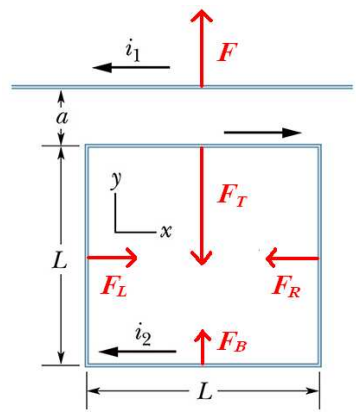
TA: Tomoyuki Nakayama Friday, July 2, 2010

PHY 2048: Physic 2, Discussion Section 8704
Quiz 5 (Homework Sets #8 & #9)

Name: **UFID:**

Formula sheets are not allowed. Calculators are allowed. Do not store equations in your calculator. You need to show all of your work for full credit.

In the figure below right, a long straight wire carries a current i_1 = 80.0 A and a square loop carries current i_2 = 50.0 A. Take a = 5.00 cm and L = 20.0 cm.



a) What are the magnitude and direction of the force exerted on the top edge of the loop? What are the magnitude and direction of the force exerted on the bottom edge? (To show the directions of the forces, draw arrows in the figure.)

The strength of the magnetic field due to a long straight wire depends on the perpendicular distance r from the wire and it is given by $B = \mu_0 i/(2\pi r)$. *Therefore, the fields at the top and bottom edges are, respectively*
$B_T = \mu_0 i_1/(2\pi a)$, $B_B = \mu_0 i_1/(2\pi(a+L))$
The right-hand rule tells you that the direction of the field below the straight wire is out of the paper. (Point your thumb in the direction of i, your fingers curl in the direction of B.)
Magnetic force exerted on a current in a magnetic field perpendicular to the current is $F = iBL$. *Thus the forces on the top and bottom edges are*
$F_T = = i_2 B_T L = \mu_0 i_1 i_2 L/(2\pi a) = 3.20 \times 10^{-3}$ N, $F_B = i_2 B_T L = \mu_0 i_1 i_2 L/(2\pi(a+L)) = 0.64 \times 10^{-3}$ N
To find the directions of the forces, curl your fingers from the direction of current to the direction of field, your extended thumb points in the direction of force.

b) Find the magnitude and direction of the force exerted on the left edge and those exerted on the right edge. (Again, to show the directions of the forces, draw arrows in the figure.)

By symmetry, the magnitudes of the forces exerted on the left edge and right edge are the same. The differential force exerted on small segment dr of these edges is
$dF = \quad = i_2 B dr = \mu_0 i_1 i_2 dr/(2\pi r)$
Integrating from the top end to the bottom end, we get
$F = \int_a^{a+L} = \mu_0 i_1 i_2 dr/(2\pi r) = \mu_0 i_1 i_2/(2\pi) \ln(a+L/a) = 1.29 \times 10^{-3}$ N
The right-hand rule gives the directions of the forces.

c) What are the magnitude and direction of the net force exerted on the long straight wire by the loop? (Not the force exerted on the loop, but that exerted on the straight wire. Draw an arrow to show the direction.)

The forces on the left and right edges cancel. The magnitude of the net force on the loop is
$F = F_T - T_B = 2.56 \times 10^{-3}$ N,
which is downward. According to the Newton's 3rd law, the same and opposite force is exerted on the straight wire by the loop. The force on the straight wire is upward.