Magnetic Field

21. V A wire carries a steady current of 2.40 A. A straight section of the wire is 0.750 m long and lies along the x axis within a uniform magnetic field, $\vec{\mathbf{B}} = 1.60\hat{\mathbf{k}}$ T. If the current is in the positive x direction, what is the magnetic force on the section of wire?

33. T A rectangular coil consists of $N = 100$ closely wrapped turns and has dimensions $a = 0.400$ m and $b = 0.300$ m. The coil is hinged along the y axis, and its plane makes an angle $\theta = 30.0°$ with the x axis (Fig. P28.33). (a) What is the magnitude of the torque exerted on the coil by a uniform magnetic field $B = 0.800$ T directed in the positive x direction when the current is $I = 1.20$ A in the direction shown? (b) What is the expected direction of rotation of the coil?

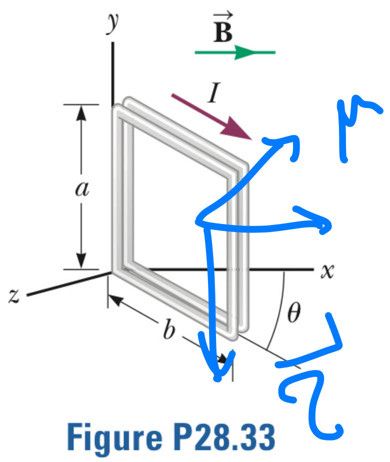


Figure P28.33

Hall Effect

47. BIO Q|C A heart surgeon monitors the flow rate of blood through an artery using an electromagnetic flowmeter (Fig. P28.47). Electrodes A and B make contact with the outer surface of the blood vessel, which has a diameter of 3.00 mm. (a) For a magnetic field magnitude of 0.040 0 T, an emf of 160 μV appears between the electrodes. Calculate the speed of the blood. (b) Explain why electrode A has to be positive as shown. (c) Does the sign of the emf depend on whether the mobile ions in the blood are predominantly positively or negatively charged? Explain.

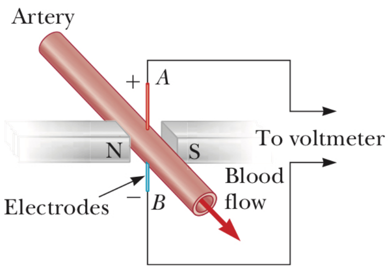


Figure P28.47

21. $F_B = I\,\vec{L} \times \vec{B} = -2.4\,(0.75 \times 1.6 \times \sin\frac{\pi}{2})\,\hat{j}$

$= -2.88\,\hat{j}$

33. $\vec{\tau} = N\,\vec{\mu} \times \vec{B}$

$= N\,I\vec{A} \times \vec{B}$

$= 100\,(1.2\,ab)\,0.8\,\sin(90^\circ - 30^\circ)$

$= 9.98\ (N \cdot m)$ #

47.

Hall Effect

Source of the Magnetic Field

5. **S** A long, straight wire carries a current I. A right-angle bend is made in the middle of the wire. The bend forms an arc of a circle of radius r as shown in Figure P29.5. Determine the magnetic field at point P, the center of the arc.

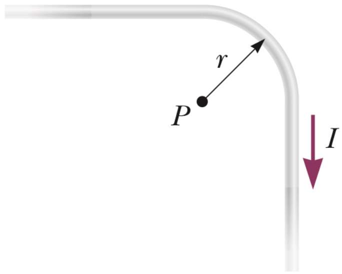


Figure P29.5

Solenoid and Gauss's Law

29. **V** A solenoid of radius $r = 1.25$ cm and length $\ell = 30.0$ cm has 300 turns and carries 12.0 A. (a) Calculate the flux through the surface of a disk-shaped area of radius $R = 5.00$ cm that is positioned perpendicular to and centered on the axis of the solenoid as shown in Figure P29.29a. (b) Figure P29.29b shows an enlarged end view of the same solenoid. Calculate the flux through the tan area, which is an annulus with an inner radius of $a = 0.400$ cm and an outer radius of $b = 0.800$ cm.

