COURSE OF STUDIES

ELECTRONIC SCIENCE

Programme Level	Master of Science (MSc)
Subject / Discipline	Electronic Science
Faculty	Faculty of Science
University	Universities of Bihar Established under the BSU AC 1976/PU Act 1976.
Duration	Two Years / Four Semesters
NHEQF Level	Level 6.5
Effective from	2026-27 onwards

A PART A — PROGRAMME OVERVIEW & OBJECTIVES

A.1 Graduate Attributes (GAs)

The programme nurtures the following Graduate Attributes in alignment with the National Higher Education Qualifications Framework (NHEQF) Level 6.5:

- Develop a strong foundation in fundamental and advanced areas of Electronics Science, integrating contemporary technologies and emerging developments.
- Acquire proficiency in experimental design, laboratory practices, instrumentation, data acquisition, analysis, and interpretation of scientific results.
- Gain hands-on research experience through independent project work involving problem identification, experimentation, data analysis, and dissertation preparation.
- Demonstrate effective technical communication, scientific writing, seminar presentation, and professional reporting skills.
- Apply analytical thinking, critical reasoning, and innovative problem-solving approaches to address complex scientific and technological challenges.
- Prepare for successful careers in industry, academia, research and development organizations, entrepreneurship, and higher studies in Electronics and allied disciplines.

A.2 Programme Outcomes (POs)

The Programme Educational Objectives describe the career and professional accomplishments that graduates are expected to attain within three to five years of graduation.

- **PO 1:** Demonstrate advanced knowledge and technical competence in electronic devices, circuits, communication systems, embedded systems, instrumentation, and emerging areas of Electronics Science.
- **PO 2:** Apply mathematical, computational, and engineering principles to analyze, model, and solve complex problems in electronics and allied technologies.
- **PO 3:** Design, conduct, and interpret experiments using modern electronic instruments, measurement techniques, simulation tools, and data analysis methods.
- **PO 4:** Design, develop, implement, and optimize electronic hardware and software systems to address real-world technological challenges.
- **PO 5:** Utilize programming, simulation platforms, data analytics, artificial intelligence, machine learning tools, and contemporary design methodologies in electronic applications.

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- **PO 6:** Demonstrate professional ethics, leadership, teamwork, entrepreneurial aptitude, and adaptability to emerging technologies through lifelong learning and continuous professional development
- **PO 7:** Conduct independent research, develop innovative solutions, and contribute to technological advancements.

A.3 Programme Specific Outcomes (PSOs)

Upon successful completion of this programme, a student shall demonstrate the following learning outcomes:

1. PSO 1 — Apply advanced mathematical, computational, and engineering principles to analyze, model, and solve complex problems in electronics and allied technologies.
2. PSO 2 — Design, simulate, and evaluate semiconductor devices, integrated circuits, and VLSI systems using modern fabrication techniques and electronic design automation (EDA) tools.
3. PSO 3 — Develop intelligent embedded systems, IoT-enabled devices, and digital electronic solutions for real-time monitoring, control, automation, and smart applications.
4. PSO 4 — Integrate concepts of advanced communication systems, artificial intelligence, machine learning, robotics, and digital image processing to design next-generation electronic systems.
5. PSO 5 — Employ contemporary laboratory instrumentation, simulation platforms, and emerging technologies such as MEMS and renewable energy systems for innovation and technological development.
6. PSO 6 — Conduct independent research, analyze experimental data, communicate technical findings effectively, and demonstrate professional ethics for careers in academia, research, entrepreneurship, and industry.

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B PART B — COURSE STRUCTURE (CBCS/NHEQF FRAMEWORK)

B.1 Semester-wise Course Structure

The following table presents the full four-semester course structure. Column headings: L = **Lectures per week**; T = Tutorials per week; P = Practicals per week; CC = Core Course; DSE = Discipline Specific Elective; GE/OE = Generic/Open Elective; SEC = Skill Enhancement Course; PROJ = Project/Dissertation.

S.No.	Paper Code	Title of the Course/Paper	L	T	P	Credits	Max. Marks	Type
SEMESTER I								
1	MSELE-CC101	Core Course I: Advanced Mathematical Techniques and Applications	3	1	0	4	100	CC
2	MSELE-CC102	Core Course II: IC Fabrication and VLSI Technology	3	1	0	4	100	CC
3	MSELE-CC103	Core Course III: Real Time Embedded System Design & IoT	3	1	0	4	100	CC
4	MSELE-PC104	Core Course IV: Practical	0	0	4	4	100	PC
5	MSELE-GE105/GE106	Generic Elective I: (One course to be chosen from the basket I)	3	1	0	4	100	GE
6		VAC/AEC/SEC	2	0	0	2	100	VAC/AEC/SEC
		Total — Semester I	**14**	**4**	**4**	**22**	**600**	
SEMESTER II								
1	MSELE-CC201	Core Course I: Digital Integrated Circuits	3	1	0	4	100	CC
2	MSELE-CC202	Core Course II: Artificial Intelligence & Robotics	3	1	0	4	100	CC
3	MSELE-CC203	Core Course III: Advanced Communication Systems	3	1	0	4	100	CC
4	MSELE-PC204	Core Course IV: Practical	0	0	4	4	100	PC
5	MSELE-GE205/GE206	Generic Elective I: (One course to be chosen from the basket I)	3	1	0	4	100	GE
6		VAC/AEC/SEC	2	0	0	2	100	VAC/AEC/SEC
		Total — Semester II	**14**	**4**	**4**	**22**	**600**	

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Particulars	Semester	Course Code	Course Title
Basket I	I	MSELE-GE105	Advanced Semiconductor Physics and Devices
		MSELE-GE106	Electronics for Renewable Energy Systems
Basket II	II	MSELE-GE205	Micro Electro Mechanical Switches Devices (MEMS)
		MSELE-GE206	Machine Learning and Deep Learning

Note: Tutorial classes in the concerned paper will include open discussions on the topics and subject matter covered in the lectures, problem-solving sessions, student questions, and discussions on recent developments related to the topics taught. These sessions are intended to deepen students' understanding, encourage active participation, develop critical thinking, prepare students for assessments, and bridge the gap between classroom lectures and self-study.

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PART C — COURSES OF STUDIES

C.1 Paper Identification

PAPER PROFILE	
Paper Code	MSELE-CC101
Title of the Paper	Core Course I: Advanced Mathematical Techniques and Applications
Programme / Subject	MSc - Electronic Science
Semester	Semester I
Nature of Course	Core Course (CC)
L – T – P	3 – 1 – 0
Credits	4
Maximum Marks	100 (ESE: 70 + Internal Assessment: 30)
Duration of Examination	3 Hours

C.2 Marks Distribution

Component	Paper	Practical	IA	Total (ESE+IA/ESE+PRAC)
End Semester Examination	70	—	—	70
Practical / Lab Work	—	—	—	—
Internal Assessment	—	—	30	30
Maximum Marks	**70**	**—**	**30**	**100**
Passing Marks	**32**	**—**	**13**	**45 (45%)**

Note: Internal Assessment shall be conducted on the basis of attendance, class tests, seminars, assignments, and viva voce as provided in the regulation.

C.3 Course Objectives (COBs)

COB No.	Course Objectives
COB 1	Build proficiency in linear algebra and vector space methods.
COB 2	Understand PDEs, boundary value problems, and transform techniques.
COB 3	Apply Laplace and Fourier methods in engineering analysis.
COB 4	Learn numerical optimization and regression techniques.
COB 5	Develop modelling, interpolation, and curve-fitting skills.

C.4 Course Outcomes (COs)

CLO No.	Course Learning Outcome
CLO 1	Analyze vector spaces, matrices, and linear transformations.
CLO 2	Solve differential equations using analytical and transform methods.
CLO 3	Apply Fourier and Laplace techniques to engineering systems.
CLO 4	Formulate and solve optimization and regression problems.
CLO 5	Perform interpolation, approximation, and engineering data modelling.

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C.5 Syllabus — Unit-wise Breakdown

Course Name: Advance Mathematical Techniques and Applications (MSELE-CC101)		
Unit	**Content**	**Suggested Lectures hours**
I	**Vector spaces and subspaces:** axioms, Coordinate representations and change of basis matrices. Linear transformations, matrix representation, composition, invertibility, rank of a matrix. Inner product spaces, orthogonality, orthonormal bases, and the Gram-Schmidt orthogonalization process. Projection onto subspaces and least squares interpretation.	10
II	**Differential Equations:** Classification of second-order partial differential equations: elliptic, parabolic, and hyperbolic types. Canonical forms and the significance of classification for solution behaviour, boundary conditions, and numerical methods. Boundary value problems: Dirichlet, Neumann, and Robin boundary conditions. Physical examples of each type of boundary condition. Transform methods for partial differential equations.	10
III	**Fourier Series & Transform:** Definition and Properties, Fourier Series in the Interval, Uses of Fourier Series, Physical Examples of Fourier Series. **Laplace Transform:** The Region of Convergence for Laplace Transforms, Inverse Laplace Transform, Properties of the Laplace Transform, and its applications in system modelling.	05
IV	**Numerical Techniques and Optimisation** Concept of optimisation, convexity, necessary and sufficient conditions for optimality, unconstrained and constrained optimisation problems. Newton's method, quasi-Newton methods, BFGS and limited-memory BFGS (L-BFGS), line search techniques, trust-region methods. Lagrange multipliers, Karush-Kuhn-Tucker (KKT) conditions, penalty function methods, barrier function methods. Formulation of linear programming problems, simplex method, duality theory, sensitivity analysis.	10
V	**Linear Regression Models:** Simple and multiple linear regression, Ordinary Least Squares (OLS) estimation, derivation of normal equations, geometric interpretation of least-squares solutions. **Nonlinear and Logistic Regression**: Nonlinear regression models, logistic regression, maximum likelihood estimation (MLE), parameter estimation techniques. **Curve Fitting and Engineering Applications**: Fitting of engineering models including exponential decay, saturation curves, power-law models, and model evaluation. **Interpolation and Approximation:** Polynomial interpolation, Newton's divided difference interpolation, Lagrange interpolation, approximation techniques.	10
	Total Suggested Lectures (45 L +15 T)	**60 (For 4 Credit Course)**

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C.6 Prescribed Textbooks

1. Jain, R. K., & Iyengar, S. R. K. (2016). *Advanced Engineering Mathematics* (5th ed.). Narosa Publishing House.
2. Bali, N. P., Goyal, M., & Watkins, C. (2020). *A Textbook of Engineering Mathematics*. Laxmi Publications.
3. Sastry, S. S. (2018). *Introductory Methods of Numerical Analysis* (5th ed.). PHI Learning.

