**ShriMataVaishnoDeviUniversity**
श्री माता वैष्णो देवी विश्वविद्यालय
Kakryal, Katra-182320 (J&K),India
**School of Physics**

# Minutes of the 11th Meeting of Board of Studies of SoP

**Date: 07/03/2024**
**Time: 11:30 a.m. onwards**
**Venue: Conference Hall, SoP**

# ShriMataVaishnoDeviUniversity

# श्री माता वैष्णो देवी विश्वविद्यालय

Kakryal, Katra-182320 (J&K),India

# School of Physics

## Detailed Agenda

The chair welcome all the members of BoS and thanked them, particularly Prof. D. K. Pandya for his continued guidance and involvement in shaping the various programmes being offered by the school. He further informed that due to some prior commitments Prof. Geeta Bhatt, University of Delhi could not attend the meeting. The chair also expressed great sense of appreciation on behalf of school of Physics to all the external participants in the two days Curriculum Development Workshop for their valuable contributions in evolving the FYUG programme in Physics. He also thanked Head, Department of Physics IIT Jammu for agreeing to host students for internship and project work after working out the modalities at institutional level on both sides.

**Agenda Item No. 11.1:**

**To confirm the minutes of the 10th Meeting of BoS, SoP held on 31st July, 2023.**

**Resolution:**

BoS confirmed the minutes of the 10th Meeting of BoS of SoP held in 31st July, 2023 were circulated vide Ref. No. SMVDU/SoP/23/309 dated: 02-08-2023 as appended as **Annexure-I**.

**Agenda Item No. 11.2:**

**To consider and approve the detailed course contents of the courses for the semesters IX & X applicable for the Integrated B.Sc. (Hons.) – M.Sc. Physics and M.Sc. Physics (Lateral Entry) batches admitted in 2020-21 & 2021-22.**

**Resolution:**

The course structure for the final four semesters for the 2020-21 and 2021-22 batches was presented before the members and after discussion on the same BoS approved the detailed course contents for the courses being offered in IX and X semesters for the Postgraduate level (Second year) of the Integrated B.Sc.(Hons.) - M.Sc. Physics programme for batches admitted in AY 2020-21 & AY 2021-22 annexed as **Annexure-II.**

**Agenda Item No. 11.3:**

**To consider and ratify the Modified Course Structure and course contents as per NEP-2020 & NCrF for Five Year Integrated B.Sc./ M.Sc. Programme in Physics 2022-23 and 2023-24 batch 3rd to 6th Semester applicable for batch admitted in AY 2022-23 and 2023-2024.**

**Resolution:**

# School of Physics

The Course Structure and course contents as per NEP-2020 & NCrF for Five Year Integrated B.Sc.-M.Sc. (Physics) programme 2022-23 and B.Sc./ M.Sc. Physics Programme batch 2022-23 and 2023-24 for semesters 3rd to 6th was placed before the board and after deliberations the same was approved and is Annexed as **Annexure-III.**

**Agenda Item No. 11.4:**

**To consider and approve the course structure and detailed course contents of the courses for the semester I to VIII Semesters applicable for the Four Year Undergraduate Programme (FYUP) in Physics for batch to admitted in AY 2024-25 and onwards as per NEP 2020.**

**Resolution:**

The course structure for 4 years and detailed contents upto 6th Semester for Four year Undergraduate Program (FYUP) to be offered from AY 2024-25 as per NEP 2020 guidelines was prepared after thorough deliberations during the two day "Workshop on Curriculum Development for FYUP" which was attended by a galaxy of exerts from IIT Delhi, IIT Jammu, University of Jammu, University of Kashmir, MD of Electricfield Pvt. Ltd. Jammu besides heads of various schools of SMVDU, Associate Dean Academic Affairs (non-engineering programmes) SMVDU and all the faculty members of SoP. After threadbare deliberations the Structure (All semesters) and contents (upto 6th Semester) were approved and same is annexed as **Annexure – IV**. This shall be applicable to the batch of students to be admitted in AY 2024-25 and onwards for Four Year Undergraduate Programme (FYUP) in Physics under NEP 2020. Considering the overall scheme expanding the canvas of courses to various engineering schools besides internship and skill oriented courses, the Board unanimously recommended naming of the degree programme as BS in Applied Physics. The Board also congratulated the school for being able to rope in an industrial partner, "M/s Electricfield Pvt. Ltd. Jammu", for this programme and expected that this will benefit students in terms of internships and skill upgradation opportunities.

**Agenda Item No. 11.5:**

**To report the organization of various activities since the 10th BoS Meeting.**

**Resolution:**

The Board noted the reported position and appreciated the efforts put in by various faculty and staff members in having organized variety of programmes including external funding component and encouraged the faculty members to continue with the same zeal and enthusiasm.

# ShriMataVaishnoDeviUniversity

# श्री माता वैष्णो देवी विश्वविद्यालय

Kakryal, Katra-182320 (J&K),India

# School of Physics

The School of Physics, SMVD University organized the following activities since the 10th BoS meeting:

1. Curriculum Review Workshop was held on 5th and 6th Match, 2024 to finalize the structure and contents of FYUG Programme in Physics. The workshop was attended by experts from IIT Delhi, IIT Jammu, University of Jammu, University of Kashmir, MD of Electricfield Pvt. Ltd. Jammu besides heads of various schools of SMVDU, Associate Dean Academic Affairs (non-engineering programmes) SMVDU and all the faculty members of SoP.

2. Stage Show on "Innovative and Fascinating Experiments in Science" to be conducted by Prof. Bhagwan Dattatraya Chakradeo and his team on 09/09/2023, Matrika Auditorium organized by School of Physics in association with Indian Association of Physics Teachers (IAPT-RC-02).

3. SERB Sponsored 6th expert committee meeting for the evaluation of proposals under NPDF (Physical and Mathematical Sciences) during 22-24, November, 2023.

4. Five days training programme on "Materials Characterization Techniques" during 4-8 December, 2023 through virtual mode jointly with NITTR, Chandigarh.

5. Two days workshop on "Arduino for Physics Experiments" during 18-19 January, 2024 through hybrid mode Jointly with IIT Bombay.

6. The Faculty of Sciences and IIC, SMVD University in collaboration with Jammu And Kashmir Energy Development Agency (JAKEDA) organized the National Science Day on the theme "Solar Energy for Sustainable Future and Viksit Bharat" on 29th February, 2024.

**<u>Agenda Item No. 11.6</u>:**

Any other agenda item(s) with the permission of the Chair.

No Items were raised.

| | | |
|---|---|---|
| Dr.Yugal Khajuria<br>Assoc. Professor<br>Member | Dr. Jitendra Sharma<br>Asstt. Professor<br>Member | Dr. Kamni<br>Asstt. Professor<br>Member |

# Shri Mata Vaishno Devi University

श्री माता वैष्णो देवी विश्वविद्यालय

Kakryal, Katra-182320 (J&K),India


## School of Physics

7/3/24

Dr. Ram Prakash
Asstt. Professor
Member

Dr. Pankaj Biswas
Asstt. Professor
Member

7/3/24

Dr. Deepa Singh
Asstt. Professor (on contract)
Member

Dr. Mudasir A. Mir
Asst. Professor (on contract)
Member

Prof. Ashok K. Sharma
Professor (on contract)
Member

07/03/2024

Dr. S. K. Wanchoo
Assoc. Professor & Head, SoP
Chairman

7/3/2024

Prof. D.K. Pandya
Former Professor of Physics, IIT Delhi
Member Expert (External)

Submitted for your kind consideration and necessary action for approval of the same in the forthcoming Academic Council meeting.

**Dr. Pankaj Biswas**
**Member Secretary BoS, SoP**

**Head, SoP:**

07/03/2024

Ref.No: SMVDU/SoP/24/138
Dated: 07/03/2024

**To**

All members for the information.

**Copy to:**

1. Dean (AA) for information.
2. Registrar, SMVDU for information & placing of the same before Academic Council.
3. AR, VC office for kind information of the Hon'ble Vice Chancellor.
4. Concerned file.

Minutes
~~Agenda~~ for 11th meeting of BoS of SoP

Annexure - I

Shri Mata Vaishno Devi University

श्री माता वैष्णो देवी विश्वविद्यालय

Kakryal, Katra-182320 (J&K),India

School of Physics

# Minutes of the 10th Meeting of Board of Studies of SoP

*held on*

# 31/07/2023

# (Hybrid Mode)



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Ref. no. SMVDU/SoP/23/309 Dated: 02-08-2023

# Shri Mata Vaishno Devi University

श्री माता वैष्णो देवी विश्वविद्यालय

Kakryal, Katra-182320 (J&K),India

## School of Physics

SMVDU/SoP/2023/ Dated:

### Minutes of the 10th meeting of Board of Studies (BoS) of School of Physics (SoP) held on 31/07/2023 at 12.00 noon in hybrid mode

The 10th meeting of board of Studies (BoS) of School of Physics (SoP), SMVDU was held on 31/07/2023 at 12:00 noon in hybrid mode (External members attended the meeting through online mode due to paucity of time and other commitments at their end). Agenda of this meeting (which was finalized after multiple rounds of consultations held internally with all the faculty members of the school), was circulated to all the worthy members of the board. Following members attended the meeting:

| S. No. | Name | Affiliation |
|---|---|---|
| 1. | Dr. S.K. Wanchoo | Associate Professor & Head, SoP<br>Chairman (Ex-Officio) |
| 2. | Prof. D.K. Pandya (online mode) | Visiting Professor, Adjunct Professor, Department of Physics, IIT Jammu (Former Professor of Physics, IIT Delhi), External Member Expert |
| 3. | Prof. Geeta Bhatt (online mode) | Director, NCWEB, University of Delhi, formerly Associate Professor, Department of Instrumentation, Bhaskaracharya College of Applied Science, University of Delhi. |
| 4. | Dr.Yugal Khajuria | Associate Professor, SoP |
| 5. | Dr. Kamni | Assistant Professor, SoP |
| 6. | Dr. Ram Prakash | Assistant Professor, SoP |
| 7. | Dr. Pankaj Biswas | Assistant Professor, SoP<br>Member Secretary, BoS of SoP |
| 8. | Dr. Deepa Singh | Assistant Professor, (contract) SoP |

*Dr. Jitendra Sharma and Dr. M. A. Mir being on leave could not attend the meeting and were granted leave of absence.*

At the outset, the Chairman BoS on behalf of School of Physics placed on record deep sense of appreciation and gratitude to Prof. D.K. Pandya, IIT Jammu and Prof. Saumitra Mukherjee, JNU, New Delhi for providing constant guidance to the school which has greatly helped the school in



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shaping its academic programmes, particularly the integrated program. He further stated that the fresh constitution of the BoS has recently been approved by the Competent Authority and has been notified vide No. SMVDU/AA/22/3048 dated: 30/12/2022 for a period of three years. He further informed the Board that recognizing the important contributions made by Prof. Pandya. University has once again nominated him for the BoS and he thanked him for accepting be to on the Board. Chairman then accorded warm welcome to Prof. Geeta Bhat from University of Delhi for accepting the invitation to be on BoS of the School and expressed confidence that her vast experience and presence will enrich the academic programs of the School.

Accordingly, based on the deliberations those were held during the meeting, the resolutions on individual agenda items are as follows:

**Agenda Item No. 10.1:**

**To confirm the minutes of the 9th Meeting of BoS, SoP held on 31st October, 2022.**

**Resolution:** The Board confirmed the minutes of its 9th meeting held on 31st October, 2022 which stand circulated vide No. SMVDU/SoP/22/352 dated 07/11/2022. **[Annexure-I]**

**Agenda Item No. 10.2:**

**To consider and approve the detailed course contents of the courses for the semesters VII & VIII applicable for the Integrated B.Sc. (Hons.) – M.Sc. Physics batches admitted in 2020-21 & 2021-22.**

**Resolution:** The Board resolved to approve the detailed course contents for the courses being offered in VII and VIII semesters for Integrated B.Sc. (Hons) Physics – M.Sc. Physics batches admitted in AY 2020-21 & 2021-22. This structure and contents shall also be applicable to students admitted during AY 2023-24 & AY 2024-25 directly to the first year of the two year M.Sc. Physics program. **[Annexure-II]**

**Agenda Item No. 10.3:**

**To consider and approve the minor changes in the course structure of the semester VI applicable for the Integrated B.Sc. (Hons.) – M.Sc. Physics batch admitted in 2021-22.**

**Resolution:** After due deliberations the Board approved the proposed credit reduction in the weight-age of the elective course as proposed in the agenda from 4 to 3 offered by other schools and increased credit weight-age for the Numerical Computation Lab from 0-0-4 = 2 to 0-0-6 = 3.


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**Agenda Item No. 10.4:**

**To consider and approve the course structure and detailed course contents of the courses for the semester III & IV applicable for the Integrated B.Sc. – M.Sc. Physics batch admitted in 2022-23 under NEP 2020.**

**Resolution:** The Board after detailed deliberations approved the course structure and detailed course contents for the courses proposed to be offered in semesters III and IV applicable to the batch of students admitted in 2022-23 to the Integrated B.Sc. - Physics-M.Sc. Physics under NEP 2020. However, it was resolved that there should be more weight-age for Lab work vis-à-vis theory course for course titled "Measurement and Analysis" (IV Semester) considering the nature of the course. Accordingly, it was resolved to revise the theory course credits to 2 and lab course credits to 2. **[Annexure-III]**

**Agenda Item No. 10.5:**

**To consider and approve the course structure and detailed course contents of the courses for the semester I to IV applicable for the Integrated B.Sc. – M.Sc. Physics batch to be admitted in AY 2023-24 under NEP 2020.**

**Resolution:** The Board resolved to approve the course structure and detailed contents only for the semesters I and II after due deliberations. This is only applicable to the batch of students to be admitted in AY 2023-24 to the Integrated B.Sc. - Physics-M.Sc. Physics programme under NEP 2020 and has been prepared on the outcome based model of education as per recent instructions received from academic affairs wing of the University. **[Annexure-IV]**

**Agenda Item No. 10.6:**

**To consider and approve proposed new Pre-Ph.D. courses.**

**Resolution:** The Board after detailed deliberations resolved to approve three courses proposed for the pre-Ph.D. course work. Prof. Pandya proposed that the course coordinator/ course instructors, particularly in case of course on characterization techniques, should give actual data based assignments to the students for better learning and to be able to do the basic analysis of data in a meaningful manner. This proposal was agreed to for implementation. Furthermore, based on the suggestion, it was agreed that for such multi-techniques based courses preferably more than one instructor may be assigned based on their expertise of specific technique(s), thus enabling the students a better understanding of the technique(s) and data analysis. **[Annexure-V]**

**Agenda Item No. 10.7:**

**To present stakeholder feedback on our curriculum as mandated by DIQA, SMVDU for the purpose of NAAC process.**



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**Resolution:** The Board appreciated the first ever exercise of this nature by the School based on the instructions received from DIQA, SMVDU vide no. SMVDU/DQA/2023/418-421 dated 06.06.2023 regarding the stakeholder feedback on curriculum development as per prescribed format received from their end. Board was informed that the School has obtained the feedback from students (current as well as alumni) and faculty and has carried out analysis thereof (**Annexure-VI**). Based on this exercise, minor changes wherever required have been incorporated in the agenda items of this meeting. Board resolved to approve the same for further submission to DIQA. Board further directed that this should be made into a regular annual exercise which is mainly based on feedback from passing out batches and important alumni.

**Agenda Item No. 10.8:**

**To report changes in credits and/ or L-T-P of courses offered by other schools.**

**Resolution:** Board was informed that some Schools such as School of Mathematics had made changes in L-T-P scheme of courses offered to the students of Integrated B.Sc. (Hons.) - M.Sc. Physics 2020 batch. This was done by merging and Lab and theory courses into a single course without altering the overall credits. Similarly, in the VI semester under open elective category students had to opt for a 3 credit course in lieu of 4 credits. This was due to the reason that all other schools were offering this course with 3 credits only. Similarly, in their III semester they were to opt for an open elective of 4 credits, however, the only option available at that time was of a course offered by School of Economics having 6 credits. While effecting these changes, it has been ensured that students do not fall short on total credits required for award for Degree. The board noted this information and resolved to ratify the same.

**Agenda Item No. 10.9:**

**To report about the procurement of items for various Labs.**

**Resolution:** BoS, SoP was pleased to note that the School has utilized the allocated budget as far as possible for FY 2022-23 and has acquired most of the items as had been approved by BoS at its 7th meeting.

**Agenda Item No. 10.10:**

**To report the organization of a half day event "Science is Fun" jointly with IAPT. The event had been sponsored by IAPT-RC-02.**

**Resolution:** BoS, SoP appreciated the organization of this activity jointly with the Indian Association of Physics Teachers (IAPT-RC-02), to reveal the joy of learning through hands-on-science held on 27.01.2023 being attended by over 200 participants from the University.



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**Agenda Item No. 10.11:**

**To report the qualification in the prelim round of NEAST-2023 by Akshita, B.Sc. (Hons.) Physics Sem-IV student.**

**Resolution:** BoS, SoP was happy and expressed satisfaction over the achievement of Ms. Akshita of B.Sc. (Hons.) Physics Sem-IV who qualified the prelim round of NAEST 2023 conducted as part of the annual National Anveshika Experimental Skills Test (NAEST-2023) under the able guidance and coordination of Prof. H.C. Verma (Padma Shri) former professor of Physics at IIT, Kanpur. Prof. Pandya, suggested that she should share her experiences with other students of the School so as to motivate them to take part in such events in future.

**Agenda Item No. 10.12:**

**To report the successful defence of Ph.D. thesis by research students of the school since 31st, October, 2022:**

**Resolution:** BoS, SoP expressed satisfaction and noted that two students, namely, Ms. Parul Sharma (18DPH002) under the supervision of Dr. Kamni and Ms. Pooja Khajuria, (18DPH001) under the supervision of Dr. Ram Prakash, have qualified for award of Ph.D. Degree since the 9th meeting of BoS.

**Agenda Item No. 10.13:**

**To report the selection of two students of Integrated B.Sc. (Hons.) – M.Sc. Physics VI Semester students in Summer Research Fellowship Programme-2023 (SRFP-2023) offered by Joint Science Education Panel of three Science Academies of India.**

**Resolution:** BoS, SoP was delighted to note that the school has been encouraging its students to apply and participate in National level events and activities. The Board unanimously resolved to congratulate Ms. Ritika Baigra, 20IBY029 (for securing SRF at Indian Institute of Science, Banglore) and Mr. Piyush Bhardwaj, 20IBY028 (for securing SRF at Institute of Physics, Bhubaneswar) under the programme operated by Joint Science Education Pannel of the three premier Science Academies of India.

**Agenda Item No. 10.14:**

**Resignation of Dr. V. K. Singh from the services of the University.**

**Resolution:** BoS noted the information regarding tendering of his resignation from the services at this University. The Board resolved to appreciate the services rendered by Dr. Vivek K. Singh at this University.

**Agenda Item No. 10.15:**

Any other agenda item (s) with the permission of the chair.

**Agenda item no. 10.15.1**

**To consider and approve creation of supernumerary seats in Integrated B.Sc. Physics – M.Sc. Physics programme w.e.f. 2023-24.**

**Resolution:** University has implemented reservation policy as applicable in the UT of J&K w.e.f AY 2023-24 and accordingly has asked all the schools to propose supernumerary seats to compensate for the vacancies, if any, against the reserved category seats so as put the available infrastructure to full use. Their seats shall be available under UR category only and shall (being supernumerary in nature) not affect the number of seats under any other category. After due deliberations, the Board approved the proposal and decided that the number of supernumerary seats shall be floating in nature year on year and shall be equal to the no of vacancies arising out of the less response under reserved category seats without affecting the quota allocated to any particular category. Board suggested that these supernumerary seats should be filled from amongst the remaining applicants who could not be offered admission due to non-availability of vacant seats in their parent category. It was further suggested that University may evolve a uniform SoP for all the programs for the purpose.

**Agenda item no. 10.15.2**

**To report and ratify the budget estimates as submitted to the finance wing of the University for the FY 2023-24.**

**Resolution:** The Board was informed that the School was asked to submit the budget estimate for the FY 2023-24 by the Finance section of the University. Accordingly, after due deliberations among the faculty members of the school the same was prepared and submitted for the approval of the Competent Authority. The main focus of this year's proposal is to repair the faulty equipments and experimental setups as far as possible. Board noted the reported positions and decided to ratify the same.

The decisions taken by the BoS of SoP as listed hereinabove were finally recommended for discussion and approval in the next scheduled Academic Council meeting of the University.

# Shri Mata Vaishno Devi University

श्री माता वैष्णो देवी विश्वविद्यालय

Kakryal, Katra-182320 (J&K),India

## School of Physics

Dr. Yugal Khajuria
Assoc. Professor
Member

(on leave)
Dr. Jitendra Sharma
Asstt. Professor
Member

Dr. Kamni
Asstt. Professor
Member

2/8/2023
Dr. Ram Prakash
Asstt.Professor
Member

Dr. Pankaj Biswas
Asstt. Professor
Member

Dr. Deepa Singh
Asstt. Professor (Contract)

02/08/2023
Dr. S. K. Wanchoo
Assoc. Professor & Head, SoP
Chairman

(Minutes have been confirmed via email copy of the same is enclosed)

Prof. Geeta Bhatt
Director, NCWEB,
University of Delhi
Member Expert (External)

Prof. D.K. Pandaya
Adjunct Professor, IIT Jammu
Member Expert (External)

Submitted for your kind consideration and necessary action for approval of the same in the forthcoming Academic Council meeting.

02/08/23
**Dr. Pankaj Biswas**
**Member Secretary BoS, SoP**

**Head, SoP:**

**To**

All members for the information.

**Copy to:**

1. Dean (AA) for information.
2. Registrar, SMVDU for information & placing of the same b efore Academic Council.
3. PS to VC for kind information of the Hon'ble Vice Chancellor.
4. Concerned file.



