MCL731: Analytical Dynamics **3 Credits (3-0-0): 28 Classes**

B-slot, Mon Thu: 9.30-10.50

Rama Krishna K (III 355, Tel: X 1105)

S. K. Saha (II 419, Tel: X 1135, sksaha.com)

Introduction (1 class)

- Introducing title of course and contents
- Brief timeline of development of dynamics
- Basic Vector Algebra with equivalent Matrix computations
- Concepts of Particle, Mass, Motion, Frames

Dynamics of Single Particle (3 classes)

- Particle kinematics in Cartesian, Polar, Cylindrical, Spherical Frames
  - Examples: Plane Logarithmic spiral +…
- Motion of particle in moving coordinate system (Introduce Angular velocity) (2 classes)
- Newton's Laws for particle
- Solving dynamics equations for time history of motion (1 class)
  - Example of Initial Value problem using Numerical schemes in MATLAB
  - *Project-1*

Self-Study: Vector Algebra, Differential Equations

Dynamics of System of Particles (11 classes)

- Generalized coordinates
- Constraints
- Degrees of Freedom (1 class)
- Principle of Virtual Work
  - Example (1+1)
- Lagrange's Equations of motion of first kind (1 class)
  - Example (1+1)
- D'Alembert's principle (1 class)
  - Example (1+1)
- Generalized Force
- Generalized Momentum
- Generalized Energy (1 class)
- Euler-Lagrange equations of motion for holonomic systems
  - Example (1+1)
  - *Project-2* (2 classes)
- Euler-Lagrange equations of motion for non-holonomic systems/ systems with constraint equations
  - Example (1+1) (1 classes)
- Integrals of motion
- Ignorable coordinates (1 class)
- Routhian
  - Example (1+1)
- Form of Lagrange's Equations
- Rayleigh dissipation function
  - Example (1+1) (1 class)
- Hamilton's principle
  - Example (1+1)
- Hamilton's equations (2 classes)

Dynamics of Rigid Body (4 classes)

- Mathematical representation of rigid body (1 class)
  - Position and Orientation of rigid body
  - Coordinate transformations using Euler angles
- Instantaneous kinematics of rigid body (1 class)
- Euler's equations of rotation (2 classes)

Dynamics of Flexible Body (3 classes)

- Dynamics of strings
- Dynamics of Euler beams

Stability of Motion (5 classes)

- Hamilton's canonical equations
- Phase space
- Geometric theory
- Routh's criterion
- Lyapunov's direct method;

Suggested References

1. Principles of Dynamics by *Donald. T. Greenwood*, Prentice-Hall Inc., 2nd edition, 1988.
2. Classical Dynamics by *Donald. T. Greenwood,* Prentice-Hall Inc., 1977.
3. Classical Mechanics by *Sankara Rao* , PHI Learing Pvt. Ltd., 2005.
4. Analytical Dynamics by *Leonard Meirovitch, Dover Publications, 1970.*
5. Introduction to Robotics by *S. K. Saha,* McGraw Hill, 2008.

Advanced Dynamics by *Donald T. Greenwood*, Cambridge University Press, 2003

This book subsumes topics from [1] and [2]

Other References

1. Classical Mechanics by *Rana* and *Joag*, McGraw Hill, 2017.
2. Classical Mechanics by *Herbert Goldstein,* Pearson India Pvt. Ltd., 3rd edition, 2011.
3. Analytical Dynamics by *Haim Baruh,* McGraw Hill, 1998.

Marking Scheme

Minor - I (Scheduled in Semester Time Table)	: 20 Marks
Minor - II (Unscheduled)	: 20 Marks
Major	: 30 Marks
Project and Assignments	: 20 Marks
Quiz (Every Monday first 5 min)	: 10 Marks

Attendance Policy: 15 min after the commencement of class, your attendance would be NULL.