C.7 Reference Books & Readings

1. Grewal, B. S. (2022). *Higher Engineering Mathematics* (45th ed.). Khanna Publishers.
2. Gupta, S. C., & Kapoor, V. K. (2020). *Fundamentals of Mathematical Statistics*. Sultan Chand & Sons.
3. Jain, M. K., Iyengar, S. R. K., & Jain, R. K. (2019). *Numerical Methods for Scientific and Engineering Computation* (7th ed.). New Age International Publishers.

C.7 Suggested E-Resources / Digital Repositories

- SWAYAM: **Numerical Methods for Engineers,** and https://nptel.ac.in/courses/127106019
- SWAYAM: **Engineering Mathematics** and https://nptel.ac.in/courses/111105121

C.8 Assessment Pattern & Question Paper Design

The End-Semester shall be conducted as per the following question paper design:

- Section A: Short Answer Questions (10 × 2 marks = 20 marks) — Covering all units (mandatory)
- Section B: Medium Answer Questions (4 × 5 marks = 20 marks) — Attempt any 4 out of 6
- Section C: Long Answer / Essay Questions (3 × 10 marks = 30 marks) — Attempt 3 out of 5.

Internal Assessment (30 marks) breakdown:

- Written Test(s): 20 marks
- Seminar / Assignment / Project: 05 marks
- Attendance & Class Participation: 05 marks

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C PART C — COURSES OF STUDIES

C.1 Paper Identification

PAPER PROFILE	
Paper Code	MSELE-CC102
Title of the Paper	Core Course II: IC Fabrication and VLSI Technology
Programme / Subject	MSc - Electronic Science
Semester	Semester I
Nature of Course	Core Course (CC)
L – T – P	3 – 1 – 0
Credits	4
Maximum Marks	100 (ESE: 70 + Internal Assessment: 30)
Duration of Examination	3 Hours

C.2 Marks Distribution

Component	Paper	Practical	IA	Total (ESE+IA/ESE+PRAC)
End Semester Examination	70	—	—	70
Practical / Lab Work	—	—	—	—
Internal Assessment	—	—	30	30
Maximum Marks	**70**	**—**	**30**	**100**
Passing Marks	**32**	**—**	**13**	**45 (45%)**

Note: Internal Assessment shall be conducted on the basis of attendance, class tests, seminars, assignments, and viva voce as provided in the regulation.

C.3 Course Objectives (COBs)

COB No.	Course Objectives
COB 1	Understand cleanroom technology and silicon wafer preparation processes.
COB 2	Learn oxidation, diffusion, and doping mechanisms in semiconductor fabrication.
COB 3	Study epitaxy, lithography, etching, and pattern transfer techniques.
COB 4	Understand thin-film deposition and metallization processes used in IC fabrication.
COB 5	Develop knowledge of materials, devices, and manufacturing technologies for VLSI circuits.

C.4 Course Outcomes (COs)

CLO No.	Course Learning Outcome
CLO 1	Explain cleanroom protocols, wafer processing, and contamination control methods.
CLO 2	Analyze oxidation, diffusion, and dopant distribution in silicon devices.
CLO 3	Evaluate thin-film deposition and metallization methods for integrated circuits..
CLO 4	Interpret fabrication process flows and technology requirements for VLSI manufacturing.

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C.5 Syllabus — Unit-wise Breakdown

Course Name: IC Fabrication and VLSI Technology (MSELE-CC102)		
Unit	**Content**	**Suggested Lectures hours**
I	**Clean Room Technology:** Clean room concept, Growth of single crystal Si, surface contamination, cleaning & etching. (Laboratory Practices: Cleaning of p-type & n-type Si-wafer by solvent method & RCA cleaning) Oxidation -Growth mechanism and kinetic oxidation, oxidation techniques and systems, oxide properties, oxide induced defects, characterization of oxide films. Use of thermal oxide and CVD oxide; growth and properties of dry and wet oxide.	10
II	**Oxidation Growth:** mechanism and kinetic oxidation, oxidation techniques and systems, oxide properties, oxide induced defects, characterisation of oxide films, Use of thermal oxide and CVD oxide; growth and properties of dry and wet oxide, dopant distribution, oxide quality.	08
III	**Solid State Diffusion:** Fick's equation, atomic diffusion mechanisms, measurement techniques, diffusion in polysilicon and silicon di-oxide diffusion systems.	07
IV	**Materials For Integrated Circuits and Fabrication Technology:** Classification of IC's, Electronic grade silicon, Silicon shaping lapping polishing and wafer preparation, Vapour phase epitaxy, Molecular beam epitaxy, Optical lithography, Photomask, Photoresist and process, Limitation of optical Lithography, Idea of electron and X-ray Lithography, Wet chemical etching, reactive plasma etching.	10
V	**Lithography and Metallisation:** Photo-lithography, E-beam lithography, Some Advanced lithographic techniques. Physical Vapour Deposition – E-beam evaporator, CVD, PECVD, MOCVD. Different types of metallisation, uses & desired properties.	10
	Total Suggested Lectures (45 L +15 T)	**60 (For 4 Credit Course)**

C.6 Prescribed Textbooks

1. Sze, S. M., & Ng, K. K. (2021). *Physics of Semiconductor Devices* (4th ed.). Wiley.
2. Plummer, J. D., Deal, M. D., & Griffin, P. B. (2019). *Silicon VLSI Technology: Fundamentals, Practice and Modeling*. Pearson.
3. Jaeger, R. C., & Blalock, T. N. (2016). *Microelectronic Circuit Design* (5th ed.). McGraw-Hill.

C.7 Reference Books & Readings

1. Ghandhi, S. K. (2017). *VLSI Fabrication Principles: Silicon and Gallium Arsenide* (2nd ed.). Wiley.
2. May, G. S., & Spanos, C. J. (2018). *Fundamentals of Semiconductor Manufacturing and Process Control*. Wiley.
3. Roy, S. K. (2010). *Fundamentals of VLSI Design*. Prentice Hall India.

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C.7 Suggested E-Resources / Digital Repositories

- SWAYAM: Semiconductor Device Fabrication, https://onlinecourses.nptel.ac.in/e-learning/preview/noc26_ee04
- SWAYAM: VLSI Design Flow: RTL to GDS, https://onlinecourses.nptel.ac.in/e-learning/preview/noc25_ee106
- SWAYAM: Basic Overview of Semiconductor Device Processing and IC Fabrication, https://onlinecourses.nptel.ac.in/e-learning/preview/noc26_ee04

C.8 Assessment Pattern & Question Paper Design

The End-Semester shall be conducted as per the following question paper design:

- Section A: Short Answer Questions (10 × 2 marks = 20 marks) — Covering all units (mandatory)
- Section B: Medium Answer Questions (4 × 5 marks = 20 marks) — Attempt any 4 out of 6
- Section C: Long Answer / Essay Questions (3 × 10 marks = 30 marks) — Attempt 3 out of 5.

Internal Assessment (30 marks) breakdown:

- Written Test(s): 20 marks
- Seminar / Assignment / Project: 05 marks
- Attendance & Class Participation: 05 marks

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C PART C — COURSES OF STUDIES

C.1 Paper Identification

PAPER PROFILE	
Paper Code	MSELE-CC103
Title of the Paper	Core Course III: Real Time Embedded System Design & IoT
Programme / Subject	MSc - Electronic Science
Semester	Semester I
Nature of Course	Core Course (CC)
L – T – P	3 – 1 – 0
Credits	4
Maximum Marks	100 (ESE: 70 + Internal Assessment: 30)
Duration of Examination	3 Hours

C.2 Marks Distribution

Component	Paper	Practical	IA	Total (ESE+IA/ESE+PRAC)
End Semester Examination	70	—	—	70
Practical / Lab Work	—	—	—	—
Internal Assessment	—	—	30	30
Maximum Marks	**70**	**—**	**30**	**100**
Passing Marks	**32**	**—**	**13**	**45 (45%)**

Note: Internal Assessment shall be conducted on the basis of attendance, class tests, seminars, assignments, and viva voce as provided in the regulation.

C.3 Course Objectives (COBs)

COB No.	Course Objectives
COB 1	Understand the architecture and design methodology of embedded systems.
COB 2	Learn embedded software development and cross-compilation processes.
COB 3	Study processor architectures, memory systems, and hardware interfacing techniques.
COB 4	Explore communication protocols, embedded networks, and IoT technologies.
COB 5	Develop knowledge of RTOS concepts and multitasking in real-time applications.

C.4 Course Outcomes (COs)

CLO No.	Course Learning Outcome
CLO 1	Develop and deploy embedded applications using appropriate toolchains.
CLO 2	Interface processors with memory, peripherals, and communication modules.
CLO 3	Implement IoT-based solutions using standard networking protocols.
CLO 4	Apply RTOS concepts for multitasking, synchronization, and real-time control.

