**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).*

*A template is also provided. You should submit your homework by converting your .m file solution to pdf by using* ***publish*** *command. Required explanations and several tips are given in the template.*

**Q.1.** Consider the simple rail gun composed of a conductive rail, a conductive rod and a voltage source shown in Figure 1. There a magnetic source which supplies a constant magnetic flux density of 0.5 Tesla (into the paper). Vt = 100 V. R = 10 Ω. l = 10 cm. m = 0.1 kg.



Figure 1: Simple Rail Gun

**a)** Obtain and plot the force acting on the copper rod in terms of the displacement x in the interval of [0-2m].

**b)** Obtain and plot the acceleration of the copper rod in terms of the displacement x in the interval of [0-2m].

**c)** Obtain and plot the velocity of the copper rod in terms of the displacement x in the interval of [0-2m].

**d)** Suppose that the copper rod is stationary at x=0 at t=0 and the switch S is closed. Obtain and plot the position of the copper rod against time until it reaches x=2m.

**e)** For the conditions in (d), calculate the induced voltage between the terminals of the copper rail at x = 0.5m, x = 1m and x=2m.

***Hints:***

*The magnetic flux density created by the copper rod itself can be neglected.*

*The electrical source is not a current source, therefore the effect of the voltage induced on the rod by its velocity should be taken into account.*

**Q.2.** Consider the electromechanical energy conversion device shown in Figure 2. The system is frictionless and there is a rubber stopper as shown thickness of which is 1cm. I = 10 A. N = 45 turns.   
A = 10 cm2. µ0 = 4π10-7. m = 0.5 kg. k = 0.5.



Figure 2: Electromechanical Energy Conversion Device

**a)** Obtain and plot the net force acting on the mass in terms of the displacement x in the interval of [0-2m].

**b)** Obtain and plot the acceleration of the mass in terms of the displacement x in the interval of [0-2m].

**c)** Obtain and plot the velocity of the mass in terms of the displacement x in the interval of [0-2m].

**d)** Obtain and plot the electromechanical energy converted by the magnetic device in terms of the displacement x in the interval of [0-2m].

**e)** Suppose that the mass is held stationary at x=0 and then released at t=0. Obtain and plot the position of the mass against time.