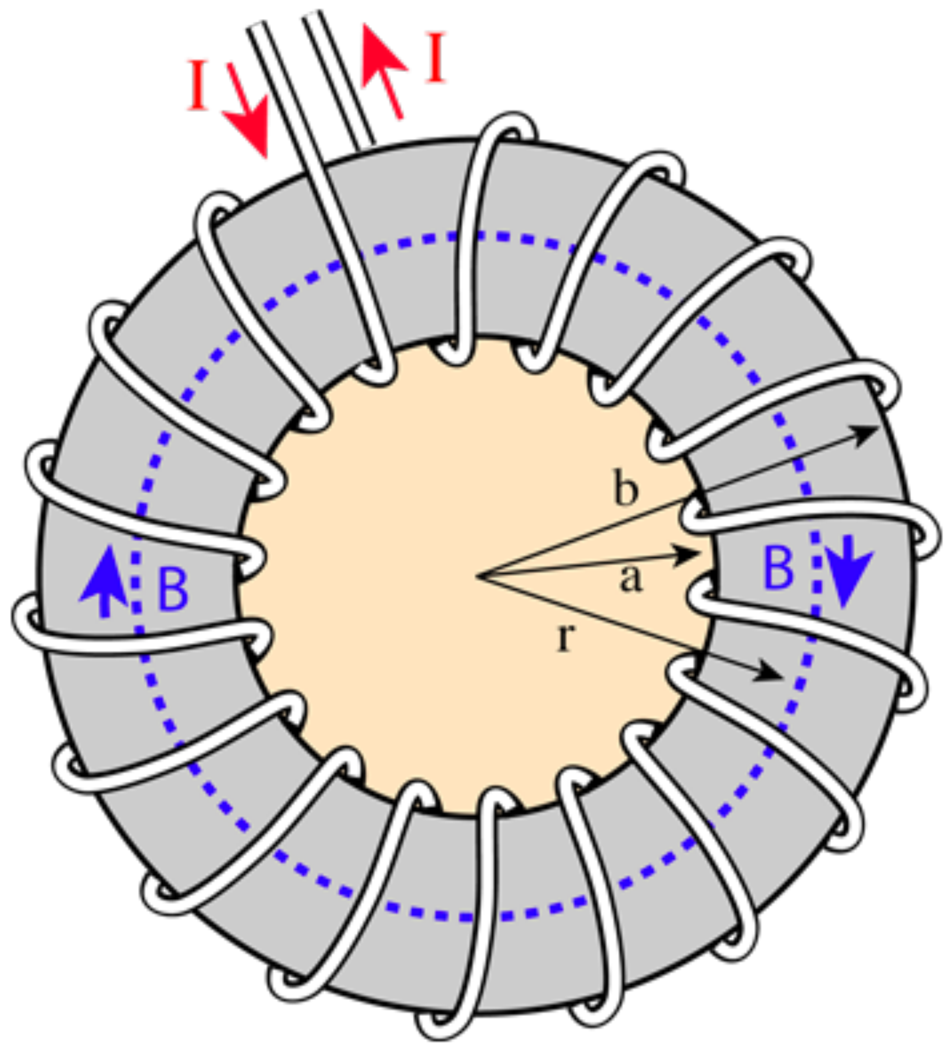
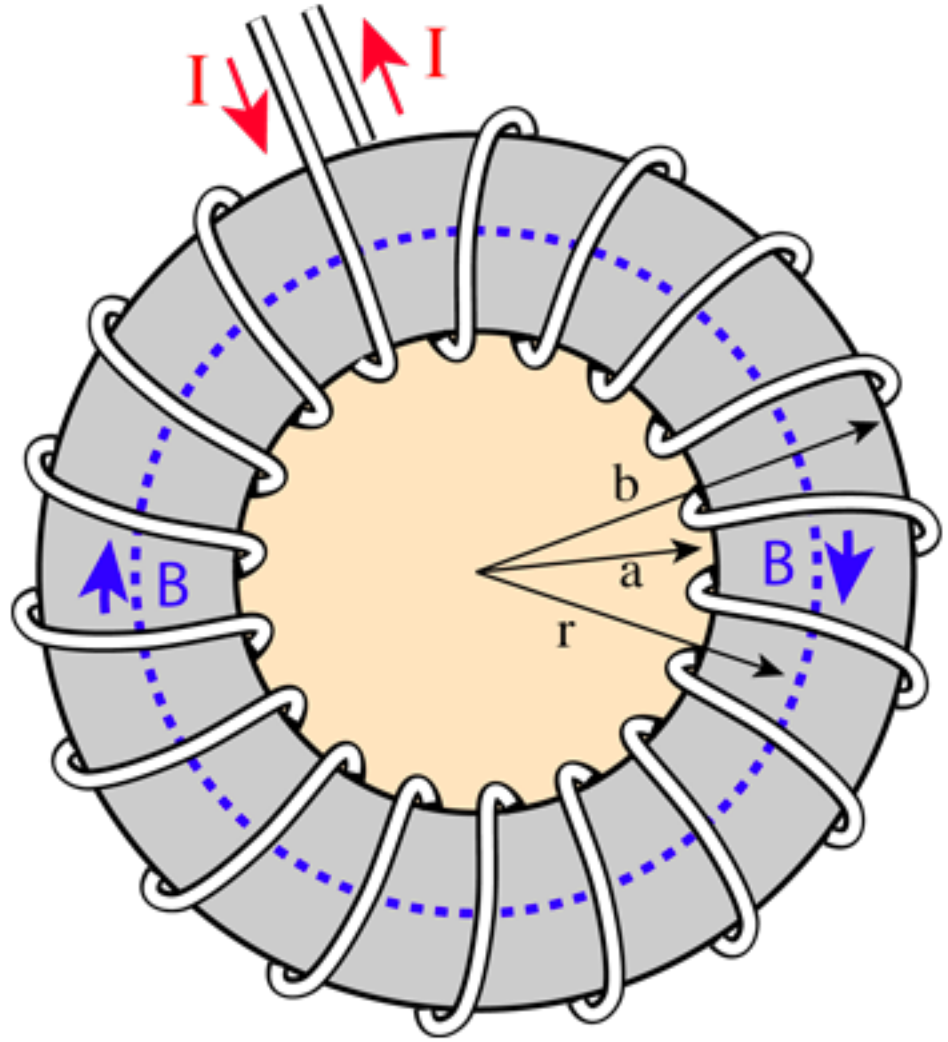
Toroidal Solenoid



