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**XXXIII Academic council – Annexure 2.7**

**Date: 21 May 2021**

**Department of Electronics and Communication Engineering**

**Minutes of 33rd Board of Studies Meeting**

The Department Board of Studies meeting was held on 21st May 2021 through an online mode, starting from 6:45 pm onwards.

**Following members were present in the meeting**

1. Dr. M. Suman, Professor and HoD, BoS Chair,
2. Dr. Vinay Kumar Mittal, Professor & Dept. Chair, Member
3. Mr. V. Ramani Kumar, Advisor & Adj. Professor, Member
4. Dr. L. Koteswara Rao, Professor & HOD-ECE, KLH, Member
5. Dr. V. Anil Kumar, Asst. Professor, IIIT Hyderabad, Member
6. Dr. Habibullah Khan, Professor & Dean Student Affairs, Member
7. Dr. K.Sarat Kumar, Professor, Member
8. Dr. K.Ch. Sri Kavya, Professor, Member
9. Dr. M Venkata Narayana, Professor & DHOD, Member
10. Dr. M.Siva Ganga Prasad, Professor & DHOD, Member
11. Dr. Lakshman Pappula, Assoc.Professor & DHOD, Member
12. Dr. 1.Govardhani, Professor & RPAC, Member
13. Dr. M Sridhar, Professor, Member
14. Dr. S Koteswara Rao, Professor, Member
15. Dr. G V Subbarao, Professor & RPAC, Member
16. Dr. M Venugopal Rao Professor & Assoc, Dean IQAC, Member
17. Dr. BTP Madhav, Professor & Assoc. Dean R&D, Member
18. Dr. D Venkat Ratnam, Professor, Member
19. Dr. K Srinivas Rao, Professor, Member
20. Dr. K Kumar Naik, Professor, Member
21. Dr. V. S. V. Prabhakar, Professor & Director IC, Member
22. Dr. Madhukar Deshmukh, Professor & Assoc. Dean, Member
23. Dr. T.V.Rama Krishna, Professor & Director (E- resources) , Member
24. Dr. K.S.Kamesh, Professor, Member
25. Dr. Md. Z Rehman, Professor, Member

**The following members are absent**

1. Dr. T. Kishore Kumar, Professor, NIT Warangal, Member
2. Dr. V Rajesh, Professor & Dean & D, Member
3. Dr. A.S.C.S.Sastry, Professor & COE, Member
4. Dr. P Satyanarayana, Professor & HOD ECM, Member
5. Dr. PVV Kishore, Professor, Member

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## AGENDA and RESOLUTIONS

### AGENDA ITEM-1

| | |
|---|---|
| **To consider and approve the minutes of the Department Academic Committee (DAC) meeting held on 18th May 2021 and recommend the same to the Academic Council for further approval.** | Resolution Approved and Forwarded to Academic Council |

The Chairman of the Board of Studies (BoS) informed the members about the Department Academic Committee (DAC) meeting held on 18th May 2021 and highlighted the significant resolutions discussed. These resolutions were brought to the notice of the DAC by the student members, and the Board unanimously resolved to approve the recommendations made by the DAC (Annexure-1: DAC minutes dated 18th May 2021).

### AGENDA ITEM-2

| | |
|---|---|
| **To consider and approve the proposal for the new 4-year B. Tech [IoT] Internet of Things Program for the Academic Year 2021-2022.** | Resolution Approved and Forwarded to Academic Council |

1. The Chairman of the BoS informed the members present about the proposal for the new 4-year B.Tech [IoT] program in Internet of Things for the Academic Year 2021-2022 onwards (Annexure-2: Proposed Program Development Document [PDD]).
2. He explains the features of the proposed new B.Tech [IoT] program and its course structure.
3. Emphasizing the need for integrated engineering for the future, the B.Tech. Internet of Things (IoT)programme is an integrated program that blends electronics, computer, and communication and focusses on electronics hardware design, programming techniques, telecommunication engineering, and software development for IT aspects. The B.Tech. Internet of Things (IoT) with specialization in Wearable Devices program aims to create engineers proficient in dealing with real-world problems dealing with design, computation, communication, or control. The Wearable Devices course aims to enhancing the skill of the students with sound knowledge in both the computer and electronics domains. It offers ample opportunity for both electronic hardware and IT development. Wearable devices are a perfect balance of the best software-driven by Hardware with an aim towards a new breed of engineers with electronic and computing skills to meet high-tech industry needs. The B.Tech Internet of Things (IoT) program offers specializations in AI & ML applications, Wearable devices, 5G and 6G technology, and Industrial drives.
4. All the members have accepted the proposal and recommended it to the Academic Council for further approval.
5. Feedback from a wide array of stakeholders is carefully collected, analysed, and their suggestions are taken into consideration during the curriculum design process.
6. All the Courses Curriculum are designed under domains of employability or entrepreneurship or skill development.

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7. All the courses have been unanimously approved by all BoS members.
    a. Integrated Professional English
    b. Mathematics for Computing
    c. Computational Thinking for Structured Design
    d. Design Tools Workshop - I
    e. Digital Logic & Processors
    f. English Proficiency
    g. Mathematics for Engineers
    h. Data Structures
    i. Design Tools Workshop -II
    j. Design of Basic Electronics Circuits
    k. Science Elective – 1
    l. Science Elective-2
    m. Computer Organization & Architecture
    n. Design Thinking and Innovation
8. All members approved the incorporation of all the above recommendations into the curriculum of B. Tech (IoT) for the academic year 2021.

(Annexure-II)

**AGENDA ITEM-3**

| | |
|---|---|
| **Discussion on faculty members completion status of Huawei HCIA AI global certification, Faculty achievements, recognitions, and awards, Current placement status of Y17 admitted students.** | Recommended and forwarded to AC for approval |

- 42 faculty members have completed Huawei HCIA AI global certification. Out of which 26 faculty members have received the certificates
- Dr. K. Sarat Kumar, Professor has received "Best Electronics and Communications Engineering Teacher" by ISTE, A P. Section
- Dr. K. Sarat Kumar, Professor, ECE has been recognized by MHRD as a member in NAAC peer review committee
- Dr. B. T. P. Madhav, Professor, ECE has received an award from Asia book of records for publishing maximum number of articles in reputed journals
- Placement status for Y17 is discussed

[Annexure III]

**AGENDA ITEM-4**

| | |
|---|---|
| **Approval of the action taken report on the feedback analysis of the curriculum from the Department Academic Committee (DAC)** | Recommended and forwarded to AC for approval |

BOS Members discussed the recommendation from the DAC minutes and the status is given in the Annexure III.

[Annexure IV]

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**AGENDA ITEM-5**

| | |
|---|---|
| **Proposal for a new M.Tech IoT program for the academic year 2021-2022.** | Resolution Approved and Forwarded to Academic Counsel |

M.Tech program in the Internet of Things (IoT) holds significance by equipping individuals with specialized knowledge and cross-disciplinary skills essential for addressing the challenges and opportunities presented by IoT in various industries. With a focus on technological advancements, industry relevance, and research components, the program ensures graduates are well-prepared to contribute to the dynamic field of IoT. The global connectivity and societal impact of IoT further emphasize the program's importance, offering opportunities for professionals to engage in projects worldwide and contribute to solutions that address pressing societal challenges. Overall, an M.Tech IoT program provides a comprehensive education that not only meets the increasing demand for skilled IoT professionals but also prepares graduates to make meaningful contributions to the advancement and positive impact of IoT on a global scale.

Board of studies members reviewed the course structure of M. Tech IoT and approved the courses and syllabus.

| S. No. | Course Code | Course Title | Course Type |
|---|---|---|---|
| 1. | 21IN5101 | EMBEDDED CONTROLLERS & SOCS | Professional core |
| 2. | 21IN5202 | WIRELESS SENSOR NETWORK AND SECURITY | Professional core |
| 3. | 21IN5203 | IOT CLOUD COMPUTING | Professional core |
| 4. | 21IN5204 | BIG DATA ANALYTICS FOR IOT | Professional core |
| 5. | 21IN5205 | IOT SYSTEM DESIGN TECHNIQUES | Professional core |
| 6. | 21IN51A1 | IOT 4.0 FOR AUTOMATION IN INDUSTRIES | Professional elective |
| 7. | 21IN51A2 | ENERGY HARVESTING TECHNOLOGIES FOR IoT | Professional elective |
| 8. | 21IN51B1 | HUMAN MACHINE INTERFACE & BRAIN MACHINE INTERFACE | Professional elective |
| 9. | 21IN51B3 | COMPUTER VISION & APPLICATIONS | Professional elective |
| 10. | 21IN51C1 | EDGE COMPUTING AND MOBILE APPLICATIONS | Professional elective |

The detailed course structure and syllabus of courses under the new M.Tech IoT program are presented in Annexure-V.

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[Annexure-V]

**AGENDA ITEM-6**

| | |
|---|---|
| **Proposal of new M. Tech Robotics & Automation program for the academic year 2021-2022** | Resolution Approved and Forwarded to Academic Counsel |

The Master of Technology (M. Tech) program in Robotics and Automation is highly significant due to its alignment with industry demands and the dynamic nature of the field. This interdisciplinary program equips students with in-demand skills in mechanical and electrical engineering, computer science, and control systems. Graduates are well-prepared to tackle real-world challenges and stay abreast of the latest technological advancements in robotics. The program offers opportunities for research and development, fostering innovation and preparing students for diverse career paths globally. With a focus on practical applications, M. Tech graduates in Robotics and Automation can contribute to improving efficiency, safety, and overall quality of life, making the program a valuable investment for those seeking career advancement and impactful contributions to the field.

Board of studies members reviewed the course structure of M. Tech Robotics and Automation and approved the courses and syllabus.

| S. No. | Course Code | Course Title | Course type |
|---|---|---|---|
| 1. | 21RA5141 | NON-LINEAR SYSTEMS AND CONTROL OPTIMIZATION FOR ROBOTICS | Professional core |
| 2. | 21RA5142 | ROBOTICS CYBER PHYSICAL SYSTEMS | Professional core |
| 3. | 21RA5143 | IIoT 4.0 FOR AUTOMATION AND ROBOTIC SYSTEMS | Professional core |
| 4. | 21RA51A1 | ROBOTICS: DESIGN OF SENSORS, DRIVES AND ACTUATORS | Professional elective |
| 5. | 21RA51C1 | ADAPTIVE MOTION CONTROL SYSTEMS FOR AUTOMATION AND ROBOTICS | Professional elective |
| 6. | 21RA51D2 | AUTOMOTIVE ELECTRONICS & AVIONICS | Professional elective |
| 7. | 21RA5244 | DESIGN OF MEMS SENSORS AND ACTUATORS FOR ROBOTICS | Professional core |
| 8. | 21RA5245 | OPTIMIZATION ALGORITHMS FOR AUTONOMOUS SYSTEMS | Professional core |

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| | | | |
|---|---|---|---|
| 9. | 21RA5246 | SIGNAL PROCESSING FOR ROBOTICS | Professional core |
| 10. | 21RA5247 | SWAM ROBOTICS CONTROL SYSTEMS | Professional core |

The detailed course structure and syllabus of courses under new M. Tech Robotics and Automation program is presented in Annexure-V

[Annexure-V]

**AGENDA ITEM-7**

| | |
|---|---|
| **To include the course codes for internships, which will be offered during both odd and even semesters of the final year (Y18 batch).** | Recommended and forwarded to AC for approval |

- All the committee members have been informed about the inclusion of the course codes for internship which will be offered during odd and even semesters of final year (Y18 batch).

[Annexure-VI]

**AGENDA ITEM-8**

| | |
|---|---|
| **Approval of pre-PhD courses** | Recommended and forwarded to AC for approval |

- All the committee members have accepted to include new courses for pre-PhD examination.

[Annexure-VII]

**AGENDA ITEM-9**

| | |
|---|---|
| **QP Mapping of NSDC skills.** | Recommended and forwarded to AC for approval |

- As per the suggestions from Dean skilling NSDC skill set has been identified and mapped with the courses offered under ECE for the Odd Semester AY 2021-22.
- The skill set is also mapped with the various job profiles.

[Annexure-VIII]

**AGENDA ITEM-10**

| | |
|---|---|
| **Embedded controllers (19EC2106) with LTPS: 2-0-3-2 has been modified as Embedded Controllers & Embedded Systems Design** | Recommended and forwarded to AC for approval |

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| | |
|---|---|
| **(20EC2106) for B.Tech ECE Y19 regulation based on Stakeholders feedback** | |

- The course 19EC2106 Embedded controllers with LTPS: 2-0-3-2 has been modified as 20EC2106 Embedded Controllers & Embedded Systems Design with LTPS: 3-0-2-2. As the integration of embedded technologies becomes increasingly prevalent in various industries, ranging from automotive and healthcare to consumer electronics, there is a critical need for a comprehensive educational program that addresses the intricacies of embedded controllers and systems design. This course will fill a crucial gap in our curriculum, providing students with hands-on experience in designing and implementing embedded systems, fostering a deep understanding of microcontroller architectures, real-time operating systems, and the principles of hardware-software co-design.

[Annexure-IX]

**AGENDA ITEM-11**

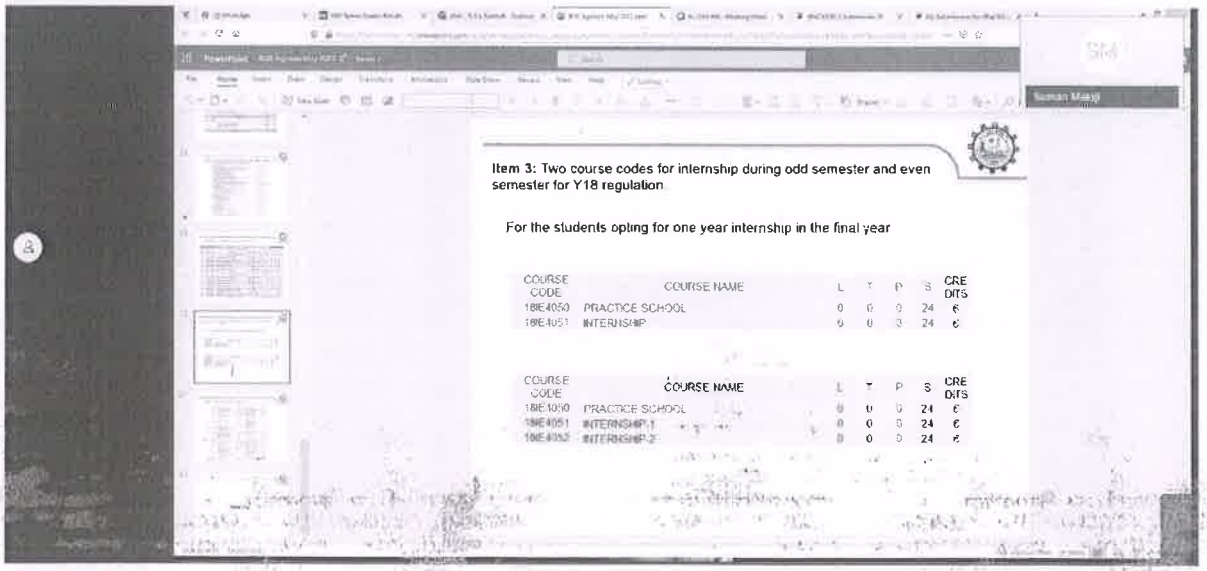
| | |
|---|---|
| **To approve the value-added courses for odd semester 2021-2022.** | Recommended and forwarded to AC for approval |

- The BoS members approved the list of value added courses offered in the AY 2021-22.

[Annexure-X]

**Few pics/Screenshots of BOS meeting**

KLEF-ECE-BOS Meeting-20210520 1240-1

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## DEPARTMENT OF ELECTRONICS AND COMMUNICATIONS ENGINEERING

KLEF

BOS MEETING

| S. No | Name of the Faculty | Designation | Signature |
|---|---|---|---|
| 1 | Dr. M. Suman, Professor & HOD | BOS Chair | |
| 2 | Dr. Vinay Kumar Mittal, Professor & Dept. Chair | Member | |
| 3 | Mr. V. Ramani Kumar, Advisor & Adj. Professor | Member | |
| 4 | Dr. L. Koteswara Rao,Professor & HOD-ECE, KLH | Member | |
| 5 | Dr. V. Anil Kumar, Asst. Professor, IIIT Hyderabad | External Member | |
| 6 | Dr. T. Kishore Kumar, Professor, NIT Warangal | External Member | |
| 7 | Dr. Habibullah Khan, Professor & Dean Student Affairs | Member | |
| 8 | Dr. V Rajesh, Professor & Dean P & D, | Member | |
| 9 | Dr. K Sarat Kumar, Professor | Member | |
| 10 | Dr. A.S.C.S Sastry, Professor & COE | Member | |
| 11 | Dr. K.Ch.Sri Kavya, Professor | Member | |
| 12 | Dr. M Venkata Narayana, Professor & DHOD | Member | |
| 13 | Dr. M Siva Ganga Prasad, Professor & DHOD | Member | |
| 14 | Dr. Lakshman Pappula, Assoc. Professor & DHOD | Member | |
| 15 | Dr. I.Govardhani, Professor & RPAC | Member | |
| 16 | Dr. P Satyanarayana, Professor & HOD ECM | Member | |
| 17 | Dr. P V V Kishore, Professor | Member | |
| 18 | Dr. M Sridhar, Professor | Member | |
| 19 | Dr. S Koteswara rao, Professor | Member | |
| 20 | Dr. G V Subbarao, Professor & RPAC | Member | |
| 21 | Dr. M Venugopal Rao Professor & Assoc. Dean IQAC | Member | |
| 22 | Dr. B.T.P Madhav, Professor & Assoc. Dean R&D | Member | |
| 23 | Dr. D Venkat Ratnam, Professor | Member | |
| 24 | Dr. K Srinivas Rao, Professor | Member | |
| 25 | Dr. K. Kumar Naik, Professor | Member | |
| 26 | Dr. V. S. V. Prabhakar, Professor & Director IC | Member | |
| 27 | Dr. Madhukar Deshmukh, Professor & Assoc. Dean R&D | Member | |
| 28 | Dr. I.V.Rama Krishna, Professor & Director (E-resources) | Member | |
| 29 | Dr. K.S.Ramesh, Professor | Member | |
| 30 | Dr. K.Hari Kishore, Professor | Member | |
| 31 | Dr. Md.Z.Rehman, Professor | Member | |
| 32 | Dr. P.Pardhasaradhi, Professor | Member | |
| 33 | Dr. B.Polaiah, Professor | Member | |

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**Annexure I**

DAC minutes of meeting is enclosed

**Annexure II**

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# KLEF
## Department of Internet of Things
## B.Tech 2021-22 Admitted Batch Category wise Course Structure

| Sl No | Course Code | Course Title | Category | L | T | P | S | Cr | CH | Pre-requisite |
|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 20UC1101 | Integrated Professional English | HSS | 0 | 0 | 4 | 0 | 2 | 4 | Nil |
| 2 | 20UC1202 | English Proficiency | HSS | 0 | 0 | 4 | 0 | 2 | 4 | Nil |
| 3 | 21UC2103 | Essential Skills for Employability | HSS | 0 | 0 | 4 | 0 | 2 | 4 | Nil |
| 4 | 21UC2204 | Corporate Readiness Skills | HSS | 0 | 0 | 4 | 0 | 2 | 4 | Nil |
| 5 | 21UC0010 | Universal Human Values & Professional Ethics | HSS | 2 | 0 | 0 | 0 | 2 | 2 | Nil |
| 6 | 20UC0007 | Indian Heritage and Culture | HSS | 2 | 0 | 0 | 0 | 0 | 2 | Nil |
| 7 | 20UC0008 | Indian Constitution | HSS | 2 | 0 | 0 | 0 | 0 | 2 | Nil |
| 8 | 20UC0009 | Ecology & Environment | HSS | 2 | 0 | 0 | 0 | 0 | 2 | Nil |
| 9 | 21UC0011 | Gender Sensitization | HSS | 2 | 0 | 0 | 0 | 2 | 2 | Nil |
| 10 | 20MT1101 | Mathematics for Computing | BS | 2 | 2 | 0 | 2 | 4.5 | 6 | Nil |
| 11 | 21MT2102 | Mathematics for Engineers | BS | 2 | 1 | 0 | 0 | 3 | 3 | Nil |
| | BS | Mathematics-3(Department Specific) | BS | 3 | 0 | 0 | 0 | 3 | 3 | Nil |
| 13 | 20UC1102 | Design Thinking and Innovation-1 | BS | 1 | 0 | 0 | 4 | 2 | 5 | Nil |
| 14 | 20UC1203 | Design Thinking and Innovation-2 | BS | 1 | 0 | 0 | 4 | 2 | 5 | Nil |
| 15 | | Science Elective - 1 | BS | 3 | 1 | 0 | 0 | 4 | 4 | Nil |
| | 21PH1008 | Physics for Electronics Engineering | BS | | | | | | | Nil |
| | 21PH1004 | Solid State Physics | BS | | | | | | | Nil |
| | 21PH2101 | Quantum Mechanics for Engineers | BS | | | | | | | Nil |
| 16 | | Science Elective - 2 | BS | 3 | 0 | 2 | 0 | 4 | 5 | Nil |
| | 21CY1101 | Engineering Chemistry | BS | | | | | | | Nil |
| | 21CY1003 | Chemistry & Bio-Informatics for Engineers | BS | | | | | | | Nil |
| | 21CY1004 | Organic Electronics | BS | | | | | | | Nil |
| 17 | 21UC3105 | Problem Solving Skills-I | BS | 0 | 0 | 2 | 2 | 1.5 | 4 | Nil |

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| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| 18 | 21UC3206 | Problem Solving Skills-II | BS | 0 | 0 | 2 | 2 | 1.5 | 4 | Nil |
| 19 | 21SC1101 | Computational Thinking for Structured Design | ES | 3 | 0 | 2 | 6 | 5.5 | 11 | Nil |
| 20 | 20ME1103 | Design Tools Workshop – I | ES | 0 | 0 | 4 | 0 | 2 | 4 | Nil |
| 21 | 21SC1209 | Design Tools Workshop – II | ES | 0 | 0 | 4 | 0 | 2 | 4 | Nil |
| 22 | 21SC1202 | Design of Data Structures | ES | 3 | 0 | 2 | 4 | 5 | 9 | 20SC1101 |
| 23 | 21EC1101 | Digital Logic & Processors | ES | 3 | 0 | 2 | 0 | 4 | 5 | Nil |
| 24 | 20EC1202 | Computer Organization & Architecture | ES | 2 | 0 | 0 | 0 | 2 | 2 | 21EC1101 |
| 25 | 21EC1203 | Design of Basic Electronic Circuits | ES | 3 | 0 | 0 | 0 | 3 | 3 | Nil |
| 26 | 21EC2104 | Electronic Devices & Circuits | PC | 3 | 0 | 2 | 2 | 4.5 | 7 | Nil |
| 27 | 21EC2208 | Analog and Digital Communication | PC | 3 | 0 | 3 | 0 | 4.5 | 6 | Nil |
| 28 | 21IN2101 | Processors and Controllers | PC | 3 | 0 | 2 | 0 | 4 | 5 | Nil |
| 29 | 21EC2107 | AI, ANN Tools and Applications | PC | 3 | 0 | 0 | 0 | 3 | 3 | Nil |
| 30 | 21IN2102 | Sensors and Actuators | PC | 3 | 0 | 2 | 0 | 4 | 5 | Nil |
| 31 | 21IN2201 | Embedded Systems Design | PC | 3 | 0 | 2 | 0 | 4 | 5 | Nil |
| 32 | 21EC2210 | Data Networks & Protocols | PC | 3 | 0 | 2 | 0 | 4 | 5 | Nil |
| 33 | 21IN2202 | IoT Principles & Architecture | PC | 3 | 0 | 0 | 0 | 3 | 3 | Nil |
| 34 | 21IN2203 | Data Science and Data Analytics | PC | 3 | 0 | 2 | 0 | 4 | 5 | Nil |
| 35 | 21IN3101 | Cloud Computing for IoT | PC | 3 | 0 | 2 | 0 | 4 | 5 | Nil |
| 37 | 21IN3201 | Internet Programming and Web Technologies | PC | 3 | 0 | 2 | 0 | 4 | 5 | Nil |
| 38 | | OOPS | PC | 3 | 0 | 2 | 0 | 4 | 5 | Nil |
| 39 | FC-1 | Flexi Core -1 | FC | 3 | 0 | 2 | 0 | 4 | 5 | Nil |
| 40 | FC-2 | Flexi Core -2 | FC | 3 | 0 | 2 | 0 | 4 | 5 | Nil |
| 41 | PE-1 | Professional Elective – 1 | PE | 3 | 0 | 0 | 0 | 3 | 3 | - |
| 42 | PE-2 | Professional Elective – 2 | PE | 2 | 0 | 0 | 4 | 3 | 6 | - |
| 43 | PE-3 | Professional Elective – 3 | PE | 2 | 0 | 2 | 0 | 3 | 4 | - |
| 44 | PE-4 | Professional Elective – 4 | PE | 2 | 0 | 2 | 0 | 3 | 4 | - |
| 45 | PE-5 | Professional Elective – 5 | PE | 2 | 0 | 2 | 0 | 3 | 4 | - |
| 46 | OE | Open Elective – 1 | OE | 3 | 0 | 0 | 0 | 3 | 3 | Nil |
| 47 | OE | Open Elective – 2 | OE | 3 | 0 | 0 | 0 | 3 | 3 | Nil |

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| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| 48 | OE | Open Elective – 3 | OE | 3 | 0 | 0 | 0 | 3 | 3 | Nil |
| 49 | OE | Management Elective (OE-4) | OE | 3 | 0 | 0 | 0 | 3 | 3 | Nil |
| 50 | OE | Foreign Language Elective (OE-5) | OE | 2 | 0 | 0 | 0 | 2 | 2 | Nil |
| 51 | 21IE2040 | Social Internship | PR | 0 | 0 | 0 | 4 | 1 | 4 | Nil |
| 52 | 21IE3041 | Technical Internship | PR | 0 | 0 | 0 | 4 | 1 | 4 | Nil |
| 53 | 21IE4042 | Industry Internship | PR | 0 | 0 | 0 | 4 | 1 | 4 | Nil |
| 54 | 21IE2046 | Project Based Learning -1 (Electronic System Design Workshop) | PR | 0 | 0 | 0 | 6 | 1.5 | 6 | Nil |
| 55 | 21IE2047 | Project based learning -2 (IoT Tools and Applications Workshop) | PR | 0 | 0 | 0 | 6 | 1.5 | 6 | Nil |
| 56 | 21IE3043 | Term paper | PR | 0 | 0 | 0 | 4 | 1 | 4 | Nil |
| 57 | 21IE3044 | Mid Grad Capstone Project – I | PR | 0 | 0 | 0 | 8 | 2 | 8 | Nil |
| 58 | 21IE3045 | Mid Grad Capstone Project – II | PR | 0 | 0 | 0 | 8 | 2 | 8 | Nil |
| 59 | 21IE4048/21IE4051/21IE4050 | Project / Internship -1/Practice School | PR | 0 | 0 | 0 | 16 | 4 | 16 | Nil |
| 60 | 21IE4049/21IE4052/21IE4050 | Project / Internship 2/Practice School | PR | 0 | 0 | 0 | 16 | 4 | 16 | Nil |
| **Total Credits** | | | | | | | | **164** | | |

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**List of Professional Electives for 2021-22 admitted batch of B.Tech IoT**

| Sl No | Course Code | Course Title | Specialization | L | T | P | S | Cr | CH | Pre-requisite |
|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 21IN3051 | Flexible Hybrid Electronics for IoT Systems | Renewable Energy and Smart Cities | 3 | 0 | 0 | 0 | 3 | 3 | Relevant core course |
| 2 | 21IN3052 | Energy Harvesting Technologies for IoT | | 2 | 0 | 0 | 4 | 3 | 6 | Relevant core course |
| 3 | 21IN3053 | Systems for Renewable Energy & Smart Grid | | 2 | 0 | 2 | 0 | 3 | 4 | Relevant core course |
| 4 | 21IN3054 | Industrial IoT | | 2 | 0 | 2 | 0 | 3 | 4 | Relevant core course |
| 5 | 21IN3055 | Systems for Smart Cities & Smart Villages | | 2 | 0 | 2 | 0 | 3 | 4 | Relevant core course |
| 6 | 21IN3061 | Advanced Embedded Systems Design | Embedded System | 3 | 0 | 0 | 0 | 3 | 3 | Relevant core course |
| 7 | 21IN3062 | Embedded Systems for IoT | | 2 | 0 | 0 | 4 | 3 | 6 | Relevant core course |
| 8 | 21IN3063 | Embedded Linux | | 2 | 0 | 2 | 0 | 3 | 4 | Relevant core course |
| 9 | 21IN3064 | Embedded and Real-time systems | | 2 | 0 | 2 | 0 | 3 | 4 | Relevant core course |
| 10 | 21IN3065 | Edge Computing & Big Data Analytics in IoT | | 2 | 0 | 2 | 0 | 3 | 4 | Relevant core course |
| 11 | 21IN3071 | Electronic Circuits for Medical Instrumentation | IoT for Health care | 3 | 0 | 0 | 0 | 3 | 3 | Relevant core course |
| 12 | 21IN3072 | Biomedical Signal and Image Processing | | 2 | 0 | 0 | 4 | 3 | 6 | Relevant core course |
| 13 | 21IN3073 | Advanced Biomedical signal processing | | 2 | 0 | 2 | 0 | 3 | 4 | Relevant core course |

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| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| 14 | 21IN3074 | Biomedical device design Fundamentals | | 2 | 0 | 2 | 0 | 3 | 4 | Relevant core course |
| 15 | 21IN3075 | Bio Inspired Robotics | | 2 | 0 | 2 | 0 | 3 | 4 | Relevant core course |
| 16 | 21IN3081 | Control Systems & Introduction to Robotics | ROBOTICS & AUTOMATION | 3 | 0 | 0 | 0 | 3 | 3 | Relevant core course |
| 17 | 21IN3082 | Autonomous Vehicles & Automotive Electronics | | 2 | 0 | 0 | 4 | 3 | 6 | Relevant core course |
| 18 | 21IN3083 | Advanced Robotics | | 2 | 0 | 2 | 0 | 3 | 4 | Relevant core course |
| 19 | 21IN3084 | Computer Vision & Applications | | 2 | 0 | 2 | 0 | 3 | 4 | Relevant core course |
| 20 | 21IN3085 | Human Machine Interface & Brain Machine Interface | | 2 | 0 | 2 | 0 | 3 | 4 | Relevant core course |
| 21 | 21IN3091 | AI Applications Design | Artificial Intelligence & Intelligent Process Automation | 3 | 0 | 0 | 0 | 3 | 3 | Relevant core course |
| 22 | 21IN3084 | Computer Vision & Applications | | 2 | 0 | 0 | 4 | 3 | 6 | Relevant core course |
| 23 | 21IN3085 | Human Machine Interface & Brain Machine Interface | | 2 | 0 | 2 | 0 | 3 | 4 | Relevant core course |
| 24 | 21IN3094 | Advanced Machine Learning, DNN & CNN | | 2 | 0 | 2 | 0 | 3 | 4 | Relevant core course |
| 25 | 21IN3095 | Automated Vehicles & Avionics | | 2 | 0 | 2 | 0 | 3 | 4 | Relevant core course |
| 26 | 21IN3101 | Speech Signal Processing | MACHINE LEARNING & DIGITAL MEDIA PROCESSING | 3 | 0 | 0 | 0 | 3 | 3 | Relevant core course |
| 27 | 21IN3102 | Computer Vision & Applications | | 2 | 0 | 0 | 4 | 3 | 6 | Relevant core course |
| 28 | 21IN3103 | Natural Language Processing & Applications | | 2 | 0 | 2 | 0 | 3 | 4 | Relevant core course |

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|---|---|---|---|---|---|---|---|---|---|---|
| 29 | 21IN3 104 | Big Data Analytics | | 2 | 0 | 2 | 0 | 3 | 4 | Relevant core course |
| 30 | 21IN3 105 | Digital Twin Technologies | | 2 | 0 | 2 | 0 | 3 | 4 | Relevant core course |
| 31 | 21IN3 111 | Big Data Analysis & Decision Making | Cyber Security & Block Chain Technology | 3 | 0 | 0 | 0 | 3 | 3 | Relevant core course |
| 32 | 21IN3 112 | Block Chain & Cyber Security | | 2 | 0 | 0 | 4 | 3 | 6 | Relevant core course |
| 33 | 21IN3 113 | Cloud Computing Network Security | | 2 | 0 | 2 | 0 | 3 | 4 | Relevant core course |
| 34 | 21IN3 114 | NLP & Sentiment Analysis | | 2 | 0 | 2 | 0 | 3 | 4 | Relevant core course |
| 35 | 21IN3 094 | Advanced Machine Learning, DNN & CNN | | 2 | 0 | 2 | 0 | 3 | 4 | Relevant core course |
| 36 | 21IN3 121 | TCP/IP & Other Protocol Suite | COMPUTER COMMUNICATION & NexGen TECHNOLOGIES | 3 | 0 | 0 | 0 | 3 | 3 | Relevant core course |
| 37 | 21IN3 122 | VoIP Systems & Broad Band Networks | | 3 | 0 | 0 | 0 | 3 | 3 | Relevant core course |
| 38 | 21IN3 123 | 5G Mobile, Wireless Technologies & IEEE 802 Standards | | 3 | 0 | 0 | 0 | 3 | 3 | Relevant core course |
| 39 | 21IN3 113 | Cloud-Computing & Network Security / (Hardware Security) | | 3 | 0 | 0 | 0 | 3 | 3 | Relevant core course |
| 40 | 21IN3 125 | IP Multimedia Sub-System & Emerging Technologies | | 3 | 0 | 0 | 0 | 3 | 3 | Relevant core course |

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**Annexure-III**

**1. 42 faculty members have completed Huawei HCIA AI global certification. Out of which 26 faculty members have received the certificates.**

| | | |
|---|---|---|
| 1 | 1181 | Dr. M.Ravikumar |
| 2 | 1286 | Dr. S.Nagendram |
| 3 | 2221 | Dr.Murali Krishna Bopanna |
| 4 | 2224 | Dr. G.Venkata Ganesh |
| 5 | 2469 | Dr. M.Sridhar |
| 6 | 2812 | Dr. MVD PRASAD |
| 7 | 2922 | Dr. Venu Gopala Rao Matcha |
| 8 | 2978 | Dr. D.Bhavana |
| 9 | 2980 | SUBBA REDDY VASIPALLI |
| 10 | 3011 | K.Sony |
| 11 | 3028 | N.Durga Indira |
| 12 | 3066 | Dr.Siddaiah Nalluri |
| 13 | 3452 | Dr. P V V Kishore |
| 14 | 3621 | Dr. P.PARDHA SARADHI |
| 15 | 4173 | Dr. Katta Rajesh Babu |
| 16 | 4263 | Ms.V.Sahithi |
| 17 | 4387 | Dr. B.Polaiah |
| 18 | 4818 | ALI BAIG MOHAMMAD |
| 19 | 4858 | Dr. Lakshman Pappula |
| 20 | 4975 | Dr. G.Siva Vara Prasad |
| 21 | 5129 | Dr. C.S. Preetham Reddy |
| 22 | 5230 | T Penchala Naidu |
| 23 | 5239 | Mr. M. Lakshmanakumar |
| 24 | 5251 | Muzammil Parvez M |
| 25 | 5413 | Mohan K N |
| 26 | 5891 | Dr. E.Kiran Kumar |

**2. Faculty achievements, recognitions, and awards.**

- Dr. K. Sarat Kumar, Professor has received "Best Electronics and Communications Engineering Teacher" by ISTE, A P. Section.
- Dr. K. Sarat Kumar, Professor has been recognized by MHRD as a member in NAAC peer review committee.
- Dr. B. T. P. Madhav, Professor has received an award from Asia book of records for publishing maximum number of articles in reputed journals.