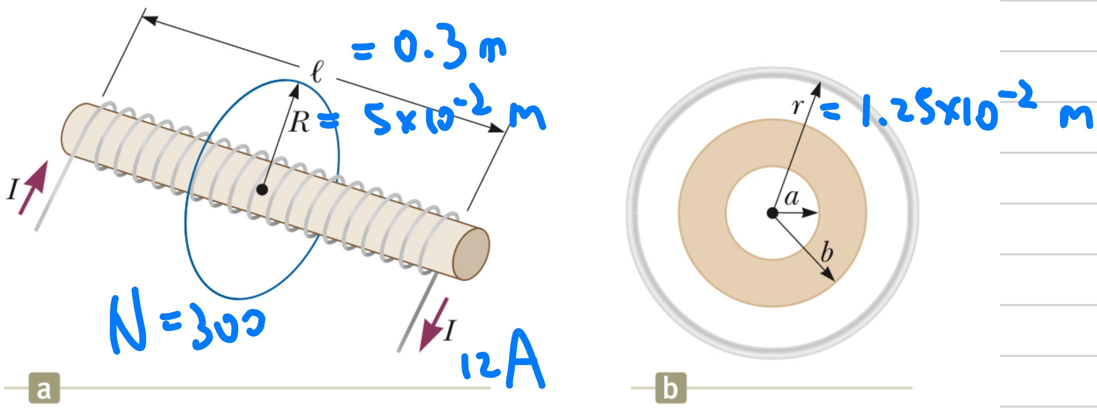
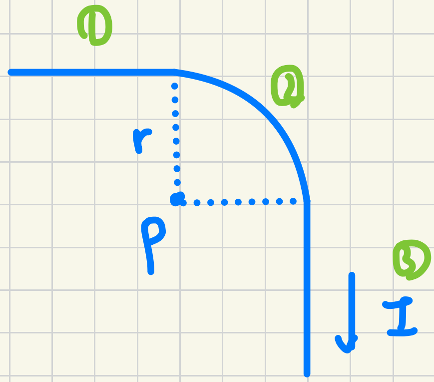


Figure P29.29

3.



①, ③ :

$$B = \frac{\mu_0 I}{4\pi} \int_{\theta=-\frac{\pi}{2}}^{\theta=0} \frac{dx \sin\theta}{(r/\cos\theta)^2}\hat{k}$$

$x = -r\tan\theta$

$\Rightarrow dx = -r\sec^2\theta\, d\theta$

$$= \frac{\mu_0 I}{4\pi} \int_{-\frac{\pi}{2}}^{0} \frac{-r\cancel{\sec^2\theta}\sin\theta}{(r/\cancel{\cos\theta})^2}\hat{k}$$

$$= \frac{\mu_0 I}{4\pi r}\left[\cos\theta\right]_{-\pi/2}^{0}\hat{k} = \frac{\mu_0 I}{4\pi r}\hat{k}$$

② : $dl = r\,d\theta$

$$B = \frac{\mu_0 I}{4\pi} \int_{\theta=0}^{\theta=\frac{\pi}{2}} \frac{d\vec{l} \times \hat{r}}{r^2}$$

$dl = r\,d\theta$

$$= \frac{\mu_0 I}{4\pi r}\left[\theta\right]_{0}^{\frac{\pi}{2}}\hat{k}$$

$$= \frac{\mu_0 I}{8r}\hat{k}$$

$$\Rightarrow B_{total} = \left(\frac{\mu_0 I}{2\pi r} + \frac{\mu_0 I}{8r}\right)\hat{k} \quad \#$$

29.

$$B = \mu_0 n I = (4\pi \times 10^{-7})\left(\frac{300}{0.3}\right)(12)$$
$$= 0.015\ (T)$$

(a) $$\phi_B = BA = (0.015)\,\pi\,(1.25\times10^{-2})^2$$
$$= 7.36\times10^{-6}\ (Wb)\ \#$$

(b) $$\phi_B = BA$$
$$= 0.015\left[\pi\left[(0.8\times10^{-2})^2 - (0.4\times10^{-2})^2\right]\right]$$
$$= 2.26\times10^{-6}\ (Wb)$$