$$\mu_0 I_{encl} = \oint \vec{B} \cdot d\vec{\ell}$$

I_{encl} = NI = Number of loops x current in the wire
B is constant in magnitude and tangent to the dotted amperian loop.

by symmetry

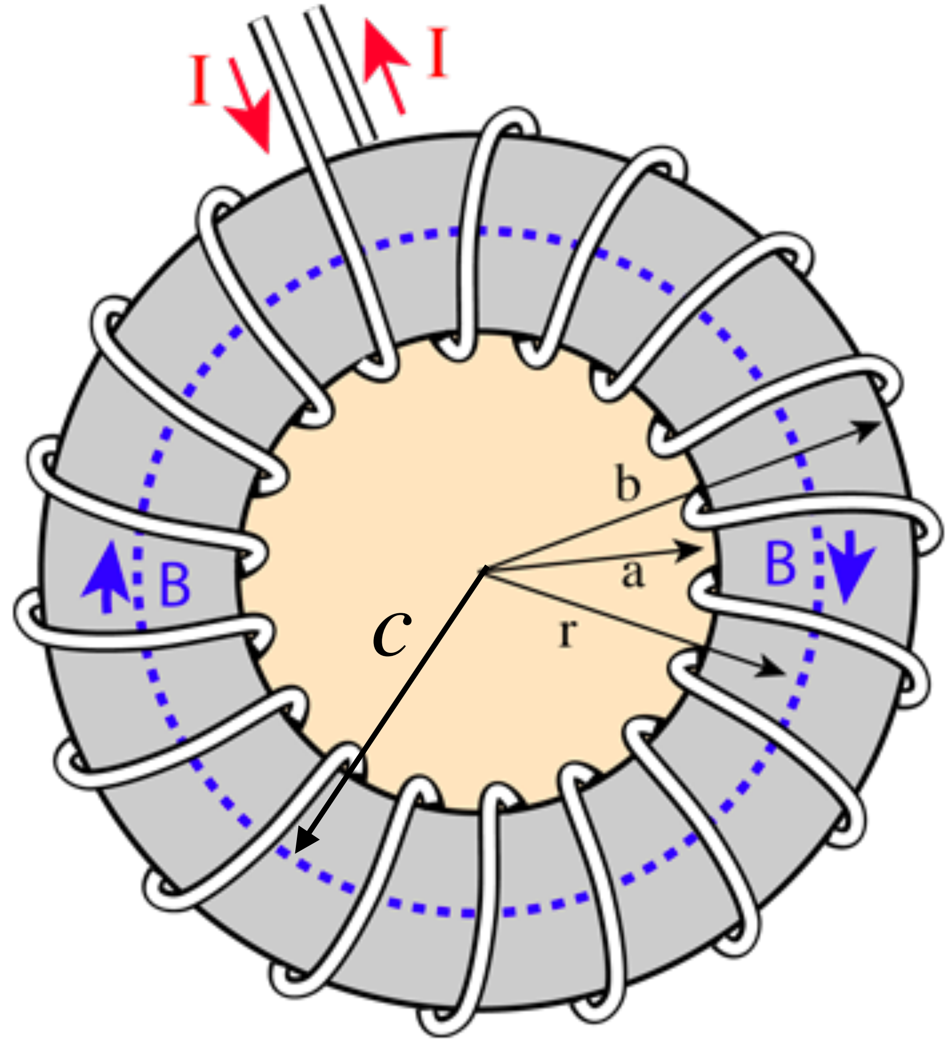


