शैक्षणिक विभाग
गणेशखिंड, पुणे-४११ ००७
दूरध्वनी क्र. : ०२०-२५६०१२५७/५८/५९
ई-मेल : boards@pun.unipune.ac.in
संकेतस्थळ : www.unipune.ac.in

सावित्रीबाई फुले पुणे विद्यापीठ
(पूर्वीचे पुणे विद्यापीठ)
Savitribai Phule Pune University
(Formerly University of Pune)

Academic Section
Ganeshkhind, Pune - 411 007
Phone : 020-25601257/58/59
E-mail : boards@pun.unipune.ac.in
Website : www.unipune.ac.in

संदर्भ क्र : CBS/694

दिनांक : 22/7/2019

परिपत्रक क्र. १७९/२०१९

विषय: विद्यापीठातील सर्व विद्याशाखांचे प्रथम वर्ष पदवी अभ्यासक्रम सत्र पध्दत (Semester-wise) व पसंती श्रेयांक पध्दतीनुसार (Choice Based Credit System) शैक्षणिक वर्ष २०१९—२० पासून सुधारित करण्याबाबत...

सर्व संबंधितांना याद्वारे कळविण्यात येते की, विद्यापीठातील सर्व विद्याशाखांचे प्रथम वर्ष पदवी अभ्यासक्रम सत्र पध्दत (Semester-wise) व पसंती श्रेयांक पध्दतीनुसार (Choice Based Credit System) शैक्षणिक वर्ष २०१९—२० पासून सुधारित करण्यास विद्यापीठ अधिकार मंडळाने मान्यता दिलेली आहे.

सदरचे अभ्यासक्रम सावित्रीबाई फुले पुणे विद्यापीठाच्या www.unipune.ac.in या संकेत स्थळावर Syllabi ↔ Revised Syllabus from the Academic Year 2019 (New Syllabus) या शीर्षकाखाली विद्याशाखेनुसार उपलब्ध आहेत.

मा. प्राचार्य, सर्व संलग्नित महाविद्यालये व मा. संचालक, सर्व मान्यताप्राप्त संस्था यांना विनंती की, सदर परिपत्रकाचा आशय सर्व संबंधितांच्या निदर्शनास आणून द्यावा.

उपकुलसचिव
(शैक्षणिक विभाग)

ATTESTED
PRINCIPAL
Smt. Vimlaben Jhunjhunwala Arts Science & Commerce College
Deolali-Camp (Nashik

प्रत माहीतीसाठी व पुढील योग्य त्या कार्यवाहीसाठी:—

१. मा. अधिष्ठाता, विज्ञान व तंत्रज्ञान विद्याशाखा
२. मा. संचालक, परीक्षा व मूल्यमापन मंडळ
३. मा. प्राचार्य, सर्व संलग्नित महाविद्यालये
४. मा. उपकुलसचिव, शैक्षणिक प्रवेश विभाग
५. मा. उपकुलसचिव, नियोजन व विकास विभाग
६. मा. उपकुलसचिव, शैक्षणिक पात्रता विभाग
७. मा. उपकुलसचिव, सभा व दप्तर विभाग
८. सहाय्यक कुलसचिव, परीक्षा समन्वय कक्ष
९. सहाय्यक कुलसचिव, परीक्षा—एस. ॲण्ड टी. विभाग
१०. सहाय्यक कुलसचिव, गोपनीय कक्ष
११. वरिष्ठ कायदा अधिकारी
१२. मा. संचालक, आंतरराष्ट्रीय केंद्र
१३. जनसंपर्क अधिकारी
१४. कक्षाधिकारी (बहि:स्थ)
१५. मा. अधिकारी, सिस्टीम ॲनालिस्ट डेटा प्रोसेसिंग युनिट
१६. सहायक कुलसचिव, मा. प्र—कुलगुरू कार्यालय
१७. प्रमुख, विद्यापीठ उपकेंद्र : अहमदनगर, नाशिक.

ATTESTED
PRINCIPAL
Smt. Vimlaben Khimji Tejookaya Arts Science & Commerce College
Deolali-Camp (Nashik

शैक्षणिक विभाग
गणेशखिंड, पुणे-४११ ००७
दूरध्वनी क्र. : ०२०-२५६०१२५७/५८/५९
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संदर्भ क्र : सीबीसीएम/६२५

दिनांक : 3 जुलै, २०१९.

परिपत्रक क्र. १४२/ २०१९

विषय : वाणिज्य व व्यवस्थापन विद्याशाखेंतर्गत एम.कॉम. (Semester & Choice Based Credit System) या पदव्युत्तर पदवीच्या सुधारित अभ्यासक्रमास शैक्षणिक वर्ष २०१९—२० पासून मान्यता देणेबाबत.

विद्यापीठ अधिकार मंडळाने घेतलेल्या निर्णयानुसार सर्व संबंधितांस या परिपत्रकाद्वारे कळविण्यात येते की, वाणिज्य व व्यवस्थापन विद्याशाखेतील वाणिज्य व व्यवस्थापन विद्याशाखेंतर्गत एम.कॉम. (Semester & Choice Based Credit System) या पदव्युत्तर पदवीच्या सुधारित अभ्यासक्रमास शैक्षणिक वर्ष २०१९—२० पासून मान्यता देण्यात येत आहे.

सदर अभ्यासक्रम विद्यापीठाच्या www.unipune.ac.in या संकेतस्थळावर syllabi > Revised syllabus from the Academic Year 2019 > Faculty - Commerce & Management - I) Commerce या शीर्षकाखाली उपलब्ध करण्यात आला आहे.

मा. प्राचार्य, सावित्रीबाई फुले पुणे विद्यापीठाशी सर्व संलग्न महाविद्यालय यांना विनंती की, सदर परिपत्रकाचा आशय सर्व संबंधितांच्या निदर्शनास आणून द्यावा.

उपकुलसचिव
(शैक्षणिक विभाग)

ATTESTED
PRINCIPAL
Smt. Vimlaben Khimji Tejookaya. Arts, Science & Commerce College
Deolali-Camp (Nashik

प्रत माहिती व पुढील योग्य त्या कार्यवाहीसाठी :

१. मा. अधिष्ठाता, वाणिज्य व व्यवस्थापन विद्याशाखा
२. मा. सहयोगी अधिष्ठाता, वाणिज्य व व्यवस्थापन विद्याशाखा
३. मा. प्राचार्य, सर्व संलग्न महाविद्यालये
४. मा. विभागप्रमुख, वाणिज्य विभाग
५. मा. संचालक, परीक्षा व मूल्यमापन मंडळ
६. मा. संचालक, स्पर्धा परीक्षा केंद्र
७. मा. संचालक, आंतरराष्ट्रीय विद्यार्थी केंद्र
८. मा.प्रमुख, विद्यापीठ उपकेंद्र : अहमदनगर, नाशिक
९. मा. उपकुलसचिव, परीक्षा (१ व २)
१०. मा. उपकुलसचिव, शैक्षणिक प्रवेश विभाग
११. मा. उपकुलसचिव, नियोजन व विकास विभाग
१२. मा. उपकुलसचिव, शैक्षणिक पात्रता विभाग
१३. मा. उपकुलसचिव, सभा व दप्तर विभाग
१४. वरिष्ठ कायदा अधिकारी
१५. सहायक कुलसचिव, मा. प्र—कुलगुरू कार्यालय
१६. सहायक कुलसचिव, गोपनीय कक्ष, परीक्षा विभाग
१७. सहायक कुलसचिव, परीक्षा समन्वय विभाग
१८. सहायक कुलसचिव, परीक्षा — एस. ॲण्ड टी. विभाग
१९. पध्दती विश्लेषक, व्यवस्थापन व माहिती विभाग
२०. सहायक कुलसचिव, संलग्नता विभाग
२१. जनसंपर्क अधिकारी
२२. कक्षाधिकारी, बहिस्थ विभाग

♦ मा. विद्यापरिषद ठराव क्रमांक —:

वि.प.क्र. ब २८ पीए/२८/२०१९, दि. ११ जून, २०१९

शैक्षणिक विभाग
गणेशखिंड, पुणे-४११ ००७
दूरध्वनी क्र. : ०२०-२५६०१२५७/५८/५९
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संदर्भ क्र : सीबीएच/६७२

दिनांक : १६/०७/२०१९

परिपत्रक क्र.१७३/२०१९

विषय —: मानवविज्ञान विद्याशाखेअंतर्गत एम.ए. भाग—१ (Semester I & II) (Choice Based Credit System) पदव्युत्तर पदवीच्या अभ्यासक्रमाच्या प्रथम वर्ष कला विषयांच्या सुधारित अभ्यासक्रमाबाबत.....

विद्यापीठ अधिकार मंडळाने घेतलेल्या निर्णयानुसार सर्व संबंधितांस या परिपत्रकाद्वारे कळविण्यात येते की, मानवविज्ञान विद्याशाखेअंतर्गत एम.ए. भाग—१ (Semester I & II) (Choice Based Credit System) पदव्युत्तर पदवीच्या खालील विषयांच्या सुधारित अभ्यासक्रमास शैक्षणिक वर्ष २०१९—२० मान्यता देण्यात येत आहे.

एम.ए. भाग १ (विषय) : मराठी, इंग्रजी, हिंदी, संस्कृत, जर्मन, फ्रेंच, रशियन, संस्कृत, संस्कृत व प्राकृत, ऊर्दू, अरेबिक, पर्शियन, पाली, अर्थशास्त्र, इतिहास, मानसशास्त्र, राज्यशास्त्र, तत्वज्ञान, समाजशास्त्र, संरक्षण व सामरिकशास्त्र इ.

एम.ए./एम.एस्सी. भाग १ व २ विषय : मानसशास्त्र.

एम.एस्सी. भाग १. विषय : संरक्षण व सामरिकशास्त्र, भूगोल, संख्याशास्त्र इ.

सदरचा अभ्यासक्रम हा सावित्रीबाई फुले पुणे विद्यापीठाच्या www.unipune.ac.in या संकेतस्थळावर **Syllabi** या शीर्षकाखाली उपलब्ध आहे.

मा. प्राचार्य, सर्व संबंधित महाविद्यालये यांना विनंती की, सदर परिपत्रकाचा आशय सर्व संबंधितांच्या निदर्शनास आणून द्यावा .

उपकुलसचिव,
(शैक्षणिक विभाग)

ATTESTED
PRINCIPAL
Smt. Vimlaben Khimji Tejookaya Arts, Science & Commerce College
Deola i-Camp (Nashik

CBCS: 2020-2021 T. Y. B. Sc.Mathematics

SavitribaiPhule Pune University

(Formerly University of Pune)

Three Year B.Sc. Degree Program in Mathematics

(Faculty of Science and Technology)

T.Y.B.Sc. (Mathematics)

Choice Based Credit System Syllabus

(With effect from June 2021)

To be implemented from Academic Year 2021-2022

Title of the Course: B. Sc. (Mathematics)

Preamble:

University of Pune has decided to change the syllabi of various faculties from June, 2019. Taking into consideration the rapid changes in science and technology and new approaches in different areas of mathematics and related subjects, Board of Studies in Mathematics with concern of the teachers of Mathematics from different colleges affiliated to University of Pune has prepared the syllabus of T.Y.B.Sc. Mathematics. To develop the syllabus the U.G.C. Model curriculum is followed.

Programme Specific Outcome (PSO)

i) Give the students a sufficient knowledge of fundamental principles, methods and a clear perception of innumerous power of mathematical ideas and tools and know how to use them by modeling,solving and interpreting.

ii) To equip the students sufficiently in both analytical and computational skills in Mathematical Sciences.

iii) To develop a competitive attitude for building a strong academic - industrial collaboration, with focus on continuous learning skills.

iv) Enhancing students overall development and to equip them with mathematical modeling abilities, problem solving skills, creative talent and power of communication necessary for various kinds of employment.

v) Enabling students to develop a positive attitude towards mathematics as an interesting and valuable subject of study.

vi) Enabling students to Gauge the hypothesis, theories, techniques and proofs provisionally.

Programme Outcome:(PO)

A graduate of this program are expected to:

i) Gain sound knowledge on fundamental principles and concepts of Mathematics and computing with their applications related to Industrial, Engineering, Biological and Ecological problems.

ii) Exhibit in depth the analytical and critical thinking to identify, formulate and solve real world problems of science and engineering.

iii) Get a relational understanding of mathematical concepts and concerned structures, and should be able to follow the patterns involved, mathematical reasoning.

iv) A student should get adequate exposure to global and local concerns that explore them many aspects of Mathematical Sciences.

v) Apply their skills and knowledge,that is, translate information presented verbally into mathematical form, select and use appropriate mathematical formulae or techniques in order to process the information and draw the relevant conclusion.

vi) Be capable of undertaking suitable experiments/research methods while solving the real-life problem and would arrive at valid conclusions based on appropriate interpretations of data and experimental results.

vii) Develop written and oral communications skills in order to effectively communicate design, analysis and research results.

viii) Demonstrate appropriate inter-personal skills to function effectively as an individual, as a member or as a leader of a team and in a multi-disciplinary setting.

ix) Acquire competent positions in industry and academia as well.

Eligibility:

S.Y.B.Sc. (with Mathematics)or T.Y.B.Sc. Computer Science as per University rules.

Medium of Instruction: English

Structure of the Course:

Semester –V		**Semester-VI**	
DSE-1A	**MT 351: Metric Spaces**	**DSE-4A**	**MT 361: Complex Analysis**
DSE-1 B	**MT 352: Real Analysis-I**	**DSE-4 B**	**MT 362: Real Analysis-II**
DSE-2 A	**MT 353: Group Theory**	**DSE-5 A**	**MT 363: Ring Theory**
DSE-2 B	**MT 354: Ordinary Differential Equations**	**DSE-5 B**	**MT 364: Partial Differential Equations**
Select any one out of three		**Select any one out of three**	
DSE-3A	**MT 355(A):Operations Research** **MT 355(B): Differential Geometry** **MT 355(C):C- Programming**	**DSE-6A**	**MT 365(A): Optimization Techniques** **MT 365(B):Calculus of Variation and Classical Mechanics** **MT 365(C): Financial Mathematics**
Select any one out of three		**Select any one out of three**	
DSE-3B	**MT 356(A): Machine Learning-I** **MT 356(B): Number Theory** **MT 356(C): Laplace Transform and Fourier Series**	**DSE-6B**	**MT 366(A): Machine Learning-II** **MT 36 (B): Computational Geometry** **MT 366(C): LebesgueIntegration**
Practical Lab		**Practical Lab**	
DSE-1	**MT 357: Practical Course Lab-1 (on Metric Space and Real Analysis-I)**	**DSE-4**	**MT 367: Practical Course Lab-1 (on Complex Analysis and Real Analysis-II)**
DSE-2	**MT 358: Practical Course Lab-II (on Group Theory and Ordinary Differential equations)**	**DSE-5**	**MT 368: Practical Course Lab-II (on Ring Theory and Partial Differential Equations)**
DSE-3	**MT 359: Practical Course Lab-III (on DSE-3A and DSE-3B)**	**DSE-6**	**MT 369: Practical Course Lab-III (on DSE-6A and DSE-6B)**
SEC-I	**MT -3510: Programming in Python-I**	**SEC-III**	**MT 3610: Programming in Python-II**
SEC-II	**MT-3511: LaTeX for Scientific Writing**	**SEC-IV**	**MT 3611: Mathematics into LaTeX**

Note.

i) Papers MT-351 to MT-354 are compulsory, a student can opt one paper from MT-355(A) to MT-355 (C) and opt one paper from MT-356(A) to MT-356 (C) in fifth semester.

ii) Papers MT-361 to MT-364 are compulsory, a student can opt one paper from MT-365(A) to MT-365 (C) and opt one paper from MT-366(A) to MT-366 (C) insixth semester.

iii) For MT-351 to MT-359 and MT-361 to MT-369 each course is of 50 marks (35 marks external examination and 15 marks internal examination).

iv) For SEC: MT-3510, MT-3511, MT-3610 and MT-3611 each course is of 50 marks (15 marks internal evaluation: assignments/ tutorial/seminar/test and 35 marks external theory and practical examination).

Examination:

A) Pattern of examination: **Semester wise**.

B) Standard of passing: 20 Marks out of 50 marks for each paper. (But for passing a student should obtain minimum 14 marks out of 35 in the externalUniversity examination and should obtain minimum 06 marks out of 15 in the internal examination). For Skill enhancement courses a student should obtain minimum 06 marks out of 15 in internal examination and theory/practical external examination 14 marksout of 35 in the external University examination.

C)Pattern of question papers: For MT-351 to MT-354 and MT-361 to MT-364.

Q.1. Attempt any 05 out of 07 questions each of 01 marks. [05 Marks]

Q.2. Attempt any 02 out of 04 questions each of 05 marks. [10 Marks].

Q.3. Attempt any 02 out of 04 questions each of 05 marks. [10 Marks].

Q.4. Attempt any 02 out of 04 questions each of 10 marks. [10 Marks].

D) External Students: **Not allowed**.