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C.5 Syllabus — Unit-wise Breakdown

Course Name: Real Time Embedded System Design & IoT (MSELE-CC103)		
Unit	**Content**	**Suggested Lectures hours**
I	**Introduction to Embedded Systems:** Embedded system processor, hardware and software components, examples, design life cycle, layers of embedded systems. Embedded System Design Methodologies: FSM, SysML, MARTE, UML notation, requirement analysis, use-case modelling and design examples.	10
II	**Building Process for Embedded Systems:** Preprocessing, compiling, cross-compiling, linking, linker scripts, loading on target and embedded file systems. System Design Using General Purpose Processors: RISC/CISC architectures, embedded memory, cache mapping techniques, DMA and processor-memory selection.	10
III	**Component Interfacing and Networks:** Memory and I/O interfacing, interrupt controllers, UART, SPI, I2C, CAN, USB, PCIe, Bluetooth, ZigBee, Wi-Fi and 6LoWPAN.	07
IV	**Internet of Things (IoT):** IoT architecture, sensors and actuators, edge devices, cloud platforms, MQTT/CoAP protocols, IoT security, smart home, healthcare, agriculture and industrial IoT applications.	08
V	**Operating Systems and RTOS:** Kernel features, tasks, threads, scheduling, dispatcher and process control blocks. Multitasking and Contemporary Issues: Context switching, IPC, semaphores, mutexes, deadlocks, priority inversion and emerging trends in embedded AIoT systems.	10
	Total Suggested Lectures (45 L +15 T)	**60 (For 4 Credit Course)**

C.6 Prescribed Textbooks

1. Raj Kamal. (2019). *Embedded Systems: Architecture, Programming and Design* (4th ed.). McGraw Hill Education.
2. Shibu K. V. (2017). *Introduction to Embedded Systems* (2nd ed.). McGraw Hill Education.
3. Lyla B. Das. (2013). *Embedded Systems: An Integrated Approach*. Pearson Education India.

C.7 Reference Books & Readings

1. Tammy Noergaard. (2018). Embedded Systems Architecture (2nd ed.). Newnes, Elsevier.
2. Jonathan W. Valvano. (2017). Embedded Systems: Real-Time Interfacing to ARM Cortex-M Microcontrollers. Cengage Learning.
3. David Hanes, Gonzalo Salgueiro, Patrick Grossetete, Rob Barton & Jerome Henry. (2017). IoT Fundamentals: Networking Technologies, Protocols and Use Cases for the Internet of Things. Cisco Press.

C.7 Suggested E-Resources / Digital Repositories

- NPTEL: Embedded Systems Design, https://onlinecourses.nptel.ac.in/c-learning/preview/noc20_cs14
- NPTEL: Introduction to Real Time Embedded Systems, https://nptel.ac.in/courses/108105057

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C.8 Assessment Pattern & Question Paper Design

The End-Semester shall be conducted as per the following question paper design:

- Section A: Short Answer Questions (10 × 2 marks = 20 marks) — Covering all units (mandatory)
- Section B: Medium Answer Questions (4 × 5 marks = 20 marks) — Attempt any 4 out of 6
- Section C: Long Answer / Essay Questions (3 × 10 marks = 30 marks) — Attempt 3 out of 5.

Internal Assessment (30 marks) breakdown:

- Written Test(s): 20 marks
- Seminar / Assignment / Project: 05 marks
- Attendance & Class Participation: 05 marks

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C PART C — COURSES OF STUDIES

C.1 Paper Identification

PAPER PROFILE	
Paper Code	MSELE-PC104
Title of the Paper	Core Course IV: Practical
Programme / Subject	MSc - Electronic Science
Semester	Semester I
Nature of Course	Practical Course (PC)
L – T – P	0 – 0 – 4
Credits	4
Maximum Marks	100 (ESE: 70 + Internal Assessment: 30)
Duration of Examination	3 Hours

C.2 Marks Distribution

Component	Paper	Practical	IA	Total (ESE+IA/ESE+PRAC)
End Semester Examination	—	70	—	70
Practical / Lab Work	—	—	—	—
Internal Assessment	—	—	30	30
Maximum Marks	—	**70**	**30**	**100**
Passing Marks	—	32	**13**	**45 (45%)**

Note: Internal Assessment shall be conducted on the basis of attendance, class tests, seminars, assignments, and viva voce as provided in the regulation.

C.3 Course Objectives (COBs)

COB No.	Course Objectives
COB 1	Develop skills in mathematical modelling and numerical computation.
COB 2	Apply transform techniques for engineering problem analysis.
COB 3	Understand simulation and characterization of CMOS devices and circuits.
COB 4	Gain hands-on experience in embedded system interfacing and programming.
COB 5	Integrate mathematical, electronic, and computational tools for problem-solving.

C.4 Course Outcomes (COs)

CLO No.	Course Learning Outcome
CLO 1	Analyze PDEs, transforms, and engineering data using computational tools.
CLO 2	Perform curve fitting, interpolation, and signal analysis techniques.
CLO 3	Simulate and characterize MOSFETs and CMOS logic circuits.
CLO 4	Develop sensor-based measurement and control applications using microcontrollers.
CLO 5	Students experience Understand simulation and characterization the embedded system concepts, simulation, programming, and circuit analysis to electronic system design.

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C.5 Syllabus — Unit-wise Breakdown

Course Name: Practical (MSELE-PC104)	
List of Experiments	**Suggested Lectures hours**
1. Implementation of second-order partial differential equations (elliptic, parabolic, and hyperbolic) and determination of their canonical forms. 2. Computation of Laplace and inverse Laplace transforms and application to differential equations. 3. Fourier transform analysis of engineering signals and frequency spectrum visualization. 4. Curve fitting using exponential decay, saturation, and power-law models; interpolation using Newton's divided difference and Lagrange methods 5. To plot the (i) output characteristics & (ii) transfer characteristics of an n-channel and p-channel MOSFET. 6. To design and plot the static and dynamic characteristics of a digital CMOS inverter. 7. To design and plot the dynamic characteristics of 2-input NAND, NOR, XOR and XNOR logic gates using CMOS technology. 8. To measure propagation delay of a given CMOS Inverter circuit. 9. Program to interface seven segment display from no. 0 to 99. 10. Program to interface stepper/DC Motor to rotation control. 11. Use the thermistor to estimate the temperature and print the raw value on the serial monitor. 12. Program to measure distance using IR/ ultrasonic sensor. (**Software Used**: MATLAB, Mathematica, Python, Origin, Multisim, Pspice, Arduino IDE, Keil µVision IDE, NL5, etc)	120
Total Suggested Contact Hours For Practical Course	**120 Hours/Semester**

C.6 Prescribed Textbooks

1. Kumar, A. (2014). *Fundamentals of Digital Circuits*. PHI Learning.
2. Raj Kamal. (2019). *Embedded Systems: Architecture, Programming and Design* (4th ed.). McGraw Hill Education.
3. Roy, S. K. (2010). *Fundamentals of VLSI Design*. Prentice Hall India.

C.7 Reference Books & Readings

1. Gupta, S. C., & Kapoor, V. K. (2020). *Fundamentals of Mathematical Statistics*. Sultan Chand & Sons.
2. Sastry, S. S. (2018). *Introductory Methods of Numerical Analysis* (5th ed.). PHI Learning.
3. Weste, N. H. E., & Harris, D. (2015). *CMOS VLSI Design: A Circuits and Systems Perspective* (4th ed.). Pearson.

C.7 Suggested E-Resources / Digital Repositories

- SWAYAM / NPTEL: Introduction to VLSI Design, https://nptel.ac.in/courses/117106092
- Virtual Lab, https://vlabs.iitkgp.ac.in/vlt/
- SWAYAM: Scientific Computing using Matlab, https://onlinecourses.nptel.ac.in/e-learning/preview/noc20_ma40

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C.8 Assessment Pattern & Question Paper Design

C.8 Assessment Pattern & Question Paper Design

The End-Semester shall be conducted as per the following question paper design (**70 Marks**):

- Section A: Practical Note Book Assessment -20
- Section B: Practical – 40
- Section C: Viva – 10

Internal Assessment (30 Marks)

- Section A: Practical -20
- Section B: Practical Note Book Assessment-05
- Section C: Attendance/Participation – 05

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C PART C — COURSES OF STUDIES

C.1 Paper Identification

PAPER PROFILE	
Paper Code	MSELE-GE105
Title of the Paper	General Elective I: Advanced Semiconductor Physics and Devices
Programme / Subject	MSc - Electronic Science
Semester	Semester I
Nature of Course	General Elective (GE)
L – T – P	3 – 1 – 0
Credits	4
Maximum Marks	100 (ESE: 70 + Internal Assessment: 30)
Duration of Examination	3 Hours

C.2 Marks Distribution

Component	Paper	Practical	IA	Total (ESE+IA/ESE+PRAC)
End Semester Examination	70	—	—	70
Practical / Lab Work	—	—	—	—
Internal Assessment	—	—	30	30
Maximum Marks	**70**	**—**	**30**	**100**
Passing Marks	**32**	**—**	**13**	**45 (45%)**

Note: Internal Assessment shall be conducted on the basis of attendance, class tests, seminars, assignments, and viva voce as provided in the regulation.

C.3 Course Objectives (COBs)

COB No.	Course Objectives
COB 1	Develop a fundamental understanding of semiconductor materials, energy bands, and carrier transport mechanisms.
COB 2	Introduce the physics and operation of semiconductor junctions, diodes, and heterostructures.
COB 3	Explain the principles and characteristics of BJT, MOSFET, and advanced semiconductor devices.
COB 4	Familiarize students with semiconductor fabrication, CMOS technology, and optoelectronic devices.
COB 5	Provide knowledge of nanostructures, low-dimensional materials, and emerging semiconductor technologies.

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C.4 Course Outcomes (COs)

CLO No.	Course Learning Outcome
CLO 1	Explain semiconductor physics, carrier dynamics, and energy band concepts.
CLO 2	Analyze the characteristics and performance of semiconductor junction devices.
CLO 3	Evaluate the operation of BJT, MOSFET, and advanced electronic devices.
CLO 4	Assess semiconductor fabrication processes and optoelectronic device technologies.
CLO 5	Interpret the properties and applications of nanostructures, 2D materials, and wide band-gap semiconductors.

