EECS 412 Electromagnetic Fields III
Fall 2003

Homework #2:

Due September 29th

Reference Ramo, Whinnery, Van Duzer, Fields and Waves in Communications Electronics, 3rd Edition, Chapter 2.

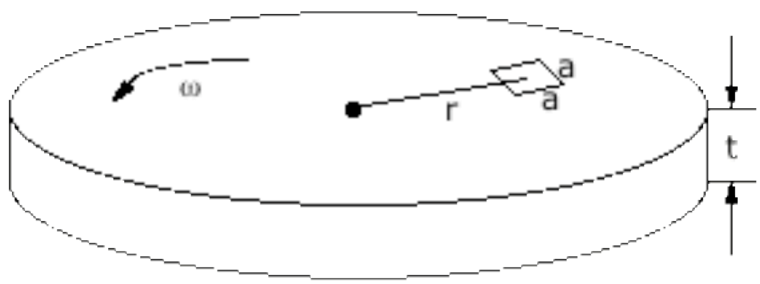
Biot-Savart	2.3a
Helmholtz coils	2.3e (not as simple as it looks)
Field from a current distribution	2.4e
Inductance of a coaxial line	2.5

The following will require additional references and are not restricted to subjects covered in class.

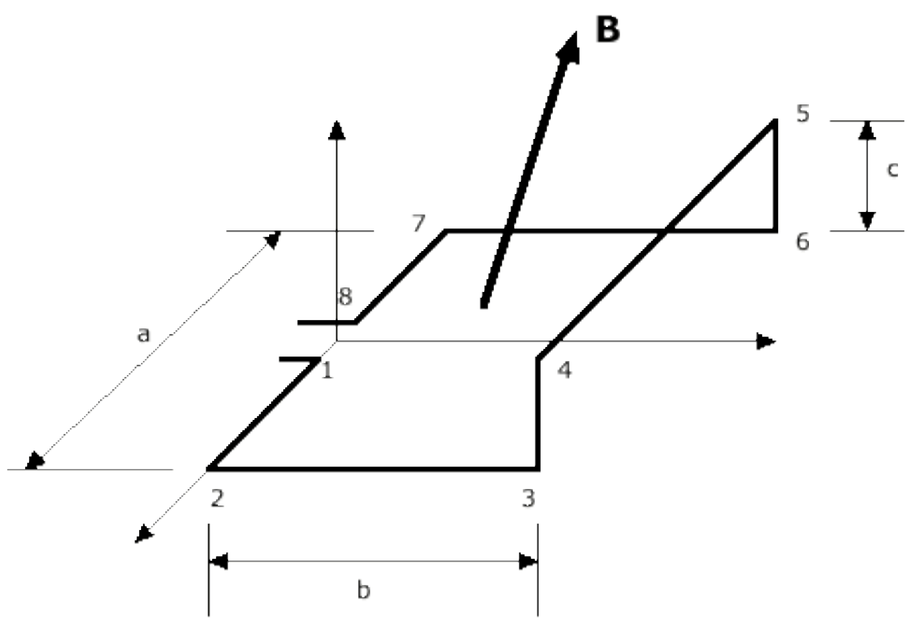
Eddy currents	1 (attached)
Induced voltages	2,3 (attached)
Mutual inductance	4 (attached)
Solenoid & magnetic forces	5 (attached)

1. An electromagnetic “eddy current” brake consists of a disk of conductivity σ and thickness t rotating about its center with a magnetic field B applied perpendicular to the plane of the disk over a small area a^2.

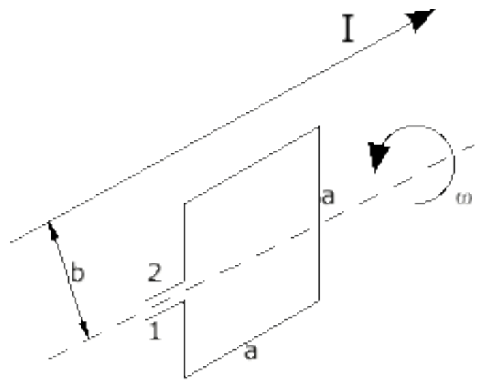
If the area a^2 is at a distance r from the axis, find an approximate expression for the torque tending to slow down the disk at the instant its angular velocity equals ω.



2. A conducting wire is bent into the shape shown below. The segments 1-2, 4-5, and 7-8 are parallel to the x-axis. The segments 2-3 and 6-7 are parallel to the y-axis and the segments 3-4 and 5-6 are parallel to the z-axis. This conducting loop is immersed in a magnetic field given by $\overline{B} = B_o(\hat{y} + 2\hat{z})\cos\omega t$. Find the induced voltage that would be measured between terminals 1 and 8.



3. A very long thin wire has a current I flowing in it. A square single turn coil is rotated about an axis parallel to the wire at an angular rate w. Derive an expression for the EMF between terminals 1 and 2 as a function of time. At t=0 the coil is in the plane defined by the wire and the axis of rotation of the coil.

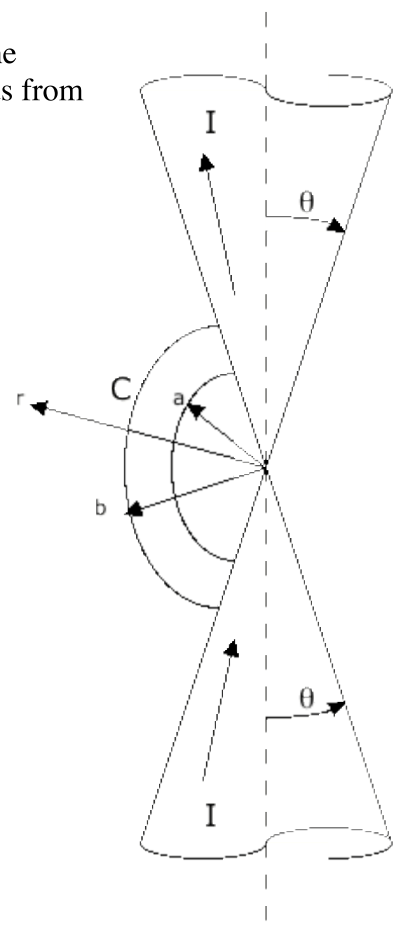


4. Consider two infinitely long metal cones with a half angle θ_o as shown below. A current I, uniformly distributed over the cone surface, flows in the upward direction on the upper cone and flows towards the origin on the lower cone.

(a) Find the magnetic field **H** surrounding the cones.

(b) Find the mutual inductance between the two cones and the conducting loop labeled C in the figure. The loop extends from r=a to r=b and infinitesimally close to the cone surfaces.

HINT: A useful integral is $\int \frac{d\theta}{\sin\theta} = \ln\left(\tan\frac{\theta}{2}\right)$



5. Derive an expression for the required current to cause the armature in the illustrated relay to pull in. All iron paths have a cross-sectional area A. The spring force is F.