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3. Placement status of Y17 admitted batch.

| KLEF<br>DEPARTMENT OF ELECTRONICS AND COMMUNICATION ENGINEERING | | | | |
|---|---|---|---|---|
| Category | Pega | WTN | NWTN | Total |
| Registered | 105 | 399 | 52 | 556 |
| Placed | 103 | 348 | 46 | 497 |
| Not Interested | 0 | 24 | 4 | 28 |
| Backlog/Low CGPA | 0 | 1 | 0 | 1 |
| Yet 2 be Placed | 2 | 26 | 2 | 30 |

out of the remaining 30 Yet to be placed students, 12 students are already in various stages of interviews and expected to be placed in couple of days

| | | |
|---|---|---|
| SUMMARY | 1. Total Placement Registered | 556 |
| | 2. Placed | 497 |
| | 3. Yet to be Placed | 30 |
| | 4. Total Number of Placement Offers | 819 |
| | 5. Total No.of Companies visted for ECE | 56 |
| | 6. Total No.of NR Students Placed | 30 |
| | 7. Highest Package Offered | 12.2 |

**Annexure-IV**

| Sl.No. | Name of the resource person | Designation & Affiliation | Recommendation on Curriculum during DAC meeting | Approval by BOS committee | Remarks |
|---|---|---|---|---|---|
| A. | Industry Personnel | | | | |
| 1. | Mr. R Nagesh | Associate Director, CDAC, Bengaluru | Suggested To Revise Syllabus of Embedded Controllers & Embedded Systems Design | Approved | To improve employment opportunity |
| 2. | Mr. Srinivas Vedala | Apple Inc., Bengaluru | Suggested To include Machine Learning for Pre-Ph.D. | Approved | To improve employment opportunity |
| 3. | Dr. Subba Rao | Head Budget, P&M division, NRSC, Bengaluru | Suggested To include Modern Digital Communication for Pre-Ph.D. | Approved | To improve employment opportunity |
| 4. | Mr. Visweswaran Jagadeesan | National Instruments, Bengaluru | Suggested To include Radiating systems for Pre-Ph.D. | Approved | To improve employment opportunity |

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| | | | | | |
|---|---|---|---|---|---|
| **5.** | Mr. M. Kannan | Honeywell, Bangalore | Suggested To include Micro Electro Mechanical Systems in Pre-Ph.D. | Approved | To improve employment opportunity |
| **6.** | Mr. Birupaksha | Bosch, Bangalore | Suggested To include Detection and Estimation Of Signals in Pre-Ph.D | Approved | To improve employment opportunity |
| **7.** | Mr. Kevin | TSMC, Taiwan | Suggested To include Real Time Concepts for Embedded Systems in Pre-Ph. D | Approved | To improve employment opportunity |
| **8.** | Mr. Balamurugan | CTS, Coimbatore | Suggested To include Advanced Embedded Processor Architecture for pre-Ph.D. | Approved | To improve employment opportunity |
| **B.** | | | | | |
| **9.** | Dr. V.Anil Kumar | IIIT Hyderabad | Suggested To include Advanced Computational Mathematics in Pre-Ph.D. | Approved | To improve employment opportunity |
| **10.** | Dr. T.Kishore Kumar | NIT Warangal | Suggested To include VLSI System Design for Pre-Ph.D. | Approved | To improve employment opportunity |
| **11.** | Dr. Selvarajan, E | Assistant professor, SRM Institute of Science and Technology, Chennai, Tamil Nadu | Suggested To include Advanced Analog IC Design for Pre-Ph.D. | Approved | To improve employment opportunity |
| **12.** | Dr. Narendhar C | Research Assistant professor, | Suggested To include | Approved | To improve employment opportunity |

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| | | | | | |
|---|---|---|---|---|---|
| | | Jeju University, South Korea. | Pattern Recognition for Pre-Ph.D. | | |
| **13.** | Dr. Melvin. S | Marquette University, USA | Suggested to integrate CMOS RF Circuit Design in Pre-Ph.D. | Approved | To improve employment opportunity |
| **14.** | Dr.Mohanraj | CYUT, Taiwan | Suggested to integrate Computer Vision & Applications in M. Tech IoT | Approved | To improve employment opportunity |
| **15.** | Dr. Renganathan. V | NTU, Taiwan | Suggested to integrate Internet Of Things Architecture And Protocols in M. Tech VLSI | Approved | To improve employment opportunity |
| **C.** | | | | | |
| **16.** | Vamsi. Ch | Third Leap. INC. | Suggested to integrate Embedded Controllers & SOCS in M. Tech IoT | Approved | To improve employment opportunity |
| **17.** | Bhanushankar Buddi | Wipro | Recommended to add Wireless Sensor Network and Security in M. Tech IoT | Approved | To improve employment opportunity |
| **18.** | Sri Haritha | Analog Devices | Recommended to add IoT Cloud Computing in M. Tech IoT | Approved | To improve employment opportunity |
| **19.** | Tejkumar | Dell | Recommended to add Big Data Analytics for IoT in M. Tech IoT | Approved | To improve employment opportunity |

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| | | | | | |
|---|---|---|---|---|---|
| **20.** | Ramkiran Reddy | TCS | Recommended to add IoT System Design Techniques in M. Tech IoT | Approved | To improve employment opportunity |
| **D.** | | | | | |
| **21.** | Dr. S. Koteshwara Rao | K. L. University | Recommended to add Non-Linear Systems And Control Optimization For Robotics in M. Tech Robotics And Automation | Approved | To improve employment opportunity |
| **22.** | Dr. B. T. P. Madhav | K. L. University | Recommended to add Robotics Cyber Physical Systems in M. Tech Robotics And Automation | Approved | To improve employment opportunity |
| **23.** | Dr. P.V.V. Kishore | K. L. University | Recommended to add IIOT 4.0 For Automation And Robotic Systems in M. Tech Robotics And Automation | Approved | To improve employment opportunity |
| **24.** | Dr. Govardhani | K. L. University | Recommended to add Robotics: Design Of Sensors, Drives And Actuators in M. Tech Robotics And Automation | Approved | To improve employment opportunity |

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| | | | | | |
|---|---|---|---|---|---|
| **25.** | Dr. M. Sridhar | K. L. University | Recommended to add Adaptive Motion Control Systems For Automation And Robotics in M. Tech Robotics and Automation | Approved | To improve employment opportunity |
| **26.** | Dr. Venkata Ratnam | K. L. University | Recommended to add Automotive Electronics & Avionics in M. Tech Robotics and Automation | Approved | To improve employment opportunity |
| **27.** | Dr. P. Satyanarayana | K. L . University | Recommended to add Design Of MEMS Sensors And Actuators For Robotics in M. Tech Robotics and Automation | Approved | To improve employment opportunity |
| **28.** | Dr. P. Parthasarathi | K. L . University | Recommended to add Optimization Algorithms For Autonomous Systems in M. Tech Robotics and Automation | Approved | To improve employment opportunity |
| **29.** | Dr. K. Kumar Naik | K. L. University | Recommended to add Signal Processing For Robotics in M. Tech Robotics and Automation | Approved | To improve employment opportunity |

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| | | | | | |
|---|---|---|---|---|---|
| **E.** | | | | | |
| **30.** | Balaprabhu Charan (2000040045) | K. L. University | Recommended to add Swam Robotics Control Systems in M. Tech Robotics and Automation | Approved | To improve employment opportunity |
| **31.** | Laxmi.Naga.Sai. (2000040005) | K. L. University | Recommended to add Technical Skilling (Ros, Webot, Matlab, Msc Adams) in M. Tech Robotics and Automation | Approved | To improve employment opportunity |
| **32.** | Vamsi Reddy (190040012) | K. L. University | Recommended to add Technical Skilling-I in M. Tech IoT | Approved | To improve employment opportunity |
| **33.** | Hemanth Kumar (190040099) | K. L. University | Recommended to add Technical Skilling in M. Tech | Approved | To improve employment opportunity |
| **34.** | Venkata Goutham Reddy (190040127) | K. L. University | Recommended to add Technical Skilling-I in M. Tech IoT | Approved | To improve employment opportunity |

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**Annexure- V**

Course structures and Syllabus of M. Tech programs.

**i. M. Tech IOT**

**KLEF**
**Dept. of Electronics and Communication Engineering**
**M. Tech IoT**
**AY. 2021-22**

**Semester-I**

| S. No. | Course Code | Course Title | Periods | | | | Credits |
|---|---|---|---|---|---|---|---|
| | | | L | T | P | S | |
| 1 | 21EC51R2 | Internet of Things Architecture and Protocols | 3 | 0 | 0 | 0 | 3 |
| 2 | 21IN5101 | Embedded Controllers & SoCs | 3 | 1 | 2 | 0 | 5 |
| 3 | 21EC5101 | Wireless Communication and Data Networks | 3 | 1 | 2 | 0 | 5 |
| 4 | 21EC5104 | Artificial Intelligence and Machine Learning | 3 | 0 | 2 | 0 | 4 |
| 5 | | Elective 1 | 3 | 0 | 0 | 0 | 3 |
| 6 | | Elective 2 | 3 | 0 | 0 | 0 | 3 |
| 7 | 21IE3149 | Seminar | 0 | 0 | 4 | 0 | 2 |
| 8 | 21TS51I1 | Technical Skilling-I | 0 | 0 | 0 | 8 | 2 |
| **Total** | | | **18** | **2** | **10** | **8** | **27** |

**Semester-II**

| S. No. | Course Code | Course Title | Periods | | | | Credits |
|---|---|---|---|---|---|---|---|
| | | | L | T | P | S | |
| 1 | 21IN5202 | Wireless Sensor Network and Security | 3 | 0 | 2 | 0 | 4 |
| 2 | 21IN5203 | IoT Cloud computing | 3 | 0 | 2 | 0 | 4 |
| 3 | 21IN5204 | Big data Analytics for IoT | 3 | 0 | 0 | 0 | 4 |
| 4 | 21IN5205 | IoT System Design Techniques | 3 | 1 | 2 | 0 | 5 |
| 5 | | Elective – 3 | 3 | 0 | 0 | 0 | 3 |
| 6 | | Elective – 4 | 3 | 0 | 0 | 0 | 3 |
| 7 | 21IE3250 | Term Paper | 0 | 0 | 4 | 0 | 2 |
| 8 | 21TS52I2 | Technical Skilling-II | 0 | 0 | 0 | 8 | 2 |
| **Total** | | | **18** | **1** | **10** | **8** | **27** |

**Semester-III&IV**

| S. No. | Course Code | Periods Course Title | Periods | | | | Credits |
|---|---|---|---|---|---|---|---|
| | | | L | T | P | S | |
| 1 | 21IE6050 | M. Tech. Project Dissertation - Part 1 & Part 2 | 0 | 0 | 72 | 0 | 36 |
| **Total Program Credits** | | | | | | | **90** |

**Subject Options as per Specialization**

| S. No. | Course Code | Course Title | Periods | | | | Credits |
|---|---|---|---|---|---|---|---|
| | | | L | T | P | S | |

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| | | | | | | | |
|---|---|---|---|---|---|---|---|
| **Elective-1** | | | | | | | |
| 1 | 21IN51A1 | IIoT 4.0 for Automation in Industries | 3 | 0 | 0 | 0 | 3 |
| 2 | 21IN51A2 | Energy Harvesting Technologies for IoT | 3 | 0 | 0 | 0 | 3 |
| 3 | 21IN51A3 | Advanced Embedded System Design | 3 | 0 | 0 | 0 | 3 |
| 4 | 21IN51A4 | Data Management and Security | 3 | 0 | 0 | 0 | 3 |
| **Elective-2** | | | | | | | |
| 1 | 21EC51B3 | Computer Vision & Video Surveillance Systems | 3 | 0 | 0 | 0 | 3 |
| 2 | 21RA51B2 | Human Machine Interface & Brain Machine Interface (HMIBMI) | 3 | 0 | 0 | 0 | 3 |
| 3 | 21IN51B2 | Data Bases, Data Modeling & Data Structure | 3 | 0 | 0 | 0 | 3 |
| 4 | 21IN51B3 | Computer Vision & Applications | 3 | 0 | 0 | 0 | 3 |
| 5 | 21EC51Q2 | System on Chip Design | 3 | 0 | 0 | 0 | 3 |
| **Elective-3** | | | | | | | |
| 1 | 21IN51C1 | Edge Computing and Mobile Applications | 3 | 0 | 0 | 0 | 3 |
| 2 | 21IN51C2 | 5G NR - Next Generation Wireless Technologies | 3 | 0 | 0 | 0 | 3 |
| 3 | 21RA5245 | Optimization algorithms for autonomous systems | 3 | 0 | 0 | 0 | 3 |
| 4 | 21RA51C1 | Adaptive motion control systems for automation and robotics | 3 | 0 | 0 | 0 | |
| **Elective-4** | | | | | | | |
| 1 | 21EC51D4 | Block Chain & Cyber Security | 3 | 0 | 0 | 0 | 3 |
| 2 | 21RA51D2 | Automotive Electronics & Avionics | 3 | 0 | 0 | 0 | 3 |
| 3 | 21EC51D1 | FPGA-Based Wireless System Design | 3 | 0 | 0 | 0 | 3 |
| 4 | 21IN51D4 | Cyber Physical Systems | 3 | 0 | 0 | 0 | 3 |

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## Syllabus for M. Tech IoT:

| Course Title: | Internet of Things Architecture and Protocols | | |
|---|---|---|---|
| Course Code: | 21EC51R2 | L-T-P-S | 3-0-0-0 |
| Pre-requisite: | Course Code: Nil<br>Course Title: Nil | Credits | 3 |
| CO. No. | Course Outcome | Mapped PO | BTL |
| CO1 | Understand the concepts of IoT Architecture, Reference model, and IoT enabling technologies. | 1,4 | 2 |
| CO2 | Understand the logical design of IoT systems and communication technologies. | 1,3 | 2 |
| CO3 | Understand IoT networking protocols and Authentication Protocols for the IoT Application layer. | 1,4 | 2 |
| CO4 | Apply IoT protocols and programming concepts for real-world problems. | 3,7 | 3 |

| CO | Syllabus | CH |
|---|---|---|
| 1 | IoT Reference Architecture: Introduction to IoT, Introduction, IoT definition, Characteristics of IoT, IoT Architecture, Physical Design of IIoT Logical design of IoT, IoT enabling technologies IoT Levels & Development Templates, Difference between IoT and M2M, SDN and NFV for IoT. RFIDs, and wireless sensor networks technology. Embedded devices for IoT and Sensor Technology | 9 |
| 2 | IoT Systems-Logical using Python: Installing Python, Python Data Types & Data Structures, Control Flow, Functions, Modules, Packages, Date/ Time Operations, Classes, Python Packages. IoT Design Methodology, Case study using weather monitoring. I o T Physical Devices & Endpoints' Device, Exemplary Device, Board, Linux on Raspberry Pi, Programming of IoT. IoT Communication Technologies: wired - UART, USART, SPI , I 2 C, Modbus, CAN, Ethernet, USB | 9 |
| 3 | IoT Networking Protocols: IPv4 and IPv6.6lowPAN, TCP/IP, IP addressing of I oT devices MAC addresses of the communication circuit Web connectivity for connected devices Application Protocols – HTTP, Web sockets, Node, MQTT, UDP, CoAP, XMPP, AMQP and gateway protocols. Link Layer protocols: 802.3 – Ethernet 802.11 – WiFi 802.16 – WiMax 802.15.4 – LR-WPAN,2G/3G/4G Wireless - Bluetooth, BLE, IEEE 802.11, IEEE 802.15, Zigbee, SIGFOX.4 Cloud storage Models and Communication APIs. Web application management protocol, Python web application framework. | 9 |
| 4 | IoT Design Technologies: Case studies illustrating IoT design: Home Automation: Smart lighting, Smart Appliances, Cities: Smart Parking, Smart Lighting, Smart Roads, Emergency response, Environment: Weather monitoring, Air Pollution Monitoring, Noise pollution, Forest fire, River flood, Agriculture: Smart irrigation, Green House control. | 9 |

| Text Books | |
|---|---|
| 1. | Bernd Scholz-Reiter, Florian Michahelles, "Architecting the Internet of Things", ISBN 978-3-642-19156-5 e-ISBN 978-3-642-19157-2, Springer |
| 2. | Vijay Madisetti, Arshdeep Bahga, Adrian McEwen (Author), Hakim Classically "Internetof Things AHands-on-Approach" Arshdeep Bahga & Vijay Madisetti, 2014. |
| **Reference Books** | |
| 1. | Bassi, Alessandro, et al, "Enabling things to talk", Springer-Verlag Berlin An, 2016. |
| 2. | Buyya, Rajkumar, and Amir Vahid Dastjerdi, eds. Internetof Things: Principles and Paradigms. Elsevier, 2016. |
| 3. | David Hanes, Gonzalo Salgueiro, Patrick Grossetete, Robert Barton, Jerome Henry, "IoT Fundamentals: Networking Technologies, Protocols, and Use Cases for the Internet of Things", CISCO Press, 2017 |

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| | |
|---|---|
| 4. | Jan Holler, Vlasios Tsiatsis, Catherine Mulligan, Stefan Avesand, Stamatis Karnouskos, David Boyle, "From Machine-to-Machine to the Internet of things: Introduction to a New Age of Intelligence", 1st Edition, Academic Press,2014. |
| **Web References** | |
| 1 | https://www.altexsoft.com/blog/iot-architecture-layers-components/ |
| 2 | https://www.coursera.org/learn/iot-wireless-cloud-computing/home/welcome |
| 3 | https://wso2.com/whitepapers/a-reference-architecture-for-the-internet-of-things/ |
| 4 | https://www.igi-global.com/chapter/iot-architecture-and-protocols-in-5g-environment/185923 |

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| | | | |
|---|---|---|---|
| **Course Title:** | **Embedded Controllers & SOCs** | | |
| **Course Code:** | **21IN5101** | **L-T-P-S** | **3-1-2-0** |
| **Pre-requisite:** | **Course Code: NilCourse**<br>**Title: Nil** | **Credits** | **5** |
| **CO. No.** | **Course Outcome** | **Mapped PO** | **BTL** |
| **CO1** | Understand the concept of embedded system, microcontroller, different components of microcontroller, and their interactions. | **1,2** | **2** |
| **CO2** | Get familiarized with the programming environment to develop embedded solutions. | **7,2** | **2** |
| **CO3** | Program ARM microcontroller to perform various tasks. | **2,5** | **3** |
| **CO4** | Understand the key concepts of embedded systems such as I/O, timers, interrupts, and interaction with peripheral devices. | **2,5** | **2** |
| **CO5** | SoC and H/W-S/WCo-Design | **2,5,6** | **2** |

| **CO** | **Syllabus** | **CH** |
|---|---|---|
| 1 | **Modern Microcontrollers:** Basics and History of Processors & Microcontroller, Introduction and Architecture of PIC Microcontrollers, Basics of CORTEX-ARM (STM 32) & ARM7 (LPC2148) Microcontrollers, Architecture of ARM7, Pin Description, and Advanced Microcontroller Bus Architecture (AMBA) concepts, Basic concepts of Real-Time operating systems (RTOS) and applications of RTOS. | 9 |
| 2 | **Applications with Microcontroller Boards:** ARM7 (LPC2148) Microcontrollers - Using timers of LPC2148 to generate delay, Interrupt Structure, Serial communication programming, LPC2148 GPIO Programming examples, I2Cand SPI Protocol. | 9 |
| 3 | **:** ARM 7 (LPC-2148) – Interfacing with LED, LCD, GLCD & Keypad. GSM Module, GPS Module, interfacing with on-chip (Internal) ADC & DAC, Interfacing with EEPROM using I2C, SD Card, and Interfacing with LPC2148 using SPI Module. | 9 |
| 4 | **System on Chips (SoC):** SoC and H/W-S/W Co-Design: Introduction to SoC design, SoC design flow, System Level design issues in SoC, Transition of SoC design methodology, Classic Hardware-Software co-design System-level H/W-S/Wco-designprocess, Design flow of co-design process | 9 |


| **Text Books** | |
|---|---|
| 1 | Steve Furber, "ARM System on Chip Architecture", 2nd Edition, 2000, Addison Wesley Professional. |
| 2 | Practical Microcontroller Engineering with ARM Technology by Ying Bai |
| 3 | On-Chip Communication Architectures: System on Chip Interconnect by Sudeep Pasricha, Nikil Dutt. |
| **Reference Books** | |
| 1 | Ahmed Amine Jerraya, Wayne Wolf, "Multiprocessor Systems-on-Chip", Morgan Kaufmann, Elsevier, Second Edition, 2005 |
| 2 | Fundamentals of System-on-Chip Design on Arm Cortex-M Microcontrollers, By René Beuchat, Florian Depraz, Sahand Kashani, Andrea Guerrieri |
| **Web References** | |
| 1 | https://www.youtube.com/watch?v=fI20Bsx3EPM |
| 2 | https://nptel.ac.in/courses/108/102/108102045/ |
| 3 | https://www.youtube.com/watch?v=dHsHP9RrXBw&list=PLJ5C_6qdAvBH-JNRIlupFb44miyx9M8JD |
| 4 | https://www.wikinote.org/course/view.php?id=7 |


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| Course Title: | Wireless Communication and Data Networks | | |
|---|---|---|---|
| Course Code: | 21EC5101 | L-T-P-S | 3-1-2-0 |
| Pre-requisite: | Course Code: Nil<br>Course Title: Nil | Credits | 5 |
| CO. No. | Course Outcome | Mapped PO | BTL |
| CO1 | To understand the importance of Spreading Sequences and Multiuser systems | 2 | 2 |
| CO2 | To understand the importance of Multicarrier in present Communication Systems | 2 | 2 |
| CO3 | To understand the concepts of MIMO Systems, Spatial Multiplexing, and the Importance of Ultra-Wideband Communications | 2 | 2 |
| CO4 | To understand the basic concept of mobile ad hoc networks and Wireless LAN Wi-Fi and IEEE802.11 Standard Bluetooth and IEEE 802.15 Standards | 2 | 2 |
| CO5 | To analyze the concepts of wireless communications and data networking using Relevant software tools | 3 | 3 |

| CO | Syllabus | CH |
|---|---|---|
| 1 | **Spreading Sequences and Multiuser systems:** Properties of spreading sequences, PN sequences, Gold Sequences and Walsh Sequences. Orthogonal variable spreading f actor sequences (OVSF). Introduction to CDMA, DS-CDMA, Multiuser detection, DSSS Techniques, FHSS versus DSSS. | 9 |
| 2 | **Multi-carrier Communication Systems:** Introduction to multiuser modulations, Principal of OFDM (Block Diagram), Cyclic Prefix, Introduction to long term evaluation (LTE-5E), Transceivers, Channel estimation, OFDM issues, Peak to Average Power Ratio (PAPR), Carrier frequency Offset (CFO), Synchronization, PAPR reduction techniques, Multicarrier and Multi-access Systems-OFDMA, MC-CDMA. | 9 |
| 3 | **MIMO Systems, Spatial Multiplexing:** Ultra-Wideband Communications Channel Models, VBAST Architecture, Channel Modelling, SIMO, MISO, MIMO fading channels- MIMO diversity-Almouty, Orthogonal space-time block code, OSTBC- MIMO-SSC, MIMO-OFDM, Introduction to features of UWB technology- applications, UWB indoor channel, UWB Capacity, Pulsed UWB, Pulse shape, Modulation and Multiple access of Pulse UWB, Time Hopping, DSUWB. Challenges for Pulsed UWB systems- Multiband UWB-Modulation of Pulsed Multiband UWB, Multiband OFDM UWB. | 9 |
| 4 | **Ad-Hoc Wireless Networks:** Design Challenges in Ad-hoc wireless networks, the concept of cross-layer design, security in wireless networks, energy-constrained networks. MANET and WSN. Wireless system protocols: mobile network layer protocol (mobile IP, IPv6, dynamic host configuration protocol), mobile transport layer protocol (traditional TCP, classical TCP improvements), support for mobility (wireless application protocol). Wireless LAN Wi-Fi and IEEE 802.11 Standard Bluetooth and IEEE802.15 Standard | 9 |


| Text Books | |
|---|---|
| 1. | Du, K., Swamy, M. N. S. (2010). Wireless Communication Systems: From RF Subsystems to 4G Enabling Technologies. (n.p.): Cambridge University Press |
| 2. | Viswanath, P., Tse, D. (2005). Fundamentals of wireless communication. United Kingdom: Cambridge University Press. |
| 3. | Rappaport Theodore S.Wireless Communications: Principles and Practice, 2/E, (2010). India: Pearson Education. |
| 4. | Kumar, S. (2015). Wireless Communication: The Fundamental and Advanced Concepts. Denmark: River Publishers. |
| **Reference Books** | |
| 1. | Mobile cellular Telecommunications, William C.Y.Lee, TMH Publications 2006 |
| 2. | "New directions in wireless communication research", V. Tarokh, Springer,2009 |
| 3. | "Orthogonal Frequency Division Multiplexing for Wireless Communications", Ye (Geoffrey) Li, Gordon Stuber Springer, 2006. |
| **Web References** | |
| 1 | Advanced Wireless communications 4G Technologies, SAVO Glisic |
| 2 | W. C. Y. Lee, "Mobile Cellular Communications, 2nd Edition", Mc Graw Hill, 1995. |
| 3 | Simon R. Saunders, "Antennas and Propagation for Wireless Communication Systems", 2nd Edition, John Wiley & Son, 2007. |
| 4 | Andrea Goldsmith, "Wireless Communications", Cambridge University Press, 2005. |
| 5 | Vijay K Garg, "Wireless Communications and Networks", Morgan Kaufmann Publishers |


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|---|---|
| 6 | The imprint of Elsevier, USA 2009 (Indian reprint) J. Schiller, "Mobile Communication" 2/e, Pearson Education, 2012. |

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| Course Title: | Artificial Intelligence and Machine Learning | | |
|---|---|---|---|
| Course Code: | 21EC5104 | L-T-P-S | 3-0-2-0 |
| Pre-requisite: | Course Code: Nil<br>Course Title: Nil | Credits | 4 |
| CO. No. | Course Outcome | Mapped PO | BTL |
| CO1 | Understanding of basic search algorithms | 1,2 | 2 |
| CO2 | Study and applications of ANN and deep learning | 2,3 | 1 |
| CO3 | Application of various ML techniques of kMeans, kNN, SVM and GMM | 3,4 | 3 |
| CO4 | Understand various advanced computing methods | 2,4 | 2 |
| C05 | Analysis and implementation of ML and genetic algorithm computing for various applications | 3,4 | 4 |

| CO | Syllabus | CH |
|---|---|---|
| 1 | **Introduction and Overview of AI:** Meaning of AI, The AI Problems, Task Domains. Problems, Problem Spaces & Search: Defining the Problem as a State Space Search, Production Systems – BFS, DFS, Heuristic Search, Problem & Production System Characteristics, Issues in the Design of Search Programs, Common AI Problems. Knowledge Representation using Rules: Procedural vs Declarative Knowledge, Logic Programming, Forward vs Backward Reasoning, Matching& Control Knowledge. | 9 |
| 2 | **Introduction to artificial neural networks (ANN) PDP models:** Interactive and competition (IAC) and Constraint Satisfaction (CS) models. Analysis of Feedforward Neural Networks (FFNN): Overview, linear associative networks, perceptron network, multilayer perceptron, gradient descent methods. Analysis of Feedback Neural Networks (FBNN): Overview, Hopfield model, Boltzmann-Gibbs Law, simulated annealing, Boltzmann machine. | 9 |
| 3 | **Introduction to Machine Learning, Unsupervised & Semi-Supervised Learning:** Clustering (K-means, GMMS), Factor Analysis (PCA, LDA). Supervised Learning: K- Nearest Neighbour, Naive Bayes, Linear Regression, Logistic Regression, Support Vector Machines, Neural Networks and Gaussian Mixture Models Introduction to R Programming. | 9 |
| 4 | **Introduction to Fuzzy logic, Genetic Algorithms:** Concept of "Genetics" and "Evolution" and its application to probabilistic search techniques. Natural Language processing, applications to Computer Vision and Biometrics | 9 |

| Text Books | |
|---|---|
| 1. | Simon Haykin, Neural networks, and learning machines, Pearson Education, 2016 |
| 2. | B Yegnanarayana, Artificial Neural Networks, Prentice-Hall of India, New Delhi, 1999 |
| **Reference Books** | |
| 1. | Mitchell, Tom. Machine Learning. New York, NY: McGraw-Hill, 1997 |
| 2. | MacKay, David. Information Theory, Inference, and Learning Algorithms. Cambridge, UK: Cambridge University Press, 2003 |
| **Web References** | |
| 1. | https://cse.iitkgp.ac.in/ dsamanta/courses/sca/index.htm |
| 2. | https://programs.emeritus.org/mit-pe-digital-transformation/index |

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| Course Title: | IIoT 4.0 for Automation in Industries | | |
|---|---|---|---|
| Course Code: | 21IN51A1 | L-T-P-S | 3-0-0-0 |
| Pre-requisite: | Course Code: Nil<br>Course Title: Nil | Credits | 3 |
| CO. No. | Course Outcome | Mapped PO | BTL |
| CO1 | Knowledge of theory and practice related to Industrial IoT Systems | 1,2 | 2 |
| CO2 | Ability to identify, formulate and solve engineering problems by using Industrial IoT | 2,3 | 3 |
| CO3 | Knowledge of the design and analysis of Cyber-Physical System | 1,2 | 3 |
| CO4 | Ability to implement real field problems by gaining knowledge of Industrial applications with IoT capability. | 1,2,3 | 3 |

| CO | Syllabus | CH |
|---|---|---|
| 1 | **Introduction to Industrial IoT (IIoT) Systems:** The Various Industrial Revolutions, Role of Internet of Things (IoT) & Industrial Internet of Things (IIoT) in Industry, Industry 4.0 revolutions, Support System for Industry 4.0, Smart Factories. Implementation systems for IIoT- Sensors and Actuators for Industrial Processes, Sensor networks, Process automation, and Data Acquisitions on IoT Platform. | 10 |
| 2 | **IIoT Data Monitoring & Control:** Microcontrollers and Embedded PC roles in IIoT, Wireless Sensor nodes with Bluetooth, WiFi, and LoRa Protocols and IoT Hub systems, IoT Gateway, IoT Edge Systems, and Its Programming, Cloud computing, Real-Tim e Dashboard for Data Monitoring, Data Analytics and Predictive Maintenance with IIoT technology. | 10 |
| 3 | **Cyber-Physical Systems:** Next Generation Sensors, Collaborative Platform, and Product Lifecycle Management, Augmented Reality and Virtual Reality, Core elements of Cyber-Physical Systems and Cyber-Physical Production Systems, Control theory, and real-time requirements, Self-organization principles ("Self-X", autonomy, negotiations), Communication in cyber-physical systems. Applications of CPS existing or future applications in the field of manufacturing, traffic, medical technology, etc. | 10 |
| 4 | **Industrial IoT- Applications:** Healthcare, Power Plants, Inventory Management & Quality Control, Plant Safety and Security (Including AR and VR safety applications), Facility Management. Case Studies of IIoT Systems: IIoT application development with Embedded PC-based development boards, Development of m in i-Project on the new version of Operating systems, and Edge development board. That project should also Address the current societal needs. | 10 |

| Textbooks | |
|---|---|
| 1. | Industry 4.0: The Industrial Internet of Things Alasdair Gilchrist Publications: Apress |
| 2. | The Concept Industry 4.0 An Empirical Analysis of Technologies and Applications in Production Logistics Authors: Bartodziej, Christoph Jan Springer: Publication in the field of economic science. |
| 3. | Hands-on Industrial Internet of Things by GiacomoVeneri and Antonio Capasso, Packt publisher. 2018 edition (e-book). |
| 4. | Anandarup Mukherjee, Chandana Roy, and Sudip Misra, Introduction to Industrial Internet of Things and Industry 4. 0 (2020) |
| **Reference Books** | |
| 1. | Embedded System: Architecture, Programming, and Design by Rajkamal, TMH3. |
| 2. | Dr. OvidiuVermesan, Dr. Peter Friess, "Internet of Things: Converging Technologies for Smart Environments and Integrated Ecosystems", River Publishers |
| **Web References** | |
| 1. | https://nptel.ac.in/courses/106105195 |
| 2. | https://www.shodan.io/ |

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| Course Title: | Energy Harvesting Technologies for IoT | | |
|---|---|---|---|
| Course Code: | 21IN51A2 | L-T-P-S | 3-0-0-0 |
| Pre-requisite: | Course Code: Nil<br>Course Title: Nil | Credits | 3 |
| CO. No. | Course Outcome | Mapped PO | BTL |
| CO1 | Understand the concepts of renewable energy systems and energy harvesting for WSN. | 1,5 | 2 |
| CO2 | Understand the solar energy harvesting technologies and designing solar power systems for IoT. protocols for standards | 1,7 | 2 |
| CO3 | Apply mechanical energy harvesting technology for WSN and design a system for real-world problems | 6,7 | 3 |
| CO4 | Apply Electromagnetic energy harvesting technologies for small-power applications and current research on hybrid systems. | 5,7 | 3 |

| CO | Syllabus | CH |
|---|---|---|
| 1 | **Alternate Sources of Energy:** Fossil fuels and nuclear energy, their limitation, the need for renewable energy, and non-conventional energy sources. Introduction to energy harvesting f or autonomous systems; energy requirements and power sources. The role of materials in energy harvesting. Energy storage- Primary and Secondary batteries, Supercapacitors. Energy harvesting circuits and architectures. Power management electronics, Relevant circuits, and systems. | 9 |
| 2 | **Solar Energy Harvesting:** Characteristics of Photovoltaic (PV) Systems, PV Models and Equivalent Circuits, Sun Tracking Systems, Maximum Power Point Tracking (MPPT) Techniques, Power Electronic Interfaces for PV Systems, Sizing the PV Panel and Battery Pack in a Stand-alonePV Applications. Evolution of PV materials and devices. Nanostructuring as a route to cheap and efficient PV technologies. | 9 |
| 3 | **Mechanical Energy Harvesting**: Transduction mechanisms - Physics and Characteristics of Piezoelectric Effects, Materials, and Mathematical Description of Piezoelectricity Effect, Piezoelectric Parameters, and Modelling Piezoelectric Generators, Power Electronic Interfaces f or Piezoelectric Energy Harvesting. Nano-piezoelectric generators: materials, performance, and example devices. New-generationtriboelectric nanogenerators. | 9 |
| 4 | **Electromagnetic Energy Harvesting**: Linear Generators, Physics, Mathematical Models, and Structures, Recent Applications, a nd Projects on Electromagnetic Energy Harvesting. Thermoelectric energy harvesting, Basic thermoelectric theory, Thermoelectric figures of merit, Thermodynamic cycles for pyroelectric energy harvesting. Novel nanostructured thermoelectric materials and devices. Hybrid: Solar PV-Piezoelectric-Electromagnetic-Thermoelectric Energy Harvesting. | 9 |

**Text Books**

1. Yen Kheng Tan, Mark Wong, Energy Harvesting Systems for IoT Applications: Generation, Storage, and Power Management, CRC, 2019.
2. Carlos Manuel Ferreira Carvalho, Nuno Filipe Silva Veríssimo Paulino, "CMOS Indoor Light Energy Harvesting System for Wireless Sensing Applications", springer
3. Di Paolo Emilio, Maurizio, Microelectronic Circuit Design for Energy Harvesting Systems, Springer, 2017.
4. Shashank Priya, Daniel J. Inman, Energy Harvesting Technologies, Springer, 2007.

