INSTITUTE OF AERONAUTICAL ENGINEERING

(Autonomous)

Dundigal, Hyderabad -500 043

COMPUTER SCIENCE AND ENGINEERING

COURSE DESCRIPTOR

Course Title	**SEMICONDUCTOR PHYSICS**				
Course Code	AHSB13				
Programme	B.Tech				
Semester	II	CSE | IT			
Course Type	Foundation				
Regulation	IARE - R18				
Course Structure	**Theory**			**Practical**	
	Lectures	**Tutorials**	**Credits**	**Laboratory**	**Credits**
	3	1	4	3	1.5
Chief Coordinator	Mr. A Chandra Prakash, Assistant Professor				
Course Faculty	Ms. S Charvani, Assistant Professor Mr. K Sai Baba, Assistant Professor Mr. T Srikanth, Assistant Professor				

I. COURSE OVERVIEW:

The course matter is divided into five modules covering duly-recognized areas of theory and study. This course develops abstract and critical reasoning by studying mathematical and logical proofs and assumptions as applied in basic physics. The topics include quantum mechanics, semiconductors, opto electronic devices, magnetism, dielectrics, lasers and fiber optics. The course helps students to gain knowledge of basic principles and appreciate the diverse real-time applications in technological fields in respective branches.

II. COURSE PRE-REQUISITES:

Level	Course Code	Semester	Prerequisites
-	-	-	Basic principles of semiconductors

III. MARKS DISTRIBUTION:

Subject	SEE Examination	CIA Examination	Total Marks
Semiconductor Physics	70 Marks	30 Marks	100

IV. DELIVERY / INSTRUCTIONAL METHODOLOGIES:

✘	Chalk & Talk	✔	Quiz	✔	Assignments	✘	MOOCs
✔	LCD / PPT	✔	Seminars	✘	Mini Project	✔	Videos
✘	Open Ended Experiments						

V. EVALUATION METHODOLOGY:

The course will be evaluated for a total of 100 marks, with 30 marks for Continuous Internal Assessment (CIA) and 70 marks for Semester End Examination (SEE). Out of 30 marks allotted for CIA during the semester, marks are awarded by taking average of two CIA examinations or the marks scored in the make-up examination.

Semester End Examination (SEE): The SEE is conducted for 70 marks of 3 hours duration. The syllabus for the theory courses is divided into FIVE modules and each module carries equal weightage in terms of marks distribution. The question paper pattern is as follows. Two full questions with "either" or "choice" will be drawn from each module. Each question carries 14 marks. There could be a maximum of two sub divisions in a question.

The emphasis on the questions is broadly based on the following criteria:

50 %	To test the objectiveness of the concept.
50 %	To test the analytical skill of the concept OR to test the application skill of the concept.

Continuous Internal Assessment (CIA):

CIA is conducted for a total of 30 marks (Table 1), with 20 marks for Continuous Internal Examination (CIE), 05 marks for Quiz and 05 marks for Alternative Assessment Tool (AAT).

Table 1: Assessment pattern for CIA

Component	**Theory**			**Total Marks**
Type of Assessment	CIE Exam	Quiz	AAT	
CIA Marks	20	05	05	30

Continuous Internal Examination (CIE):

Two CIE exams shall be conducted at the end of the 8th and 16th week of the semester respectively. The CIE exam is conducted for 20 marks of 2 hours duration consisting of five descriptive type questions out of which four questions have to be answered where, each question carries 5 marks. Marks are awarded by taking average of marks scored in two CIE exams.

Quiz - Online Examination

Two Quiz exams shall be online examination consisting of 25 multiple choice questions and are to be answered by choosing the correct answer from a given set of choices (commonly four). Such a question paper shall be useful in testing of knowledge, skills, application, analysis, evaluation and understanding of the students. Marks shall be awarded considering the average of two quiz examinations for every course.

