INSTITUTE OF AERONAUTICAL ENGINEERING
(Autonomous)
Dundigal - 500 043, Hyderabad, Telangana

COURSE CONTENT

NANO ELECTRONICS								
VII Semester: ECE								
Course Code	**Category**	**Hours / Week**			**Credits**	**Maximum Marks**		
		L	**T**	**P**	**C**	**CIA**	**SEE**	**Total**
AECD56	**Elective**	3	-	-	3	40	60	100
Contact Classes: 48	**Tutorial Classes: Nil**	**Practical Classes: Nil**				**Total Classes: 48**		
Prerequisite: Electronic Devices and Circuits								

I. COURSE OVERVIEW:
This course introduces students to the principles and applications of nanoelectronics, focusing on electronic devices and circuits at the nanoscale. It covers electrical and optical properties of materials and nanostructures, fabrication of nanostructures, nano electronic devices including resonant-tunneling devices, transistors, and single-electron transfer devices, as well as applications of nanotechnologies in molecular biology and medicine.

II. COURSES OBJECTIVES:
The students will try to learn

I. The state of the art in the areas of semiconductor device physics and materials technology to enable the Nanoelectronics.
II. The quantum mechanics behind nanoelectronics, nanodevices, spintronics and molecular electronics.
III. The principle and the operation of nano electronic devices and fabrication technologies
IV. Applications of nanotechnologies, nanoscale structures in molecular biology and medicine applications.

III. COURSE OUTCOMES:
At the end of the course students should be able to:

CO1: Understanding the basic principles that govern the operation for electrical characteristics of nano electronic devices.

CO2: Explain the concepts of a quantum well, quantum transport and tunnelling effect to characterizing new materials and devices.

CO3: Examines nonclassical device structures for design of multiple-gate field-effect transistors.

CO4: Describe different mechanisms for nucleation and growth of amorphous and crystalline nanoparticles for nucleation and growth rates for nanoparticles.

CO5: Understand the quantum mechanics of low-dimensional semiconductor structures for quantum wells, superlattices, quantum dots and quantum wires.

CO6: Summarize the applications nanoelectronics to characterize and study reliability of materials and nanoscale electronic devices.

IV. COURSE CONTENT:

MODULE - I: INTRODUCTION TO NANOELECTRONICS (10)

Definition and significance of nanoelectronics, Historical development and milestones, Comparison with conventional electronics, Wave-particle duality, Quantum states and wavefunctions, Schrödinger equation, Quantum tunneling.

MODULE –II: FABRICATION OF NANOSTRUCTURES (09)

Electrons in low-dimensional structures: Electrons in quantum wells, Electrons in quantum wires, Electrons in quantum dots. Fabrication of nanostructures: Crystal growth, Nanolithography, Clusters and nanocrystals, Nanotube growth, Characterization of nanostructures

MODULE –III: QUANTUM ELECTRONIC DEVICES (10)

Nano electronic and spintronic devices: quantum dots, nanowires, nanopillars, quantum transport and tunneling effects, magnetoresistance, spin-dependent electron transport, molecular electronics, and single electron transistors.

MODULE –IV: NON-CLASSICAL MOS TRANSISTOR (10)

Requirements for Non classical MOS transistor. MOS capacitor, Role of interface quality and related process techniques, Gate oxide thickness scaling trend, SiO2 vs High-k gate dielectrics. Integration issues of high-k. Interface states, bulk charge, band offset, stability, reliability.

MODULE –V: EMERGING NANOELECTRONIC TECHNOLOGIES (09)

Beyond CMOS technologies, Spintronics and magnetic devices, Topological insulators, Other emerging trends in nanoelectronics. Applications of Nanoelectronics: Nano sensors and detectors, Biomedical applications, Energy harvesting and storage, Environmental monitoring

V. TEXT BOOKS:

1. Nanoelectronics: Materials, Devices, Applications, Dr. Dr. h.c. Marcel Van de Voorde Professor, Robert Puers Professor,, Dr. Livio Baldi, Dr. Sebastiaan E van Nooten, 2017.
2. "Nanoelectronics and Information Technology" by Rainer Waser: This comprehensive book covers various aspects of nanoelectronics, including the physics of nanoscale materials and devices, quantum effects, and emerging technologies.

VI. REFERENCE BOOKS:

1. Fundamentals of Modern VLSI Devices, Y. Taur and T. Ning, Cambridge University Press.
2. Silicon VLSI Technology, Plummer, Deal , Griffin , Pearson Education India.
3. Encyclopedia of Materials Characterization, Edited by: Brundle, C.Richard; Evans, Charles A. Jr.; Wilson, Shaun ; Elsevier.

VII. ELECTRONICS RESOURCES:

1. http://home.iitk.ac.in/~anandh/MSE694/Introduction_to_Nanomaterials-3.pdf
2. https://nptel.ac.in/courses/117108047
3. https://onlinecourses.nptel.ac.in/noc22_ee47/preview
4. http://ece.iisc.ernet.in/~navakant/nano/2007/course.html

VIII. MATERIALS ONLINE

1. Course template
2. Tutorial question bank
3. Definition and terminology
4. Tech-talk topics
5. Assignments
6. Model question paper - I
7. Model question paper - II
8. Lecture notes
9. Early learning readiness videos (ELRV)
10. Power point presentations