**Reference Books**

1. Godfrey Boyle, "Renewable Energy, Power for a sustainable future", 2004, Oxford University Press, in association with The Open University.
2. Haruo Kobayashi, Takashi Nabeshima, Handbookof Power Management Circuits, Jenny Stanford Publishing, 2016
3. Mohammad Alha wari, Energy Harvestingfor Self-Powered Wearable Devices, Springer, 2018.
4. Solanki C.S, Solar Photovoltaics - Fundamentals, Technologies, and Applications, PHI, 2015
5. D. Mukherjee, S. Chakrabarti, Fundamentals of Renewable Energy Systems, New Age International, 2004.

**Web References**

1. https://ieeexplore.ieee.org/document/9370135
2. https://www.enocean.com/en/applications/internet-of-things/

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| 3 | https://www.energiot.com/; https://www.coursera.org/learn/energy-harvesting |

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| Course Title: | Data Management and Security | | |
|---|---|---|---|
| Course Code: | 21IN51A4 | L-T-P-S | 3-0-0-0 |
| Pre-requisite: | Course Code: Nil<br>Course Title: Nil | Credits | 3 |
| CO. No. | Course Outcome | Mapped PO | BTL |
| CO1 | Understanding of database systems and architecture, data models, and declarative query languages | 1,2 | 2 |
| CO2 | Understand and characterize modern techniques of database information security threats and techniques for database security assessment | 2,3 | 2 |
| CO3 | analyse information in a database to identify information security incidents | 3,4 | 3 |
| CO4 | Tools for database management systems monitoring | 2,4 | 3 |
| CO | Syllabus | | CH |
| 1 | **Database:** Introduction to Databases and Information Systems, An example of usage context, Database system concepts, and architecture. Overview of Information Security, Database design using the relational model: - Functional dependencies: Keys in a relational model, Concept of functional dependencies, Normal forms based on primary keys, BCNF Further Dependencies: Multi-values dependencies and fourth normal form, join dependencies and fifth normal form, Inclusion dependencies, other dependencies, and normal forms. | | 9 |
| 2 | **Database security:** issues, the role of databases in information systems, Access control management features, Cryptographic data protection, SQL language features, Statistical databases. Database security methods and techniques. Access control to database objects: tables, attributes, records. Triggers, views, data masking. Cryptographic methods of protection. Escaping queries to a database. Change Tracking. Data integrity in the databases. Database backups. | | 9 |
| 3 | Database security lifecycle, data risk assessment, Analyse data threats, risks, and vulnerabilities, the need for a database security architecture, the database security architecture, implementation of a feedback mechanism, adjustment policies and practices based on feedback mechanisms using different security models. | | 9 |
| 4 | Access control of relational databases, Temporal role-based access control in database management, Access control models for XML databases. Managing and Querying Encrypted Data, Security in Data Warehouses and OLAP Systems. Secure Semantic Web Services, Geospatial Database Security, Damage Quarantine and Recovery in Data Processing Systems, Privacy-enhanced Location-based Access Control, Efficiently Enforcing the Security and Privacy Policies in a Mobile Environment. | | 9 |

| Text Books | |
|---|---|
| 1. | An introduction to database systems Date C. J. Pearson 2003 |
| 2. | Principles of Database and Knowledge-Base Systems Ullman J. D. Computer Science Press 1990 |
| 3. | Bhavani Thuraisingham, Database, and Applications Security: Integrating Information Security and Data Management, CRC Press, Taylor & Francis Group, 2005 |
| **Reference Books** | |
| 1. | Database Security Basta A., Zgola M. Cengage Learning 2011 |
| 2. | Implementing database security and auditing Ron Ben Natan Digital Press 2005 |
| 3. | Handbook of Database Security: Applications and Trends by Michael Gertz and Sushil Jajodia |
| **Web References** | |
| 1. | https://www.edx.org/learn/data-management |
| 2. | https://programsandcourses.anu.edu.au/course/comp2420 |

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| Course Title: | Human Machine Interface& Brain-Machine Interface | | |
|---|---|---|---|
| Course Code: | 21IN51B1 | L-T-P-S | 3-0-0-0 |
| Pre-requisite: | Course Code: Nil<br>Course Title: Nil | Credits | 3 |
| CO. No. | Course Outcome | Mapped PO | BTL |
| CO1 | Understanding the basics of HMI: Asimov's Laws, GUI Design, Aesthetics, Developments in Biochips, Heuristics. | 1,2 | 2 |
| CO2 | Understanding the HMI Technologies such as GMOs Models, CMN-GOMS, Fitts Laws, Hick-Hyman Laws, Norman's 7 Principles. | 1,2 | 2 |
| CO3 | Understanding the concept of Brainwaves & BMI | 1,2 | 2 |
| CO4 | Analyzing Humanoids & HMI/BMI Applications: Hierarchical Task] Analysis, Dialog Design, Use of FEM] | 1,2 | 4 |
| CO | Syllabus | | CH |
| 1 | Introduction to HMI: Asimov's Laws, GUI Design, Aesthetics, Developments in Biochips, Heuristics, Introduction to the course and HMI/HCI, HMI/HCI Its history Relation to Ergonomics and Human Factors Problems and challenges Recurrent HMI Themes, Historical evolution of the field, Concept of usability – definition, and elaboration, HCI and software engineering, GUI design and aesthetics, Prototyping techniques. | | 9 |
| 2 | **HMI Technology**: GMOS Models, CMN-GOMS, Fitts Laws, Hick -Hyman Laws, Norman's 7 Principles, Design rules Authority vs. generality Principles, introduction to different types of models, GOMS family of models (KLM and CMN-GOMS, Fitts' law and Hick-Hyman's law, Guidelines in HCI: Norman's seven principles, Norman's model of interaction, Heuristic evaluation, Contextual inquiry, Cognitive walkthrough. | | 9 |
| 3 | **Brainwaves & BMI:** Alpha, Beta, Theta, Gamma wave, Brain-Control Interface, ARMA Model, Introduction to ***Brain Control Interface*** Fundamentals of BCI – Structure of BCI system – Classification of BCI: Invasive, Non-invasive, and Partially invasive BCI Brain signal acquisition, Experiment design, and data analysis (with an explanation of one-way ANOVA), ARMA Model. | | 9 |
| 4 | **Humanoids & HMI/BMI Applications:** Hierarchical Task] Analysis, Dialog Design, Use of FSM] Task modelling and analysis through Hierarchical task analysis (HTA), GUI design f or a m obile phone-based Matrimonial application, Employment Information System for unorganized construction workers on a Mobile Phone. Dialog Design using FSM (finite state machines), Cognitive architecture, Object-Oriented Modelling of User Interface Design. | | 9 |

**Text Books**


1. Dix A., Finlay J., Abowd G. D., and Beale R. Human-Computer Interaction, 3rd edition, Pearson Education, 2005.
2. Preece J., Rogers Y., Sharp H., Baniyon D., Holland S., and Carey T. Human-Computer Interaction, Addison-Wesley, 1994.


**Reference Books**


1. B. Schneiderman; Designing the User Interface, Indian Reprint, Addison Wesley 2000.
2. Jonathan Wolpaw, Elizabeth Winter Wolpaw,' Brain-Computer Interfaces: Principles and practice", Edition 1, Oxford University Press, USA, January 2012
3. Special Issue on Brain Control Interfaces, IEEE Transactions on Neural Systems and Rehabilitation Engineering, Vol 14, June 2006


**Web References**

1. https://www.expertsnotes.com/2016/04/jntuk-r-10-4-2-cse-human-computer.html
2. https://nptel.ac.in/courses/106103115/4
3. http://www.eolss.net/sample-chapters/c18/e6-43-37-06.pdf
4. https://www.Tutorials.in/How_Does_Your_HMI_Design.

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| Course Title: | Data Bases, Data Modelling& Data Structure | | |
|---|---|---|---|
| Course Code: | 21RA51B2 | L-T-P-S | 3-0-0-0 |
| Pre-requisite: | Course Code: Nil<br>Course Title: Nil | Credits | 3 |
| CO. No. | Course Outcome | Mapped PO | BTL |
| CO1 | Understanding of database systems and architecture, and data models. | 1,2 | 2 |
| CO2 | Understand and characterize modern techniques of database information. | 2,3 | 2 |
| CO3 | Understand the concept of database to identify information and ER Modelling. | 3,4 | 2 |
| CO4 | Apply the concurrency control, recovery, security, and indexing for the real-time data | 2,4 | 3 |

| CO | Syllabus | CH |
|---|---|---|
| 1 | **Basic concepts about Algorithms**: Data Structures, Recursion, Iteration, Big-O Notation, Brief Foundations and Applications of Stacks, Queues, Arrays, Linked Lists – Singly, Doubly, and Circular Linked Lists, Trees – Definitions, Representations, Binary Tree and Its Usefulness, Binary Search Tree, Tree Traversal, Threaded Binary Trees, Binary Tree Representation of any Tree other than Binary Tree, Decision Trees, Balanced Tree Schemes – AVL Trees, 2-3 Trees. | 10 |
| 2 | **Basics of Analysis of Algorithms:** Worst case, best case, and average case cost analysis. Asymptotic order of growth notations: Big-O, Omega, and Theta. Analysis of the cost of iterative and recursive algorithms. Basic implementations: tables and lists. Advanced implementations: hash tables, binary search trees, and AVL trees. Graphs Representations: adjacency matrices, adjacencylists, and implicit representations. Depth-first search(DFS). Breadth-first search (BFS). Topologicalsort. Algorithms for shortest paths. Algorithm for minimum spanning trees. | 10 |
| 3 | **Data Modelling:** Entity-Relationship Model: Types of Attributes, Relationship, Structural Constraints - Relational Model, Relational model Constraints - Mapping ER model to a relational schema - Integrity constraints. Relational database management systems. SQL: Data-definition language and data-manipulation language Introductionto the SQL language. | 10 |
| 4 | **Optimization:** Evaluation of Relational Algebra Expressions, Query Equivalence, Join strategies, Query Optimization Algorithms. Transaction Processing: Transaction concepts, Recovery, and Concurrency Control Locking and Timestamp based protocols, Multi-version and Optimistic Concurrency Control schemes, Database security: Threats and countermeasures. Advanced Topics: Object-orientedand Object- Relational Databases, Distributed Databases, Data Warehouse, and Data Mining. | 10 |

**Text Books**

1. RamezElmasri, Shamkant B. Navathe, "Fundamentals of Database Systems", Seventh Edition, Pearson Education, 2016.
2. Principles of Databaseand Knowledge-Base Systems Ullman J. D. Computer Science Press 1990
3. Bhavani Thuraisingham, Database and Applications Security: Integrating Information Security and Data Management, CRCPress, Taylor & Francis Group, 2005

**Reference Books**

1. Database Security Basta A., Zgola M. Cengage Learning 2011
2. Implementing database security andauditing Ron Ben Natan Digital Press 2005
3. Handbook of Database Security: Applications and Trends by Michael Gertz and Sushil Jajodia

**Web References**

1. https://www.fib.upc.edu/en/studies/masters/master-data-science/curriculum/syllabus/ADSDB-MDS

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| Course Title: | Computer Vision & Applications | | |
|---|---|---|---|
| Course Code: | 21IN51B3 | L-T-P-S | 3-0-0-0 |
| Pre-requisite: | Course Code: Nil<br>Course Title: Nil | Credits | 3 |
| CO. No. | Course Outcome | Mapped PO | BTL |
| CO1 | Implement fundamental image processing techniques required for computer vision. | 1,2 | 2 |
| CO2 | Apply Hough Transform for line, circle, and ellipse detections | 1,2 | 3 |
| CO3 | Apply 3D vision techniques. Implement motion-related techniques; develop applications using computer vision techniques. | 1,2 | 3 |
| CO4 | Understands motion analysis. To study some applications of compute vision algorithms. | 1,2 | 2 |

| CO | Syllabus | CH |
|---|---|---|
| 1 | **Introduction to Computer Vision (CV):** Basic Block Diagram Computer Vision; Principle of Computer Vision; Perception of 2 Dimensional & 3Dimensional Transformation (2DCVT &3DCT); 3D Rotation; Histogram, Texture Analysis; Image formation, Geometric Primitives and transformations, Geometric Primitives, 3D to 2D Projections, Lens distortions, Colour, Compositing and matting, Point, Pixel transforms, Histogram equalization, Application: Tonal adjustment, 4D to 11D Transformation on a CV. | 9 |
| 2 | **Optical Features Extraction (OFE):** Overview of Feature Extraction on Computer Vision; Edges, HOG, SIFT, SURF, DTW, Gabor Filter, Scale-Space Analysis; Analysis Edges, Edge detection, Edge linking, Application: Edge editing and enhancement, A comparative study of CFs, LBP, HOG, SIFT, SURF, and BRIEF for security and face recognition, Gabor filter for image processing and computer vision. | 9 |
| 3 | **Video Features & CV Methods:** Optical Flow, Optical Flowrate, Elastic Band, Boundary Detection. Optical Flow-Rate, Optical Flow Estimation, Elastic Band, Selection of Terminal Point of the Line, Texture Segmentation, Edge Flow and Anisotropic Diffusion, Edge Flow Definition, Edge Flow Intensity, Edge Flow Texture, Edge Flow, Edge Flow Basedon Gabor Phase, Edge Flow Integration, Edge Flow Propagation, and Boundary Detection. | 9 |
| 4 | **Pattern Analysis-Dimension Reduction:** VQ, ICA, KNN, PCA, LDA, Classifiers: GMM, SVM, CNN, DNN Gaussian Mixture Model and Deep Neural Network Recognizing faces with PCA and ICA, K-nearest Neighbors (KNN), Classification Model LDA in Python for Computer Vision, LDA in Python for Computer Vision, Deep Learning for Computer Vision, Support Vector Machines (SVM), Image Processing with the Computer Vision API vision field, LDA in Python for Computer Vision, Robust Principal Component Analysis for Computer Vision, Diagnosis and Treatment of Computer Vision Syndrome, Image Classifier using CNN. | 9 |


| Text Books | |
|---|---|
| 1. | Ayman Al Falou -Advanced Secure Optical Image Processing for Communications APRIL 2008 |
| 2. | Richard Szeliski- Computer Vision: Algorithms and Applications March 30, 2008 |
| 3. | Noah Snavely's - Introduction to Computer Vision class at Cornell Tech (Spring 2019) |
| 4. | Bharath Hariharan's - Computer Vision class at Cornell(Spring 2019) |
| **Reference Books** | |
| 1. | Pascal Fua's - Introduction to Computer Vision class at EPFL (Spring 2019). |
| 2. | Bill Freeman, Antonio Torralba, and Phillip Isola's 6.819/6.869- Advances in Computer Vision class at MIT (Fall 2018) |
| 3. | Alyosha Efros, Jitendra Malik, and Stella Yu's CS280- Computer Vision class at Berkeley (Spring 2018) |
| 4. | Ioannis Gkioulekas's - Computer Vision class at CMU (Spring 2019) |
| 5. | Deva Ramanan's - Computer Vision class at CMU (Spring 2017) |
| **Web References** | |
| 1. | https://www.javatpoint.com/computer-graphics-elastic-or-rubber-band-techniques |
| 2. | http://www.cs.jhu.edu/~misha/ReadingSeminar/Papers/Ma00.pdf |
| 3. | https://www.geeksforgeeks.org/image-classifier-using-cnn/ |
| 4. | http://vqlsr.com/vision-services/computer-vision.html |


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| Course Title: | System on Chip Design | | |
|---|---|---|---|
| Course Code: | 21EC51Q2 | L-T-P-S | 3-0-0-0 |
| Pre-requisite: | Course Code: Nil<br>Course Title: Nil | Credits | 3 |
| CO. No. | Course Outcome | Mapped PO | BTL |
| CO1 | Acquire knowledge about Top-down SoC design flow | 1,2 | 1 |
| CO2 | Understand the system-level design of communication networks. | 2,3 | 2 |
| CO3 | Apply system-level design and analyse MPSoC concepts | 1,2 | 3 |
| CO4 | Acquire knowledge about NoC | 1,2,3 | 2 |
| **CO** | **Syllabus** | | **CH** |
| 1 | **SoC and H/W-S/W Co-Design:** Introduction to SoC design, SoC design f low, System-level design issues in SoC, Transition of SoC design methodology, Classic Hardware-Software co - design, System-level H/W-S/W co-design process, Design flow of co-design process | | 10 |
| 2 | **System-level design**- Platform based SoC design, Types of platforms based SoC, Concepts of bus-based on-chip communication architecture: Bus topologies – Bus physical structure – Arbitration schemes – Bus data transfer modes – Bus clocking, On-chip standard bus architecture: AMBA 2.0 and AMBA 3.0 bus standards | | 10 |
| 3 | **Multi-Processor SoC (MPSoC) –** Introduction to MPSoC, Types of MPSoC, Design methodologies, Design issues of MPSoC, Designing of energy-aware MPSoC: Processor design – Memory Design – On-Chip Communication Design, MPSoC performance modelling: Architecture component performance modelling and analysis – Process execution modeling – Modelling of shared resources – Global performance analysis. | | 10 |
| 4 | **Network-on-Chip (NoC) –** ASIC to System and NOC, Comparison of bus-based and No C based system design, NoC for SoC design, Network topologies, Switching strategies, Routing algorithms, Flow control and clocking schemes, Quality of service (QoS) in NOC. | | 10 |

| **Text Books** | |
|---|---|
| 1. | Sudeep Pasricha, Nikil Dutt, "On-Chip Communication Architectures: System-on-Chip Interconnect", Morgan Kaufmann, Elsevier, Second Edition, 2008 |
| **Reference Books** | |
| 1. | Hoi- Jun Yoo, Kangmin Lee and Kyong Kim, "Low Power NoC for High-Performance SoC Design", CRC Press, 2008 |
| 2. | Ahmed Amine Jerraya, Wayne Wolf, "Multiprocessor Systems-on-Chip", Morgan Kaufmann, Elsevier, Second Edition, 2005 |

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| Course Title: | Wireless Sensor Network and Security | | |
|---|---|---|---|
| Course Code: | 21IN5202 | L-T-P-S | 3-0-2-0 |
| Pre-requisite: | Course Code: Nil<br>Course Title: Nil | Credits | 4 |
| CO. No. | Course Outcome | Mapped PO | BTL |
| CO1 | Understand the fundamentals of wireless sensor networks and the various protocols at various layers. | 1,2 | 2 |
| CO2 | Understand MAC Protocols and sensor networks application. | 1,2 | 2 |
| CO3 | Understand the issues pertaining to sensor networks and the challenges involved in managing a sensor network. | 1,4 | 2 |
| CO4 | Identify security threats in wireless networks and design strategies to manage network security | 2,4 | 3 |
| CO5 | Design and Development of energy efficient and Secured Wireless Sensor Networks in IoT environment. | 3,5 | 4 |

| CO | Syllabus | CH |
|---|---|---|
| 1 | **Introduction:** Fundamentals of wireless communication technology, the electromagnetic spectrum radio propagation, characteristics of wireless channels, modulation techniques, multiple access techniques, wireless LANs, PANs, WANs, and MANs, Wireless Internet, IEEE 802.15.4. Network Architecture-Traditional layered stack, Cross-layer designs, Sensor Network Architecture. Design of sensor network, sensor network architecture, data dissemination and gathering. | 9 |
| 2 | **MAC Protocols:** MAC Protocols: Issues in designing MAC protocols for adhoc wireless networks, design goals, classification of MAC protocols, MAC protocols for sensor network, location discovery, quality, other issues, S-MAC. WSN potential applications in environmental monitoring, surveillance, military, health, and security. | 9 |
| 3 | **Network layer protocols:** Designing a routing protocol, classification of routing protocols, table-driven, on-demand, hybrid, flooding, hierarchical, and power aware routing protocols. Data dissemination and processing, multihop and cluster-based routing protocols-Energy efficient routing- Geographic routing, Flat-Based Routing, Hieratical-Based Routing and Location-Based Routing. | 9 |
| 4 | **Security in Sensor Networks:** Fundamentals of network security-challenges and attacks - the Growth of Sensor Networks, Design Factors in Sensor Networks, Security in Sensor Networks, Security Mechanisms and Best Practices for Sensor, Protocols, Confidentiality, Integrity, Authenticity, Nonrepudiation, Freshness, Availability, Intrusion Detection, Key Management Case study- Possible strategies against WSN Attacks. Handling attacks in Tiny OS. Trends in Sensor Network Security. | 9 |

| Text Books | |
|---|---|
| 1. | Holger Karl, Technical University of Berlin, Andreas Willig, University of Potsdam, Protocols and Architectures for Wireless Sensor Networks, Wiley, 2005 |
| 2. | William Stallings, "Wireless Communications and Networks ", Pearson Education – 2004 |
| **Reference Books** | |
| 1. | Y. Xiao, X. Shen, D. Z.Du, Wireless Network Security, Springer International Edition. |
| 2. | Lei Chen, JiahuangJi, Zihong Zhang, Wireless Network Security, Springer Science& Business Media. |

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| | | | |
|---|---|---|---|
| **Course Title:** | **IoT Cloud computing** | | |
| **Course Code:** | **21IN5203** | **L-T-P-S** | **3-0-2-0** |
| **Pre-requisite:** | **Course Code: Nil**<br>**Course Title: Nil** | **Credits** | **4** |
| **CO. No.** | **Course Outcome** | **Mapped PO** | **BTL** |
| **CO1** | Understand the concepts of IoT system architecture, important IoT features and platforms | **1,3** | **2** |
| **CO2** | Distinguish the cloud computing architecture, web services and related services | **1,5** | **2** |
| **CO3** | Apply the cloud computing platforms such as Microsoft Azure and Google Cloud Platform (GCP) | **1,5** | **3** |
| **CO4** | Analyse the security in cloud computing, significance of Fog computing and green cloud | **1,5** | **4** |
| **CO5** | Analysis and study of networking with IoT and Cloud platforms | **5,6,7** | **4** |

| **CO** | **Syllabus** | **CH** |
|---|---|---|
| 1 | **Introduction to the Internet of Things**: IoT system architecture and standards; Introduction to Embedded Systems; Hardware platforms f or I o T; The Arm Cortex-M4 Processor architecture; Interrupts and low power features; Introduction to Mbed Platform; IoT Connectivity; The Cloud; IoT Security; Current and Future IoT trends. | 9 |
| 2 | **Cloud Computing**: Introduction; Architecture; Deployment models Virtualization; XML Basics; Webs services & Service Oriented Architecture; Service Level Agreement; Cloud Economics; Managing Data. | 9 |
| 3 | Introduction to MapReduce; Open Stack; Opensource cloud – Open stack demo; Cloud Computing Case Study with a Commercial Cloud-Microsoft Azure; Cloud Computing Demo - Microsoft Azure Cloud Computing Case Study - Google Cloud Platform (GCP) Cloud SLA (Cloud Service-Level Agreement); Cloud – Economics Cloud – MapReduce; Cloud – Resource management. | 9 |
| 4 | Cloud computing – Security; Cloud Computing Security Issues in Collaborative Saa S Cloud; Cloud Computing Broker for Cloud Marketplace; Mobile Cloud Computing; Fog Computing; Use Case-Geo-spatial Cloud; DOCKER Container; Green Cloud; Sensor Cloud Computing; IoT Cloud; Research Areas. | 9 |


| **Text Books** | |
|---|---|
| 1. | Bahga, Arshdeep, and Vijay Madisetti. Internetof Things: A hands-onapproach. Vpt, 2014. |
| 2. | Marinescu, Dan C. Cloud computing: theory and practice. Morgan Kaufmann, 2022. |
| 3. | Buyya, Rajkumar, James Broberg, and Andrzej M. Goscinski, eds. Cloudcomputing: Principles and paradigms. John Wiley & Sons, 2010 |
| **Reference Books** | |
| 1. | Sosinsky, Barrie. Cloud computing bible. John Wiley & Sons, 2010. |
| 2. | Smith, Jim, and Ravi Nair. Virtual machines: versatile platforms for systems and processes. Elsevier, 2005 |
| 3. | Ruparelia, Nayan B. Cloud computing. Mit Press, 2016. |
| **Web References** | |
| 1 | https://www.altexsoft.com/blog/iot-architecture-layers-components/ |
| 2 | https://dl.acm.org/doi/fullHtml/10.1145/1364782.1364786 |
| 3 | https://ieeexplore.ieee.org/abstract/document/5474674 |
| 4 | https://link.springer.com/chapter/10.1007/978-3-642-10665-1_63 |


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| Course Title: | Big data Analytics for IoT | | |
|---|---|---|---|
| Course Code: | 21IN5204 | L-T-P-S | 3-0-0-0 |
| Pre-requisite: | Course Code: Nil<br>Course Title: Nil | Credits | 3 |
| CO. No. | Course Outcome | Mapped PO | BTL |
| CO1 | Big Data Science and Machine Intelligence | 1,2 | 2 |
| CO2 | Machine Learning for Big Data in Healthcare Applications | 1,2 | 2 |
| CO3 | Apache Hadoop and Apache Spark | 1,2 | 2 |
| CO4 | Data Analytics using Azure | 2,4 | 3 |

| CO | Syllabus | CH |
|---|---|---|
| 1 | **Big Data Acquisition and Analytics Evolution** - Big Data Value Chain Extracted from Massive Data - Data Quality Control, Representation and Database Models - Big Data Acquisition and Pre-processing - Evolving Data Analytics over the Clouds - **Machine Intelligence and Big Data Applications** - Data Mining and Machine Learning - Big Data Applications | 9 |
| 2 | **Healthcare Problems and Machine Learning Tools** - Healthcare and Chronic Disease Detection Problem - Software Libraries for Machine Learning Applications - **Big Data Analytics for Healthcare Applications** - Healthcare Big Data Pre-processing - Predictive Analytics for Disease Detection - Performance Analysis of Five Disease Detection Methods - Mobile Big Data for Disease Control | 9 |
| 3 | **Apache Hadoop** – Introduction - Hadoop Common- Hadoop Distributed File System (HDFS) - Yet Another Resource Negotiator (YARN) - MapReduce V1 and V2, Storage options – Features - **Apache Spark** – Introduction – Map Reduce issues - Spark's stack - Features | 9 |
| 4 | **Azure Stream Analytics** - Key Benefits and Capabilities - Creating an Azure Stream Analytics Job – Scaling – Event ordering – Audit Log – **Azure Data Lake Analytics** – Creating and Working with Azure Data Lake Analytics - **Azure HDInsight** - Big Data Processing Decision Tree | 9 |

| Text Books | |
|---|---|
| 1. | Kai Hwang, Min Chen, "Big-Data Analytics for Cloud, IoT and Cognitive Computing" JohnWiley & Sons, 2017, ISBN: 9781119247029 |
| **Reference Books** | |
| 1. | Venkat Ankam, "Big Data Analytics", Packt Publishing Ltd, UK, 2016, ISBN 978-1-78588-469-6 |
| 2. | Scott Klein, "IoT Solutions in Microsoft's Azure IoT Suite Data Acquisition and Analysis in the Real World", Apress, Redmond, Washington, USA, ISBN-13 (pbk): 978-1-4842-2142-6 |

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| Course Title: | IoT System Design Techniques | | |
|---|---|---|---|
| Course Code: | 21IN5205 | L-T-P-S | 3-1-2-0 |
| Pre-requisite: | Course Code: Nil<br>Course Title: Nil | Credits | 5 |
| CO. No. | Course Outcome | Mapped PO | BTL |
| CO1 | Understand various building blocks and working of state-of-the-art IoT systems and IoT system design enabling technologies. | 1,2 | 2 |
| CO2 | Understand the Real-world design constraints and design and develop the system with Hardware and software tools. | 1,2 | 3 |
| CO3 | Understand Product Design and Development process and gain enough insights to conceive and build IoT systems on their own | 1,2 | 2 |
| CO4 | Apply the design concepts for Industrial IoT and Health Care applications. | 2,4 | 3 |
| CO5 | IoT system design and development, cloud computing, and data analysis. | 5,7 | 4 |

| CO | Syllabus | CH |
|---|---|---|
| 1 | **IoT Design Methodology**: Specification - Purpose & Requirements, Process, Domain Model, Information Model, Service, IoT Level, Functional View, Operational View. Device & Component Integration, Application Development. IoT System Design Challenges: Availability of internet/ Network Communication, Acceptability among the society and individuals, Low-cost smart sensor node development, Computational ability, Security issues, Scalability, Reliability, Fault Tolerance, Power Consumption of nodes and transceiver. | 9 |
| 2 | **Real-World Design Constraints**: Introduction, Technologies involved in IoT development, Technical Design constraints, hardware platforms, Wireless networking equipment, and configurations, Connecting to cloud and cloud storage, Data analytics, representation and visualization, Interaction, Remote monitoring and control, and Software & Management Tools. Application Development with Sensors and Sensor Node and interfacing using any Embedded target boards (Arduino/ ESP-32/ Raspberry Pi / Intel Galileo/ARM Cortex) | 9 |
| 3 | **Product Design and Development:** Development processes, identifying customer needs, establishing a product, specifications, Concept generation, Concept selection, Product architecture, Design for Manufacturing, Prototyping, Robust Design, Patents, and Intellectual property, Product Development Economics, Managing Product Development Projects. Case Studies: Smart City with Smart Vehicles and Smart Home, Smart Grid, Agriculture-Agri of Things. | 9 |
| 4 | **Industrial IoT and Health Care**: Fundamentals and Components, Industrial Manufacturing, Monitoring, Control, Optimization and Autonomy, Introduction to Hadoop and big data analytics, smart Manufacturing, Future Factory Concepts, Brownfield IoT, Smart Objects, Smart Applications. The architecture of IoT for Healthcare, Multiple views coalescence, Internet of Medical Things (IoMT), Wearable smart devices for Remote monitoring of Physiological parameters. | 9 |

**Text Books**

1. Vijay Madisetti and ArshdeepBahga, "Internet of Things (A Hands-on-Approach)", 1 st Edition, VPT, 2014
2. Adrian McEwen, Hakim Cassimally, "Designing the Internet of Things", November 2013, John Wiley and Sons
3. Sumeet Arora, Ramachandra Gambheer, Meenakshi Vohra, Design of Seeure IoT Systems: A Praetical Approach Across Industries, Mc Graw Hill, 2021.

