National Institute of Technology Karnataka, Surathkal

Short Course Sponsored by GIAN (MHRD)

On

An introduction to engineering: Simple ideas – major impact

August 1 – 5, 2016

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Overview

The goal of this course is to introduce students to the power of ideas in engineering. In particular, this course will introduce students to simple ideas, each of which has made a major impact on multiple areas of engineering. The instructor will pose everyday problems and guide discussions that will enable students re-discover ideas that have had a major impact on multiple areas of engineering.

In classroom sessions, the instructor will pose problems, present background material for each topic, raise the key questions, and guide discussions. Between the classroom sessions, the students will solve more complex versions of the problems discussed in the class and prepare for a deeper discussion in the next session.

Objectives

(1) Developing a first-principles and intuitive understanding of some foundational ideas in engineering – *pipelining, feedback, compression, and the law of large numbers* – and illustrations of the dramatic benefits these ideas provide to a broad range of applications.

Each foundational principle will be introduced into the classroom using simple application scenarios. Via guided discussion, the students will identify the key elements of the principle. Homework assignments and in-class hands-on activities will enhance understanding of the principle, including why it provides benefits, how much benefit can it provide, and what are its limitations. Presentations, including topical videos, will be used to illustrate practical impacts.

In addition to imparting the joy and benefits of intuitive understanding of each foundational idea, this course will also clearly illustrate the importance of the rigorous approaches that they will learn in other courses.

(2) Developing an understanding of engineering profession by analyzing major challenges facing society. Students will identify recent media reports that discuss major challenges facing society and identify a short list of challenges they wish to use as case studies to identify suitable project topics. Students (or student teams) will be guided via a process that will include (a) brainstorming to identify the key

challenges that may be addressable by engineering, (b) identifying ideas that will help address these challenges, (c) conducting a first-order analysis of the potential costs and benefits of each idea to identify which ideas should be pursued further, and (d) identifying some of the difficult engineering problems that underlie these ideas.

Students will then select one or two of these ideas as project topics. Each project will require deeper examination of the ideas, prototype implementations, periodic presentations to the class, and final demonstration to all classmates as well as visitors.

(3) Developing an understanding of ethical, political, and societal consequence of engineering. Most case studies discussed in the class will be analyzed in terms of their societal consequences, political challenges, and ethical questions.

Course details

1) **Module-1: Pipelining:** How assembly lines revolutionized manufacturing and pipelining enabled high speed computing
   a) Discussions/lectures
      i) How can we all read *War and Peace* in one week, using only one copy? Efficient computing and manufacturing via *pipelining* and *assembly lines*.
      ii) Efficient assembly and manufacturing: Utilizing workers and equipment by designing sub-assemblies and assembly lines.
      iii) Why pipelining works? How well can it work and how to design optimal pipelines? What are the major costs of pipelining? What are the challenges that make pipelining difficult?
   b) Activities
      i) Everyone in class will read an article about Henry Ford's introduction of assembly lines and its indelible impact on the auto industry and manufacturing – using only one copy of the article! Goal: Understanding the notion of pipelining and deriving first-order properties of linear pipelines.
   c) Media: Automobile assembly line. Goal: Understanding assembly line design considerations – efficiency of manufacturing and beyond, particularly maintaining workers' health and utilizing their ideas for improvements.

2) **Module-2: Feedback and its applications**
   a) Discussions/lectures
      i) Role of *feedback* in engineering systems.
      ii) Imagining a temperature controller that does not use feedback.
      iii) Developing an intuitive understanding of feedback control. In particular, understanding overshoots, undershoots, settling times, P, I, and D.
   b) Activities
      i) Analyzing the performance of a room temperature controller.
      ii) Threading the needle, with full feedback, no feedback, and various types of partial/delayed feedbacks. Goal: To appreciate the benefits of feedback and importance of its precision and timeliness.

3) **Module-3: Compression: Compressing data, music, and video**
   a) Discussions/lectures
      i) Why can we compress text/data files? How do we compress?
      ii) How do we compress music and video?
      iii) Analogy between compression and developing an efficient approach for providing tech support to a large number of customers.
   b) Activities
      i) Compressing a text file using Huffman coding.
      ii) Visual exploration of image compression.
      iii) How to minimize the cost of tech support hotline?

4) **Module-4: The Law of Large Numbers: engineering reasoning in the presence of uncertainty**
   a) Discussions/lectures
      i) Why do we need to model randomness in engineering?
      ii) Do relative frequency counts converge? To what? How fast?
      iii) How does sample size impact the confidence of our conclusions?
      iv) Examples of how we exploit these concepts in the design of wireless communications, data centres, aerospace systems, social networks, political polling, and finance.
   b) Activities
      i) Games of chance.
      ii) Mind reading machines and the "law of averages" – human bias.
      iii) Using computers to model random experiments – Monte Carlo simulation.

Grading

The grading criteria for this course will be determined in conjunction with NITK faculty, *keeping in mind that the purpose of this course is to encourage students explore without the fear of failure*.

Module	**An introduction to engineering: Simple ideas – major impact :** **August 1 – 5, 2016** **Number of participants for the course will be limited to fifty.**
You Should Attend If…	▪ You are a first or a second year student of any engineering discipline. ▪ You are a faculty member teaching in an Engineering College.
Fees	The participation fees for taking the course is as follows: **Participants from abroad : US $500** **Faculty from Academic Institutions: Rs.5000/-** **Students: Rs. 500/-** The above fee includes instructional materials, computer facilities for assignments and internet facility on campus. The participants will be provided with accommodation on payment basis.

The Faculty

Sandeep Gupta received the B.Tech. (Hons.) degree in Electrical Engineering from Indian Institute of Technology, Kharagpur, in 1985 and the M.S. and Ph.D. degrees in Electrical and Computer Engineering from the University of Massachusetts, Amherst, in 1989 and 1991, respectively.

Sandeep Gupta is a Professor and Chair of the Department of Electrical Engineering-Systems, University of Southern California. He is the author (with N. Jha) of Testing of Digital Systems (Cambridge University Press, 2004). His research interests are in the areas of very large scale integration design, test, and validation; defect- and error-tolerance; and analysis of network protocols.

He has received the National Science Foundation's Research Initiation Award in 1992 and the CAREER Award in 1995. He also received the Northrop Grumman Assistant Professorship in 1995 and the Zumberge Fellowship in 1996 at the University of Southern California. He received the Honorable Mention Award from the International Test Conference in 1997 and the Best Paper Award from Asian Test Symposium in 2000. He was also a distinguished Lecturer for the IEEE CAS Society from 2005 to 2006.

M. S. Bhat is a Professor in the Department of Electronics and Communication Engineering, National Institute of Technology, Karnataka, Surathkal. His research interests are in the domains of Computer Architecture, Analog, Digital and Mixed Signal Design, Semiconductor Device Physics and DSP.

Course Co-ordinator

Dr. M. S. Bhat
Professor, Department of E&C Engg., NITK
Surathkal - 575025
Phone: +91-824-3507
+91-9448887426
E-mail: **msb@nitk.ac.in,**
msbhat@ieee.org