Inductance of a Toroid

- Total number of turns: N
- Magnetic field inside toroid: $B = \dfrac{\mu_0 I}{2\pi r}$
- Magnetic flux through each turn (loop):

$$\Phi_B = \int_a^b BH\,dr = \frac{\mu_0 INH}{2\pi}\int_a^b \frac{dr}{r} = \frac{\mu_0 INH}{2\pi}\ln\frac{b}{a}$$

- Inductance: $L \equiv \dfrac{N\Phi_B}{I} = \dfrac{\mu_0 N^2 H}{2\pi}\ln\dfrac{b}{a}$
- Narrow toroid: $s \equiv b - a \ll a$

$$\ln\frac{b}{a} = \ln\left(1 + \frac{s}{a}\right) \simeq \frac{s}{a}$$

- Inductance: $L = \dfrac{\mu_0 N^2 (sH)}{2\pi a}$