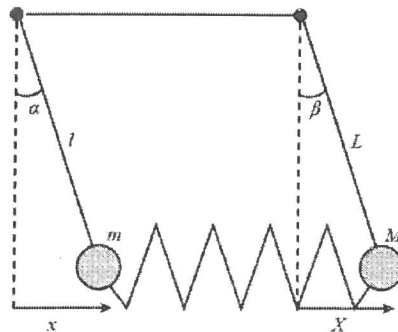


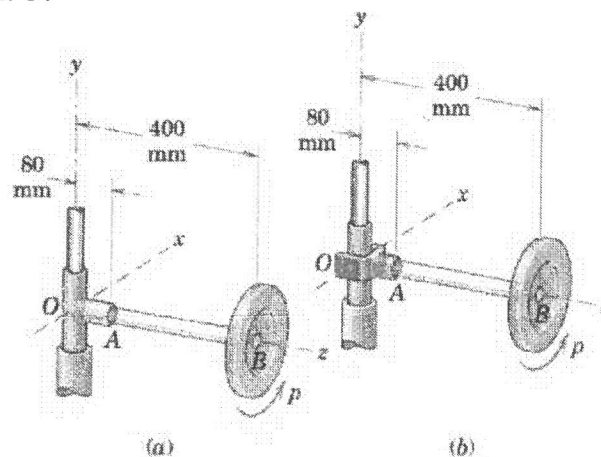
End Sem Examination
Dynamics and Control of Mechanical Systems (ME1406)
Full Marks 30, Time: 3 hrs
IET, JK Lakshmipat University, Jaipur

Note: Use of class notes, books, ebooks, and laptop with internet connection are allowed.

1. Obtain the equations of motion of coupled pendulum (two pendulums connected by a spring) using the Lagrangian method. **(6 Marks)**



2. Each of the identical wheels has a mass of 4 kg and a radius of gyration $k_z = 120$ mm and is mounted on a horizontal shaft AB secured to the vertical shaft at point O . In case (a), the horizontal shaft is fixed to a collar at point O which is free to rotate about a vertical y -axis. In case (b), the shaft is secured by a yoke hinged about the x -axis to the collar. If the wheel has a large angular velocity $p = 3600$ rev/min about its z -axis in the position shown in figure, determine any procession which occurs and the bending moment M_A in the shaft at point A for each case. Neglect the small mass of the shaft and fitting at point O . **(4 + 4 Marks)**

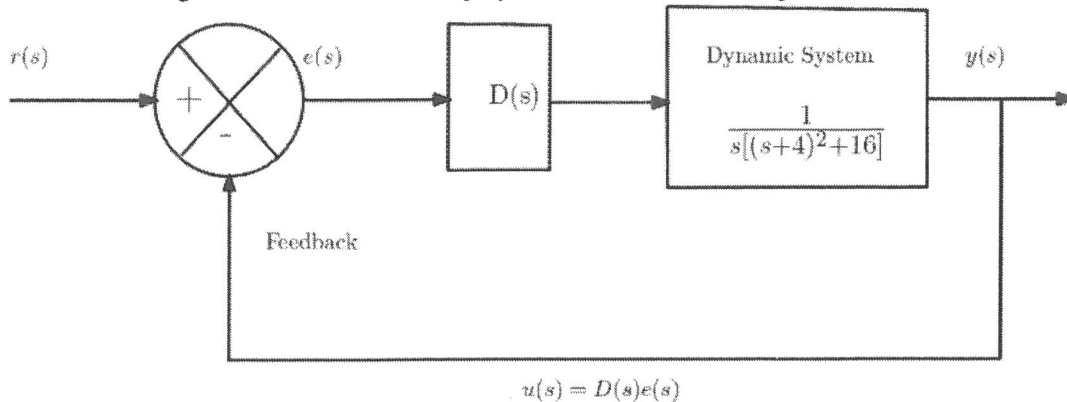


3. The open loop transfer function of a plant given by

(2 × 8 Marks)

$$G(s) = \frac{1}{s[(s+4)^2+16]}$$

The block diagram for the closed-loop system is as shown in figure



In figure, $e(s) = r(s) - y(s)$ and $D(s)$ is the controller. Different controllers are to be designed to meet a requirement on the output $y(s)$.

PID controller:

- For a simple proportional controller, $D(s) = K_p$, plot the root locus of the closed-loop system and obtain value of gain K_p after which the system is unstable.
- Plot the step response of the closed-loop system for $K_p = 100$.
- Design a PID controller such that the steady state error is less than 0.05 and there is no overshoot.
- Show the step response and verify that the PID controller achieves the desired performance.

Controller designed by pole-placement

- Obtain the state space representation for $G(s)$ given above.
- Choose desired poles $s = -4 \pm 2j$ and $s = -15$, design as a dominant second-order system.
- Obtain controller gains $[K_1, K_2, K_3]$, assuming full state feedback and $u = -[K]X$.
- Show step response and verify that the two controller designed using pole placement meets the requirements.

Discuss the results obtained using two-controller design approaches.