**Reference Books**

1. Francis da Costa, "Rethinking the Internet of Things: A Scalable Approach to Connecting Everything", 1 st Edition, Apress Publications, 2013
2. CunoPfister, Getting Started with the Internet of Things, O"Reilly Media, 2011
3. Zach Shelby, Carsten Bormann, "6LoWPAN: The Wireless Embedded Internet", John Wiley and Sons.
4. OvidiuVermesan,"Internet of Things: Converging Technologies for Smart Environments and Integrated Ecosystems", River Publishers

**Web References**

1. https://onlinecourses.nptel.ac.in/noc21_ee85/preview ; https://nptel.ac.in/courses/108/108/108108098/
2. https://www.arm.com/resources/education/online-courses/internet-of-things
3. https://www.edx.org/course/iot-system-design-software-and-hardware-integratio

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|---|---|
| 4 | https://www.coursera.org/learn/m2m-iot-interface-design-embedded-systems |

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Guntur Dist., A.P. PIN: 522

**Koneru Lakshmaiah Education Foundation**
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Phone No. 08645 - 350200, www.klef.ac.in; www.klef.edu.in; www.kluniversity.in
Admin Off: 29-36-38, Museum Road, Governorpet, Vijayawada - 520 002, Ph: +91 - 866 - 3500122, 2577715, 2576129

| Course Title: | Edge Computing and Mobile Applications | | |
|---|---|---|---|
| Course Code: | 21IN51C1 | L-T-P-S | 3-1-2-0 |
| Pre-requisite: | Course Code: Nil<br>Course Title: Nil | Credits | 3 |
| CO. No. | Course Outcome | Mapped PO | BTL |
| CO1 | Understand various Edge computing scenario and casestudies. | 1,2 | 2 |
| CO2 | Understand the Edge computing Architectures and protocols. | 1,2 | 3 |
| CO3 | Develops mobile computing and standardized hardware and software platforms. | 1,2 | 2 |
| CO4 | Apply the Edge concepts for Mobile application development. | 2,4 | 3 |
| CO5 | IoT system design and development, Edge computing, and Mobile Applications. | 5,7 | 4 |

| CO | Syllabus | CH |
|---|---|---|
| 1 | **IoT and Edge Computing:** Definition and Introduction to Edge Computing Scenarios and Use cases - purpose, Edge computing hardware architectures, Edge platforms, Edge vs Fog Computing, Communication Models - Edge, Fog, and M2M. Edge devices, edge server cluster, cloud server, networking architecture, network management and control, edge computing simulators | 9 |
| 2 | **Edge to Cloud Protocol:** MQTT, MQTT publish-subscribe, MQTT architecture details, MQTT state transitions, MQTTpacket structure, MQTT data types, MQTT communication formats, MQTT working example. Edge computing with Raspberry Pi, Industrial and Commercial IoT, and Edge, Edge computing and solutions. | 9 |
| 3 | **Mobile Computing**: – Mobile Computing Vs wireless, Networking – Mobile Computing Applications – Characteristics of Mobile Computing-Structure of Mobile Computing Application. MAC Protocols – Wireless MAC Issues – Fixed, Assignment Schemes– Random Assignment Schemes – Reservation Based Schemes. | 9 |
| 4 | **MOBILE PLATFORMS AND APPLICATIONS**: Mobile Device Operating Systems – Special Constraints & Requirements – Commercial Mobile Operating Systems – Software Development Kit: iOS, Android, BlackBerry, Windows Phone – MCommerce –Structure – Pros & Cons – Mobile Payment System – Security Issues. | 9 |

| Textbooks | |
|---|---|
| 1. | IoT and Edge Computing for Architects - Second Edition, by Perry Lea, Publisher: Packt Publishing, 2020, ISBN: 9781839214806 |
| 2. | Raspberry Pi Cookbook, 3rd Edition, by Simon Monk, Publisher: O'Reilly Media, Inc., 2019, ISBN: 978149204322. |
| 3. | Mobile Communications by Jochen H. Schller, Second Edition, Pearson Education, NewDelhi, 2007. |
| **Reference Books** | |
| 1. | Fog and Edge Computing: Principles and Paradigms by Rajkumar Buyya, Satish Narayana Srirama, wiley publication, 2019, ISBN: 9781119524984. |
| 2. | David Jensen, "Beginning Azure IoT Edge Computing: Extending the Cloud to the Intelligent Edge, MICROSOFT AZURE |
| 3. | Introduction to Wireless and Mobile systems by Dharma Prakash Agarval, Qingand An Zeng, Thomson Asia Pvt Ltd, 2005. |
| **Web References** | |
| 1 | https://www-users.cselabs.umn.edu/classes/Fall-2021/csci8980-ec/ |

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|---|---|
| 2 | https://canvas.harvard.edu/courses/8361/assignments/syllabus |

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| | | | |
|---|---|---|---|
| **Course Title:** | **5G NR - Next Generation Wireless Technologies** | | |
| **Course Code:** | **21IN51C2** | L-T-P-S | 3-0-0-0 |
| **Pre-requisite** | NIL | Credits: | 3 |
| **CO. No** | **Course Outcome** | Mapped PO/PSO | BTL |
| **CO1** | Understand the 5G New Radio and Road map to 5G, Pillars of 5G New Multicarrier Modulation schemes. | 1,2 | 2 |
| **CO2** | Apply the massive MIMO technologies for 5G and look into the schemes of pre-coding, channels, and communications on machine and device to device | 1,2 | 3 |
| **CO3** | Applying the 5G technology to Millimeter-wave communication and transceiver Architecture | 1,2 | 3 |
| **CO4** | Applying the concepts of 5G on vehicular communication, architectures of intelligent vehicles. | 1,2 | 3 |
| CO | Syllabus | | CH |
| 1 | **5G New Radio:** Historical Trends in Wireless Communications, 1G, 2G, 3G, 4G, Evolution of LTE to Beyond 4G, Introduction to 5G-NR, 5G Road map, Pillars of 5G, 5G use cases-eMMB, m MTC, URLLC, The spectrum of 5G mobile systems, Frequency bands for new radio, New Multicarrier Modulation schemes, (FBMC, GFBM, BFDM, UFMC, and TFP), Waveform Pulses – RRC pulse, PHYDYAS pulse, DC pulse | | 10 |
| 2 | **Massive MIMO for 5G and Beyond 5G**: Introduction to MIMO, Massive MIMO theory- (Downlink, Linear pre-coding schemes, Uplink, Linear detection schemes, Channel estimation), Massive MIMO channels- (Existing conventional MIMO models, Necessary model extensions, MIMO extension of the COST2100 channel model), Beyond 5G-Nonorthogonal multiple access (NOMA), Machine type communications, Device to device communications. | | 10 |
| 3 | **Millimeter wave Communications**: Millimeter wave characteristics, Development of millimeter wave standards, Modulations of millimeter wave communications- (OOK, PSK, FSK), Millimeter wave link budget, Transceiver Architecture, Millimeter wave antennas- Path Loss, Antenna directivity and Antenna beam width, Advanced diversity over MIMO channels for millimeter wave systems-(Spatial and Temporal diversity, Spatial and Frequency diversity), Preamble design. | | 10 |
| 4 | **Vehicular Communications and other Advanced Topics**: Introduction to Vehicular communication, Applications of Vehicular communications- (Safety, Resource efficiency, Infotainment), Communication Regimes- (Bi-directional, position based, Multi hop position based), Architectures for intelligent vehicles- (protocol architectures in communications, architectures f or platoon, architectures for sensors). Overview of Cognitive Radio technology in 5G wireless networks, Spectrum optimization using Cognitive Radio, Dynamic spectrum access, Cognitive Radio and Carrier Aggregation. | | 10 |
| **Text Books** | | | |
| 1. | 5G NR: The Next Generation Wireless Access Technology, Erik Dahlman, Stefan Parkvall and Johan Skold, Academic Press, 1 edition (17 August 2018). | | |
| 2. | Fundamentals of 5GMobile Networks, Jonathan Rodriguez Wiley, 1 edition (27 April 2015). | | |
| **Reference Books** | | | |
| | | | |
| 1. | Signal Processing for 5G: Algorithms and Implementations, Fa -Long Luo and Charlie Jianzhong Zhang, Wiley-Blackwell, 1 edition (14 October 2016) | | |
| 2. | A Comprehensive Surveyof RAN Architectures Toward 5G Mobile Communication System, Mohammad Asif Habibi, MeysamNasimi, Bin Han, May 28, 2019, date of current version June 11, 2019. | | |
| 3. | Emergingwireless lans, wireless pans, and wireless mans, yangxiaoyipan, John Wiley & sons, inc.,publication, 2009. | | |
| 4. | Wireless communication standards, Todor cook lev, IEEE press,2004 Automotive Embedded Systems Handbook CRC Press Taylor & Francis Group Richard Zurawski | | |

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| Course Title: | Adaptive motion control systems for automation and robotics | | |
|---|---|---|---|
| Course Code: | 21RA5IC1 | L-T-P-S | 3-0-0-0 |
| Pre-requisite: | Course Code: Nil<br>Course Title: Nil | Credits | 3 |
| CO. No. | Course Outcome | Mapped PO | BTL |
| CO1 | Understand the Principles and design concepts of various adaptive control Mechanisms. | 1,2,3 | 2 |
| CO2 | Understand the Principles and design concepts of Autonomous Tracked Robots | 4,5 | 2 |
| CO3 | Understand the Principles and design concepts of Motion Vision and Motion Estimation | 5,6 | 3 |
| CO4 | Understand the Principles and design of Optimization for Motion Control Systems | 6,7 | 3 |

| CO | Syllabus | CH |
|---|---|---|
| 1 | Introduction to adaptive control, Least Squares and Regression Models, Estimating Parameters in Dynamical Systems, Indirect Self-tuning Regulators, Continuous-Time Self tuners, Direct Self Tuning Regulators, Stochastic Self-tuning Regulators, Adaptive predictive Control. Model reference adaptive control -Determination of the Adaptive Ga in, Review of Lyapunov stability theory, Design of MRAS using Lyapunov theory, Bounded-Input Bounded-Output Stability, Application to adaptive control. Stochastic Adaptive control. Auto Tuning. | 10 |
| 2 | Autonomous Tracked Robots in Planar Off-Road Conditions - Importance of Tracked Vehicles, Modelling Tracked Robots- Extended Kinematic Model with Slip- Extended Trajectory Tracking Error Model with Slip- Discrete-Time Trajectory Tracking Error Model and Model Uncertainties- Localization of Tracked Robots, Estimating Robot Displacement, Estimating Robot Orientation: Visual Compass, Localization Approach Combining Visua l Odometry with Visual Compass, Adaptive Motion Controllers- Slip Compensation Adaptive Controller Using Dynamic Feedback Linearization, Slip Compensation Adaptive Controller Using an LMI-Based Approach, Input and state Constraints, Robust Predictive Motion Controller | 10 |
| 3 | Motion Vision - Visual motion estimation, Temporal integration, Motion estimation hardware, Real-time motion processing- Frequency domain analysis of image motion, Rigid body motion and the pinhole camera model, Linking temporal aliasing to the safety margin, Motion estimation for autonomous navigation- motion estimation algorithm, Monte Carlo study of the LTSV estimator, Dynamic scale space implementation, Temporal integration implementation. | 10 |
| 4 | Advanced Optimization for Motion Control Systems- Model-Based Optimization for Motion Control Systems, Constrained Linear Quadratic Optimization Algorithm, Constrained H2 Optimization Algorithm, Constrained H2 Guaranteed Cost Optimization Algorithm, Da ta - Based Optimization for Motion Control Systems- Reduced-Order Inverse Model Optimization Algorithm, Optimization Algorithm for Reference Profile Alteration. | 10 |

**Text Books**

1. Karl Ja Astrom_ Bjorn Wittenmark- Adaptivecontrol(1994_Dover Publications)
2. Ramón González, Francisco Rodríguez,José Luis Guzmán "Autonomous TrackedRobotsin Planar Off -Road Conditions" http://www.springer.com/series/13304
3. [IEE Control Series] Ljubo Vlacic Julian Kolodko - Motion Vision_ Design of Compact Motion Sensing Solutions for navigation of Autonomous systems, 2005, Published by The Institution of Engineering a nd Technology, London, United Kingdom

**Reference Books**

1. H. K. Khalil, Nonlinear Systems, 3rd edition, Prentice Hall, 2002
2. S. Sastry and M. Bodson, Adaptive Control, Prentice-Hall, 1989
3. Andrew Parr, Industrial drives, Butterworth– Heineamann

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| Course Title: | Optimization Algorithms for Autonomous Systems | | |
|---|---|---|---|
| Course Code: | 21RA51D1 | L-T-P-S | 3-0-0-0 |
| Pre-requisite: | Course Code: Nil<br>Course Title: Nil | Credits | 3 |
| CO. No. | Course Outcome | Mapped PO | BTL |
| CO1 | Understand Machine Learning based Optimization models for various problem specific solutions. | 1,2 | 2 |
| CO2 | Apply evolutionary programming and strategies in engineering aspects. | 2,3 | 3 |
| CO3 | Design Mathematical Models of Genetic Algorithms fitness functions. | 2,3 | 3 |
| CO4 | Apply and analysis of advanced autonomous optimization techniques. | 2,4 | 3 |
| CO | Syllabus | | CH |
| 1 | **Machine Learning based Optimization for Autonomous systems:** Evolutionary optimization-optimization process-basic optimization problem-Derivatives and gradients-Bracketing-local decent-Direct method-stochastic method-population method-linear constrained optimization-multi objective optimization-surrogate optimization- optimization under uncertainty-uncertainty propagation-discrete optimization-expression optimization-design studies on ML optimization using Julia and python. | | 9 |
| 2 | **Optimization on constrained un-constrained model:** Constrained optimization, un-Constrained Optimizations, Multi-objective optimization, multi-model optimization, Combinatorial optimization, Hill-climbing, Monte-Carlo importance, Intelligence-Adaptation, Randomness, Communication. **Genetic Algorithm (GA):** History- Charles Darwin, Gregor Mendel; A simple binary GA; Simple GA for Robot design; Selection; Cross-over; Mutation; Tuning parameters, Simple continuous GA. | | 9 |
| 3 | **Mathematical Models of Genetic Algorithms:** Modeling GA: Schema theory; Markov chains; Markov model for GA- Selection, mutation and cross-over; Dynamic system model-Selection, Mutation, Cross-over-Evolutionary Programming (EP) and Strategies: Continuous EP; Finite-state-machine optimization; Discrete evolutionary programming; The Prisoner's dilemma; Artificial ant problem; (1 + 1) evolutionary strategy; The 1/5 rule of derivation; The (μ + 1) evolution strategy; The (μ + λ) and (μ, λ) evolution strategy; Self adaptive evolution strategy | | 9 |
| 4 | **Evolutionary and Deep Neural Network Optimization algorithm for Autonomy:** Basic terms and architecture of Deep Neural networks -partial Swam optimization (PSO)-Optimized Support Vector Machine (OSVM)-optimized SLAM- shuffled Frog leafing optimization-artificial bee colony optimization- grey wolf optimizer-whale optimization- Bat algorithm-firefly algorithm-Gravitational Search algorithm-convex optimization-Teamwork on Design project of optimization algorithm using MATLAB, Webot, python | | 9 |

| Text Books | |
|---|---|
| 1. | Kochenderfer, Mykel J. Wheeler, Tim Allan - Algorithms for optimization (2019, The MIT Press) |
| 2. | Dan Simon," Evolutionary Optimization Algorithms", Wiley |
| 3. | Altaf Q. H. Badar - Evolutionary Optimization Algorithms (2021, CRC Press) |
| **Reference Books** | |
| 1. | Artificial-intelligence-modern-approach.9780131038059.25368 |

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| Course Title: | BlockChain & Cyber Security | | |
|---|---|---|---|
| Course Code: | 21EC51D4 | L-T-P-S | 3-0-0-0 |
| Pre-requisite: | Course Code: Nil<br>Course Title: Nil | Credits | 3 |
| CO. No. | Course Outcome | Mapped PO | BTL |
| CO1 | Understand emerging abstract models for Blockchain Technology | 1,2 | 2 |
| CO2 | Analyze the concept of bitcoin and the mathematical background behind it | 2,3 | 3 |
| CO3 | Apply the tools for understanding the background of cryptocurrencies | 2,3 | 3 |
| CO4 | Identify major research challenges and technical gaps existing between theory and practice in the cryptocurrency domain | 1,2 | 2 |

| CO | Syllabus | CH |
|---|---|---|
| 1 | **Introduction:** Basic of Blockchain Architecture, Challenges, Applications, Block chain Design Principles: The Blockchain Ecosystem, The consensus problem, Asynchronous Byzantine Agreement, AAP protocol and its analysis, Nakamoto Consensus on permission-less, nameless, peer-to-peer network, Abstract Models for BLOCKCHAIN - GARAY model: RLA Model, Proof of Work (PoW) as random oracle, formal treatment of consistency, liveness and fairness, Proof of Stake ( PoS) based Chains - Hybrid models (PoW + PoS). | 9 |
| 2 | **Cryptographic Fundamentals:** Cryptographic basics for crypto currency, a short overview of Hashing, cryptographic algorithm, SHA 256, signature schemes, encryption schemes and elliptic curve cryptography- Introduction to Hyperledger, Hyperledger framework, Public and Private Ledgers. Bit Coin - Wallet - Blocks - Merkley Tree - hardness of mining – transaction verifiability - anonymity - forks - double spending - mathematical analysis of properties of Bit coin. Bitcoin blockchain, the challenges, and solutions, proof of work, Proof of stake, alternatives to Bitcoin consensus, Bitcoin scripting language and their uses. | 9 |
| 3 | **Ethereum:** Ethereum Virtual Machine (EVM) - Wallets for Ethereum - Solidity - Sm a rt Contracts - some attacks on smart contracts. Ethereum and Smart Contracts - The Turing Completeness of Smart Contract Languages and verification challenges- comparing Bitcoin scripting vs. Ethereum Smart Contracts. | 9 |
| 4 | **Blockchain Implementation Challenges-** Zero Knowledge proofs and protocols in Block chain, Succinct noninteractive argument for Knowledge (SNARK), pairing on Elliptic curves, Zcash - attacks on Blockchains – such as Sybilattacks, selfish mining, 51% attacks - -adventof algorand, and Shardingbased consensus algorithms | 9 |

**Text Books**


1. Melanie Swan, "Block Chain: Blueprint for a New Economy", OReilly, first edition – 2015
2. Daniel Drescher, "Block Chain Basics", Apress; 1stedition, 2017
3. Anshul Kaushik, "Block Chain and Crypto Currencies", Khanna Publishing House, Delhi.
4. Imran Bashir, "Mastering Block Chain: Distributed Ledger Technology, Decentralization and Smart Contracts Explained", Packt Publishing, first edition – 2012.


**Reference Books**


1. Ritesh Modi, "Solidity Programming Essentials: A Beginners Guide to Build Smart Contracts for Ethereum andBlock Chain", Packt Publishing.


**Web References**

1. https://developer.ibm.com/patterns/create-and-deploy-block chain-network using fabric-sdk-java/

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https://docs.docker.com/getstarted/https:/console.ng.bluemix.net/docs/services/ block%2520chain/index.html

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| Course Title: | **Automotive Electronics & Avionics** | | |
|---|---|---|---|
| Course Code: | **21RA51D2** | L-T-P-S | 3-0-0-0 |
| Pre-requisite | NIL | Credits: | 3 |
| CO. No | Course Outcome | Mapped PO/PSO | BTL |
| **CO1** | Acquire the fundamental knowledge of automotive electronics. | 1,2 | 2 |
| **CO2** | Explore and conjugate the emerging technologies utilized to assist Autonomous Vehicles. | 2,3 | 2 |
| **CO3** | Analyze Electronics Embedded to Automotive Electronics and autonomous Vehicles | 2,3 | 3 |
| **CO4** | Acquire the basic knowledge of aviation technology. | 1,2 | 2 |
| CO | Syllabus | | CH |
| 1 | **Automotive Electronics (AE):** Introduction to Modern Automotive Systems-Evolution of Electronics and Software in automobiles -ECUs and their application areas in Automotive - Engine Management Systems -Body & Comfort Electronics Systems -Infotainment Systems -Advanced Driver Assistance Systems and V2X Systems -Autonomous Driving Systems - Current Trends and Challenges Micro Controllers in ECU Design: Overview of AURI X Micro Controller -Architecture, Memory Map, Lock Step etc Bluetooth low energy and the automotive (BLE-AE): Block Diagram-Functional of personalization using BLE-AE, Piloted/assisted/remote parking BLE-AE. | | 9 |
| 2 | **Automotive Wireless (AW):** Wireless Networking and Applications to Vehicle Autonomy; Integration of Wireless Networking and On-Board Vehicle Networks; Wireless Access in Vehicular Environments (WAVE) amendment to IEEE 802.11; IEEE 802.11ac WLAN PHY and dual-band (2.4 GHz/5 GHz) support; EEE 1609 - Family of Standards for Wireless Access in Vehicular Environments (WAVE). Automotive GPRS Vehicle Tracking (AGPRS-VT) Vehicle Tracking System; Principle of working for Vehicle Tracking system. GPS and GPRS tracking system. | | 9 |
| 3 | **Embedded to Automotive Electronics and autonomous Vehicles:** In vehicle communication protocols: Overview of In-Vehicle Communication Protocols – CAN, LI N, Flex Ray, MOST, Ethernet -Controller Area Network (CAN)-CANoe, CANalyzer Fundamentals. Vehicle Area Network (VAN): Architecture-EBD-ESP-ICP-OPC-RPVs-UAV Vehicle Networking & Diagnostics Stacks – KWP 2000 and UDS. Automotive Functional Testing: HIL, MIL and SIL testing-AUTOSAR Overview - Automotive Quality, Safety and Security Standards Common Failures in Automotive Systems. Case studies on design Project Automotive Sensors, Drives, Actuators. | | 9 |
| 4 | **Avionics:** Introduction, Construction and Working and Indication System. Introduction: Construction of aircraft, UAV, RPV. Flight control systems: Airspeed Indicator, Altitude Indicator, Compass system, Gyroscopic system, heading indicator, Turning indicator, Flight director systems, Navigation systems, Auto Pilot System, Very-High Frequency Omnidirectional Range (VOR), Nondirectional Radio Beacon(NDB). | | 9 |

**Text Books**


| | |
|---|---|
| [1]. | Ronald K Jurgen: "Distributed Automotive Embedded Systems" SAE International, 2007 |
| [2]. | Williams. B, Ribbens: "Understanding Automotive Electronics", 7th Edition, Elsevier Inc, 2012. |
| [3]. | Crating Autonomous Vehicle Systems byshaoshan liu, liyun li |


**Reference Books**


| | |
|---|---|
| [4]. | Automotive Embedded Systems Handbook CRCPress Taylor & Francis Group Richard Zurawski |
| [5]. | Bosch Automotive Electrics and Automotive Electronics Systems and Components, Networking and HybridDrive Robert Bosch GmbH (Ed.) 5th Edition |


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| Course Title: | FPGA-Based Wireless System Design | | |
|---|---|---|---|
| Course Code: | 21EC51D1 | L-T-P-S | 3-0-0-0 |
| Pre-requisite: | Course Code: Nil<br>Course Title: Nil | Credits | 3 |
| CO. No. | Course Outcome | Mapped PO | BTL |
| CO1 | Understand basic concepts of software defined radio | 1,2 | 2 |
| CO2 | Analysis of FPGA Speed, Area & Power | 2,4 | 3 |
| CO3 | Acquire knowledge on advanced encryption standards | 1,2 | 2 |
| CO4 | Understand the FPGA for wireless system application | 2,6 | 2 |

| CO | Syllabus | CH |
|---|---|---|
| 1 | **Software Defined Radio (SDR):** Essential functions of the SDR, SDR architecture, design principles of SDR, traditional radio implemented in hardware and SDR, transmitter architecture and its issues, A/D & D/A conversion, parameters of practical data converters, techniques to improve data converter performance, complex ADC and DAC architectures, digital radio processing, reconfigurable wireless communication systems. | 9 |
| 2 | **Analysis of FPGA Speed, Area & Power:** High throughput, Low latency, Timing, Rolling Up the Pipeline, Control-Based Logic Reuse, Resource Sharing, Impact of Reseton Area, Clock Control, Input Control, Reducing the Voltage Supply, Dual-Edge Triggered Flip-flops, Modifying Terminations. | 9 |
| 3 | **Advanced Encryption Standards & High-Level Design:** AES Architectures, Performance versus Area and other Optimizations, Abstract Design Techniques, Graphical State Machines, DSP Design, Software/Hardware Codesign. Clock domains, Reset Circuits & Implementing Math Functions: Crossing Clock Domains, Ga ted Clocks in ASIC Prototypes, Asynchronous Versus Synchronous, Mixing Reset Types, Multiple Clock Domains, Hardware Division, Taylor, and Maclaurin Series Expansion, CORDIC Algorithm, Floating-Point Formats, Pipelined Architecture. | 9 |
| 4 | **FPGA for Wireless System:** System Design and Modeling, Transmitter Design, Channel Modeling, Receiver Design, Automatic Hardware Generation, Co-Simulation and Hardware Verification, Simulation Acceleration with Simulink/(Xilinx) Vivado. | 9 |

| Text Books | |
|---|---|
| 1. | Steve Kilts, "Advanced FPGA Design: Architecture, Implementation, and Optimization", McGraw-Hill Education TAB; 1 edition (October 5, 2016) |
| 2. | Narinder Lall, "FPGA-Based Wireless System Design", Xilinx, Inc. |

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| Course Title: | Cyber-Physical Systems | | |
|---|---|---|---|
| Course Code: | 21IN51D4 | L-T-P-S | 3-0-0-0 |
| Pre-requisite: | Course Code: Nil<br>Course Title: Nil | Credits | 3 |
| CO. No. | Course Outcome | Mapped PO | BTL |
| CO1 | Understand the basics of cyber-physical systems. | 1,2 | 2 |
| CO2 | Enumerates several fields where cyber-physical systems are widely used. | 1,2 | 2 |
| CO3 | Design and develop robotics algorithms and cyber physical systems | 1,2 | 3 |
| CO4 | Apply modern tools to develop CPS applications | 2,4 | 3 |

| CO | Syllabus | CH |
|---|---|---|
| 1 | **Introduction to Cyber-Physical Systems:** Physical and Logical Design of Cyber-Physical System-Physical design of a CPS, Computation Processor, Network Connectivity, Analysis and Processing. Generic Block Diagram of a cyber physical system, Logical design and protocols for the implementation of a CPS- Network Layer, Transport layer, HTTP, CoAP, MQTT, DDS, Adaptive Control in cyber-physical systems, Security and Privacy issues in CPS. | 10 |
| 2 | **Modeling the Physical Systems:** Cyber-Physical Systems (CPS) in the real world, Ba sic principles of design and validation of CPS, CPS HW platforms: Processors, Sensors, Actuators, CPS Network, CPS SW stack RTOS, Scheduling Real-Time control tasks. Principles of Automated Control Design: Dynamical Systems and Stability, Controller Design Techniques. | 10 |
| 3 | **Analysis of CPF:** Stability Analysis: CLFs, MLFs, stability under slow switching, Performance under Packet drop and Noise. CPS Performance Analysis: effect of scheduling, bus latency, sense and actuation faults on control performance, network congestion. Formal Analysis: Flow pipe construction, reachability analysis, Analysis of CPS Software, Weakest Pre-conditions, Bounded Model checking, Hybrid Automata Modelling Flowpipe construction using Flowstar, SpaceX and Phaver tools. | 10 |
| 4 | **Application of Cyber-Physical Systems** CPS SW Verification: Frama-C, CBMC, Secure Deployment of CPS: Attack models, Secure Task mapping and Partitioning, State estimation for attack detection, Automotive Case study: Vehicle ABS hacking, Power Distribution Case study: Attacks on Smart grid | 10 |

| Text Books | |
|---|---|
| 1. | Smart Cyber Physical Systems: Advances, Challenges and Opportunities G.R. Karpagam, B Vinoth Kumar, J.Uma Maheswari· 2020 |
| 2. | E. A. Lee and S. A. Seshia, "Introduction to Embedded Systems: A Cyber-Physical Systems Approach", 2011. |
| 3. | R. Alur, "Principles of Cyber-Physical Systems," MIT Press, 2015. |
| 4. | T. D. Lewis "Network .Science: Theoryand Applications", Wiley, 2009. |
| **Reference Books** | |
| 1. | P. Tabuada, "Verification and control of hybrid systems: a symbolic approach", Springer-Verlag 2009. |
| 2. | C. Cassandras, S. Lafortune, "Introduction to Discrete Event Systems", Springer 2007. |
| 3. | Constance Heitmeyer and Dino Mandrioli, "Formalmethods for real-timecomputing", Wiley publisher, 1996. |

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# TECHNICAL SKILLING-I

**Course Code: 21TS51I1** **LTPS: 0-0-0-8**

**Pre Requisite: Nil** **Credits: 2**

**COURSE OUTCOMES (COs):**

| CO NO | Course Outcome (CO) | PO/PSO | Blooms Taxonomy Level (BTL) |
|---|---|---|---|
| CO1 | Understanding the Domain based tool and the real time Applications for all specialization | PO2 | 2 |
| CO2 | Applying the tool for basic operational applications | PO5 | 3 |
| CO3 | Applying the tool for Real time applications like minor projects | PO6 | 3 |
| CO4 | Analysing the domain based tool for project developments which can be used as a product. | PO7 | 4 |

**Syllabus :**Embedded & IOT: 1.Introduction to TINKERCAD and ARDUINO. 2.Introduction to Internet of Things. 3.Communication with cloud (Thing speak). 4.Monitoring Home appliances using IoT 5.Controllingdevices using IoT Environment.

**Text Books :**Rajesh Singh, Anita Gehlot, Lovi Raj Gupta, Bhupendra Singh, Mahendra Swain, Internet of Things with Raspberry Pi and Arduino, CRC Press, 2019. David Hanes and Gonzalo Salgueiro, IoT Fundamentals: Networking Technologies, Protocols, and Use Cases for the Internet of Things, Cisco Press, 2017.

**Reference Books :**Jan Holler and Vlasios Tsiatsis, From Machine-to-Machine to the Internet of Things Introduction to a New Age of Intelligence, Elsevier Ltd., 2014

**Web Links :**https://www.youtube.com/watch?v=hvaBonZMRQ&ab_channel=IITKharagpurJuly2018
https://www.youtube.com/watch?v=nE1C4ghfvac&list=PLgMDNELGJ1CbufZjqWa8uoSlQWKqVwPN7&ab_channel=IIScBangaloreJuly2018 https://www.youtube.com/watch?v=R5YfLySWQAc&ab_channel=EmbeddedWorld
https://www.youtube.com/watch?v=QUfNGwBQJ-s&ab_channel=APMonitor.com
https://www.youtube.com/watch?v=mqz8yf0BFAk&ab_channel=BesantTechnologies
https://www.youtube.com/watch?v=ZVmD4O7rj9U&ab_channel=miraldonda
https://www.youtube.com/watch?v=h_b4ejF4anw&ab_channel=ComputerForEveryone

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## TECHNICAL SKILLING-II

**Course Code: 21TS51I2** **LTPS: 0-0-0-8**

**Pre Requisite: Nil** **Credits: 2**

**COURSE OUTCOMES (COs):**

| CO NO | Course Outcome (CO) | PO/PSO | Blooms Taxonomy Level (BTL) |
|---|---|---|---|
| CO1 | Understanding and Designing IOT applications with NODE MCU and Arduino | PO1,PO2 | 2 |
| CO2 | Study of Raspberry Pi with different communication module to design IOT applications | PO2,PO1 | 3 |
| CO3 | Designing of Web Page, control and analyze sensor data through it | PO1,PO2 | 3 |
| CO4 | Understanding the inbuilt protocols and IOT management with STM 32 | PO2,PO4 | 3 |

**Syllabus :**CO1: IoT Applications & Sensors: Analog & Digital sensors, MPU 6050, MCP2515(CAN), DS2321 (RTC), Applications CO2: Interfacing to IoT : Micro controllers boards, ESP8266, Peripherals (Motors, Camera, Speaker, Displays), Controlling through Mobile & Web CO3: IoT Data Communication: Wi-Fi Protocols, Bluetooth, BLE, WSN, Zigbee, RFID, NFC, Client Server, Cloud. CO4: Protocols & Case Studies : Issues & Challenges : Security, Privacy, Scalability, Store and Analytics Case Studies: Health, Smart cities, Village/ Agriculture

**Text Books :**Internet of Things a hands-on Approach by Arshdeep behga and Vijay madisetti ,Orient Black Swan Publications.