C.5 Syllabus — Unit-wise Breakdown

Course Name: : Advanced Semiconductor Physics and Devices (MSELE-GE105)		
Unit	**Content**	**Suggested Lectures hours**
I	Crystal structure of semiconductors, Energy band theory, Direct and indirect band gap semiconductors, Intrinsic and extrinsic semiconductors, Carrier concentration and Fermi energy, Carrier transport mechanisms: Drift and diffusion, Einstein relation, Continuity equation	10
II	Formation of p–n junction, Depletion region and built-in potential, Current-voltage characteristics, Junction capacitance, Breakdown mechanisms, Schottky diode, Metal–semiconductor contacts, Heterojunctions and quantum wells	08
III	Bipolar Junction Transistor (BJT), Current transport mechanism, MOS capacitor, MOSFET structure and operation, Threshold voltage, Short channel effects, High electron mobility transistor (HEMT)	10
IV	Semiconductor fabrication overview, CMOS technology, Power semiconductor devices, LED and laser diode, Photodetectors, Solar cells, Wide band-gap semiconductors (SiC and GaN)	10
V	Nano structures and concepts: quantum wells, supper lattice structures, nanorod, quantum dot, CNTs, 2D materials: Graphene, BN, MoS2 etc, matamaterials.	07
	Total Suggested Lectures (45 L +15 T)	**60 (For 4 Credit Course)**

C.6 Prescribed Textbooks

1. Semiconductor Physics and Devices. Neamen, D. A. (2012). *Semiconductor Physics and Devices: Basic Principles* (4th ed.). McGraw-Hill.
2. Solid State Electronic Devices. Streetman, B. G., & Banerjee, S. K. (2016). *Solid State Electronic Devices* (7th ed.). Pearson.
3. Physics of Semiconductor Devices. Sze, S. M., & Ng, K. K. (2007). *Physics of Semiconductor Devices* (3rd ed.). Wiley.

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C.7 Reference Books & Readings

1. Introduction to Solid State Physics. Kittel, C. (2005). *Introduction to Solid State Physics* (8th ed.). Wiley.
2. Microelectronic Circuits. Sedra, A. S., & Smith, K. C. (2020). *Microelectronic Circuits* (8th ed.). Oxford University Press.
3. Nanotechnology: Principles and Practices. Kulkarni, S. K. (2015). *Nanotechnology: Principles and Practices* (4th ed.). Springer.

C.7 Suggested E-Resources / Digital Repositories

- NPTEL: Introduction to Semiconductor Devices, https://nptel.ac.in/courses/108106181
- NPTEL: Fundamentals of semiconductor devices, https://onlinecourses.nptel.ac.in/e-learning/preview/noc20_bt17
- NEPTEL: Semiconductor Devices to Sensors: Principles, Design, and Application, https://onlinecourses.nptel.ac.in/e-learning/preview/noc26_ee101

C.8 Assessment Pattern & Question Paper Design

The End-Semester shall be conducted as per the following question paper design:

- Section A: Short Answer Questions (10 × 2 marks = 20 marks) — Covering all units (mandatory)
- Section B: Medium Answer Questions (4 × 5 marks = 20 marks) — Attempt any 4 out of 6
- Section C: Long Answer / Essay Questions (3 × 10 marks = 30 marks) — Attempt 3 out of 5.

Internal Assessment (30 marks) breakdown:

- Written Test(s): 20 marks
- Seminar / Assignment / Project: 05 marks
- Attendance & Class Participation: 05 marks

Note: *Generic/Open Elective–I (Course Code) and II (Course Code) courses in Semester- I and Generic/Open Elective–III (Course Code) and IV (Course Code) courses in Semester- II of 2 Year Postgraduate Programme may be offered by an institution based on student demand, academic interest, and the availability of qualified faculty members. These courses shall be open to students of the concerned discipline as well as students from other disciplines, with the objective of promoting multidisciplinary and interdisciplinary learning in accordance with the principles of the National Education Policy (NEP), 2020.*

For fulfilment of the programme requirements, a student shall be required to successfully complete any one of the Generic Elective courses offered during the semester. The institution may decide to offer either or both of the Generic Elective courses, subject to academic feasibility, availability of faculty expertise, and student enrolment.

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C PART C — COURSES OF STUDIES

C.1 Paper Identification

PAPER PROFILE	
Paper Code	MSELE-GE106
Title of the Paper	General Elective II: Electronics for Renewable Energy Systems
Programme / Subject	MSc - Electronic Science
Semester	Semester I
Nature of Course	General Elective (GE)
L – T – P	3 – 1 – 0
Credits	4
Maximum Marks	100 (ESE: 70 + Internal Assessment: 30)
Duration of Examination	3 Hours

C.2 Marks Distribution

Component	Paperl	Practical	IA	Total (ESE+IA/ESE+PRAC)
End Semester Examination	70	—	—	70
Practical / Lab Work	—	—	—	—
Internal Assessment	—	—	30	30
Maximum Marks	**70**	—	**30**	**100**
Passing Marks	**32**	—	**13**	**45 (45%)**

Note: Internal Assessment shall be conducted on the basis of attendance, class tests, seminars, assignments, and viva voce as provided in the regulation.

C.3 Course Objectives (COBs)

COB No.	Course Objectives
COB 1	Develop fundamental understanding of photovoltaic materials, solar cell physics, and renewable energy conversion.
COB 2	Introduce advanced photovoltaic technologies and analytical modelling of solar cells.
COB 3	Provide knowledge of power electronics, instrumentation, IoT, and monitoring systems for renewable energy applications.
COB 4	Familiarize students with diverse renewable energy sources, energy harvesting techniques, and energy storage technologies.
COB 5	Enable understanding of renewable energy system design, grid integration, and techno-economic aspects of sustainable energy systems.

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C.4 Course Outcomes (COs)

CLO No.	Course Learning Outcome
CLO 1	Explain the principles of photovoltaic devices, carrier transport, and solar cell performance.
CLO 2	Analyze conventional and emerging solar cell technologies and their operational characteristics.
CLO 3	Evaluate power electronic converters, control systems, and IoT-based monitoring for renewable energy systems.
CLO 4	Assess renewable energy sources, energy storage technologies, and energy harvesting methods.

C.5 Syllabus — Unit-wise Breakdown

Course Name: Electronics for Reneable Energy System (MSELE-GE106)		
Unit	**Content**	**Suggested Lectures hours**
I	**Foundations for Photovoltaics:** Crystal Structure and Energy Band Theory, Carrier Statistics and Equilibrium Properties, Quasi-Fermi levels under illumination: fundamental concept for solar cells, Optical Properties and Light Absorption, Carrier Transport and Recombination, p-n Junction Solar Cell: Fundamentals, Loss Mechanisms and Performance Analysis, Silicon Solar Cell Technologies, Thin-Film and III-V Solar Cell Technologies	10
II	**Next-Generation Photovoltaics:** Perovskite Solar Cells, Organic and Dye-Sensitised Solar Cells, Approaches Beyond the Shockley-Queisser Limit, Analytical Modelling of Solar Cells.	08
III	**Power Electronics for Renewable Energy Systems:** DC-DC Converters for PV Systems, DC-AC Inverters for Grid Connection, Power Conditioning and Grid Interface, Power Electronics for Wind and Other Renewables Sensors, Instrumentation, and IoT for Renewable Systems, Measurement and Characterization of PV Systems, IoT-Enabled Monitoring and AI in Renewable Energy Assessment and Evaluation	10
IV	**Other Renewable Energy Sources and Electronics:** Wind Energy Systems, Biomass, Geothermal, and Tidal Energy, Hydrogen Economy and Fuel Cells, Thermoelectric and Piezoelectric Energy Harvesting, concept of lightening energy harvesting	05
V	**Energy Storage Systems and Interface Electronics:** Battery Technologies for Renewable Energy Storage, Bidirectional DC-DC Converters and Battery Chargers, Flow Batteries, Pumped Hydro, and Compressed Air Storage, Renewable Energy System Design and Grid Integration, Stand-Alone and Hybrid Renewable Systems, Grid-Connected PV Power Plant Design, Smart Grid Technologies and Renewable Integration, financial and management aspect of renewable energy systems	12
	Total Suggested Lectures (45 L +15 T)	**60 (For 4 Credit Ccurse)**

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C.6 Prescribed Textbooks

1. A. Luque and S. Hegedus (Eds.), Handbook of Photovoltaic Science and Engineering, 2nd ed., Wiley, 2011.
2. M. A. Green, Solar Cells: Operating Principles, Technology and System Applications, Prentice Hall, 1982.
3. S. M. Sze and K. K. Ng, Physics of Semiconductor Devices, 3rd ed., Wiley, 2006.
4. A. Goetzberger and V. U. Hoffmann, Photovoltaic Solar Energy Generation, Springer, 2005.

C.7 Reference Books & Readings

1. Physics of Solar Cells. Würfel, P., & Würfel, U. (2016). *Physics of Solar Cells: From Basic Principles to Advanced Concepts* (3rd ed.). Wiley-VCH.
2. Renewable Energy Resources. Twidell, J., & Weir, T. (2021). *Renewable Energy Resources* (4th ed.). Routledge.
3. Power Electronics: Converters, Applications and Design. Mohan, N., Undeland, T. M., & Robbins, W. P. (2014). *Power Electronics: Converters, Applications and Design* (3rd ed.). Wiley.
4. Renewable and Efficient Electric Power Systems. Masters, G. M. (2013). *Renewable and Efficient Electric Power Systems* (2nd ed.). Wiley.

C.7 Suggested E-Resources / Digital Repositories

- NPTEL: Renewable Energy Engineering: Solar, Wind And Biomass Energy Systems
- https://nptel.ac.in/courses/103103206
- NPTEL: Solar Photovoltaics Fundamentals, Technology and Applications, https://onlinecourses.nptel.ac.in/e-learning/preview/noc25_ph34
- NPTEL: Renewable Energy Technologies, https://onlinecourses.swayam2.ac.in/e-learning/preview/ntr25_ed119

C.8 Assessment Pattern & Question Paper Design

The End-Semester shall be conducted as per the following question paper design:

- Section A: Short Answer Questions (10 × 2 marks = 20 marks) — Covering all units (mandatory)
- Section B: Medium Answer Questions (4 × 5 marks = 20 marks) — Attempt any 4 out of 6
- Section C: Long Answer / Essay Questions (3 × 10 marks = 30 marks) — Attempt 3 out of 5.

