ELEN 3401 Electromagnetics
Problem Set #7

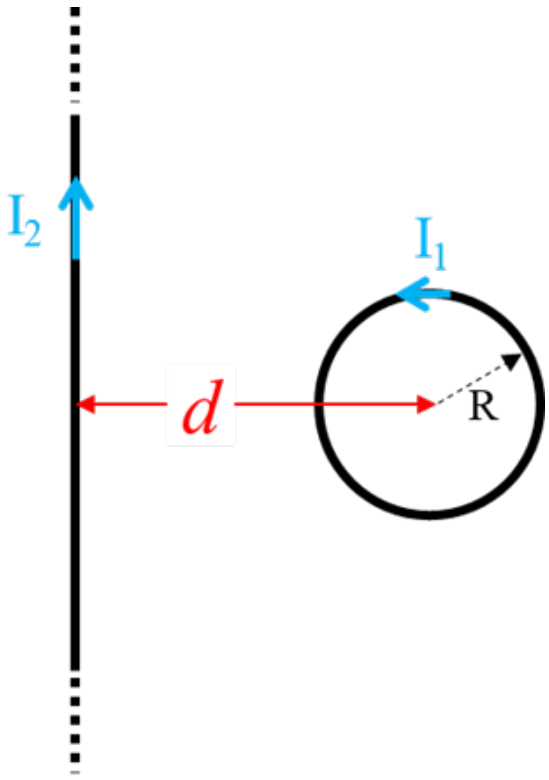
DUE: Friday April 11

Please include your name and UNI on the assignment

Problem 1: Magnetic Flux and Mutual Inductance

A loop of radius R and current I_1 is in the same plane and located a distance d from an infinitely long wire carrying current I_2 as shown in the figure below.

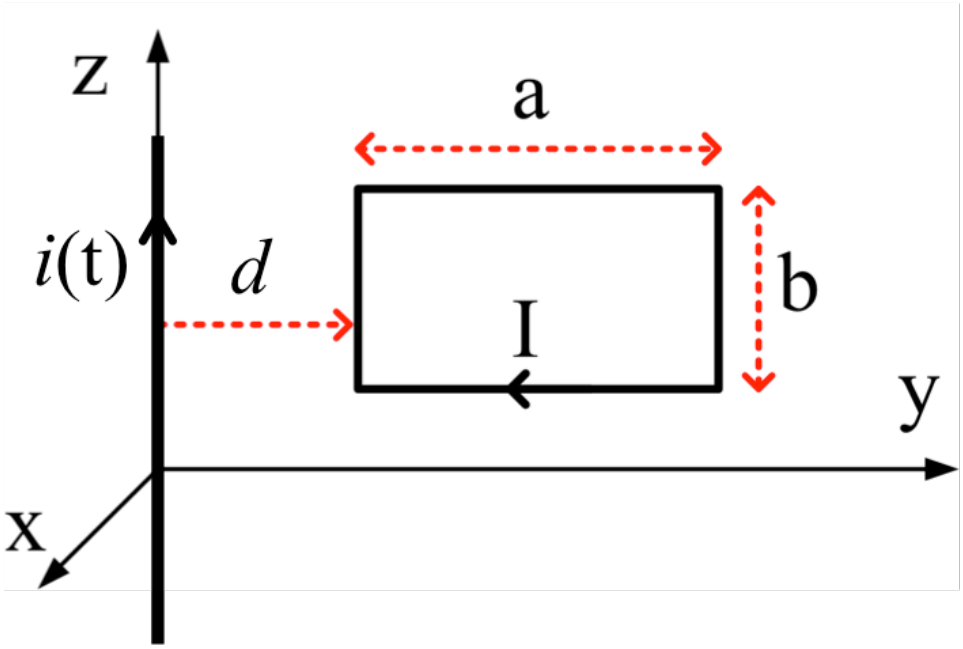
a. Find the total magnetic flux density $\vec{B}$ going through the loop due to I_2.
b. Find the mutual inductance between the loop and the wire.



Problem 2: Stationary Loop in a Time-varying Magnetic Field

An infinitely long thin wire carrying time-varying current $i(t) = I_0 \cos \omega t$ is located along the *z*-axis. An adjacent rectangular metallic loop with dimensions *(a,b)* and resistivity R is located in the *y*-*z* plane at a distance d from the *z*-axis, as shown in the diagram below.

Obtain an expression for the induced current, I, inside the loop.



Problem 3: Toroidal transformer

The transformer structure shown below consists of a long wire along the *z*-axis carrying a time-varying current $I(t) = I_0 \sin\left(\omega t - \frac{\pi}{3}\right)$, coupling magnetic energy to a toroidal core situated in the *x*-*y* plane and centered at the origin, as shown in the figure below. The toroidal core uses iron material with relative permeability μ_r, around which N turns of a tightly wound coil serves to induce a voltage V_{emf}.

a. Obtain an expression for V_{emf}.
b. You are tasked with designing a toroidal transformer with V_{emf} = 120 V. You have access to a supply current of $I(t) = 2\sin\left(1000t - \frac{\pi}{3}\right)$ A and must choose the material to fabricate the toroidal core with. Determine this material's permeability μ as a function of the toroidal transformer's geometric parameters *a*, *b*, *c*, and *N*.