E) Verification / Revaluation: **Allowed for Theory papers only.**

F) Qualifications for Teacher: **M.Sc. Mathematics (with NET /SET as per UGC existing rules).**

Equivalence of Previous syllabus along with new syllabus:

New Course	**Old Course**	**New Course**	**Old Course**
Semester-V	**Semester-III**	**Semester-VI**	**Semester-IV**
MT-351: Metric Spaces	MT 331 : Metric Spaces	MT 361: Complex Analysis	MT 341: Complex Analysis
MT-352: Real Analysis-I	MT 332: Real Analysis-I	MT 362 : Real Analysis-II	MT 342: Real Analysis-II

MT 353:Group Theory	MT 334 : Group Theory	MT 363 : Ring Theory	MT 344: Ring Theory
MT 354 : Ordinary Differential Equations	MT 335 : Ordinary Differential Equations	MT 364 : Partial Differential Equations	MT 345: Partial Differential Equations
MT 355 (A): Operations Research	MT 337 A. Operations Research	MT 365 (A): Optimization Techniques	MT 347 A : Optimization Techniques
MT 355 (B): Differential Geometry	MT 337 D: Lattice Theory	MT 365 (B): Calculus of Variation and Classical Mechanics	MT 347 B : Differential Geometry
MT 355 (C): C-Programming	MT 337 B. Dynamical System	MT 365(C): Financial Mathematics	MT 347 E: Lebesgue Integration
MT 356 (A): Machine Learning-I	MT 347D. Graph theory	MT 366 (A): Machine Learning-II	MT 347 C: C-Programming-II
MT 356 (B): Number Theory	MT 337 F. Number Theory	MT 366 (B): Computational Geometry	MT 347F : Computational Geometry
MT 356 (C): Laplace Transform and Fourier Series	MT 337 C. C- Programming I	MT 366(C): Lebesgue Integration	MT 337 E. Financial Mathematics
MT 357: Practical CourseLab-I: Metric Spaces and Real Analysis-I	MT 333 : Problem Course on MT 331 and MT 332	MT 367: Practical CourseLab-I: Complex Analysis and Real Analysis-II	MT 343 : Problem Course on MT 341 and MT 342
MT 358: Practical CourseLab-II: Group Theory and Ordinary Differential Equations	MT 336 : Problem Course on MT 334 and MT 334	MT 368: Practical CourseLab-II: Ring Theory and Partial Differential Equations	MT 346 : Problem Course on MT 344 and MT 345
MT 359: Practical Course Lab-III: DSE-3A and DSE-3B	MT 338: Practical based on papers selected from 337 A to 337 F	MT 369:Practical CourseLab-III: DSE-6A and DSE-6B	MT 348: Practical based on papers selected from 347 A to 347 F
MT 3510: Programming in Python-I		MT 3610: Programming in Python -II	
MT 3511: LaTeX for Scientific Writing		MT 3611: Mathematics IntoLatex	

Details of Syllabus:

Semester-V

DSE-1A: MT 351: Metric Spaces (2 credits)

Course Objectives: The course aims at providing the basic knowledge pertaining to metric spaces such as neighborhood, interior, closure, open and closed balls, continuity, completeness, compactness and connectedness etc.

Course Learning Outcomes: The course will enable the students to:

i) understand the introductory concepts of metric spaces;
ii) correlate these concepts to their counter parts in modern analysis by studying examples;
iii) learn to analyze mappings between spaces.
iv) attain background for advanced courses in real analysis, functional analysis, and topology.
v) appreciate the abstractness of the concepts such as open balls, closed balls, compactness, connectedness etc. beyond their geometrical imaginations.

Course Contents:

Unit 1: Basic Notions **[09 Lectures]**

1.1 Definition and examples
1.2 Open Balls and Open Sets

Unit 2: Convergence **[09 Lectures]**

2.1 Convergent Sequences
2.2 Limit and Cluster points
2.3 Cauchy Sequences and Completeness
2.4 Bounded Sets
2.5 Dense Sets
2.6 Boundary of a set

Unit 3: Continuity **[08 Lectures]**

3.1 Continuous Functions
3.2 Equivalent Definitions of Continuity
3.3 Topological Property
3.4 Uniform Continuity
3.5 Limit of **a** Function
3.6 Open and closed maps

Unit 4:CompactnessandConnectedness **[10 Lectures]**

4.1 Compact Spaces and their Properties
4.2 Connected Spaces

Text Book:

1. **Topology of Metric Spaces, S. Kumaresan, Narosa Publishing House (2nd edition), 2011.**

Unit 1: Chapter-1: Sec. 1.1; 1.1.14(only Statement) (Except- 1.1.9 to 1.1.12, 1.1.15 to 1.1.27, 1.1.33 to 1.1.37), Sec. 1.2; 1.2.40(only Statement), 1.2.42 (only Statement) (Except - 1.2.9 to 1.2.17, 1.2.41, 1.2.49 to 1.2.55, 1.2.57 to 1.2.60, 1.2.65, 1.2.66, 1.2.70 to 1.2.73, 1.2.76, 1.2.77, 1.2.87, 1.2.88, 1.2.107).

Unit 2: Chapter -2: Sec. 2.1 (Except 2.1.7, 2.1.8, 2.1.11 to 2.1.13, 2.1.15 to 2.1.19), Sec. 2.2; 2.2.7 (on metric space), 2.2.19(on metric space) (Except- 2.2.11, 2.2.21, 2.2.31), Sec. 2.3; 2.3.12(only statement) (Except - 2.3.4, 2.3.19, 2.3.20), Sec. 2.4 (Except 2.4.8 to 2.4.13, 2.4.16), Sec. 2.5 (Except 2.5.3, 2.5.4, 2.5.15), Sec. 2.7.

Unit 3: Chapter – 3: Sec. 3.1 (Except 3.1.9, 3.1.10, 3.1.12, 3.1.14, 3.1.21to 3.1.24), Sec. 3.2; 3.2.35 (only statement), 3.2.53 (only statement), (Except- 3.2.3, 3.2.4, 3.2.6, 3.2.8, 3.2.12 to 3.2.15, 3.2.19, 3.2.29, 3.2.37 to 3.2.43, 3.2.51, 3.2.52), Sec. 3.3 (Except 3.3.5, 3.3.6, 3.3.10), Sec. 3.4 (Except 3.4.4, 3.4.5, 3.4.12 to 3.4.14, 3.4.16), Sec. 3.5, Sec. 3.6.

Unit 4: Chapter -4: Sec. 4.1; 4.1.15(only statement) (Except - 4.1.27 to 4.1.31, 4.1.35, 4.1.36), Sec. 4.2 (Except- 4.2.2, 4.2.6, 4.2.9, 4.2.12 to 4.2.14), Sec. 4.3; 4.3.1(only statement) (Except 4.3.16. 4.3.25, 4.3.26, 4.3.27).
Chapter -5: Sec. 5.1; 5.1.6(on metric space), 5.1.7(only statement) (Except - 5.1.12, 5.1.15 to 5.1.17, 5.1.23, 5.1.24, 5.1.27, 5.1.33, 5.1.34, 5.1.36,5.1.48).

Reference Books:

1. Metric Spaces, Q.H. Ansari: Narosa Publishing House, New Delhi, Chapters 1 – 5.
2. Metric Spaces, SatishShirali, H. Vasudeva, Springer.
3. First Course in Metric Spaces, B. K. Tyagi, Cambridge University Press
4. M. O. Searcoid: Metric spaces, Springer, 2007.
5. Metric Spaces, E.T.Copson, University Press, Cambridge, 2nd edition, Mumbai, 1978.

DSE-1B: MT: 352 Real Analysis-I (2 credits)

Course Objectives: The course will provide students with a thorough understanding of real lines and distinguishing concepts in order to prove convergence and divergence of real number sequences and series. These principles have a wide variety of real-world applications.

Course Learning Outcomes: This course will enable the students to:

i) learn the basic facts in logic and set theory
ii) learn to define sequence in terms of functions from N to a subset of R and to understand several properties of the real line.
iii) recognize bounded, convergent, divergent, Cauchy and monotonic sequences and to calculate their limit superior, limit inferior, and the limit of a bounded sequence.
iv) use the ratio, root, alternating series and limit comparison tests for convergence and absolute convergence of an infinite series of real numbers.

Course Contents:

Unit 1: Logic and Set Theory **[10 Lectures]**

1.1 Introduction
1.2 "And" and "Or"
1.3 "Not" and "If-Then"

1.4 Contrapositive, Converse, and Iff
1.5 Quantifiers
1.6 Set Theory and Venn Diagrams
1.7 Relations and Functions
1.8 Countable and Uncountable Sets

Unit 2: Sequences of Real Numbers **[07 Lectures]**

2.1 Definition of sequence and subsequence
2.2. Limit of a sequence
2.3 Convergent sequences
2.4 Divergent sequences
2.5 Bounded sequences
2.6 Monotone sequences

Unit 3:Operations on convergent sequences and Limit Superior, Limit Inferior **[07 Lectures]**

3.1 Operations on convergent sequences
3.2 Operations on divergent sequences
3.3 Limit superior and limit inferior
3.4 Cauchy sequences

Unit 4: Series of Real Numbers **[12 Lectures]**

4.1 Convergence and divergence
4.2 Series with nonnegative terms
4.3 Alternating series
4.4 Conditional convergence and absolute convergence
4.5 Rearrangements of series
4.6 Tests for absolute convergence
4.7 Series whose terms form a non-increasing sequence
4.8 The class l^2.

Text Books: -

1. **Real Analysis and Foundations, Second Edition, Steven G. Krantz, Chapman and Hall/CRC.**
   Unit 1: Chapt. 1- Sec.: 1.1, 1.2,1. 3, 1.4, 1.5, 1.6, 1.7, 1.8
2. **Methods of Real Analysis, Second Edition, Richard R. Goldberg, John Wiley & Sons, Inc.**
   Unit 2: Chapt.-2: Sec.: 2.1, 2.2, 2.3, 2.4, 2.5, 2.6,
   Unit3: Chapt.-2 Sec.: 2.7, 2.8, 2.9, 2.10,
   Unit 4: Capt.- 3: Sec.: 3.1, 3.2, 3.3, 3.4, 3.5, 3.6, 3.7, 3.10

Reference Books: -

1. Real Analysis, N.L. Carothers, Cambridge University Press
2. Introduction to Real Analysis, Third edition, Robert, G. Bartle, Donald Sherbert , John Wiley and Sons.

3. A Basic Course in Real Analysis, Ajit Kumar and S.Kumaresan ,CRC Press, Second Indian, , CRC Press (Chapman and Hall)
4. A course of Mathematical Analysis, Revised edition, Shantinarayan and Mittal - S. Chand and Co. (2002).
5. Mathematical Analysis, third Edition, S.C. Malik and Savita Arora - New Age International Publications.

DSE-2A: MT-353: Group Theory(2 credits)

Course Objectives: The course objective is to introduce students to the fundamental theory of groups and their homomorphisms. Symmetric groups and symmetries in groups, Lagrange's theorem are also studied in depth.

Course Learning Outcomes: The course will enable the students to:

i) recognize the mathematical objects that are groups, and classify them as abelian, cyclic and permutation groups, etc;
ii) analyze consequences of Lagrange's theorem
iii) learn about structure preserving maps between groups and their consequences.
iv) explain the significance of the notion of cosets, normal subgroups, and factor groups.

Course Contents:

Unit 1. Groups **[06 lectures]**
1.1 Binary Operation
1.2 Isomorphic Binary Structures
1.3 Groups

Unit 2. Subgroups **[06 lectures]**
2.1 Subgroups
2.2 Cyclic Groups

Unit 3. Permutations[12 lectures]
3.1 Groups of Permutations
3.2 Orbits
3.3 Cycles
3.4 Alternating Groups
3.5Cosets and the Theorem of Lagrange
3.6 Direct Products

Unit 4.Homomorphisms and Factor Group **[12 lectures]**
4.1 Homomorphisms
4.2 Factor Groups
4.3 Factor Group Computations and Simple Groups

Text book:

1. **John B. Fraleigh, A First Course in Abstract Algebra, Seventh Edition, Pearson. Sections:** 2,3,4,5,6,8,9,10, 11(only Direct Product), 13,14,15.

Reference Books:

1. P.B. Bhattacharya, S.K. Jain and S.R. Nagpal, Basic Abstract Algebra, Second Ed., Foundation Books, New Delhi, 1995.

2. I. N. Herstien, Topics in Algebra, John Wiely and Sons.
3. N.S. Gopalakrishnan, University Algebra, Second Edition, New Age International, New Delhi, 1986.
4. Joseph. A. Gallian, Contemporary Abstract Algebra,(4th Edition), Narosa Publishing House.

DSE-2B: MT-354- Ordinary Differential Equations (2 credits)

Course Objectives: The main objectives of this course are to introduce the students to the exciting world of differential equations, system of differential equationsand their applications.

Course Learning Outcomes: The course will enable the students to:

i) understand the genesis of ordinary differential equations.
ii) learn various techniques of getting exact solutions of solvable first order differential equations and linear differential equations of higher order.
iii) grasp the concept of a general solution of a linear differential equation of an arbitrary order and also learn a few methods to obtain the general solution of such equations.

Course Contents:

Unit 1. Linear Differential Equations with constant coefficients [12 lectures]

1.1 Constant coefficient homogeneous equations
1.2 Characteristic equations
- 1.2.1 distinct real roots
- 1.2.2 repeated roots
- 1.2.3 complex roots

1.3 Particular solution
1.4 Initial value problem
1.5 The operator $\frac{1}{f(D)}$ and its evaluation for the functions x^m, e^{ax} , $e^{ax}v$, xv and the operator $\frac{1}{D^2+a^2}$ acting on $\sin ax$ and $\cos ax$ with proofs.

Unit 2. Non -Homogeneous Linear Equations [08 lectures]

2.1 Principle of superposition
2.2 Method of undetermined coefficients
2.3 Method of reduction of order
2.4 Method of variation of parameters.

Unit 3. Series Solutions of Linear Second Order Equations [06 lectures]

3.1 Review the properties of power series
3.2 Series solution near an ordinary point
3.3Regular singular points
3.4 Euler equations

Unit 4. System of Equations [10 lectures]

4.1 Introduction to system of differential equations
4.2 Linear systems: basic theory of homogeneous linear systems, constant coefficient
4.3 Homogeneous systems.

Text Books:

1. **William F Trench , Elementary Differential Equations with Boundary Value Problems ,** E book (Free download)

Unit 1 : Chapter 5: Sections 2 to 3 . Unit 2 : Chapter 5: Sections 4 to 7 .
Unit 3: Chapter 7: sections 1 to 4. Unit 4 : Chapter 10 : sections 1 to 6.

2. **Frank Ayres JR, Theory and Problems on Differential Equations, Schaum's outline Series, SI (metric) edition.** Unit 1 Chapter 16 Short methods

Reference Books:

1. M. D. Raisinghania , Ordinary and Partial Differential Equations , S. Chand and Company LTD 2009.
2. Elementary Differential Equations seventh edition by Earl D. Rainville and Philip E Bedient.
3. George F. Simmons and Stevan G. Krantz , Differential Equations, Tata McGraw-Hill.
4. W. R. Derrick and S. I. Grossman, A First Course in Differential Equations with Applications . CBS Publishers and Distributors , Delhi 110032, Third Edition.
5. Daniel Murray, Introductory Course in Differential Equations, Orient Longman.

DSE-3A: MT 355(A): Operations Research (2 credits)

Course Objectives: This course develops the ideas underlying the Simplex method for Linear programming problem, as an important branch of operations research. The course covers Linear programming with applications to Transportation and Assignment problem. Such problems arise in manufacturing resource planning and financial sectors.

Course Learning Outcomes: This course will enable the students to learn:

i) Analyze and solve linear programming models of real-life situations.
ii) The graphical solution of LPP with only two variables, and illustrate the concept of convex set and extreme points. The theory of the simplex method is developed.
iii) The relationships between the primal and dual problems and their solutions with applications to transportation, assignment and two-person zero-sum game problem.

Course Contents:

Unit 1. Modeling with Linear Programming **[08 Lectures]**

1.1Two variable LP Model
1.2 Solution of LP Model by Graphical Method
1.3 Selected LP Model Applications
1.4 Graphical Sensitivityanalysis.

Unit 2. TheSimplex Method and Duality **[12 Lectures]**

2.1 LP Model in equation form
2.2 Transition from graphical to algebraic solutions
2.3 The Simplex method.
2.4 Definition of the dual problem
2.5 Primal dual relationship
2.6 Economic interpretation of Duality.

Unit 3. Transportation Model **[10 Lectures]**

3.1 Definition of the Transportation model
3.2 The Transportation algorithm.

Unit 4. The Assignment Model **[06 Lectures]**

4.1 The Hungarian method
4.2 Simplex explanation of the Hungarian method.

Text Book:

1. **Hamdy A. Taha, Operation Research (Eighth Edition, 2009), Prentice Hall of India Pvt. Ltd, New Delhi.**

Unit 1: Chapter-2: 2.1,2.2,2.3(2.3.4, 2.3.5, 2.3.6).

Unit 2:**Chapter-3**: 3.1, 3.2, 3.3, 3.4, 3.5, 3.6 (3.6.1), Chapter-4: 4.2, 4.3

Unit 3:Chapter -5: 5.1,5.3 (5.3.1, 5.3.2, 5.3.3), **Unit 4:Chapter-5**: 5.4(5.4.1, 5.4.2).

Reference Books:

1. Frederick S. Hillier, Gerald J. Lieberman, Introduction toOperation Research (Eighth Edition) Tata McGrawHill.
2. J K Sharma, Operations Research (Theory and Applications,second edition, 2006), Macmillan IndiaLtd.
3. Hira and Gupta, Operation Research.

DSE-3A: MT-355(B): Differential Geometry (2 credits)

Course Objectives: This course enables the students to understand differential geometry of curves, their fundamental properties like torsion, curvature etc. along with their different forms. Also, to make understand different forms of curves and surfaces, along with their diverse properties through the use of differential calculus.

Course Learning Outcomes: The course will enable the students to:

i) Gain an understanding to solve problems with the use of differential geometry to diverse situations in mathematical contexts.
ii) Develop different properties associated with curves and surfaces.
iii) Demonstrate a depth of understanding in advanced mathematical topics in relation to geometry of curves and surfaces Learn to analyze mappings between spaces.
iv) Apply the theory of differential geometry to specific research problems in mathematics or other fields.

Course Contents:

Unit 1: Curves in the plane and in space [04 Lecture]

1.1 What is a curve?
1.2 Arc-length
1.3 Reparameterization
1.4 Level Curves vs. Parameterized Curves

Unit 2 : How much does a curve? [06 Lecture]

2.1 Curvature
2.2 Plane Curves
2.3 Space Curves

Unit 3 : Global Properties of curves [06 Lecture]

3.1 Simple Closed Curves
3.2 The Isoperimetric Inequality
3.3 The Four Vertex Theorem

Unit 4 : Surfaces in three dimensions [06 Lecture]

4.1 What is a Surface?
4.2 Smooth Surfaces
4.3 Tangents, Normal and Orientability

4.4 Examples of surfaces
4.5 Quadratic Surfaces
4.6 Triply orthogonal Systems
4.7 Applications of the Inverse Function Theorem

Unit 5 : The first fundamental form [07 Lecture]

5.1 Lengths of Curves on Surfaces
5.2 Isometries of Surfaces
5.3 Conformal Mappings of Surfaces
5.4 Surface Area
5.5 Equiareal Maps and Theorem of Archimedes

Unit 6 : Curvature of surfaces [07 Lecture]

6.1 The Second Fundamental Theorem
6.2 The Curvature of Curves on a Surface
6.3 The Normal and Principal Curvatures
6.4 Geometric Interpretation of Principal Curvatures.

