VE230 Mid2 Review Class

Shangquan

Announcement

- Exam Time & Place: 2018/12/10, Mon. 10:00-12:00 Dong Xia Yuan 215
- Cheating Sheet: May not be allowed
- Calculator: May not be helpful
- Topics: All.
- Review Materials: Slides, Books, HWs, Quizes, etc.
- Big Office Hour: 12/9, Sun. 18:20-20:00 326E JI Building
- Paper checking for Mid2: After this review

Concept

- Maxwell equations
- Faraday's law
- EMF
- Lenz law

Tools & Methods

- Principle of Superposition
- Symmetry
- Image
- Vector Calculus
- Stokes Theorem $\oint_{\Gamma} \vec{F} \cdot d\vec{\Gamma} = \iint_{S} \vec{\nabla} \times \vec{F} \cdot d\vec{S}$
- Gauss Theorem (Divergence Theorem) $\iiint_{V} \vec{\nabla} \cdot \vec{F} = \oiint_{S} \vec{F} \cdot d\vec{A}$
- Uniqueness theorem

Maxwell Equations

Formulation in SI units convention [edit]

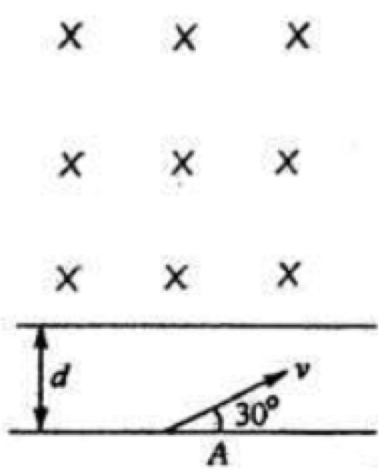
Name	Integral equations	Differential equations
Gauss's law	$\oiint_{\partial\Omega} \mathbf{E} \cdot \mathrm{d}\mathbf{S} = \frac{1}{\varepsilon_0} \iiint_{\Omega} \rho \, \mathrm{d}V$	$\nabla \cdot \mathbf{E} = \frac{\rho}{\varepsilon_0}$
Gauss's law for magnetism	$\oiint_{\partial\Omega} \mathbf{B} \cdot \mathrm{d}\mathbf{S} = 0$	$\nabla \cdot \mathbf{B} = 0$
Maxwell–Faraday equation (Faraday's law of induction)	$\oint_{\partial\Sigma} \mathbf{E} \cdot \mathrm{d}\boldsymbol{l} = -\frac{\mathrm{d}}{\mathrm{d}t} \iint_{\Sigma} \mathbf{B} \cdot \mathrm{d}\mathbf{S}$	$\nabla \times \mathbf{E} = -\frac{\partial \mathbf{B}}{\partial t}$
Ampère's circuital law (with Maxwell's addition)	$\oint_{\partial\Sigma} \mathbf{B} \cdot \mathrm{d}\boldsymbol{l} = \mu_0 \left(\iint_{\Sigma} \mathbf{J} \cdot \mathrm{d}\mathbf{S} + \varepsilon_0 \frac{\mathrm{d}}{\mathrm{d}t} \iint_{\Sigma} \mathbf{E} \cdot \mathrm{d}\mathbf{S} \right)$	$\nabla \times \mathbf{B} = \mu_0 \left(\mathbf{J} + \varepsilon_0 \frac{\partial \mathbf{E}}{\partial t} \right)$

From Wikipedia: https://en.wikipedia.org/wiki/Maxwell%27s_equations

Exercise (moving in B)

