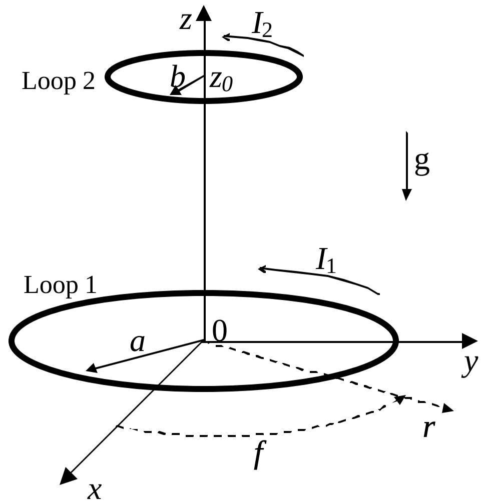
A wire loop (loop 1 in the figure) of radius a, centered at the origin of a cylindrical (r, f, z) coordinate system, lies in the $z = 0$ plane and has a current $I_1 = I_0 \cos(wt)$ flowing around it. A second loop (loop 2 in the figure), of radius b, lies in the $z = z_0$ plane with its center on the z-axis. Assume that $z_0 >> a$ and $z_0 >> b$. (The figure is not to scale.) Also, ignore radiation effects.



(a) Consider the magnetic field produced at position $r = b$ and $z = z_0$ (*i.e.*, on loop 2) by the current I_1. The field is proportional to I_1:

$$B_r = a_r I_1 z_0^a$$
$$B_f = a_f I_1 z_0^b \; ,$$
$$B_z = a_z I_1 z_0^g$$

where a_r, a_f, and a_z are not functions of I_1 or z_0.

i. Show that $a_f = 0$.
ii. What are the values of a and g?

In case you could not solve part **(a)**, you may express your answers to parts **(b)**, **(c)**, and **(d)** in terms of a and g, as well as the other quantities defined in the problem.

(b) Assume that loop 2 has self inductance, L, and negligible resistance. Determine I_2, the current induced in loop 2 as a function of time. Take positive current to be in the direction of increasing f, as shown in the figure.

(c) Calculate the z-component of the force on the second loop as a function of time.

(d) Assume that w is sufficiently large that the height of loop 2 (which has mass, m) is determined only by the time averaged force. Determine the equilibrium height, z_0. Gravity, $\vec{g}$, points in the $-z$ direction.

(e) Calculate a_r and a_z in terms of a, b, z_0, and constants. Keep only the largest nonvanishing terms in a/z_0 and b/z_0.