Official Starting Equations
PHYS 2135, Engineering Physics II

From PHYS 1135:

$x = x_0 + v_{0x}\Delta t + \frac{1}{2}a_x(\Delta t)^2$ $v_x = v_{0x} + a_x\Delta t$ $v_x^2 = v_{0x}^2 + 2a_x(x - x_0)$ $\sum \vec{F} = m\vec{a}$

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

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

Constants:

$g = 9.8\,\frac{\text{m}}{\text{s}^2}$ $m_{\text{electron}} = 9.11 \times 10^{-31}\text{kg}$ $m_{\text{proton}} = 1.67 \times 10^{-27}\text{kg}$ $e = 1.6 \times 10^{-19}\text{C}$

$c = 3.0 \times 10^8\,\frac{\text{m}}{\text{s}}$ $k = \frac{1}{4\pi\epsilon_0} = 9 \times 10^9\,\frac{\text{Nm}^2}{\text{C}^2}$ $\epsilon_0 = 8.85 \times 10^{-12}\,\frac{\text{C}^2}{\text{Nm}^2}$ $\mu_0 = 4\pi \times 10^{-7}\,\frac{\text{Tm}}{\text{A}}$

Electric Force, Field, Potential and Potential Energy:

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

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

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

$\Phi_E = \int_S \vec{E} \cdot d\vec{A}$ $\oint_S \vec{E} \cdot d\vec{A} = \frac{q_{\text{enclosed}}}{\epsilon_0}$ $\lambda \equiv \frac{\text{charge}}{\text{length}}$ $\sigma \equiv \frac{\text{charge}}{\text{area}}$ $\rho \equiv \frac{\text{charge}}{\text{volume}}$

Circuits:

$C = \frac{Q}{V}$ $\frac{1}{C_T} = \sum \frac{1}{C_i}$ $C_T = \sum C_i$ $C_0 = \frac{\epsilon_0 A}{d}$ $C = \kappa C_0$

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

$\vec{J} = \sigma\vec{E}$ $V = IR$ $R = \rho\frac{L}{A}$ $\sigma = \frac{1}{\rho}$ $\rho = \rho_0[1 + \alpha(T - T_0)]$

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

$Q(t) = Q_{\text{final}}\left[1 - e^{-t/\tau}\right]$ $Q(t) = Q_0 e^{-t/\tau}$ $\tau = RC$

Magnetic Force, Field and Inductance:

$\vec{F} = q(\vec{E} + \vec{v} \times \vec{B})$ $\vec{F} = I\vec{L} \times \vec{B}$ $\Phi_B = \int_S \vec{B} \cdot d\vec{A}$ $\oint_S \vec{B} \cdot d\vec{A} = 0$

$\oint_L \vec{B} \cdot d\vec{s} = \mu_0 I_{\text{enclosed}}$ $\vec{\mu} = NI\vec{A}$ $\vec{\tau} = \vec{\mu} \times \vec{B}$ $U_{\text{dipole}} = -\vec{\mu} \cdot \vec{B}$

$\vec{B} = \frac{\mu_0}{4\pi}\frac{q\vec{v}\times\hat{r}}{r^2}$ $d\vec{B} = \frac{\mu_0 I}{4\pi}\frac{d\vec{s}\times\hat{r}}{r^2}$ $\mathcal{E} = -N\frac{d\Phi_B}{dt}$ $\oint_L \vec{E} \cdot d\vec{s} = -\frac{d\phi_B}{dt}$

$\oint_L \vec{B} \cdot d\vec{s} = \mu_0 I_{\text{enclosed}} + \mu_0\epsilon_0\frac{d\phi_E}{dt}$ $B = \frac{\mu_0 I}{2\pi r}$ $B = \mu_0 n I$

Electromagnetic Waves:

$I = \frac{P}{A}$ $u = \frac{1}{2}\left(\epsilon_0 E^2 + \frac{B^2}{\mu_0}\right) = \epsilon_0 E^2 = \frac{B^2}{\mu_0}$ $\langle u\rangle = \frac{1}{4}\left(\epsilon_0 E_{\text{max}}^2 + \frac{B_{\text{max}}^2}{\mu_0}\right) = \frac{1}{2}\epsilon_0 E_{\text{max}}^2 = \frac{B_{\text{max}}^2}{2\mu_0}$

