Official Starting Equations
PHYS 2135, Engineering Physics II

From PHYS 1135:

$x=x_o+v_{ox}\Delta t+\frac{1}{2}a_x(\Delta t)^2$ $\quad v_x=v_{ox}+a_x\Delta t$ $\quad v_x^2=v_{ox}^2+2a_x(x-x_o)$ $\quad \sum\vec{F}=m\vec{a}$

$F_r=-\frac{mv_t^2}{r}$ $\quad P=\frac{F}{A}$ $\quad \vec{p}=m\vec{v}$ $\quad P=\frac{dW}{dt}$ $\quad W=\int\vec{F}\cdot d\vec{s}$

$K=\frac{1}{2}mv^2$ $\quad U_f-U_i=-W_{\text{conservative}}$ $\quad E=K+U$ $\quad E_f-E_i=(W_{\text{other}})_{i\to f}$ $\quad E=P_{\text{ave}}t$

Constants:

$g=9.8\frac{\text{m}}{\text{s}^2}$ $\quad m_{\text{electron}}=9.11\times10^{-31}\text{kg}$ $\quad m_{\text{proton}}=1.67\times10^{-27}\text{kg}$ $\quad e=1.6\times10^{-19}\text{C}$

$c=3.0\times10^8\frac{\text{m}}{\text{s}}$ $\quad k=\frac{1}{4\pi\epsilon_o}=9\times10^9\frac{\text{Nm}^2}{\text{C}^2}$ $\quad \epsilon_o=8.85\times10^{-12}\frac{\text{C}^2}{\text{Nm}^2}$ $\quad \mu_o=4\pi\times10^{-7}\frac{Tm}{A}$

Electric Force, Field, Potential and Potential Energy:

$\vec{F}=k\frac{q_1q_2}{r_{12}^2}\hat{r}_{12}$ $\quad \vec{E}=k\frac{q}{r^2}\hat{r}$ $\quad \vec{F}=q\vec{E}$ $\quad \Delta V=-\int_i^f\vec{E}\cdot d\vec{s}$

$U=k\frac{q_1q_2}{r_{12}}$ $\quad V=k\frac{q}{r}$ $\quad \Delta U=q\Delta V$ $\quad E_x=-\frac{\partial V}{\partial x}$

$\vec{p}=q\vec{d}$ (from – to +) $\quad \vec{\tau}=\vec{p}\times\vec{E}$ $\quad U_{\text{dipole}}=-\vec{p}\cdot\vec{E}$

$\Phi_E=\int_S\vec{E}\cdot d\vec{A}$ $\quad \oint_S\vec{E}\cdot d\vec{A}=\frac{q_{\text{enclosed}}}{\epsilon_o}$ $\quad \lambda\equiv\frac{\text{charge}}{\text{length}}$ $\quad \sigma\equiv\frac{\text{charge}}{\text{area}}$ $\quad \rho\equiv\frac{\text{charge}}{\text{volume}}$

Circuits:

$C=\frac{Q}{V}$ $\quad \frac{1}{C_T}=\sum\frac{1}{C_i}$ $\quad C_T=\sum C_i$ $\quad C_o=\frac{\epsilon_o A}{d}$ $\quad C=\kappa C_o$

$U=\frac{1}{2}CV^2=\frac{1}{2}\frac{Q^2}{C}=\frac{1}{2}QV$ $\quad I=\frac{dq}{dt}$ $\quad J=\frac{I}{A}$ $\quad \vec{J}=nq\vec{v}_d$

$\vec{J}=\sigma\vec{E}$ $\quad V=IR$ $\quad R=\rho\frac{L}{A}$ $\quad \sigma=\frac{1}{\rho}$ $\quad \rho=\rho_o[1+\alpha(T-T_o)]$

$\sum I=0$ $\quad \sum\Delta V=0$ $\quad \frac{1}{R_T}=\sum\frac{1}{R_i}$ $\quad R_T=\sum R_i$ $\quad P=IV=\frac{V^2}{R}=I^2R$