Text book:

1. **Andrew Pressley: Elementary Differential Geometry, Springer International Edition, Indian Reprint 2004.**
   Unit 1: Chapter 1: Section 1.1 to 1.4, Unit 2: Chapter 2: Section 2.1 to 2.3,
   Unit 3: Chapter 3: Section 3.1 to 3.3, Unit 4: Chapter 4: Section 4.1 to 4.7,
   Unit 5: Chapter 5: Section 5.1 to 5.5, Unit 6: Chapter 6: Section 6.1 to 4.4.

Reference Books:

1. John A. Thorpe, Differential Geometry, Springer International Edition, Indian Reprint 2004.
2. M. DoCarmo, Diffrential geometry of Curves and surfaces, Prentice Hall, 1976.

DSE-3A: MT 355(C): C-Programming (2 credits)

Course Objectives: The **course** is designed to provide complete knowledge of **C-language**. Students will be able to develop logics which will help them to create **programs**, applications in **C**. Also, by **learning** the basic **programming** constructs they can easily switch over to any other **language** in future.

Course Learning Outcomes: After the completion of this course, the students will be able to develop applications.

Course Contents:

Unit 1. Fundamentals of C – programming: [06 Lectures]

1.1 Introduction to C, The character set. Identifier and keywords. Data types, Constants.
1.2 Variables and arrays.
1.3 Declarations. Expressions., Statements, Symbolic constants, Operators and Expressions.

Unit 2. Data Input and Output: [06 Lectures]

2.1 Preliminaries. Single character input- the getchar() function.
2.2 Single character output-the putchar() function.
2.3 Entering input data- the scanf() function.
2.4 Writing output data- the printf function.
2.5 The gets and puts functions.

Unit 3. Preparing, running a complete C Program and Control Statements: [10 Lectures]

3.1Preliminaries.The while statement.The do-while statement.

3.2 The for statement, Nested loops. The if-else statement.The switch statement.

3.3. The break statement. The continue statement. The comma operator.The goto statement.

Unit 4. Functions and Arrays: [14 Lectures]

4.1 Introduction to a function. Defining a function. Accessing a function.

4.2 Passing arguments to a function. Function prototypes, Recursion, Defining an array.

4.3 Processing an array. Passing arrays to functions. Multidimensional arrays. Arrays and strings.

Text Book:

1. **Programming with C. By Byron S. Gottfried. Schaum's Outline series.**
   Unit-1: Chapters: 1, 2, 3, Unit-2: Chapter: 4, Unit-3: Chapters: 5, 6.
   Unit-4: Chapters: 7, 9.

Reference Books:

1. The C Programming Language. By Brian W. Kernighan, Dennis M. Ritchie, 2nd Edition.
2. Spirit of C: An Introduction to Modern Programming. By Henry Mullish and Herbert L. Cooper, Jaico Publishers.

DSE-3B: MT-356(A): Machine Learning-I (2 credits)

Course Objectives:

Students will try to learn:

1. To introduce students to the basic concepts and techniques of Machine Learning.
2. To become familiar with **introduction to NumPy Array and Matrices**.
3. To become familiar with discover and visualize data to gain insights.
4. To become familiar with Fine-tuning the model - Grid Search, Randomized Search.
5. To develop the ability to write database applications in Python.

Course Learning Outcomes:

Upon successful completion of this course the student will be able to:

1. Gain knowledge about basic concepts of Machine Learning.
2. Identify machine learning techniques suitable for a given problem.
3. Solve the problems using various machine learning techniques.

Course Contents:

Unit 1: Introduction to Machine Learning [08 Lectures]

1.1 What & why behind machine learning

1.2 Types of Machine Learning - Supervised vs Unsupervised

1.3 Model Based Training

1.4 Main challenges of Machine Learning

1.5. Testing and Validating

Unit 2: Introduction to Python [08 Lectures]

2.1 The Way Of The Program

2.2 Variables, Expressions and Statements

2.3 Functions
2.4 Conditionals and Recursion
2.5 Strings
2.6 Lists

Unit 3: Understanding ML related Python Packages [10 Lectures]

3.1 Numpy Basics: Arrays and Vectorized Computation
1. The NumPyndarray: A Multidimensional Array Object
2. Universal Functions: Fast Element-wise Array Functions
3. Data Processing Using Arrays
4. Linear Algebra

3.2 Getting Started with Pandas
1. Introduction to pandas Data Structures
2. Essential Functionality
3. Summarizing and Computing Descriptive Statistics
4. Handling Missing Data
5. Hierarchical Indexing

3.3 Plotting and Visualization
1. A Brief matplotlib API Primer
2. Plotting Functions in Pandas
3. Plotting Maps: Visualizing Haiti Earthquake Crisis Data

Unit 4: End to End Machine Learning Project [10 Lectures]

4.1 Get the data
4.2 Discover &Visualize the data to gain insights
4.3 Preparing the data for machine learning - Cleaning, Handling categorical values, Feature scaling
4.5 Select and Train a model - Training and Evaluating on the Training Set
4.4 Fine-tuning the model - Grid Search, Randomized Search

Text Books:-

1. **Hands-on Machine Learning with Scikit-Learn, Keras and Tensorflow–AurelienHeron, Sections: 1, 2**
2. **Python for Data Analysis by Wes McKinney (O' Reilly publication)Chapter -4:4.1, 4.2, 4.3, 4.5, Chapter -5: 5.1, 5.2, 5.3, 5.4, 5.5, Chapter-8:8.1, 8.2, 8.3**
3. **Allen Downey,Think Python,How to Think Like a Computer Scientist, Green Tea Press Needham, Massachusetts, 2015, Sections - 1, 2, 3, 5, 8, 10**

Reference Book:-

1. Introduction to Machine Learning With Python - Andreas C. Muller & Sarah Guide
2. Head first Python by Paul Barry (O Reilly publication)
3. Jason Brownlee - Basics of Linear Algebra for Machine Learning, 2018
4. M. P. Deisenroth, A. A. Faisal, C. S. Ong - Mathematics for Machine Learning, Cambridge University Press, 2019
5. DipanjanSarkar, Raghav Bali, Tushar Sharma - Practical Machine Learning with Python, 2018.
6. **Extra Reference Resources -**
   geeksforgeeks.org/machine-learning
   https://towardsdatascience.com/search?q=machine%20learningwww.kaggle.com

DSE-3B: MT-356(B): Number Theory (2 credits)

Course Objectives: There are difficult open problems in number theory that are understandable at the undergraduate level; this course is designed to develop a micro aptitude for understanding the aesthetic aspect of mathematical instructions and to prepare young minds to ponder such problems. Another goal is to familiarise students with basic number theoretic techniques that can be used in data protection.

Course Learning Outcomes: This course will enable the students to learn:

i) some of the open problems related to prime numbers.
ii) about number theoretic functions and modular arithmetic.
iii) the Law of Quadratic Reciprocity and other methods to classify numbers as primitive roots, quadratic residues, and quadratic non-residues.

Course Contents:

Unit 1. Divisibility **[06 Lectures]**

1.1 Introduction
1.2 Divisibility
1.3 Prime

Unit 2.Congruences **[08 Lectures]**

2.1 Congruences
2.2 Solution of Congruences
2.3 The Chinese Remainder Theorem

Unit 3. Greatest integer function **[08 Lectures]**

3.1 Greatest integer function
3.2 Arithmetic functions
3.3 The Mobius Inversion formula

Unit 4.Quadratic Reciprocity **[08 Lectures]**

4.1 Quadratic residues
4.2 Quadratic reciprocity
4.3 The Jacobi Symbol

Unit 5. Diophantine Equations **[06 Lectures]**

5.1 Diophantine equations $ax + by = c$
5.2 Pythagorean triplets.

Text Book:

1. **I. Niven, H. Zuckerman and H.L. Montgomery, An Introduction to Theory of Numbers, 5th Edition, John Wiley and Sons.**
   Unit 1 : Chapter 1 Section 1.1- 1.3, Unit 2 : Chapter 2 Section 2.1- 2.3,
   Unit 3 : Chapter 3 Section 3.1- 3.3, Unit 4 : Chapter 4 Section 4.1 -4.3,
   Unit 5 : Chapter 5 Section 5.1 and 5.3

Reference Book:

1. David M. Burton, Elementary Number Theory (Second Ed.), Universal Book Stall, New Delhi, 1991.

DSE-3B: MT-356 (C): Laplace Transform and Fourier Series (2 credits)

Course Objectives: The main objective of this course is to determine properties of Laplace Transform and Fourier series which may be solved by application of special functions.

Course Learning Outcomes: This course will enable the students to learn:

i) Students will be able to know the use of Laplace transform in system modeling, digital signal processing, process control.
ii) Solve an initial value problem for an nth order ordinary differential equation using the Laplace transform.
iii) Find the Fourier series representation of a function of one variable

Course Contents:

Unit 1: The Laplace Transform [10Lectures]

1.1 Definition, Laplace Transform of some elementary functions.
1.2 Sufficient condition for existence of Laplace Transform
1.3 Some important properties of Laplace Transform.
1.4 Methods of finding Laplace Transform: Direct Method, Series Method
1.5 Evaluation of Integration
1.6 Some Special Functions

Unit2: The Inverse Laplace Transform [10Lectures]

2.1 Definition, Some inverse Laplace Transform.
2.2 Some important properties of Inverse Laplace Transform.
2.3 Methods of finding inverse Laplace Transforms: Partial Fraction Method and Series Method.
2.4 The Heaviside's Expansion formula.
2.5 Beta function, Evaluation of Integration.

Unit3: Applications to Differential Equations [10Lectures]

3.1 Ordinary Differential Equations with constant coefficients.
3.2 Ordinary Differential Equations with variable coefficients.
3.3 Simultaneous Ordinary Differential Equations.

Unit 4: Fourier series [06Lectures]

4.1 Even and Odd functions, Its properties.
4.2 Fourier series and its Examples.

Text Book:

1. **Schaum's Outline Series-Theory and Problems of Laplace Transform by Murray R. Spiegel.**
   Unit1:Chapter-1, Unit2:Chapter-2, Unit3:Chapter-3 (Excluding Applications to Mechanics, Electrical circuits, Beam and PDE).
2. **Richard R. Goldberg, Methods of Real Analysis, Oxford and IBH Publishing Co.Pvt.Ltd.(1970).**
   Unit4: Chapter-12(only12.1)

ReferenceBooks:

1. Phil Dyke, An Introduction to Laplace Transforms and Fourier Series, Second Edition, Indian Reprint 2014.
2. Joel L. Schiff, The Laplace Transforms- Theory and Applications, Springer Verlag New York 1999.
3. Lokenath Debnath and Dambaru Bhatta, Integral Transforms and Their Applications, Third Edition, CRC Press.

DSE-1: MT 357: Practical Course Lab-I (Metric Spaces and Real Analysis-I)(2 credits)

Section-I: Metric Spaces Practical

Practical 1: Definition and examples of Metric Spaces (Unit-1; 1.1)

Practical 2: Open and Closed sets in metric spaces (Unit-1; 1.2)

Practical 3: Convergences (Unit 2)

Practical 4: Continuity (Unit 3)

Practical 5: Compactness (Unit 4)

Practical 6: Connectedness (Unit 4)

Section-II: Real Analysis-I Practical

Practical 1: Logic, Set Theory, Functions and Cardinality (Unit-1)

Practical 2: Convergent and Divergent Sequences of Real Numbers (Unit-2)

Practical 3: Monotone Sequences and Algebra of Convergent Sequences (Unit-2)

Practical 4: Limit Superior, Inferior and Cauchy Sequences (Unit-3)

Practical 5: Series of Real Numbers, Alternating Series and Conditional/Absolute Convergence (Unit-4)

Practical 6: Convergent and Divergent Series of Real Numbers (Unit-4)

DSE-2: MT 358: Practical Course Lab-II (Group Theory and Ordinary Differential Equations)(2 credits)

Section-I: Group Theory Practical

Practical 1: Isomorphic Binary Structures and Groups (Unit-1)

Practical 2: Subgroups and Cyclic Groups (Unit-2)

Practical 3: Groups of Permutations, Orbits and Cycles (Unit-3)

Practical 4: Alternating Groups, Cosets and the Theorem of Lagrange (Unit-3)

Practical 5: Direct Productsand Homomorphisms (Unit-4)

Practical 6: Factor Groups, Factor Group Computations and Simple Groups (Unit-4)

Section-II: Ordinary Differential Equations Practical

Practical 1: Linear differential equations with constant coefficients (Unit 1.1 to 1.4)

Practical 2: Inverse differential operators (Short methods) (Unit 1.5)

Practical 3: Non homogeneous linear equations Part I (Unit 2.1 to 2.2)

Practical 4: Non homogeneous linear equations Part II (Unit 2.3 to 2.4)

Practical 5: Series solution of linear second order equations (Unit 3)

Practical 6: System of equations (Unit 4).

DSE-3: MT 359: Practical Course Lab-III (Based on DSE-3A and DSE-3B)(2 credits)

Section-I: Operations Research/ Differential Geometry/C-Programming

Section-I (A): Operations Research Practical

Practical 1: Modeling withLinearProgramming (Unit-1)

Practical 2: TheSimplex Method-I (Unit-2)

Practical 3: TheSimplex Method-II (Unit-2)

Practical 4: Duality (Unit-2)

Practical 5: TransportationModel (Unit-3)

Practical 6: TheAssignmentModel (Unit-4)

OR

Section-I (B): Differential GeometryPractical

Practical 1: Curves in the plane and in space (Unit 1)

Practical 2: How much does a curve? (Unit 2)

Practical 3: Global Properties of curves (Unit 3)

Practical 4: Surfaces in three dimensions (Unit 4)

Practical 5: The first fundamental form (Unit 5)

Practical 6: Curvature of surfaces (Unit 6)

OR

Section-I(C): C- Programming Practical

Practical-1: Operators and expressions-I (Unit 1)

Practical-2: Operators and expressions-II (Unit 2)

Practical-3: Control statements-I (Unit 3)

Practical-4: Control statements-II (Unit 3)

Practical-5: Arrays (Unit 4)

Practical-6: Functions (Unit 4)

Section-II: Machine Learning-I/ Number Theory/Laplace Transform and Fourier Series

Section-II(A): Machine Learning-I Practical

Practical 1: Introduction to Python, Python Data Types-I (Unit 2)

Practical 2: Python Data Types- II (Unit 2)

Practical 3: Control statements in Python-I (Unit 2)

Practical 4: Control statements in Python-II (Unit 2)

Practical 5: Python collection type - List (Unit 2)

Practical 6: Data handling with Panda - 1 (Unit 3)

Practical 7: Data handling with Panda - 2 (Unit 3)

Practical 8: Data visualization with Matplotlib (Unit 3)

Practical 9: Introduction to scikit-learn (Unit 3)

Practical 10: End to end model implementation - 1 (Unit 4)

Practical 11: End to end model implementation - 2 (Unit 4)

Practical 12: End to end model implementation - 3 (Unit 4)

OR

Section-II(B): Number TheoryPractical

Practical 1: Divisibility and GCD – I (Unit 1)

Practical 2: Divisibility and GCD – II (Unit 1)

Practical 3: Congruences (Unit 2)

Practical 4: Quadratic Reciprocity (Unit 3)

Practical 5: Number Theoretic Functions (Unit 4)

Practical 6: Linear Diophantine Equations, Pythagorean Triplets (Unit 5)

OR

Section-II(C): LaplaceTransformsandFourierSeries Practical

Practical1:The Laplace Transform(Unit1:1.1,1.2,1.3,1.4)

Practical2:Special Functions(Unit1:1.5,1.6)

Practical3:The Inverse Laplace Transform-I(Unit2:2.1,2.2,2.3,2.4)

Practical4:The Inverse Laplace Transform-II(Unit2:2.4, 2.5)

Practical5:Applications to Differential Equations(Unit3)

Practical6:Fourier Series(Unit4)

SEC-I: MT -3510: Programming in Python–I (2 credits)

Course Objectives:

1. To understand why **Python** is a useful scripting language for developers.
2. To learn how to use lists, tuples, and dictionaries in **Python** programs.

3. To learn and understand python looping, control statements and string manipulations.
4. To acquire programming skills in core Python.

Course Learning Outcomes: At the end of the course:

1. The student will be able to explain basic principles of Python programming language.
2. The student will implement object oriented concepts.

Course Contents:

Unit 1: Introduction to Python [06 Lectures]

1.1 Installation of Python
1.2 Values and types: int, float and str,
1.3 The Print Function: Print basics
1.4 Variables: assignment statements, printing variable values, types of variables.
1.5 Mathematical Operators, operands and precedence:+, -, /, *, **, % PEMDAS (Rules of precedence)
1.6 String operations: + : Concatenation, * : Repetition
1.7 Boolean operator:
1.7.1 Comparison operators: ==, !=, >, =, <=
1.7.2 Logical operators: and, or, not
1.8 Mathematical functions from math, cmath modules, random module
1.9 Keyboard input: input() statement
1.10 Calculus: Differentiation, Integration, Limit and Series

Unit 2: String, list, tuple [06 Lectures]

2.1 Strings:
2.1.1 Length (Len function)
2.1.2 String traversal: Using while statement, Using for statement
2.1.3 String slice
2.1.4 Comparison operators (>, <, ==)
2.2 Lists:
2.2.1 List operations
2.2.2 Use of range function
2.2.3 Accessing list elements
2.2.4 List membership and for loop
2.2.5 List operations
2.2.6 Updating list: addition, removal or updating of elements of a list
2.3 Tuples:
2.3.1 Defining a tuple,
2.3.2 Index operator,
2.3.3 Slice operator,
2.3.4 Tuple assignment,
2.3.5 Tuple as a return value

Unit 3: Iterations and Conditional statements [10 Lectures]

3.1 Conditional and alternative statements, Chained and Nested Conditionals: if, if-else, if-elif-else, nested if, nested if-else
3.2 Looping statements such as while, for etc, Tables using while.
3.3 Functions:

3.3.1 Calling functions: type, id
3.3.2 Type conversion: int, float, str
3.3.3 Composition of functions, Returning values from functions
3.3.4 User defined functions, Parameters and arguments

Unit 4: Linear Algebra [04 Lectures]

4.1 Matrix construct, eye(n), zeros(n,m) matrices
4.2 Addition, Subtraction, Multiplication of matrices, powers and invers of a matrix.
4.3 Accessing Rows and Columns, Deleting and Inserting Rows and Columns
4.4 Determinant, reduced row echelon form, nullspace, columnspace, Rank
4.5 Solving systems of linear equations (Gauss Elimination Method, Gauss Jordan Method, LU- decomposition Method)
4.6 Eigenvalues, Eigenvectors, and Diagonalization

Unit 5: Numerical methods in Python [06 Lectures]

5.1 Roots of Equations
5.2 Newton-Raphson Method
5.3 False Position (RegulaFalsi) Mehtod
5.4 Numerical Integration:
5.4.1 Trapezoidal Rule,
5.4.2 Simpson's $1/3^{rd}$ Rule,
5.4.3 Simpson's $3/8^{th}$ Rule

Unit 6: 2D and 3D Graphs [04 Lectures]

6.1 Installation of numpy, matplotlib packages
6.2 Graphs plotting of functions
6.3 Different formats of graphs, PyDotPlus (Scalable Vector Graphics), PyGraphviz.
Decorate Graphs with Plot Styles and Types: Markers and line styles, Control colors, Specifying styles in multiline plots, Control linestyles, Control marker styles.
Polar charts: Navigation Toolbar with polar plots, Control radial and angular grids.
6.4 Three-dimensional Points and Lines
6.5 Three-dimensional Contour Plots, Wireframes and Surface Plots.