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# Annexure-II
# School of Physics

**Detailed course contents for IX & X semesters applicable for the Integrated B.Sc. (Hons.) – M.Sc. Physics admitted in 2020-21 & 2021-22 and M.Sc. Physics (Lateral Entry) batches admitted in 2023-24 and 24-25 batches**
**(Course structure given below is already approved in 7th BoS of SoP held on 05.10.2020)**

**Course codes are tentative and subject to correction by the Examination Wing**

| Course Code | Semester - IX | L-T-P (Credits) |
|---|---|---|
| PHL 7101 | Condensed Matter Physics | 4-0-0 (4) |
| PHL 7071 | Atomic and Molecular Physics | 4-0-0 (4) |
| PHL 7XXX | DSE-V | 4-0-0 (4) |
| *XXX XXXX | Open Elective-III (Management/ Humanities/ Engineering/ Philosophy) | x-x-x (4) |
| PHD 7134 | Project – Part I | 0-0-16 (8) |
| | **Total Credits** | 22 |
| | **Semester - X** | |
| PHL 7091 | Nuclear and Particle Physics | 4-0-0 (4) |
| PHL 7022 | Thermodynamics and Statistical Physics | 4-0-0 (4) |
| PHL 7XXX | DSE-VI | 4-0-0 (4) |
| *XXX XXXX | Open Elective-III (Management/ Humanities/ Engineering/ Philosophy) | x-x-x (4) |
| PHD 7135 | Project – Part II | 0-0-16 (8) |
| | **Total Credits** | 22 |

*** Students can choose any course out of the elective courses floated by respective schools.**

# Semester-IX

## Condensed Matter Physics
## (PHL 7101) (4-0-0)

**Unit I:**
Bravais lattices, crystal systems, crystal planes and Miller indices, closed packed structures, symmetry elements in crystals, point groups and space groups, common crystal structures, reciprocal lattice, Ewald sphere, Brillouin zone, X-ray diffraction, Bragg's law, Diffraction and the structure factor. **[10]**

**Unit II:**
Response and relaxation phenomena. Drude model of electrical and thermal conductivity. Hall effect and thermoelectric power, Free electron gas (theory), density of states, and Fermi Energy, Electron motion in a periodic potential Bloch theorem, Kronnig –Penny model, band theory of solids: metals, insulators and semiconductors **[12]**

**Unit III:**
Bonding of solids. Elastic properties, Lattice waves, Vibrations of one–dimensional monatomic lattice, Linear diatomic lattice, Three-dimensional lattice, Lattice optical properties in ionic crystal, Quantization of Lattice vibrations, phonons, Lattice specific heat, electronic specific heat. **[10]**

**Unit 1V:**
Defects and dislocations – Point defects (Frenkel and Schottky), line defects (slip, plastic deformation, edge and screw dislocation, Ordered phases of matter: translational and orientational order, kinds of liquid crystalline order. Quasi crystals. **[8]**

**Unit V:**
Superconductivity: Phenomenology, review of basic properties, London's equation and Meissner effect, Type-I and Type-I superconductors, Josephson junctions, Superfluidity. **[5]**

**SUGGESTED BOOKS**

1. Introduction to Solid State Physics by C. Kittle
2. Introduction to Solids by Azaroff
3. Crystallography Applied to Solid State Physics by A.R. Verma and O.N. Srivastava
4. Principles of Condensed Mater Physics by P.M. Chaikin and .C. Lubensky.
5. Solid State physics: A.J. Dekker

## Atomic and Molecular Physics
## (PHL 7071) (4-0-0)

**Unit-I:**
Introduction to Spectroscopy and types of Spectra, Spectrum of Hydrogen Atom, Bohr Model for hydrogen atom, Bohr-Sommerfeld model of Hydrogen Atom, Sommerfeld's Relativistic Correctionfor energy levels of hydrogen atom, Fine Structure of Hydrogen Atom. **[8]**

**Unit-II:**
Magnetic Dipole Moments, Electron Spin and Vector Atom Model and Sterrn-Gerlach Experiment, , Zeeman Effect, Paschen-Back effect, Stark Effect, Spin-orbit interaction for two valance electron system (LS and JJ Coupling), Pauli's exclusion Principle, Singlet and Triplet States, Selection Rules, Hyperfine Structure of Spectral Lines and isotopic shift, Spectrum of helium and alkali atom **[12]**

**Unit-III:**
Breadth of Spectral Lines, Effect of Nuclear Properties on Spectral Lines, X-ray Spectra, Moseley's Law, Regular and Irregular Doublet Law, Photoelectron Spectra. **[5]**

**Unit-IV:**
Frank-Condon principle Born-Oppenheimer approximation Electronic, rotational, vibrational and Raman spectra of diatomic molecules, selection rules **[10]**

**Unit-V:**
Nuclear Magnetic Resonance (NMR), and Electron Spin Resonance (ESR). Lasers: spontaneous and stimulated emission, Einstein A & B coefficients. Optical pumping, population inversion, rate equation. Modes of resonators and coherence length. **[10]**

**SUGGESTED BOOKS**


1. H.E. White, Introduction to Atomic Spectra, 1934, McGraw-Hill Kogakusha Ltd., Tokyo
2. C.N. Banwell and E.M. McCash, Fundamentals of Molecular Spectroscopy, Third Edition 1972, McGraw-Hill book company, London
3. G. Aruldhas, Molecular Structure and Spectroscopy, Second Edition 2007, Prentice Hall Of India, New Delhi

# Semester-X

## Nuclear & Particle Physics
## (PHL 7091) (4-0-0)

**Unit-I**

Basic nuclear properties: size, shape and charge distribution, spin and parity. Binding energy, semi-empirical mass formula, liquid drop model.Nature of the nuclear force, form of nucleon-nucleon potential, charge-independence and charge-symmetry of nuclear forces. **[10]**

**Unit-II**

Deuteron problem: Simple theory of ground and excited states of deuteron, spin dependence of nuclear forces, nucleon-nucleon scattering, Evidence of shell structure, single-particle shell model, its validity and limitations, collective model, Rotational spectra. **[10]**

**Unit-III**

Elementary ideas of alpha, beta and gamma decays and their selection rules. Fission and fusion, Bohr-Wheeler theory of nuclear fission, Nuclear reactions, reaction mechanism, endothermic and exothermic reactions, Compound nucleus model, Resonance scattering: Breit-Wigner formula, optical model, direct reactions. **[10]**

**Unit-IV**

Sensitivity of detector, response of detector, energy resolution of detector, efficiency of detector, dead time detector, ionization chamber, proportional counter, Geiger-Muller counter, scintillation detector, Synchro-cyclotron, betatron, linear accelerator, nuclear chain reaction, general aspects of reactor design, classification of reactors. **[6]**

**Unit-V**

Classification of fundamental forces, Elementary particles and their quantum numbers (charge, spin, parity, isospin, strangeness, etc.). Fundamental interactions among particles Gellmann-Nishijima formula.Quark model, baryons and mesons.C, P, and T invariance.Application of symmetry arguments to particle reactions.Parity non-conservation in weak interaction.Relativistic kinematics. **[9]**

**SUGGESTED BOOKS**


1. Cohen, B.L., Concepts of Nuclear Physics, 2005, Tata McGraw-Hill, New Delhi
2. Griffiths, D., Introduction to Elementary Particles, 1987, John Wiley & SonsHeyde, K., Basic Ideas and Concepts in Nuclear Physics, 2005, Overseas Press, India
3. Kaplan, I., Nuclear Physics, 1998, Narosa Publishing House, New Delhi
4. Wong, S.S.M., Introductory Nuclear Physics, 2005, Prentice-Hall, India

## Thermodynamics and Statistical Physics
## (PHL 7022) (4-0-0)

**Unit-I:**

Laws of thermodynamics and their consequences. Thermodynamic potentials, Maxwell relations, chemical potential, phase equilibrium. The macroscopic and microscopic states – contact between statistics and thermodynamics – the classical ideal gas. **[12]**

**Unit-II:**

Phase space, density of distribution in phase space, ergodic hypothesis, Classical distribution law: micro- and macro-states. Micro-canonical, canonical and grand-canonical ensembles and partition functions. Free energy and its connection with thermodynamic quantities. Postulate of equal a priori probability. **[12]**

**Unit-III:**

Ideal Bose and Fermi gases. Energy and pressure of gas, Bose Einstein condensation, thermal properties of BE gas, liquid helium, London theory, Ideal Fermi Dirac gas, energy and pressure of gas, slight and strong degeneracy, thermodynamic function of FD gas. Principle of detailed balance. Blackbody radiation andderivation of Planck's distribution law. **[12]**

**Unit-IV:**

Classification of phase transitions, First- and second-order phase transitions. Critical exponents, Ising model, Bragg William Approximation, Diamagnetism, paramagnetism, and ferromagnetism. Fluctuations in thermodynamic quantities: energy, pressure, volume, enthalpy. **[12]**

**Unit-V:**

Diffusion equation. Random walk and Brownian motion, Fokker Planck equation, Wiener and Khintchine theorem, electrical noise. Introduction to non-equilibrium processes. Boltzmann transport equation-drift variation and collisions or scattering variations, chamber's equation. **[12]**

**SUGGESTED BOOKS**


1. Walter Greiner, Ludwig Neise, Horst Stocker "Thermodynamics and Statistical Mechanics" Springer
2. Kerson Huang "Introduction to Statistical Physics" Taylor and Francis, 2001
3. P K Pathria "Statistical Mechanics" 2nd Ed.
4. J K Battacharjee, Statistical Physics; Allied Publishers (India)
5. F Reif, Statistical and Thermal Physics, McGraw Hill
6. C Kittel, Thermal Physics, CBS Indian Ed.

# Discipline Specific Electives DSE-V & DSE-VI

## Introduction to Nanoscience and Nanotechnology (PHL 7193) (4-0-0)

**Unit-I**
**Introduction** **9**

Introduction to nanotechnology, Comparison of bulk and nanomaterials change in band gap - novel properties of nanomaterial, classification of nanostructured materials.

**Unit-II**
**Synthesis of nanomaterials** **8**

Classification and fabrication methods - Top down and bottom up methods.

**Unit-III**
**Concept of Quantum Confinement and Phonon Confinement** **12**

Basic concepts - excitons, effective mass, free electron theory and its features, band structure of solids.Bulk to nano transition - Density of states, quantum confinement effect - weak and strong confinement regime.Electron confinement in infinitely deep square well, confinement in two and three dimension.Blue shift of band gap, Effective mass approximation.Vibrational properties of Solids - Phonon Confinement effect and presence of surface modes.

**Unit 4**
**Tools for Characterization** **12**

Structural - X-ray Diffraction, Surface analysis-Transmission Electron Microscope, Scanning Tunneling Microscope, Atomic Force Microscope. Optical studies - UV - Visible absorption, Photoluminescence, Raman spectroscopy.

**Unit 5**
**Nanostructured Materials** **9**

Properties and Applications.Carbon nanotube - structure,electrical, vibration and mechanical properties.Applications of carbon nanotubes.Quantum dots and Magnetic nanomaterials – Applications.

**Reference Books:**


1. Robert W. Kelsall, Ian W. Hamley and Mark Geoghegan, Nanoscale Science and Technology, John Wiley and Sons Ltd 2004.
2. W.R. Fahrner (Ed.), Nanotechnology and Nanoelectronics, Springer 2006.
3. Charles P. Poole, Jr.Frank J. Owens, "Introduction to nanotechnology", AJohn Wiley 81 Sons, Inc., Publication

## Atomic and Molecular Structure (PHL 7076) (4-0-0)

**Unit-I**
**Hydrogen Atom and Helium Atom Spectrum** **[15]**

Lamb-shift in Hydrogen Spectrum, Rydberg Atoms and Rydberg States, Transition Probability, Helium Atom and Its Spectrum, Alkali Spectrum, Quantum Virial Theorem, Thomas-Fermi Method, Ionization Potential, Electron Affinity.

**Unit-II**
**Many-Electron Atoms** **[15]**

Interpretation of the Spectra of Two Electron Systems, Representation of States for Coupling Schemes, L-S and j-j coupling, Hunds rule, Selection Rules, Complex Spectra and Their Interpretation, Nitrogen, Oxygen and Manganese as examples, Alteration of Multiplicity, Inversion of States, The Atom in magnetic field, Zeeman and Paschen-Back Effect for Two Valance Electron System, Normal and anomalous Zeman Effect, Stark Effect.

**Unit-III**
**Magnetic Moment and Resonance Spectroscopy**: **[10]**

Electron Spin Resonance (ESR), Nuclear Magnetic Moment, Resonance Phenomenon, Magnetic Resonance, Quantum Mechanical Treatment of ESR, NMR Magnetic Structure, Fine Structure in ESR, g-value and Effect of Anisotropy, Chemical Shift and ENDOR.

**Unit-IV**
**Light Sources, Detectors and Spectroscopic Techniques:** **[10]**

Lasers, Grating Spectrographs and Spectrometers based on Czerny-Turner, Thermal Detector, Photodiode, Photomultiplier Tube, Charge Coupled Detector, Infrared and Raman Spectrometer, Saturation Spectroscopy.

**Reference Books:**


1. G. Aruldhas, Molecular Structure and Spectroscopy.
2. Laser Spectroscopy: W. Demtroder.
3. High Resolution Spectroscopy: J. M. Hollas.
4. Spectrophysics: A. Thorpe.
5. C.N. Banwell and E.M. McCash, Fundamentals of Molecular Spectroscopy.
6. V.K. Jain, Introduction to Atomic and Molecular Spectroscopy.
7. SuneSvanberg, Atomic and Molecular Spectroscopy.
8. H.E. White, Introduction to Atomic Spectra.
9. M. Karplus and R.N. Porter,Atoms and Molecules: An Introduction for Students of Physical Chemistry.
10. P.W. Atkins and R.S. Friedman, Molecular Quantum Mechanics.
11. L. Fetter and J. D. Walecka, Quantum Theory of Many-Particle Systems.
12. W.A. Harrison,Applied Quantum Mechanics.

## Microcontrollers and Embedded Systems
## (PHL 7058) (4-0-0)

**Unit-I** **8**

Introduction to Microcontrollers and Embedded Processors - Microcontrollers survey-four bit, eight bit, sixteen bit, thirty two bit Microcontrollers, Historical perspective, von Neumann versus Harvard Architecture and CISC versus RISC Processors, Comparing Microprocessors and Microcontrollers-Overview of the 8051 family.

**Unit-II** **8**

The 8051 Architecture- Hardware- Oscillator and clock-program counter –data pointer-registers-stack and stack pointer-special function registers- -memory organization-program memory-data memory -Input / Output Ports –External memory/ counter and timer-serial data Input / output-Interrupts.

**Unit-III** **10**

8051 Assembly Language Programming-Structure of Assembly language, Assembling and running an 8051 program- Addressing modes-Accessing memory using various addressing modes- Instruction set- Arithmetic operations and Programs-Logical operations and Programs -Jump and Call instructions and Programs -I/O Pot Programs - Single bit instructions and Programs –Timer and counter - and Programs.

**Unit IV** **9**

8051 Serial Communication -Connection to RS-232- Serial Communication Programming- Interrupts Programming, Microcontroller Interfacing -Key Board - Displays- Pulse Measurement - D / A and A/D conversion- Stepper Motor.

**Unit-V** **10**

PIC 16F8XX flash Microcontrollers-Overview and features, Pin diagram, STATUS register, OPTION register,FSR (File Selection Register), PIC reset actions. PIC Oscillator connections, PIC memory organization, PIC 16F8XX instructions, Addressing modes.

**Reference Books:**


1. The 8051 Microcontrollers and Embedded Systems, Muhammed Ali Mazidi, Pearson, 2018.
2. The 8051 Microcontrollers Architecture, Programming & Applications Kenneth J. Ayala
3. Microcontrollers: Theory and Applications, A. V. Deshmukh, TMH, 2019.


## Electronic Theory of Solids
## (PHL 7107) (4-0-0)

**Unit-I** **9**

Free electron theory of metals, Fermi-Dirac distribution, Free electrons, Density of levels in 1, 2 & 3 dimensions, Fermi momentum and Fermi energy, Connection between electron density and Fermi energy, Independent electron systems, degenerate Fermi gas, Electronic properties of solids: the two-atom solid, theory of electrons in an N-atom solid, linear combination of atomic orbitals – band formation.

**Unit-II** **8**

Elementary concepts of low dimensional electron gas, quantum dot, 1D and 2D electron gas introduced. 2D electrons in a magnetic field, integer quantum hall effect.Spin filtering and magnetoresistance.Spintronics and its applications.Novel electronic structures: graphene and carbon nanotubes.

**Unit-III**
**Magnetic properties of Solids** **10**

Magnetism and its origin, magnetization and susceptibility, dia-, para- and ferro-magnetism.Larmour diamagnetism.Hund's rule and paramagnetism, Curie's law.Magnetic interactions, two-electron system, spin-spin interactions – exchange interaction, direct, super and itinerant exchange.

**Unit-IV**
**Superconductivity-I** **9**
Phenomenology of Superconductors, Superconductivity in metals and alloys, New Superconductors, Zero Resistance,Meissner Effect, London equation and two- fluid model. Attractive interaction, Cooper problem – instability of the Fermi surface, pair formation and binding energy.

**Unit-V**
**Superconductivity-II** **9**

BCS theory, tunneling, SC gap and transition temperature. Sp. heat jump at $T_c$, coherence length and penetration depth: electrodynamics of superconductors, Type-I and II SC, vortices, Quantum interference, Josephson effect, SC junctions, squid and its application. Novel superconductors.

**Reference Books:**


1. Solid State Physics, N W Ashcroft and N D Mermin, Thomson Learning, 1976.
2. An Introduction to the Electron Theory of Solids, John Stringer, W. S. Owen, D. W. Hopkins and H. M. Finniston – Pergamon, 1967
3. Condensed Matter Physics, M. Marder, Wiley, 2010.
4. Advanced Solid State Physics, Ed. 2, Phillip Phillips.Cambridge University Press, 2012.
5. Band Theory and Electronic Properties of Solids, John Singleton, Oxford University Press, 2001


## Plasma Physics and Plasmonics (PHL 7191) (4-0-0)

**Unit I**
**Plasma Production and Diagnostics** **15**

Definition of plasma, basic properties and occurrence, criteria for plasma behavior, plasma oscillation, quasi-neutrality and Debye shielding, plasma parameter, astrophysical plasmas, plasma in magnetosphere and ionosphere, plasma production and diagnostics, thermal ionization, Saha equation, methods of plasma production, steady stage glow discharge, microwave breakdown and induction discharge, elementary ideas about plasma diagnostics.

**Unit II**
**Motion of Charged Particles and Time Varying Fields** **10**

Electrostatic and magnetic probes, charged particle motion and drifts, motion in (i) uniform electric and magnetic field (ii) gravitational and magnetic fields, motion in non-uniform magnetic field, grad B perpendicular and parallel to B, motion in non-uniform electric field for small larmour radius, time varying electric field and polarization drift, time varying magnetic field adiabatic invariance of magnetic moment.

**Unit III**

**Plasma Fluid Equations** **5**

Plasma fluid equations, convective, two fluid and single fluid equations, fluid drifts perpendicular to B, diamagnetic drift.

**Unit IV**

**Diffusion and Resistivity** **10**

Diffusion and resistivity, collision and diffusion parameters, decay of a plasma by diffusion, ambipolar diffusion, diffusion across magnetic field, collision in fully ionized plasma, plasma resistivity, diffusion in fully ionized plasmas, diffusion equation.

**Unit V**

**Equilibrium and Stability** **10**

Equilibrium and stability, hydromagnetic equilibrium, concept of magnetic pressure, equilibrium of a cylindrical pinch, the bennett pinch, diffusion of magnetic field into a plasma, classification instabilities, two stream instability, the gravitational instability, resistive drift waves.

**Reference Books:**


1. F.F. Chen : An Introduction to Plasma Physics (Plenum Press) 1977.
2. R.C. Davidson : Methods in Non-linear Plasma Theory (Academy Press) 1972.
3. W.B. Kunkel : Plasma Physics in Theory and Application (McGraw Hill)1966.
4. J.A. Bittencoms : Fundamentals of Plasma Physics (Pergamons Press) 1986.
5. Kallenrode, M.B., Space Physics: An introduction to plasmas and particles in the Heliosphereand Magnetosphers (Springer) 2004.
6. Fundamentals of plasma physics, J. A. Bittencourt, Springer-Verlag New York Inc., 2004
7. The Fourth state of matter- Introduction to plasma science, S. Eliezer and Y. Eliezer, IoPPublishing Ltd., 2001


## Electronic Communication (PHL 7059) (4-0-0)

**Unit-I** **14**

Introduction to Analog Communication: Elements of communication system - Transmitters, Transmission channels & receivers, Concept of modulation, its needs, Continuous Wave Linear Modulation: a) Amplitude modulation (AM-DSB/TC): Time domain representation of AM signal (expression derived using a single tone message), modulation index, frequency domain (spectral) representations, illustration of the carrier and side band components; transmission bandwidth for AM; Phasor diagram of an AM signal; Calculation of Transmitted power & sideband power & Efficiency; concept of under, over and critical modulation of AM-DSB-TC. b) Other Amplitude Modulations: Double side band suppressed carrier (DSBSC) modulation: time and frequency domain expressions, bandwidth and transmission power for DSB. Single side band modulation (SSB) both TC & SC and only the basic concept of VSB, Spectra and band-width.

**Unit-II** **12**

Generation & Detection of Amplitude Modulation: a) Generation of AM: Concept of i) Gated and ii) Square law modulators, Balanced Modulator. b) Generation of SSB: Filter method, Phase shift method and the Third method Demodulation for Linear Modulation: Demodulation of AM signals: Detection of AM by envelope detector, Synchronous detection for AM-SC, Effects of Frequency & Phase mismatch, Corrections. Principle of Super heterodyne receivers: Super heterodyning principle, intermediate frequency, Local oscillator frequency, image frequency.

**Unit–III** **12**

Angle Modulation: a) Frequency Modulation (FM) and Phase Modulation (PM): Time and Frequency domain representations, Spectral representation of FM and PM for a single tone message, Bessel's functions and Fourier series.; Phasor diagram; b) Generation of FM & PM: Narrow and Wide-band angle modulation, Basic block diagram representation of generation of FM & PM, Concept of VCO & Reactance modulator c) Demodulation of FM and PM: Concept of frequency discriminators, Phase Locked Loop

**Unit- IV** **12**

Multiplexing a) Frequency Division Multiplexing, Time Division Multiplexing, (FDM) b) Stereo – AM and FM: Basic concepts with block diagrams c) Random Signals and Noise in Communication System: i) Noise in Communication systems – Internal & External noise, Noise Temperature, Signal-to-Noise ratio, White noise, thermal noise, Figure of Merit. iii)Noise performance in Analog Communication systems: SNR calculation for DSB/TC, DSB-SC, SSB-TC, SSBSC & FM.

**Reference Books:**


1. Taub and Schilling , "Principles of Communication Systems", 2nd ed., Mc-Graw Hill
2. B.P.Lathi -Communication Systems- BS Publications
3. V Chandra Sekar – Analog Communication- Oxford University Press
4. Carlson—Communication System,4/e , Mc-Graw Hill
5. Proakis&Salehi Fundamentals of Communication Systems- Pearson
6. Singh &Sapre—Communication Systems: 2/e, TMH
7. P K Ghosh- Principles of Electrical Communications- University Press
8. L.W.Couch Ii, "Digital and Analog Communication Systems", 2/ e, Macmillan Publishing
9. Blake, Electronic Communication Systems- Cengage Learning
   S Sharma, Analog Communication Systems- Katson Books


## Introduction to Photonics and Plasmonics (PHL 7191) (4-0-0)

**UNIT** **10**

Laser fundamentals- Einstein's coefficients, gain coefficient, laser rate equations, optical resonator, Q-factor and stability of optical resonator – modes of laser resonator, Q-switching and mode locking. Properties of lasers – coherence, line width and divergence.Laser systems- Ruby laser, Nd YAG, CO2 laser, excimer laser, Ti Sapphire laser, and fibre laser.Applications –holography, laser fusion, laser cooling and Bose-Einstein condensates.

**UNIT II** **10**

Photo detectors and display devices, photodiodes, Photo transistor, APD, PMT, CCD, Photo voltaic cells. Optical modulators-acousto-optics, electro-optics and magneto-optics. Physical origin of nonlinear optical coefficients, Second order optical nonlinearity, Propagation of EMW through NLO medium, optical second harmonic generation, phase matching conditions, Third order NLO, intensity dependent refractive index, Four wave mixing and optical phase conjugation.

**UNIT III** **10**

Fibre Optics – classification of fibres- step index, graded index fibres. Numerical aperture, modes in optical fibre – single, multimode and fibre, V Parameter, evanescent waves, losses in fibres- bending and coupling losses, dispersion in fibres. Photonic materials – optical processes in semiconductors, quantum well lasers, photoluminescence, and electroluminescence.Photonic crystals and origin of photonic band gap.

**UNIT IV** 10

Optical Properties of Metals – Maxwell's equations, dielectric function of metals, Drude-Lorentz approximation, plasma frequency of metals, skin depth, and absorption in metals. Bulk Plasmon Polaritons – Field distribution and dispersion of surface-plasmonpolaritons, methods of excitation, plasmonic waveguide, and spoof plasmons. Longitudinal and transversal electromagnetic wave in plasma, bulk plasmons, spatial dispersion, waves in anisotropic plasma.

