Unit M1.1
Introduction

<u>Readings</u>:

CDL 1.1, 1.2, 1.3

16.001/002 -- *"Unified Engineering"*
Department of Aeronautics and Astronautics
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LEARNING OBJECTIVES FOR UNIT **M1.1**

Through participation in the lectures, recitations, and work associated with Unit M1.1, it is intended that you will be able to………

- ….**describe** what engineering is about in general
- ….**explain** the basic concepts, limitations, and utility associated with modeling and a model
- ….**describe** a structure, its functions, and associated objectives and tradeoffs
- ….**list** the “Three Great Principles” of solid mechanics

Some Engineering Perspective......

Let's ask the question:

--> "What is Engineering?"

(Lagace) Definition:

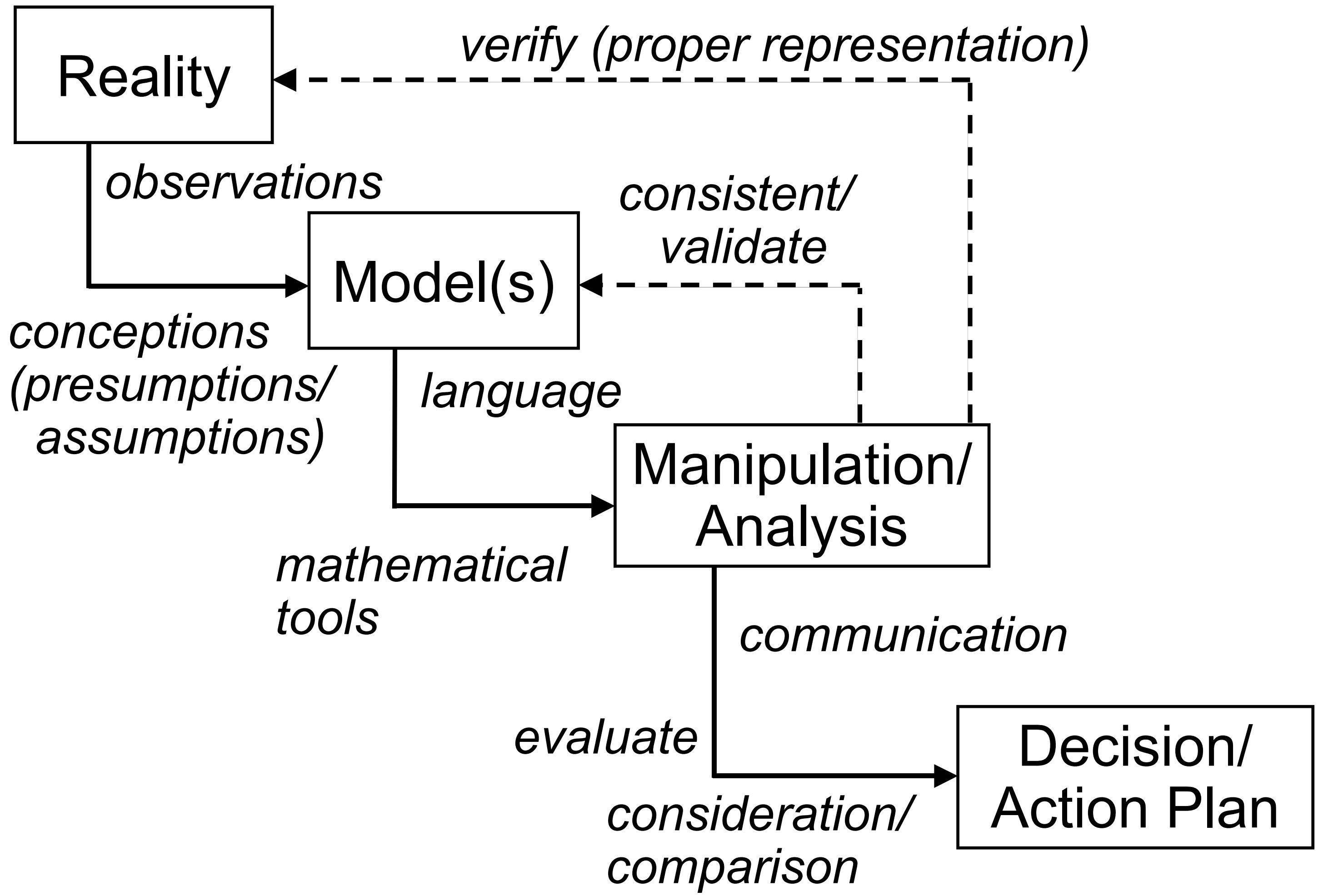
"The application of science, experience, and common sense for the design, manufacture and operation of systems for the betterment of humankind."