Practicals:

Practical 1: Introduction to Python, Python Data Types-I (Unit 1)

Practical 2: Python Data Types- II (Unit 2)

Practical 3: Control statements in Python-I (Unit 3- 3.1, 3.2)

Practical 4: Control statements in Python-II (Unit 3- 3.3)

Practical 5: Application: Matrices (Unit 4 – 4.1-4.3)

Practical 6: Application: Determinants, system of Linear Equations (Unit 4- 4.4, 4.5)

Practical 7: Application: System of equations (Unit 4- 4.5)

Practical 8: Application: Eigenvalues, Eigenvectors (Unit 4 – 4.6)

Practical 9: Application: Eigenvalues, Eigenvectors (Unit 4 – 4.6)

Practical 10: Application: Roots of equations (Unit 5 – 5.1)

Practical 11: Application: Numerical integration (Unit 5 – 5.2, 5.3,5.4)

Practical 12: Graph Plotting (Unit 6)

Text Books:-

1. **Allen Downey,Think Python, How to Think Like a Computer Scientist, Green Tea Press Needham, Massachusetts, 2015,**
   Unit1-1: Chapter-1:1.1-1.5, Capter-2: 2.1-2.6, Chapter-3: 3.1-3.6, Chapter-5: 5.1-5.3
   Unit1-2: Chapter-8: 8.1-1.5, Capter-10: 10.12, Chapter-12: 12.1.- 12.6
   Unit-3: Chapter 5:5.4 -5.7, Chapter 7: 7.1-7-7.5
2. **Robert Johansson, Introduction to Scientific Computing in Python, 2016**
   Unit-1: 6.5-6.8
   Unit- 4: Chapter-4: 4.6 (4.6.1 - 4.6.6), Chapter-6: 6.9-6.10, Unit-5: Chapter-4: 4.8, Unit-6: Chapter-5
3. **Hans-PetterHalvorsen,Python for Scientific engineering, 2020 Unit-5: Chapter-31**

Reference Books:-

1. Lambert K. A., Fundamentals of Python - First Programs, Cengage Learning India, 2015.
2. Guzdial, M. J., Introduction to Computing and Programming in Python, Pearson India.
3. Perkovic, L., Introduction to Computing Using Python, 2/e, John Wiley, 2015.Zelle, J., Python Programming: An Introduction to Computer Science, Franklin,Beedle and Assiciatesn Inc.
4. SandroTosi, Matplotlib for Python Developers, Packt Publishing Ltd. (2009) BIRMINGHAM – MUMBAI. (Use for 2D and 3D plots and also use Lambert K. A book).
5. Python: Notes for Professionals, Goalkicker.com, Free Programming books.

SEC-II: MT-3511: LaTeX for Scientific Writing (2 credits)

Course Objectives: The purpose of this course is

i) To provide an understanding of the basicmechanisms of LaTeX, using plain text as a vehicle
ii) To acquaint students with the latest typesetting skills, which shall enable them to prepare high quality typesetting.

Course Learning Outcomes: After studying this course the student will be able to:

i) Write a simple LaTeX input document based on the article class.
ii) Turn the input document into pdf with the pdflatex program.
iii) Format Words, Lines, and Paragraphs.
iv) Understand how to present data using tables.

Course Contents:

Unit 1. Introduction to LaTeX [06 Lectures]

1.1 Definition and application of LaTeX
1.2 Preparation and Compilation of LaTeX input file
1.3 LaTeX Syntax
1.4 Keyboard Characters in LaTeX

Unit 2.Formatting Words, Lines, and Paragraphs [09 Lectures]

2.1 Text and Math Mode Fonts.
2.2 Emphasized and Colored Fonts

2.3 Sectional Units
2.4 Labeling and Referring Numbered Items
2.5 Texts Alignment and Quoted text
2.6 New Lines and Paragraphs
2.7 Creating and Filling Blank Space
2.8 Producing Dashes Within Texts

Unit 3.Listing and Tabbing Texts [09 Lectures]

3.1 Listing Texts
3.2 Tabbing Texts Through the tabbing Environment

Unit 4.Table Preparation [12 Lectures]

4.1Table Through the tabular Environment
4.2 Table Through the tabularx Environment
4.3 Vertical Positioning of Tables
4.4 Sideways (Rotated) Texts in Tables
4.5 Adjusting Column Width in Tables
4.6 Additional Provisions for Customizing Columns of Tables
4.7 Merging Rows and Columns of Tables.

Practicals:

Practical 1: Introduction to LaTeX (Unit-1; 1.1, 1.2)

Practical 2: Syntax and Keyboard Characters in LaTeX (Unit-1; 1.3, 1.4)

Practical 3: Fonts in LaTeX (Unit -2; 2.1, 2.2)

Practical 4: Sections, Labelling and Text Alignment in LaTeX (Unit-2; 2.3, 2.4, 2.5)

Practical 5: New Lines, Paragraphs, Blank Space and Dashes in LaTeX (Unit-2; 2.6-2.8)

Practical 6: Listing Texts -I (Unit-3; 3.1[Chapter 6, 6.1.1, 6.1.2])

Practical 7: Listing Texts -II (Unit-3; 3.1[Chapter 6, 6.1.3, 6.1.4, 6.1.5])

Practical 8: Tabbing Texts (Unit-3; 3.2)

Practical 9: Table Through the tabular Environment (Unit-4; 4.1)

Practical 10: Table Through the tabularx Environment (Unit-4; 4.2)

Practical 11: Positioning and Texts in Tables (Unit-4; 4.3, 4.4)

Practical 12: Customizing Tables in LaTeX (Unit-4; 4.5, 4.6, 4.7)

Text Book:

1. **LaTeX in 24 Hours, A Practical Guide for Scientific Writing, Dilip Datta, Springer International Publishing AG, 2017.**
   Unit 1: Chapter 1; 1.1 to 1.6, Unit 2: Chapter 2; 2.1 to 2.4, Chapter 3; 3.1 to 3.7
   Unit 3: Chapter 6; 6.1, 6.2, Unit 4: Chapter 7; 7.1 to 7.7

Reference Books:

1. LaTeX, A Document Preparation System, User's Guide and Reference Manual, Leslie Lamport, Addison-Wesley Publishing Company, Inc., 1994.
2. LaTeX Beginner's Guide, Stefan Kottwitz, Packt Publishing Ltd, 2011.

3. LaTeX and Friends, M.R.C. van Dongen, Springer-Verlag Berlin Heidelberg ,2012.

Semester-VI

DSE-4A: MT - 361: Complex Analysis (2 Credits)

Course Objectives: This course aims to introduce the basic ideas of analysis for complex functions in complex variables with visualization through relevant Practicals. Particular emphasis has been laid on Cauchy's theorems, series expansions and calculation of residues.

Course Learning Outcomes: The completion of the course will enable the students to:

i) Understand the significance of differentiability of complex functions leading to the understanding of Cauchy-Riemann equations.
ii) Evaluate the contour integrals and understand the role of Cauchy-Goursat theorem and the Cauchy integral formula.
iii) Expand some simple functions as their Taylor and Laurent series, classify the nature of singularities, find residues and apply Cauchy Residue theorem to evaluate integrals.
iv) Represent functions as Taylor, power and Laurent series, classify singularities and poles, find residues and evaluate complex integrals using the residue theorem.

Course Contents:

Unit 1: Analytic functions [09 Lectures]

1.1 Functions of a Complex Variables
1.2 Limits, Theorems on limits (Without Proof), Limitsinvolving the point at infinity, Continuity, Derivatives, Differentiation formulas (WithoutProof)
1.3 Cauchy- Riemann Equations, Sufficient Conditions for differentiability (OnlyStatement and Examples)
1.4 Polar coordinates, Analytic functions, Harmonic functions.

Unit 2: Elementary Functions [07 Lectures]

2.1 The Exponential functions
2.2 The Logarithmic function, Branches and derivatives oflogarithms, Some identities involvinglogarithms
2.3 Complex exponents, Trigonometricfunctions.

Unit 3. Integrals [11 Lectures]

3.1 Derivatives of functions, Definite integrals of functions
3.2 Contours, Contour integral,Examples
3.3 Upper bounds for Moduli of contour integrals, Anti-derivatives (Only Examples)
3.4 Cauchy-GoursatTheorem (without proof), Simply and multiply Connected domains.Cauchy integral formula, Derivatives of analytic functions. Liouville's Theorem andFundamental Theorem of Algebra (Without Proof).

Unit 4. Series [04 Lectures]

4.1 Convergence of sequences and series (Theorems without proof)
4.2 Taylor's series (without proof), Laurent series (withoutproof), examples only.

Unit 5. Residues and Poles [05 Lectures]

5.1 Isolated singular points, Residues
5.2 Cauchy residue theorem (Without Proof), residue atinfinity, types of isolated singular points,residues at poles
5.3 Zeros of analytic functions, zerosand poles.

Text Book:

1. **J.W. Brown and R.V. Churchill, Complex Variables and Applications, International StudentEdition, 2009. (Eighth Edition).**
   Unit -1: Chapter 1: Sec.11, 12, 15 to 26. Unit-2: Chapter 3: Sec.29 to 34.
   Unit -3: Chapter 4: Sec. 37 to 44, 46 and48 to53.
   Unit -4: Chapter 5:Sec. 55 to 60 and 62. Unit – 5: Chapter 6: Sec.68 to 76.

Reference Books:

1. S. Ponnusamy, Complex Analysis, Second Edition (Narosa).
2. S. Lang, Complex Analysis, (Springer Verlag).
3. A.R. Shastri, An Introduction to Complex Analysis, (MacMillan).
4. L.V.Ahlfors, Complex Analysis, 3rd edition, McGraw Hill, 2000.
5. H.A.Priestley, Introduction to Complex Analysis, 2nd edition (Indian), Oxford, 2006.

DSE-4B: MT: 362 Real Analysis-II(2 Credits)

Course Objectives: To comprehend bounded function integration on a closed and bounded interval, as well as its extension to situations where either the integration interval is infinite or the integrand has infinite limits at a finite number of points on the integration interval. The sequence and series of real-valued functions.

Course Learning Outcomes: The course will enable the students to learn about:

i) some of the families and properties of Riemann integrable functions, and the applications of the fundamental theorems of integration.
ii) beta and gamma functions and their properties.
iii) recognize the difference between pointwise and uniform convergence of a sequence of functions.
iv) illustrate the effect of uniform convergence on the limit function with respect to continuity, differentiability, and integrability.

Course Contents:

Unit 1: Riemann Integration **[12 Lectures]**

1.1 Sets of Measure zero
1.2 Definition of the Riemann Integral
1.3 Existence of the Riemann Integral
1.4 Properties of the Riemann Integral
1.5 Fundamental Theorems of Calculus

Unit 2: Improper Integrals **[10 Lectures]**

2.1 Improper Integrals on Closed and Bounded Intervals
2.2 Tests for Convergence of Positive Integrands
2.3 Improper Integrals on Unbounded Intervals and Tests for their Convergence
2.4 Tests for Convergence of the Integral of Product

Unit 3: Sequences of Functions **[07 Lectures]**

3.1 Pointwise convergence of sequences of functions
3.2 Uniform convergence of sequences of functions
3.3 Consequences of uniform convergence

Unit 4: Series of Functions **[07 Lectures]**

4.1 Convergence and uniform convergence of series of functions
4.2 Integration and differentiation of series of functions

Text Books:

1. **Methods of Real Analysis, Second Edition, Richard R. Goldberg, John Wiley and amp; Sons, Inc.**
   Unit -1:Sec.: 7.1,7.2,7.3,7.4,7.8, Unit -3: Sec.: 9.1, 9.2, 9.3, Unit-4: Sec.9.4, 9.5
2. **Introduction to Real Analysis, Eighth Edition, S.K. Mapa, Sarat Book House**
   Unit-2: Sections: 12.1, 12.2, 12.3, 12.4,12.5, 12.6, 12.7, 12.8, 12.9, 12.10

Reference Books:

1. Real Analysis, N.L. Carothers, Cambridge University Press
2. Introduction to Real Analysis, Third edition, Robert, G. Bartle, Donald Sherbert, John Wiley and Sons.
3. A Basic Course in Real Analysis, Ajit Kumar and S.Kumaresan,CRC Press, SecondIndian, CRC Press (Chapman and Hall)
4. A course of Mathematical Analysis, Revised edition, Shanti Narayan and Mittal - S.Chand and Co.(2002).
5. Mathematical Analysis, third Editions'. Malik and Savita Arora - New AgeInternational Publications

DSE-5A: MT: 363 Ring Theory (2 Credits)

Course Objectives: The objective of this course is to introduce the fundamental theory of rings and their corresponding homomorphisms. The basic concepts of ring of polynomials and irreducibility tests for polynomials over ring of integers.

Course Learning Outcomes: The course will enable the students to learn about:

i) The fundamental concept of Rings, Fields, subrings, integral domains and the corresponding morphisms.
ii) Learn in detail about polynomial rings, fundamental properties of finite field extensions, and classification of finite fields.
iii) Appreciate the significance of unique factorization in rings and integral domains.

Course Contents:

Unit 1: Rings and Fields [08 lectures]

1.1 Ring, Subring, Fields.
1.2 Divisors of zero, Integral Domain, The Characteristics of a Ring.
1.3 The Field of Quotients of an Integral Domain.

Unit 2: Rings of Polynomials & Factorization [08 lectures]

2.1 Polynomials in an determinate,
2.2 The Evaluation Homomorphism Zeros.
2.3 Factorization of a Polynomial over a Field: The Division Algorithm in F[x]
2.4 Irreducible Polynomials, Uniqueness of Factorization in F[x].

Unit 3: Ideals and Factor Rings [08 lectures]

3.1 Homomorphism, Properties of Homomorphism
3.2 Ideals, Factor Ring, Fundamental Homomorphism Theorem.
3.3 Maximal Ideal, Prime Ideal, Ideal Structure in F[x].

Unit 4: Factorization [12 Lectures]

4.1 Unique Factorization Domain, Principal Ideal Domain, Gauss Lemma, D[x] is a UFD.
4.2 Euclidean Norm, Euclidean Domain, Euclidean Algorithm (Without Proof).
4.3 Gaussian Integers, Multiplicative Norm.

Text Book:

1. **John B. Fraleigh, A First Course In Abstract Algebra, 7th Edition, Pearson.**
   Unit 1: Section 18, 19, 21. Unit 2: Section 22 and 23.
   Unit 3: Section 26 and 27. Unit 4: Section 45, 46 and 47 (except theorem 47.10).

Reference Books:

1. Josheph A. Gallian, Contemporary Abstract Algebra, 7th Edition, Narosa Publishing House.
2. David S. Dummit and Richard M. Foote, Abstract Algebra, 3rd Edition, Jonh Wiley and Sons, Inc.
3. I.N. Herstein, Abstract Algebra, 3rd Edition, Prentice Hall of India.
4. P.B. Bhattacharya, S.K. Jain and S.R. Nagpal, Basic Abstract Algebra, 2nd Edition, Cambridge University Press.

DSE-5B: MT 364: Partial Differential Equations (2 credits)

Course Objectives: The main goals of this course are to teach students how to form, solve, and apply partial differential equations to solve physical problems. Also, to introduce first and second order partial differential equations and their classifications and methods of finding solutions of these partial differential equations.

Course Learning Outcomes: The course will enable the students to:

i) formulate, classify and transform partial differential equations into canonical form.
ii) solve linear partial differential equations using various methodsand apply these methods in solving some physical problems.
iii) solve Laplace equations using various analytical methods demonstrate uniqueness of solutions of certain kinds of these equations.

