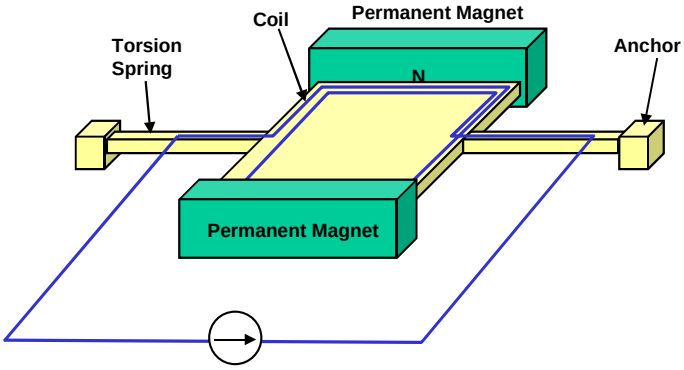
1) Consider the following electromagnetic actuator:



The torsion mirror shown above is driven by electromagnetic force produced by the coil in magnetic field. The magnetic field is generated by a pair of permanent magnets with magnetic flux density of B = 1 Tesla. The torsion mirror made of silicon has an area of WxW = 100x100 μm^2 and a thickness of 10 μm, and the coil has 10 turns. For additional material parameters, use the table for Si or poly-Si in our lecture viewgraph, or Table 8.1 in Senturia's book).

a) Derive the DC transfer function of the torsion mirror (rotation angle versus current).
b) Construct the equivalent lumped circuit element model for the actuator, including electrical, magnetic, and the mechanical domains. The mass of the torsion plate is m.
c) Solve the equivalent circuit in (a) using Kirchoff's Laws. Find the transfer function of the equivalent circuit (i.e., rotation angle as a function of input current). Compare that with the expression found in (a).
d) The torsion beam is also made of Si, and is 2 μm wide, 10 μm thick, and 500 μm long. Find out the compliance of the torsion spring. (Make sure you include both springs).
e) Use the torsion beams in (d) and the following bias parameters, find the torque and the angular displacement of the torsion mirror:
I = 10 mA, Magnetic flux density B =1 Tesla