Name of Institute: INDUS INSTITUTE OF TECHNOLOGY & ENGINEERING

Name of Faculty: Prof. Rahul Patel (Assistant Professor)

Course code: ME0323
Course name: Kinematics of Machines
Pre-requisites: Vectors, Concepts of displacement, velocity and acceleration, Basic Mechanics,
Credit points: 3
Offered Semester: 3rd Mechanical

Course coordinator and lecturer (Weeks 1 - 16)
Full name: Prof. Rahul Patel
Department with siting location: Mechanical. Bhanvar Building, 3rd Floor, DH-1
Telephone: 9428192514
Email: rahulpatel.me@indusuni.ac.in
Consultation times: Friday (4:00 to 5:00 PM)

Students will be contacted throughout the session via mail with important information relating to this course.

Course Objectives

By participating in and understanding all facets of this course a student will:

1) To understand the basic components and layout of linkages in the assembly of a system/machine.
2) To understand the principles in analyzing the assembly with respect to the displacement, velocity, and acceleration at any point in a link of a mechanism.
3) Selection of power transmission devices like belt drive, rope drive, gears, gear trains and its applications.
4) To facilitate students to understand the types of cam and follower, motion and profile drawing of cam
5) To synthesis mechanism to perform certain prescribed task/motion

Course Outcomes (CO)

1. Understand the principles of kinematic pairs, chains and their classification, DOF, inversions, equivalent chains and planar mechanisms.
2. Analyze the planar mechanisms for position, velocity and acceleration.
3. Synthesize planar four bar and slider crank mechanisms for specified kinematic conditions.
4. Evaluate gear tooth geometry and select appropriate gears for the required applications.
5. Analyze cams and followers for specified motion profiles.
6. Develop employability skills to impart Practical Knowledge in various concepts of mechanisms like straight line motion mechanisms, steering gear mechanisms and working principles of power elements (Gears, gear trains, Cams, Belt and Chain drives) and design related problems effectively.

Course Outline

UNIT-1 **[06]**

Mechanisms & Machines:
Terminology and Definitions, Mechanism & Machines. Rigid and resistance body,Gyroscope link, Kinematic pair, types of motion, classification of Kinematic pairs, Kinematic Chain, Linkage, Mechanics, degrees of freedom, Mobility – Kutzbach criterion, Gruebler's criterion, Grashof's Law, Kinematic Inversion of four bar chain, Single and Double slider crank Chain, Four bar chain mechanism with lower pairs, Steering gear mechanisms such as Davis and Ackermann Steering gear.

UNIT-2 **[08]**

Velocity and Acceleration Diagrams of Mechanisms:
Displacement, velocity and acceleration analysis in simple mechanisms, Graphical Method, Rubbing Velocity, velocity and acceleration polygons, Instantaneous Centre of Velocity, Kennedy Theorem, Angular velocity ratio theorem, Coriolis acceleration component.

UNIT-3

[10]

Belt Rope and Chain:
Introduction, belt and ropes drives, selection of belt drive, types of belt drives, Materials used for belt and rope drives, law of belting, velocity ratio, tension ratio, Length of belt, V-belts, Wire rope, Slip and Creep of belt drive, tensions

for flat belt drive, angle of contact, centrifugal tension, Maximum power transmitted by belt, chain drive & its classification.

Gears & Gear Trains:
Introduction, Classification of Gears, Gear Terminology, Law of Gearing, Velocity of Sliding, Forms of teeth, Involutes and cycloidal tooth profiles, Arc of the contact, Numbers of pairs of teeth in contact, Interference in involute Gears, Minimum Number of teeth, under cutting, Comparison of Cyclonical and involutes tooth forms, Spur, Helical, Spiral, Worm, Worm Gear and Bevel Gears (Basics only). Simple, Compound, Reverted & epicyclic gear trains, Algebraic and tabular methods of finding velocity ratio of epicyclic gear trains.

UNIT-4 **[08]**

Cam and Followers:
Introduction, Definitions of cam and followers, applications, Types of Cams, Types of Followers, Cam Terminology, displacement, velocity and acceleration curves for uniform velocity, Simple Harmonic Motion, Uniform Acceleration Retardation, Cycloidal motion, Cam profiles: cam with reciprocating/oscillating follower having knife-edge, roller and flat-face follower inline and offset. Tangent circular arc and eccentric cam.