Course Contents:

Unit 1: Introduction to Ordinary and Partial Differential Equations [10 Lectures]

1.1 Surfaces and Curves in Three Dimensions
1.2 Simultaneous Differential Equations of the First Order and the First Degree in Three Variables.
1.3 Methods of solution of $dx/P = dy/Q = dz/R$
1.4 Pfaffian Differential Forms and Equations.
1.5 Solution of Pfaffian Differential Equations in Three Variables

Unit 2: Partial Differential Equations [08 Lectures]

2.1 Introduction to Partial Differential Equations
2.2 Origin of first order Partial Differential Equations
2.3 Linear Equations of First order equations
2.4 Integral surfaces passing through given curve

Unit 3: Second Order Partial Differential Equations [10 lectures]

3.1 The Origin of Second Order Partial Differential Equations.
3.2 Linear Partial Differential Equations with constant coefficients.
3.3 Methods of solving Linear Partial Differential Equations
   3.3.1. Solution of reducible equations
   3.3.2. Solution of irreducible equations with constant coefficients

3.3.3. Rules of finding complementary functions

3.3.4. Rule of finding particular integrals

Unit 4 :Classification of Partial Differential Equations [08 lectures]

4.1 Classification of second order partial differential equations, canonical forms

4.2 Solution of Laplace equations by separation variables methods

4.3 Solution of periodic differential equations by separation variables method

4.4 Solution of wave equation by separation variables method.

Text Books:

1. **Ian Sneddon, Element of Partial Differential Equations, McGraw-Hill Book Company, McGraw-Hill Book Company.**

Unit-1: Chapter-1 : 1,2,3,5 , Unit-2: Chapter-2 :1,2,4,5, Unit-3:Chapter-3: 1,4,5

2. **J.N. Sharma, Kehar Singh, Partial Differential equations for Engineers and Scientists, second Edition, Narasa Publications.**

Unit-4: Chapter No.3: 3.3, Chapter No.4: 4.3 ,Chapter No.5: 5.5

Reference Books:

1. T. Amaranath, An Elementary Course in Partial Differential Equations, Narosa Publishing, House 2nd Edition, 2003 (Reprint, 2006).
2. K. Sankara Rao, Introduction to Partial Differential Equations, Third Edition, PHI.

DSE-6A: MT365 (A): Optimization Techniques(2 Credits)

Course Objectives: This course enables the students to get an idea about the

i) Network and basic components, Determination of critical path: Critical Path Method (CPM),Project Evaluation and Review Techniques(PERT).Time-cost optimization Algorithm.

ii) Problem of Sequencing, Processing n Jobs through Two Machines, Processing n Jobs through 3 Machines and Processing n Jobs through k Machines.

Course Learning Outcomes: The course will enable the students to:

i) understand fundamentals of Network Analysis using CPM and PERT.

ii) solve a sequencing Problem for various jobs and machines.

Course Contents:

Unit 1: Network Models [10 Lectures]

1.1 CPM and PERT, Network representation, Critical Path Computations

1.2 Construction of the time schedule, PERT networks.

Unit 2: Game Theory [08 Lectures]

2.1 Game theory, Some basic terminologies

2.2 Optimal solution of two person zero sum game

2.3 Solution of mixed strategy games (Graphical solution of gamesonly).

Unit 3: Replacement and Maintenance Models [08 Lectures]

3.1 Introduction, Types of failure

3.2 Replacement of items whose efficiencydeteriorates with time.

Unit 4: Sequencing Problems [05 Lectures]

4.1 Introduction, Notation, terminology and assumptions

4.2 processing n jobs throughtwo machines, processing n jobs through three machines.

Unit 5: Classical Optimization Theory [05 Lectures]

5.1 Unconstrained problems, Necessary and sufficient conditions

5.2 Newton Raphsonmethod, Constrained problems, Equality constraints (Lagrangian Method Only).

Text Books:

1. **Hamdy A. Taha, Operation Research (Eighth Edition, 2009), PrenticeHall of India Pvt. Ltd, New Delhi.**
   Unit-11: Ch.6: 6.5 (6.5.1 to 6.5.3 & 6.5.5), Unit-2: Ch.13: 13.4(13.4.1,13.4.2,13.4.3), Unit-4:Ch.18: 18.1(18.1.1, 18.1.2), 18.2 (18.2.1).
2. **J K Sharma, Operations Research (Theory and Applications, secondedition, 2006), Macmilan India Ltd.**
   Unit-5: Ch.17: 17.1,17.2, 17.3, Ch.20: 20.1, 20.2, 20.3, 20.4.

Reference Books:

1. Frederick S. Hillier, Gerald J. Lieberman, Introduction to OperationResearch (Eighth Edition) Tata McGraw Hill.
2. Hira and Gupta, Operation Research

DSE-6A: MT 365(B): Calculus of Variation and Classical Mechanics (2 credits)

Course Objectives: Using mathematical methods, the course seeks to comprehend various definitions of physical quantities and their effects on various bodies. It stresses the acquisition of knowledge in order to apply mathematics to the real world.

Course Learning Outcomes: The course will enable the students to:

i) understand problems, methods and techniques of calculus of variations.

ii) understand necessary conditions for the equilibrium of particles acted upon by various forces and learn the principle of virtual work for a system of coplanar forces acting on a rigid body.

iii) deal with the kinematics and kinetics of the rectilinear and planar motions of a particle including the constrained oscillatory motions of particles.

iv) determine the center of gravity of some materialistic systems and discuss the equilibrium of a uniform cable hanging freely under its own weight.

Course Contents:

Unit 1: Variational Problems with Fixed Boundaries [06 Lectures]

1.1 Necessary condition of extremum of functionals

1.2 Euler equation

1.3 Euler-Poisson equation

1.4 Euler-ostrogradsky equation

1.5 Euler equation in parametric form

1.6 Isoperimetric problems

1.7 Principle of reciprocity

Unit 2: Variational Problems with Moving Boundaries [06 Lectures]

2.1 Moving boundaries in explicit form

2.2 Moving boundaries in implicit form

2.3 One sided variation

2.4 Functional in parametric form

Unit 3: Sufficient Conditions of Extremum [03 Lectures]

3.1Higher order variations

3.2 Sufficient condition for extremum

3.3 Jacobi equation and Jacobi equation

Unit 4: Mechanics of a Particle and System of Particles [06 Lectures]

4.1 Conservation principles (laws)

4.2 Conservation of linear momentum

4.3 Conservation of angular momentum

4.4 Conservation of energy, Constrained motion, constraints, degrees of freedom

4.5 Generalized co-ordinates

4.6 Limitations of Newton's laws

Unit 5: Variational Principle and Lagrangian Formulation [15 Lectures]

5.1 Hamilton's variational principle

5.2 Deduction of Lagrange's equations of motion fromHamilton's principle

5.3 Deduction of Lagrange's equations by D'Alembert's Principle

5.4 Lagrangian for charged particle in an electromagnetic field, gyroscopic forces,nonconservative forces.

5.5 Deduction of Hamilton's principle form D'Alembert's Principle

5.6 Deduction of Newton's second law of motion from Hamilton's principle

5.7 Deduction of Lagrange's equations of motion using variational principle for non-conservative systems

5.8 Applications of Lagrange's equations of motion

5.9 Non -holonomic systems

5.10 Conservation theorems

5.11 Worked Examples

Text Books:

1. Classical Mechanics by SL Gupta, V. Kumar and H.V. Sharma PragatiPrakashan.
   Unit-4: Chapter 1: 1.1 to 1.6, Unit-5: Chapter-2: 2.1 to 2.12
2. An elementary course on variational problems in Calculus, Naveen Kumar Narosa Publishing House.
   Unit-1: Chapter 1: 1.1 to 1.9, Unit-2: Chapter-2: 2.1 to 2.4, Unit-3: Chapter-3: 3.1 to 3.3.

Reference Books:

1. Classical Mechanics by Herbert Goldstein, Pearson Publication.
2. Introduction to classical Mechanics: with problems and solutions by David J. Morrin Cambridge University Press.
3. Mathematical Methods of Classical Mechanics by V.I. Arnold. Springer Publication.

DSE-6A: MT 365 (C): Financial Mathematics (2 credits)

Course Objectives:

This course enables the students to understand the basic securities, organization of financial markets, the concept of interest rates, present and future value of cash flow.

Course Learning Outcomes: The course will enable the students to:

i) describe and explain the fundamental features of a financial instruments.
ii) demonstrate a clear understanding of financial research planning, methodology and implementation.
iii) demonstrate understanding of basic concepts in linear algebra, relating to linear equations, matrices, and optimization.
iv) demonstrate understanding of concepts relating to functions and annuities.

Course Contents:

Unit 1: Mathematical models in economics, recurrences, and the elements of finance [08 Lectures]

1.1 Introduction, a model of the market, market equilibrium and excise tax.
1.2 The first-order recurrence, limits, special cases, continuous compounding of interest.
1.3 Interest and capital growth, income generation, the interval of compounding.

Unit 2: The Cobweb model, and Introduction to optimization [10 Lectures]

2.1 Stability of market equilibrium, the general linear case and economic interpretation.
2.2 Marginal cost as a derivative, Profit maximization, critical points, optimization in an interval and infinite intervals.

Unit 3: The derivative in economics [08 Lectures]

3.1 Elasticity of demand, profit maximization again.
3.2 Competition versus monopoly, the efficient small firm, startup and break-even points.

Unit 4: Linear equations and the input-output model [10 Lectures]

4.1 Making money with matrices, a two-industry 'economy', arbitrage portfolios and state prices and IS-LM analysis.
4.2 An economy with many industries and the technology matrix.

Text Book:

1. **Martin Anthony and Norman Biggs, Mathematics for Economics and Finance Methods and Modeling, Cambridge University Press, Reprint 2012.**
   Unit-1: Chapters-3: 3.2, 3.3, 3.4 and Chapter-4,
   Unit-2: Chapter-5, Chapter-6: 6.3, Chapter-8
   Unit-3: Chapter-9, Chapter-10,
   Unit-4: Chapter-15:15.3, Chapter-16:16.1, Chapter-17:17.4, Chapter-18:18.5, Chapter- 19.

Reference Books:

1. Edward T. Dowling, Mathematical Economics, Second Edition, Schaum's Outline Series, McGraw Hill International Edition.
2. AswathDamodaran, Corporate Finance- Theory and Practice, John Wiley and Sons, Inc.
3. Sheldon M. Ross, An Introduction to Mathematical Finance, Cambridge University Press.

DSE-6B: MT-366(A): Machine Learning-II (2 Credits)

Course Objectives:

The main goal of this course is to help students learn, understand, and practice machine learning approaches, which include the study of modern computing big data technologies and scaling up machine learning techniques focusing on industry applications.

Course Learning Outcomes:

The students learning outcomes are designed to specify what the students will be able to perform after completion of the course: Ability to select and implement machine learning techniques and computing environment that are suitable for the applications under consideration.

Course Contents:

Unit 1: Classification of MNIST dataset [10 Lectures]

1.1 MNIST
1.2 Training a Binary Classifier
1.3 Performance Measures - Measuring accuracy using Cross Validation, Confusion Matrix, Precision and Recall
1.4 Multiclass Classification
1.5 Multilabel Classification

Unit 2: Linear Regression [10 Lectures]

2.1 Linear Regression
1. The Normal Equation
2.2 Gradient Descent
1. Batch Gradient Descent
2. Stochastic Gradient Descent
3. Mini-batch Gradient Descent
2.3 Polynomail Regression

Unit 3: Logistic Regression [06 Lectures]

3.1 Estimating Probabilities
3.2 Training and Cost Function
3.3 Decision Boundary
3.4 Softmax Regression

Unit 4: Other Supervised Algorithms [10 Lectures]

4.1 K Nearest Neighbors
4.2 Decision Trees
4.3 Ensembles of Decision Trees - Random Forest
4.4 Support Vector Machines

Text Books:-

1. **Hands-on Machine Learning with Scikit-Learn, Keras and Tensorflow – Aurelien Geron. Chapter-3:** Sections: 3.1, 3.2, 3.3, 3.4, 3.6, Chapter-4: 4.1, 4.2, 4.3, 4.6
2. **Introduction to Machine Learning With Python - Andreas C. Muller & Sarah Guido,** Chapter-2: Sections: 2.2.2, 2.2.5, 2.2.6, 2.2.7

Reference Book:-

1. Introduction to Machine Learning With Python - Andreas C. Muller & Sarah Guide.
2. Head first Python by Paul Barry (O Reilly publication).
3. Jason Brownlee - Basics of Linear Algebra for Machine Learning, 2018.
4. M. P. Deisenroth, A. A. Faisal, C. S. Ong - Mathematics for Machine Learning, Cambridge University Press, 2019.

5. DipanjanSarkar, Raghav Bali, Tushar Sharma - Practical Machine Learning with Python, 2018.
6. Andrew Ng Playlist - https://www.youtube.com/playlist?list=PLLssT5z_DsK-h9vYZkQkYNWcItqhlRJLN **(First 4 Lectures (till 4.6))**

geeksforgeeks.org/machine-learning
https://towardsdatascience.com/search?q=machine%20learningwww.kaggle.com

DSE-6B: MT- 366(B): Computational Geometry(2 credits)

Course Objectives: This course enables the students to gain detailed knowledge of the fundamental problems within computation geometry and general techniques for solving problems within computational geometry and practical experience with implementation issues involved in converting computation geometry algorithms into running programs.

Course Learning Outcomes: The course will enable the students to:

v) construct algorithms for simple geometrical problems.
vi) characterize invariance properties of Euclidean geometry by groups of transformations.
vii) describe and construct basic geometric shapes and concepts by computational means.

Course Contents:

Unit 1: Two Dimensional Transformations [12 Lectures]

1.1 Introduction.
1.2 Representation of points.
1.3 Transformations and matrices.
1.4 Transformation of – points, straight lines.
1.5 Midpoint Transformation.
1.6 Transformation of – parallel lines, intersecting lines.
1.7 Transformation: rotations, reflections, scaling.
1.8 Combined transformations.
1.9 Transformation of a unit square.
1.10 Solid body transformations.
1.11 Translations and homogeneous coordinates.
1.12 Rotation about an arbitrary point.
1.13 Reflection through an arbitrary line.
1.14 Projection – A Geometric Interpretation of Homogeneous Coordinates.
1.15 Overall Scaling.
1.16 Points at Infinity.

Unit 2: Three Dimensional Transformations [08 Lectures]

2.1 Introduction.
2.2 Three dimensional – Scaling, shearing, rotation, reflection, translation.
2.3 Multiple transformations.
2.4 Rotation about – an axis parallel to coordinate axes, an arbitrary axis in space.
2.5 Reflection through an arbitrary plane.

Unit 3: Projection [08 Lectures]

3.1 Orthographic projections.
3.2 Axonometric projections.

3.3 Oblique projections.
3.4 Perspective Transformations.

Unit 4: Plane and Space Curves [08 Lectures]

4.1 Introduction.
4.2 Curve representation.
4.3 Parametric curves.
4.4 Parametric representation of a circle.
4.5 Bezier Curves – Introduction, definition, properties (without proof), Curve fitting (up to n = 3), equation of the curve in matrix form (up to n = 3).

Text Book:

1. **D. F. Rogers, J. A. Adams, Mathematical Elements for Computer Graphics,Tata McGraw Hill, Second Edition.**

Unit 1: Chapter 2: Sec. 2.1 to 2.20, Unit 2: Chapter 3: Sec. 3.1 to 3.10.
Unit 3: Chapter 3: Sec. 3.12 to 3.15, Unit 4: Chapter 4: Sec. 4.1, 4.2, 4.4, 4.5,
Chapter 5: Sec. 5.1, 5.8.

Reference Books:

1. Computer Graphics with OpenGL, Donald Hearn, M. Pauline Baker, WarrenCarithers, Pearson (4th Edition).
2. Schaum Series, Computer Graphics by Zhigang Xiang and Roy A. Plastock.

DSE-6B: MT-366(C): Lebesgue Integration (2 Credits)

Course Objectives: To develop skills and to acquire knowledge on basic concepts of Lebesgue Measure, The Lebesgue Integral, Measurable Functions, Convergence and completeness.

Course Learning Outcomes: The course will enable the students:

i) To understand the concept of measure and properties of Lebesgue measure.
ii)To study the properties of Lebesgue integral and compare it with Riemann integral.

Course Contents:

Unit 1.Measurable Sets: [08 Lectures]

1.4 Length of open sets and closed sets
1.5 Inner and outer measure
1.6 Measurable sets
1.7 Properties of measurable sets.

Unit 2. Measurable Functions: [08 Lectures]

1.4 Definition of measurable functions and other criteria for measurability equivalent
1.5 Sums, Products, and limits of a measurable functions
1.6 Sequences of a measurable function

Unit 3. The Lebesgue integral for bounded function [10 Lectures]

3.1 Measurable partition, lower sum, upper sum,
3.2 Lebesgue integral for bounded measurable function
3.3 Properties of Lebesgue integrals for bounded measurable functions

Unit 4. The Lebesgue integral for unbounded function [10 lectures]

4.1 The Lebesgue integral for non-negative valued function
4.2 The Lebesgue integral for real valued function
4.3 Properties of Lebesgue integrals for unbounded functions
4.4 Some fundamental theorems

Text-Book:

1. **Richard R. Goldberg, Methods of Real Analysis, Oxford and IBH Publishing Co. Pvt. Ltd. (1970).**

Unit 1: Chapter 11: Sec 11.1 to 11.3. (Theorem No. 11.1B and 11.1C Statements only).
Unit 2: Chapter 11: Sec 11.4. Unit 3: Chapter 11: Sec 11.5 to 11.4.
Unit 4: Chapter 11: Sec. 11.5 to 11.8 (Theorem 11.8 D statement only)

Reference Books:

1. Tom M. Apostol, Mathematical Analysis, Second Edition, Narosa Publishing House.
2. D. Somasundaram and B. Choudhari, A first course in Mathematical Analysis,Narosa Publishing House.
3. R.G. Bartle and D.R. Scherbert, Introduction to real analysis Fourth Edition, Wiley India Edition.
4. Inder K. Rana, An Introduction to Measure and Integration Second Edition, NarosaPublishing House.
5. G. de Barra, Measure Theory and Integration, New Age International (P) Limited, Publishers.

