MAULANA ABUL KALAM AZAD UNIVERSITY OF TECHNOLOGY, WB

(Formerly West Bengal University of Technology)

Syllabus for B. Sc. In Robotics& 3D Printing (In-house)
(Effective for Students Admitted in Academic Session 2020-2021)
In CBCS Format

5th Semester

Subject Type			Course Code	Course Name	Credit Points	Credit Distribution			Mode of Delivery		
						Th	Pr	Tu	Offline	Online	Blended
CC	CC11	CC11.1	RBEE501	Control System	4	4	0	0	✓	✓	✓
		CC 11.2	RBEE591	Control System Lab	2	0	2	0	✓	✓	✓
	CC12	CC12.1	RBPR501	Introduction to Robotics II	4	4	0	0	✓	✓	✓
		CC12.2	RBPR592	Robotics II Lab	2	0	2	0	✓	✓	✓
DSE		DSE 1.1	RBPR502	Industrial Design And Applied Ergonomics	4	4	0	0	✓	✓	✓
		DSE1.2	RBPR592	Industrial Design And Applied Ergonomics lab	2	0	2	0	✓	✓	✓
DSE		DSE 2.1	RBMS501	Mechanical design	4	4	0	0	✓	✓	✓
		DSE2.2	RBMS591	Mechanical Design lab	2	0	2	0	✓	✓	✓
Semester Credits					**24**						

***Course to be completed from MOOCs Platform.**

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Semester-V

Subject: Control System
Code: RB-EE501
Contact Hours/week: 3L+1T
Credits: 4

OBJECTIVES:

- To study the basics of control system and its response .stability of mechanical and electrical systems . Use of MATLAB to design a stable control system.
- To introduce the elements of control system and their modeling using various Techniques.
- To introduce methods for analyzing the time response.
- To impart knowledge about the frequency response and the stability of systems
- To introduce the state variable analysis method

UNIT I INTRODUCTION

Open loop and closed loop systems - Examples - Elements of closed loop systems - Transfer function - Modeling of physical systems – Mechanical, Thermal, Hydraulic systems and Electric Networks - Transfer function of DC generator, DC servomotor, AC servomotor ,Potentiometer, Synchros, Tachogenerator, Stepper motor - Block diagram - reduction techniques, Signal flow graph – Mason‟ gain formula. (Related Tutorials Using MATLAB/ Simulink – Toolboxes & Functions)

UNIT II TIME DOMAIN ANALYSIS

Standard Test signals – Time response of second order system - Time domain specifications - Types of systems - Steady state error constants - Introduction to P, PI and PID modes of feed back control. (Related Tutorials Using MATLAB/ Simulink – Toolboxes & Functions)

UNIT III FREQUENCY DOMAIN ANALYSIS

Frequency domain specifications - Time and frequency response correlation – Polar plot – Bode plot – All pass minimum phase and non-minimum phase systems. (Related Tutorials Using MATLAB/ Simulink – Toolboxes & Functions)

UNIT IV SYSTEM STABILITY

Characteristic equation - Routh Hurwitz criterion of stability - Absolute and Relative stability - Nyquist stability - Nyquist stability criterion - Assessment of relative stability – Gain and Phase Margin. (Related Tutorials Using MATLAB/ Simulink – Toolboxes & Functions)

UNIT V ROOT LOCUS METHOD

Root locus concepts - Construction of root loci – Root contours. (Related Tutorials Using MATLAB/ Simulink – Toolboxes & Functions) STATE SPACE ANALYSIS: Limitations of conventional control theory - Concepts of state, state variables and state model – state model

for linear time invariant systems - Introduction to state space representation using physical - Phase and canonical variables. (Related Tutorials Using MATLAB/ Simulink – Toolboxes & Functions)

OUTCOMES:

- To understand the basic of the control system
- Ability to know about the time and frequency domain analysis
- To know about the different stability of the systems
- To expose students to the state space representation and its analysis.
- To introduce non-linear systems and their control and to impart knowledge on advanced control techniques

TEXT BOOKS:

1. Nagrath I J, and Gopal, M, 'Control Systems Engineering" Prentice Hall of India, New Delhi, 2008.
2. Richard C Dorf and Robert H Bishop, "Modern Control Systems.", Addison-Wesley -2007

REFERENCES:

1. Ogata K, "Modern Control Engineering", Pearson Education, New Delhi, 2006.
2. Kuo B C, "Automatic Control Systems", Prentice-Hall of India Pvt. Ltd, New Delhi, 2004.
3. Norman C. Nise S, “Control system Engineering“, John Wiley & Sons, Singapore, 2004.

