X AC- 11
09-12-2022

GOA UNIVERSITY
Taleigao Plateau, Goa 403 206

# F I N A L   A G E N D A

For the 11$^{th}$ Meeting of the

X ACADEMIC COUNCIL

Day & Date

Friday, 9$^{th}$ December, 2022

Time

10.00 a.m.

Venue
Conference Hall
Administrative Block
Goa University

Date: 19.10.2022
Place: Goa University

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**D 3.20** **Minutes of the Board of Studies in Electronics meeting held on 19.10.2022.**

**Part A**

1) Recommendations regarding courses of study in the subject or group of subjects at the undergraduate level: Nil
2) Recommendations regarding courses or group of subjects at postgraduate level:
   - Semester III & IV Syllabus as per NEP 2020 **(Annexure I Refer page No. 777)**

**Part B**

(I) Scheme of the Examinations at Undergraduate Level:Nil
(II) Panel of examiners for different examinations at Undergraduate Level:Nil
(III) Scheme of the examinations at post-graduate level:As per ordinances in place.
(IV) Panel of examiners for different examinations at post-graduate Level: Nil

**Part C**

1) Recommendations regarding preparation and publication and selection of Anthologies in any subject or group of subjects and the names of person recommended for appointment to make the selection. Nil

**Part D**

1) Recommendations regarding general academic requirements in the Departments of University or affiliated colleges:Nil
2) Recommendation of Academic Audit Committee and status thereof Nil

**Part E**

1) Recommendations of text books for the course for study at the Undergraduate level:Nil
2) Recommendations of text books for the courses of study at the post Graduate level: List of books required is indicated below each subject in the syllabus.

**Part F**

Important points for consideration/approval of Academic Council

(i) The Important points/recommended of BOS that require consideration/approval of Academic council (points to be highlighted) as mentioned below.
   - **Approval of M.Sc. Electronics syllabus Semester III and IV as per NEP 2020**

(II) The declaration by the Chairman, that the minutes were read out by the Chairman at the meeting itself.

**Sd/-**
Signature of Chairman

Date:
Place: Goa University

**Part G: The remarks of the Dean of the Faculty.**

(I) The minutes are in order.
(II) The minutes may be placed before the Academic Council with remarks if any.

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| | (III) May be recommended for approval of Academic Council.<br>(IV) Special remarks if any.<br>**Sd/-**<br>Signature of the Dean<br>Date:<br>Place: Goa University<br>**(Back to Index)** |
| **D 3.21** | **Minutes of the Board of Studies in Marathi meeting held on 19 and 20.10.2022.**<br>**Part A**.<br>i. Recommendations regarding courses of study in the subject or group of subjects at the undergraduate level: NIL<br>ii. Recommendations regarding courses of study in the subject or group of subjects at the postgraduate level: **(Annexure I Refer page No. 799)**<br>**1. The BoS finalized Research Specific Optional (MRTR) courses for the semester III and IV.**<br>**Following are the courses:**<br><br>MRTR 501<br>संशोधन पद्धती व तंत्र<br>MRTR 502<br>लोकसाहित्याचे संशोधन<br>MRTR 503<br>तौलनिक साहित्याभ्यास<br>MRTR 504<br>स्त्रीवादी मराठी साहित्य : स्वरूप आणि संशोधन<br>MRTR 205<br>महानगरीय मराठी साहित्य : स्वरूप आणि संशोधन<br>MRTR 506<br>ग्रामीण मराठी साहित्य : स्वरूप आणि संशोधन<br>MRTR 507<br>मराठीतील नियतकालिके<br>MRTR 508<br>भारतीय साहित्याचा अभ्यास<br><br>**2. BoS also finalized optional Generic Course (MRTG) for semester III and IV. (Annexure II. Refer page No.818)**<br><br>MRTG 501<br>मराठीतील विज्ञान साहित्य<br>MRTG 502<br>भाषांतरविद्या<br>MRTG 503<br>साहित्याचा समाजशास्त्रीय अभ्यास |

**D 3.20 Minutes of the Board of Studies in Electronics meeting held on 19.10.2022.**

**Annexure I**

**M.Sc. Electronics Programme Course Syllabus as per NEP 2020**

| Semester | Course Code | Course Title | Theory/ Lab | Course Credits | Contact Hours |
|---|---|---|---|---|---|
| **Semester I** | **Discipline Specific Core Courses (DSCC)** | | | | |
| | ELTC 401 | **Micro Electronics and VLSI Design** | Theory | 4 | 60 |
| | ELTC 402 | **Instrumentation & Control Theory** | Theory | 4 | 60 |
| | ELTC 403 | **Advanced Digital Communication System** | Theory | 4 | 60 |
| | ELPC 401 | **Electronics Practical I** | Lab | 4 | 120 |
| | **Discipline Specific Optional Courses (DSOC)** | | | | |
| | ELTE401 | **Numerical Computation and Algorithms** | Theory | 4 | 60 |
| | ELTE402 | **EDA Tools** | Theory | 4 | 60 |
| **Semester II** | **Discipline Specific Core Courses (DSCC)** | | | | |
| | ELTC404 | **Embedded System Design** | Theory | 4 | 60 |
| | ELTC 405 | **Real Time Operating System** | Theory | 4 | 60 |
| | ELTC 406 | **Digital System Design** | Theory | 4 | 60 |
| | ELPC402 | **Electronics Practical II** | Lab | 4 | 120 |
| | **Discipline Specific Optional Courses (DSOC)** | | | | |
| | ELTE 403 | **Internet of Things** | Theory | 4 | 60 |
| | ELTE 404 | **Switching and Routing** | Theory | 4 | 60 |
| **Semester II** | **Research Specific Optional Courses (RSOC)** | | | | |
| | ELTR 501 | **Signals and Systems** | Theory | 4 | 60 |
| | ELTR 502 | Artificial Intelligence and Application | Theory | 4 | 60 |
| | ELTR 503 | **Robotics** | Theory | 4 | 60 |
| | **Optional Generic Course (OGC)** | | | | |
| | ELTG 501 | **Laser System Engineering** | Theory | 4 | 60 |
| | ELTG 502 | **Data Science and Machine Learning** | Theory | 4 | 60 |
| | ELTG 503 | Electric Vehicle Technology | Theory | 4 | 60 |
| | ELTG 504 | **Biomedical Instrumentation** | Theory | 4 | 60 |
| **Semester IV** | **Research Specific Optional Courses (RSOC)** | | | | |
| | ELTR 504 | **Optical Communication Systems** | Theory | 4 | 60 |
| | ELTR 505 | **Digital Image Processing** | Theory | 4 | 60 |
| | ELTR 506 | **Neuromorphic Computing** | Theory | 4 | 60 |
| | **Discipline Specific Dissertation (DSD)** | | | | |
| | ELGD 501 | **Project** | -- | 16 | 480 |

