

## Module 3 - Newton's Approach

ME3050 - Dynamics Modeling and Controls

Mechanical Engineering

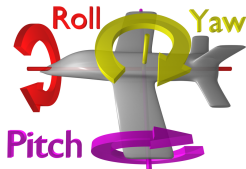
Tennessee Technological University

### Topic 2 - Equations of Motion

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- Modeling Rigid Body Mechanical Systems
- Derive Equations of Motion
- Newton's Second Law Approach
- Conervation of Energy Method

# Modeling Rigid Body Mechanical Systems



*When modeling the motion of objects, the bending or twisting of the object is often negligible, and we can model the object as a rigid body. We begin this chapter by reviewing Newton's laws of motion and applying them to rigid bodies where the object's motion is relatively uncomplicated, simple translations and simple rotations about a fixed axis.* System Dynamics, Third Edition, Palm - Pg. 117

## Derive Equations of Motion

To analyze the dynamics (motion and forces) of a system we start by deriving the **equations of motion** (EOM). This is typically done in one of two ways.



The \_\_\_\_\_ are  
\_\_\_\_\_describing the dynamic  
relationships between the bodies in the system.

## Newton's Second Law Approach

To derive the equations of motion with Newton's Second Law:

- 1 Draw a **free body diagram** (FBD) for each body in the system.  
Identify all forces acting on the bodies in the system.
- 2 Apply Newton's Second Law for each **DOF**.

Translation:  $\Sigma \mathbf{F} = m\mathbf{a}$      $\Sigma F_x = ma_x$   
 $\Sigma F_y = ma_y$   
 $\Sigma F_z = ma_z$

Rotation:  $\Sigma \mathbf{M} = I_o \alpha$      $\Sigma M_o = I_o \alpha_z$

## Conservation of Energy Method

Alternatively with Conservation of Energy:

- 1 Draw a **free body diagram** (FBD) for each body in the system. Identify all **kinetic** and **potential** energies present in the system.
- 2 Write the **total energy** equation as the sum of all energies for a particular body.
- 3 If no \_\_\_\_\_ forces are considered, Conservation of Energy states the change in the \_\_\_\_\_ must equal zero. \_\_\_\_\_ . This relation is used to derive the EOM(s).

# Conservation of Energy Method

## Note:

Either method can be used and for some problem types one or the other is preferred. We will look at several examples of both but the course will primarily focus on the Newton's Second Law approach.

The Conservation of Energy method, which is based upon Newton's law, is commonly used in advanced dynamics courses.