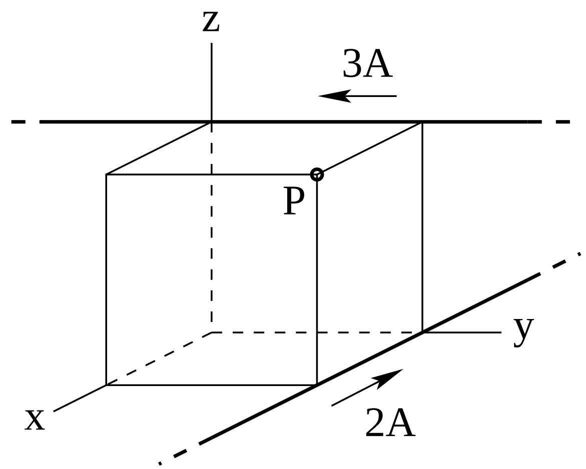
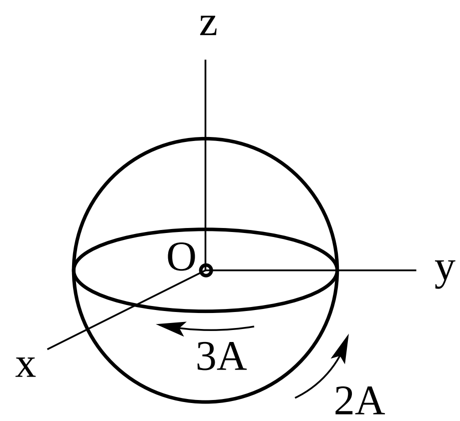
(a) Two very long straight wires carry currents as shown. A cube with edges of length 8cm serves as scaffold. Find the magnetic field at point P in the form $\mathbf{B} = B_x\hat{\mathbf{i}} + B_y\hat{\mathbf{j}} + B_z\hat{\mathbf{k}}$ with B_x, B_y, B_z in SI units.
(b) Two circular currents of radius 5cm, one in the xy-lane and the other in the yz-plane, carry currents as shown. Both circles are centered at point O. Find the magnetic field at point O in the form $\mathbf{B} = B_x\hat{\mathbf{i}} + B_y\hat{\mathbf{j}} + B_z\hat{\mathbf{k}}$ with B_x, B_y, B_z in SI units.



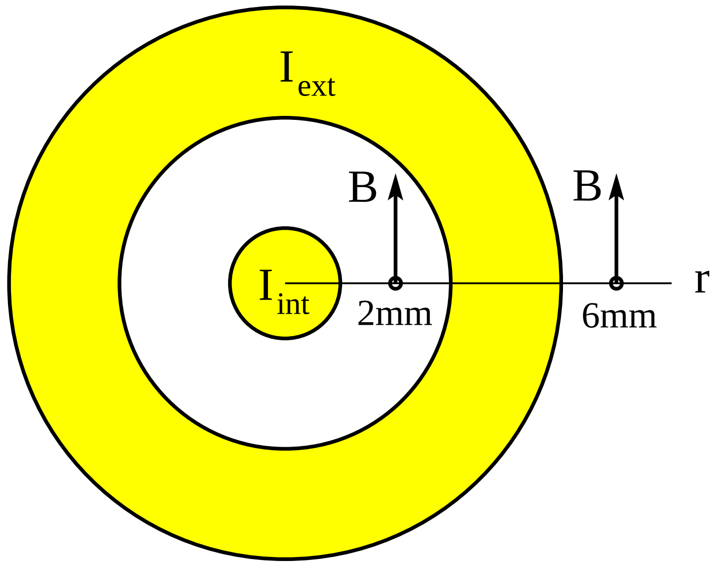


Solution:

(a) $B_x = 0, \quad B_y = \dfrac{\mu_0(2\mathrm{A})}{2\pi(0.08\mathrm{m})} = 5\mu\mathrm{T}, \quad B_z = \dfrac{\mu_0(3\mathrm{A})}{2\pi(0.08\mathrm{m})} = 7.5\mu\mathrm{T}.$

(b) $B_x = \dfrac{\mu_0(2\mathrm{A})}{2(0.05\mathrm{m})} = 25.1\mu\mathrm{T}, \quad B_y = 0, \quad B_z = -\dfrac{\mu_0(3\mathrm{A})}{2(0.05\mathrm{m})} = -37.7\mu\mathrm{T}.$

The coaxial cable shown has surfaces at radii 1mm, 3mm, and 5mm. The magnetic field is the same at radii 2mm and 6mm, namely $B = 7\mu$T in the direction shown.
(a) Find magnitude (in SI units) and direction (in/out) of the current $I_{\rm int}$ flowing through the inner conductor.
(b) Find magnitude (in SI units) and direction (in/out) of the current $I_{\rm ext}$ flowing through the outer conductor.

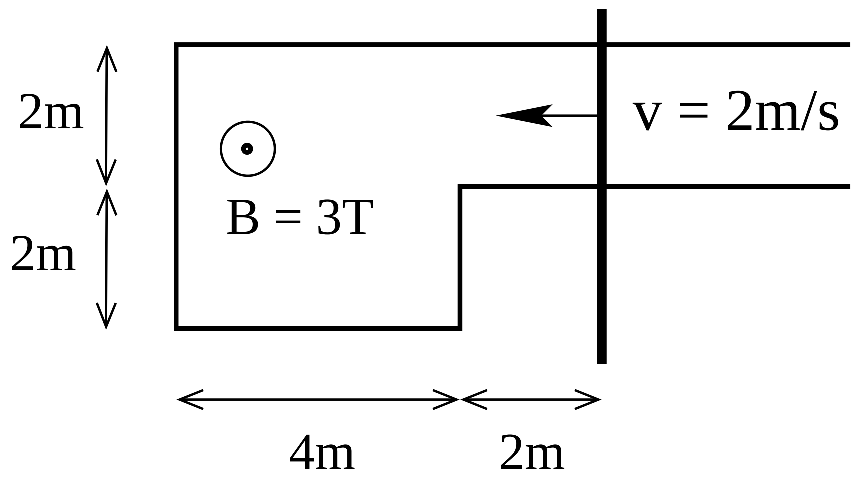


Solution:

(a) $(7\mu\text{T})(2\pi)(0.002\text{m}) = \mu_0 I_{\rm int} \quad \Rightarrow \; I_{\rm int} = 0.07\text{A}$ (out)

(b) $(7\mu\text{T})(2\pi)(0.006\text{m}) = \mu_0 (I_{\rm int} + I_{\rm ext}) \quad \Rightarrow \; I_{\rm int} + I_{\rm ext} = 0.21\text{A}$ (out)
$\Rightarrow \; I_{\rm ext} = 0.14\text{A}$ (out)

A conducting frame with a moving conducting rod is located in a uniform magnetic field as shown. The rod moves at constant velocity.
(a) Find the magnetic flux Φ_B through the frame and the induced emf $\mathcal{E}$ around the frame at the instant shown.
(b) Find the magnetic flux Φ_B through the frame and the induced emf $\mathcal{E}$ around the frame two seconds later.
Write magnitudes only (in SI units), no directions.



Solution:

(a) $\Phi_B = (20\text{m}^2)(3\text{T}) = 60\text{Wb}, \quad \mathcal{E} = (2\text{m/s})(3\text{T})(2\text{m}) = 12\text{V}.$

(b) $\Phi_B = (8\text{m}^2)(3\text{T}) = 24\text{Wb}, \quad \mathcal{E} = (2\text{m/s})(3\text{T})(4\text{m}) = 24\text{V}.$