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**Semester III**

| | | |
|---|---|---|
| **Course Code: ELTR 501**<br>**Course Title: Signals and Systems** | | |
| **Number of Credits: 04** | **Total Hours: 60** | **Total Marks: 100** |
| **Prerequisites for the course** | | |
| Should have the basic knowledge of Integration, Differentiation, Complex Numbers | | |
| **Objectives of Course** | | |
| This course is intended to:<br>• To develop understanding about signals, systems and their classification.<br>• To provide with necessary tools and techniques to analyse electrical networks and systems to develop expertise in time-domain and frequency domain approaches.<br>• Also discusses different types of Filters and its design. | | |
| **Course Content** | | |
| **Unit I** | **Signals and Signal Processing** | **05 Hours** |
| Characterization and Classification of Signals, Typical Signal Processing Operations. | | |
| **Unit II** | **Discrete Time Signal and Systems** | **08 Hours** |
| Discrete-Time Signals, Sequence Representation, Sampling Process, Simple Interconnection Schemes, Correlation of Signals, Random Signal. | | |
| **Unit III** | **Discrete Transform** | **17 Hours** |
| Fourier series, Continuous and Discrete-time Fourier Transform, Laplace Transform, Energy Density Spectrum, Phase and Group Delays. Digital Processing of Continuous Time Signals - Sampling of Continuous Time Signal, Low-pass & Band-pass Signal, Anti-Aliasing Filter design, Sample-and-Hold (S/H), Analog to Digital, Digital to Analog Convertors, Effects of S/H, Short-Time Fourier Transform, Wavelet Transform | | |
| **Unit IV** | **Digital Filter Structure** | **08 Hours** |
| Block Diagram Representation, FIR, IIR filter, Allpass Filter, Tunable IIR Digital Filter, Digital Sin-Cosine Generator, Computational Complexity. | | |
| **Unit V** | **FIR Digital Filter Design** | **10 Hours** |
| Preliminary Considerations, FIR Filter Design Based on Windowed Fourier Series, Design of Minimum Phase FIR Filters. | | |
| **Unit VI** | **DSP Algorithm Implementation** | **08 Hours** |
| Computability Equation Describing Filter Structure, Verification, Computation of Discrete Fourier Transform (DFT), FFT, DFT & Inverse-DFT using MATAB, Number Representation, Handling Overflow, Tunable Digital Filters. | | |
| **Unit VII** | **Application of Digital Signal Processing** | **04 Hours** |
| Dual-Tone Multi-Frequency Signal Detection, Musical Sound Processing, Signal Compression, Transmultiplexers | | |
| **Case Studies** | | |
| 1. Implementation of Filters – Ensemble Average filter, Exponential weighted running system, Median Filter.<br>2. Implementation of aliasing effect and interpolation<br>3. Implementation of DFT and FFT algorithms<br>4. Design Oscillator system - Lorentz and Gaussian oscillator system<br>5. Design Transfer function and convolution | | |

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| **Pedagogy** |
| lectures/ Experiential Learning |
| **Course Outcome** |
| Students will:<br>1. Explain classification of signals and signal processing operations.<br>2. Understand the discrete time signals and its discrete time Fourier transform representation.<br>3. Learn different structural representation of FIR and IIR digital filters. |
| **References/Readings** |
| 1. Sanjit K Mitra, 'Digital Signal Processing: A computer Based Approach, 3rd Edition, Tata MacGraw-Hill, 2011<br>2. Johnny R. Johnson, Introduction To Digital Signal Processing, Prentice Hall, 1989.<br>3. John G. Proakis, Dimitris G. Manolakis, Digital Signal Processing, 4th Edition, Pearson Education, 2007.<br>4. Simon Haykin, Van Veen, Signals and Systems, 2nd Edition, Wiley, 2007<br>5. Richard G. Lyons, 'Understanding Digital Signal Processing', Pearson, 2022<br>6. S. Palani, 'Signals and Systems', Springer International Publishing, 2021 |

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|---|---|---|
| **Course Code: ELTR 502**<br>**Course Title: Artificial Intelligence and Applications** | | |
| **Number of Credits: 04** | **Total Hours: 60** | **Total Marks: 100** |
| **Prerequisites for the course** | | |
| Should have knowledge of Basic electronics and programming. | | |
| **Objectives of Course** | | |
| This course is intended to:<br>• Introduce the foundation concepts in the field of artificial intelligence.<br>• Become familiar with basic principles of AI toward Problem solving<br>• Know approaches of inference, perception, Uncertain Knowledge, and Reasoning<br>• Prepares a student to take a variety of focused, advanced courses in various subfields of AI. | | |
| **Course Content** | | |
| **Unit I** | **Introduction** | **08 Hours** |
| History, Philosophy of AI, Definitions,<br>Introduction to:<br>• AI System Hardware CPU, RAM, GPU, Interconnects, Storage, Network Controller; | | |

