



Middle East Technical University  
Department of Electrical and Electronics Engineering

## EE 212

### *Semiconductor Devices and Modeling* Spring 2020-2021

Section	Instructor	Office	E-mail Address	Phone
1	Serdar Kocaman	E-112	skocaman@metu.edu.tr	210 2372
2	Murat Eyüboğlu	DZ-09	meyub@metu.edu.tr	210 2361
3	Nevzat G. Gençer	DZ-02/1	ngencer@metu.edu.tr	210 2314
4	Selçuk Yerci	C-110	syerci@metu.edu.tr	210 2344
5	Cengiz Beşikci	G-101	besikci@metu.edu.tr	210 4530
6	Cengiz Beşikci	G-101	besikci@metu.edu.tr	210 4530

**Course Description:** Basic semiconductor concepts. Conduction mechanisms in semiconductors and physical electronics. Physics of p-n junction diodes, bipolar junction transistors (BJTs) and field-effect transistors (FETs). Modes of operation and characteristics. Transistor biasing and small-signal models for BJTs and FETs. Secondary effects in transistors. Dynamic models for diodes and transistors. Modeling concepts for computer-aided design.

#### After taking this course you will be able to

- understand the fundamentals of semiconductors and solid-state electronics
- understand how transistors and amplifiers work
- understand how semiconductor devices can be utilized for electronic applications
- model and predict the behaviour of semiconductor devices
- simulate electronic circuits containing semiconductor devices on PC

**Reference Books :** 1) *Solid State Electronic Devices*, B. G. Streetman, S. K. Banerjee, 5th or 6th Edition, Prentice Hall, 2006.  
2) *Semiconductor Device Fundamentals*, R. F. Pierret, Addison Wesley, 1996.  
3) *Microelectronic Circuits*, A.S. Sedra and K. C. Smith, 5<sup>th</sup> or 4<sup>th</sup> Edition, Oxford University Press.  
4) *Microelectronic Circuit Design*, R. C. Jaeger and T. N. Blalock, 4<sup>th</sup>, 3<sup>rd</sup>, 2<sup>nd</sup> or 1<sup>st</sup> Edition, Mc Graw Hill.

**Online lectures will be delivered at** <https://metu.webex.com/meet/besikci>

Links for the office (recitation) hours will be announced later.

### Grading

Midterm Examination 1 : 16 %

Midterm Examination 2 : 16 %

Midterm Examination 3 : 16 %

Midterm Examination 4 : 16 %

Homework : 6 %

Final Examination : 30 %

**In order to take the final examination, student must meet the following condition:**

An average score of 30.00 (out of 100) in the midterm examinations.

**Students who fail to meet the above condition will be assigned the NA grade.**

Course rules and regulations are listed in the Lecture Notes that can be downloaded from METUCLASS.

# EE 212-SEMICONDUCTOR DEVICES AND MODELING-Spring 2020-2021

Topic	Textbook/Reference Book Sections*,**	Week
Course introduction, solid-state electronic materials, bonding forces and energy bands in solids	Lecture Notes: Chapter 1 Ref.1: 3.1.1-3.1.3, 3.2.3, 3.2.4 Ref. 2: 2.2, 2.3.3	<b>1</b> March 15-19
Impurities in semiconductors, drift and diffusion in semiconductors	Lecture Notes: Chapter 1 Ref.1: 3.3.1, 3.3.4, 3.4.2, 3.4.3, 3.4.4, 4.4.1, 4.4.2 Ref. 2: 2.3.4, 2.3.5, 2.4.2, 2.5.4, 2.5.5, 2.5.7, 3.1, 3.2	<b>2</b> March 22-26
Generation-recombination of electrons and holes, continuity and diffusion equations	Lecture Notes: Chapter 1 Ref.1 : 4.1, 4.3.1, 4.4.3, 4.4.4 Ref. 2: 3.3.1, 3.4, 3.5.1	<b>3</b> March 29-April 2
p-n junction under equilibrium and forward and reverse bias, derivation of diode current expression	Lecture Notes: Chapter 2 Ref.1: 5.2.1, 5.2.2, 5.2.3, 5.3.1, 5.3.2, 5.3.3 Ref.2: 5.1, 6.1.1, 6.2.1, 6.2.2	<b>4</b> April 5-9
Diode I-V characteristics, p-n junction capacitance, breakdown mechanisms, dynamic switching behavior of diode, photodetectors, solar cells, LEDs	Lecture Notes: Chapters 2 and 3 Ref.1 : 5.4.1, 5.4.2, 5.5.2, 5.5.4, 8.1.1, 8.1.2, 8.1.3, 8.2.1 Ref. 2: 7.2.1, 8.1.1, 8.1.2, 9.1, 9.2.1, 9.3.1, 9.3.2, 9.4.1	<b>5</b> April 12-16
Introduction to the Bipolar Junction Transistor (BJT)	Lecture Notes: Chapter 4 Ref.1: 7.1, 7.2 Ref. 2: 10.1, 10.2, 10.3, 10.4, 10.5	<b>6</b> April 19-23
BJT I-V characteristics and Ebers-Moll model	Lecture Notes: Chapter 4 Ref.4 : 5.2, 5.3, 5.4, 5.5, 5.6, 5.7, 5.9	<b>7</b> April 26-30
BJT capacitances, Early Effect in BJT and BJT biasing	Lecture Notes: Chapter 4 Ref. 3: 5.5 Ref. 4: 5.10, 5.12	<b>8</b> May 3-7
<b>BREAK</b>		<b>May 10-14</b>
MOS capacitor and introduction to MOSFET	Lecture Notes: Chapter 5 Ref.4: 4.1.1, 4.1.2, 4.1.3, 4.2.1,4.2.2,4.2.3, 4.2.4, 4.2.5, 4.2.6, 4.2.7 Ref.3: 4.1.1, 4.1.2, 4.1.3, 4.1.4, 4.1.5, 4.1.6 Ref.2: 16.1, 16.2	<b>9</b> May 17-21
MOSFET types and I-V characteristics, Body effect and channel length modulation	Lecture Notes: Chapter 5 Ref.4: 4.2.8, 4.2.9, 4.2.10, 4.3, 4.4, 4.6 Ref.3 : 4.1.7, 4.2.1, 4.2.2, 4.2.3,4.2.4,4.2.5	<b>10</b> May 24-28
MOSFET biasing	Lecture Notes: Chapter 5 Ref. 4: 4.8, 4.9 Ref. 3: 4.3, 4.5	<b>11</b> May 31-June 4
MOSFET as a switching device	Lecture Notes: Chapter 5 Ref. 4: 6.1, 6.2, 6.3, 6.6.1, 6.6.4-6.6.8	<b>12</b> June 7-11
Small signal models for diodes and BJTS, transistor as an amplifier	Lecture Notes: Chapter 6 Ref. 3: 3.3.8, 5.6.1-5.6.10	<b>13</b> June 14-18
The common emitter amplifier, small signal model for FETs, the common source amplifier	Lecture Notes: Chapter 6 Ref.3: 5.7.3, 4.6.1-4.6.7, 4.7.3	<b>14</b> June 21-25

\* The section numbers are based on the following editions: Ref.1: 6<sup>th</sup> Ed., Ref.3: 5<sup>th</sup> Ed., Ref.4: 2<sup>nd</sup> Ed.

\*\* Lecture notes are self-sufficient for students regularly attending the on line lectures. Good attendance will minimize your need for the additional sources (above listed references).