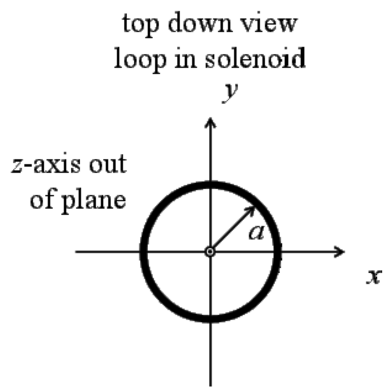
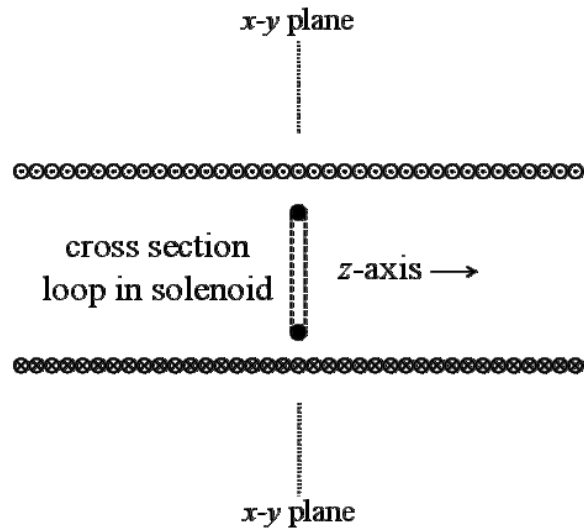
**EMA** Consider a wire loop of radius $a$ and area $A_{\text{loop}} = \pi a^2$ that lies in the $x$-$y$ plane. The loop has self inductance $L$ and total resistance $R$.




a) If the loop carries a current $I(t)$ write down the expression involving $L$ and perhaps $A_{\text{loop}}$ that gives the magnetic flux $\Phi_{\text{self}}$ that passes through the loop and that is due to the current $I(t)$.

b) The loop is placed in long solenoid as shown in the figure. The solenoid has cross sectional area $A_{\text{solenoid}}$ and $N$ turns per meter. Compute the *mutual inductance* $M$ of the solenoid and the loop.

c) The solenoid is now driven by an alternating current so that it applies an external magnetic field $B_z = \text{Re}(B_0 e^{i\omega t})$ perpendicular to the plane of the loop. This external field will induce an alternating current in the loop. Consider first the two extreme cases $R$ very large, and $R = 0$. How do you expect the *total* flux through the loop to vary with time in the these two cases? (Assume the current has been oscillating for a long time — *i.e.*, ignore any transient effects.)

d) By considering all sources of flux through the loop, find an expression in terms of $L$, $B_0$, $a$, $\omega$ and $I(t)$ for the total EMF $\mathcal{E}(t)$ driving the current in the loop.

e) Use your answer to part (d) to solve for current $I(t)$ in the loop, and hence find the total flux $\Phi_{\text{tot}}(t)$ passing through the loop. Examine your answer to see if it agrees with your expectation from part (c).