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|---|---|---|
| • AI Accelerators GPUs;<br>• System Software Operating System, Virtualization, Cloud. | | |
| **Unit II** | **Containers, IDE & Schedulers** | **08 Hours** |
| Introduction to Containers and IDE; Scheduling and Resource Management Introduction to schedulers and orchestration tools; DeepOps: Deep-dive into Kubernetes with the deployment of various AI-based services. | | |
| **Unit III** | **Problem-solving by search** | **12 Hours** |
| Introduction to unguided and guided search;<br>State Space Search: Depth First Search, Breadth First Search, Depth First Iterative Deepening<br>Heuristic Search: Best First Search, Hill Climbing, Solution Space, TSP, Escaping Local Optima, Stochastic Local Search | | |
| **Unit IV** | **Knowledge Representation and Reasoning** | **10 Hours** |
| Knowledge Representation (KR) Introduction, Knowledge Progression, KR model, category: typology map, type, relationship, framework, mapping, forward & backward representation, KR system requirements; KR schemes; KR issues; KR using predicate logic, KR using Rules<br>Reasoning: Definitions Reasoning, formal logic, and informal logic, uncertainty, monotonic logic, non-monotonic Logic; Methods of reasoning and examples – deductive, inductive, abductive, analogy; Sources of uncertainty; Approaches to reasoning – symbolic, statistical and fuzzy; Symbolic Reasoning, Statistical Reasoning | | |
| **Unit V** | **Learning System & Neural Networks** | **12 Hours** |
| Definition, learning agents, components of the learning system; Rote Learning, Learning from examples; Explanation-based learning, Clustering, Reinforcement Learning<br>Introduction to NN, ANN, CNN, ML, Deep Learning: Model, architecture, Learning Methods | | |
| **Unit VI** | **Applications of AI** | **10 Hours** |
| Game playing, Computer Vision, Expert Systems, agricultural and soil management applications, Cognitive Science, Finance, meteorology, Health care. | | |
| **Case Studies:** | | |
| 1. Implementation of CNN for databases available in the public domain.<br>2. Development of your own deep network.<br>3. Image processing of the data collected using UAV/drone<br>4. Solving health care/ meteorology problem using AI algorithm. | | |
| **Pedagogy** | | |
| Lectures/Experiential Learning | | |

| Course Outcome |
|---|
| Students will:<br>• Gain knowledge of the basic concepts of Artificial Intelligence.<br>• Learn Problem-solving, knowledge representation, and reasoning approaches.<br>• Able to deal with all the concepts and problems using NN, ANN, CNN, ML, and deep learning.<br>• Able to apply the knowledge and will generate automated systems (Applications) using AI. |
| **References/Readings** |
| 1. Deepak Khemani, 'A First Course in Artificial Intelligence', McGraw Hill Education (India), 1st ED, 2014.<br>2. Stuart J. Russell and Peter Norvig, 'Artificial Intelligence', Pearson, 3rd ED, 2016<br>3. George F Lugar, Artificial Intelligence: Structure and strategies for complex, Problem Solving, 6th ED, 2021.<br>4. Wolfgang Ertel, Nathanael T. Black, Introduction to Artificial Intelligence Nils J Nilsson, Springer,2018<br>5. Principles of Artificial Intelligence, Illustrated Reprint Edition, Springer Heidelberg, 2014.<br>6. Alexander Jung Machine, 'Learning: The Basics (Machine Learning: Foundations, Methodologies, and Applications)', Springer, 2022<br>7. Cherry Bhargava, Pardeep Kumar Sharma, 'Artificial Intelligence. Fundamentals and Applications', CRC Press, 2022 |

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| **Course Code: ELTR 503**<br>**Course Title: Robotics** | | |
|---|---|---|
| **Number of Credits: 04** | **Total Hours: 60** | **Total Marks: 100** |
| **Prerequisites for the course** | | |
| Should have knowledge of Basic electronics hardware, Mathematics, and programming. | | |
| **Objectives of Course** | | |
| This course is intended to:<br>• Introduce robotics and the key elements and constituents of a robot; science and technology in robots; ROS.<br>• Understand and explain the various elements of the robotic system.<br>• Study all necessary kinematics and various analysis techniques.<br>• Understand the robot dynamics and control theory.<br>• Give exposure to futuristic robotic technologies. | | |

| Course Content | | |
|---|---|---|
| **Unit I** | **Introduction** | **10 Hours** |
| Introduction- Brief history, types, classification and usage, growth; Robot applications- Manufacturing industry, defense, rehabilitation, medical, etc.; Laws of Robotics; Introduction to ROS | | |
| **Unit II** | **Elements of robots** | **12 Hours** |
| Links, joints, actuators, and sensors;<br>Position and orientation of a rigid body, Homogeneous transformations;<br>Representation of joints, link representation using D-H parameters, Examples of D-H parameters, and link transforms;<br>Different kinds of actuators – stepper, DC servo and brushless motors, model of a DC servo motor; Types of transmissions;<br>Purpose of sensors, internal and external sensors, common sensors – encoders, tachometers, strain gauge-based force-torque sensors, proximity, and distance measuring sensors, and vision sensors. | | |
| **Unit III** | **Kinematics** | **07 Hours** |
| Direct and Inverse Kinematics;<br>Kinematics of serial robots: Direct and inverse kinematics problems, Inverse kinematics of constrained and redundant robots, Tractrix-based approach for fixed and free robots and multi-body systems;<br>Kinematics of parallel robots: direct and inverse kinematics problems, Mobility, Stewart-Gough platform, Degrees-of- freedom of parallel mechanisms and manipulators, Active and passive joints. | | |
| **Unit IV** | **Velocity and static analysis** | **05 Hours** |
| Linear and angular velocity of links, Manipulator Jacobians for serial and parallel manipulators;<br>Statics of serial and parallel manipulators, Statics and force transformation matrix of a GoughStewart platform, Singularity and Statics analysis. | | |
| **Unit V** | **Robot Dynamics & Controls** | **10 Hours** |
| Robot dynamics equation; General procedure for dynamics equation forming and introduction to control; Actuator dynamics and PD, PID control for robots; Trajectory tracking control; Lyapunovs theorems; Neural network control design | | |
| **Unit VI** | **Robotics Applications** | **09 Hours** |
| Introduction, development, and working of: UAV, Drone, Humanoid Robots & Underwater robot | | |
| **Unit VII** | **Futuristic robots** | **07 Hours** |
| Introductions to MEMS (micro-electro-mechanical systems), | | |

