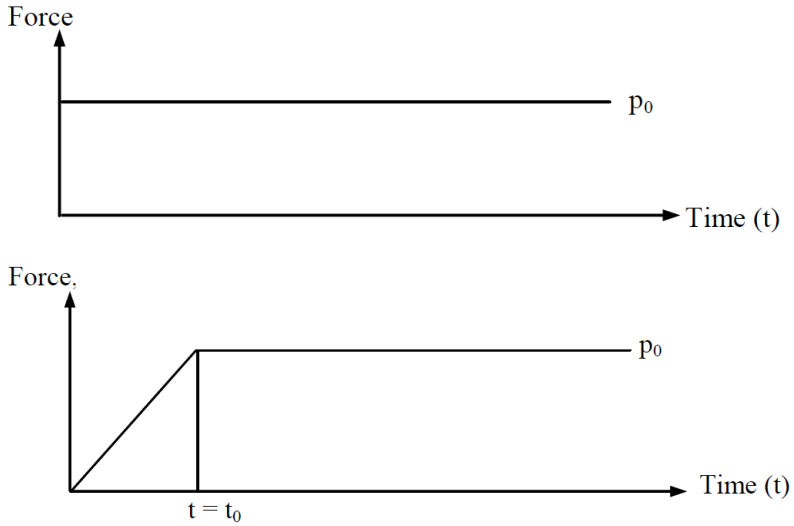
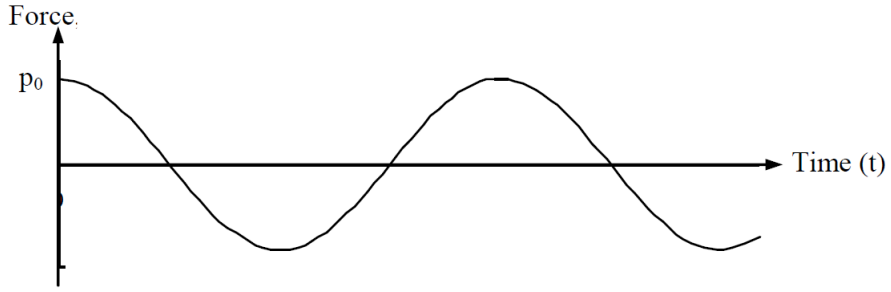
ASSIGNMENT #1
(Due November 6, 2019)

1. An undamped structural system with stiffness (k) = 25 kN/m and mass (m) = 1 kN-sec^2/m is subjected to an initial displacement (u_0) = 0.3 m and an initial velocity (v_0) = 1.2 m/sec. (i) Calculate the natural frequency and natural period of the system. (ii) Plot the free vibration of the system vs. time.

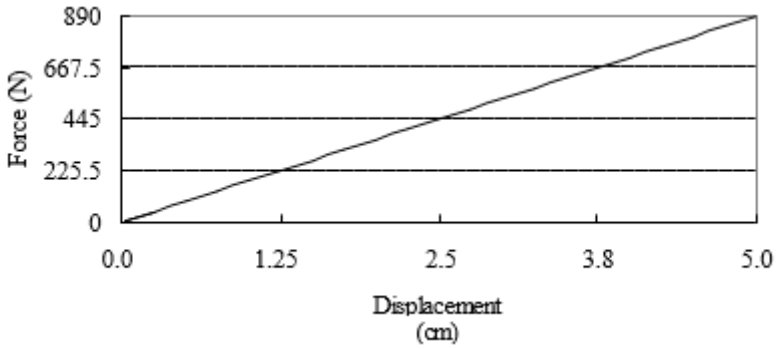
2. A damped structural system with stiffness (k) = 25 kN/m and mass (m) = 1 kN-sec^2/m is subjected to an initial displacement (u_0) = 0.3 m and an initial velocity (v_0) = 1.2 m/sec. Plot the free vibration of the system vs. time if the Damping Ratio (ξ) is
    a. 0.00 (undamped system),
    b. 0.05 (underdamped system),
    c. 0.50 (underdamped system),
    d. 1.00 (critically damped system),
    e. 1.50 (overdamped system).

3. Develop equations of motion for a damped single-degree-of-freedom system for (a) step loading, (b) ramped step function, (c) harmonic loading

