Lecturer: Mohammad Suliman Abuhaiba, Ph.D., P.E., mhaiba@yahoo.com

Course Objectives:

1. Develop the ability to analyze and understand the dynamic (position, velocity, acceleration, force and torque) characteristics of mechanisms such as linkages and cams.
2. Develop the ability to systematically design and optimize mechanisms to perform a specified task.
3. Effectively integrate computer simulations and analysis into the mechanism design process.
4. Increase the ability of students to effectively present written, oral, and graphical solutions to design problems.
5. Increase the ability of students to work cooperatively on teams in the development of mechanism designs.
6. Make connections between design theory, computer simulations and actual performance through the construction and testing of working prototypes.
7. Compute, both analytically and graphically forces and couples for reciprocating parts and dynamically equivalent system.
8. Understand the theory of inertia force and apply to four-bar linkage mechanism.
10. Apply the theory of balancing to reciprocating and rotating masses.
11. Understand techniques of kinematic synthesis

Text Book:

References:
2. JS Rao and Dukkipati; “Mechanism and Machine Theory”; Wiley Eastern, New Delhi
4. RT. Hinckle; “Kinematics of Machines”; Prentice Hall Inc.
5. Sadhu singh; “Kinematics of Machines”
6. V. Ramamurti; “Mechanics of Machines”
10. Malhotra & Gupta; “Theory of Machines”
11. R. K. Bansal; “Theory of Machines”
12. Thomas Bevan; “Theory of Machines”
13. V. P. Singh; “Theory of Machines”
14. Shigley; “Theory of Machines and Mechanisms”
15. Jagdish LaI; “Theory of Machines”
16. Hams Crone and Roggers; “Theory of Machines”
17. PL Ballaney; “Theory of Machines”
18. SS Rattan,Tata Mc; “Theory of Machines”; Graw Hill, New Delhi
Grading Policy: (subject to change during the semester)

<table>
<thead>
<tr>
<th>Component</th>
<th>Percentage</th>
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<tbody>
<tr>
<td>Attendance and book</td>
<td>5%</td>
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<tr>
<td>5 to 7 “one hour” quizzes</td>
<td>45%</td>
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<tr>
<td>Projects: Technical report, PowerPoint file,</td>
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<td>team presentation video, professional</td>
<td>10%</td>
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<td>engineering drawings, technical report. If</td>
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<td>Project is not submitted, course grade will</td>
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<td>directly be F.</td>
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<td>Final: Final is a comprehensive exam</td>
<td>40%</td>
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<td>Total</td>
<td>100%</td>
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Class Schedule: SMW 9-10
Office Hours: SMW 10-11, 12-13 or by appointment

Exam Policy:
- During the exams, a personal calculator may be used.
- Laptops, computers, phones, mp3 players or any electronic device will not be allowed.
- Lecture notes, PowerPoint files and problem solutions will not be allowed.
- No material or calculator may be shared by students.

Make-up Exams:
- Make-up exams will be allowed only after the student provides a medical doctor’s original report describing the problem and a statement that it was an emergency. The report should be verified and notarized by the University clinic.
- No make-up will be provided for missed quizzes under any circumstance. If a student misses a quiz, he should be prepared to receive a 0 score as a result.

Academic Misconduct:
- Academic dishonesty is a serious offense and will be treated according to the University policy as outlined below:
  - All students should respect the right of others to have an equitable opportunity to learn and honestly to demonstrate the quality of their learning. Therefore, all students are expected to adhere to a standard of academic conduct, which demonstrates respect for themselves, their fellow students, and the educational mission of the University.
  - All students are deemed by the University to understand that if they are found responsible for academic misconduct, they will be subject to the Academic Misconduct procedures and sanctions, as outlined in the Student Handbook.

Ethics:
- All work prepared and submitted in this course in the form of projects, presentations, problem solutions in quizzes and exams are expected to be original and produced by the submitting student.
- Any portion that may have been borrowed from a previous work must be clearly identified and referenced to indicate the original author along with the title of the work, and where and when it appeared. The origin of each figure, photograph, table as well as text used from other sources must be clearly identified.

General:
- Late homework or late project will not be graded and cannot receive any credit.
- Cheating or copying on homework, exams, or the project, are grounds for failing the course.
- In the event of a major campus emergency, course requirements, deadlines and grading percentages are subject to changes that may be necessitated by a revised semester calendar or other circumstances.
Content of Course:

1. **Introduction**
   - Definition
   - Sub-divisions of Theory of Machines

2. **Simple Mechanisms**
   - Kinematic Link or Element
   - Types of Links
   - Structure
   - Difference between a Machine and a Structure
   - Kinematic Pair
   - Types of Constrained Motions
   - Classification of Kinematic Pairs
   - Kinematic Chain
   - Types of Joints in a Chain
   - Mechanism
   - Number of Degrees of Freedom for Plane Mechanisms
   - Application of Kutzbach Criterion to Plane Mechanisms
   - Grubler's Criterion for Plane Mechanisms
   - Inversion of Mechanism
   - Types of Kinematic Chains
   - Four Bar Chain or Quadric Cycle Chain
   - Inversions of Four Bar Chain
   - Single Slider Crank Chain
   - Inversions of Single Slider Crank Chain
   - Double Slider Crank Chain
   - Inversions of Double Slider Crank Chain

3. **Velocity in Mechanisms**
   - Space and Body Centroids
   - Methods for Determining the Velocity of a Point on a Link
   - Velocity of a Point on a Link by Instantaneous Centre Method
   - Properties of the Instantaneous Centre
   - Number of Instantaneous Centers in a Mechanism
   - Types of Instantaneous Centers
   - Location of Instantaneous Centers
   - Aronhold Kennedy (or Three Centers in Line) Theorem
   - Method of Locating Instantaneous Centers in a Mechanism