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| Introduction to Cognitive Robotics and Human-Robot Interaction,<br>Robots in Space & Defense applications |
| **Case Studies:** |
| 1. Development of obstacle avoidance and line follower robot.<br>2. Implementation of ROS.<br>3. Simulation of robotic trajectories.<br>4. Drone-based image analysis. |
| **Pedagogy** |
| Lectures/Experiential Learning |
| **Course Outcome** |
| Students will:<br>• Gain knowledge of the basic concepts in robotics, ROS, key elements, and constituents of the robotic system.<br>• Learn the kinematics of serial and parallel robots and will be able to perform various analyses.<br>• Understand the various robotic dynamics and control designs.<br>• Able to understand and develop robotic systems.<br>• Have an update on the latest robotic research & technologies. |
| **References/Readings** |
| 1. Ghosal, A., 'Robotics: Fundamental Concepts and Analysis', Oxford University Press, 9$^{th}$ reprint, 2013<br>2. Robert J Schilling, 'Fundamentals of Robotics', Prentice Hall India, 1$^{st}$ ED, 2003<br>3. John J Craig, 'Introduction to Robotics', Prentice Hall International, 3$^{rd}$ ED, 2005<br>4. Jitendra R. Raol, Ramakalyan Ayyagari, 'Control Systems: Classical, Modern, and AI-Based Approaches', CRC Press, 1$^{st}$ ED, 2019<br>5. Gao, Yang, 'Space Robotics and Autonomous Systems', Institution of Engineering & Technology, 2021<br>6. Lentin Joseph, Aleena Johny, 'Robot Operating System (ROS) for Absolute Beginners', 2$^{nd}$ ED, 2022 |

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| **Course Code: ELTG 501**<br>**Course Title: Laser System Engineering** | | |
| **Number of Credits: 04** | **Total Hours: 60** | **Total Marks: 100** |
| **Prerequisites for the course** | | |
| Graduate level knowledge in Electronics/Physics | | |
| **Objectives of Course** | | |
| This course is intended to:<br>● Teach the difference between ordinary light and light emitted by a laser device.<br>● Introduce the method used for excitation of laser devices.<br>● Explain the theory behind generation of stimulated emissions.<br>● Cover various application of lasers in medical, civil and defense areas. | | |
| **Course Content** | | |
| **Unit I** | **Optical Resonators** | **12 Hours** |
| Energies in resonator, Febry-Perot Etalon , Febry-Perot Etalon as Optical Spectrum Analyzer, Mode Stability Criteria , Resonance Frequency of Optical Resonator,Unstable Resonator | | |
| **Unit II** | **Interaction of Radiation with Atomic System** | **10 Hours** |
| Spontaneous transmission between Atomic layer, Homogenous and In-Homogeneous broadening , Line shape functions, Stimulated transmission , Absorption and amplification , gain saturation in Homogenous media . | | |
| **Unit III** | **Theory of Laser Oscillator** | **10 Hours** |
| Febry Perot Laser , Three and Four Level Laser , Power in Laser Oscillator, Optimum Light coupling , Multimode Laser Oscillator and Mode Locking Methods of Mode locking , Pulse length Measurements , Q-Switching , methods of Q-Switching . | | |
| **Unit IV** | **Laser Systems** | **8 Hours** |
| Pumping and laser Efficiency, Ruby Laser, Flash Pumping ,Nd-YAG Laser , Nd Glass Laser , Threshold for CW and Pulse operation , HeNe Laser , CO2 Laser , Ar-Ion Laser , Excimer Laser , Dye Laser. | | |
| **Unit V** | **Non –Linear Optics** | **6 Hours** |
| Origins of Non-Linear Polarization, relation between induced Polarization | | |
| **Unit VI** | **Interaction of Light and Sound** | **7 Hours** |

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| Scattering of Light by Sound, RamanNath and Bragg diffraction , Diffraction of light by Sound , Intensity modulation. | | |
| **Unit VII** | **Applications of Lasers** | **7 Hours** |
| Lidar, Laser cutting and welding, lunar laser ranging, Optical Network, optical tweezers, microscopy, Laser Leveling, Surface Defects scanning, bar code scanner | | |
| | **Case Studies** | |
| 1. Understanding the diffraction of Laser Light using grating<br>2. Comparison of resolving power of Prism and Grating.<br>3. Focusing of Laser Light.<br>4. Collimation of Laser Light. | | |
| **Pedagogy** | | |
| lectures/ tutorials/assignments/presentation | | |
| **Course Outcome** | | |
| The student will,<br>● have sufficient knowledge of lasers for applications involving medical treatment as well as defence needs.<br>● have a full knowledge of classification of lasers and its usage.<br>● Have working knowledge to handle high power industrial lasers. | | |
| **References/Readings** | | |
| 1. A. Yariv, "Optical Electronics", 4th Edition by, HRW publication, 1991.<br>2. A. Ghatak and K. Tyagarajan, "Optical Electronics", by Cambridge University Press, 1989 .<br>3. William T. Silfvast, "Laser fundamentals", 2$^{nd}$ Edition, Cambridge University Press, 2008<br>4. K.Thyagarajan, and Ajoy Ghatak, Lasers: Fundamentals and Applications (Graduate Texts in Physics), Springer publication, 2012.<br>5. L. Tarasov, "Laser Physics and application" , Mir Publication, 1987 | | |

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| **Course Code: ELTG 502**<br>**Course Title: Data Science and Machine Learning** | | |
| **Number of Credits: 04** | **Total Hours: 60** | **Total Marks: 100** |
| **Prerequisites for the course** | | |
| Should have the basic knowledge of linear algebra and Python programming language. | | |
| **Objectives of Course** | | |
| This course is intended to: | | |

- Introduce the mathematical foundations required for Data Science and Machine learning.
- Introduce the statistical and probabilistic concepts.
- Learn the data analysis and processing.
- To study different machine learning and deep learning techniques.