Internal Assessment (30 marks) breakdown:

- Written Test(s): 20 marks
- Seminar / Assignment / Project: 05 marks
- Attendance & Class Participation: 05 marks

Note: *Generic/Open Elective–I (Course Code) and II (Course Code) courses in Semester- I and Generic/Open Elective–III (Course Code) and IV (Course Code) courses in Semester- II of 2 Year Postgraduate Programme may be offered by an institution based on student demand, academic interest, and the availability of qualified faculty members. These courses shall be open to students of the concerned discipline as well as students from other disciplines, with the objective of promoting multidisciplinary and interdisciplinary learning in accordance with the principles of the National Education Policy (NEP), 2020.*

For fulfilment of the programme requirements, a student shall be required to successfully complete any one of the Generic Elective courses offered during the semester. The institution may decide to offer either or both of the Generic Elective courses, subject to academic feasibility, availability of faculty expertise, and student enrolment.

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C PART C — COURSES OF STUDIES

C.1 Paper identification

PAPER PROFILE	
Paper Code	MSELE-CC201
Title of the Paper	Core Course I: Digital Integrated Circuits
Programme / Subject	MSc - Electronic Science
Semester	Semester II
Nature of Course	Core Course (CC)
L – T – P	3 – 1 – 0
Credits	4
Maximum Marks	100 (ESE: 70 + Internal Assessment: 30)
Duration of Examination	3 Hours

C.2 Marks Distribution

Component	Paper	Practical	IA	Total (ESE+IA/ESE+PRAC)
End Semester Examination	70	—	—	70
Practical / Lab Work	—	—	—	—
Internal Assessment	—	—	30	30
Maximum Marks	**70**	**—**	**30**	**100**
Passing Marks	**32**	**—**	**13**	**45 (45%)**

Note: Internal Assessment shall be conducted on the basis of attendance, class tests, seminars, assignments, and viva voce as provided in the regulation.

C.3 Course Objectives (COBs)

COB No.	Course Objectives
COB 1	Understand CMOS technology, IC fabrication processes, and VLSI design fundamentals.
COB 2	Analyze digital integrated circuits at device, circuit, and system levels.
COB 3	Develop proficiency in CMOS logic design, layout, and performance optimization.
COB 4	Apply VLSI design methodologies using modern CAD and simulation tools.
COB 5	Explore emerging trends and challenges in semiconductor and integrated circuit technologies.

C.4 Course Outcomes (COs)

CLO No.	Course Learning Outcome
CLO 1	Explain semiconductor fabrication processes and CMOS technology used in IC manufacturing.
CLO 2	Design and analyze combinational and sequential CMOS digital circuits.
CLO 3	Evaluate power, delay, area, and reliability trade-offs in VLSI systems.
CLO 4	Utilize EDA/CAD tools for circuit simulation, layout design, and verification.
CLO 5	Apply VLSI design principles to develop integrated circuit solutions for real-world applications.

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C.5 Syllabus — Unit-wise Breakdown

Course Name: Digital Integrated Circuits (MSELE-CC201)		
Unit	**Content**	**Suggested Lectures hours**
I	**Introduction:** Historical Perspective, Issues in Digital Integrated Circuit Design, Quality Metrics of a Digital Design: Cost of an Integrated Circuit, Functionality and Robustness, Performance, Power and Energy Consumption.	05
II	**MOS-Transistor:** The MOS Transistor under Static Conditions, Dynamic Behavior, The Actual MOS Transistor, Some Secondary Effects, SPICE Models for the MOS Transistor, Method of Logical Effort for transistor sizing.	08
III	**CMOS Inverter:** Introduction, The Static CMOS Inverter, An Intuitive Perspective, Evaluating the Robustness of the CMOS Inverter: The Static Behavior, Switching Threshold, Noise Margins, Robustness Revisited, Performance of CMOS Inverter: The Dynamic Behavior, Computing the Capacitances, Propagation Delay: First-Order Analysis, Propagation Delay from a Design Perspective, Power, Energy, and Energy-Delay: Dynamic Power Consumption, Static Consumption, Perspective: Technology Scaling and its Impact on the Inverter Metrics .	10
IV	**Designing Combinational Logic Gates in CMOS:** Introduction, Static CMOS Design: Complementary CMOS, Ratioed Logic, Pass-Transistor Logic, Dynamic CMOS Design: Dynamic Logic- Basic Principles, Speed and Power Dissipation of Dynamic Logic, Issues in Dynamic Design, Cascading Dynamic Gates, Perspectives: How to Choose a Logic Style, Designing Logic for Reduced Supply Voltages	10
V	**Designing Sequential Logic Circuits:** Introduction, Timing Metrics for Sequential Circuits, Classification of Memory Elements, Static Latches and Registers: The Bistability Principle, Multiplexer-Based Latches Master-Slave Edge-Triggered Register, Low-Voltage Static Latches, Static SR Flip-Flops—Writing Data by Pure Force, Dynamic Latches and Registers: Dynamic Transmission-Gate Edge-triggered Registers, Sequential Circuits: The Schmitt Trigger, Monostable Sequential Circuits, Astable Circuits, Perspective: Choosing a Clocking Strategy.	12
	Total Suggested Lectures (45 L +15 T)	**60 (For 4 Credit Course)**

C.6 Prescribed Textbooks

1. Rabaey, J. M., Chandrakasan, A., & Nikolic, B. (2003). *Digital Integrated Circuits: A Design Perspective* (2nd ed.). Prentice Hall of India.
2. Kang, S. M., & Leblebici, Y. (2003). *CMOS Digital Integrated Circuits: Analysis and Design* (3rd ed.). McGraw-Hill.

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C.7 Reference Books & Readings

1. Hodges, D. A., Jackson, H. G., & Saleh, R. A. (2005). *Analysis and Design of Digital Integrated Circuits* (3rd ed.). McGraw-Hill.
2. Martin, K. (2000). *Digital Integrated Circuit Design*. Oxford University Press.
3. Sedra, A. S., & Smith, K. C. (2015). *Microelectronic Circuits* (7th ed.). Oxford University Press.
4. Weste, N. H. E., & Harris, D. (2011). *CMOS VLSI Design: A Circuits and Systems Perspective* (4th ed.). Pearson.
5. Uyemura, J. P. (2002). *Introduction to VLSI Circuits and Systems*. Wiley India.
6. Taur, Y., & Ning, T. H. (2013). *Fundamentals of Modern VLSI Devices* (2nd ed.). Cambridge University Press.

C.7 Suggested E-Resources / Digital Repositories

1. SWAYAM:CMOS Digital VLSI Design, https://onlinecourses.nptel.ac.in/e-learning/preview/noc21ee09
2. SWAYAM: Digital VLSI Testing, https://onlinecourses.nptel.ac.in/e-learning/preview/noc26_ee45

C.8 Assessment Pattern & Question Paper Design

The End-Semester shall be conducted as per the following question paper design:

- Section A: Short Answer Questions (10 × 2 marks = 20 marks) — Covering all units (mandatory)
- Section B: Medium Answer Questions (4 × 5 marks = 20 marks) — Attempt any 4 out of 6
- Section C: Long Answer / Essay Questions (3 × 10 marks = 30 marks) — Attempt 3 out of 5.

Internal Assessment (30 marks) breakdown:

- Written Test(s): 20 marks
- Seminar / Assignment / Project: 05 marks
- Attendance & Class Participation: 05 marks

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C PART C — COURSES OF STUDIES

C.1 Paper Identification

PAPER PROFILE	
Paper Code	MSELE-CC202
Title of the Paper	Core Course II: Artificial Intelligence & Robotics
Programme / Subject	MSc - Electronic Science
Semester	Semester II
Nature of Course	Core Course (CC)
L – T – P	3 – 1 – 0
Credits	4
Maximum Marks	100 (ESE: 70 + Internal Assessment: 30)
Duration of Examination	3 Hours

C.2 Marks Distribution

Component	Paper	Practical	IA	Total (ESE+IA/ESE+PRAC)
End Semester Examination	70	—	—	70
Practical / Lab Work	—	—	—	—
Internal Assessment	—	—	30	30
Maximum Marks	**70**	**—**	**30**	**100**
Passing Marks	**32**	**—**	**13**	**45 (45%)**

Note: Internal Assessment shall be conducted on the basis of attendance, class tests, seminars, assignments, and viva voce as provided in the regulation.

C.3 Course Objectives (COBs)

COB No.	Course Objectives
COB 1	Understand the foundations of Artificial Intelligence, Robotics, Machine Learning, and Intelligent Systems.
COB 2	Develop knowledge of robot kinematics, dynamics, motion planning, and control techniques.
COB 3	Apply machine learning, deep learning, and reinforcement learning methods to robotic systems.
COB 4	Analyze robot sensing, computer vision, localization, mapping, and autonomous navigation techniques.
COB 5	Evaluate ethical, safety, and societal implications of AI-driven autonomous and collaborative robots.

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C.4 Course Outcomes (COs)

CLO No.	Course Learning Outcome
CLO 1	Explain AI paradigms, intelligent agents, knowledge representation, Generative AI, LLMs, and neurosymbolic AI concepts.
CLO 2	Model and analyze robotic systems using kinematic, dynamic, and trajectory-planning methodologies.
CLO 3	Implement machine learning and reinforcement learning algorithms for robotic perception and decision-making.
CLO 4	Apply computer vision, sensor fusion, SLAM, and probabilistic state estimation techniques in autonomous robots.
CLO 5	Design and assess intelligent robotic systems for industrial, mobile, collaborative, and human-centered applications while adhering to ethical and safety standards.

