Week 7 Homework

Physics 1B

February 21, 2007

1 Serway C19.16

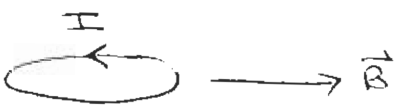
Magnetic fields exert a torque on current loops in configurations where the perpendicular to the loop is not parallel to the magnetic field. Therefore, one could hold the current loop in different orientations in the region of the expected magnetic field and see if there is a torque on the loop.

2 Serway C19.22

a) Like poles of magnets exert a repulsive force on each other. If this force is greater than the force due to gravity on the upper magnet, the upper magnet will levitate. b) The pencil makes sure the magnets are vertically aligned. As can be seen from figure 19.30, the magnetic field has a sideways component away from the center, so the slightest movement off center would ruin the vertical alignment. c) Since like poles repel and these magnets are repelling each other, we know that either the north poles of the magnets are facing each other or the south poles of the magnets are facing each other. We cannot tell which case it is, as both cases could create this picture. d) If the upper magnet were inverted, the opposite poles of the two magnets would be facing each other. Since opposite poles attract, the magnets would attract, sitting one on top of the other.

1B Week 7 HW

22.

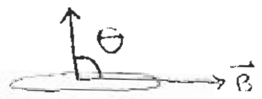


$\tau = BIAN \sin\Theta$

Area of current loop ← A

Number of current loops ← N

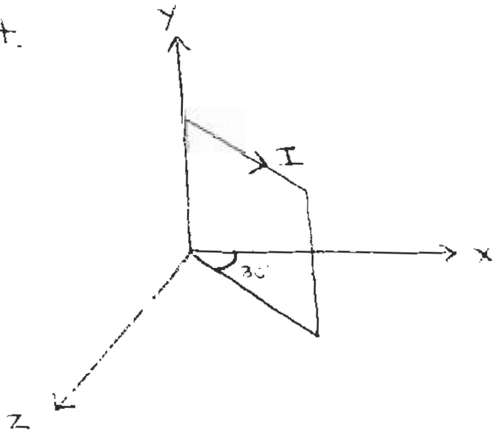
Θ → angle between magnetic field and line perpendicular to current loop

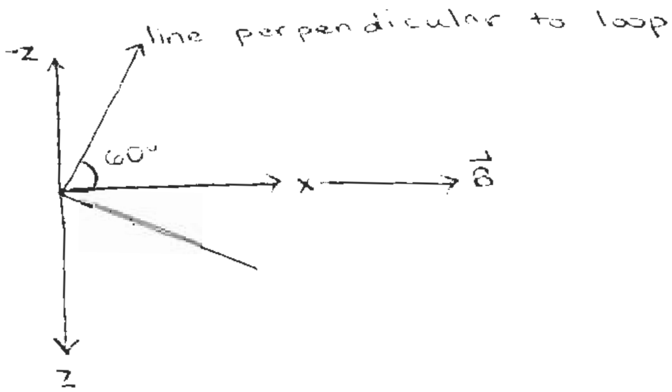


$\tau = (0.800\ T)(1.70\times10^{-2}\ A)\left[\pi\left(\frac{2.00\ m}{2\pi}\right)^2\right](1)\sin 90°$

$\boxed{\tau = 4.33\times10^{-3}\ N\cdot m}$

24.





$\tau = BIAN\sin\Theta$

$= (0.80\ T)(1.2\ A)[(0.40\ m)(0.30\ m)](100)\sin 60°$

$\boxed{\tau = 10\ N\cdot m}$

Loop will rotate to align bottom with +z axis.

1B Week 7 HW

29. Using the right hand rule, we see that positive charges moving as shown in the picture will feel a magnetic force upward and electric force downward.

$$F_{mag} = qvB\sin\theta \qquad \text{(from picture } \theta = 90^\circ\text{)}$$

$$F_{elec} = qE$$

For particles to go through undeflected, the net force on the particle must be zero.

$$\sum F = qvB\sin\theta - qE$$
$$= m\cancel{a}^{0}$$
$$= 0$$

$$qvB\sin\theta = qE$$

$$\boxed{v = \frac{E}{B}} \qquad (\theta = 90^\circ)$$

Particles with velocity greater than E/B will be deflected upwards ($F_{mag} > F_{elec}$), those with velocity less than E/B will be deflected downwards ($F_{mag} < F_{elec}$).

1B Week 7 HW

30. From problem 29, we know undeflected particles have $v = E/B$. When the particle enters the uniform magnetic field of the deflection chamber, it moves in a circular orbit.

$$F_{mag} = ma_{centripetal}$$

$$= \frac{mv^2}{r}$$

$$F_{mag} = qvB \sin\theta \qquad (\theta = 90°)$$

$$qvB = \frac{mv^2}{r}$$

$$r = \frac{mv}{qB} \qquad \text{where } v = E/B$$

$$= \frac{mE}{qB^2}$$

$$= \frac{(2.18\times10^{-26}\ \text{kg})(950\ \text{V/m})}{(1.60\times10^{-19}\ \text{C})(0.930\ \text{T})^2}$$

note: for a singly charged ion, $q = e$

$$\boxed{r = 1.50\times10^{-4}\ \text{m}}$$

1B Week 7 HW

37. The magnetic field a distance r from a long, straight wire:

$$B = \frac{\mu_0 I}{2\pi r}$$

$$r = \frac{\mu_0 I}{2\pi B}$$

$$= \frac{(4\pi \times 10^{-7}\ T\cdot m/A)(20\ A)}{2\pi(1.7\times10^{-3}\ T)}$$

$$\boxed{r = 2.4\times10^{-3}\ m}$$

38. Magnetic fields obey superposition, so to find B at any point we must consider contributions from both wires: $\vec{B}_{tot} = \vec{B}_{left} + \vec{B}_{right}$

