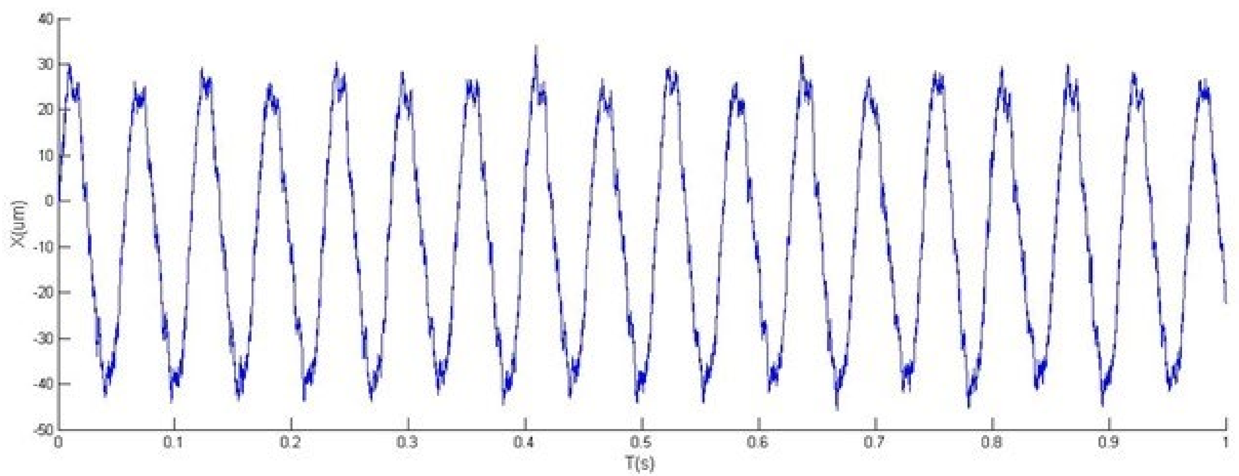
School of Engineering
Brown University

EN40: Dynamics and Vibrations

Homework 5: Vibrations
Due Friday March 25 2022



1. The figure (from this publication) shows a displacement measurement from a test on the vibration characteristics of a magnetic bearing (the units for the displacement are microns).

1.1 The amplitude of the displacement

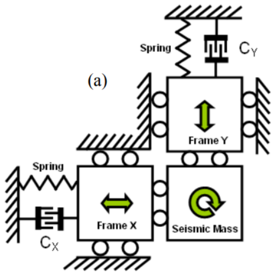
1.2 The period of the vibration

1.3 The frequency (in Hertz) and angular frequency (in rad/s)

1.4 The amplitude of the velocity

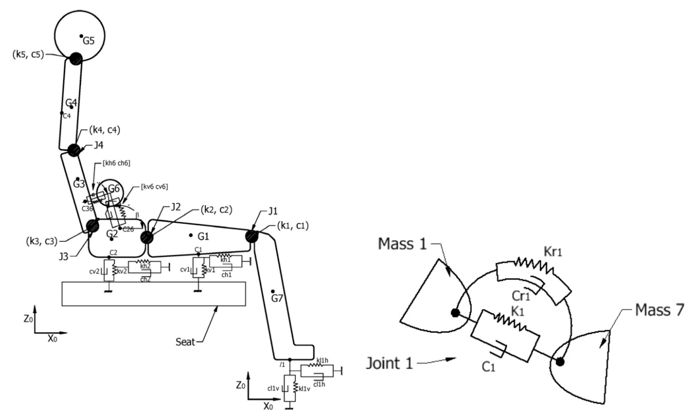
1.5 The amplitude of the acceleration

2. Find the number of degrees of freedom and vibration modes for each of the systems shown in the figures (you may need to consult the publications to understand the system)

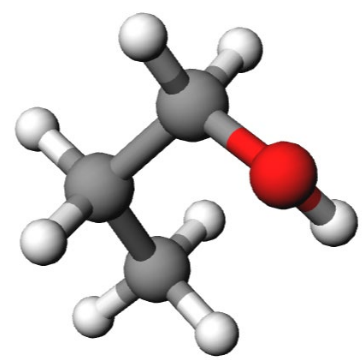


(a) 2D model of an energy harvesting system

(b) Motion simulation platform (the joints connecting the platform to the members beneath it are spherical joints. The rest are all pin joints)



(c) Human body on a seat (masses 1,2,3,4,5 and 7 are rigid bodies; mass 6, representing the viscera, is a particle. Note that the joints are flexible, and permit relative rotation and motion)



(d) 1-Propanol molecule

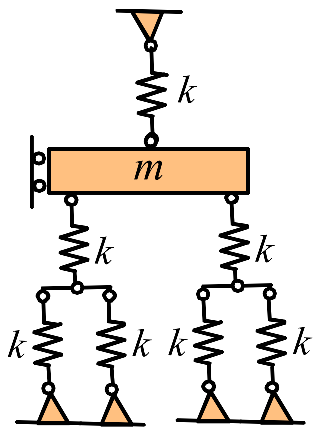
3. Solve the following differential equations (please solve them by hand, using the tabulated solutions to differential equation – you can check the answers with matlab if you like)