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Subject: Control System Lab
Code: RB-EE591
Contact Hours/week: 3L+1T
Credits: 2

Laboratory Experiments:
1. Familiarization with MAT-Lab control system tool box, MAT-Lab- simulink tool box & PSPICE
2. Determination of Step response for first order & Second order system with unity feedback with the help of CRO &calculation of control system specification , Time constant, % peak overshoot, settling time etc. from the response.
3. Simulation of Step response & Impulse response for type-0, type-1 & Type-2 system with unity feedback using MATLAB & PSPICE.
4. Determination of Root locus, Bode plot, Nyquist plot using MATLAB control system tool box for 2nd order system & determination of different control system specification from the plot.
5. Determination of PI, PD and PID controller action of first order simulated process.
6. Determination of approximate transfer functions experimentally from Bode plot.
7. Evaluation of steady state error, setting time , percentage peak overshoot, gain margin, phase margin with addition of Lead, Lag, Lead-lag compensator.
8. Study of a practical position control system obtaining closed step responses for gain setting corresponding to over-damped and under-damped responses. Determination of rise time and peak time using individualized components by simulation. Determination of un-damped natural frequency and damping ration from experimental data.
9. Design of Lead, Lag and Lead-Lag compensation circuit for the given plant transfer function. Analyze step response of the system by simulation.
10. Determination of Transfer Function of a given system from State Variable model and vice versa. Analysis of a physical system by State variable and to obtain step response for the system by simulation.
11. Study of State variable analysis using simulation tools. To obtain step response and initial condition response for a single input, two-output system in SV form by simulation.
Institute may develop experiments based on the theory taught in addition to experiments mentioned.

Course outcome: After completion of this course, the learners will be able to
1. identify appropriate equipment and instruments for the experiment.
2. test the instrument for application to the experiment.
3. construct circuits with appropriate instruments and safety precautions.
4. use MAT-Lab control system tool box, MAT-Lab- simulink tool box & PSPICE for simulation of systems.
5. determinecontrol system specifications of first and second order systems.

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In CBCS Format

Subject: Introduction to Robotics II
Code: RB-PR501
Contact Hours/week: 3L+1T
Credits: 4

OBJECTIVES:

- To study the various parts of robots and fields of robotics.
- To study the various kinematics and inverse kinematics of robots.
- To study about the localization, planning and navigation.
- To study the control of robots for some specific applications.
- To study about the humanoid robots.

UNIT I INTRODUCTION

History of service robotics – Present status and future trends – Need for service robots - applicationsexamples and Specifications of service and field Robots. Non conventional Industrial robots.

UNIT II LOCALIZATION

Introduction-Challenges of Localization- Map Representation- Probabilistic Map based LocalizationMonte carlo localization- Landmark based navigation-Globally unique localization- Positioning beacon systems- Route based localization.

UNIT III PLANNING AND NAVIGATION

Introduction-Path planning overview- Road map path planning- Cell decomposition path planningPotential field path planning-Obstacle avoidance - Case studies: tiered robot architectures. UNIT IV FIELD ROBOTS 9 Ariel robots- Collision avoidance-Robots for agriculture, mining, exploration, underwater, civilian and military applications, nuclear applications, Space applications.

UNIT V HUMANOIDS:

Wheeled and legged, Legged locomotion and balance, Arm movement, Gaze and auditory orientation control, Facial expression, Hands and manipulation, Sound and speech generation, Motion capture/Learning from demonstration, Human activity recognition using vision, touch, sound, Vision, Tactile Sensing, Models of emotion and motivation. Performance, Interaction, Safety and robustness, Applications, Case studies.

UNIT VI BOT CREATOR

Introduction – Recorders – Smart Recorders – Web Recorders – Screen Recorders - Task Editor – Variables - Command Library – Loop Command – Excel Command – Database Command - String Operation Command - XML Command - Terminal Emulator Command - PDF Integration Command - FTP Command - PGP Command - Object Cloning Command -

Error Handling Command - Manage Windows Control Command - Workflow Designer - Report Designer - Best Practices – Summary

UNIT VII META BOT AND BOT INSIGHT

Introduction - MetaBot Designer - MetaBot With AI Sense - Bot Insight -Transactional Analytics - Operational Analytics - Course Key Points.

