# System modeling and simulation (ME340)

Chapter 1. Introduction

1.1 Concept of modeling and simulation

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# before this class...

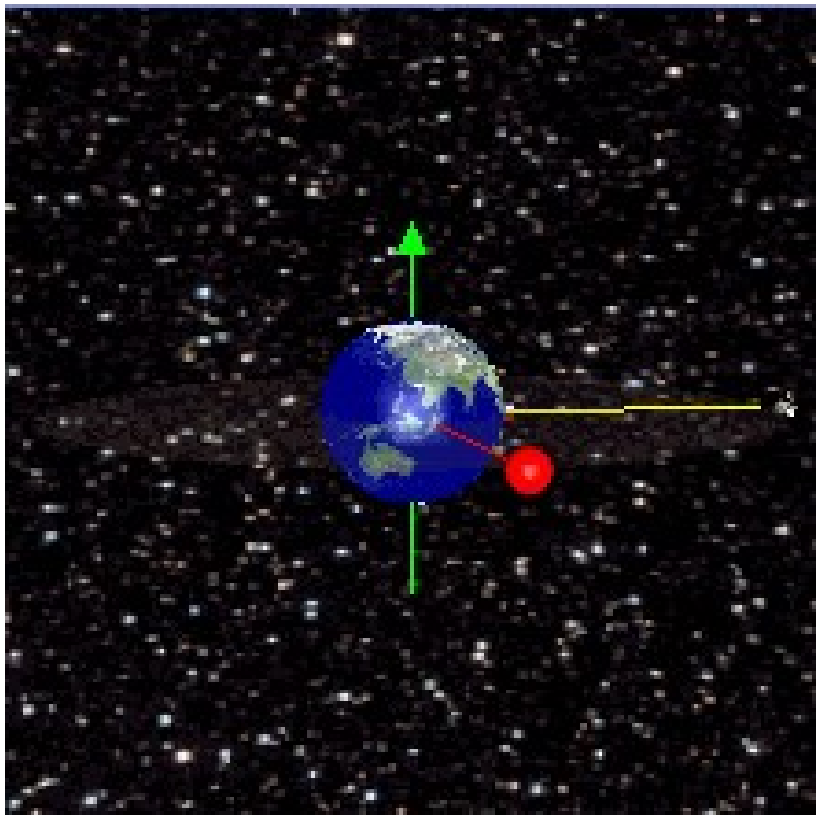
- Course website:

  http://www.nev-dsc.com/me3040-modeling-and-simulation-of-system-system-dynamics-for-undergraduates/

  All the slides will be uploaded here.
- A laptop with Matlab software is suggested.
- Material reading is required.
- More information is available in syllabus.

# System?

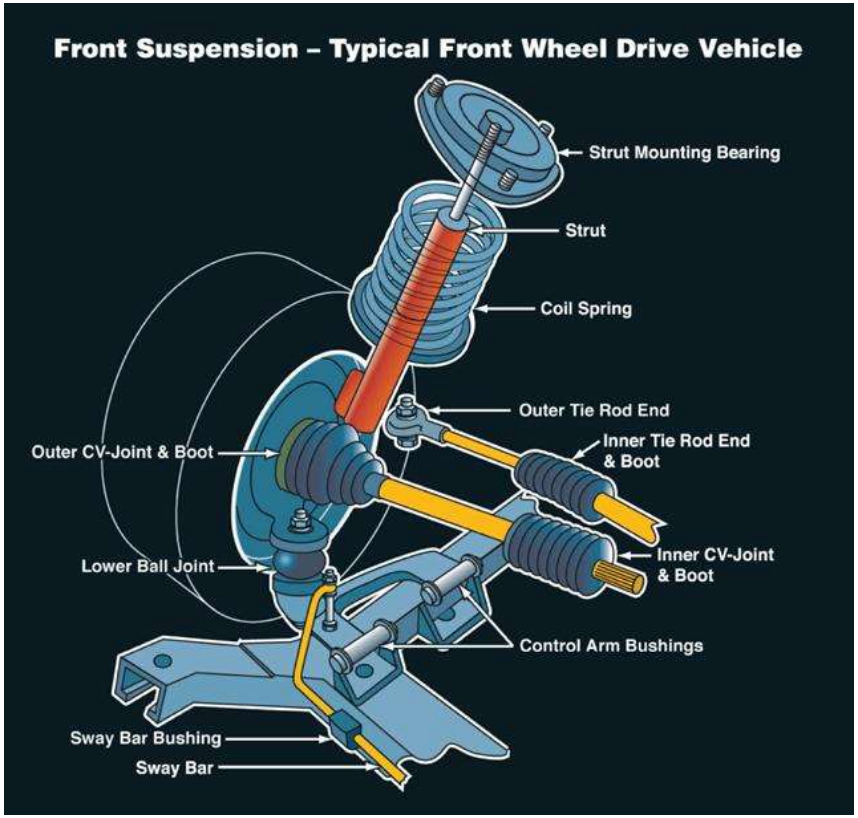
- Always remains in the sky above the earth same area
- How does it work?



