# ACADEMIC CURRICULA

# UNDERGRADUATE/ INTEGRATED POST GRADUATE DEGREE PROGRAMMES

(With exit option of Diploma)

(Choice Based Flexible Credit System)

Regulations 2021

Volume – 18
(Syllabi for Mechatronics Engineering Programme Courses)
(Revised on August 2024)


## SRM INSTITUTE OF SCIENCE AND TECHNOLOGY

(Deemed to be University u/s 3 of UGC Act, 1956)

Kattankulathur, Chengalpattu District 603203, Tamil Nadu, India

# ACADEMIC CURRICULA

Engineering Science Course

**Regulations 2021**

## SRM INSTITUTE OF SCIENCE AND TECHNOLOGY

**(Deemed to be University u/s 3 of UGC Act, 1956)**

Kattankulathur, Chengalpattu District 603203, Tamil Nadu, India

| Course Code | 21MHS201T | Course Name | THERMODYNAMICS AND HEAT TRANSFER | Course Category | S | ENGINEERING SCIENCE | L | T | P | C |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | 3 | 0 | 0 | 3 |

| Pre-requisite Courses | *Nil* | Co- requisite Courses | *Nil* | Progressive Courses | *Nil* |
|---|---|---|---|---|---|
| Course Offering Department | *Mechatronics Engineering* | Data Book / Codes / Standards | | *Nil* | |

| Course Learning Rationale (CLR): | *The purpose of learning this course is to:* |
|---|---|
| ***CLR-1:*** | *evaluate the internal energy, work done and analyze the Coefficient of performance of heat engine, refrigerator and heat pump* |
| ***CLR-2:*** | *analyze the different properties of air using psychrometry chart and the working principle of different air conditioning and refrigeration systems* |
| ***CLR-3:*** | *apply the basic concepts of heat transfer and evaluate the conduction and convection heat transfer in plane wall, cylinder and sphere* |
| ***CLR-4:*** | *analyze the heat transfer effects in different electronics components* |
| ***CLR-5:*** | *study the mathematical modelling of different thermal systems and different cooling techniques of transformer and electric motor* |

| Course Outcomes (CO): | *At the end of this course, learners will be able to:* | Program Outcomes (PO) | | | | | | | | | | | | Program Specific Outcomes | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | | | |
| | | Engineering Knowledge | Problem Analysis | Design/development of solutions | Conduct investigations of complex problems | Modern Tool Usage | The engineer and society | Environment & Sustainability | Ethics | Individual & Team Work | Communication | Project Mgt. & Finance | Life Long Learning | PSO-1 | PSO-2 | PSO-3 |
| ***CO-1:*** | *define and apply the concepts of first law and second law of thermodynamics in different real systems* | *1* | *2* | - | - | - | - | - | - | - | - | - | - | - | - | - |
| ***CO-2:*** | *define the psychrometry properties and evaluate the performance of refrigeration and air conditioning systems using psychrometry chart* | *1* | *2* | - | - | - | - | - | - | - | - | - | - | - | - | - |
| ***CO-3:*** | *recap the basics of heat transfer and demonstrate the application of conduction, convection and radiation in different real time systems* | *1* | *2* | - | - | - | - | - | - | - | - | - | - | - | - | - |
| ***CO-4:*** | *estimate the amount of heat generation in different electronic components and select the suitable cooling system* | *1* | *2* | - | - | *3* | - | - | - | - | - | - | - | - | - | - |
| ***CO-5:*** | *gain the knowledge of thermal system design modelling and different cooling methods of electrical machines* | *1* | *2* | - | - | *3* | - | - | - | - | - | - | - | - | - | - |

| ***Unit-1 - Fundamentals of Thermodynamics*** | ***9 Hour*** |
|---|---|
| *Thermodynamic concepts and definitions – System, Surroundings, Cycle, process, path and point function, Mechanical, thermal, chemical and thermodynamic Equilibrium - Laws of thermodynamics – Zeroth law, first law and second law – Application of first law of thermodynamics to non-flow process - Application of first law of thermodynamics to flow process - Second law of thermodynamics – Application of second law of thermodynamics in heat engine, refrigerator and heat pump - Entropy – Change in entropy for isobaric process, isochoric process and isentropic process* | |
| ***Unit-2 - Psychrometry and Applications in Refrigeration and Air Conditioning*** | ***9 Hour*** |
| *Psychrometry properties definition – Psychrometry chart – Psychrometry process – sensible heating, sensible cooling, humidification and dehumidification process – cooling and humidification, cooling and dehumidification, Heating and humidification, Heating and dehumidification - mixing of air streams - Refrigeration and air conditioning system – Fundamentals of refrigeration – vapour compression refrigeration and vapour absorption refrigeration system – types and working principle of window, split and centralized air conditioning system* | |
| ***Unit-3 - Fundamentals of Heat Transfer*** | ***9 Hour*** |
| *Modes of heat transfer – conduction, convection and radiation – one dimensional steady state heat conduction – heat transfer in plane wall, cylinder and spherical shell - heat transfer in composite wall, cylinder and spherical shell – Free convection and forced convection – Free convection over a horizontal plate - Free convection over a vertical plate, cylinder - Free convection over an inclined surface* | |

| | |
|---|---|
| ***Unit-4 - Application of Heat Transfer in Electronics Systems*** | ***9 Hour*** |
| *Heat generation in active devices – CMOS device – JFET – MOSFET, Heat generation in passive devices – Resistor – capacitor – Thermal Management system design for electronic systems – Cooling of electronic components with heat pipes* | |
| ***Unit-5 – Application of Heat Transfer in Mechanical and Electrical Systems*** | ***9 Hour*** |
| *Elements of IC engine – analysis of heat transfer in IC engine – elements of refrigeration system – modes of heat transfer in refrigeration system – thermos-electric effect – Seeback effect – Peltier effect – Thomson effect – thermoelectric cooler and heat pumps- cooling system and methods in transformer and electric motors – modelling of heat transfer systems* | |

| | | |
|---|---|---|
| **Learning Resources** | 1. *Yunus A Cengel Michael A Boles, Thermodynamics, 8th ed., Tata McGraw-Hill, 2017*<br>2. *Nag.P.K., Engineering Thermodynamics, 6th ed., Tata McGraw-Hill, 2017*<br>3. *Yunus A. Cengel, Afshin J. Ghajar, Heat and Mass Transfer - Fundamentals and Applications \| 6th Edition, 2020* | 4. *Upadhyay, K.G, Design of Electrical Machines, New Age International Publishers, 1st edition, 2018*<br>5. *Ralph Remsburg, Advanced thermal design of electronic equipment, Springer, 1998th edition, 2012*<br>6. *Dhar P.L, Thermal System Design and Simulation, Academic Press Inc., 2016* |

**Learning Assessment**

| | Bloom's Level of Thinking | Continuous Learning Assessment (CLA) | | | | Summative Final Examination (40% weightage) | |
|---|---|---|---|---|---|---|---|
| | | Formative CLA-1 Average of unit test (50%) | | Life-Long Learning CLA-2 (10%) | | | |
| | | Theory | Practice | Theory | Practice | Theory | Practice |
| Level 1 | *Remember* | *15%* | - | *15%* | - | *15%* | - |
| Level 2 | *Understand* | *25%* | - | *20%* | - | *25%* | - |
| Level 3 | *Apply* | *30%* | - | *25%* | - | *30%* | - |
| Level 4 | *Analyze* | *30%* | - | *25%* | - | *30%* | - |
| Level 5 | *Evaluate* | - | - | *15%* | - | - | - |
| Level 6 | *Create* | - | - | - | - | - | - |
| | *Total* | *100 %* | | *100 %* | | *100 %* | |

**Course Designers**

| Experts from Industry | Experts from Higher Technical Institutions | Internal Experts |
|---|---|---|
| 1. *Mr. K. Gopinath, Intel Technology India Pvt Ltd.,* | 1. *Dr. M. Baskaran, Associate Professor, KSR College of Technology* | 1. *Dr. S. Senthilraja, SRMIST* |
| 2. *Mr. S. Senthilkumar, Grundfos Pumps India Pvt. Ltd.,* | 2. *Dr. P. Ravichandran, Associate Professor, Kongu Engineering College* | 2. *Mr. M. Thirugnanam, SRMIST* |

# ACADEMIC CURRICULA

Professional Core Courses

Regulations 2021

## SRM INSTITUTE OF SCIENCE AND TECHNOLOGY

(Deemed to be University u/s 3 of UGC Act, 1956)

Kattankulathur, Chengalpattu District 603203, Tamil Nadu, India

| Course Code | 21MHC201T | Course Name | ELECTRICAL ACTUATORS AND DRIVES | Course Category | C | PROFESSIONAL CORE | L | T | P | C |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | 3 | 0 | 0 | 3 |

| Pre-requisite Courses | Nil | Co- requisite Courses | 21MHC202J | Progressive Courses | 21MHE403T |
|---|---|---|---|---|---|
| Course Offering Department | Mechatronics Engineering | Data Book / Codes / Standards | | Nil | |

| Course Learning Rationale (CLR): | The purpose of learning this course is to: |
|---|---|
| CLR-1: | outline the concepts of DC and AC Electrical Machines |
| CLR-2: | gain knowledge on Stepper, Servo, BLDC Motors and their applications |
| CLR-3: | familiarize the different Power Electronic Devices and Converters |
| CLR-4: | illustrate the working of different DC Electrical Drives |
| CLR-5: | acquire the knowledge on AC Electrical Drives |

| Course Outcomes (CO): | At the end of this course, learners will be able to: | Program Outcomes (PO) | | | | | | | | | | | | Program Specific Outcomes | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | | | |
| | | Engineering Knowledge | Problem Analysis | Design/development of solutions | Conduct investigations of complex problems | Modern Tool Usage | The engineer and society | Environment & Sustainability | Ethics | Individual & Team Work | Communication | Project Mgt. & Finance | Life Long Learning | PSO-1 | PSO-2 | PSO-3 |
| CO-1: | examine the fundamentals of DC and AC Machines | 3 | 3 | 2 | - | - | - | - | - | - | - | - | - | - | - | 2 |
| CO-2: | apply the Special Machines for different actuations | 3 | 2 | 2 | - | - | - | - | - | - | - | - | - | - | - | 2 |
| CO-3: | describe the working principle of Rectifiers, Choppers and Inverters | 3 | 2 | 2 | - | - | - | - | - | - | - | - | - | - | 2 | - |
| CO-4: | summarize the working of Electrical Drives | 3 | 2 | 2 | - | - | - | - | - | - | - | - | - | - | - | - |
| CO-5: | disseminate the latest trends in applications of Electrical Drives | 3 | 3 | 2 | - | - | - | - | - | - | - | - | - | - | - | - |

| | |
|---|---|
| **Unit-1 - DC and AC Electrical Actuators** | **9 Hour** |
| Overview of DC Machines, Single Phase Transformers, Three phase Induction Motors, Single Phase Induction Motors, Synchronous Motors, Characteristics, Speed Control, Starting and Braking of DC and AC Machines | |
| **Unit-2 - Special Machines and Actuators** | **9 Hour** |
| Overview of PMDC, Stepper, BLDC and Servo Motors, Robotic grippers, MEMS actuators, Introduction to solenoids, Solenoid operated fuel injection systems | |
| **Unit-3 - Power Electronic Devices and Converters** | **9 Hour** |
| Power semiconductor devices and their working -Power Diode, Power BJT, MOSFET, IGBT, SCR, Power Converters-Single Phase and Three Phase Rectifiers, Choppers, Buck, Boost and Buck boost converters, Three Phase Voltage Source Inverters, Voltage regulators, Cycloconverters | |
| **Unit-4 - DC Electric Drives** | **9 Hour** |
| Introduction to Electric Drives, Choice of electric drives - Status of DC and AC drives, Fundamental Torque Equations, Speed Torque Conventions and Multiquadrant Operation, Control of Electrical Drives, Speed Control methods - Armature Voltage Control and Ward Leonard Drives, Controlled Rectifier fed DC Drives, Chopper, Controlled DC drives, Traction Drives, Problems | |
| **Unit-5 - AC Electric Drives** | **9 Hour** |
| Speed Control of Three phase Induction Motors - Stator Voltage Control, Variable frequency Control, Voltage source inverter (VSI) Control, Cycloconverter control ,Rotor Resistance Control and Slip Power recovery schemes, Problems, BLDC motor Drives, Stepper Motor Drives and Battery powered Drives, Applications of Drives | |

| | | |
|---|---|---|
| **Learning Resources** | 1. *Bhimbra. Dr.P.S., "Power Electronics", Khanna Publishers, 2012.*<br>2. *Dubey.G.K., "Fundamentals of Electrical Drives", Narosa publishing house 2001.*<br>3. *Muhammad H. Rashid, "Power Electronics - Circuits, Devices and Applications", Prentice Hall of India, New Delhi, 2003.* | 4. *Edward Hughes, John Hiley, Keith Brown, Ian McKenzie Smith, Hughes Electrical and Electronics Technology, Pearson Education, 12th ed., 2016.*<br>5. *B. L Theraja, A. K. Theraja, A text book of Electrical Technology, Volume II, S.Chand Publications, 2008*<br>6. *S. K. Bhattacharya, S. Chatterjee, Industrial Electronics and Control, TTTI, Chandigarh, Vol.II, 2017* |

**Learning Assessment**

| | *Bloom's Level of Thinking* | *Continuous Learning Assessment (CLA)* | | | | *Summative Final Examination (40% weightage)* | |
|---|---|---|---|---|---|---|---|
| | | *Formative CLA-1 Average of unit test (50%)* | | *Life-Long Learning CLA-2 (10%)* | | | |
| | | *Theory* | *Practice* | *Theory* | *Practice* | *Theory* | *Practice* |
| Level 1 | *Remember* | *15%* | - | *15%* | - | *15%* | - |
| Level 2 | *Understand* | *25%* | - | *20%* | - | *25%* | - |
| Level 3 | *Apply* | *30%* | - | *25%* | - | *30%* | - |
| Level 4 | *Analyze* | *30%* | - | *25%* | - | *30%* | - |
| Level 5 | *Evaluate* | - | - | *10%* | - | - | - |
| Level 6 | *Create* | - | - | *5%* | - | - | - |
| | *Total* | *100 %* | | *100 %* | | *100 %* | |

**Course Designers**

| **Experts from Industry** | **Experts from Higher Technical Institutions** | **Internal Experts** |
|---|---|---|
| 1. *Dr. N. Gunavardhini, TANGEDCO, Salem, gunatneb1990@gmail.com* | 1. *Dr.K.Sujatha,Dr.MGR Educational and Research Institute, sujatha.eee@drmgrdu.ac.in* | 1. *Dr. M. Santhosh Rani, SRMIST* |
| 2. *Ms.Joyce Sumathi, CMWSSB, sumathijoyce1968@gmail.com* | 2. *Dr.G.R.Kanagachidambaresan, Vel Tech, kanagachidambaresan@gmail.com* | 2. *Dr.R.Gangadevi, SRMIST* |

| Course Code | 21MHC202J | Course Name | ANALOG AND DIGITAL ELECTRONICS | Course Category | C | PROFESSIONAL CORE | L | T | P | C |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | 2 | 0 | 2 | 3 |

| Pre-requisite Courses | Nil | Co- requisite Courses | Nil | Progressive Courses | Nil |
|---|---|---|---|---|---|
| Course Offering Department | Mechatronics Engineering | Data Book / Codes / Standards | | Nil | |

| Course Learning Rationale (CLR): | The purpose of learning this course is to: |
|---|---|
| CLR-1: | outline the concepts of various semiconductor devices |
| CLR-2: | illustrate the working of amplifiers biasing and significance of amplifier for various wave shaping circuits |
| CLR-3: | gain knowledge on operational amplifiers and its applications |
| CLR-4: | familiarize the concepts of digital circuits |
| CLR-5: | acquire the knowledge on sequential circuits |

| Course Outcomes (CO): | At the end of this course, learners will be able to: | Program Outcomes (PO) | | | | | | | | | | | | Program Specific Outcomes | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | | | |
| | | Engineering Knowledge | Problem Analysis | Design/development of solutions | Conduct investigations of complex problems | Modern Tool Usage | The engineer and society | Environment & Sustainability | Ethics | Individual & Team Work | Communication | Project Mgt. & Finance | Life Long Learning | PSO-1 | PSO-2 | PSO-3 |
| CO-1: | analyze the characteristics of special semiconductor devices | 3 | 1 | 1 | - | - | - | - | - | - | - | - | - | - | 2 | - |
| CO-2: | analyze different types of amplifiers, oscillators and multivibrator circuits | 3 | 3 | 3 | - | - | - | - | - | - | - | - | - | - | 2 | - |
| CO-3: | design linear and non-linear applications of Op-amps | 3 | 2 | 2 | - | - | - | - | - | - | - | - | - | - | 2 | - |
| CO-4: | design various combinational digital circuits using logic gates | 3 | 3 | 3 | - | - | - | - | - | - | - | - | - | - | 2 | - |
| CO-5: | understand the concepts and applications of various sequential circuits | 3 | 3 | 3 | - | - | - | - | - | - | - | - | - | - | 2 | - |

**Unit-1 - Applications of PN Junctions** — **12 Hour**

*Operation and Vi Characteristics - Tunnel Diode, Varactor Diode, Photo Diode, Light Emitting Diode and Laser Diode, UJT. Diode Applications – Clippers, Clampers, Half Wave, Full Wave and Bridge Rectifier, with and without filter. Transistor Biasing – Overview (Concepts) of Fixed Bias, Emitter Bias with and without Emitter Resistance. Analysis and Design*

*Experiments:*

*1. Characteristics of Half Wave and Full Wave Rectifier With and Without Filter. 2. Characteristics of UJT*

**Unit-2 - Feedback Amplifiers, Oscillators and Multivibrators** — **12 Hour**

*Feedback Amplifiers: Concepts of Feedback – Classification of Feedback Amplifiers – General Characteristics of Negative Feedback Amplifiers – Effect of Feedback on Amplifier Characteristics – Voltage Series, Voltage Shunt, Current Series and Current Shunt Feedback Configurations – Simple Problems. Oscillators: Barkhausen Criterion for Oscillation – Types of Oscillators. Construction and Working Principle of RC and LC Oscillators. Multivibrators: Construction and Working Principle of Astable, Bistable and Monostable Multivibrator.*

*Experiments:*

*1. Design of Astable Multivibrator. 2. Design of RC Phase Shift Oscillator*

**Unit-3 - Operational Amplifier Applications** — **12 Hour**

*Basic Information About Op-Amps – Ideal Operational Amplifier – General Operational Amplifier Stages -And Internal Circuit Diagrams of IC 741, DC and AC Performance Characteristics, Slew Rate, Open and Closed Loop Configurations, Inverting and Non-Inverting Amplifier, Differential Amplifier, Sign Changer, Scale Changer, Phase Shift Circuits, Voltage Follower, V-to-I And I-to-V Converters, Adder, Subtractor, Integrator, Differentiator, Logarithmic Amplifier, Antilogarithmic Amplifier, Comparators, Zero Crossing Detector, Schmitt Trigger, Precision Rectifier, Peak Detector, Clipper and Clamper.*

*Experiments:*

*1. Inverting and Non-Inverting Amplifiers Using Op-Amp. 2. Study of Half Wave and Full Wave Precision Rectifier*

| **Unit-4 - Combinational Logic Circuits** | **12 Hour** |
|---|---|
| *Introduction to minterms and maxterms, Minimization of Boolean Expressions Using K – Map, Combinational Circuits -Design steps - Adder and Subtractor, Multiplexer and De-Multiplexer, Encoder and Decoder, Logic Diagram of Parallel Binary Adder/Subtractor, Code Converters, Magnitude Comparator. Programmable Logic Devices - PLA, PAL, Complex PLD*<br>*Experiments:*<br>*1. Realization of Logic Circuits of Multiplexer and De-Multiplexer. 2. Realization of Logic Circuits of Encoder and Decoder. 3. Design of Code Converters* | |
| **Unit-5 - Sequential Logic Circuits** | **12 Hour** |
| *Introduction to Latches and Flip-Flop, Triggering of Flip Flops, Truth Table, Characteristic Table, Excitation Table and Equations for Flip Flops, Conversion of Flip Flops, Master – Slave Flip-Flop, Design of Sequential Circuits - Synchronous and Asynchronous counters, Shift Registers - Serial in Serial Out, Serial In Parallel Out, Parallel In Serial Out and Parallel In Parallel Out*<br>*Experiments:*<br>*1. Study of Flip Flop – SR, JK, T and D. 2. Design of Shift Registers using Flip-Flops. 3. Design of Synchronous Counter* | |

| | | |
|---|---|---|
| **Learning Resources** | 1. *Robert L. Boylestad and Louis Nasheresky, Electronic devices and circuit theory, Tenth edition, Pearson, 2013.*<br>2. *D Roy Choudhury and Shail Bala Jain, Linear Integrated Circuits, Fifth edition, new age International 2017.*<br>3. *Sergio Franco, Design with operational amplifiers and analog integrated circuits, Fourth edition, McGraw Hill, 2017.* | 4. *M. Morris Mano and Michael D.Ciletti, Digital design, Pearson education, 2008.*<br>5. *Thomas L. Floyd, Digital Fundamentals, Tenth edition, Pearson education, 2011.*<br>6. *David A.Bell, Electronic Devices and Circuits, Fifth edition, Oxford University Press, 2008.*<br>7. *Adel S. Sedra and Kenneth C. smith, Microelectronic Circuits theory and applications, sixth edition, Oxford University Press, 2010.*<br>8. *Jacob Millman, Microelectronics, McGraw Hill, 2nd Edition, Reprinted, 2009.* |

**Learning Assessment**

| | *Bloom's Level of Thinking* | *Continuous Learning Assessment (CLA)* | | | | *Summative Final Examination (40% weightage)* | |
|---|---|---|---|---|---|---|---|
| | | *Formative CLA-1 Average of unit test (45%)* | | *Life-Long Learning CLA-2 (15%)* | | | |
| | | *Theory* | *Practice* | *Theory* | *Practice* | *Theory* | *Practice* |
| Level 1 | *Remember* | *15%* | - | - | *15%* | *15%* | - |
| Level 2 | *Understand* | *25%* | - | - | *20%* | *25%* | - |
| Level 3 | *Apply* | *15%* | - | - | *25%* | *30%* | - |
| Level 4 | *Analyze* | - | - | - | *25%* | *30%* | - |
| Level 5 | *Evaluate* | - | - | - | *10%* | - | - |
| Level 6 | *Create* | - | - | - | *5%* | - | - |
| | *Total* | *100 %* | | *100 %* | | *100 %* | |

**Course Designers**

| **Experts from Industry** | **Experts from Higher Technical Institutions** | **Internal Experts** |
|---|---|---|
| 1. *Subramani K.P,CTO, vTitan Corporation Pvt. Ltd.* | 1. *Dr.R.Thiyagarajan, Indian Institute of Technology ,Tirupati, thiyagu@iittp.ac.in* | 1. *Dr.V.Krithika, SRMIST* |
| 2. *T.S.Srikanth, Principal Chief Engineer, CREAT UNO Minda Group* | 2. *Dr.Sreejith.S, National Institute of Technology, Silchar(NITS),Assam, sreejith@ee.nits.ac.in* | 2. *Dr.S.Vasanth, SRMIST* |

| Course Code | 21MHC203J | Course Name | FLUID POWER SYSTEM AND AUTOMATION | Course Category | C | PROFESSIONAL CORE | L | T | P | C |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | 2 | 0 | 2 | 3 |

| Pre-requisite Courses | *Nil* | Co- requisite Courses | *Nil* | Progressive Courses | *Nil* |
|---|---|---|---|---|---|
| Course Offering Department | *Mechatronics Engineering* | Data Book / Codes / Standards | | *Nil* | |

| Course Learning Rationale (CLR): | *The purpose of learning this course is to:* |
|---|---|
| ***CLR-1:*** | *get exposed to the fundamentals of fluid power principles and fluid power components* |
| ***CLR-2:*** | *explore various control valves and logics used in fluid power systems* |
| ***CLR-3:*** | *realize sequencing control of fluid power actuators for an application* |
| ***CLR-4:*** | *apply positioning control of fluid power actuators* |
| ***CLR-5:*** | *acquire knowledge on role of PLC in fluid power system automation* |

| Course Outcomes (CO): | *At the end of this course, learners will be able to:* | Program Outcomes (PO) | | | | | | | | | | | | Program Specific Outcomes | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | | | |
| | | Engineering Knowledge | Problem Analysis | Design/development of solutions | Conduct investigations of complex problems | Modern Tool Usage | The engineer and society | Environment & Sustainability | Ethics | Individual & Team Work | Communication | Project Mgt. & Finance | Life Long Learning | PSO-1 | PSO-2 | PSO-3 |
| ***CO-1:*** | *select fluid power system sources and actuators for an application* | *3* | - | - | - | - | - | - | - | - | - | - | - | - | *3* | - |
| ***CO-2:*** | *demonstrate competency in choice of control valves and logics based on application* | *3* | *1* | - | - | - | - | - | - | - | - | - | - | - | *3* | - |
| ***CO-3:*** | *design and implement any sequencing of actuations based on the application requirements* | - | *2* | *3* | - | *1* | - | - | - | - | - | - | - | - | *1* | *2* |
| ***CO-4:*** | *implement positioning control of cylinders using servo valve* | - | *2* | *3* | - | *1* | - | - | - | - | - | - | - | - | *1* | *2* |
| ***CO-5:*** | *develop PLC ladder logic programming control for fluid power circuits* | *2* | - | *3* | - | *1* | - | - | - | - | - | - | - | - | *1* | *2* |

| ***Unit-1 - Fluid Power Sources and Actuators*** | ***12 Hour*** |
|---|---|
| *Introduction to fluid power system – Types, Advantages and Applications - Physics of fluid power - Pneumatic sources – Compressors and its types –Working principle, design and selection criteria - Hydraulic sources – Pumps and its types – Working principle, design and selection criteria - Types of fluid power actuators - Special cylinders – Design and selection criteria.*<br>*1. Study experiment on pneumatic components and their symbolic representation, 2. Experiment on direct and indirect control of fluid power actuators* | |
| ***Unit-2 - Control Valves in Fluid Power Systems*** | ***12 Hour*** |
| *Direction control valves – Types, actuation techniques and neutral positions - Continuous reciprocation of single-acting and double-acting cylinder - Flow control valves, their needs and types-Speed control circuits - Pressure control valves, their needs and types - Logic valves – Actuator control with logic valves - Time delay valve, and Quick exhaust valve.*<br>*1. Experiment on continuous reciprocation of fluid power actuators, 2. Experiment on speed control circuits* | |
| ***Unit-3 - Design and Implementation of Fluid Power Circuits*** | ***12 Hour*** |
| *Two-cylinder and three-cylinder sequencing – Pneumatic and electro-pneumatic implementation - Two-cylinder and three-cylinder sequencing with signal conflict – Pneumatic and electro-pneumatic cascading implementation - Timer and counter-based control of fluid power actuators.*<br>*1. Experiment on pneumatic and electro-pneumatic implementation of multiple actuator sequencing control with and without signal conflict*<br>*2. Experiment on timer and counter-based control of pneumatic actuators* | |
| ***Unit-4 - Position Control of Fluid Power Actuators*** | ***12 Hour*** |
| *Synchronization circuits - Accumulators and application circuits - Need for positioning control of fluid power actuators - Proportional valves – working, types and applications - Servo valves – working, types and applications - Servo pneumatic/Servo hydraulic positioning system - Application case studies.*<br>*1. Experiment on synchronization circuits, 2. Experiment on servo pneumatic position control* | |

| ***Unit-5 - Applications of PLC in Fluid Power Systems*** | ***12 Hour*** |
|---|---|
| *Introduction to programmable logic controllers - Architecture and advantages of PLC - Ladder logic programming – Logic gates, start/stop operation with latching - Timers and counters - Interlocking - Continuous reciprocation circuit and sequential circuit implementation using PLC.*<br>*1. Experiment on basic ladder logic programming of PLC and continuous reciprocation of fluid power actuator using PLC*<br>*2. Experiment on multiple actuator sequencing control using PLC* | |

| | | |
|---|---|---|
| **Learning Resources** | 1. *Anthony Esposito, "Fluid Power with applications", Prentice Hall International, 7th edition, 2014.*<br>2. *Majumdar .S.R., "Oil Hydraulics: Principle and Maintenance", Tata McGraw Hill Education, 2012.*<br>3. *Werner Deppert , Kurt Stoll, "Pneumatic Application", Vogel verlag, 1986* | 4. *James L. Johnson, "Introduction to Fluid Power", Prentice Hall, 2004.*<br>5. *Andrew Parr, "Hydraulics and Pneumatics", Jaico Publishing House, 2003.*<br>6. *G. Dunning, "Introduction to Programmable Logic Controllers", Cengage Learning.* |