MT 367: Practical Course Lab-I (Complex Analysis and Real Analysis-II) (2 Credits)

Section-I: Complex Analysis Practical

Practical No. 1: Analytic Functions (Unit 1)

Practical No. 2: Elementary Functions (Unit 2)

Practical No. 3: Integrals - I (Unit 3 upto and including Anti-derivatives)

Practical No. 4: Integrals – II(Unit 3 from Cauchy-Groursat's Theoremonwards)

Practical No. 5: Series (Unit 4)

Practical No. 6: Residues and Poles (Unit 5)

Section-II: Real Analysis-IIPractical

Practical 1: Definition and Existence of Riemann Integral (Unit 1)

Practical 2: Properties of Riemann Integrals and Applications (Unit 1)

Practical 3: Improper Integrals (Unit 2)

Practical 4: Pointwise Convergence of Sequences of Functions (Unit 3)

Practical 5: Uniform Convergence of Sequences of Functions (Unit 3)

Practical 6: Series of Functions: Convergence and Divergence (Unit 4)

MT 368: Practical Course Lab-II (Ring Theory and Partial Differential equations) (2 credits)

Section-I: Ring Theory Practical

Practical 1: Rings and Fields (Unit 1)

Practical 2: Rings of Polynomials (Unit 2)

Practical 3: Homomorphism and Factor Ring (Unit 3: 3.1)

Practical 4: Ideals in a Ring (Unit 3: 3.2)

Practical 5: Unique Factorization Domain (Unit 4: 4.1)

Practical 6: Euclidean Domain and Gaussian Integers (Unit 4: 4.2, 4.3)

Section-II: Partial Differential Equations Practical

Practical 1: Simultaneous Differential Equations of the First Order and the First Degree in Three Variables (Unit 1: 1.1, 1.2, 1.3)

Practical 2: Pfaffian Differential Equations and their Solution (Unit 1: 1.4, 1.5)

Practical 3: Solution of First order Partial Differential Equations (Unit 2: 2.1, 2.2, 2.3)

Practical 4: Linear Equations of First order equations and Integral surfaces passing through given curve (Unit 2: 2.3, 2.4)

Practical 5: Solution of Second order Partial Differential Equations (Unit 3)

Practical 6: Canonical Forms and Solution of Second order Partial Differential Equations by Separation Variables Method (Unit 4)

MT 369: Practical Course Lab-III (Based on DSE-6A and DSE-6B) (2 credits)

Section-I: Optimization Techniques/Calculus of Variation and Classical Mechanics/Financial Mathematics

Section-I(A): Optimization Techniques Practical

Practical 1: Network Models (Unit 1)

Practical 2: Game Theory (Unit 2)

Practical 3: Network Models and Game Theory (Unit 1, Unit 2)

Practical 4: Replacement Theory (Unit 3)

Practical 5: Sequencing (Unit 4)

Practical 6: Classical Optimization Theory (Unit 5)

OR

Section-I(B): Calculus of variation and classical Mechanics Practical

Practical 1: Applications of Euler -Lagrange's equation (Unit 1)

Practical 2: Isoperimetric Problems and Variational Problems with Moving Boundaries (Unit 1 and Unit 2)

Practical 3: Degrees of freedom and Generalized coordinates (Unit 3)

Practical 4: Problems on Conservation laws (Unit 4)

Practical 5: Lagrangian Formulation and worked examples-I (Unit 5)

Practical 6: Lagrangian Formulation and worked examples-II (Unit 5)

OR

Section-I (C): Financial Mathematics Practical

Practical 1: Mathematical Models in Economics (Unit 1)

Practical 2: Rrecurrences and the elements of finances (Unit 1)

Practical 3: The Cobweb model (Unit 2)

Practical 4: Introduction to Optimization (Unit 2)

Practical 5: The derivative in Economics (Unit 3)

Practical 6: Linear Equations and the Input Output Model (Unit 4)

Section-II(A): Machine Learning-II Practical

Practical 1: Revision of python and scikit learn (Unit 1)

Practical 2: MNIST classification with python - 1 (Unit 1)

Practical 3: MNIST classification with python - 1 (Unit 1)

Practical 4: Linear Regression Implementation - 1 (Unit 2)

Practical 5: Linear Regression Implementation - 2 (Unit 2)

Practical 6: LogisticRegressionImplementation 1 (Unit 3)

Practical 7: LogisticRegressionImplementation 2 (Unit 3)

Practical 8: Dealingwith Data (Unit 4)

Practical 9: KNN Implementation (Unit 4)

Practical 10: Decision Tree Implementation 4 (Unit 4)

Practical 11: Random Forest Implementation 4 (Unit 4)

Practical 12: Support Vector Machine Implementation 4 (Unit 4)

OR

Section-II (B): Computational Geometry Practical

Practical 1: Two Dimensional Transformation-I (Unit 1)

Practical 2: Two Dimensional Transformation-II (Unit 1)

Practical 3: Two and three Dimensional Transformation-I (Unit 1, Unit 2)

Practical 4: Three Dimensional Transformation-II (Unit 2)

Practical 5: Projection (Unit 3)

Practical 6: Plane and Space Curve (Unit 4)

OR

Section-II(C): Lebesgue Integration Practical

Practical 1: Length of Open and closed sets (Unit 1:1.1, 1.2)

Practical 2: Measurable Sets (Unit 1: 1.2, 1.3)

Practical 3: Measurable functions (Unit 2)

Practical 4: Lebesgue Integral - I (Unit 3: 3.1, 3.2, 3.3)

Practical 5: Lebesgue Integral - II (Unit 3: 3.3, 3.4)

Practical 6: Fourier Series(Unit 4: 4.1, 4.2)

SEC-III: MT-3610: Programming in Python –II(2 Credits)

Course Objectives:

1. To acquire Object Oriented Skills in Python.
2. To develop the skill of designing Graphical user Interfaces in Python.
3. To learn and understand Python programming basics and paradigm.
4. To learn the concepts of visualization of data and database connectivity.
5. To develop the ability to write database applications in Python.

Course Learning Outcomes:

Upon successful completion of this course the student will be able to:

1. Demonstrate the use of Python in Mathematics such as operations research and computational Geometry etc.
2. Study graphics and design and implement a program to solve a real world problem.
3. The students will implement the concepts of data with python and database connectivity.

Course Contents:

Unit 1: Graphics [06 Lectures]

1.1 Turtle Graphics: Overview of Turtle Graphics , Turtle Operations, Object Instantiation and the turtle graphics Module.
1.2 Drawing Two-Dimensional Shapes
1.3 Taking a Random Walk
1.4 Colors and the RGB System
1.5 Drawing with Random Colors
1.6 Using the str Function with Objects.

Unit 2: Data Visualization with Python [04 Lectures]

2.1 Seaborn
2.2 Matplotlib
2.3 Plotly
2.4 MayaVI

Unit 3: Dictionary and Sorting, Minimum and Maximum: [08 Lectures]

3.1 Introduction to Dictionary , Avoiding Key Error Exceptions, Iterating Over a Dictionary,

3.2 Dictionary with default values, Merging dictionaries, Accessing keys and values,Accessing values of a dictionary, Creating dictionary, Creating an ordered dictionary,Unpacking dictionaries using the ** operator.

3.3 Sorting, Minimum and Maximum:Special case: dictionaries, Using the key argument, Default Argument to max, min,Getting a sorted sequence, Extracting N largest or N smallest items from an iterable,Getting the minimum or maximum of several values, Minimum and Maximum of asequence.

Unit 4: Computational Geometry [10 Lectures]

4.1 Points: The distance between two points, Lists of Points - the PointList class, Integer point lists, Ordered Point sets, Extreme Points of a PointList, Random sets of Points not in general position.

4.2 Points: Displaying Points and other geometrical objects, Lines, rays, and line segments, The geometry of line segments, Displaying lines, rays and line segments.

4.3 Polygon: Representing polygons in Python, Triangles, Signed area of a triangle, Triangles and the relationships of points to lines, is Collinear, is Left, is Left On, is Right, is Right On, Between

4.4 Two dimensional rotation and reflection

4.5 Three dimensional rotation and reflection

4.6 Generation of Bezier curve with given control points

Unit 5: Study of Operational Research in Python [08 Lectures]

5.1 Linear Programming in Python

5.2 Introduction to Simplex Method in Python

Practicals:

Practical 1: Turtle Graphics (Unit 1)

Practical 2: Data Visualization (Unit 2)

Practical 3: Dictionary and Sorting, Minimum and Maximum (Unit 3)

Practical 4: Application to Computational Geometry-I (Unit 4)

Practical 5: Application to Computational Geometry-II (Unit 4)

Practical 6: Application to Computational Geometry-II (Unit 4)

Practical 7: Study of Graphical aspects of Two dimensional transformation matrix using Matplotlib (Unit 4)

Practical 8: Study of Graphical aspects of Three dimensional transformation matrix using Matplotlib (Unit 4)

Practical 9: Study of Graphical aspects of Three dimensional transformation matrix using Matplotlib and Study of effect of concatenation of Two dimensional and Three dimensional transformations(Unit 4)

Practical 10: Generation of Bezier curve using given control points (Unit 4)

Practical 11: Study of Operational Research in Python (Unit 5-5.1)

Practical 12: Study of Operational Research in Python (Unit 5-5.2)

Text Books:

1. **Kenneth A. Lambert, Fundamentals of Python:From First Programs to DataStructure, Martin Osborne, 2010, Course Technology, Cengage Learning.** Unit-1: Chapter-7: Sec-7.1.1 to 7.1.8
2. **Python: Notes for Professionals, Goalkicker.com, Free Programming books.** Unit-2: Chapter-108, Unit-3: Chapter-19 Section:19.1 to 19.10 and Chapter-72:Section:72.1 to 72.8
3. **Jim Arlow, Interactive Computational Geometry in Python.** Unit-4: Chapter-1: Sec.-1 to 7, Chapter-2: Sec.-1 to 2, Chapter-3: Sec.-1, 3 to 11, Chapter-4: Sec.-1 to 3, :Chapter-5: Sec.-3 to 7.
4. **Operations Research: Unit-5:** https://pypi.org/project/PuLP/

Reference Books:

1. Guzdial, M. J., Introduction to Computing and Programming in Python, Pearson India.
2. Perkovic, L., Introduction to Computing Using Python, 2/e, John Wiley, 2015.
3. Zelle, J., Python Programming: An Introduction to Computer Science, Franklin,Beedle and Associates Inc.
4. Jim Arlow, Interactive Computational Geometry in Python.
5. Robert Johansson, Introduction to Scientific Computing in Python.
6. Jason Brownlee, Basics of Linear Algebra for Machine Learning, Discover the Mathematical Language of Data in Python.
7. JaanKiusalaas, Numerical Methods in Engineering with Python, Cambridge University Press, (2005).

SEC-IV: MT-3611: Mathematics into LaTeX(2 Credits)

Course Objectives: The purpose of this course is to acquaint students with typesetting basic Mathematics in LaTeX.

Course Learning Outcomes: After studying this course the student will be able to:

i) typeset mathematical formulas, use nested list, tabular and array environments.

ii) import figures and pictures that are stored in external files.

Course Contents:

Unit 1. Figure Insertion **[06 Lectures]**

1.1 Commands and Environment for Inserting Figures
1.2 Inserting a Simple Figure
1.3 Side-by-Side Figures
1.4 Sub-numbering a Group of Figures
1.5 Figures in Tables

Unit 2. Equation Writing -I **[12 Lectures]**

2.1 Basic Mathematical Notations and Delimiters.
2.2 Mathematical Operators
2.3 Mathematical Expressions in Text-Mode

2.4 Simple Equations
2.5 Array of Equations
2.6 Left Aligning an Equation
2.7 Sub-numbering a Set of Equations

Unit 3.Equation Writing -II **[12 Lectures]**

3.1 Texts and Blank Space in Math-Mode
3.2 Conditional Expression
3.3 Evaluation of Functional Values
3.4 Splitting an Equation into Multiple Lines
3.5 Vector and Matrix
3.6 Overlining and Underlining
3.7 Stacking Terms
3.8 Side-by-Side Equations

Unit 4. User-Defined Macros **[06 Lectures]**

4.1 Defining New Commands
4.2 Defining New Environments

Practicals:

Practical 1: Commands and Environment for Inserting Figures (Unit 1: 1.1, 1.2)

Practical 2: More about Figure Insertion (Unit-1; 1.3, 1.4, 1.5)

Practical 3: Mathematical Notations, Operators and Expression in LaTeX (Unit 2: 2.1- 2.3)

Practical 4: Simple Equations (Unit-2: 2.4)

Practical 5: Array of Equations (Unit-2: 2.5)

Practical 6: Alignment and numbering a Set of Equations (Unit-2: 2.6, 2.7)

Practical 7: Texts, Blank Space and Conditional Expression in Math mode (Unit-3: 3.1, 3.2)

Practical 8: Evaluation of Functional Values and Splitting an Equation (Unit-3: 3.3, 3.4)

Practical 9: Vector and Matrix (Unit-3; 3.5)

Practical 10: More about equation writing in LaTeX (Unit-3: 3.6, 3.7, 3.8)

Practical 11: New Commands in LaTeX (Unit-4: 4.1)

Practical 12: New Environments in LaTeX (Unit-4: 4.2)

Text Book:

1. **LaTeX in 24 Hours, A Practical Guide for Scientific Writing, Dilip Datta, Springer International Publishing AG 2017.**
   Unit 1: Chapter 9; 9.1 to 9.4, 9.8, Unit 2: Chapter 11; 11.1 to 11.7
   Unit 3: Chapter 12; 12.1 to 12.8 , Unit 4: Chapter 13; 13.1, 13.3 (13.3.1, 13.3.2, 13.3.3)

Reference Books:

1. LaTeX, A Document Preparation System, User's Guide and Reference Manual, Leslie Lamport, Addison-Wesley Publishing Company, Inc., 1994.
2. LaTeX Beginner's Guide, Stefan Kottwitz, Packt Publishing Ltd, 2011.
3. LATEX and Friends, M.R.C. van Dongen, Springer-Verlag Berlin Heidelberg ,2012.
4. Math into LaTeX, George Gratzer, Springer Science Business Media New York, 1996.

Modalities For Conducting The Practical and The Practical Examination:

1. There will be one 4 hours and 20 minutes (260 minutes) practical session for each batch of 15 students per week for each practical course.
2. The College will conduct the Practical Examination at least 15 days before the commencement of the Main Theory Examination. The University practical examination will consist of written examination of 30 marks and oral examination of 05 marks.
3. There will be external examiner; the practical exam will be of the duration of 3hours. The teacher will set a question paper at the time of paper setting meeting conducted by SavitribaiPhule Pune University, Pune based on respective papers I and II given in **Practical Lab-I, Practical Lab-II and Practical Lab-III**,and the pattern is as follows

Q1. Any 3 out of 5 each question of 5 marks on paper – I (from Practical Lab-I,

Practical Lab-II and Practical Lab-III).

Q2. Any 3 out of 5 each question of 5 marks on paper – II(fromPractical Lab-I,

Practical Lab-II and Practical Lab-III).

4. **SEC:MT -3510, MT -3511, MT -3610**, **MT -3611 University practical writtenexaminationof 30 marks, oral examination 05 marks and internal examination of 15 marks.**
5. **The courses MT-356(A): Machine Learning-I, MT-366(A): Machine Learning-II, MT -3510: Programming in Python -I, MT -3610: Programming in Python –II, MT-3511: LaTeX for Scientific Writing and MT 3611: Mathematics into LaTeX**will teach in Computer Laboratory with live sessions for better understanding of students.
6. Each student will maintain a journal to be provided by the college.The internal 15 marks will be given on the basis of journal prepared by student and the cumulative performance of student at practical.**Methods of assessment for Internal exams:** Seminars, Viva-voce, Projects, Surveys, Field visits, Tutorials, Assignment, Group Discussion.
7. It is recommended that concept may be illustrated using computer software (Python, Maxima etc.) and graphing calculators wherever possible.
8. Study tours may be arranged at places having important mathematical institutes or historical places.
9. **Special Instruction:**
   a) There should be well equipped mathematics practical laboratory of size 20x20 sq. fts containing at least 20 computers because there are six papers based on Software's (**like Machine Learning-I & II, Programming in Python –I & II, LaTeX Software for Scientific Writing and Mathematics into LaTeX**).
   b) Examiners should set separate question papers, solutions and scheme of marking for each batch and claim the remuneration as per University rule.
   c) Before starting each practical necessary introduction, basic definitions, intuitive inspiring ideas and prerequisites must be discussed**.**

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Savitribai Phule Pune University

(Formerly University of Pune)

Three Year B.Sc. Degree Program in Physics

(Faculty of Science & Technology)

T.Y.B.Sc. (Physics)

Choice Based Credit System

To be implemented from Academic Year 2021-2022

Savitribai Phule Pune University, Pune

Revised syllabus for T.Y.B.Sc. (Physics) (CBCS Pattern-2021-22)

To be implemented from Academic Year 2021-22

Salient Features of Revised Syllabi in Physics

As far as possible to promote:

1) Physics Education through Master Texts:
It helps in understanding the theoretical and mathematical development of the subject and to create interest in the subject.

2) Physics Education through Experimentation:
It helps in general to improve scientific attitude. So emphasis is given on the development of experimental skills, data analysis, calculations, and also on the limitations of the experimental method and data and, results obtained.

3) Physics Education through Problem Solving: It helps in understanding the concepts of physics. It underline the strength of equations, formulae, graphs, mathematical tools to tackle the problems. So accordingly, we have introduced compulsory problem part in the question paper.

4) Physics Education through History and Philosophy:
It helps in understanding the conceptual development of the subject and thereby increase the interest in the subject. A topic on this is introduced in the Physics Course.

5) Physics Education through Awareness of Misconceptions:
It improves the scientific awareness among the students. A discussion on different subjects are encouraged.

6) Physics Education through Proto-research:
It creates interest in the subject and improves technological aspect. Accordingly, mini projects, hands-on activities, projects, models and demonstrations etc. is included in the syllabi.

7) Physics Education through Qualitative Overview:
It creates interest in the subject to continue to work in the field of science in general and physics in particular. Accordingly future directions and frontiers of the subject are included in the syllabi.

8) **Structure of Question paper:**
Existing structure shall continue.

9) **ATKT Rules:**
Existing rules shall apply.

