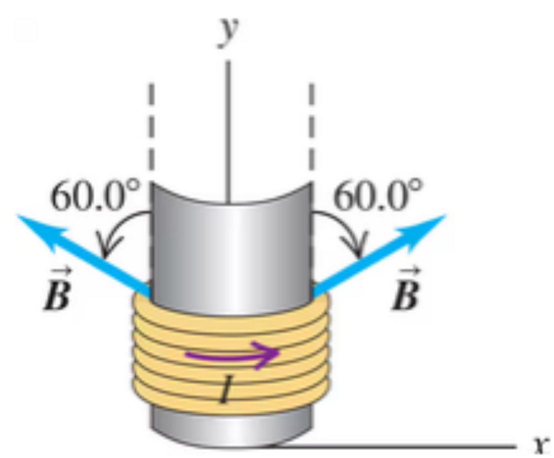
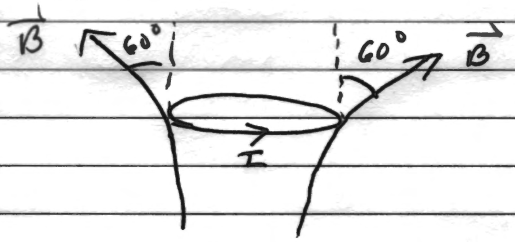
27.69 •• CALC **A Voice Coil.** It was shown in Section 27.7 that the net force on a current loop in a *uniform* magnetic field is zero. The magnetic force on the voice coil of a loudspeaker (see Fig. 27.28) is nonzero because the magnetic field at the coil is not uniform. A voice coil in a loudspeaker has 50 turns of wire and a diameter of 1.56 cm, and the current in the coil is 0.950 A. Assume that the magnetic field at each point of the coil has a constant magnitude of 0.220 T and is directed at an angle of 60.0° outward from the normal to the plane of the coil (Fig. P27.69). Let the axis of the coil be in the *y*-direction. The current in the coil is in the direction shown (counterclockwise as viewed from a point above the coil on the *y*-axis). Calculate the magnitude and direction of the net magnetic force on the coil.

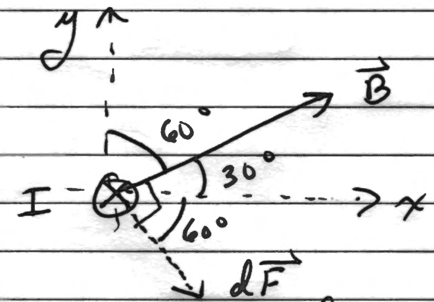
Figure P27.69



Ch. 27 #73 Voice Coil (27.69 in 15th edition)



Consider one small segment of the coil on the right, where the current is heading into the page $I \otimes \nearrow \vec{B}$ and use $d\vec{F} = I\,d\vec{l} \times \vec{B}$



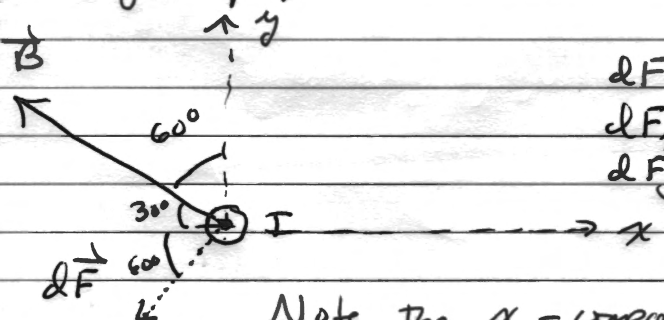
$dF = I\,dl\,B$

Break into components:

$dF_x = I\,dl\,B\cos 60°$

$dF_y = I\,dl\,B\sin(-60°)$.

Similarly, look on the left where the current is coming out of the page



$dF = I\,dl\,B$

$dF_x = -I\,dl\,B\cos 60°$

$dF_y = I\,dl\,B\sin(-60°)$

Note the x-components cancel. They y-components are always negative.

Then $\vec{F} = \left[\int_{loop} (I\,d\vec{l} \times \vec{B})_y \right] \times 50$ ← because there are 50 loops.

$F_y = 50 \int_{loop} I\,dl\,B\sin(-60°) = 50 \cdot I\,B\sin(-60°) \int_{loop} dl$

$F_y = 50\,I\,B\sin(-60°)(\pi d)$, where d = diameter of the loop.

Given $I = 0.950\,A$, $B = 0.220\,T$, $d = 1.56\,cm = 0.0156\,m$,

$F_y = 0.512\,N \sin(-60°) = \boxed{-0.444\,N}$

since $F_x = 0$, $\boxed{\vec{F} = -0.444N\,\hat{j}}$