**UNIT V** 10

Surface Plasmon-Polaritons – Particles in electromagnetic field, Mie theory, scattering and absorption cross-sections, localized plasmon resonance of a spherical metal nanoparticle. Applications – radiation enhancement and quenching via plasmonic structures, Surface-enhanced Raman scattering, plasmonic waveguide for quantum cascade lasers, solar energy harvesting with plasmonic structures.

**Reference Books:**


1. A.Ghatak& K. Thyagarajan, Lasers: Theory & Applications, Macmillan India LTD. 2003
2. A.Ghatak& K. Thyagarajan, Optical Electronics, Cambridge University Press, 2004
3. AmonYariv, Optical Electronics, Saunders College Publishing, 1991
4. Francis T.S Yu, Shizhuo Yin (Eds), Fiber Optic Sensors, Marcel Dekker Inc., New York, 2002.
5. Fundamentals of Optical Fibres, J.A. Buck, John Wiley & Son, 2004.
6. Photonic Crystals: Moulding the Flow of Light,J. D. Joannopoulos, S.G. Johnson, J. N. Winn, and R.D. Meade, 2nd Edition, Princeton Univ. Press, 2008.


## Thin Films and Vacuum Technology (PHL 7194) (4-0-0)

**Unit-I**
**Introduction to Thin films** 6

Thermodynamics and Thin Film growth

**Unit -II**
**Vacuum Technology** 8

Gas Laws, Kinetic Theory of Gases, Conductance and Throughput, Gas Sources in a Vacuum Chamber, Vacuum Pumps vacuum pumps (Rotary, diffusion and turbo molecular pump) and measurement gauges.

**Unit -III**
**Film Formation and Structure** 12

Stages of thin film formation: Nucleation, Adsorption, Surface diffusion, capillarity theory of nucleation, statistical theory of nucleation, growth and coalescence of islands, grain structure and microstructure of thin films, diffusion during film growth, polycrystalline and amorphous films.

**Unit -IV**
**Methods of Preparation of Thin Films** 15

Physical vapour deposition: Vacuum evaporation-Hertz- Knudsen equation, evaporation from a source and film thickness uniformity, Sputtering (Plasma Physics (DC Diode), rf Plasmas, Magnetic Fields in Plasmas, Sputtering Mechanisms) and sputtering yield, Sputtering of alloys; magnetron Sputtering, Reactive sputtering; Pulsed laser deposition (PLD). Chemical vapour deposition: Mechanisms, Materials, Chemistries, Systems, PECVD.

**Unit -V**
**Characterization of thin films** **9**

Deposition rate, Film thickness and uniformity, Structural properties: Crystallographic properties, defects, residual stresses, adhesion, hardness, ductility, electrical properties, magnetic properties; optical properties.

**Reference Books:**


1. R. K. Waits, Thin Film Deposition and Patterning, American Vacuum Society, 1998.
2. M. Ohring, The Materials Science of Thin Films, Academic Press, Boston, 1991.
3. LudmilaEckertova, Physics of Thin Films, 2nd Plenum Press New York, 1986
4. Kasturi L. Chopra, Thin Film Phenomena (McGraw-Hill, 1969)


## Advanced Particle Physics
## (PHL 7094) (4-0-0)

**Unit-I** **8**

Elementary particles and the fundamental forces,Quarks and Leptons, The mediators of the electromagnetic, weak and strong interactions. Interaction of particles with matter; Decays and conservation laws, Unification schemes

**Unit-II** **8**

Relativistic kinematics: Lorentz transformations, Four-vectors, Four-forces, Energy and momentum, Collisions, Classical and relativistic collisions, Examples and applications.

**Unit-III** **12**

Symmetries, group theory, The group SU(2), Finite Symmetry Group: P and C, SU(2) of Isospin, The group SU(3), Angular momentum and its addition, Spin ½, Flavor symmetries, Discrete symmetries, Parity, Charge conjugation, CP, Neutral kaons, CP violation, Time reversal, the CPT theorem, Bound states.

**Unit-IV** **12**

Decay rates and Cross sections, Feynman diagrams, Introduction to Feynman integrals. The Dirac equation and its solution, Feynman rules for quantum electrodynamics (no derivation), Examples, Quark content of Mesons and Baryons,Color factors, Pair annihilation in quantum chromodynamics, Asymptotic freedom.

**Unit-V** **10**

Charged leptonic weak interactions, Decays of Muon, Neutron and Pion, Charged Weak interactions of Quarks, Neutral weak interactions, Electroweak unification, Beyond the standard model (elementary idea only).

**Reference Books:**

1. Francis Halzen and Allan D. Martin, Quarks and Leptons: An Introductory Course in Modern Particle Physics, John Wiley and Sons
2. B.R. Martin and G. Shaw, Particle Physics, 2nd edition, J. Wiley and Sons (1997).
3. The Review of Particle Physics, (Particle Data Group)
4. David Griffiths: Introduction to Elementary Particles.
5. Byron Roe: Particle Physics at the New Millennium.
6. Donald Perkin: Introduction to high energy physics.
7. Nuclear and Particle Physics, W.E. Burcham, Pearson.

## Liquid and Polymer Physics

## (PHL 7108) (4-0-0)

**UNIT I** **9**

Liquid**s** – Local Order and the Pair Distribution Function; Liquid Crystals – The Nematic Liquid-Crystalline State, Orientational Order and Optical Anisotropy; Polymers –Chemical Structure and Chain Conformation, Polymer melts, Solid polymers.

**UNIT II** **9**

Random walk models in polymer physics; bead-spring model, ideal polymer chain and finite extension models, radius of gyration.Excluded volume interaction.Flory theory in good solvent, bad solvent, and theta solvent.Concentrated polymer solutions.

**UNIT III** **9**

Review of Solution thermodynamics: Mixing and phase separation, osmotic pressure, chemical potential, thermodynamic origin of diffusion. Lattice model of solutions, Flory-Huggins theory of polymer solutions, definition of partition function and free energy,phase separation in Polymer blends/solutions – binodal and spinodal curves, critical point.

**UNIT IV** **9**

Viscoelasticity in polymers – experimental rheology: rheometers, linear viscoelasticity, superposition principle, relaxation modulus, storage modulus, loss modulus. Polymer Melts: Chain Dynamics – Rubber-Elastic Forces and the Rouse Model, Entanglement Effects and the Tube Model – Rouse, Zimm and Reptation models of polymer dynamics.

**UNIT V** **9**

Microscopic Dynamics– Liquids: Diffusive Motion, Diffusion Coefficients, Mobility and the Einstein Relation; Liquid Crystals: Orientational Fluctuations. Time-Resolved Scattering Experiments, Time- and Frequency-Dependent Structure Factors, Dynamic Light Scattering in Liquids.

**Reference Books**

1. Condensed Matter Physics: Crystals, Liquids, Liquid Crystals and Polymers, G. R. Strobl, Springer (2004).
2. Polymer Physics, Ulf W. Gedde, Chapman and Hall, London (1995).
3. J. D. Ferry, Viscoelastic Properties of Polymers, 2nd Ed., Wiley, New York, 1970.

4. Principles of Condensed Matter Physics, P.M. Chaikin& T.C. Lubensky, Cambridge University Press, 1995.
5. Materials Science and Engineering: An Introduction, William D. Callister, Jr., and David G. Rethwisch, 8th Edition, WileyPLUS.

# Annexure-III

## School of Physics

## Final Course Structure as per NEP-2020 &NCrF for Five Year Integrated B.Sc.-M.Sc. (Physics) Programme (3rd to 6th Semesters) applicable for batch admitted in AY 2022-23 & 2023-24

## Course codes are tentative and subject to correction by the Examination Wing

| | Second Year | | Third Year | |
|---|---|---|---|---|
| Type of Course | Semester- III | Semester-IV | Semester- V | Semester-VI |
| Major Course (Physics) (4 credits) | Analog Electronics **3-0-0(3 credits) [PHL 2051]**<br>Analog Electronics Lab **0-0-2(1 credit) [PHP 2051]**<br><br>Mathematical Methods -I **3-1-0(4 credits) [PHL 2033]** | Digital Fundamentals **3-0-0(3 credits) [PHL 2054]**<br>Digital Fundamentals Lab **0-0-2 (1 credit) [PHP 2054]**<br><br>Mathematical Methods -II **3-1-0(4 credits) [PHL 2036]**<br><br>Elementary Nuclear Physics**4-0-0 (4 credits) [PHL-2092]**<br><br>Foundations of Modern Physics**4-0-0 (4 credits) [PHL 2044]** | Elementary Statistical Mechanics **(3-1-0) [4 credits]**<br><br>Classical Mechanics **(3-1-0) [4 credits]**<br><br>Atomic and Molecular Physics (3-0-0) **[3 credits]**<br><br>Atomic and Molecular Physics Lab (0-0-2) **[1 credit]**<br><br>Introduction to Numerical Computation **3-0-2(4 credits) [PHL 3032]** | Quantum Mechanics **(3-1-0) [4 credits]**<br><br>Introductory Solid State Physics **(3- -0) [3 credits]**<br><br>DSE-I **4-0-0 (4 credits) [PHL 3XXX]**<br><br>DSE-II **4-0-0 (4 credits) [PHL 3XXX]** |
| Minor Course (4 credits) | Waves and Oscillations **3-0-0 (3 credits) {PHL 2013]**<br><br>Waves and Oscillations Lab **0-0-2 (1 credit) {PHP 2013]** | Measurements and Analysis **2-0-0 (2 credits) {PHL 2125]**<br><br>Measurements and Analysis Lab **0-0-4 (2 credit) {PHP 2125]** | Fundamentals of Material Science **4-0-0(4 credits) [PHL 3084]** | Circuit Theory **3-0-0(3 credits) [PHL 3060]**<br><br>Circuit Theory Lab **0-0-2(1 credits) [PHP 3060]** |
| Multidisciplinary (MD) (3 credits) | Elements of Thermodynamics **3-0-0 (3 credits) [PHE 2024]** is the MD-III offered to other schools. Physics students to choose one course from MD-III offered by other schools | | | |
| Ability Enhancement Course (AEC) (3 credits) | Choose one course from the pool of courses from AEC-III: English Language (General), Communication Skills, Mathematical Ability [In house/ Swayam platform] | | | |

| | | | | |
|---|---|---|---|---|
| | (3 credits) | | | |
| Skill Enhancement Course (SEC) **(2 credits)** | Choose one course from the pool of courses from SEC-III [In house/ Swayam platform/ Industry based] **(2 credits)** | | | Choose one from the pool of courses SEC-4(2) |
| Skill Development/ Training/ Laboratory Skills/ Project/ Dissertation/ Internship | | | | Summer Internship after 4th Semeter **0-0-4(2 credits)** **[PHL 3032]** |
| **Total credits** | **20** | **20** | **20** | **20** |

** The course structure and detailed course contents for Semesters III to VI for the batch of students admitted in AY 2022-23 & 2023-24. Students shall continue to be governed by the Multiple Entry and Multiple Exit norms as applicable under NEP-2020.*

## Semester - III

## Analog Electronics (PHL 2051) (3-0-0)

**UNIT-I**
**Circuit Theory** **[10]**

Voltage and Current sources, Conversion of current source to voltage source and vice versa, Series-Parallel Circuits, Voltage Dividers and Current Dividers, Kirchhoff's Laws, Node-Voltage Analysis, Mesh-Current Analysis, Superposition Theorem, Thevenin's Theorem and Norton's Theorem, Thevenin-Norton Conversions.

**UNIT-II**
**PN-Junction Diode and Applications** **[10]**

Diode operation, V-I characteristics, Half-Wave Rectifiers, Full-Wave Rectifiers, Power Supply Filters and Regulators, Diode Limiters and Clampers, Zener Diode and its Applications

**UNIT-III**
**Bipolar Junction Transistors** **[12]**

Basic BJT Operation, BJT Characteristics and Parameters, BJT Operating Regions, The DC operating point, Voltage divider bias, Other Bias Methods, BJT Amplifier operation, Single stage RC coupled CE-amplifier, Frequency response curve (qualitative)

**UNIT-IV**
**Operational Amplifiers and Oscillators** **[13]**

Operational Amplifier, Op-Amp Input modes and Parameters, Bias current and offset voltage, Basic Op-Amp Circuits- Comparator, Summing Amplifiers, Integrator and Differentiators, Concept of feedbacks in Op-Amps, Oscillators, Barkhausen criterion, RC oscillators (Wein-bridge & Phase-shift), The 555 timer as an oscillator.

**Reference Books:**

1. Grob's Basic Electronics: Mitchel E. Schultz (11e).
2. Electronic Devices, Thomas L. Floyd (9e).

## Analog Electronics Lab

## (PHP 2051) (0-0-2)

**Every student must perform at least 5 experiments as listed below, however additional experiments can be identified by the course coordinator to complete this requirement.**

1. To verify Kirchhoff's Laws (KCL/ KVL).
2. To verify Thevenin's theorem
3. To verify Norton's theorem.
4. To study PN junction diode characteristics (forward & reverse).
5. To draw V-I characteristics of Zener diode and to study it as a voltage regulator.
6. To find the Ripple factor of Half wave rectifier with different filters.
7. To find the Ripple factor of Full wave rectifier with different filters.
8. To draw characteristics of common base NPN/ PNP transistor.
9. To draw characteristics of common emitter NPN/ PNP transistor.
10. To draw the JFET characteristics.

## Mathematical Methods-I
## (PHL 2033) (3-1-0)

**UNIT-I**
**Elements of Probability Theory** **[10]**

Probability: Definitions, Simple Properties, Random Variables, Binomial Distribution, Poisson Distribution, Gauss' Normal Distribution

**UNIT-II**
**Vector Analysis** **[15]**

Review of Basics Properties of vectors, Vector in 3-D Spaces, Differential Vector Operators (gradient, divergence and curl), Properties of Differential Vector Operators, Vector Integrations- Line, surface and volume integrals, Green's theorem (in a plane), Stoke's theorem, Gauss's divergence theorem

**UNIT-III**
**Coordinate Systems**

Unit vectors, displacement vector, area elements and volume elements in Cartesian Coordinates, Plane Polar Coordinates, Spherical Polar Coordinates and Circular Cylindrical Coordinates. **[10]**

**UNIT-IV**
**First Order Differential Equations (ODE)**

First Order Equations- Separable equations, Exact differentials, Equations homogeneous in x and y, Linear first order ODE, ODEs with constant coefficients **[10]**

**Reference Books:**

1. Mathematical Methods for Physicists: Arfken, Weber and Harris (7e)
2. Mathematical Physics: Dass and Verma, S. Chand (8e) 2018

# Waves and Oscillations (PHL 2013) (3-0-0)

**UNIT-I**
**Simple Harmonic Motion** **[15]**

Differential equation of simple harmonic oscillator, its solution and characteristics, energyin simple harmonic motion, linearity and superposition principle, rotating vectorrepresentation of simple harmonic oscillation, motion of simple and compound pendulum(Bar and Kater's pendulum), loaded spring.Superposition of N collinear harmonic oscillations with (1) equal phase differences and (2), equal frequency differences, BeatsSuperposition of two perpendicular harmonic oscillations: Graphical and AnalyticalMethods. Lissajous Figures with equal and unequal frequencies, effect of variation of phase.

**Unit-II**
**Damped and Forced Oscillations** **[12]**

Damped Oscillations: Equation of motion, dead beat motion, critically damped system, lightly damped system: relaxation time, logarithmic decrement, quality factor Forced Oscillations: Equation of motion, complete solution, steady state solution, resonance, sharpness of resonance, power dissipation, quality factor.

**Unit-IV**
**Coupled Oscillations** **[8]**

Coupled oscillators, normal coordinates and normal modes, energy relation and energy transfer, di-atomic molecules, representation of a general solution as a linear sum of normal modes, normal modes of N coupled oscillators.

**Unit-VI**
**Wave Motion** **[8]**

One dimensional plane wave, classical wave equation, standing wave on a stretched string (both ends fixed), normal modes. Travelling wave solution.

**Suggested Readings:**

1. Vibrations and Waves by A. P. French. (CBS Pub. and Dist., 1987).
2. The Physics of Waves and Oscillations by N.K. Bajaj (Tata McGraw-Hill, 1988).
3. Fundamentals of Waves and Oscillations By K. Uno Ingard (Cambridge University Press, 1988).

## Waves and Oscillations Lab (PHP 2013) (0-0-2)

**Every student must perform at least 5 experiments as listed below, however additional experiments can be identified by the course coordinator to complete this requirement.**

1. Various experiments using bar pendulum.
2. Understand the applications of CRO by measuring voltage and time period of a periodic waveform using CRO. And study the superposition of two perpendicular simple harmonic oscillations using CRO (Lissajous figures)
3. To determine the current amplitude and phase response of a driven series LCR circuit with driving frequency and resistance. Draw resonance curves and find quality factor for low and high damping.
4. Experiments with spring and mass system
   a) To calculate g, spring constant and mass of a spring using static and dynamic methods.
   b) To calculate spring constant of series and parallel combination of two springs.
5. To determine the current amplitude and phase response of a driven series LCR circuit with driving frequency and resistance. Draw resonance curves and find quality factor for low and high damping.
6. To determine the value of acceleration due to gravity using Kater's pendulum for both the cases (a) $T_1 \approx T_2$ and (b) $T_1 \neq T_2$ and discuss the relative merits of both cases by estimation of error in the two cases.
7. Frequency of tuning fork using Sonometer.

## Suggested Readings:


1. Advanced Practical Physics for students, B. L. Flint and H. T. Worsnop, 1971, Asia Publishing House.
2. Engineering Practical Physics, S. Panigrahi and B. Mallick, 2015, Cengage Learning India Pvt. Ltd.
3. Practical Physics, G. L. Squires, 2015, 4/e, Cambridge University Press.
4. A Text Book of Practical Physics, Vol I and II, Prakash and Ramakrishna, 11/e, 2011, KitabMahal.
5. An Introduction to Error Analysis: The study of uncertainties in Physical Measurements,J. R. Taylor, 1997, University Science Books List of experiments

## Elements of Thermodynamics (PHP 2024) (3-0-0)

**UNIT-I**
**Zeroth Law of Thermodynamics** **[10]**

Macroscopic and Microscopic point of view, Thermal equilibrium and Zeroth law, Concept of Temperature, Thermometers and Measurement of Temperature, Ideal-Gas Temperature, Platinum Resistance Thermometry.Rankine and Fahrenheit Temperature Scales.

**UNIT-II**
**First Law of Thermodynamics** **[12]**

Work and Heat, Adiabatic Work, Internal-Energy Function, Mathematical Formulation of First Law, Concept of Heat, Differential Form of the First Law, Equation of State of a Gas, Internal Energy of a Real Gas.

**UNIT-III**
**Second Law of |Thermodynamics** **[12]**

Conversion of Work into Heat and Vice-Versa, The Diesel Engine, The Steam Engine, Heat Engine, Kelvin-Planck Statement of the Second Law, Equivalence of Kelvin-Planck and Clausius Statements, Entropy and Disorder, Entropy of Ideal Gas, TS diagram, Entropy and Reversibility, Entropy and Irreversibility.

**UNIT-IV**
**Third Law of Thermodynamics** **[11]**

Third Law of Thermodynamics, Carnot Cycle, Examples of Carnot Cycles, Carnot Refrigerator, Carnot's Theorem, The Thermodynamic Temperature Scale, Absolute Zero and Carnot Efficiency, Equality of Ideal-Cas and Thermodynamic Temperature.

**Reference Books:**

1. Heat and Thermodynamics: Zemansky and Dittman 7(e).
2. Heat, Thermodynamics and Statistical Physics: Lal and Subrahmanyam, S. Chand, 2018

# Semester – IV

## Digital Fundamentals (PHL 2054) (3-0-0)

**UNIT-I**
**Number Systems and Logic Gates** **[12]**

Number systems and their conversions: Decimal, binary and hexadecimal, binary arithmetic, binary coded decimal, Logic Gates – NOT, AND, OR, NAND, NOR, EX-OR and EX-NOR, Universal property of NAND and NOR gates.

**UNIT-II**
**Boolean Algebra and Logic Simplification** **[12]**

Boolean operations and expressions, Laws of Boolean algebra, DeMorgan's Theorems, Boolean analysis of logic circuits, Logic simplification using Boolean algebra, Standard forms of Boolean expressions, Boolean expressions and truth tables.

**UNIT-III**

**Combinational Logic** **[11]**

Basic combinational logic circuits, Combinational logic using NAND and NOR gates, Half and Full adders, Parallel binary adders, comparators, decoders, encoders, multiplexers, de-multiplexers, parity generators/ checkers.

**Unit-IV**

**Sequential logic** **[8]**

Latches, Flip-Flops- Operating characteristics and applications, one-shots, Astable multivibrators

**Reference Books:**

1. Digital Fundamentals: Floyd 11(e), Pearson (Textbook).
2. Modern Digital Electronics: R.P. Jain, 4e (2009), TMH.

## Digital Fundamentals Lab

## (PHP 2054) (0-0-2)

**Every student must perform at least 5 experiments as listed below, however additional experiments can be identified by the course coordinator to complete this requirement.**

1. To study performance of a NOT circuit.
2. To verify De Morgan's theorem and some relationships in Boolean algebra.
3. To design OR & AND logic with diode and resistor.
4. To realize basic logic gates with any type of universal gate NAND/NOR.
5. To form different combinational problems by construction of Truth Table and implement it using basic logic gates.
6. To design half adder circuit and to verify its truth table.
7. To design full adder circuit and to verify its truth table.
8. To design half subtractor, full subtractor, adder-subtractor using full adder.
9. To construct i) RS ii) D, and JK FF circuits using NAND gates.

**Suggested Books:**

1. Digital Fundamentals: Floyd 11(e), Pearson.
2. Modern Digital Electronics: R.P. Jain, 4e (2009), TMH Advanced Practical Physics for Students by Worsnop and Flint.
3. Basic Electronics-A text Lab Manual, Zbar&Malvino, (Tata McGraw-Hill, 1999).

## Mathematical Methods-II
## (PHL 2034) (3-1-0)

**UNIT-I**
**Linear Differential Equations of Second Order** **[12]**

Second order linear and no-linear differential equations with constant coefficients, Non-homogeneous and Homogeneous differential equations, Methods to find the complementary function and particular integral.

**UNIT-II**
**Double and Triple Integrals** **[12]**

Evaluation of double integration in Cartesian and Polar coordinates, Applications of double integrals in finding area, centre of gravity, mass and volume, Triple integration in Cartesian and Polar coordinates, Applications of triple integrals in calculating volume, area, centre of gravity, mass and moment of inertia

**UNIT-III**
**Fourier Series** **[10]**

Periodic functions, Fourier Series, Dirichlet's condition, Useful integrals, Determination of Fourier Coefficients, Fourier series for discontinuous functions, Even and Odd functions, Half-range series, Half period series, Parseval's formula, complex form of fourier series

**UNIT-IV**
**Special Functions** **[11]**

Legendre's and Hermite functions- Equation, Polynomials, General solution, Generating function, Orthogonality, Recurrence formulae for each

**Reference Books:**


1. Mathematical Methods for Physicists: Arfken, Weber and Harris (7e) (Textbook)
2. Mathematical Physics: Dass and Verma, S. Chand (8e) 2018


## Foundations of Modern Physics
## (PHL 2044) (4-0-0)

**Unit – I**
**Special Theory of Relativity** **[12]**

Postulates – Lorenz transformations – Time dilation – Length contraction – Doppler effect – Twin paradox – velocity addition – relativistic momentum – Mass energy equivalence – Electricity and Magnetism in relativity – Introduction to general relativity.