10) **Structure of the Course:**

Semester	Course Type	Course Code	Course Name	Credit
V	Discipline Specific Elective Course	PHY-351	Mathematical Methods in Physics-II	2
		PHY-352	Electrodynamics	2
		PHY-353	Classical Mechanics	2
		PHY-354	Atomic and Molecular Physics	2
		PHY-355	Computational Physics	2
		PHY-356: Elective-I (Select any One)		2
		PHY-356**(A)**	Astronomy and Astrophysics-I	
		PHY-356(**B**)	Elements of Materials Science	
		PHY-356(**C**)	Biophysics	
		PHY-356(**D**)	Renewable Energy Sources-I	
		PHY-356(**E**)	Applied Optics	
		PHY-356(**F**)	C# programming	
		PHY-357	Physics Laboratory-3A	2
		PHY-358	Physics Laboratory-3B	2
		PHY-359	Project-I	2
	Skill Enhancement Course	**PHY-3510: Skill Enhancement Course-I (Select any One)**		2
		PHY-3510(**G**)	Python Programming	
		PHY-3510(**H**)	Energy studies	
		PHY-3510(**I**)	Introduction to Arduino	
		PHY-3510(**J**)	Sensors and Transducer	
		PHY- 3511: Skill Enhancement Course-II (Select any One)		2
		PHY-3511(**K**)	Physics Workshop Skill	
		PHY-3511(**L**)	Biomedical Instrumentation	
		PHY-3511(**M**)	Non-destructive Testing Techniques	
		PHY- 3511(**N**)	Acoustics Applications	
VI	Discipline Specific Elective Course	PHY-361	Solid State Physics	2
		PHY-362	Quantum Mechanics	2
		PHY-363	Thermodynamics and Statistical Physics	2
		PHY-364	Nuclear Physics	2
		PHY-365	**(A)** Electronics-II **OR** **(B)** Advanced Electronics	2

		PHY-366: Elective-II (Select any One)		
		PHY-366(**O**)	Medical Electronics	2
		PHY-366(**P**)	Physics of Nanomaterials	
		PHY-366(**Q**)	Microcontrollers	
		PHY-366(**R**)	Lasers	
		PHY-366(**S**)	Astronomy and Astrophysics-II	
		PHY-366(**T**)	Renewable Energy Sources-II	
		PHY-367	Physics Laboratory-4A	2
		PHY-368	Physics Laboratory-4B	2
		PHY-369	Project-II	2
	Skill Enhancement Course	**PHY-3610: Skill Enhancement Course-III (Select any One)**		2
		PHY-3610(**U**)	Scientific Data Analysis using Python	
		PHY-3610(**V**)	Solar PV System: Installation, Repairing and Maintenance	
		PHY-3610(**W**)	Applications of Internet of things (IOT)	
		PHY-3610(**X**)	Calibration Techniques	
		PHY- 3611: Skill Enhancement Course-IV (Select any One)		2
		PHY- 3611(**Y**)	Microcontrollers	
		PHY- 3611(**Z**)	Instrumentation for Agriculture	
		PHY- 3611(**AA**)	Radiation Physics	
		PHY- 3611(**AB**)	Photography	

Semester-V

T.Y.B.Sc. (Physics) (Sem-V)
PHY-351: Mathematical Methods in Physics-II

Lectures: 36 **(Credits-02)**

1: Curvilinear Co-ordinates **(10L)**

Review of Cartesian, spherical and cylindrical co-ordinate, transformation equation, General Curvilinear co-ordinate system: Co-ordinate surface, co-ordinate lines, length, surfaces and volume elements in curvilinear co-ordinate system.

Orthogonal curvilinear co-ordinate system, expressions for gradient, divergence, Laplacian, and curl, special case for gradient, divergence and curl in Cartesian, spherical polar and cylindrical co-ordinate system, Problems.

2: The Special Theory of Relativity **(10L)**

Introduction and applications, Newtonian relativity, Galilean transformation equation, Michelson-Morley experiment, Postulates of special theory of relativity, Lorentz transformations, Kinematic effects of Lorentz transformation, Length contraction, Proper time, Problems.

3: Partial Differential Equations **(8L)**

Introduction and applications of Partial differential equations (PDE), General methods for solving second order PDE, Method of separation of variables in Cartesian, Spherical polar and cylindrical co-ordinate system (two dimensional Laplace's equation, one dimensional Wave equation), Singular points ($x = x_0$), Solution of differential equation-Statement of Fuch's theorem, Frobenius method of series solution.

4: Special Functions **(8L)**

Introduction, generating function for Legendre Polynomials: $P_n(x)$, Properties of Legendre Polynomials, Generating function for Hermite Polynomials: $H_n(x)$, Properties of Hermite Polynomials, Bessel function of first kind: $J_n(x)$, Properties of Bessel function of first kind, Applications of Special Functions in Physics, Problems.

Reference books:

1. Mathematical methods for physicists, Arfken and Weber, Acadmic press Newyork, 7th Edition.
2. Mathematical physics, Rajput, Pragati prakashan-1997.
3. Mathematical methods in the physical sciences – Marry L. Boas, John Willy & Sons publication, 3rd Edition-2005.
4. Introduction to special relativity, Robert Resnick, John Wiley & Sons, Inc.-1968.
5. Mathematical physics, B. D. Gupta, Vikas publishing house Pvt. Ltd., 4th edition-2010.
6. Mathematical physics, H. K. Dass, Dr. Rama Varma, S. Chand & Company Pvt. Ltd.,7th Edition-2014
7. The Special Theory of Relativity: A Mathematical Approach-Farook Rahaman, Springer Publication -2014.

T.Y.B.Sc. (Physics) (Sem-V)
PHY-352: Electrodynamics

Lectures: 36 **(Credits-02)**

1: Electrostatics **(12 L)**

- **a.** Revision of Coulomb's law, Gauss law, Electric field, Electrostatic Potential.
- **b.** Potential energy of system of charges.
- **c.** Statement of Poisson's and Laplace's equation, Boundary Value problems in electrostatics- **S**olution of Laplace equation in Cartesian system, Boundary conditions.
- **d.** Polarization **P**, Electric displacement **D**, Electric susceptibility and dielectric constant, bound volume and surface charge densities.
- **e.** Electric field at an exterior and interior point of dielectric.

2: Magnetostatics **(12 L)**

- a. Concepts of magnetic induction, magnetic flux and magnetic field.
- b. Magnetic induction due to straight current carrying conductor, magnetization of matter, relationship between **B, H** and **M.**
- c. Boundary conditions at the interface of two magnetic media (Normal and tangential components).
- d. Biot-Savart's law, Ampere's force law, Magnetic force between two current carrying loops, Ampere's circuital law.
- e. Equation of continuity, Magnetic vector potential **A,** Magnetic susceptibility and permeability.

3: Electrodynamics **(12 L)**

- **a.** Day to day applications of Electrodynamics.
- **b.** Concept of electromagnetic induction, Faradays law of induction, Lenz's law, displacement current, generalization of Amperes' law.
- **c.** Maxwell's equations (Differential and Integral form) and their physical significance.
- **d.** Polarization, reflection and refraction of electromagnetic waves through media.
- **e.** Wave equation and plane waves in free space.
- **f.** Poynting theorem and Poynting vector.

Reference Books:

1. Introduction to Electrodynamics; D. J. Griffith; Cambridge India; Fourth edition (2020)
2. Classical Electrodynamics; J. D. Jackson; Wiley; Third edition (2007)
3. Introduction to Electrodynamics; A. Z. Capri, Panat P. V.; Alpha science international ltd; Illustrated edition(2002)
4. Foundations of electromagnetic theory; Reitz, Milford and Christy; Pearson education India; Fourth edition (2010)
5. Electrodynamics; Gupta, Kumar, Singh; Pragati Prakashan; Ninteenth edition (2011)
6. Electromagnetic field and waves; Paul-Lorrain, D. R. Corson; W.H. Freeman & co. Ltd; Second edition (1970)
7. Electricity and magnetism; Murugeshan; S. Chand; (2020)
8. Electromagnetic theory and electrodynamics; Satya Prakash; Kedar Nath Ram Nath; (2020)

T.Y.B.Sc. (Physics) (Sem-V)
PHY-353: Classical Mechanics

Lectures: 36 **(Credits-02)**

1: Motion of Particles **(8L)**

a. Charged Particles: Motion of a charged particle in constant electric, magnetic and electromagnetic field,
b. System of particles: Concept of Centre of mass, Conservation of linear momentum, angular momentum, energy of system of particles.(statements only)
c. Day to day applications of Classical mechanics,
d. Problems

2: Central force Field **(8L)**

a. Central force Field: Definition and Properties of central force field. Reduction of two body problem to an equivalent one body problem
b. Motion in central force field,
c. Kepler's laws of planetary motion and their proof
d. Artificial satellite and its orbit
e. Problems.

3: Scattering of particles **(10L)**

a. Elastic and inelastic scattering: Definition and properties,
b. Elastic scattering - Laboratory and center of mass system.
c. Scattering: Scattering angles in laboratory and center of mass system.
d. Differential cross-section, impact Parameter, total cross-section in brief.
e. Problems

4: Langrangian and Hamiltonian formulation **(10L)**

a. Limitations of Newton's Law of Motion,
b. Constraints and Their Classification, Example of Constrains, degrees of freedom, generalized coordinate, configuration space,
c. Principle of Virtual work done,
d. D'Almeberts Principle of virtual work,
e. Langrangian equation from D' Alembert's principle, cyclic coordinates,
f. Phase space, Hamiltonian's equations
g. Problems

Reference books:

1. **Classical Mechanics**, J.C. Upadhyaya, Himalaya publishing Houses, 2nd Edition of 2005.
2. **Introduction to Classical Mechanics,** R. G. Takawale, P. S. Puranik, Tata McGraw Hill publishing Company Ltd., New Delhi.
3. **Classical Mechanics,** NC Rana and PS Joag, Tata McGraw Hill Education Private Limited, New Delhi, 1991.
4. **Classical Mechanics** by P.V.Panat.
5. **Classical Mechanics,** Herbert Goldstein, Narosa Publishing House.

T.Y.B.Sc. (Physics) (Sem-V)
PHY-354: Atomic and Molecular Physics

Lectures: 36 **(Credits-02)**

1: Atomic structure **(6 L)**

1. Revision of various atomic models
2. Vector atom model (Concepts of space quantization and electron spin)
3. Pauli Exclusion Principle and electron configuration, Quantum states, Spectral notations of quantum states.
4. Problems

2: One and Two Valence electron systems **(12 L)**

1. Spin-Orbit Interaction (Single valence electron atom), Energy levels of Na-atom, Selection rules, Spectra of sodium atom, Sodium doublet.
2. Spectral terms of two electron atoms, terms for equivalent electrons, LS and JJ-coupling schemes.
3. Singlet-Triplet separations for interaction energy of LS coupling, Lande's interval rule, Spectra of Helium atom.
4. Problems

3: Zeeman Effect **(4 L)**

1. Zeeman Effect
2. Experimental arrangement
3. Normal and anomalous Zeeman Effect
4. Stark effect (Qualitative discussion)
5. Applications of Zeeman effects
6. Problems

4: Molecular spectroscopy **(8 L)**

1. Introduction of molecular spectra and its types
2. Rotational energy levels, Rotational spectra of rigid diatomic molecule
3. Vibrational energy levels
4. Rotational and Vibrational spectra
5. Electronic spectra of molecules
6. Applications of UV-Vis spectroscopy
7. Problems

5: Raman spectroscopy **(6 L)**

1. History of Raman effect, Molecular polarizability
2. Classical theory and Quantum theory of Raman Effect
3. Characteristics Raman Lines and Applications of Raman spectroscopy
4. Problems

Reference books:

1) R. Murugeshan, Er. K. Sivaprasath, Modern Physics, S. Chand, 2014, Revised edition
2) Robert Eiseberg, Robert Resnik, Quantum Physics of Atoms, Molecules, Solids, Nuclei and Particles, Wiley, 2016, 2nd edition
3) G. Aruldhas, Molecular structure and Spectroscopy, PHI, 2015, 2nd edition
4) Colin Banwell, Elaine McCash, Fundamentals of Molecular Spectroscopy, TMH, 4th ed
5) Arthur Baiser, Concepts of Modern Physics , McGraw Hill International, 4th edition
6) White H. E, Introduction to Atomic spectra, McGraw Hill International

T.Y.B.Sc. (Physics) (Sem-V)
PHY-355: Computational Physics

Lectures: 36 **(Credits-02)**

1: Concepts of Programming and Introduction to C-programming: (14 L)

a) Definition and Properties of algorithms, Algorithm development, Flow charts- symbols and simple flowcharts.
b) Introduction and Structure of C-program, 'C' Character set, key words, Constants and variables, Variable names, Data types, qualifiers and their declarations, Symbolic Constants.
c) Input/output functions: scanf( ), printf( ), getchar(), putchar(), gets(), puts().
d) Operators and Expressions: Arithmetic Operators, Relational Operators, Logical Operators, Assignment Operators, Conditional Operator.
e) Control statements: if, if else, while, do while, for loop, nested control structures (nested if, nested loops), break, continue, switch- case statement, goto statement.
f) Use of Library functions: e.g. mathematical, trigonometric, graphics.

2: Arrays, Pointers and user defined function in C-Language (8 L)

a) Arrays: 1-D, 2-D: Arranging numbers in descending and ascending order, Sum of matrices, multiplication of matrices.
b) Concept of pointers with suitable illustrative examples.
c) User defined functions: Definitions and declaration of function, function prototype, passing arguments (Call by value, Call by reference). Simple illustrative examples.

3: Graphics in C-Language: (3 L)

Concepts of graphics in C, Some simple graphic commands- Point, Line, Circle, Arc, Ellipse, Bar with suitable illustrative examples.

4: Computational Physics: (11 L)

Numerical Methods to solve the Physics Problems

a) **Iterative methods:** Bisection method and Newton-Raphson Method– Algorithm, Flowchart and writing C- program for finding the roots of the equation, problems
b) **Integration:** Trapezoidal rule, Simpson's $1/3^{rd}$ rule – Algorithm, Flowchart and C-program, problems

Reference Books:

1. Programming in C- (Schaum's series), Gottfreid, TMH
2. Programming in C- Balgurusami, Prentice Hall publications
3. Let us C- Yashwant Kanetkar, BPB publications
4. Programming with C- K.R. Venugopal, S. R. Prasad, TMH.
5. Introductory methods of numerical analysis-S. Sastry, Prentice Hall
6. Computer oriented numerical methods – V. Rajaraman.

PHY-356: Elective-I

T.Y.B.Sc. (Physics) (Sem-V)
PHY-356 Elective-I (A): Astronomy and Astrophysics-I

Lectures: 36 **(Credits-02)**

1: Fundamentals of Astronomy: **(10 L)**

Introduction: Components of the Universe; Stars, Planets, Asteroids, Meteors, Comets, Galaxies. Solar System: Age, Origin Basic measurements: Planetary orbits, distances, physical size, mass, density, temperature, rotation period determination, Co-ordinate system, Celestial hemisphere,

2: Astronomical Instruments: **(8 L)**

Optical telescopes, mounts, light gathering power, magnification, Resolution. Spectroscopes, CCD camera, photometer, filters Radio telescopes, Interferometry (only introduction)

3: Star Systems and basic observations: **(10 L)**

Stars life cycle, Stellar processes (Nuclear). Neutron stars, black holes, Chandrasekhar limit. Spectral classification of stars, O, B, A, F, G, K, M. Star Systems: Binaries / Cepheids / RR Lyrae, Observation of Sun: Eclipses, Moon, planets, meteor showers, transits, occultations.

4: Galaxies, Dark Matter and Dark Energy **(8 L)**

A) Galaxies, types, their formation, Hubble's tuning fork diagram, Open and Globular clusters, Dark Matter / Energy (evidence for both), Cosmology: Theories: BBT, Steady State, Oscillating Universe Theory.

B) Observational Astronomy: Concept of time, Magnitudes: apparent and absolute, introduction to Constellations, Star dial.

Reference books:

1. Astronomy structure of the Universe. A.E. Roy and D. Clarke, Adam Hilger Pub.
2. Source Book of Space Sciences, Samuel Galsstone; D.Van Nostrand Co. Inc
3. Astrophysics - Stars and Galaxies, K.D. Abhyankar, Tata McGraw Hill Pub.
4. Textbook of Astronomy and Astrophysics with elements of cosmology, V.B. Bhatia, Narosa Pub.
5. Structure of the Universe, J.V. Narlikar
6. Astrophysics, Baidyanath Basu.
7. Astrophysical Techniques, third Edition, C. R. Kitchin
8. Fundamentals of Astronomy, Michael Seed
9. Telescopes and techniques, C. R. Kitchin (Springer)

List of experiments: (Any 2)

1. Study of Binocular, refracting and reflecting telescopes and their mounts.
2. To determine the diameter of the Moon.
3. Measurement of Solar Constant.
4. Observation of emission, continuous and absorption spectra. (Mercury, sodium or iodine spectra could be obtained.)
5. Study of Construction and working of CCD.
6. Study of Solar Eclipse and Lunar Eclipse.

T.Y.B.Sc. (Physics) (Sem-V)

PHY-356 Elective-I (B): Elements of Material Science

Lectures: 36 **(Credits-02)**

1: Defects in Solids **(7 L)**

1. Material Properties – Mechanical, Electrical, and thermal
2. Impurities in solids.
3. Solid solutions in metals.
4. Rules of solid solubility.
5. Imperfection in crystals.
6. Defects in solids point, line, surface, and volume.
7. Atomic diffusions definition, mechanism, Fick's laws.

2: Single Phase Metals **(6 L)**

1. Single phase alloys
2. Deformation
3. Elastic Deformation and Plastic Deformation
4. Mechanism of plastic Deformation by slip
5. Critical resolved shear stress (CRSS)
6. Plastic deformation in poly crystalline materials

3: Ceramic Materials **(10 L)**

1. Ceramic Phases, Classification of ceramic materials
2. Ceramic crystals (AX)
3. Mechanical behavior of ceramics
4. Electromagnetic behavior of ceramics –
   a) Electric properties dielectrics, semiconductors, piezoelectric
   b) Magnetic Properties Magnetic Ceramics, hard and soft ferrites

4: Phase Diagrams **(9 L)**

1. Basic terms System, Surrounding, Component, Coordinates, Phase, Equilibrium.
2. Phase Diagram definition, importance, and objective
3. Lever rule
4. Gibb's phase rule
5. Phase diagram of a) Sugar water b) NaCl water
6. Types of phase diagrams with construction
   a) Type I Lens type CuNi phase diagram
   b) Type II Only introduction
   c) Type III Eutectic type PbSn phase diagram
7. Isothermal cuts

5: Introduction to smart materials **(4 L)**

1. Definition of smart materials
2. Types and structure of smart materials,
3. Properties of smart materials
4. Applications of smart materials.

Reference books :

1. Elements of Materials Science and Engineering I. H. Vanvlach (4^{th} Edition)
2. Materials Science and Engineering - V. Raghavan

List of experiments : (Any 2)

1. To determine the dipole moment of a given liquid
2. To determine magnetic susceptibility of $FeCl_3$
3. To determine the specific heat of graphite
4. Determination of the yield point and the breaking point of an elastic material
5. Ionic conductivity of NaCl/ NaI
6. Grain size and grain boundary measurement using optical microscope.

