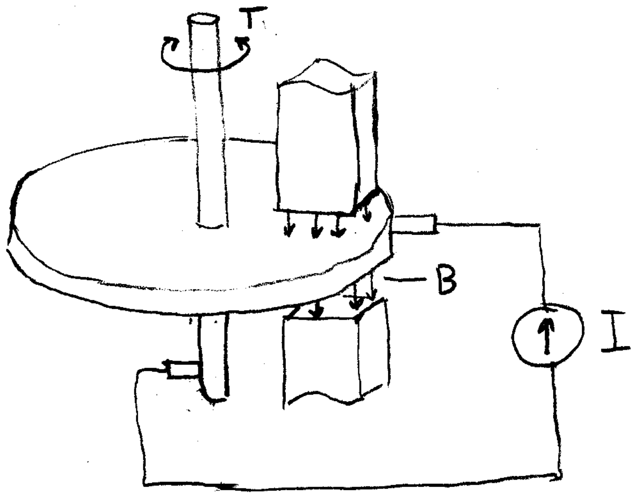
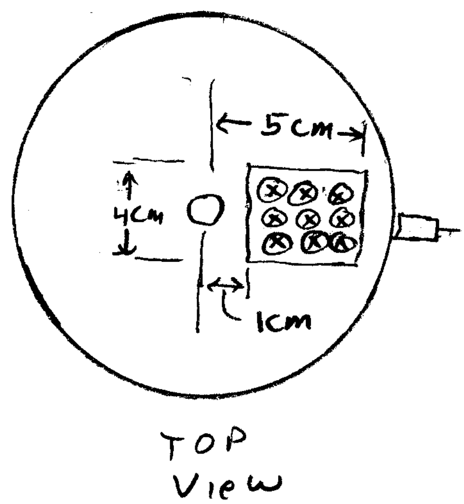
ELEC 435
Problem Set 6
Due: October 10, 2014

Homework Problems.

H6.1 The device below is a *homopolar motor*. It consists of a copper disk which is free to rotate in an axial field of $B = 1\text{T}$. The faces of the pole pieces are 4 cm on a side and are positioned as shown in the top view. Current is supplied to the disk through *brushes* or *slip rings* which provide electrical contact between the fixed current source and the rotating disk.

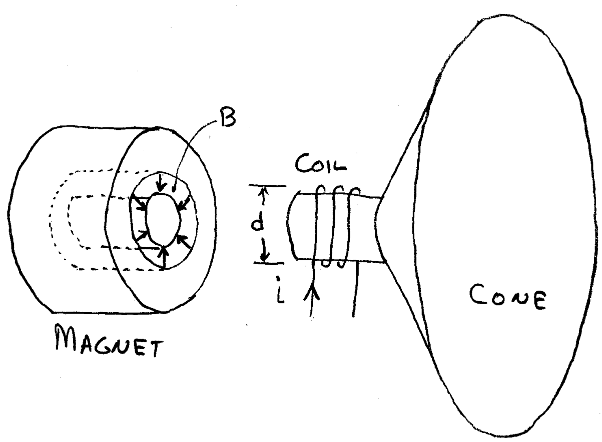
Estimate the torque T which is produced. What is the direction of the torque?





H6.2 The figure below is an exploded view of a moving coil loudspeaker. The magnet structure produces a uniform, radial magnetic flux density of 0.8 T in the cylindrical air gap. The coil has 30 turns wound in a cylinder of 2 cm diameter. When the speaker is assembled, the coil is inserted into the air gap of the magnet.

- **(a)** What is the force on the cone as a function of the current i?
- **(b)** What is the induced voltage in the coil as a function of coil velocity?
- **(c)** Neglecting coil resistance, show that the electrical power input to the coil is equal to the mechanical power deliv



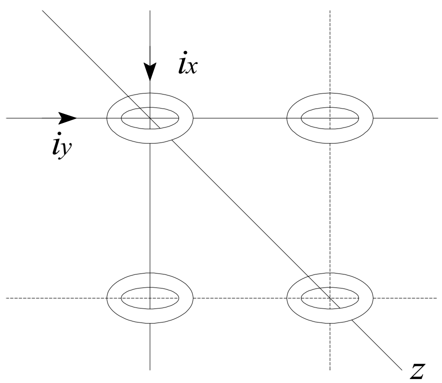
H6.3 The left hand figure below shows a small portion of a single "bit plane" from a *core memory* array. Each of the doughnut shaped "cores" stores a single bit in its state of magnetization: clockwise for a 1 and counterclockwise for 0. Each core has a rectangular hysteresis loop of the form shown in the right hand figure, with $B_r = 0.3$ T and $H_c = 25$ A/m. Each core has a mean diameter of 2 mm and a cross-sectional area of $10^{-7}\mathrm{m}^2$.