N loops

$$\mu_0 I_{encl} = \oint \vec{B} \cdot d\vec{\ell}$$

$$\mu_0 N I = B \oint d\ell = B(2\pi r)$$

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



N loops

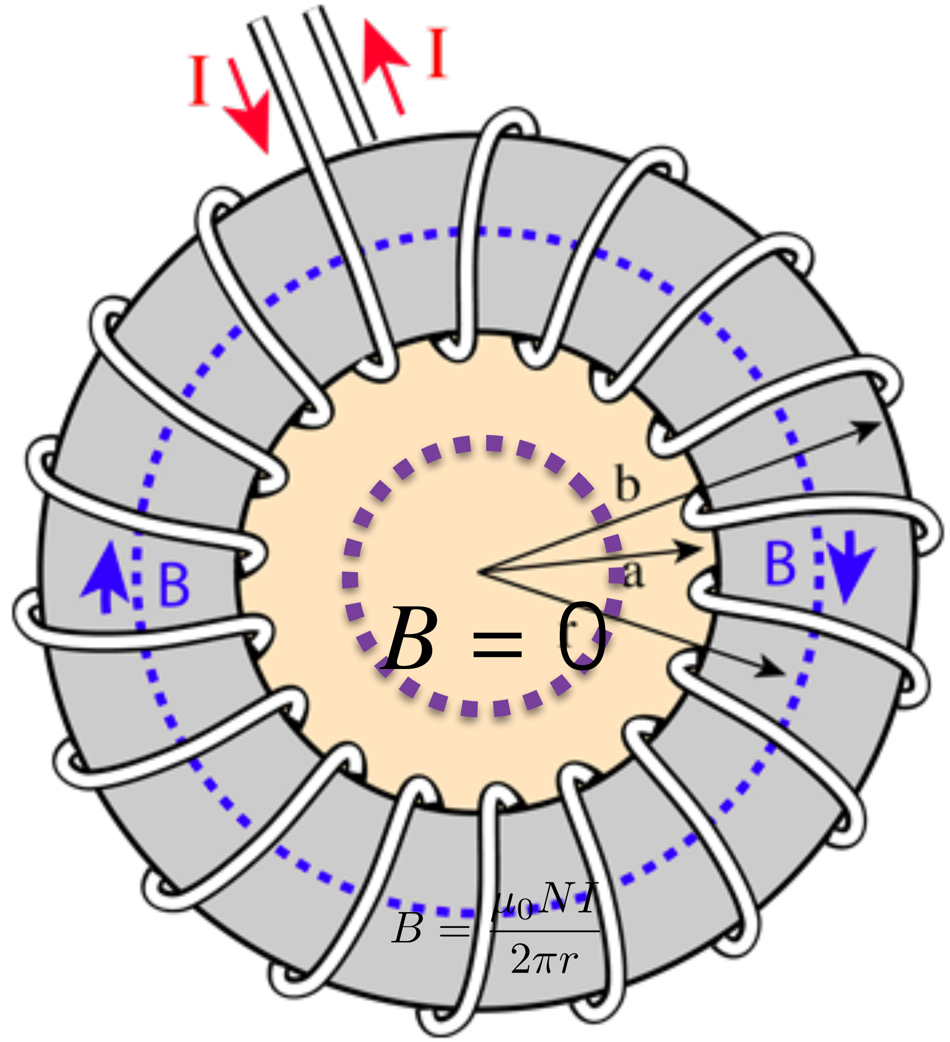
