

MASSACHUSETTS INSTITUTE OF TECHNOLOGY

Department of Mechanical Engineering

Course 2.05 Kinematics and Dynamics of Mechanisms and Manipulators
Fall 2000

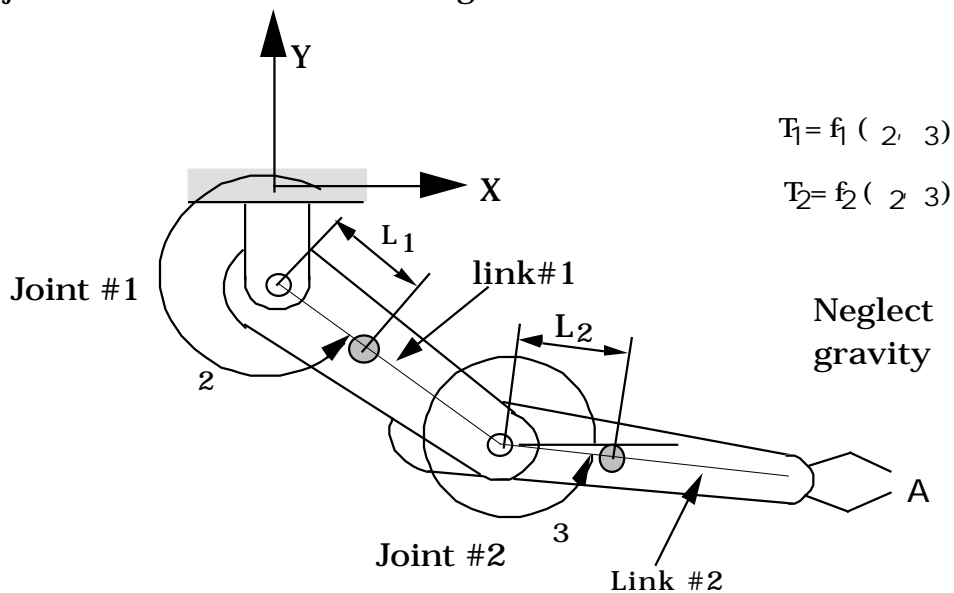
Problem Set No. 8

Assigned: 11/21/00

Due: 11/30/00

Problem 8.1

The device shown below is to be used as the arm on an industrial robot. It is driven by applying torques between the elements, at the connections, as functions of the arm position (θ_2 and θ_3). Note the torque motors are between successive links so only the motor at joint #1 would be mounted to ground.



Link #1 length = L_1

Inertia = J_1

Mass = m_1

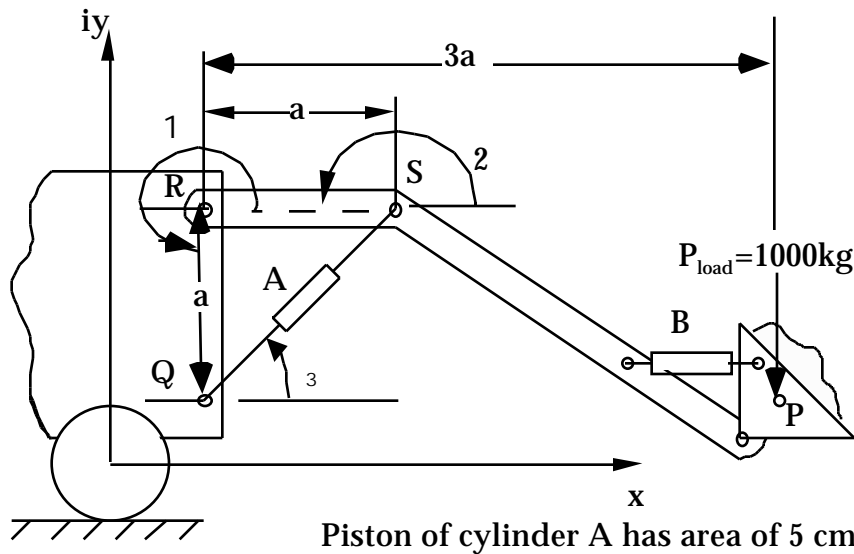
Link #2 Length = L_2

Inertia = J_2

Mass = m_2

- Develop the dynamic equations of the system using Lagrange's Equation. Use θ_2 and θ_3 as your generalized coordinates.
- Discuss the advantages and disadvantages of this method compared to the Newtonian approach.

Problem 8..2



The figure shows a loader on the front end of a tractor. At the instant shown the tractor is stopped and hydraulic cylinder B is locked. (its length is fixed). Cylinder A is increasing its length at the rate of 1 meter per second.

- (a) Using complex variables find the angular velocity of the large arm of the loader in the position shown.
- (b) Find the complex velocity of point P in the X-iY coordinates. Identify the vertical component of V_p .
- (c) Neglecting the weight and mass of all the elements of the system, except the weight of the Load (P_{load}) calculate, using the result of part (b), the pressure required in hydraulic cylinder A in order to raise the load, you may use the units of kg/cm^2 . You may also assume the load is moving at almost constant velocity for the position shown.
- (d) Assume the arm has stopped in the position shown. Under the load of 1000kg, calculate the cylinder force, and the reaction forces (F_x , F_y) at joint R. Does your cylinder force agree with the result obtained in part (c)? If not, explain why.

Problem 8.3

The system shown in Figure below consists of a cam with a rotary follower.

The cam has been designed so that $\theta = A_0 \sin(\omega t)$.