**Learning Assessment**

| | *Bloom's Level of Thinking* | *Continuous Learning Assessment (CLA)* | | | | *Summative Final Examination (40% weightage)* | |
|---|---|---|---|---|---|---|---|
| | | *Formative CLA-1 Average of unit test (45%)* | | *Life-Long Learning CLA-2 (15%)* | | | |
| | | *Theory* | *Practice* | *Theory* | *Practice* | *Theory* | *Practice* |
| Level 1 | *Remember* | *5%* | - | - | *10%* | *5%* | - |
| Level 2 | *Understand* | *15%* | - | - | *10%* | *15%* | - |
| Level 3 | *Apply* | *15%* | - | - | *10%* | *15%* | - |
| Level 4 | *Analyze* | *15%* | - | - | *20%* | *15%* | - |
| Level 5 | *Evaluate* | - | - | - | - | - | - |
| Level 6 | *Create* | - | - | - | - | - | - |
| | *Total* | *100 %* | | *100 %* | | *100 %* | |

**Course Designers**

| **Experts from Industry** | **Experts from Higher Technical Institutions** | **Internal Experts** |
|---|---|---|
| 1. *Mr. C. Elan Chezhian, Keyence Engineering, Chennai* | 1. *Dr. D. Saravanakumar, VIT University, Chennai* | 1. *Dr. T. Muthuramalingam, SRMIST* |
| 2. *Mr. K. Elango, Sealed Air Company, Chennai* | 2. *Dr. V. Mugendiran , MIT, Anna University, Chennai* | 2. *Mrs. G. Madhumitha, SRMIST* |

| Course Code | 21MHC204L | Course Name | ELECTRICAL ACTUATORS AND DRIVES LABORATORY | Course Category | C | PROFESSIONAL CORE | L | T | P | C |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | 0 | 0 | 2 | 1 |

| Pre-requisite Courses | *Nil* | Co- requisite Courses | *21MHC201T* | Progressive Courses | *Nil* |
|---|---|---|---|---|---|
| Course Offering Department | *Mechatronics Engineering* | Data Book / Codes / Standards | | *Nil* | |

| Course Learning Rationale (CLR): | *The purpose of learning this course is to:* |
|---|---|
| ***CLR-1:*** | *apply the basic concepts of DC motor* |
| ***CLR-2:*** | *analyze the basic concepts of BLDC motor* |
| ***CLR-3:*** | *demonstrate their ability in selecting motors for particular application* |
| ***CLR-4:*** | *implement characteristics of semiconductor devices and converters* |
| ***CLR-5:*** | *illustrate the basic concepts of power converters* |

| Course Outcomes (CO): | *At the end of this course, learners will be able to:* | Program Outcomes (PO) | | | | | | | | | | | | Program Specific Outcomes | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | | | |
| | | Engineering Knowledge | Problem Analysis | Design/development of solutions | Conduct investigations of complex problems | Modern Tool Usage | The engineer and society | Environment & Sustainability | Ethics | Individual & Team Work | Communication | Project Mgt. & Finance | Life Long Learning | PSO-1 | PSO-2 | PSO-3 |
| ***CO-1:*** | *implement the functionality of DC motors* | *3* | *2* | *2* | - | - | - | - | - | - | - | - | - | - | - | - |
| ***CO-2:*** | *apply the knowledge on basic concepts in operating BLDC motors* | *3* | *2* | *2* | - | - | - | - | - | - | - | - | - | - | - | - |
| ***CO-3:*** | *analyze the Performance Characteristics of drives* | *3* | *2* | *2* | - | - | - | - | - | - | - | - | - | - | - | - |
| ***CO-4:*** | *apply the knowledge in selecting motors for different applications* | *3* | *2* | *2* | - | - | - | - | - | - | - | - | - | - | - | - |
| ***CO-5:*** | *illustrate characteristics of semiconductor devices and power converters* | *3* | *2* | *2* | - | - | - | - | - | - | - | - | - | - | - | - |

| ***Unit-1*** | ***6 Hour*** |
|---|---|
| *1. Control of DC motor.*<br>*2. Control of stepper motor.* | |
| ***Unit-2*** | ***6 Hour*** |
| *3. Control of servomotor*<br>*4. Control of BLDC motor* | |
| ***Unit-3*** | ***6 Hour*** |
| *5.Light dimmer control*<br>*6. Relay-based control circuit* | |
| ***Unit-4*** | ***6 Hour*** |
| *7.Rectifier-based control*<br>*8. Chopper-based control* | |
| ***Unit-5*** | ***6 Hour*** |
| *9.Cycloconverter based control*<br>*10.Applications of DC,Stepper and Servo motors*<br>*11. Development of a converter using power devices for drives* | |

| | | |
|---|---|---|
| **Learning Resources** | 1. *Bhimbra. Dr.P.S. "Power Electronics", Khanna Publishers, 2012.*<br>2. *Dubey.G.K. "Fundamentals of Electrical Drives", Narosa publishing house 2001.* | 3. *Edward Hughes, John Hiley, Keith Brown, Ian McKenzie Smith, Hughes Electrical and Electronics Technology, Pearson Education, 12th ed., 2016*<br>4. *Lab Manuals.* |

**Learning Assessment**

| | *Bloom's Level of Thinking* | *Continuous Learning Assessment (CLA)* | | | | | | *Final Examination (0% weightage)* | |
|---|---|---|---|---|---|---|---|---|---|
| | | *CLA-1 Average of first cycle experiments (30%)* | | *CLA-2 Average of second cycle experiments (30%)* | | *Practical Examination (40% weightage)* | | | |
| | | *Theory* | *Practice* | *Theory* | *Practice* | *Theory* | *Practice* | *Theory* | *Practice* |
| Level 1 | *Remember* | - | *15%* | - | *15%* | - | *15%* | - | - |
| Level 2 | *Understand* | - | *25%* | - | *20%* | - | *25%* | - | - |
| Level 3 | *Apply* | - | *30%* | - | *25%* | - | *30%* | - | - |
| Level 4 | *Analyze* | - | *30%* | - | *25%* | - | *30%* | - | - |
| Level 5 | *Evaluate* | - | - | - | *10%* | - | - | - | - |
| Level 6 | *Create* | - | - | - | *5%* | - | - | - | - |
| | *Total* | *100 %* | | *100 %* | | *100%* | | - | |

**Course Designers**

| **Experts from Industry** | **Experts from Higher Technical Institutions** | **Internal Experts** |
|---|---|---|
| 1. *Dr.N.Gunavardhini, TANGEDCO, Salem, gunatneb1990@gmail.com* | 1. *Dr.K.Sujatha,Dr.MGR Educational and Research Institute, sujatha.eee@drmgrdu.ac.in* | 1. *Dr. M. Santhosh Rani, SRMIST* |
| 2. *Ms.Joyce Sumathi, MWSSB, sumathijoyce1968@gmail.com.* | 2. *Dr.G.R.Kanagachidambaresan, Vel Tech, kanagachidambaresan@gmail.com* | 2. *Mr. A. Lakshmi Srinivas, SRMIST* |

| Course Code | 21MHC205T | Course Name | MICROCONTROLLER AND EMBEDDED SYSTEMS | Course Category | C | PROFESSIONAL CORE | L | T | P | C |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | 3 | 0 | 0 | 3 |

| Pre-requisite Courses | Nil | Co- requisite Courses | 21MHC207L | Progressive Courses | 21MHE412T |
|---|---|---|---|---|---|
| Course Offering Department | Mechatronics Engineering | Data Book / Codes / Standards | | Nil | |

| Course Learning Rationale (CLR): | The purpose of learning this course is to: |
|---|---|
| CLR-1: | familiarize with the functionality of microprocessors and microcontrollers |
| CLR-2: | acquire knowledge of microcontroller programming in Mechatronics systems |
| CLR-3: | realize the fundamentals of embedded system design with real time systems |
| CLR-4: | assimilate the way to create and optimize programs |
| CLR-5: | incorporate the fundamentals of embedded systems design with real time system |

| Course Outcomes (CO): | At the end of this course, learners will be able to: | Program Outcomes (PO) | | | | | | | | | | | | Program Specific Outcomes | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 1 Engineering Knowledge | 2 Problem Analysis | 3 Design/development of solutions | 4 Conduct investigations of complex problems | 5 Modern Tool Usage | 6 The engineer and society | 7 Environment & Sustainability | 8 Ethics | 9 Individual & Team Work | 10 Communication | 11 Project Mgt. & Finance | 12 Life Long Learning | PSO-1 | PSO-2 | PSO-3 |
| CO-1: | evaluate and compare various embedded processors | 3 | - | - | - | 1 | - | - | - | - | - | - | - | - | 1 | - |
| CO-2: | implement the concepts of microcontroller to Mechatronics systems | 3 | - | 2 | - | 2 | - | - | - | - | - | - | - | - | - | 2 |
| CO-3: | apply the fundamentals of embedded system design with real time systems | 3 | - | - | - | 1 | - | - | - | - | - | - | - | - | - | 2 |
| CO-4: | appreciate the way programs are created and optimized | 3 | - | - | - | - | - | - | - | - | - | - | - | - | 1 | - |
| CO-5: | build simple embedded applications | 3 | - | 1 | - | - | - | - | - | - | - | - | - | - | - | 2 |

| | |
|---|---|
| **Unit-1 - Microprocessor and Microcontrollers** | **9 Hour** |
| 8-bit and 16-bit microprocessor - architecture - instruction set- addressing mode, Instruction cycle, 8-bit microcontroller – architecture - special function registers - instruction set - addressing mode, - interrupt handling | |
| **Unit-2 - ARM Controller** | **9 Hour** |
| ARM Controller - Architecture - Functional description - ARM state instruction - Thumb state instruction - Addressing modes - Operating modes | |
| **Unit-3 - Introduction to Embedded System** | **9 Hour** |
| Embedded System - Definition, Key Elements- Design Metric Challenges - Design technology - IC technology - Processor technology, Introduction to Arduino – Hardware interfacing - controlling embedded system based devices using Arduino - Arduino IDE - Introduction to Raspberry pi | |
| **Unit-4 - Embedded System – Debugging & Development Environment** | **9 Hour** |
| Debugging Techniques/ Challenges - Program Design and Analysis – Components for Embedded systems- Model of programs - DFG and CDFG - Assembly, linking and loading - Basic compilation techniques - optimization, Interrupts - Interrupt Latency, Embedded software architectures | |
| **Unit-5 - RTOS Based Embedded System Design** | **9 Hour** |
| Introduction to basic concepts of RTOS, Task, process & threads - Task management and scheduling - Interrupt servicing - Multiprocessing and Multitasking - Inter task Communication and data exchange - Synchronization between processes: Semaphores - Memory management - Issues in real-time system design - Design of Embedded Systems – Development of IoT Applications | |

| | | |
|---|---|---|
| **Learning Resources** | 1. *Muhammed Ali Mazidi, Janice Gillispie Mazidi, Rolin D. McKinlay, "The 8051 Microcontroller and Embedded Systems", Pearson Education, Second Edition, 2014.*<br>2. *Douglas V Hall, "Microprocessors and Interfacing", McGraw Hill Education, 3rd Edition (SIE), 2017*<br>3. *Frank Vahid and Tony Givargis, "Embedded system design: A unified hardware software approach", Pearson Education Asia, 3rd edition, 2009*<br>4. *Wayne Wolf, "Computers as Components: Principles of Embedded Computing System Design (The Morgan Kaufmann Series in Computer Architecture and Design)", 5th Edition, 2022* | 5. *Andrew N Sloss, D. Symes, C. Wright, "Arm System Developers Guide", Morgan Kauffman/ Elsevier, 2006.*<br>6. *Michael McRoberts, " Beginning Arduino", Apress, Year: 2010*<br>7. *Massimo Banzi, "Getting Started with Arduino: The Open Source", Shroff Publishers & Distributors Pvt Ltd, 2014*<br>8. *M. A. Mazidi, S. Naimi, S. Naimi, The AVR Microcontroller and Embedded Systems Using Assembly and C, Pearson, 2015* |

**Learning Assessment**

| | *Bloom's Level of Thinking* | *Continuous Learning Assessment (CLA)* | | | | *Summative Final Examination (40% weightage)* | |
|---|---|---|---|---|---|---|---|
| | | *Formative CLA-1 Average of unit test (50%)* | | *Life-Long Learning CLA-2 (10%)* | | | |
| | | *Theory* | *Practice* | *Theory* | *Practice* | *Theory* | *Practice* |
| Level 1 | *Remember* | *15%* | - | - | - | *15%* | - |
| Level 2 | *Understand* | *25%* | - | - | - | *25%* | - |
| Level 3 | *Apply* | *30%* | - | *50%* | - | *30%* | - |
| Level 4 | *Analyze* | *30%* | - | *50%* | - | *30%* | - |
| Level 5 | *Evaluate* | - | - | - | - | - | - |
| Level 6 | *Create* | - | - | - | - | - | - |
| | *Total* | *100 %* | | *100 %* | | *100 %* | |

**Course Designers**

| **Experts from Industry** | **Experts from Higher Technical Institutions** | **Internal Experts** |
|---|---|---|
| 1. *Mr.N.Ravi,L&T GeoStructure Private Limited, Ravinagarajan@Intecc.com* | 1. *Dr.BamaSrinivasan, Anna University, Guindy, Chennai,bama@annauniv.edu* | 1. *Mrs.T.S.Rajalakshmi, SRMIST* |
| 2. *Mr. SathiyaMoorthi, Broadcom Inc, sathiyamoorthi.chinnappan@broadcom.com* | 2. *Dr.Thiyagarajan, Indian Institute of Technology Tirupati, thiyagu@iittp.ac.in* | 2. *Mrs.M.Nandhini, SRMIST* |

| Course Code | 21MHC206T | Course Name | MECHANICS OF SOLIDS AND FLUIDS | Course Category | C | PROFESSIONAL CORE | L | T | P | C |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | 3 | 0 | 0 | 3 |

| Pre-requisite Courses | Nil | Co- requisite Courses | 21MHC208L | Progressive Courses | Nil |
|---|---|---|---|---|---|
| Course Offering Department | Mechatronics Engineering | Data Book / Codes / Standards | | Nil | |

| Course Learning Rationale (CLR): | The purpose of learning this course is to: |
|---|---|
| CLR-1: | understand the behavior and properties of materials under external loading conditions, and Analyze the behavior of fluids using the concepts and equations |
| CLR-2: | analyze the beams and shafts under pure bending and torsion, Analyze the columns using the buckling effect |
| CLR-3: | identify types of beams and understand their deflection under different types of load |
| CLR-4: | understand the applications of Bernoulli's equation |
| CLR-5: | summarize the various losses in pipes |

| Course Outcomes (CO): | At the end of this course, learners will be able to: | Program Outcomes (PO) | | | | | | | | | | | | Program Specific Outcomes | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | | | |
| | | Engineering Knowledge | Problem Analysis | Design/development of solutions | Conduct investigations of complex problems | Modern Tool Usage | The engineer and society | Environment & Sustainability | Ethics | Individual & Team Work | Communication | Project Mgt. & Finance | Life Long Learning | PSO-1 | PSO-2 | PSO-3 |
| CO-1: | estimate the different types of stress induced in materials | 3 | 3 | 3 | - | - | - | - | - | - | - | - | - | - | - | - |
| CO-2: | evaluate the bending stress and shear stress under pure bending and torsion | 3 | 3 | 3 | - | - | - | - | - | - | - | - | - | - | - | - |
| CO-3: | calculate the maximum shear stress and bending moment at the critical section | 3 | 3 | 3 | - | - | - | - | - | - | - | - | - | - | - | - |
| CO-4: | determine the coefficient of discharge of different devices | 3 | 3 | 2 | - | - | - | - | - | - | - | - | - | - | - | - |
| CO-5: | estimate losses in pipes | 3 | 3 | 2 | - | - | - | - | - | - | - | - | - | - | - | - |

***Unit-1 - Mechanics of Materials and Fluids*** ***9 Hour***

*Introduction-Stress, Strain and Displacement, Fundamental equations deformable body mechanics, Equilibrium, Determination of Internal Resultant Forces by Method of Joints and Method of Sections, Stress-strain relationship, Axially Loaded Bars, Elastic Constants, Poisson's Ratio, Stress-strain diagrams- Tension Test, Compression test, Mechanical properties of materials. Introduction- Fluid Properties, Types of Fluids, Types of Flow, Pressure and its measurement, Pressure measurement devices – Different types of manometers*

***Unit-2 - Pure Bending, Torsion and Columns*** ***9 Hour***

*Pure Bending-Bending equation and its assumptions, Moment of Inertia for different cross sections, Bending Stress in beams- Torsion- Torsion Equation and its assumptions, Polar moment of inertia, Torsion in stepped and composite shafts- Columns-Buckling of slender column, Critical load, critical stress and effective length for a Column with pinned end, Column Fixed at the Base and Free at the Top, Column with Both Ends Fixed Against Rotation, Column Fixed at the Base and Pinned at the top.*

***Unit-3 - Beams and Shafts*** ***9 Hour***

*Beams - Types of beams - cantilever, simply supported, fixed and continuous beam Types of loads, Sign conventions, Shear force and bending moment diagram – cantilever, simply supported and over hanging beams. Shafts- Equivalent twisting moment-Shaft with pulley and gear.*

***Unit-4 - Kinematics and Dynamics of Fluids*** ***9 Hour***

*Fluid flow, Streamline-streak line-path line - stream function - Continuity equation and its application, Rate of flow, Derivation of Euler's equation, Bernoulli's equation and its assumptions, Application of Bernoulli's equation – Venturi meter, Orifice meter*

***Unit-5 - Flow Through Pipes*** ***9 Hour***

*Introduction to losses in pipes, Types of losses, Darcy – Weisbach's equation, Friction factor, Analysis of Minor losses and Major losses in pipes- pipes in series and parallel, construction and working principle of centrifugal pump and reciprocating pump, Performance of pumps*

| Learning | 1. R.K.Bansal, "Strength of Materials", 6th ed., Lakshmi Publications, 2022. | 4. Bansal. R. K, "Fluid Mechanics and Hydraulic Machines", 11th ed., Laxmi publications (P) |
|---|---|---|

| | | |
|---|---|---|
| **Resources** | 2. *Ramamurtham S and Narayanan R, "Strength of Materials", 20th ed., Dhanpat Rai Pvt. Ltd., 2022.*<br>3. *Timoshenko. S. P., Gere .M. J, "Mechanics of Materials", 5th ed., Stanley Thornes (PUB) Ltd, 1999.* | *Ltd., 2022.*<br>5. *Kumar. K. L, "Engineering Fluid Mechanics", S Chand Publications, 2016.*<br>6. *John.M.Cimbala Yunus A.Cengel, "Fluid Mechanics: Fundamentals and Applications", 4th ed. Mc Graw Hill Higher Education, 2019.* |

**Learning Assessment**

| | *Bloom's Level of Thinking* | *Continuous Learning Assessment (CLA)* | | | | *Summative Final Examination (40% weightage)* | |
|---|---|---|---|---|---|---|---|
| | | *Formative CLA-1 Average of unit test (50%)* | | *Life-Long Learning CLA-2 (10%)* | | | |
| | | *Theory* | *Practice* | *Theory* | *Practice* | *Theory* | *Practice* |
| Level 1 | *Remember* | *15%* | - | *15%* | - | *15%* | - |
| Level 2 | *Understand* | *25%* | - | *20%* | - | *25%* | - |
| Level 3 | *Apply* | *30%* | - | *25%* | - | *30%* | - |
| Level 4 | *Analyze* | *30%* | - | *25%* | - | *30%* | - |
| Level 5 | *Evaluate* | - | - | *10%* | - | - | - |
| Level 6 | *Create* | - | - | *5%* | - | - | - |
| | *Total* | *100 %* | | *100 %* | | *100 %* | |

**Course Designers**

| **Experts from Industry** | **Experts from Higher Technical Institutions** | **Internal Experts** |
|---|---|---|
| 1. *Mr.G.Gopinath, R&D Manager, ZF, Chennai, Email ID: gopinath.gunasekaran@zf.com* | 1. *Dr. D. Madesh, Professor, Dept of Mechanical Engineering, AMET University, Chennai, Email ID: madesh.d@ametuniv.ac.in.* | 1. *Mr. M. Chandrasekaran, SRMIST* |
| 2. *Mr. K.Maheshwaran, Assistant Manager , TAFE, Madurai, Email ID: maheshwaran@tafe.com* | 2. *Dr. L. Ranganathan, Professor and Head, Dept. of Mechanical Engineering, Agni College of Technology, Chennai, Email ID: mechod@act.edu.in* | 2. *Ms. D. Gayathiri, SRMIST* |

| Course Code | 21MHC207L | Course Name | MICROCONTROLLER AND EMBEDDED SYSTEMS LABORATORY | Course Category | C | PROFESSIONAL CORE | L | T | P | C |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | 0 | 0 | 2 | 1 |

| Pre-requisite Courses | Nil | Co- requisite Courses | 21MHC205T | Progressive Courses | 21MHE412T |
|---|---|---|---|---|---|
| Course Offering Department | Mechatronics Engineering | Data Book / Codes / Standards | | Nil | |

| Course Learning Rationale (CLR): | The purpose of learning this course is to: |
|---|---|
| CLR-1: | familiarize with the functionality of microprocessors and microcontrollers |
| CLR-2: | gain knowledge of microcontroller programming and embedded system |
| CLR-3: | assimilate the way programs are to be created and optimized |
| CLR-4: | apply the concepts of IoT and programming using open-platform |
| CLR-5: | incorporate the fundamentals of embedded systems design with real time system |

| Course Outcomes (CO): | At the end of this course, learners will be able to: | Program Outcomes (PO) | | | | | | | | | | | | Program Specific Outcomes | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | | | |
| | | Engineering Knowledge | Problem Analysis | Design/development of solutions | Conduct investigations of complex problems | Modern Tool Usage | The engineer and society | Environment & Sustainability | Ethics | Individual & Team Work | Communication | Project Mgt. & Finance | Life Long Learning | PSO-1 | PSO-2 | PSO-3 |
| CO-1: | evaluate and compare various embedded processors | 3 | 2 | 2 | - | 2 | - | - | - | - | - | - | - | - | 1 | - |
| CO-2: | analyze applications of IoT using Arduino | 3 | 2 | 2 | - | 2 | - | - | - | - | - | - | - | - | - | 2 |
| CO-3: | appreciate the way programs are created and optimized | 3 | 2 | 2 | - | 2 | - | - | - | - | - | - | - | - | - | - |
| CO-4: | design portable IoT using Raspberry Pi /open platform | 3 | - | - | - | - | - | - | - | - | - | - | - | - | - | 2 |
| CO-5: | design simple embedded applications | 3 | - | 2 | - | - | - | - | - | 1 | - | - | - | - | - | 2 |

| | |
|---|---|
| **Unit-1 - Microprocessor and Microcontrollers** | **6 Hour** |
| 1. Microprocessor and Microcontroller programming for basic operations<br>2. Interfacing of motors of any type with Microprocessor and Microcontroller | |
| **Unit-2 - Arduino Programming and Introduction to Embedded System** | **6 Hour** |
| 3.Basic Operations in Arduino Programming<br>4. Interfacing of motors and displays with Arduino | |
| **Unit-3 - Embedded System – Debugging & Development Environment** | **6 Hour** |
| 5. Interrupt-based programs in microprocessor and microcontroller<br>6. Sensor and actuator interfacing with Arduino controller | |
| **Unit-4 -** | **6 Hour** |
| 7. Basic operations in ARM controller<br>8. Interfacing of motors with ARM controller | |
| **Unit-5 - RTOS Based Embedded System Design** | **6 Hour** |
| 9. Programs to explore the internal features of ARM controller.<br>10. Interrupts handling in ARM controller | |

| | | |
|---|---|---|
| **Learning Resources** | 1. *Muhammed Ali Mazidi, Janice Gillispie Mazidi, Rolin D. McKinlay, "The 8051 Microcontroller and Embedded Systems", Pearson Education, Second Edition, 2014.*<br>2. *Douglas V Hall, "Microprocessors and Interfacing", McGraw Hill Education, 3rd Edition (SIE), 2017* | 3. *Andrew N Sloss, D. Symes, C. Wright, "Arm System Developers Guide", Morgan Kauffman/ Elsevier, 2006.*<br>4. *Laboratory Manuals* |

**Learning Assessment**

| | *Bloom's Level of Thinking* | *Continuous Learning Assessment (CLA)* | | | | | | *Final Examination (0% weightage)* | |
|---|---|---|---|---|---|---|---|---|---|
| | | *CLA-1 Average of first cycle experiments (30%)* | | *CLA-2 Average of second cycle experiments (30%)* | | *Practical Examination (40% weightage)* | | | |
| | | *Theory* | *Practice* | *Theory* | *Practice* | *Theory* | *Practice* | *Theory* | *Practice* |
| Level 1 | *Remember* | - | *15%* | - | *15%* | - | *15%* | - | - |
| Level 2 | *Understand* | - | *25%* | - | *25%* | - | *25%* | - | - |
| Level 3 | *Apply* | - | *30%* | - | *30%* | - | *30%* | - | - |
| Level 4 | *Analyze* | - | *30%* | - | *30%* | - | *30%* | - | - |
| Level 5 | *Evaluate* | - | - | - | - | - | - | - | - |
| Level 6 | *Create* | - | - | - | - | - | - | - | - |
| | *Total* | *100 %* | | *100 %* | | *100%* | | - | |