$Q(t)=Q_{\text{final}}[1-e^{-t/\tau}]$ $\quad Q(t)=Q_o e^{-t/\tau}$ $\quad \tau=RC$

Magnetic Force, Field and Inductance:

$\vec{F}=q(\vec{E}+\vec{v}\times\vec{B})$ $\quad \vec{F}=I\vec{L}\times\vec{B}$ $\quad \Phi_B=\int_S \vec{B}\cdot d\vec{A}$ $\quad \oint_S \vec{B}\cdot d\vec{A}=0$ $\quad \oint_L \vec{B}\cdot d\vec{s}=\mu_o I_{\text{enclosed}}$

$\vec{\mu}=NI\vec{A}$ $\quad \vec{\tau}=\vec{\mu}\times\vec{B}$ $\quad U_{\text{dipole}}=-\vec{\mu}\cdot\vec{B}$ $\quad \vec{B}=\frac{\mu_o}{4\pi}\frac{q\vec{v}\times\hat{r}}{r^2}$ $\quad d\vec{B}=\frac{\mu_o I}{4\pi}\frac{d\vec{s}\times\hat{r}}{r^2}$

$\mathcal{E}=-N\frac{d\Phi_B}{dt}$ $\quad \oint_L \vec{E}\cdot d\vec{s}=-\frac{d\Phi_B}{dt}$ $\quad \oint_L \vec{B}\cdot d\vec{s}=\mu_o I_{\text{enclosed}}+\mu_o\epsilon_o\frac{d\Phi_E}{dt}$

$B=\frac{\mu_o I}{2\pi r}$ $\quad B=\mu_o n I$

Electromagnetic Waves:

$I=\frac{P}{A}$ $\quad u=\frac{1}{2}\left(\epsilon_o E^2+\frac{B^2}{\mu_o}\right)=\epsilon_o E^2=\frac{B^2}{\mu_o}$ $\quad \langle u\rangle=\frac{1}{4}\left(\epsilon_o E_{\text{max}}^2+\frac{B_{\text{max}}^2}{\mu_o}\right)=\frac{1}{2}\epsilon_o E_{\text{max}}^2=\frac{B_{\text{max}}^2}{2\mu_o}$

$\frac{E}{B}=c=\frac{1}{\sqrt{\epsilon_o\mu_o}}$ $\quad \vec{S}=\frac{1}{\mu_o}\vec{E}\times\vec{B}$ $\quad I=\langle S\rangle=c\langle u\rangle$ $\quad \langle P_{\text{rad}}\rangle=\frac{I}{c}$ or $\frac{2I}{c}$

$k=\frac{2\pi}{\lambda}$ $\quad \omega=2\pi f$ $\quad T=\frac{1}{f}$ $\quad v=f\lambda=\frac{\omega}{k}=\frac{c}{n}$

Optics:

$I=I_{\text{max}}\cos^2\phi$ $\quad \theta_r=\theta_i$ $\quad n=\frac{c}{v}=\frac{\lambda_o}{\lambda_n}$ $\quad n_r\sin\theta_r=n_i\sin\theta_i$

$\frac{1}{s}+\frac{1}{s'}=\frac{1}{f}$ $\quad m=\frac{y'}{y}=-\frac{s'}{s}$ $\quad \frac{1}{f}=(n-1)\left(\frac{1}{R_1}-\frac{1}{R_2}\right)$ $\quad f=\frac{R}{2}$

$\frac{n_a}{s}+\frac{n_b}{s'}=\frac{n_b-n_a}{R}$ $\quad m=\frac{y'}{y}=-\frac{n_a s'}{n_b s}$ $\quad \Delta L=m\lambda$ $\quad \Delta L=\left(m+\frac{1}{2}\right)\lambda$

$\Delta L=d\sin\theta$ $\quad \phi=2\pi\left(\frac{\Delta L}{\lambda}\right)$ $\quad I=I_o\cos^2\frac{\phi}{2}$ $\quad R=\frac{\lambda}{\Delta\lambda}=Nm$

$m\lambda=a\sin\theta$ $\quad \beta=\frac{2\pi}{\lambda}a\sin\theta$ $\quad I=I_o\left[\frac{\sin(\beta/2)}{\beta/2}\right]^2$