Alternative Assessment Tool (AAT)

This AAT enables faculty to design own assessment patterns during the CIA. The AAT converts the classroom into an effective learning centre. The AAT may include tutorial hours/classes, seminars, assignments, term paper, open ended experiments, METE (Modeling and Experimental Tools in Engineering), five minutes video, MOOCs etc.

The AAT chosen for this course is given in section XI.

VI. HOW PROGRAM OUTCOMES ARE ASSESSED:

Program Outcomes (POs)		Strength	Proficiency assessed by
PO 1	**Engineering knowledge**: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.	3	Presentation on real-world problems
PO 2	**Problem analysis**: Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences	2	Term paper
PO 4	**Conduct investigations of complex problems**: Use research- based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.	1	Seminars

3 = High; 2 = Medium; 1 = Low

VII. HOW PROGRAM SPECIFIC OUTCOMES ARE ASSESSED:

Program Specific Outcomes (PSOs)		Strength	Proficiency assessed by
PSO 1	**Professional Skills:** The ability to understand, analyze and develop computer programs in the areas related to algorithms, system software, multimedia, web design, big data analytics, and networking for efficient design of computer-based systems of varying complexity.	1	Seminar
PSO 2	**Problem-Solving Skills:** The ability to apply standard practices and strategies in software project development using open-ended programming environments to deliver a quality product for business success.	-	-

PSO 3	**Successful Career and Entrepreneurship:** The ability to employ modern computer languages, environments, and platforms in creating innovative career paths to be an entrepreneur, and a zest for higher studies.	-	-

3 = High; 2 = Medium; 1 = Low

VIII. COURSE OBJECTIVES (COs):

The course should enable the students to:	
I	Enrich knowledge in principles of quantum mechanics and semiconductors.
II	Develop strong fundamentals of electronic and optoelectronic materials.
III	Enrich knowledge about measuring resistivity, conductivity and other parameters.
IV	Correlate principles and applications of lasers and fiber optics.

IX. COURSE OUTCOMES (COs):

COs	Course Outcome	CLOs	Course Learning Outcome
CO 1	Interpret the concept of quantum mechanics with dual nature of matter.	CLO 1	Recall the basic principles of physics and apply the concepts of physics in solving the real-time problems.
		CLO 2	Acquire knowledge about fundamental in quantum mechanics.
		CLO 3	Interpretation of dual nature of matter wave concept using Davisson & Germer's experiment
CO 2	Identify different types of semiconductors and dependence of their Fermi level on various factors.	CLO 4	Estimate the energy of the particles using Schrödinger's wave equation and apply it to particle in potential box.
		CLO 5	Recollect the conductivity mechanism involved in semiconductors and calculate carrier concentrations.
		CLO 6	Understand the band structure of a solid and Classify materials as metals, insulators, or semiconductors, and sketch a schematic band diagram for each one.
CO 3	To give knowledge about semiconductor physics and discus working and applications of basic devices, including p-n junctions, PIN, Avalanche photodiode, Solar cell	CLO 7	Acquire knowledge about fundamentals in semiconducting devices
		CLO 8	Understand the basics of a p-n junction and construction of optoelectronic devices like LED, photo diode, solar cell.

COs	Course Outcome	CLOs	Course Learning Outcome
CO 4	Ability to identify appropriate magnetic, and dielectric, materials required for various engineering applications.	CLO 9	Recollect the concept of electric polarization and classify dielectric materials.
		CLO 10	Recollect the concept of magnetization and classify magnetic materials.
		CLO 11	Apply different laws of radiation to understand the phenomenon behind production of light.
CO 5	Understand the working principle of different types of lasers and optical fibre communication.	CLO 12	Understand the basic principles involved in the production of Laser light and also real- time applications of lasers.
		CLO 13	Recollect basic principle, construction, types and attenuation of optical fibers.
		CLO 14	Understand the importance of optical fibers in real time communication system.