Kinematic Synthesis of Mechanisms:
Types of synthesis, Function generation, Path generation, Motion generation, Graphical synthesis, Chebyshev's spacing for accuracy points, Freudenstein's equation.

Method of delivery
(Online Mode, PPT, Active Learning Techniques with solving Tutorial)

Study time
1) Two lectures each of one hours
2) One tutorial of one hours

CO-PO Mapping (PO: Program Outcomes)

PO1. **Engineering knowledge**: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.

PO2. **Problem analysis**: Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.

PO3. **Design/development of solutions**: Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate

consideration for the public health and safety, and the cultural, societal, and environmental considerations.

PO4. **Conduct investigations of complex problems**: Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.

PO5. **Modern tool usage**: Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations.

PO6. **The engineer and society**: Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.

PO7. **Environment and sustainability**: Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.

PO8. **Ethics**: Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.

PO9. **Individual and team work**: Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.

PO10. Communication: Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.

PO11. Project management and finance: Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.

PO12. Life-long learning: Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.

	PO 1	**PO 2**	**PO 3**	**PO 4**	**PO 5**	**PO 6**	**PO 7**	**PO 8**	**PO 9**	**PO 10**	**PO 11**	**PO 12**
CO1	3	1	1	-	1	-	-	-	-	-	-	1
CO2	2	3	2	2	-	-	-	-	-	-	1	1
CO3	2	1	3	1	2	-	-	-	-	-	1	2
CO4	2	2	1	1	1	-	-	-	-	-	-	2
CO5	1	2	1	-	2	-	-	-	-	-	-	1
CO6	1	2	1	-	-	-	-	-	-	-	-	-

1-LightlyMapped 2-Moderately Mapped 3- Highly Mapped

Blooms Taxonomy and Knowledge retention(For reference)

(Blooms taxonomy has been given for reference)

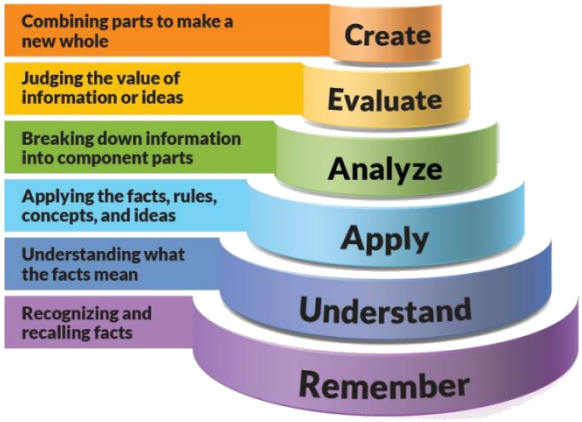

Figure 1: Blooms Taxonomy

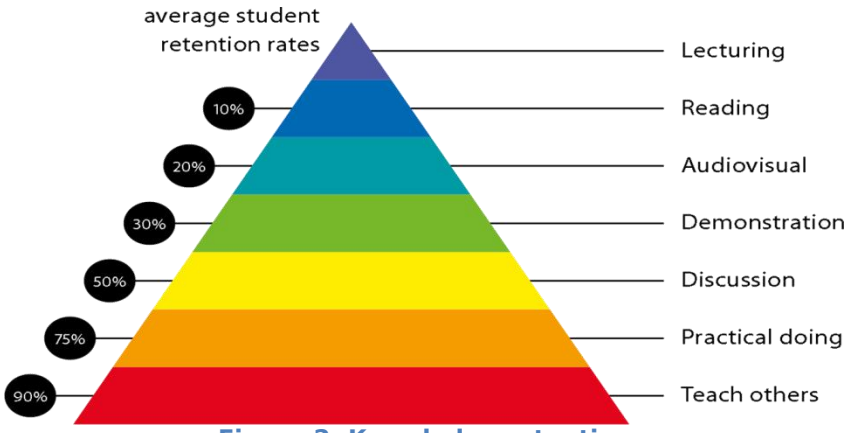

Figure 2: Knowledge retention

Graduate Qualities and Capabilities covered

(Qualities graduates harness crediting this Course)