--> Three key parts to this

1. Understand science, know history (past experience), develop common sense
2. Know how to apply
3. Understand needs, develop objectives

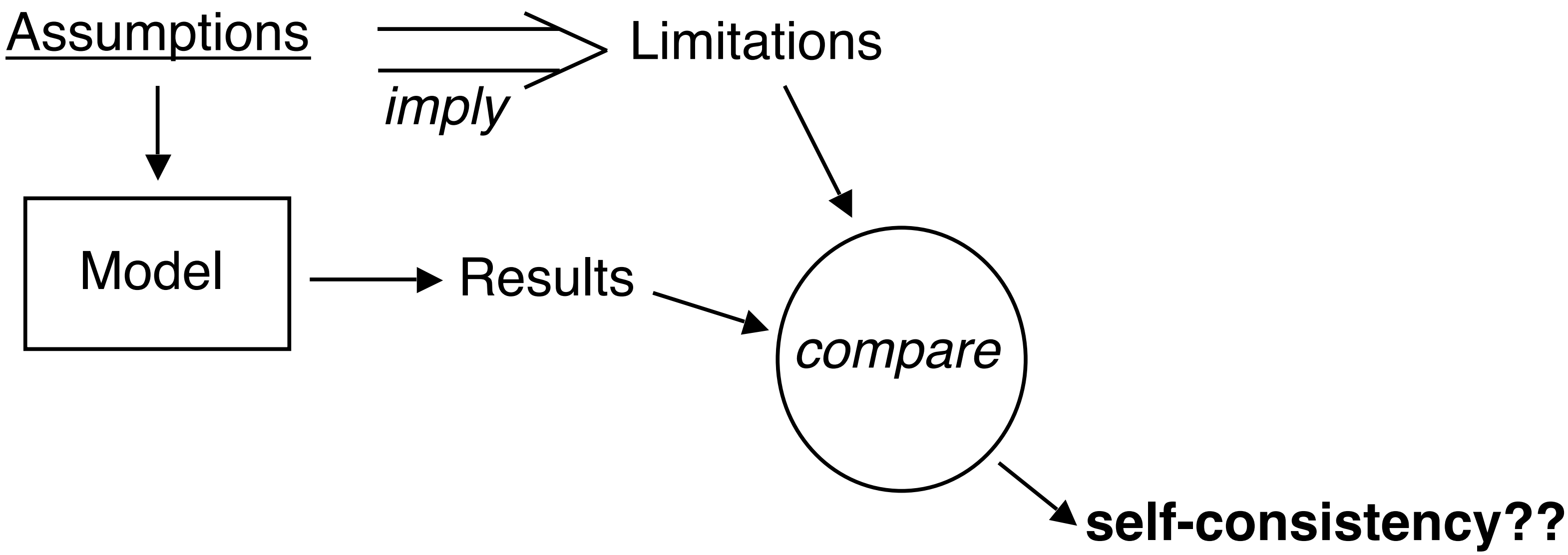
Modeling is a key concept

Figure UM*.1 **A look at the world around us…**



--> In modeling, a key issue is <u>self-consistency</u>

Figure UM.2* The flow of a model and self-consistency



The results must be self-consistent with the assumptions and the implied limitations

Stay within your realm and know what that is!

