

## Exam I

instructor: Marwan Darwish

date: Monday October 15, 2013

duration: 50 minutes

type: closed book exam

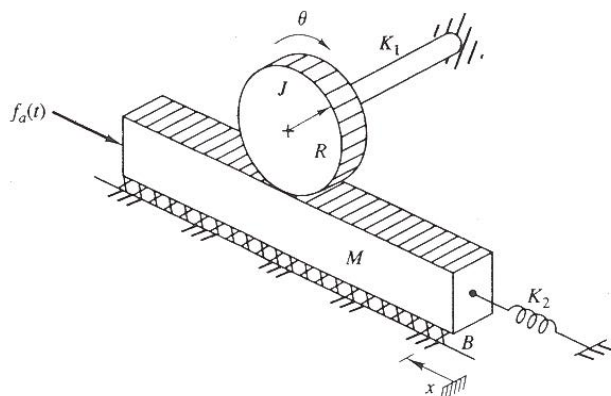
No questions are allowed during the exam

### Problem 1 [50 points]

The input to the combined translational and rotational system shown in the figure below is the force  $f_a(t)$  applied to the mass  $M$ . The elements  $K_1$  and  $K_2$  are undeflected when  $x=0$  and  $\theta=0$

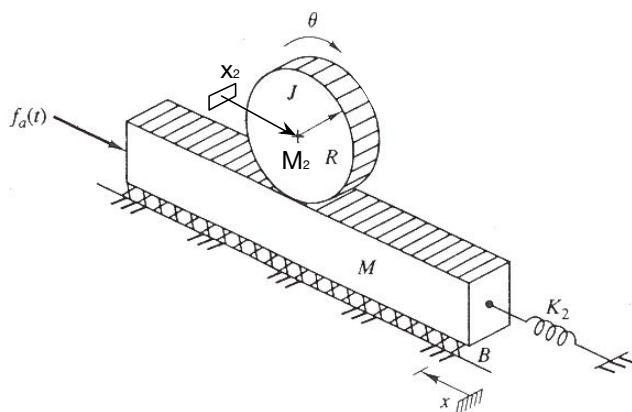
a. Develop a mathematical model for the system

a. Write the input-output equation for  $x$



### Problem 1 [20 points]

The system of problem 1 is modified and now the cylinder is free to roll and translate, but it rolls without slipping. Derive the equations describing the motion of the modified system noting that the mass of the cylinder is  $M_2$ .



### Problem 2 [30 points]

Draw a block diagram for the following set of state-variable equations

$$\begin{bmatrix} \dot{\theta} \\ \dot{\omega} \\ \dot{x} \\ \dot{v} \end{bmatrix} = \begin{bmatrix} 0 & 1 & 0 & 0 \\ -8 & -4 & 2 & 0 \\ 0 & 0 & 0 & 1 \\ 6 & 0 & -3 & 0 \end{bmatrix} \begin{bmatrix} \theta \\ \omega \\ x \\ v \end{bmatrix} + \begin{bmatrix} 0 \\ 0 \\ 0 \\ u(t) \end{bmatrix}$$