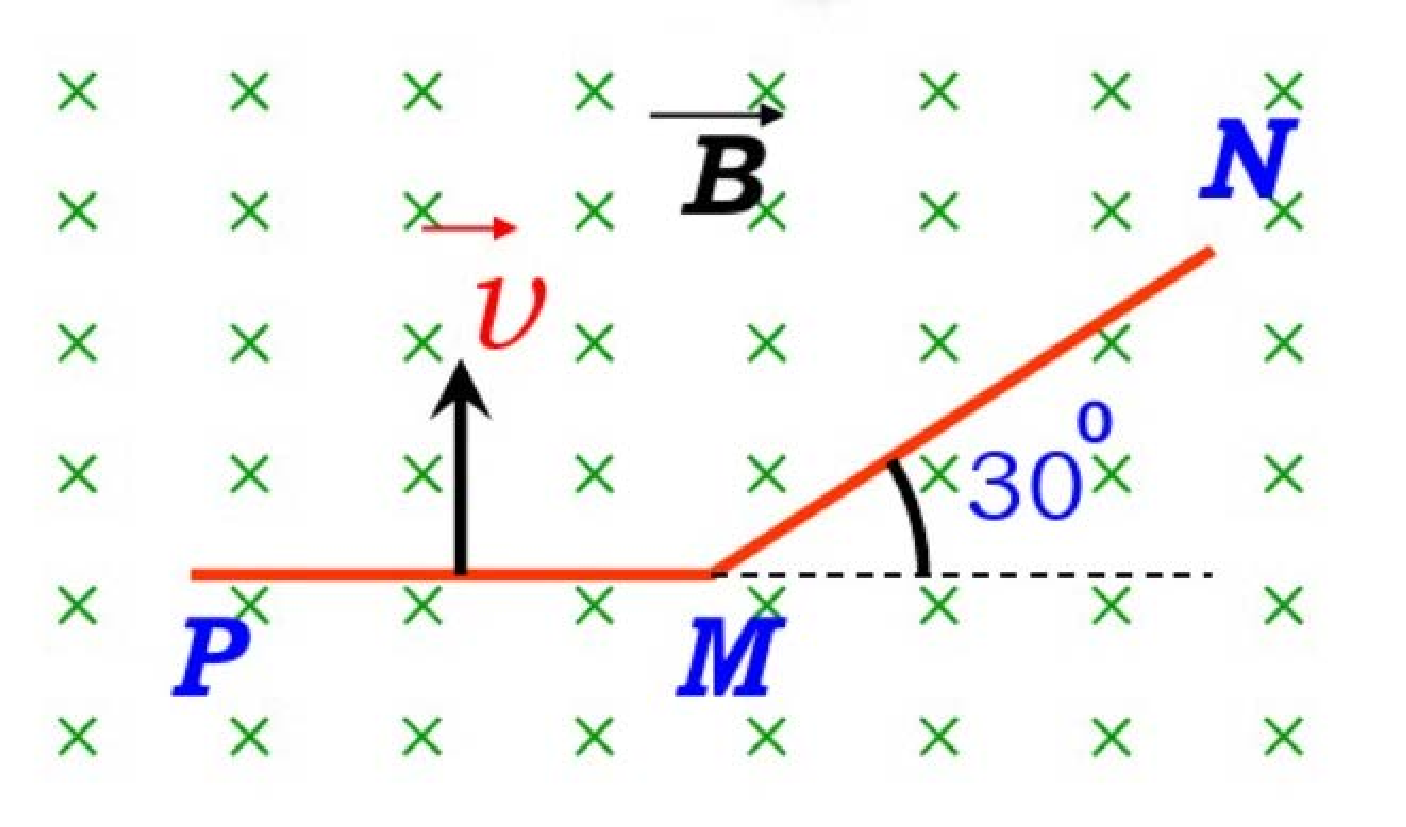
Electromagnetic Waves

- Wave equation
- Wave characteristics
- E-M wave equation
- Polization
- Poynting vector
- Standing wave

Solving Problems

E-M induction

Find the emf between P and N. The side length is L.



Solution

We find the force on the left part first.

$$\varepsilon = \vec{v} \times \vec{B} dl = vBL$$

Then we find the force on the left part .