X. COURSE LEARNING OUTCOMES (CLOs):

CLO Code	CLO's	At the end of the course, the student will have the ability to:	PO's Mapped	Strength of Mapping
AHSB13.01	CLO 1	Recall the basic principles of physics and apply these concepts of physics in solving the real-time problems.	PO 1, PO 2	3
AHSB13.01	CLO 2	Acquire knowledge about fundamentals in quantum mechanics.	PO 1	3
AHSB13.01	CLO 3	Interpretation of dual nature of matter wave concept using Davisson & Germer's experiment.	PO 1	3
AHSB13.01	CLO 4	Estimate the energy of the particles using Schrödinger's wave equation and apply it to particle in potential box.	PO 1	3
AHSB13.01	CLO 5	Understand the band structure of a solid and Classify materials as metals, insulators, or semiconductors, and sketch a schematic band diagram for each one.	PO 1	3
AHSB13.01	CLO 6	Recollect the conductivity mechanism involved in semiconductors and calculate carrier concentrations.	PO 1	3
AHSB13.01	CLO 7	Acquire knowledge about fundamentals in semiconducting devices	PO 1	3
AHSB13.01	CLO 8	Understand the basics of a p-n junction and construction of optoelectronic devices like LED, photo diode, solar cell.	PO 1, PO 2	3
AHSB13.01	CLO 9	Recollect the concept of electric polarization and classify dielectric materials.	PO 2	2
AHSB13.01	CLO 10	Recollect the concept of magnetization and classify magnetic materials.	PO 1	3
AHSB13.01	CLO 11	Apply different laws of radiationto understand the phenomenon behind production of light.	PO 1	3

AHSB13.01	CLO 12	Understand the basic principles involved in the production of Laser light and also Real-time applications of lasers.	PO 2, PO 4	2
AHSB13.01	CLO 13	Recollect basic principle, construction, types and attenuation of optical fibers.	PO 1	3
AHSB13.01	CLO 14	Understand the importance of optical fibers in real-time communication system.	PO 4	2

3 = High; 2 = Medium; 1 = Low

XI. MAPPING COURSE OUTCOMES LEADING TO THE ACHIEVEMENT OF PROGRAM OUTCOMES:

Course Outcomes (COs)	Program Outcomes (POs)			
	PO 1	PO 2	PO 4	PSO1
CO 1	3	2		1
CO 2	2	2	1	1
CO 3	2			
CO 4		2		
CO 5	3			1

XII. MAPPING COURSE LEARNING OUTCOMES LEADING TO THE ACHIEVEMENT OF PROGRAM OUTCOMES AND PROGRAM SPECIFIC OUTCOMES:

Course Learning Outcomes (CLOs)	Program Outcomes (POs)												Program Specific Outcomes (PSOs)		
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CLO 1	3	2												1	
CLO 2	3														
CLO 3	3														
CLO 4	3														
CLO 5	3														
CLO 6	3														
CLO 7	3														
CLO 8	3	2													
CLO 9		2													
CLO 10	3														
CLO 11	3														

Course Learning Outcomes (CLOs)	Program Outcomes (POs)												Program Specific Outcomes (PSOs)		
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CLO 12		2		1										1	
CLO 13	3														
CLO 14				1										1	

3 = High; 2 = Medium; 1 = Low

XIII. ASSESSMENT METHODOLOGIES – DIRECT

CIE Exams	PO1, PO2, PO4, PSO2	SEE Exams	PO 1, PO2, PO4, PSO2	Assignments	-	Seminars	PO1, PO2, PO4, PSO2
Laboratory Practices	-	Student Viva	-	Mini Project	-	Certification	-
Term Paper	PO1, PO2, PO4, PSO2						

XIV. ASSESSMENT METHODOLOGIES - INDIRECT

✔	Early Semester Feedback	✔	End Semester OBE Feedback
✘	Assessment of Mini Projects by Experts		