***Course Designers***

| **Experts from Industry** | **Experts from Higher Technical Institutions** | **Internal Experts** |
|---|---|---|
| 1. *Mr. N.Ravi, L&T GeoStructure Private Limited, Ravinagarajan@Intecc.com* | 1. *Dr.BamaSrinivasan, Anna University, Guindy, Chennai,bama@annauniv.edu* | 1. *Dr.M.Mohamed Rabik, SRMIST* |
| 2. *Mr. SathiyaMoorthi, Broadcom Inc, sathiyamoorthi.chinnappan@broadcom.com* | 2. *Dr.Thiyagarajan, Indian Institute of Technology Tirupati, thiyagu@iittp.ac.in* | 2. *Dr.Cross T Asha Wise, SRMIST* |

| Course Code | 21MHC208L | Course Name | MECHANICS OF SOLIDS AND FLUIDS LABORATORY | Course Category | C | PROFESSIONAL CORE | L | T | P | C |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | 0 | 0 | 2 | 1 |

| Pre-requisite Courses | Nil | Co- requisite Courses | 21MHC206T | Progressive Courses | Nil |
|---|---|---|---|---|---|
| Course Offering Department | Mechatronics Engineering | Data Book / Codes / Standards | Nil | | |

| Course Learning Rationale (CLR): | The purpose of learning this course is to: |
|---|---|
| CLR-1: | understand the behavior and properties of materials under external loading conditions, and Analyze the behavior of fluids using the concepts and equations |
| CLR-2: | analyze the beams and shafts under pure bending and torsion, Analyze the columns using the buckling effect |
| CLR-3: | identify types of beams and understand their deflection under different types of load |
| CLR-4: | understand the applications of Bernoulli's equation |
| CLR-5: | summarize the various losses in pipes |

| Course Outcomes (CO): | At the end of this course, learners will be able to: | Program Outcomes (PO) | | | | | | | | | | | | Program Specific Outcomes | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | | | |
| | | Engineering Knowledge | Problem Analysis | Design/development of solutions | Conduct investigations of complex problems | Modern Tool Usage | The engineer and society | Environment & Sustainability | Ethics | Individual & Team Work | Communication | Project Mgt. & Finance | Life Long Learning | PSO-1 | PSO-2 | PSO-3 |
| CO-1: | estimate the different types of stress induced in materials | 3 | 3 | 3 | - | - | - | - | - | - | - | - | - | - | - | - |
| CO-2: | evaluate the bending stress and shear stress under pure bending and torsion | 3 | 3 | 3 | - | - | - | - | - | - | - | - | - | - | - | - |
| CO-3: | calculate the maximum shear stress and bending moment at the critical section | 3 | 3 | 2 | - | - | - | - | - | - | - | - | - | - | - | - |
| CO-4: | determine the coefficient of discharge of different devices | 3 | 3 | 2 | - | - | - | - | - | - | - | - | - | - | - | - |
| CO-5: | estimate losses in pipes | 3 | 2 | 2 | - | - | - | - | - | - | - | - | - | - | - | - |

| | |
|---|---|
| **Unit-1 - Basics of Mechanics of Materials and Fluids** | **6 Hour** |
| Tensile test of metallic materials<br>Deflection test on simply supported beam | |
| **Unit-2 - Pure Bending, Torsion and Columns** | **6 Hour** |
| Charpy / Izod impact test on a steel specimen Torsional test on mild steel rod<br>Double Shear test on metallic materials | |
| **Unit-3 - Beams and Shafts** | **6 Hour** |
| Fatigue test<br>Surface Hardness test on metallic materials<br>Determine the coefficient of discharge of the orifice meter | |
| **Unit-4 - Kinematics and Dynamics of Fluids** | **6 Hour** |
| Verification of Bernoulli's theorem.<br>Determine the coefficient of discharge of venturi meter | |
| **Unit-5 - Flow Through Pipes** | **6 Hour** |
| Determination of minor losses due to pipe fittings. Determination of pipe friction factor<br>Performance test on centrifugal pump | |

| | | |
|---|---|---|
| **Learning Resources** | 1. *R.K.Bansal, "Strength of Materials", 6th ed., Lakshmi Publications, 2022.*<br>2. *Ramamurtham S and Narayanan R, "Strength of Materials", 20th ed., Dhanpat Rai Pvt. Ltd., 2022.*<br>3. *Strength of Material Lab Manual* | 4. *Bansal. R. K, "Fluid Mechanics and Hydraulic Machines", 11th ed., Laxmi publications (P) Ltd., 2022.*<br>5. *Kumar. K. L, "Engineering Fluid Mechanics", S Chand Publications, 2016.*<br>6. *Fluid Mechanics Lab Manual* |

**Learning Assessment**

| | Bloom's Level of Thinking | Continuous Learning Assessment (CLA) | | | | | | Final Examination (0% weightage) | |
|---|---|---|---|---|---|---|---|---|---|
| | | CLA-1 Average of first cycle experiments (30%) | | CLA-2 Average of second cycle experiments (30%) | | Practical Examination (40% weightage) | | | |
| | | Theory | Practice | Theory | Practice | Theory | Practice | Theory | Practice |
| Level 1 | *Remember* | - | *15%* | - | *15%* | - | *15%* | - | - |
| Level 2 | *Understand* | - | *25%* | - | *25%* | - | *25%* | - | - |
| Level 3 | *Apply* | - | *30%* | - | *30%* | - | *30%* | - | - |
| Level 4 | *Analyze* | - | *30%* | - | *30%* | - | *30%* | - | - |
| Level 5 | *Evaluate* | - | - | - | - | - | - | - | - |
| Level 6 | *Create* | - | - | - | - | - | - | - | - |
| | *Total* | *100 %* | | *100 %* | | *100%* | | - | |

**Course Designers**

| Experts from Industry | Experts from Higher Technical Institutions | Internal Experts |
|---|---|---|
| 1. *Mr. G. Gopinath, R&D Manager, ZF, Chennai, gopinath.gunasekaran@zf.com* | 1. *Dr. D. Madesh, Professor, AMET University, Chennai, madesh.d@ametuniv.ac.in.* | 1. *Mr. M. Chandrasekaran, SRMIST* |
| 2. *Mr. K. Maheshwaran, Assistant Manager, TAFE, Madurai, Email ID: maheshwaran@tafe.com* | 2. *Dr. L. Ranganathan, Professor and Head, Dept. of Mechanical Engineering, Agni College of Technology, Chennai, Email ID: mechod@act.edu.in* | 2. *Mr. G. Balakumaran, SRMIST* |

| Course Code | 21MHC209T | Course Name | PROJECT MANAGEMENT AND INDUSTRIAL PRACTICES | Course Category | C | PROFESSIONAL CORE | L | T | P | C |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | 3 | 0 | 0 | 3 |

| Pre-requisite Courses | *Nil* | Co- requisite Courses | *Nil* | Progressive Courses | *Nil* |
|---|---|---|---|---|---|
| Course Offering Department | *Mechatronics Engineering* | Data Book / Codes / Standards | | *Nil* | |

| Course Learning Rationale (CLR): | *The purpose of learning this course is to:* |
|---|---|
| ***CLR-1:*** | *introduce the concepts and components of Project Management* |
| ***CLR-2:*** | *gain knowledge in the fundamentals project scheduling* |
| ***CLR-3:*** | *gain apply knowledge of time, cost and resource management* |
| ***CLR-4:*** | *introduce the concepts of new product development, productivity, reliability and Quality* |
| ***CLR-5:*** | *introduce modern industrial practice - digitization* |

| Course Outcomes (CO): | *At the end of this course, learners will be able to:* | Program Outcomes (PO) | | | | | | | | | | | | Program Specific Outcomes | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 1 Engineering Knowledge | 2 Problem Analysis | 3 Design/development of solutions | 4 Conduct investigations of complex problems | 5 Modern Tool Usage | 6 The engineer and society | 7 Environment & Sustainability | 8 Ethics | 9 Individual & Team Work | 10 Communication | 11 Project Mgt. & Finance | 12 Life Long Learning | PSO-1 | PSO-2 | PSO-3 |
| ***CO-1:*** | *understand main aspects of project management: time, money and resources* | - | - | - | - | - | - | - | - | - | - | *3* | - | - | - | - |
| ***CO-2:*** | *design project scheduling using Gant, CPM and PERT methods* | - | - | - | - | - | - | - | - | - | - | *3* | - | *2* | - | - |
| ***CO-3:*** | *apply project management technique for managing time, cost and resources* | - | - | - | - | - | - | - | - | - | - | *3* | - | - | - | - |
| ***CO-4:*** | *understand productivity and NPD in engineering* | - | - | - | - | - | - | - | - | - | - | *2* | - | - | - | - |
| ***CO-5:*** | *understand modern industrial practice system using digitization tools* | - | - | - | - | *2* | - | - | - | - | - | *2* | - | - | - | - |

***Unit-1 - Project, Program, and Project Life Cycle*** — ***9 Hour***

*Project scope management, Work Breakdown Structure (WBS) and Responsibility Assignment Matrix (RAM), Project communications and documentation, Project evaluation: Benefit-Cost Ratio (BCR), Project performance and Earned Value Management (EVM), Professional project management organizations, Introduction to software project management*

***Unit-2 - Project Scheduling*** — ***9 Hour***

*Project scheduling - Terms, terminologies, and definitions, Gantt Chart, Activity On Arc (AOA), Activity On Node (AON), CPM, PERT, Examples*

***Unit-3 - Project Time, Costing, Budget, Crashing*** — ***9 Hour***

*Trade-offs in project-time and -cost, Project crashing with examples, Project cost estimation, budgeting, Actual Cost, Budgeted cost, Value of work done, Cost Performance Analysis (CPA), Resource constrained planning, Resource allocation, Resource loading, Resource levelling*

***Unit-4 - New Product Development (NPD) and Productivity*** — ***9 Hour***

*New Product Development (NPD)– an industrial practice, Ideation, development, testing, launch and track – phases NPD, Value driven management, Innovation Driven management, Break-Even Analysis, Productivity, Reliability, Quality management, Process control, ISO9000.*

***Unit-5 - Digitization in Industry*** — ***9 Hour***

*Modern industrial practice, Digital transformation and exponential growth, Work styles, Product- to service-oriented model, Digitization solutions- IT solutions, IOT, Industry 4.0, 3D printing, VR & AR, Wearables, Blockchain, Digitization in Automotive industry, Digital twins*

| | | |
|---|---|---|
| **Learning Resources** | 1. *Pradeep Pai, Project management, Pearson India, 2019*<br>2. *D.R.Kiran, Production planning and control – A comprehensive approach, BSP books pvt ltd-Elsevier, 2019*<br>3. *Juran, Gryna, Quality Planning and Analysis, McGraw-Hill, New York, 1993.* | 4. *Lewis, R., Project Management, McGraw-Hill, 2006, ISBN 0-07-147160-X*<br>5. *Uwe Winkelhake, The digital transformation of the automotive industry- Catalysts, Roadmap, Practice, Springer, 2022*<br>6. *Phillips, J., PMP Project Management Professional Study Guide, McGraw- Hill, 2003.* |

**Learning Assessment**

| | *Bloom's Level of Thinking* | *Continuous Learning Assessment (CLA)* | | | | *Summative Final Examination (40% weightage)* | |
|---|---|---|---|---|---|---|---|
| | | *Formative CLA-1 Average of unit test (50%)* | | *Life-Long Learning CLA-2 (10%)* | | | |
| | | *Theory* | *Practice* | *Theory* | *Practice* | *Theory* | *Practice* |
| Level 1 | *Remember* | - | - | - | - | *20%* | - |
| Level 2 | *Understand* | *55%* | - | *50%* | - | *30%* | - |
| Level 3 | *Apply* | *45%* | - | *50%* | - | *50%* | - |
| Level 4 | *Analyze* | - | - | - | - | - | - |
| Level 5 | *Evaluate* | - | - | - | - | - | - |
| Level 6 | *Create* | - | - | - | - | - | - |
| | *Total* | *100 %* | | *100 %* | | *100 %* | |

**Course Designers**

| **Experts from Industry** | **Experts from Higher Technical Institutions** | **Internal Experts** |
|---|---|---|
| 1. *Dr Venkat Perumal, Ph.D., Sr. Principal Engineer, R&D, Stryker* | 1. *Dr VeeraRagavan, Senior Lecturer, Monash University (Malaysia campus), Malaysia* | 1. *Dr Madhavan Shanmugavel, SRMIST* |
| 2. *Mr Koteswaran Srinivasan, Director, HCL Technologies Ltd, Chennai* | 2. *Elango Natarajan, Associate Professor, Faculty of Engineering, Technology and Built Environment,, UCSI University, 56000 Cheras, Kuala Lumpur, Malaysia* | 2. *Dr Senthilnathan, SRMIST* |

| Course Code | 21MHC301T | Course Name | SYSTEM DYNAMICS AND CONTROL | Course Category | C | PROFESSIONAL CORE | L | T | P | C |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | 3 | 0 | 0 | 3 |

| Pre-requisite Courses | Nil | Co- requisite Courses | 21MHC304L | Progressive Courses | 21MHE414T |
|---|---|---|---|---|---|
| Course Offering Department | Mechatronics Engineering | Data Book / Codes / Standards | | Nil | |

| Course Learning Rationale (CLR): | The purpose of learning this course is to: |
|---|---|
| CLR-1: | model the electrical, mechanical, and electromechanical dynamic systems |
| CLR-2: | analyze a dynamic system using procedural methods |
| CLR-3: | construct the control systems in the time domain |
| CLR-4: | analyze control systems in the frequency domain |
| CLR-5: | develop a state space model |

| Course Outcomes (CO): | At the end of this course, learners will be able to: | Program Outcomes (PO) | | | | | | | | | | | | Program Specific Outcomes | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | | | |
| | | Engineering Knowledge | Problem Analysis | Design/development of solutions | Conduct investigations of complex problems | Modern Tool Usage | The engineer and society | Environment & Sustainability | Ethics | Individual & Team Work | Communication | Project Mgt. & Finance | Life Long Learning | PSO-1 | PSO-2 | PSO-3 |
| CO-1: | construct the basic dynamic systems | 3 | 2 | - | - | - | - | - | - | - | - | - | - | 3 | - | - |
| CO-2: | design a conventional controller for a dynamic system | 3 | 2 | - | - | - | - | - | - | - | - | - | - | 3 | - | - |
| CO-3: | analyze a controller based on time domain specifications | 3 | 2 | 3 | - | - | - | - | - | - | - | - | - | 3 | - | 2 |
| CO-4: | apply the procedure of frequency response plot to design a compensator | 3 | 2 | 3 | - | - | - | - | - | - | - | - | - | 3 | - | 2 |
| CO-5: | develop a controller using state space approach | 3 | 2 | 3 | - | - | - | - | - | - | - | - | - | 3 | - | 2 |

| | |
|---|---|
| **Unit-1 - Modeling of Systems** | **9 Hour** |
| *Introduction to signals and their properties- Elementary Signals-Introduction to systems and properties- LTI system- Solving differential equation using Laplace transform -Transfer function/System function, poles and zeros-Modeling of mechanical, electrical, and electromechanical dynamic systems, and numerical examples on modeling.* | |
| **Unit-2 - Time Domain Specifications and Controllers** | **9 Hour** |
| *Introduction to open loop and closed loop control system, -Block diagram and signal flow graph reduction techniques, Response of I and II order systems and their time domain specifications- Steady state error constant of the system for type numbers and inputs-PID control-Analytical design for PD, PI, PID control systems- Design of PID controller using Model-based /Zeigler Nichols method* | |
| **Unit-3 - Concept of stability and Design** | **9 Hour** |
| *Stability of system- Routh-Hurwitz stability criterion- Root locus method, steps in obtaining a root-locus-Design of controllers using root-locus-Introduction to compensator - Compensator design using root locus-Cascade Lead, lag, and lag-lead compensation* | |
| **Unit-4 - Frequency Response Analysis and Design** | **9 Hour** |
| *Closed loop frequency response-Performance specification in frequency domain-Frequency response of standard second order system- Construction of Bode Plots and Polar Plots - Compensator design using Bode Plots -Cascade Lead, lag, and lag-lead compensation.* | |
| **Unit-5 - State Space Analysis and Design** | **9 Hour** |
| *State variable representation-Conversion of state variable models to transfer functions-Conversion of transfer functions to state variable models-Solution of state equations-Concepts of Controllability and Observability-Stability of linear systems-Full state feedback controller design-Full order observer design-Design examples.* | |

| | | |
|---|---|---|
| **Learning Resources** | 1. B P Lathi, Principles of Linear Systems and Signals, 2nd edition, Oxford University Press, 2009.<br>2. J Nagrath, M Gopal, Control Systems Engineering, 5th Edition, New Age International, 2007. | 3. Norman S Nise, Control Systems Engineering, 7th edition, Wiley, 2015.<br>4. Roland S. Burns, Advanced Control Engineering, Butterworth- Heinemann, First edition, 2001 |

**Learning Assessment**

| | Bloom's Level of Thinking | Continuous Learning Assessment (CLA) | | | | Summative Final Examination (40% weightage) | |
|---|---|---|---|---|---|---|---|
| | | Formative CLA-1 Average of unit test (50%) | | Life-Long Learning CLA-2 (10%) | | | |
| | | Theory | Practice | Theory | Practice | Theory | Practice |
| Level 1 | Remember | 15% | - | 15% | - | 15% | - |
| Level 2 | Understand | 25% | - | 25% | - | 25% | - |
| Level 3 | Apply | 30% | - | 30% | - | 30% | - |
| Level 4 | Analyze | 30% | - | 30% | - | 30% | - |
| Level 5 | Evaluate | - | - | | - | - | - |
| Level 6 | Create | - | - | | - | - | - |
| | Total | 100 % | | 100 % | | 100 % | |

**Course Designers**

| Experts from Industry | Experts from Higher Technical Institutions | Internal Experts |
|---|---|---|
| 1. Dr. K. Karthikeyan Ph.D.,R &D Team Manager, Power Quality Products, Hitachi Energy, Bangalore | 1. Dr.M.Mythili, Assistant Professor, Department of Electronics and Instrumentation Engineering, Anna University, Chennai - 600025.Email - mythilym@annauniv.edu | 1. Dr.M.Mohamed Rabik, AP, SRMIST |
| 2. Mr. Emmanuel Thangiah Director-Operations, E73 AI Innovations Pvt Ltd Email – emmanuel@73.ai | 2. Dr. P. Karthikeyan, Assistant Professor, Department of Production Technology, MIT Campus, Anna University, Chennai- 600044. Email id:pkrthikeyan@mit.edu | 2. Ms.D.Sasikala , AP, SRMIST |

| Course Code | 21MHC302J | Course Name | DESIGN AND ANALYSIS OF MACHINE ELEMENTS | Course Category | C | PROFESSIONAL CORE | L | T | P | C |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | 2 | 0 | 2 | 3 |

| Pre-requisite Courses | Nil | Co- requisite Courses | Nil | Progressive Courses | Nil |
|---|---|---|---|---|---|
| Course Offering Department | Mechatronics Engineering | Data Book / Codes / Standards | Nil | | |

| Course Learning Rationale (CLR): | The purpose of learning this course is to: |
|---|---|
| CLR-1: | formulate, design, and identify torque elements |
| CLR-2: | estimate the life of sliding and rolling contact bearings |
| CLR-3: | analyze the gear failure modes, and evaluate forces and stresses within a gear system |
| CLR-4: | construct flexible drive systems and design for light, medium, and heavy-duty applications |
| CLR-5: | summarize the basics of finite element formulation |

| Course Outcomes (CO): | At the end of this course, learners will be able to: | Program Outcomes (PO) | | | | | | | | | | | | Program Specific Outcomes | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | | | |
| | | Engineering Knowledge | Problem Analysis | Design/development of solutions | Conduct investigations of complex problems | Modern Tool Usage | The engineer and society | Environment & Sustainability | Ethics | Individual & Team Work | Communication | Project Mgt. & Finance | Life Long Learning | PSO-1 | PSO-2 | PSO-3 |
| CO-1: | design suitable shafts and coupling for particular engineering applications | 3 | 3 | 2 | 2 | 3 | - | - | - | - | - | - | - | 2 | 2 | - |
| CO-2: | analyze and select bearings and lubricants for various engineering applications | 3 | 3 | 2 | 2 | 3 | - | - | - | - | - | - | - | 2 | 2 | - |
| CO-3: | design and analyze various simple gear trains for various power transmission applications | 3 | 3 | 2 | 2 | 3 | - | - | - | - | - | - | - | 2 | 2 | - |
| CO-4: | design and select suitable flexible drive systems for power transmission applications | 3 | 3 | 2 | 2 | 3 | - | - | - | - | - | - | - | 2 | 2 | - |
| CO-5: | apply finite element formulations to solve one-dimensional and two-dimensional Problems | 3 | 3 | 2 | 2 | 3 | - | - | - | - | - | - | - | 2 | 2 | - |

***Unit-1 - Design of Power Transmission and Energy Storing Elements*** ***9 Hour***

*Introduction to the design process, factors influencing machine design, selection of materials based on mechanical properties, Preferred numbers, fits, and tolerances. Design of rigid and flexible couplings, Keys, keyways, and splines, Various types of springs; design and optimization of helical springs; design of power screws.*
*Experiments:*
*Modeling of basic mechanical components using Solid Works Coupling and spring Modeling and Analysis (Solid works & Ansys)*

***Unit-2 - Design of Bearings*** ***9 Hour***

*Design of Bearings (Ball Bearing, Roller Bearing & Sliding Contact Bearing) Sliding contact and rolling contact bearings – Hydrodynamic journal bearings, Sommerfeld Number, Raimondi and Boyd graphs, Selection of Rolling Contact bearings.*
*Experiments:*
*screw jack Modeling Simulation and Analysis (Solid works & Ansys)*
*Plummer Block Modeling Simulation and Analysis (Solid works & Ansys)*

***Unit-3 - Design of Gears and Gear Trains*** ***9 Hour***

*Types of Gears, Gear materials, Gear Nomenclature, Design of spur gear based on Lewis and Buckingham equations: Helical Gear Nomenclature, Design of helical gear based on modified Lewis equations: Bevel Gear Nomenclature, Design of bevel gear based on Lewis and Buckingham equations. Gears and Gear trains, Design of Gears using Gear Life: Design of Gearbox.*
*Experiments:*
*Universal Coupling Modeling Simulation and Analysis (Solid works & Ansys)*
*Modeling, Simulation, and Analysis of Mechanisms (Four bar, Slider crank Mechanisms)*

| | |
|---|---|
| ***Unit-4 - Design of Flexible Drives*** | ***9 Hour*** |
| *Types of Flexible Drives, Belt Materials and Constructions, Design of Flat Belt Drive & V- Belt Drive, Chain Drive: Types, Failures, Designation Selection of Chain Drive, Chain Lubrication Wire Rope - Types, Construction, Lays of Wire Rope, Selection of Wire Rope, Stresses in Wire Rope, Design of a Wire Rope Drive.*<br>*Experiments:*<br>*Mode thermal analysis of Composite material Frequency analysis, Harmonic Analysis* | |
| ***Unit-5 - Finite Element Method*** | ***9 Hour*** |
| *Finite element method: Introduction, types of elements, shape function, types of forces, elemental stiffness matrix, elemental force matrix, assembly, truss, introduction to 2-dimensional finite element method.*<br>*Experiments:*<br>*Modeling, Simulation, and Analysis of a robotic arm* | |

| | | |
|---|---|---|
| **Learning Resources** | 1. *Bhandari.V.B, "Design of Machine Elements", 3rd ed., Tata McGraw- Hill, 2010.*<br>2. *Robert L. Norton, "Machine Design: An Integrated Approach", 5th ed., Prentice Hall, 2013.*<br>3. *Merhyle Franklin Spotts, Terry E. Shoup and Hornberger.L.E, "Design of Machine Elements", 8th ed.,, Prentice Hall,2003* | 4. *Joseph Shigley and Charles Mischke, "Standard Handbook of Machine Design", 3rd ed., Tata McGraw Hill, 2004.*<br>5. *Richard G.Budynas, J.KeithNisbett, "Shigley's Mechanical Engineering Design", 10th ed., Tata McGraw-Hill, 2015.*<br>6. *PSG, "Design Data" [Data Book Of Engineers], Kalaikathir Achagam, 2016.*<br>7. *CAD Laboratory Manual.* |

**Learning Assessment**

| | *Bloom's Level of Thinking* | *Continuous Learning Assessment (CLA)* | | | | *Summative Final Examination (40% weightage)* | |
|---|---|---|---|---|---|---|---|
| | | *Formative CLA-1 Average of unit test (45%)* | | *Life-Long Learning CLA-2 (15%)* | | | |
| | | *Theory* | *Practice* | *Theory* | *Practice* | *Theory* | *Practice* |
| Level 1 | *Remember* | *10%* | - | - | *20%* | *15%* | - |
| Level 2 | *Understand* | *30%* | - | - | *20%* | *25%* | - |
| Level 3 | *Apply* | *30%* | - | - | *20%* | *30%* | - |
| Level 4 | *Analyze* | *30%* | - | - | *40%* | *30%* | - |
| Level 5 | *Evaluate* | - | - | | - | - | - |
| Level 6 | *Create* | - | - | | - | - | - |
| | *Total* | *100 %* | | *100 %* | | *100 %* | |

