Ampère's Law: Magnetic Field Inside a Wire

Consider a long, straight wire of radius R.
The current is I distributed uniformly over the cross section.

Apply Ampère's law, $\oint \vec{B} \cdot d\vec{\ell} = \mu_0 I_C$, to the circular loop of radius $r < R$.

- The symmetry dictates that the magnetic field $\vec{B}$ is directed tangentially with magnitude B depending on R only.
- Line integral: $\oint \vec{B} \cdot d\vec{\ell} = B(2\pi r)$.
- Fraction of current inside loop: $\dfrac{I_C}{I} = \dfrac{\pi r^2}{\pi R^2}$.
- Magnetic field at radius $r < R$: $B = \dfrac{\mu_0 I_C}{2\pi r} = \dfrac{\mu_0 I r}{2\pi R^2}$.
- B increases linearly with r from zero at the center.
- Magnetic field at the perimeter: $B = \dfrac{\mu_0 I}{2\pi R}$.