**Unit – II**
**Matter and Radiations** **[12]**

EM waves – Black body radiation – Photoelectric effect – X-rays – Diffraction of x-rays– Compton effect – de Broglie waves – Phase and group velocities – Electron diffraction – Uncertainty principle.

**Unit-III**
**Quantum mechanics** **[12]**

Wave equation – Schrödinger equation – Operators – Postulates of quantum mechanics – Particle in a box – Finite potential well – Introduction to quantum tunneling – Harmonic oscillator.

**Unit-IV**
**Hydrogen atom** **[12]**

Schrödinger equation – Separation of variable – Quantum numbers – Quantization of energy – Angular momentum – Electron Probability density, Radiative transitions, Selection Rules, Zeeman effect.

**Unit-V**
**Atomic structure** **[12]**

Electron orbits – Atomic spectra – Bohr atom – Energy levels and spectra – Absorption spectra – Finite nuclear mass correction, Sommerfeld model – Bohr's quantization rule, Bohr's correspondence principle, Vector atom model, L-S and j-j coupling.

**Suggested books:**

1. Concepts of Modern Physics, Arthur Beiser, Tata McGraw Hill, (2002), 6th Edition.
2. Introduction to Modern Physics, H. S. Mani and G. K. Metha, Affiliated East-West Press, (1988).

## Elementary Nuclear Physics (PHL-2092) (4-0-0)

**Unit-I**
**General Properties of Nuclei:**

Basic nuclear properties: Size Measurement of Nuclear Radius by Electron Scattering methodand Mirror Nuclei method, Nuclear Density, Packing Fraction, Mass Defect, Binding energy,Discussion of Average Binding energy curve, Nuclear Stability, N/Z plot, angular momentum, parity, magnetic moment, electric moments, nuclear excites states. **[12]**

**Unit-II**
**Nuclear Models:**

Liquid drop model approach, Weizsacker's Semi-Empirical Mass Formula and significance of various terms, condition of nuclear stability. Two nucleon separation energies, Fermi gas model (degenerate fermion gas, nuclear symmetry potential in Fermi gas, NuclearForces and their properties (qualitative treatment) **[12]**

**Unit-III**
**Radioactivity and Nuclear Decays:**

Laws of radioactive decay, Radioactive Series, Alpha Decay (qualitativetreatment), Discrete Nature of α-particle energies, Measurement of velocity of α-particle, BetaDecay, Beta particle energy spectrum, Pauli's theory of Neutrino, Inverse Beta decay, Simple ideaabout Gamma Decay. **[12]**

**Unit-IV**

**Nuclear Reactions:**

Types of Nuclear Reactions, Conservation Laws, kinematics of reactions, Q-value, reaction rate, reaction cross section, Concept of compound and direct reaction, Coulomb scattering (Rutherford scattering). **[12]**

**Unit-IV**
**Particle Physics:**

Classification of elementary particles,Strangeness, Baryon Number and Isospin, Parity Quantum Number, Gell-Mann and NishijimaScheme, Quark as the basic constituent of matter, quark properties, Quark contents in low lyingBaryons and Mesons, Fundamental Forces (Strong, Weak and Electromagnetic and theircharacteristics). **[12]**

**Reference Books:**


1. Introductory Nuclear Physics by Kenneth S. Krane (Wiley India Pvt. Ltd., 2008).
2. Nuclear Physics, S. N. Ghoshal (S. Chand Publishing, 2019).


## Measurements and Analysis (PHL 2125) (2-0-0)

**UNIT-I**
**Some Laboratory Instruments and Methods** **[10]**

Metre rule, Micrometer screw gauge, Measurement of length, Measuring frequency, Negative feedback amplifier, Servo systems, Natural limits of measurements

**UNIT-II**
**Experimental Techniques and Logic** **[12]**

Rayleigh refractometer, Measurement of resistivity, Measurement of 'g', Measurement of frequency and time, The Global positioning system, Sequence of measurements, Drift, Systematic variations, Relative methods, Null methods, Repetition of measurements

**UNIT-III**
**Uncertainty in Measurements** **[11]**

Measuring errors, Systematic and random errors, Set of measurements, Distribution of measurements, Estimation of $\sigma$ and $\sigma_m$, Propagation of errors

**UNIT-IV**
**Data Handling** **[12]**

Parent and Sample Distributions, Mean and Standard Deviation of Distributions, The Gaussion distribution, The integral function, The treatment of functions, Method of least squares for fitting a straight line

**Suggested Books:**


1. Practical Physics: G. L. Squires (4e) Cambridge University Press, 2001 (Textbook).
2. Data Reduction and Error Analysis for Physical Sciences: Bevington and Robinson (3e) McGraw Hill, 2003

## Measurements and Analysis Lab (PHP 2125) (0-0-4)

**Choose any 5 experiments from the list given below:**

1. To observe the loading effect of a multimeter while measuring voltage across a low resistance and high resistance.
2. To observe the limitations of a multimeter for measuring high frequency voltage and currents.
3. To measure Q of a coil and its dependence on frequency, using a Q- meter.
4. Measurement of voltage, frequency, time period and phase angle using CRO.
5. Measurement of time period, frequency, average period using universal counter/ frequency counter.
6. Measurement of rise, fall and delay times using a CRO.
7. Measurement of distortion of a RF signal generator using distortion factor meter.
8. Measurement of R, L and C using a LCR bridge/ universal bridge.

**Suggested Readings:**


1. A text book in Electrical Technology - B L Theraja - S Chand and Co.
2. Performance and design of AC machines - M G Say ELBS Edn.
3. Digital Circuits and systems, Venugopal, 2011, Tata McGraw Hill.
4. Digital Electronics, Subrata Ghoshal, 2012, Cengage Learning.
5. Electronic Devices and circuits, S. Salivahanan & N. S.Kumar, 3rd Ed., 2012, Tata Mc-Graw Hill


# Semester – V

## Elements of Statistical Physics (PHL-3062) (3-1-0)

**Unit-1**
**Classical Statistics** **[12]**

Macrostate& Microstate, Elementary Concept of Ensemble, Phase Space, Entropy and Thermodynamic Probability, Maxwell-Boltzmann Distribution Law, Partition Function, Thermodynamic Functions of an Ideal Gas, Classical Entropy Expression, Gibbs Paradox, Law of Equipartition of Energy (with proof) – Applications to Specific Heat and its Limitations, Thermodynamic Functions of a Two-Energy Levels System, Negative Temperature.

**Unit-II**
**Classical Theory of Radiation** **[10]**

Properties of Thermal Radiation.BlackbodyRadiation.Pure temperature dependence.Kirchhoff's law. Stefan-Boltzmann law: Thermodynamic proof. Radiation Pressure.Wien's Displacement law. Wien's Distribution Law. Saha's Ionization Formula. Rayleigh-Jean's Law.Ultraviolet Catastrophe.

**Unit-III**
**Quantum Theory of Radiation** **[8]**

Spectral Distribution of Black Body Radiation. Planck's Quantum Postulates. Planck's Law of Blackbody Radiation: Experimental Verification. Deduction of Wien's Distribution Law, Rayleigh-Jeans Law, Stefan-Boltzmann Law, Wien's Displacement law from Planck's law.

**Unit-IV**
**Quantum Statistics** **[12]**

B-E distribution law, Thermodynamic functions of a strongly Degenerate Bose Gas, Bose Einstein condensation, properties of liquid He (qualitative description), Radiation as a photon gas and Thermodynamic functions of photon gas. Bose derivation of Planck's law. Fermi-Dirac Distribution Law, Fermi Energy, Electron gas in a Metal, Specific Heat of Metals, Relativistic Fermi gas

**Text Book:**

1. Statistical Mechanics, R.K. Pathria, Butterworth Heinemann: 2nd Ed., 1996, Oxford University Press.

**Suggested Reading(s):**

2. Statistical Physics, Berkeley Physics Course, F. Reif, 2008, Tata McGraw-Hill

## Classical Mechanics (PHL 6021) (4-0-0)

**Unit I:** **[10]**

Newton's laws, Mechanics of systems of particles, conservation laws, dynamical systems: conservative versus dissipative systems, Phase space dynamics, stability analysis, degrees of freedom, constraints, and generalized coordinates, velocities, momenta and forces.

**Unit-II** **[15]**

Hamilton's variational principle, the Lagrangian and the Euler-Lagrange equations, the Hamiltonian, Cyclic Coordinates and Canonical Momenta, Applications of the Lagrangian and Hamiltonian formalisms to systems with one and two degrees of freedom, Principle of least action, Canonical transformations, Poisson brackets, the Hamilton-Jacobi theory, symmetry, invariance and Noether's theorem.

**Unit-III** **[9]**

Central force problem, Kepler's problem, bound and scattering motions, Scattering in a central potential, Rutherford formula, and the Scattering cross section. Two body Collisions–scattering in laboratory and Centre of mass frames.

**Unit-IV** **[10]**

Moment of inertia tensor, Euler forces, Euler angles, symmetric top, Periodic motion; Small Oscillations: Normal modes analysis, and Normal modes of a harmonic chain

**Unit-V** **[12]**

Inertial frames, Postulates of special relativity. Lorentz transformations relativistic velocity addition formula, Relativistic kinematics–Four- vector notation.Velocity-energy-momentum-force four-vectors for a particle. Relativistic invariance of physical laws, relativistic mass-energy equivalence

**Text Book:**

1. Classical Mechanics: H Goldstein

**Suggested Reading(s):**

2. Classical Dynamics of Particles and Systems: Stephen Thornton
3. Classical Mechanics by J. C.Upadhyay

## Atomic and Molecular Physics
## (PHL 7071) (3-0-0)

**Unit-I:**
Introduction to Spectroscopy and types of Spectra, Spectrum of Hydrogen Atom, Bohr Model for hydrogen atom, Bohr-Sommerfeld model of Hydrogen Atom, Sommerfeld's Relativistic Correctionfor energy levels of hydrogen atom, Fine Structure of Hydrogen Atom. **[9]**

**Unit-II:**
Magnetic Dipole Moments, Electron Spin and Vector Atom Model and Sterrn-Gerlach Experiment, Zeeman Effect, Paschen-Back effect, Stark Effect, Spin-orbit interaction (LS and JJ Coupling), Pauli's exclusion Principle, Singlet and Triplet States, Selection Rules, Hyperfine Structure of Spectral Lines and isotopic shift, Spectrum of helium and alkali atom **[12]**

**Unit-III:**
Breadth of Spectral Lines, Effect of Nuclear Properties on Spectral Lines, X-ray Spectra, Moseley's Law, Regular and Irregular Doublet Law, Photoelectron Spectra. **[9]**

**Unit-IV:**
Born-Oppenheimer approximation Electronic, rotational, vibrational spectra of diatomic molecules, selection rules, Raman spectroscopy, Pure rotational Raman spectra, Vibrational Raman spectra, Rotational Fine Structure, Frank-Condon principle **[12]**

**Text Book(s):**

1. H.E. White, Introduction to Atomic Spectra, 1934, McGraw-Hill Kogakusha Ltd., Tokyo
2. C.N. Banwell and E.M. McCash, Fundamentals of Molecular Spectroscopy, Third Edition 1972, McGraw-Hill book company, London

**Suggested Reading(s):**

3. G. Aruldhas, Molecular Structure and Spectroscopy, Second Edition 2007, Prentice Hall Of India, New Delhi

## Atomic and Molecular Physics Lab
## (PHL 7071) (0-0-2)

1. To determine the wavelength of the H-alpha emission line of Hydrogen atoms.
2. To determine the ionization potential of mercury.
3. To Measure Charge-to-Mass (e/m) Ratio for the Electron by magnetic focussing.
4. To measure the ratio of Planck's constant to the electron charge (h/e) using the photoelectric effect.
5. To study the Zeeman Effect
6. To determine structure from Raman spectra
7. To determine structure using Infra-red spectra

**Choose any 5 experiments from the list given below:**

**Suggested Reading(s):**

1. Advanced Practical Physics for Students by Worsnop and Flint.
2. B. Sc Practical Physics by C. L. Arora.
3. C.N. Banwell and E.M. McCash, Fundamentals of Molecular Spectroscopy, Third Edition 1972, McGraw-Hill book company, London
4. H.E. White, Introduction to Atomic Spectra, 1934, McGraw-Hill Kogakusha Ltd., Tokyo

## Introduction to Numerical Computation (PHL-3032) (3-0-2)

**Unit-I**
**Introduction** **6**

Approximations, Computational Algorithms, Computer Arithmetic, Errors in numbers

**Unit-II**
**Non-Linear Equations** **12**

Solving f(x) = 0 using an Iterative Method, the Method of Successive Bisection, the Method of False Position, Newton-Raphson Iterative Method, the Secant Method, the Method of Successive Approximation, Comparison of Iterative Methods, Solving Polynomial Equations, Solving Simultaneous Non-linear Equations.

**Unit-III**
**Simultaneous Linear Algebraic Equations** **8**

The Gauss Elimination Method, Pivoting, Refinement of the solution obtained by Gauss Elimination, the Gauss-Seidel Iterative Method-algorithm, Comparison of direct and iterative methods.

**Unit-IV**
**Approximation of Functions** **9**

Least Squares: Linear Regression-algorithm, Polynomial Regression, Fitting Exponential and Trigonometric Functions, Taylor Series Representation, Chebyshev Series.

**Unit-V**
**Numerical Differentiation and Integration** **10**

Formulae for Numerical Differentiation, Numerical Integration using Trapezoidal Rule, Simpson's Rule, Truncation error, Integration of Tabulated and known Functions, Gaussian Quadrature Formulae, Comparison of Integration Formulae.

**Reference Books:**

1. An Introduction to Numerical Analysis, Kendall E. Atkinson, second edition, Wiley, 1989.
2. Computer Oriented Numerical Methods, V. Rajaraman, PHI, 2018.

## Lab Component

The laboratory exercise involves writing programs in C/ FORTRAN to solve problems of numerical techniques for the topics listed above.

**Choose any 6 experiments from the list given below:**

1. Program to solve a linear equation using Gauss Elimination method.

2. Program to solve a linear equation using Gauss-Seidel Iterative method.
3. Program for finding roots of f(x)=0 by Newton Raphson method.
4. Program for finding roots of f(x)=0 by Bisection method.
5. Program for finding roots of f(x)=0 by Secant method.
6. Program for finding roots of f(x)=0 by the method of False Position.
7. Program for finding roots of f(x)=0 by the method of Successive Approximation.
8. Program to solve numerical integration by simpson's 1/3 rule.
9. Program to solve numerical integration byTrapezoidal rule.
10. Program to find the linear regression coefficients for a curve using method of least squares.

**Reference Books:**


1. Richard Hamming. Numerical Methods for Scientists and Engineers. Dover publications.
2. Computer Oriented Numerical Methods, V. Rajaraman, PHI, 2018.


## Fundamentals of Materials Science (PHL 3084) (4-0-0)

**Unit-I**
**Introduction to Materials** 6

Materials, Classification, Crystalline and Amorphous, Glasses, Metals, Alloys, Semiconductors, Polymers, Ceramics, Bio-materials, Composites, Bulk and nanomaterials.

**Unit-II**
**Crystal Structure and Bonding** 7

Introduction to crystals – Classification of crystal systems – Introduction to Bravais lattice – Calculation of distance between crystal planes – Miller indices – ionic crystals-covalent crystals- Vander wall-Metallic bonds.

**Unit-III**
**Materials Defects, Diffusion and Deformation** 10

Types of defect, Point defects, Line defects, Surface defects, Volume defects, Production and removal of defects, Diffusion in solids- Self diffusion - Concentration gradient-Diffusion constant - Fick's laws of diffusion and its applications, Elastic deformation – Fracture – Plastic deformation Slip – Critical shear stress.

**Unit-IV**
**Band Theory** 10

Introduction to band theory of solids, Classification of metals, insulators and semiconductors, Forbidden gap, Types of semiconductors. Conductivity of semiconductors, mobility, Hall Effect, Hall coefficient.

**Unit-V**
**Magnetic and Dielectric Materials** 12

Dia-, Para-, Ferri- and Ferromagnetic materials, Curie's law, Weiss's theory of ferromagnetism, Ferromagnetic Domains, B-H Curve, Hysteresis and energy loss.Dielectric Materials: Dielectric constant, dielectric strength and dielectric loss.polarizability, mechanism of polarization,factors affecting polarization, polarization curve and hysteresis loop.

**Suggested Reading**

1. Material Science and Engineering (2001) W.D. Callister, John Wiley Sons.
2. Solid State Physics, M.A. Wahab, 2011, Narosa Publications.

## Semester-VI

# Quantum Mechanics
# (PHL-6041) (3-1-0)

**Unit-I** **[9]**
Wave-function in coordinate and momentum representations, Schrödinger equation (time-dependent and time-independent), Expectation Values, current density, equation of continuity, Ehrenfest's theorem.

**Unit-II** **[8]**
Particle in a Well (infinite and finite), harmonic oscillator, Potential Step, Potential Barrier, Rigid rotator and Hydrogen atom problem.

**Unit-III** **[10]**
Fundamental postulates of wave mechanics, Commutators, Hermitian operators, properties of eigen functions and eigen values of Hermitian operators, Dirac notation for state vectors (Bra and ket notations), matrix representation of wave function and operator, energy spectrum of one dimensional harmonic oscillator using matrix mechanics.

**Unit-IV** **[15]**
Angular momentum algebra: operators for $J_+$, $J_-$and $J_z$, Commutation relation, Spectrum of eigen values of $J^2$ and $J_z$, operators for angular momentum L in spherical polar co-ordinates, Eigen values and eigen functions of $L^2$ and $L_z$. Spin angular momentum, Eigen values and eigen functions of $S^2$ and $S_z$. Matrix representation of $J^2$, $J_z$, $J_+$, J, $J_x$, $J_y$ for j=1/2 and 1. Pauli's spin matrices and their properties, Addition of two angular momenta; Clebsch Gordon coefficients.

**Text Book:**
1. Introduction of Quantum Mechanics: D.J. Griffiths.

**Suggested Reading(s):**
2. Quantum Mechanics, Ghatak & Loknathan, 1st Edition, MacMillan India
3. Quantum Mechanics, L. I. Schiff, 3rd Edition, McGraw-Hill (1968).

# Introductory Solid State Physics
# (PHL-2101) (3-1-0)

**Unit-I** **[10]**

Atomic Structure: Fundamental Concepts, Electrons in Atoms, The Periodic Table, Atomic Bonding in Solids: Bonding Forces and Energies, Primary Interatomic Bonds- Ionic Bonding, Covalent Bonding, Metallic Bonding, Secondary Bonding or van der Waals, Mixed Bonding

**Unit-II** **[10]**

Single Crystals, Polycrystalline Materials, Unit Cells, Crystal Lattice, Density Computations, Polymorphism and Allotropy, Crystal Systems, Point Coordinates, Crystallographic Directions, Crystallographic Planes, Linear and Planar Densities, Close-Packed Crystal Structures, Anisotropy

**Unit-III** **[12]**

X-ray Diffraction – Diffraction Phenomenon, Bragg's law, Laue's Equations, X-ray diffraction methods – The Laue's Method, Rotating Crystal Method, Powder Method, Reciprocal Lattice Vectors, Reciprocal Lattice to sc, bcc and fcc lattices, Properties of Reciprocal Lattice

**Unit-IV** **[10]**

Free electron gas (theory), density of states, and Fermi Energy, One Dimensional Lattice: Kronig-Penny Model, Bloch Theorem, Band Gap, Effective mass, TO and LO Modes

**Text Book:**

1. Introduction to Solid State Physics by C. Kittel

**Suggested Reading(s):**

2. Materials Science and Engineering by William D. Callister (Wiley $10^{th}$ Ed., 2018)
3. Solid State Physics by Puri and Babbar (S. Chand & Co., Ist Ed., 2021)

**DSE – I and DSE – II Basket**

## Discipline Specific Electives (DSE-I & II)

## Applied Optics (PHL 3153) (4-0-0)

**Unit I**
**Light Sources** **10**

Lasers, spontaneous and stimulated, theory of laser action, Einstein's coefficients, Light amplification, characterization of laser beam, He-Ne laser, semiconductor lasers, Q-switching, mode locking, nano-second laser, femto-second laser.

**Unit II**
**Fourier Optics** **10**

Concept of spatial frequency filtering, fourier transforming property of a thin lens, fourier optic and image processing, fourier transform spectroscopy (FTS), emission and absorption spectra, application of FTS in atmospheric remote sensing, NMR spectrometry and forensic science.

**Unit III**
**Holography** **10**

Basic principle and theory of holography, coherence, resolution, types of holograms, white light reflection hologram, application of holography in microscopy, interferometry, and character recognition.

**Unit IV**
**Photonics and Fibre Optics** **10**

Optical fibres and their properties, types of optical fibers, principal of light propagation through a fibre, the numerical aperture, attenuation in optical fibre and attenuation limit, single mode and multimode fibres, fibre optic sensors, Fibre Bragg grating, optical communication systems.

**Unit V**
**Non-Linear Optics** **10**

Introduction, wave propagation and momentum conservation, linear medium, nonlinear polarization, second harmonic generation, phase matching, sum and difference frequency generation, parametric oscillation, self-focusing of light, stimulated Raman scattering.

**Reference Books:**

1. Fundamental of optics, F. A. Jenkins & H. E. White, 1981, Tata McGraw hill.
2. LASERS: Fundamentals & applications, K.Thyagrajan & A.K.Ghatak, 2010, Tata McGraw Hill
3. Fibre optics through experiments,M.R.Shenoy, S.K.Khijwania, et.al. 2009, Viva Books
4. Nonlinear Optics, Robert W. Boyd, 2008, Elsevier.
5. Optics, Karl Dieter Moller, Learning by computing with model examples, 2007, Springer.
6. Optical Systems and Processes, Joseph Shamir, 2009, PHI Learning Pvt. Ltd.
7. Optoelectronic Devices and Systems, S.C. Gupta, 2005, PHI Learning Pvt. Ltd.
8. Optical Physics, A.Lipson, S.G.Lipson, H.Lipson, 4th Edn., 1996, Cambridge Univ. Press.

## Basic Experimental Techniques
## (PHL 3125) (4-0-0)

**Unit-I**
**Physical measurement** **[6]**

Measurement, result of a measurement, sources of uncertainty and experimental error, Systematic error, random error, Reliability- chi square test, Analysis of repeated measurement, Precision and accuracy, Elementary data fitting.

**Unit-II**
**Instrumentation Electronics** **[10]**

Transducers, Transducer characteristics, selection of a instrumentation transducer, Transducer as an electrical element, Signal processing – A/D conversion – multichannel analyzers– Time of flight technique

**Unit-III**
**Vacuum Techniques** **[10]**

Basic idea of conductance, pumping speed, Pumps: Mechanical Pump, Diffusion pump, Gauges, Thermocouple gauge, Penning gauge, Pirani gauge,Hot Cathode gauge, Low temperature systems, Cooling a sample over a range up to 4 K, Measurement of low temperatures.

**Unit-IV**
**Signal Conditioning** **[9]**

Signal Conditioning, Analog signal conditioning: Operational amplifier, Instrumentation amplifiers, precision absolute value circuits, True RMS to DC converters, Phase sensitive detection: lock-in detector, box-car integrator, Spectrum analyser, Introduction to Digital signal conditioning.

