Birla Institute of Technology & Science – Pilani, K.K.Birla – Goa Campus,
IInd Semester 2019-20
Handout for Course No.:- PHYF341
Course Title :- Solid State Physics

Instructor in Charge **:-E. S. Kannan (ESK); (eskannan@goa.bits-pilani.ac.in) ;Voip : 458**

Lecture Hrs. **:- Tuesday, Thursday, Saturday (11 am- 12 pm),**

All students are expected to be on time for lecture & tutorial session.

Tutorial Hrs **:- Friday (2 pm)**

Classroom **: C307**

Course Description **:-** This course is intended for students pursuing Masters in Physics. The course aims to provide a strong foundation for understanding the physical properties of solids. The course begins with a study of atomic arrangements and structures of various crystalline solids. Electron and lattice dynamics inside the crystal will be covered in detail. A thorough illustration of physics behind the thermal, electrical and magnetic properties of solids will discussed in detail .

Text Book **:-** *Introduction to Solid State Physics* by Charles Kittel. (Eighth Edition) Wiley India

Reference Book **:-***Solid State Physics,* by *N.W Aschroft and N.D Mermin* Thomson (1976).

:- *Structure and Properties of Materials by* M. A. Wahab, 2nd Edition, Narosa (2005).

Notices **:-** Please visit LMS on every Saturday to see latest announcements.

Make-Up Policy **:-** Only for hospitalized cases with proper medical certificate. No makeup for missed Quizzes for any reason. NC will be awarded to a student who misses 30% of evaluation components. NC will also be awarded to those scoring 0 or absent in comprehensive examination regardless of his performance in other evaluation components.

Consultation Hours **:-** Monday, Wednesday and Friday (6.30 pm to 7.30 pm)

Grading **:-** Mid-semester Grading will be displayed after mid semester results. Final grading will be displayed only by the Instruction Division. Students are expected to check the marks recorded and report any discrepancies in recording, and get the records corrected as soon as possible. They must retain all corrected answer books as proof if they want to correct discrepancies. Claims made without showing adequate proof (Un-tampered corrected answer books) will **not** be considered.

Attendance **:-** Students are expected to attend 100 % of all classes and tutorials.

Quizzes **:-** Marks for all **the** Quizzes will be taken for final grading. No make-ups for quizzes for any reason.

Lecture Plan:-

Lecture Nos.	Topic to be covered in Lecture	Lecture Title	Ref.
1	Course Objective and Motivation; Learning Outcomes; Lecture Plan; Evaluation Scheme Importance of crystal structure, Lattice types, characteristics of cubic lattices	Course Introduction and basics of crystal structure	Chapter 1: Charles Kittel
2	Lattice types, Index system for crystal planes, Different types of simple crystal structures	Crystal Lattices and Planes	Chapter 1: Charles Kittel
3	Wave diffraction inside crystals and Bragg Law.	Bragg's Law	Chapter 2: Charles Kittel
4	Concept of Reciprocal lattice, Diffraction condition and Laue equations.	Reciprocal Lattice	Chapter 2: Charles Kittel
5	Brillouin Zones and its practical implications, Structure factor and atomic form factor.	Brillouin zones	Chapter 2: Charles Kittel
6-8	Crystal vibration and concept of phonon. Vibration in crystal with monoatomic and diatomic basis, Group velocity. Quantization of elastic waves, Phonon Momentum and inelastic scattering by Phonons.	Crystal vibration	Chapter 4: Charles Kittel
9	Phonon heat capacity and Plank Distribution	Thermal properties	Chapter 5: Charles Kittel
10	Density of states for different dimensions.	Thermal properties	Chapter 5: Charles Kittel
11	Thermal conductivity, Umklapp processes and thermal expansion.	Thermal properties	Chapter 5: Charles Kittel
12	Fermi Dirac distribution, free electron gas in 3 dimensions	Free electron and Fermi gas	Chapter 6: Charles Kittel
13	Heat Capacity of electron gas and concept of heavy fermions.	Free electron and Fermi gas	Chapter 6: Charles Kittel
14	Electrical conductivity, Ohms Law, Effect of magnetic field, Hall effect	Free electron and Fermi gas	Chapter 6: Charles Kittel
15	Thermal conductivity of metals	Free electron and Fermi gas	Chapter 6: Charles Kittel