C.5 Syllabus — Unit-wise Breakdown

Course Name: Artificial Intelligence & Robotics (MSELE-CC202)		
Unit	**Content**	**Suggested Lectures hours**
I	Introduction to AI History, intelligent agents, problem solving, search techniques, knowledge representation, Generative AI & Large Language Models (LLMs), symbolic and LLM based expert systems, Neurosymbolic AI, Reasoning in Neural Networks, Explainable AI, AI Ethics and safety.	07
II	Robotics overview, robot classification and applications, Robot Kinematics and Dynamics: Coordinate transformations, Rotation Matrices, forward and inverse kinematics, D-H parameters Jacobian matrix and joint variables robot dynamics and motion control, Lagrangian Formulation of Robot Dynamics. Generation of mass matrix, Coriolis/centrifugal forces, and gravity vectors.Recursive Newton-Euler and Lagrangian dynamics for n-DoF chains; trajectory planning, robot programming	12
III	Machine Learning for Robotics: Supervised and unsupervised learning, neural networks, reinforcement learning, pattern recognition and decision making. ROS and ML integration.	06
IV	Robot Sensing and Computer Vision: Sensors, actuators, image acquisition, image processing, feature extraction, object detection and SLAM concepts. Introduction to Deep Reinforcement Learning (DRL) in robotics,	10
V	Autonomous and Intelligent Systems: Mobile robots, Kinematics of wheeled mobile robots. Probabilistic State Estimation: Extended Kalman Filters (EKF), Unscented Kalman Filters (UKF), and Particle Filters for localization path planning, human-robot interaction, collaborative and assistive robots, industrial robotics, ethical and safety issues.	10
	Total Suggested Lectures (45 L +15 T)	**60 (For 4 Credit Course)**

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C.6 Prescribed Textbooks

1. Russell, S., & Norvig, P. (2021). Artificial Intelligence: A Modern Approach (4th ed.). Pearson.
2. Siciliano, B., Sciavicco, L., Villani, L., & Oriolo, G. (2019). Robotics: Modelling, Planning and Control (2nd ed.). Springer.
3. Goodfellow, I., Bengio, Y., & Courville, A. (2016). Deep Learning. MIT Press.

C.7 Reference Books & Readings

4. Murphy, K. P. (2022). Probabilistic Machine Learning: An Introduction. MIT Press.
5. Craig, J. J. (2018). Introduction to Robotics: Mechanics and Control (4th ed.). Pearson.
6. Arkin, R. C. (1998). Behavior-Based Robotics. MIT Press.
7. Spong, M. W., Hutchinson, S., & Vidyasagar, M. (2020). Robot Modeling and Control (2nd ed.). Wiley.

C.7 Suggested E-Resources / Digital Repositories

- NPTEL: Introduction to Robotics, https://onlinecourses.nptel.ac.in/elearning/preview/noc20_de11
- NPTEL: Introduction to Robotics, https://nptel.ac.in/courses/107106090

C.8 Assessment Pattern & Question Paper Design

The End-Semester shall be conducted as per the following question paper design:

- Section A: Short Answer Questions (10 × 2 marks = 20 marks) — Covering all units (mandatory)
- Section B: Medium Answer Questions (4 × 5 marks = 20 marks) — Attempt any 4 out of 6
- Section C: Long Answer / Essay Questions (3 × 10 marks = 30 marks) — Attempt 3 out of 5.

Internal Assessment (30 marks) breakdown:

- Written Test(s): 20 marks
- Seminar / Assignment / Project: 05 marks
- Attendance & Class Participation: 05 marks

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C PART C — COURSES OF STUDIES

C.1 Paper Identification

PAPER PROFILE	
Paper Code	MSELE-CC203
Title of the Paper	Core Course III: Advanced Communication Systems
Programme / Subject	MSc - Electronic Science
Semester	Semester II
Nature of Course	Core Course (CC)
L – T – P	3 – 1 – 0
Credits	4
Maximum Marks	100 (ESE: 70 + Internal Assessment: 30)
Duration of Examination	3 Hours

C.2 Marks Distribution

Component	Paper	Practical	IA	Total (ESE+IA/ESE+PRAC)
End Semester Examination	70	—	—	70
Practical / Lab Work	—	—	—	—
Internal Assessment	—	—	30	30
Maximum Marks	**70**	**—**	**30**	**100**
Passing Marks	**32**	**—**	**13**	**45 (45%)**

Note: Internal Assessment shall be conducted on the basis of attendance, class tests, seminars, assignments, and viva voce as provided in the regulation.

C.3 Course Objectives (COBs)

COB No.	Course Objectives
COB 1	Develop a strong foundation in digital communication systems, signal representation, and information theory.
COB 2	Understand stochastic processes, noise characterization, and their role in communication system analysis.
COB 3	Analyze sampling, quantization, pulse shaping, and digital baseband transmission techniques.
COB 4	Study digital modulation schemes and their performance in practical communication channels.
COB 5	Explore source coding, channel coding, and error control techniques for reliable digital communications

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C.4 Course Outcomes (COs)

CLO No.	Course Learning Outcome
CLO 1	Explain the principles, architecture, and operation of modern digital communication systems.
CLO 2	Apply probability theory and random process concepts to analyze communication signals and noise.
CLO 3	Design and evaluate sampling, PCM, DPCM, delta modulation, and pulse-shaping techniques.
CLO 4	Analyze the performance of digital modulation schemes such as PSK, FSK, QAM, MSK, and GMSK.
CLO 5	Evaluate channel capacity, information measures, and coding techniques for efficient and reliable data transmission.

C.5 Syllabus — Unit-wise Breakdown

Course Name: Advanced Communication Systems (MSELE-CC203)		
Unit	**Content**	**Suggested Lectures hours**
I	**Introduction to Digital Communications:** Introduction to Digital Communications; Block Diagram of Digital Communication System; Information Theoretic Approach to Digital Communications; Digital Communication Blocks Realized as Software-Defined Radio; Pre-envelope and canonical representation of band pass signals	10
II	**Random Variables and Process:** Review of Probability and Random Variables; Random Processes: Basic Concepts- Introduction to Stochastic Processes, Statistical Averages, Autocorrelation and Cross-correlation, Orthogonality and Statistical Independence, Stationary and Ergodic Process, Wide Sense Stationary Processes, Response of Linear System to Random Processes, Power Spectral Density of Stationary Processes and Sum Process, Statistical Properties of Additive White Gaussian Noise	10
III	**Digital Baseband Transmission for Analog Signal:** Sampling Theorem, Sampling of Low Pass Signals, Reconstruction of Sampled Signals, Interpolation, Aliasing Effects, Aperture Effect; Pulse Code Modulation (PCM), Quantization Noise, Delta Modulation, Differential PCM (DCPM), Adaptive DCPM; Pulse Shaping: Nyquist Signals, Nyquist Pulse Shaping with Raised Cosine Filtering, Duobinary Signalling	10
IV	**Digital Carrier Modulation:** Introduction to Carrier Modulation, ASK, BPSK, QPSK, BFSK, M-ary PSK, M-ary FSK Modulations, QAM, CPFSK, CPM, MSK and GMSK Modulation, Differential Encoding and Decoding	07
V	**Concepts of Information Theory and Coding:** Information, Mutual Information, Measure of Information, Entropy, Information Rate, Shannon's Theorem, Channel Capacity, Capacity of Gaussian Channel, Bandwidth-SNR Trade-off; Coding for Discrete Sources- Need for coding source letters, Introduction to source and channel coding techniques; Error Control coding	08
	Total Suggested Lectures (45 L +15 T)	**60 (For 4 Credit Course)**

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C.6 Prescribed Textbooks

1. Simon Haykin, *Communication Systems* (5th ed.), Wiley India, 2009.
2. Bernard Sklar, *Digital Communications: Fundamentals and Applications* (2nd ed.), Pearson Education, 2001.

C.7 Reference Books & Readings

1. Simon Haykin & Michael Moher, *Introduction to Analog and Digital Communications* (2nd ed.), Wiley India, 2007.
2. B. P. Lathi & Zhi Ding, *Modern Digital and Analog Communication Systems* (4th ed.), Oxford University Press, 2010.
3. Taub, H., Schilling, D. L., & Saha, G., *Principles of Communication Systems* (3rd ed.), Tata McGraw-Hill, 2008.
4. Theodore S. Rappaport, *Wireless Communications: Principles and Practice* (2nd ed.), Pearson Education, 2002.
5. Ranjan Bose, *Information Theory, Coding and Cryptography* (2nd ed.), McGraw-Hill Education, 2008.
6. K. Sam Shanmugam, *Digital and Analog Communication Systems*, Wiley India, 2005.

C.7 Suggested E-Resources / Digital Repositories

- NPTEL:Principles of Digital Communications, https://onlinecourses.nptel.ac.in/e-learning/preview/noc25_ee152
- NPTEL:Information Theory and Coding, http://digimat.in/nptel/courses/video/117101053/L13.html
- NPTEL:Principles of Digital Communications, http://www.digimat.in/nptel/courses/video/108101113/L01.html

C.8 Assessment Pattern & Question Paper Design

The End-Semester shall be conducted as per the following question paper design:

- Section A: Short Answer Questions (10 × 2 marks = 20 marks) — Covering all units (mandatory)
- Section B: Medium Answer Questions (4 × 5 marks = 20 marks) — Attempt any 4 out of 6
- Section C: Long Answer / Essay Questions (3 × 10 marks = 30 marks) — Attempt 3 out of 5.

Internal Assessment (30 marks) breakdown:

- Written Test(s): 20 marks
- Seminar / Assignment / Project: 05 marks
- Attendance & Class Participation: 05 marks

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PART C — COURSES OF STUDIES

C.1 Paper Identification

PAPER PROFILE	
Paper Code	MSELE-PC204
Title of the Paper	Core Course IV: Practical
Programme / Subject	MSc - Electronic Science
Semester	Semester II
Nature of Course	Practical Course (PC)
L – T – P	0 – 0 – 4
Credits	4
Maximum Marks	100 (ESE: 70 + Internal Assessment: 30)
Duration of Examination	3 Hours

C.2 Marks Distribution

Component	Paper	Practical	IA	Total (ESE+IA/ESE+PRAC)
End Semester Examination	—	70	—	70
Practical / Lab Work	—	—	—	—
Internal Assessment	—	—	30	30
Maximum Marks	—	**70**	**30**	**100**
Passing Marks	—	**32**	**13**	**45 (45%)**

Note: Internal Assessment shall be conducted on the basis of attendance, class tests, seminars, assignments, and viva voce as provided in the regulation.