**Unit-V**
**Radiation Detectors** **[10]**

Detection of X-rays, Gamma rays, charged particles, neutron, Ionization chamber, Proportional counter, GM counter, Scintillation detectors, Solid State detectors, Measurement of energy and time using electronic signals from the detectors and associated instrumentation.

**Reference Books:**

1. Measurement, Instrumentation and Experimental desigh in Physics and EngineeringMichaelSayer and AbhaiMansingh, Prentice Hall of India 2005
2. Data Reduction and Error Analysis for the Physical Sciences, P.R. Bevington and K.D Robinson, McGraw Hill, 2003
3. Electronic Instrumentation- H.S. Kalsi, TMH Publishing Co. Ltd. 1997
4. Vacuum Technology, A. Roth, North Holland Amsterdam
5. Techniques for Nuclear and Particle Physics Experiments, W. R. Leo, Springer, 1994.
6. Modern Electronic Instrumentation and Measurement Techniques, Helfrick, A.D., Cooper, W.D., Prentice Hall of India (2007).

# UNIX, FORTRAN-90 and C++
# (PHL 3114) (3-0-2)

**Unit-I**
**Unix Operating System** **[15]**

Introduction to operating system, General OS architecture, Evolution of Unix operating system, Architecture of the Unix OS, The kernel, Memory management, Virtual memory, Paging, Segmentation, Shells and GUI, Directory structure, File systems in Unix, Mount point, Processes and threads, Multithreading Semaphores, Mutex, CPU process scheduling, Concept of deadlock, Services and Daemons, Introduction to Networking, Network file systems, Elements of system administration, Principles of topography, Typesetting in LaTeX, Elements of bibliography and citation, The Harvard system.

**Unit-II**
**Fortran-90** **[15]**

Evolution of Fortran language, Different Fortran compilers, Skeleton of a general Fortran 90 program, Free source format and character set, Specifications, Derived types, Control Structure, CASE construct, New features of DO loop: EXIT, CYCLE statements, Control clauses, Concept of internal, and external procedures, modules and INTERFACE blocks, Concept of scope, CONTAINS statement, Procedure Arguments, Optional arguments, Keyword arguments, Recursive procedures, Modules, Array Processing, Terminology and Specifications, Whole array operations, Vector subscripts, Array assignment, Array constructor, Allocatable dynamic array, Pointers and Dynamic Data Structures, Concept of pointers, Example programs.

**Unit-III**
**C++ Programming** **[15]**

Introduction, Algorithms, Control Structures, if Selection Statement, if-elsestatement, do-whilerepetition Statement, Nested Control Statements, Assignment Operators, Increment and decrement operators, break and continue Statements, Logical Operators, C++ math library functions, Function definitions withmultiple parameters, Function prototypes, C++ standard library header files, Random Number Generation, Inline functions, Arrays, Declaring arrays, Examples using Arrays, Passing arrays to functions, Pointervariable declarations and initialization, Pointer Operators, Passing arguments to functions by reference withpointers, Using const with pointers, Introduction to operator overloading.

**Reference Books:**


1. Jerry Peek, Grace Todino Gonguet, John Strang (2002), Learning the UNIX Operating System, 5th Edition. O'Reilly Media, Inc.
2. Stephen Chapman (2003). Fortran 90 / 95 for Scientists and Engineers (2nd Edition) McGraw Hill.
3. Bjarne Stroustrup (2000). The C++ Programming Language (3rd Edition).


# Atmosphere and Space Physics
# (PHL 3171) (4-0-0)

**Unit-I**
**Essentials of Atmospheric Physics** **[10]**

Structure of the atmosphere: troposphere, stratosphere, mesosphere, thermosphere, Composition of air, Greenhouse effect Transport of matter, energy and momentum in nature,. Elements of weather and climate of India.

**Unit-II**
**Atmospheric Pollution and Degradation** **[15]**

Factors governing air, water and noise pollution air and water quality standards, Waste disposal, Heat island defect, Land and sea breeze Puffs and plumes, Gaseous and particulate matters, Pollutants ( different compounds), aerosols, toxic gases and radioactive particles& trace gases.

**Unit-III**
**Ionosphere** **[10]**

Formation of the Ionosphere and Its layers D,E,F (F1 &F2) Layers. Propagation of radio waves through ionosphere. Ionosphere's parameters.

**Unit-IV**
**Space Exploration** **[10]**

Techniques of space exploration, orbits of the earth, geostationary and geosynchronous orbits, Polar orbits, elliptical orbits. Remote sensing satellites, Communication satellite, Carto Sats

**Reference Books:**


1. Meteorology for Scientists & Engineers: Ronald B. Still, Brooks/ Cole Cengage Learning 1995.
2. Environmental Physics: Edbert B and Reink V Groundelle, John Wiley
3. The Physics of Atmosphere: J.T. Houghton, Cambridge Univ. Press, 1977.
4. Atmospheric Science: John M. Wallace & Peter V. Hobbs, Academic Press (2006)
   Meteorology for Scientists and Engineers: Ronald B. Stull, Brocks/Cole Cengage Learning (1995)
5. The Lightning Discharge: Martin A. Uman, Academic Press (1987)


## Fundamentals of Microprocessors
## (PHL 3056) (4-0-0)

**Unit I** **[12]**

Introduction to Microcomputer based system. History Evolution of Microprocessor and microcontrollers and their advantages and disadvantages.Architecture of 8085 Microprocessor. Address / Data Bus multiplexing and de-multiplexing, Status and Control signal generation, block diagram, pin diagram.

**Unit II** **[16]**

The 8085 programming model, Instruction set of 8085 Microprocessor, Classification of instructions, addressing modes, timing diagram of the instructions. Assembly language programming: Addition, Multiplication, Block Transfer, Ascending order, Descending order, Finding largest & smallest number, Look-up table etc.

**Unit III** **[12]**

Basic interfacing concepts, Memory interfacing, interfacing the 8155 memory segment, Interfacing output displays, interfacing input devices, Memory mapped I/O

**Unit IV** **[12]**

Interrupts of 8085 processor: classification of interrupts, Programming using interrupts (programming using INTR is not required). Serial and parallel data transfer – Basic concept of serial I/O, DMA, Asynchronous and synchronous serial transmission using SID and SOD pins of 8085 Microprocessor.

Prerequisites: Shall require fundamental knowledge of digital electronics fundamentals and number systems.

**Reference Books:**

1. Microprocessor architecture, programming and application with 8085 – R. Gaonkar (Penram International)|
2. Microprocessors & interfacing – D. V. Hall (Tata McGraw-hill)
3. An Introduction to Microprocessor and Applications –Krishna Kant (Macmillan)
4. Microprocessors and microcontrollers - N. Senthil Kumar, M. Saravanan and Jeevananthan (Oxford university press)

# Circuit Theory
# (PHL-1051) (3-1-2)

**UNIT-I**
**Series-Parallel Networks** **[9]**

Kirchhoff's laws, Ladder networks, Current sources, Conversion of current source to voltage source and vice versa, Current sources in series and parallel, Mesh analysis, Nodal analysis, Bridge networks.

**UNIT-II**
**Network Theorems** **[9]**

Superposition theorem, Thevenin's theorem, Norton's theorem, Maximum power transfer theorem, Millman's theorem, Substitution theorem, Reciprocity theorem.

**UNIT–III**
**Capacitive, Inductive and Magnetic Circuits** **[9]**

Transients in capacitative networks, Time constant, Capacitor networks, Energy relations, Introduction to Magnetic circuit, Series and parallel magnetic circuits, Analogy between electromotive force (e.m.f) and magneto motive force (m.m.f), Inductors, resistor-inductor (RL) transients, Time constant.

**UNIT–IV**
**AC Circuits** **[9]**

Introduction to a.c. waveforms, Definition of terminology, Average and effective values, Introduction to phasor notation, Response of basic R, L and C elements to a sinusoidal signal, Frequency response, Power factor, Series and parallel a.c. circuits, Impedance and phase diagram, Voltage divider rule for a.c circuits, Current divider rule for a.c. circuits, Power in a.c. circuits, The power triangle.

**UNIT–V**
**Resonance** **[9]**

Introduction to resonance, Series LCR resonant circuit, Q factor, Variation of impedance with frequency, Selectivity of a series resonant circuit, Parallel LCR resonant circuit, Qfactor, Selectivity curves, Application to tuned filters, Bode plots.

**Reference Books**

1. Introductory Circuit Analysis. 11th edition. Robert L. Boylestad (2006). Prentice Hall.
2. Fundamentals of Electric Circuits, 3rd Edition.Charles Alexander and MatthewSadiku (2006).McGraw Hill.
3. Electric Circuit Fundamentals (7th Edition). Thomas L. Floyd (2006).Prentice Hall.
4. Circuit Theory - Analysis and Synthesis, A. Chakrabarti, (2018), DanpatRai& Co.

## Circuit Theory Lab

**Choose any 6 experiments from the list given below:**

1. To verify Kirchhoff's Laws (KCL/ KVL).
2. To verify Thevenin's theorem
3. To verify Norton's theorem.
4. To verify maximum power transfer theorem.
5. To verify superposition theorem
6. To study of the rise and decay of current in RC circuit.
7. To study of the rise and decay of current RL circuits.
8. To study frequency response of series LCR Circuit and to determine its (a) resonant frequency and (b) the Q-factor.
9. To study frequency response of parallel LCR Circuit and to determine its (a) anti-resonant frequency and (b) the Q-factor.

**Reference Books:**


1. Practical Physics by G L Squires Cambridge University Press.
2. Advanced Practical Physics for Students by Worsnop and Flint.
3. Practical Physics by R K Shukla.
4. B.Sc Practical Physics by Harnam Singh.
5. B. Sc Practical Physics by C. L. Arora.
6. An Advanced Course in Practical Physics by D. Chattopadhyay, P.C. Rakshit.
7. A Text Book of Practical Physics, S.K. Ghosh, 2015, New Central Book Agency.

Annexure -IV

# STRUCTURE & SYLLABUS
for
# FOUR YEAR UNDERGRADUATE PROGRAMME (FYUGP)

## PHYSICS

**SHRI MATA VAISHNO DEVI UNIVERSITY**
**As per Curriculum and Credit Framework for Undergraduate Programmes**

**released by UGC, NEW Delhi under NEP-2020 Guidelines**

## Approved by the Board of Studies in Physics (11th Meeting) held on 7th March 2024

# School of Physics
Shri Mata Vaishno Devi University, Katra–182320,J&K,India

## Preamble

The National Education Policy (NEP) 2020 (hereafter referred to as NEP or Policy) has come as a major policy initiative in the domain of Education, To implement this mandate towards the realization of the broad objectives of the NEP 2020, the Shri Mata Vaishno Devi University has progressively initiated the implementation process of NEP w.e.f. A.Y 2022-23 by drafting a new curriculum as per requirements of NEP-2020. UGC has issued the Curriculum and Credit Framework document for Undergraduate Programmes which reflects the NEP's recommendations and the University has felt a need to initiate the four year undergraduate programme to attract best talent w.e.f. AY 2024-25. Accordingly, with the requirements of NEP 2020, the Board of Studies (BoS) in Physics, convened on 7th March 2024, approved the detailed course structure and syllabus for FYUGP in Physics for implementation for the batch to be admitted in 2024-25. This structure and contents have resulted out of curriculum development workshop which was held during 5-6, March, 2024 where emphasis had been laid on the development of a comprehensive understanding of the discipline to enable the students to develop and inculcate critical thinking and problem-solving skills so that they are ready to take on and holistically tackle the issues.

## Introduction

The NEP-2020 has presented us with a unique opportunity to overhaul the higher education system in India by shifting the approach of teacher centric to learner centric policy implementation. This documents lays lot of emphasis on the Outcome-Based Education, which requires desired graduate attributes to act as the foundation and basis for evolving new programs, courses, and supplementary activities so as to enable learners to attain desired learning outcomes. The Curriculum and Credit Framework for Undergraduate Programme in Physics has resulted out of two day brainstorming workshop held on 5-6, March, 2024 which was followed by 11th meeting of BoS (Physics) held on 7th March, 2024. The salient features of the same are to equip the students with a strong foundation in the subject and hone their abilities and skills so that they are able to perform to the best of their abilities in diverse professional careers and are able contribute meaningfully to the society at large. The framework lays emphasis on development of enquiring spirit, problem-solving aptitude, and promotion of rational and critical thinking.

As stated in the NEP 2020 that, "Assessments of educational approaches in undergraduate education that integrate the humanities and arts with Science, Technology, Engineering and Mathematics (STEM) have consistently shown positive learning outcomes, including increased creativity and innovation, critical thinking and higher-order thinking capacities, problem-solving abilities, teamwork, communication skills, more in-depth learning and mastery of curricula across fields, increase in social and moral awareness, etc., besides general engagement and enjoyment of learning". The policy also recommends that "the undergraduate degree will be of either 3 or 4-year duration, with multiple exit options within this period, with appropriate certifications, e.g., a UG certificate after completing 1 year in a discipline or field including vocational and professional areas, or a UG diploma after 2 years of study, or a Bachelor's degree after a 3-year programme. The 4-year multidisciplinary Bachelor's programme, however, shall be the preferred option since it allows the opportunity to experience the full range of holistic and multidisciplinary education in addition to the focus on the chosen major and minors as per the choices of the student". In accordance with the NEP 2020, the UGC has formulated a new student-centric "Curriculum and Credit Framework for Undergraduate Programmes (CCFUP)" which lays emphasis on and incorporates a flexible choice-based credit system, multidisciplinary approach, and multiple entry and exit options. This is expected to facilitate and enable students to pursue their career path by choosing the subject/field of their interest as per their needs.

In order to develop and implement such a holistic and multidisciplinary structure and curriculum, the framework for the FYUGP in Physics has been designed accordingly. The FYUGP in Physics in line with the broad mandate provided by the University comprises of six different types of courses- (i) Major Core courses, (ii) Minor stream courses, (iii) Multidisciplinary courses (GEC), (iv) Ability enhancement courses (AEC), (v) Skill Enhancement Courses (SEC), (vii) Value Added Courses common for all UG (vii) Summer Internship and (viii) Research Project / Dissertation (if applicable).

As stipulated in NEP-2020 the FYUGP in Physics features multiple exit options-

1. A Certificate after completing 1 year of study
2. A Diploma after completing 2 years of study
3. A Bachelor's degree after completion of a 3-year programme
4. A Bachelor's degree with Honours or Honours with Research after completion of a 4-year programme

## Objectives

The objectives of FYUGP in Physics are:

1. To provide a conducive environment for students to apply the basic principles acquired to make them interested in deep pursuits of concepts and principles of Physics.
2. To hone and harness their skills towards experimentation so that they can apply the concepts and principles in an experiential setting.
3. To motivate them to apply the knowledge and skills to real-life problems being faced by society at large.
4. To provide exposure to students about various career opportunities and to motivate them to pursue physics in the long run.
5. To motivate students to pursue interdisciplinary and cross-disciplinary courses so that they emerge as holistic problem solvers.
6. To provide exposure to industrial scenarios through the medium of Internship/ project-based learning.

The proposed curriculum has exposure to career prospects in physics or to become successful entrepreneurs so that the students can become job providers rather than just job seekers. Necessary training shall be ensured through the basket of Skill Enhancement/ Ability Enhancement Courses/ Exposure to industry. Students shall also be exposed to Indian Knowledge System appropriately during their stay on Campus.

## Graduate Attributes

The graduate attributes for students who would pursue FYUGP in Physics are expected to equip them with the required knowledge and skill set broadly mandated by NEP-2020. They are also expected to train them to face the prevalent challenges and succeed in their area of interest which they may choose or pursue as part of their career. Some of the possible attributes attached to FYUGP in Physics are as follows:

1. Graduates in Physics should be able to possess capabilities that would assist them in broadening their current knowledge base and skills and to aid them in gaining and applying new knowledge and skills.
2. They should be able to undertake future studies independently and perform well in a chosen career, play a constructive role as a responsible citizen in society.
3. They should be able to possess excellent interpersonal skills so that they can communicate their ideas and findings through oral, written, and visual means to diverse audiences at State/ National/ International levels.
4. They should be able to translate raw data into meaningful information after analyzing the same and be able to identify and define problems to arrive at possible decisions driven by reasoning and evidence.
5. They should be able to hone and harness their observational skills in a self-driven approach besides the mentoring from teachers and peers to be able to pose inquisitive questions in individual as well as team settings.
6. They should be able to plan, organize, and conduct project-based studies.
7. They should be fully aware and proficient with the Digital and ICT tools including associated software aspects of such tools as far as possible.
8. They should possess strong ethical standing and be able to see things through the prism of ethics including senility towards social, cultural, and environmental impacts.
9. They should be abreast with recent happenings at National and International levels in their domain of interest to be able to constantly progress towards being true global citizens.

## Programme Learning Outcomes

Outcome based education is at the core of NEP 2020, which underscores the importance of course wise learning outcomes. For the FYUGP in Physics, following are the programme learning outcomes:

On successful completion of the programme students are expected to be in a position to demonstrate understanding through comprehension and application of fundamental principles and concepts of physics, including classical mechanics, electromagnetism, thermodynamics, quantum mechanics, and statistical mechanics etc. as part of major discipline. Similarly they shall also be able to demonstrate similar comprehension levels in the chosen minor area.

Students are expected to have acquired the ability of application of their basic knowledge of physical concepts and principles to analyze and resolve problems of varying nature, by applying relevant mathematical, experimental, and or computational tools at their command.

They are expected to acquire the ability to undertake inquiry-based research and development activities, through planning and executing experiments, assimilation and evaluation of data, and clear, simple and effective communication their findings to the community effectively through both written and oral presentations, utilizing suitable scientific language and tools.

Students are expected to possess sufficient exposure to the ethical and social implications of their work and be able to display dedication and commitment to ethical and responsible conduct in all their activities.

Students are expected to be able to possess interdisciplinary and multidisciplinary exposure and knowledge while being conscious of environmental implications.

The NEP 2020 also emphasizes multiple entry and multiple exit options for students after completion of different durations in a specific programme of study. The program learning outcomes for each exit option are as follows:

**Certificate (after completing 1year of study):**

1. Be able to acquire basic understanding of fundamental concepts related to the major field of study.
2. Be able to acquire a basic set of skills as imparted in the first year.
3. Be able to apply the basic knowledge and skills acquired to real-world problems.

**Diploma (after completing 2 years of study):**

1. Be able to acquire a deeper understanding of the fundamental concepts related to the major field of study.
2. Be able to acquire an advanced set of skills as imparted in the first and second year of study.
3. Be able to apply the advanced knowledge and skills to real-world problems.

**Bachelor's Degree (after completing a 3-year programme):**

1. Be able to acquire and display c omprehensive understanding of the fundamental concepts related to the major field of study and allied disciples to which he/ she has been exposed.
2. Be able to pick up skills and demonstrable competencies.
3. Be able to apply the knowledge and skills acquired to real-world problems.
4. Be able to undertake independent study or minor research.
5. Be able to possess effective communication and presentation skills.
6. Be able to conduct work in an ethical and just manner.

**4-Year Bachelor's Degree:**

1. All the learning out comes after 3years Bachelor Degree.
2. Be able to integrate multidisciplinary perspective while pursuing Major in Physics.
3. Be able to undertake and engage in multidisciplinary research work.

4. Develop leadership and team work skills.

# Teaching-Learning Process

The NEP2020 has brought about a revolutionary change in the way education is to be delivered. There is lot of emphasis on outcome based education integrated with choice based credit system. Education system in India, as a fortuitous coincidence our University since inception has been following IIT model so far has teaching learning processes are concerned. Each and every course is to be designed with specific objectives and outcomes in mind.

The pedagogy in SMVDU has always been based on the **L+T+P** model where **L**, **T**, and **P** stand for Lecture, Tutorial, and Practical respectively. This approach allows delivery of a well-rounded education which has all the requisite elements of theoretical knowledge, practical experience, and personal development.

The teaching method for a theory course includes lectures, tutorials etc. which are supplemented by the prescribed textbooks, reference books, e-resources, and self-study besides peer learning. All these components provide a student with an opportunity to get sufficient exposure towards all the elements of the learning tree.

To establish the synergy between the theory and practical work, laboratory courses have been carefully designed to provide experiential learning environment to the students. Students are expected to experience a joyous learning environment which are expected to compel them to spend long hours in the laboratory.

All the above activities are conducted by adopting a holistic approach to education while keeping in mind the outcome-based approach so as to allow students pick up critical thinking skills, problem-solving skills, communication skills, and an aptitude for teamwork.

The students of FYUGP will have the option of earning a major Degree in Physics besides earning a minor Degree in a subject of their choice out of the basket of subject as may be available to them. For instance it is possible that a student may be able to qualify for the award of a 3 year UG Degree in Physics (if he/she has completed at-least 50% of Major courses from Physics) and a minor Degree in Computer Science, Mathematics, Electrical Science, Business Administration, economics etc. if he/ she has completed a minimum of 12 credits from the basket of Minor courses from a particular subject. This unique blend of Science, Engineering, Management, Humanities courses is expected to position our students on a distinct platform with a skill set that will help them succeed in the future goals.

### Structure of the Undergraduate Programme

The FYUG programme will consist of the following categories of courses and the minimum credit requirements for 3-year UG and 4-year UG (Honours) or UG (Honours with Research) programmes are given below:

Table 1: Minimum Credit Requirements to Award Degree under Each Category

| S. No. | Broad Category of Course | Minimum Credit Requirement | |
|---|---|---|---|
| | | 3-year UG | 4-Year UG |
| 1 | Major (Core) | 60 | 80 |
| 2 | Minor Stream | 24 | 32 |

| | | | |
|---|---|---|---|
| 3 | Multidisciplinary | 09 | 09 |
| 4 | Ability Enhancement Courses (AEC) | 09 | 09 |
| 5 | Skill Enhancement Courses (SEC) | 08 | 08 |
| 6 | Value Added Courses common for all UG | 08 | 08 |
| 7 | Summer Internship | 02 | 02 |
| 8 | Research Project / Dissertation | -- | 12 |
| 9 | Total | 120 | 160 |

Note:* Honours students not undertaking research will do 3 courses for 12 credits in lieu of a research project/ Dissertation

## Assessment Methods

The outcome-based education emphasizes the importance of measuring the learning outcomes of students. Assessment is an integral part of the pedagogy for FYUGP in Physics. The assessment methods used are designed to evaluate the understanding of the subject matter, the ability to apply theoretical knowledge to practical situations, and the development of critical thinking skills.

All the Core and Minor courses of the FYUGP in Physics are designed with 4 credits, while those of Generic Elective and Skill Enhancement courses (GEC and SEC) are 3-credit courses. The entire assessment of a 3-credit/ 4-credit course will be performed over a total of 100 marks, out of which 50 marks is allotted to an Major examination and 20 marks each are assigned to Minor I and Minor II examinations besides 10 marks for Assignment/ Quiz. The total of 50 marks in the End-semester examination for a particular course is distributed over different units as per corresponding weightage and content of the unit. The question paper should contain short answer type questions, problem solving questions and descriptive type questions. During the semester evaluation shall be done in a continuous mode throughout the semester.

