Birla Institute of Technology & Science, Pilani
Hyderabad Campus

SECOND SEMESTER 2018-2019

Course Handout Part II

Date: 07-01-2019

In addition to part-I (General Handout for all courses appended to the time table) this portion gives further specific details regarding the course.

Course No. : **BITS F441**
Course Title : **ROBOTICS**
Instructor-in-Charge : **Dr. ARSHAD JAVED**
Instructors : **Dr. ARSHAD JAVED, Dr. Shaikshavali Chitraganti**

Course Description: See Page VI-23 in Bulletin 2017-2018.

Scope and Objective: This course is intended to provide a comprehensive knowledge of the technology related to robotics. The necessity of human like machines to replace human beings from the work-sites have been long felt for a large variety of reasons. The field of robotics has emerged as one of the important present engineering areas.

The course will develop overall background of the student in interdisciplinary robotic technology with emphasis on mechanical and control aspects. Important aspect of mobile robotics such as dynamics and control is also focused using latest examples such as Quadcopters and Segway mobile robots.

Text Book:

(T) Mittal R. K. & Nagrath I. J., "*Robotics and Control"*, TMH, 2003 (Reprint 2007 or later).

Reference Books:

(R1) Groover, M. P., et al., "*Industrial Robotics*", MGHISE, 1986.
(R2) Fu, K. S., et al., *Robotic: Control, Sensing, Vision & Intelligence*, MGHISE, 1987.
(R3) Robert J., Schilling, *Fundamentals of Robotics: Analysis and Control*, Prentice Hall, NJ, 2002.
(R4) Siegwart R., Nourbakhsh I.R., Scaramuzza D., "Introduction to Autonomous Mobile Robots", The MIT Press, second edition 2011.
(R5) Beard R., McLain T., "Small unmanned aircraft: Theory and practice", Oxford university press, 2012
(R6) Bouabdallah, S, "Design and control of quadrotors with application to autonomous flying", EPFL, 2007.

Course Plan:

Lecturer No.	Learning Objectives	Topics to be covered	Chapter in Textbook
1	Introduction	Introduction of Robotics, Progressive Advancement. The Robotics trends and the future prospects.	T1-1
2	Fundamentals of Robot Technology	Robot Anatomy, Degrees of Freedom (DOF) in a Manipulator	T1-1, R1-2
3		Arm & Wrist Configuration, The End-effector, Human arm characteristics, Design & Control issues	T1-2 R1-2
4-5	Robot Motion Analysis	Co-ordinate frames mapping, Mapping between frames, Transformations, Fundamental Rotation Matrices – Principle axes Rotation fixed, Euler and Equivalent angle axis Representations	T1-2 R1-4 R2-2
6-8	Kinematics of Manipulators	Kinematic Modeling of Manipulator, Direct kinematics model mechanical structure & Notations Description of links & Joints, Denavit – Hertenberg Notation, Examples.	T1-3 R1-4, R1-3
9-10		The Inverse kinematics manipulator: workspace, solvability of inverse kinematic model. Solution technique, closed form solutions, Singularities.	T1-4, 5 R1-4, R3-3
11-12	Differential Motion	Differential kinematics, linear and angular velocity of a Rigid Body, Relationship	T1-5

	and Statics	between Transformation matrix and angular velocity, mapping velocity vectors, velocity propagation along links. Manipulator Jacobian, Jacobian Inverse, Jacobian singularities, Static Analysis. Jacobian, Examples.	R1-5 R3-5
13-15	Dynamics of Mechanisms	Introduction, Lagrangian Mechanics, Lagrange – Euler formulation - Velocity of a point on the manipulator, The inertia tensor, The kinetic energy, the potential energy. Equations of Motions, the Lagrangian-Euler (LE) Dynamic model algorithm. Examples on Dynamic modeling.	T1-6 R2-3 R3-6 R1-4
16, 17	Trajectory Planning	Terminology, Joint-Space Technique, Cartesian Space Technique	T1-7
18, 19	Robot Control	Control of movements of mechanical joints, control sequence, n-joints manipulator control system, system performance, control system with damping, control strategy, Architecture of control systems.	T1-8, R2-5 R1-8, R3-7
20, 21	Sensors and Actuators	The meaning of sensing, sensors in Robotics kinds of sensor used in Robotics, Tactile sensors Force-Torque sensors. Types of actuators, AC, DC, motors	T1-8, R2-5 R1-6, R3-7
22	Robot Programming	Types of programming method, Robot Programming issues, commands, Writing programs for different tasks	R1-8, 9 R2-9,R3-9
23	Fundamentals of Mobile robot	Introduction to Mobile robots, Legged and Wheeled Mobile Robots	R4-1, 2
24-25	Perception and localization	Simultaneous Localization and mapping using robot operating system (ROS)	Class notes,
26, 27	Mobile robotics	Introduction, Aerial robotics-quadrotor, Wheeled robot-segway styled robot or self-balancing robot	Class notes, R5-1, R6-1
28, 29	Aerial robotics	Basic mechanics and design considerations	Class notes, R5-2,3,4, R6-3
30-32	Mobile robot dynamics: Quadrotor	Derivation of quadrotor dynamics and its state space representation	Class notes, R5-2,3,4,R6-2
33-34	Mobile robot Control	Nested control structure and trajectory tracking in three dimensions: Application to hovering	Class notes, R6-4
35-37	Mobile Robot Kinematics and dynamics : Segway	Modeling and dynamics	Class notes
38, 39	Control Segway styled robot	Control of Segway styled robot	Class notes
40, 42	Advance robotic controls	Shortest distance and minimum jerk robotic control algorithms: application to hovering of a quadrotor	Class notes

Evaluation Scheme:

Component	Duration	Weightage (%)	Date & Time	Nature of Component
Mid semester Test	90 min	25	12/3 11.00 -12.30 PM	Close Book
Quiz	--	15	--	Close Book
Project	--	15	--	--
Comprehensive- Examination	3 Hrs	45	03/05 AN	Partially Close & Open Book (at least 20%)

Chamber Consultation Hour: To be decided based on Timetable.
Notices: All notices will be put up on CMS only.
Make-up Policy: Make-up will be given with prior concern and genuine reasons only.
Academic Honesty and Integrity Policy: Academic honesty and integrity are to be maintained by all the students throughout the semester and no type of academic dishonesty is acceptable.

INSTRUCTOR-IN-CHARGE