Physics of Semiconductors and Devices

College: College of Engineering

Department: Electrical Engineering Dept.

First: Course Definition

1- Course Code: EE610

2- Units: 3 Credit Hrs

3 – Semester First semester of MSC program

4 -Prerequisite ----- 

5- Co-requisite ----- 

6- Location (if not on main Campus):

Second: Course Objectives

- Developing a Solid foundation in the physics of semiconductors to appreciate the working principle of the current electronic devices
- Give students an appreciation of the role of semiconductors in novel applications, and solid foundation for new semiconductor devices as they materialize and evolve in future years.
- To give students an understanding of the concept of crystal structures, bonding properties, energy band theory, carrier distribution and recombination, theory of transport and scattering.
- To ensure that students know some characteristic properties of theory of p-n junction, and operation of majority carrier diodes and transistors.
- To make students familiar with a range of fast, low power and reliable electronics consists of superconducting electronics and its application will also be covered with modern electronic components in the field.

Third: Course Specifications

1- Topics to be covered

<table>
<thead>
<tr>
<th>Subject</th>
<th>No of Weeks</th>
<th>Units</th>
</tr>
</thead>
</table>

1. **Introduction to Materials**: Metal, Semiconductor, Insulator and Superconductors, Bonding in materials and their characteristics, Crystal Structures, Introduction to Crystal Growth Techniques

2. **Introduction to Quantum Mechanics**: Principles of Quantum Mechanics, Schrodinger's Wave Equation, Applications of Schrodinger's Wave Equation, Tunneling, Allowed and Forbidden Energy Bands


4. **Carrier Transport Phenomena in Semiconductors**: Carrier Drift, Carrier Diffusion, Graded Impurity Distribution.


6. **Properties of interest for device applications**: Surface morphology, IV characteristics, Resistivity, conductivity, band gap, doping concentration, Type of doping etc.

7. **Introduction to superconductivity and superconducting devices**: Definition and critical quantities, Types of Superconductor, General Applications Areas, Superconducting Electronics: Josephson tunnel Junction, Superconducting Quantum Interference Devices (SQUID), Rapid Single-Flux-Quantum (RSFQ), Infrared detectors

---

**2- Course components (Total hrs in the Semester): 42**

<table>
<thead>
<tr>
<th>Lecture</th>
<th>Exercises</th>
<th>Others</th>
</tr>
</thead>
<tbody>
<tr>
<td>42</td>
<td>-----</td>
<td>-----</td>
</tr>
</tbody>
</table>

**3- Intended Learning Outcomes of the Course (ILO’s)**

a. **Knowledge**

i) **Description of the knowledge to be acquired**:

- To apply the fundamental knowledge from Quantum Mechanics and Solid State Physics to the technologically important and useful materials.
- To comprehensively understand the physics of semiconductors.
- To understand the physical basis and the use of typical semiconductor devices.
- To gain updated knowledge in the most advanced development of low dimensional semiconductor hetero structures and their applications.

ii) **Teaching strategies to be used to develop that knowledge**

- Lectures
- Assignments, at home
- Discussions in the Class
### iii) Methods of assessment of knowledge acquired

- **Quizzes**: to assess understanding of the course knowledge.
- **Assignment reports**: to assess ability to answer some comprehensive questions.
- **Midterm Exams**: to assess understanding of the course knowledge.
- **Final Exam**: to assess understanding of the course knowledge.

### b- Cognitive (Intellectual) Skills

#### i) Cognitive skills to be developed

- The ability to analyze, and determine the micro Fabrication.
- The ability to select the suitable technology,
- The ability to control the synchronous machines.

#### ii) Teaching strategies to be used to develop these cognitive skills

- Lectures
- Assignments, at home
- Discussions in the Class
- Literature Survey Report (data collection, internet search, and reporting)

#### iii) Methods of assessment of student’s cognitive skills

- **Quizzes**: to assess understanding of the course knowledge.
- **Assignment reports**: to assess ability to answer some comprehensive questions.
- **Midterm Exams**: to assess understanding of the course knowledge.
- **Final Exam**: to assess understanding of the course knowledge.