Move to specific consideration........

"Why study Materials and Structures?"

....what is it all about?

--> objects need some "form"

Definition:

A structure is an item or system of items that holds things together, provides form, and gives integrity.

--> think of examples

Materials are absolutely necessary to build the structure.
Thus, materials and structures are integrally linked in the area of "Structural Engineering"

We thus consider these two aspects as a single discipline

Note: structures with the same purpose may look different if made out of different materials.

--> *why?*

So let's talk about…

Structural Engineering

and its objective:

(Lagace) Definition:

"To devise structures to fulfill their expected mission and to assure ***structural integrity*** throughout their operation while minimizing ***cost***."

Examine the key pieces: "***structural integrity***" and "***cost***"

What is "***structural integrity***"?

--> Depends on operation and form of structure

--> Deals with…

- carrying loads (strength)
- resisting deformation (rigidity)
- having sufficient lifetime (longevity: fatigue, corrosive resistance, etc.)

--> Think about considerations for different structures (especially special considerations)

- house floor
- pool deck
- airplane wing
- satellite antenna support

Now turn to ***<u>cost</u>***…

--> Why is "cost" a/the key??

- where is weight?
- where is safety?

--> <u>The "cost" of weight</u>:

Saving a pound of weight means more

- payload (extra passengers, more satellites, …)
- fuel (longer distance, longer duration via extended station keeping)
- performance (more versatility, speed….generally military)

▪
▪
▪

Amount industries (civilian) are willing to pay to save a pound of weight:

Satellites	\$10k - \$50k (w/o servicing)
Transport Aircraft	\$100 - \$200
General Aircraft	\$25 - \$50
Automobile	almost \$0

Factors in determining cost:

--> The "cost" of safety

Key Question: How safe is safe enough?

Think of:
- Challenger
- DC-10 Sioux City
- Aloha 737
-
- Big Dig
-
-
-

--> Can it ever be 100% safe?

A key decision/point in engineering--lawyers have become critically involved here

Leads to another question…

--> "How right is right enough"

- go back to discussion with models and related assumptions
- never (almost…in real cases) 100% correct

--> to 1%?; to 10%?;…

Depends on need, stage of design, cost to get it that right, etc.

Recall important concept of "Fidelity of model"

A question and issue across all areas of application

--> Need mathematics to deal with models

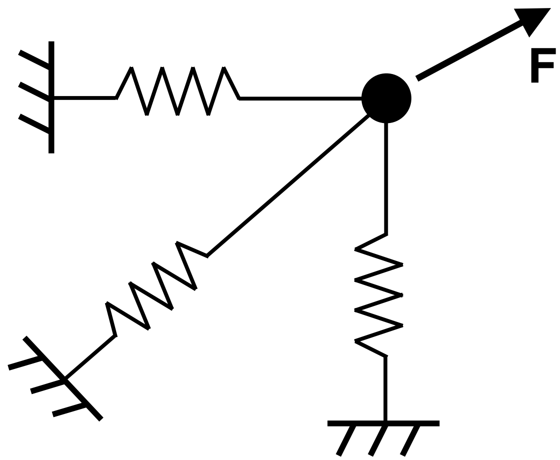
- go to 18.01, 18.02 notes (especially for vectors)
- look at U lectures
- review 8.01 Newtonian mechanics principles

--> During this term we will deal with the…

Three Great Principles of Solid Mechanics

First devise a model of a system that is coherent and quantifiable and captures the essentials of the physics.

Figure M1.1.1 Consider a body under a force attached by three springs



1. Concept of Equilibrium

   Forces must balance

2. Compatibility of Displacement

   Each segment displacement must match at the connection point

3. Constitutive Relations (Force - Deflection)

   How much force is needed to cause a certain deflection (or vice versa)

   e.g., spring: $F = k\delta$