GUJARAT TECHNOLOGICAL UNIVERSITY

Program Name: Master of Engineering

Level: PG

Branch: Machine Design

Subject Code : ME02078031

Subject Name : Multibody Dynamics

w. e. f. Academic Year:	2024-25
Semester:	2
Category of the Course:	Professional Elective Course

Prerequisite:	Zeal to learn the subject
Rationale:	This course reviews and reinforces the student's understanding Kinematics and Dynamics of multibody systems with immediate application to the dynamics of systems of rigid bodies. The course will place equal emphasis on gaining both an analytical understanding and insight/intuition on the subject.

Course Outcome:

After Completion of the Course, Student will able to:

No	Course Outcomes	RBT level
1	Students will be able to apply basic particle dynamics and 2-dimensional rigid body mechanics to 3-dimensional rigid bodies.	35
2	Students will be able to analyse interconnected bodies in a multi-body system.	35
3	Students will be able to use numerical methods for the analysis of multi-body system.	30

Teaching and Examination Scheme:

Teaching Scheme (in Hours)			Total Credits L+T+ (PR/2)	Assessment Pattern and Marks				Total Marks
				Theory		Tutorial / Practical		
L	T	PR	C	ESE (E)	PA / CA (M)	PA/CA (I)	ESE (V)	
3	0	2	4	70	30	20	30	150

Course Content:

Unit No.	Content	No. of Hours	% of Weightage
1.	**Basic concepts in 3-D rigid-body mechanics** Degrees-of-freedom;Rigid body vs flexible body; Spatial kinematics (3-D rotation transformations); Euler theorem, rotation	11	26

	parameterization, Rodriguez formula; Moments and products of inertia; Newton-Euler equations of motion; Lagrange Equation; Generalized forces.		
2.	**Inter-connected rigid bodies** Kinematic pairs (joints) with classification of constraints; holonomic and non-holonomic constraints; Springs, dampers, actuators and controllers with brief introduction of controls theory.	06	14
3.	**Formulation of equations of motion for inter-connected bodies** Relative coordinates, generalized coordinates, Cartesian co-ordinates ; Lagrange' s equations and other approaches; Differential equations (ODE) and differential algebraic equations (DAE); Co-ordinate partitioning and Lagrange multipliers; Types of analyses (kinematic, static, quasi-static, kineto-static, dynamic and linear dynamic).	12	28
4.	**Application of numerical methods** NR method, Jacobian, ODE integrators (Euler methods and Implicit methods); Stability, accuracy and Dahlquist's tradeoff criteria; Stiffness and damping - physical vs numerical; Lock-up, bifurcation and singularities.	08	16
5.	**Flexible Multibody Systems** Dynamic analyses using classical approximation, FEM	08	16
	Total	**45**	**100**

Suggested Specification Table with Marks (Theory):

Distribution of Theory Marks					
R Level	**U Level**	**A Level**	**N Level**	**E Level**	**C Level**
10	**20**	**20**	**30**	**10**	**10**

Where R: Remember; U: Understanding; A: Application, N: Analyze and E: Evaluate C: Create (as per Revised Bloom's Taxonomy)

References/Suggested Learning Resources:
(a) Books:

1. Computational dynamics, Shabana A. A., John Wiley & Sons.
2. Dynamics of Multibody Systems, Roberson R. E., and Richard S., Springer-Verlag.
3. Dynamics of Multibody Systems, Shabana A. A., Cambridge University press.
4. Flexible Multibody Dynamics, Bauchau O. A., Vol. 176. Springer.

5. Dynamics and Balancing of Multibody Systems, Chaudhary H., and S K Saha. Springer.

(b) Open-source software and website:

1. Scilab Software

Suggested Course Practical List:

1. Kinematics of a planar open-loop system using MATLAB/Scilab
2. Inverse dynamics of planar open-loop systems using MATLAB/Scilab
3. Forward dynamics of planar open-loop systems using MATLAB/Scilab
4. Kinematics of a planar closed-loop system using MATLAB/Scilab
5. Inverse dynamics of planar closed-loop systems using MATLAB/Scilab
6. Forward dynamics of planar closed-loop systems using MATLAB/Scilab
7. Kinematics of a spatial closed-loop system using MATLAB/Scilab
8. Inverse dynamics of spatial closed-loop systems using MATLAB/Scilab
9. Forward dynamics of spatial closed-loop systems using MATLAB/Scilab
10. Modellingand analysis of multibody systems using MBD software.

List of Laboratory/Learning Resources Required:

Major Equipment:

1. Computational facility and Matlab / Scilab.
2. Mechanism analysis software.

Suggested Project List:

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