| | | |
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| **Course Content** | | |
| **Unit I** | **Introduction** | **05 Hours** |
| Introduction to Data Science, Data Science Process, Fundamentals of linear algebra | | |
| **Unit II** | **Foundations of Data Science** | **08 Hours** |
| Python for Data Science- Programming basics, libraries – Numpy, SciPy, Scikit-Learn, Tensor flow, Keras, Py-tourch, Pandas, Matplotlib, Seaborn. Statistical concepts – Descriptive and Inferential Statistics, Probability | | |
| **Unit III** | **Data Visualization, Exploration and Manipulation** | **12 Hours** |
| Types of Data, Visualization, Exploratory Data Analysis, Data Cleansing, Data Manipulation, Feature Extraction and Feature Selection | | |
| **Unit IV** | **Regression and Classification** | **10 Hours** |
| Linear Regression, Logistic Regression, Multivariate Regression, Support Vector Machine, Decision Tree, Random Forest, Naive Bayes, Regularization, Goodness of fit | | |
| **Unit V** | **Machine Learning** | **15 Hours** |
| Machine Learning Process Flow, Overfitting and under fitting, Bias-Variance, Types of machine learning, Dimensionality Reduction-Principal Component Analysis, K-Nearest Neighbor, Clustering-K-means | | |
| **Unit VI** | **Deep Learning** | **10 Hours** |
| Neural Networks, Convolutional Neural Networks, Transfer Learning, Reinforcement learning, Recurrent Neural Networks | | |
| case studies | | |

1. Implement data cleansing and manipulation operations
2. Implement Support Vector Machine algorithm for multiclass classification
3. Implement clustering algorithm
4. Demonstrate the overfitting and under fitting conditions
5. Face recognition using deep convolutional neural network and using transfer learning.

**Pedagogy**

lectures/ Experiential Learning

**Course Outcome**

The Students will:

1. Understand the fundamental concepts of data science and machine learning.
2. Perform data processing technique using python.
3. Explain and implement the machine learning methods.

**References/Readings**

1. Trevor Hastie, Robert Tibshirani, Jerome Friedman, 'The Elements of Statistical Learning - Data Mining, Inference, and Prediction', Springer New York, 2013
2. Joel Grus, 'Data Science from Scratch - First Principles with Python', 2nd Edition, O'Reilly Media, 2019.
3. Cathy O'Neil and Rachel Schutt, 'Doing Data Science - Straight Talk From The Frontline', O'Reilly. 2013.

4. Laura Igual, Santi Seguí, Eloi Puertas, Petia Radeva, Oriol Pujol, Sergio Escalera, Francesc Dantí, Lluís Garrido, 'Introduction to Data Science - A Python Approach to Concepts, Techniques and Applications', Springer International Publishing, 2017
5. Samir Madhavan, 'Mastering Python for Data Science', Packt Publishing, 2015
6. Ian Goodfellow, Yoshua Bengio, Aaron Courville, 'Deep Learning', MIT Press, 2016
7. Zhi-Hua Zhou, 'Machine Learning', Springer Nature Singapore, 2021

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| **Course Code: ELTG 503**<br>**Course Title: Electric Vehicle Technology** | | |
| **Number of Credits: 04** | **Total Hours: 60** | **Total Marks: 100** |
| **Prerequisites for the course** | | |
| **Should have graduate level knowledge in Basic Electrical and Electronics** | | |
| **Objectives of Course** | | |
| This course is intended to:<br>• Introduce to Hybrid & Electric Vehicle<br>• Cover various types of Electric Drives and energy<br>• Modelling and Characteristics of EV/HEV Powertrains Components<br>• Matlab Simulink modeling of Electric Vehicle | | |
| **Course Content** | | |
| **Unit I** | **Introduction to Hybrid Electric Vehicle** | **5 Hours** |
| Review of Conventional Vehicle, Introduction to Hybrid Electric Vehicles, Types of EVs, Hybrid Electric Drive-train, Tractive effort in normal driving | | |
| **Unit II** | **Electric Drives** | **10 Hours** |
| Energy consumption Concept of Hybrid Electric Drive Trains, Architecture of Hybrid Electric Drive Trains, Series Hybrid Electric Drive Trains, Parallel hybrid electric drive trains, Electric Propulsion unit, Configuration and control of DC Motor drives, BLDC,Induction Motor drives, Permanent Magnet Motor drives, switched reluctance motor | | |
| **Unit III** | **Energy Storage** | **8 Hours** |
| Introduction to Energy Storage Requirements in Hybrid and Electric Vehicles:- Battery based energy storage and its analysis, Fuel Cell based energy storage and its analysis, Hybridization of different energy storage devices. Sizing the drive system, Design of Hybrid Electric Vehicle and Plug-in Electric Vehicle | | |
| **Unit IV** | **Energy Management System** | **8 Hours** |
| Energy Management Strategies, Automotive networking and communication, EV charging standards, V2G, G2V, V2B, V2H | | |
| **Unit V** | **Mobility and Connectors** | **8 Hours** |
| Connected Mobility and Autonomous Mobility- case study Emobility Indian Roadmap Perspective. Policy: EVs in infrastructure system, integration of EVs in smart grid, social dimensions of EVs.<br><br>Connectors- Types of EV charging connector, North American EV Plug Standards, DC Fast Charge EV Plug Standards in North America, CCS (Combined Charging System), CHAdeMO, Tesla, European EV Plug Standards | | |