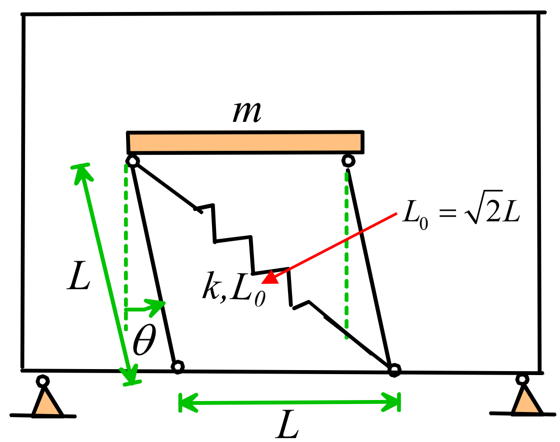
3.1 $\frac{d^2y}{dt^2} + 144y = 24 \qquad y = 1 \qquad \frac{dy}{dt} = 0 \qquad t = 0$

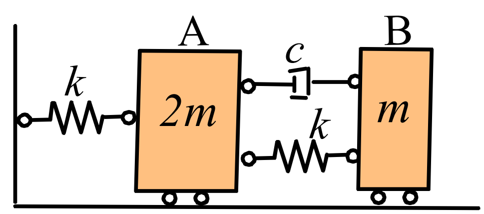
3.2 $\frac{d^2y}{dt^2} + 5\frac{dy}{dt} + 25y = 0 \qquad y = 1 \qquad \frac{dy}{dt} = 0 \qquad t = 0$

3.3 $\frac{d^2y}{dt^2} + 20\frac{dy}{dt} + 100y = 200\sin 10t \qquad y = -2 \qquad \frac{dy}{dt} = 5\sqrt{3} \qquad t = 0$

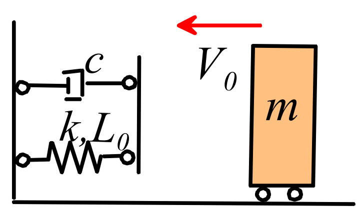
4. Find formulas for the natural frequency of vibration for the systems shown in the figure. For the system on the right, the unstretched length of the spring $L_0 = \sqrt{2}L$







5. When mass A is held fixed and mass B vibrates, the system shown in the figure has natural frequency ω_n and damping factor ζ. Find the natural frequency and damping factor when mass B is held fixed and mass A vibrates.



6. A shock absorber (consisting of a spring and dashpot) is to be designed for installation at the end of a linear conveyor. Its purpose is to bring packages to rest at the end of the moving conveyor. It must meet the following specifications:

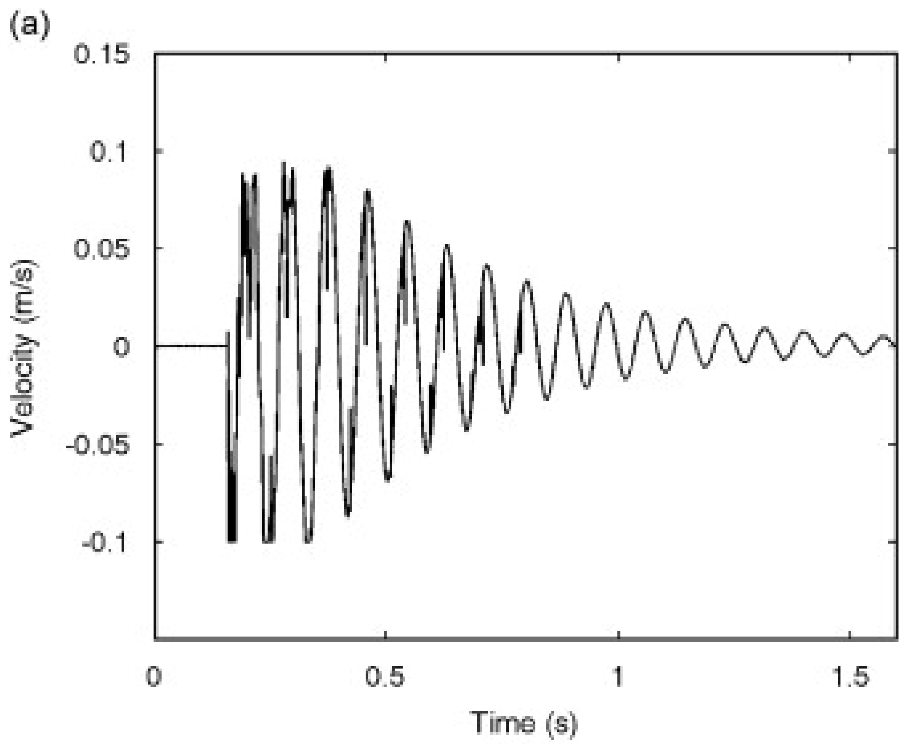
(i) Packages have mass 5kg and strike the shock absorber at speed 2 m/s

(ii) The maximum acceleration of the package must not exceed 2g

(iii) The shock absorber should recover to its stretched length as quickly as possible, and the package should not rebound off the absorber.

6.1 Find the spring stiffness and dashpot coefficient that will meet the specification.

6.2 Find the maximum deflection of the absorber after it is struck, and the time required for the shock absorber's deflection to recover to below 1% of the max deflection.



7. The figure (from this publication) shows the measured velocity at the tip of a cantilever beam as a function of time.

7.1 Find the period and log decrement of the signal

7.2 Hence, calculate the natural frequency and damping factor for the beam.