General Graduate Qualities	Specific Department of _____ Graduate Capabilities
Informed Have a sound knowledge of an area of study or profession and understand its current issues, locally and internationally. Know how to apply this knowledge. Understand how an area of study has developed and how it relates to other areas.	**1 Professional knowledge, grounding & awareness**
Independent learners Engage with new ideas and ways of thinking and critically analyze issues. Seek to extend knowledge through ongoing research, enquiry and reflection. Find and evaluate	**2 Information literacy, gathering & processing**

information, using a variety of sources and technologies. Acknowledge the work and ideas of others.	
Problem solvers Take on challenges and opportunities. Apply creative, logical and critical thinking skills to respond effectively. Make and implement decisions. Be flexible, thorough, innovative and aim for high standards.	**4 Problem solving skills**
Effective communicators Articulate ideas and convey them effectively using a range of media. Work collaboratively and engage with people in different settings. Recognize how culture can shape communication.	**5 Written communication** **6 Oral communication** **7 Teamwork**
Responsible Understand how decisions can affect others and make ethically informed choices. Appreciate and respect diversity. Act with integrity as part of local, national, global and professional communities.	**10 Sustainability, societal & environmental impact**

Practical work: NA
(Only Tutorial)

Lecture/tutorial times: As per Time Table

1) Two lectures each of one hours/Week
2) One tutorial of one hours/Week

Attendance Requirements

The University norms states that it is the responsibility of students to attend all lectures, tutorials, seminars and practical work as stipulated in the course outline. Minimum attendance requirement as per university norms is compulsory for being eligible for semester examinations.

Details of referencing system to be used in written work

Text books

1. Theory of Machines and Mechanisms, Shigley, J.E and Uicker, J.J , Oxford University Press , 5th Edition, 2016.
2. Theory of Machines, Rattan S.S, Tata McGraw-Hill Publishing Co. Ltd, New Delhi, 4th Edition, 2014.

Reference Books:

1. Theory of Machines, Thomas Bevan, CBS Publishers and Distributors, New Delhi, 3rd Edition, 1984.
2. Mechanisms and Machine Theory, Rao.J.S. and Dukkipati.R.V, Wiley-Eastern Ltd, New Delhi, 2nd Edition, 1992.
3. Theory of Mechanisms and Machines, C.S. Sharma and Kamlesh Purohit, PHI Learning Pvt. Limited, New Delhi**,** 6th Edition, 2006
4. Mechanics of Machines, Cleghorn. W. L, Oxford University Press, 2nd Edition, 2014
5. Kinematics and Dynamics of Machinery, Robert L. Norton, Tata McGraw-Hill, New Delhi, 2nd Edition, 2009.
6. Kinematics and Linkage Design, Allen S. Hall Jr, Prentice Hall, US, 1st Edition, 1961.
7. Theory of Mechanisms and Machines, Ghosh. A and Mallick, A.K., Affiliated East-West Pvt. Ltd, New Delhi, 3rd Edition, 2015.
8. Theory of Machines, Sadhu Sigh, Pearson Education, New Delhi**,** 3rd Edition, 2012

Web resources:

1. https://nptel.ac.in/courses/112104121
2. http://kmoddl.library.cornell.edu/
3. https://www.journals.elsevier.com/mechanism-and-machine-theory
4. Mech analyzer software for mechanism, http://www.roboanalyzer.com/mechanalyzer.html

ASSESSMENT GUIDELINES

Your final course mark will be calculated from the following:

Theory Assessment:

Your final course mark will be calculated from the following:

(a) **CIE Theory 60 marks** (40 marks mid semester examination + 20 marks internal evaluation)
> Components of internal evaluation need to include (05 marks as attendance bonus for all students having attendance > 80%)+(05 marks for presentation)+(10 marks for assignment or case studies, limited to minimum 02 assignments per course).
(b) **End Semester Theory 40 marks.**

SUPPLEMENTARY ASSESSMENT

Students who receive an overall mark less than 40% in internal component or less than 40% in the end semester will be considered for supplementary assessment in the respective components (i.e internal component or end semester) of semester concerned. Students must make themselves available during the supplementary examination period to take up the respective components (internal component or end semester) and need to obtain the required minimum 40% marks to clear the concerned components.

Practical Work Report/Laboratory Report:

A report on the practical work is due the subsequent week after completion of the class by each group.