## School of Physics, Shri Mata Vaishno Devi University

### Credit Frameworkof the Four Year Undergraduate Programme in Physics as per NEP-2020 &NCrFforthe batch to be admitted in AY 2024-25

| Semester | I | II | III | IV | V | VI | VII | VIII | |
|---|---|---|---|---|---|---|---|---|---|
| Courses | UG Certificate | | UG Diploma | | UG Degree (3 yrs) | | | 4 Yrs UG Honours | 4 Yrs UG Honours with Research |
| Major Course | 4-Credits (100 Levels) | 4-Credits (100 Levels) | 8-Credits (2 courses) (200 Levels) | 16-Credits (4 courses) (200 Levels) | 12-Credits (3 courses – 4 Credits each) (300 Levels) | 16-Credits 4 courses – 4 Credits each) (300 Levels) | 16-Credits (4 courses – 4 Credits each) (400 Levels) | 16-Credits (4 courses – 4 Credits each) (400 Levels) | 4-Credits (1 course – 4 Credits) (400 Levels) |
| Minor Course | 4-Credits (100 Levels) | 4-Credits (100 Levels) | 4-Credits (200 Levels & above) | 4-Credits (200 Levels & above) | 4-Credits (200 Levels & above) | 4-Credits (200 Levels & above) | 4-Credits (300 Levels & above) | 4-Credits (300 Levels & above) | 4-Credits (300 Levels & above) |
| Multidisciplinary (MD) | 3-Credits | 3-Credits | 3-Credits | ----- | ----- | ----- | ----- | ----- | ----- |
| Ability Enhancement Course (AEC) | 3-Credits | 3-Credits | 3-Credits | ----- | ----- | ----- | ----- | ----- | ----- |
| Skill Enhancement Course (SEC) | 2-Credits | 2-Credits | 2-Credits | ----- | 2-Credits | ----- | ----- | ----- | ----- |
| Value Added Course (VAC) | 4-Credits (2 courses – 2 Credits each) | 4-Credits (2 courses – 2 Credits each) | | ----- | ----- | ----- | ----- | ----- | ----- |
| Skill Development/ Training/ Laboratory Skills/ Summer Internship/ Project/ Dissertation | | | | | 2-Credits (IAPC) | | 2-Credits Project-I (*Optional) | | 12-Credits (Research Project/ Dissertation) |
| Total Credits (120 Credits) – 3 Yr UG Degree (160 Credits) – 4 Yr UG Degree + 2 Credits Optional | 20-Credits | 20-Credits | 20-Credits | 20-Credits | 20-Credits | 20-Credits | 20-Credits + 2-Credits (Optional) | 20-Credits | 20-Credits |

* For Honours with Research Students

# School of Physics, Shri Mata Vaishno Devi University

## Course Structure as per NEP-2020 &UGC Guidelines for the Four Year Undergraduate Programme (FYUGP) in Physics and detailed contents with COs applicable for batch to be admitted in AY 2024-25

(Course Codes shall be incorporated in consultation with the Examination Wing of the University)

| | First Year | | Certificate [Level-5] | Second Year | | Diploma [Level-6] | Third Year Bachelor's Degree [Level-7] | | Fourth Year Bachelors Degree (Level-8) | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Semester/ Type of Course | I | II | | III | IV | | V | VI | VII | VIII (Hons.) | VIII (Hons.+Research) |
| Major Course | Newtonian Mechanics (3-0-0)<br><br>Newtonian Mechanics Lab (0-0-2) | Applied Optics (3-0-0)<br><br>Applied Optics Lab (0-0-2) | | Analog Electronics (3-0-0)<br><br>Analog Electronics Lab (0-0-2)<br><br>Mathematical Methods-I(3-1-0) | Digital Fundamentals (3-0-0)<br><br>Heat and Thermodynamics(3-0-0)<br><br>Electromagnetic Interactions (3-0-0)<br><br>Waves and Oscillations (3-0-0)<br><br>Heat and Wave Propagation Lab(0-0-4)<br><br>Electromagnetic Interactions and Digital Fundamentals Lab(0-0-4) | | Elements of Statistical Physics (3-1-0)<br><br>Classical Mechanics (3-1-0)<br><br>Atomic and Molecular Physics (3-0-0)<br><br>Atomic and Molecular Physics Lab (0-0-2) | Mathematical Methods-II (3-1-0)<br><br>Quantum Mechanics-I (3-0-0)<br><br>Introductory Solid State Physics (3-1-0)<br><br>Modern Physics Lab (0-0-2)<br><br>DSE (CE)-I (Basket-1) | Quantum Mechanics-II (3-1-0)<br><br>An Introduction to Research Methods (1-0-6)<br><br>Computational Physics (2-0-4)<br><br>Condensed Matter Physics (3-0-0)<br><br>Condensed Matter Physics Lab (0-0-2)<br><br>Project-I (0-0-4) [For Hons. with research] | Electrodynamics and Plasma (3-1-0)<br><br>DSE (CE)-II (Basket-2) 4 credits<br><br>DSE (CE)-III (Basket-3) 4 credits<br><br>DSE (CE)-IV (Basket-4) 4 credits | Electrodynamics and Plasma (3-1-0)<br><br>Project/ Dissertation (0-0-24) |
| Minor Course | @Choose one Minor Course form the Basket of courses offered by any alliedSchool | | | | | | | | | | |
| Multidisciplinary (MD) | Choose one Minor Course form the Pool of courses offered by other schools MD-I 3-0-0 (3 credits) | Choose one Minor Course form the Pool of courses offered by other schools MD-II 3-0-0 (3 credits) | | Choose one Minor Course form the Pool of courses offered by other schools MD-III 3-0-0 (3 credits) | | | | | | | |

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **Ability Enhancement Course (AEC)** | Choose one course from the pool of courses from AEC-I **(3 credits)** | Choose one course from the pool of courses from AEC-II **(3 credits)** | | Choose one course from the pool of courses from AEC-III **(3 credits)** | | | | | | | |
| **Skill Enhancement Course (SEC)** | Choose one course from the pool of courses from SEC-I **(2 credits)** | Choose one course from the pool of courses from SEC-II **(2 credits)** | | Choose one course from the pool of courses from SEC-III **(2 credits)** | | | Choose one course from the pool of courses from SEC-IV **(2 credits)** | | | | |
| **Value Addition Course (VAC)** | Choose two courses from the pool of courses from VAC-I & VAC-II **(4 credits: 2 courses of 2 credits each)** | Choose two courses from the pool of courses from VAC-III & VAC-IV **(4 credits: 2 courses of 2 credits each)** | | | | | | | | | |
| **Skill Development/ Training/ Laboratory Skills/ Summer Internship/ Project/ Dissertation** | | | **[An exit 4 credit skill enhancement course]** | | | **[An exit 4 credit skill enhancement course]** | **IAPC [2 credits]** | | | Dissertation/ Project **(0-0-24) [12 credits]** | |
| **Total Credits** | 20 | 20 | 4 | 20 | 20 | 4 | 20 | 20 | 20+2* | 20 | 20 |
| **Exit Options** | | | **Certificate [44 credits]** | | | **Diploma [84 credits]** | | **Bachelor's Degree [120 credits]** | *Optional For Research Student | **Bachelor's Degree Hons. [160 credits]** | **Bachelor's Degree Res. [160+2 credits]** |

## Minor Courses offered equal to 24 credits (for B.Sc.) and 32 credits (for B.Sc. Hons.) offered by SoP to the other schools

| | First Year | | | Second Year | | | Third Year | | Fourth Year | |
|---|---|---|---|---|---|---|---|---|---|---|
| **Semester/ Course Typer** | **I** | **II** | | **III** | **IV** | | **V** | **VI** | **VII** | **VIII** |
| **Minor Course** | Newtonian Mechanics **(3-0-0)**<br><br>Newtonian Mechanics Lab **(0-0-2)** | Applied Optics **(3-0-0)**<br><br>Applied Optics Lab **(0-0-2)** | | Analog Electronics **(3-0-0)**<br><br>Analog Electronics Lab **(0-0-2)** | Heat and Thermodynamics **(3-0-0)**<br>Heat and Thermodynamics Lab **(0-0-2)**<br>**OR**<br>Electromagnetic Interactions **(3-0-0)**<br>Electromagnetic Interactions Lab **(0-0-2)**<br>**OR**<br>Waves and Oscillations **(3-0-2)**<br>Waves and Oscillations Lab **(0-0-2)** | | Mathematical Methods-I **(3-1-0)**<br>**OR**<br>Classical Mechanics **(3-1-0)**<br>**OR**<br>Atomic and Molecular Physics **(3-0-0)**<br>Atomic and Molecular Physics Lab **(0-0-2)** | Quantum Mechanics-I **(3-1-0)**<br>**OR**<br>Introductory Solid State Physics **(3-1-0)** | Quantum Mechanics-II **(3-1-0)**<br>**OR**<br>Condensed Matter Physics **(3-0-0)**<br>Condensed Matter Physics Lab **(0-0-2)**<br>**OR**<br>Elementary Statistical Mechanics **(3-1-0)** | Mathematical Methods-II **(3-1-0)** |

Minors from Allied Schools (Min. 12 Credits out of a total of 24 Credits for 3 year Degree Course/ Min. 16 Credits out of a total of 32 Credits for 4 year Degree Course). Rest 12/16 credits shall be at the discretion of the student.

1. School of Computer Science & Engineering
   a. AI & ML
   b. Cyber System Security
   c. CSE General Basket
2. School of Electrical Engg.
   a. Power Electronics
   b. Control Systems
   c. Energy Management
3. School of Electronics and Communication Engineering
   a. VLSI Design
   b. Millimeter Wave Technology
   c. Embedded Systems and Networks
   d. Multimedia Technologies
4. School of Mechanical Engineering
5. School of Mathematics

6. School of Biotechnology
7. School of Business
8. School of Economics
9. School of Energy Management

* The minors' baskets of the allied schools being dynamic in nature shall be updated from time-to-time by the AAC of the School of Physics and shall be reported to the BoS. If a student completes 50% of the minor credits from a basket in a given area, then he/ she will be eligible to receive minor degree in that area.

## Multidisciplinary Courses offered by SoP to the other schools in this programme

| | First Year | | | Second Year | |
|---|---|---|---|---|---|
| Semester/ Course Typer | MD-I | MD-II | | MD-III | |
| Multidisciplinary Course (MD) | Quantum in Everyday Life 3-0-0 (3 credits) | Lasers and Its Applications 3-0-0 (3 credits) | | Nanotechnology for Beginners 3-0-0 (3 credits) | |

## Discipline Specific Elective-DSE (Core Electives) CE-1 offered by the school in Semester VI

| S. No. | Course Name | Course Code | L-T-P | Credits |
|---|---|---|---|---|
| 1. | Essentials of Nano-Physics | PHL XXXX | 3-1-0 | 4 |
| 2. | Nuclear Radiation: Energy, Medicine and Agriculture | PHL XXXX | 3-1-0 | 4 |
| 3. | Measurements and Analysis | PHL XXXX | 2-0-4 | 4 |

# Detailed Syllabi for FYUP in Physics

## Semester - I

### Major-1 (Part –A)

## NewtonianMechanics (PHL-1023) (3-0-0)

### *Learning Objectives*

*This course aims to review the concepts of mechanics learnt at school in a more advanced perspective and progressively builds up new concepts. The students will be able to apply the learnt concepts to many real world problems.*

### *Course Outcomes:*

*After completing this course, the students will be able to*

- *Apply the principles of non-inertial systems and fictitious forces to analyze motion in accelerating and rotating frames.*
- *Develop the ability to apply conservation laws to solve problems related to collisions in different reference frames.*
- *Apply the principles of central force motion to analyze and interpret planetary motion.*
- *Students will demonstrate a comprehensive understanding of angular velocity, angular momentum, and their vector nature in rigid body motion.*

**Unit-I**
**Non-Inertial Systems and Fictitious Forces** **[12]**

Unit vectors, Displacement, Velocity, Acceleration, Area and Volume elements in Cartesian and Plane Polar coordinates, Dynamics Using Polar Coordinates; Galilean Transformation; Uniformly Accelerating Systems; The Principle of Equivalence; Physics in a Rotating Coordinate System–Rate of Change of a Rotating Vector, Time Derivative of a Vector, Velocity and Acceleration, Fictitious Forces in a Rotating Coordinate System.

**Unit-II**
**Collisions and Conservation Laws** **[10]**

Concept Centre of Mass; Elastic Collision in Laboratory and Centre of MassCoordinates; Relationship between Displacement, Velocities, Kinetic energies and Angles in Laboratory and Centre ofMass Coordinates.

**Unit-III**
**Central Force Motion** **[10]**

Central Force Motion as a One-body Problem; Universal Features of Central Force Motion –Consequences of the Conservations of Angular Momentum and Energy, The Effective Potential, The Formal Solution for Central Force Motion; The Energy Equation and Energy Diagrams; Planetary Motion – Hyperbolic Orbits, Elliptic Orbits and Planetary Motion.

**Unit-IV**
**Rigid Body Motion** **[10]**

The Vector Nature of Angular Velocity andAngular Momentum;The Gyroscope; Examples of Rigid Body Motion;Conservation of Angular Momentum; Rigid Body Rotation – Angular Momentum and the Tensor of Inertia, Principal Axes, Rotation of a Rigid Body, Rotational kinetic energy, Euler forces, Euler angles, symmetric top

**Text Book:**

1. An Introduction to Mechanics, 2nd Ed., D. Kleppner, R. Kolenkow, McGraw-Hill, 2014 (Textbook).

**Suggested Reading(s):**

2. Mechanics, Berkeley Physics, vol.1, C. Kittel, W. Knight, et al., Tata McGraw-Hill, 2007.
3. Mechanics, D.S. Mathur, S.Chand and Company Limited, 2000.

**Major-1 (Part –B)**

## Newtonian Mechanics Lab (PHP-1023) (0-0-2)

### *Course Outcomes:*

*After completing this course, the students will be able to*

- *Use various instruments for measurements and perform experiments related to rotational dynamics, elastic properties, fluid dynamics, acceleration due to gravity, collisions, etc.*
- *Learn to estimate the error for every experiment performed and report the result of experiment along with the uncertainty in the result up to correct significant figures.*

**Choose a minimum of 5 experiments from the list given below:**

1. To determine the Young's modulus of material of a metallic bar by bending of beam method.
2. To determine the coefficient of viscosity of highly viscous liquid by Stoke's method.
3. To find the surface tension of water by Jaeger's Method.
4. To determine the value of 'g' using bar pendulum.
5. To determine the Moment of Inertia of a Flywheel.
6. To determine the Elastic constants of a wire by Searle's method.
7. To find modulus of rigidity by Maxwell's needle.
8. To determine the moment of inertia of objects of regular shapes (rod, sheet, cylinder, sphere, spherical shell) and verify the parallel and perpendicular axes theorems.
9. To study oscillations of a bifilar pendulum.

**Suggested Reading(s):**

1. Advanced Practical Physics for Students, Worsnop and Flint, Methuen & Co. Ltd., 1957.
2. B. Sc. Practical Physics, C. L. Arora, S. Chand., 2001

# Semester II

**Major-2 (Part –A)**

## Applied Optics (PHL 3153) (3-0-0)

### *Learning Objectives*

*This course aims to apply the concepts of Optics learnt at school in a more advanced perspective and progressively builds up new concepts. The students will be able to apply the learnt concepts to many real world problems.*

### *Course Outcomes:*

*After completing this course, the students will be able to*

- *Analyze the historical developments in understanding thermal radiation and the resolution of the Ultraviolet Catastrophe through Planck's Radiation Law.*
- *Evaluate the different types of lasers, including semiconductor lasers, and their characteristics.*
- *Evaluate the properties of holograms and classify them based on their characteristics.*
- *Explain the principles of total internal reflection and its role in the propagation of light through optical fibers.*

**Unit-I** **[12]**
**Mechanism of Light Emission**

Introduction; Oscillating Electric Dipole; Thermal Radiation; The Ultraviolet Catastrophe; ThePlanck's Radiation Law; The Photon; Photoelectric Effect; Compton Effect; Spectrum and Spectral Lines; Atomic Structure; De Broglie Hypothesis; Heisenberg Uncertainty Principle;Wave Functions; Schrödinger Wave Equation;The Wave Mechanical Model of Atom; TheStructure of the Atom; Wave Mechanical Explanation of Photon Emission; Properties ofSpectral Lines; Luminescence; Scattering

**Unit-II** **[12]**
**Lasers**

Introduction; Attenuation of Light in anOptical Medium; Thermal Equilibrium;Interaction of Light with Matter; EinsteinCoefficients and Their Relations; LightAmplification; Meeting the three Requirements; Components of Laser; Lasing Action;Principal Pumping Schemes; Role of ResonantCavity; Modes of the Laser Beam; TransverseModes; Types of Lasers; SemiconductorLaser; Laser Beam Characteristics; Applications.

**Unit-III** **[8]**
**Holography**

Introduction; Principle of Holography; Coaxial Holography; Off-axis Holography;Holograms; Important Properties of Hologram; Classification of Holograms Applications; Medical Applications of Holography.

**Unit-IV** **[12]**
**Fibre Optics**

Introduction; Optical Fibre; Total InternalReflection; Propagation of Light Through an opticalfibre; Fractional Refractive Index Change;Numerical Aperture; Skip Distance and Number ofTotal Internal Reflections; Modes of Propagation;Types of Rays; Classification of Optical Fibres;Three Types of Fibres; Materials; V-Number–Fabrication–Losses in Optical fibre–Distortion–Bandwidth–Characteristics of the Fibres–Splicing–Application; Fibre Optic Communication System;Merits of Optical fibres; Fibre Optic Sensors.

**Text Book:**

1. Optics, A. Ghatak, 6th Ed., Mc Graw Hill Education, 2017

**Suggested Reading(s):**

2. A Textbook of Optics, Subramanyam, Brij Lal and Avadhanulu, S. Chand & Co., 2020

**Major-2 (Part –B)**

## Applied Optics Lab (PHL 3153) **(0-0-2)**

***Course Outcomes:***

*After completing this course, the students will be able to*

- *Use various instruments for measurements and perform experiments related to interference, diffraction, holography, optical fibres etc.*
- *Learn to estimate the error for every experiment performed and report the result of experiment along with the uncertainty in the result up to correct significant figures.*

**Choose any 6 experiments from the list given below:**

1. To find the width of the wire or width of the slit using diffraction pattern obtained by a He-Ne or solid state laser.
2. To determine the wavelength and angular spread of laser light by using plane diffraction grating.
3. Optical image addition/subtraction.
4. Optical image differentiation
5. Recording and reconstruction of holograms (Computer simulation can also be done).
6. To determine the wavelength of sodium light by using Michelson"s interferometer.
7. To measure the numerical aperture of an optical fibre.
8. To measure the near field intensity profile of a fibre and study its refractive index profile.
9. To study the variation of the bending loss in a multimode fibre

**Suggested Reading(s):**


1. Fibre optics through experiments, M.R.Shenoy, S.K.Khijwania, et.al. 2009, Viva Books.
2. Introduction to Fourier Optics, Joseph W. Goodman, Tata McGraw- Hill, 1996.
3. An advanced course in Practical Physics: D. Chattopadhyay& P.C. Rakshit (New Central Book Agency).


## Semester III

### Major-3 (Part –A)

## Analog Electronics (PHL 2051) (3-0-0)

### *Learning Objectives*

*This course aims to learn the core concepts of Analog Electronics learnt at school in a more advanced perspective and progressively builds up new concepts. The students will be able to apply the learnt concepts to many real world problems.*

### *Course Outcomes:*

*After completing this course, the students will be able to*

- *Develop proficiency in resolving, understanding and designing simple circuits.*
- *Apply diode principles to solve real-world circuit problems.*
- *Apply BJT principles to design amplifiers for specific frequency ranges.*
- *Understand characteristics of Op-Amps and their use in designing basic circuits including oscillators.*

**UNIT-I**
**Circuit Theory** **[10]**

Voltage and Current sources, Conversion of current source to voltage source and vice versa, Series-Parallel Circuits, Voltage Dividers and Current Dividers, Kirchhoff's Laws, Node-Voltage Analysis, Mesh-Current Analysis, Superposition Theorem, Thevenin's Theorem and Norton's Theorem, Thevenin-Norton Conversions.

**UNIT-II**
**PN-Junction Diode and Applications** **[10]**

Diode operation, V-I characteristics, Half-Wave Rectifiers, Full-Wave Rectifiers, Power Supply Filters and Regulators, Diode Limiters and Clampers, Zener Diode and its Applications

**UNIT-III**
**Bipolar Junction Transistors** **[12]**

Basic BJT Operation, BJT Characteristics and Parameters, BJT Operating Regions, The DC operating point, Voltage divider bias, Other Bias Methods, BJT Amplifier operation, Single stage RC coupled CE-amplifier, Frequency response curve (qualitative)

**UNIT-IV**
**Operational Amplifiers and Oscillators** **[13]**

Operational Amplifier, Op-Amp Input modes and Parameters, Bias current and offset voltage, Basic Op-Amp Circuits- Comparator, Summing Amplifiers, Integrator and Differentiators, Concept of feedbacks in Op-Amps, Oscillators, Barkhausen criterion, RC oscillators (Wein-bridge & Phase-shift), The 555 timer as an oscillator.

**Text Book:**

1. Electronic Devices, Thomas L. Floyd (9e) (Textbook).

**Suggested Reading(s)**

2. Grob's Basic Electronics: Mitchel E. Schultz (11e).

**Major-3 (Part –B)**

## Analog Electronics Lab (PHP 2051) (0-0-2)

***Course Outcomes:***

*After completing this course, the students will be able to*

- *Use various electronic instruments for measurements and perform experiments related to circuit theory, diodes, transistors and Op-Amps.*
- *Learn to estimate the error for every experiment performed and report the result of experiment along with the uncertainty in the result up to correct significant figures.*

**Every student must perform at least 5 experiments as listed below, however additional experiments can be identified by the course coordinator to complete this requirement.**

1. To verify Kirchhoff's Laws (KCL/ KVL).
2. To verify Thevenin's theorem
3. To verify Norton's theorem.
4. To study PN junction diode characteristics (forward & reverse).
5. To draw V-I characteristics of Zener diode and to study it as a voltage regulator.
6. To find the Ripple factor of Half wave rectifier with different filters.
7. To find the Ripple factor of Full wave rectifier with different filters.
8. To draw characteristics of common base NPN/ PNP transistor.
9. To draw characteristics of common emitter NPN/ PNP transistor.
10. To draw the JFET characteristics.

**Suggested Reading(s):**

1. Basic Electronics A Text-Lab Manual, Zbar, Malvino, Miller, 7th Ed. McGraw Hill
2. Fundamentals of Electric Circuits, Charles K. Alexander, McGraw-Hill, 2004

Major-4

# Mathematical Methods-I
# (PHL 2033) (3-1-0)

### *Learning Objectives*

*This course aims to learn the core concepts of Mathematical Methods learnt at school in a more advanced perspective and progressively builds up new concepts. The students will be able to apply the learnt concepts to many real world problems.*

### *Course Outcomes:*

*After completing this course, the students will be able to*

- *Apply probability theory to solve problems related to random variables*
- *Demonstrate proficiency in working with Plane Polar Coordinates, Spherical Polar Coordinates, and Circular Cylindrical Coordinates.*
- *Analyze and interpret physical situations using vector analysis and integral theorems.*
- *Apply techniques to solve linear first-order ODEs with constant coefficients.*

**UNIT-I**
**Elements of Probability Theory [10]**

Probability: Definitions, Simple Properties, Random Variables, Binomial Distribution, Poisson Distribution, Gauss' Normal Distribution

**UNIT-II**
**Coordinate Systems [10]**

Unit vectors, displacement vector, area elements and volume elements in Cartesian Coordinates, Plane Polar Coordinates, Spherical Polar Coordinates and Circular Cylindrical Coordinates.