16	Formation of energy bands, Periodic potential and wave equation in periodic potential.	Energy Bands	Chapter 7: Charles Kittel
17	Origin of band gap and Kronig Penney Model	Energy Bands	Chapter 7: Charles Kittel
18	Concept of metals, semiconductors and Insulators	Energy Bands	Chapter 7: Charles Kittel
19	Band gap in semiconductors, concept of holes, effective mass of electrons and holes and its physical interpretation.	Semiconductors	Chapter 8: Charles Kittel
20	Band gap in semiconductors, concept of holes, effective mass of electrons and holes and its physical interpretation.	Semiconductors	Chapter 8: Charles Kittel
21	Effective masses in semiconductors, effect of impurities on conduction in semiconductors	Semiconductors	Chapter 8: Charles Kittel
22	Thermoelectric effects-semimetals	Semiconductors	Chapter 8: Charles Kittel
23	Magnetism-origin of magnetism-Quantum theory	Magnetism	Chapter 11: Charles Kittel
24	Magnetic Susceptibility, Ferro and anti ferromagntism	Ferromagnetism and anti ferromagnetism	Chapter 12: Charles Kittel
25	Magnons, Curie temperature, order in ferro and antiferromagnetism	Ferromagnetism and anti ferromagnetism	Chapter 12: Charles Kittel

Evaluation Scheme:-

Evaluation Component	Evaluation type	Date & Time	Wtg %	Remarks
Attendance in Lectures and Tutorial classes	Attendance will be taken before the commencement of tutorial and lectures	All Lecture and Tutorial days	5%	Marks will be awarded based on the percentage of class attended.
Quiz	Objective and descriptive	Will be announced in class	15%	Closed or Open Book
Class room activity	Group or individual activity during the tutorial session	Will be in the class.	10%	Text book can be used as reference

Mid semester Exam	1. Written test; 2.Descriptive and quantitative type questions 3. Time Duration = 90 mts	6th March (Friday) 9 am to 10.30 am	25%	Closed Book
Student Project	Experimental or Theoretical Presentation.	April 2nd Week	5%	Details will be announced in the class
Compre	1. Written test; 2. Descriptive and quantitative type questions 3. Time Duration = 180 mts	12th May (Tuesday) 9 am – 12 pm	40%	Open Book

Student Project Details:-

1. Student projects are meant to illustrate the concepts in Solid State Physics that is covered as a part of this course. It carries a weightage of 5%.
2. Students can undertake this project as a group. Lab access to students will be provided based on written request.
3. A maximum of only 2 students are permitted to be in the group.
4. Enrollment of student groups will commence from 20th January until 31st of January.
5. No groups will be enrolled beyond 31st January.
6. Students are entitled to take up any topic for their project provided it falls within the scope of this course. Some suggestions are given below.

Suggestions (Not limited to the topics presented below):

Suggestions 1: Growing Nanomaterials using chemical route and report their optical and electrical properties -Experimental
Suggestion 2: Growing nanomaterials using hydrothermal method and report their optical and electrical properties – Experimental
Suggestion 3: Structural and electrical properties of any 4 crystalline materials - Experimental
Suggestion 4: Transmission electron microscopy and X-ray diffraction studies of four different materials - Theoretical
Suggestion 5: Organic Semiconductors - Theoretical
Suggestion 6: Superconductors and the possibility of room temperature superconductivity – Theoretical
Suggestion 7: 2D Materials Graphene, MoS_2, $MoSe_2$ Structural and electrical properties – Theoretical.
Suggestion 8: High Temperature Superconductivity