# Problem Set #10 –Chapter 28 – 68, 75, 80, Chapter 29 – 12, 21, 22, 23

68. The drift speed is $v = \Delta V/wB$. Using the same current means that the current densities and thus the drift speeds are the same.

When we form the ratio of the two readings, we have

$B_2/B_1 = \Delta V_2/\Delta V_1$;

$B_2/(7500\text{ G}) = (390\text{ mV})/(165\text{ mV})$, which gives

$B_2 = \boxed{1.77 \times 10^4\text{ G} = (1.77\text{ T})}$.

75. The radius of the path in the magnetic field is

$r = mv/eB$, or $mv = eBr$.

The kinetic energy of the electron is

$K = 1/2mv^2 = 1/2(eBr)^2/m$.

If the energy changes to $K - \Delta K$, the radius will change to $r - \Delta r$. If we form the ratio for the two energies, we have

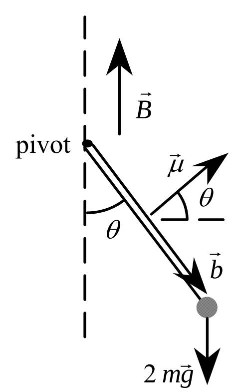
$(K - \Delta K)/K = [(r - \Delta r)/r]^2$;

$1 - \Delta K/K = (1 - \Delta r/r)^2$;

$1 - 0.10 = (1 - \Delta r/r)^2$, which gives $\boxed{\Delta r/r = 0.05\text{ (decrease)}}$.

80. The magnetic dipole moment of the loop is

$\mu = IA = Iab$ perpendicular to the loop.




The diagram shows the loop as viewed along the pivot axis.

At equilibrium, the net torque is zero:

$\vec{\tau}_{\text{net}} = \vec{\mu} \times \vec{B} + \vec{b} \times (2m\vec{g}) = 0$, or

$IabB \sin(90° - \theta) - 2mgb \sin\theta = 0$, which gives

$\theta = \boxed{\tan^{-1}(IaB/2mg)}$.

We choose the horizontal plane through the pivot as the reference

level for the gravitational potential energy. The total potential energy is

$U = -\vec{\mu} \cdot \vec{B} + 2mgh = -IabB \sin\theta - 2mgb \cos\theta$.

To find the angle which minimizes the potential energy, we set $dU/d\theta = 0$:

$dU/d\theta = -IabB\cos\theta + 2mgb\sin\theta = 0$, which gives

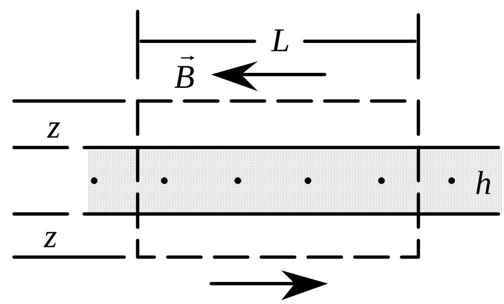
$\tan\theta = IaB/2mg$.

If the current is reversed, the magnetic dipole moment reverses.

The loop will rise to the same angle on the other side of the vertical.

# Chapter 29

12. The sheet may be thought of as an infinite number of parallel wires. The figure shows a view looking directly at the current. If we consider a point above the sheet, the wire directly underneath produces a magnetic field parallel to the sheet. By considering a pair of wires symmetrically placed about the first one, we see that the net field will be parallel to the sheet. Below the sheet, the field will be in the opposite direction. We apply Ampere's law to the rectangular path shown in the diagram. For the sides perpendicular to the sheet, $\vec{B}$ is perpendicular to $d\vec{s}$. For the sides parallel to the sheet, $\vec{B}$ is parallel to $d\vec{s}$ and constant in magnitude, because the upper and lower paths are equidistant from the sheet. We have




$$\oint \vec{B}\cdot d\vec{s} = \mu_0 I_{\text{enclosed}};$$

$$\int \vec{B}\cdot d\vec{s} + \int_{\text{lengths}} \vec{B}\cdot d\vec{s} = 0 + B\int_{\text{lengths}} ds = B2L = \mu_0 hL.$$

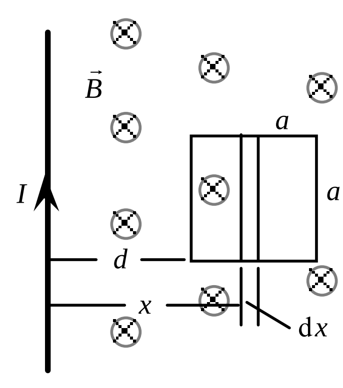
This gives

$B = \mu_0 h/2$ parallel to sheet and perpendicular to current (opposite directions on the two sides).

21. At a distance $x$ from the wire, the magnetic field is directed into the paper with magnitude

$B = \mu_0 I/2\pi x$.

Because the field is not constant over the square, we find the magnetic flux by integration. We choose a differential element parallel to the wire at position $x$ with area $a\,dx$:



$$\Phi_B = \iint \vec{B} \cdot d\vec{A} = \iint B\, dA = \int_d^{a+d} \frac{\mu_0 I}{2\pi x} a\, dx$$

$$= \frac{\mu_0 I a}{2\pi} \ln\left(\frac{a+d}{d}\right).$$

22. For a Gaussian surface, we choose a cylinder with ends of area $A$ and its axis parallel to the $x$-axis. On the cylindrical surface, $\vec{B}$ and $\mathrm{d}\vec{A}$ are perpendicular, so $\vec{B} \cdot \mathrm{d}\vec{A} = 0$. For Gauss' law, we have

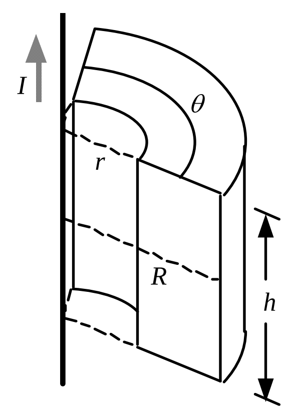
$$\Phi_B = \oiint \vec{B} \cdot d\vec{A} = \iint_{x=x_1} \left(B\hat{i}\right) \cdot \left(-\,\mathrm{dA}\ \hat{i}\right) + \iint_{x=x_2} \left(B\hat{i}\right) \cdot \left(+\,\mathrm{d}A\ \hat{i}\right)$$

$$= -\,B(x_1)A + B(x_2)A = 0, \quad \text{which gives}$$

$$B(x_2) = B(x_1).$$

Because $x_1$ and $x_2$ are arbitrary, $B$ must be constant.

23. The magnetic field of the straight wire is circular, with magnitude depending on the radial distance from the wire. Over the top, bottom, and curved sides of the Gaussian surface, $\vec{B}$ and $\mathrm{d}\vec{A}$ are perpendicular, so $\vec{B} \cdot \mathrm{d}\vec{A} = 0$. The magnetic field is not constant over the rectangular surfaces. The field enters the front rectangle and leaves the rear rectangle. We choose a vertical differential element parallel to the wire at position $r'$ with thickness $\mathrm{d}r'$:




$$\Phi_B = \oiint \vec{B} \cdot d\vec{A} = \int_{\text{front}} \left(-\frac{\mu_0 I}{2\pi r'}\right) h\,\mathrm{d}r' + \int_{\text{rear}} \left(+\frac{\mu_0 I}{2\pi r'}\right) h\,\mathrm{d}r' = 0.$$