| **Unit VI** | **Modelling of Vehicle Performance Parameter** | **7 Hours** |
|---|---|---|
| Modelling Vehicle Acceleration - Acceleration performance parameters, modeling the acceleration of an electric scooter, modeling the acceleration of a small car. | | |
| **Unit VII** | **Modelling of Battery Electric Vehicles** | **7 Hours** |
| Electric Vehicle Modelling - Tractive Effort, Rolling resistance force, Aerodynamic drag, Hill climbing force, Acceleration force, Total tractive effort, Modelling Electric Vehicle Range - Driving cycles, Range modelling of battery electric vehicles, Constant velocity range modelling, Range modelling of fuel cell vehicles, Range modelling of hybrid electric vehicles | | |
| **UNIT VIII** | **Drivetrain Characteristics** | **7 Hours** |
| Modelling and Characteristics of EV/HEV Powertrains Components- ICE Performance Characteristics, Electric Motor Performance Characteristics - Battery Performance Characteristics-Transmission and Drivetrain Characteristics-Regenerative Braking Characteristics-Driving Cycles Modelling and Analysis of Electric and Hybrid Electric Vehicles Propulsion and Braking - Longitudinal Dynamics Equation of Motion - Vehicle Propulsion Modelling and Analysis - Vehicle Braking Modelling and Analysis | | |
| **Case studies** | | |
| 1. Explore Electric Powertrain Architectures<br>2.Tune Regenerative Braking Algorithms<br>3.Modify Suspension Design<br>4.Optimize Vehicle-Level Performance<br>5.Model Inverters, Traction Motors, and Develop Motor Control Software<br>6. Model Batteries and Develop Battery management System(BMS) | | |
| **Pedagogy** | | |
| **Lectures/Experiential Learning** | | |
| **Course Outcome** | | |
| Students will,<br>• To understand about basics of hybrid electric vehicle<br>• To understand about drives and control.<br>• Select battery, battery indication system for EV applications<br>• Design battery charger for an EV<br>• Modelling of Electric Vehicle in MATLAB | | |
| **References/Readings** | | |
| 1. Emadi, A. (Ed.), Miller, J., Ehsani, M., Boca Raton, “Vehicular Electric Power Systems” CRC Press, 2003<br>2. Husain, I. Boca Raton ,“Electric and Hybrid Vehicles” , CRC Press, 2010.<br>3. Larminie, James, and John Lowry, “Electric Vehicle Technology Explained” John Wiley and Sons, 2012<br>4. Tariq Muneer and Irene IllescasGarcía, ,“The automobile, In Electric Vehicles: Prospects and Challenges” , Elsevier, 2017<br>5. Sheldon S. Williamson ,”Energy Management Strategies for Electric and Plug-in Hybrid Electric Vehicles” , Springer, 2013 | | |

6. Amir Khajepour, Saber Fallah and Avesta Goodarzi, “Electric and Hybrid Vehicles Technologies, Modelling and Control: A Mechatronic Approach” John Wiley & Sons Ltd, 2014.
7. Antoni Szumanowski, “Hybrid Electric Power Train Engineering and Technology: Modelling, Control, and Simulation” IGI Global, 2013.

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| **Course Code: ELTG 504**<br>**Course Title: Biomedical Instrumentation** | | |
| **Number of Credits: 04** | **Total Hours: 60** | **Total Marks: 100** |
| **Prerequisites for the course** | | |
| **Graduate level knowledge in analog and digital electronics.** | | |
| **Objectives of Course** | | |
| This course is intended to: ·<br>● Introduce fundamentals of biomedical instrumentation and measurements<br>● Introduce concepts of biotelemetry and Non-invasive diagnostic imaging<br>● Cover Noise reduction technique in electronics systems | | |
| **Course Content** | | |
| **Unit I** | **Introduction to biomedical instrumentation** | **10 Hours** |
| Components of Man-Measurement system, Physiological system of body, problems encountered in measuring a living System, Basic transducer principle, Source of Bioelectric Potential, Skin contact Impedance, Electrodes: ECG, EEG, EMG, Microelectrodes. | | |
| **Unit II** | **Noise reduction technique in electronics systems** | **10 Hours** |
| Introduction, cabling, grounding, balancing and filtering, shielding, contact protection, Intrinsic Noise Source, Active device Noise, and Electrostatic discharge. | | |
| **Unit III** | **Cardiovascular measurements.** | **8 Hours** |
| Heart and cardiovascular system, characteristics of blood flow, Electrocardiography, measurement for Blood Pressure, ,photoplethysmography,FunctionalNIR for brain oxygenation. | | |
| **Unit IV** | **Non-invasive diagnostic imaging** | **8 Hours** |
| X-Ray, CT, MRI, fMRI, PET and SPECT, ULTRASOUND, Optical Tomography | | |
| **Unit V** | **Biotelemetry** | **10 Hours** |
| Introduction to Biotelemetry, Physiological parameters Adaptable to Biotelemetry, The components of Biotelemetry System, Implantable Units, and Applications of telemetry in-Patient care. | | |

| Unit VI | Instrumentation for clinical laboratory | 6 Hours |
|---|---|---|
| The Blood, Test for Blood cells, chemical Tests, Automation of chemical Test | | |
| **Unit VII** | **Applications in biomedical field** | **8 Hours** |
| Wearable devices: activity trackers, hearing aid, Electromyogram band. Laser applications in biomedical fields: Ophthalmology, dermatology, urology, Photoacoustic Tomography. | | |
| **Case Studies** | | |
| 1. ECG wave analysis using simulator<br>2. Signal condition for EMG<br>3. Signal condition for photoplethysmography<br>4. Implementation of noise reduction techniques | | |
| **Pedagogy** | | |
| lectures/ Experiential Learning | | |
| **Course Outcome** | | |
| The student will,<br>● Understand Fundamentals of medical instrumentation, Bioelectric potential, electrodes<br>● Understand concepts of biotelemetry<br>● Understand application of laser in biomedical field<br>● Implement Noise reduction technique in electronics systems | | |
| **References/Readings** | | |
| 1. Leslie Cromwell, Fred J. Weibell, and Erich A. Pfeiffer, "Biomedical instrumentation and Measurements" Prentice Hall India, 2011.<br>2. R .S, Khandpur, "Handbook of Biomedical instrumentation", Tata Mc GRAW Hill, 2014.<br>3. Henry W. Ott, "Noise reduction Technique in Electronic systems" , Wiley & sons, 1998.<br>4. Paul Suetens, "Fundamentals Of Medical Imaging", 3rd Edition, Cambridge University Press, 2017. | | |

