MECH 364: Assignment 3

Requires course text book: Mechanical Vibrations by S.S. Rao (4th Edition). Solutions will appear approximately ten days after the assignment is posted on VISTA.

Q1. Undamped Free Vibration.

(A) (**T 2.1**) An industrial press is mounted on a rubber pad to isolate it from its foundation. If the rubber pad is compressed by 5 mm by the self-weight of the press, find the natural frequency of the system.

(B) (**T 2.3**) A spring-mass system has a natural frequency of 10 Hz. When the spring constant is reduced by 800 N/m, the natural frequency is altered by 45 %. Find the mass and spring constants of the original system.

(C) (**T 2.33**) The crate of mass, 250 kg, hanging from a helicopter can be modelled as shown below. The rotor blades of the helicopter rotate at 300 rpm. Find the diameter of the steel cables such that the natural frequency of vibration of the crate is at least twice the frequency of the rotor blade. Steel has Young's modulus of $E = 210$ GPa. Ignore the mass of the cables. You may find the formula $k = \frac{AE}{L}$ for axial stiffness of a cable useful here.

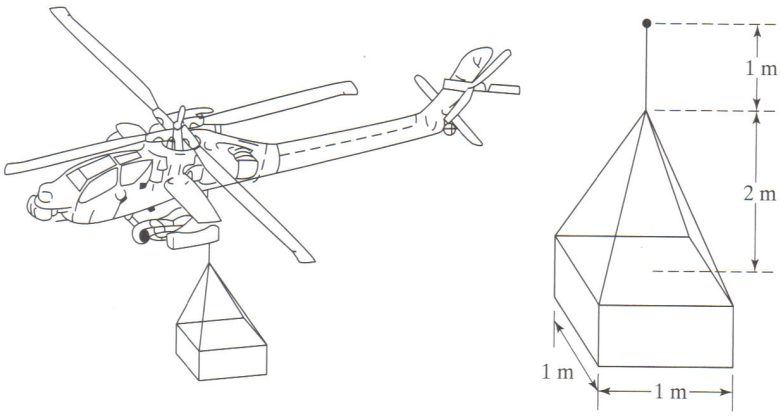


Figure A3.1: Figure for Question 1(C).

Q2. Damped Free Vibration.

(**T 2.89**) The free vibration response of an electric motor of weight 500 N mounted on different types of foundations are shown below. Identify the following in each case: (i) the nature of damping provided by the foundation, and (ii) the undamped and damped natural frequencies of the electric motor.

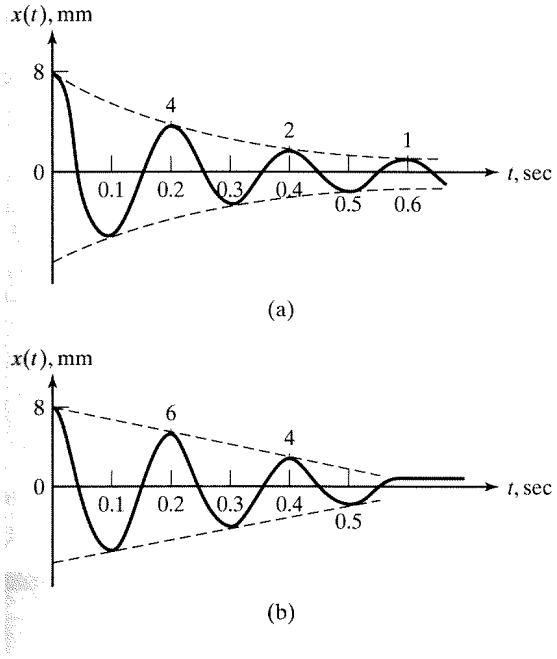


Figure A3.2: Figure for Question 2.

Q3. Undamped Forced Vibration.

(**T 3.6**) Consider a spring-mass system, with $k = 4000N/m$ and $m = 10kg$, subject to a harmonic force $f(t) = 400\cos 30t$ N. Find (and plot, if possible) the total response of the system under the following initial conditions:

(a) x_0=0.1 m; $\dot{x}_0$=0

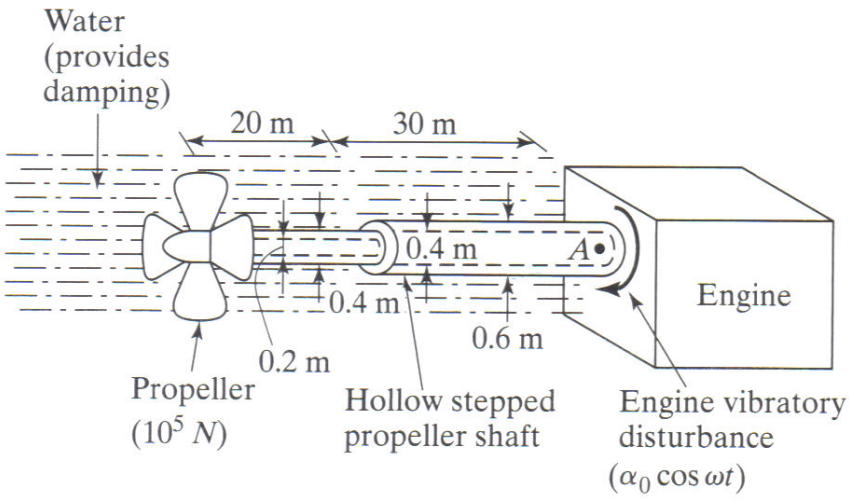
(b) x_0=0 m; $\dot{x}_0$=10 m/s

(c) x_0=0.1 m; $\dot{x}_0$=10 m/s.

Q4. Damped Forced Vibration (Base Excitation).

(**T 3.26**) The propeller of a ship, of weight $10^5 N$ and polar mass moment of inertia 10,000 kg-m^2, is connected to the engine through a hollow stepped steel propeller shaft, as shown below. Assuming that water provides viscous damping ratio of 0.1, determine the torsional vibratory response of the propeller when the engine induces a harmonic angular displacement of $0.05 \sin 314.16t$ rad at the base (point A) of the propeller shaft. You may find the formula $k_\theta = \frac{GI_p}{L}$ for torsional stiffness of a shaft useful here. I_p is polar area moment of inertia which depends on the cross sectional geometry.

(a)



(b)

Figure A3.3: Figure for Question 4.