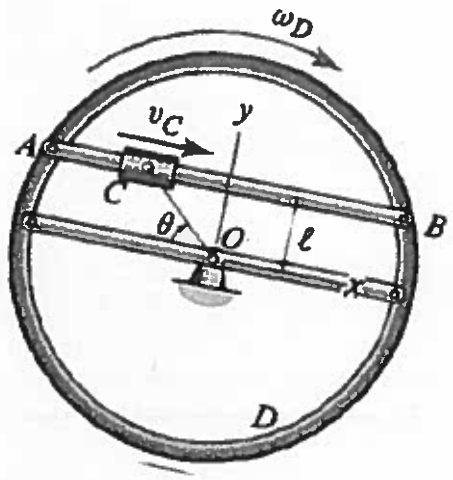
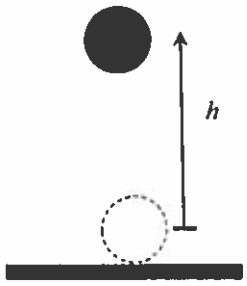
Problem 1

The wheel *D* rotates with a constant angular velocity ω_D = 14 rad/s about the fixed point *O*, which is assumed to be stationary relative to an inertial frame of reference. The *xyz* frame rotates with the wheel. Collar *C* has a mass of 1 slug and slides along the bar *AB* with a constant velocity v_C = 4 ft/s relative to the *xyz* frame. Letting length *l* = 0.25 ft, determine the force acting on C when θ = 25 degrees. Express the result in terms of the *xyz* frame.



Problem 2

An elastic ball of mass m=0.1 Kg is dropped from an initial height of h_0=20 m. Modeling the ball as a mass-spring-damper with stiffness k=10 N/m and damping coefficient c=0.2 N.sec/m, find the height $h(t)$ and plot it vs. t from the moment the ball is released until it reaches its maximum height after it bounces off the ground. For simplicity, you may assume g=10 m/sec^2.



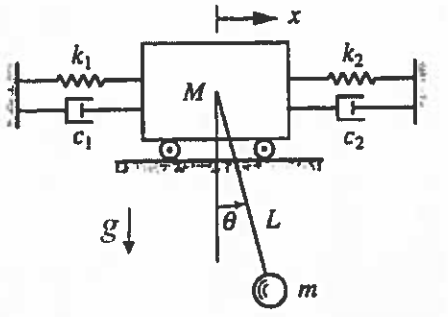
Problem 3

Consider the following 2-DOF system for small oscillations of the pendulum attached to a mass-spring-damper system.

(a) For free vibrations, derive the linearized differential equations of motion and express them in matrix form.

(b) For the undamped case ($c_1 = c_2 = 0$), let $M = m = 2\,\text{kg}$, $k_1 = k_2 = 10\,\text{N/m}$, $L = 0.5\,\text{m}$ (and $g = 9.81\,\text{m/s}^2$), calculate the natural frequencies and mode shapes. Sketch the mode shapes.

(c) For the undamped case ($c_1 = c_2 = 0$), the mass M is to be excited horizontally by the harmonic force $F(t) = 50\cos 10t$ (in Newtons). What should be the length (L) of the pendulum for the forced response of mass M to be zero (i.e. for $x = 0$)?

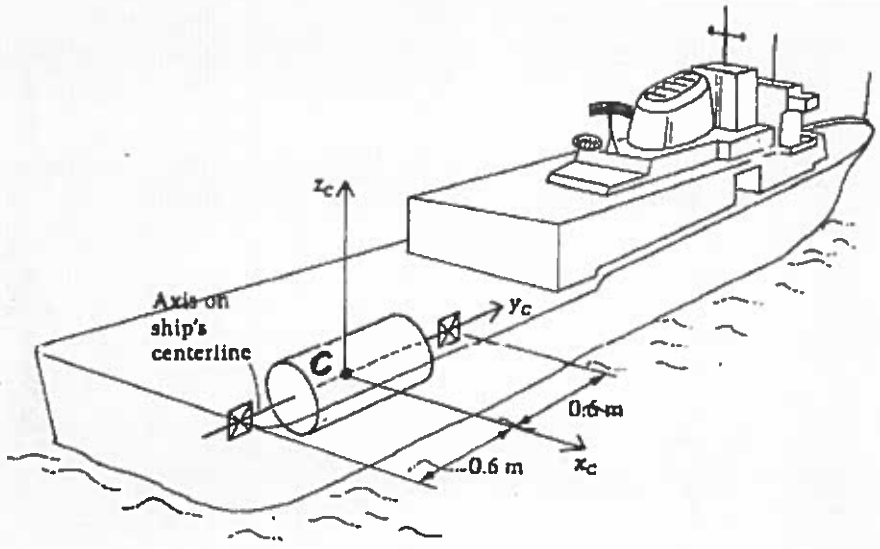


Problem 4

A ship's turbine has a mass of 2500 kg and a radius of gyration about its axis (y_c in Figure ..) of 0.45 m. It is mounted on bearings as indicated and turns at 5000 rpm clockwise when viewed from the stern (rear) of the boat.

a. If the ship is in a steady turn to the right of radius 500 m and is traveling at 15 knots, what are the reactions exerted on the shaft by the bearings? (1 knot = 1.15 mph = 1.85 km/hr)

b. If the ship on a straight course in rough seas pitches sinusoidally at ±12° amplitude with a 6-s period, what are the maximum bearing reactions then?



Hints: (i) pitching: $\theta_x \rightarrow \bar{\omega}_x = \dot{\theta}_x \hat{i}$.

(ii) the bearings can only exert forces.

C: mass center of turbine.