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**SEMESTER IV**

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|---|---|---|
| **Course Code: ELTR 504**<br>**Course Title: Optical Communication Systems** | | |
| **Number of Credits: 04** | **Total Hours: 60** | **Total Marks: 100** |
| **Prerequisites for the course** | | |
| Should have knowledge of Electro statics and electromagnetics.<br>Also, a basic understanding of analog and digital communication is preferable. | | |
| **Objectives of Course** | | |
| This course is intended to:<br>• Highlight the importance of optical communication over existing copper cable and microwave communication.<br>• Elaborate on electromagnetic spectrum usage for various applications, from telephone to satellite communication.<br>• Create a strong theoretical base to understand the difference between the ray theory and wave theory approach for the passage of signals in optical fibers.<br>• Discuss the estimation of Noise in optical detection in detail.<br>• Emphasizes the industrial needs in cabling technique and type of cable used.<br>• Discuss different techniques of optical fiber manufacturing and their characteristic | | |
| **Course Content** | | |
| **Unit I** | **Light Propagation in Optical Fiber** | **14 Hours** |
| Introduction & Evolution of Fiber optics system;<br>Geometric picture, Pulse spread due to material dispersion, loss mechanism, Theory of Optical waveguides, methods of waveguides analyses, modes in steps and graded index fiber, new types of optical fibers | | |
| **Unit II** | **Fiber Optics Technology** | **08 Hours** |
| Fiber materials & fiber fabrication, cable design, coupling, splicing and connectors, splicing methods, connectors, fiber measurements.<br>Signal Degradation: Attenuation, Losses, Distortion, Pulse broadening. | | |
| **Unit III** | **Optical Sources & Power Launching** | **08 Hours** |
| LED and LDs, development of Laser diodes structures, transmitter circuits, Coupling efficiency of the source to fiber.<br>Source to fiber power launching, fiber joints, splicing. | | |
| **Unit IV** | **Optical detectors** | **09 Hours** |

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| Photoconductive detector: biasing circuit, Commercial photoconductor, Heterodyne Detection, p-n junction & its Equivalent circuit.<br>Photodiode: Geometry of p-i-n, Frequency Response of Photodiodes/N ratio, Schottky photodiode.<br>Avalanche diode: Construction, S/R ratio, minimum detection of power.<br>Noise in detectors | | |
| **Unit V** | **Receiver sensitivity and BER** | **05 Hours** |
| Receiver design & configuration, Receiver operations, Error sources, Receiver noise | | |
| **Unit VI** | **Communication System design** | **08 Hours** |
| System requirement, System design, Link analyses, Power budgeting, Line coding (NRZ, RZ, Block codes), | | |
| **Unit VII** | **Advance System** | **08 Hours** |
| TDM, Undersea fiber optics communication system, fibers in a telephone network, WDM, DWDM, OAE techniques, LAN topologies & fail safe fiber optics nodes. | | |

**Case Studies**

1. To compute Numerical aperture of a fiber.
2. Launching light in single mode fiber.
3. Computing losses in fiber link.
4. Analysing fiber networks.

**Pedagogy**

Lectures/Experiential Learning

**Course Outcome**

Students will:

- Have some knowledge of designing a point-to-point optical link for a given situation
- Able to choose the right type of components for designing an optical network.
- Able to monitor signal losses during signal transmission
- Develop skills to join telecom industries, as many aspects of a practical situation are discussed during the course of study.

**References/Readings**

1. Gerd Keiser , 'Optical Fiber Communication', MGH, 5th ED, 2017
2. A. Selvarajan and et al, 'Optical Fiber Communication', TMH, 1st ED, 2002
3. A. Yariv, 'Optical Electronics', HRW publication, 4th ED, 1991
4. P. Chakrabarti, ' Optical fiber Communication' MGH, 2015
5. Reinhold Noé, 'Essentials of Modern Optical Fiber Communication', Springer, 2nd ED, 2016
6. Govind P. Agrawal, 'Fiber-Optic Communication Systems', Wiley, 5th ED, 2021

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|---|---|---|
| **Course Code: ELTR 505**<br>**Course Title: Digital Image Processing** | | |
| **Number of Credits: 04** | **Total Hours: 60** | **Total Marks: 100** |
| **Prerequisites for the course** | | |
| Concepts of Digital Signal Processing | | |
| **Objectives of Course** | | |
| • Learn fundamentals of digital image processing.<br>• To study image processing techniques such as image enhancement, reconstruction, segmentation, morphing and representation | | |
| **Course Content** | | |
| **Unit I** | **Introduction** | **10 Hours** |
| Digital image fundamentals, Sampling and quantization, Pixel relationship, Imaging geometry, Image transforms | | |
| **Unit II** | **Image Enhancement** | **10 Hours** |
| Spatial domain- Gray level transformations, Histogram processing, Smoothing and sharpening Spatial filtering. Frequency domain- Fourier Transform, Smoothing and sharpening, Highpass and lowpass filters | | |
| **Unit III** | **Image Restoration and Segmentation** | **10 Hours** |
| Image Restoration - Degradation/Restoration process, Noise model, Restoration approach, Inverse filtering, Weiner filtering. Segmentation - Detection of discontinuities, Edge linking and boundary detection, Region based segmentation | | |
| **Unit IV** | **Color Depth and Image Processing Across Spectrum** | **10 Hours** |
| Color Image Processing - Color models, Color transformations, Smoothing and sharpening, Segmentation. Depth Imaging processing – RGBD image processing, filling holes. Image Processing across spectra- Multi-spectral imaging, Hyperspectral Imaging, Image feature extraction, fusion. | | |
| **Unit V** | **Morphological Image Processing and Image Compression** | **10 Hours** |
| Morphological Image Processing – Dilation and Erosion, Hit or Miss transform, Morphological algorithms. Image Compression – Lossy and Lossless compression, Image compression standards. | | |
| **Unit VI** | **Object Representation, Description and Recognition** | **10 Hours** |
| Representation, Boundary descriptors, Regional descriptor, Patterns and Pattern classes, Matching | | |
| **Case studies** | | |
| 1. Image enhancement in spatial and frequency domain<br>2. Implementing degradation and restoration of image<br>3. Implement feature extraction algorithms<br>4. Object detection from the image<br>5. Spatio-spectral image fusion | | |
| **Pedagogy** | | |
| Lectures/ Experiential Learning | | |
| **Course Outcome** | | |

The Students will:
1. Know and understand the fundamentals of digital image processing.
2. Operate on images using the techniques of smoothing, sharpening and enhancement.
3. Explain the concept of image restoration, segmentation and Morphological image processing algorithms.
4. Explain object representation along with the pattern matching.

