Course Specification

Course Title:	**Theory of Machinery**
Course Code:	**ME3134**
Program:	**Mechanical Engineering**
Department:	**Mechanical Engineering department**
College:	**College of Engineering & Architecture**
Institution:	**Umm Al-Qura University**
Version:	**One**
Last Revision Date:	**25/12/2024**

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A. General information about the course:

1. Course Identification

1. Credit hours: (3)

2. Course type

A.	☐ University	☐ College	☒ Department	☒ Track	☐ Others
B.	☒ Required		☐ Elective		

3. Level/year at which this course is offered: (6)

4. Course General Description:

Theory of Machinery provides a comprehensive understanding of the fundamental principles of mechanisms and machines. It covers key topics such as kinematics, dynamics, and the design of mechanical systems, with practical applications in engineering. The course integrates lectures with laboratory exercises, allowing students to gain hands-on experience in analyzing and designing mechanical systems and machinery. Concepts explored in the course are applicable to both traditional mechanical systems as well as modern mechatronics systems, with an emphasis on real-world applications, including robotics and automation.

5. Pre-requirements for this course (if any):

ME2134

6. Co-requisites for this course (if any):

None

7. Course Main Objective(s):

1. **To provide a strong foundation in the fundamental principles of machinery and mechanisms:**
   - Introduce students to key concepts such as kinematics, dynamics, linkages, and degrees of freedom.
   - Ensure students understand how mechanisms and machinery are designed, analyzed, and applied in mechanical systems.
2. **To develop students' ability to perform kinematic and dynamic analysis of mechanisms:**
   - Enable students to analyze the motion, velocities, accelerations, and forces involved in various mechanical systems and robotic mechanisms.
   - Teach students how to use both graphical and analytical methods for solving kinematic and dynamic problems.
3. **To teach the design and synthesis of mechanisms:**
   - Provide students with the tools to design and synthesize linkages and mechanisms to meet specific motion requirements.
   - Focus on practical applications of mechanism synthesis in the design of machinery and robotic systems.
4. **To familiarize students with the concepts of machine power transmission and balancing:**
   - Teach the principles behind gear mechanisms, power transmission systems, and balancing of rotating machinery.

- Explore real-world applications in industries such as automotive, aerospace, and robotics.

5. **To emphasize the importance of safety, ethics, and sustainability in machinery design:**
   - Address safety standards and ethical responsibility in machine design and operation.
   - Introduce students to sustainable design practices and their implications in machinery and automation systems.
6. **To prepare students for real-world applications in mechanical and mechatronic systems:**
   - Equip students with the skills to apply the concepts learned in the course to the design, analysis, and optimization of machines and robotic systems in modern engineering environments.

2. Teaching mode (mark all that apply)

No	Mode of Instruction	Contact Hours	Percentage
1	Traditional classroom	3	100%
2	E-learning	-	-
3	Hybrid • Traditional classroom • E-learning	-	-
4	Distance learning	-	-

3. Contact Hours (based on the academic semester)

No	Activity	Contact Hours
1.	Lectures	2 hours per week
2.	Laboratory/Studio	3 hours oer week
3.	Field	-
4.	Tutorial	-
5.	Others (specify)	-
Total		5 hours per week

B. Course Learning Outcomes (CLOs), Teaching Strategies and Assessment Methods

Code	Course Learning Outcomes	Code of PLOs aligned with the program	Teaching Strategies	Assessment Methods
1.0	**Knowledge and understanding**			
1.1	Understand the fundamental principles of mechanisms, kinematics, and dynamics in mechanical and mechatronic systems.	K1	Lectures: In-depth coverage of kinematic and dynamic principles.	Case Studies Quizzes Exam

Code	Course Learning Outcomes	Code of PLOs aligned with the program	Teaching Strategies	Assessment Methods
2.0	**Skills**			
2.1	Apply kinematic and dynamic analysis methods to the design and analysis of mechanical systems, including robotic systems.	S3	Labs: Hands-on exercises with mechanisms, including robotic arms and linkages.	Workshops Laboratory Reports Project Assessment
3.0	**Values, autonomy, and responsibility**			
3.1	Demonstrate ethical responsibility and safety awareness in the design and analysis of machinery and mechatronic systems.	V4	Lectures: Focus on safety protocols and ethical responsibility in machine design.	Case Studies Case Study Analysis Exam

C. Course Content

No	List of Topics	Contact Hours

1.	**Introduction to Theory of Machinery**
	• **Definition and Importance of Theory of Machinery**
	  ○ The role of machinery in mechanical and mechatronics systems.
	  ○ Basic principles of mechanisms and machine components.
	• **Fundamental Concepts**
	  ○ Mechanisms, linkages, degrees of freedom, and mobility.
	  ○ Kinematic and dynamic systems overview.
		2

2.	**Kinematics of Mechanisms**
	• **Kinematic Chains and Mechanisms**
	  ○ Gruebler's criterion for calculating degrees of freedom.
	  ○ Types of mechanisms: four-bar, slider-crank, cam, etc.
	• **Kinematic Analysis**
	  ○ Use of graphical methods for kinematic analysis.
	  ○ Introduction to velocity and acceleration analysis.
		2

3.	**Kinematic Analysis of Mechanisms**
	• **Velocity and Acceleration in Mechanisms**
	  ○ Analytical and graphical methods to analyze velocities and accelerations.
	• **Instantaneous Center of Rotation (ICR)**
	  ○ Calculating and applying ICR in mechanism analysis.
	• **Velocity and Acceleration Diagrams**
	  ○ Construction and analysis of velocity and acceleration
		2

	diagrams.	