**UNIT-III**
**Vector Analysis [12]**

Review of Basics Properties of vectors, Vector in 3-D Spaces, Differential Vector Operators (gradient, divergence and curl), Properties of Differential Vector Operators, Vector Integrations- Line, surface and volume integrals, Green's theorem (in a plane), Stoke's theorem, Gauss's divergence theorem

**UNIT-IV**
**First Order Differential Equations (ODE) [10]**

First Order Equations- Separable equations, Exact differentials, Equations homogeneous in x and y, Linear first order ODE, ODEs with constant coefficients

**Text Book:**

1. Mathematical Methods for Physicists: Arfken, Weber and Harris (7e) (Textbook).

**Suggested Reading(s):**

2. Mathematical Physics: Dass and Verma, S. Chand (8e) 2018

# Semester - IV

## Major-5 (Part –A)

## Digital Fundamentals (PHL 2052) (3-0-0)

### *Learning Objectives*

*This course aims to learn the core concepts of Digital Electronics learnt at school in a more advanced perspective and progressively builds up new concepts. The students will be able to apply the learnt concepts to many real world problems.*

### *Course Outcomes:*

*After completing this course, the students will be able to*

- *Apply number system conversions and their arithmetic to solve practical problems.*
- *Solve practical problems in logic simplification using Boolean algebra techniques.*
- *Apply combinational logic circuits in real-world applications such as arithmetic operations and data manipulation.*
- *Apply sequential logic elements in the design of practical circuits.*

**UNIT-I**
**Number Systems and Logic Gates** **[12]**

Number systems and their conversions: Decimal, binary and hexadecimal, binary arithmetic, binary coded decimal, Logic Gates – NOT, AND, OR, NAND, NOR, EX-OR and EX-NOR, Universal property of NAND and NOR gates.

**UNIT-II**
**Boolean Algebra and Logic Simplification** **[12]**

Boolean operations and expressions, Laws of Boolean algebra, DeMorgan's Theorems, Boolean analysis of logic circuits, Logic simplification using Boolean algebra, Standard forms of Boolean expressions, Boolean expressions and truth tables.

**UNIT-III**
**Combinational Logic** **[11]**

Basic combinational logic circuits, Combinational logic using NAND and NOR gates, Half and Full adders, Parallel binary adders, comparators, decoders, encoders, multiplexers, de-multiplexers, parity generators/ checkers.

**Unit-IV**
**Sequential logic** **[8]**

Latches, Flip-Flops- Operating characteristics and applications, one-shots, Astablemultivibrators

**Text Book:**

1. Digital Fundamentals: Floyd 11(e), Pearson (Textbook).

**Suggested Reading(s):**

2. Modern Digital Electronics: R.P. Jain, 4e (2009), TMH.

Major-6 (Part –A)

# Electromagnetic Interactions (PHL 1029) (3-0-0)

### *Learning Objectives*

*This course aims atfamiliarizing the students with the fundamental concepts and laws in Electricity and Magnetismusing standard mathematical toolsand applying the knowledge of gained in this field to explain natural physical processes and related technological advances.*

### *Course Outcomes:*

*After completing this course, the students will be able to*

- *Understand the concepts of divergence and curl of the electric field (E).*
- *Evaluate the polarization of dielectrics and understand the role of the polarization vector (P) and bound charges.*
- *Understand and apply boundary conditions for the magnetic field (B).*
- *Understand and apply Maxwell's equations, the continuity equation, and Poynting's Theorem.*
- *Apply the principles learned to solve problems related to wave propagation and reflection in different media.*

**Unit I**
**Electrostatics** **[12]**

Divergence and Curl of E, Electric Potential, Energy of a point charge and that of a continuous charge distribution, Polarization of Dielectrics, Polarization vector P, Bound charges, The field inside a dielectric, The electric displacement, Gauss's law in presence of dielectrics, Boundary conditions for E, Susceptibility, Permittivity and Dielectric Constant

**Unit II**
**Magnetostatics** **[12]**

Lorentz Force Law, Line, Surface and Volume current densities, Equation of continuity, Div and Curl of B, Magnetic vector potential A, Boundary conditions for B, Bound currents and their physical interpretation, The magnetic field inside the matter, Auxiliary magnetic field H, Ampere's law in magnetic materials, Boundary conditions for H, Magnetic susceptibility and Permeability

**Unit III**
**Electrodynamics** **[8]**

Faraday's Law, The induced electric field, Inductance, Energy in magnetic fields, Maxwell's equations, The Continuity equation, Poynting's Theorem

**Unit IV**
**Electromagnetic Waves in Matter** **[10]**

Propagation in linear media, Reflection and Transmission in normal and oblique incidence, Electromagnetic waves in conductors, Reflection at a conducting surface, Dispersion of electromagnetic waves (elementary idea)

**Text Book:**

1. Introduction to Electrodynamics, D. J. Griffiths, 4th Ed. Pearson (Textbook).

**Suggested Reading(s):**

2. Schaum's Outline of Electromagnetics, 4th Ed., J. A. Edminister, TMH

Major-5 & 6 (Part –B)

## Electromagnetic Interactions and Digital Lab (PHP 1029) (0-0-2)

### *Course Outcomes:*

*After completing this course, the students will be able to*

- *Use various instruments for measurements and perform experiments related to Electricity and Magnetism.*
- *Use various electronic instruments for measurements and perform experiments related to Logic gates, Adders and Flip-flops.*
- *Learn to estimate the error for every experiment performed and report the result of experiment along with the uncertainty in the result up to correct significant figures.*

**Every student must perform at least 6 experiments as listed below, however additional experiments can be identified by the course coordinator to complete this requirement.**

1. To determine e/m ratio by Millikan's Oil-drop method.
2. To determine dielectric constant of the material.
3. To verify Biot-Savart's law.
4. To measure field strength B and its variation in a Solenoid (determine dB/dx).
5. To find Capacity of a Capacitor by Electrical vibrator.
6. Find Horizontal component of Earth's magnetic field by using vibration and deflection magnetometer.
7. To find Self-inductance by Anderson's bridge.
8. To calibrate a ballistic galvanometer.
9. To determine the mutual inductance between a pair of coils using a ballistic galvanometer.
10. To study performance of a NOT circuit.
11. To verify De Morgan's theorem and some relationships in Boolean algebra.
12. To design OR & AND logic with diode and resistor.
13. To realize basic logic gates with any type of universal gate NAND/NOR.
14. To form different combinational problems by construction of Truth Table and implement it using basic logic gates.
15. To design half adder circuit and to verify its truth table.
16. To design full adder circuit and to verify its truth table.
17. To design half subtractor, full subtractor, adder-subtractor using full adder.
18. To construct i) RS ii) D, and JK FF circuits using NAND gates.

**Suggested Reading(s):**


1. Practical Physics by G L Squires, Cambridge University Press.
2. Advanced Practical Physics for Students by Worsnop and Flint.
3. B. Sc Practical Physics by C. L. Arora.
4. Digital Fundamentals: Floyd 11(e), Pearson.
5. Modern Digital Electronics: R.P. Jain, 4e (2009), TMH Advanced Practical Physics for Students by Worsnop and Flint.
6. Basic Electronics-A text Lab Manual, Zbar&Malvino, (Tata McGraw-Hill, 1999).


Major-7 (Part –A)

## Heat and Thermodynamics (PHL 1024) (3-0-0)

*This course aims to learn the core concepts of Heat and Thermodynamics learnt at school in a more advanced perspective and progressively builds up new concepts. The students will be able to apply the learnt concepts to many real world problems.*

## *Course Outcomes:*

*After completing this course, the students will be able to*

- *Apply the First Law of Thermodynamics to analyze internal energy, work, and heat transfer in different processes.*
- *Calculate and interpret entropy changes in different processes and represent them on T-S diagrams.*
- *Understand the Third Law of Thermodynamics and its implications.*
- *Apply Maxwell's thermodynamical relations to analyze various thermodynamic processes.*
- *Explore the liquefaction of various gases, including helium I and II.*

**Unit-I**
**Thermodynamics-I** **[12]**

Thermodynamic system, Zeroth law of thermodynamics, concept of heat, thermodynamic equilibrium, work and their path-dependence, internal energy, First law of thermodynamics, specific heat of a gas, applications of first law of thermodynamics, work done during the isothermal and adiabatic process, reversible and irreversible process, heat engine, definition of efficiency, carnot's ideal heat engine.

**Unit-II**
**Thermodynamics-II** **[10]**

Second Law of thermodynamics, carnot's theorem, steam engine, internal combustion engine, diesel engine, multi-cylinder engine, concept and physical significance of entropy, change in entropy, principle of increase of entropy, T-S diagram, thermodynamical scale of temperature. Third law of thermodynamics, zero point energy.

**Unit-III**
**Thermodynamical relations** **[10]**

Thermodynamic variables, extensive and intensive variables, Maxwell thermodynamical relations and their applications, clausius-clapeyron's equations, thermodynamical potentials and significance, relation of thermodynamical potentials with their variables, relation between $C_p$, $C_u$ and $\mu$, adiabatic stretching of a wire, Joule-Kelvin coefficient, Phase transitions.

**Unit-IV**
**Liquefaction of gases** **[10]**

Methods of Liquefaction of gases, method of freezing mixture, cooling by evaporation under reduced pressure, cooling by adiabatic expansion, Joule-Thomson expansion, regenerative cooling, liquefaction of air, principle of cascade cooling, liquefaction of various gases including helium I and II, production of low temperature, conversion of magnetic temperature into Kelvin temperature, measurement of very low temperature, superconductivity and Meissner effect.

**TextBook:**

1. Heat, Thermodynamics & Statistical physics, Lal and Subrahmanyam, S Chand, 2018.

**Suggested Reading(s):**

2. Thermal physics, Robert F. Sekerka, Elsevier, 2015.

## Major-8 (Part –A)

# Waves and Oscillations (PHL 2013)

**(3-0-0)**

### *Learning Objectives*

*This course aims atfamiliarizing the students with the fundamental concepts and formulations in Waves and Oscillationsusing standard mathematical toolsand applying the knowledge of gained in this field to explain natural physical processes and related technological advances.*

### *Course Outcomes:*

*After completing this course, the students will be able to*

- *Students will be able to solve problems related to one-dimensional waves, applying the wave equation and understanding the principles of reflection, transmission, and polarization.*
- *Understand the practical applications of acoustic waves, such as the Doppler effect, beats, acoustic shadow, and architectural acoustics.*
- *Demonstrate a deep understanding of particle diffraction, the particle in a box model, and the uncertainty principle, applying these concepts to analyze and interpret scenarios related to matter waves.*
- *Develop proficiency in analyzing and predicting the behavior of different types of oscillations, applying concepts of resonance and coupled vibrations to real-world situations.*

**UNIT-I**
**Electromagnetic Wave** **[10]**

Waves in one dimension: The wave equation, Sinusoidal waves, Boundary conditions- reflection and transmission, polarization, Electromagnetic waves in vacuum: Wave equations for E and B, Monochromatic plane waves, Energy and momentum in electromagnetic waves

**Unit-II**
**Acoustic Waves** **[12]**

Propagation of sound wave through air, Differential equation for wave in three dimension, Reflection, Refraction and Interference of sound waves, Beats, Acoustic shadow, Doppler effect, Velocity of sound through gases and solid medium, Architectural acoustics (elementary idea)

**Unit-III**
**Matter Waves** **[10]**

De-Broglie waves, Waves of probability: Wave function, Probability density, General formula for waves, Phase and Group velocities, Particle diffraction, Particle in a box, Uncertainty principle,

**Unit-VI**
**Oscillations** **[10]**

Simple harmonic motion: Examples, Differential equation and its solution, Energy in S.H.M., Lissajous figures, Experimental determination of Lissajous figures using CRO, Free, Damped and Forced Vibrations, Resonance, Coupled Vibrations

**Text Book:**

1. A Textbook of Oscillations, Waves and Acoustics, Ghosh and Bhattacharya, S. Chand and Co., 5th Ed. (2016)

**Suggested Reading(s):**

2. Concepts of Modern Physics, A. Beiser, 6th Ed. McGraw-Hill, 2003

**Major-7 & 8 (Part –B)**

## Heat and Wave Propagation Lab (PHP 2013) (0-0-2)

### *Course Outcomes:*

*After completing this course, the students will be able to*

- *Use various instruments for measurements and perform experiments related to thermal conductivity, thermal expansion, specific heat and temperature changes, Oscillations and Waves.*
- *Learn to estimate the error for every experiment performed and report the result of experiment along with the uncertainty in the result up to correct significant figures.*

**Every student must perform at least 6 experiments as listed below, however additional experiments can be identified by the course coordinator to complete this requirement.**

1. To determine the thermal conductivity of a bad conductor by the Lee's disc method.
2. To determine the ratio of the specific heats of air by Kundt's tube method.
3. To determine the thermal conductivity of a good conductor by Searle's method.
4. To determine the value of Stefan's constant.
5. To determine the specific heat of a liquid by the method of Newton's law of cooling correction.
6. To find the latent heat of fusion of ice by the method of mixture.
7. To determine specific heat of bad conductor by method of mixture.
8. To find the thermal conductivity of rubber.
9. To study the heating efficiency of electrical kettle with varying voltages.
10. To measure the thermoemf of a given thermo couple.
11. To study the thermal behavior of an electric bulb (filament/torch light bulb).
12. To study of variation of resistance with temperature - thermistor.
13. To verify Stefan's law using a torch bulb.
14. Various experiments using bar pendulum.
15. To understand the applications of CRO by measuring voltage and time period of a periodic waveform using CRO. And study the superposition of two perpendicular simple harmonic oscillations using CRO (Lissajous figures)
16. To determine the current amplitude and phase response of a driven series LCR circuit with driving frequency and resistance. Draw resonance curves and find quality factor for low and high damping.
17. Experiments with spring and mass system
    a) To calculate g, spring constant and mass of a spring using static and dynamic methods.
    b) To calculate spring constant of series and parallel combination of two springs.
18. To determine the current amplitude and phase response of a driven series LCR circuit with driving frequency and resistance. Draw resonance curves and find quality factor for low and high damping.
19. Frequency of tuning fork using Sonometer.

### Suggested Reading(s):

1. Advanced Practical Physics for students, B. L. Flint and H. T. Worsnop, 1971, Asia Publishing House.
2. Engineering Practical Physics, S. Panigrahi and B. Mallick, 2015, Cengage Learning India Pvt. Ltd.

3. Practical Physics, G. L. Squires, 2015, 4/e, Cambridge University Press.
4. A Text Book of Practical Physics, Vol I and II, Prakash and Ramakrishna, 11/e, 2011, KitabMahal.
5. An Introduction to Error Analysis: The study of uncertainties in Physical Measurements,J. R. Taylor, 1997, University Science Books List of experiments

## Semester – V

**Major-9**

## Elements of Statistical Physics (PHL-3062) (3-1-0)

### *Learning Objectives*

*This course aims atfamiliarizing the students with the fundamental concepts and formulations in Statistical Physics at elementary level using standard mathematical toolsand applying the knowledge of gained in this field to explain natural physical processes and related technological advances.*

### *Course Outcomes:*

*After completing this course, the students will be able to*

- *Master the concepts of phase space, entropy, and thermodynamic probability, and apply them to describe the statistical behavior of a system.*
- *Demonstrate the ability to analyze and interpret temperature-dependent phenomena associated with thermal radiation.*
- *Develop the ability to explain and interpret blackbody radiation using Planck's Quantum Postulates, and understand the transition from quantum to classical radiation laws.*
- *Explore quantum statistics concepts, such as Bose-Einstein condensation, Fermi-Dirac Distribution Law, and their applications in diverse physical systems.*

**Unit-1**
**Classical Statistics** **[12]**

Macrostate& Microstate, Elementary Concept of Ensemble, Phase Space, Entropy and Thermodynamic Probability, Maxwell-Boltzmann Distribution Law, Partition Function, Thermodynamic Functions of an Ideal Gas, Classical Entropy Expression, Gibbs Paradox, Law of Equipartition of Energy (with proof) – Applications to Specific Heat and its Limitations, Thermodynamic Functions of a Two-Energy Levels System, Negative Temperature.

**Unit-II**
**Classical Theory of Radiation** **[10]**

Properties of Thermal Radiation.BlackbodyRadiation.Pure temperature dependence.Kirchhoff's law. Stefan-Boltzmann law: Thermodynamic proof. Radiation Pressure.Wien's Displacement law. Wien's Distribution Law. Saha's Ionization Formula. Rayleigh-Jean's Law.Ultraviolet Catastrophe.

**Unit-III**
**Quantum Theory of Radiation** **[8]**

Spectral Distribution of Black Body Radiation. Planck's Quantum Postulates. Planck's Law of Blackbody Radiation: Experimental Verification. Deduction of Wien's Distribution Law, Rayleigh-Jeans Law, Stefan-Boltzmann Law, Wien's Displacement law from Planck's law.

**Unit-IV**

**Quantum Statistics** **[12]**

B-E distribution law, Thermodynamic functions of a strongly Degenerate Bose Gas, Bose Einstein condensation, properties of liquid He (qualitative description), Radiation as a photon gas and Thermodynamic functions of photon gas. Bose derivation of Planck's law. Fermi-Dirac Distribution Law, Fermi Energy, Electron gas in a Metal, Specific Heat of Metals, Relativistic Fermi gas

**Text Book:**

1. Statistical Mechanics, R.K. Pathria, Butterworth Heinemann: 2nd Ed., 1996, Oxford University Press.

**Suggested Reading(s):**

2. Statistical Physics, Berkeley Physics Course, F. Reif, 2008, Tata McGraw-Hill

**Major-10**

## Classical Mechanics (PHL 6021) (3-1-0)

### *Learning Objectives*

*This course aims atfamiliarizing the students with the fundamental concepts and formulations in Classical Mechanics at intermediate level using standard mathematical toolsand applying the knowledge of gained in this field to explain natural physical processes and related technological advances.*

### *Course Outcomes:*

*After completing this course, the students will be able to*

- *Acquire proficiency in the principles of conservation laws, stability analysis, and the distinction between conservative and dissipative systems in the context of classical mechanics.*
- *Derive and solve Euler-Lagrange equations and apply Lagrangian and Hamiltonian formalisms to systems with different degrees of freedom.*
- *Gain and analyzethe ability to Kepler's Problem, periodic motion, and perform normal modes analysis for physical systems.*
- *Develop proficiency in applying relativistic concepts, including Lorentz transformations, four-vector notation, and the equivalence of mass and energy.*

**Unit I:** **[8]**

Newton's laws, Mechanics of systems of particles, conservation laws, dynamical systems: conservative versus dissipative systems, Phase space dynamics, stability analysis, degrees of freedom, constraints, and generalized coordinates, velocities, momenta and forces.

**Unit-II** **[15]**

Hamilton's variational principle, the Lagrangian and the Euler-Lagrange equations, the Hamiltonian, Cyclic Coordinates and Canonical Momenta, Applications of the Lagrangian and Hamiltonian formalisms to systems with one and two degrees of freedom, Principle of least action, Canonical transformations, Poisson brackets, the Hamilton-Jacobi theory, symmetry, invariance and Noether's theorem.

**Unit-III** **[10]**

Central force problem, Kepler's problem, bound and scattering motions, Scattering in a central potential, Rutherford formula, and the Scattering cross section, Periodic motion; Small Oscillations: Normal modes analysis, and Normal modes of a harmonic chain

**Unit-IV** **[9]**

Inertial frames, Postulates of special relativity, Lorentz transformations relativistic velocity addition formula, Relativistic kinematics–Four- vector notation.Velocity-energy-momentum-force four-vectors for a particle. Relativistic invariance of physical laws, relativistic mass-energy equivalence

**Text Book:**

1. Classical Mechanics: H Goldstein

**Suggested Reading(s):**

2. Classical Dynamics of Particles and Systems: Stephen Thornton
3. Classical Mechanics by J. C.Upadhyay

**Major-11 (Part-A)**

## Atomic and Molecular Physics (PHL 7071) (3-0-0)

### *Learning Objectives*

*This course aims atfamiliarizing the students with the fundamental concepts and formulations in Atomic and Molecular Physics at intermediate level using standard mathematical and quantum mechanical toolsand applying the knowledge of gained in this field to explain natural physical processes and related technological advances.*

### *Course Outcomes:*

*After completing this course, the students will be able to*

- *Gain proficiency in the theoretical aspects of the hydrogen atom, from the Bohr-Sommerfeld model to Sommerfeld's relativistic correction and the fine structure of the hydrogen atom.*
- *Explore the important electric and magnetic effects and models in context of atomic systems.*
- *Develop a detailed understanding of pure rotational spectra of diatomic molecules, distinguishing between rigid rotators and non-rigid rotators, and determining bond lengths from rotational spectra.*
- *Understand the salient features of vibrational-rotational spectra, including the behavior of diatomic molecules as rigid and harmonic oscillators.*

**Unit-I** **[12]**

Introduction to Spectroscopy and types of Spectra, Spectrum of Hydrogen Atom, Bohr-Sommerfeld model of Hydrogen Atom, Sommerfeld's Relativistic Correctionfor energy levels of hydrogen atom, Fine Structure of Hydrogen Atom.

**Unit-II** **[9]**

Magnetic Dipole Moments, Electron Spin, Vector Atom Model, Zeeman Effect, Paschen-Back effect, Stark Effect, Spin-orbit interaction, LS and JJ Coupling, Spectrum of helium and alkali atom

**Unit-III** **[9]**

Introduction to molecular Spectra, types of molecular spectra, Born-Oppenheimer approximation. Pure rotational spectra of diatomic molecule as rigid rotator, diatomic molecule as non-rigid rotator, Bond length from rotational spectra.Salient feature of vibrational spectra, vibrational spectra of diatomic molecule as harmonic and anharmonic oscillator.

**Unit-IV** **[12]**

Salient feature of vibrational-rotational spectra, spectra of diatomic molecule as rigid and harmonic oscillator, spectra of diatomic molecule as non-rigid and anharmonic oscillator, fine structure of rotational-vibrational bands.Raman effect, classical and quantum theory of Raman effect. Rotational and vibrational Raman spectra

**Text Book(s):**


1. H.E. White, Introduction to Atomic Spectra, 1934, McGraw-Hill Kogakusha Ltd., Tokyo
2. C.N. Banwell and E.M. McCash, Fundamentals of Molecular Spectroscopy, Third Edition 1972, McGraw-Hill book company, London


**Suggested Reading(s):**


3. G. Aruldhas, Molecular Structure and Spectroscopy, Second Edition 2007, Prentice Hall Of India, New Delhi


**Major-11 (Part-B)**

## Atomic and Molecular Physics Lab (PHL 7071) (0-0-2)

***Course Outcomes:***

*After completing this course, the students will be able to*

- *Use various instruments for measurements and perform experiments related to thermal conductivity, thermal expansion, specific heat and temperature changes, Oscillations and Waves.*
- *Learn to estimate the error for every experiment performed and report the result of experiment along with the uncertainty in the result up to correct significant figures.*

**Every student must perform at least 5 experiments as listed below, however additional experiments can be identified by the course coordinator to complete this requirement.**

1. To determine the wavelength of the H-alpha emission line of Hydrogen atoms.
2. To determine the ionization potential of mercury.
3. To Measure Charge-to-Mass (e/m) Ratio for the Electron by magnetic focussing.
4. To measure the ratio of Planck's constant to the electron charge (h/e) using the photoelectric effect.
5. To study the Zeeman Effect
6. To study spectra of Sodium and Mercury.
7. To determine the absorption lines in the rotational spectrum of Iodine vapour.