a) Midway btwn wires (5.0 cm from both wires)
Using rhr #2, we see both wires create fields into page. Therefore, we add their magnitudes:

$$B_{tot} = \frac{\mu_0 I_{left}}{2\pi(5.0\times10^{-2}\ m)} + \frac{\mu_0 I_{right}}{2\pi(5.0\times10^{-2}\ m)} = \underline{4.0\times10^{-5}\ T}$$

b) At P_1, $r_{left} = 20.0\text{cm}$ & $r_{right} = 10.0\text{cm}$. Using rhr #2, $\vec{B}_{right}$ points out of page, $\vec{B}_{left}$ points into page. Letting out of page be the $+\hat{x}$ direction (into page $-\hat{x}$ dir)

$$\vec{B}_{tot} = \vec{B}_{left} + \vec{B}_{right} = \frac{(4\pi\times10^{-7}\ T\cdot m/A)(5.00\ A)}{2\pi(20.0\times10^{-2}\ m)}(-\hat{x}) + \frac{(4\pi\times10^{-7}\ T\cdot m/A)(5.00\ A)}{2\pi(10.0\times10^{-2}\ m)}(\hat{x})$$

$$\boxed{\vec{B}_{tot} = 0.5\times10^{-5}\ T\ \hat{x}\ \text{(out of page)}}$$

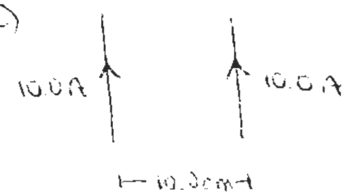
c) Left: $r_{left} = 20.0\text{cm}$, $\vec{B}_{left}$ out of pg. Right: $r_{right} = 30.0\text{cm}$, $\vec{B}_{right}$ into pg.

$$\vec{B}_{tot} = \vec{B}_{left} + \vec{B}_{right} = \frac{(4\pi\times10^{-7}\ T\cdot m/A)(5.00\ A)}{2\pi(20.0\times10^{-2}\ m)}(\hat{x}) + \frac{(4\pi\times10^{-7}\ T\cdot m/A)(5.00\ A)}{2\pi(30.0\times10^{-2}\ m)}(-\hat{x})$$

$$\boxed{\vec{B}_{tot} = 0.167\times10^{-5}\ T\ \hat{x}\ \text{(out of pg.)}}$$

1B Week 7 HW

44. a)



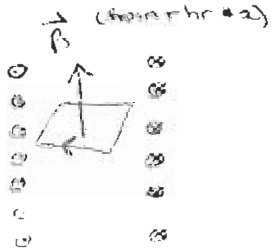
$$\frac{F}{l} = \frac{\mu_0 I_1 I_2}{2\pi d}$$

$$= \frac{(4\pi \times 10^{-7}\ T\cdot m/A)(10.0A)(10.0A)}{2\pi(10.0 \times 10^{-2}\ m)}$$

$$\boxed{\frac{F}{l} = 2.00 \times 10^{-4}\ N/m}$$ currents in same direction attract

b) Currents in opposite direction repel. F/l is the same as in (a).

49. First we find the $\vec{B}$ due to the solenoid



$$B = \mu_0 \underbrace{n}_{\text{turns per unit length}} I$$

$$= (4\pi \times 10^{-7}\ T\cdot m/A)(30/10^{-2}\ m)(15.0\ A)$$

$$= 5.65 \times 10^{-2}\ T$$

• Force on each side of loop

$$F = BIl\sin\theta \qquad (\theta = 90°)$$

$$= (5.65 \times 10^{-2}\ T)(0.200\ A)(2.00 \times 10^{-2}\ m)$$

$$\boxed{F = 2.26 \times 10^{-4}\ N}$$ using the rHr, we see force is towards center of loop

• Torque acting on loop is zero because line perpendicular to loop is parallel to $\vec{B}$.

1B Week 7 HW

58. a) $\frac{F}{l} = \frac{\mu_0 I_1 I_2}{2\pi d}$

$= \frac{(4\pi \times 10^{-7}\ \mathrm{T \cdot m/A})(140\ \mathrm{A})(140\ \mathrm{A})}{2\pi(1.00 \times 10^{-3}\ \mathrm{m})}$

$= 3.92\ \mathrm{N/m}$

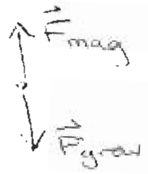
$l = 2\pi r$

$= 2\pi(10.0 \times 10^{-2}\ \mathrm{m})$

$= 0.628\ \mathrm{m}$

$\boxed{F = 2.46\ \mathrm{N}}$ rhr #2 shows force on top loop is up

b)



$\sum F = ma$

$= F_{mag} - F_{grav}$

$= F_{mag} - mg$

$= 2.46\ \mathrm{N} - (0.0210\ \mathrm{kg})(9.80\ \mathrm{m/s^2})$

$= 2.25\ \mathrm{N}$

$a = \frac{F}{m}$

$= \frac{2.25\ \mathrm{N}}{0.0210\ \mathrm{kg}}$

$\boxed{a = 107\ \mathrm{m/s^2}}$