

$$U = \frac{1}{2} L I^2$$

For a solenoid

$$B = \mu_0 n i$$

$$L = \mu_0 \frac{N^2}{l} \cdot A$$

$N = \#$  turns

$n = \#$  turns per unit length

$$L = \frac{\mu_0 n^2 l^2 \cdot A}{l}$$

$$n = \frac{N}{l}$$

$$L = \mu_0 n^2 \cdot l \cdot A$$

$$N = n \cdot l$$

$$U = \frac{1}{2} (\mu_0 n^2 \cdot l \cdot A) \cdot I^2$$

Potential energy density

$$u = \frac{U}{V} = \frac{U}{A \cdot l}$$

$$u = \frac{1}{2} \frac{\mu_0 n^2 \cdot l \cdot A \cdot I^2}{A \cdot l}$$

$$\cdot \frac{\mu_0}{\mu_0}$$

$$u = \frac{1}{2\mu_0} \mu_0^2 n^2 I^2$$

$$B = \mu_0 n \cdot I$$

$$u = \frac{1}{2\mu_0} B^2$$