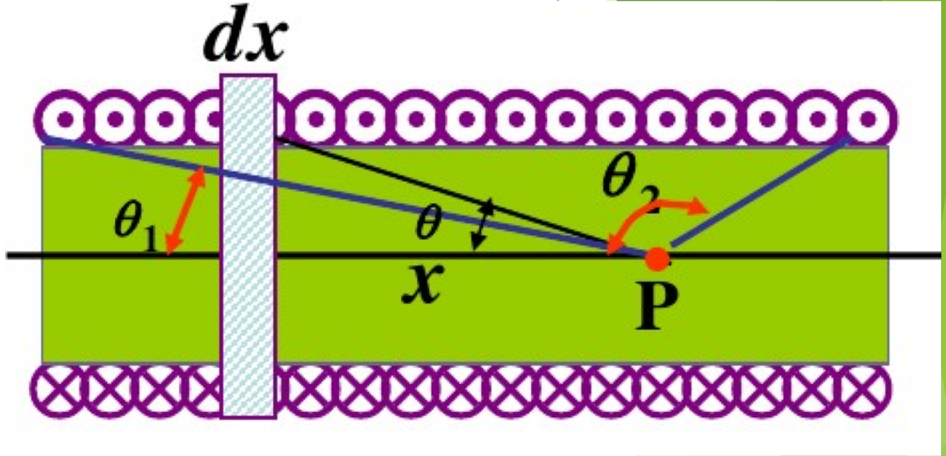
There is magnetic field in the upper half of the space. At distance d below the edge, there is a particle with m and +q moving with speed v as shown in figure. Give that after a period of time, the particle will come back to the position A, please

1. Find v
2. Find the time t.



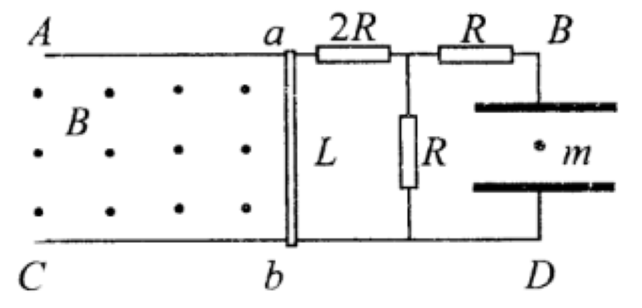
Exercise (B from I)

- 1. Find the magnetic field at a point P in a solenoid.
- 2. How about the solenoid is infinitely long. (Also try Ampere's circuital law)

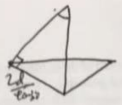


Exercise (EMF)

- The system is shown as the figure. There is B in the left half of the region. There is a particle m between the capacitor.
- 1. When ab is moving at v0 towards left, the particle is still. Find its charge q.
- 2. If ab is initially still and start moving with acceleration a1, find the particle’s acceleration of different time.



1.



$v = 2d/\tan 30°$ $\quad m\frac{v^2}{r} = qvB$

$r = \frac{mv}{qB} = 2d/\tan 30°$

$v = \frac{2\sqrt{3}d\,qB}{m}$

$t = \frac{2\times 2d + 2\pi \cdot 2\sqrt{3}d \cdot \frac{300}{360}}{v}$

$= \frac{4d + \frac{\pi}{3} 10\sqrt{3}\pi d}{\frac{2\sqrt{3}d\,qB}{m}} = \frac{2\sqrt{3}}{3}\frac{m}{qB} + \frac{5}{3}\frac{m\pi}{qB}$

2. $n = [/m]$

$dI = nI\,dx$

$dB = \frac{\mu_0 R^2 n I\,dx}{2(x^2+R^2)^{3/2}}$

$\boxed{B = \frac{\mu_0}{4\pi}\frac{R \cdot I}{\sqrt{R^2+x^2}^3} \cdot 2\pi R = \frac{\mu_0 R^2 I}{2(R^2+x^2)^{3/2}}}$

$x = -R\cot\theta$

$dx = \frac{R\,d\theta}{\sin^2\theta}$, $\quad dB = \frac{\mu_0 R^2 n I}{2(x^2+R^2)^{3/2}} \cdot \frac{R}{\sin^2\theta}d\theta = \frac{\mu_0 n I \sin\theta}{2R}$

$dB = \int dB = \int_{\theta_1}^{\theta_2} \frac{\mu_0 n I}{2}\sin\theta\,d\theta = \frac{\mu_0 n I}{2}\cdot(\cos\theta_1 - \cos\theta_2)$

3. 1) 2.

$d\Phi = v\,dt\,L \cdot B$

$V = \frac{d\Phi}{dt} = vLB$

$\frac{1}{3}V = E \cdot d$

$qE = mg$

$q = \frac{3mgd}{vLB}$

2)

$d\phi = v\,dt\,LB =$

$v = at$

$V = atLB$

$E = \frac{1}{3d}aLBt$

$a' = \frac{mg - qE}{m} = g - \frac{q}{m3d}aLBt$