C.3 Course Objectives (COBs)

COB No.	Course Objectives
COB 1	Understand the fundamentals of CMOS technology, Artificial Intelligence, Robotics, and Digital Communication systems.
COB 2	Develop practical skills in modeling, simulation, and analysis of electronic, robotic, and communication systems.
COB 3	Apply AI and machine learning techniques for intelligent decision-making and autonomous system design.
COB 4	Analyze digital communication techniques, modulation schemes, and information-theoretic concepts for reliable data transmission.
COB 5	Gain proficiency in modern software tools for circuit design, robotic control, and communication system simulation.

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C.4 Course Outcomes (COs)

CLO No.	Course Learning Outcome
CLO 1	Characterize and analyze CMOS devices, logic circuits, and VLSI design parameters using simulation tools.
CLO 2	Implement AI algorithms, machine learning models, and robotic kinematic solutions for engineering applications.
CLO 3	Design and simulate autonomous robotic systems incorporating sensing, navigation, and control functions.
CLO 4	Evaluate sampling, coding, modulation, and demodulation techniques used in digital communication systems.
CLO 5	Use MATLAB/Simulink, Scilab, Python, or equivalent software tools to model, analyze, and solve interdisciplinary electronics problems.

C.5 Syllabus — Unit-wise Breakdown

Course Name: Practical (MSELE-PC204)	
List of Experiemnts	**Suggested Lectures-hours**
1. To study the static characteristics of NMOS and PMOS transistors. 2. Design a CMOS inverter using PMOS and NMOS transistors. 3. To study the effect of wire resistance and capacitance on circuit performance. 4. To implement combinational logic circuits using CMOS logic. 5. To implement classical AI search techniques for path finding and problem solving. 6. To study forward and inverse kinematics of a robotic manipulator. 7. To apply machine learning techniques for classification and prediction. 8. To simulate autonomous robot navigation. 9. To study sampling, quantization, and PCM encoding of analog signals. 10. To evaluate digital communication system performance in noisy environments. 11. To study Generate and demodulation digital carrier modulation schemes (ASK, BPSK) 12. To study Generate and demodulation digital carrier modulation schemes (BFSK, QPSK) (**Software Used**: MATLAB & Simulink, Python, Ltspice, Cadence,Webots, Gazebo Simulator, NVIDIA Isaac Sim, Visual Prolog etc)	120
Total Suggested Contact Hours For Practical Courses	**120 Hours/Semester**

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C.6 Prescribed Textbooks

1. Rabaey, J. M., Chandrakasan, A., & Nikolic, B. (2003). *Digital Integrated Circuits: A Design Perspective* (2nd ed.). Prentice Hall of India.
2. Russell, S., & Norvig, P. (2021). *Artificial Intelligence: A Modern Approach* (4th ed.). Pearson Education.
3. Proakis, J. G., & Salehi, M. (2008). *Digital Communications* (5th ed.). McGraw-Hill Education.

C.7 Reference Books & Readings

1. Siciliano, B., Sciavicco, L., Villani, L., & Oriolo, G. (2010). *Robotics: Modelling, Planning and Control*. Springer.
2. Haykin, S. (2009). *Communication Systems* (5th ed.). Wiley India.
3. Weste, N. H. E., & Harris, D. (2011). *CMOS VLSI Design: A Circuits and Systems Perspective* (4th ed.). Pearson Education.
4. Sklar, B. (2001). *Digital Communications: Fundamentals and Applications* (2nd ed.). Pearson Education.

C.7 Suggested E-Resources / Digital Repositories

- SWAYAM:Artificial Intelligence, http://www.digimat.in/nptel/courses/video/106106126/L04.html
- NPTEL:CMOS Digital VLSI Design, http://digimat.in/nptel/courses/video/108107129/L01.html
- NPTEL:VLSI Physical Design, https://onlinecourses.nptel.ac.in/e-learning/preview/noc22_cs50
- NPTEL:Digital Design with Verilog, https://onlinecourses.nptel.ac.in/e-learning/preview/noc25_cs25

C.8 Assessment Pattern & Question Paper Design

The End-Semester shall be conducted as per the following question paper design (**70 Marks**):

- Section A: Practical Note Book Assesment -20
- Section B: Practical – 40
- Section C: Viva – 10

Internal Assessment (30 Marks)

- Section A: Practical -20
- Section B: Practical Note Book Assesment -05
- Section C: Attendance/Participation – 05

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C PART C — COURSES OF STUDIES

C.1 Paper Identification

PAPER PROFILE	
Paper Code	MSELE-GE205
Title of the Paper	General Elective I: Micro Electro Mechanical Switches (MEMS)
Programme / Subject	MSc - Electronic Science
Semester	Semester II
Nature of Course	General Elective (GE)
L – T – P	3 – 1 – 0
Credits	4
Maximum Marks	100 (ESE: 70 + Internal Assessment: 30)
Duration of Examination	3 Hours

C.2 Marks Distribution

Component	Paper	Practical	IA	Total (ESE+IA/ESE+PRAC)
End Semester Examination	70	—	—	70
Practical / Lab Work	—	—	—	—
Internal Assessment	—	—	30	30
Maximum Marks	**70**	**—**	**30**	**100**
Passing Marks	**32**	**—**	**13**	**45 (45%)**

Note: Internal Assessment shall be conducted on the basis of attendance, class tests, seminars, assignments, and viva voce as provided in the regulation.

C.3 Course Objectives (COBs)

COB No.	Course Objectives
COB 1	Understand MEMS and microsystem technologies.
COB 2	Learn MEMS materials and micromachining processes.
COB 3	Study design methodologies and CAD tools for MEMS.
COB 4	Understand MEMS sensors and actuators.
COB 5	Develop knowledge of MEMS applications in engineering systems.

C.4 Course Outcomes (COs)

CLO No.	Course Learning Outcome
CLO 1	Explain MEMS fabrication technologies and materials.
CLO 2	Analyze micromachining and MEMS manufacturing processes.
CLO 3	Design MEMS structures using CAD and simulation tools.
CLO 4	Evaluate MEMS sensors, actuators and transduction mechanisms.
CLO 5	Apply MEMS concepts in industrial and biomedical applications.

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C.5 Syllabus — Unit-wise Breakdown

Course NameMicro Electro Mechanical Switches (MEMS) (MSELE-GE205)		
Unit	**Content**	**Suggested Lectures hours**
I	Overview of MEMS and Microsystems: MEMS vs Microsystems, microelectronics, multidisciplinary nature of MEMS, applications, scaling laws, MEMS materials including Silicon, SiO_2, Si_3N_4, SiC, GaAs, piezoelectric materials and polymers.	10
II	Micromachining Processes: Bulk micromachining, isotropic and anisotropic etching, wet and dry etching, surface micromachining, LIGA process, bonding techniques and MEMS foundry processes.	08
III	MEMS Design: Design constraints, material selection, manufacturing process selection, signal transduction, electromechanical systems, packaging, thermal stress analysis and finite element methods.	07
IV	MEMS Sensors and Actuators: Piezoresistive sensing, capacitive transduction, pressure sensors, accelerometers, resonant sensors, thermal sensing and actuation mechanisms.	08
V	MEMS applications in consumer electronics: smartphones, wearables and IoT devices; Automotive MEMS: airbag sensors, tire pressure monitoring systems (TPMS), Biomedical MEMS: biosensors, lab-on-chip systems, implantable devices and drug delivery systems; RF MEMS: switches, resonators, filters and antennas, Energy harvesting MEMS.	12
	Total Suggested Lectures (45 L +15 T)	**60 (For 4 Credit Course)**

C.6 Prescribed Textbooks

1. Tai-Ran Hsu, MEMS and Microsystems: Design, Manufacture, and Nanoscale Engineering (3rd ed.), Wiley, 2017.
2. Nadim Maluf & Kirt Williams, An Introduction to Microelectromechanical Systems Engineering (2nd ed.), Artech House, 2004.

C.7 Reference Books & Readings

1. Stephen D. Senturia, Microsystem Design, Springer, 2001.
2. Mohamed Gad-el-Hak, The MEMS Handbook (3 Volumes), CRC Press, 2006.
3. Julian W. Gardner, Vijay K. Varadan, & Osama O. Awadelkarim, Microsensors, MEMS and Smart Devices, Wiley, 2001.
4. Chang Liu, Foundations of MEMS (2nd ed.), Pearson Education, 2012.
5. Marc Madou, Fundamentals of Microfabrication and Nanotechnology (3rd ed.), CRC Press, 2011.
6. Nicolae Lobontiu & Ephrahim Garcia, Mechanics of Microelectromechanical Systems, Springer, 2005.
7. Gabriel M. Rebeiz, RF MEMS: Theory, Design and Technology, Wiley, 2003.

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C.7 Suggested E-Resources / Digital Repositories

- NPTEL:Introduction to MEMS & Microsystems, https://nptel.ac.in/courses/117105082
- NPTEL:A brief introduction of Micro - Sensors, https://onlinecourses.nptel.ac.in/e-learning/preview/noc24_ee09
- NPTEL:Fabrication Techniques for MEMs-based Sensors, https://onlinecourses.nptel.ac.in/e-learning/preview/noc25_ee144

C.8 Assessment Pattern & Question Paper Design

The End-Semester shall be conducted as per the following question paper design:

- Section A: Short Answer Questions (10 × 2 marks = 20 marks) — Covering all units (mandatory)
- Section B: Medium Answer Questions (4 × 5 marks = 20 marks) — Attempt any 4 out of 6
- Section C: Long Answer / Essay Questions (3 × 10 marks = 30 marks) — Attempt 3 out of 5.

