Lecture Module - Introduction

ME3050 - Dynamics Modeling and Controls

Mechanical Engineering

Tennessee Technological University

Module 1 - Introduction

Module 1 - Introduction

- Topic 1 - System Dynamics
- Topic 2 - Units and Conversions
- Topic 3 - Models and Assumptions

Topic 1 - System Dynamics

- Definition of Dynamics
- Modeling and Analysis
- Model Based Design
- Course Topics

Definition of Dynamics

Dynamics is ...

the study of how moving objects behave,

or

an area of mechanics that studies movement and its causes,

or

system dynamics is the study of **modeling** and **analysis** of dynamical systems as a function of time.

Dynamics vs System Dynamics

Dynamics: find state of object at a specific instant in time

System Dynamics: find state of system as a function of time

$\rightarrow$ Leads to use of differential equations. $m\ddot{x} + c\dot{x} + kx = f(t)$

Modeling and Analysis

A mathematical model is a description of a system using mathematical concepts and language. The process of developing a mathematical model is termed mathematical **modeling** ...

... used in the natural sciences and engineering disciplines ... Wikipedia

- Model Simplification
- Force and Loading Analysis with FBDs
- Fundamental Laws Lead to Equations of Motion
- Newton's Second Law and Conservation of Energy

Modeling and Analysis

Analysis is the process of breaking a complex topic or substance into smaller parts in order to gain a better understanding of it...

Wikipedia

- Study Model to find System Response
- Time-Domain analysis: examine system response in time to various inputs and initial conditions
- Frequency-Domain analysis: examine system response when subject to sinusoidal inputs

Model Based Design

Model-Based Design (MBD) is a mathematical and visual method of addressing problems associated with designing complex control, signal processing and communication systems. It is used in many motion control, industrial equipment, aerospace, and automotive applications... Wikipedia

Image: Wikipedia

Image: TH

Image: Wikipedia

Course Topics

Discussion of ME3050 Course topics here

Topic 2 - Units and Conversions

- Standard Units
- Unit Conversions
- Frequency and Circular Frequency
- Example - Units Matter

Standard Units

Quantity	Unit(SI)	Symbol(SI)	Unit(US)	Symbol(US)
time	second	(s)	second	(sec)
length	meter	(m)	foot	(ft)
force	newton	(N)	pound	(lb)
mass	kilogram	(kg)	slug	(?)
energy	joule	(J)	foot-pound	(ft-lb)
power	watt	(W)	?	(ft-lb/sec)
temp.	degrees	$^\circ C$, $^\circ K$	degrees	$^\circ F$, $^\circ R$

When possible work in the *base* units. SI is preferred but engineers must know both systems.

Standard Units

If you are unsure about the units, WRITE THEM OUT!
Unit consistency is required for valid results. One method is to write out the conversion as a fraction and cancel the terms visually.

Example: Find the number of seconds that are in 3 days.

3 Days =

Frequency and Circular Frequency

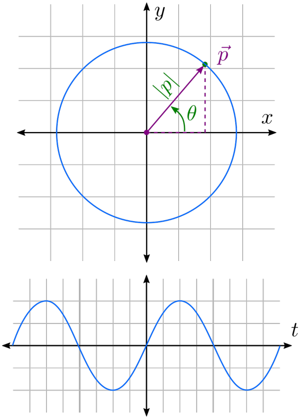
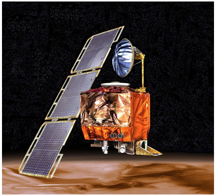


Image: TH

Frequency (Hz) and circular-frequency ($\frac{rad}{s}$) are both commonly used.

You can easily convert from one to the other by multiplying or dividing by 2π.

Example - Units Matter



The Mars Climate Orbiter (formerly the Mars Surveyor '98 Orbiter) was a 638-kilogram (1,407 lb)[1] robotic space probe launched by NASA on December 11, 1998 to study the Martian climate, Martian atmosphere, and surface changes and to act as the communications relay in the Mars Surveyor '98 program for Mars Polar Lander.

Full Story and Images: Wikipedia

Topic 3 - Models and Assumptions

- Mathematical Modeling
- Solid Mechanics and Dynamics
- Thermal and Fluid Systems
- Electrical and Power Systems

Mathematical Modeling

Engineers encounter complex systems and these systems are difficult to model and analyze. Analysis requires multiple steps or processes and modeling requires iteration. Typically, you cannot solve these complex problems in your head alone.

Image: Wikipedia

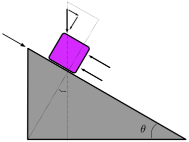
Mathematical Modeling

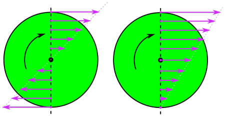
Engineers model and analyze complex systems one piece at a time on a component level.

In system dynamics we study the behavior of complex systems by modeling the iterations and responses of the different components involved. Our models will start simple and build in complexity as the theory is presented.

Solid Mechanics and Dynamics

- Frictionless Sliding ?
- Pure Roll - No Slip
- Planar Motion





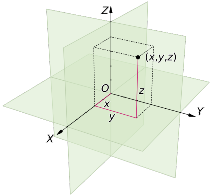


Image: TH

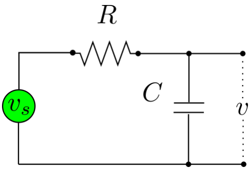
Images: TH, Wikipedia

Thermal and Fluid Systems

- Viscous Boundary Layer
- Insulated or Constant Flux Boundaries
- Others?

Electrical and Power Systems

- No Heat Loss or Generation
- Ideal Conductors
- Zero Order, First Order System Behavior



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