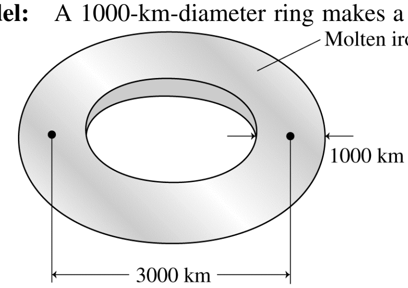
32.53. Model: A 1000-km-diameter ring makes a loop of diameter 3000 km.

Visualize:



Solve: **(a)** The current loop has a diameter of 3000 km, so its nominal area, ignoring curvature effects, is

$$A_{\text{loop}} = \pi r^2 = \pi(1500 \times 10^3 \text{ m})^2 = 7.07 \times 10^{12} \text{ m}^2$$

Because the magnetic dipole moment of the earth is modeled to be due to a current flowing in such a loop, $\mu = I A_{\text{loop}}$. The current in the loop is

$$I = \frac{\mu}{A_{\text{loop}}} = \frac{8.0 \times 10^{22} \text{ A m}^2}{7.07 \times 10^{12} \text{ m}^2} = 1.13 \times 10^{10} \text{ A}$$

(b) The current density J in the above loop is

$$J_{\text{loop}} = \frac{I}{A} = \frac{1.13 \times 10^{10} \text{ A}}{\pi\left(\frac{1}{2} \times 1000 \times 10^3 \text{ m}\right)^2} = 0.014 \text{ A / m}^2$$

(c) The current density in the wire is

$$J_{\text{wire}} = \frac{I}{A} = \frac{1.0 \text{ A}}{\pi\left(\frac{1}{2} \times 1.0 \times 10^{-3} \text{ m}\right)^2} = 1.3 \times 10^6 \text{ A / m}^2$$

You can see that $J_{\text{loop}} << J_{\text{wire}}$. The current in the earth's core is large, but the current density is actually quite small.