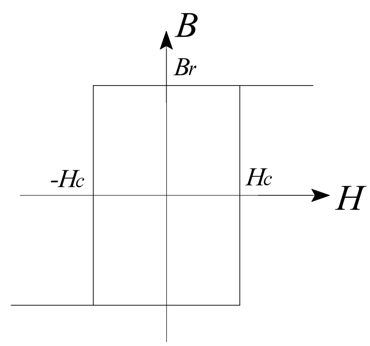
(a) Determine the magnitude of a current pulse i_x that will provide a magnetic field intensity of 0.7 H_c in the core. Note that this pulse alone will not change the state of the core.

(b) To change the magnetic state of a core from counterclockwise to clockwise, simultaneous current pulses i_x and i_y are applied, each having the amplitude found in part (a). Simultaneous pulses of reversed polarity return the core to the state of reverse saturation.

A *sense line*, labeled z in the figure, passes through all the cores. The appearance of a voltage pulse e_z on this line indicates that the flux in the core linked by the simultaneous currents i_x and i_y is changing state. If the core flux switches at a uniform rate between saturation limits in 1.0 μsec, what will be the amplitude of the pulse e_z?

(c) If the core is already in the saturation state corresponding to the polarity of the applied currents, will any voltage e_z be produced when the pulsed currents i_x and i_y are applied?





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Quiz Problems.

Q6.1 The structure shown below in Figure (a) is part of a Junior Woodchucks Magnetic Experimenter's Kit. Parts A_1 and A_2 are made of ideal soft ferromagnetic material ($\mu = \infty$) and have a 1 cm square cross section (i.e. $w = 1$ cm). The coil has 800 turns and the length of the gap (g) is 1 mm. Part X may be any of several 1 cm cubes (i.e. $l = 1$ cm), each made of a different material.

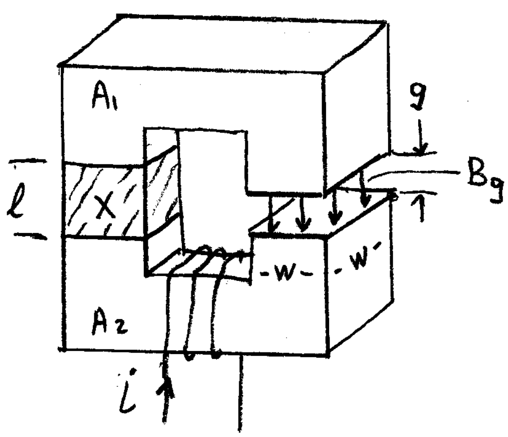
Find the magnetic flux density in the gap (B_g) for each of the following situations:

(a) X is made of the same material as A_1 and A_2, $i = 0.5$ A.

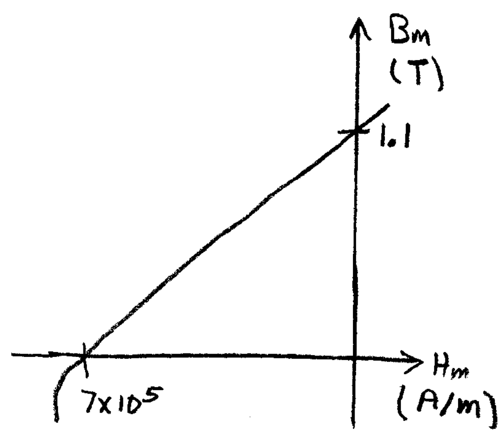
(b) X is made of soft iron, having a relative permeability (μ_r) of 4000, $i = 0.5$ A.

(c) X is made of copper, $i = 0.5$ A.

(d) X is made of a permanent magnetic material whose demagnetization characteristic (second quadrant B-H curve) is given in Figure (b), with $i = 0$.



(a)



(b)