$$B = \frac{\mu_0 N I}{2\pi r}$$

let c be the centre radius

$$N = 2\pi c\ n$$

$$B = \mu_0 n I \frac{c}{r}$$

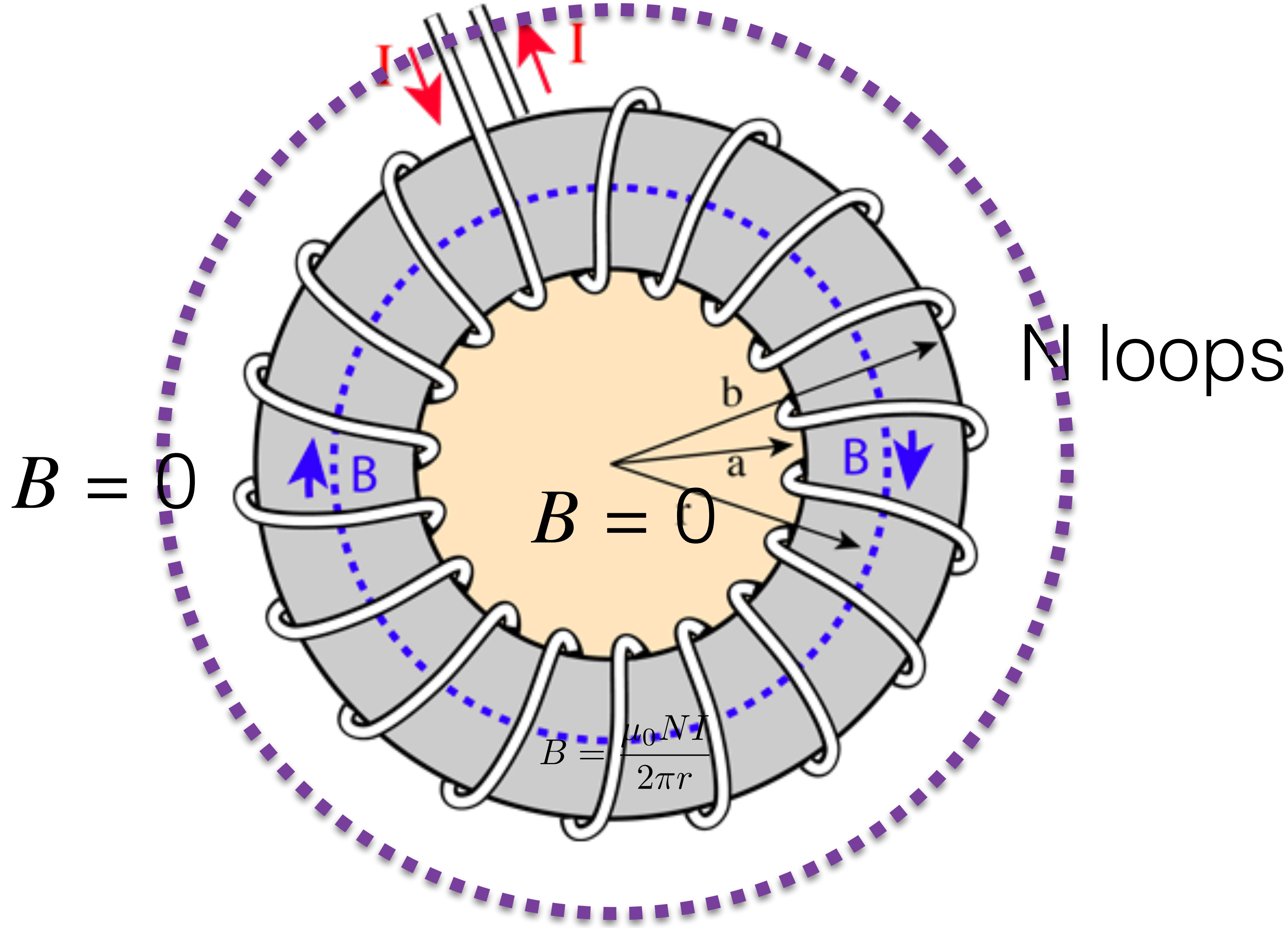
as the torus gets bigger $c\,/\,r \rightarrow 1$ then $B \rightarrow \mu_0 n I$