4.	**Cam Mechanisms**
	• **Types of Cams and Followers**
	  ○ Radial, cylindrical, and other cam types.
	  ○ Types of followers and their motion characteristics.
	• **Cam Profile Design**
	  ○ Designing cam profiles based on follower motion types.
	  ○ Displacement, velocity, and acceleration analysis of followers.
		2

5.	**Gear Mechanisms**
	• **Types of Gears**
	  ○ Spur, helical, bevel, worm gears, and their applications.
	• **Gear Trains and Gear Ratio**
	  ○ Simple, compound, and planetary gear trains.
	  ○ Calculating gear ratios and speed reduction.
	• **Force Analysis in Gears**
	  ○ Torque, load, and efficiency calculations in gear systems.
		2

6.	**Dynamics of Machinery**
	• **Forces in Machinery**
	  ○ External and internal forces, inertia forces.
	• **Force Analysis Techniques**
	  ○ Free-body diagrams and equilibrium equations.
	  ○ Dynamic analysis of linkages and gear systems.
	• **Applications of Dynamics**
	  ○ Dynamic force analysis in robotic and automation systems.
		2

7.	**Balancing of Machines**
	• **Need for Balancing**
	  ○ Importance of balancing rotating and reciprocating parts to reduce vibration.
	• **Single and Multi-Plane Balancing**
	  ○ Techniques for balancing single and multiple rotating parts.
	• **Dynamic Balancing**
	  ○ Application of balancing in robotic systems and engines.
		2

8.	**Synthesis of Mechanisms**
	• **Graphical and Analytical Methods for Mechanism Synthesis**
	  ○ Designing linkages based on given motion requirements.
	• **Dimensional Synthesis**
	  ○ Applying dimensional synthesis for motion generation.
	• **Case Study**
	  ○ Practical synthesis of a mechanism for a given motion.
		2

9.	**Power Transmission in Machines** • **Mechanical Power Transmission** ○ Types of mechanical power transmission systems: gears, belts, pulleys, and chains. • **Gear Design and Efficiency**	**2**

	○ Efficiency considerations in power transmission systems. • **Design of Power Transmission Systems** ○ Practical design of gear and belt systems for machines and robots.	
10.	**Vibrations in Machinery** • **Types of Vibrations** ○ Free and forced vibrations, resonance phenomena. • **Vibration Analysis** ○ Analyzing vibration behavior in machinery. • **Vibration Control** ○ Methods to reduce vibrations in mechanical and mechatronic systems.	**2**
11.	**Robotics and Mechatronics Applications** • **Robotic Kinematics and Dynamics** ○ Kinematic and dynamic analysis of robotic arms and other automated systems. • **Design of Robotic Linkages** ○ Design principles of robotic linkages and actuators. • **Mechatronic Systems Design** ○ Integrating mechanical, electrical, and control systems in mechatronics applications.	**4**
12.	**Advanced Topics in Theory of Machinery** • **Multi-Body Dynamics** ○ Understanding and analyzing systems with multiple interconnected bodies. • **Automation and Control** ○ The role of automation and control in machinery systems. • **Emerging Trends in Robotics and Mechatronics** ○ Current research and future directions in robotic systems, smart machinery, and automation.	**4**
13.	**Final Review and Project Preparation** • **Review of Key Concepts** ○ Overview of all topics covered in the course. ○ Preparation for the final exam and project submissions. • **Group Project Discussion** ○ Discussing the design and analysis of a complex mechanism or robotic system.	**2**
Total		**30**

D. Students Assessment Activities

No	Assessment Activities *	Assessment timing (in week no)	Percentage of Total Assessment Score
1.	Quizzes	3, 6	10%

No	Assessment Activities *	Assessment timing (in week no)	Percentage of Total Assessment Score
2.	Midertm Wxam	8	20%
3.	Projects (Mechanism design, robotics applications)	10, 12	15%
4.	Case Study Analysis	11	5%
5.	Final Exam	15	50%

*Assessment Activities (i.e., Written test, oral test, oral presentation, group project, essay, etc.).

