GEORGIA INSTITUTE OF TECHNOLOGY

The George W. Woodruff
School of Mechanical Engineering

Ph.D. Qualifiers Exam - Spring Quarter 1996

DYNAMICS & VIBRATIONS

EXAM AREA

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

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

Dynamics and Vibrations Qualifying Exam, Spring, 1996

Work any 3 of the 4 problems. Show all of your work. Clearly state all assumptions.

A typical bicycle is steered by turning the handle bars towards the desired direction of travel. Experimental rear wheel steering bicycles have been tested but are extremely difficult to ride. Often they include compensating linkages so the handle bar motion is similar to a typical bicycle (i.e. turning the handle bars towards the desired direction of travel steers the bicycle in that direction).

Please answer the following questions. Use and state simplifying assumptions that make physical phenomena evident.

a) For a typical bicycle, explain the dynamics of steering.
b) Repeat for a rear steering bicycle. Why are they reported difficult to steer?
c) Consider a bicycle that simultaneously steers the front and rear wheels. Predict the steering dynamics based on the above analyses.

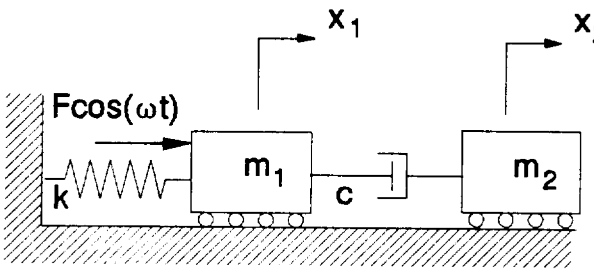
The two-degree-of-freedom system shown below is a linear Lanchester damper. The primary system (k-m_1) is forced with a harmonic excitation, $F(t)=F\cos(\omega t)$. In order to alleviate large-amplitude vibrations of mass 1, a secondary mass-damper system (m_2-c) is attached.

(a) Find the equations of motion for this system and write them in matrix form.

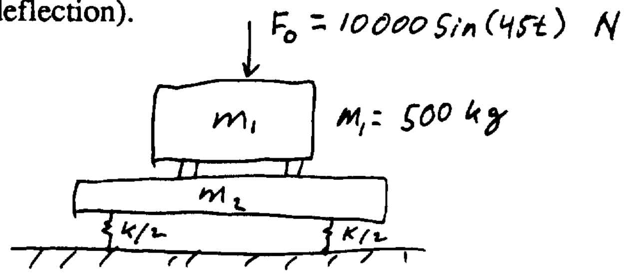
(b) For the following parameter values: $m_1=m_2=1$kg, $k=1$N/m, $c=1$Ns/m, $F=1$N, and $\omega=2$rad/s, find the natural frequencies and natural modes.

(c) For the same parameter values used in part (b), find the steady-state response, $x_1(t)$ and $x_2(t)$ magnitude and phase.

(d) Even if you could not do parts (a)-(c), what qualitative behavior do you expect to see in the forced response as c goes from 0 to infinity?



In vibration isolation applications, a device may sometimes be mounted on what is termed an inertial base. The inertial base increases the overall mass of the system. Isolators are then installed between the base and the foundation. The inertial base is intended to lower the natural frequency of the system, while also limiting the displacement amplitude of the system. For the system depicted below, determine suitable values for the inertial mass *m2* and the isolator stiffness *k* required to satisfy *all* of the indicated constraints (constraint on displacement, constraint on transmissibility ratio, constraint on static deflection).



Transmissibility Ratio < 6%

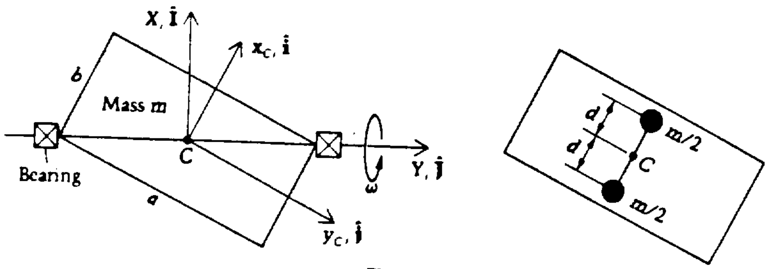
Steady-state displacement amplitude < 0.004 m

Static deflection < 0.1 m

A thin rectangular plate (Figure) is brought up from rest to speed ω_0 about a horizontal axis Y.

a. Find the work that is done.

b. If two concentrated masses of $m/2$ each are added on the x_C axis, one on each side of the mass center, find their distances d from the mass center that will eliminate the bearing reactions.



Figure