**Suggested Reading(s):**


1. Advanced Practical Physics for Students by Worsnop and Flint.
2. B. Sc Practical Physics by C. L. Arora.
3. C.N. Banwell and E.M. McCash, Fundamentals of Molecular Spectroscopy, Third Edition 1972, McGraw-Hill book company, London
4. H.E. White, Introduction to Atomic Spectra, 1934, McGraw-Hill Kogakusha Ltd., Tokyo


**Major-12**

## Mathematical Methods-II (PHL 2034) (3-1-0)

***Learning Objectives***

*This course aims to learn the fundamental concepts of Mathematical Methods in Physics learnt at school in an intermediate perspective and progressively builds up new concepts. The students will be able to apply the learnt concepts to many real world problems.*

***Course Outcomes:***

*After completing this course, the students will be able to*

- *Develop a comprehensive understanding of second-order linear differential equations with constant coefficients, both linear and nonlinear.*
- *Understand the concept of triple integrals in Cartesian and Polar coordinates and apply them to calculate volumes, surface areas, centroids, masses, and moments of inertia for three-dimensional objects.*
- *Understand the principles of Fourier Series, including periodic functions, Dirichlet's condition, and the determination of Fourier coefficients.*
- *Develop the skills to apply generating functions, orthogonality, and recurrence formulae for Legendre's and Hermite's functions.*

**UNIT-I**
**Linear Differential Equations of Second Order** **[10]**

Second order linear and no-linear differential equations with constant coefficients, Non-homogeneous and Homogeneous differential equations, Methods to find the complementary function and particular integral.

**UNIT-II**
**Double and Triple Integrals** **[12]**

Evaluation of double integration in Cartesian and Polar coordinates, Applications of double integrals in finding area, centre of gravity, mass and volume, Triple integration in Cartesian and Polar coordinates, Applications of triple integrals in calculating volume, area, centre of gravity, mass and moment of inertia

**UNIT-III**
**Fourier Series** **[10]**

Periodic functions, Fourier Series, Dirichlet's condition, Useful integrals, Determination of Fourier Coefficients, Fourier series for discontinuous functions, Even and Odd functions, Half-range series, Half period series, Parseval's formula, complex form of fourier series

**UNIT-IV**
**Special Functions** **[10]**

Legendre's and Hermite functions- Equation, Polynomials, General solution, Generating function, Orthogonality, Recurrence formulae for each

**Text Book:**

1. Mathematical Methods for Physicists: Arfken, Weber and Harris (7e) (Textbook)

**Suggested Reading(s):**

2. Mathematical Physics: Dass and Verma, S. Chand (8e) 2018

**<u>Major-13</u>**

## Quantum Mechanics-I (PHL-6041) (3-0-0)

***Learning Objectives***

*This course aims atfamiliarizing the students with the fundamental concepts and formulations in Quantum Mechanics at intermediate level using standard mathematicaltoolsand applying the knowledge of gained in this field to explain natural physical processes and related technological advances.*

### *Course Outcomes:*

*After completing this course, the students will be able to*

- *Comprehend the Schrödinger equation in both its time-dependent and time-independent forms, and apply it to describe quantum systems.*
- *Gain proficiency in understanding the energy states and wave functions associated with quantum mechanical systems, showcasing problem-solving skills in different potential scenarios.*
- *Grasp the use of Dirac notation (Bra and Ket notations) and matrix representation to describe quantum states and operators.*
- *Students will demonstrate proficiency in applying angular momentum algebra to quantum mechanical problems, including determining the spectrum of eigenvalues for $J^2$ and $J_Z$.*

**Unit-I** **[9]**

Wave-function in coordinate and momentum representations, Schrödinger equation (time-dependent and time-independent), Expectation Values, current density, equation of continuity, Ehrenfest's theorem.

**Unit-II** **[8]**

Particle in a Well (infinite and finite), harmonic oscillator, Potential Step, Potential Barrier, Rigid rotator and Hydrogen atom problem.

**Unit-III** **[10]**

Fundamental postulates of wave mechanics, Commutators, Hermitian operators, properties of eigen functions and eigen values of Hermitian operators, Dirac notation for state vectors (Bra and ket notations), matrix representationof wave function and operator, energy spectrum of one dimensional harmonic oscillator using matrix mechanics.

**Unit-IV** **[15]**

Angular momentum algebra: operators for $J_+$, J_and $J_Z$, Commutation relation, Spectrum of eigen values of $J^2$ and $J_Z$, operators for angular momentum L in spherical polar co-ordinates, Eigen values and eigen functions of $L^2$ and $L_Z$. Spin angular momentum, Eigen values and eigen functions of $S^2$ and $S_Z$. Matrix representation of $J^2$, $J_Z$, $J_+$, J, $J_x$, $J_y$ for j=1/2 and 1. Pauli's spin matrices and their properties, Addition of two angular momenta; Clebsch Gordon coefficients.

**Text Book:**

1. Introduction of Quantum Mechanics: D.J. Griffiths.

**Suggested Reading(s):**

2. Quantum Mechanics, Ghatak&Loknathan, 1st Edition, MacMillan India
3. Quantum Mechanics, L. I. Schiff, 3rd Edition, McGraw-Hill (1968).

**Major-14**

## IntroductorySolid State Physics (PHL-2101) (3-1-0)

### *Learning Objectives*

*This course aims atfamiliarizing the students with the basic concepts and formulations in Solid State Physics at beginner level using standard mathematicaltoolsand applying the knowledge of gained in this field to explain natural physical processes and related technological advances.*

### *Course Outcomes:*

*After completing this course, the students will be able to*

- *Gain proficiency in understanding different types of atomic bonding in solids, including the forces and energies associated with each, providing a foundation for understanding material properties.*
- *Understand the concepts of single crystals, polycrystalline materials, unit cells, and crystal lattices.*
- *Grasp various X-ray diffraction methods, including the Laue's method, rotating crystal method, and powder method. Understand the concept of reciprocal lattice vectors and their properties.*
- *Explain the electronic properties of materials using Free-electron model, Kronig-Penny model, understanding Bloch's theorem, and explaining band gaps, effective mass, and optical modes.*

**Unit-I** **[10]**

Atomic Structure: Fundamental Concepts, Electrons in Atoms, The Periodic Table, Atomic Bonding in Solids: Bonding Forces and Energies, Primary Interatomic Bonds- Ionic Bonding, Covalent Bonding, Metallic Bonding, Secondary Bonding or van der Waals, Mixed Bonding

**Unit-II** **[10]**

Single Crystals, Polycrystalline Materials, Unit Cells, Crystal Lattice, Density Computations, Polymorphism and Allotropy, Crystal Systems, Point Coordinates, Crystallographic Directions, Crystallographic Planes, Linear and Planar Densities, Close-Packed Crystal Structures, Anisotropy

**Unit-III** **[12]**

X-ray Diffraction – Diffraction Phenomenon, Bragg's law, Laue's Equations, X-ray diffraction methods – The Laue's Method, Rotating Crystal Method, Powder Method, Reciprocal Lattice Vectors, Reciprocal Lattice to sc, bcc and fcc lattices, Properties of Reciprocal Lattice

**Unit-IV** **[10]**

Free electron gas (theory), density of states, and Fermi Energy, One Dimensional Lattice: Kronig-Penny Model, Bloch Theorem, Band Gap, Effective mass, TO and LO Modes

**Text Book:**

1. Introduction to Solid State Physics by C. Kittel

**Suggested Reading(s):**

2. Materials Science and Engineering by William D. Callister (Wiley 10th Ed., 2018)
3. Solid State Physics by Puri and Babbar (S. Chand & Co., Ist Ed., 2021)

## Modern Physics Lab (PHL 7071) (0-0-2)

### *Course Outcomes:*

*After completing this course, the students will be able to*

- *Use various instruments for measurements and perform experiments related to Modern Physics.*
- *Learn to estimate the error for every experiment performed and report the result of experiment along with the uncertainty in the result up to correct significant figures.*

**Every student must perform at least 5 experiments as listed below, however additional experiments can be identified by the course coordinator to complete this requirement.**

1. To measure Plank constant using LED
2. To determine ionization potential of Mercury
3. To determine e/m by using Thomson's bar magnet.

4. To study the photoelectric effect: variation of photocurrent versus intensity and wavelength of light.
5. To determine (1) wavelength and (2) angular spread of He-Ne laser/ solid state laser using plane diffraction grating.
6. To study the atomic spectra of certain noble gases and metallic vapors using diffraction grating and spectrometer.
7. To determine the de Broglie wavelength of an accelerated electron beam using Debeye-Scherrer diffraction method.
8. To confirm the quantum theory of light, that photoelectrons depends only on the frequency of the incident light and is independent of the intensity, and calculate the Planck's constant $h$.

**Suggested Reading(s):**


1. Advanced Practical Physics for Students by Worsnop and Flint.
2. B. Sc Practical Physics by C. L. Arora.
3. C.N. Banwell and E.M. McCash, Fundamentals of Molecular Spectroscopy, Third Edition 1972, McGraw-Hill book company, London
4. H.E. White, Introduction to Atomic Spectra, 1934, McGraw-Hill Kogakusha Ltd., Tokyo


# Detailed Syllabi for Discipline Specific Electives (DSEs) CE-1

## Essentials of Nano-Physics (PHL 3192) (3-1-0)

### *Learning Objectives*

*This course aims atfamiliarizing the students with the basic concepts on useful aspects of physics of nanomaterials to meet the challenges faced by material scientist at in intermediate level and to apply the knowledge gained in this field to explain natural physical processes and related technological advances.*

### *Course Outcomes:*

*After completing this course, the students will be able to*

- *Analyze the quantum confinement of electrons in different semiconductor nanostructures (3D, 2D, 1D, and zero-dimensional) and its impact on material properties.*
- *Select appropriate nanosynthesis techniques based on the top-down or bottom-up approach, demonstrating a practical understanding of synthesis methods.*
- *Understand the types, structures, and applications of carbon-based nanomaterials, including carbon nanotubes, graphene, and fullerene.*
- *Gain practical insights into the applications of nanomaterials in different fields, fostering an understanding of their real-world impact.*

**Unit - I**
**Introduction** **[7]**

Essentials and opportunities:Introduction and classification of nanomaterials on the basis of dimensions, Quantum confinement of electrons in semiconductor nanostructures- 3D, 2D, 1D and zero dimensional structures ; Size effect and properties of nanostructures.

**Unit – II**
**Synthesis of Nanomaterials** **[12]**

Nanosynthesis techniques: Top down and bottom up approach, Homogeneous and Heterogeneous nucleation, Growth of nuclei controlled by diffusion and surface process. Sintering, Ostwald ripening. Physical methods of synthesis: High energy Ball Milling, Melt mixing, Physical Vapour Deposition, Chemical Methods: Wet chemical method (colloidal route), Electrochemical Method, Sol-gel method and Hydro thermal method.

**Unit – III** **[8]**
**Special Nanomaterials**

Quantum dots, Carbon Based Nano's, Types and Structures of Carbon nanotubes, Graphene- Discovery, strength and stiffness, heat conductivity, electronic properties, Impermeability,Fullerene-features and applications.

**Unit – IV** **[15]**
**Properties and Applications**

Mechanical, Thermal, Electrical, Optical and Magnetic Properties, Application to Nanoelectronics, Super capacitors, nano based solar cells, Optical Devices, Social and Ethical issues involved in applications of nanomaterials.

**Text Book:**

1. Nanotechnology: Principles and Practices. Sulbha K. Kulkarni, Capital Pub.

**Suggested Reading(s):**

2. Nanostructures and Nanomaterials Synthesis, Properties & Applications. Guozhong Cao, Imperials college Press London.
3. Nanomaterials: Synthesis, Properties & Applications. Edited by A. S. Edelstein & R. C. Commorata.Institute of Physics Publishing, Bristol & Philadelphia.

## Nuclear Radiation: Energy, Medicine and Agriculture

## (PHL 3093) (3-1-0)

### *Learning Objectives*

*This course aims atfamiliarizing the students with the basic concepts on the use of Nuclear Radiations meeting the current energy requirements, medicine and agriculture at beginner level for applying the knowledge gained in this field to explain natural physical processes and related technological advances.*

### *Course Outcomes:*

*After completing this course, the students will be able to*

- *Recognize the diverse applications of nuclear radiation in materials science research, energy production, and security initiatives.*
- *Describe the physics behind nuclear energy, including nuclear fusion and fission reactions.*
- *Gain an understanding of the application of radionuclides in radiation therapy and be able to calculate internal radiation doses in the context of diagnostic nuclear medicine.*
- *Acquire the skills to use radiation techniques for inducing mutations in crops, contributing to a comprehensive understanding of their commercial applications in agriculture.*

**UNIT I** **[10]**
**Introduction**

Basics of nuclear radiations; Interaction of nuclear radiation with matter, Peaceful applications of nuclear radiation, Reactors for materials science research, Nuclear medicine as energy source and for security initiatives. Radiation sources and metrics, Types of radiation dosimeters -Thermoluminescence, Radiographic films, Semiconductor diodes, etc.

**UNIT-II** **[10]**
**Nuclear Energy**

Physics of nuclear energy and radiation, Contribution of nuclear power to climate change,Nuclear fusion and fission, Fission reactors, Nuclear fuel cycles – characteristics of nuclear fuel and spent fuel characteristics.

**UNIT III** **[10]**
**Nuclear medicine**

Imaging techniques in medical sciences using nuclear radiation, Radiopharmaceuticals, and radiation therapy – using radionuclides; Internal radiation doses in diagnostic nuclear medicine

**UNIT IV** **[12]**
**Nuclear Techniques in Agriculture**

Applications of isotopes and radiation in agriculture – Radioisotopes in soil and plant studies such as plant breeding, Plant nutrition, Pesticide research, and Nutrient transformations, Efficient use of nitrogen fertilizer; Measurement of root activity using radioisotope techniques; The use of radiolabelled chemicals to study the dynamics of pesticides; Radiation techniques to induce desirable mutation in crops of commercial interest.

**Suggested Reading(s):**


1. Basic Physics and Radiation Safety in Nuclear Medicine, A. K. Shukla, Himalaya Publishing House, Mumbai, 2nd Edition, 2018.
2. Introduction to Radiological Physics and Radiation Dosimetry, Frank H. Attix, John Wiley & Sons, 1986.
3. Radioisotopes in Biology and Agriculture: Principles and Practice, C.L. Comer, Tata McGraw Hill, 1955.
4. Introduction to Nuclear Techniques in Agronomy and Plant Biology, P.B. Vose, Oxford Pergamon Press, London, 1980.
5. Understanding Radioactive Waste, R. L. Murray, 4th edition, Battelle Press, 1994.


## Measurements and Analysis (PHL 2125) **(2-0-0)**

### *Learning Objectives*

*This course aims atfamiliarizing the students with the fundamental concepts of measurements and their use in the error analysis at intermediate level for applying the knowledge gained in this field to explain natural physical processes and related technological advances.*

### *Course Outcomes:*

*After completing this course, the students will be able to*

- *Demonstrate proficiency in the precise use of laboratory instruments, showcasing their ability to measure length and frequency accurately.*
- *Demonstrate proficiency in using various experimental techniques for measurements, applying knowledge gained in real-world scenarios.*
- *Able to critically assess and categorize different types of measuring errors, enhancing their ability to recognize and mitigate uncertainties.*
- *Apply knowledge of parent and sample distributions to analyze and interpret data, improving their ability to recognize patterns in experimental results.*

**UNIT-I** **[10]**
**Some Laboratory Instruments and Methods**

Metre rule, Micrometer screw gauge, Measurement of length, Measuring frequency, Negative feedback amplifier, Servo systems, Natural limits of measurements

**UNIT-II** **[12]**
**Experimental Techniques and Logic**

Rayleigh refractometer, Measurement of resistivity, Measurement of 'g', Measurement of frequency and time, The Global positioning system, Sequence of measurements, Drift, Systematic variations, Relative methods, Null methods, Repetition of measurements

**UNIT-III** **[11]**
**Uncertainty in Measurements**

Measuring errors, Systematic and random errors, Set of measurements, Distribution of measurements, Estimation of $\sigma$ and $\sigma_m$, Propagation of errors

**UNIT-IV** **[12]**
**Data Handling**

Parent and Sample Distributions, Mean and Standard Deviation of Distributions, The Gaussion distribution, The integral function, The treatment of functions, Method of least squares for fitting a straight line.

**Text Book:**

1. Practical Physics: G. L. Squires (4e) Cambridge Universiry Press, 2001 (Textbook).

**Suggested Reading(s):**

2. Data Reduction and Error Analysis for Physical Sciences: Bevington and Robinson (3e) McGraw Hill, 2003

## Measurements and Analysis Lab (PHP 2125) (0-0-4)

### *Course Outcomes:*

*After completing this course, the students will be able to*

- Use various instruments for measurements of physical quantities.
- Use propagation of errors to estimate uncertainty in the outcome of an experiment and perform the statistical analysis of the random errors in the observations.

**Choose any 5 experiments from the list given below:**

1. To observe the loading effect of a multimeter while measuring voltage across a low resistance and high resistance.
2. To observe the limitations of a multimeter for measuring high frequency voltage and currents.
3. To measure Q of a coil and its dependence on frequency, using a Q- meter.
4. Measurement of voltage, frequency, time period and phase angle using CRO.
5. Measurement of time period, frequency, average period using universal counter/ frequency counter.
6. Measurement of rise, fall and delay times using a CRO.
7. Measurement of distortion of a RF signal generator using distortion factor meter.
8. Measurement of R, L and C using a LCR bridge/ universal bridge.

**Suggested Readings:**

1. A text book in Electrical Technology - B L Theraja - S Chand and Co.
2. Performance and design of AC machines - M G Say ELBS Edn.
3. Digital Circuits and systems, Venugopal, 2011, Tata McGraw Hill.
4. Digital Electronics, SubrataGhoshal, 2012, Cengage Learning.
5. Electronic Devices and circuits, S. Salivahanan& N. S.Kumar, 3rd Ed., 2012, Tata Mc-Graw Hill

# Detailed Syllabi for Multidisciplinary Courses: MD-I, MD-II & MD-III

## Quantum in Everyday Life (3-0-0)
## (PHL-2101)

### *Learning Objectives*

*This course aims at familiarizing the students with the basic concepts on useful aspects of Quantum Physics to meet the challenges faced by Physicists at an introductory level and to apply the knowledge gained in this field to explain natural physical processes and related technological advances.*

### *Course Outcomes:*

*After completing this course, the students will be able to*

- *Apply the principles of quantum mechanics, particularly wave-particle duality and its experimental validations, to solve theoretical and practical problems related to quantum phenomena.*
- *Explain the classical and quantum explanations of the Particle in a Box model, emphasizing energy quantization.*
- *Apply the Schrodinger equation and quantum numbers to describe energy levels and electron configurations.*
- *Quantitatively analyze the relationship between quantum properties and electrical heating.*

**Unit-I** **[12]**

Schrodinger's Cat Paradox, Absolute nature of size, characteristics and types of waves, Photoelectric effect, Einstein's explanation, Dual nature of light waves, Free particle wave function, Interference of waves, momentum superposition, Wave packet, Heisenberg uncertainty principle

**Unit-II** **[10]**

Waves of photons, electrons and baseballs (particles), Particle in a Box- Classical and Quantum explanation, Energies of the quantum particle, Energy quantization, Black body radiation spectrum of sun

**Unit-III** **[12]**

The hydrogen atom: Bohr's theory, Quantum theory, Schrodinger equation, quantum numbers, Energy levels, Band Gap, Fermi level, Metals, insulators and semiconductors, Phonons, Electron-Photon scattering, superconductivity

**Unit-IV** **[8]**

Daily life Quantum phenomena: Color of objects, Shapes of molecules, Greenhouse nature of $CO_2$ gas, Visible radiations of hot bodies, Electrical heating

**Textbook:**

1. Absolutely Small: How Quantum Theory Explains Our Everyday World, Michael D. Fayer, AMACOM (2010)

**Suggested Reading(s):**

2. Quantum Physics For Dummies, Steven Holzner, Wiley (2012).

# Lasers and Its Applications (PHL 7091) (3-0-0)

## *Learning Objectives*

*This course aims at familiarizing the students with the basic concepts of Lasers and its applications to meet the challenges faced by industries and corporate world at an introductory level and to apply the knowledge gained in this field to explain natural physical processes and related technological advances.*

## *Course Outcomes:*

*After completing this course, the students will be able to*

- *Explain the fundamental principles of LASER, including the processes of induced absorption, spontaneous emission, and stimulated emission.*
- *Analyze the interplay of Lasers' characteristics in determining the their overall performance.*
- *Gain undestanding of the functioning of different types of lasers.*
- *Demonstrate the ability to predict the behavior of lasers based on their characteristics in real-world contexts, enabling effective utilization in various fields.*

**Unit-I**
**Laser Principle** **[12]**

Introduction to LASER, Interaction of radiation with matter – Induced absorption, Spontaneous Emission, Stimulated Emission, Population inversion, Optical Pumping, Laser materials, Resonant cavity.

**Unit-II**
**Laser Characteristics** **[8]**

Wavelength, Intensity, Coherency, Monochromaticity, Output power, Polarization, Focussibility and Gain Bandwidth.

**Unit-III**
**Laser Types** **[12]**

LASER action: Two level, Thee level and Four level laser systems, Types of lasers (Elementary idea); Gas laser, Solid state laser, Fiber laser, Diode and Semiconductor laser.

**Unit-IV**
**Laser Applications** **[10]**

General Applications of Lasers including Industry; Drilling, cutting and welding, Defense, Medicine; Dermatology, cardiology, dentistry etc, Communication etc.

**Text Book:**

1. Jeff Hecht "Understanding Lasers" (4e), IEEE press, Wiley.

**Suggested Reading(s):**

2. Andrews, "An Introduction to Laser Spectroscopy (2e)", Ane Books India (Distributors).

# Nanotechnology for Beginners (PHL-2101) (3-0-0)

*This course aims at familiarizing the students with the basic concepts of Nanotechnology at the beginner level and to apply the knowledge gained in this field to explain natural physical processes and related technological advances.*

***Course Outcomes:***

*After completing this course, the students will be able to*

- *Explore different approaches to nanotechnology from both macroscopic and microscopic perspectives.*
- *Develop a thorough understanding of the unique properties of nanomaterials and their significance in various applications.*
- *Demonstrate proficiency in using nano-level tools, understanding their principles and applications.*
- *Understand the significance of customizing material structures using nanotechnology.*
- *Gain insight into the diverse applications of nanotechnology in electronics, construction, automotive, healthcare, energy, environment and defense.*

**Unit-I**
**Introduction** **[7]**

What Is Nanotechnology, Approaching Nanotechnology from Above and Below, How Nano Changes Things, Nano Is Everywhere, Brief Evolution of Nanotechnology,

**Unit-II**
**Nanomaterials and Nano Tools** **[15]**

Properties of Nanomaterials, Buckyballs, Carbon nanotubes, Graphene, Diamondoid, Non-carbon Nanoparticles, Searching for Nanoparticles, Brief overview of Tools at Nano Level: Electron microscopy, Atomic force microscopy, Spectroscopy, Scanning tunnelling microscope

**Unit-III**
**Nanotechnology at work** **[8]**

Nanolithography, Changing the Size of Things, Modifying Material Properties, Customizing the Structure of Coatings and Films, Integrating Nanoparticles into Materials

**Unit-IV**
**Nano Applications** **[12]**

Nanoscale Electronics, Building Tougher Building Materials, Applying Nanotechnology to Cars, Nano for personalized use, Nano in Medicine, Nano for Energy conservation, Nano for environment improvement, Nano in Space and Defense.

**Textbook:**

1. Nanotechnology for Dummies, E.Boysen and N. Boysen, 2nd Ed. (Wiley)

**Suggested Reading(s):**

2. Nano: The Essentials, T. Pradeep, Tata McGraw Hill (2008)