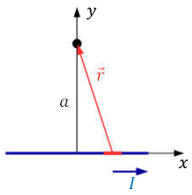
Sources of Magnetic Field

Currents produce magnetic fields.

$$\vec{B} = \frac{\mu_0}{4\pi}\frac{q\vec{v}\times\hat{r}}{r^2} \quad \Rightarrow \quad d\vec{B} = \frac{\mu_0}{4\pi}\frac{I\,d\vec{s}\times\hat{r}}{r^2}$$

Example: calculate the magnetic field at point *P* due to a thin straight wire of length *L* carrying a current *I*. (*P* is on the perpendicular bisector of the wire at distance *a*.)



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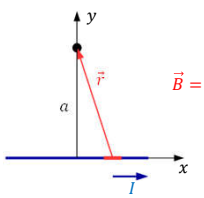

$$\vec{B} = \frac{\mu_0 IL}{4\pi a\sqrt{\frac{L^2}{4}+a^2}}\hat{k} = \frac{\mu_0 I}{2\pi a\sqrt{1+\frac{4a^2}{L^2}}}\hat{k}$$

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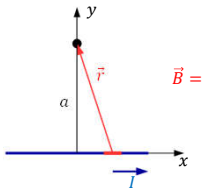

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For infinite wire:

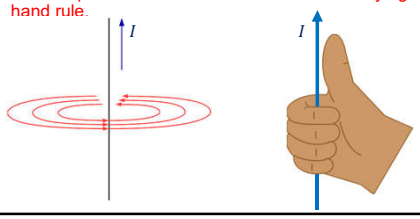
$$\vec{B} = \frac{\mu_0 I}{2\pi a}\hat{k}$$

Good approximation for field near long wire far from ends.

Magnetic Field Due to Long Straight Wire

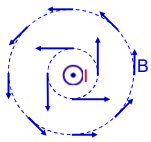
$$B = \frac{\mu_0 I}{2\pi r}$$

Field loops around wire in direction indicated by right hand rule.

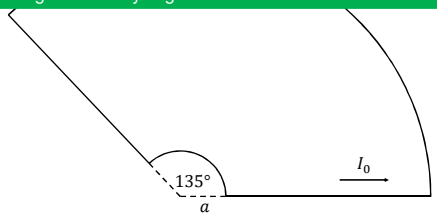


Magnetic Field Due to Long Straight Wire

- Field has constant magnitude along circles centered on wire.
- Field decreases with increased distance from wire.
- Field direction is tangent to circles centered on wire.



Example: A circuit consists of two wire arcs and two straight wires, as illustrated. The wires carry a current I_0. Determine the magnetic field at point P, at the center of curvature, due to the current. The radius of the small arc is a and the radius of the large arc is very large.



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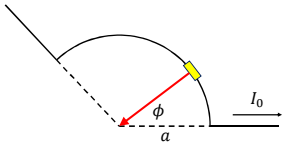

Example: An electric cord consists of two parallel wires separated by a distance d each carrying a current I_0 in opposite directions. Determine the force per length on each wire due to the other wire.