N loops

Amperian loop with radius < **a** encloses no current.

$$B = 0$$

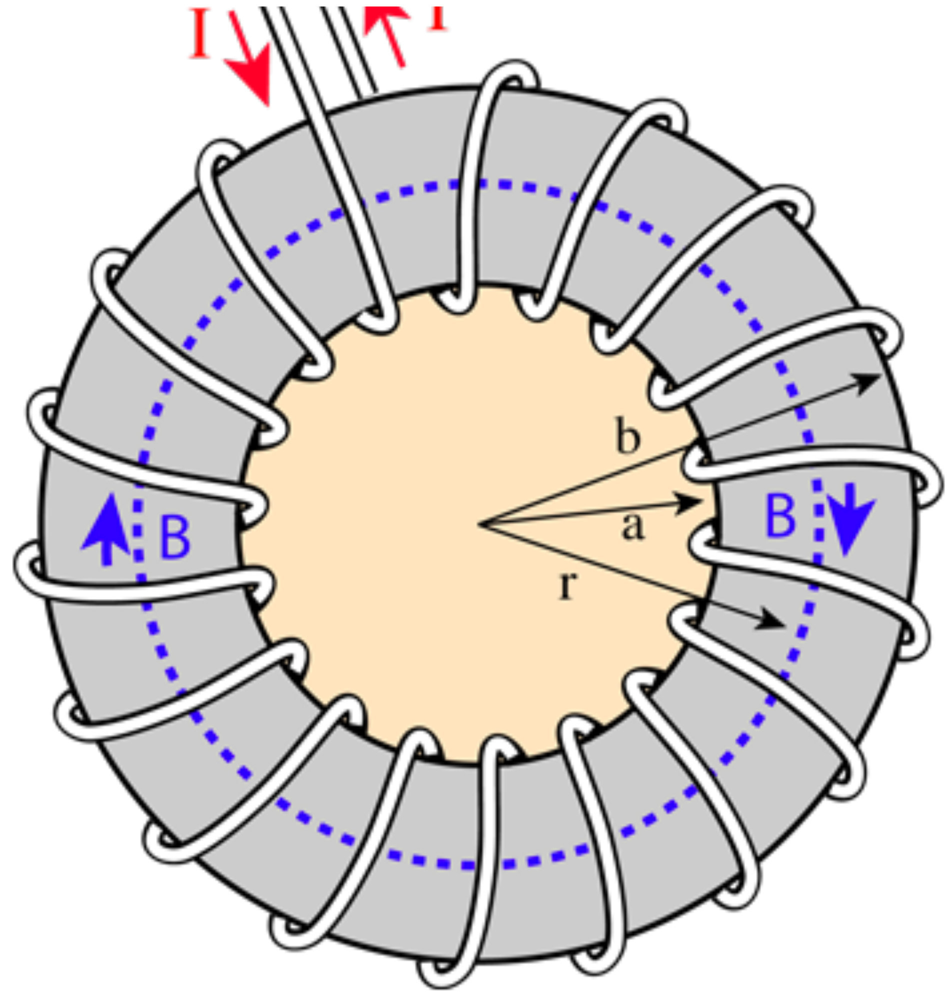


Amperian loop with radius > **b** encloses no **net** current.

