PHE-13

ASSIGNMENT BOOKLET
Bachelor's Degree Programme

PHYSICS OF SOLIDS

Valid from January 1, 2026 to December 31, 2026

It is compulsory to submit the Assignment before filling in the Term-End Examination Form.

Please Note

- You can take electives (56 to 64 credits) from a minimum of TWO and a maximum of FOUR science disciplines, viz. Physics, Chemistry, Life Sciences and Mathematics.
- You can opt for elective courses worth a MINIMUM OF 8 CREDITS and a MAXIMUM OF 48 CREDITS from any of these four disciplines.
- At least 25% of the total credits that you register for in the elective courses from Life Sciences, Chemistry and Physics disciplines must be from the laboratory courses. For example, if you opt for a total of 64 credits of electives in these 3 disciplines, at least 16 credits should be from lab courses.
- You cannot appear in the Term-End Examination of any course without registering for the course. Otherwise, your result will not be declared and the onus will be on you.

School of Sciences
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2026

Dear Student,

We hope you are familiar with the system of evaluation to be followed for the Bachelor's Degree Programme. At this stage you may probably like to re-read the section on assignments for Elective Courses in the Programme Guide that we sent you after your enrolment. A weightage of 30 per cent, as you are aware, has been earmarked for continuous evaluation which would consist of **one tutor-marked assignment (TMA)** for this course.

Instructions for Formatting Your Assignments

Before attempting the assignment please read the following instructions carefully.

1) On top of the first page of your TMA answer sheet, please write the details exactly in the following format:

ENROLMENT NO. : ……

NAME : ……

ADDRESS : ……

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COURSE CODE : ……..

COURSE TITLE : ……..…….

ASSIGNMENT NO. : ……..…

STUDY CENTRE : ……..……. DATE : …..……...……

PLEASE FOLLOW THE ABOVE FORMAT STRICTLY TO FACILITATE EVALUATION AND TO AVOID DELAY.

2) Use only foolscap size writing paper (but not of very thin variety) for writing your answers.

3) Leave 4 cm margin on the left, top and bottom of your answer sheet.

4) Your answers should be precise and in your own words. Do not copy answers from study material.

5) While solving problems, clearly indicate the question number along with the part being solved. Write units at each step of your calculations as done in the text because marks will be deducted for such mistakes. Take care of significant digits in your work. Recheck your work before submitting it.

6) **This assignment will remain valid from January 1, 2026 to December 31, 2026**. However, you are advised to submit it within **12 weeks** of receiving this booklet to accomplish its purpose as a teaching-tool.

Answer sheets received after the due date shall not be accepted. **We strongly feel that you should retain a copy of your assignment response to avoid any unforeseen situation and append, if possible, a photocopy of this booklet with your response.** If you have any problems or queries related to the course, you can write to us on the e-mail **slamba@ignou.ac.in**.

We wish you good luck.

Tutor Marked Assignment
PHE-13: Physics of Solids

Course Code: PHE-13
Assignment Code: PHE-13/TMA/2026
Max. Marks: 100

Note: Attempt all questions. Symbols have their usual meanings. The marks for each question are indicated against it.

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1. Answer in brief: (2×10 = 20)

   i. List the symmetries of the C_6H_6 molecule.

   ii. Draw the first Brillouin zone for a 2D oblique reciprocal lattice.

   iii. What are the advantages of the neutron diffraction method?

   iv. Write down the electronic configuration of the Si atom. What type of bonding would you expect to find in Si?

   v. The electronic and lattice heat capacities for copper at 0.01 K are $5.04\times10^{-6}\ \mathrm{J/(kmole-K)}$ and $4.60\times10^{-11}\ \mathrm{J/(kmole-K)}$ respectively. What do you conclude from these magnitudes?

   vi. Is the following statement true for vibrations of a chain of two different types of atoms: "At the centre of the Brillouin zone, the frequency of the optical branch is less than the frequency of the acoustic branch"? Explain.

   vii. The Fermi energy for silver is 5.48 eV. Which of the following is true : (a) the density of energy states is greater at 2 eV (b) the density of energy states is greater at 6 eV or (c) the density of energy states is same near both energies ?

   viii. What is the probability that a donor atom at energy E_D is ionized ?

   ix. In which of the following ions do you expect angular momentum quenching and why:

   $$Ti^{3+},\ Gd^{3+},\ Ni^{2+}$$

   x. What is the function of the quartz crystal used in a digital watch?

