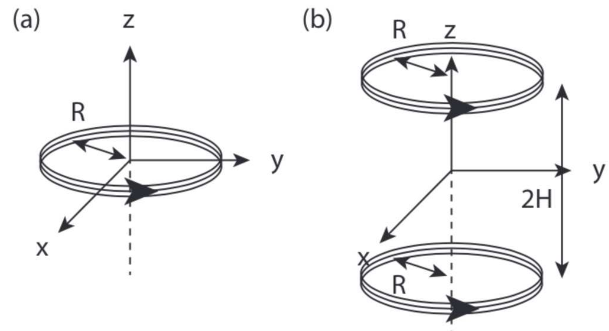
Q2: Consider a short coil of wire with N turns, radius R, and carrying a constant current I. (See part (a) of the figure.).



a) Calculate the magnetic field $\mathbf{B} = (B_x, B_y, B_z)$ at points $\mathbf{r} = (0, 0, z)$ along the symmetry axis of the coil. **Hint**: The Biot-Savart law in SI units is $d\mathbf{B} = \mu_0 I d\mathbf{l} \times \hat{\mathbf{r}}/(4\pi r^2)$.

b) Two coils, each identical to that in part (a) are separated by a distance $2H$ along the symmetry axis z. (See part (b) of the figure.) Find the magnetic field on the z axis between the two coils as a function of z, where $z = 0$ is the midpoint between the two coils.

c) At a separation of $H = R/2$, the magnetic field is very uniform near $z = 0$. This configuration is called a *Helmholtz coil*. Using your results from part (b), calculate the on-axis magnetic field from the pair of coils for $z = 0$ and $H = R/2$. Draw a sketch of the magnetic field lines along the axis and off-axis. Calculate the magnetic field at $z = 0$ for $R = 0.1$m, $N = 100$, $I = 100$A expressing your answer in Tesla (T).

d) Imagine that we reverse the direction of the current through the bottom coil. This configuration is called "anti-Helmholtz" (or "holtz-Helm"). Sketch the magnetic field lines along the axis and off-axis.

e) In the anti-Helmholtz case, the on-axis magnetic field near $z = 0$ varies linearly in z as $B_z = cNIz$, where c is a constant that you do not have to find. Use this fact to find $\partial B_x/\partial x$ and $\partial B_y/\partial y$ at the center of the system ($x = y = z = 0$).