IIT TIRUPATI, 2023
ME308M, System Dynamics and Control

Welcome to my course on **System Dynamics and Control**. In this course, we are going to model and analyze the **dynamics** of mechanical engineering systems, and then use that information to design mechanisms that **control** their behavior.

A general engineering system may be visualized as a mathematical object that takes an input $u(t)$ and produces an output $y(t)$ (refer to Figure 1 for an illustration), where the argument t denotes time. The system itself may be mathematically described in the form of an algebraic or differential equation $f(t, u, y) = 0$.

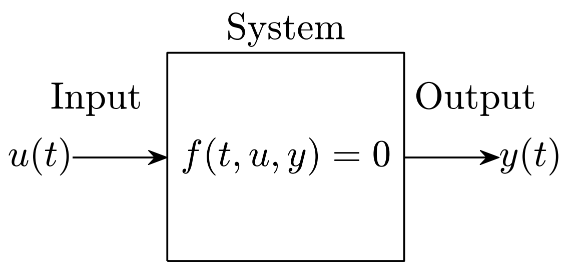

Figure 1: An abstract depiction of a physical system with input $u(t)$ and output $y(t)$.

Two important questions that arise about such a system are:

1. How may we predict the behavior of the system for a given input (the question of *dynamics*)? That is, what may we say about $y(t)$ if we knew $u(t)$?

2. How may we design the input so that the system behaves in a desired way (the *control* problem)? That is, what $u(t)$ do we feed in order to obtain a desired $y(t)$?

The answers to the above two questions are fundamental to understanding and building automatic systems such as robots, unmanned spacecraft, self-driving vehicles etc, and form the subject matter of the important engineering field of Controls. The present course is a first step in that direction.

Specifically, we shall look at
1. The mathematical modelling of engineering systems;
2. The characteristic properties of systems;
3. Linearization of real systems;
4. Linear Time-invariant (LTI) systems and their properties;
5. Time-domain and frequency-domain analysis of system dynamics;
6. Equilibrium and stability of dynamical systems;
7. Feedback and its effects on system stability and performance;
8. Design of controllers using negative feedback;
9. PID control of systems.

At the end of this course, students are expected to be able to
1. Mathematically model simple systems and linearize them;
2. Analyze the stability and dynamics of LTI systems;
3. Apply negative feedback to design simple controllers for LTI systems.

Lectures are during the **E slot** period on Monday (11:00 to 12:00 hrs), Wednesday (10:00 to 11:00 hrs), and Friday (09:00 to 10:00 hrs), at Classroom 4, in Department Building 2. Laboratory work is scheduled in the **P1 slot** on Monday (15:00 to 18:00 hrs) at the Applied Mechanics Laboratory in Lab1. I will be available for office hours on Mondays from 14:00 to 15:00 hrs in the Administration Block (old E Block) Room number 109.

We have two **Teaching Assistants** assigned for this course: Mr. Mukund S. (me21m006@iittp.ac.in) and Mr. Manish Kaushik (me21m005@iittp.ac.in). They will assist me and you with respect to lectures, practicals, and exams. They will usually be your first point of contact for any logistical issues.

Your **final grades** in the course shall be computed as follows:

- 25% for Homework.
- 25% for Laboratory work (attendance and reports).
- 20% for Test 1.
- 30% for the final end-semester exam.

All homework assignments and solutions shall be posted on the course's Google classroom website.

I shall be using the following **textbooks** for this course:

1. R. C. Dorf and R. H. Bishop, *Modern Control Systems*, 12th edition, Pearson, 2014.
2. K. Ogata, *Modern Control Engineering*, 5th edition, Pearson, 2017.

Besides the above, you may find the following references useful:

1. J. P. Hespanha, *Linear Systems Theory*, 2nd edition, Princeton University Press, 2018.
2. A. V. Oppenheim, A. S. Willsky, *Signals and Systems*, 2nd edition, Pearson, 2015.

And lastly, I expect all students to follow the student honour code, and abide by the Institute's academic honesty policy. Incidents of cheating and malpractice shall be reported to the Dean, and appropriate actions taken. That being said, I do not expect to have to resort to the above punitive measures in this class.