$\frac{E}{B} = c = \frac{1}{\sqrt{\epsilon_0\mu_0}}$ $\vec{S} = \frac{1}{\mu_0}\vec{E} \times \vec{B}$ $I = \langle S\rangle = c\langle u\rangle$ $\langle P_{\text{rad}}\rangle = \frac{I}{c}$ or $\frac{2I}{c}$

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

Optics:

$I = I_{\text{max}}\cos^2\phi$ $\theta_r = \theta_i$ $n = \frac{c}{v} = \frac{\lambda_0}{\lambda_n}$ $n_r \sin\theta_r = n_i \sin\theta_i$

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

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

$\Delta L = d\sin\theta$ $\phi = 2\pi\left(\frac{\Delta L}{\lambda}\right)$ $I = I_0\cos^2\frac{\phi}{2}$ $R = \frac{\lambda}{\Delta\lambda} = Nm$

$m\lambda = a\sin\theta$ $\beta = \frac{2\pi}{\lambda}a\sin\theta$ $I = I_0\left[\frac{\sin(\beta/2)}{\beta/2}\right]^2$

Last updated, January 18, 2019

Exam Total

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PHYS 2135 Exam II
November 12, 2019

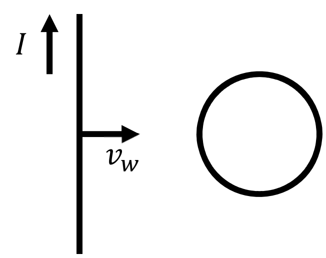
Name: ____________________ Section: _________

For questions 1-5, select the best answer. For problems 6-9, solutions must begin with an Official Starting Equation, when appropriate. Work for problems must be shown and answers provided in the given boxes. Calculators are not allowed.

(8) _________ **1.** Light from a laser in medium A is totally internally reflected off the surface of medium B even though medium B is clear. Select the correct statement about the speed of light in the two media.

[A] $v_A < v_B$
[B] $v_A = v_B$
[C] $v_A > v_B$
[D] The relative speeds in the two media cannot be determined.

(8) _________ **2.** A wire carrying a current upward is moved to the right near a stationary loop of wire, as illustrated. The current induced in the loop of wire is …

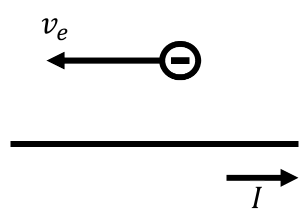


[A] clockwise.
[B] counter-clockwise.
[C] zero.
[D] downward.

(8) _________ **3.** An electromagnetic wave traveling in the $+y$ direction has an electric field in the $+x$ direction at a particular location and time. At the same location and time, the wave's magnetic field is in which direction?

[A]	$\hat{\imath}$	[B]	$\hat{\jmath}$	[C]	$\hat{k}$
[D]	$-\hat{\imath}$	[E]	$-\hat{\jmath}$	[F]	$-\hat{k}$

(8) _________ **4**. At a particular moment in time, an electron is moving parallel to a long straight wire carrying a current in the opposite direction, as illustrated. At the given moment of time, the force on the electron is in which direction?



[A]	up	[B]	right	[C]	into page
[D]	down	[E]	left	[F]	out of page

(8) _________ **5** (Free). Gauss, Ampere, Faraday and Maxwell would be a good name for which of the following?

[A] A law firm
[B] An electric company
[C] An ELO tribute band
[D] A company that recycles gravitational lenses.

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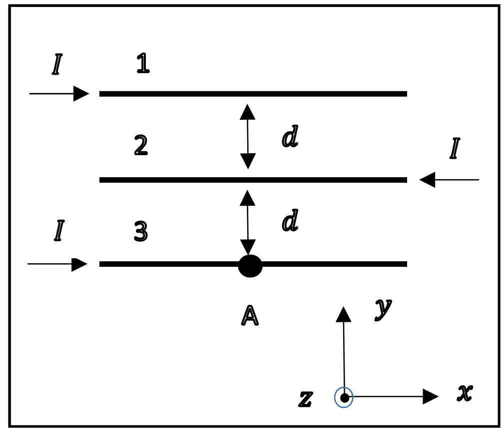
6. Three long parallel wires, all located within the $x-y$ plane, each carry a current I in the directions shown. The separation between adjacent wires is d. Point A is located at the midpoint of wire 3. [Express answers using given symbols and constants.]



