Course Title: Electrical Machines I **Course Code:** EE321

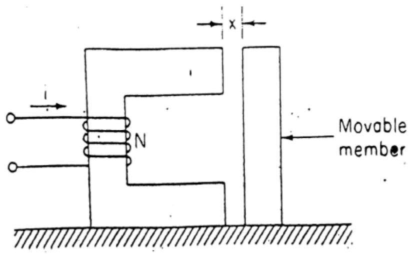
<u>Sheet 3</u>

Electromechanical Energy Conversion

1- Consider the magnetic circuit shown. Find an expression for the force developed by the field. Suppose that the voltage applied to the coil is

$$e(t) = E_m \cos \omega t$$

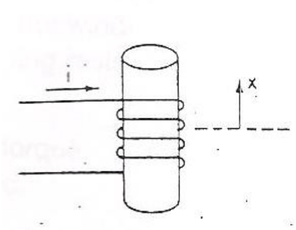
Express the developed force as a function of time.



2- The variation of inductance of the coil shown with the distance x is found experimentally to fit the expression

$$L(x) = \frac{L_0}{1 + \alpha x^2}$$

Where L_o and α are constants. The position x=0 corresponds to the core being in the center of the coil. Express the force developed as a function of the current i and the displacement x. If the terminal voltage e(t) is given by:



$$e(t) = E_m \cos \omega_s t$$

3- The relay shown is made from infinitely-permeable magnetic material with a movable plunge, also of infinitely-permeable material. The height of the plunger is much greater than the air gap length (h>>g).Calculate the magnetic stored energy as a function of plunger position (0 < x <d) for N=1000 turns, g= 2 mm, d=0.15 m, l=0.1 m, and i=10 A.

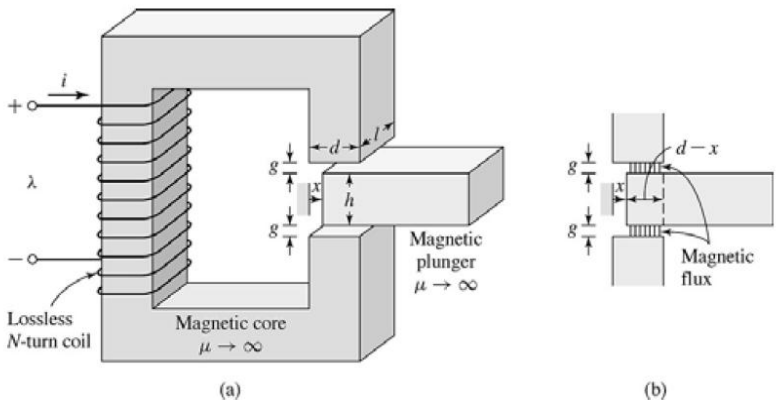


Figure 3.6 (a) Relay with movable plunger for Example 3.2.
(b) Detail showing air-gap configuration with the plunger partially removed.

4- For the relay of problem (2) , find the force on the plunger as a function of x when the coil is driven by a controller which produces a current as a function of x in the form

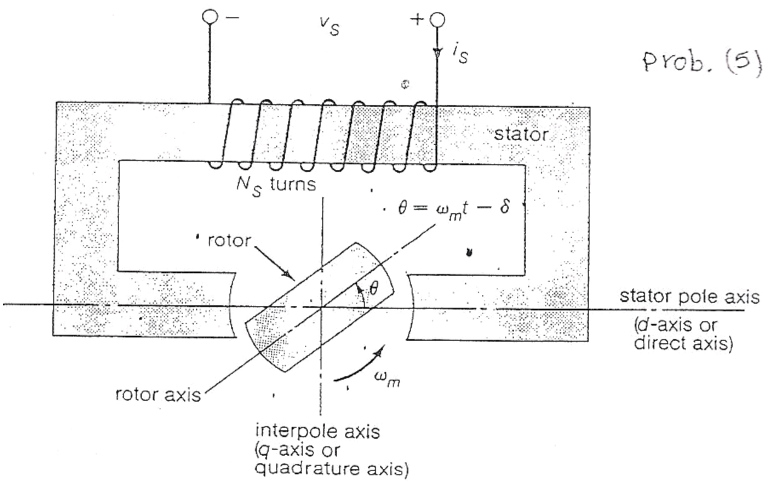
$$i(x) = I_0\left(\frac{x}{d}\right) \text{ A}$$

5- A rotating reluctance machine of the form shown has a coil inductance that can be approximated by:

$$L(\theta) = 0.02 - 0.04 \cos 2\theta - 0.03 \cos 4\theta \text{ H.}$$

A current of 5A (rms) at 60 Hz is passed through the coil. And the rotor is driven at a speed , which can be controlled, of ω_m rad/sec.

a. Find the values of of ω_m at which the machine can develop average torque.
b. At each of the speeds obtained in part (a), determine the maximum value of the average torque and the maximum mechanical power output.



6- Consider an elementary rotating reluctance machine with 4 rotor poles instead of two. The poles are so shaped that the reluctance of the magnetic system is given by:

$$R(\theta) = 4*10^5 - 3*10^5 \cos 4\theta \qquad \text{A.T/wb}$$

The stator coil has 100 turns and negligible resistance. An ac voltage of 110 (RMS) at 60 Hz is applied to the coil terminals:

a. Sketch the function of R versus θ
b. Determine the synchronous speed of the rotor and the maximum average torque that the machine can develop.