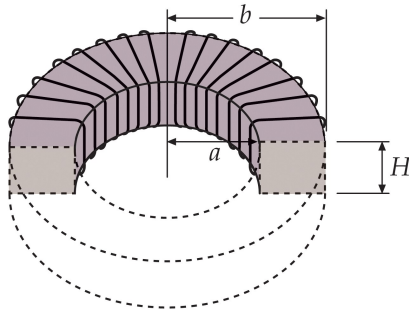


### [lex77] Inductance of a toroid

Consider a toroid with a tightly wound wiring of rectangular cross section as shown. The total number of turns is  $N$  and the current in the wire is  $I$ . Ampère's law states that the magnetic field vanishes outside the wiring. Symmetry suggests that the magnetic field  $B$  at radius  $r$  is tangential to the circle of radius  $r$  and at most weakly dependent on the vertical position inside the rectangular cross section.

- Use Ampère's law to determine the function  $B(r)$ .
- Calculate the magnetic flux  $\Phi_B$  across one rectangular loop by integration.
- Calculate the inductance of the toroid from the definition  $L = N\Phi_B/I$ .
- Simplify (by expansion) the expression for  $L$  pertaining to the case where  $s \doteq b - a \ll a$ .



**Solution:**