**Web Links :**1. https://www.eventshigh.com/detail/chennai/33e6f1710a75921963a8e81f394c4f5b-internet-of-things-iot-workshop 2. https://www.skyfilabs.com/iot-courses-and-workshops 3. https://www.youtube.com/watch?v=SiU-QZwik8w 4. https://www.youtube.com/watch?v=p82vmuJqu-8 5. https://www.youtube.com/watch?v=bOsjfixX_lk 6. https://www.youtube.com/watch?v=9ev3xTDEhtw

**MOOCS :**https://www.coursera.org/specializations/uiuc-iot 2. https://www.coursera.org/learn/introduction-iot-boards 3. https://www.linkedin.com/learninglogin/share?account=89447330&forceAccount=true&redirect=https%3A%2F%2Fwww%2Elinkedin%2Ecom%2Flearning%2Fpaths%2Fkl-university-20ec2214

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ii. M. Tech Robotics &Automation

## KLEF
## Dept. of Electronics and Communication Engineering
## M. Tech Robotics & Automation
## AY. 2021-22

### Semester-I

| S. No. | Course Code | Course Title | Periods | | | | Credits |
|---|---|---|---|---|---|---|---|
| | | | L | T | P | S | |
| 1 | 21RA5141 | Non-linear systems and control optimization for robotics | 3 | 1 | 2 | 0 | 5 |
| 2 | 21RA5142 | Robotics Cyber Physical Systems | 3 | 0 | 2 | 0 | 4 |
| 3 | 21RA5143 | IIoT 4.0 for Automation and Robotic systems | 3 | 0 | 2 | 0 | 4 |
| 4 | 21EC5104 | Artificial intelligence & Machine learning | 3 | 0 | 2 | 0 | 4 |
| 5 | | Elective – 1 | 3 | 0 | 0 | 0 | 3 |
| 6 | | Elective – 2 | 3 | 0 | 0 | 0 | 3 |
| 7 | 21IE3149 | Seminar | 0 | 0 | 4 | 0 | 2 |
| 8 | 21TS51A1 | Technical Skilling-1 (ROS, Webot, Matlab, MSC ADAMS) | 0 | 0 | 0 | 8 | 2 |
| **Total** | | | **18** | **1** | **12** | **8** | **27** |

### Semester-II

| S. No. | Course Code | Course Title | Periods | | | | Credits |
|---|---|---|---|---|---|---|---|
| | | | L | T | P | S | |
| 1 | 21RA5244 | Design of MEMS Sensors and Actuators for Robotics | 3 | 1 | 2 | 0 | 5 |
| 2 | 21RA5245 | Optimization algorithms for autonomous systems | 3 | 1 | 2 | 0 | 5 |
| 3 | 21RA5246 | Signal processing for robotics | 3 | 0 | 2 | 0 | 4 |
| 4 | 21RA5247 | Swam Robotics Control Systems | 3 | 0 | 0 | 0 | 4 |
| 5 | | Elective – 3 | 3 | 0 | 0 | 0 | 3 |
| 6 | | Elective – 4 | 3 | 0 | 0 | 0 | 3 |
| 7 | 21IE3250 | Term Paper | 0 | 0 | 4 | 0 | 2 |
| 8 | 21TS52A2 | Technical Skilling-2 | 0 | 0 | 0 | 8 | 2 |
| **Total** | | | **18** | **2** | **10** | **8** | **28** |

### Semester-III&IV

| S. No. | Course Code | Course Title | Periods | | | | Credits |
|---|---|---|---|---|---|---|---|
| | | | L | T | P | S | |
| 1 | 21IE6050 | M. Tech. Project Dissertation – Part 1 & Part 2 | 0 | 0 | 72 | 0 | 36 |
| | Total | | | | | | |
| **Total Program Credits** | | | | | | | **91** |

### Subject Options as per Specialization

| S. No. | Course Code | Course Title | Periods | | | | Credits |
|---|---|---|---|---|---|---|---|
| | | | L | T | P | S | |
| Professional Elective-1 | | | | | | | |
| 1 | 21RA51A1 | Robotics: Design of Sensors, Drives and Actuators | 3 | 0 | 0 | 0 | 3 |

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|---|---|---|---|---|---|---|---|
| 2 | 21RA51A2 | Autonomous mobile Robot systems | 3 | 0 | 0 | 0 | 3 |
| 3 | 21RA51A3 | Deep Neural Network algorithm for Robotics | 3 | 0 | 0 | 0 | 3 |
| 4 | 21RA51A4 | Algorithms for Robotics Sensor Fusion | 3 | 0 | 0 | 0 | 3 |
| Professional Elective-2 | | | | | | | |
| 1 | 21RA51B1 | Soft Robots and Biomechanics system | 3 | 0 | 0 | 0 | 3 |
| 2 | 21RA51B2 | Human Machine Interface & Brain Machine Interface | 3 | 0 | 0 | 0 | 3 |
| 3 | 21EC51B1 | LiDAR & RADAR System Control | 3 | 0 | 0 | 0 | 3 |
| 4 | 21EC51B3 | Computer Vision & Applications | 3 | 0 | 0 | 0 | 3 |
| Professional Elective-3 | | | | | | | |
| 1 | 21RA51C1 | Adaptive motion control systems for automation and robotics | 3 | 0 | 0 | 0 | 3 |
| 2 | 21RA51C2 | FPGA-Based Wireless System Design | 3 | 0 | 0 | 0 | 3 |
| 3 | 21RA51C3 | Advanced Robotic Wireless Sensor Networks | 3 | 0 | 0 | 0 | 3 |
| 4 | 21RA51C4 | Cloud and Robotics Process Automation | 3 | 0 | 0 | 0 | 3 |
| Professional Elective-4 | | | | | | | |
| 1 | 21RA51D1 | Autonomous mobile robots and Automotive Electronics | 3 | 0 | 0 | 0 | 3 |
| 2 | 21RA51D2 | Automotive Electronics & Avionics | 3 | 0 | 0 | 0 | 3 |
| 3 | 21RA51D3 | Operation Research, System Engineering, Design & Optimization | 3 | 0 | 0 | 0 | 3 |
| 4 | 21RA51D4 | Design of automation systems and Assistive Robotic systems | 3 | 0 | 0 | 0 | 3 |

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Syllabus for M. Tech Robotics and Automation:

## Non-Linear Systems and Control Optimization for Robotics

**Course Code: 21RA5141** **L-T-P-S: 3-0-2-0**

**Pre-requisite: NIL** **Credits: 4**

| CO. No | Course Outcome | Mapped PO | BTL |
|---|---|---|---|
| **CO1** | Introduce the need and concept of nonlinear system and optimizations for robotics | 1,2 | 2 |
| **CO2** | Impart knowledge about different strategies adopted in the of nonlinear systems for robotics engineering | 2,3 | 3 |
| **CO3** | Apply constrained optimization to various physical systems. Implement optimal control algorithms to track the response of the system through a predefined trajectory | 2,3 | 3 |
| **CO4** | Familiarize with the design of different types of nonlinear Robotics controllers | 2,3 | 3 |
| CO | Syllabus | | CH |
| 1 | Introduction: Components of Robotics Automatic control systems- Open loop and closed loop systems - Examples - Transfer function Time Domain analysis: Linear, Nonlinear- P, PI and PID modes of feedback control. Overview of robotic dynamics-Forward and inverse dynamics Properties of the dynamic model and case studies- Nonlinear systems and control schemes System stability and types of stability - Nonlinear control schemes-Observer based on acceleration, velocity, and position feedback-Numerical simulations using software packages namely MATLAB/MATHEMATICA. | | 8 |
| 2 | State-space representation of dynamic systems, phase-portraits of second order systems, types of equilibrium points: stable/unstable node, stable/unstable focus, saddle- Existence and uniqueness of solutions: Lipschitz continuity, Picard's iteration method, proof of existence and uniqueness theorem, continuous dependence of solutions on initial conditions; Features of nonlinear dynamical systems: multiple disjoint equilibrium points, limit cycles, Bendixson criterion, Poincare-Bendixson criterion- Hamilton-Jacobi-Bellman equation-Pontryagin Maximum Principle | | 12 |

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|---|---|---|
| 3 | System Stability: Concept of stability – stability & location of the poles in S-plane - Characteristic equation, Routh-Hurwitz stability criterion, Root Locus concepts- Construction of root locus – Nyquist stability - Nyquist stability criterion - Linearization: linearization around an equilibrium point, validity of linearization: hyperbolic equilibrium points, linearization around a solution; Stability analysis: Lyapunov | 12 |
| | stability of autonomous systems, Lyapunov theorem of stability, converse theorems of Lyapunov theorem, construction of Lyapunov functions: Krasovskii method and variable gradient method, LaSalle invariance principle, region of attraction, input/output stability of non - autonomous systems, L-stability | |
| 4 | Control of nonlinear systems: describing functions method, passivity theorem, small gain theorem, Kalman-Yakubovich-Popov lemma, Aizermann conjecture, circle/Popov criteria, methods of integral quadratic constraints and quadratic differential forms for designing stabilizing linear controllers, multiplier techniques. | 8 |

**Textbooks / References:**


| | |
|---|---|
| [1]. | H. K. Khalil, Nonlinear systems, Prentice Hall, 3rd Edn., 2002. |
| [2]. | M. Vidyasagar, Nonlinear systems analysis, 2nd Edn., Society of Industrial and Applied Mathematics, 2002. |
| [3]. | H. Marquez, Nonlinear Control Systems: Analysis and Design, Wiley, 2003. |
| [4]. | A. Isidori, Nonlinear Control Systems, Springer, 3rd Edn., 1995. |
| [5]. | F. Verhulst, Nonlinear Differential Equations and Dynamical Systems, Springer, 1990. |
| [6]. | H. K. Khalil, Nonlinear systems, Prentice Hall, 3rd Edn., 2002. |
| [7]. | Sabanovic A and Ohnishi K, Motion Control Systems, 1st Edition, John Wiley & Sons (Asia)(2011). |
| [8]. | Smarajit Ghosh, —Control Systems Theory and Applicationsl, 2nd Edition, Pearson Education, New Delhi, 2012 |


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## IIoT4.0 for Automation and Robotic Systems

**Course Code: 21RA5143** **L-T-P-S:** 3-0-2-0

| CO. No | Course Outcome | Mapped PO | BTL |
|---|---|---|---|
| **CO1** | Describe IOT,IIOT | 1,2 | 2 |
| **CO2** | Understand the opportunities, challenges brought about by Industry 4.0 and how organizations and individuals should prepare to reap the benefits | 2,3 | 3 |
| **CO3** | Understand, design, and develop the real life IoT applications using off the shelf hardware and software | 2,3 | 3 |
| **CO4** | Understand the concepts of Design Thinking | 2,3 | 3 |
| CO | Syllabus | | CH |
| 1 | **Overview of Robotic and automation Industrial IoT (IIoT) 4.0:** Industry 4.0 and 5.0 Basic terms – Ecosystem IOT and IIOT -History of IIOT 4.0-Components of IIOT-Robotics Industry IoT 5.0 sensing and process systems -Business Models and Reference Architecture of IIoT-Challenges & Benefits in implementing IIOT 4.0-Business Models and Reference Architecture of IIoT -Service Level Agreement of IIOT 4.0-Characteristics of robotics and automation industry 4.0 IOT. | | 8 |
| 2 | **Robotic Industry IOT Devices:** IIOT based Sensors and Actuators, Categories, Functionality, and characteristics- Industrial Data Transmission: Foundation Fieldbus, profibus, HART, Interbus, Bitbus, Digital STROM, CAN, DeviceNet, LoRaandLoRaWAN.<br>**Industrial Data Acquisition:** Distributed Control System-PLC-SCADA –Factory<br>**IIoT Analytics:**Sentinel for Industrial Robots IoT 5.0-Categorization of analytics: IIoT and Industry 4.0 context-Mapping of analytics with the IIRA architecture-Discovering OPC | | 12 |
| 3 | **Cognitive Sensors and IoT4.0:** Introduction to Cognition in IoT- Information- Centric Sensor Networks-for Cognitive IoT- Cognitive-Node Architecture and a Deployment Strategy for the Future Sensor Networks- A Data Delivery Framework for Cognitive Information-Centric Sensor Networks in Smart Outdoor Monitoring- Cognitive Routing Protocol for Disaster-Inspired WSNs on the Internet of Things-<br>Fog-Based Caching and Learning for Information-Centric Networks-M2 M To IOT - M2M Vs IOT – A vision from M2M to IOT – Case Study | | 8 |

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|---|---|---|
| 4 | **Collaborative Man and Machine Workforce (IIoT 4.0):**Technological Architecture Collaborative Robots in Industry 5.0 -Robotics Modeling and Design: Mathematical Model of a Swarm Robotic-System with Wireless Bi- directional-Energy Transfer - Machine Learning and Deep Learning in Industries IOT 5.0-Pareto Optimal Solutions and Their-Application in Designing Robots-and Robotic Systems.<br>**Collaborative Robotics IOT 5.0:** Control and Ergonomic Problems of Collaborative Robotics-Human-Robot Interaction Efficiency and Human-Robot Collaboration - Human-Robot Cooperation in Technological Wall Climbing Robot-Features of | 12 |

**Pre-requisite: NIL** **Credits: 4**

| | | |
|---|---|---|
| | Human-Exoskeleton Interaction System-Analysis of Dynamics in Human Exoskeleton<br>Collaborative System-Design studies on Siemens Melds Mendix with MindSphere to Boost IIoT Development. | |
| **Text Books** | | |
| [1]. | Hands on Industrial Internet of Things by GiacomoVeneri and Antonio Capasso, Packt publisher. 2018 edition (e- book). | |
| [2]. | Anandarup Mukherjee, Chandana Roy, and Sudip Misra - Introduction to Industrial Internet of Things and Industry 4. 0 (2020) | |
| [3]. | Fadi Al-Turjman - Cognitive Sensors and IoT_ Architecture, Deployment, and Data Delivery (2017, CRC PRESS) | |
| [4]. | Alla G. Kravets - Robotics_ Industry 4.0 Issues &amp_ New Intelligent Control Paradigms (2020,<br>Springer International Publishing_Springer) | |
| **Reference Books** | | |
| [5]. | The Concept Industry 4.0 An Empirical Analysis of Technologies and Applications in Production Logistics Authors: Bartodziej, Christoph Jan Springer: Publication in the field of economic<br>science. | |
| [6]. | Embedded System: Architecture, Programming and Design by Rajkamal, TMH3. | |
| [7]. | Dr. OvidiuVermesan, Dr. Peter Friess, "Internet of Things: Converging Technologies for Smart Environments and Integrated Ecosystems", River Publishers | |

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## Robotics and Cyber Physical Systems

**Course Code: 21RA5142** **L-T-P-S:** 3-0-2-0
**Pre-requisite: NIL** **Credits: 4**

| CO. No | Course Outcome | Mapped PO | BTL |
|---|---|---|---|
| **CO1** | Ability to understand cyber-physical systems are and highlight the main challenges they currently face | 1,2 | 2 |
| **CO2** | Ability to Enumerates several fields where cyber-physical systems are widely used. | 2,3 | 2 |
| **CO3** | Gain a knowledge Ability to use and develop robotics algorithms and cyber physical systems | 2,3 | 3 |
| **CO4** | Creates wider design analysis on RCPSand fabricate engineering systems that interact with humans and the environment and create sustainable solutions | 3,4 | 4 |
| CO | Syllabus | | CH |
| 1 | **Structure and Functions of Cyber Physical Systems:**Key Features of Cyber-Physical Systems-Synchronous Model-Safety Requirements-Asynchronous Model-Liveness Requirements-Dynamical Systems-Timed Model-Real-Time Scheduling | | 10 |
| 2 | **Advanced Modeling and Simulation of Robotics cyber physical systems(RCPS):**Modeling Physical Systems-Hybrid Systems -Control Theory-Modeling Computational Systems -Coordinate Transformation (Robot Arm)- Game Theory: The Role of Game Theory in CPS Design - Sensing and Actuation based on CPS-Design project. | | 10 |
| 3 | **Drones as Cyber-Physical Systems:** Introduction to the Fourth Industrial Revolution-Drone Flight Ready-Cyber Systems: Drone Cyber- Systems as CPS Components-Drone Assembly-radio control transmitter- radio communication-software-sensors in CPS-Location Sensor-image sensors-Valuing Cyber-Physical Bridging Intensity of Drone - Futurology and Future Prospect of Drone CPS | | 10 |
| 4 | **Practical Introduction to Human-in-the-Loop Cyber-Physical Systems:** Humans as Elements of Cyber-Physical Systems- Evolution of HiTL Technologies- Theory of HiTLCPSs- Human-in-the-Loop: Hands-On- Future of Human-In-the-Loop Cyber-Physical Systems<br>**Case Study** Cooperative and Autonomous Systems with cyber-physical systems<br>**Teamwork:** Design a Robotics cyber-physical system verify with robotics software's. | | 10 |

**Text Books**

Rajeev Alur - Principles of Cyber-Physical Systems (2015, The MIT Press)

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| |
|---|
| Walid M. Taha, Abd-Elhamid M. Taha, Johan Thunberg - Cyber-Physical Systems_ A Model-Based Approach (2021, Springer International Publishing Springer) |
| **Reference Books** |
| Jung-Sup Um - Drones as Cyber-Physical Systems_ Concepts and Applications for the Fourth Industrial Revolution (2019, Springer Singapore) |
| Boavida, Fernando_ Nunes, David_ Silva, Jorge Sá - A practical introduction to human-in-the-loop cyber-physical systems (2017, John Wiley & Sons) |

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# Robotics: Design of Sensors, Drives and Actuators

L-T-P-S : 3-0-0-0 Credits: 3
Pre-requisites : NIL Course code: 21RA51A1

**Mapping of Course Outcomes to Program outcomes:**

| CO# | Course Outcome | PO/PSO | BTL |
|---|---|---|---|
| CO1 | Acquire knowledge about the fundamental principles, Robot Sensors, and implementation strategies of Internal Sensors and Inertial Sensors. | 1,2 | 2 |
| CO2 | Provide solutions for Ultrasonic Sensors in Home, industry, Vision, Stereo Vision, and Proximity Sensors | 2,3 | 2 |
| CO3 | Understanding Robot Actuators and Industrial Robots, cooperative robotics Electrical actuators, automated kitchen, studying about various home automation. | 2,3 | 3 |
| CO4 | Fundamentals of Motors, DC Motors;<br>understanding Functionality of the Harmonic Drive<br>Justify the use of robots in DC and AC servo drives for axis motors | 2,3 | 3 |

**Syllabus:**

| |
|---|
| **Introduction** to Robot Sensors -Definition, types, merits, and Internal Sensors and External Sensors, and operations-Optical Encoder-Basic elements of Other position sensor: Potentiometer,-Levels of Velocity Measurement - Process, Inertial Sensors, Applications of Gyroscopes, -An overview of Accelerometer, - Fundamentals of Force Sensors, Torque Sensor, Range Sensors, IR Range Sensors, Limitations of Infrared Sensors, Time of Flight Range Sensors. |
| **Ultrasonic Sensors:** Introduction Ultrasonic Sensors; Determining Limitations of Ultrasonic Sensors; Laser Ranger Finder: Example (Laser Range Finder), Vision, Stereo Vision, and Proximity Sensors, Infrared (IR) Detector, Touch Sensors, Tactile Sensors |
| **Robot Actuators and Industrial Robots:** Study of Basic Functionality of **Robot Actuators**, Operations of Electrical actuators; Robotics Hydraulic actuators in Advanced Automation; Pneumatic actuators in conveyor Belts operations, robots in industry real time embedded systems, Industrial Robots: Approach Manipulators by Using Visual; Tracking Over a Distributed System; Baggage Collection Automation Applications for Human Safety: Dangerous domains for humans, (Mine Detection), Hazardous domains for humans (chemical fumes etc.), Nuclear Biological Chemical warfare, dangerous exploratory missions UAVs, unmanned Rockets, Mars Mission, Chandrayaan. |
| Introduction to Motors and Drives: Fundamentals of Motors, T DC Motors; Stepping Motors, Principles of Servo Motors, Working Definition of Motion Transmission, Gear Ratio, Functionality of the Harmonic Drive, feature and limitation drive; Axis drive arrangements, ball |

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| screw, timing belts and couplings, Analog and digital drives. AC&DC servomotors, DC and AC servo drives for axis motors, servo tuning. Stepper motors and drives, spindle motors & drives - DC &AC. Selection criteria, drive optimization and protection. |

**Textbooks**

| |
|---|
| R K Mittal and I J Nagrath, Robotics and Control, Tata McGraw Hill, New Delhi, 2003. |
| N.Viswanadham and Y.Narahari, Performance Modeling of Automated Manufacturing Syetms, Printice Hall India Pvt. Ltd. |
| HMT Limited, "Mechatronics", Tata McGraw Hill, New Delhi, 1998. |
| https://www.keyence.com/ss/products/sensor/sensorbasics/ |

**Reference Textbooks**

| |
|---|
| Mikell P Groover,Automation, Production Systems, and computer integrated Manufacturing‖, Prentice Hall, 2001. |
| Deb S R.andDebS., —Robotics Technology and Flexible Automation‖, Tata McGraw Hill Education Pvt. Ltd, 2010. |

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## Autonomous Mobile Robot Systems

L-T-P-S : 3-0-0-0 Credits: 3
Pre-requisites : NIL Contact Hours: 3

**Mapping of Course Outcomes to Program outcomes:**

| CONO. | Course Outcome | Mapped | BTL |
|---|---|---|---|
| **CO1** | Robot locomotion, and Types of locomotion, unchartered territories in the Universe. | 1,2 | 2 |
| **CO2** | Design of mobile robot kinematics and dynamics, onomic constraints. | 2,3 | 3 |
| **CO3** | Development of passive/active sensors and mobile robots like global positioning system. | 2,3 | 2 |
| **CO4** | of path planning algorithms based on A-star, Dijkstra | 3,4 | 3 |
| CO | Syllabus | | CH |
| 1 | **Robot locomotion:** Types of locomotion, hopping robots, legged robots, wheeled robots, stability, maneuverability, controllability; unchartered territories in the Universe, distant as Mars, glaciers of Antarctic, mobile robots. | | 8 |
| 2 | **Mobile robot kinematics and dynamics:** Forward and inverse kinematics, holonomic and nonholonomic constraints, kinematic models of simple car and legged robots, dynamics simulation of mobile robots; | | 12 |
| 3 | **Perception:** Proprioceptive/Exteroceptive and passive/active sensors, performance measures of sensors, sensors for mobile robots like global positioning system (GPS), Doppler effect-based sensors, vision-based sensors, uncertainty in sensing, filtering; | | 12 |
| 4 | **Introduction** to planning and navigation: path planning algorithms based on A-star, Dijkstra, Voronoi diagrams, probabilistic roadmaps (PRM), rapidly exploring random trees (RRT), Markov Decision Processes (MDP), stochastic dynamic programming (SDP). | | 8 |
| **Text Books** | | | |
| [9]. | R. Siegwart, I. R. Nourbakhsh, "Introduction to Autonomous Mobile Robots", The MIT Press, 2011. | | |
| [10]. | Peter Corke , Robotics, Vision and Control: Fundamental Algorithms in MATLAB, Springer Tracts in Advanced Robotics, 2011. | | |

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# Swam Robotics Control Systems

L-T-P-S : 3-0-0-0 Credits: 3
Pre-requisites: NIL Course Code: 21RA5247

| CO. | Course Outcome | Mapped | BTL |
|---|---|---|---|
| **CO1** | Understand the principles and various Swam Robotics Control Systems | 1,2 | 1 |
| **CO2** | Knowledge explore on multi-agent systems, Parallel, Scalable, Stable. | 2,3 | 2 |
| **CO3** | Design concepts of Swam Robotics Control Systems and Creating Advanced behavior module. | 2,3 | 3 |
| **CO4** | Analyze and Evaluate the Cooperative algorithms, earlier progress of swarm robotics algorithms, Features of swarm robotics algorithm | 3,4 | 3 |
| CO | Syllabus | | CH |
| 1 | robotics, swarm intelligence and robotics, several aspects. Definition swarm robotics, Characteristics of nature swarms, nature swarm, special features of the swarm robotics, single robot and other multi-individual systems, nature swarm to swarm intelligence, Advantages of swarm robotics | | 12 |
| 2 | Scalable, Stable, Economical, Energy efficient, Different multi-agent systems: Tasks cover large area robot, Tasks dangerous to robot, scaling population and redundancy, Swarm robotics system in real life. Modeling swarm robotics, General model of swarm robotics, Information exchange module, Direct communication, Communication through environment- Sensing, Basic behavior module. | | 8 |
| 3 | swarm robotics. Sensor-based modeling, Microscopic modeling, Macroscopic modeling, Modeling swarm intelligence algorithms, Cooperation schemes between robots, Architecture of swarm, Locating, Physical connections, Self-organization and self-assembly, Entity projects | | 12 |

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|---|---|---|
| 4 | earlier progress of swarm robotics algorithms, Features of swarm robotics algorithm, Simple, Scalable, Decentralization, Local, Parallel, Fundamental tasks of swarm robotics, Formation, Potential field functions, Positioning and navigation, Navigation, Obstacle avoidance, Swarm robotics searching algorithms, Inspired from swarm intelligence algorithms, Optimizing the parameters, Modeling the individual behaviors, Mixing and Inspired methods. | 12 |

**Text Books**


| | |
|---|---|
| [15]. | go, G. Theraulaz, **Natural to Artificial Swarm Intelligence,** Oxford University Press, Oxford (1999) |
| [16]. | eubourg, N.R. Frank, J. Sneyd, G. Theraulaz, E. Bonabeau, Self-Organization in Biological systems, Princeton University Press, Princeton (2003) |
| [17]. | otb, J. Gautraisb, V. Fourcassiéb, A.F.R. Araújoa, G. Theraulazb<br>t Foraging Trails In An Artificial Network, J Theor Biol, 239 (2006), pp. 507-515. |
| [18]. | ais, S. Camazine, J.L. Deneubourg<br>atial patterns in social insects: from simple behaviours to complex structures. philosophica transactions of the Royal Society of London. Series a: mathematical<br>07) (2003), pp. 1263-1282 |


**Reference Books**


| | |
|---|---|
| [19]. | S.N. Beshers, J.H. Fewell<br>**Models of Division of Labor In Social Insects** Annu Rev Entomol, 46 (2001), pp. 413-440. |
| [20]. | K. Thorup, T. Alerstam, M. Hake, N. Kjellén<br>Bird orientation: compensation for wind drift in migrating raptors is age dependent Proc Biol Sci, 270 (Suppl. 1) (2003), pp. S8-S11 |


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| Course Title: | **Human Machine Interface & Brain Machine Interface** | | |
|---|---|---|---|
| Course Code: | **21RA51B2** | L-T-P-S | 3-0-2-0 |
| Pre-requisite | NIL | Credits: | 4 |
| CO. No | Course Outcome | Mapped PO | BTL |
| **CO1** | Understanding the basics of HMI: Asimov's Laws, GUI Design, Aesthetics, Developments in Bio-Chips, Heuristics. | 1,2 | 3 |
| **CO2** | Understanding the HMI Technologies such as GMOS Models, CMN-GOMS, Fitts Laws, Hick-Hyman Laws, Norman's 7 Principles. | 2,3 | 3 |
| **CO3** | Understanding the concept of Brainwaves & BMI | 2,3 | 3 |
| **CO4** | Analyzing Humanoids & HMI/BMI Applications: Hierarchical Task] Analysis, Dialog Design, Use of FEM | 3,4 | 3 |
| CO | Syllabus | | CH |
| 1 | Intro. to HMI: Asimov's Laws, GUI Design, Aesthetics, Developments in Bio-Chips, Heuristics Introduction to the course and to HMI/HCI, HMI/HCI Its history Relation to Ergonomics and Human Factors Problems and challenges Recurrent HMI Themes, Historical evolution of the field, Concept of usability - definition and elaboration, HCI and software engineering, GUI design and aesthetics, Prototyping techniques. | | 10 |
| 2 | Design rules Authority vs. generality Principles, introduction to different types of models, GOMS family of models (KLM and CMN-GOMS, Fitts' law and Hick-Hyman's law, Guidelines in HCI: Norman's seven principles, Norman's model of interaction, Heuristic evaluation, Contextual inquiry, Cognitive walkthrough | | 10 |
| 3 | Brainwaves & BMI: Alpha, Beta, Theta, Gamma wave, Brain-Control Interface, ARMA Model -Introduction to ***Brain Control Interface*** Fundamentals of BCI – Structure of BCI system – Classification of BCI: Invasive, Non-invasive, and Partially invasive BCI Brain signal acquisition, Experiment design and data analysis (with explanation of one-way ANOVA), ARMA Model MEMS Simulators-Team-Design studies on MEMS based Sensors and Actuators: Using COMSOL Multiphysics | | 10 |

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|---|---|---|
| 4 | Humanoids & HMI/BMI Applications: Hierarchical Task] Analysis, Dialog Design, Use of FSM] Task modelling and analysis through Hierarchical task analysis (HTA), GUI design for a mobile phone based Matrimonial application, Employment Information System for unorganized construction workers on a Mobile Phone. Dialog Design | 10 |

| | | |
|---|---|---|
| | using FSM (finite state machines), Cognitive architecture, Object Oriented Modelling of User Interface Design. | |
| **Text Books** | | |
| [1]. | Dix A., Finlay J., Abowd G. D. and Beale R. Human Computer Interaction, 3rd edition, Pearson Education, 2005. | |
| [2]. | Preece J., Rogers Y., Sharp H., Baniyon D., Holland S. and Carey T. Human Computer Interaction, Addison-Wesley, 1994. | |
| **Reference Books** | | |
| | | |
| [3]. | B. Schneiderman; Designing the User Interface, Indian Reprint, Addison Wesley 2000. | |
| [4]. | Jonathan Wolpaw, Elizabeth Winter Wolpaw,'Brain Computer Interfaces: Principles and practice", Edition 1, Oxford University Press, USA, January 2012 | |

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## LiDAR & RADAR System Control

**Course Code:** **L-T-P-S: 3-0-0-0**
**Pre-requisite: NIL** **Credits: 3**

**Mapping of Course Outcomes to Program outcomes:**

| CO. No | Course Outcome | Mapped PO | BTL |
|---|---|---|---|
| **CO1** | Understand the Principles and design concepts of various LiDAR Systems and control Mechanisms. | 1,2 | 2 |
| **CO2** | Study and analysis LiDAR Beam Steering and Optics System | 1,2 | 2 |
| **CO3** | Analyze an existing radar system, synthesize the information, and explain to an audience to establish the principle working CW radar, FM-CW radar | 2,3 | 3 |
| **CO4** | Creating strong knowledge on algorithm for design radars in various autonomy control | 2,3 | 3 |

**CO 1:**

**Principles and terms of LiDAR**

Principle operation of LiDAR Technology-LiDAR Terms: Detection Range, Power, wavelength, Spatial resolution, Field of view (FOV) Pulse, Scan, and Frame Rate- LiDAR measurement principles-History of Lidar Development-LiDAR Components-Characteristics of Lidar Data-LiDAR Range Equation-Classification based on: Orientation, scanning mechanism-LiDAR detection modes: Coherent and In-Coherent-Significations of LiDAR- Coherent LiDAR System: Laser vibration detection- Range-Doppler imaging LiDAR -Speckle imaging LiDAR Aperture-synthesis-Different LiDAR manufactures stocks-Design Problem.

**CO 2:**

**LiDAR Sources and Modulations:** Laser Waveforms for LiDAR-Lasers Used in LiDAR; LiDAR Receivers: Avalanche Photodiodes and Direct Detection-Silicon Detectors-Heterodyne Detection.

**LiDAR Beam Steering and Optics System:** LiDAR processing-system control -industrial rotational LiDAR -Solid State LiDAR Processing- Nonmechanical Beam-Steering Approaches for Steering LiDAR Optical Beams-Testing, and Calibration for LiDAR- Design studies on LiDAR System based Sensing and Control for Land, Water and Air Vehicles.

**LiDAR System Control:** Autonomous landing- Autonomous Rotorcraft-Odometry Control-Design study on 2D LiDAR with Robotic Operating System.

**CO 3:**

**Radar Systems:** Fundamentals of Radar Systems- The Radar Equation- Signal Processing for Radar Systems- Radar Waveforms and Their Mathematical Models- Radar Target Detection-Direction of Arrival (DOA)- Pulse radars and CW radars, Advantages of coherent radar, Doppler

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radar, and MTI: Doppler effect, delay-line cancellers, blind speeds, staggered PRFs, Digital filter bank, Moving Target Detector, Detection of Radar Signals in Noise- Radar Receivers.

**FMCW Radar Design:** The Advent of FMCW Radars- FMCW Waveform- The Radar Ambiguity Function- Noise in Radar Receivers- Radar Detection- Radar System Components- Radar Transmitter/Receiver Architectures-System design examples

**CO 4:**

**LiDAR and RADAR system Control**: LiDAR 2D and 3D Mapping – Lidar and RADAR based Adaptive Cruise Control Systems- Lane Estimation for Autonomous Vehicles using Vision and LIDAR- Algorithms used in the Airborne Lidar Processing System; Ribotoxin LiDAR Perception system and algorithm-Algorithm for R2V LiDAR and RADAR System-Trends of LiDAR and RADAR in Automotive industry 5.0-LiDAR Simulation ( MatLAB&Python):Teamwork: Design practice on LiDAR and RADARsystem control

**Text Books**

1. Paul McManamon - LiDAR technologies and systems (2019, SPIE)
2. Paul Merritt Beam Control for Laser Systems Hardback Textbook Accompanying CD 373 Pages 2011
3. Thor I. Fossen, Kristin Y. Pettersen, Henk Nijmeijer (eds.) - Sensing and Control for Autonomous Vehicles_ Applications to Land, Water and Air.
4. Introduction to Radar Systems – Merrill I. Skolnik, TMH Special Indian Edition, 2nd Edition,Tata McGraw-Hill, 2007.