$$B = 0$$

Numerical Example

r = 6 cm
a = 5 cm
b = 7 cm
I = 1 A
N = 100



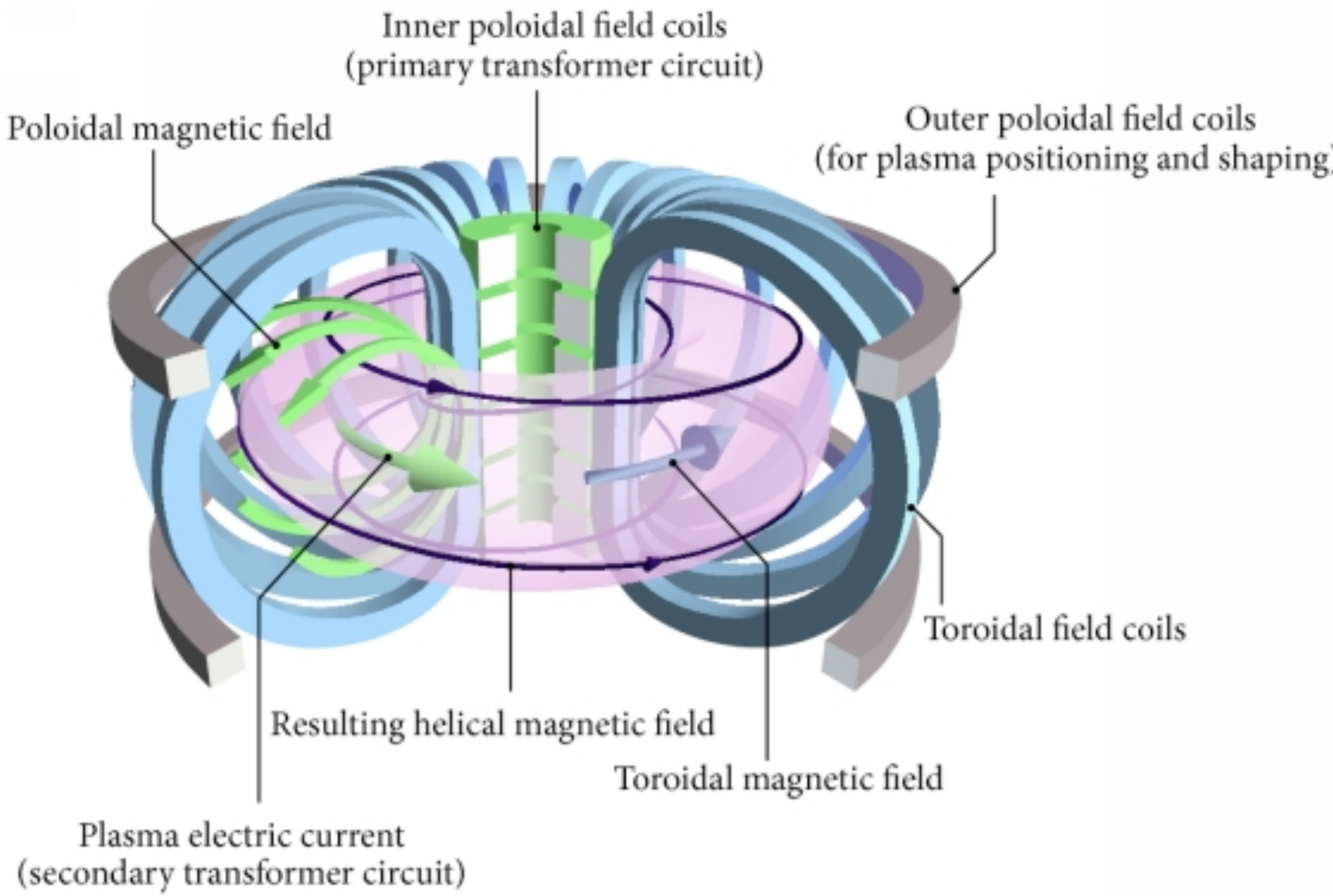
N loops

at radius r = 6 cm:

$$B = \frac{\mu_0 N I}{2\pi r} = \frac{(4\pi \times 10^{-7})(100)(1)}{2\pi(6 \times 10^{-2})} = 0.000333 \text{ T}$$

at radius **a:** B = 0.000400 T
at radius **b:** B = 0.000286 T

Application



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