**References/Readings**

1. Rafael C Gonzalez and Richard E Woods, 'Digital Image Processing', 4th Edition, Pearson, 2018
2. Anil K Jain, 'Fundamentals of Digital Image Processing', Prentice Hall India Learning Private Limited, 1994
3. William K Pratt, 'Digital Image Processing', 4th Edition, A Wiley-Interscience Publication, 2006
4. Edward R. Dougherty, 'Digital Image Processing Methods', CRC Press, 2020
5. Kumar Navulur, 'Multispectral Image Analysis Using the Object-Oriented Paradigm', CRC Press, 2020
6. Paul L. Rosin, Yu-Kun Lai, Ling Shao, Yonghuai Liu, 'RGB-D Image Analysis and Processing', Springer International Publishing, 2020
7. D. Sundararajan, 'Digital Image Processing - A Signal Processing and Algorithmic Approach', Springer Nature Singapore, 2017

**Course Code: ELTR 506**
**Course Title: Neuromorphic Computing**

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| **Number of Credits: 04** | **Total Hours: 60** | **Total Marks: 100** |

**Prerequisites for the course**

Graduate level knowledge in analog and digital electronics. Preferable to have exposure to programming.

**Objectives of Course**

This course is intended to:
- Introduce Neuromorphic computing and spiking neural networks (SNN).
- Introduce operational principles and learning models for Artificial Neural Networks and Spiking Neural Networks
- Cover various Neuromorphic computing architectures

**Course Content**

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| **Unit I** | **Introduction** | **7 Hours** |

Basics of brain-inspired computing and history of neural computing, Comparison of neuromorphic and conventional computing, Basics of linear algebra and probability theory needed for modelling of neural networks.

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| **Unit II** | **Shallow neural networks** | **17 Hours** |

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| Deep learning techniques using convolutional neural networks( AlexNet, VGG, Inception Net, GoogLeNet, and ResNet), Python programming preliminaries and Software development tools for Deep Neural Net (DNN), Shallow neural networks – Perceptron, Hopfield network, Boltzmann machine, Recurrent neural network, and Kohonen's self-organizing map | | |
| **Unit III** | **Operational principles and learning models** | **17 Hours** |
| Operational principles and learning models for Artificial Neural Networks and Spiking Neural Networks(SNN) such as spike timing dependent plasticity (STDP), Q-learning, actor-critic reinforcement learning, supervised learning, and back-propagation algorithms. | | |
| **Unit IV** | **Neuromorphic computing architectures** | **11 Hours** |
| Neuromorphic computing architectures- Loihi, TrueNorth, Neurogrid, Brainchip and SpiNNaker, Commercial hardware acceleration platforms such as NVDIA's graphics processing unit (GPU), Google's tensor processing unit (TPU), and Intel's vision processing unit (VPU) and FPGA accelerators. | | |
| **Unit V** | **Applications and Emerging technologies** | **8 Hours** |
| Application-specific VLSI chips capable of STDP learning, actor/critic reinforcement learning, and Q-learning, Emerging technologies in neuromorphic circuits such as memristors, spin transfer torque devices, and photonic devices. | | |
| **Case Studies** | | |
| 1. Setup of python environment for implementation of Spiking neural network(SNN)<br>2. Implementation of SNN for Image classification<br>3. Implementation of SNN for pattern recognition.<br>4. Handwritten digit recognition Using STDP | | |
| **Pedagogy** | | |
| lectures/ Experiential Learning | | |
| **Course Outcome** | | |
| Students will,<br>● Apply concepts of neuromorphic computing in research as well as industry in various applications such as computer vision, speech processing, pattern recognition etc.<br>● The student will be able to The students can also pursue research in development of neruromorphic hardware. | | |
| **References/Readings** | | |

1. Nan Zheng and Pinaki Mazumder, "Learning in Energy-Efficient Neuromorphic Computing: Algorithm and Architecture Co-Design", John Wiley & Sons, USA, 2019.
2. Aaron C. Courville, Ian Goodfellow, and Yoshua Bengio, " Deep Learning", MIT Press, 2015.
3. Pinaki Mazumder, Yalcin Yilmaz, Idongesit Ebong, "Neuromorphic Circuits for Nanoscale Devices", River Publishing, 2019.

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**Course Code: ELGD 501**
**Course Title: Project**

| **Number of Credits: 16** | **Total Hours: 480** | **Total Marks: 400** |
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**Prerequisites for the course**

Understanding of Electronics in the area such as Embedded programming, Machine learning, Signals & System, IoT, Robotics.

**Objectives of Course**

**This course is intended to:**

- Course train students to develops conceptual design and implementation.
- Hands on experience in H/W and S/W integration.
- Train students to plan and execute the projects and tasks.
- Train students to work in groups
- Hands on exposure to work of Technology development

**Methodology**

The Project course will commence at beginning of the I $^{st}$ /III $^{rd}$ semester.

If student wishes to take up project in industry/Academic institution/organization, such projects can be taken over six-month period in such case the student has to complete 4(four) credit RSOC course prior to II$^{nd}$ /IV$^{th}$ semester. Such student will have to associated with the mentor from industry/Academic institution/organization who will liaison with local supervisor from parent institution.

This course is basically to apply the knowledge they have acquired during the course of study and apply them for designing a gadget/interface/module required for an electronic industry/Research & Academic Institutions.

The progress of the project is monitored by the local supervisor/guide/discipline members over the period of a month for the I $^{st}$ /III $^{rd}$ semester and fortnightly for II$^{nd}$ /IV$^{th}$ semester for internal

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| evaluation. There will be final evaluation of the projects. The scheme of evaluation will be decided by the school discipline members. |
| **Pedagogy** |
| Presentation /Experiential Learning/Practical implementation |
| **Course Outcome** |
| **Students will:**<br>● The student will be exposed to the different kinds of working environments in electronic industries.<br>● Should able to understand product development cycle, team work, research survey, technical writing. |

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