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

System Dynamics
Units and Conversions
Models and Assumptions

Definition of Dynamics
Modeling and Analysis
Model Based Design
Course Topics

Topic 1 - System Dynamics

- Definition of Dynamics

- Modeling and Analysis

- Model Based Design

- Course Topics

System Dynamics
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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.

System Dynamics
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Dynamics vs System Dynamics

Dynamics: find state of <u>object</u> at <u>a specific instant in time</u>

System Dynamics: find state of <u>system</u> as a <u>function of time</u>

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

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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

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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

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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

System Dynamics
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Course Topics

Discussion of ME3050 Course topics here

System Dynamics
Units and Conversions
Models and Assumptions

Standard Units
Frequency and Circular Frequency
Example - Units Matter

Topic 2 - Units and Conversions

- Standard Units

- Unit Conversions

- Frequency and Circular Frequency

- Example - Units Matter

System Dynamics
Units and Conversions
Models and Assumptions

Standard Units
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.

System Dynamics
Units and Conversions
Models and Assumptions

Standard Units
Frequency and Circular Frequency
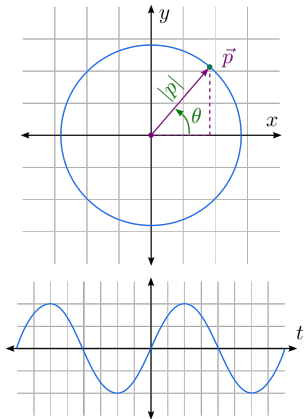Example - Units Matter

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.

<u>Example</u>: Find the number of seconds that are in 3 days.
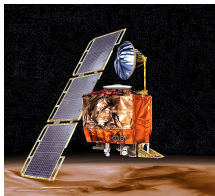
3 Days $=$

System Dynamics
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Standard Units
Frequency and Circular Frequency
Example - Units Matter

Frequency and Circular Frequency

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.

Image: TH

System Dynamics
Units and Conversions
Models and Assumptions

Standard Units
Frequency and Circular Frequency
Example - Units Matter

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

System Dynamics
Units and Conversions
Models and Assumptions

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

Topic 3 – Models and Assumptions

- Mathematical Modeling

- Solid Mechanics and Dynamics

- Thermal and Fluid Systems

- Electrical and Power Systems

System Dynamics
Units and Conversions
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

System Dynamics
Units and Conversions
Models and Assumptions

Mathematical Modeling
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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.

System Dynamics
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Solid Mechanics and Dynamics

- Frictionless Sliding ?

- Pure Roll - No Slip

- Planar Motion
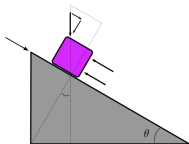
Image: TH

Images: TH, Wikipedia

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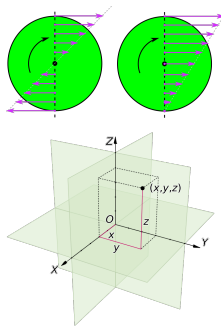
Thermal and Fluid Systems

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

System Dynamics
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Mathematical Modeling
Solid Mechanics and Dynamics
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Electrical and Power Systems

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