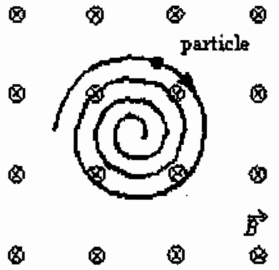
Physics 241 (Fall 2002) Midterm Exam #2 November 7, 2002

Instructions:

1) The problems are NOT given in the order of their degrees of difficulty.
2) There are 17 problems. Each problem is worth 6 points.
3) Please find possibly useful formulae and constants in a separate page.
4) One 8.5"x11" crib sheet (both sides) is allowed; the use of any additional material (except for those provided) is considered cheating.

1. An electron travels due north through a vacuum in a region of uniform magnetic field $\vec{B}$ that is also directed due north. It will:
   A) be unaffected by the field
   B) speed up
   C) slow down
   D) follow a right-handed corkscrew path
   E) follow a left-handed corkscrew path

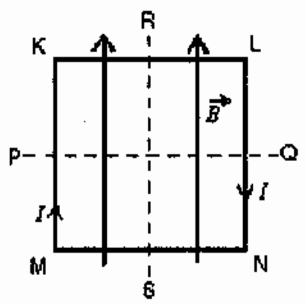
2. A uniform magnetic field is directed into the page. A charged particle, moving in the plane of the page, follows a clockwise spiral of decreasing radius as shown. A reasonable explanation is:



   A) the charge is positive and slowing down
   B) the charge is negative and slowing down
   C) the charge is positive and speeding up
   D) the charge is negative and speeding up
   E) none of the above

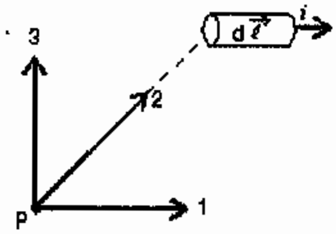
3. A loop of wire carrying a current of 2.0 A is in the shape of a right triangle with two equal sides, each 15 cm long. A 0.7 T uniform magnetic field is in the plane of the triangle and is perpendicular to the hypotenuse. The resultant magnetic force on the two sides has a magnitude of:
   A) 0
   B) 0.21 N
   C) 0.30 N
   D) 0.41 N
   E) 0.51 N

4. A square loop of wire lies in the plane of the page and carries a current I as shown. There is a uniform magnetic field $\vec{B}$ parallel to the side MK as indicated. The loop will tend to rotate:



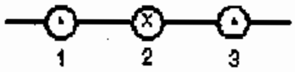
   A) about PQ with KL coming out of the page
   B) about PQ with KL going into the page
   C) about RS with MK coming out of the page
   D) about RS with MK going into the page
   E) about an axis perpendicular to the page

5. In the figure, the current element $i d\vec{\ell}$, the point P, and the three vectors (1, 2, 3) are all in the plane of the page. The direction of $d\vec{B}$, due to this current element, at the point P is:



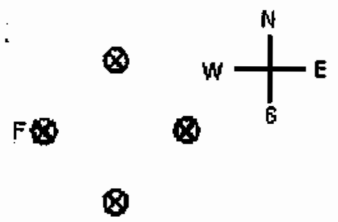
A) in the direction marked "1"
B) in the direction marked "2"
C) in the direction marked "3"
D) out of the page
E) into the page

6. The diagram shows three equally spaced wires that are perpendicular to the page. The currents are all equal, two being out of the page and one being into the page. Rank the wires according to the magnitudes of the magnetic forces on them, from least to greatest.



A) 1, 2, 3
B) 2, 1 and 3 tie
C) 2 and 3 tie, then 1
D) 1 and 3 tie, then 2
E) 3, 2, 1

7. Four long straight wires carry equal currents into the page as shown. The magnetic force exerted on wire F is:

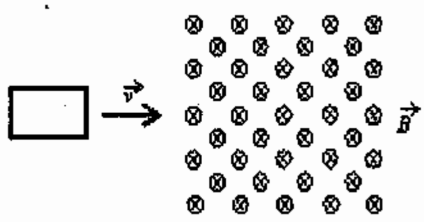


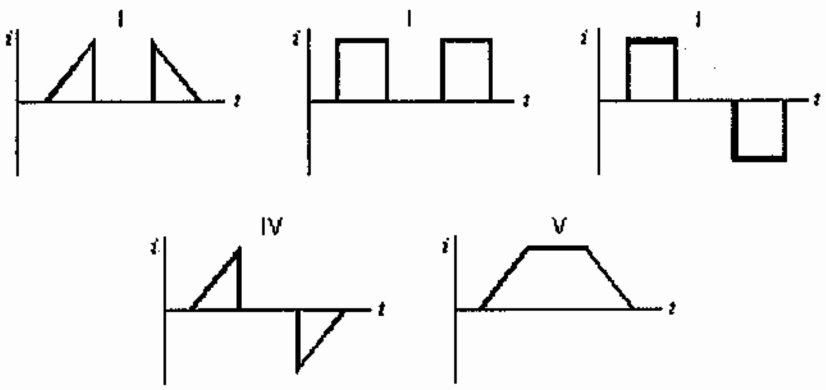
A) north
B) east
C) south
D) west
E) zero