XV. SYLLABUS

Module-I	QUANTUM MECHANICS
Introduction to quantum physics, Black body radiation, Planck's law, Photoelectric effect, Compton effect, De-Broglie's hypothesis, Wave-particle duality, Davisson and Germer experiment, Time-independent Schrodinger equation for wave function, Born interpretation of the wave function, Schrodinger equation for one dimensional problems–particle in a box.	
Module-II	**ELECTRONIC MATERIALS AND SEMICONDUCTORS**
Free electron theory, Bloch's theorem for particles in a periodic potential, Kronig-Penney model (Qualitative treatment), Origin of energy bands, Types of electronic materials: metals, semiconductors, and insulators. Intrinsic and extrinsic semiconductors, Carrier concentration, Dependence of Fermi level on carrier-concentration and temperature, Hall effect.	
Module-III	**LIGHT-SEMICONDUCTOR INTERACTION**
Carrier generation and recombination, Carrier transport: diffusion and drift, Direct and indirect band gaps, p-n junction, V-I characteristics, Energy Band diagram, Biasing of a junction.	
Module-IV	**ENGINEERED ELECTRIC AND MAGNETIC MATERIALS**
Polarization, Permittivity, Dielectric constant, Internal field in solids, Clausius Mosotti equation, Ferroelectricity, Piezoelectricity, Pyroelectricity. Magnetization, Permeability, Susceptibility, Classification of dia, Para and Ferro magnetic materials on th basis of magnetic moment, Domain theory of Ferro magnetism on the basis of hysteresis curve.	

Module-V	LASERS AND FIBER OPTICS
Characteristics of lasers, Spontaneous and stimulated emission of radiation, Metastable state, Population inversion, Lasing action, Ruby laser, Semiconductor diode laser and applications of lasers. Principle and construction of an optical fiber, Acceptance angle, Numerical aperture, Types of optical fibe (Single mode, multimode, step index, graded index), Attenuation in optical fibers, Optical fiber communic system with block diagram.	
Text Books:	
1. Dr. K. Vijaya Kumar, Dr. S. Chandralingam, "Modern Engineering Physics", Chand & Co. New Delhi, Edition, 2010. 2. Dr. M. N. Avadhanulu, Dr. P. G. Kshirsagar, A text book of engineering physics, S. Chand. 3. B. K Pandey and S. Chaturvedi, Engineering physics – Cengage learning	
Reference Books:	
1. J. Singh, Semiconductor Optoelectronics: Physics and Technology, McGraw-Hill Inc. (1995). 2. R. K. Gaur, S. L. Gupta, "Engineering Physics", Dhanpat Rai Publications, 8th Edition, 2001 3. Online course: "Optoelectronic Materials and Devices" by Monica Katiyar and Deepak Gupta on NPTEL. 4. O. Svelto, "Principles of Lasers", Springer Science & Business Media, 2010	
Photo voltaic effect, Construction and working of LED, Photo detectors, PIN, Avalanche photodiode, Solar c	

XVI. COURSE PLAN:

The course plan is meant as a guideline. Probably there may be changes.