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Exam Total
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PHYS 2135 Exam III
April 23, 2019

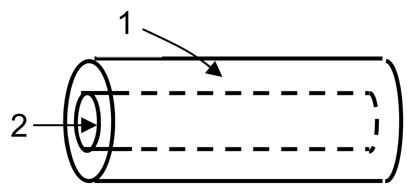
Name: ____________________ Section: _________

For questions 1-5, select the best answer. For problems 6-10, solutions must begin with an Official Starting Equation, when appropriate. Work must be shown to receive credit. Calculators are not allowed.

(8) _________ **1.** Two long, straight, parallel wires carry identical currents in opposite directions. The force between the two wires is

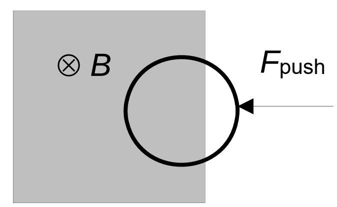
[A] attractive [B] repulsive
[C] zero [D] indeterminate

(8) _________ **2.** Two solenoids, wound in the same direction, are coaxial as shown. Solenoid 1, outer, has 1000 turns/meter and twice the radius of solenoid 2, inner, which has 2000 turns/meter. What direction and ratio of currents, I_1/I_2 will result in zero magnetic field near the axis of solenoid 2?



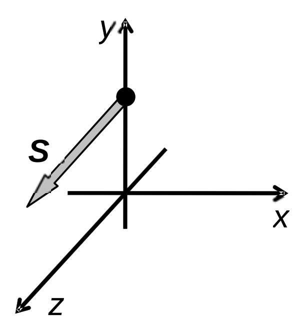
[A] $I_1/I_2=2$, currents in same direction
[B] $I_1/I_2=1/2$, currents in same direction
[C] $I_1/I_2=2$, currents in opposite direction
[D] $I_1/I_2=1/2$, currents in opposite direction

(8) _________ **3.** A circular conducting loop is pushed into a region of uniform magnetic field, directed into the page as shown in the diagram. In which direction will the induced current flow?



[A]  [B]  [C] ⊙ [D] ⊗

(8) _________ **4.** The figure to the right shows the direction of propagation (Poynting vector) of an electromagnetic wave at a certain point in space and a certain instant in time. If the magnetic field direction at this point and time is in the positive y direction, what is the direction of the electric field at this point and time?



[A] negative z [B] positive z
[C] negative x [D] positive x .

(8) _________ **5** (Free). Electric and magnetic fields
[A] are hard to plow.
[B] provide a good foundation for power lines.
[C] flourish in sunlight.
[D] need water to grow currants.

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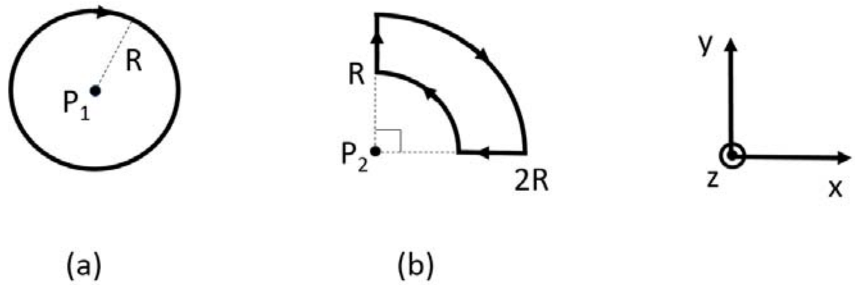
6. Two thin wires are shaped as in the figure (a) and (b) below. They each carry a steady current I in the direction indicated by the arrows.



(15) (a) Calculate the magnitude and direction of the magnetic field at the center P_1 of the loop of radius R as a function of μ_0, I, and R. You must show the steps of your derivation and explain the result to get credit.

(25) (b) Calculate the magnitude and direction of the magnetic field at the point P_2 as a function of μ_0, I, and R. You must show the steps of your derivation and explain the result to get credit. The inner arc has a radius R and the outer arc has a radius 2R.