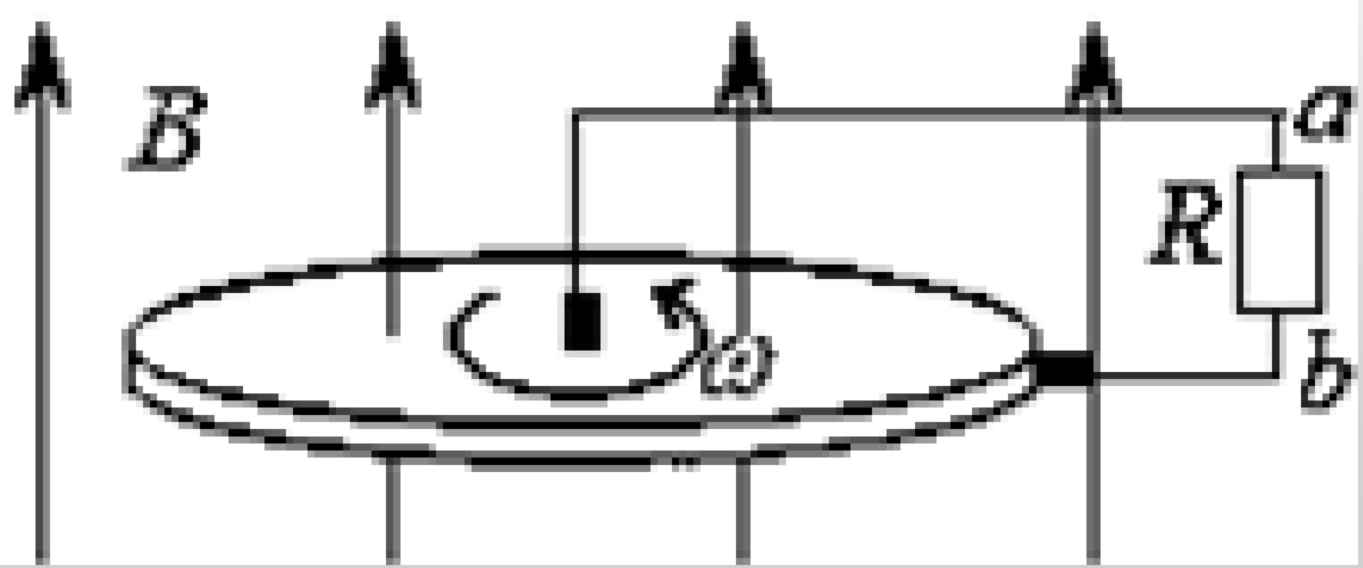
$$\varepsilon = \vec{v} \times \vec{B} dl = \frac{\sqrt{3}}{2} vBL$$

Hence the total emf is

$$\varepsilon = (\frac{\sqrt{3}}{2} + 1) vBL$$

E-M induction

There is a disk conductor, it rotate according to its axis with ω. There is not resistance for the disk conductor. Find the current through the resistance ab (including direction)



Solution

For a small length along the radius

$$d\varepsilon = \vec{v} \times \vec{B} dl = B\omega r dr$$

Hence

$$\varepsilon = \int d\varepsilon = \int_0^R B\omega r dr = \frac{1}{2} B\omega r^2$$

B to A

E-M induction

If there is a magnetic field $B = B_0 \sin \omega_1 t$ in z direction. A square conductor loop with side length a rotating according to the x axis with ω2. The initial position is in x-y plane. What is the emf in the conductor loop according to time.

Solution

First we calculate the flux go through the conductor loop.

$$flux = B_0 \sin \omega_1 t \cos \omega_2 t$$

Then we get

$$\varepsilon = -\frac{d\Phi}{dt} = -B_0(\omega_1 \cos \omega_1 t \cos \omega_2 t - \omega_1 \sin \omega_1 t\, sin\, \omega_2 t)$$

EM Wave

Find the moving direction, E (or B) and the speed of the following EM plane wave. (k>0, w>0)

- $E = E_0 \sin(kx - wt)\ \hat{y}$
- $B = B_0 \cos(-kz + wt)\hat{x}$
- $E = E_0 \sin(-ky - wt)\hat{z}$

Solution

$$\vec{B} = \frac{1}{c}\hat{k} \times \vec{E}$$

1 along x,$c = \frac{\mathrm{w}}{\mathrm{k}}, \mathrm{B} = \frac{E_0}{c}\sin(kx - wt)\,\hat{z}$

2 along z,$c = \frac{\mathrm{w}}{\mathrm{k}}, \mathrm{E} = -\mathrm{cB}_0\, cos(-kz + wt)\,\hat{y}$

3 along -y,$c = \frac{\mathrm{w}}{\mathrm{k}}, \mathrm{B} = -\frac{E_0}{c}\sin(-ky - wt)\,\hat{x}$