2. a) A plane intercepts the *x*-axis at 3a, the *y*-axis at 2b and the *z*-axis at 4c. Determine the Miller indices of this plane.

   b) Sodium metal crystallizes in the *bcc* structure. The metal has atomic weight 23 and density $971\ \mathrm{kg\,m^{-3}}$. Calculate the cubic lattice parameter *a* and the shortest distance between atoms in this structure.

   c) The Bragg angle for reflection from the (110) planes in *bcc* iron is 22º for an *x*-ray of wavelength 1.54 Å. Find the cube edge for iron (take n = 1). What is the minimum wavelength with which the structure of this unit cell can be probed ?

   d) Show that the reciprocal lattice for an *fcc* lattice is a *bcc* lattice. If the lattice constant of the unit cell of the *fcc* lattice is *a*, determine the lattice constant for the unit cell of the reciprocal *bcc* lattice? (5×4 = 20)

3. a) The potential energy of the Neon crystal is described by the expression:

$$U(r) = -4\varepsilon\left[\left(\frac{\rho_0}{r}\right)^6 - \left(\frac{\rho_0}{r}\right)^{12}\right]$$

where $\varepsilon = 3.12\times10^{-3}\,\text{eV}$ and $\rho_0 = 2.82\,\text{Å}$. Calculate the lattice parameter of the Neon crystal (*fcc* structure).

b) The frequency of the longitudinal optical phonon for NaCl at the centre of the first Brillouin zone is $5\,\text{rad}\,\text{s}^{-1}$. Calculate the interatomic force constant for this material. (The atomic weight of $\text{Na} = 23$ and $\text{Cl} = 37$)

c) Calculate the Debye specific heat of copper at 300 K, given that its Debye frequency is $4.11\times10^{13}\,\text{rad}\,\text{s}^{-1}$.

d) The values of the elastic stiffness constants for GaAs are:

$$C_{11} = 1.18\times10^{11}\,\text{Nm}^{-2},\ C_{44} = 0.59\times10^{11}\,\text{Nm}^{-2} \text{ and } C_{12} = 0.54\times10^{11}\,\text{Nm}^{-2}$$

Given that the density of GaAs is $5.32\,\text{g}\,\text{cm}^{-3}$, determine the bulk modulus of elasticity and the velocity of the transverse and longitudinal elastic waves in the [100] direction. (5×4 = 20)

4. a) Consider a superconductor with an energy gap of $1.7\times10^{-4}\,\text{eV}$. Find the maximum wavelength of electromagnetic radiation which will be absorbed by this superconductor.

b) In a *p-n* junction in *Si*, $N_d = N_a = 10^{22}\,\text{m}^{-3}$. Calculate the built in potential for *Si* at 300 K if n_i for *Si* at $300\,\text{K} = 10^{16}\,\text{m}^{-3}$.

c) A monovalent metal has a *bcc* structure and its lattice parameter is 1.5 Å. Calculate its Fermi energy.

d) A metal has an *fcc* structure, a lattice parameter a = 0.4 nm, and a valence Z = 1. Calculate its Hall coefficient. (5×4 = 20)

5. a) The saturation magnetization of *fcc* Ni is $5.1\times10^5\,\text{A/m}$. If the lattice constant for Ni is 3.52 Å, calculate the net magnetic moment per Ni atom in the crystal in units of Bohr magnetons.

b) What are fusible alloys? Explain their use in safety sprinklers.

c) Explain addition and condensation polymerization with an example of each.

d) Explain, with a diagram, the operation of a photovoltaic solar cell. (5×4 = 20)

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