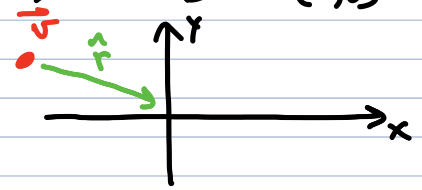
example A proton is moving with $\vec{v} = 3.6\cdot10^{7}\ m/s\,(\hat{\imath})$ along the line $y = +0.30\,\mu m$.

a) Find $\vec{B}$ @ (0,0) when proton's at $x = -0.40\,\mu m$



$$\vec{r} = 0.40\,\mu m\,\hat{\imath} - 0.30\,\mu m\,\hat{\jmath}$$

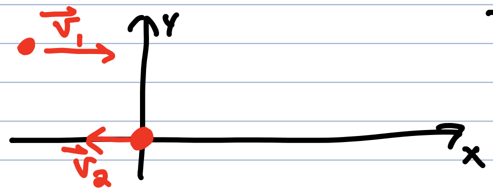
$$r = \sqrt{(0.40\,\mu m)^2 + (-0.30\,\mu m)^2} = 0.5\,\mu m$$

$$\hat{r} = \frac{\vec{r}}{r} = 0.8\hat{\imath} - 0.6\hat{\jmath}$$

$$\vec{v}\times\hat{r} = v[\hat{\imath}\times(0.8\hat{\imath} - 0.6\hat{\jmath})] = v(-0.6\hat{k})$$

$$\vec{B} = \frac{\mu_0}{4\pi}\,\frac{q\,\vec{v}\times\hat{r}}{r^2} = \left(\frac{4\pi\cdot10^{-7}}{4\pi}\,\frac{T\cdot m}{A}\right)\frac{(1.6\cdot10^{-19}C)(3.6\cdot10^{7}\,m/s)(0.6)(-\hat{k})}{(0.5\,\mu m)^2} = 1.4\cdot10^{-6}\,T(-\hat{k})$$

b) What is the B force on another proton at (0,0) if it were moving with $v = 3.6\cdot10^{7}\ m/s\,(-\hat{\imath})$?



$$\vec{F}_{1on2} = q_2(\vec{v}_2\times\vec{B}_1) = q_2 v_2 B_1(-\hat{\imath}\times-\hat{k})$$

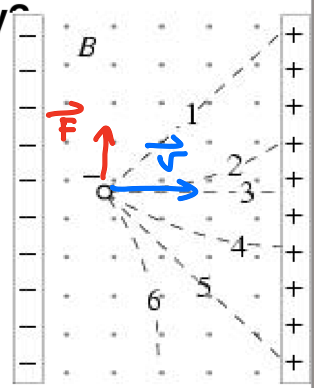
$$= q_2 v_2 B_1(-\hat{\jmath})$$

$$= (1.6\cdot10^{-19}C)(3.6\cdot10^{7}\,m/s)(1.4\cdot10^{-6}\,T)(-\hat{\jmath})$$

$$= 8.0\cdot10^{-18}\,N(-\hat{\jmath})$$

A negatively-charged particle is released from rest between the plates of a capacitor under the combined influence of a magnetic field and the electric field in the capacitor. Which path best represents the particle trajectory?

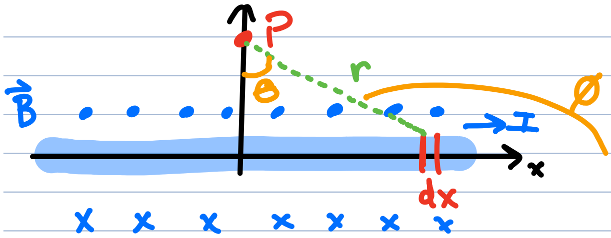
ConceptQ #1 ch 12



a) 1
b) 2
c) 3
d) 4
e) 5
f) 6
g) the particle remains at rest
h) the particle moves out of the plane of drawing

$q\vec{v}\times\vec{B}$ gets stronger over time since particle accelerates in the E field

Example B field of a thin, straight current-carrying conductor



$$dB = \frac{\mu_0}{4\pi} I \frac{dx}{r^2} \sin\phi$$ note: $\theta = \phi - \pi/2$

$$= \frac{\mu_0}{4\pi} I \frac{dx}{r^2} \cos\theta$$

$$x = y\tan\theta \qquad dx = y\sec^2\theta\, d\theta = \frac{y\, r^2}{y^2} d\theta = \frac{r^2 d\theta}{y}$$

$$\rightarrow dB = \frac{\mu_0 I}{4\pi}\frac{1}{r^2}\frac{r^2 d\theta}{y}\cos\theta = \frac{\mu_0 I}{4\pi}\frac{\cos\theta\, d\theta}{y}$$