Geostationary satellite

# System?

- How  is the vibration introduced ?
- Can we control the vibration to make the passenger feel better?
- What part or property contribute most to the human's feeling?




Car's suspension

# System?

- Many DOFs.
- How does it work if the electric motor rotates at the different speed?

Robot arm

# Compare? Contrast?

- Could we summarize some common characteristic of the above system?

- A kind of combination of components;
- A kind of combination of processes;
- Different physical phenomena;
- Different sizes;
- Different speeds;
- .....

# *System definition*

- Vague due to overuse
- A **system** is a set of interacting or interdependent components forming an integrated whole[1] or a set of elements (often called *'components'* ) and relationships which are different from relationships of the set or its elements to other elements or sets.
- Combination of elements intended to act together to accomplish an objective.

# Example

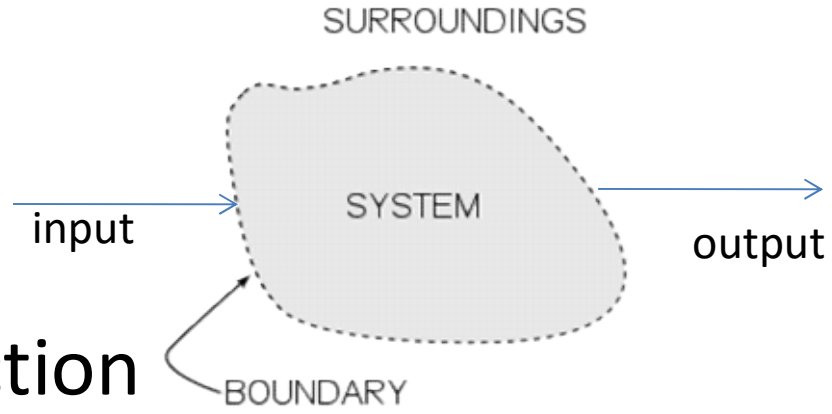
- Bicycle is a system
- Bicycle chain: One link is not system, but a chain is.
- Subsystems
- Interaction between subsystems
- System point of view

# Input and output

- Cause and effect

  Pedal-> Acceleration

  Steering Angle->direction




- System behavior- input-output relationship
- Boundary- Define inside and outside
- Input-output always reversible? Acceleration and velocity?