### c. Interpersonal Skills and Responsibility

#### i) Description of the interpersonal skills and capacity to carry responsibility to be developed

- Team work
- Ideas development and sharing with others

#### ii) Teaching strategies to be used to develop these skills

- Assignments, at home
- Discussions in the Class
- Case study Report (data collection, Internet search, and reporting)

#### iii) Methods of assessment of student’s interpersonal skills and capacity to carry responsibility

Unified reports and Seminars: to assess the integration done by the student in a unified report and presentations.
**d. Communication, Information Technology and Numerical Skills**

*i) Description of the skills to be developed in this domain*
- Use of the internet search
- Technical report writing

*ii) Teaching strategies to be used to develop these skills*
- Assignments, at home
- Assignment Reports (data collection, Internet search, and reporting)

*iii) Methods of assessment of students numerical and communication skills*
- Assignment Reports: to assess technical report writing abilities.
- Discussion Groups: to assess interactive and communication abilities.

**e. Psychomotor (if applicable) & Other Non-cognitive Skills**

*i) Description of the psychomotor or other skills to be developed and the level of performance required*

Not Applicable

*ii) Teaching strategies to be used to develop these skills*

----------

*iii) Methods of assessment of student’s psychomotor skills*

----------

### 4- Student Assessment Schedule

<table>
<thead>
<tr>
<th>Serial</th>
<th>Assessment tool (test, group project, examination etc.)</th>
<th>Week due</th>
<th>Weight</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Quiz 1 on Introduction to Materials</td>
<td>2</td>
<td>1%</td>
</tr>
<tr>
<td>2</td>
<td>Short Quiz 2</td>
<td>3</td>
<td>1%</td>
</tr>
<tr>
<td>3</td>
<td>HW 1</td>
<td></td>
<td>2%</td>
</tr>
<tr>
<td>4</td>
<td>Extended QUIZ on Introduction to Quantum Mechanics</td>
<td>4</td>
<td>3%</td>
</tr>
<tr>
<td>5</td>
<td>Short Quiz 3</td>
<td>5</td>
<td>1%</td>
</tr>
<tr>
<td></td>
<td>HW 2</td>
<td></td>
<td>2%</td>
</tr>
<tr>
<td>6</td>
<td>Extended QUIZ on Homogeneous Semiconductors in Thermodynamic Equilibrium</td>
<td>6</td>
<td>3%</td>
</tr>
<tr>
<td>7</td>
<td>Midterm Exam 1</td>
<td>7</td>
<td>15%</td>
</tr>
<tr>
<td>Week</td>
<td>Assignment</td>
<td>Details</td>
<td></td>
</tr>
<tr>
<td>------</td>
<td>------------</td>
<td>---------</td>
<td></td>
</tr>
<tr>
<td>8</td>
<td>Short Quiz 4</td>
<td>HW3</td>
<td>1%</td>
</tr>
<tr>
<td>9</td>
<td>Extended QUIZ on Carrier Transport Phenomena in Semiconductors</td>
<td>9</td>
<td>3%</td>
</tr>
<tr>
<td>10</td>
<td>Quiz 5 on Principles of Semiconductor Devices</td>
<td>10</td>
<td>1%</td>
</tr>
<tr>
<td>11</td>
<td>Midterm Exam II</td>
<td>11</td>
<td>15%</td>
</tr>
<tr>
<td>12</td>
<td>Presentation on Properties of interest for device applications</td>
<td>12</td>
<td>5%</td>
</tr>
<tr>
<td>13</td>
<td>Extended QUIZ on Introduction to superconductivity and superconducting devices</td>
<td>HW4</td>
<td>2%</td>
</tr>
<tr>
<td>14</td>
<td>Final</td>
<td>14</td>
<td>3%</td>
</tr>
</tbody>
</table>

---

**5- Student Support**

1. Office hours per week are offered by the instructor to aid the students and support them.
2. Tutorial arranged to help in understanding the course material

**6- Learning Resources**

**i) Essential Books (References)**
- S. M. Sze, “Physics of Semiconductor Device”, Wiley Inter science.

**ii) Course Notes**
Lecture notes on semiconductor material physics, providing a deeper treatment than that available in Taur, will be distributed in class.

