GUJARAT TECHNOLOGICAL UNIVERSITY

Program Name: Master of Engineering
Level: PG
Branch: Electronics And Communication (VLSI Design)
Subject Code: ME01096011
Subject Name: Physics of MOS Transistor

WEF Academic Year	2025-26
Semester	01
Category of the Course	PCC-01

Prerequisite:	Semiconductor physics, semiconductor devices, mathematics
Rationale:	The students need to learn a good understanding of concepts of physic of MOSFET. Students also need to learn about various short channel effects and its modeling. This is a foundation courses for designing state of-art MOSFET based circuits for applications demanding low-power, low-voltage, and high speed application

Course Scheme:

Teaching Scheme			Total Credits	Assessment Pattern and Marks				Total Marks
				Theory		Practical		
L	T	PR	C	ESE (E)	PA(M)	ESE (V)	PA (I)	
03	00	02	04	70	30	30	20	150

Course Content:

U. No	Course Content	No of Hours	% weightage
1	**Semiconductors, Junctions, and MOSFET Overview:** Semiconductors, Conduction, Contact Potentials, pn junction, Overview of MOS Transistor	4	10
2	**Two-Terminal MOS Structure:** Introduction, Flat-band voltage, Potential and Charge balance, Effect of Gate-Substrate Voltage on Surface Condition, Regions of Inversion and Analysis, Small-Signal Capacitance	8	20

3	**Three-Terminal MOS Structure:** Introduction, Contacting the Inversion layer, Body effect, Regions of Inversion and Mathematical Analysis, Study of MOS Structure from "VCB" Control Point of View	8	20
4	**Four-Terminal MOS Structure:** Transistor Regions of Operation, General Charge Sheet Models, Strong Inversion, Weak Inversion, Moderate Inversion, Interpolation Models, Source Referenced versus Body Referenced Modeling, Effective Mobility, Temperature Effects, Breakdown, p-channel MOS Transistor, Enhancement-Mode and Depletion-Mode Transistors, Model Parameter Values, Model Accuracy, Model Comparison	7	15
5	**Small-Dimension Effects:** Introduction, Channel Length Modulation, Barrier Lowering, Two-Dimensional Charge Sharing, Threshold Voltage, Punch-through, Carrier Velocity Saturation, Hot Carrier Effects, Scaling, Effects of Surface and Drain Series Resistances, Effects due to Thin Oxides and High Doping	7	15
6	**MOSFET Modeling for Circuit Simulation:** Introduction, Types of Models, Combining Several Effects into One Physical Model, Parameter Extraction, Accuracy, Properties of Good Models, General Considerations, Benchmark Tests, Nontechnical Consideration	8	20
		42	100

Reference Book:

- Y. Tsividis, C. McAndres, Operation and Modeling of the MOS Transistor, 3rd Edition, Oxford University Press, 2010.
- N. D. Arora, MOSFET Models for VLSI Circuit Simulation, Springer-Verlag.
- S. M. Sze, Physics of Semiconductor Devices, 2nd Edition, Wiley Eastern.
- J. P. Colinge, Fin-FETs and other multi-gate Transistors, Springer.
- Operation and Modeling of the MOS Transistor, Y. Tsividis

Course Outcome:

After Completion of the Course, Student will able to:

No	Course Outcomes	RBT Level*
01	Understand basics of concepts of semiconductor physics.	UN

02	Modeling of 2T and 3T MOS structures.	AP
03	Modeling of MOSFET operation.	AP
04	Modeling small-dimension effects of MOSFET.	AN
05	MOSFET Model parameters' measurements and benchmark tests.	EL

*RM: Remember, UN: Understand, AP: Apply, AN: Analyze, EL: Evaluate, CR: Create

Suggested Course Practical List:

- The practical work will be carried out based on the content covered during the academic session.

List of Laboratory/Learning Resources Required:

- List of Hardware: FPGA Boards
- List of Software: EDA Tools – Cadence, Synopsis,
- List of Open Source Tools/Simulator: NIL
- **List of Useful websites/MOOCs:**
  - Course-related online MOOCs on NPTEL/SWAYAM platform
  - Recent publications in reputed journal/conferences

****