1. *Course number and name*

**ENGR 307: Systems Dynamics and Mechanical Vibrations**

1. *Credits and contact hours*

3 credit hours; three 75-minute lecture sessions/week, or two 1-hr-15-minute lecture sessions/week, depending on semester; engineering topic

1. *Instructor’s or course coordinator’s name*

Instructor: M. Azadi, Associate Professor of Mechanical Engineering

Course coordinator: M. Azadi, Associate Professor of Mechanical Engineering

1. *Text book, title, author, and year*

System Dynamics, 4th Edition, By William Palm, ISBN10: 0078140056, ISBN13: 9780078140051, Copyright: 2021

1. *other supplemental materials*

[Rao, S. S. *Mechanical Vibrations.*6th edition, Pearson Prentice Hall, 2016.](https://www.pearson.com/us/higher-education/program/Rao-Mechanical-Vibrations-6th-Edition/PGM173840.html)

[System Dynamics, 4th Edition, Katsuhiko Ogata, Pearson ©2004](https://www.pearson.com/us/higher-education/program/Ogata-System-Dynamics-4th-Edition/PGM257440.html)

[Modern Control Engineering, 5th Edition, Katsuhiko Ogata, Pearson, ©2010](https://www.pearson.com/us/higher-education/program/Ogata-Modern-Control-Engineering-5th-Edition/PGM100186.html)

Control Systems Engineering, 7th Edition: Norman, S. Nise (CSU faculty), Wiley

MATLAB & Simulink, Mathworks, Available to all SFSU student

Interactive Control Systems Tutorial (i.e., Onramps that are available on the web)

1. *Specific course information*
2. *brief description of the content of the course (catalog description*

Modeling and analysis of dynamic systems (particles and rigid bodies) including translational and rotational mechanical systems, fluid systems, and electrical systems. Numerical and analytical solutions of linear algebraic and ordinary differential equations in Time and Laplace domain governing the behavior of single and multiple degree of freedom systems. Discussion of free and forced vibration of mechanical systems, as well as periodic and aperiodic excitation, and vibration isolation. Determination of Natural Frequencies and Mode Shapes. (Plus-minus letter grade only)

1. *prerequisites or co-requisites*

ENGR 205 with a grade of C- or better ; MATH 245 or equivalent. Students are highly encouraged to take the Engr 271 Introduction to MATLAB simultaneously if not taken before.

1. *indicate whether a required, elective, or selected elective course in the program*

Required for Mechanical Engineering

1. *Specific goals for the course*
2. *specific outcomes of* instruction*,*

Students will:

* model, analyze mathematical models, and interpret dynamic systems.
* employ analytical and numerical methods to investigate response and behavior of dynamics systems.
* develop intuition about the time-dependent nature of dynamic systems. become familiarized with MATLAB as related to modelling of linear systems and manipulations of signals.
* demonstrate the ability to determine the linearity, time invariance, causality and stability of systems.
* demonstrate the ability to use time-domain methods of solving differential equations to determine the impulse response.
* demonstrate the ability to determine Laplace transforms and inverse transforms.
* demonstrate the ability to determine Fourier transform as a special form of Laplace transform.
* demonstrate the ability to determine the system transfer function, Bode plots and pole-zero plots.
* Student will become familiar with basic concepts of mass, stiffness, and damping for a single degree of freedom (SDOF) system.
* Students are able to determine the mass and stiffness for a SDOF system using dynamic equilibrium.
* Students are able to generate the free vibration response to an impact load.
* Students are able to generate the steady-state response due to a harmonic load or ground motion.
* determine the transient vibration to Step, impulse, and ramp inputs.
* use dynamic equilibrium to create the differential equation of motion for a simple Multi degree of freedom (MDOF) system, thus determining mass and stiffness matrices.
* obtain modal frequencies and mode shapes.
* obtain steady-state solutions for harmonic loads using modal analysis.
* obtain transient solutions and maximum responses for non-harmonic loads using modal analysis.
* understand the concept of vibration isolation using spring -damper to eliminate excessive vibrations when SDOF systems are subjected to input frequencies at or near resonant frequency.
* select the stiffness and mass for a vibration isolator.

1. *explicitly indicate which of the student outcomes listed in Criterion 3 or any other outcomes are addressed by the course.*

Course addresses ABET Student Outcome(s): 1, 2, 4, 5, 7

1. *Brief list of topics to be covered*

* Introduction to system dynamics
* Time domain presentation of dynamic systems in the form of Ordinary Differential Equations (ODE)
* Review of ODEs and solution of simple 1st and 2nd order ODEs
* Frequency domain presentation of dynamic systems using the Laplace Transform
* Linearization of simple nonlinear dynamic system using Taylor Formula
* Modeling general translational and rotational mechanical systems
* Electrical and electromechanical systems
* Fluid and thermal systems
* Block diagrams, and simulation methods
* Equations of motion for multibody systems using Newton-Euler versus Lagrange
* System analysis in the time domain
* Time response to step impulse for first and second order systems
* System analysis in the frequency domain
* Detailed discussion on modeling vibrational mechanical systems
* Free vibration of single-degree-of-freedom systems
* Harmonically excited vibration and bode plots
* Introducing vibration under general forcing conditions using simulation approach
* Example of two-degree-of-freedom systems
* Example of multi-degree-of-freedom systems
* Determination of natural frequencies and mode shapes