GEORGIA INSTITUTE OF TECHNOLOGY

The George W. Woodruff
School of Mechanical Engineering

Ph.D. Qualifiers Exam - Spring Quarter 1995

DYNAMICS AND VIBRATIONS
EXAM AREA

Assigned Number **(DO NOT SIGN YOUR NAME)**

-- Please sign your name on the back of this page --

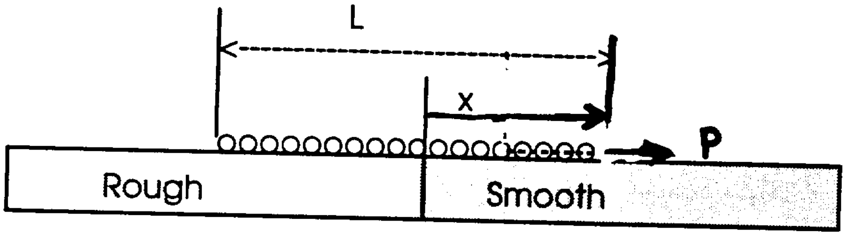
Ph.D Qualifying Exam
Dynamics and Vibrations
Spring 1995

This is a closed-book, closed-notes test. You have two hours to work any 4 of the 5 problems contained in this test. Show all your work and define any coordinate systems that you use. Good Luck!

Problem 1

A heavy chain with a mass ρ per unit length is pulled along a horizontal surface consisting of a smooth section and a rough section by a force whose magnitude is given by $P = \rho L g t$ N. If the chain is initially at rest on the rough surface with $x = 0$ and if the coefficients of static and kinetic friction are μ_s and μ_k respectively, determine position of the center of mass of the chain as a function of time (for $0 < x < L$).

Assume that the chain remains taut throughout the motion and thus moves as a unit.



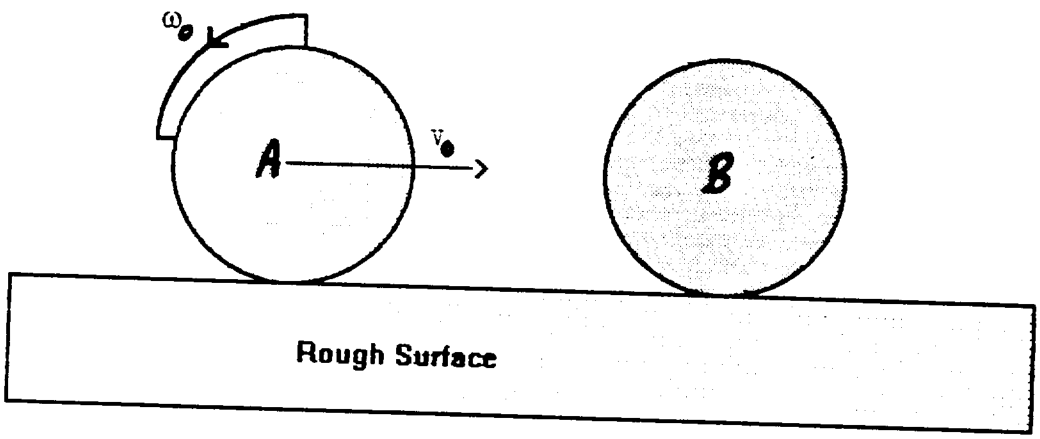
Problem 2

The disk A has a mass m and radius r. It skids along the rough surface. At the instant that its mass center velocity is v_0 and the backspin of the disk is ω_0, it hits squarely an identical disk that is initially at rest. Assume that impact is elastic (i.e. the coefficient of restitution $e = 1$). The coefficient of friction between each sphere and the horizontal surface is μ and between the spheres is negligible.

a) Find the mass center velocity and angular velocity after impact.

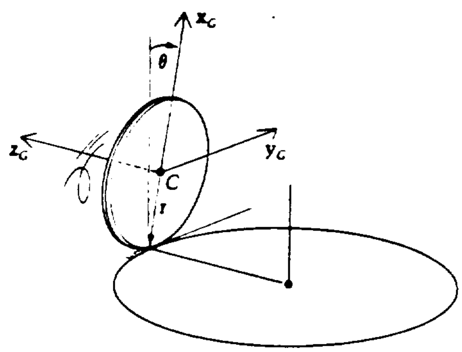
b) Find the mass center velocity of each sphere after it has started rolling uniformly.

c) How would the resulting motion change if the horizontal surface had been smooth?

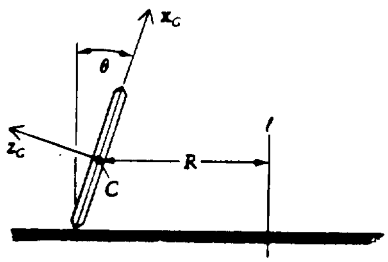


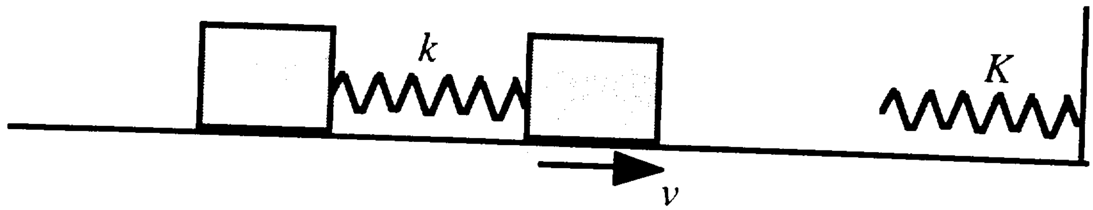
Problem 3

A disk D rolls around in a circle with its plane at a constant angle θ to the vertical and its center travelling at a constant speed v_C. Find the relationship between v_C, g, r, R and θ which allows the disk to undergo this prescribed motion.



(a)





Two masses of mass m, attached by an unstretched spring of length l with spring constant k, slide without friction with velocity v to the right as shown above. At $t=0$ the mass on the right makes contact with the spring K which is secured to an immovable wall.

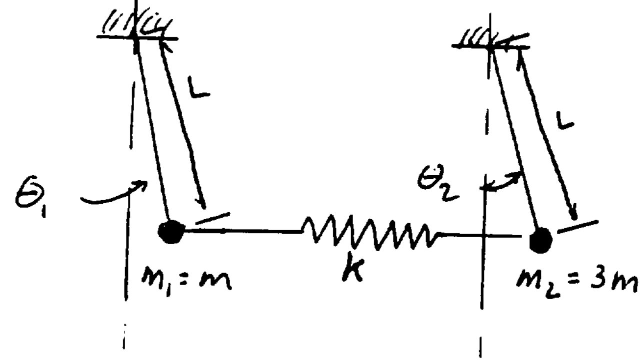
a. Describe the subsequent motion of the system if $k >> K$. (Do not actually solve the equations of motion.)

b. Describe the subsequent motion of the system if $K >> k$. (Do not actually solve the equations of motion.)

c. For $K = 2k$, solve for the motion of the system from $t=0$ to the time, t_c, when the mass loses contact with K,

d. How would one determine t_c? How would one find the motion for $t > t_c$? (Just tell how you would do it, don't actually do it)

Consider system (1) below. Find the natural frequencies and mode shapes.



Consider system (2) below, which is identical to system (1) except for the addition of torsional dampers with the indicated damping constants. Qualitatively, how does this specific damping addition impact the natural frequencies and the natural mode shapes?