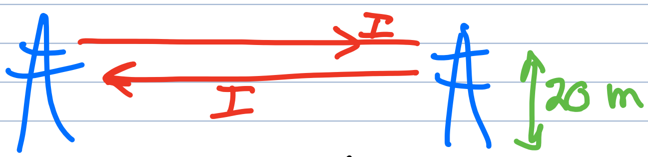
$$B = \int dB = \int_{-\theta_2}^{+\theta_1} \frac{\mu_0 I}{4\pi y}\cos\theta\, d\theta = \frac{\mu_0 I}{4\pi y}\int_{-\theta_2}^{+\theta_1}\cos\theta\, d\theta$$

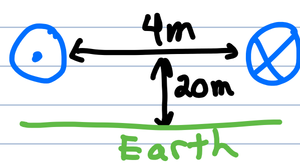
$$= \frac{\mu_0 I}{4\pi y}(\sin\theta_1 + \sin\theta_2) \xrightarrow{\theta_1 \,\&\, \theta_2 \to \pi/2} \frac{\mu_0 I}{2\pi y} = B$$

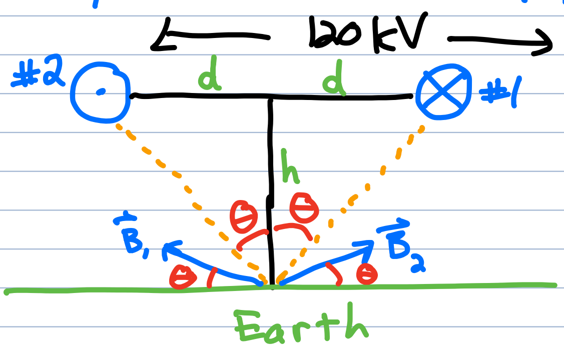
For comparison $E(r) = \frac{1}{2\pi\epsilon_0}\frac{\lambda}{r}$

We discussed s4.html in ch12 slides

Application 2 high voltage power lines 20 m above ground, 4 m apart and 120 kV produces 200 A current. What is $\vec{B}$ at the ground, beneath the wires?





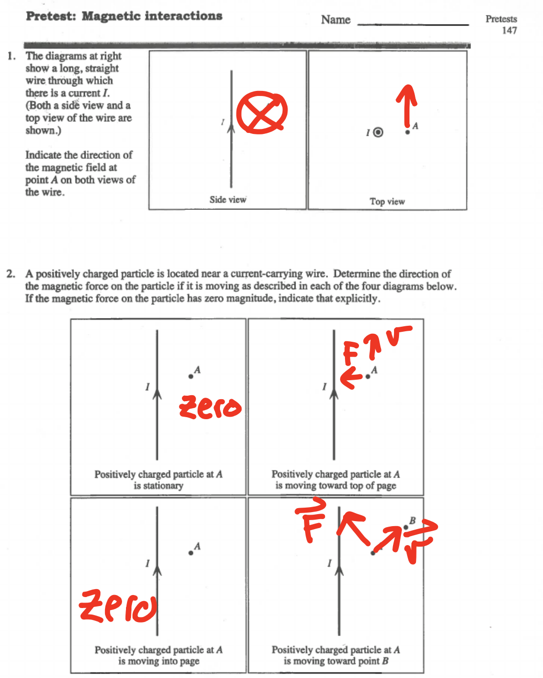


$$|\vec{B}_1| = |\vec{B}_2| = \frac{\mu_0 I}{2\pi r} = \frac{\mu_0 I}{2\pi\sqrt{h^2+d^2}}$$

x-direction $B_{1x} = -B_{2x} \rightarrow \sum B_x = 0$

y-direction $B_{1y} = B_{2y} \rightarrow \sum B_y = 2\,\frac{\mu_0 I}{2\pi\sqrt{h^2+d^2}}\sin\theta$

$$= \frac{2\mu_0 I}{2\pi\sqrt{h^2+d^2}}\,\frac{d}{\sqrt{h^2+d^2}} = 0.4\,\mu T$$


Pretest: Magnetic interactions Name ____________ Pretests 147

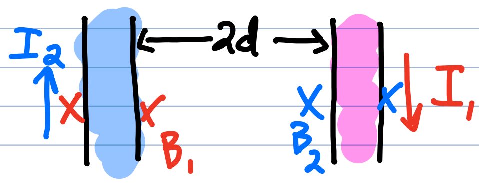
1. The diagrams at right show a long, straight wire through which there is a current *I*. (Both a side view and a top view of the wire are shown.)

Indicate the direction of the magnetic field at point *A* on both views of the wire.

2. A positively charged particle is located near a current-carrying wire. Determine the direction of the magnetic force on the particle if it is moving as described in each of the four diagrams below. If the magnetic force on the particle has zero magnitude, indicate that explicitly.

ch 12 tutorial

Follow-up to power line problem - what is the B force between the wires?



$B_{2\,\text{at wire 1}} = \frac{\mu_0 I_2}{2\pi(2d)}$ into page

$B_{1\,\text{at wire 2}} = \frac{\mu_0 I_1}{2\pi(2d)}$ into page