**Course Designers**

| **Experts from Industry** | **Experts from Higher Technical Institutions** | **Internal Experts** |
|---|---|---|
| 1. *Mr. R. Nirmal, Caterpillar India, Chennai* | 1. *Dr. R Arvindraj, VIT vellore* | 1. *Mr.G.Balakumaran ,SRMIST* |
| 2. *Mr. R. DhineshBabu, Technofit, Malaysia* | 2. *Dr. R. Senthilkumar, Mohamed Sathak A.J.College of Engineering* | 2. *Mr.S.M. Vignesh SRMIST* |

| Course Code | 21MHC303J | Course Name | MEASUREMENT, SENSORS AND INTERFACES | Course Category | C | PROFESSIONAL CORE | L | T | P | C |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | 2 | 0 | 2 | 3 |

| Pre-requisite Courses | Nil | Co- requisite Courses | Nil | Progressive Courses | 21MHE401T, 21MHE410T |
|---|---|---|---|---|---|
| Course Offering Department | Mechatronics Engineering | Data Book / Codes / Standards | | Nil | |

| Course Learning Rationale (CLR): | The purpose of learning this course is to: |
|---|---|
| CLR-1: | perceive the fundamental understanding of design, calibration, characterization and analysis of measuring systems and data acquisition |
| CLR-2: | gain knowledge of the working principle of sensors used for force and displacement measurement |
| CLR-3: | acquire the knowledge of the working principle of sensors for measurement of position, distance and acceleration |
| CLR-4: | explore the basic principles of pressure, flow, and temperature sensors |
| CLR-5: | comprehend different interfacing standards for sensors and their physical applications |

| Course Outcomes (CO): | At the end of this course, learners will be able to: | Program Outcomes (PO) | | | | | | | | | | | | Program Specific Outcomes | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 1 Engineering Knowledge | 2 Problem Analysis | 3 Design/development of solutions | 4 Conduct investigations of complex problems | 5 Modern Tool Usage | 6 The engineer and society | 7 Environment & Sustainability | 8 Ethics | 9 Individual & Team Work | 10 Communication | 11 Project Mgt. & Finance | 12 Life Long Learning | PSO-1 | PSO-2 | PSO-3 |
| CO-1: | implement the physical principles applied in measurement systems and data acquisition systems | 3 | 2 | - | - | - | - | - | - | - | - | - | - | 1 | - | - |
| CO-2: | analyze the sensors and their selection criteria for the measurement of force and displacement | 3 | - | 2 | - | - | - | - | - | - | - | - | - | - | - | - |
| CO-3: | evaluate the sensors for the measurement of position, distance and acceleration based on selection criteria | 3 | - | 2 | - | - | - | - | - | - | - | - | - | - | - | - |
| CO-4: | analyze the sensors and their selection criteria for the measurement of pressure, flow and temperature | 3 | - | 2 | - | - | - | - | - | - | - | - | - | - | - | - |
| CO-5: | acquire knowledge about different sensor interfaces and their real time applications | 3 | 2 | - | - | - | - | - | - | - | - | - | - | - | - | - |

***Unit-1 - Sensor Based Measurement Systems and Data Acquisition*** — ***12 Hour***

*Sensor Classification - Static and Dynamic Characteristics of Measurement Systems - Errors in Measurement - Statistical Evaluation of Measured Data - Standard and Calibration - Amplification and Signal Conditioning - Digital Conversion - Elements of Data Acquisition Systems - Time Division and Space Division Channeling in Data Acquisition Systems*

*Experiments:*

*1. Design of instrumentation amplifiers. 2. Design of active filters*

***Unit-2 - Sensors for Force and Displacement Measurement*** — ***12 Hour***

*Potentiometric Sensors - Capacitive Sensors - Working Principle of Strain Gauges - Quarter Bridge, Half Bridge and Full Bridge Configuration of Load Cell - Magnetic and Inductive Proximity Sensors - Working Principle and Applications of LVDT and RVDT - Tactile Sensors*

*Experiments:*

*1. Study of characteristics of load cell. 2. Study of characteristics of LVDT*

***Unit-3 - Sensors for Position, Distance and Acceleration Measurement*** — ***12 Hour***

*Working Principle of Eddy Current Sensors - Hall Effect Sensors - Distance Measurement using IR and Ultrasonic Sensors - SONAR, RADAR, Optical Sensors - LIDAR - Optical Encoders - IMU*

*Experiments:*

*1. Distance measurement using IR. 2. Distance measurement using optical encoder*

| | |
|---|---|
| ***Unit-4 - Sensors for Temperature, Pressure and Flow Measurement*** | ***12 Hour*** |
| *Piezoresistive Sensors - Working Principle and Applications of Bourdon Tube, Bellows and Diaphragm - Thermoresistive Sensors: Thermistor - RTD - Thermoelectric contact sensors: Thermocouple - Thermal Transport Sensors: Hot wire Anemometer Experiments:*<br>*1. Study of characteristics of pressure sensors. 2. Study of characteristics of temperature sensors* | |
| ***Unit-5 - Sensor Interfacing*** | ***12 Hour*** |
| *Smart Sensor Systems – Role of sensors in IOT - Multichannel Sensor Interfacing - Standards - Integrated Circuit Bus (I2C) - Serial Peripheral Interface (SPI) - Controller Area Network (CAN) Bus - Universal Transducer Interface (UTI) - Case studies related to different Interfacing Standards Experiments:*<br>*1. Interfacing temperature sensor with data acquisition system. 2. Interfacing ultrasonic sensor with data acquisition system* | |

| | | |
|---|---|---|
| **Learning Resources** | 1. *Jacob Fraden, "Hand Book of Modern Sensors: physics, Designs and Applications", 2015, 3rd edition, Springer, New York.*<br>2. *John G Webster, "Measurement, Instrumentation and sensor Handbook", 2014, 2nd edition, CRC Press, Florida.*<br>3. *Kirianaki N.V., Yurish S.Y., Shpak N.O., Deynega V.P., Data Acquisition and Signal Processing for Smart Sensors, John Wiley & Sons, Chichester, UK, 2002.* | 4. *Ramon Pallas-Areny and John G Webster, Sensors and Signal Conditioning, 2012, 2nd ed., Wiley India Pvt. Ltd.*<br>5. *John Park and Steve Mackay, Practical Data acquisition for Instrumentation and Control, 2011, 1st ed., Newness publishers, Oxford, UK.*<br>6. *Paul P.L Regtien, "Sensors for Mechatronics", Elsevier publications, 1st edition, 2012.* |

**Learning Assessment**

| | Bloom's Level of Thinking | Continuous Learning Assessment (CLA) | | | | Summative Final Examination (40% weightage) | |
|---|---|---|---|---|---|---|---|
| | | Formative CLA-1 Average of unit test (45%) | | Life-Long Learning CLA-2 (15%) | | | |
| | | Theory | Practice | Theory | Practice | Theory | Practice |
| Level 1 | *Remember* | *15%* | - | - | *15%* | *15%* | - |
| Level 2 | *Understand* | *25%* | - | - | *25%* | *25%* | - |
| Level 3 | *Apply* | *30%* | - | - | *30%* | *30%* | - |
| Level 4 | *Analyze* | *30%* | - | - | *30%* | *30%* | - |
| Level 5 | *Evaluate* | - | - | - | - | - | - |
| Level 6 | *Create* | - | - | - | - | - | - |
| | *Total* | *100 %* | | *100 %* | | *100 %* | |

**Course Designers**

| Experts from Industry | Experts from Higher Technical Institutions | Internal Experts |
|---|---|---|
| 1. *Dr.S. Shaffath Hussain Shakir, Project lead,VIASAT* | 1. *Dr.R.Thiyagarajan, Assistant Professor, Department of Mechanical Engineering, IIT,Tirupati.* | 1. *Dr. S.Fouziya Sulthana, SRMIST* |
| 2. *Mr.T.Sathish, Lead Engineer-Systems Engineering GE Power conversion.* | 2. *Dr K. Navin sam, Assistant Professor , Department of Electrical and Electronics Engineering, NIT, Puducherry* | 2. *Mr. J.Thiyagarajan, SRMIST* |

| Course Code | 21MHC304L | Course Name | MODELLING AND CONTROL LABORATORY | Course Category | C | PROFESSIONAL CORE | L | T | P | C |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | 0 | 0 | 2 | 1 |

| Pre-requisite Courses | Nil | Co- requisite Courses | 21MHC301T | Progressive Courses | 21MHE414T |
|---|---|---|---|---|---|
| Course Offering Department | Mechatronics Engineering | Data Book / Codes / Standards | | Nil | |

| Course Learning Rationale (CLR): | The purpose of learning this course is to: |
|---|---|
| CLR-1: | model the electrical, mechanical, and electromechanical dynamic systems |
| CLR-2: | analyze a dynamic system using procedural methods |
| CLR-3: | construct the control systems in the time domain |
| CLR-4: | analyze a control systems in the frequency domain |
| CLR-5: | develop a state space model |

| Course Outcomes (CO): | At the end of this course, learners will be able to: | Program Outcomes (PO) | | | | | | | | | | | | Program Specific Outcomes | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | | | |
| | | Engineering Knowledge | Problem Analysis | Design/development of solutions | Conduct investigations of complex problems | Modern Tool Usage | The engineer and society | Environment & Sustainability | Ethics | Individual & Team Work | Communication | Project Mgt. & Finance | Life Long Learning | PSO-1 | PSO-2 | PSO-3 |
| CO-1: | construct the basic dynamic systems | 2 | 2 | 3 | - | 2 | - | - | - | - | - | - | - | 3 | - | - |
| CO-2: | design a conventional controller for a dynamic system | 2 | 2 | 3 | - | 2 | - | - | - | - | - | - | - | 3 | - | - |
| CO-3: | analyze a controller based on time domain specification | 2 | 2 | 3 | - | 2 | - | - | - | - | - | - | - | 3 | - | 2 |
| CO-4: | apply the procedure of frequency response plot to design a compensator | 2 | 2 | 3 | - | 2 | - | - | - | - | - | - | - | 3 | - | 2 |
| CO-5: | develop a controller using state space approach | 2 | 2 | 3 | - | 2 | - | - | - | - | - | - | - | 3 | - | 2 |

| | |
|---|---|
| **Unit-1 - Modeling of Systems** | **6 Hour** |
| 1. Modelling of electrical and mechanical dynamic systems and validation using simulation software. | |
| 2. Modelling of electromechanical systems and validation using simulation software. | |
| **Unit-2 - Time Domain Specifications and Controllers** | **6 Hour** |
| 1. Determine the time domain specifications of I and II order systems. | |
| 2. Performance comparison of open loop system and closed loop system with a PID controller. | |
| **Unit-3 - Concept of Stability and Design** | **6 Hour** |
| 1. Experimentation of root locus method, gain determination, and stability analysis. | |
| 2. Design of compensators using the root locus method. | |
| **Unit-4 - Frequency Domain Analysis and Design** | **6 Hour** |
| 1. Experimentation on Bode plot method, calculation of gain, and phase margins with a suitable example. | |
| 2. Design of compensators using Bode plot method. | |
| **Unit-5 - State Space Analysis and Design** | **6 Hour** |
| 1. Experiment on state space representation of a system, conversions between transfer function and state space approaches. | |
| 2. Design of full state feedback controllers with a suitable example using DC servo motor | |

| Learning Resources | | |
|---|---|---|
| | 1. Roland S. Burns, Advanced Control Engineering, Butterworth- Heinemann, First edition, 2001 | 3. Laboratory Manuals for Qube servo, and compensation circuit kits. |
| | 2. J Nagrath, M Gopal, Control Systems Engineering, 5th Edition, New Age International, 2007. | |

| Learning Assessment | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | Bloom's Level of Thinking | Continuous Learning Assessment (CLA) | | | | | | Final Examination (0% weightage) | |
| | | CLA-1 Average of first cycle experiments (30%) | | CLA-2 Average of second cycle experiments (30%) | | Practical Examination (40% weightage) | | | |
| | | Theory | Practice | Theory | Practice | Theory | Practice | Theory | Practice |
| Level 1 | Remember | - | 20% | - | - | - | 15% | - | - |
| Level 2 | Understand | - | 25% | - | - | - | 25% | - | - |
| Level 3 | Apply | - | 30% | - | 50% | - | 30% | - | - |
| Level 4 | Analyze | - | 25% | - | 50% | - | 30% | - | - |
| Level 5 | Evaluate | - | - | - | - | - | - | - | - |
| Level 6 | Create | - | - | - | - | - | - | - | - |
| | Total | 100 % | | 100 % | | 100% | | - | |

| Course Designers | | |
|---|---|---|
| **Experts from Industry** | **Experts from Higher Technical Institutions** | **Internal Experts** |
| 1. Dr. K. Karthikeyan, R &D Team Manager, Power Quality Products, Hitachi Energy, Bangalore | 1. Dr. M. Mythily Assistant Professor, Department of Electronics and Instrumentation Engineering, Email - mythilym@annauniv.edu | 1. Dr.M.Mohamed Rabik, SRMIST |

| Course Code | 21MHC305J | Course Name | MANUFACTURING PROCESSES | Course Category | C | PROFESSIONAL CORE | L | T | P | C |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | 2 | 0 | 2 | 3 |

| Pre-requisite Courses | *Nil* | Co- requisite Courses | *Nil* | Progressive Courses | *Nil* |
|---|---|---|---|---|---|
| Course Offering Department | *Mechatronics engineering* | Data Book / Codes / Standards | | *Nil* | |

| Course Learning Rationale (CLR): | ***The purpose of learning this course is to:*** |
|---|---|
| ***CLR-1:*** | *understand the principle and process of different metal forming and metal cutting process* |
| ***CLR-2:*** | *impart knowledge on types and approaches of advanced manufacturing process* |
| ***CLR-3:*** | *gain knowledge in concept of computerized machine tool for metal cutting process* |
| ***CLR-4:*** | *understand the concept of automation in manufacturing process* |
| ***CLR-5:*** | *familiar in manufacturing metrology* |

| Course Outcomes (CO): | ***At the end of this course, learners will be able to:*** | Program Outcomes (PO) | | | | | | | | | | | | Program Specific Outcomes | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | | | |
| | | Engineering Knowledge | Problem Analysis | Design/development of solutions | Conduct investigations of complex problems | Modern Tool Usage | The engineer and society | Environment & Sustainability | Ethics | Individual & Team Work | Communication | Project Mgt. & Finance | Life Long Learning | PSO-1 | PSO-2 | PSO-3 |
| ***CO-1:*** | *explain the process of different metal forming and metal cutting processes* | *1* | *2* | - | - | - | - | - | - | - | - | - | - | - | - | - |
| ***CO-2:*** | *distinguish the types and approaches of advanced manufacturing process* | *1* | *2* | *2* | - | - | - | - | - | - | - | - | - | - | - | - |
| ***CO-3:*** | *implement the concept of computerized machine tool for metal cutting process* | *2* | - | - | *2* | - | - | *1* | - | - | - | - | - | - | - | - |
| ***CO-4:*** | *understand the concept of automation in manufacturing process* | *1* | *2* | - | *2* | - | - | - | - | - | - | - | - | - | - | - |
| ***CO-5:*** | *acquire knowledge on manufacturing metrology* | *1* | *2* | *2* | *1* | - | - | *1* | - | - | - | - | - | - | - | - |

***Unit-1 - Conventional Manufacturing Process and Metal Cutting Theory*** ***12 Hour***

*Introduction to casting process and mechanical working of metals- fundamentals of metal cutting process- types of cutting tools- Tool life- Prediction of tool life using tailors tool life equations- Cutting forces in orthogonal cutting, merchant circle analysis- Calculation of various forces involved during orthogonal cutting- finishing process and superfinishing process.*

*Experiments*

**Multiple turning with grooving and thread cutting by applying canned cycle using CNC turning centre. *Multiple turning with axial drilling operation by applying canned cycle using CNC turning centre.*

***Unit-2 - Advanced Manufacturing Process*** ***12 Hour***

*Rapid Prototyping- Working Principles- Rapid tooling, Techniques of rapid manufacturing- Additive manufacturing: concept, types- Stereo Lithography, Laser Sintering, Fused Deposition Method, Applications and Limitations - Methods of micromachining- Abrasive jet, Ultrasonic, Abrasive water jet micromachining, Micro turning, Micro drilling.*

*Experiments*

*1. Part Program for drilling and Peck drilling operation by applying canned cycle using CNC milling centre. 2. *Profile cutting using Wire cut Electrical Discharge Machine (WEDM)*

***Unit-3 - CNC Machines and Its Architecture*** ***12 Hour***

*Introduction to CNC machine tools – Classifications and Constructional feature of CNC turning and milling centre – Open loop and closed loop CNC systems- CNC controllers- Structural members of CNC machines: slide ways, linear motion - Automatic tool changer- fundamentals of part programming- Types of programming: manual part programming- Canned cycle and subroutines.*

*Experiments*

*1. CNC Part Program for Facing, Step turning, Tapper and Finish turning using ordinary cycle. 2. CNC Part Program for Facing, Step turning, Tapper and Finish turning using canned cycle.*

| | |
|---|---|
| ***Unit-4 - Automation in Manufacturing Process*** | ***12 Hour*** |
| *Automation in Production systems- Components of a Manufacturing systems- Single Station Manned Workstations and Single Station Automated Cells- Manufacturing Operations- Cellular Manufacturing, Flexible Manufacturing Systems: FMS Components, FMS Applications, and FMS Planning.*<br>*Experiments*<br>*1. Pocketing of Linear and Circular profile using CNC vertical machining centre. 2. Part Program for End milling and Drilling operation by applying canned cycle using CNC milling centre* | |
| ***Unit-5 - Advanced Inspection Technologies*** | ***12 Hour*** |
| *Automated Inspection, Coordinate Measuring Machines Construction, operation & Programming, Software, Application & Benefits, Flexible Inspection System, Inspection Probes on Machine Tools, Machine Vision, contact and non-contact Optical Inspection Techniques & Non-contact Non-optical Inspection Technologies.*<br>*Experiments*<br>*1. Profile cutting by applying Mirroring operation using CNC vertical machining centre* | |

| | | |
|---|---|---|
| **Learning Resources** | 1. *Sharma.P.C, "A textbook of Production Technology", Vol I and II, S. Chand and Company Ltd., New Delhi, 2007.*<br>2. *SeropeKalpakjian and Steven Schmid, "Manufacturing Engineering and Technology", Pearson Education, 7th edition, 2014.*<br>3. *Radhakrishnan.P, "CNC Machines", New Central Book Agency, 2000.*<br>4. *Pandey and H.S.Shah, "Modern Machining Process", Tata McGraw Hill Publishing Co., New Delhi, 2008.*<br>5. *Chua C.K., Leong K.F., and Lim C.S., "Rapid prototyping: Principles and applications", 3rd edition, World Scientific Publishers, 2010.* | 6. *R. S. Khandpur"Printed Circuit Boards: Design, Fabrication, and Assembly" Tata McGraw Hill Publishing Co., New Delhi, 2010.*<br>7. *S.K. HajraChoudry, S.K.Bose, A.K. HajraChoudry , "Elements of Workshop Technology Vol II: Machine tools", Media promoters and Publishers Pvt Ltd, 2002.*<br>8. *Chapman.W.A.J, "Workshop Technology" Vol. I and II, Arnold Publisher, 1996.*<br>9. *Elanchezhian.C, VijayaRamnath.B and Sunder Selwyn, T., Engineering Metrology, Eswar Press, Chennai, 2004.*<br>10. *John A. Bosch, Giddings and Lewis Dayton, Co-ordinate Measuring Machines and Systems, Marcel Dekker, Inc, 1999*<br>11. *ZuechNello, Understanding and Applying Machine Vision, Marcel Dekker, Inc, 2000* |

**Learning Assessment**

| | *Bloom's Level of Thinking* | *Continuous Learning Assessment (CLA)* | | | | *Summative Final Examination (40% weightage)* | |
|---|---|---|---|---|---|---|---|
| | | *Formative CLA-1 Average of unit test (45%)* | | *Life-Long Learning CLA-2 (15%)* | | | |
| | | *Theory* | *Practice* | *Theory* | *Practice* | *Theory* | *Practice* |
| Level 1 | *Remember* | *15%* | - | - | *15%* | *15%* | - |
| Level 2 | *Understand* | *25%* | - | - | *20%* | *25%* | - |
| Level 3 | *Apply* | *30%* | - | - | *25%* | *30%* | - |
| Level 4 | *Analyze* | *30%* | - | - | *25%* | *30%* | - |
| Level 5 | *Evaluate* | - | - | - | *10%* | - | - |
| Level 6 | *Create* | - | - | - | *5%* | - | - |
| | *Total* | *100 %* | | *100 %* | | *100 %* | |

**Course Designers**

| **Experts from Industry** | **Experts from Higher Technical Institutions** | **Internal Experts** |
|---|---|---|
| 1. *Mr.K.Balaguru, Deputy Manager, Hindustan Aeronautics limited, Structural Design, gurubala07@gmail.Com.* | 1. *Dr.V. Senthilkumar , NIT Tiruchirappalli, Production department, vskumar@nitt.edu* | 1. *Mr.Arivarasan J, SRMIST* |
| 2. *.Mr.S.Hari bala manoj, Assistant Manager, Renault Nissan Technology, sbalamanoj@gmail.com* | 2. *Dr.C.Velmurugan, IIIT Tiruchirappalli, Mechanical Engineering Department, velmuruganc@iiitt.ac.in* | 2. *Mr.K.Saravanan, SRMIST* |

| Course Code | 21MHC306T | Course Name | KINEMATICS AND DYNAMICS OF MECHANISMS | Course Category | C | PROFESSIONAL CORE | L | T | P | C |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | 3 | 0 | 0 | 3 |

| Pre-requisite Courses | Nil | Co- requisite Courses | Nil | Progressive Courses | Nil |
|---|---|---|---|---|---|
| Course Offering Department | Mechatronics Engineering | Data Book / Codes / Standards | | Nil | |

| Course Learning Rationale (CLR): | The purpose of learning this course is to: |
|---|---|
| CLR-1: | appraise the fundamental concepts Mechanisms, degrees of freedom and inversions of different mechanisms |
| CLR-2: | analyze the forces of different machines under static and dynamic conditions |
| CLR-3: | acquire the knowledge about the principles of CAM and Gyroscopes |
| CLR-4: | explore the undesirable effects of balancing in different real time systems |
| CLR-5: | estimate the frequency of torsional, transverse and torsional vibrations under different loading conditions |

| Course Outcomes (CO): | At the end of this course, learners will be able to: | Program Outcomes (PO) | | | | | | | | | | | | Program Specific Outcomes | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | | | |
| | | Engineering Knowledge | Problem Analysis | Design/development of solutions | Conduct investigations of complex problems | Modern Tool Usage | The engineer and society | Environment & Sustainability | Ethics | Individual & Team Work | Communication | Project Mgt. & Finance | Life Long Learning | PSO-1 | PSO-2 | PSO-3 |
| CO-1: | comprehend the basic concepts of mechanisms and its inversions | 1 | 2 | - | - | 1 | - | - | - | - | - | - | - | - | - | - |
| CO-2: | examine the forces and its impact on different machines under static and dynamic conditions | 1 | 2 | - | - | 1 | - | - | - | - | - | - | - | - | - | - |
| CO-3: | understand the knowledge of CAM and gyroscope | 1 | 2 | - | - | 1 | - | - | - | - | - | - | - | - | - | - |
| CO-4: | learn and implement the balancing techniques in different loading conditions | 1 | 2 | - | - | 1 | - | - | - | - | - | - | - | - | - | - |
| CO-5: | gain the knowledge of vibrations and to estimate the frequency of different vibrations | 1 | 2 | - | - | 1 | - | - | - | - | - | - | - | - | - | - |

**Unit-1 - Elements of Mechanisms** — **9 Hour**

Machine, mechanism, links, pair, Degrees of freedom, determining DOF using Kutzbach criteria - Grashoff law – 4 bar chain mechanism – inversions of 4 bar chain mechanism – single slider mechanism – inversions of single slider mechanism – position, displacement and velocity analysis – simulation of 4 bar chain mechanism

**Unit-2 - Force Analysis of Machines** — **9 Hour**

Static force analysis: Constraint forces and applied forces – Free body diagrams – Conditions for equilibrium – Equilibrium for two, three and four force members – Centroid and Moment of inertia – D – Alembert's principle – Principle of super position – Turning of moment diagram of flywheel – Fluctuation of energy – dimensions of flywheel

**Unit-3 - CAMS and Gyroscope** — **9 Hour**

CAMS: Classifications of cam and follower- Construction of cam profile when the follower moves with uniform velocity and simple harmonic motion - Construction of cam profile when the follower moves with uniform acceleration and retardation - Construction of cam profile when the follower moves in cycloidal motion- Gyroscope: Gyroscopic couple – Effect of gyroscopic couple on an aeroplane - Effect of gyroscopic couple on naval ship during steering and pitching – stability of a two-wheel vehicle

**Unit-4 - Balancing of Rotating and Reciprocating Masses** — **9 Hour**

Balancing of rotating masses: Static balancing – dynamic balancing – Balancing of several masses in single plane – balancing of several masses in different planes Balancing of reciprocating masses: Primary and Secondary unbalanced forces of reciprocating masses – Partial balancing of locomotives – Tractive force – Hammer blow – Swaying couple

**Unit-5 - Vibrations** — **9 Hour**

Types of free vibration – Natural frequency of free transverse and longitudinal vibration - Natural frequency of free transverse vibration due to single and multiple point load over a simply supported shaft - Natural frequency of free transverse vibration due to uniformly distributed load over a simply supported shaft – Critical speed of shaft – frequency of free damped vibration – frequency of underdamped forced vibration - Frequency of free torsional vibration of a single, two and three rotor system – Torsionally equivalent shaft

| Learning | 1. Ratan.S.S, Theory of Machines, 5th ed., Tata McGraw Hill, 2019 | 4. Dechev, Nikolai. Cleghorn, William L. Mechanics of Machines. Oxford University Press, |
|---|---|---|

| | | |
|---|---|---|
| **Resources** | 2. *R.L. Norton, Kinematics and Dynamics of Machinery, 1st ed., Tata McGraw Hill, 2017*<br>3. *Gordon R. Pennock & Shigley J.E John J Uicker, 4th ed., Theory of machines and mechanisms, Oxford university press, 2016* | *2nd edition, 2015.*<br>5. *Dukkipati, Rao V. Mechanism and Machine Theory. India: New Age International (P) Limited, 2nd edition, 2007.* |

**Learning Assessment**

| | *Bloom's Level of Thinking* | *Continuous Learning Assessment (CLA)* | | | | *Summative Final Examination (40% weightage)* | |
|---|---|---|---|---|---|---|---|
| | | *Formative CLA-1 Average of unit test (50%)* | | *Life-Long Learning CLA-2 (10%)* | | | |
| | | *Theory* | *Practice* | *Theory* | *Practice* | *Theory* | *Practice* |
| Level 1 | *Remember* | *15%* | - | *15%* | - | *15%* | - |
| Level 2 | *Understand* | *25%* | - | *20%* | - | *25%* | - |
| Level 3 | *Apply* | *30%* | - | *25%* | - | *30%* | - |
| Level 4 | *Analyze* | *30%* | - | *25%* | - | *30%* | - |
| Level 5 | *Evaluate* | - | - | *15%* | - | - | - |
| Level 6 | *Create* | - | - | - | - | - | - |
| | *Total* | *100 %* | | *100 %* | | *100 %* | |

**Course Designers**

| **Experts from Industry** | **Experts from Higher Technical Institutions** | **Internal Experts** |
|---|---|---|
| 1. *Mr. N. Manojprabhakar.N, FLSmidth Private Limited, mnp-in@flsmidth.com* | 1. *Dr. V. Muralidharan, Associate Professor,BS Abdur Rahman Crescent Institute of Science & Tech, muralidharan@crescent.education* | 1. *Dr.S.Senthilraja, SRMIST* |
| 2. *Mr. P. Thangadurai, Aditya Auto Components, thangadurai08@gmail.com* | 2. *Mr. P. Nantha Kumar, Associate Professor, Sri Sai Ram Institute of Technology, nanthakumar.mech@sairamit.edu.in* | 2. *Mr. M. Thirugnanam, SRMIST* |

| Course Code | 21MHC307P | Course Name | MODEL BASED SYSTEMS ENGINEERING | Course Category | C | PROFESSIONAL CORE | L | T | P | C |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | 1 | 2 | 0 | 3 |

| Pre-requisite Courses | Nil | Co- requisite Courses | Nil | Progressive Courses | Nil |
|---|---|---|---|---|---|
| Course Offering Department | Mechatronics Engineering | Data Book / Codes / Standards | Nil | | |

| Course Learning Rationale (CLR): | The purpose of learning this course is to: |
|---|---|
| CLR-1: | introduce systems engineering concepts for solving the problems in developing complex engineering systems |
| CLR-2: | familiarize the various modeling approaches and methodologies |
| CLR-3: | analyze stakeholders' expectations using stakeholders value network and capture systems requirements effectively |
| CLR-4: | create systems architecture for new or improved complex systems |
| CLR-5: | apply verification and validation techniques to evaluate the system design |

| Course Outcomes (CO): | At the end of this course, learners will be able to: | Program Outcomes (PO) | | | | | | | | | | | | Program Specific Outcomes | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | | | |
| | | Engineering Knowledge | Problem Analysis | Design/development of solutions | Conduct investigations of complex problems | Modern Tool Usage | The engineer and society | Environment & Sustainability | Ethics | Individual & Team Work | Communication | Project Mgt. & Finance | Life Long Learning | PSO-1 | PSO-2 | PSO-3 |
| CO-1: | familiarize the systems engineering concepts for solving the problems in developing complex engineering systems | 3 | 3 | - | 1 | - | 1 | - | - | - | 2 | - | - | 2 | 2 | 2 |
| CO-2: | develop various models for systems using SysML | 3 | 3 | - | 2 | 2 | - | - | - | - | - | - | - | 1 | 1 | 1 |
| CO-3: | analyze stakeholders' expectations using stakeholders value network and capture systems requirements effectively | 3 | 3 | 3 | 1 | 1 | 2 | - | - | 2 | 3 | 2 | - | 3 | 3 | 3 |
| CO-4: | develop systems architecture for new or improved complex systems | 3 | 3 | 3 | 3 | 2 | 3 | - | - | 2 | 3 | 2 | - | 3 | 3 | 3 |
| CO-5: | use verification and validation techniques to evaluate the system design | 3 | 3 | 1 | 3 | 2 | 3 | - | - | 2 | 2 | 2 | - | 1 | 3 | 3 |

**Unit-1 - Introduction to Systems Engineering** — **9 Hour**

Definitions and concepts of system-system science and systems engineering, life cycle stages, definitions of requirement, architecture, design. System analysis, interface management, system integration, system verification, system transition, system validation, system operation, system maintenance, system disposal. Project planning, project management and control, decision management, risk management, configuration, Case studies: Refrigerator and Washing Machine.

