King Fahd University of Petroleum & Minerals
MECHANICAL ENGINEERING DEPARTMENT
ME 309: Mechanics of Machines

Catalogue Description: (3-0-3)
Kinematics of mechanisms, vector method of analysis of plane mechanisms. Static and dynamic analysis of machines, inertia forces, gyroscopic forces, Static and dynamic balancing, balancing machines. Dynamics and balancing of reciprocating engines. Flywheels. Kinematics and dynamics of cam mechanisms. Elements of mechanical vibrations.

Status in Curriculum (Required or Elective): Required (offered Fall & Spring)

Prerequisites: ME 201

Co-requisites: None

Prerequisites by Topics:
- Kinematics of rigid body (ME201)
- Center of mass and Mass moment of inertia (ME201, CE201)
- Kinetics of rigid body and Newton's second law (ME201)

Textbook: **Mechanics of Machines**, Cleghorn, W. L., Oxford University Press, 1st Edition, 2005.

References:
1) **Kinematics and Dynamics of Machinery**, C. Wilson and J. Sadler, Harper Collins, 2003.

Coordinator: **Dr. Yehia Khulief,** Professor of Mechanical Engineering

Goals: **(general objectives)**
This course is intended to cover theory and techniques of kinematics and dynamic analysis of mechanisms. The course emphasizes the practical design considerations of mechanisms and machines. The problems of balancing and machine vibrations are introduced.

Course Outline (Lecture Topics):
1. Introduction to mechanisms: *Definitions of Mechanisms, Links, Joints, … etc* (2 hours)
2. Kinematics pairs and mobility of **planar** mechanisms: *Types of Joints, Degrees of Freedom (Mobility), Grashof Criterion, Transmission Angle, Limiting Positions, Examples of Quick Return Mechanisms for planar mechanisms*. (5 hours)
3. Displacement, Velocity and Acceleration analyses in planar mechanisms: *(a) Complex Number Methods* (6 hours)
4. Displacement, Velocity and Acceleration analyses in planar mechanisms: *(b) Graphical Methods.* (6 hours)
5. Cam motions and dynamics: *Introduction, Types of cam-follower mechanisms, Follower motion diagrams, Design of cam profile.* (6 hours)
6. Static force analysis in planar mechanisms: *(a) Graphical Analysis, (b) Analytical Analysis. (No Friction)* (6 hours)
7. Dynamic force analysis in planar mechanisms: *(a) Graphical Analysis, (b) Analytical Analysis. (No Friction)* (6 hours)
8. Balancing of rotating machines: *Definition of Balancing, Causes of imbalance, Correction methods: (a) Static Balancing, (b) Dynamic Balancing* (4 hours)
9. Introduction to mechanical vibrations and whirling of shafts. (4 hours)

Design Activities/Projects:
Design assignments including kinematic design for four-bar linkage and the cam-profile design are assigned.

Computer Usage:
Students are encouraged to solve some assigned homework problems using the available engineering software, such as MATLAB

Laboratory: None

Assessment Tools:
i- Mid-term Examinations

ii- Homework Assignments
iii- Quizzes
iv- Final Exam

Course Learning Outcomes:

I- Students shall gain clear knowledge about some of the basic mechanisms, such as four-bar and slider crank linkages; demonstrate a clear understanding of the physical meaning of degree of freedom; gain the ability to identify mechanical joints of mechanisms; and to visualize their mobility.

II- Students shall demonstrate the ability to draw the kinematic diagrams of actual mechanisms and determine their mobility, and perform kinematic design of Grashof's four-bar linkages.

III- Students shall demonstrate the ability to determine the position parameters, velocities, and accelerations (linear and angular) of various planarmechanisms using both analytical complex number methods and graphical methods.

IV- Students shall be able to perform static and dynamic force analyses, and solve for the forces and moments acting on the mechanism; including joint reaction forces, by applying Newton's laws of motion and D'Alembert's principle; both analytically and graphically.

V- Students shall demonstrate ability to construct various follower motion diagrams and understand the advantages and disadvantages of each type of motion; and to be able to design cam profiles for any given follower displacement using graphical methods.

VI- Students shall demonstrate a basic understanding of the balancing of rotating machinery, dynamics of flywheels, and mechanical vibrations; including concepts of natural frequency, damping and resonance.

Course Learning Outcomes mapped to Student Outcomes:

Student Outcomes	*a*	*b*	*c*	*d*	*e*	*f*	*g*	*h*	*i*	*j*	*k*
Course-to-Student outcome mapping	I, III, IV		II, V		II, III, IV, V			VI			
Emphasis*	**S**		**M**		**L**			**L**			

* **L**:: Little/None **M**: Moderate **S**: Strong

Status of Continuous Improvement review of this Course:

Date reviewed: ---------- **Reviewed by:** Design Dynamics Group
Prepared by: Dr. Yehia Khulief **Date prepared:** April 24, 2013