8. In Ampere's law, $\oint \vec{B} \cdot d\vec{s} = \mu_0 i$, the integration must be over any:
A) surface
B) closed surface
C) path
D) closed path
E) closed path that surrounds all the current producing $\vec{B}$

9. A square loop of wire lies in the plane of the page. A decreasing magnetic field is directed into the page. The induced current in the loop is:
A) counterclockwise
B) clockwise
C) zero
D) depends upon whether or not B is decreasing at a constant rate
E) clockwise in two of the loop sides and counterclockwise in the other two

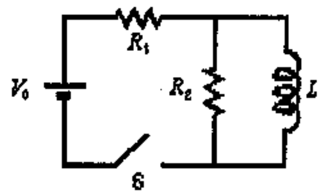
10. A square loop of wire moves with a constant speed v from a field-free region into a region of uniform B field, as shown. Which of the five graphs correctly shows the induced current i in the loop as a function of time t?





A) I
B) II
C) III
D) IV
E) V

11. Immediately after switch S in the circuit shown is closed, the current through the battery shown is:



A) 0
B) V_0/R_1
C) V_0/R_2
D) $V_0/(R_1 + R_2)$
E) $V_0(R_1 + R_2)/(R_1R_2)$

12. An 6.0-mH inductor and a 3.0-Ω resistor are wired in series to a 12-V ideal battery. A switch in the circuit is closed at time 0, at which time the current is zero. 2.0 ms later the energy stored in the inductor is:
A) 0
B) 2.5×10^{-2} J
C) 1.9×10^{-2} J
D) 3.8×10^{-2} J
E) 9.6×10^{-3} J

13. A 1.2-m radius cylindrical region contains a uniform electric field that is perpendicular to the cross sections of the region. At $t = 0$ the field is 0 and increases uniformly to 200 V/m at $t = 5.0$ s. The total displacement current through a cross section of the region is:
A) 4.5×10^{-16} A
B) 2.0×10^{-15} A
C) 3.5×10^{-10} A
D) 1.6×10^{-9} A
E) 8.0×10^{-9} A

14. At time $t = 0$ the charge on the 50-μF capacitor in an LC circuit is 15 μC and there is no current. If the inductance is 20 mH the maximum current is:
A) 15 nA
B) 15 μA
C) 6.7 mA
D) 15 mA
E) 15 A

15. An ac generator producing 10 V (rms) at 200 rad/s is connected in series with a 50-Ω resistor, a 400-mH inductor, and a 200-μF capacitor. The rms voltage (in volts) across the inductor is:
A) 2.5
B) 3.4
C) 6.7
D) 10.0
E) 10.8

16. The primary of an ideal transformer has 100 turns and the secondary has 600 turns. Then:
A) the power in the primary circuit is less than that in the secondary circuit
B) the currents in the two circuits are the same
C) the voltages in the two circuits are the same
D) the primary current is six times the secondary current
E) the frequency in the secondary circuit is six times that in the primary circuit

17. In an ideal 1:8 step-down transformer, the primary power is 10 kW and the secondary current is 25 A. The primary voltage is:
A) 25,600 V
B) 3200 V
C) 400 V
D) 50 V
E) 6.25 V

$$\vec{F}_B = q\vec{v}\times\vec{B},\ \vec{F}_B = i\vec{L}\times\vec{B},\ d\vec{F}_B = id\vec{L}\times\vec{B}$$

$$\vec{\tau} = \vec{\mu}\times\vec{B}, U = -\vec{\mu}\cdot\vec{B},\ d\vec{B} = \frac{\mu_0}{4\pi}\frac{id\vec{s}\times\vec{r}}{r^3}$$

$$\oint \vec{B}\cdot d\vec{s} = \mu_0 i_{enc},\ B = \mu_0 in,\ B = \frac{\mu_0 i}{2\pi R},\ B = \frac{\mu_0 i\phi}{4\pi R}$$

$$B = \frac{\mu_0 iN}{2\pi r},\ \varepsilon = -N\frac{d\Phi_B}{dt},\ \varepsilon = \oint \vec{E}\cdot d\vec{s},\ L = \frac{N\Phi_B}{i}$$

$$\varepsilon_L = -L\frac{di}{dt},\ i = i(\infty)(1-e^{-t/\tau_L}),\ i = i(0)e^{-t/\tau_L},$$

$$U_B = \frac{1}{2}Li^2,\ u_B = \frac{B^2}{2\mu_0},\ \omega_0 = \frac{1}{\sqrt{LC}},\ X_L = \omega L,$$

$$X_C = \frac{1}{\omega C},\ Z = \sqrt{R^2 + (X_L - X_C)^2},\ \tan\phi = \frac{X_L - X_C}{R}$$

$$P_{ave} = \varepsilon_{rms} I_{rms}\cos\phi,\ \frac{V_p}{V_s} = \frac{N_p}{N_s},\ \frac{I_p}{I_s} = \frac{N_s}{N_p}$$

$$\varepsilon_0 = 8.85\times10^{-12}\ F/m,\ \mu_0 = 1.26\times10^{-6}\ H/m$$