Engineering Mechanics

Introduction

General Details

- Instructor Details:
 - Mandar M. Inamdar
 - Diffice: Civil 136, x7314
 - <u>email</u>: minamdar AT civil.iitb.ac.in
 - Office Hours: drop by or write to fix a time
- Course Location and Timings:
 - Slot-8: LH 102
 - Monday: 2-3.30pm
 - Thursday: 2-3.30pm
 - Slot 5: LH 102
 - Wednesday: 9.30-11am
 - One class above will be a tutorial
 - Website: http://www.civil.iitb.ac.in/~minamdar/ce102/

Some Course Policies

- You have a choice between:
 - $\square \ge 80\%$ attendance or DX grade/Grade Penalty.
- Bringing calculator and handout to every class is a <u>must</u>.
- Please keep your cell phones on <u>non-disturbing</u> mode.
- Academic malpractice will not be tolerated.
- General Observations and Guidelines:
 - Please come on (or before) time.
 - I strongly encourage interactions in the class.
 - In case you don't like the class, please sleep or fantasize rather than talk/make noise.

Course Objectives

- What do you expect from this class?
 - good grade, surely
 - what else, truly helpful in the long run

Think

Think: engineering problems Think: most direct ways for engineering problems Think: multiple ways for consistency checks Think: comparative analysis of different methods

clarity and discipline: thinking and expression

Simple but not trivial

Specifically:

- We will predominantly study statics:
 Involve study of methods for quantifying effect of forces between objects such that mechanical equilibrium is maintained.
 - No real world problem is truly static: but many problems can be modeled as static problems in time/length scales of interest.
- Study of interactions and forces: man-made and natural structures
- The concepts and methods: firm grounding for your future courses on solid mechanics, fluid mechanics, kinetics and dynamics of machines.
- This training: prepare you for solving open-ended questions in your profession (design or research).

Mechanics – Introduction

- Mechanics describes and predicts the conditions of rest or motion of bodies under the action of forces.
- Mechanics is the foundation of most engineering
 - Aerospace Engineering
 - Bio Medical Engineering
 - Mechanical Engineering
 - Computer Science Engineering
 - Civil Engineering ...



 Almost everyday, in everybody's life Mechanics play a vital role (knowingly or unknowingly!)

Example: 1 Mechanical Engg.





• Use of statics in Robotics (http://www.societyofrobots.com/

mechanics_statics.shtml)





 The bridge should be capable of being in equilibrium while subject to self-load, wind-load etc

(http://oli.web.cmu.edu)

Example 3 Biomedical Engg.

 Force applying mechanisms are applied to bones for lengthening or removing deformities.



(http://oli.web.cmu.edu)

Example-4 Computer Engg.



 Hard-drives are complex mechanical systems. High magnetic forces are used to swivel recording head to required position. (http://oli.web.cmu.edu)

Example-5 Seismology (natural phenomena)



 Earthquake results because of release of pent-up up energy between two sliding tectonic plates. (http:// oli.web.cmu.edu)

Course Content

- Introduction, Fundamentals of Mechanics (~3hrs)
- Equilibrium of 2D and 3D systems (~6hrs)
- Truss (~3hrs)
- Friction (~4hrs)
- Methods of Virtual Work and Potential Energy (~5hrs)
- Vibration (~3hrs)
- In-class tutorials every week (~10-15hrs)

General Assesment Scheme

| Exam | Weightage | Tentative Date & Time |
|---------|-----------|--------------------------|
| Quiz-1 | 10% | ~last week of Jan. |
| Mid-sem | 30% | ~third week of Feb. |
| Quiz-2 | 10% | ~last week of Mar. |
| End-sem | 50% | ~third week of Apr. |
| | | |

Syllabus for exams will be announced in class

Texts and References

Texts

- Beer, F. P. and E. R. Johnston, *Vector Mechanics for Engineers Statics and Dynamics,* Tata-McGraw-Hill, New Delhi, 8th edition (2007).
- Shames, I. H., *Engineering Mechanics-Statics and Dynamics*, Prentice Hall India Ltd., New Delhi, 4th edition (1996).
- Merriam, J. L. and L. G. Kraige, *Engineering Mechanics Vol-1 & 2,* Wiley India Ltd., New Delhi, 5th edition (2007).
- General Interest
- Bloomfield, L. A., How everything works: making physics out of ordinary, Hoboken: John-Wiley, 2008.
- General illuminating web-site about how many things around us function:

http://www.howstuffworks.com/

YouTube channel <u>Engineering Guy</u>

What is Mechanics?

Main Entry: me·chan·ics 🌒

Pronunciation: \mi-'ka-niks\

Function: noun plural but singular or plural in construction

Date: 1612

- 1 : a branch of physical science that deals with energy and forces and their effect on bodies
- 2: the practical application of mechanics to the design, construction, or operation of machines or tools
- 3 : mechanical or functional details or procedure <the mechanics of the brain>



What's the big deal with E. Mech?

- In principle, like cricket, it's a simple game.
 Simply, force balance and moment balance.
- What is the need for an elaborate course?
 - The basic rules are simple but there are many intricacies. Multi-body interactions can be very complex.
 - A good understanding of fundamentals goes a long way in solving such complex problems.
 - Concepts of appropriate Free Body Diagrams and equations of equilibrium (motion in dynamics) will be indispensable in later studies of mechanical engineering.

Fundamental Principles



 Parallelogram Law



Principle of Transmissibility

Inertia

Newton's First Law of Motion; An object will remain at rest until a force is applied.

Low energy state

Newton's

Laws





Newton's Laws



Systems of Units

- *Kinetic Units*: length, time, mass, and force.
- Three of the kinetic units, referred to as *basic units*, may be defined arbitrarily. The fourth unit, referred to as a *derived unit*, must have a definition compatible with Newton's 2nd Law,
- *International System of Units* (SI): The basic units are length, time, and mass which are arbitrarily defined as the meter (m), second (s), and kilogram (kg). Force is the derived unit,

$$F = ma$$

$$\ln N = \left(1 \, \text{kg}\right) \left(1 \frac{\text{m}}{\text{s}^2}\right)$$

In this course we will predominantly use SI system of units. At times we may use imperial units (length:foot, mass:pound, time:second, force:pounds/kips. Conversion of units can be easily done on your mobile apps of your silent cellphone or at: http://www.onlineconversion.com/

Modeling Real Life Problems

- Any physical/mechanical model is simple a caricature of a real-world problem.
- Such a model is our way of understanding of realworld in as simple and tractable way as possible.
- Allows us to calculate forces/etc., which can then be re-mapped to the real problem.
- The real skill is to remove unwanted flab, and get a bare-bones model, which gives a quick and reasonably accurate solution.

Idealisation of a Real Problem

- First step is modelling. You can only approximate reality.
- All models are wrong, but some models are useful.

Since all models are wrong the scientist cannot obtain a "correct" one by excessive elaboration. On the contrary following William of Occam he should seek an economical description of natural phenomena. Just as the ability to devise simple but evocative models is the signature of the great scientist so overelaboration and overparameterization is often the mark of mediocrity.

-George Box, Journal of American Statistical Association, 1976.

Example-1: Roof Truss





Another Example: Aircraft Landing Gear







Example 4 Simple basket-ball pole





http://oli.web.cmu.edu

Example-5 Ladder Climbing





http://oli.web.cmu.edu

Example-5 Draw-Bridge





Newton's third law on a lighter note



"for every action there is an equal and opposite reaction" and we shouldn't forget the laws of cause and effect, karma or whatever