4. **Mechanisms with Lower Pairs**
   - Pantograph
   - Straight Line Mechanism
   - Exact Straight Line Motion
   - Mechanisms made up of Turning Pairs
   - Exact Straight Line Motion Consisting of One Sliding Pair (Scott Russel’s Mechanism)
   - Approximate Straight Line Motion Mechanisms
   - Straight Line Motions for Engine Indicators
   - Steering Gear Mechanism
     - Davis Steering Gear
     - Ackerman Steering Gear
   - Universal or Hooke’s Joint
     - Ratio of the Shafts Velocities
     - Maximum and Minimum Speeds of the Driven Shaft
     - Condition for Equal Speeds of the Driving and Driven Shafts
     - Angular Acceleration of the Driven Shaft
     - Maximum Fluctuation of Speed
   - Double Hooke’s Joint

5. **Inertia Forces in Reciprocating Parts**
   - Resultant Effect of a System of Forces Acting on a Rigid Body
- D-Alembert’s Principle
- Velocity and Acceleration of the Reciprocating Parts in Engines
- Klien’s Construction
- Ritterhaus’s Construction
- Bennett’s Construction
- Approximate Analytical Method for Velocity and Acceleration of the Piston
- Angular Velocity and Acceleration of the Connecting Rod
- Forces on the Reciprocating Parts of an Engine Neglecting Weight of the Connecting Rod
- Equivalent Dynamical System
- Determination of Equivalent Dynamical System of Two Masses by Graphical Method
- Correction Couple to be Applied to Make the Two Mass Systems Dynamically Equivalent
- Inertia Forces in a Reciprocating Engine Considering the Weight of Connecting Rod
- Analytical Method for Inertia Torque

6. Turning Moment Diagrams and Flywheel
- Turning Moment Diagram for a Single Cylinder Double Acting Steam Engine
- Turning Moment Diagram for a Four Stroke Cycle Internal Combustion Engine
- Turning Moment Diagram for a Multicylinder Engine
- Fluctuation of Energy
- Determination of Maximum Fluctuation of Energy
- Coefficient of Fluctuation of Energy
- Flywheel
- Coefficient of Fluctuation of Speed
- Energy Stored in a Flywheel
- Dimensions of the Flywheel Rim
- Flywheel in Punching Press

7. Balancing of Rotating Masses
- Balancing of Rotating Masses
- Balancing of a Single Rotating Mass By a Single Mass Rotating in the Same Plane
- Balancing of a Single Rotating Mass By Two Masses Rotating in Different Planes
- Balancing of Several Masses Rotating in the Same Plane
- Balancing of Several Masses Rotating in Different Planes

8. Balancing of Reciprocating Masses
- Primary and Secondary Unbalanced Forces of Reciprocating Masses
- Partial Balancing of Unbalanced Primary Force in a Reciprocating Engine
- Partial Balancing of Locomotives
- Effect of Partial Balancing of Reciprocating Parts of Two Cylinder Locomotives
- Variation of Tractive Force
- Swaying Couple
- Hammer Blow
- Balancing of Coupled Locomotives
- Balancing of Primary Forces of Multi-cylinder In-line Engines
- Balancing of Secondary Forces of Multi-cylinder Inline Engines
- Balancing of Radial Engines (Direct and Reverse Crank Method)
- Balancing of V-engines

9. Cams
- Classification of Followers
- Classification of Cams
- Terms used in Radial cams
- Motion of the Follower
- Displacement, Velocity and Acceleration Diagrams when the Follower Moves with Uniform Velocity
- Displacement, Velocity and Acceleration Diagrams when the Follower Moves with Simple Harmonic Motion
- Displacement, Velocity and Acceleration Diagrams when the Follower Moves with Uniform Acceleration and Retardation
- Displacement, Velocity and Acceleration Diagrams when the Follower Moves with Cycloidal Motion
- Construction of Cam Profiles
- Cams with Specified Contours
- Tangent Cam with Reciprocating Roller Follower
- Circular Arc Cam with Flatfaced Follower
10. Toothed Gearing
- Friction Wheels
- Advantages and Disadvantages of Gear Drive
- Classification of Toothed Wheels.
- Terms Used in Gears.
- Gear Materials.
- Law of Gearing.
- Velocity of Sliding of Teeth.
- Forms of Teeth.
- Cycloidal Teeth.
- Involute Teeth.
- Effect of Altering the Centre Distance.
- Comparison Between Involute and Cycloidal Gears.
- Systems of Gear Teeth.
- Length of Path of Contact.
- Length of Arc of Contact.
- Contact Ratio
- Interference in Involute Gears.
- Minimum Number of Teeth on the Pinion.
- Minimum Number of Teeth on the Wheel.
- Minimum Number of Teeth on a Pinion for Involute Rack in Order to Avoid Interference.
- Helical Gears.
- Spiral Gears.
- Centre Distance For a Pair of Spiral Gears.
- Efficiency of Spiral Gears.

11. Gear Trains
- Types of Gear Trains.
- Simple Gear Train.
- Compound Gear Train.
- Design of Spur Gears.
- Reverted Gear Train.
- Epicyclic Gear Train.
- Velocity Ratio of Epicyclic Gear Train.
- Compound Epicyclic Gear Train (Sun and Planet Wheel).
- Epicyclic Gear Train With Bevel Gears.
- Torques in Epicyclic Gear Trains.
- Understand the types of both tooth gear and the nomenclature of gears.
- Understand the concepts of interference in gears, and its removal.
- Compare the cycloid and involute tooth profile.
- Understand the various types of gear trains.
- Apply the theory of gear trains to solve simple numerical problems.
- Understand gyro effect on moving bodies.