OUTCOMES: Upon completion of the course, the student should be able to: • Explain the basic concepts of working of robot • Analyze the function of sensors in the robot • Write program to use a robot for a typical application • Use Robots in different applications • Know about the humanoid robots.

TEXT BOOKS:

1. Roland Siegwart, Illah Reza Nourbakhsh, Davide Scaramuzza, „Introduction to Autonomous Mobile Robots", Bradford Company Scituate, USA, 2004

2. Riadh Siaer, „The future of Humanoid Robots- Research and applications", Intech Publications, 2012.

3. Learning Robotic Process Automation: Create Software robots and automate business processes with the leading RPA tool - UiPath: Create Software robots. with the leading RPA tool – UiPath Kindle Edition

4. Robotic Process Automation A Complete Guide - 2020 Edition Kindle Editio

REFERENCES: 1. Richard D Klafter, Thomas A Chmielewski, Michael Negin, "Robotics Engineering – An Integrated Approach", Eastern Economy Edition, Prentice Hall of India P Ltd., 2006.

2. Kelly, Alonzo; Iagnemma, Karl; Howard, Andrew, "Field and Service Robotics ", Springer, 2011

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Subject: Introduction to Robotics II Lab
Code: RB-PR591
Contact Hours/week: 3P
Credits: 2

LIST OF PRACTICALS

1. 3D Modelling of a single component.
2. Assembly of CAD modelled Components
3. Exercise on CAD Data Exchange.
4. Generation of .stl files.
5. Identification of a product for Additive Manufacturing and its AM process plan.
6. Printing of identified product on an available AM machine.
7. Post processing of additively manufactured product.
8. Inspection and defect analysis of the additively manufactured product.
9. Comparison of Additively manufactured product with conventional manufactured counterpart.

10. Software Installation Procedure – Installation of AA Control Room, SQL Server and AA Client.

- Bot Creation using recorders (Smart, Web and Screen).
- Bot Creation using command library – (Loop Command).
- Bot Creation to invoke database automation
- Bot Creation for automating excel operations
- Bot Creation for PDF Integrations.
- Bot Creation and working on error handling.
- Bot Development using Object Cloning Command.
- FTP and PGB Command Execution by Bots
- MetaBot Designing with AI Sense.

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Subject: Industrial Design & Applied Ergonomics
Code: RB-PR502
Contact Hours/week: 3L+1T
Credits: 4

OBJECTIVES:

- To explain the general principles that governs the interaction of humans in their working environment
- To improve improving worker performance and safety.

- To know about the environmental conditions in the industry.
- To know about bio thermodynamics and bioenergetics
- To know about the human factors in industrial aspects

UNIT I INTRODUCTION

Definition, human technological system, multidisciplinary engineering approach, human–machine system, manual, mechanical, automated system, human system reliability, conceptual design, advanced development, detailed design and development. INFORMATION INPUT: Input and processing, text, graphics, symbols, codes, visual display of dynamic information, auditory, tactual, olfactory displays, speech communications.

UNIT II HUMAN OUTPUT AND CONTROL

Physical work, manual material handling, motor skill, human control of systems, controls and data entry devices, hand tools and devices. WORKPLACE DESIGN: Applied anthropometry, workspace design and seating, arrangement of components within a physical space, interpersonal aspects of work place design, design of repetitive task, design of manual handling task, work capacity, stress, and fatigue.

UNIT III ENVIRONMENTAL CONDITIONS

Illumination, climate, noise, motion, sound, vibration, colour and aesthetic concepts. BIOMECHANICS: Biostatic mechanics, statics of rigid bodies, biodynamic mechanics, human body kinematics, kinetics, impact and collision.

UNIT IV BIOTHERMODYNAMICS AND BIOENERGETICS

Biothermal fundamentals, human operator heat transfer, human system bioenergetics, thermoregulatory physiology, human operator thermo regularity, passive operator, active operator, heat stress.

UNIT V HUMAN FACTORS APPLICATIONS

Human error, accidents, human factors and the automobile, organizational and social aspects, steps according to ISO/DIS6385, OSHA‟s approach, virtual environments.

