Unified Materials and Structures. Lecture 1

INTRODUCTION TO MATERIALS AND STRUCTURES

Today we are going to have a discussion of why we are studying materials and structures. In particular what the key ideas are that are going to motivate the analytical methods and models that we will learn about in class.

Structure Definition
A structure is a solid object or assembly. A structure connects components, carries loads, provides form and *integrity*.

Think of examples of structures

Structures are made of materials. Examples:

Materials in turn have *microstructures* that dictate how they carry loads and undergo deformation. The selection and development of a particular material is largely driven by structural and system considerations. The choice of material often defines the structural configuration employed.

Examples:
- 1903 Wright Flyer vs. 1943 Mosquito vs. 2003 Boeing 777 or F22
- Wood flagpole vs metal flagpole vs. fiberglass
- Wood beam (solid structure) vs. Steel beam (I-beam)

Thus, materials and structures are integrally linked within the area of Structural Engineering.

Objective of Structural Engineering
"To devise structures to fulfill their expected mission and to assure structural integrity throughout their operation while minimizing cost".

There are two key words/phrases here: Structural Integrity and Cost

What is Structural Integrity?

Depends on operation and form of structure. In general deals with:

1.

2.

3.

Think about considerations for different structures.

- House floor - strength, deformation, cost, appearance, cost of assembly
- Harvard Bridge- deformation, cost, life (salt corrosion)
- Airplane wing -
- Satellite antenna support -

NOTE: Many of the design considerations for different structures are different, but the same techniques and concepts are used to analyze the structures (deformation, strength, longevity)

Second key phrase in objectives of structual engineering: minimizing cost

Why is "cost" the key?

<u>The Cost Of Weight</u>

Saving a kilogram of weight means:

- More payload (passengers, satellites…)
- More fuel (range, duration….)
- Performance (maneuverability….)

Amount industry sectors are willing to pay to save a kg of weight.

Satellites
Combat aircraft
Commercial transport aircraft
General aviation aircraft
Automobile

<u>The cost of safety?</u>

Think of:

- Challenger, Columbia
- DC-10 Sioux City - disk failure
- Air France Concorde
- Aloha 737

Can a system/vehicle ever be 100% safe?. This issue is a key decision point in the engineering of a system. This in turn leads to another question: How right (good) is right (good) enough? How do we know?

- We will develop models to predict structural integrity
- We will make assumptions
- We will do experiments to verify/validate models

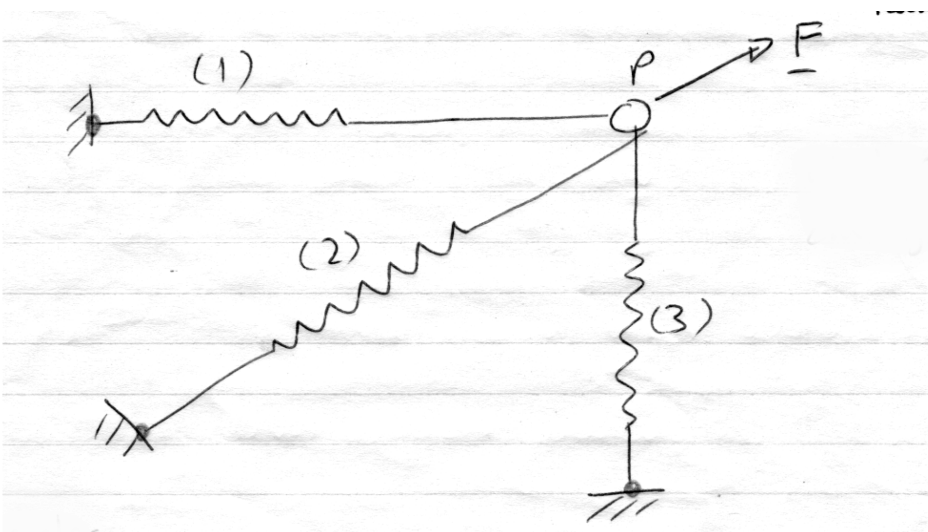
Never, in real cases, 100% correct. Required accuracy depends on many factors
Depends on need, stage of design, cost to get it closer.

Important Concept: "Fidelity of Model"
How good is it? We will ask this question again and again.

So what Engineering Science methods and models do we use to do Structural Engineering?

During Unified we will deal with the principles of SOLID MECHANICS

Illustrative Example Consider a simple "structure" consisting of a particle "P" acted on by a force, restrained by three springs whose deformation is governed by Hooke's Law (forces in spring = $k\delta$)



UNIFIED – MATERIALS AND STRUCTURES

Learning Objectives:

Students graduating from Unified will be able to:
use the one-dimensional idealizations of slender members (i.e. rods, simple beams, simple columns and circular cross-section shafts) **to calculate** stress and deformation states in structures, including trusses, beams and shafts.
apply the basic concepts of material properties and the underlying deformation and failure mechanisms in order to perform materials selection and preliminary sizing of the classes of structure discussed above.
assess the applicability of such idealizations of materials and structures and the errors introduced in their use.

Measurable Outcomes:

Students graduating from Unified will be able to:

- **Explain** the basic considerations of structural design (concept quizzes/quizzes)
- **Explain** the basic assumptions underlying the idealizations of simple beams, columns, trusses, circular cross-section shafts and material properties. (concept quizzes/quizzes)
- **Apply a basic physical intuition** for the function and sizing of structural elements and the selection of materials for use in them. (demonstrations, laboratory work, concept quizzes)
- **Calculate** the two dimensional stress and strain state at a point given three components of stress or strain (problem sets, quizzes, design problems)
- **Calculate** the stress and strain distributions and deformation of simple structural idealizations, such as those listed in part b) (problem sets, quizzes, laboratory work, design problems)
- **Design/specify** an internal structural configuration for simple trusses, beams, columns and shafts in order to meet specifed loading and deformation criteria (design problems)
- **Assess** the conditions under which the idealizations listed in (b) cease to be applicable (design problems, concept quizzes)