Module 4 - Energy Methods

ME3050 - Dynamics Modeling and Controls

Mechanical Engineering

Tennessee Technological University

Topic 2 - Deriving EOMS from Energy

Topic 2 - Deriving EOMS from Energy

- System Model
- Collect Kinetic and Potential
- Change in Total Energy
- Example: Falling Mass

System Model

The modeling process begins with a description of the system and the modeling assumptions that will be used. Typically a diagram of the system is included.

In rigid body motion, one free body diagram (FBD) per body is required for derivation of the equations of motion of the system. However, the vector analysis of the forces involved is *not required* as it is in Newton's method.

Question: Why is the vector analysis not required for this method?

Collect Kinetic and Potential

After the model has been established, all kinetic energies associated with motion and all stored potential energies must be identified.

Kinetic Energy	(translation)	$T = \frac{1}{2}mv^2$
	(rotation)	$T = \frac{1}{2}I\omega^2$
Potential Energy	(gravity)	$V = mgx$
	(spring)	$V = \frac{1}{2}kx^2$
	(electrical)	$V = \kappa Qq/r$ (typically per unit charge is used)

A zero potential reference is required to properly define the potential energy function, $V(x)$.

Change in Total Energy

The conservation of energy can be used for deriving the dynamics (EOMs) for many systems. In some situations this is simpler that using Newton's method, however both methods will produce equivalent equations of motion.

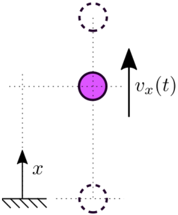
We know	$\Delta KE + \Delta PE = 0$	(1)
implies	$KE + PE = Constant$	(2)
as well as	$\frac{d}{dt}(KE + PE) = \frac{d}{dt}(Constant) = 0$	(3)

We will use equation (3) to derive the equations of motion.

Example: Falling Mass

You may recognize this problem from dynamics or physics class.

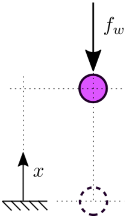
However, today we will use the Conservation of Energy to derive the equations of motion which contain the dynamic relationships between the system variables as functions of time.



Images: T.Hill

Example: Falling Mass

This a simple problem, but it shows the method clearly. To ensure correctness, validate the result with Newton's Approach



Images: T.Hill