GUJARAT TECHNOLOGICAL UNIVERSITY

MECHANICAL (CAD/CAM) (08)/ MECHANICAL (MACHINE DESIGN) (09)

MULTIBODY DYNAMICS
SUBJECT CODE: 2720820
SEMESTER: II

Type of course: Engineering Science

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.

Teaching and Examination Scheme:

Teaching Scheme			Credits	Examination Marks						Total Marks
				Theory Marks		Practical Marks				
L	T	P	C	ESE (E)	PA (M)	ESE (V)		PA (I)		
						ESE	OEP	PA	RP	
3	0	2#	4	70	30	20	10	10	10	150

Contents:

Sr. No	Topic	Lectures	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 parameterization, Rodriguez formula; Moments and products of inertia; Newton-Euler equations of motion; Lagrange Equation; Generalized forces.	**11**	**30%**
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.	**6**	**10%**
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).	**11**	**30%**
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.	**7**	**15%**
5	**Flexible Multibody Systems**	**7**	**15%**

	Dynamic analyses using classical approximation, FEM		

References 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.

Course Outcome:

After learning the course the students should be able to:

1. Students will be able to apply basic particle dynamics and 2-dimensional rigid body mechanics to 3-dimensional rigid bodies.
2. Students will be able to analyse interconnected bodies in a multi-body system.
3. Students will be able to use numerical methods for the analysis of multi-body system.

List of Experiments:

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. Modelling and analysis of multibody systems using MBD software.

Design based Problems (DP)/Open Ended Problem:

1. Develop a code for dynamic analysis of multi-body system.
2. Analyse behaviour of chain considering it as a multi-body system.

Major Equipment:

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

List of Open Source Software/learning website:

Review Presentation (RP): The concerned faculty member shall provide the list of peer reviewed Journals and Tier-I and Tier-II Conferences relating to the subject (or relating to the area of thesis for seminar) to the students in the beginning of the semester. The same list will be uploaded on GTU website during the first two weeks of the start of the semester. Every student or a group of students shall critically study 2 papers, integrate the details and make presentation in the last two weeks of the semester. The GTU marks entry portal will allow entry of marks only after uploading of the best 3 presentations. A unique id number will be generated only after uploading the presentations. Thereafter the entry of marks will be allowed. The best 3 presentations of each college will be uploaded on GTU website