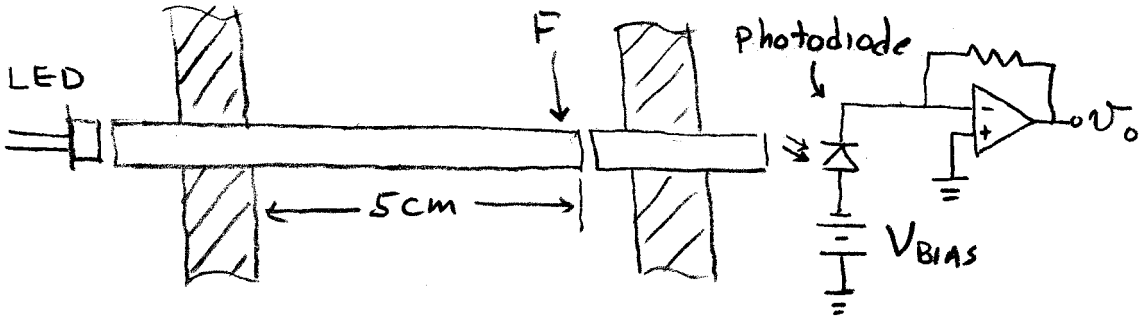
ELEC 435
Problem Set 12
Due: December 5, 2014

Homework Problems.

H12.1 The device below is a fiber-optic force sensor. The two fibers are made of quartz and have an outside diameter of 2 mm and a core diameter of 1.95 mm.

Plot the output voltage (as a percentage of maximum) vs. F. What is the useful range of this device?

Useful information: A force F applied to the end of a cylindrical cantilever beam of diameter d and length l produces a deflection at the free end of $\frac{64Fl^3}{3\pi Ed^4}$. The elastic modulus of quartz is 95 GPa.

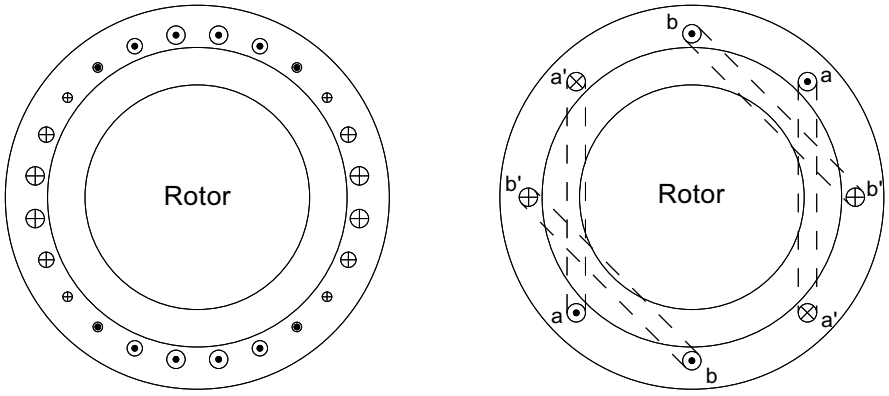


H12.2 The AC motors we've seen in class have been *two-pole* structures: at any point in time the magnetic field in the air gap has a single pair of extrema (i.e. a north and a south pole). The figure on the left below shows the windings for a single phase of a *four-pole* structure. The varying size of the coils is intended to indicate a sinusoidally distributed field. The figure on the right shows a two-phase, four-pole structure consisting of two sets of sinusoidally distributed coils spaced 45° apart. For simplicity, each winding is indicated as a single coil.

(a) Sketch the field produced by the single phase winding on the left.

(b) If the windings on the right are connected to a two-phase current of frequency ω (i.e. $i_a(t) = \cos(\omega t)$ and $i_b(t) = \sin(\omega t)$), at what rate will the resulting field rotate?

(c) If the structure in part (b) is generalized to p poles, what is the speed of rotation as a function of the frequency of the applied current and the number of poles?



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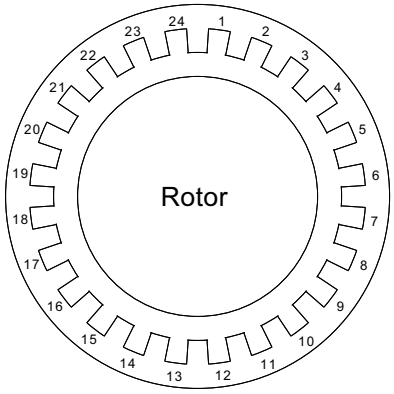
H12.3 In the cylindrical magnetic structure below, the gap width is 0.9 mm. It is desired to have a two pole flux pattern with the North pole at 0° and a peak flux density of 1.0 T.

(a) Show the locations of the coils and currents on the stator. Mark "+" where current enters the paper and "·" where it leaves the paper.

(b) How many total turns per coil are required if the peak current is 10 A? (Each turn consists of a pair of wires in the stator: one carrying current from front to back (into the paper) in one slot and the other returning the current to the front (out of the paper) in another slot.)

(c) Give the number of wires to be placed in each slot to approximate a sinusoidally distributed flux density.



Quiz Problems.

Q12.1 Design an actuator which will produce an approximately constant force of 1N over a range of motion of 1cm when a current of 1A is applied. You have available: permanent magnets which will produce a flux density of 1T in an air gap of 2mm, an unlimited supply of .5mm dia wire, soft magnetic material of infinite permeability, and a wide selection of mechanical components (gears, cables, bearings, etc.). You may use as many or as few of these ingredients as you need.