E. Learning Resources and Facilities

1. References and Learning Resources

Essential References	1. **Rattan, S. S.** (2015). *Theory of Machines* (3rd ed.). Tata McGraw-Hill Education. 2. **Shigley, J. E., & Uicker, J. J.** (2011). *Theory of Machines and Mechanisms* (4th ed.). Oxford University Press. 3. **Gillespie, D. T.** (2013). *Mechanisms and Dynamics of Machinery* (3rd ed.). Prentice Hall. 4. **Jain, A. K., & Mehta, S.** (2017). *Kinematics and Dynamics of Mechanical Systems* (2nd ed.). Wiley.
Supportive References	**Supportive References** 1. **Lynch, R. A.** (2015). *Introduction to Robotics: Mechanics and Control* (3rd ed.). Pearson. 2. **Bishop, R. H.** (2007). *The Mechatronics Handbook*. CRC Press. 3. **Fay, D. A., & Kinzel, G. L.** (2010). *Engineering Mechanics of Solids* (4th ed.). Pearson. 4. **Beckwith, T. G., & Buck, D.** (2017). *Mechanical Engineering Design* (10th ed.). McGraw-Hill Education.
Electronic Materials	1. **MIT OpenCourseWare** ○ *Mechanical Engineering Courses – Introduction to Mechanisms*: Free online course materials from **MIT**, including lecture notes, problem sets, and solutions related to **mechanisms** and **machine theory**. 2. **Coursera Course on Mechanics of Machinery** ○ A **free course** offered by institutions like **Georgia Tech** that provides access to online lectures, practical demonstrations, and assignments on **mechanical systems** and **machinery**. 3. **YouTube Channels** ○ *Engineering Mechanics Channel*: A channel offering

	educational content on the **kinematics and dynamics of machinery**. ○ *The Engineering Toolbox*: Provides visual guides and explanations of **machine design concepts** and **mechanical systems**. 4. **Simulation Software** ○ **SolidWorks Simulation**: Used for **virtual kinematic and dynamic analysis** of mechanisms and components in machinery. ○ **MATLAB**: For solving complex **mathematical models** related to **mechanism design** and **dynamic systems**.
Other Learning Materials	1. **Software Tools**: ○ **AutoCAD** or **SolidWorks** for **mechanism design**, **3D modeling**, and **motion analysis**. ○ **MATLAB/Simulink** for numerical analysis, **kinematic simulations**, and **dynamic modeling**. 2. **Diagnostic Tools**: ○ **Vibration Analyzers** (e.g., **SKF Microlog**): Used in laboratory settings to measure the **vibrational behavior**of mechanical systems and evaluate their health and performance. ○ **Thermography Cameras** (e.g., **FLIR**): Used to visualize and measure the **thermal behavior** of machinery, an important diagnostic tool in **machine health monitoring**. 3. **Case Studies and Research Articles**: ○ Articles from journals like **Mechanical Systems and Signal Processing** and **Journal of Mechanisms and Robotics** for **current research** and **real-world applications** in machinery theory and robotics. ○ **Industry Case Studies**: Examining the use of **mechanisms** in industries like automotive, robotics, and manufacturing, helping students apply theory to practical systems.

2. Required Facilities and equipment

Items	Resources
facilities (Classrooms, laboratories, exhibition rooms, simulation	• **Classrooms**: Lecture halls with seating, projectors, and whiteboards. • **Laboratories**: Mechanism testing setups and robotic arms

Items	Resources
rooms, etc.)	for hands-on exercises. • **Exhibition Rooms**: Display space for student projects and presentations. • **Simulation Rooms**: Equipped with simulation software (MATLAB, SolidWorks).
Technology equipment (projector, smart board, software)	• **Projector**: For presentations and lectures. • **Smart Board**: Interactive board for real-time problem-solving. • **Software**: CAD software (SolidWorks), MATLAB, and vibration analysis tools.
Other equipment (depending on the nature of the specialty)	• **Diagnostic Tools**: Vibration analyzers, thermography cameras, ultrasound equipment. • **Workstations**: High-performance computers for design and simulations. • **Spare Parts and Kits**: Gears, linkages, toolkits, and PPE for lab work. • **Sensors and Data Loggers**: For monitoring motion and forces in systems.

F. Assessment of Course Quality

Assessment Areas/Issues	Assessor	Assessment Methods
Effectiveness of teaching	Students	Indirect: Surveys, feedback forms.
Effectiveness of Students assessment	Faculty	Direct: Analysis of assessment results.
Quality of learning resources	Faculty, Students, Program Leaders	Direct: Review of resources by faculty, surveys on resource usefulness. Indirect: Student satisfaction surveys.
The extent to which CLOs have been achieved	Faculty, Program Leaders	Direct: Analysis of student performance in assessments, CLO-PLO alignment matrices. Indirect: Student self-assessment surveys, alumni feedback.
Other	-	-

Assessors (Students, Faculty, Program Leaders, Peer Reviewers, Others (specify)

Assessment Methods (Direct, Indirect)

G. Specification Approval

COUNCIL /COMMITTEE	

REFERENCE NO.	
DATE	**25/12/2024**