Homework 4 – Electromechanical Energy Conversion Principles

This homework is to be solved using computational tools (such as MATLAB). You should show your work (how the resultant plot is obtained analytically, and required explanations).
The provided template must be used and the homework should be submitted by converting the .m file solution to pdf by using ***publish*** *command. Required explanations and several tips are given in the template.*

Consider the electromechanical energy conversion device (harmonic oscillator) shown in Figure 1. The core is fixed, a plunger of mass m can move horizontally in a frictionless surface and there is a rubber stopper with a thickness of 1cm. The spring is at balance ($F_{spring} = 0$) at the position shown in the figure (x=0). I = 15 A. N = 150 turns. A = 10 cm^2. $\mu_0 = 4\pi 10^{-7}$ H/m. m = 0.5 kg. k = 20 N/m (spring constant).

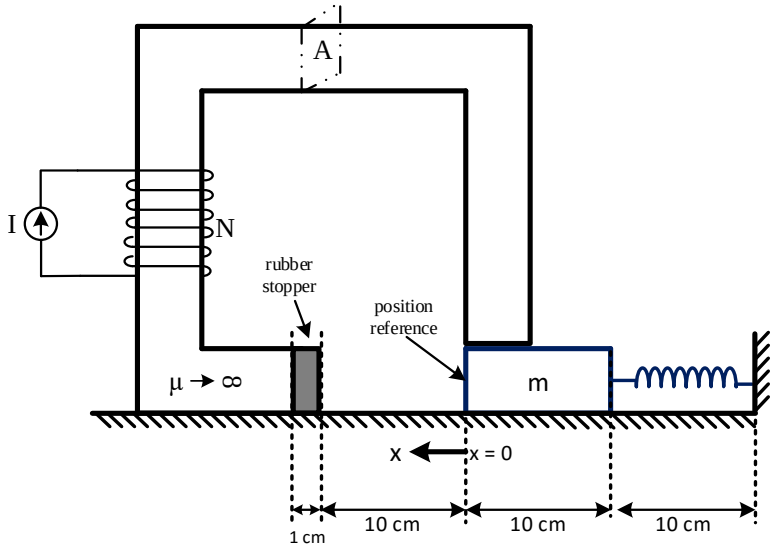

Figure 1: Electromechanical Energy Conversion Device

a) Obtain the reluctance and inductance ***as a function of displacement (x)***.
b) Obtain and plot the stored magnetic energy, in Joules, ***as a function of displacement***.
c) ***As a function of displacement,***

i) Obtain the electromagnetic force, in Newtons
ii) Mechanical spring force, in Newtons
iii) Net force, in Newtons
acting on the mass.
iv) Plot these forces as a function of displacement, on the same figure.
v) Define the position intervals at which the net force acting on the mass is in the direction of +x and in the direction of –x and comment on the results.

d) Obtain and plot the acceleration of the mass, in m/s^2, ***as a function of displacement***.
e) Suppose that the mass is stationary at x=0 and then the current is applied at t=0. ***As a function of time***, i) Obtain the acceleration, velocity and position of the mass.
ii) Plot the acceleration, velocity and position of the mass on the same axis, using **subplot**.
f) Comment on the behaviour of the mechanical system.
g) Comment on the direction of mechanical and electrical energies during the motion in part (e).

May the electromagnetic force be with you!