Material Given in Modern Control
Material Given in First Lecture

1. Method followed in classical control:
   a. Differential equations
   b. Laplace transforms
   c. Laplace of input
   d. Laplace of output = product of band
   e. Inverse Laplace transform of d gives output.

2. Classical control assumes:
   - Single input and single output (SISO).
   - Linearity
   - Time invariance (i.e., parameters do not change in time).

   The classical control method also employs the Laplace transform.

3. To address these issues, we use modern control. In state space modeling, the following is true:
   - Multiple input multiple output (MIMO).
   - Non-linearity
   - Time variant system (e.g., changing mass).

   The state space model keeps the relationships in the time domain format.
4 When we try to model a system that can be described by a \( n \)th order differential equation, the order of the system is \( n \). The state space model converts the \( n \)th order differential equation into \( n \) first order differential equations. For example, a 2nd order system will have 2 equations, each of 1st order.

5 In order to describe the "state" of the system at any point in time, we use a vector \( x \) of dimension \( n \), that fully describes the status of the system.

\[
x = \begin{bmatrix}
x_1 \\
x_2 \\
\vdots \\
x_n
\end{bmatrix}
\]

The order of \( x \) is \( n \), which is the order of the system.

6 The concept of state is similar to describing the state of a student by using for example 3 parameters: happiness (1-10); satisfaction/hunger: (1-10); rested/hired (1-10). These three parameters fully describe the status of the student at any point in time. From the state we can for example judge how well he can understand the lecture out:

\[
y(t) = c_1 x_1(t) + c_2 x_2(t) + c_3 x_3(t)
\]
7. Fully present model with A, B, C and D.

8. Dimensions:

\[ n \rightarrow n \times n \quad n \times i \]

\[ j \rightarrow j \times n \quad j \times i \]

9. Also note that thick lines denote vectors.

10. The output of every integrator holds a state variable.

\[ v(t) = -\frac{1}{RC} \int v_i(\tau) d\tau \]

11. Then solve the mass spring damper using two methods:

   **Method I**: Write differential equations and then separate \( x \) on LHS and \( x \) and \( u \) on RHS.

   **Method II**: Draw block diagram. Then relate input and outputs of all blocks with
Laplace operators (e.g., \( \frac{x(t)}{x_{2s}(s)} = \frac{1}{s+3} \)).

Then find inverse Laplace transforms.