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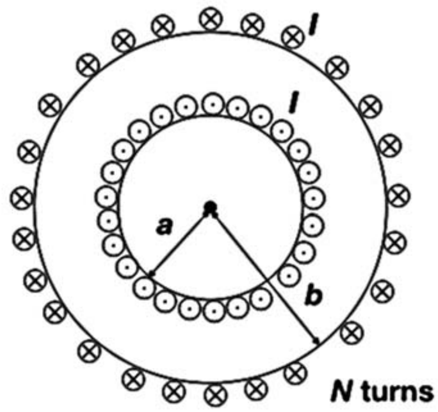
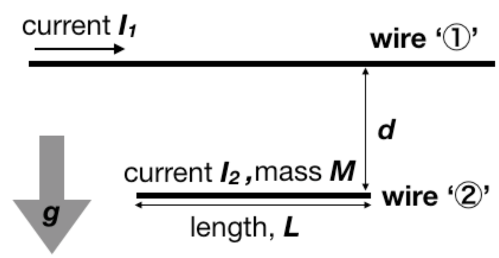
7. Consider an ideal toroidal solenoid with N turns, each carrying a current I directed as shown in the figure. Applying Ampere's law, find the direction and magnitude of the magnetic field in the following regions:



(10) (a) $r > b$.

(10) (b) $a < r < b$.

8. As shown in the figure, a long straight wire, labeled ①, carries a current I_1 and is fixed in position. Wire ②, of length L and mass M, carries a current I_2 and is placed a distance d from wire ①.



(10) (a) **Applying Ampere's law**, find the direction and magnitude of the magnetic field produced **at** wire ② **by** wire ①.

Direction: (circle one) up (↑) down (↓) into page (⊗) out of page (⊙)

(10) (b) Wire ② does not fall, but stays at the same vertical position. Under this condition, find the direction of the current in wire ②. Also, express the distance d in terms of I_1, I_2, L, M, and constants. Note that gravity is NOT ignorable.

Direction: (circle one) left to right (→) right to left (←)

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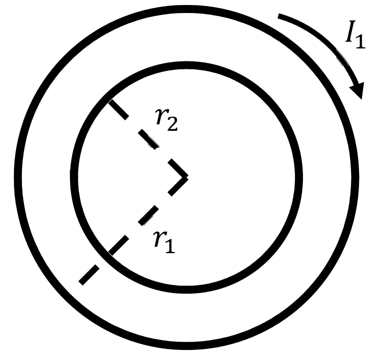
9. The current in a long solenoid is given by $I_1 = I_0 e^{-\alpha t}$ and is clockwise as illustrated in the figure. The solenoid has N_1 windings, length L_1, radius r_1 and resistance R_1. A single circular wire loop of radius $r_2 < r_1$ and resistance R_2 is placed at the center of the solenoid as shown in the figures. (I_0 and α are both positive quantities.

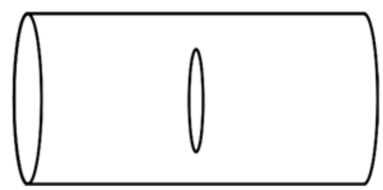
End View



(10) (a) In what direction is the induced current in the loop for $t > 0$? [Circle the correct answer.]
[A] Clockwise
[B] Counter-clockwise

(20) (b) Determine the induced emf $\mathcal{E}$ in the loop for $t > 0$.

Side View



(10) (c) Determine the current I_2 in the loop for $t > 0$.

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10. A satellite located a distance H above the surface of the earth emits a radio signal of frequency f uniformly in all directions. The signal with intensity I_0 is received by a totally absorbing square antenna with side length L on the surface of the earth that is perpendicular to the incoming signal. All answers should be expressed in terms of H, f, I_0, L, and fundamental constants.

(10) (a) What is the power of the signal generated by the satellite?

(10) (b) What is the maximum electric field at the location of the antenna?

(10) (c) What is the average energy density delivered to the antenna by the electric field?

(10) (d) What force does the radiation exert on the antenna?

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