Lecture No	Topics to be covered	Course Learning Outcomes (CLOs)	Reference
1	Introduction to quantum physics	CLO 2	T2:5.5 R1:1.12.1
2	Black body radiation	CLO 2	T2:5.6 R1:1.12.3
3	Planck's law, Photoelectric effect, Compton effect	CLO 2	T2:5.10 R1:1.15
4	De-Broglie's hypothesis, Wave-particle duality	CLO 3	T2:5.15 R1:1.16
5	Davisson and Germer experiment	CLO 3	T2:5.17 R1:1.13.1
6	Time-independent Schrodinger equation for wave function	CLO 4	T2:5.18 R1:1.13.2
7	Born interpretation of the wave function	CLO 4	T2:5.19 R1:1.13.3
8	Schrodinger equation for one dimensional problem– particle in a box.	CLO 4	T2:5.20 R1:1.17.1
9	Bloch's theorem for particles in a periodic potential, Kronig-Penney model (Qualitative treatment)	CLO 5	T2:5.24 R1:1.17.3
10	Kronig-Penney model (Qualitative treatment)	CLO 5	T2:6.1 R1:2.3
11	Origin of energy bands	CLO 5	T2:6.3 R1:2.6.1
12	Types of electronic materials: metals, semiconductors, and insulators	CLO 5	T2:6.5 R1:2.6.2
13	Intrinsic semiconductors Carrier concentration	CLO 6	T2:7.3 R1:2.8
14	Intrinsic semiconductors Carrier concentration	CLO 6	T2:7.5,7.6 R1:2.9.2
15	Extrinsic semiconductors, Carrier concentration	CLO 6	T2:7.7 R1:2.10
16	Extrinsic semiconductors, Carrier concentration	CLO 6	T2:7.7 R2:2.10
17	Dependence of Fermi level on carrier-concentration and temperature	CLO 6	T2:7.11 R2:2.10.2
18	Carrier generation and recombination, Hall effect	CLO 6	T2:7.11 R2:2.32
19	Carrier generation and recombination, Carrier transport: diffusion and drift, Direct and indirect band gaps	CLO 7	T2:7.11 R2:2.10
20	p-n junction, V-I characteristics	CLO 7	T2:7.12 R2:2.10.3
21	Energy Band diagram, Biasing of a junction	CLO 8	T2:7.12 R2:2.10.3
22	Photo voltaic effect, Construction and working of LED	CLO 8	T2:7.13 R1:2.10.4
23	Photo detectors, PIN, Avalanche photodiode	CLO 8	T2:7.14 R1:2.10.6
24	Solar cell	CLO 8	T2:7.15 R1:2.10.7
25	Polarization, Permittivity, Dielectric constant	CLO 9	T1:7.15 R2:2.10.7

26	Internal field in solids, Clausius Mosotti equation	CLO 9	T1:7.15 R2:2.10.7
27	Ferro electricity	CLO 9	T1:7.15 R2:2.10.7
28	Piezoelectricity, Pyroelectricity	CLO 9	T1:7.15 R2:2.10.7
29	Magnetization, Permeability, Susceptibility	CLO 10	T1:16.9 R2:8.11.1
30	Classification of dia, para and ferro magnetic materials on the basis of magnetic moment	CLO 10	T1:16.9 R2:8.11.2
31	Domain theory of Ferro magnetism on the basis of hysteresis curve	CLO 10	T1:16.8 R2:8.12.1
32	Introduction and Characteristics of lasers	CLO 11	T1:15.2 R4:8.2
33	Spontaneous and stimulated emission of radiation	CLO 11	T2:15.7 R4:8.3.3
34	Metastable state, Population inversion, Lasing action	CLO 11	T2:15.13 R4:8.7.2
35	Ruby laser	CLO 12	T2:15.13 R4:8.7.2
39	He-Ne laser and applications of lasers	CLO 12	T2:15.16 R1:8.7.3
40	Introduction and Principle and construction of an optical fiber	CLO 13	T1:11.9 R2:12.24
41	Acceptance angle, Numerical aperture	CLO 13	T1:11.9 R3:12.25
42	Types of optical fibers (Single mode, multimode, step index, graded index)	CLO 13	T1:3.2 R3:3.2
43	Attenuation in optical fibers	CLO 13	T1:3.3.1 R3:3.2
44	Optical fiber communication system with block diagram.	CLO 14	T2:16.5 R3:8.10
45	Applications of Optical fiber communication system	CLO 14	T2:16.5 R3:8.10

XVII. GAPS IN THE SYLLABUS - TO MEET INDUSTRY / PROFESSION REQUIREMENTS:

S No	DESCRIPTION	PROPOSED ACTIONS	RELEVANCE WITH POs	RELEVANCE WITH PSOs
1	Encourage the students to design the working models which are correlated with the syllabus.	Seminars / Laboratory Practices	PO 2	PSO 1
2	Insist the students to collect real-time applications of the basic principlesthey learn in physics.	Seminars / NPTEL	PO 1	PSO 1
3	Motivate the students to organize theseminars for the awarenessof upcoming applications in physics.	Seminars / NPTEL	PO 4	PSO 1

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