**Reference Books**

1. Introduction to Radar Systems – Merrill I. Skolnik, MC GRAW HILL EDUCATION Special Indian Edition, 2nd Ed., 2007.
2. Automotive_LiDAR_Technology_A_Survey

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## Automated Dynamic Analysis of MEMS sensors &actuators

**Course Code:** 21RA51B1 **L-T-P-S: 3-0-0-0**
**Pre-requisite: NIL** **Credits: 3**

**Mapping of Course Outcomes to Program outcomes:**

| | | | |
|---|---|---|---|
| **CO1** | nano mechanics, Piezo Resistive Pressure sensors. | | 1 |
| **CO2** | calibration of different sensors | | 2 |
| **CO3** | encoder and tactile and proximity | | 3 |
| **CO4** | pneumatic actuator, Electrical actuating systems and Piezoelectric actuator. | | 3 |
| CO | Syllabus | | CH |
| 1 | Acoustic wave sensors, resonant sensor, Vibratory gyroscope, Capacitive and Piezo Resistive Pressure sensors- engineering mechanics behind these Microsensors. Case study: Piezo-resistive pressure sensor | | 8 |
| 2 | Actuation using thermal forces, Actuation using shape memory Alloys, Actuation using piezoelectric crystals, Actuation using Electrostatic forces (Parallel plate, Torsion bar, Comb drive actuators), Micromechanical Motors and pumps. Case study: Comb drive actuators | | 12 |
| 3 | classification, characteristics and calibration of different sensors. Measurement of displacement, position, motion, force, torque, strain gauge, pressure flow, temperature sensor sensors, smart sensor. and proximity, ultrasonic transducers, opto-electrical sensor, gyroscope. Principles and structures of modern micro sensors, micro-fabrication technologies:, LIGA, bulk micromachining, surface micromachining assembly and packaging | | 12 |

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|---|---|---|
| 4 | actuators, definition, example, types, selection. Pneumatic actuator. Electro-pneumatic actuator. Hydraulic actuator, control valves, valve sizing valve selection. Electrical actuating systems: solid-state switches, solenoids, voice coil; electric motors; DC motors, AC motors, single phase motor; 3 -phase motor; induction motor; synchronous motor; stepper motors. Piezoelectric actuator: characterization, operation, and fabrication; shape memory alloys. | 8 |

**Text Books**


| | |
|---|---|
| [1]. | Electromechanical Sensors and Actuators, Ilene J. Busch-Vishniac, Springer, 2008 |
| [2]. | . Introduction to Microelectronics Fabrication, Vol. V, G. W. Neudeck and R. F. Pierre (eds.), Addison – Wesley, 1988 |
| [3]. | Introduction to Microelectromechanical Microwave Systems, H. J. De Loss Santos, 2n edition, Norwood, MA: Artech, 2004 |
| [4]. | John G. Webster, Editor-in-chief, "Measurement, Instrumentation, and Sensors Handbook" CRC Press (1999) |


**Reference Books**


| | |
|---|---|
| [5]. | plications, D. K. Roy, World Scientific, Singapore, 1986 |
| [6]. | logy, Vol. 5, H. S. Nalwa (ed.), American scientific Publishers, 2004 |


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## Computer Vision & Applications

L-T-P-S : 3-0-0-0 Credits: 3
Pre-requisites : NIL Contact Hours: 3

**Mapping of Course Outcomes to Program outcomes:**

| CO. No | Course Outcome | Mapped PO | BTL |
|---|---|---|---|
| **CO1** | Implement fundamental image processing techniques required for computer vision. | 1,2 | 3 |
| **CO2** | Apply Hough Transform for line, circle, and ellipse detections | 2,3 | 3 |
| **CO3** | Apply 3D vision techniques. Implement motion related techniques; develop applications using computer vision techniques. | 2,3 | 3 |
| **CO4** | Understands motion analysis. To study some applications of computer vision algorithms. | 3,4 | 3 |
| CO | Syllabus | | CH |
| 1 | **Introduction to Computer Vision (CV)**<br>Basic Block Diagram Computer Vision; Principle of Computer Vision; Perception of 2 Dimensional & 3Dimensional Transformation (2 DCVT &3DCT); 3D Rotation; Histogram, Texture Analysis; Image formation, Geometric Primitives and transformations, Geometric Primitives, 3 D to 2D Projections, Lens distortions, Color, Compositing and matting, Point, Pixel transforms, Histogram equalization, Application: Tonal adjustment, 4D to 11D Transformation on CV. | | 10 |
| 2 | **Optical Features Extraction (OFE)**<br>Overview of Feature Extraction on Computer Vision ; Edges, HOG, SIFT, SURF, DTW, Gabor Filter, Scale Space Analysis; Analysis Edges, Edge detection , Edge linking , Application: Edge editing and enhancement ,A comparative study of CFs, LBP, HOG, SIFT, SURF, and BRIEF for security and face recognition , Gabor filter for image processing and computer vision. | | 10 |
| 3 | **Video Features & CV Methods**<br>Optical Flow, Optical Flowrate, Elastic Band, Boundary Detection.<br>Optical Flow-Rate, Optical Flow Estimation,Ealstic Band ,Selection of Terminal Point of the Line, Texture Segmentation, Edge Flow and Anisotropic Diffusion, Edge Flow Definition, Edge Flow Intensity ,Edge Flow Texture, Edge Flow, Edge Flow Based on Gabor Phase , Edge Flow Integration , Edge Flow Propagation and Boundary Detection. | | 10 |
| 4 | **Pattern Analysis-Dimension Reduction**<br>VQ, ICA, KNN, PCA, LDA, Classifiers: GMM, SVM, CNN, DNN | | 10 |

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| | Gaussian Mixture Model and Deep Neural Network Recognizing faces with PCA and ICA, K-nearest Neighbors (KNN) ,Classification ModelLDA in Python for Computer Vision ,LDA in Python for Computer Vision, Deep Learning for Computer Vision, Support Vector Machines (SVM), Image Processing with the Computer Vision API vision field, LDA in Python for Computer Vision, Robust Principal Component Analysis for Computer Vision, Diagnosis and Treatment of Computer Vision Syndrome, Image Classifier using CNN | |
| **Text Books** | | |
| [1]. | Ayman Al Falou -Advanced Secure Optical Image Processing for Communications APRIL 2008 | |
| [2]. | Richard Szeliski- Computer Vision: Algorithms and Applications March 30, 2008 | |
| **Reference Books** | | |
| | | |
| [3]. | Noah Snavely's - Introduction to Computer Vision class at Cornell Tech (Spring 2019) | |
| [4]. | Bharath Hariharan's - Computer Vision class at Cornell (Spring 2019) | |

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**Advanced Robotic Wireless Sensor Networks**

L-T-P-S: 3-0-0-2 Credits: 4
Pre-requisites : NIL Contact Hours: 5

**Mapping of Course Outcomes to Program outcomes:**

| CO. No | Course Outcome | Mapped PO | BTL |
|---|---|---|---|
| **CO1** | To know the Basic Robots Advancements and terminologies | 1,2 | 3 |
| **CO2** | To impart knowledge in Advances in Robotic Kinematics | 2,3 | 3 |
| **CO3** | Examining the Varieties of Robots & Advanced Robotics Heterogeneity (ARH) | 2,3 | 3 |
| **CO4** | Understanding the Robotic Wireless Sensor Networks and Design project on various robots | 3,4 | 3 |
| CO | Syllabus | | CH |
| 1 | **Basic Robots Advancement:** Anatomy of Robot-principles and Laws- brief history-Advancement in Degrees of Freedom (DoF): 6DOF,16DOF-Actuators and Drives- Control Components- Kinematics-Differential Motion-Statics, Energy Method-Hybrid Position-force Control-Compliance, End-effecter Design-Non-holonomic Systems-Legged Robots, Multi-fingered Hands- Dynamics-Computed Torque Control-Computer Vision- Navigation-Tele-robotics and Virtual Reality. | | 8 |
| 2 | **Advances in Robotic Kinematics:** Facts and thoughts-Forward Kinematics 4-1CableDriven Parallel Robot-Inverse Kinematics Converging Paths Algorithm-1DoF 7-R Closed Loop-Linkage as a Building Block of Nanorobots- Bennett Based Balanced Butterfly LinkAge-Cooperative Object-Manipulation Through a Heterogeneous Mobile-Multi-robot System-Robust Trajectory Planning of Under-Actuated-Cable-Driven Parallel Robot with 3 Cables-Kinematic Synthesis Modified Jansen LegMechanism-Kinematics and Orientation Workspace3-DOF Parallel Robotic Wrist-Actuated Spherical Four-Bar Linkages-Real-Time Motion-Planning Dynamic Environments via Enhanced Velocity Obstacle-Design Project verification on robot simulator CoppeliaSim. | | 12 |

| | | |
|---|---|---|
| 3 | **Varieties of Robots & Advanced Robotics Heterogeneity (ARH)**Design Studies on Boston Dynamics Products: Cheetah, Atlas, SpotMini, Legged Robots, Wheeled Robots, Mobile Robots, Telerobots, Service Robots; Design considerations On: Large Robots, Miniature Robot (Swarm robotics), Auto-bots, Swarm-Robotics, Micro-bots, wheeled mobile robots, bipeds,KUKA Collaborative Robot Serie, autonomous Underwater Vehicle, Unmanned Aerial Vehicle; Reactor Pressure Vessel (RPV) Measuring Robots, Introduction to Autonomous | 12 |
| | Electric Vehicles (AEVs)- Design Project verification on robot simulator CoppeliaSim. | |
| 4 | **Robotic Wireless Sensor Networks:** Basic terms of RWSN-Architecture -working principles of RWSN-robotics Router- RSSI Models, Measurements, and RF mapping- RWSN Systems Components-Communication Aware Robot Positioning and Movement Control-RWSN Network Stack Layer Analysis<br>**Case Studies:** IoT and Wireless Sensor Network based Autonomous Farming Robot | 8 |

**Text Books**


| | |
|---|---|
| [1]. | Asada, H., and J. J. Slotine. Robot Analysis and Control. New York, NY: Wiley, 1986. ISBN: 9780471830290. |
| [2]. | JadranLenarcic, Bruno Siciliano - Advances in Robot Kinematics 2020 (2021, Springer International Publishing_Springer) |
| [3]. | Jürgen Sturm (auth.) - Approaches to Probabilistic Model Learning for Mobile Manipulation Robots (2013, Springer-Verlag Berlin Heidelberg) |
| [4]. | Cheng, Long, Cheng-Dong Wu, and Yun-Zhou Zhang. "Indoor robot localization based on wireless sensor networks." *IEEE Transactions on Consumer Electronics* 57.3 (2011): 1099-1104. |
| [5]. | Sebastian Thrun, Wolfram Burgard, Dieter Fox - Probabilistic Robotics (2005) |


**Reference Books**


| | |
|---|---|
| [6]. | Sergey Yu. Misyurin, Vigen Arakelian, Arutyun I. Avetisyan - Advanced Technologies in Robotics and Intelligent Systems_ Proceedings of ITR 2019 (2020 |


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## Autonomous Mobile Robots and Automotive Electronics

**Course Code:** **L-T-P-S: 3-0-0-0**
**Pre-requisite: NIL** **Credits: 3**

| CO. No | Course Outcome | Mapped PO | BTL |
|---|---|---|---|
| **CO1** | Understand the basics of Autonomous Mobile Robots dynamics and design electronics to complement those features. | 1,2 | 3 |
| **CO2** | Understand **Mobile robot kinematics and dynamics, Motion Control** | 2,3 | 3 |
| **CO3** | Examining the autonomous mobile robot Perceptions with algorithms. | 2,3 | 3 |
| **CO4** | Design studies on embedded to Automotive Electronics protocols vehicle testing, vibration. | 3,4 | 3 |
| CO | Syllabus | | CH |
| 1 | **Introduction:** Outdoor Mobile Robots-Mechanism<br>**Robot locomotion:** Types of locomotion, hopping robots, legged robots, wheeled robots, stability, maneuverability,controllability.<br><br>**Mobile robot kinematics and dynamics:** Forward and inverse kinematics, holonomic and nonholonomic constraints,kinematic models of simple car and legged robots, dynamics simulation of mobile robots.<br>**Motion Control:** Cooperative Motion control land sensing Architecture-kinematic Motion Control<br>Sensory System: basic terms-relative position sensor-first tier data fusion-second tier data fusion-static testing of the RPS-Testing of the RPS and data fusion | | 12 |
| 2 | **Robust Motion Control:** kinematic and dynamic models-single axle nonlinear damping control design-multi axle distributed control design - controller evaluation<br><br>**Perception:** Proprioceptive/Exteroceptive and passive/active sensors, performance measures of sensors, sensors formobile robots like global positioning system (GPS), Doppler effect-based sensors, vision-based sensors, uncertaintyin sensing, filtering. | | 8 |

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| 3 | Localization: Terrain inclination based localization and mapping - Odometric position estimation, belief representation, probabilistic mapping, Markov localization,Bayesian localization, Kalman localization, positioning beacon systems;Introduction to planning and navigation: path planning algorithms based on A-star, Dijkstra, Voronoi diagrams,probabilistic roadmaps (PRM), rapidly exploring random trees (RRT), Markov Decision Processes (MDP),stochastic dynamic | 12 |
| | programming (SDP); Planning and<br>**Cloud based localization architecture in large scale environments:** basics-cloud based outsourcing localization architecture-cloud based localization algorithms-Design project | |
| 4 | **Embedded to Automotive Electronics and autonomous Vehicles**<br>Fundamentals of Automotive Electronics (FAE)-Advanced driver-assistance systems-Controlled Area Network (CAN)-Local Interconnect Network (LIN) -FlexRay Consortium -Media Oriented Systems Transport (MOST)- Vehicle Area Network (VAN)-Integrated to Automotive Electronic Protocols: EBD, Electronics stability programs (ESP)- OPC, Remotely Piloted Vehicles (RPVs)-UAV-Vehicle Networking & Diagnostics Stacks;Automotive Functional Testing: The Process Flow-diagram. HIL Testing, MIL Testing, SIL Testing,Navigation.<br>**Robotics Design Project:** Students will work on a semester long project consisting of design, fabrication, and programming a mobile robotic platform. | 8 |

**Text Books**


| | |
|---|---|
| [1]. | Xiaorui Zhu_ Youngshik Kim_ Mark A Minor - Autonomous mobile robots in unknown outdoor environments (2018, CRC Press) |
| [2]. | R. Siegwart, I. R. Nourbakhsh, "Introduction to Autonomous Mobile Robots", The MIT Press, 2011 |
| [3]. | S. M. LaValle, "Planning Algorithms", Cambridge University Press, 2006. (Available online http://planning.cs.uiuc.edu/) |
| [4]. | Intelligent Robotics and Autonomous Agents] Roland Siegwart_ Illah Reza Nourbakhsh_ Davide Scaramuzza - Introduction to autonomous mobile robots (2011, MIT Press) |
| [5]. | Understanding Automotive Electronics an Engineering Perspective Seventh edition William Ribbens3 |


**Reference Books**


| | |
|---|---|
| [6]. | Thrun, S., Burgard,W., and Fox, D., Probabilistic Robotics. MIT Press, Cambridge, MA, 2005. |
| [7]. | Melgar, E. R., Diez, C. C., Arduino and Kinect Projects: Design, Build, Blow Their Minds, 2012. |


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|---|---|
| [8]. | H. Choset, K. M. Lynch, S. Hutchinson, G. Kantor, W. Burgard, L. E. Kavraki, and S. Thrun, Principles of Robot Motion: Theory, Algorithms and Implementations, PHI Ltd., 2005. |

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# Design of MEMS Sensors And Actuators For Robotics

**Course Code: 21RA5244** **L-T-P-S: 3-0-0-0**
**Pre-requisite: NIL** **Credits: 3**

| CO. No | Course Outcome | Mapped PO | BTL |
|---|---|---|---|
| **CO1** | Ability to understand the operation of micro devices, micro systems and their applications | 1,2 | 3 |
| **CO2** | Ability to design the micro devices, micro systems using the MEMS fabrication process. | 2,3 | 3 |
| **CO3** | Gain a knowledge of basic approaches for various sensor design for robotics | 2,3 | 3 |
| **CO4** | Gain a knowledge of basic approaches for various actuator design for robotics | 3,4 | 3 |
| CO | Syllabus | | CH |
| 1 | **MEMS Basics:** Definition of MEMS, MEMS history and development, Characteristics of MEMS, micro machining, lithography principles & methods, structural and sacrificial materials, thin film deposition, impurity doping, etching, surface micro machining, wafer bonding, LIGA-<br>**Micro-Opto-Electro-Mechanical-Systems:** Principle of MOEMS technology, properties of light, light modulators, beam splitter, micro lens, micro mirrors, digital micro mirror device (DMD), light detectors, grating light valve (GLV), optical switch, wave guide and tuning, shear stress measurement. | | 10 |
| 2 | **Mems Fabrication Technologies**: Microsystem fabrication processes: Photolithography, Ion Implantation, Diffusion, Oxidation.Thin film depositions: LPCVD, Sputtering, Evaporation, Electroplating; Etching techniques: Dry and wet etching, electrochemical etching; Micromachining: Bulk Micromachining, Surface Micromachining, High Aspect-Ratio (LIGA and LIGA-like) Technology; Packaging: Microsystems's packaging, Essential packaging technologies, Selection of packaging materials.<br>Team Design studies on MEMS based Sensors and Actuators: Using COMSOL Multiphysics | | 10 |

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|---|---|---|
| 3 | **MEMS Sensors for Robotics:** Design of Acoustic wave sensors, resonant sensor, Vibratory gyroscope, Capacitive, Piezoelectric sensors, Piezo Resistive Pressure sensors, Magneto strictive sensors, Optical sensors, Resonant sensors, Semiconductor-based sensors, engineering mechanics behind these Microsensors. Case study: Piezo-resistive pressure sensor<br>**MEMS Sensors for Robotics:** Design of Actuators: Actuation using thermal forces, Actuation using shape memory Alloys, Actuation using piezoelectric crystals, Actuation using Electrostatic forces (Parallel plate, Torsion bar, Comb drive actuators), Micromechanical Motors and | 10 |
| | pumps. Case study: Comb drive actuators<br>MEMS Simulators-Team-Design studies on MEMS based Sensors and Actuators: Using COMSOL Multiphysics | |
| 4 | **Advancement of MEMS Sensors in Robotics:**Accelerometers- Inertial Measurement Units- Magnetometer- Pressure and Inertial Sensor- Flusso's FLS110 small airflow sensor- TDK's Chirp CH-101 ultrasonic sensor-USound'sConamara UT-P4010 speaker-imec's optomechanical ultrasound sensor in silicon photonics-Fuel Sensor- Impact and Crash Sensor-Camera, SONAR, LiDAR, RADAR, GPS,Vesper's VM3011 microphone<br>MEMS Simulators:Team Design studies on MEMS based Sensors and Actuators: Using COMSOL Multiphysics | 10 |

**Text Books**


| | |
|---|---|
| [1]. | Liu, Chang – Foundations of MEMS (2012, Prentice Hall) |
| [2]. | MEMS and NEMS, Sergey Edward Lyshevski, CRC Press, Indian Edition. |
| [3]. | Vijay K. Varadan, K. J. Vinoy, S. Gopalakrishnan - Smart material systems and MEMS_ design and development methodologies (2006, John Wiley & Sons) |
| [4]. | Marc Madou, "Fundamentals of Micro fabrication", CRC press 1997 |


**Reference Books**


| | |
|---|---|
| | |
| [5]. | MEMS and Micro Systems: Design and Manufacture, Tai-Ran Hsu, TMH Publishers. |
| [6]. | Introductory MEMS, Thomas M Adams, Richard A Layton, Springer International Publishers. |


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## Algorithms for Robotics Sensor Fusion

L-T-P-S : 3-0-2-0 Credits: 4
Pre-requisites : NIL Contact Hours: 5

| CO. | Course Outcome | Mapped | BTL |
|---|---|---|---|
| **CO1** | concepts and techniques used in sensor data fusion | 1,2 | 3 |
| **CO2** | levelop and apply data fusion algorithms | 2,3 | 3 |
| **CO3** | state of the art in multi sensor/ source integration,target tracking and identification | 2,3 | 3 |
| **CO4** | fusion algorithms with autonomous robots | 3,4 | 3 |
| CO | Syllabus | | CH |
| 1 | introduction, sensors and sensor data, Use of multiple sensors, Fusion applications. The inference hierarchy: output data. Data fusion model. Architectural concepts and issues. Benefits of data fusion, Mathematical tools used: Algorithms, co-ordinate transformations, rigid body motion. Dependability and Markov chains, Meta - heuristics. | | 10 |
| 2 | Taxonomy of algorithms for multisensory data fusion. Data association. Identity declaration, practical aspects of Kalman filtering, extended Kalman filters. Decision levels identify fusion. Knowledge based approaches | | 10 |
| 3 | information filter, extended information filter. Decentralized and Calable decentralized estimation. Sensor fusion and approximate greement. Optimal sensor fusion using range trees recursively. istributed dynamic sensor fusion. | | 10 |
| 4 | **Structures:**Tessellated, trees, graphs, and function. Representing anges and uncertainty in data structures. Designing optimal sensor Systems within dependability bounds. Implementing data fusion ystem-3D Sensing and Sensor Fusion: Introduction to Lidar and Point Clouds- Point Cloud Segmentation- Clustering Obstacles- mera Based 2D Feature Tracking- Track an Object in 3D Space- mbining Camera and Lidar- Radar Target Generation and Detection and Unscented Kalman Filter Highway Project based on Machine Learning, Deep Neural networks sensor fusion algorithms. | | 10 |
| **Text Books** | | | |
| [5]. | McMullen, Mathematical techniques in Multisensor data fusion, Artech House, Boston, 2nd Edition, 2004 | | |

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|---|---|
| [6]. | R.R. Brooks and S.S.Iyengar, Multisensor Fusion: Fundamentals and Applications with Software, Prentice Hall Inc., New Jersey, 1998. |
| [7]. | Jitendra R.Raol, Multi sensor data fusion with MATLAB, CRC Press, 2010. |

**Reference Books**

| | |
|---|---|
| [8]. | Multisensor Fusion: Fundamentals and Applications with Software, Prentice Hall Inc., New Jersey, 1998. |
| [9]. | Processing: The Model Based Approach, McGraw –Hill Book Company, 1987. |

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## 21RA51C1-Adaptive Motion Control Systems for Automation and Robotics

L-T-P-S: 3-0-0-2 Credits: 4
Pre-requisites : NIL Contact Hours: 5

| CO. No | Course Outcome | Mapped PO | BTL |
|---|---|---|---|
| **CO1** | Understand the Principles and design concepts of various adaptive control Mechanisms. | 1,2 | 2 |
| **CO2** | Understand the Principles and design concepts of Autonomous Tracked Robots | 1,2 | 2 |
| **CO3** | Understand the Principles and design concepts of Motion Vision and Motion estimation | 1,2 | 2 |
| **CO4** | Understand the Principles and design of Optimization for Motion Control Systems | 1,2 | 2 |
| CO | Syllabus | | CH |
| 1 | Introduction to adaptive control, Least Squares and Regression Models, Estimating Parameters in Dynamical Systems, Indirect Self-tuning Regulators, Continuous-Time Self tuners, Direct Self Tuning Regulators, Stochastic Self-tuning Regulators, Adaptive predictive Control. Model reference adaptive control - Determination of the Adaptive Gain, Review of Lyapunov stability theory, Design of MRAS using Lyapunov theory, Bounded-Input Bounded-Output Stability, Application to adaptive control. Stochastic Adaptive control. Auto Tuning. | | 10 |
| 2 | Autonomous Tracked Robots in Planar Off-Road Conditions - Importance of Tracked Vehicles, Modelling Tracked Robots- Extended Kinematic Model with Slip- Extended Trajectory Tracking Error Model with Slip- Discrete-Time Trajectory Tracking Error Model and Model Uncertainties- Localization of Tracked Robots, Estimating Robot Displacement, Estimating Robot Orientation: Visual Compass, Localization Approach Combining Visual Odometry with Visual Compass, Adaptive Motion Controllers- Slip Compensation Adaptive Controller Using Dynamic Feedback Linearization, Slip Compensation Adaptive Controller Using an LMI-Based Approach, Input and state Constraints, Robust Predictive Motion Controller | | 10 |
| 3 | Motion Vision - Visual motion estimation, Temporal integration, Motion estimation hardware, Real-time motion processing- Frequency domain analysis of image motion, Rigid body motion and the pinhole camera model, Linking temporal aliasing to the safety margin, Motion estimation for autonomous navigation- motion estimation algorithm, Monte Carlo study of the LTSV estimator, Dynamic scale space implementation, Temporal integration implementation | | 9 |

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| 4 | Advanced Optimization for Motion Control Systems- Model-Based Optimization for Motion Control Systems, Constrained Linear Quadratic Optimization Algorithm, Constrained H2 Optimization Algorithm, Constrained H2 Guaranteed Cost Optimization Algorithm, Data-Based Optimization for Motion Control Systems- Reduced-Order Inverse Model Optimization Algorithm, Optimization Algorithm for Reference Profile Alteration. | 10 |

**Text Books**


| | |
|---|---|
| [1]. | Karl J. Astrom_ Bjorn Wittenmark - Adaptive control (1994_ Dover Publications) |
| [2]. | Ramón González, Francisco Rodríguez,José Luis Guzmán "Autonomous TrackedRobots in Plana Off -Road Conditions" http://www.springer.com/series/13304 |
| [3]. | [IEE Control Series] Ljubo Vlacic Julian Kolodko - Motion Vision_ Design of Compact Motion Sensing Solutions for navigation of Autonomous systems, 2005, Published by The Institution of Engineering and Technology, London, United Kingdom |
| [4]. | Jun Ma (Author)_ Xiaocong Li (Author)_ Kok Kiong Tan (Author) - Advanced Optimization for Motion Control System, 2020, CRC press. |

**Reference Books**

| | |
|---|---|
| [5]. | H. K. Khalil, Nonlinear Systems, 3rd edition, Prentice Hall, 2002 |
| [6]. | S. Sastry and M. Bodson, Adaptive Control, Prentice-Hall, 1989 |
| [7]. | Andrew Parr, Industrial drives, Butterworth – Heineamann |


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# Signal Processing for Robotics

**Course Code: 21RA5246** **L-T-P-S: 3-0-0-0**
**Pre-requisite: NIL** **Credits: 3**

| CO. No | Course Outcome | Mapped PO | BTL |
|---|---|---|---|
| **CO1** | Basics classification of signals & types Characterization, typical Signal Processing operations | 1,2 | 1 |
| **CO2** | Construction of manipulators, advantages and disadvantages of various kinematic structures. Applications | 2,3 | 2 |
| **CO3** | Design Feedback systems, encoders Kinematics, homogeneous coordinate solution of the inverse kinematic problem. | 2,3 | 3 |
| **CO4** | Apply and analysis Programming Language: Mobile robots, walking devices. Robot reasoning. | 3,4 | 3 |

| CO | Syllabus | CH |
|---|---|---|
| 1 | Signals and signal Processing: Characterization & classification of signals, typical Signal Processing operations, example of typical signals, typical Signals Processing applications. Time Domain Representation of Signals & Systems: Discrete Time Signals, Operations on Sequences, the sampling process, Discrete-Time systems, Time Domain characterization of LTI Discrete-Time systems. | 12 |
| 2 | Construction of manipulators, advantages and disadvantages of various kinematic structures. Applications,. Trajectory planning. Joint Interpolated Trajectory, Link joints and their Manipulator dynamics and force control. Sensors: Vision, ranging, laser, acoustic, tactile. Developments in sensor technology, sensory control. | 12 |
| 3 | Non servo robots, motion planning. Feedback systems, encoders Kinematics, homogeneous coordinates solution of the inverse kinematic problem. multiple solutions, jacobian, work | 8 |

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| 4 | Programming Language: VAL, RAIL, AML, Mobile robots, walking devices. Robot reasoning. | 8 |
| **Text Books** | | |
| [1]. | A. Y. Oppenhein and R. W. Schater, "Digital Signal Processing", PHI 1975. | |
| [2]. | J.J. Craig, Robotics, Addison-Wesley, 1986. | |
| [3]. | K.S Fu, R.C. Gonzalez, C.S.G. Lee, Robotics, McGraw Hill, 1987. | |
| [4]. | Y. Koren, Robotics for Engineers, McGraw Hill, 1985 | |
| **Reference Books** | | |
| [5]. | Saeed B. Niku, " Introduction to Robotics – Analysis, Systems and Application" : PHI 2006 | |
| [6]. | R.K. Mittal & I.J. Nagrath, "Robotics & Control" TMH-2007. | |

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## Cloud Robotics and Automation

**Course Code** **L-T-P-S: 3-0-0-0**
**Pre-requisite: NIL** **Credits: 3**

| CO. No | Course Outcomes | Mapped PO | BTL |
|---|---|---|---|
| **CO1** | Automation principles and strategies, Methods of Work part Transport. | 1,2 | 2 |
| **CO2** | Control Functions, Automation for Machining Operations and Assembly Systems and Line Balancing. | 2,3 | 2 |
| **CO3** | Storage System Performance, Automated Storage/Retrieval Systems, Carouse | 2,3 | 2 |
| **CO4** | Sensor Technologies for Automated Inspection and Analytical Models. | 3,4 | 3 |

| CO | Syllabus | CH |
|---|---|---|
| 1 | Introduction: Definition, automation principles and strategies, scope of automation, socio-economic consideration, low cost automation, basic elements of advanced functions, Information processing in manufacturing industry, Production concepts and automation strategies. Fixed Automation: Automated Flow lines, Methods of Work part Transport, Transfer Mechanism - Continuous transfer, intermittent transfer, Indexing mechanism, | 8 |
| 2 | Operator-Paced Free Transfer Machine, Buffer Storage, Control Functions, Automation for Machining Operations, Design and Fabrication Considerations. Assembly Systems and Line Balancing: The Assembly Process, Assembly Systems, Manual Assembly Lines, The Line Balancing Problem, Methods of Line Balancing, Computerized Line Balancing Methods, Other ways to improve the Line Balancing. | 12 |
| 3 | Automated Materials Handling: The material handling function, Types of Material Handling Equipment, Analysis for Material Handling Systems, Design of the System, Conveyor Systems, Automated Guided Vehicle Systems. Automated Storage - Systems: Storage System Performance, Automated Storage/Retrieval Systems, Carousel Storage Systems, Work-in- | 12 |

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| | process Storage, Interfacing Handling and Storage with Manufacturing. | |
| 4 | Automated Inspection and Testing: Inspection and testing, Statistical Quality Control, Automated Inspection Principles and Methods, Sensor Technologies for Automated Inspection, Coordinate Measuring Machines, Other Contact Inspection Methods, Machine Vision, Other optical Inspection Methods. Modeling Automated Manufacturing Systems: Role of Performance Modeling, Performance Measures, Performance Modeling Tools: Simulation Models, Analytical Models. | 8 |
| **Text Books** | | |
| [1]. | Mikell P.Grover, "Automation, Production Systems and Computer Integrated Manufacturing", Pearson Education Asia, 2001. | |
| [2]. | C.RayAsfahl, "Robots and manufacturing Automation", John Wiley and Sons New York, 1992. | |
| [3]. | | |
| [4]. | | |
| **Reference Books** | | |
| [5]. | N.Viswanadham and Y.Narahari, "Performance Modeling of Automated Manufacturing Systems", Prentice Hall India Pvt. Ltd, 1992. | |
| [6]. | Stephen J. Derby, "Design of Automatic Machinery", Special Indian Edition, Marcel Decker, New York, Yesdee publishing Pvt. Ltd, Chennai, 2004. | |

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## FPGA-Based Wireless System Design

L-T-P-S : 3-0-0-2 Credits: 4
Pre-requisites : NIL Contact Hours: 5

CO 1: Software Defined Radio (SDR)
CO 2: Analysis of FPGA Speed, Area & Power
CO 3: Advanced Encryption Standards & High-Level Design
CO 4: FPGA for Wireless System

### Syllabus

**CO 1: Software Defined Radio (SDR)**

Essential functions of the SDR, SDR architecture, design principles of SDR, traditiona l radio implemented in hardware and SDR, transmitter architecture and its issues, A/D & D/A conversion, parameters of practical data converters, techniques to improve data converter performance, complex ADC and DAC architectures, digital radio processing, reconfigurable wireless communication systems.

**CO 2: Analysis of FPGA Speed, Area & Power**

High throughput, Low latency, Timing, Rolling Up the Pipeline, Control-Based Logic Reuse, Resource Sharing, Impact of Reset on Area, Clock Control, Input Control, Reducing the Voltage Supply, Dual-Edge Triggered Flip-flops, Modifying Terminations.

**CO 3: Advanced Encryption Standards & High-Level Design**

AES Architectures, Performance versus Area and other Optimizations, Abstract Design Techniques, Graphical State Machines, DSP Design, Software/Hardware Co-design.

**Clock domains, Reset Circuits & Implementing Math Functions**: Crossing Clock Domains, Gated Clocks in ASIC Prototypes, Asynchronous Versus Synchronous, Mixing Reset Types, Multiple Clock Domains, Hardware Division, Taylor, and Maclaurin Series Expansion, CORDIC Algorithm, Floating-Point Formats, Pipelined Architecture.

**CO 4: FPGA for Wireless System**

System Design and Modeling, Transmitter Design, Channel Modeling, Receiver Design, Automatic Hardware Generation, Co-Simulation and Hardware Verification, Simulation Acceleration with Simulink/(Xilinx) Vivado

**Textbooks**

1. Steve Kilts, "Advanced FPGA Design: Architecture, Implementation, and Optimization", McGraw-Hill Education TAB; 1 edition (October 5, 2016)
2. Narinder Lall, "FPGA-Based Wireless System Design", Xilinx, Inc.