# Static and dynamic elements

- Static element (Simplification)

  Present output depends on current input

- Dynamic element

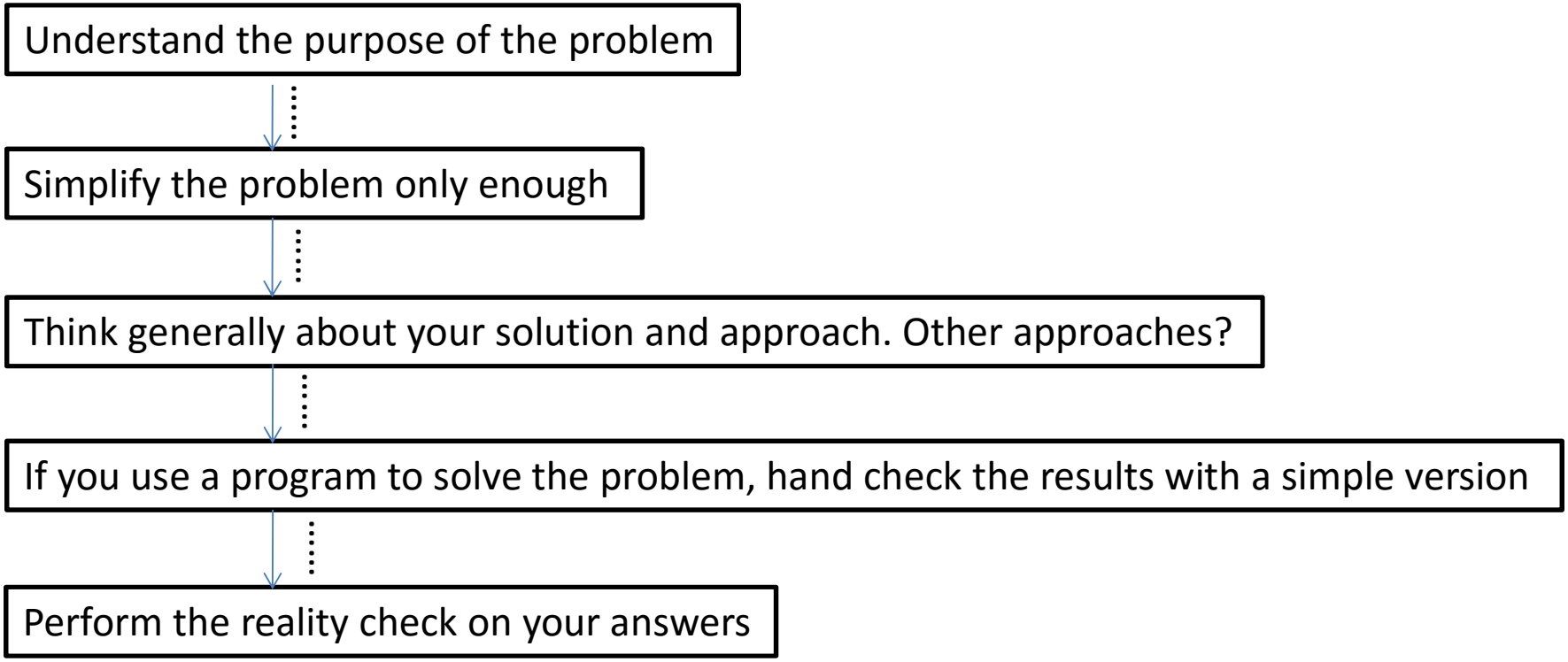
  Present output depends on past input

# Modeling a system

- *Modeling:*

  -Simplifying the problem sufficiently and applying the appropriate fundamental principles
- Mathematical model

# Steps in an engineering problem solving



# Why control involved?

- Often Dynamic systems require a control system
- Why: DYNAMIC
- Without control system, people will afford that task. (bad and unexpected)

# Computer method

- There are different mathematical issues in system modeling and simulation. Many algorithms to solve the different mathematical equations has been developed, such as Matlab.
- This course is Matlab-based.

# Home work 1.1

- Find the system interesting you and try to define the boundary, input and output.

- Describe another example of integral causality and explain why cause-effect relationship is not reversible.