Internal Assessment (30 marks) breakdown:

- Written Test(s): 20 marks
- Seminar / Assignment / Project: 05 marks
- Attendance & Class Participation: 05 marks

Note: *Generic/Open Elective–I (Course Code) and II (Course Code) courses in Semester- I and Generic/Open Elective–III (Course Code) and IV (Course Code) courses in Semester- II of 2 Year Postgraduate Programme may be offered by an institution based on student demand, academic interest, and the availability of qualified faculty members. These courses shall be open to students of the concerned discipline as well as students from other disciplines, with the objective of promoting multidisciplinary and interdisciplinary learning in accordance with the principles of the National Education Policy (NEP), 2020.*

For fulfilment of the programme requirements, a student shall be required to successfully complete any one of the Generic Elective courses offered during the semester. The institution may decide to offer either or both of the Generic Elective courses, subject to academic feasibility, availability of faculty expertise, and student enrolment.

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C PART C — COURSES OF STUDIES

C.1 Paper Identification

PAPER PROFILE	
Paper Code	MSELE-GE206
Title of the Paper	General Elective II: Machine Learning and Deep Learning
Programme / Subject	MSc - Electronic Science
Semester	Semester II
Nature of Course	General Elective (GE)
L – T – P	3 – 1 – 0
Credits	4
Maximum Marks	100 (ESE: 70 + Internal Assessment: 30)
Duration of Examination	3 Hours

C.2 Marks Distribution

Component	Paper	Practical	IA	Total (ESE+IA/ESE+PRAC)
End Semester Examination	70	—	—	70
Practical / Lab Work	—	—	—	—
Internal Assessment	—	—	30	30
Maximum Marks	**70**	**—**	**30**	**100**
Passing Marks	**32**	**—**	**13**	**45 (45%)**

Note: Internal Assessment shall be conducted on the basis of attendance, class tests, seminars, assignments, and viva voce as provided in the regulation.

C.3 Course Objectives (COBs)

COB No.	Course Objectives
COB 1	Introduce the fundamentals of Machine Learning and Deep Learning.
COB 2	Develop understanding of data preprocessing, feature reduction, and model validation.
COB 3	Familiarize students with classification, regression, and clustering techniques.
COB 4	Provide knowledge of CNN architectures and deep learning model training.
COB 5	Expose students to modern deep learning frameworks and emerging applications.

C.4 Course Outcomes (COs)

CLO No.	Course Learning Outcome
CLO 1	Explain core concepts of Machine Learning, Deep Learning, feature engineering, and model evaluation.
CLO 2	Apply classification and regression algorithms to solve predictive analytics problems.
CLO 3	Implement and analyze clustering techniques for pattern discovery and data segmentation.
CLO 4	Design, train, and evaluate Convolutional Neural Network (CNN) models.
CLO 5	Assess advanced deep learning architectures and their applications in real-world domains.

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C.5 Syllabus — Unit-wise Breakdown

Course Name: Machine Learning and Deep Learning (MSELE-GE206)		
Unit	**Content**	**Suggested Lectures hours**
I	Introduction to Machine Learning and Deep Learning, Types of Learning: Supervised, Unsupervised, Reinforced learning, Features and Features vector, Feature Reduction/Dimensionality reduction, Data partitioning (K-fold cross-validation, leave one out, leave m-out), Performance measurement metrics.	10
II	Machine learning Classifiers: Statistical: Bayesian theorem, Bayesian classifier, k- nearest neighbor (K-NN), Linear Discriminant Analysis, Support Vector Machines, Artificial Neural Networks. Machine learning Regression and its type, Machine learning Clustering: Distance measures, Different clustering methods (Distance, Density, Hierarchical), Iterative distance-based clustering, dealing with continuous, categorical values in K-Means.	10
III	Introduction to building blocks of convolutional neural networks (CNNs), Convolutional, Pooling, activation functions, padding, SoftMax layers, flatten layers, training CNNs, initialization, dropout, batch normalization, overfitting and loss functions.	10
IV	Deep learning approaches: Introduction, Architecture (such as CNN, AlexNet, GoogleNet, ResNet, VGG-16/19, Fast-RCNN, Faster R-CNN, Mask RCNN), and its applications.	08
V	Recent trends in machine learning and deep learning methods for medical, speech, videos and remote sensing applications	07
	Total Suggested Lectures (45 L +15 T)	**60 (For 4 Credit Course)**

C.6 Prescribed Textbooks

1. Pattern Recognition and Machine Learning. Bishop, C. M. (2006). *Pattern Recognition and Machine Learning*. Springer.
2. Machine Learning. Mitchell, T. M. (1997). *Machine Learning*. McGraw-Hill.
3. Deep Learning. Goodfellow, I., Bengio, Y., & Courville, A. (2016). *Deep Learning*. MIT Press.
4. Hands-On Machine Learning with Scikit-Learn, Keras, and TensorFlow. Géron, A. (2022). *Hands-On Machine Learning with Scikit-Learn, Keras, and TensorFlow* (3rd ed.). O'Reilly Media.

C.7 Reference Books & Readings

1. The Elements of Statistical Learning. Hastie, T., Tibshirani, R., & Friedman, J. (2017). *The Elements of Statistical Learning* (2nd ed.). Springer.
2. Introduction to Machine Learning with Python. Müller, A. C., & Guido, S. (2016). *Introduction to Machine Learning with Python*. O'Reilly Media.
3. Neural Networks and Deep Learning. Aggarwal, C. C. (2018). *Neural Networks and Deep Learning*. Springer.
4. Deep Learning with Python. Chollet, F. (2021). *Deep Learning with Python* (2nd ed.). Manning Publications.

C.7 Suggested E-Resources / Digital Repositories

- NPTEL:Machine Learning And Deep Learning - Fundamentals And applications, https://onlinecourses.nptel.ac.in/e-learning/preview/noc23_ee87
- NEPTEL: Foundations of Deep Learning: Concepts and Applications, https://onlinecourses.nptel.ac.in/e-learning/preview/noc26_cs01
- NPTEL:Introduction to Machine Learning, https://nptel.ac.in/courses/106106139

C.8 Assessment Pattern & Question Paper Design

The End-Semester shall be conducted as per the following question paper design:

- Section A: Short Answer Questions (10 × 2 marks = 20 marks) — Covering all units (mandatory)
- Section B: Medium Answer Questions (4 × 5 marks = 20 marks) — Attempt any 4 out of 6
- Section C: Long Answer / Essay Questions (3 × 10 marks = 30 marks) — Attempt 3 out of 5.

Internal Assessment (30 marks) breakdown:

- Written Test(s): 20 marks
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- Attendance & Class Participation: 05 marks

Note: *Generic/Open Elective–I (Course Code) and II (Course Code) courses in Semester- I and Generic/Open Elective–III (Course Code) and IV (Course Code) courses in Semester- II of 2 Year Postgraduate Programme may be offered by an institution based on student demand, academic interest, and the availability of qualified faculty members. These courses shall be open to students of the concerned discipline as well as students from other disciplines, with the objective of promoting multidisciplinary and interdisciplinary learning in accordance with the principles of the National Education Policy (NEP), 2020.*

For fulfilment of the programme requirements, a student shall be required to successfully complete any one of the Generic Elective courses offered during the semester. The institution may decide to offer either or both of the Generic Elective courses, subject to academic feasibility, availability of faculty expertise, and student enrolment.

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PART D — GENERAL REGULATIONS & PROVISIONS

D.1 Attendance & Eligibility

- A student must have a minimum of 75% attendance in each paper to be eligible to appear in the Semester / Annual Examination.
- Condonation of attendance deficiency shall be governed by the Regulation..
- A student detained due to shortage of attendance may appear to the examinations of same semester in the next academic session subject to payment of prescribed fees.

D.2 Examination & Promotion Rules

- A student is required to clear **at least** 60% (4 out of 6) papers of a particular Semester before being promoted to the succeeding Semester.
- Back / Ex-Student candidates shall be governed by the rules in force at the time of their original admission unless otherwise specifically notified.
- A candidate who fails in one or more papers shall be required to appear only in the failed paper(s) (Carry Forward System) in subsequent examinations of the same Semester.
- A candidate is required to clear all his papers within a maximum of **Five Years of duration** to qualify for the degree.

D.3 Grading System (CBCS)

Letter Grade	% Range	Grade Point	Performance Description	Remarks
O	≥90-100	10	Outstanding	Pass
A+	≥80<90	9	Excellent	Pass
A	≥70<80	8	Very Good	Pass
B+	≥60<70	7	Good	Pass
B	≥55<60	6	Above Average	Pass
C	≥50<55	5	Average	Pass
P	≥45<50	4	Pass	Pass
F	<45	0	Fail	Fail
Ab/M	0	0	Absent/Malpractice	Fail / Reappear

PART E — ABBREVIATIONS & AUTHENTICATION

E.1 List of Abbreviations

Abbr.	Expansion	Abbr.	Expansion
CC	Core Course	DSE	Discipline Specific Elective
GE	Generic Elective	OE	Open Elective
AEC	Ability Enhancement Course	VAC	Value Added Course
SEC	Skill Enhancement Course	IKS	Indian Knowledge System
L	Lecture (hours per week)	T	Tutorial (hours per week)
P	Practical (hours per week)	IA	Internal Assessment
CCA	Continuous & Comprehensive Assess.	CLO	Course Learning Outcome
PLO	Programme Learning Outcome	GA	Graduate Attribute
NHEQF	National HE Qualifications Framework	PROJ	Project / Dissertation

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E.2 Authentication

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Subject Expert-1
Prof. Rajkishore Prasad
Principal, B. N. College, Patna
Patna University, Patna-800004
Date: 01/07/2026

Amitesh Kumar

Subject Expert-2
Dr. Amitesh Kumar
Assistant Professor, Department of Electrical EngineeringNIT Patna, Patna-80005
Date: 01/07/2026

Bhandari

Subject Expert-3
Dr. Ashish Bhandari
Assistant Professor
Department of Electronic and Communication Engineering, NIT Patna, Patna-80005
Date: 01/07/2026

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Subject Expert-4
Dr. Gaurav Varshney
Assistant Professor
Department of Electronic and Communication Engineering, NIT Patna, Patna-80005
Date: 01/07/2026

Sunil Kumar

Subject Expert-5
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Assistant Professor
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Subject Expert-6
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