(8) (a) What is the magnitude of the magnetic field generated by wire 1 at point A?

(8) (b) What is the direction of the magnetic field from wire 1 at point A? Circle the correct direction.

$\hat{\imath}$ $-\hat{\imath}$ $\hat{\jmath}$ $-\hat{\jmath}$ $\hat{k}$ $-\hat{k}$

(8) (c) What is the magnitude of the magnetic field generated by wire 2 at point A?

(8) (d) What is the direction of the magnetic field from wire 2 at point A? Circle the correct direction.

$\hat{\imath}$ $-\hat{\imath}$ $\hat{\jmath}$ $-\hat{\jmath}$ $\hat{k}$ $-\hat{k}$

(8) (d) Compute the force per unit length on wire 3 from wires 1 and 2.

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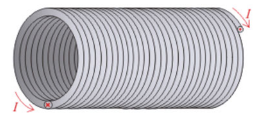
7. A thin, very long solenoid of diameter D and length $L >> D$ has a total of N turns of wire and carries a current I.



(10) (a) Calculate the magnitude of the magnetic field B_1 near the center of the solenoid. Express your answer using given symbols. You need to show derivation to get full credit.

B_1 =

(5) (b) The solenoid is stretched to twice its length while the total number of turns and the current are kept constant. What is the value of the magnetic field B_2 at the center of the solenoid after it has been stretched? Express your answer using B_1.

B_2 =

(10) (c) The original solenoid is now curved into the shape of a circle to form a toroidal solenoid. Calculate the magnitude of the magnetic field B_3 inside the toroid at a distance r from the center of the toroid. Express your answer using given symbols. You need to show derivation to get credit.

B_3 =

(10) (d) Calculate the magnitude of the magnetic field B_4 outside the toroid. Express your answer using given symbols. You need to show derivation to get credit.

B_4 =

(5) (e) Is the field inside the toroid uniform like in the solenoid? Circle the correct answer:

YES NO

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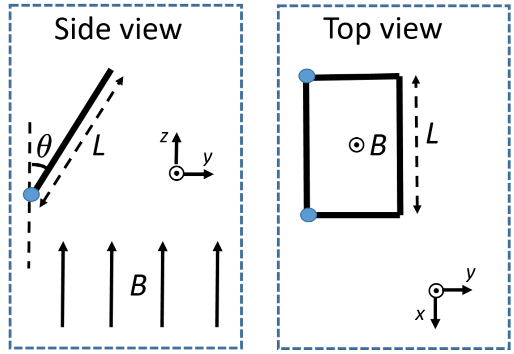
8. A square wire loop of side L is at an angle of θ (θ<90°) with respect to the vertical, as shown in the figure. The loop is in a spatially uniform magnetic field B pointing upward and has electrical resistance R. The magnetic field decreases with time as $B(t) = B_0 e^{-\alpha t}$ with $\alpha > 0$.



(8) (a) Calculate the magnitude of magnetic flux through the loop.

(8) (b) Calculate the magnitude of the induced current in the loop

(8) (c) What is the direction of the induced current in the loop as seen from the top (circle one)?

(i) ⊙ (ii)  (iii) ⊗ (iv) 

(8) (d) Calculate the magnitude of the force on the right side of the loop.

(8) (e) In what direction (as seen from the side view) does the loop "want" to rotate in response to the magnetic force (circle one)? Ignore gravity.
(i) counter-clockwise (ii) clockwise

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9. The Sirius satellite orbits the Earth with its orbit radius 4×10^7 m (measured from the center of the Earth). The satellite transmits electromagnetic wave of 2×10^9 Hz. Assume the satellite transmits the radiation uniformly in all directions. The electromagnetic wave intensity received by a disk antenna on the Earth's surface is 2×10^{-12} W/m^2 when the satellite is 3×10^7 m above it. The disk antenna has radius 2 m. (Your solution must begin with a starting equation. Use $\pi \approx 3$)

(value) (units)

(10) (a) What is the wavelength of the Sirius satellite's radiation?

(10) (b) Calculate the total power output of the Sirius satellite.

(10) (c) Calculate the amplitude of the electric and magnetic fields at the surface of the antenna. [Answer symbolically, using given symbols and constants.]

(10) (d) Suppose the satellite's radiation is perpendicularly incident on disk antenna. If the radiation is completely absorbed by the antenna, what force does the radiation exert on the antenna?

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