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# Optimization Algorithms for Autonomous Systems

**Course Code: 21RA5245** **LTPS: 3-1-2-0**

COURSE OUTCOMES (COs):

| CO NO | Course Outcome (CO) | PO/PSO | Blooms Taxonomy Level (BTL) |
|---|---|---|---|
| CO1 | Develop Machine Learning based Optimization models for various problem specific solutions. | PO1,PO2 | 3 |
| CO2 | Apply evolutionary programming and strategies in engineering aspects. | PO4,PO3 | 3 |
| CO3 | Design Mathematical Models of Genetic Algorithms fitness functions. | PO5,PO6 | 3 |
| CO4 | Apply and analysis of advanced autonomous optimization techniques. | PO6,PO7 | 3 |
| CO5 | Examine and Experimental analysis on Optimization algorithms for autonomous systems and verify with suitable simulations/software tools. | PO7 | 4 |

**Syllabus:**

**CO 1: Optical Atmospherics Propagation characteristics**

Basic concept of Optical wireless communication, Optical Wireless channels, Light sources and spectra, Modulators, Characteristics of Atmospheric transmission and limitations, Effect of Rain, Fog, and Mist, Scintillation, Optical Path Length and Fermat's Principle, The Etendue or Lagrange Invariant, Edge Ray Principle.

**CO2: Optical Channel Modelling**

Indoor Optical Wireless Communication, LOS Propagation Model, Non-LOS Propagation Model, Ceiling Bounce Model, , Outdoor Channel, Channels: Atmospheric Channel Loss, Fog and Visibility, Beam Divergence, Optical and Window Loss, Pointing Loss, The Atmospheric Turbulence Models: Log-Normal Turbulence Model, Spatial Coherence in Weak Turbulence, The Gamma-Gamma Turbulence Model, The Negative Exponential Turbulence, Atmospheric Effects on OWC Test Bed Model, Calibration of the Test Bed to the Real Outdoor Environment, Demonstration of Scintillation Effect on Data Carrying Optical Radiation.

**CO 3: Information Transmission on Optical Wireless Channel& VLC**

Bidirectional VLC, VLC System Description, VLC System Model, Channel Delay

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Spread, Holographic Diffuser, SNR Analysis, VCL system Implementations: On-Off Keying (OOK) with a Forward Error Correction, Bit Angle Modulation (BAM), Pulse Modulation Schemes, PWM with Discrete Multitone Modulation (DMT), Multilevel PWM-PPM, PWM with NRZ- OOK, Multiple-Input, Multiple-Output (MIMO) VLC, Orthogonal Frequency Division Multiplexing (OFDM), Channel Estimation, Equalisations and Synchronisation

**CO 4: Optical Source Detectors**

Optical Communications Basics, Optical Transmitters, Optical Receivers, Optical Fibers, Optical Amplifiers, Optical Processing Components and Modules, Principles of Coherent Optical Detection. Optical Hybrids, Coherent Optical Balanced Detectors, Direct Digital Synthesizer (DDS). Multi-rate DSP and Resampling, Antenna Arrays, Automatic Gain Control (AGC)

**Textbook**

1. Rajbhandari, S., Ghassemlooy, Z., Popoola, W. (2019). Optical Wireless Communications: System and Channel Modelling with MATLAB®, Second Edition. United States: CRC Press.
2. Djordjevic, I. B. (2018). Advanced Optical and Wireless Communications Systems. Switzerland: Springer International Publishing.

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## Automotive Electronics & Avionics

**Course Code: 21RA51D2** **LTPS: 3-0-0-0**

| CO NO | Course Outcome (CO) | PO/PSO | Blooms Taxonomy Level (BTL) |
|---|---|---|---|
| CO1 | Acquire the fundamental knowledge on automotive electronics. | PO1,PO2 | 2 |
| CO2 | Explore and conjugate the emerging technologies utilized to assist the Autonomous Vehicles. | PO3,PO2 | 2 |
| CO3 | Analyze Electronics Embedded to Automotive Electronics and autonomous Vehicles | PO2,PO3 | 3 |
| CO4 | Acquire the basic knowledge on aviation technology. | PO1,PO2 | 2 |

**Syllabus :**CO-1:Automotive Electronics (AE) Introduction to Modern Automotive Systems-Evolution of Electronics and Software in automobiles -ECUs and their application areas in Automotive -Engine Management Systems -Body & Comfort Electronics Systems -Infotainment Systems -Advanced Driver Assistance Systems and V2X Systems -Autonomous Driving Systems - Current Trends and Challenges Micro Controllers in ECU Design: Overview of AURIX Micro Controller -Architecture, Memory Map, Lock Step etc Bluetooth low energy and the automotive (BLE-AE): Block Diagram-Functional of personalization using BLE-AE, Piloted/assisted/remote parking BLE-AE. CO -2: Automotive Wireless (AW):Wireless Networking and Applications to Vehicle Autonomy; Integration of Wireless Networking and On-Board Vehicle Networks; Wireless Access in Vehicular Environments (WAVE) amendment to IEEE 802.11; IEEE 802.11ac WLAN PHY and dual-band (2.4 GHz/5 GHz) support ; EEE 1609 - Family of Standards for Wireless Access in Vehicular Environments (WAVE). Automotive GPRS Vehicle Tracking (AGPRS-VT) Vehicle Tracking System; Principle of working for Vehicle Tracking system. GPS and GPRS tracking system. CO-3: Embedded to Automotive Electronics and autonomous Vehicles : In vehicle communication protocols: Overview of In-Vehicle Communication Protocols – CAN, LIN, Flex Ray, MOST, Ethernet -Controller Area Network (CAN)-CANoe, CANalyzer Fundamentals . Vehicle Area Network (VAN): Architecture-EBD-ESP-ICP-OPC-RPVs- UAV Vehicle Networking & Diagnostics Stacks – KWP 2000 and UDS. Automotive Functional Testing: HIL, MIL and SIL testing-AUTOSAR Overview - Automotive Quality, Safety and Security Standards Common Failures in Automotive Systems .Case studies on design Project Automotive Sensors, Drives, Actuators. CO-4 : Avionics: Introduction, Construction and Working and Indication System. • Introduction: Construction of aircraft, UAV, RPV. • Flight control systems: Airspeed Indicator, Altitude Indicator, Compass system, Gyroscopic system, heading indicator, Turning indicator, Flight director systems, Navigation systems, Auto Pilot System, Very-High Frequency Omnidirectional Range (VOR), Nondirectional Radio Beacon (NDB)

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**Text Books :**[1]. Ronald K Jurgen: "Distributed Automotive Embedded Systems" SAE International, 2007 [2]. Williams. B. Ribbens: "Understanding Automotive Electronics", 7th Edition, Elsevier Inc, 2012. [3]. Crating Autonomous Vehicle Systems by shaoshan liu, liyun li

**Reference Books :**[1]. Automotive Embedded Systems Handbook CRC Press Taylor & Francis Group Richard Zurawski [2]. Bosch Automotive Electrics and Automotive Electronics Systems and Components, Networking and Hybrid Drive Robert Bosch GmbH (Ed.) 5th Edition

**Web Links :**1 https://toshiba.semicon-storage.com/ap-en/product/automotive/micro.html 2 https://www.tesla.com/autopilot 3 https://www.audi.com/en/experience-audi/mobility-and-trends/autonomous-driving.html 4 https://global.toyota/en/mobility/ 5. http://www.ebooklibrary.org/articles/autonomous_car 6. https://link.springer.com/book/10.1007/978-3-662-48847-8 7. https://www.mazdausa.com/ 8. https://roboticsbiz.com/top-wireless-technologies-used-in-autonomous-vehicles 9. https://standards.ieee.org/standard/802_11p-2010.html 10. https://www.networkworld.com/article/3238664/80211-wi-fi-standards-and-speeds-explained.html

**MOOCS :**:1.https://www.coursera.org/specializations/self-driving-cars 2.https://swayam.gov.in/nd1_noc20_de06 3. https://www.mooclist.com/tags/autonomous-vehicles 4. https://www.edx.org/course/autonomous-mobile-robots-ethx-amrx 5.https://nptel.ac.in/courses/101/104/101104073/

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## TECHNICAL SKILLING (ROS, WEBOT, MATLAB, MSC ADAMS)

**Course Code: 21TS51A1** **LTPS: 0-0-0-8**

**Pre requisite: NIL** **Credits: 2**

**COURSE OUTCOMES (COs):**

| CO NO | Course Outcome (CO) | PO/PSO | Blooms Taxonomy Level (BTL) |
|---|---|---|---|
| CO1 | Basic Design and Numerical simulation of Non-linear control systems using suitable mini project | PO1,PO2 | 1 |
| CO2 | Understanding Design and Numerical simulation of order of dynamic equations using simulation software's | PO3,PO2 | 2 |
| CO3 | Design and Numerical simulation of optimal control with one mini project | PO4,PO5 | 1 |
| CO4 | Implementation of Numerical simulation of Non-linear systems and optimal control for robotics systems with suitable mini project | PO6,PO7 | 2 |

**Syllabus :**Project 1. Design and implementation of Robotic Arm ( Error Resolving) 2. Design and implementation of wall climbing robot ( Level-1 design I/I level-2 design I/II )

**Text Books :**Team Project: website, Simulation, Hardware Implementation

**Reference Books :**Team Project: website, Simulation, Hardware Implementation

**Web Links :**https://www.linkedin.com/learning/search?keywords=robotic%20arm&u=89447330 https://www.coursera.org/learn/robotica-inicial/home/welcome

**MOOCS :**Mograph Techniques: Rigging a Robot Arm in Cinema 4D Robótica

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# TECHNICAL SKILLING

**Course Code: 21TS52A2** **LTPS: 0-0-0-8**

**Pre requisite: NIL** **Credits: 2**

**COURSE OUTCOMES (COs):**

| CO NO | Course Outcome (CO) | PO/PSO | Blooms Taxonomy Level (BTL) |
|---|---|---|---|
| CO1 | Understand and recognize various Robots | PO1,PO4 | 1 |
| CO2 | Interpret and demonstrate Actuators and Sensors with different task performed by the robots | PO5 | 2 |
| CO3 | Applying Feedback Control of Robot for Pick and Place Operation and Trajectory Planning | PO2,PO4 | 3 |
| CO4 | Analyze the swarm or team robots for autonomous tunnelling | PO7 | 4 |

**Syllabus :**Technology of Robots, Basic Principles in Robotics; Mathematical Representation of Robots. Robot Hardware- Remotely Triggered Actuators and Sensors-Remotely triggered Feedback Control of Robot for Pick and Place Operation- Trajectory Planning of Mobile Robot with Obstacles-Conceptualisation of swarm or team robots for autonomous tunnelling.

**Text Books :** E. Bonabeau, M. Dorigo, G. Theraulaz, Natural to Artificial Swarm Intelligence, Oxford University Press, Oxford (1999)

**Reference Books :**S. Camazine, J.L. Deneubourg, N.R. Frank, J. Sneyd, G. Theraulaz, E. Bonabeau, Self-Organization in Biological systems, Princeton University Press, Princeton (2003)

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iii. M. Tech VLSI

## KLEF
## Dept. of Electronics and Communication Engineering
## M. Tech VLSI
## AY. 2021-22

### Semester-I

| S. No. | Course Code | Course Title | Periods | | | | Credits |
|---|---|---|---|---|---|---|---|
| | | | L | T | P | S | |
| 1 | 21EC5128 | MOS Circuit Design | 3 | 1 | 2 | 0 | 5 |
| 2 | 21EC5129 | Digital VLSI Design | 3 | 0 | 2 | 0 | 4 |
| 3 | 21EC5130 | Low power VLSI System Design | 3 | 1 | 0 | 0 | 4 |
| 4 | 21EC5104 | Artificial Intelligence & Machine Learning | 3 | 0 | 2 | 0 | 4 |
| 5 | | Elective – 1 | 3 | 0 | 0 | 0 | 3 |
| 6 | | Elective – 2 | 3 | 0 | 0 | 0 | 3 |
| 7 | 21IE5149 | Seminar | 0 | 0 | 4 | 0 | 2 |
| 8 | 21TS51V1 | Technical Skilling-I | 0 | 0 | 0 | 8 | 2 |
| **Total** | | | **18** | **2** | **10** | **8** | **27** |

### Semester-II

| S. No. | Course Code | Course Title | Periods | | | | Credits |
|---|---|---|---|---|---|---|---|
| | | | L | T | P | S | |
| 1 | 21EC5231 | Analog IC Design | 3 | 1 | 2 | 0 | 5 |
| 2 | 21EC5232 | VLSI Testing and Design for Testability | 3 | 1 | 2 | 0 | 5 |
| 3 | 21EC5233 | Algorithms for VLSI Design Automation | 3 | 0 | 2 | 0 | 4 |
| 4 | 21EC5234 | ASIC and FPGA Design | 3 | 0 | 0 | 0 | 3 |
| 5 | | Elective – 3 | 3 | 0 | 0 | 0 | 3 |
| 6 | | Elective – 4 | 3 | 0 | 0 | 0 | 3 |
| 7 | 21EC5250 | Term Paper | 0 | 0 | 4 | 0 | 2 |
| 8 | 21TS52V2 | Technical Skilling-II | 0 | 0 | 0 | 8 | 2 |
| **Total** | | | **18** | **2** | **10** | **8** | **27** |

### Semester-III&IV

| S. No. | Course Code | Course Title | Periods | | | | Credits |
|---|---|---|---|---|---|---|---|
| | | | L | T | P | S | |
| 1 | 21EC6050 | M. Tech. Project Dissertation - Part 1 & Part 2 | 0 | 0 | 72 | 0 | 36 |
| **Total** | | | | | | | |
| **Total Program Credits** | | | | | | | **90** |

### Subject Options as per Specialization

| S. No. | Course Code | Course Title | Periods | | | | Credits |
|---|---|---|---|---|---|---|---|
| | | | L | T | P | S | |

**Professional Elective-1**

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| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 1 | 21EC51Q1 | IC Fabrication Technology | 3 | 0 | 0 | 0 | 3 |
| 2 | 21EC51Q2 | System on Chip Design | 3 | 0 | 0 | 0 | 3 |
| 3 | 21EC51Q3 | Nano Electronics | 3 | 0 | 0 | 0 | 3 |
| 4 | 21EC51Q4 | Semiconductor Device Modelling | 3 | 0 | 0 | 0 | 3 |
| **Professional Elective-2** | | | | | | | |
| 1 | 21EC51R1 | VLSI Signal Processing | 3 | 0 | 0 | 0 | 3 |
| 2 | 21EC51R2 | Internet of Things Architecture and Protocols | 3 | 0 | 0 | 0 | 3 |
| 3 | 21EC51R3 | VLSI Circuits for BioMedical Applications | 3 | 0 | 0 | 0 | 3 |
| 4 | 21EC51R4 | Optimization Techniques in VLSI Design | 3 | 0 | 0 | 0 | 3 |
| **Professional Elective-3** | | | | | | | |
| 1 | 21EC51S1 | Advanced Digital IC Design | 3 | 0 | 0 | 0 | 3 |
| 2 | 21EC51S2 | Embedded System Design | 3 | 0 | 0 | 0 | 3 |
| 3 | 21EC51S3 | CAD Tools for VLSI | 3 | 0 | 0 | 0 | 3 |
| 4 | 21EC51S4 | Memory Design and Testing | 3 | 0 | 0 | 0 | 3 |
| **Professional Elective-4** | | | | | | | |
| 1 | 21EC51T1 | FPGA-Based Wireless System Design | 3 | 0 | 0 | 0 | 3 |
| 2 | 21EC51T2 | RF Mixed Signal IC Design | 3 | 0 | 0 | 0 | 3 |
| 3 | 21EC51T3 | MEMS System Design | 3 | 0 | 0 | 0 | 3 |
| 4 | 21EC51D4 | Block Chain & Cyber Security | 3 | 0 | 0 | 0 | 3 |

**Syllabus of newly added course in M. Tech VLSI:**

## INTERNET OF THINGS ARCHITECTURE AND PROTOCOLS

**Course Code: 21EC51R2** **LTPS: 3-0-0-0**

**Pre requisite: NIL** **Credits: 3**

**COURSE OUTCOMES (COs):**

| CO NO | Course Outcome (CO) | PO/PSO | Blooms Taxonomy Level (BTL) |
|---|---|---|---|
| CO1 | Understand the concepts of IoT Architecture, Reference model and IoT enabling technologies. | PO1,PO4 | 2 |
| CO2 | Understand the logical design of IoT system and communication technologies. | PO3,PO1 | 2 |

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| | | | |
|---|---|---|---|
| CO3 | Understand IoT networking protocols and Authentication Protocols for IoT Application layer. | PO1,PO4 | 2 |
| CO4 | Apply IoT protocols and programming concepts for real-world problems. | PO3,PO7 | 3 |

**Syllabus :**IoT Reference Architecture: Introduction to IoT, Introduction, IoT definition, Characteristics of IoT , IoT Architecture, Physical Design of IOT, Logical design of IoT, IoT enabling Technologies, IoT Levels & Development Templates, Difference between IoT and M2M, SDN and NFV for IoT. RFIDs, and wireless sensor networks technology. Embedded devices for IoT and Sensor Technology. IoT Systems-Logical using Python: Installing Python, Python Data Types & Data Structures, Control Flow, Functions, Modules, Packages, Date/ Time Operations, Classes, Python Packages. IoT Design Methodology, Case study using weather monitoring. IoT Physical Devices & Endpoints: IoT Device, Exemplary Device, Board, Linux on Raspberry Pi, Programming of IoT. IoT Communication Technologies: wired - UART, USART, SPI, I2C, ModBUS, CAN, Ethernet, USB. IoT Networking Protocols: IPv4 and IPv6.6lowPAN, TCP/IP, IP addressing of IoT devices MAC addresses of communication circuit .Web connectivity for connected devices Application Protocols – HTTP, Web sockets, Node, MQTT,UDP, CoAP, XMPP, AMQP and gateway protocols. Link Layer protocols: 802.3 – Ethernet 802.11 – WiFi 802.16 – WiMax 802.15.4 – LR-WPAN ,2G/3G/4G Wireless - Bluetooth, BLE, IEEE 802.11, IEEE 802.15,Zigbee, SIGFOX.4 Cloud storage Models and Communication APIs. Web application management protocol, Python web application framework. IoT Design Technologies: Case studies illustrating IoT design: Home Automation: Smart lighting, Smart Appliances, Cities: Smart Parking, Smart Lighting, Smart Roads, Emergency response, Environment: Weather monitoring, Air Pollution Monitoring, Noise pollution, Forest fire, River flood, Agriculture: Smart irrigation, Green House control.

**Text Books :**1. Vijay Madisetti, Arshdeep Bahga, Adrian McEwen (Author), Hakim Cassimally "Internet of Things A Hands-on-Approach" Arshdeep Bahga & Vijay Madisetti, 2014. 2.Bernd Scholz-Reiter, Florian Michahelles, "Architecting the Internet of Things", ISBN 978-3-642-19156-5 e-ISBN 978-3-642-19157-2, Springer

**Reference Books :**1. Bassi, Alessandro, et al, "Enabling things to talk", Springer-Verlag Berlin An, 2016. 2. Buyya, Rajkumar, and Amir Vahid Dastjerdi, eds. Internet of Things: Principles and paradigms. Elsevier, 2016. 3. David Hanes, Gonzalo Salgueiro, Patrick Grossetete, Robert Barton, Jerome Henry, "IoT Fundamentals: Networking Technologies, Protocols, and Use Cases for the Internet of Things", CISCO Press, 2017 4. Jan Holler, VlasiosTsiatsis, Catherine Mulligan, Stefan Avesand,StamatisKarnouskos, David Boyle, "From Machine-to-Machine to the Internet of Things: Introduction to a New Age of Intelligence", 1st Edition, Academic Press,2014.

**Web Links :**1 https://www.altexsoft.com/blog/iot-architecture-layers-components/ 2 https://www.coursera.org/learn/iot-wireless-cloud-computing/home/welcome 3 https://www.wiley.com/en-it/Internet+of+Things%3A+Architectures%2C+Protocols+and+Standards-p-9781119359678 4

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https://wso2.com/whitepapers/a-reference-architecture-for-the-internet-of-things/ 5
https://www.igi-global.com/chapter/iot-architecture-and-protocols-in-5g-environment/185923

**Annexure- V**

| COURSE CODE | COURSE NAME | L | T | P | S | CREDITS |
|---|---|---|---|---|---|---|
| 18IE4050 | PRACTICE SCHOOL | 0 | 0 | 0 | 24 | 6 |
| 18IE4051 | INTERNSHIP-1 | 0 | 0 | 0 | 24 | 6 |
| 18IE4052 | INTERNSHIP-2 | 0 | 0 | 0 | 24 | 6 |

**Inclusion of the course codes for internship which will be offered during odd and even semesters of final year (Y18 batch) is included.**

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**Annexure- VI**

Include new courses for pre-PhD examination

## Machine Learning

**Course Code: 21EC202** **LTPS: 3-0-0-0**

**Pre requisite: NIL** **Credits: 3**

**COURSE OUTCOMES (COs):**

| CO NO | Course Outcome (CO) | PO/PSO | Blooms Taxonomy Level (BTL) |
|---|---|---|---|
| CO1 | Understand the basic terminology and measurements of Machine Learning and Apply Machine Learning techniques using Tree and Bayesian models. | PO3,PSO2 | 3 |
| CO2 | Build Neural Network and SVM Algorithm for solving Classification and Prediction problems | PSO2,PO4 | 4 |
| CO3 | Apply Dimensionality reduction methods, Evolutionary learning and Ensembled methods to solve classification problems | PO3,PSO2 | 3 |
| CO4 | Illustrate different unsupervised models, Analytical, Explanation-Based and reinforcement learning methods | PO2 | 2 |
| CO5 | Implement Machine Learning Techniques using Python Language | PO5,PSO2 | 5 |

**Syllabus:** Learning, Types of Machine Learning, Supervised Learning: The Machine Learning Process, Performance Measures, The Bias-Variance Tradeoff, Learning with Trees: Using Decision Trees, Constructing Decision Trees, Classification and Regression Trees (CART), Turning Data into Probabilities: The Naïve Bayes' Classifier, Bayesian Networks. The EM Algorithm: Estimate Means of K Gaussians, General Statement of EM Algorithm Neural Networks: The Brain and The Neuron, Neural Networks, The Perceptron, Linear Separability, The

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Multi-Layer Perceptron: Going Forwards, Going Backwards Back-Propagation of Error, The Multi-Layer Perceptron in Practice, Deriving Back-Propagation. Support Vector Machines: Optimal Separation, Kernels, The Support Vector Machine Algorithm, Extensions to the SVM. Dimensionality Reduction: The Curse of Dimensionality, Linear Discriminant Analysis, (LDA), Principal Components Analysis (PCA), Evolutionary Learning: The Genetic Algorithm (GA), Generating Offspring: Genetic Operators, Using Genetic Algorithms. Ensemble Learning: Boosting, Bagging and Random Forests. Unsupervised Learning: The k-means algorithm, Hierarchical Clustering, The Self-Organising Feature Map. Explanation based Learning, Reinforcement Learning and Evaluating Hypotheses: Introduction, Learning Task, Q Learning, Non-Deterministic Rewards and Actions. Active Reinforcement Learning, Generalization in Reinforcement Learning.

**Text Books :**1. Tom M. Mitchell, "Machine Learning", McGrawHill, 1997 2. Stephen Marsland, "Machine Learning an Algorithmic Perspective", CRC Press, (2009)

**Reference Books :**1. Peter Harrington, "Machine Learning in Action", Manning Publications 2. Ethem lpaydin, "Introduction to Machine Learning", The MIT Press, (2010). 3. Programming Python by Mark Lutz, O'Reilly 4. Chun, J Wesley, Core Python Programming, 2 nd Edition Pearson 2007 Reprint

**Web Links :**1. Data Science and Machine Learning: https://www.edx.org/course/data-science-machine-learning 2. Machine Learning: https://www.ocw.mit.edu/courses/6-867-machine-learning-fall-2006/

**MOOCS :**1. Machine Learning Professional Certificate: https://www.coursera.org/professional-certificates/ibm-machine-learning 2. Machine learning - https://www.coursera.org/learn/machine-learning

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## Modern Digital Communication

**Course Code: 21EC204** **LTPS: 3-0-0-0**

**Pre requisite: NIL** **Credits: 3**

**COURSE OUTCOMES (COs):**

| CO NO | Course Outcome (CO) | PO/PSO | Blooms Taxonomy Level (BTL) |
|---|---|---|---|
| CO1 | Understand the various digital modulation techniques like ASK, PSK, QAM, etc., and select a modulation scheme based on error performance | PO1,PO2 | 2 |
| CO2 | Design baseband binary PAM systems for optimizing the performance of communication system | PO4,PO3 | 3 |
| CO3 | Design and analyze the channel coding techniques for optimum conditions | PO4,PO5 | 4 |
| CO4 | Analyze the performance of FH spread signals in an AWGN channel | PO5 | 4 |
| CO5 | Analyze various digital communication systems and their applications | PO7 | 5 |

**Text Books :**1. Wayne Tomasi, "Advanced Electronic Communications Systems", 6th Edition, Pearson Education. 2. K.Sam Shanmugam, "Digital and Analog Communication Systems", John Wiley and Sons (Asia) Pvt. Ltd.

**Reference Books :**1. Simon Haykin, Digital Communications, John Wiley and Sons, 1998. 2. B.P.Lathi, "Modern Digital and Analog Communication Systems, 3rd Edition", Oxford University, Press, 1998

**Web Links :**1. https://swayam.gov.in/courses/4769-july-2018-principles-of-digital-communications 2. https://onlinecourses.nptel.ac.in/noc17_ec12/announcements 3. http://www.infocobuild.com/education/audio-video-courses/electronics/ModernDigitalCommunication-IIT-Kharagpur/lecture-01.html 4. https://ocw.mit.edu/courses/electrical-engineering-and-computer-science/6-450-principles-of-digital-communications-i-fall-2006/

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## Radiating systems

**Course Code: 21EC207** **LTPS: 3-0-0-0**

**Pre requisite: NIL** **Credits: 3**

**COURSE OUTCOMES (COs):**

| CO NO | Course Outcome (CO) | PO/PSO | Blooms Taxonomy Level (BTL) |
|---|---|---|---|
| CO1 | Demonstrate the radiation mechanism and antenna parameters | PO2 | 2 |
| CO2 | Distinguish different types of radiation from apertures | PO2 | 2 |
| CO3 | Select the antennas and arrays based on the specific application | PO2 | 2 |
| CO4 | Evaluate the antenna performance with measurement techniques | PO2 | 2 |

**Syllabus :**Basics Concepts Of Radiation: Radiation from surface current and current line current distribution, Basic antenna parameters, Radiation mechanism-Current distribution of Antennas, Impedance concept-Balanced to Unbalanced transformer Radiation From Apertures Field equivalence principle, Rectangular and circular apertures, Uniform distribution on an infinite ground plane, Aperture fields of Horn antenna-Babinets principle, Geometrical theory of diffraction, Reflector antennas, and Design considerations - Slot antennas Synthesis Of Array Antennas Types of linear arrays, current distribution in linear arrays, Phased arrays, Optimization of Array patterns, Continuous aperture sources, Antenna synthesis techniques Micro Strip Antennas Radiation mechanisms, Feeding structure, Rectangular patch, Circular patch, Ring antenna. Input impedance of patch antenna, Microstrip dipole, Microstrip arrays Antenna Measurements: Log periodic, Bi conical, Log spiral ridge Guide, Multi turn loop, Traveling Wave

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antenna, Antenna measurement and instrumentation, Amplitude and Phase measurement, Gain, Directivity, Impedance and polarization measurement, Antenna range, Design and Evaluation

**Text Books :**1. Kraus.J.D.,"Antennas"II Edition, John wiley and Sons. 2. Balanis.A, "Antenna Theory Analysis and Design", John Wiley and Sons, New York, 1982

**Reference Books :**1. RF System Design, Peter Kinget Bell Laboratories, Lucent Technologies Murray Hill, 2. Practical RF system design, Wiley-IEEE, 2003 - Technology & Engineering.

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## Micro Electro Mechanical Systems

**Course Code: 21EC208** **LTPS: 3-0-0-0**

**Pre requisite: NIL** **Credits: 3**

**COURSE OUTCOMES (COs):**

| CO NO | Course Outcome (CO) | PO/PSO | Blooms Taxonomy Level (BTL) |
|---|---|---|---|
| CO1 | Introduction to MEMS and Microelectronic technologies used for MEMS | PO2 | 2 |
| CO2 | Micro-sensors & MEMS applications in Biological, Chemical and Acoustic field. | PO3,PO4 | 2 |
| CO3 | Introduction to MEMS based nanotechnology | PO3,PO5 | 2 |
| CO4 | NEMS physics and NEMS architecture | PO3 | 2 |

**Syllabus :**Micro and nano mechanics – principles, methods and strain analysis, an introduction to micro sensors and MEMS, Evolution of Micro sensors & MEMS, Micro sensors & MEMS applications, Microelectronic technologies for MEMS, Micromachining Technology – Surface and Bulk Micromachining, Micro machined Micro sensors, Mechanical, Inertial, Biological, Chemical, Acoustic, Microsystems Technology, Integrated Smart Sensors and MEMS, Interface Electronics for MEMS, MEMS Simulators, MEMS for RF Applications, Bonding & Packaging of MEMS, Conclusions & Future Trends. Nanoelectromechanical systems (NEMS) – a journey from MEMS to NEMS, MEMS vs. NEMS, MEMS based nanotechnology – fabrication, film formation and micromachining, NEMS physics –manifestation of charge discreteness, quantum electrodynamical (QED) forces, quantum entanglement and teleportation, quantum interference, quantum resonant tunneling and quantum transport, Wave phenomena in periodic and aperiodic media – electronic and photonic band gap crystals and their applications, NEMS architecture, Surface Plasmon effects and NEMS fabrication for nanophotonics and nanoelectronics, Surface Plasmon detection – NSOM/SNOM.

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**Text Books :**1. Electromechanical Sensors and Actuators, Ilene J. Busch-Vishniac, Springer, 2008. 2. Introduction to Microelectronics Fabrication, Vol. V, G. W. Neudeck and R. F.Pierret (eds.), Addison – Wesley, 1988. 3. Introduction to Microelectromechanical Microwave Systems, H. J. De Loss Santos,2nd edition, Norwood, MA: Artech, 2004. 4. Microsystems Design, S. D. Senturia, Kluwer – Academic Publishers, Boston MA,2001. 5. Principles and Applications of Nano-MEMS Physics, H. J. Delos Santos, Springer,2008. 6. Materials and Process Integration for MEMS Microsystems, Vol. 9, Francis E. H. Tay, Springer, 2002.

**Reference Books :**1. Electromechanical Sensors and Actuators, Ilene J. Busch-Vishniac, Springer, 2008. 2. Introduction to Microelectronics Fabrication, Vol. V, G. W. Neudeck and R. F.Pierret (eds.), Addison – Wesley, 1988. 3. Introduction to Microelectromechanical Microwave Systems, H. J. De Loss Santos,2nd edition, Norwood, MA: Artech, 2004. 4. Microsystems Design, S. D. Senturia, Kluwer – Academic Publishers, Boston MA,2001. 5. Principles and Applications of Nano-MEMS Physics, H. J. Delos Santos, Springer,2008. 6. Materials and Process Integration for MEMS Microsystems, Vol. 9, Francis E. H. Tay, Springer, 2002.

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## Detection and Estimation Of Signals

**Course Code: 21EC211** **LTPS: 3-0-0-0**

**Pre requisite: NIL** **Credits: 3**

**COURSE OUTCOMES (COs):**

| CO NO | Course Outcome (CO) | PO/PSO | Blooms Taxonomy Level (BTL) |
|---|---|---|---|
| CO1 | Understand and remember the concepts of probability theory, random Process, and Linear Algebra to be used for signal estimation and detection. | PO1,PO3 | 2 |
| CO2 | Understand the decision theory and apply it for the detection of signals | PO3,PO1 | 3 |
| CO3 | Understand the various parameter estimation techniques. | PO1,PO3 | 2 |
| CO4 | Understand the state-space estimation and apply it to filtering and various estimation applications. | PO5 | 3 |

**Syllabus :**Review of Probability and Random Processes: Probability, Conditional Probability, and Bayes' rule, random variables, random data, Generation of Pseudo-random noise, Moments and moment generating functions, distributions, random processes, power spectral density, ergodicity. Statistical Decision Theory and signal detection: Bayes' criteria, binary and M-ary hypothesis testing, Maximum likelihood, Neyman-Pearson criterion, composite hypothesis testing, sequential detection, energy detector, detection in presence of noise. Estimation Theory and properties of estimator: Introduction, Generalized likelihood ratio test, MAP and ML estimation, Uniform cost function, Mean Square estimation, Criteria for the good estimator, CR inequality, Bayes' estimation, Multiple parameter estimation. State Estimation: State-space model and the optimal state estimation problem, Prediction, Digital Discrete Kalman Filter, Weiner filter, Stored Data Weiner Filter, Signal Processing examples: Time-varying channel estimation, Vehicle tracking.

**Text Books :** T1 Signal Detection and Estimation, 2nd edition, Mourad Barkat, Artech House Inc, Norwood, MA 02062, 2005. T2 Fundamentals of Statistical Signal Processing: Estimation Theory, Steven M. Kay, Prentice Hall New Jersey, 1993. T3 Signal Processing: Discrete Spectral Analysis, Detection and Estimation, Mischa Schwartz and Leonard Shaw, Mc-Graw Hill Book Company, 1975.

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**Reference Books :**R1. Probability, Random Variables and Random Signal Principles", Peyton Z.Peebles Jr, 4th Edition, Tata Mc Graw Hill. R2. Jerry M. Mendel, Lessons in Estimation Theory for Signal Processing, Communication and Control, Prentice Hall Inc., 1995. R3. Srinath, Rajasekaran & Viswanathan, Introduction to statistical Signal processing, with Applications, Prentice Hall of India, New Delhi, 110 001,1989.

