All Assignments

Use MATLAB wherever possible to work the problem or check your work on a problem. ***Whenever a requested problem asks you to plot or sketch the answer, you must use MATLAB to do your work***. (Remember to annotate each plot appropriately.)

Treat the homework like a quiz! In other words, don't do the homework with the notes open. Instead, study and learn the material as well as you can, and then try to work the homework problems. If you get stuck, cover up the homework, re-read the notes, and try again.

If you work homework as a group, you **must** identify the group*.

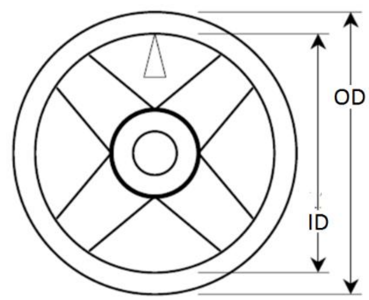
Assignment-4†

- Reading - Lecture Notes
  - Sections #3 & #4
- Reference - *Tse, Morse, & Hinkle*
  - Chapter 3 - Single Degree of Freedom Applications
- Homework

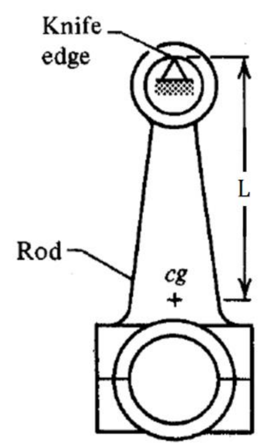
  Note: *solve all problems in the units system given or requested*.

  For the following two problems (4-A & 4-B): solve using Newton's Method, select a set of coordinates, draw the complete two-sided free body diagram, identify any constraint equations, determine the equations of motion, then identify the requested information.

  - **4-A)** A flywheel ($ID = 12\ in$; $OD = 15\ in$) weighing 28.8 lb was allowed to swing as a pendulum about a knife-edge at the inner side of the rim, as shown. If the measured period of oscillation was 1.6 s, determine the moment of inertia ($lb_m \cdot in^2$) of the flywheel about its geometric center.



  - **4-B)** A connecting rod ($L = 300\ mm$) of 2.21 kg mass is suspended on a knife-edge as shown in the adjacent figure. If the period of oscillation is 1.45 s, find the mass moment of inertia J_{cg} ($kg \cdot m^2$) of the rod about it mass center *cg*.



* *Remember that failure to provide proper reference/citation is called* ***plagiarism.***

† Note: *For this* ***and all future assignments****, remember to fully evaluate all numerical expressions. Make sure to retain at least 3 place accuracy.*

- **4-C)** For a one-degree-of-freedom system, if $m = 3.50\ kg$, $k = 13.9\,{}^{kN}\!/_{m}$, $c = 95.1\,{}^{Ns}\!/_{m}$, find:
  a) the damping factor ζ
  b) the logarithmic decrement δ
  c) the ratio of any two consecutive amplitudes

- **4-D)** A vibrating system consists of a mass of $8\ kg$, a spring of stiffness $52\,{}^{N}\!/_{cm}$, and a dashpot[‡] with a damping coefficient of $0.45\,{}^{Ns}\!/_{cm}$. Find:
  a) the damping factor ζ
  b) the logarithmic decrement δ
  c) the ratio of any two consecutive amplitudes.

- **4-E)** A vibrating system has the following constants: $m = 11.4\ kg$, $k = 112\,{}^{N}\!/_{cm}$, and $c = 1.21\,{}^{Ns}\!/_{cm}$. Determine:
  a) the damping factor ζ
  b) the damped natural frequencies (rad/sec & Hz)
  c) the logarithmic decrement δ
  d) the ratio of any two consecutive amplitudes.

- **4-F)** A vibrating system consisting of a mass of $8.6\ kg$ and a spring of stiffness $105\,{}^{N}\!/_{cm}$ is viscously damped such that the amplitude of two consecutive amplitudes is observed to be $6.2\ cm$ and $5.3\ cm$. Determine:
  a) the damped & undamped natural frequencies of the system (rad/sec & Hz)
  b) the logarithmic decrement δ
  c) the damping factor ζ
  d) the damping coefficient

- **4-G)** A damper can be calibrated by measuring the velocity of the plunger when a given force is applied to it. If a $8.41\ lb$ weight produces a constant velocity of $12.4\,{}^{in}\!/_{s}$, and it is then used in a system where a mass of $2.1\ kg$ is attached to the end of a spring with a stiffness of $13.1\,{}^{N}\!/_{cm}$. Determine:
  a) the damping coefficient c for the system (in British units)
  b) the critical damping coefficient c_c for the system (in SI units)
  c) the damping factor ζ of the system

- **4-H)** Find the solution of the homogeneous equation $\ddot{x} + 36x = 0$ for the following initial conditions. Give solutions to initial conditions in terms of damped exponentials as in the notes (*<u>not</u> sines and cosines*). Then identify the system pole, damped natural frequency, undamped natural frequency, and damping ratio. Plot each case (both displacement & velocity) for $0 \le t \le 5s$. *Remember the rules for plotting.*
  a) $x(0) = 4.0\ in$ and $\dot{x}(0) = 0.0\ in/s$
  b) $x(0) = 0.0\ in$ and $\dot{x}(0) = 6.0\ in/s$

- **4-I)** Find the solution of the homogeneous equation $3\ddot{x} + 2\dot{x} + 75x = 0$ for the following initial conditions. Give solutions to initial conditions in terms of damped exponentials (*not sines and cosines*), as in the notes. Then identify the system pole, damped natural

[‡] A type of damper.

frequency, undamped natural frequency, and damping ratio. Lastly, find the log decrement for each of the different initial conditions. Plot each case (both displacement & velocity) for $0 \leq t \leq 8s$. *Remember the rules for plotting.*

a) $x(0) = 2.2\ mm$ and $\dot{x}(0) = \quad 0.0\ mm/s$
b) $x(0) = 0.0\ mm$ and $\dot{x}(0) = -4.8\ mm/s$
c) $x(0) = 2.2\ mm$ and $\dot{x}(0) = -4.8\ mm/s$

- Selected Answers
  - **4-C)** (c) $x_0/x_1 = 4.0$
  - **4-F)** (c) $\zeta = 2.5\%$