جامعة الملك عبدالله
للعلوم والتقنية
King Abdullah University of
Science and Technology

Course Syllabus: Integrated Circuits - EE 303

Division	Computer, Electrical and Mathematical Sciences & Engineering
Course Number	EE 303
Course Title	Integrated Circuits
Academic Semester	Fall
Academic Year	2019/2020
Semester Start Date	08/25/2019
Semester End Date	12/10/2019
Class Schedule (Days & Time)	10:30 AM - 12:00 PM | Sun Tue

Instructor(s)

Name	Email	Phone	Office Location	Office Hours
Muhammad Mustafa Hussain	MuhammadMustafa.Hussain @Kaust.edu.sa	+966128084450	3274, 3, Ibn Sina (bldg. 3)	Sunday 12 - 2 pm

Teaching Assistant(s)

Name	Email
TBD	TBD

Course Information

Comprehensive Course Description	Physical principles and operational characteristics of semiconductor devices. Emphasis is on MOS field-effect transistors and their behaviors dictated by present and probable future technologies. Metal-oxide-semiconductor systems, short-channel and high field effects. Alternate device architectures, materials and physics for integrated circuits based on alternate channel materials like SiGe, Ge, III-V, two (2) dimensional materials such as graphene, dichalcogenides, one (1) dimensional nanowire and nanotube architecture devices, negative capacitance devices for logic computation and ultra-mobile communication devices.
Course Description from Program Guide	Alternate device architectures, materials and physics for integrated circuits based on alternate channel materials like SiGe, Ge, III-V, two (2) dimensional materials such as graphene, dichalcogenides, one (1) dimensional nanowire and nanotube architecture devices, tunneling FET, spin logic, ferroelectric devices, nanoelectromechanical (NEM) switches and such for logic computation and ultra-mobile communication devices.
Goals and Objectives	This coure plans to instill the knowledge on solid state device focusing on MOS devices - their physics and technology. Successful completion of the course will allow the students to have enahnced knowledge and experience on solid state device technology to thrive in semiconductor device research and development both in academia as well as in semiconductor industries.
Required Knowledge	Solid state physics - EE 206 or equivalent course related knowledge
Reference Texts	1. Prof. Mark Lundstrom, Fundamentals of Nanotransistors, https://doi.org/10.1142/9018 | September 2017 Pages: 388 2. Journal papers and class note slides - given during the semester using Blackboard 3. Online resources via edX and Purdue nanohub.
Method of evaluation	**60.00**% - Tests **30.00**% - Course Project(s) **10.00**% - Active participation

Nature of the assignments	It is expected that students will be participating in active learning both in the classrooms and through online resources. There will be tests on the following topics: 1. Solid state device physics - 15% [multiple choice questions and true/false questions, closed book] 2. MOS capacitors - 15% [closed book] 3. Long channel MOSFETs - 15% [closed book] 4. Short channel MOSFETs - 15% [open book, offline materials] Course project: Individual project presentation (12 min) and a 4 pages long publication grade review paper. From the variety of modern transistor options we will review, each of you will choose one option and dig upon what is one of the most intriguing challenges for that option, will review it and present the challenge and potential pathways to overcome that. An example: M. A. Zidan, H. A. H. Fahmy, M. M. Hussain, K. N. Salama, “Memristor-Based Memory: The Sneak Paths Problem and Solutions”, *Microelectronics Journal*, 44(2), 176–183 (2013).
Course Policies	1. Standard policies and university guidelines prescribed by KAUST will be in practice related to absences and disability. 2. Assignments must be turned in by the deadline to ensure no point deduction due to late submission. 3. In case of natural calamity, university closer, family emergency, health emergency, tests and course project deadline will be changed to accommodate a fair evaluation for all.
Additional Information	

Tentative Course Schedule *(Time, topic/emphasis & resources)*		
Week	**Lectures**	**Topic**
1	Sun 08/25/2019 Tue 08/27/2019	Semester starts 08/25/2019: Introduction, content discussion, course policy, logistics 08/27/2019: Energy levels to energy bands Crystalline, polycrystalline, and amorphous semiconductors Miller indices
2	Sun 09/01/2019 Tue 09/03/2019	09/01/2019: Properties of common semiconductors Free carriers in semiconductors Doping The Fermi function 09/03/2019: Carrier concentration vs. Fermi level Carrier concentration vs. doping density Carrier concentration vs. temperature
3	Sun 09/08/2019 Tue 09/10/2019	09/08/2019: Drift-diffusion equation Carrier recombination Carrier generation 09/10/2019: Energy band diagram
4	Sun 09/15/2019 Tue 09/17/2019	09/15/2019: Online resource review 09/17/2019: Test 01 on the course materials covered from 08/27/2019 - 09/10/2019.
5	Sun 09/22/2019 Tue 09/24/2019	09/22/2019: University holiday 09/24/2019: MOSFET Device Metrics
6	Sun 09/29/2019 Tue 10/01/2019	09/29/2019: MOSCAPs: The Depletion Approximation MOSCAPs: Gate Voltage and Surface Potential MOSCAPs: Flat-band Voltage 10/01/2019: MOSCAPs: MOS CV MOSCAPs: The Mobile Charge vs. Surface Potential MOSCAPs: The Mobile Charge vs. Gate Voltage
7	Sun 10/06/2019 Tue 10/08/2019	10/06/2019: 2D MOS Electrostatics Energy Band Diagram Review 10/08/2019: Test 02 on the course materials covered from 09/24/2019 to 10/01/2019.
8	Sun 10/13/2019 Tue 10/15/2019	10/13/2019: Energy Band View of the MOSFET MOSFET IV Theory The Square Law MOSFET 10/15/2019: The Landauer Approach Landauer at Low and High Bias
9	Sun 10/20/2019 Tue 10/22/2019	10/20/2019: The Ballistic MOSFET Transmission Theory of the MOSFET 10/22/2019: Limits of MOSFETs
10	Sun 10/27/2019 Tue 10/29/2019	10/27/2019: Mid-semester break 10/29/2019: Test 3 on the course materials from 10/01/2019 to 10/13/2019.
11	Sun 11/03/2019 Tue 11/05/2019	11/03/2019: High-k/metal gate transistors 11/05/2019: FinFET. Multi-gate transistors

12	Sun 11/10/2019 Tue 11/12/2019	11/10/2019: 3D-ICs 11/11/2019: Attendance talks delivered as part of IEEE EDS Mini Colloquium organized in KAUST 11/12/2019: Negative capacitance transistors
13	Sun 11/17/2019 Tue 11/19/2019	11/17/2019: Off class review of lectures delivered as part of IEEE EDS Mini Colloquium organized in KAUST on 11/11/2019. 11/19/2019: Test 4 on the course materials from 10/15/2019 to 10/22/2019.
14	Sun 11/24/2019 Tue 11/26/2019	11/24/2019: 1D transistors 11/26/2019: 2D transistors
15	Sun 12/01/2019 Tue 12/03/2019	12/01/2019: Off class review and preparation for course projects. 12/03/2019: Individual class presentations on course projects.
16	Sun 12/08/2019 Tue 12/10/2019	There will be no mid-term or final exams in this course.

Note

The instructor reserves the right to make changes to this syllabus as necessary.