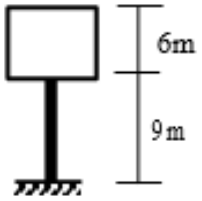




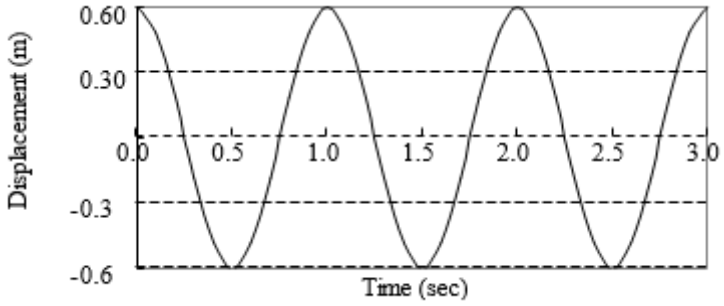
4. For the system mentioned in Questions 1 and 2 (i.e., k = 25 kN/m, m = 1 kN-sec^2/m), plot the displacement vs. time if a static load p_0 = 25 kN is applied on the system and the Damping Ratio (ξ) is
    a. 0.00 (undamped system),
    b. 0.05,
    c. 0.50.
5. For the system mentioned in Question 4, plot the displacement vs. time if a ramped step load with p_0 =25 kN is applied on the system with ξ = 0.00 if t_0 is (a) 0.5 second, (b) 2 seconds.
6. For the system mentioned in previous examples, plot the displacement vs. time if a harmonic load with p_0 = 25 kN is applied on the system with ξ = 0.05 and 0.00, if ω is (a) 2.0, (b) 5.0, (c) 10.0 radian/sec.
7. For the undamped SDOF system (m = 1 kN-sec^2/m, k = 25 kN/m, c = 0 kN-sec/m), calculate the dynamic response for a Ramped Step Loading with p_0 = 25 kN and t_0 = 0.5 sec using numerical integration. Assume a total duration of 2 seconds and use Δt = 0.05 sec in the solution
8. The force vs. displacement relationship of a spring is shown below. If the spring weighs 4.48 N, calculate its natural frequency and natural period of vibration. If the damping ratio of the spring is 5%, calculate its damping.



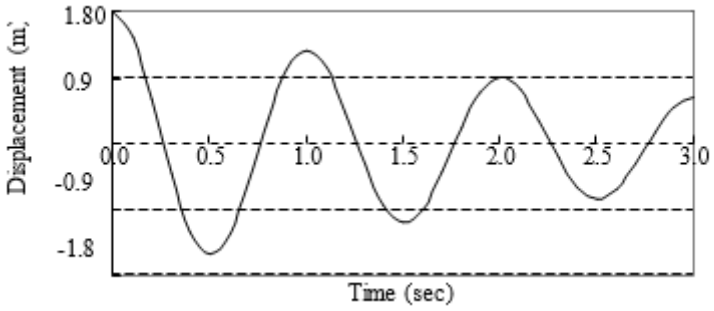
9. For the (6m x 6m x 6m) overhead water tank shown below supported by a 63.5cm x 63.5cm square column, calculate the undamped natural frequency for (i)horizontal vibration (k=3EI/L^3), (ii) vertical vibration (k = EA/L). Assume the total weight of the system to be concentrated in the tank [Given: Modulus of elasticity of concrete = 19152 10^3 kN/m^2, Unit weight of water = 9.817 kN/m^3].



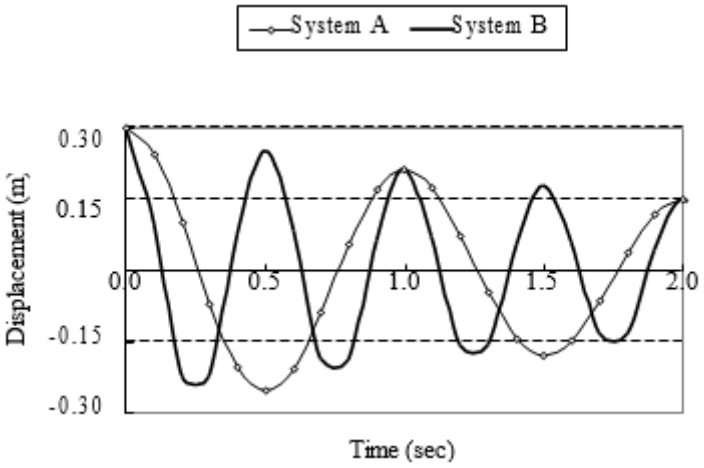
10. The free vibration of an undamped system is shown below. Calculate its (i) undamped natural period, (ii) undamped natural frequency in Hz and radian/second, (iii) stiffness if its mass is 29.76×10^{-3} kN-sec^2/m.



11. If a linear viscous damper 21.82×10^{-3} KN-sec/m is added to the system described in Question 10, calculate its (i) damping ratio, (ii) damped natural period, (ii) free vibration at t = 2 seconds [Initial velocity = 0].
12. The free vibration response of a SDOF system is shown in the figure below. Calculate its (i) damped natural frequency, (ii) damping ratio, (iii) stiffness and damping if its weight is 44.8×10^{-3} kN.



13. The free vibration responses of two underdamped systems (A and B) are shown below. (i) Calculate the undamped natural frequency and damping ratio of system B. (ii) Explain (qualitatively) which one is stiffer and which one is more damped of the two systems.



14. A SDOF system with k = 145 N/m, m = 14.5 N-sec^2/m, c = 0 is subjected to a force (in N) given by (i) p(t) = 222, (ii) p(t) = 445 t, (iii) p(t) = 222 cos(3t). In each case, calculate the displacement (u) of the system at time t = 0.1 seconds, if the initial displacement and velocity are both zero.
15. Calculate the maximum displacement of the water tank described in Problem 9 when subjected to (i) a sustained wind pressure of 1915 kN/m^2 (ii) a harmonic wind pressure of 1915 cos(2t) kN/m^2.
16. An undamped SDOF system suffers resonant vibration when subjected to a harmonic load (i.e., of frequency $\omega = \omega_n$). Of the control measures suggested below, explain which one will minimize the steady-state vibration amplitude. (i) Doubling the structural stiffness, (ii) Doubling the structural stiffness and the mass, (iii) Adding a damper to make the structural damping ratio = 10%.
17. For the system defined in Question 14, calculate u(0.1) in each case using the CAA method.