OUTCOMES:
The Student should
- Know about ergonomic principles to design workplaces
- improve human performance • judge the environmental conditions in the work place.
- know about biothermodynamics and bioenergetics
- implement latest occupational health and safety to the work place.

TEXT BOOK:

1. Chandler Allen Phillips, "Human Factors Engineering", John Wiley and Sons, New York, 2000.

REFERENCES:
1. Bridger R S, "Introduction to Ergonomics", Taylor and Francis, London, 2003.
2. Mayall W H, "Indus trial Design for Engineers", London ILIFFEE Books Ltd., UK, 1998.
3. Mark S Sanders, "Human Factors in Engineering and Design", McGraw Hill, New York, 1993.

Subject: Industrial Design & Applied Ergonomics Lab
Code: RB-PR592
Contact Hours/week: 3L+1T
Credits: 2

List of Experiments:

1. Measure Anthropometric Dimensions of a group of Human Subjects and express the Data in percentile
2. Design a Biomechanical Model based on Anthropometric Dimensions of Human subject
3. Estimate Manual Material Handling Capacity of a group of Human Subjects using Biomechanical Model
4. Estimate Manual Material Handling Capacity of a group of Human Subjects using Psychophysical Methodology
5. Record Heart Beat, Pressure and ECG data for few subjects for a manual task and analyse the data.
6. Design a Robotic Grip using Biomechanical insight of Human Fingures.

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Subject: Mechanical design
Code: RB-MS 501
Contact Hours/week: 3L+1T
Credits: 4

Module 1: Introduction to Mechanical Engineering Design- Review of models of Solid mechanics,
uncertainties in design equations and factor of safety. Role of off the shelf available machine elements and standards. Standard numbering system including BIS designations of materials. Application of theories of failure to design
Module 2: Design procedure and applications of Statically Loaded Machine Elements- Design of
elements subjected to simple loading: Riveted joints, Screws including power screws Bolted joints
including eccentrically loaded joints, Axles, and coupling, Clutches and brakes.
Module 3: Fatigue- Introduction to design for fatigue strength. Endurance and modifying factors.
Surface strength. Review of design procedure of fatigue failure with application to the design of
bolts and springs subjected to fatigue loading.
Module 4: Design procedure and applications of Dynamically Loaded Machine Elements. Shafts,
Spur, helical, bevel and worm gears, Journal and rolling contact bearings, Belts and chains. Assemblies of various machine elements like those of a screw jack and a gear box.

Text/Reference Books:
1. Budynas, R. G., & Nisbett, J. K.. Shigley's mechanical engineering design: McGraw-Hill.
2. Norton, R. L. Machine design: an integrated approach: Prentice Hall
3. Spotts, M. F., Shoup, T. E., & Hornberger, L. E. Design of machine elements: Pearson /Prentice Hall
4. Hamrock,B.J. et.al., Fundamentals of Machine Elements, McGraw Hill86
5. Bhandari, V. B. Design of Machine Elements: McGraw-Hill Education (India) Pvt Ltd.
6. Juvinall, R. C., & Marshek, K. M. Fundamentals of machine component design: John Wiley.
7. NPTEL courses: http://nptel.iitm.ac.in/courses.php - web and video resources on Dynamics of Mechanical
System/ Design of Machine Elements /Machine Design.

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Subject: Mechanical design Lab
Code: RB-MS 591
Contact Hours/week: 3L+1T
Credits: 2

OBJECTIVE:

- The main objective is to give an opportunity to the student to get hands on training in the fabrication of one or more components of a complete working model, which is designed by them.

GUIDELINE FOR REVIEW AND EVALUATION The students may be grouped into 2 to 4 and work under a project supervisor. The device/ system/component(s) to be fabricated may be decided in consultation with the supervisor and if possible with an industry. A project report to be submitted by the group and the fabricated model, which will be reviewed and evaluated for internal assessment by a Committee constituted by the Head of the Department. At the end of the semester examination the project work is evaluated based on oral presentation and the project report jointly by external and internal examiners constituted by the Head of the Department. TOTAL : 60 PERIODS

OUTCOMES: Upon the completion of this course the students will be able to
CO1 design and Fabricate the machine element or the mechanical product.
CO2 demonstrate the working model of the machine element or the mechanical product.