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1.2 Matlab-based modeling case

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# Matlab *.m basic usage

- **a=3;**
- **eps; Inf; NaN;pi;lasterr;lastwarn**
- **A=[1 2 3;4 5 6;7 8 9];**
- **B=[1 2 3;4 5 6;7 8 9]**
- **A=[A;[1,3,4]]**
- **A=0:0.1:6**
- **Structure: .**
- **Cell: {}**
- **C=A*B**
- **C=A.*B**
- **C=fliplr(C)**
- **C=flipud(C)**
- **C=rot90(A)**
- **C=C’**
- **A^2**
- **A.^2**
- **A.^A**
- **a+A**

- A&B;
- A|B
- ~A
- Xor(A,B)
- A>5
- A>B
- find(A=1)
- floor;
- ceil;
- round;
- fix

# Process control function (1)

- for Var=Vect

  Argument

  end

  Example: 1+2+…+100
- If Var

  Argument

  end

# Process control function (2)

```
switch Var
case 1 expression1
argument1
case 2 expression2
argument2
….
Otherwise
argument
end
```

```
try
argument1
catch
argument2
end
```

# function invoke

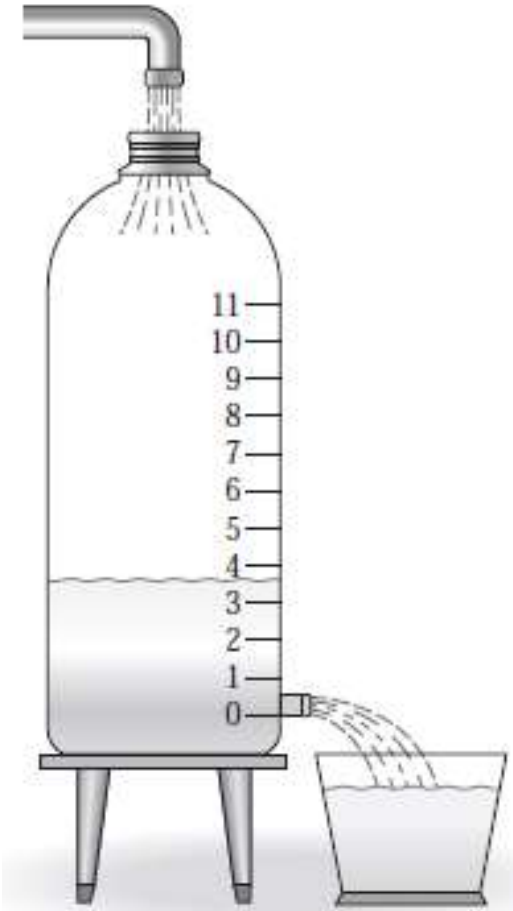
- function [out1, out2]=func(in1,in2,in3)
- nargin—
  自动生成函数内部变量，函数输入量
- Nargout
  返回变量实际个数

# Orifice flow

While adjusting the tap flow to keep the water height constant, the tune for the overflow to fill a 250 ml cup was measured. The data are show as the following table.

Height *h* (cm): 11 10 9 8 7 6 5 4 3 2 1

Time t (s): 7,7.5, 8, 8.5, 9, 9,5, 11, 12, 14, 19, 26



# Temperature dynamics of water

**Problem**:

Water in a glass measuring cup was allowed to cool after being heated to 204°F. The ambient air temperature was 70°F. The measured water temperature at various times is given in the following table.

| Time (sec) | 0 | 120 | 240 | 360 | 480 | 600 |
|---|---|---|---|---|---|---|
| Temperature (°F) | 204 | 191 | 178 | 169 | 160 | 153 |

| Time (sec) | 720 | 840 | 960 | 1080 | 1200 |
|---|---|---|---|---|---|
| Temperature (°F) | 147 | 141 | 137 | 132 | 127 |

Obtain a functional description of the water temperature versus time.

# Home work 1.2

- Reading Chapter 1, especially chapter 1.3-1.6
- Problem 1.39
- Problem 1.41
- Problem 1.43
- Problem 1.48