**Unit-2 - Introduction to MBSE and SysML Overview** — **9 Hour**

Introduction to MBSE-MBSE concepts- MBSE Ontology-Introduction to Object Process modelling OPM- Object process language-Overview of SysML-Block definition diagrams-Internal block diagrams-Use case diagrams-Activity diagrams-Sequence diagrams-State machine diagrams-Parametric diagrams-Requirements diagram-package diagrams-Operational analysis modeling-functional analysis modeling-logical architecture modeling-Physical architecture modeling-architecture frameworks.

**Unit-3 - Stakeholder Analysis and Requirements Definition** — **9 Hour**

Stakeholder's identification, Concept of operations, Stakeholders value network analysis, Requirements: Purpose, Types, challenges, allocation and verification and validation and Volatility. Systems Requirements Review (SRR).

**Unit-4 - System Design and Architecture** — **9 Hour**

Architecture definition, architecture viewpoints, concept analysis, models and views of architecture (functional/behavioral/data/performance etc.) – Structure and behavior- Evaluating candidate architectures-System/subsystem analysis- tradeoff analysis- Architecture frameworks and standards-design progression-architecture domains (software/IT/ Manufacturing/social etc)-architecture heuristics- acquisition management-tailoring processes-industrial design-design for manufacturability- robustness design

| ***Unit-5 - Verification and Validation*** | ***9 Hour*** |
|---|---|
| *System verification-System validation-various approaches to system validation and verification-inspection/testing/analysis/demonstration-Generation of Test cases using the Markov Chain model-Writing verification/validation plans-introduction to formal methods-formal approaches to system validation/verification-focus on specialty areas (eg.. EMI/EMC)-test automation models (computation/timed automation)-simulation-model checking verification-verification validation activities prescribed in standards for safety critical systems* | |

| ***List of Recommended Exercises in Tutorial*** |
|---|
| 1. *Assign a case study to every batch (Washing Machine, Refrigerator, or any other equivalent systems), and ask them to identify characteristics of complex engineering systems and familiarize with complexity level* |
| 2. *Analyze stakeholders associated with the system using SVN* |
| 3. *Based on Stakeholder's analysis, develop requirements model for the system* |
| 4. *Brainstorm and explore various possible concepts, choose the feasible concept for implementation based on trade-off study* |
| 5. *Create an architecture based upon the chosen concept, mapping forms and functions.* |
| 6. *Develop functional models for various functions and incorporate in the architecture* |
| 7. *Perform model-based simulation by using various verification and validation strategies* |
| 8. *Document the complete work carried out in this course* |

| | | |
|---|---|---|
| **Learning Resources** | 1. *National Aeronautics and Space Administration, "NASA Systems Engineering Handbook", (Rev 1, Dec 2007).*<br>2. *INCOSE, "Systems Engineering Handbook"*<br>3. *Kossiakof, Alexander and William N. Sweet; "Systems Engineering: Principles and Practice" Wiley, 2011* | 4. *"SysML distilled: A brief guide to the Systems modeling language". Lenny Deligatti-Addison Wesley Professional, Ed 1, 2013*<br>5. *Rechtin, E., and M.W.Maier, "The art of Systems architecting", Boca Raton, FL: CRC Press, 2000*<br>6. *Engel, Avner, "Verification, Validation and Testing of Engineered Systems; John Wiley & Sons, 2010.* |

**Learning Assessment**

| | *Bloom's Level of Thinking* | *Continuous Learning Assessment (CLA)* | | | | | | *Final Examination (0% weightage)* | |
|---|---|---|---|---|---|---|---|---|---|
| | | *Formative CLA-1 Average of unit test (20%)* | | *Project Based Learning CLA-2 (60%)* | | *Report and Viva Voce (20%)* | | | |
| | | *Theory* | *Practice* | *Theory* | *Practice* | *Theory* | *Practice* | *Theory* | *Practice* |
| Level 1 | *Remember* | *40%* | - | - | - | - | - | - | - |
| Level 2 | *Understand* | *40%* | - | - | - | - | - | - | - |
| Level 3 | *Apply* | *20%* | - | - | *20%* | - | *20%* | - | - |
| Level 4 | *Analyze* | - | - | - | *30%* | - | *30%* | - | - |
| Level 5 | *Evaluate* | - | - | - | *30%* | - | *30%* | - | - |
| Level 6 | *Create* | - | - | - | *20%* | - | *20%* | - | - |
| | *Total* | *100 %* | | *100 %* | | *100%* | | - | |

| **Course Designers** | | |
|---|---|---|
| **Experts from Industry** | **Experts from Higher Technical Institutions** | **Internal Experts** |
| 1. *Mr.Gaurav Dubey, Mathworks, India* | 1. *Dr.P.Karthikeyan, MIT Campus, Anna University, pkarthikeyan@annauniv.edu* | 1. *Dr.K Sivanathan, SRMIST* |
| 2. *Dr.Guna Surendra, Hitachi, Japan* | 2. *Dr.Thiyagarajan, Indian Institute of Technology Tirupati, thiyagu@iittp.ac.in* | 2. *Dr.T.Muthuramalingam , SRMIST* |

# ACADEMIC CURRICULA

# UNDERGRADUATE/ INTEGRATED POST GRADUATE DEGREE PROGRAMMES

(With exit option of Diploma)

(Choice Based Flexible Credit System)

Regulations 2021

Volume – 18D
(Syllabi for Mechatronics Engineering (Immersive Technologies) Programme Courses)

SRM
INSTITUTE OF SCIENCE & TECHNOLOGY
(Deemed to be University u/s 3 of UGC Act, 1956)

## SRM INSTITUTE OF SCIENCE AND TECHNOLOGY

(Deemed to be University u/s 3 of UGC Act, 1956)

Kattankulathur, Chengalpattu District 603203, Tamil Nadu, India

# ACADEMIC CURRICULA

Professional Elective Courses

**Regulations 2021**

## SRM INSTITUTE OF SCIENCE AND TECHNOLOGY

**(Deemed to be University u/s 3 of UGC Act, 1956)**

Kattankulathur, Chengalpattu District 603203, Tamil Nadu, India

| Course Code | 21MHE422L | Course Name | CREATIVE PROGRAMMING | Course Category | E | PROFESSIONAL ELECTIVE | L | T | P | C |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | 0 | 0 | 6 | 3 |

| Pre-requisite Courses | *Nil* | Co- requisite Courses | *Nil* | Progressive Courses | *Nil* |
|---|---|---|---|---|---|
| Course Offering Department | *Mechatronics Engineering* | Data Book / Codes / Standards | | *Nil* | |

| Course Learning Rationale (CLR): | ***The purpose of learning this course is to:*** |
|---|---|
| ***CLR-1:*** | *learn game logic, behaviors and waypoint systems* |
| ***CLR-2:*** | *gain the skill set for implementing various applications* |
| ***CLR-3:*** | *learn core principles of object oriented programming* |
| ***CLR-4:*** | *gain proficiency in advanced concepts in C#* |
| ***CLR-5:*** | *develop console application classes and animation* |

| Course Outcomes (CO): | ***At the end of this course, learners will be able to:*** | Program Outcomes (PO) | | | | | | | | | | | | Program Specific Outcomes | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | | | |
| | | Engineering Knowledge | Problem Analysis | Design/development of solutions | Conduct investigations of complex problems | Modern Tool Usage | The engineer and society | Environment & Sustainability | Ethics | Individual & Team Work | Communication | Project Mgt. & Finance | Life Long Learning | PSO-1 | PSO-2 | PSO-3 |
| ***CO-1:*** | *demonstrate the fundamentals of game engine and waypoint systems* | *3* | - | - | - | *3* | - | - | - | - | - | - | - | *1* | - | - |
| ***CO-2:*** | *design console- based applications and game engine* | - | - | *2* | - | *3* | - | - | - | - | - | - | - | *1* | - | - |
| ***CO-3:*** | *develop programs using the concept of class structures, constructors, and overloading* | - | - | *2* | - | *3* | - | - | - | - | - | - | - | - | *2* | - |
| ***CO-4:*** | *comprehend multicasting delegates and master the use of events, threads and object pooling* | - | - | *2* | - | *3* | - | - | - | - | - | - | - | *1* | - | - |
| ***CO-5:*** | *create realistic interaction within game environment* | - | - | *2* | - | *3* | - | - | - | - | - | - | - | - | *2* | - |

***Unit-1 – Essentials of Game Engine*** ***15 Hour***

*Manage project with hub. Identify and make use of essential features of editor, Create and make use of game objects in a scene. Manipulate coordinates in a local and global axes, Create and modify materials and prefabs., Importing assets, configure and use a character controller, Working with transformations, velocities, pre-defined paths and waypoints*

***Unit-2 – Foundation of C#*** ***15 Hour***

*CONSOLE-BASED TOPICS*
*Introduction to Basic datatypes, declaring variables and constants, Type Conversion, Boxing and Unboxing, Structure String, Manipulation, String Builder class, Decision-making statements, Switch Case.*
*GAME-ENGINE-BASED TOPICS*
*Serialize variables in inspector, implement functions, methods and properties, implement time handling, implement transformations with the transform class.*

***Unit-3 – Object Oriented Programming in C#*** ***15 Hour***

*Creating a C# Class, declaring variables and methods and Access Modifiers, Constructors, Abstract Class, Partial, Class, Inheritance, method, overloading, method overriding, Anonymous method, Properties, Indexers, Exception Handling, Case Study - Class contains member variable Basic, member functions to compute a task, Case Study - Inheritance Case Study - Polymorphism*

***Unit-4 - Advanced Concepts in C#*** ***15 Hour***

*Delegates, Multicasting Delegates, Events, Using events in delegates, Dictionary & List, Threads, Object Pooling, Singleton Class. Detailed examples C# implementation for each of the concepts.*

***Unit-5 – Application Development Programming in Game Engine with C#*** ***15 Hour***

*Implementation of Point Lights, Implementation of Conditional Statements, Implementation of Input Handling, Finding game objects and components in a scene, Adding Forces and Torque to Rigid Bodies, Instantiation of Game Objects dynamically, Destroying Game Objects dynamically, Implementation of Rigid Body velocities, Implementation of Rigid Body impulses, Implementation of Collision Detections, Play sound effects, Working with 3D character model and creation of basic animations for walking, running and jumping.*

| Learning | *1. Jon Skeet, C# in Depth, Fourth Edition, Manning Publications, 2019* | *2. Casey Hardman, Game programming with Unity and C#, First Edition, Springer, 2020.* |
|---|---|---|

| Resources | | 3. https://dotnet.microsoft.com/learn/csharp |
|---|---|---|

**Learning Assessment**

| | Bloom's Level of Thinking | Continuous Learning Assessment (CLA) | | | | | | Final Examination (0% weightage) | |
|---|---|---|---|---|---|---|---|---|---|
| | | CLA-1 Average of first cycle experiments (30%) | | CLA-2 Average of second cycle experiments (30%) | | Practical Examination (40% weightage) | | | |
| | | Theory | Practice | Theory | Practice | Theory | Practice | Theory | Practice |
| Level 1 | Remember | - | 20% | - | - | - | 15% | - | - |
| Level 2 | Understand | - | 25% | - | - | - | 25% | - | - |
| Level 3 | Apply | - | 30% | - | 50% | - | 30% | - | - |
| Level 4 | Analyze | - | 25% | - | 50% | - | 30% | - | - |
| Level 5 | Evaluate | - | - | - | - | - | - | - | - |
| Level 6 | Create | - | - | - | - | - | - | - | - |
| | Total | 100 % | | 100 % | | 100% | | | |

**Course Designers**

| Experts from Industry | Experts from Higher Technical Institutions | Internal Experts |
|---|---|---|
| 1. Dr. Sathyanarayanan, NIOT | 1. Dr. P.V. Manivannan, IIT Madras, Chennai | 1. Dr. R. Senthilnathan, SRMIST |
| 2. Mr. Jai Nareesh, HP | 2. Dr. P. Karthikeyan, Assistant Professor, Department of Production Technology, MIT Campus, Anna University, Chennai- 600044. | 2. Dr. S. Anitha Kumari, SRMIST |

| Course Code | 21MHE423T | Course Name | FOUNDATIONS OF IMMERSIVE TECHNOLOGIES | Course Category | E | PROFESSIONAL ELECTIVE | L | T | P | C |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | 3 | 0 | 0 | 3 |

| Pre-requisite Courses | *Nil* | Co- requisite Courses | *Nil* | Progressive Courses | *Nil* |
|---|---|---|---|---|---|
| Course Offering Department | *Mechatronics Engineering* | Data Book / Codes / Standards | | *Nil* | |

| Course Learning Rationale (CLR): | *The purpose of learning this course is to:* |
|---|---|
| ***CLR-1:*** | *obtain motivation to get the nuances of XR technologies* |
| ***CLR-2:*** | *appreciate the human ability to sense and process information through different biological senses* |
| ***CLR-3:*** | *understand the various geometrical transformations involved in computer graphics* |
| ***CLR-4:*** | *get introduced to the foundations of computer graphics concepts* |
| ***CLR-5:*** | *understand the ethics and ergonomic aspects of immersive tech.* |

| Course Outcomes (CO): | *At the end of this course, learners will be able to:* | Program Outcomes (PO) | | | | | | | | | | | | Program Specific Outcomes | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | | | |
| | | Engineering Knowledge | Problem Analysis | Design/development of solutions | Conduct investigations of complex problems | Modern Tool Usage | The engineer and society | Environment & Sustainability | Ethics | Individual & Team Work | Communication | Project Mgt. & Finance | Life Long Learning | PSO-1 | PSO-2 | PSO-3 |
| ***CO-1:*** | *formulate the mathematical expressions of geometric camera modelling and calibration* | *3* | *2* | - | - | - | - | - | - | - | - | - | - | *1* | - | - |
| ***CO-2:*** | *express clarity on the physical limitations of human perception* | - | *3* | - | - | *2* | - | - | - | - | - | - | - | - | *2* | - |
| ***CO-3:*** | *comprehend the basic math involved in computer graphics* | - | *3* | - | - | *2* | - | - | - | - | - | - | - | - | *2* | - |
| ***CO-4:*** | *develop of basic intuition about computer graphics* | - | *3* | - | - | *2* | - | - | - | - | - | - | - | - | *2* | - |
| ***CO-5:*** | *appreciate the frontiers in the fields related to the X-reality* | *3* | - | - | - | - | - | - | - | - | - | - | - | - | - | *2* |

***Unit-1 - Introduction*** ***9 Hour***

*History of Immersive technologies, Evolution, Formal definitions of key terminologies, Theoretical foundations for immersive technologies, XR conceptual framework, General pipeline in XR, Game engine based XR development tech-stack ideas of experience, The Reality–Virtuality continuum, Examples for each category, VR AR/VR characteristics, start of the art in VR/AR/MR technologies, Research directions in immersive technologies, Careers in immersive technologies*

***Unit-2 – Human Perception and Processing*** ***9 Hour***

*Light and optics, human perception requirements of XR, Visual physiology, Visual Perception, Depth perception, Acuity Over Retina, Foveated Rendering, focus cues, Types of cues in XR displays, perception of motion, Visual perception in XR displays: Phenomena, problems and solutions, Types of motion sickness, Physics of sound, Human Audio Sensation and Perception, auditory localization and rendering, Human Haptic and Tactile Sensation and Perception, Smell and Taste.*

***Unit-3 - Geometrical Transformations and Viewing*** ***9 Hour***

*Modelling 3D geometry, Coordinate systems, Primitives, and fragments, Vertex transforms, Vertex transforms, Spatial descriptions: Operators and mapping, Rotation matrices, Euler angles, axis and angle, gimbal lock, rotations with quaternions, representing translations and scaling, Homogeneous transformation matrices, Vector and normal transforms, View transform, Projection transform, Perspective projection and Orthographic projection*

***Unit-4 - Basics of 3D Models and Graphics*** ***9 Hour***

*3D objects and models, polygonal representations, Introduction to computer graphics, the graphics pipeline, Vertex processor, Rasterization and Scanline interpolation, Fragment processor, optimization techniques in 3D models for real-time rendering, Lighting: Phong model and Physically based rendering, Shaders: Basic types, Depth Test, Texture Mapping: Basic types, The basic ray tracking algorithm, stereo rendering: types of stereo glasses for 3D viewing, depth of field rendering, distortion, anti-aliasing, panoramic rendering, Understanding the basic specifications of graphical processing units and selection criteria*

***Unit-5 – Animations, Frontiers and Ethics*** ***9 Hour***

*Principles of animation, keyframing, animation types and procedural techniques, Haptic Rendering, Haptic Loop, Robotic Interfaces, Teleoperation, Brain-computer interface, Ethical, Social and Legal aspects of XR, Effects of VR Simulations on Users, Cybersickness before and now, Guidelines for Proper VR Usage, User-Centered Design, User Experience and an Ethical Code of Conduct, Immersive tech. Impact on Professional, Public and Private Life, Detailed application case study on VR/AR/MR.*

| | | |
|---|---|---|
| **Learning Resources** | 1. *Ralf Doerner, Wolfgang Broll, Paul Grimm and Bernhard Jung, Virtual and Augmented Reality (VR/AR): Foundations and Methods of Extended Realities (XR), First Edition, Springer, 2022*<br>2. *Bruno Siciliano, Oussama Khatib, Handbook of Robotics (Haptics Chapter), Second Edition, Springer, 2016* | 3. *Fabio Ganovelli, Massimiliano Corsini, Sumanta Pattanaik and Marco Di Benedetto, Introduction to Computer Graphics: A Practical Learning Approach, First Edition, CRC Press, 2015.*<br>4. *Marschner, Shirley "Fundamentals of Computer Graphics", 5th Edition, CRC Press, 2021.*<br>5. *Ayoung Suh, Jane Prophet,The state of immersive technology research: A literature analysis, Computers in Human Behavior, Volume 86, Pages 77-90, 2018.* |

**Learning Assessment**

| | Bloom's Level of Thinking | Continuous Learning Assessment (CLA) | | | | Summative Final Examination (40% weightage) | |
|---|---|---|---|---|---|---|---|
| | | Formative CLA-1 Average of unit test (50%) | | Life-Long Learning CLA-2 (10%) | | | |
| | | Theory | Practice | Theory | Practice | Theory | Practice |
| Level 1 | *Remember* | *15%* | - | *15%* | - | *15%* | - |
| Level 2 | *Understand* | *25%* | - | *20%* | - | *25%* | - |
| Level 3 | *Apply* | *30%* | - | *25%* | - | *30%* | - |
| Level 4 | *Analyze* | *30%* | - | *25%* | - | *30%* | - |
| Level 5 | *Evaluate* | - | - | *10%* | - | - | - |
| Level 6 | *Create* | - | - | *5%* | - | - | - |
| | *Total* | *100 %* | | *100 %* | | *100 %* | |

**Course Designers**

| Experts from Industry | Experts from Higher Technical Institutions | Internal Experts |
|---|---|---|
| *1. Dr. Sathyanarayanan, NIOT* | *1. Dr. P.V. Manivannan, IIT Madras, Chennai* | *1.Dr. R. Senthilnathan, SRMIST* |
| *2. Mr. Jai Nareesh, HP* | *2. Dr. P. Karthikeyan, MIT Campus, Anna University* | *2. Dr. S. Anitha Kumari, SRMIST* |

| Course Code | 21MHE424T | Course Name | SYSTEM INTEGRATION IN XR TECHNOLOGIES | Course Category | E | PROFESSIONAL ELECTIVE | L | T | P | C |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | 3 | 0 | 0 | 3 |

| Pre-requisite Courses | *Nil* | Co- requisite Courses | *Nil* | Progressive Courses | *Nil* |
|---|---|---|---|---|---|
| Course Offering Department | *Mechatronics Engineering* | Data Book / Codes / Standards | | *Nil* | |

| Course Learning Rationale (CLR): | *The purpose of learning this course is to:* |
|---|---|
| ***CLR-1:*** | *articulate the potential of immersive technologies to create effective learning environments* |
| ***CLR-2:*** | *emphasize the connection between optics, vision and display in the context of human-computer interaction* |
| ***CLR-3:*** | *explore the role of input devices in facilitating hands-on interaction within virtual spaces* |
| ***CLR-4:*** | *get introduced to vision-based tracking to control virtual objects and interfaces with natural hand movements* |
| ***CLR-5:*** | *learn fundamental principles of spatial mapping and HMDs* |

| Course Outcomes (CO): | *At the end of this course, learners will be able to:* | Program Outcomes (PO) | | | | | | | | | | | | Program Specific Outcomes | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | | | |
| | | Engineering Knowledge | Problem Analysis | Design/development of solutions | Conduct investigations of complex problems | Modern Tool Usage | The engineer and society | Environment & Sustainability | Ethics | Individual & Team Work | Communication | Project Mgt. & Finance | Life Long Learning | PSO-1 | PSO-2 | PSO-3 |
| ***CO-1:*** | *discuss the rapid evolution and impact of various immersive technologies* | *3* | *2* | - | - | - | - | - | - | - | - | - | - | *2* | - | - |
| ***CO-2:*** | *illustrate the influence of optics in human visual perception and various display technologies* | *2* | *2* | - | - | - | - | - | - | - | - | - | - | *2* | - | - |
| ***CO-3:*** | *express accurate position and orientation tracking for creating immersive simulations* | *3* | - | - | - | *3* | - | - | - | - | - | - | - | - | *2* | - |
| ***CO-4:*** | *investigate vision-based tracking for recognizing gestures and tracking hand movements* | *2* | - | - | - | *3* | - | - | - | - | - | - | - | - | *2* | - |
| ***CO-5:*** | *explore spatial mapping and HMD design to enhance the sense of presence and realism for users.* | *2* | - | - | - | *3* | - | - | - | - | - | - | - | - | *2* | - |

***Unit-1 – Introduction to XR Technologies*** ***9 Hour***

*History of Immersive technologies, Evolution, Formal definitions of key terminologies, Theoretical foundations for immersive technologies, XR conceptual framework, General pipeline in XR, Game engine based XR development tech-stack ideas of experience, The Reality–Virtuality continuum, Examples for each category, VR AR/VR characteristics, start of the art in VR/AR/MR technologies, Research directions in immersive technologies, Careers in immersive technologies, Overview of the graphics and viewing pipeline*

***Unit-2 – Optics, Vision and Displays*** ***9 Hour***

*Basics of image formation in HMD, stereo aspect of image formation in HMD, optical specifications of HMDs, field of view and visual field, calculations of field of view, lens distortion: modeling and correction, Vergence-Accommodation Conflict and its addressing in HMDs, Case study of specifications of optics in VR, AR and MR HMDs, Overview of microdisplays: LCD, LCoS, OLED, DMD, Varifocal displays, multiplane displays, light field stereoscope, holographic near-eye displays, optical see-through AR displays: Types, specifications, challenges. Case study of specifications of VR, AR and MR displays*

***Unit-3 – Input Devices and IMU-Based Tracking*** ***9 Hour***

*Fundamentals of inputs, Tracking techniques, Inside-out tracking vs. Outside-in tracking, Inertial measurement units, rotation order and fundamental equations, Gyro modeling and integration, Accelerometer model and fusing of gyro and accelerometer data for orientation tracking, Pitch and Roll from 3-axis Accelerometer, Reading data from 9-axis IMUs, Foundations of quaternions, Quaternion-based 6-DOF Orientation Tracking, tilt correction, complementary filters with quaternions, head and neck model*

***Unit-4 – Vision-Based Tracking*** ***9 Hour***

*marker-based tracking, feature-based tracking techniques, hybrid tracking techniques, Triangulation, Steps involved in pose estimation, Combining IMU and vision data for pose tracking,*