Consider the follower and cam as rigid elements, neglect friction and gravity. The angle, θ , is 0 , when the spring is in its relaxed state. A torque, T , is the input to the system. J_1 and J_2 are the moments of inertia of the cam and follower about their respective axes of rotation.

- Using Lagrang's equations, develop a matrix differential equation which describes the dynamic behavior of this device. Use θ and x as generalized coordinates.
- Outline how this equation could be solved to obtain the time response of $\theta(t)$ and $x(t)$ for a given $T(t)$.

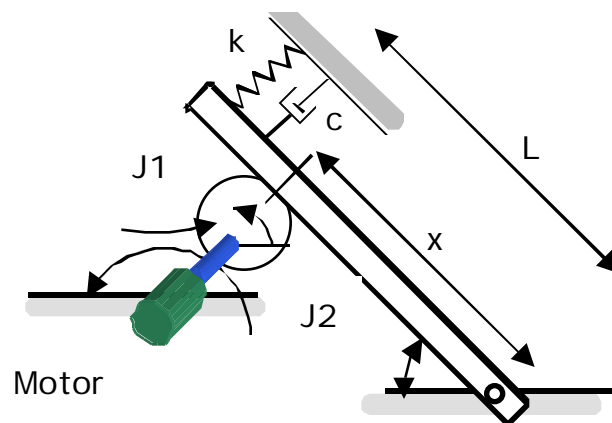
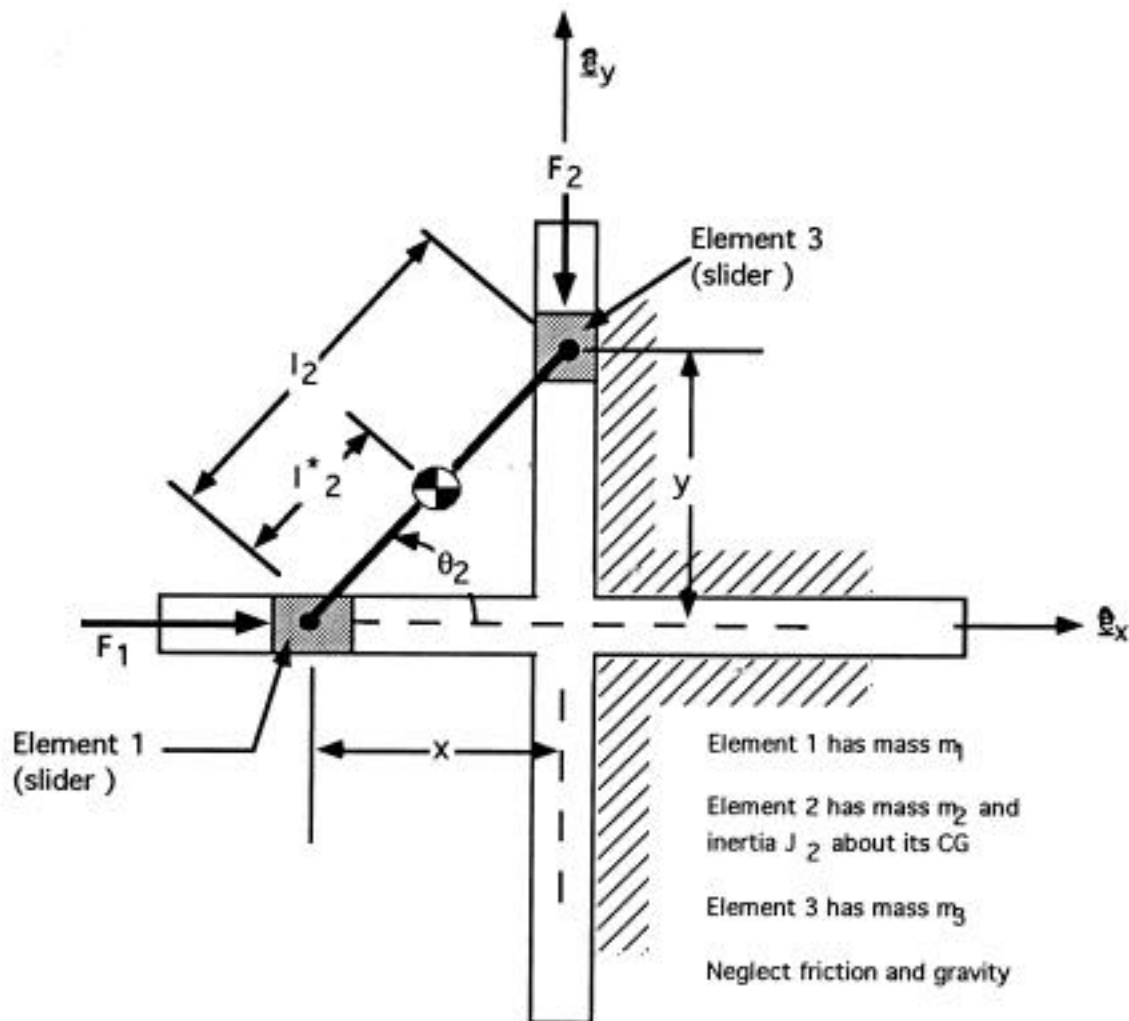


Figure. Cam Follower

Problem 8.4



The mechanism shown below is called an epicyclical linkage. It consists of two slider (elements 1 and 3) traveling in perpendicular tracks and connected by a link (element 2). The link-slider connections are simple pin joints.

Write the equations of motion for this system in matrix form, using a Newtonian approach. Treat F_1 as the input, and assume $F_2 = 0$.

You may neglect gravity and friction in your analysis.

Be sure to:

- draw free-body diagrams.
- Label and identify all variables and parameters.