Late Work

Late assignments will not be accepted without supporting documentation. Late submission of the reports will result in a deduction of -% of the maximum mark per calendar day

Format

All assignments must be presented in a neat, legible format with all information sources correctly referenced. **Assignment material handed in throughout the session that is not neat and legible will not be marked and will be returned to the student.**

Retention of Written Work

Written assessment work will be retained by the Course coordinator/lecturer for two weeks after marking to be collected by the students.

University and Faculty Policies

Students should make themselves aware of the University and/or Faculty Policies regarding plagiarism, special consideration, supplementary examinations and other educational issues and student matters.

Plagiarism - Plagiarism is not acceptable and may result in the imposition of severe penalties. Plagiarism is the use of another person's work, or idea, as if it is his or her own - if you have any doubts at all on what constitutes plagiarism, please consult your Course coordinator or lecturer. Plagiarism will be penalized severely.

Do not copy the work of other students.
Do not share your work with other students (except where required for a group activity or assessment)

Course schedule :

	Week	Topic & contents	CO Addressed	Teaching Learning Activity (TLA)
	Week1	Terminology and Definitions, Mechanism & Machines, Rigid and resistance body, link, Kinematic pair, classification of Kinematic pairs, Kinematic Chain,	1	PPT, Animation, Tutorial
	Week 2	Linkage, Mechanics, degrees of freedom, Mobility – Kutzbach criterion, Gruebler's criterion, Grashof's Law, Kinematic Inversion of four bar chain	1	PPT, Tutorial
	Week 3	Kinematic Inversion of four bar chain, Single and Double slider crank Chain, Four bar chain mechanism with lower pairs, Steering gear mechanisms such as Davis and Ackermann Steering gear.	1	PPT, Animation, Tutorial
	Week 4	Velocity and acceleration analysis in simple mechanisms, Graphical Method - velocity and acceleration polygons	2	PPT, Tutorial
	Week 5	Graphical Method - velocity and acceleration polygons, Instantaneous Centre of Velocity	2	PPT, Tutorial
	Week 6	Instantaneous Centre of Velocity, Kennedy Theorem	2	PPT, Tutorial
	Week 7	Angular velocity ratio theorem, Coriolis acceleration component	2	PPT, Animation, Tutorial
	Week 8	Introduction, belt and ropes drives, selection of belt drive, types of belt drives, Materials used for belt and rope drives, law of belting, velocity ratio, tension ratio	6	PPT, Animation, Tutorial
	Week 9	Length of belt, V-belts, Wire rope, Slip and Creep of belt drive, tensions for flat belt drive, Angle of contact, centrifugal tension, Maximum power transmitted by belt, chain drive & its classification.	6	PPT, Tutorial
	Week 10	Introduction, Classification of Gears, Gear Terminology, Law of Gearing, Velocity of Sliding, Forms of teeth, Involutes and cycloidal tooth profiles, Arc of the contact, Numbers of pairs of teeth in contact, Interference in involute Gears	4	PPT, Animation, Tutorial
	Week 11	Minimum Number of teeth, Under cutting, Comparison of Cyclonical and involutes tooth forms, Spur, Helical, Spiral, Worm, Worm Gear and Bevel Gears (Basics only)	4	PPT, Tutorial

	Week 12	Simple, Compound, Reverted & Epicyclic gear trains, Algebraic and tabular methods of finding velocity ratio of epicyclic gear trains.	4	PPT, Animation, Tutorial
	Week 13	Introduction, Definitions of cam and followers, applications, Types of Cams, Types of Followers, Cam Terminology	5	PPT, Animation, Tutorial
	Week 14	displacement, velocity and acceleration curves for uniform velocity, Simple Harmonic Motion, displacement, velocity and acceleration curves for Uniform Acceleration Retardation, Cycloidal motion	5	PPT, Tutorial
	Week 15	Cam profiles: cam with reciprocating/oscillating follower having knife-edge, Cam profiles: cam with roller and flat-face follower inline and offset. Tangent circular arc and eccentric cam.	5	PPT, Tutorial
	Week 16	Types of synthesis, Function generation, Path generation, Motion generation, Graphical synthesis, Chebyshev's spacing for accuracy points, Freudenstein's equation	3	PPT, Tutorial