***Unit-5 –Spatial Mapping and HMD Design*** ***9 Hour***

*Visual SLAM, Basic requirement for spatial mapping, sensing technology for spatial mapping, common usage scenarios, mesh processing, factors influencing spatial mapping quality.*

| Learning | 1. *Ralf Doerner, Wolfgang Broll, Paul Grimm and Bernhard Jung, Virtual and Augmented* | 4. *Marschner, Shirley "Fundamentals of Computer Graphics", 5th Edition, CRC Press, 2021.* |
|---|---|---|

| | | |
|---|---|---|
| **Resources** | *Reality (VR/AR): Foundations and Methods of Extended Realities (XR), First Edition, Springer, 2022*<br>2. *Fabio Ganovelli, Massimiliano Corsini, Sumanta Pattanaik and Marco Di Benedetto, Introduction to Computer Graphics: A Practical Learning Approach, First Edition, CRC Press, 2015.*<br>3. *Steven M. LaValle, Virtual Reality, Cambridge University Press, 2023* | 5. *Ayoung Suh, Jane Prophet,The state of immersive technology research: A literature analysis, Computers in Human Behavior, Volume 86, Pages 77-90, 2018.*<br>6. *Course Notes of EE267: Virtual Reality, Stanford University.*<br>7. *Sherman, William R. and Alan B. Craig. Understanding Virtual Reality – Interface, Application, and Design, Morgan Kaufmann,2018.* |

**Learning Assessment**

| | *Bloom's Level of Thinking* | *Continuous Learning Assessment (CLA)* | | | | *Summative Final Examination (40% weightage)* | |
|---|---|---|---|---|---|---|---|
| | | *Formative CLA-1 Average of unit test (50%)* | | *Life-Long Learning CLA-2 (10%)* | | | |
| | | *Theory* | *Practice* | *Theory* | *Practice* | *Theory* | *Practice* |
| Level 1 | *Remember* | *15%* | - | *15%* | - | *15%* | - |
| Level 2 | *Understand* | *25%* | - | *20%* | - | *25%* | - |
| Level 3 | *Apply* | *30%* | - | *25%* | - | *30%* | - |
| Level 4 | *Analyze* | *30%* | - | *25%* | - | *30%* | - |
| Level 5 | *Evaluate* | - | - | *10%* | - | - | - |
| Level 6 | *Create* | - | - | *5%* | - | - | - |
| | *Total* | *100 %* | | *100 %* | | *100 %* | |

**Course Designers**

| **Experts from Industry** | **Experts from Higher Technical Institutions** | **Internal Experts** |
|---|---|---|
| *1. Dr. Sathyanarayanan, NIOT* | *1. Dr. P.V. Manivannan, IIT Madras, Chennai* | *1.Dr. R. Senthilnathan, SRMIST* |
| *2. Mr. Jai Nareesh, HP* | *2. Dr. P. Karthikeyan, MIT Campus, Anna University* | *2. Dr. S. Anitha Kumari, SRMIST* |

| Course Code | 21MHE425J | Course Name | VIRTUAL REALITY AND ITS APPLICATIONS | Course Category | E | PROFESSIONAL ELECTIVE | L | T | P | C |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | 2 | 0 | 2 | 3 |

| Pre-requisite Courses | *Nil* | Co- requisite Courses | *Nil* | Progressive Courses | *Nil* |
|---|---|---|---|---|---|
| Course Offering Department | *Mechatronics Engineering* | Data Book / Codes / Standards | | *Nil* | |

| Course Learning Rationale (CLR): | *The purpose of learning this course is to:* |
|---|---|
| ***CLR-1:*** | *understand VR hardware, locomotion methods, and controller-based interactions* |
| ***CLR-2:*** | *encompass a comprehensive understanding of user interactions in immersive environments* |
| ***CLR-3:*** | *get introduced to wide range of interface modalities in immersive technologies* |
| ***CLR-4:*** | *equip with the knowledge and skills necessary to create VR experiences effectively.* |
| ***CLR-5:*** | *leverage VR for real-world applications.* |

| Course Outcomes (CO): | *At the end of this course, learners will be able to:* | Program Outcomes (PO) | | | | | | | | | | | | Program Specific Outcomes | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | | | |
| | | Engineering Knowledge | Problem Analysis | Design/development of solutions | Conduct investigations of complex problems | Modern Tool Usage | The engineer and society | Environment & Sustainability | Ethics | Individual & Team Work | Communication | Project Mgt. & Finance | Life Long Learning | PSO-1 | PSO-2 | PSO-3 |
| ***CO-1:*** | *identify the principles and techniques for implementing motion tracking, navigation, and controller interactions in virtual reality environments* | - | 2 | - | - | 3 | - | - | - | - | - | - | - | 1 | - | - |
| ***CO-2:*** | *explore the intricacies of user interactions in virtual reality environments* | - | 2 | - | - | 3 | - | - | - | - | - | - | - | - | 2 | - |
| ***CO-3:*** | *recognize principles and techniques for creating visual, tracking, auditory, primary user input, haptic, and olfactory interfaces.* | 2 | - | - | - | 3 | - | - | - | - | - | - | - | - | 2 | - |
| ***CO-4:*** | *demonstrate structured workflow that encompasses planning, design, development, testing, and deployment* | - | - | 2 | - | 3 | - | - | - | - | - | - | - | 1 | - | - |
| ***CO-5:*** | *illustrate the application of VR technology across various industries* | - | - | 2 | - | 3 | - | - | - | - | - | - | - | - | - | 2 |

| ***Unit-1 - Motion tracking, Navigation and Controllers*** | ***12 Hour*** |
|---|---|
| *Importance of motion tracking, position tracking methods- outside-in/inside-out room-scale, rotational tracking, Navigation - Travel techniques, User-centered way finding, Environment-centered way-finding, motion controllers - Data gloves and gesture control* | |
| ***Unit-2 - VR Interactions*** | ***12 Hour*** |
| *Overview of user interactions, significance in immersive environments, Direct user interaction - Touch, gesture and proximity-based interaction, Remapping, Motion controller interaction, Virtual controls - buttons, dials, sliders, steering wheels, menus, Locomotion techniques - teleportation, walking, flying, Selection - Hand and Gaze based, Techniques for object grabbing and manipulation, Scaling objects, Social interactions, Specialized interaction mechanisms* | |
| ***Unit-3 – VR Interfaces*** | ***12 Hour*** |
| *Multimodal interfaces, Visual interface, Tracking interface- head and eye tracking, Auditory interface, Primary user input interfaces, Haptic interfaces - tactile interfaces, kinesthetic interfaces, Olfactory interfaces. Real-time aspects of VR Systems: Latency, efficient collision detection, real-time rendering.* | |
| ***Unit-4 - VR Workflows*** | ***12 Hour*** |
| *Ideation, Conceptualization, Storyboarding, Prototyping, Design - 3D model, animation, user interface, audio, VR development platform and programming languages, Testing and iteration, Quality assurance, deployment. Evaluating VR System and Experiences: perceptual training, recommendations for developers, best practices, VR sickness, experimental methods that involve human subjects* | |
| ***Unit-5 - Applications of VR*** | ***12 Hour*** |
| *Application of virtual environments: an overview, virtual environment for teleoperation, conceptual learning, visual perceptual skills training, 3D interactive environments for special educational needs, clinical virtual reality, entertainment applications of virtual environments* | |

| | | |
|---|---|---|
| **Learning Resources** | 1. *Kay M. Stanney, Kelly S. Hale, Handbook of Virtual Environments Design, Implementation, and Applications, Second Edition, CRC Press, 2014*<br>2. *Burdea, G. C. and P. Coffet. Virtual Reality Technology, Second Edition. Wiley-IEEE Press, 2006.*<br>3. *Sherman, William R. and Alan B. Craig. Understanding Virtual Reality – Interface, Application, and Design, Morgan Kaufmann,2018.* | 4. *Alan B. Craig, William R. Sherman, Jeffrey D. Will, Developing Virtual Reality Applications -Foundations of Effective Design, Elsevier Science, 2009.*<br>5. *Steven M. LaValle, Virtual Reality, Cambridge University Press, 2023.*<br>6. *Ralf Doerner and et al., Virtual Reality and Augmented Reality (VR/AR): Foundations and Methods of Extended Realities (XR), Springer, 2022.* |

**Learning Assessment**

| | Bloom's Level of Thinking | Continuous Learning Assessment (CLA) | | | | Summative Final Examination (40% weightage) | |
|---|---|---|---|---|---|---|---|
| | | Formative CLA-1 Average of unit test (45%) | | Life-Long Learning CLA-2- Practice (15%) | | | |
| | | Theory | Practice | Theory | Practice | Theory | Practice |
| Level 1 | *Remember* | *15%* | - | - | *15%* | *15%* | - |
| Level 2 | *Understand* | *25%* | - | - | *20%* | *25%* | - |
| Level 3 | *Apply* | *30%* | - | - | *25%* | *30%* | - |
| Level 4 | *Analyze* | *30%* | - | - | *25%* | *30%* | - |
| Level 5 | *Evaluate* | - | - | - | *10%* | - | - |
| Level 6 | *Create* | - | - | - | *5%* | - | - |
| | *Total* | *100 %* | | *100 %* | | *100 %* | |

**Course Designers**

| Experts from Industry | Experts from Higher Technical Institutions | Internal Experts |
|---|---|---|
| *1. Dr. Sathyanarayanan, NIOT* | *1. Dr. P.V. Manivannan, IIT Madras, Chennai* | *1.Dr. R. Senthilnathan, SRMIST* |
| *2. Mr. Jai Nareesh, HP* | *2. Dr. P. Karthikeyan, MIT Campus, Anna University* | *2. Dr. S. Anitha Kumari, SRMIST* |

| Course Code | 21MHE426J | Course Name | AUGMENTED AND MIXED REALITY | Course Category | E | PROFESSIONAL ELECTIVE | L | T | P | C |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | 2 | 0 | 2 | 3 |

| Pre-requisite Courses | *Nil* | Co- requisite Courses | *Nil* | Progressive Courses | *Nil* |
|---|---|---|---|---|---|
| **Course Offering Department** | *Mechatronics Engineering* | **Data Book / Codes / Standards** | | *Nil* | |

| **Course Learning Rationale (CLR):** | ***The purpose of learning this course is to:*** |
|---|---|
| ***CLR-1:*** | *get introduced to the various types and devices of AR to interact with augmented reality content.* |
| ***CLR-2:*** | *explore gestural or touch-based interaction techniques in a 3D space* |
| ***CLR-3:*** | *provide basic understanding of MR hardware and technologies* |
| ***CLR-4:*** | *acquire knowledge to design intuitive user interactions in MR* |
| ***CLR-5:*** | *identify AR and MR techniques relevant to various sectors* |

| **Course Outcomes (CO):** | ***At the end of this course, learners will be able to:*** | **Program Outcomes (PO)** | | | | | | | | | | | | **Program Specific Outcomes** | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | | | |
| | | Engineering Knowledge | Problem Analysis | Design/development of solutions | Conduct investigations of complex problems | Modern Tool Usage | The engineer and society | Environment & Sustainability | Ethics | Individual & Team Work | Communication | Project Mgt. & Finance | Life Long Learning | PSO-1 | PSO-2 | PSO-3 |
| ***CO-1:*** | *categorize different types of AR and the diverse range of AR devices* | 2 | - | - | - | 3 | - | - | - | - | - | - | - | 3 | - | - |
| ***CO-2:*** | *recognize the principles of designing effective multimodal interfaces* | - | 2 | - | - | 3 | - | - | - | - | - | - | - | - | 2 | - |
| ***CO-3:*** | *define Mixed Reality and differentiate between virtual and augmented reality* | 2 | - | - | - | 3 | - | - | - | - | - | - | - | 3 | - | - |
| ***CO-4:*** | *implement tracking methods and navigate real-world environments to anchor virtual content in the physical world.* | - | 2 | - | - | 3 | - | - | - | - | - | - | - | 3 | - | - |
| ***CO-5:*** | *illustrate Augmented and Mixed Reality offers in real-world applications* | - | - | 2 | - | 3 | - | - | - | - | - | - | - | - | - | 2 |

| ***Unit-1: AR Types and Devices*** | ***12 Hour*** |
|---|---|
| *AR technology, Types - Marker-based AR, Markerless AR, Projection based AR, Superimposition-based AR, Outlining-based AR. AR devices- Smart phones and tablets-ARKit and ARCore, AR glasses, Head-Mounted displays, Smart Eyewear* | |
| ***Unit-2: AR Techniques*** | ***12 Hour*** |
| *Multimodal interaction techniques - Touch gestures, Hand gestures and tracking, voice commands, head and gaze tracking, physical controllers, Registration: Geometric and Photometric, Special AR Techniques: Head-up content, Occlusion and Phantom objects, Cross-fading markers, virtual holes, X-ray vision. Special AR Interaction Techniques: Interaction by navigation, gaze-based interaction, tangible user interface.* | |
| ***Unit-3: Foundations of Mixed Reality*** | ***12 Hour*** |
| *I/O devices - Cave Automatic Virtual Environment, Head-Up display, Head-mounted display, Holograms, Algorithms in mixed reality, Calibration, Object Recognition, Object tracking* | |
| ***Unit-4: Spatial Mapping and Scene Understanding*** | ***12 Hour*** |
| *Depth sensing, Mesh generation, Simultaneous Localization and Mapping (SLAM), Scene objects, Scene components - Quads and Meshes, bounding boxes, collision meshes, metadata* | |
| ***Unit-5: Applications of AR and MR*** | ***12 Hour*** |
| *Case studies on Interactive gaming, educational simulations, medical visualization, Architectural design* | |

| | | |
|---|---|---|
| **Learning Resources** | 1. *Bernhard Jung, Paul Grimm, Ralf Doerner, Wolfgang Broll, Virtual and Augmented Reality (VR/AR) Foundations and Methods of Extended Realities (XR), Springer International Publishing, 2022.*<br>2. *Dieter Schmalstieg, Tobias Hollerer, Augmented Reality Principles and Practice, Pearson Education, 2016* | 3. *Yuichi Ohta, Hideyuki Tamura, Mixed Reality: Merging Real and Virtual Worlds, Springer- Verlag, 2013.*<br>4. *Maas, M. J., & Hughes, J. M. (2020). Virtual, augmented and mixed reality in K–12 education: A review of the literature. Technology, Pedagogy and Education, 29(2), 231-249.*<br>5. *Ralf Doerner and et al., Virtual Reality and Augmented Reality (VR/AR): Foundations and Methods of Extended Realities (XR), Springer, 2022.* |

**Learning Assessment**

| | *Bloom's Level of Thinking* | *Continuous Learning Assessment (CLA)* | | | | *Summative Final Examination (40% weightage)* | |
|---|---|---|---|---|---|---|---|
| | | *Formative CLA-1 Average of unit test (45%)* | | *Life-Long Learning CLA-2- Practice (15%)* | | | |
| | | *Theory* | *Practice* | *Theory* | *Practice* | *Theory* | *Practice* |
| Level 1 | *Remember* | *15%* | - | - | *15%* | *15%* | - |
| Level 2 | *Understand* | *25%* | - | - | *20%* | *25%* | - |
| Level 3 | *Apply* | *30%* | - | - | *25%* | *30%* | - |
| Level 4 | *Analyze* | *30%* | - | - | *25%* | *30%* | - |
| Level 5 | *Evaluate* | - | - | - | *10%* | - | - |
| Level 6 | *Create* | - | - | - | *5%* | - | - |
| | *Total* | *100 %* | | *100 %* | | *100 %* | |

**Course Designers**

| **Experts from Industry** | **Experts from Higher Technical Institutions** | **Internal Experts** |
|---|---|---|
| *1. Dr. Sathyanarayanan, NIOT* | *1. Dr. P.V. Manivannan, IIT Madras, Chennai* | *1.Dr. R. Senthilnathan, SRMIST* |
| *2. Mr. Jai Nareesh, HP* | *2. Dr. P. Karthikeyan, MIT Campus, Anna University* | *2. Dr. S. Anitha Kumari, SRMIST* |

| Course Code | 21MHE427J | Course Name | HAPTICS | Course Category | E | PROFESSIONAL ELECTIVE | L | T | P | C |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | 2 | 0 | 2 | 3 |

| Pre-requisite Courses | *Nil* | Co- requisite Courses | *Nil* | Progressive Courses | *Nil* |
|---|---|---|---|---|---|
| Course Offering Department | *Mechatronics Engineering* | Data Book / Codes / Standards | | *Nil* | |

| Course Learning Rationale (CLR): | *The purpose of learning this course is to:* |
|---|---|
| ***CLR-1:*** | *get aware of the human touch system* |
| ***CLR-2:*** | *understand the mechatronics behind building haptics devices* |
| ***CLR-3:*** | *learn the link between haptics and X-reality* |
| ***CLR-4:*** | *familiarize the dynamics of a haptics device* |
| ***CLR-5:*** | *explore the applications of haptics technology* |

| Course Outcomes (CO): | *At the end of this course, learners will be able to:* | Program Outcomes (PO) | | | | | | | | | | | | Program Specific Outcomes | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | | | |
| | | Engineering Knowledge | Problem Analysis | Design/development of solutions | Conduct investigations of complex problems | Modern Tool Usage | The engineer and society | Environment & Sustainability | Ethics | Individual & Team Work | Communication | Project Mgt. & Finance | Life Long Learning | PSO-1 | PSO-2 | PSO-3 |
| ***CO-1:*** | *analyze the abilities and limitations of human touch system* | *2* | - | - | - | *3* | - | - | - | - | - | - | - | *3* | - | - |
| ***CO-2:*** | *integrate the various hardware elements in a typical haptics device* | - | *2* | - | - | *3* | - | - | - | - | - | - | - | *3* | - | - |
| ***CO-3:*** | *link haptics sensations and actuation to virtual environments* | - | *2* | - | - | *3* | - | - | - | - | - | - | - | *3* | - | - |
| ***CO-4:*** | *model the dynamics of a haptics device* | - | *2* | - | - | *3* | - | - | - | - | - | - | - | *3* | - | - |
| ***CO-5:*** | *apply the haptics technology in various domains* | - | - | *2* | - | *3* | - | - | - | - | - | - | - | - | - | *3* |

***Unit-1 - Introduction to Haptic Technology and Human Haptics*** ***12 Hour***

*Taction and haptics - definitions, Human touch system - tactual stereognosis, Cutaneous senses, Kinesthetic senses, Human touch experiment, Trends motivating haptics, Suitability of haptics, technologies and interaction modes, Basics of psychophysics, Tactile and Kinesthetic devices - Specifications and principles, Hybrid devices - Specifications and principles, Product case study, Kinematic relationships of a sample haptic device, Force-torque Relationships, types of haptics human subjects experiments, system performance, psychophysics and ergonomics, Haptic Illusions*

***Unit-2 - The Mechatronics of Haptics Systems*** ***12 Hour***

*Haptic sensors - types, Principles and comparison, motion encoders - types, Specifications and selection criteria, Absolute encoder Interfacing and decoding Incremental encoder Interfacing and decoding, Hall effect sensors - specifications and selection criteria, mid-air haptics, eccentric mass motors, shaftless vibration motors, linear actuator, voice coil actuator, PM DC brushed motors Construction, modelling, Motor driver - purpose and types, Specifications and compatibility Controller interfacing, Control of position, velocity and torque, Transmission elements - types, Specifications and selection criteria, Integration in a microcontroller architecture.*

***Unit-3 - Programming Virtual Environments*** ***12 Hour***

*Elements of a Haptics software, Haptic rendering, admittance-type kinesthetic devices, impedance-type kinesthetic devices, kinesthetic device challenges, Transparency, The Haptic Loop, Rendering Specific Haptic Effects, Modelling of virtual spring and wall, Modelling of virtual damper, texture Rendering of virtual spring and wall, Rendering of virtual damper, texture, Multi-degrees of freedom haptic devices, Forward and Inverse kinematics of haptic device with serial and parallel mechanism, 3D Haptic rendering, Inside and Outside a box, Inside and Outside a circle, Computing end-effector velocities, Singularities and workspace analysis*

***Unit-4 - Dynamics, Control and Teleoperation*** ***12 Hour***

*Z-width, Ways to improve Z-width, Dynamic Modelling of a haptic device, stability of the virtual wall, approaches to improve stability, Design for passivity, Effect of time delay, Pade approximation, Basics of teleoperation, Controllers for teleoperation, Types and comparison, Teleoperator transparency, Teleoperator stability*

***Unit-5 - Haptic Interfaces and Applications*** ***12 Hour***

*Haptics and virtual reality, Haptics and augmented reality, Visuo-haptic Mixed reality, Tactile mobile device application, Art and Games, medicine, dentistry and Neurorehabilitation, Aviation, Automotive, Teleoperated robotics*

| | | |
|---|---|---|
| **Learning Resources** | 1. *Steinbach, E., Hirche, S., Ernst, M., Brandi, F., Chaudhari, R., Kammerl, J. and Vittorias, I., 2012. Haptic communications. Proceedings of the IEEE, 100(4), pp.937-956.*<br>2. *Kenneth Salisbury, Francois Conti and Federico Barbagli, Haptic Rendering: Introductory Concepts, IEEE computer graphics and applications. pp. 24 -32, 2004.*<br>3. *Bruno Siciliano, Oussama Khatib, Handbook of Robotics (Haptics Chapter), Second Edition, Springer, 2016.* | 4. *Jean-Pierre Bresciani, Knut Drewing and Marc O. Ernst. Human Haptic Perception and the Design of Haptic-Enhanced Virtual Environments. In A. Bicchi et al. (Eds.): The Sense of Touch and Its Rendering, STAR 45, pp. 61–106, 2008.*<br>5. *MacLean K. E, "Haptic interaction design for everyday interfaces", Reviews of Human Factors and Ergonomics, 4:149¬194, 2008.*<br>6. *Weir D. W and Colgate J. E Stability of haptic displays. In M. C. Lin and M. Otaduy, Eds., Haptic Rendering: Foundations, Algorithms, and Applications. AK Peters, 2008.* |

**Learning Assessment**

| | *Bloom's Level of Thinking* | *Continuous Learning Assessment (CLA)* | | | | *Summative Final Examination (40% weightage)* | |
|---|---|---|---|---|---|---|---|
| | | *Formative CLA-1 Average of unit test (45%)* | | *Life-Long Learning CLA-2- Practice (15%)* | | | |
| | | *Theory* | *Practice* | *Theory* | *Practice* | *Theory* | *Practice* |
| Level 1 | *Remember* | *15%* | - | - | *15%* | *15%* | - |
| Level 2 | *Understand* | *25%* | - | - | *20%* | *25%* | - |
| Level 3 | *Apply* | *30%* | - | - | *25%* | *30%* | - |
| Level 4 | *Analyze* | *30%* | - | - | *25%* | *30%* | - |
| Level 5 | *Evaluate* | - | - | - | *10%* | - | - |
| Level 6 | *Create* | - | - | - | *5%* | - | - |
| | *Total* | *100 %* | | *100 %* | | *100 %* | |

**Course Designers**

| **Experts from Industry** | **Experts from Higher Technical Institutions** | **Internal Experts** |
|---|---|---|
| *1. Dr. Sathyanarayanan, NIOT* | *1. Dr. P.V. Manivannan, IIT Madras, Chennai* | *1.Dr. R. Senthilnathan, SRMIST* |
| *2. Mr. Jai Nareesh, HP* | *2. Dr. P. Karthikeyan, MIT Campus, Anna University* | *2. Dr. S. Anitha Kumari, SRMIST* |

| Course Code | 21MHE428L | Course Name | CAPSTONE PROJECT | Course Category | E | PROFESSIONAL ELECTIVE | L | T | P | C |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | 0 | 0 | 6 | 3 |

| Pre-requisite Courses | *Nil* | Co- requisite Courses | *Nil* | Progressive Courses | *Nil* |
|---|---|---|---|---|---|
| Course Offering Department | *Mechatronics Engineering* | Data Book / Codes / Standards | | *Nil* | |

| Course Learning Rationale (CLR): | *The purpose of learning this course is to:* |
|---|---|
| ***CLR-1:*** | *Engage in high-level work focusing on an area of specialization where immersive technologies may be applied.* |
| ***CLR-2:*** | *Bridge theory and practice and are aimed to have an impact on the professional life of students.* |

| Course Outcomes (CO): | *At the end of this course, learners will be able to:* | Program Outcomes (PO) | | | | | | | | | | | | Program Specific Outcomes | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | | | |
| | | Engineering | Problem Analysis | Design/development | Conduct investigations | Modern Tool Usage | The engineer | Environment & | Ethics | Individual & Team Work | Communication | Project Mgt. & | Life Long Learning | PSO-1 | PSO-2 | PSO-3 |
| ***CO-1:*** | *illuminate and bring new insight to one or more technologies involved in autonomous driving.* | *3* | *2* | | | | | | | | | | | *3* | | - |
| ***CO-2:*** | *demonstrate a depth and breadth of knowledge and the application of this knowledge to scholarship and/or practice;* | | *2* | | | *3* | | | | | | | | *3* | | - |
| ***CO-3:*** | *present a clearly articulated investigative framework, while situating projects within established academic practices and/or ideas;* | | *2* | | | *3* | | | | | | | | | *3* | - |

*Nature of the Capstone Project*

*The following points describe the nature of the Capstone project course:*

- *The Capstone Project provides an opportunity for students to engage in high-level work focusing on an area of specialization where Autonomous driving technology may be applied.*
- *Capstone projects (CP) will be inquiry and practice-centred.*
- *All Capstones aim to bridge theory and practice and are aimed to have an impact on the professional life of students.*
- *Students will identify the topics for their Capstone Project during the end of sixth semester study of the program.*
- *Capstone projects often take their inspiration from projects, papers, and experiences related to course work in the degree program. However, to ascertain students' abilities for independent work and their capacity for self directed inquiry, capstone projects must demonstrate in what ways individual graduate students have researched, developed, and extended, or applied the ideas and strategies under investigation.*
- *Capstone Projects encourage the application of knowledge gained on teaching and learning throughout the degree program.*
- *Additionally, the Capstone Project should demonstrate the depth and extent of knowledge of students.*
- *Capstone projects may take both only simulation works as well as hardware-involved work depending on the time, will and the needs involved in the chosen application. These may be, but are not limited to, the investigation of practices and educational ideas, the development of curricular materials, or teaching approaches which may utilize the autonomous driving technologies for better understanding of concepts.*
- *It may involve work, but not limited to, in one or more of following four broad modules namely*
  - *Virtual reality*
  - *Augmented reality*
  - *Mixed reality*
  - *Haptics*

***Project Evaluation***

*The capstone project will be evaluated by a team of faculty members. The following points will be evaluated in each review.*

- *BASIC KNOWLEDGE ABOUT THE FIELDS AND TOPICS RELATED TO THE PROJECT: (Basics of the fields of study related to the project in the context of what the student presented in the scope*