**iii) Recommended Books**
- C. Weisbuch, B. Vinter, Quantum semiconductor structures, Academic Press, Inc. (Boston, 1991) QC611.W38

iv) **Electronic Books & Web Sites:**
- [http://www.optique-ingenieur.org/en/courses/OPI_ang_M05_C02/co/Grain_OPI_ang_M05_C02_2.html](http://www.optique-ingenieur.org/en/courses/OPI_ang_M05_C02/co/Grain_OPI_ang_M05_C02_2.html)
- [http://jas.eng.buffalo.edu/SUNY, Buffalo offers great graphics for SC physics and devices](http://jas.eng.buffalo.edu)
- [http://www.britneyspears.ac/lasers.htm](http://www.britneyspears.ac/lasers.htm) Britney Spears (Essex Univ. Physics Grads) provide a succinct summary of SC physics

v) **Periodicals**
- IEEE transaction on Applied superconductivity
- IEEE transaction on Quantum Electronics
- IEEE transaction on semiconductor manufacturing
- Solid State electronics IEEE

7- **Course Evaluation and Improvement Processes**

i) **Strategies for Obtaining Student Feedback on Effectiveness of Teaching**
- Course related discussions with students at the end of each section
- Introduction of class representative who convey feed backs to the teacher which helps teacher to build an appropriate strategy to improve the teaching and learning process.
- Course evaluation and suggestions form filled after first midterm exam for teacher feedback
- Official course evaluation forms should be compiled and results should be shared with the professor.
- Observing the students opinions recorded in the college student site
- Appeal box
- Carrying out extensive questioners by a sample of the distinguished students just after the graduation from the college.

ii) **Other Strategies for Evaluation of Teaching by the Instructor or by the Department**
A key to effective teaching evaluation is to collect data from multiple sources (triangulation), making sure that all education-related activities are rated by the people best qualified to rate them.

**Peer Ratings:** A far more effective procedure is for two or more reviewers to use standardized checklists to rate instructional materials and at least two class observations independently and then to reconcile their ratings.[1-3]

**Student Ratings:** Faculty performance evaluations should take into account student ratings collected over a period of several years, with relatively little weight being attached to ratings of someone’s first semester of teaching.

**The Teaching Portfolio:** Just as some performance assessment data can best be provided by students and some by peers, certain important information can only be supplied by the faculty member being reviewed. Instructors should assemble materials summarizing all of their education-related activities, including developing new courses and redesigning old ones, developing and evaluating innovative instructional methods, advising and mentoring students, writing new texts and courseware, providing instructional development to faculty colleagues and graduate students, and carrying out educational research. All of these materials except those related to educational research should be incorporated into a teaching portfolio, along with summaries of student ratings over the past two or three years, peer ratings, and reference letters from alumni and colleagues at other institutions who are familiar with the instructor’s educational activities. The portfolio provides a solid basis for evaluating the faculty member’s teaching performance and contributions to education.[4–6] [7]


### iii) Processes for Improvement of Teaching

- The following framework is one that you could use to document strategies you use and assess how they work. The framework follows the familiar "plan, do, check, act cycle" which is a continuous improvement process used in business, industry, government, and higher education.

**Plan:** Concept - The concept that you plan to teach

- Strategy - The teaching strategy that you plan to use
- Date - The day you plan to use the strategy
- Materials Needed - The teaching materials that you will need
Time Needed - Plan your teaching activity so that you can accomplish all your goals
Feedback - Decide on a strategy to obtain student feedback. Consider fast feedback, written reports and observing students’ reactions
Do: Execute your plan
Check: Review student evaluations
Act: Decide on what you would do next time. Stick with the strategy? Change?

iv) Processes for verifying standards of student achievement (e.g. check marking by an independent faculty member of a sample of student work, periodic exchange and remarking of a sample of assignments with a faculty member in another institution)
- Not required

v) Describe the planning arrangements for periodically reviewing course effectiveness and planning for improvement.
As per procedure of academic council
- Assessment and evaluation of the level of achieving the course outcomes through a continuous improvement process (part of a quality assurance system established by the university),
- Consequently, actions are to be taken to improve the course delivery when necessary.
- Review of the course objectives, outcomes and curriculum each 2 years.