INDIAN INSTITUTE OF TECHNOLOGY
Mock Test – 1

Date: 9 September 2015 **Time:** 2 Hrs **Full Marks:** 30 **No. of Students**: 175
Semester: *Autumn* **Department:** *Mechanical Engineering*
Sub. Name: *Systems and Control* **Sub. No.:** *ME40601*
Instructions: *Answer **all** questions. Make suitable assumptions if required with justifications. The nomenclature and representations used are as discussed in the class. No further clarification will be provided.*

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1. (a) Draw a reduced bond graph model of the system shown in Figure 1 by using suitable grounds. **(b)** Substitute the equivalent electrical system of the real transformer in the model developed in part (a) with magnetic domain referred to the secondary side of an ideal transformer. The magnetic core of the transformer has cross-section A, effective length or mean core length L, and magnetic permeability μ. R_c is the resistance that represents total magnetic core losses.

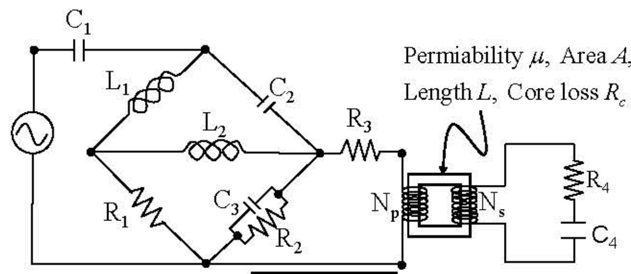

Figure 1

2. Draw a block diagram model of the system shown in Figure 2. The cylinder of mass M and rotary inertia J cannot lift up from the surface, but can roll with slip. The pendulum rod can extend or shorten axially. A friction-less revolute joint is used to suspend the pendulum. There can be large motions and the system is non-linear. Assume that the pendulum rod is massless and the bob is a point mass. Gravity must be included in the model.

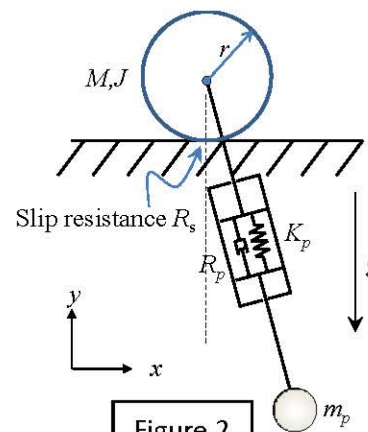

Figure 2

3. Using bond graph approach, find the degrees of freedom of the system shown in Figure 2 when the revolute joint at the top end of the pendulum is replaced by a welded joint and there is no slip between the cylinder and the flat surface (pule rolling). Hint: kinematic relations need to be suitably modeled because the pendulum rod is no more a two-force member. Note that the kinematic relation should be such that its derivative should expose Coriolis and centrifugal forces.

4. Derive the state-space equations of the system shown in Figure 3. Consider only vertical motion and pitch in the model.

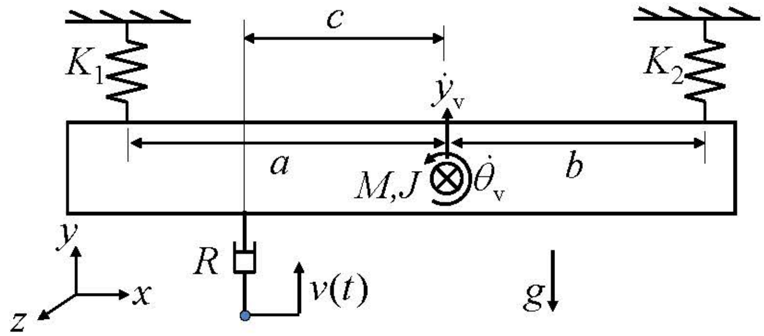

Figure 3