*of the respective review)*

- *INTELLECTUAL CONTRIBUTION (Elements which the student presented which require the proper application of physics, mathematics, theory, etc)*
- *PROGRESS IN THE PROJECT TOWARDS THE CLAIMED OBJECTIVE (How much the student have progressed towards the claimed objective for the respective phase of the project)*
- *ACCOUNTABILITY OF TIME (How effectively the student have used the time towards the project and other activities that might help him/her do perform better in the project)*
- *Ability to understand, reason, and explain the ALLOWABLE elements of the project borrowed, outsourced, copied from the internet, etc*
- *TIMELY COMPLIANCE TO PROJECT RELATED FORMALITIES (Activities such as timely progress report submission, project report submission, etc)*
- *CONTENT OF THE PRESENTATION: Clarity and Supporting Data*
- *ORGANISATION OF THE PRESENTATION: Appropriate Media (such as images, videos, tables, flowcharts for illustrative purposes), Logical Flow of Slides and Smooth Transition Between Topics*
- *DELIVERY OF THE PRESENTATION: Professional, Confidence and Body Language, Clear Voice and Language with Good Pace, Engagement with Panel Members*

| | *Continuous Learning Assessment (100% weightage)* | | | |
|---|---|---|---|---|
| | *Review - 1* | *Review - 2* | *Project Report* | *Presentation* |
| *Capstone Project* | *20 %* | *50 %* | *15 %* | *15 %* |

| **Course Designers** | | |
|---|---|---|
| **Experts from Industry** | **Experts from Higher Technical Institutions** | **Internal Experts** |
| *1. Dr. Sathyanarayanan, NIOT* | *1. Dr. P.V. Manivannan, IIT Madras, Chennai* | *1.Dr. R. Senthilnathan, SRMIST* |
| *2. Mr. Jai Nareesh, HP* | *2. Dr. P. Karthikeyan, MIT Campus, Anna University* | *2. Dr. S. Anitha Kumari, SRMIST* |

| Course Code | 21MHE427T | Course Name | INTERACTION DESIGN AND PROTOTYPING FOR XR | Course Category | E | PROFESSIONAL ELECTIVE | L | T | P | C |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | 2 | 1 | 0 | 3 |

| Pre-requisite Courses | *Nil* | Co- requisite Courses | *Nil* | Progressive Courses | *Nil* |
|---|---|---|---|---|---|
| Course Offering Department | *Mechatronics Engineering* | Data Book / Codes / Standards | | *Nil* | |

| Course Learning Rationale (CLR): | *The purpose of learning this course is to:* |
|---|---|
| ***CLR-1:*** | *get introduced to XR design process* |
| ***CLR-2:*** | *familiarize with storytelling techniques for immersive XR experiences* |
| ***CLR-3:*** | *gain proficiency in story boarding techniques* |
| ***CLR-4:*** | *learn fundamentals of UX design with an emphasis of interactive design* |
| ***CLR-5:*** | *explore principles of UI design for effective human-computer interaction* |

| Course Outcomes (CO): | *At the end of this course, learners will be able to:* | Program Outcomes (PO) | | | | | | | | | | | | Program Specific Outcomes | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | | | |
| | | Engineering Knowledge | Problem Analysis | Design/development of solutions | Conduct investigations of complex problems | Modern Tool Usage | The engineer and society | Environment & Sustainability | Ethics | Individual & Team Work | Communication | Project Mgt. & Finance | Life Long Learning | PSO-1 | PSO-2 | PSO-3 |
| ***CO-1:*** | *familiarize with the key concepts in XR design process* | *3* | *1* | - | - | - | - | - | - | - | - | - | - | *3* | - | - |
| ***CO-2:*** | *develop cohesive and narrative XR environment* | *3* | - | *1* | - | - | - | - | - | - | - | - | - | *3* | - | - |
| ***CO-3:*** | *create dynamic poses and graphic styles to enhance story telling* | *3* | - | - | - | *2* | - | - | - | - | - | - | - | *3* | - | - |
| ***CO-4:*** | *illustrate UX design for cross-platform prototyping skills* | - | - | *2* | - | *1* | - | - | - | - | - | - | - | - | *2* | - |
| ***CO-5:*** | *demonstrate UI design in the context of creating immersive experiences* | - | - | *2* | - | - | - | - | - | - | - | - | - | - | *2* | - |

***Unit-1 : XR Design Process*** — ***9 Hour***

*Designing for Imagination, Grounding, Immersion, and Presence, Overview of human-centered design to XR development, tools used for design in XR, Leveraging strengths and limitations of XR technologies, Conceptualization, brainstorming, Mission statement, XR Flow design, state machine approach*

***Unit-2 – Story Telling*** — ***9 Hour***

*Story telling Techniques, XR stories – Structure of XR Stories - XR Play - Elements of effective storytelling, XR Characters – development – archetypes-conflict –plot patterns- back-story, Dialogue, exposition, premise, psychological, Properties, level analysis, progress structure, structuring the story, Top Continued and Bottom Continued, - Locking Script Pages and Locking Scenes*

***Unit-3 – Story Boarding*** — ***10 Hour***

*Storyboarding: Usage, Importance, Functions, Terminology, difference between storyboard and Graphic Comic, Difference between Storyboard and Presentation Board, Advantages of Storyboard in Animation, Illustration, Anatomy, rendering drawings, Techniques and styles, Graphic styles, Text – as image, Projecting figures in Deep space, Framing and Composition, Perspective and Camera Anatomy of a Storyboard, Lighting and Depth, Poses and Staging, Dos and Don"ts, Thumbnail Storyboard, Preparing Storyboards using Digital software. XR design Document, Technical Document*

***Unit-4 – UX Design*** — ***10 Hour***

*Aspects of immersive experience, types of user experience in immersive worlds, tools used for UX design, stimuli from immersive worlds and reactions, common factors causing motion sickness and mitigation, best practices and patterns of UX design applied to XR Applications, Dos and donts in UX design, UX design process, Testing of UX designs, Design thinking principles for UI and UX design in XR*

***Unit-5 - UI Design*** — ***7 Hour***

*Foundation of interaction design principles, Importance of UI, Characteristics, Design Process, Visual design Concepts, tools used for UI design, types of input and output, immersive interaction: senses, haptics, features, audio and voice, types of user interactions in VR, AR and MR, UI elements, ergonomic design for interactions, best practices and Design Patterns and Style guides, Interaction Styles, Naming and Abbreviations applied to XR Applications, Dos and donts in UI design, UI design process, Testing of UI designs.*

| | | |
|---|---|---|
| **Learning Resources** | 1. *Gameplay and design Paperback – by Mr Kevin Oxland - Addison Wesley (20 May 2004)*<br>2. *Beginning Illustration and Storyboarding for Games (Premier Press Game Development) by Les Pardew - Cengage Learning PTR; 1 edition (October 8, 2004)*<br>3. *Fundamentals of Game Design, -by Adams - Pearson Education India; 3rd edition (2015)*<br>4. *Lean UX: Designing Great Products with Agile Teams - by Jeff Gothelf, Josh Seiden; Shroff/O'Reilly; Second edition (1 November 2016)- ISBN10: 9352134567,ISBN-13: 978-9352134564.* | 5. *Fundamentals of User-Centered Design: A Practical Approach Paperback – 20 Dec 2016 - by Brian Still, CRC Press; 1 edition (20 December 2016) - ISBN10: 1498764363,ISBN-13: 978-1498764360.*<br>6. *The Essential Guide to user Interface Design: An Introduction to GUI Design Principles and Techniques, - by Wilbert O.Galitz (Author) - Wiley; Second edition (2002) - ISBN-10: 8126502800,ISBN-13: 978-8126502806.*<br>7. *Human-computer Interaction- by Alan Dix and Janet Finlay – Pearson Education (2004) - ISBN-10: 9788131717035* |

**Learning Assessment**

| | *Bloom's Level of Thinking* | *Continuous Learning Assessment (CLA)* | | | | *Summative Final Examination (40% weightage)* | |
|---|---|---|---|---|---|---|---|
| | | *Formative CLA-1 Average of unit test (50%)* | | *Life-Long Learning CLA-2 (10%)* | | | |
| | | *Theory* | *Practice* | *Theory* | *Practice* | *Theory* | *Practice* |
| Level 1 | *Remember* | *15%* | - | *15%* | - | *15%* | - |
| Level 2 | *Understand* | *25%* | - | *20%* | - | *25%* | - |
| Level 3 | *Apply* | *30%* | - | *25%* | - | *30%* | - |
| Level 4 | *Analyze* | *30%* | - | *25%* | - | *30%* | - |
| Level 5 | *Evaluate* | - | - | *15%* | - | - | - |
| Level 6 | *Create* | - | - | - | - | - | - |
| | *Total* | *100 %* | | *100 %* | | *100 %* | |

**Course Designers**

| **Experts from Industry** | **Experts from Higher Technical Institutions** | **Internal Experts** |
|---|---|---|
| *1. Dr. Sathyanarayanan, NIOT* | *1. Dr. P.V. Manivannan, IIT Madras, Chennai* | *1.Dr. R. Senthilnathan, SRMIST* |
| *2. Mr. Jai Nareesh, HP* | *2. Dr. P. Karthikeyan, MIT Campus, Anna University* | *2. Dr. S. Anitha Kumari, SRMIST* |

| Course Code | 21MHE428T | Course Name | IMMERSIVE GAME DESIGN AND DEVELOPMENT | Course Category | E | PROFESSIONAL ELECTIVE | L | T | P | C |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | 2 | 1 | 0 | 3 |

| Pre-requisite Courses | *Nil* | Co- requisite Courses | *Nil* | Progressive Courses | *Nil* |
|---|---|---|---|---|---|
| Course Offering Department | *Mechatronics Engineering* | Data Book / Codes / Standards | | *Nil* | |

| Course Learning Rationale (CLR): | *The purpose of learning this course is to:* |
|---|---|
| ***CLR-1:*** | *obtain motivation to get the nuances of game development* |
| ***CLR-2:*** | *familiarize game genres and various phases of game development* |
| ***CLR-3:*** | *get introduced to the evolution of game design principles* |
| ***CLR-4:*** | *explore the strategies to create engaging and immersive gaming experiences* |
| ***CLR-5:*** | *understand the ethics and legalities of game development* |

| Course Outcomes (CO): | *At the end of this course, learners will be able to:* | Program Outcomes (PO) | | | | | | | | | | | | Program Specific Outcomes | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | | | |
| | | Engineering Knowledge | Problem Analysis | Design/development of solutions | Conduct investigations of complex problems | Modern Tool Usage | The engineer and society | Environment & Sustainability | Ethics | Individual & Team Work | Communication | Project Mgt. & Finance | Life Long Learning | PSO-1 | PSO-2 | PSO-3 |
| ***CO-1:*** | *recognize the advancement of modern gaming consoles and virtual reality in shaping gaming experience.* | *2* | - | - | - | - | - | - | - | - | - | - | - | *2* | - | - |
| ***CO-2:*** | *analyze different game genres and the game production process* | - | *3* | *2* | - | - | - | - | - | - | - | - | - | *2* | - | - |
| ***CO-3:*** | *illustrate the guidelines for game development to obtain an immersive gaming experience* | - | *3* | - | - | - | - | - | - | - | - | - | - | *2* | - | - |
| ***CO-4:*** | *demonstrate the skills necessary to create games* | - | *3* | - | - | - | - | - | - | - | - | - | - | - | *3* | - |
| ***CO-5:*** | *design gaming experiences that respect user privacy and data security.* | - | - | *1* | - | - | - | - | *3* | - | - | - | - | *1* | - | - |

| | |
|---|---|
| ***Unit-1 : Background of Games*** | ***9 Hour*** |
| *Games overview, History and Generations of Video games, Platforms and Publishing, Industry facts, Interface innovations and Novelties* | |
| ***Unit-2 - Game Genres and Development Workflow*** | ***9 Hour*** |
| *Game Genre overview, Trade-Offs in Game Design, Indicators of Poor Game Design, Game Development Cycle, Conceptualization, Pre-Production, Platform Selection, Environment and asset creation, interaction design, testing and iteration, Quality Assurance and Bug fixing, Company Organization and Production Team* | |
| ***Unit-3 - Principles of Immersive Game Design*** | ***10 Hour*** |
| *Narrative considerations for game design, Layers of Game Design, Genre-specific level design principles, Layouts, Game balancing, Game engines, Game systems and elements, Map and level editors* | |
| ***Unit-4 – Game Design Foundations*** | ***10 Hour*** |
| *Mechanics of various game genres, Real-Time Strategy, Role-Playing, Peripheral based games, Immersion in Video games, User interface technologies-Stereoscopic 3D, Head tracking, Player experience and engagement, Flow and pacing in game levels.* | |
| ***Unit-5 - Ethical, Legal and Health Topics*** | ***7 Hour*** |
| *Ethical issues in game development, Violence in games, Ethics of Monetization practices, Privacy, Legalities of game development, Quality of life then and now* | |

| | | |
|---|---|---|
| **Learning Resources** | 1. *Tracy Fullerton, Game Design Workshop: A Playcentric Approach to Creating Innovative Games, Third Edition, 2014*<br>2. *Ernest Adams and Andrew Rollings, "Fundamentals of Game Design", Prentice Hall 1st edition, 2006*<br>3. *Jeannie Novak, "Game Development Essentials", 3rd Edition, Delmar Cengage Learning, 2011* | 4. *Jason Gregory, "Game Engine Architecture", A K Peters, 2009*<br>5. *Charles Kelly "Programming 2D Games"June 2012, Publisher(s): A K Peters/CRC Press, ISBN: 9781466508705*<br>6. *Kenneth C. Finney, 3D Game Programming All in One, Cengage Learning, Inc; 3rd edition (3 December 2012)* |

**Learning Assessment**

| | *Bloom's Level of Thinking* | *Continuous Learning Assessment (CLA)* | | | | *Summative Final Examination (40% weightage)* | |
|---|---|---|---|---|---|---|---|
| | | *Formative CLA-1 Average of unit test (50%)* | | *Life-Long Learning CLA-2 (10%)* | | | |
| | | *Theory* | *Practice* | *Theory* | *Practice* | *Theory* | *Practice* |
| Level 1 | *Remember* | *15%* | - | *15%* | - | *15%* | - |
| Level 2 | *Understand* | *25%* | - | *20%* | - | *25%* | - |
| Level 3 | *Apply* | *30%* | - | *25%* | - | *30%* | - |
| Level 4 | *Analyze* | *30%* | - | *25%* | - | *30%* | - |
| Level 5 | *Evaluate* | - | - | *15%* | - | - | - |
| Level 6 | *Create* | - | - | - | - | - | - |
| | *Total* | *100 %* | | *100 %* | | *100 %* | |

**Course Designers**

| **Experts from Industry** | **Experts from Higher Technical Institutions** | **Internal Experts** |
|---|---|---|
| *1. Dr. Sathyanarayanan, NIOT* | *1. Dr. P.V. Manivannan, IIT Madras, Chennai* | *1.Dr. R. Senthilnathan, SRMIST* |
| *2. Mr. Jai Nareesh, HP* | *2. Dr. P. Karthikeyan, MIT Campus, Anna University* | *2. Dr. S. Anitha Kumari, SRMIST* |

| Course Code | 21MHE429J | Course Name | COMPUTER VISION FOR X-REALITY | Course Category | E | PROFESSIONAL ELECTIVE | L | T | P | C |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | 2 | 0 | 2 | 3 |

| Pre-requisite Courses | *Nil* | Co- requisite Courses | *Nil* | Progressive Courses | *Nil* |
|---|---|---|---|---|---|
| Course Offering Department | *Mechatronics Engineering* | Data Book / Codes / Standards | *Nil* | | |

| Course Learning Rationale (CLR): | *The purpose of learning this course is to:* |
|---|---|
| ***CLR-1:*** | *get introduced to various hardware components in imaging devices* |
| ***CLR-2:*** | *familiarize with the mathematics behind computer vision technology* |
| ***CLR-3:*** | *design and develop practical and innovative image processing technique* |
| ***CLR-4:*** | *explore advanced methods for estimating the pose of objects in 3D space* |
| ***CLR-5:*** | *integrate active-ranging techniques into various systems and platforms* |

| Course Outcomes (CO): | *At the end of this course, learners will be able to:* | Program Outcomes (PO) | | | | | | | | | | | | Program Specific Outcomes | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | | | |
| | | Engineering Knowledge | Problem Analysis | Design/development of solutions | Conduct investigations of complex problems | Modern Tool Usage | The engineer and society | Environment & Sustainability | Ethics | Individual & Team Work | Communication | Project Mgt. & Finance | Life Long Learning | PSO-1 | PSO-2 | PSO-3 |
| ***CO-1:*** | *express the basic fundamentals of the imaging hardware* | *2* | - | - | - | *3* | - | - | - | - | - | - | - | *2* | - | - |
| ***CO-2:*** | *develop and analyze various image processing algorithm* | - | *2* | - | - | *3* | - | - | - | - | - | - | - | *2* | - | - |
| ***CO-3:*** | *apply different geometrical image formation* | - | *2* | - | - | *3* | - | - | - | - | - | - | - | *2* | - | - |
| ***CO-4:*** | *demonstrate various pose estimation algorithms* | - | *2* | - | - | *3* | - | - | - | - | - | - | - | - | *3* | - |
| ***CO-5:*** | *illustrate characteristics of active ranging sensors and active ranging technologies* | - | - | *2* | - | *3* | - | - | - | - | - | - | - | - | *3* | - |

| | |
|---|---|
| ***Unit-1 : Imaging Hardware*** | ***12 Hour*** |
| *Introduction to Vision, Terminologies of fields, Comparison of biological and computer vision, Specifications and limitations, Scene constraints, Fundamentals of lighting, Lenses, Specifications, Optical filters, Specifications, Imaging Sensors Specifications, Comparison, Camera computer interfaces, Types and selection, Vision software, Selection criteria, Image Acquisition Basics, Modes of Image acquisition, Multi- camera image acquisition, Synchronization and other issues, Application case study for vision hardware selection* | |
| ***Unit-2 : Fundamentals of Image Processing*** | ***12 Hour*** |
| *Basics of digital image, Sampling, quantization effects, Point operations, 2-D convolution, Image smoothing in spatial domain, Image sharpening and Edge detection in spatial domain, Morphological Image Processing, Erosion, Dilation, Opening and Closing, Color image processing motivation, HSI space color image processing, color segmentation, Matching Algorithms, Gray-level and correlation-based matching, Descriptor based matching, Implementation details* | |
| ***Unit-3: Geometrical Image Formation and Depth Perception*** | ***12 Hour*** |
| *Projective geometry, Basics, Modelling of geometric image formation, Modelling of camera distortion and artifacts, Similarities and differences of CV with CG, Methods of camera calibration, Estimation of projection matrix, Experimental performance assessment in computer vision, Metrics and example usage, Monocular and Binocular depth cues, Depth map generation.* | |
| ***Unit-4 : Pose Estimation*** | ***12 Hour*** |
| *Feature-Based Pose estimation, Direct Pose estimation, Deep Learning-Based Pose estimation, Perspective-n-Point algorithm, Bundle Adjustment approach* | |
| ***Unit-5: Active Ranging and Advanced Topics*** | ***12 Hour*** |
| *Light patterns, calibration, precision, range and other challenges, Light Detection and Ranging (LIDAR), Time-of-Flight (ToF), Structured Light, Simultaneous Localization and Mapping (SLAM), Visual-Inertial Odometry (VIO)* | |

| | | |
|---|---|---|
| **Learning Resources** | 1. *Rafael C. Gonzales, Richard.E.Woods, "Digital Image Processing, 4th Edition, Pearson Education", 2018*<br>2. *Emanuele Trucco, Alessandro Verri, "Introductory Techniques For 3D Computer Vision", 1st Edition, Prentice Hall, 1998 Edition.* | 3. *Alexander Hornberg, "Handbook of Machine Vision", 2nd Edition, Wiley, 2006 Edition.*<br>4. *Wiley Forsyth and Ponce, Computer Vision: A Modern Approach, 2nd Edition, Pearson, 2015.* |

**Learning Assessment**

| | *Bloom's Level of Thinking* | *Continuous Learning Assessment (CLA)* | | | | *Summative Final Examination (40% weightage)* | |
|---|---|---|---|---|---|---|---|
| | | *Formative CLA-1 Average of unit test (45%)* | | *Life-Long Learning CLA-2- Practice (15%)* | | | |
| | | *Theory* | *Practice* | *Theory* | *Practice* | *Theory* | *Practice* |
| Level 1 | *Remember* | *15%* | - | - | *15%* | *15%* | - |
| Level 2 | *Understand* | *25%* | - | - | *20%* | *25%* | - |
| Level 3 | *Apply* | *30%* | - | - | *25%* | *30%* | - |
| Level 4 | *Analyze* | *30%* | - | - | *25%* | *30%* | - |
| Level 5 | *Evaluate* | - | - | - | *10%* | - | - |
| Level 6 | *Create* | - | - | - | *5%* | - | - |
| | *Total* | *100 %* | | *100 %* | | *100 %* | |

**Course Designers**

| **Experts from Industry** | **Experts from Higher Technical Institutions** | **Internal Experts** |
|---|---|---|
| *1. Dr. Sathyanarayanan, NIOT* | *1. Dr. P.V. Manivannan, IIT Madras, Chennai* | *1.Dr. R. Senthilnathan, SRMIST* |
| *2. Mr. Jai Nareesh, HP* | *2. Dr. P. Karthikeyan, MIT Campus, Anna University* | *2. Dr. S. Anitha Kumari, SRMIST* |

| Course Code | 21MHE430J | Course Name | AI FOR X-REALITY | Course Category | E | PROFESSIONAL ELECTIVE | L | T | P | C |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | 2 | 0 | 2 | 3 |

| Pre-requisite Courses | *Nil* | Co- requisite Courses | *Nil* | Progressive Courses | *Nil* |
|---|---|---|---|---|---|
| Course Offering Department | *Mechatronics Engineering* | Data Book / Codes / Standards | | *Nil* | |

| Course Learning Rationale (CLR): | *The purpose of learning this course is to:* |
|---|---|
| ***CLR-1:*** | *familiarize with general machine learning algorithm and techniques* |
| ***CLR-2:*** | *explore the core concepts of deep learning and CNN* |
| ***CLR-3:*** | *have a working knowledge of neural networks and deep learning* |
| ***CLR-4:*** | *impart the foundational concepts of generative AI, including the principles behind generative models* |
| ***CLR-5:*** | *identify the deep learning algorithms which are more appropriate for various types of learning tasks in various X Reality domains* |

| Course Outcomes (CO): | *At the end of this course, learners will be able to:* | Program Outcomes (PO) | | | | | | | | | | | | Program Specific Outcomes | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | | | |
| | | Engineering Knowledge | Problem Analysis | Design/development of solutions | Conduct investigations of complex problems | Modern Tool Usage | The engineer and society | Environment & Sustainability | Ethics | Individual & Team Work | Communication | Project Mgt. & Finance | Life Long Learning | PSO-1 | PSO-2 | PSO-3 |
| ***CO-1:*** | *express the basic fundamentals of different machine learning algorithm* | *3* | *2* | *2* | - | *2* | - | - | - | - | - | - | - | - | *1* | - |
| ***CO-2:*** | *analyze and demonstrate conventional Neural network* | *3* | *2* | *2* | - | *2* | - | - | - | - | - | - | - | - | - | *2* |
| ***CO-3:*** | *demonstrate a basic Reinforcement learning techniques* | *3* | *2* | *2* | - | *2* | - | - | - | - | - | - | - | - | - | - |
| ***CO-4:*** | *create generative AI models for various applications* | *3* | - | - | - | - | - | - | - | - | - | - | - | - | - | *2* |
| ***CO-5:*** | *construct a Deep learning strategies for X-Reality problems* | *3* | - | *2* | - | - | - | - | - | *1* | - | - | - | - | - | *2* |

***Unit-1: Foundations of ANN*** ***12Hour***

*Introduction to artificial intelligence, Intelligent agent, Categorization of AI, Model based vs. Machine learning based approaches, Classical machine learning based vs. Deep learning based approaches, Overview of different forms of learning, Statistical decision theory, Regression, Numerical problems, Over-fitting, Underfitting, Bias-variance trade-off, Outliers, scale, Data set preparation - best practices Train, Validation and test sets - Benchmarking -need Performance evaluation of machine learning techniques*

***Unit-2: Deep Learning and Convolutional NN*** ***12 Hour***

*Conventional neural networks vs. Deep learning in the context of computer vision, Softmax, Convolutional neural networks, Convolution, pooling, Deep learning hardware - CPU, GPU, TPU, Best practices in training, Training neural networks, Data augmentation, Transfer learning, DNN for Image Classification, DNN for Object detection, DNN for Semantic Image Segmentation*

***Unit-3: RNN and Reinforcement Learning*** ***12 Hour***

*Unfolding Computational Graphs, Recurrent neural networks, Deep Recurrent Networks, Long Short-Term Memory, Autoencoders, Applications of autoencoders Reinforcement learning - Numerical example, Deep reinforcement learning, Motivation, Examples for reinforcement learning, Markov decision process Major components of RL, Q-learning, Numerical example, Deep Q-learning (DQN), DQN training, best practices*

| | |
|---|---|
| ***Unit-4: Generative AI*** | ***12 Hour*** |
| *Generative AI models, Text generation models, Image generation models, Audio and Video generation models, Neural Radiance Field (NeRF) based generative AI models, Generative AI for object simulations and human interactions* | |
| ***Unit-5: Applications of AI Techniques in XR*** | ***12 Hour*** |
| *Introduction to generative adversarial networks, Deep learning-based GAN, GAN for supersampling, NVIDIA DLSS, GAN for image generation GAN for 3D object generation, Deep learning-based tracking, Deep learning based semantic action detection, Deep learning based human pose estimation Deep learning based gesture recognition, Deep learning in VR games, Deep learning in AR/MR* | |

| | | |
|---|---|---|
| **Learning Resources** | 1. *Ian Goodfellow and Yoshua Bengio and Aaron Courville, "Deep Learning", First Edition, MIT Press, 2016.*<br>2. *Simon Haykin, "Neural Networks and Learning Machines: A Comprehensive Foundation", Third Edition, Pearson, 2011.*<br>3. *John Khron, "Deep Learning Illustrated", Addison Wesley, 2019.* | 4. *Richard S. Sutton and Andrew G. Barto, Reinforcement Learning - An Introduction, Second Edition, MIT Press, 2018*<br>5. *Dr Bienvenue Maula, Generative AI- The Beginner's Guide, Amazon Digital Services LLC - Kdp, 2023.* |

**Learning Assessment**

| | *Bloom's Level of Thinking* | *Continuous Learning Assessment (CLA)* | | | | *Summative Final Examination (40% weightage)* | |
|---|---|---|---|---|---|---|---|
| | | *Formative CLA-1 Average of unit test (45%)* | | *Life-Long Learning CLA-2- Practice (15%)* | | | |
| | | *Theory* | *Practice* | *Theory* | *Practice* | *Theory* | *Practice* |
| Level 1 | *Remember* | *15%* | - | - | *15%* | *15%* | - |
| Level 2 | *Understand* | *25%* | - | - | *20%* | *25%* | - |
| Level 3 | *Apply* | *30%* | - | - | *25%* | *30%* | - |
| Level 4 | *Analyze* | *30%* | - | - | *25%* | *30%* | - |
| Level 5 | *Evaluate* | - | - | - | *10%* | - | - |
| Level 6 | *Create* | - | - | - | *5%* | - | - |
| | *Total* | *100 %* | | *100 %* | | *100 %* | |