**Web Links :** https://www.youtube.com/watch?v=bmtew4kzHXU
https://www.youtube.com/watch?v=m0B4D2_wiQU&list=PL1qOdYF_cLbqSpbZfp51Xo-J-5REr1UCg

**MOOCS :**1. https://nptel.ac.in/courses/117/103/117103018/ 2. https://ocw.mit.edu/courses/electrical-engineering-and-computer-science/6-432-stochastic-processes-detection-and-estimation-spring-2004/ 3. https://www.coursera.org/lecture/data-collection-analytics-project/overview-NjQ0c 4. Video: https://www.youtube.com/watch?v=kjBOesZCoqc

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# Real Time Concepts for Embedded Systems

**Course Code: 21EC213** **LTPS: 3-0-0-0**

**Pre requisite: NIL** **Credits: 3**

**COURSE OUTCOMES (COs):**

| CO NO | Course Outcome (CO) | PO/PSO | Blooms Taxonomy Level (BTL) |
|---|---|---|---|
| CO1 | Understand C for Embedded Systems. Analyse ARM processor and interrupt architecture | PO2,PO3,PO4,PO5,PO6,PSO1,PO7,PSO2,PO1 | 2 |
| CO2 | Apply Modern Assembly Language Programming with the ARM Processor | PO1,PO2,PO3,PO4,PO5,PO6,PSO1,PO7,PSO2 | 3 |
| CO3 | Apply I/O Synchronization and Interrupt Programming. Program the STM32F4xx chip peripherals: I/O ports, ADCs, UARTs, and Timers | PSO2,PO1,PO5,PO7,PSO1 | 3 |
| CO4 | Understand Analog Interfacing and Program the STM32F4xx chip peripherals: DACs, SPIs, and I2Cs | PO3,PO4,PO5,PO6,PSO1,PO7,PSO2,PO1,PO2 | 3 |
| CO5 | Apply Embedded Systems Programming on ARM Cortex-M3/M4 Processor | PO3 | 3 |

**Syllabus :**Introduction to embedded systems, Cortex-M Architecture, STM32 Microcontroller, Exceptions and Interrupts Architecture, C for Embedded Systems. Basics of Assembly Programming, Data Processing Instructions, Memory Access Instructions, Branch and Control Instructions. Fundamentals of Input-Output Interfacing, STM Arm I/O Programming LCD and Keyboard Interfacing, Serial Communication Interfaces, UART Serial Port Programming, Timing Interfaces, STM Arm Timer Programming, I/O Synchronization, Interrupt and Exception Programming. Analog Interfacing, ADC, DAC, and Sensor Interfacing, SPI Protocol and DAC Interfacing, I2C Protocol and RTC Interfacing, Relay, Optoisolator, and Stepper Motor Interfacing, PWM and DC Motor Control, Programming Graphic LCD, DMA Programming

**Text Books :**1. Yifeng Zhu - Embedded Systems with ARM Cortex-M Microcontrollers in Assembly Language and C (2018), E-Man Press LLC. 2. Mazidi, Muhammad Ali_ Chen, Shujen_ Ghaemi, Eshragh - STM32 Arm Programming for Embedded Systems, 2019, MicroDigitalEd. 3. Muhammad Tahir, Kashif Javed - arm microprocessor systems cortex-m architecture programming and interfacing (2017, CRC Press) 4. Donald Norris - Programming With STM32_ Getting Started With the Nucleo Board and C_C++ (2018, McGraw-Hill Education) 5. Muhammad Ali Mazidi, Shujen Chen, Sarmad Naimi, Sepehr Naimi, Freescale ARM Cortex-M Embedded Programming Using C Language, Microdigitaled; 2nd edition (15 October 2016)

**Reference Books :**6. Daniel Kusswurm - Modern Arm Assembly Language Programming_ Covers Armv8-A 32-bit, 64-bit, and SIMD (2020, Apress) 7. Warren Gay - Beginning STM32. Developing with FreeRTOS, libopencm3 and GCC (2018, Apress) 8. Carmine Noviello - Mastering STM32 (2018, Lean Publishing

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## Advanced Embedded Processor Architecture

**Course Code: 21EC302** **LTPS: 3-0-0-0**

**Pre requisite: NIL** **Credits: 3**

**COURSE OUTCOMES (COs):**

| CO NO | Course Outcome (CO) | PO/PSO | Blooms Taxonomy Level (BTL) |
|---|---|---|---|
| CO1 | Understand 3 and 5 stage pipelines of ARM | PO2 | 1 |
| CO2 | Apply instructions set of ARM 7 processor using assembly language | PO3,PO4 | 2 |
| CO3 | Understand the AMBA bus architecture | PO2,PO3 | 1 |
| CO4 | Analyze different advanced ARM cores and their use in SOC applications | PO4,PO5 | 2 |

**Syllabus :**ARM Processor as System-On-Chip: Acorn RISC Machine – Architecture inheritance – ARM programming model – ARM development tools – 3 and 5 stage pipeline ARM organization – ARM instruction execution and implementation – ARM Co-processor interface. ARM Assembly Language Programming: ARM instruction types – data transfer, data processing and control flow instructions – ARM instruction set – Co-processor instructions, Thumb Instruction set. Architectural Support for System Development: Advanced Microcontroller bus architecture – ARM memory interface – ARM reference peripheral specification – Hardware system prototyping tools – ARMulator – Debug architecture. ARM Processor Cores: ARM7TDMI, ARM8, ARM9TDMI, ARM10TDMI, The AMULET Asynchronous ARM Processors-AMULET1. Embedded ARM Applications: The VLSI Ruby II Advanced Communication Processor, The VLSI ISDN Subscriber Processor, The OneCTM VWS22100 GSM chip, The Ericssion-VLSI Bluetooth Baseband Controller, The ARM7500 and ARM7500FE

**Text Books :**1. ARM System on Chip Architecture – Steve Furber – 2nd ed., 2000, Addison Wesley Professional. 2. Design of System on a Chip: Devices and Components – Ricardo Reis, 1st ed., 2004, Springer.

**Reference Books :**1.. Co-Verification of Hardware and Software for ARM System on Chip Design (Embedded Technology) – Jason Andrews – Newnes, BK and CDROM 2. System on Chip Verification – Methodologies and Techniques –Prakash Rashinkar, Peter Paterson and Leena Singh L, 2001,Kluwer Academic Publishers.

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## Advanced Computational Mathematics

**Course Code: 21EC305** **LTPS: 3-0-0-0**

**Pre requisite: NIL** **Credits: 3**

**COURSE OUTCOMES (COs):**

| CO NO | Course Outcome (CO) | PO/PSOs | Bloom's Taxonomy Level (BTL) |
|---|---|---|---|
| CO1 | Model a system of equations for real world applications in engineering, physical and biological sciences, computer science, finance, economics and solve them through matrix algebra | PO1 | 3 |
| CO2 | Model basic and computational techniques on discrete structures like relations, orders, functions & FSM, Lattices, and propositional &predicate logic | PO1 | 3 |
| CO3 | Model real world structures and their related applications using advanced discrete structures like graphs and trees. | PO1 | 3 |
| CO4 | Model the given Statistical data for real world applications in Engineering science, Economics and Management. | PO1 | 3 |
| CO5 | Demonstrate the Aptitude and Reasoning skills (Tests in skilling hours) | PO1 | 2 |

**Syllabus :**Linear Algebra: Matrix Algebra: Introduction, Types of Matrices, Rank of matrix, Solutions of linear Equations by Gauss elimination and Gauss Seidel methods, Eigen values, Eigen vectors. Quadratic forms Introduction to Discrete Structures & Discrete Computation: Relations: Closures of relations. Orders, Equivalence Relations, Functions, Finite-State Machines Lattices: Partial order relation, Hesse Diagrams, Properties of Lattices and applications. Logic and Proofs: Propositional Logic, Rules of Inferences, Applications of Propositional, Propositional Equivalences, Predicates and Quantifiers, Predicate logic, Consequences, Introduction to proofs, Proof methods and strategy. Counting Techniques: Permutations and Combinations Fibonacci series, Divide-and-Conquer Algorithms, Recursive definitions, Generating Functions, Solving Linear Recurrence Relations Advanced Discrete Structures & Computation Graphs & Trees: Terminology, Types of Graphs, Bipartite graphs, Graph Isomorphism, Connectivity, Euler and Hamilton Paths, Shortest-Path, Planar Graphs, Trees, Tree Traversal Applications of trees, spanning trees and Minimal spanning trees Modeling Statistical data for real world applications Axiomatic definitions of probability, addition rule and

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conditional probability, multiplication rule, total probability, Correlation, Regression and Curve fitting. Skilling: {Tests in skilling hours} Arithmetic: Foundations in Arithmetic: Numbers, Ratio, Proportion, Variation, Averages, Percentages, Profit & loss, Time & Distance, Time & Work. Applications of Number theory: Fermat's theorem, Euclidean Algorithm. Geometry: Lines, Triangles, Quadrilaterals, Polygons, Practical applications of common solids, irregular solids and their application in various engineering problems. Logic & Reasoning: Sets and Venn diagrams Deductions, Logical Connectives, Linear and circular arrangements. Clocks, Calendars, Blood Relations, Cubes, Number and letter series, Coding and Decoding, Symbolic representations of given data, Binary Logic, Non-Verbal reasoning.

**Text Books :**1. John Bird, Basic Engineering Mathematics, Sixth edition, Taylor & Francis Ltd., 2017, UK. 2. Kenneth H Rosen, Discrete Mathematics and its Applications, Seventh edition, McGraw Hill, 2007, USA. 3. Linear Algebra and Its Applications, Gilbert Strang, Fourth Edition

**Reference Books :**1. Advanced Engineering Mathematics 10th Edition, Erwin Kreyszig 2. R.E. Walpole, R.H. Myers, S.L. Myes, Keying Ye, Probability and Statistics for engineers and scientist, Ninth edition, Pearson publications, 2012, USA. 3. Mott, J.L., Kandel, A. and Baker, T.P., Discrete Mathematics for Computer Scientists and Mathematicians, Second edition, Prentice Hall India Pvt Ltd, 1986, India. 4. Tremblay J P and Manohar R, "Discrete Mathematical Structures with Applications to Computer Science", First edition, Tata McGraw Hill, 1975, India. 5. R. S. Agarwal, A Modern Approach to Verbal and Non-verbal Reasoning, S Chand Publications, 2018, New Delhi, India.

**Web Links :**1.https://www.youtube.com/watch?v=PmO_QdLrRZg
2.https://www.khanacademy.org/partner-content/pixar/crowds/crowds2/v/combinatorics11
3.https://onlinecourses-archive.nptel.ac.in/noc18_cs53
4.https://www.indiabix.com/aptitude/questions-and-answers/
5.https://www.indiabix.com/logical-reasoning/questions-and-answers/
6.https://www.sawaal.com/aptitude-reasoning-questions-and-answers.html

**MOOCS :**1.https://nptel.ac.in/courses/111/106/111106051/
2.https://nptel.ac.in/courses/111/107/111107058/ 3.https://nptel.ac.in/courses/106106094/16
4.https://nptel.ac.in/courses/111/106/111106050/
5.https://nptel.ac.in/courses/108/106/108106083/ 6. https://www.coursera.org/programs/coursera-response-program-for-kl-university-dkj6o/browse?collectionId=&productId=H_rBZ9rMEeeCnw6tUJCJGg&productType=course&query=discrete+mathematics&showMiniModal=true 7. https://www.coursera.org/programs/coursera-response-program-for-kl-university-dkj6o/browse?collectionId=&productId=RRI51-ckEeaEXgo6pliZ4A&productType=course&query= Introduction+to+Graph+ Theory&showMiniModal =true

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## VLSI System Design

**Course Code: 21EC309** **LTPS: 3-0-0-0**

**Pre requisite: NIL** **Credits: 3**

**COURSE OUTCOMES (COs):**

| CO NO | Course Outcome (CO) | PO/PSO | Blooms Taxonomy Level (BTL) |
|---|---|---|---|
| CO1 | Understand the different design and programmable design techniques, custom, cell-based design methodologies | PO2 | 2 |
| CO2 | Analyze the different data path subsystems | PO3 | 4 |
| CO3 | Analyze the different memory and array subsystems | PO3 | 4 |
| CO4 | Develop the power and clock distribution for subsystems | PO3 | 3 |

**Syllabus :**CO I: Design Methodology: Structured design techniques; Programmable logic; Gate array and sea of gates design; cell-based design; full custom design; Design flow; Design Economics. CO II: Data path Subsystems: Adders; One/zero Detectors; Comparators; Counters; Shifters; Multipliers; Power and Speed Trade-off. CO III: Memory and Array Subsystems: SRAM, DRAM, ROM, Serial access memories; CAM, PLAs; Array yield, reliability; Power dissipation in Memories. CO IV: Special-purpose Subsystems: Packaging; power distribution; I/O pads; Interconnect: Interconnect parameters; Electrical wire models, capacitive parasitics; Resistive parasitics; Inductive parasitic; Crosstalk; Advanced Interconnect Techniques. Timing Issues: Timing classification; Synchronous design; Self-timed circuit design; Clock Synthesis and Synchronization: Synchronizers; Arbiters; Clock Synthesis; PLLs; Clock generation; Clock distribution; Synchronous vs Asynchronous Design.

**Text Books :**1. Neil H.E. Weste, David. Harris and Ayan Banerjee, "CMOS VLSI Design" - Pearson Education, Third Edition, 2004. 2. Jan M. Rabaey, Anantha Chandrakasan, Borivoje Nikolic, "Digital Integrated Circuits" Pearson Education, Second Edition.

**Reference Books :**1.Sung-Mo Kang, Yusuf Leblebici, "CMOS Digital Integrated Circuits" TMH, Third Edition, 2003 2 Wayne Wolf, "Modern VLSI Design "; 2nd Edition, Prentice Hall,1998.

**Web Links :**1.https://www.youtube.com/watch?v=QFXaddi-Ag8
2.https://www.youtube.com/watch?v=qjYI-RNBTKo

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## Advanced Analog IC Design

**Course Code: 21EC312** **LTPS: 3-0-0-0**

**Pre requisite: NIL** **Credits: 3**

**COURSE OUTCOMES (COs):**

| CO NO | Course Outcome (CO) | PO/PSO | Blooms Taxonomy Level (BTL) |
|---|---|---|---|
| CO1 | Small Signal & large signal Models of MOS & BJT transistor. Analog MOS Process Passive & Active Current Mirrors: Basic current mirrors, Cascode current mirror, Active loads, and voltage and current references | PO1,PO3,PO5 | 3 |
| CO2 | Frequency response of integrated circuits: Single Stage (CS,CG,CD) amplifiers, Cascade Stage; frequency response( miller effect) of CG, CS, CD, Operation of Basic Differential Pair, differential pair with MOS loads, Frequency response of Cascade & Differential Pair | PO1,PO3,PO5 | 4 |
| CO3 | Operational Amplifiers with single ended outputs: Applications of operational amplifiers, basic two stage MOS operational amplifiers, Deviations from ideality in real operational amplifiers, Basic two-stage MOS operational amplifier, MOS Folded –cascode operational amplifiers | PO3,PO5,PO7 | 4 |
| CO4 | Feedback: Ideal feedback equation, gain sensitivity, feedback configurations, practical configuration and effect of loading; Nonlinear Analog circuits & other applications: Precision rectification, phased locked loops, Sampling Switches, switched capacitor integrator, oscillators, ADC, DAC. | PO7,PO3,PO5 | 4 |
| CO5 | Design and analysis of analog circuits with the application of multiple circuit typologies and configurations using Mentor Graphics. | PO5,PO7 | 4 |

**Syllabus :**CO-1: Small Signal & large signal Models of MOS & BJT transistor. Analog MOS Process Passive & Active Current Mirrors: Basic current mirrors, Cascode current mirror, Active loads, and voltage and current references; CO-2: Frequency response of integrated circuits: Single Stage (CS,CG,CD) amplifiers, Cascade Stage; frequency response( miller effect) of CG, CS, CD, Operation of Basic Differential Pair, differential pair with MOS loads, Frequency response of Cascade & Differential Pair; CO-3: Operational Amplifiers with single ended outputs: Applications of operational amplifiers, basic two stage MOS operational amplifiers, Deviations from ideality in real operational amplifiers, Basic two-stage MOS operational amplifier, MOS Folded –cascode operational amplifiers, CO-4: Feedback: Ideal feedback equation, gain sensitivity, feedback configurations, practical configuration and effect of loading; Nonlinear Analog circuits & other applications: Precision rectification, phased locked loops, Sampling Switches, switched capacitor integrator, oscillators, ADC, DAC.

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**Text Books :**1. Gray & Meyer, Analysis & Design of Analog Integrated Circuits, 4th edition, Wiley, 2001. 2. Behzad Razavi, "Design Of Analog CMOS Integrated Circuits", Tata Mcgraw Hill,2005.

**Reference Books :**1. Jacob Baker,"CMOS Mixed Signal Circuit Design", John Wiley. 2. Gray, Wooley, Brodersen, "Analog MOS Integrated Circuits ", IEEE Press, 1989. 3. Kenneth R. Laker, Willy M.C. Sansen, William M.C.Sansen, "Design of Analog Integrated Circuits and Systems", McGraw Hill.

**Web Links :**https://ece.illinois.edu/academics/courses/profile/ECE483

**MOOCS :**1. https://nptel.ac.in/courses/117/106/117106030/# 2. https://swayam.gov.in/nd1_noc20_ee26/preview

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# Pattern Recognition

**Course Code: 21EC314** **LTPS: 3-0-0-0**

**Pre requisite: NIL** **Credits: 3**

**COURSE OUTCOMES (COs):**

| CO NO | Course Outcome (CO) | PO/PSO | Blooms Taxonomy Level (BTL) |
|---|---|---|---|
| CO1 | To understand the concept of pattern recognition | PSO1,PO1,PO2 | 2 |
| CO2 | To explore Statistical pattern recognition | PSO1,PO1,PO2 | 2 |
| CO3 | To classify Syntactic pattern recognition | PSO1,PO1,PO3 | 2 |
| CO4 | To apply pattern recognition techniques in real time scenario | PO4,PSO1,PO2 | 3 |

**Syllabus :**1 Introduction and general pattern recognition: Pattern Recognition (PR), Pattern Recognition Approaches, Examples of PR Applications, Pattern Recognition Extensions. What is Pattern Recognition (PR). Pattern Recognition Approaches, Examples of PR Applications, Pattern Recognition Extensions. Statistical pattern recognition: Introduction, Supervised, Parametric Approaches, Unsupervised Approaches. 2 Statistical pattern recognition: Introduction, Supervised, Parametric Approaches, Unsupervised Approaches. Bayes Classifier: Bayes Theorem, Minimum Error Rate Classifier, Estimation of Probabilities Comparison with the NNC, Naive Bayes Classifier. Hidden Markov Models: Markov Models for Classification, Hidden Markov Models, HMM Parameters, Learning HMMs, Classification Using HMMs, Classification of Test Patterns. 3 Syntactic (structural) pattern recognition & NN Classifiers: Introduction, Structural Analysis Using Constraint Satisfaction and Structural Matching, The Formal Language-based Approach, Learning/Training in the Language-based Approach. Nearest Neighbour Based Classifiers: Nearest Neighbour Algorithm, Variants of the NN Algorithm, Use of the Nearest Neighbour Algorithm for Transaction Databases, Minimal Distance Classifier (MDC). 4 Applications of Pattern Recognition: Finger printing, cursive characteristic recognition, Biometrics, Rice inspection, Food quality analysis, etc.

**Text Books :**1 R. O. Duda, P. E. Hart, and D. G. Stork, Pattern Classification, 2nd edition, Wiley-Inter science. ISBN 0-471-05669-3 . 2 Pattern Recognition, An Algorithmic Approach, M. Narasimha Murty • V. Susheela Devi, 2011, Universities Press (India) Pvt. Ltd, Co-Published by Springer.

**Reference Books :**1 Hastie, Tibshirani, Friedman," The Elements of Statistical Learning," Springer.

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**Web Links :**1. https://www.youtube.com/watch?v=mWYUx_HJeSM 2. https://www.youtube.com/watch?v=O0f_p09nV4U 3. https://www.youtube.com/watch?v=zb4J8_weas0 4. https://www.youtube.com/watch?v=fTeilfNM88U 5.

## CMOS RF Circuit Design

**Course Code: 21EC315** **LTPS: 3-0-0-0**

**Pre requisite: NIL** **Credits: 3**

**COURSE OUTCOMES (COs):**

| CO NO | Course Outcome (CO) | PO/PSO | Blooms Taxonomy Level (BTL) |
|---|---|---|---|
| CO1 | Understand semiconductor device fabrication process | PO1 | 2 |
| CO2 | Analyze the characteristics of CMOS circuits Construction and the comparison between different state-of-the-art CMOS technologies and processes | PO3,PO1,PO2 | 3 |
| CO3 | Understand a complete design verification process using computer- aided tools for scaling, layout, extraction, simulation, and timing analysis | PSO1,PO1,PO2,PO5 | 2 |
| CO4 | Understand and analyze the design testing principle, time-delay concepts | PSO2,PO1,PO3 | 2 |
| CO5 | Evaluating the MOS circuit modules through project oriented approach using e-CAD tools | PO11 | 5 |

**Syllabus :**Technology Introduction: Introduction to IC Technology – MOS, PMOS, NMOS, CMOS & Bi-CMOS Technologies. VLSI Fabrication, Oxidation, Lithography, Diffusion, Ion Implantation, Metallization, Integrated Resistors and Capacitors. MOS Theory Analysis: Basic Electrical Properties of MOS Circuits: Ids-Vds Relationships, MOS Transistor Threshold Voltage Vth, gm, gds, Figure of Merit ωo, Short Channel and Narrow Channel Width Effects. Pass Transistor, Transmission Gate, NMOS Inverter, Various Pull-ups, CMOS Inverter Analysis and Design, Bi-CMOS Inverters, Latch up in CMOS Circuits. CMOS Circuits and Logic Design Rules: MOS Layers, Stick Diagrams, Design Rules and Layout, 2μm, 1.2 μm Design Rules, Rules for Vias and Contacts, Stick Diagrams and Simple Symbolic Encodings for NMOS, PMOS, CMOS and BiCMOS Logic Gates, Scaling of CMOS Circuits. CMOS Circuit Characterisation and Performance Estimation: Sheet Resistance RS and its Concept to MOS, Area Capacitance Units, Calculations - Delays, Driving Large Capacitive Loads, Delay Estimation, Logical Effort and Transistor Sizing, Power Dissipation, Reliability, CMOS Fault models: need for testing, manufacturing test principles.

**Text Books :**1. Kamran Ehraghian, Dauglas A. Pucknell and Sholeh Eshraghiam, "Essentials of VLSI Circuits and Systems" – PHI, EEE, 2005 Edition. 2. Neil H. E. Weste and David. Harris Ayan Banerjee, "CMOS VLSI Design" - Pearson Education, 1999.

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**Reference Books** :Sung-Mo Kang, Yusuf Leblebici,"CMOS Digital Integrated Circuits" TMH 2003 2. Jan M. Rabaey, "Digital Integrated Circuits" Pearson Education, 2003 3. Wayne Wolf, "Modern VLSI Design ", 2nd Edition, Prentice Hall, 1998.

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## Annexure- VIII - QP Mapping of NSDC skills.

| National Occupational Standards -Electronics Sector Skills Council of India | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| COURSE CODE | COURSE NAME | Sector | Sub Sector | QP Code | Occupation | QP Name | NSQF Level | QP File | Model Curriculum |
| 19EC2103 | Analog Electronic Circuit Design | Electronics Sector Skills Council of India | Semiconductor Design and Active Components | ELE/Q1201 | Designing | VLSI Design Engineer | 5 | https://nsdcindia.org/sites/default/files/ELEQ1201_VLSI_Design_Engineer_v1_04_01_2019.pdf | |
| 19EC2104 | Communication Signals & System Design | Electronics Sector Skills Council of India | Semiconductor Design and Active Components | ELE/Q1301 | Verification | Verification Engineer | 5 | https://nsdcindia.org/sites/default/files/QP_ELE-Q1301_Verification-Engineer.pdf | |
| 19EC2105 | Analog And Digital Communication | Electronics Sector Skills Council of India | Semiconductor Design and Active Components | ELE/Q1401 | Designing | Physical Design Engineer | 5 | https://nsdcindia.org/sites/default/files/QP_ELE-Q1401_Physical-Design-Engineer.pdf | |
| 19EC2208 | Digital Signal Processing | Electronics Sector Skills Council of India | Semiconductor Design and Active Components | ELE/Q1403 | Design | Embedded Product Designer - Technical Lead | 6 | https://nsdcindia.org/sites/default/files/ELEQ1403_Embedded_Product_Designer_technical_lead_v1_10_10_2019.pdf | https://nsdcindia.org/sites/default/files/MC_ELEQ1403_Embedded%20Product%20Designer-technical%20Lead%20V1.0_21.10.2019.pdf |
| 20EC2106 | Embedded Controllers & Embedded Systems Design | Electronics Sector Skills Council of India | Semiconductor & Components | ELE/Q1404 | Product Design | Embedded Full-Stack IoT Analyst | 5 | https://nsdcindia.org/sites/default/files/ELEQ1404_Embedded_FullStack_IoT_Analyst_v1_10_10_2019.pdf | https://nsdcindia.org/sites/default/files/MC_ELEQ1404_Embedded_Fullstack_IoT_Analyst_21.10.2019.pdf |
| 19EC3018 | Biomedical Electronics & Iot For Healthcare | Electronics Sector Skills Council of India | Semiconductor & Components | ELE/Q1405 | Product Design | IoT Hardware Analyst | 5 | https://nsdcindia.org/sites/default/files/ELEQ1405_IoT_Hardware_Analyst_v1_10_10_2019.pdf | https://nsdcindia.org/sites/default/files/MC_ELEQ1405_IoT%20Hardware%20Analyst_V.10_21.10.2019.pdf |
| 19EC3015 | VLSI Design | Electronics Sector Skills Council of India | Semiconductor Design and Active Components | ELE/Q1201 | Designing | VLSI Design Engineer | 5 | https://nsdcindia.org/sites/default/files/ELEQ1201_VLSI_Design_Engineer_v1_04_01_2019.pdf | |

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| S. No | Branch | Occupation / Job Role | Skilling Course to which this QP Is Mapped |
|---|---|---|---|
| 1 | ECE | VLSI Design Engineer | Semiconductor & Components<br>19EC2103 - Analog Electronic Circuit Design<br>19EC2104 - Communication Signals & System Design<br>19EC2105 - Analog And Digital Communication<br>19EC2208 - Digital Signal Processing<br>19EC3015 - VLSI Design |
| 2 | ECE | Telecom Technician- IOT Device/System | IoT Protocols & Architectures 2) IoT Sensing &Actuatiing Devices<br>20EC2106 - Embedded Controllers & Embedded Systems Design<br>19EC3018 - Biomedical Electronics & Iot For Healthcare |
| 3 | ECE | Network Engineer | 19EC2210 -Data Networks & Protocols |

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**AnnexureIX**

**Modification and upgradation of courses under Y19 regulation.**

| S.No | Course Code | Course Title | Existing Syllabus | New Syllabus | Topics added/removed/replaced | Changes in Course Outcome(s) | Justification for the modifications | Revision(%) |
|---|---|---|---|---|---|---|---|---|
| 1 | 20EC2 06 | Embedded Controllers & Embedded Systems Design | "CO1: Basics of Embedded System: Basics, Introduction and History of Processors, 8086 Architecture, Instruction set, 8086 programming and examples. 5 Hrs CO2: Microcontroller Fundamentals: 8051 Architecture,addressing modes, Instruction set, Simple Programs involving Arithmetic and Logical Instructions, Timers/Counters, Interrupts. 10 Hrs. CO3: Serial Data Communication and RS-232C Standard with 8051 Programming, Peripherals and Input Output with 8051 Microcontroller (PIO, Timers and Interfacing) Modern Microcontrollers: Introduction and Architecture of PIC Microcontroller, Introduction of ARM7 (LPC2148), Basic Architecture of ARM7, Pin Description, Advanced Microcontroller Bus Architecture (AMBA).11 Hrs CO4: Advanced Topics: Introduction to CORTEX (STM 32), Architecture and Introduction to RTOS (Real Time operating systems). Basic concepts and applications of RTOS. 4 Hrs " | "CO1: Basics of Embedded System: Basics, Introduction and History of Processors, 8086 Architecture, Instruction set, 8086 programming and examples. Microcontroller Fundamentals: 8051 Architecture, addressing modes, Instruction set, Simple Programs involving Arithmetic and Logical Instructions, Timers/Counters, Interrupts. CO2: 8051 Interfacing: Serial Data Communication and RS-232C Standard with 8051 Programming, Peripherals and Input Output with 8051 Microcontroller (PIO, Timers and Interfacing). Introduction and Architecture of PIC & ATMEGA 32 Microcontrollers. CO3: Modern Microcontrollers: Introduction to Real Time operating systems (RTOS). Basic concepts and applications of RTOS. Introduction to CORTEX-ARM (STM 32) & ARM7 (LPC2148) Microcontrollers. Basic Architecture of ARM7, Pin Description, and Advanced Microcontroller Bus Architecture (AMBA) concepts. CO4: Advanced Topics: Introduction to Multiprocessor System Design and Bus Based Communication Architecture. Basic concepts of 'System on Chip (SoC)' and its Applications. Introduction to | "Added: CO1: OLD Syllabus (CO1 & CO2) Merged. CO2: OLD Syllabus CO3 & OLD CO4 PIC MC added. CO3: OLD Syllabus CO4 Replaced to new syllabus CO3 & OLD CO4 RTOS topic newly added. CO4: Advanced Topics: Introduction to Multiprocessor System Design and Bus Based Communication Architecture. Basic concepts of 'System on Chip (SoC)' and its Applications. Introduction to Microcontroller Boards. Removed: Replaces:" | CO1, CO2 and CO3 are modified | As Per the core Companies recruitment System on Chip (SoC) newly added into CO4. As the integration of embedded technologies becomes increasingly prevalent in various industries, ranging from automotive and healthcare to consumer electronics, there is a critical need for a comprehensive educational program that addresses the intricacies of embedded controllers and systems design. This course will fill a crucial gap in our curriculum, providing | 60% |

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| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | | | Microcontroller Boards – Ex: Arduino, Beagle Bone, Raspberry Pi etc. Microcontroller Boards' Comparisons, Hardware Requirements, Pin Diagrams and detailed Descriptions, Interfacing & Instruction sets. Their key Features, Specifications, Programming & Applications." | | | students with hands-on experience in designing and implementing embedded systems, fostering a deep understanding of microcontroller architectures, real-time operating systems, and the principles of hardware-software co-design. | |

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**Annexure- X**

**List of Value added courses for AY 21-2022 ECE.**

| Program: B.Tech ECE | | Semester: Even | | AY 2021-22 |
|---|---|---|---|---|
| **Sl.** | **Specialization** | **Course Name** | **Level (1/2/3/4)** | **Certifications** |
| 1 | **NA** | NI CLAD | 0 | National Instruments |
| 2 | **NA** | NI CLD | 1 | National Instruments |
| 3 | **NA** | NI CLA | 2 | National Instruments |
| 4 | **IoT** | IOT Analytics & Data Sciences | 1 | Entuple & National Skill Development Corporation |
| 5 | | Advanced IOT Analytics with Machine Learning | 2 | Entuple & National Skill Development Corporation |
| 6 | | Embedded System Applications & IOT | 1 | Tessolve |
| 7 | | IOT & Industrial Automation | 2 | Tessolve |
| 8 | **VLSI** | Verification using system verilog | 1 | Entuple & National Skill Development Corporation |
| 9 | | Fundamentals of UVM (Universal Verification Methodology) | 2 | Entuple & National Skill Development Corporation |
| 10 | | Electronic circuit & Analog Layout Design | 1 | Entuple & National Skill Development Corporation |
| 11 | | CMOS Analog Circuit & Layout Design | 2 | Entuple & National Skill Development Corporation |
| 12 | | Synthesis and Timing analysis | 1 | Entuple & National Skill Development Corporation |
| 13 | | Physical Design and Verification | 2 | Entuple & National Skill Development Corporation |
| 14 | | VLSI Design and Verification | 1 | Tessolve |
| 15 | | VLSI-Advanced Design & Verification - System Verilog and UVM | 2 | Tessolve |
| 16 | **Data Communication** | Huawei Certified ICT Associate Routing and Switching (HCIA-R&S) | 1 | Huawei |
| 17 | | Huawei Certified ICT Professional Routing and Switching (HCIP-R&S) | 2 | Huawei |
| 18 | | Huawei Certified ICT Expert Routing and Switching(HCIE-R&S) | 3 | Huawei |
| 19 | **RF & Microwave** | RF Systems-Modelling, Design and Simulation | 1 | Entuple & National Skill Development Corporation |

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| | | | | |
|---|---|---|---|---|
| 20 | | Fabrication, Testing and Validation | 2 | Entuple & National Skill Development Corporation |
| 21 | **Data Computing** | Huawei Certified ICT Associate Artificial Intelligence (HCIA-AI) | 1 | Huawei |
| 22 | | Huawei Certified ICT Professional Artificial Intelligence (HCIP-AI) | 2 | Huawei |
| 23 | | Huawei Certified ICT Expert Artificial Intelligence (HCIE-AI) | 3 | Huawei |
| 28 | | COE Program in Cyber Security/Network Security Associate/ Network Security Professional | 2&3 | Bytex L |
| 29 | **Robotics** | Robotic Process Automation | 1 | Automation Anywhere |
| 30 | | Advanced Robotics | 2 | Automation Anywhere |
| 31 | **Bio Medical** | Medical Equipment's | 1 | Indian Biomedical Skill Consortium (IBSC) |
| 32 | | Advanced level of Bio medical(*Yet to be finalised) | 2 | Indian Biomedical Skill Consortium (IBSC) |

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