MAGNETIZATION, BOUND CURRENTS AND H
A solid cylinder has uniform magnetization $\mathbf{M}$ throughout the volume in the x direction as shown. What's the magnitude of the total magnetic dipole moment of the cylinder?

A) $\pi R^2 L \mathbf{M}$  
B) $2\pi R L \mathbf{M}$  
C) $2\pi R \mathbf{M}$  
D) $\pi R^2 \mathbf{M}$  
E) Something else/it’s complicated!
A solid cylinder has uniform magnetization $\mathbf{M}$ throughout the volume in the $z$ direction as shown. Where do bound currents show up?

A) Everywhere: throughout the volume and on all surfaces
B) Volume only, not surface
C) Top/bottom surface only
D) Side (rounded) surface only
E) All surfaces, but not volume
A solid cylinder has uniform magnetization \( \mathbf{M} \) throughout the volume in the \( x \) direction as shown. Where do bound currents show up?

A) Top/bottom surface only  
B) Side (rounded) surface only  
C) Everywhere  
D) Top/bottom, and parts of (but not all of) side surface (but not in the volume)  
E) Something different/other combination!
A solid cylinder has uniform magnetization \( \mathbf{M} \) throughout the volume in the \( \varphi \) direction as shown. In which direction does the bound surface current flow on the (curved) sides?

A. There is no bound surface current.
B. The current flows in the \( \pm \varphi \) direction.
C. The current flows in the \( \pm s \) direction.
D. The current flows in the \( \pm z \) direction.
E. The direction is more complicated than the answers B, C, or D.
A sphere has uniform magnetization $M$ in the $z$ direction.

Which formula is correct for this surface current?

A) $M \sin \theta \hat{\theta}$
B) $M \sin \theta \hat{\phi}$
C) $M \cos \theta \hat{\theta}$
D) $M \cos \theta \hat{\phi}$
E) None of these!
(after discussing linear and non-linear media)
A very long aluminum (paramagnetic!) rod carries a uniformly distributed current $I$ along the $+z$ direction.

What is the direction of the bound volume current?

A) $\mathbf{J}_B$ points parallel to $I$
B) $\mathbf{J}_B$ points anti-parallel to $I$
C) It’s zero!
D) Other/not sure
A very long aluminum (paramagnetic!) rod carries a uniformly distributed current I along the +z direction. We know B will be CCW as viewed from above.

What about H and M inside the cylinder?

A) Both are CCW
B) Both are CW
C) H is CCW, but M is CW
D) H is CW, M is CCW
E) ???
A very long aluminum (paramagnetic!) rod carries a uniformly distributed current I along the +z direction. What is the direction of the bound volume current?

A) $\mathbf{J}_B$ points parallel to I
B) $\mathbf{J}_B$ points anti-parallel to I
C) It’s zero!
D) Other/not sure
6.9 A very long aluminum (paramagnetic!) rod carries a uniformly distributed current I along the +z direction. What is the direction of the bound surface current?

A) $K_B$ points parallel to I
B) $K_B$ points anti-parallel to I
C) $K_B$ wraps around the surface
D) Other/not sure
6.8

What if that long rod (the wire) was made of copper (diamagnetic!) instead. Of $B$, $M$, $H$, and $J_b$, which ones “flip sign”? Of $B$, $M$, $H$, and $J_b$, which ones “flip sign”?

The “para” case

The “dia” case
Inside a hollow solenoid, \( B = B_0 = \mu_0 nl \).

What is the formula for \( H \) inside?
Inside a hollow solenoid, 
\[ B = B_0 = \mu_0 nI, \quad (\text{so } H = H_0 = nI) \]

If the solenoid is filled with a normal paramagnetic material, like aluminum, what is \( B \) inside?

A) Still exactly \( B_0 \)
B) a little more than \( B_0 \)
C) a lot more
D) a little less than \( B_0 \)
E) a lot less than \( B_0 \)
Inside a hollow solenoid, \( B = B_0 = \mu_0 n I \), (so \( H = H_0 = n I \) )
If the solenoid is filled with iron, what is \( H \) inside?...

A) \( H_0 \)
B) a little more than \( H_0 \)
C) a lot more
D) a little less than \( H_0 \)
E) a lot less than \( H_0 \)
A very long rod carries a uniformly distributed current $I$ along the $+z$ direction. Compare the B-field OUTSIDE when the rod is a paramagnet (e.g. Al) to the B-field outside when the rod is a diamagnet (e.g. Cu).

B outside the paramagnetic rod is …
A) Slightly smaller than…
B) The same as…
C) Slightly larger than…
B outside the diamagnetic rod
A very long rod carries a uniformly distributed current $I$ along the $+z$ direction.

Compare the B-field right outside with B right inside (assume essentially the same distance to the axis) when the rod is made from a diamagnetic material.

B right outside the diamagnetic rod is ...
A) Slightly smaller than...
B) The same as...
C) Slightly larger than...
B right inside the same rod
A large chunk of paramagnetic material ($\chi_m > 0$) has a uniform field $B_0$ throughout its bulk, and thus a uniform $H_0 = ??$
6.10 A large chunk of paramagnetic material ($\chi_m > 0$) has a uniform field $B_0$ throughout its bulk, and thus a uniform $H_0 = B_0/\mu = B_0 / \mu_0 (1 + \chi_M)$.

We then cut out a cylindrical hole (very skinny, very tall!)

What is $M$ at the center of that hole?

A) $\chi_M H_0$
B) little more than $\chi_M H_0$
C) Little less than $\chi_M H_0$ but not zero
D) Zero
A large chunk of paramagnetic material ($\chi_m > 0$) has a uniform field $B_0$ throughout its interior. We cut out a cylindrical hole (very skinny, very tall!)

What is $B$ at the center of that hole?

A) $B_0$
B) more than $B_0$
C) less than $B_0$ but not zero
D) zero
A large chunk of paramagnetic material ($\chi_m > 0$) has a uniform field $B_0$ throughout its interior. We cut out a wafer-like hole (very wide, very short!)

What is $B$ at the center of that hole?

A) $B_0$
B) more than $B_0$
C) less than $B_0$ but not zero
D) zero
A sphere (with a spherical cavity inside it) is made of a material with very large positive $\chi_m$. It is placed in a region of uniform B field. Which figure best shows the resulting B field lines?

A) None of these can be even remotely correct

B) 

C) 

D) 

E) None of these can be even remotely correct
Mu-metal (75% nickel, 15% iron, plus copper and molybdenum) acts as a sort of “magnetic shield”...
(there is no perfect “Faraday cage” effect for magnetism - why not?)