**Course Designers**

| **Experts from Industry** | **Experts from Higher Technical Institutions** | **Internal Experts** |
|---|---|---|
| *1. Dr. Sathyanarayanan, NIOT* | *1. Dr. P.V. Manivannan, IIT Madras, Chennai* | *1.Dr. R. Senthilnathan, SRMIST* |
| *2. Mr. Jai Nareesh, HP* | *2. Dr. P. Karthikeyan, MIT Campus, Anna University* | *2. Dr. S. Anitha Kumari, SRMIST* |

| Course Code | 21MHE431J | Course Name | COMPUTER GRAPHICS FOR X-REALITY | Course Category | E | PROFESSIONAL ELECTIVE | L | T | P | C |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | 2 | 0 | 2 | 3 |

| Pre-requisite Courses | *Nil* | Co- requisite Courses | *Nil* | Progressive Courses | *Nil* |
|---|---|---|---|---|---|
| Course Offering Department | *Mechatronics Engineering* | Data Book / Codes / Standards | | *Nil* | |

| Course Learning Rationale (CLR): | *The purpose of learning this course is to:* |
|---|---|
| ***CLR-1:*** | *get introduced to the application of raster graphics within creative explorative environment* |
| ***CLR-2:*** | *gain knowledge on various strategies to 3D modeling using polygons* |
| ***CLR-3:*** | *familiarize with texturing and materials* |
| ***CLR-4:*** | *learn the process of creating and moving invisible bone structure* |
| ***CLR-5:*** | *explore the principles of animation* |

| Course Outcomes (CO): | *At the end of this course, learners will be able to:* | Program Outcomes (PO) | | | | | | | | | | | | Program Specific Outcomes | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | | | |
| | | Engineering Knowledge | Problem Analysis | Design/development of solutions | Conduct investigations of complex problems | Modern Tool Usage | The engineer and society | Environment & Sustainability | Ethics | Individual & Team Work | Communication | Project Mgt. & Finance | Life Long Learning | PSO-1 | PSO-2 | PSO-3 |
| ***CO-1:*** | *apply creative thinking in self-generated digital images* | *2* | - | - | - | *3* | - | - | - | - | - | - | - | *1* | - | - |
| ***CO-2:*** | *illustrate polygonal geometry within 3D software applications* | *2* | - | - | - | *3* | - | - | - | - | - | - | - | *2* | - | - |
| ***CO-3:*** | *explain advanced modeling with textures and materials* | *2* | - | - | - | *3* | - | - | - | - | - | - | - | - | *2* | - |
| ***CO-4:*** | *create and animate invisible bone structure* | *2* | - | - | - | *3* | - | - | - | - | - | - | - | - | *2* | - |
| ***CO-5:*** | *deliver animation in immersive environment* | *2* | - | - | - | *3* | - | - | - | - | - | - | - | - | *2* | - |

| ***Unit-1 : Raster Graphics for 2D Primitives*** | ***12 Hour*** |
|---|---|
| *Scan converting lines, circles, ellipse; filling rectangles, polygons, generating characters; antialiasing. Matrix representation and Homogeneous coordinates, two dimensional transformations, 2D line clipping, polygon clipping algorithms, window to viewport transformation.* | |
| ***Unit-2 : Modelling*** | ***12 Hour*** |
| *Polygons in 3D software, Strategies of Modeling, Tips and Techniques of Modeling using Polygons, overview of Polygon selection and creation, Combining, separating and splitting. Editing polygons with Sculpting surface meshes, Coloring polygons with Blind data.* | |
| ***Unit-3: Texturing*** | ***12 Hour*** |
| *Advanced Materials Using Specialized Material Types. Unwrapping UVs and Using Pelt Mapping and Creating Baked Textures and Normal Maps. Working with Advanced Modeling and Light Tracing with Radiosity, Using Atmospheric and Render Effects Ray tracking, lighting calculations: Lighting, Shading and Material models* | |
| ***Unit-4 : Rigging*** | ***12 Hour*** |
| *Understanding Character Movements and Kinematics. Types Of Rigging, Joint Arrangement for Pure FK, IK, Spline IK, Dynamic Musculature, and other Specialized, Character Needs, MOCAP-ready bone structure* | |
| ***Unit-5: Animation*** | ***12 Hour*** |
| *Principles of animation, Squash and Stretch, Anticipation, Staging, Straight Ahead and Pose to Pose, Follow Through and Overlapping Action, Slow In And Slow Out, Arc, Secondary Action, Timing, Exaggeration, Solid Drawing, Appeal. Posing In Animation, introduction to non-linear animation, basics of character animation, timing, gestures and expressions in animation.* | |

| | | |
|---|---|---|
| **Learning Resources** | 1. *Oliver Grunow, Smart Factory and Industry 4.0. The Current State of Application Technologies -Developing a Technology Roadmap, Studylab Publishers, 2016*<br>2. *Diego Galar Pascual, Pasquale Daponte, Uday Kumar, Handbook of Industry 4.0 and SMART Systems, CRC Press, 2019* | 3. *Aydin Azizi, Reza Vatankhah Barenji, Industry 4.0 Technologies, Applications, and Challenges, Springer Nature Singapore 2022.*<br>4. *Sherman, William R. and Alan B. Craig. Understanding Virtual Reality – Interface, Application, and Design, Morgan Kaufmann,2002.* |

**Learning Assessment**

| | *Bloom's Level of Thinking* | *Continuous Learning Assessment (CLA)* | | | | *Summative Final Examination (40% weightage)* | |
|---|---|---|---|---|---|---|---|
| | | *Formative CLA-1 Average of unit test (45%)* | | *Life-Long Learning CLA-2- Practice (15%)* | | | |
| | | *Theory* | *Practice* | *Theory* | *Practice* | *Theory* | *Practice* |
| Level 1 | *Remember* | *15%* | - | - | *15%* | *15%* | - |
| Level 2 | *Understand* | *25%* | - | - | *20%* | *25%* | - |
| Level 3 | *Apply* | *30%* | - | - | *25%* | *30%* | - |
| Level 4 | *Analyze* | *30%* | - | - | *25%* | *30%* | - |
| Level 5 | *Evaluate* | - | - | - | *10%* | - | - |
| Level 6 | *Create* | - | - | - | *5%* | - | - |
| | *Total* | *100 %* | | *100 %* | | *100 %* | |

**Course Designers**

| **Experts from Industry** | **Experts from Higher Technical Institutions** | **Internal Experts** |
|---|---|---|
| *1. Dr. Sathyanarayanan, NIOT* | *1. Dr. P.V. Manivannan, IIT Madras, Chennai* | *1.Dr. R. Senthilnathan, SRMIST* |
| *2. Mr. Jai Nareesh, HP* | *2. Dr. P. Karthikeyan, MIT Campus, Anna University* | *2. Dr. S. Anitha Kumari, SRMIST* |

| Course Code | 21MHE432T | Course Name | INNOVATION, ENTREPRENEURSHIP AND ENTERPRISE | Course Category | E | PROFESSIONAL ELECTIVE | L | T | P | C |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | 3 | 0 | 0 | 3 |

| Pre-requisite Courses | *Nil* | Co- requisite Courses | *Nil* | Progressive Courses | *Nil* |
|---|---|---|---|---|---|
| Course Offering Department | *Mechatronics Engineering* | Data Book / Codes / Standards | *Nil* | | |

| Course Learning Rationale (CLR): | *The purpose of learning this course is to:* |
|---|---|
| ***CLR-1:*** | *get introduced to various aspects of XR market* |
| ***CLR-2:*** | *acquire knowledge in core principles of design thinking* |
| ***CLR-3:*** | *develop skills in management for XR projects* |
| ***CLR-4:*** | *explore existing XR business case studies* |
| ***CLR-5:*** | *explore application case studies using XR technologies* |

| Course Outcomes (CO): | *At the end of this course, learners will be able to:* | Program Outcomes (PO) | | | | | | | | | | | | Program Specific Outcomes | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | | | |
| | | Engineering Knowledge | Problem Analysis | Design/development of solutions | Conduct investigations of complex problems | Modern Tool Usage | The engineer and society | Environment & Sustainability | Ethics | Individual & Team Work | Communication | Project Mgt. & Finance | Life Long Learning | PSO-1 | PSO-2 | PSO-3 |
| ***CO-1:*** | *illustrate challenges, threats and opportunities in XR market* | *3* | *2* | *2* | *-* | *2* | *-* | *-* | *-* | *-* | *-* | *-* | *-* | *-* | *1* | *-* |
| ***CO-2:*** | *analyze situations and constructing viable solutions to entrepreneurial problems* | *3* | *2* | *2* | *-* | *2* | *-* | *-* | *-* | *-* | *-* | *-* | *-* | *-* | *-* | *2* |
| ***CO-3:*** | *create detailed plans, timelines, and resource allocation specific to XR projects.* | *3* | *2* | *2* | *-* | *2* | *-* | *-* | *-* | *-* | *-* | *-* | *-* | *-* | *-* | *-* |
| ***CO-4:*** | *develop the ability to manage customer requirements and constraints in XR business.* | *3* | *-* | *-* | *-* | *-* | *-* | *-* | *-* | *-* | *-* | *-* | *-* | *-* | *-* | *2* |
| ***CO-5:*** | *examine technological developments in XR technologies in the future* | *3* | *-* | *2* | *-* | *-* | *-* | *-* | *-* | *1* | *-* | *-* | *-* | *-* | *-* | *2* |

| | |
|---|---|
| ***Unit-1 : XR Market Understanding*** | ***9 Hour*** |
| *Mobile VR, Desktop VR, AR market, MR market, Strengths, Weaknesses, Opportunities, and Threats , Market opportunities, Analysis, Competitive Analysis, challenges, Types of applications for VR/AR/MR/haptics technologies.* | |
| ***Unit-2 : XR Entrepreneurship and Enterprises*** | ***9 Hour*** |
| *various form of business organization concept of entrepreneurship, skills/ traits required to be an entrepreneur, Creative and Design Thinking, the entrepreneurial decision process, skill gap analysis, and role models, mentors and support system, entrepreneurial success stories Identify risks, Analyze each risk, Prioritize each risk , Risk classification grid, Risk analysis spreadsheet, Risk Assessment, Risk control* | |
| ***Unit-3: Project Management*** | ***9 Hour*** |
| *XR production pipeline, principles of project management, tools for XR project management, common challenges in XR project management, key decisions and rationale in XR projects, key roles in XR development lifecycle, best practices in XR project management* | |
| ***Unit-4 : Business Case Studies*** | ***9 Hour*** |
| *This unit shall be handled by a XR entrepreneur or manager in a XR company with adequate experience and knowledge in XR business. Atleast two different people shall be invited to handle the Unit covering a minimum of 4 different case studies. The business case study shall comprise discussion in an interactive manner the problem definition, customer requirements, constraints, XR design strategy adopted, tools used, time calculations, costing, testing, delivery, feedback, etc.* | |
| ***Unit-5: Future of XR Technologies*** | ***9 Hour*** |
| *This unit shall be handled based on research papers published within a year before the date of start of the course. Atleast 5 different cutting edge applications of XR technologies shall be utilized for case study- style content delivery.* | |

| | | |
|---|---|---|
| **Learning Resources** | 1. *Dr. P.T .Vijayashree& M. Alagamma,2010,Entrepreneurial Development & Small Business Mgmt. Margham Publications, Tamilnadu, India.*<br>2. *Tim Berry,2008,The Plan-as-You-Go Business Plan, Entrepreneur Press;Fitch Irvine, CA*<br>3. *The Game Production Handbook, 3rd Edition - by Heather Maxwell Chandler - Jones & Bartlett Learning; 3 edition (March 20, 2013) - ISBN-10: 1449688098, ISBN-13: 978-1449688097.* | 4. *Game Development Essentials: Game Project Management - by John Hight, Jeannie Novak - Cengage Learning; 1 edition (March 27, 2007) - ISBN-10: 1418015415, ISBN-13: 978-1418015411.*<br>5. *The Game Producer's Handbook Paperback – Dan Irish - ISBN-10: 1449688098, ISBN-13: 978-1449688097.*<br>6. *SWOT Analysis. Idea, Methodology and A Practical Approach - by Nadine Pahl, Anne Richter - GRIN Verlag; 1 edition (March 27, 2009) - ASIN: B01M0XIF87* |

**Learning Assessment**

| | *Bloom's Level of Thinking* | *Continuous Learning Assessment (CLA)* | | | | *Summative Final Examination (40% weightage)* | |
|---|---|---|---|---|---|---|---|
| | | *Formative CLA-1 Average of unit test (50%)* | | *Life-Long Learning CLA-2 (10%)* | | | |
| | | *Theory* | *Practice* | *Theory* | *Practice* | *Theory* | *Practice* |
| Level 1 | *Remember* | *15%* | - | *15%* | - | *15%* | - |
| Level 2 | *Understand* | *25%* | - | *20%* | - | *25%* | - |
| Level 3 | *Apply* | *30%* | - | *25%* | - | *30%* | - |
| Level 4 | *Analyze* | *30%* | - | *25%* | - | *30%* | - |
| Level 5 | *Evaluate* | - | - | *10%* | - | - | - |
| Level 6 | *Create* | - | - | *5%* | - | - | - |
| | *Total* | *100 %* | | *100 %* | | *100 %* | |

**Course Designers**

| **Experts from Industry** | **Experts from Higher Technical Institutions** | **Internal Experts** |
|---|---|---|
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| *2. Mr. Jai Nareesh, HP* | *2. Dr. P. Karthikeyan, MIT Campus, Anna University* | *2. Dr. S. Anitha Kumari, SRMIST* |

| Course Code | 21MHE433T | Course Name | X-REALITY IN INDUSTRIES | Course Category | E | PROFESSIONAL ELECTIVE | L | T | P | C |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | 3 | 0 | 0 | 3 |

| Pre-requisite Courses | *Nil* | Co- requisite Courses | *Nil* | Progressive Courses | *Nil* |
|---|---|---|---|---|---|
| **Course Offering Department** | *Mechatronics Engineering* | **Data Book / Codes / Standards** | | *Nil* | |

| **Course Learning Rationale (CLR):** | ***The purpose of learning this course is to:*** |
|---|---|
| ***CLR-1:*** | *familiarize the key IIoT concepts including identification, sensors, localization, wireless protocols, data storage and security* |
| ***CLR-2:*** | *realize the value created by collecting, communicating, coordinating, and leveraging the data from connected devices* |
| ***CLR-3:*** | *explore the relationship between IoT, cloud computing, and big data* |
| ***CLR-4:*** | *develop and implement their own IoT technologies, solutions, and applications.* |
| ***CLR-5:*** | *identify and develop their IIoT solution by incorporating X-Reality domain* |

| **Course Outcomes (CO):** | ***At the end of this course, learners will be able to:*** | **Program Outcomes (PO)** | | | | | | | | | | | | **Program Specific Outcomes** | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | | | |
| | | Engineering Knowledge | Problem Analysis | Design/development of solutions | Conduct investigations of complex problems | Modern Tool Usage | The engineer and society | Environment & Sustainability | Ethics | Individual & Team Work | Communication | Project Mgt. & Finance | Life Long Learning | PSO-1 | PSO-2 | PSO-3 |
| ***CO-1:*** | *express the Definition and significance of the Internet of Things* | - | *1* | *2* | - | - | - | - | - | - | - | - | - | *2* | - | - |
| ***CO-2:*** | *comprehend IoT technologies, architectures, standards, and regulation* | *1* | - | - | - | - | - | - | - | - | - | - | - | *2* | - | - |
| ***CO-3:*** | *examine technological developments that will likely shape the industrial landscape in the future* | - | - | *2* | - | - | - | - | - | - | - | - | - | *2* | - | - |
| ***CO-4:*** | *demonstrate the development of IIoT in different industries* | - | - | *2* | - | - | - | - | - | - | - | - | - | - | *3* | - |
| ***CO-5:*** | *express the significance of IIoT in X-reality* | - | - | *2* | *2* | - | - | - | - | - | - | - | - | *2* | - | - |

***Unit-1 : Introduction to Smart Factories*** ***9 Hour***

*Globalization and Emerging Issues, The Fourth Revolution, Definition, Drivers of I4.0 - Physical Drivers of I4.0 – Digital and Biological LEAN Production Systems, Smart and Connected Business Perspective, Smart Factories, Motivational benefits, Growth, employment and nature of work Consumer expectations, data-enhanced products, Collaborative innovation, operating models, National and global status, Managing Information, Elements of Industry 4.0, Horizontal and Vertical Integration*

***Unit-2 : Elements of I4.0 and 5.0*** ***9 Hour***

*Role of Big Data, Big Data Analytics, Role of cloud computing in I4.0, Importance of cyber security, Cyber Physical Systems in smart factories, Core elements of Cyber-Physical Systems and Cyber-Physical Production Systems, Self-organization principles, Design Methods for Cyber-physical Systems, Modelling, Programming, Model-Integrated Development, Role of robotics in I4.0, Collaborative Robots, tasks, Types of Human-Robot Collaboration, Safety of Human-Robot Collaboration - Standards and Norms, Smart workpiece and digital twins, Introduction to Digital twins,Digital twins - features, implementation and types, Assistance systems for production, Additive manufacturing, Simulation in I4.0*

***Unit-3: IIoT*** ***9 Hour***

*Industrial Processes, Industrial Sensing & Actuation, Industrial Internet Systems,Industrial IoT: Business Model and Reference Architecture, Industrial IoT- Layers, Industrial IoT- Layers: IIoT Sensing, Industrial IoT- Layers: IIoT Processing, Industrial IoT- Layers: Communication, Industrial IoT- Layers: Communication, Industrial IoT- Layers: IIoT Networking,*

***Unit-4 : Nature of Applications of X-Reality*** ***9 Hour***

*XR ecosystem: hardware and software components, XR for assembly and maintenance tasks, Quality control and inspection using AR, Remote assistance and expert guidance in MR, XR in technical training and skill development, Virtual prototyping in automotive engineering*

| ***Unit-5: Applications of X-Reality in Smart Factories*** | ***9 Hour*** |
|---|---|
| *Integrating Design and Manufacturing, Training Shop floor Workers, Supporting complex Assembly Operations, Service and Maintenance, Supporting complex Sales solutions, Executive Oversight and Data Visualisation, Industry 5.0, Future prospectus* | |

| | | |
|---|---|---|
| **Learning Resources** | 1. *Oliver Grunow, Smart Factory and Industry 4.0. The Current State of Application Technologies -Developing a Technology Roadmap, Studylab Publishers, 2016*<br>2. *Diego Galar Pascual, Pasquale Daponte, Uday Kumar, Handbook of Industry 4.0 and SMART Systems, CRC Press, 2019* | 3. *Aydin Azizi, Reza Vatankhah Barenji, Industry 4.0 Technologies, Applications, and Challenges, Springer Nature Singapore 2022.*<br>4. *Sherman, William R. and Alan B. Craig. Understanding Virtual Reality – Interface, Application, and Design, Morgan Kaufmann,2002.* |

**Learning Assessment**

| | *Bloom's Level of Thinking* | *Continuous Learning Assessment (CLA)* | | | | *Summative Final Examination (40% weightage)* | |
|---|---|---|---|---|---|---|---|
| | | *Formative CLA-1 Average of unit test (50%)* | | *Life-Long Learning CLA-2 (10%)* | | | |
| | | *Theory* | *Practice* | *Theory* | *Practice* | *Theory* | *Practice* |
| Level 1 | *Remember* | *15%* | - | *15%* | - | *15%* | - |
| Level 2 | *Understand* | *25%* | - | *20%* | - | *25%* | - |
| Level 3 | *Apply* | *30%* | - | *25%* | - | *30%* | - |
| Level 4 | *Analyze* | *30%* | - | *25%* | - | *30%* | - |
| Level 5 | *Evaluate* | - | - | *10%* | - | - | - |
| Level 6 | *Create* | - | - | *5%* | - | - | - |
| | *Total* | *100 %* | | *100 %* | | *100 %* | |

**Course Designers**

| **Experts from Industry** | **Experts from Higher Technical Institutions** | **Internal Experts** |
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| *2. Mr. Jai Nareesh, HP* | *2. Dr. P. Karthikeyan, MIT Campus, Anna University* | *2. Dr. S. Anitha Kumari, SRMIST* |

| Course Code | 21MHE434T | Course Name | BRAIN COMPUTER INTERFACE IN IMMERSIVE TECHNOLOGIES | Course Category | E | PROFESSIONAL ELECTIVE | L | T | P | C |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | 3 | 0 | 0 | 3 |

| Pre-requisite Courses | *Nil* | Co- requisite Courses | *Nil* | Progressive Courses | *Nil* |
|---|---|---|---|---|---|
| Course Offering Department | *Mechatronics Engineering* | Data Book / Codes / Standards | | *Nil* | |

| Course Learning Rationale (CLR): | *The purpose of learning this course is to:* |
|---|---|
| ***CLR-1:*** | *articulate the types of BCI technologies* |
| ***CLR-2:*** | *enumerate the various BCI sensors* |
| ***CLR-3:*** | *explore the various brain activations* |
| ***CLR-4:*** | *get introduced to various feature extraction and machine learning techniques for BCI data processing* |
| ***CLR-5:*** | *get exposed to various applications of BCI technology* |

| Course Outcomes (CO): | *At the end of this course, learners will be able to:* | Program Outcomes (PO) | | | | | | | | | | | | Program Specific Outcomes | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | | | |
| | | Engineering Knowledge | Problem Analysis | Design/development of solutions | Conduct investigations of complex problems | Modern Tool Usage | The engineer and society | Environment & Sustainability | Ethics | Individual & Team Work | Communication | Project Mgt. & Finance | Life Long Learning | PSO-1 | PSO-2 | PSO-3 |
| ***CO-1:*** | *discuss the rapid evolution and impact of various immersive technologies* | *3* | *2* | - | - | - | - | - | - | - | - | - | - | *2* | - | - |
| ***CO-2:*** | *illustrate the purpose of various BCI sensors* | *2* | *2* | - | - | - | - | - | - | - | - | - | - | *2* | - | - |
| ***CO-3:*** | *express the various types of activations* | *3* | - | - | - | *3* | - | - | - | - | - | - | - | - | *2* | - |
| ***CO-4:*** | *apply the various machine learning techniques for BCI signals* | *2* | - | - | - | *3* | - | - | - | - | - | - | - | - | *2* | - |
| ***CO-5:*** | *explore the various applications of BCI-XR technologies* | *2* | - | - | - | *3* | - | - | - | - | - | - | - | - | *2* | - |

| ***Unit-1 - Introduction to BCI*** | ***9 Hour*** |
|---|---|
| *Introduction - Brain structure and function, Brain Computer Interface Types - Synchronous and Asynchronous -Invasive BCI -Partially Invasive BCI - Non Invasive BCI, Structure of BCI System,* | |
| ***Unit-2 - BCI Sensors*** | ***9 Hour*** |
| *EEG, EOG, Eye Tracking, EMG, EDA, PPG, types, specifications, type of measurement and metrics that can be derived.* | |
| ***Unit-3 - Brain Activations*** | ***9 Hour*** |
| *Brain activation patterns - Spikes, Oscillatory potential and ERD, Slow cortical potentials, Movement related potentials-Mu rhythms, motor imagery, Stimulus related potentials - Visual Evoked Potentials – P300 and Auditory Evoked Potentials, Potentials related to cognitive tasks* | |
| ***Unit-4 - Feature Extraction and Machine Learning for BCI Data Processing*** | ***9 Hour*** |
| *Data Processing – Spike sorting, Frequency domain analysis, Wavelet analysis, Time domain analysis, Spatial filtering -Principal Component Analysis (PCA), Independent Component Analysis (ICA), Artefacts reduction, Feature Extraction - Phase synchronization and coherence, Classification techniques –Binary classification, Ensemble classification, Multiclass Classification, Evaluation of classification performance, Regression - Linear, Polynomial, RBF's, Perceptron's, Multilayer neural networks, Support vector machine, Graph theoretical functional connectivity analysis* | |
| ***Unit-5 - Applications of XR-BCI Technology*** | ***9 Hour*** |
| *Attention, Emotion Classification, Cognitive load analysis, valence/arousal, motor imagery, facial expressions, emotion classification, motion artifact detection, stress/fear response analysis, physical performance analysis, focus shift understanding, biometric identification* | |

| | | |
|---|---|---|
| **Learning Resources** | 1. *Rajesh.P.N.Rao, "Brain-Computer Interfacing: An Introduction", Cambridge University Press, First edition, 2013.*<br>2. *Jonathan Wolpaw, Elizabeth Winter Wolpaw, "Brain Computer Interfaces: Principles and practice", Oxford University Press, USA, Edition 1, January 2012.*<br>3. *Ella Hassianien, Azar.A.T (Editors), "Brain-Computer Interfaces Current Trends and Applications", Springer, 2015.*<br>4. *Bernhard Graimann, Brendan Allison, GertPfurtscheller, "Brain- Computer Interfaces: Revolutionizing Human-Computer Interaction", Springer, 2010* | 5. *Ali Bashashati, MehrdadFatourechi, Rabab K Ward, Gary E Birch," A survey of signal Processing algorithms in brain–computer interfaces based on electrical brain signals" Journal of Neural Engineering, Vol.4, 2007, PP.32-57*<br>6. *Arnon Kohen, "Biomedical Signal Processing", Vol I and II, CRC Press Inc, Boca Rato, Florida. Bishop C.M., "Neural networks for Pattern Recognition", Oxford, Clarendon Press, 1995.*<br>7. *Andrew Webb, "Statistical Pattern Recognition", Wiley International, Second Edition, 2002* |

**Learning Assessment**

| | *Bloom's Level of Thinking* | *Continuous Learning Assessment (CLA)* | | | | *Summative Final Examination (40% weightage)* | |
|---|---|---|---|---|---|---|---|
| | | *Formative CLA-1 Average of unit test (50%)* | | *Life-Long Learning CLA-2 (10%)* | | | |
| | | *Theory* | *Practice* | *Theory* | *Practice* | *Theory* | *Practice* |
| Level 1 | *Remember* | *15%* | - | *15%* | - | *15%* | - |
| Level 2 | *Understand* | *25%* | - | *20%* | - | *25%* | - |
| Level 3 | *Apply* | *30%* | - | *25%* | - | *30%* | - |
| Level 4 | *Analyze* | *30%* | - | *25%* | - | *30%* | - |
| Level 5 | *Evaluate* | - | - | *15%* | - | - | - |
| Level 6 | *Create* | - | - | - | - | - | - |
| | *Total* | *100 %* | | *100 %* | | *100 %* | |

**Course Designers**

| **Experts from Industry** | **Experts from Higher Technical Institutions** | **Internal Experts** |
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# SRM INSTITUTE OF SCIENCE AND TECHNOLOGY

**(Deemed to be University u/s 3 of UGC Act, 1956)**

Kattankulathur, Chengalpattu District 603203, Tamil Nadu, India