T.Y.B.Sc. (Physics) (Sem-V)
PHY-356 Elective-I (C): Biophysics

Lectures: 36 **(Credits-02)**

1: Introduction of Biophysics **(13L)**

1.1 History of Biophysics, Concept of Biophysics and Physical properties applied to biology- Surface tension, Viscosity, adsorption, diffusion, osmosis, Definition for Biostatistics and Biometry

1.2 Cell: Animal and plant cell, types of cell, Functional aspects of cell membrane, cytoplasm, nucleus, mitochondria and chloroplast

1.3 Protein structure (Primary and Secondary), amino acid structure, Genetic code- symmetry, DNA structure

1.4 Photosynthesis process:- electron transport, Gibbs's free energy, Redox couple, Redox potential, Oxidation and reduction, Examples of redox potential in biological system.

2: Bio-potentials **(9L)**

2.1 Bioelectric signals: structure of neuron, resting potential, action Potential, Nernst equation

2.2 Bioelectrodes- Half-cell potential, polarizable and non-polarizable electrodes, Microelectrode- metal and glass electrodes

2.2 Study of Cardiovascular system, Compound action potential of human body-ECG (Electrocardiography), Electrodes for ECG

3: Bio-instruments **(6L)**

3.1 Basic principle, Construction and working of colorimeter, spectrophotometer, PH meter and Centrifuge measurement.

3.2 Electron Microscope: SEM, TEM.

4: Radiation Biophysics **(8L)**

4.1 Definition, Units of Radioactivity and radiation doses, Types of radiation (Ionizing and non- ionizing), radioimmunoassays.

4.2 Applications: PET (Positron Emission Tomography), NMR (Nuclear Magnetic Resonance), MRI (Magnetic Resonance Imaging Techniques), Ultrasonography, CT (Computed Tomography) Scan.

Reference books:

1. Introduction to Biophysics - by P. Narayanan.New Age P.
2. Medical Instrumentation - by Khandpur, TMH
3. Laboratory Manuals of Biophysics Instruments - by P.B. Vidyasagar
4. Biophysics -by Vatsala Piramal, Dominant Publisher and Distributors, New Delhi-110002
5. Textbook of Biophysics - by R.N. Roy
6. Photosynthesis - by Hall and Rao.
7. Introduction to Biomedical Equipment Technology (Fourth Edition) by-Joseph J.Carr
8. Text Book of Bio-medical Electronics-by S.S. Agrawal

List of Experiments : (Any 2)

1. Recording and analysis of ECG signals
2. Verification of Beer's and Lambert's Law
3. Absorption spectrum of Blood/Chlorophyll.
4. pH value of Amino acids.
5. Bimolecular model building using standard kits.
6. Separation of components of Milk/Chlorophyll using centrifuge machine.

T.Y.B.Sc. (Physics) (Sem-V)

PHY-356 Elective-I (D): Renewable Energy Sources-I

Lectures: 36 **(Credits-02)**

1: An Introduction to Energy Sources: **(10L)**

1. Energy: Definition, Classifications of energy sources
2. Conventional and non-conventional energy sources.
3. Sun: The source of energy (Structure, Characteristics and Composition)
4. Solar Constant
5. Electromagnetic Energy Spectrum.
6. Solar radiations outside earth atmosphere.
7. Solar radiation at the earth surface.
8. Problems.

Ref.1- page no. 1 to 11 and 15 to 37

Ref.3- 3.1, 3.2, 3.3, 3.4, 3.5

2: Photothermal Applications: **(10L)**

1. Photothermal devices: Solar Insolation, Selective Coating, Glass Cover, Heat Conductor and Heat Insulation.
2. Solar water heating systems: Types, construction and working of Liquid Flat Plate Collector (FPC) and Evacuated Tube Collector (ETC)
3. Energy Balance Equation (without thermal Analysis).
4. Concentrating collectors: Flat plate collector with plane reflector, Cylindrical parabolic, Compound parabolic, Collector with fixed circular concentrators and moving receiver, paraboloid concentrator.
5. Comparative study between flat plate collector and solar concentrators.
6. Solar distillation, Solar dryer, Solar cooker (box type)

Ref. 1: 3.3, 3.3(A), 3.5, 3.7, 3.8, 5.2, 5.8, 5.11.

Ref. 2: 2.2.6

3: Photovoltaic systems: **(10L)**

1. Introduction to Photovoltaic effect and Photovoltaic Conversion.
2. Basic photovoltaic system for power generation
3. Basics of Solar Cell, PV modules, Arrays,
4. Solar Cell: I-V characteristics, Power output and conversion efficiency.
5. Factors affecting on photovoltaic efficiency. (Change in amount of input light, solar cell area, Change in angle, Change in operating Temperature etc.)
6. Types of solar cells: p-n junction solar cell, p-i-n diode solar cell, cadmium sulphide solar cell, Gallium arsenide solar cell, Indium phosphide solar cell, nano-crystalline solar cell.
7. Application of solar photovoltaic systems.

Ref.3 -15.1, 15.3, 15.4, 15.5, 15.7, 15.8, 15.10.

Ref.8 – 3.6.1, 3.6.2, 3.6.3, 3.6.4, 3.6.5

4: Energy Storage: **(06L)**

1. Importance and Needs of Energy storage in Conventional and Nonconventional Energy Systems.
2. Various forms of Energy Storage
3. Electrical Energy: Super capacitors
4. Electrochemical Energy: Battery
5. Chemical Energy: Hydrogen Production and storage

Ref.4 - Ref.5 - Ref.6 - Ref.7 -

Reference books:

1. Non-conventional Energy sources, G. D. RAI (4th edition), Khanna Publishers, Delhi.
2. Solar Energy, S.P. Sukhatme (second edition), Tata Mc. Graw Hill Ltd, New Delhi.
3. Solar Energy Utilizations**,** G. D. RAI (5th edition), Khanna Publishers, Delhi.
4. Energy Storage: Fundamentals, Materials and Applications, by Huggins R. A., Springer
5. Chemical and Electrochemical Energy System by R. Narayan and B. Viswanathan, University Press.
6. Battery Systems Engineering by C. D. Rahn and C. Wang, Wiley Pub.
7. Electrochemical Energy Storage for Renewable sources and grid balancing by P. T. Moseley and J. Garche, Elsevier Science.
8. Solar Photovoltaic Technology and Systems by C S Solanki

List of Experiments: (Any 2)

1. To calculate the thermal efficiency of liquid flat plate collector.
2. To study the box type solar cooker.
3. To determine an instantaneous thermal efficiency of parabolic collector.
4. To calculate an efficiency and fill factor of PN junction solar cell.
5. To study I-V characteristic of various types of solar cells.

T.Y.B.Sc. (Physics) (Sem-V)
PHY-356 Elective-I (E): Applied Optics

Lectures: 36 **(Credits-02)**

1: Fermat's Principle and Matrix Methods in Paraxial Optics: (9L)

1.1 Introduction to Fermat's Principle and its Applications.
1.2 Laws of Reflection and Refraction from Fermat's Principle.
1.3 Ray paths in an Inhomogeneous Medium.
1.4 Introduction to Matrix methods in Paraxial Optics.
1.5 The matrix method, Unit planes and Nodal planes.
1.6 A System of two thin lenses.
1.7 Problems.

2: Multiple-Beam Interferometry and Diffraction: (9L)

2.1 Introduction to Multiple-Beam Interferometry.
2.2 Michelson Interferometer
2.3 The Fabry-Perot Etalon.
2.4 The Fabry-Perot Interferometer.
2.5 Introduction and revision of diffraction.
2.6 Two slit and N-Slit Fraunhofer diffraction pattern.
2.7 Fresnel half period zones, the zone plate and Fresnel Diffraction.
2.8 Problems.

3: Polarization and Holography: (9L)

3.1 Introduction and Revision of Polarization.
3.2 Malus law, Double refraction,
3.3 Phase retarded plate, Quarter wave plate and half wave plate
3.4 Optical activity and Polarimeter
3.5 Introduction and Theory of Holography.
3.6 Importance of coherence and Principle of holography.
3.7 Characteristics, recording and reconstruction of Holography
3.8 Applications of Holography.
3.9 Problems.

4: Fibre Optics: (9L)

4.1 Introduction to Fibre Optics.
4.2 The Optical Fibre: Principle and Structure.
4.3 Fibre Optics: Numerical aperture and Acceptance angle, Pulse dispersion and Calculation of pulse dispersion.
4.4 Types of Optical Fibres: Concept of Mode, Multimode and Single mode fibre.
4.5 Attenuation in optical fibers, single mode and multimode fibers.
4.6 Fibre Optic communication system: Fiber optical telecommunication system.
4.7 Advantages of Fibre Optics.
4.8 Applications of Fibre Optics.
4.9 Problems.

Reference Books:

(1) Ghatak Ajoy, Optics 3rd Edition, The McGraw Hill companies.
(2) N. Subrahmanyam, A textbook of Optics, S. Chand publications.
(3) Optical Fiber and Fiber Optic communication System, S.K Sarkar S. Chand.
(4) Practical Optics, Naftaly Menn, Academic press (2004)
(5) M. Born and E. Wolf, Principles of Optics, Cambridge University Press
(6) F. A. Jenkins, H.E White, Fundamental of Optics, McGraw companies

List of Experiments : (Any 2)

(1) Determination of the numerical aperture of the given optical fibre.
(2) Determination of the optical power loss in attenuators.
(3) Fabry Perot Etalon
(4) To study the nature of polarization of laser light using photo cell and quarter wave plate.
(5)To determine the Brewster's angle for glass using a polarized monochromatic light source.

T.Y.B.Sc. (Physics) (Sem-V)
PHY-356 Elective-I (F): C# Programming

Lectures: 36 **(Credits-02)**

1: MS.NET Framework Introduction **(8L)**

• The .NET Framework - an Overview • Framework Components • Framework Versions • Types of Applications which can be developed using MS.NET • MS.NET Base Class Library • MS.NET Namespaces • The Common Language Runtime (CLR), Common Type System (CTS) • Common Language Specification (CLS) . Installing Required Software – SQL Server and Management studio

2: C # Language Syntax **(8L)**

• Datatypes • Global, Stack and Heap Memory • Common Type System • Reference Type and Value Type • Datatypes and Variables Declaration • Implicit and Explicit Casting • Checked and Unchecked Blocks – Overflow Checks • Casting between other datatypes • Boxing and Unboxing • Enum and Constant • Operators • Control Statements • Working with Arrays • Working with Methods • Pass by value and by reference and out parameters• Writing, testing and execution of program to understand general syntax and functions available in C#.

3: Database Programming Using ADO.NET **(8L)**

• Prerequisite - Knowledge of SQL Queries • Introduction and Evolution of ADO.NET • Understanding the Role of Managed Provider and ADO.NET Objects • connecting to Database and Connection Pooling • Performing Insert, Update and Delete Operations • Fetching Data from database - Executing Select Statements • How to implement Login facility with database

4: Interactive methods **(6L)**

Preparing flowchart, algorithm for interactive methods, Bisection Methods, Newton Rapson Method, Numerical integration by Trapezoidal rule, Simpson 1/3rd rule.

5: Hands on training: **(6L)**

Hands on training to execute numerical problems for interactive methods, Bisection Methods, Newton Rapson Method, Numerical integration by Trapezoidal rule, Simpson 1/3rd rule.

Reference Books:

1. C# 8.0 Pocket Reference: Instant Help for C# 8.0 Programmers
2. Programming in C# by E Balagurusamy
3. Beginning C# Object-Oriented Programming (English, Paperback, Clark Dan)
4. Pro C# 9 with .NET 5: Foundational Principles and Practices in Programming by Troelsen, Andrew, Japikse, Philip

Web References:

1. https://dotnet.microsoft.com/learn/csharp
2. https://docs.microsoft.com/en-us/dotnet/csharp/programming-guide/
3. https://www.pragimtech.com/courses/c-sharp-tutorial-for-beginners/
4. https://www.tutorialspoint.com/csharp/csharp_tutorial.pdf

List of Experiments: (Any 2)

1. Write a program that converts 1 lower case letter ("a" - "z") to its corresponding upper case letter ("A" - "Z"). For example if the user enters "c" then the program will show "C" on the screen.
2. Write a program using a switch statement that takes one value from the user and asks about the type of conversion and then performs a conversion depending on the type of conversion. If user enters:
3. Write a program using conditional operators to determine whether a year entered through the keyboard is a leap year or not.
4. Write a program using a for loop that prints the following output (you need to find a pattern to print letters in this order): A B D H P
5. Write a program using a loop that prints the following output. 1 2 2 3 3 3 4 4 4 4 5 5 5 5 5 6 6 6 6 6 6 . . . nth iteration.

T.Y.B.Sc. (Physics) (Sem-V)
PHY-357: Physics Laboratory-3A

Lectures: 36 **(Credits-02)**

(General Laboratory, Electromagnetism, Atomic and Molecular Physics, and Optics)

(Any Eight)

GROUP-I: GENERAL PHYSICS (any FOUR)

1. Kater's pendulum
2. Moment of Inertia by Bifilar suspension
3. Young's modulus by Koeing method
4. Surface tension of mercury by ripple method
5. Surface tension liquid by Fergusson method
6. Surface tension of mercury by Quincke's method
7. 'Y' by vibration of wooden scale
8. Young's modulus by Newton's rings
9. Determination of wavelength of light by Michelson's interferometer
10. Study of damped oscillations of physical pendulum and finding log decrement

GROUP-II: ELECTROMAGNETISM (any TWO)

1. Study of forced oscillations by electromagnetically driven simple pendulum
2. Self-Inductance by Anderson's bridge
3. Core losses in transformers
4. Electromagnetic pendulum
5. Self-Inductance by Maxwell's bridge

GROUP-III: ATOMIC AND MOLECULAR PHYSICS AND OPTICS (any TWO)

1. Determination of Rydberg's constant
2. Zeeman Effect
3. Llyod's mirror
4. Determination of Resolving Power of grating
5. Determination of wavelength by Constant deviation spectrometer

Additional Activities (Any ONE)

- Demonstrations: Any 2 demonstrations equivalent to 2 experiments
- Study tour with report equivalent to 2 experiments
- Mini project equivalent to 2 experiments
- Computer aided demonstrations (simulations or animations)
  (Any 2 demonstrations equivalent to 2 experiments)

Note: *Students have to perform* ***ten*** *experiments or* ***one*** *additional activities in addition to* ***eight*** *experiments mentioned above. Total laboratory work with additional activities should be equivalent to* ***ten*** *experiments.*

T.Y.B.Sc. (Physics) (Sem-V)
PHY-358: Physics Laboratory-3B

Lectures: 36 **(Credits-02)**

GROUP-I: EXPERIMENTS USING CRO/INSTRUMENTATION (any TWO)

1. Charging and discharging of capacitor and RC time constant
2. Measurement of g using simple pendulum
3. Velocity of sound
4. Radiation detection
5. IV Characteristics of diode
6. Measuring a value of a capacitor using CRO.
7. Temperature controller using AD590
8. Study of IC 7490 as mod 2, mod 5, mod 7 and mod 10 counter.

GROUP-II: C-PROGRAMMING (any TWO)

1. Factorial of a number by simple and recursive method.
2. To find out the first 100 prime numbers
3. Matrix multiplication
4. Position time data using kinematic equations
5. Finding pressure using Van-der-Waals' equation of state

GROUP-III: COMPUTATIONAL PHYSICS (NUMERICAL BASED) (any TWO)

1. Roots of an algebraic equation (Bisection)
2. Roots of polynomial (Newton Raphson)
3. Numerical Integration by Trapezoidal rule
4. Numerical Integration by Simpson's 1/3 rule

GROUP-IV: PRACTICAL FROM OPTIONAL COURSE (Any TWO)

Additional Activities (Any ONE)

- Demonstrations: Any 2 demonstrations equivalent to 2 experiments
- Study tour with report equivalent to 2 experiments
- Mini project equivalent to 2 experiments
- Computer aided demonstrations (simulations or animations)
  (Any 2 demonstrations equivalent to 2 experiments)

Note: *Students have to perform* ***ten*** *experiments or* ***one*** *additional activities in addition to* ***eight*** *experiments mentioned above. Total laboratory work with additional activities should be equivalent to* ***ten*** *experiments.*

T.Y.B.Sc. (Physics) (Sem-V)
PHY-359: Physics Project-I

Lectures: 36 **(Credits-02)**

Guidelines:

It is expected that,

1. The student does work equivalent to about ten (10) laboratory experiments throughout the semester in the third year.
2. One bears in mind that the project work is a practical course and it is intended to develop a set of skills pertaining to the laboratory work apart from the cognition of students. Therefore, the guides should not permit projects that involve no contribution on part of student.
3. The project must have a clear and strong link with the principles of basic physics and/or their applications.
4. The theme chosen should be such that it promotes better understanding of physics concepts and brings out the creativity in the students.
5. The evaluation of the project work must give due credit to the amount of the project work actually done by a student, skills shown by the student, understanding of the physics concepts involved and the final presentation at the time of viva voce.
6. It is also recommended that a teacher will look after Four (4) projects at one time.
7. Practical examination will be conducted semester wise.
8. The student can perform an Experimental/Theoretical/Computational Project in Physics or interdisciplinary areas under the supervision of one or more guides.
9. The student can learn the basics of the topic chosen for project, to learn how to do literature survey and set up the basic experimental/theoretical and computational techniques needed for the project.
10. The department encourage to students for projects both in experimental and theoretical areas of Physics in collaboration with other institutes and industry.

The Project work shall consist of the following Criterions.

1. Project work is mandatory for all the T. Y .B. Sc. students.
2. All the T. Y. B. Sc. students will be have to complete the Project work prescribed by the Board of Studies in Physics of Savitribai Phule Pune University during the V^{th} Semester.
3. The Project work shall consist of the following Criterions.
    - It is expected that students must finalize the Title of Project, Aim and objective, Significance, Literature survey, Materials required, Method and Application etc.
    - Introduction to foundations of Project Work.
    - Introduction of Project Research Methodology.
    - Study of Data Collection Methods.
    - Project Problem Writing and Presentation Skills.

Evaluation weightage:

- Project-I: Semester End University Examination : 35 Marks
- Internal Examination: 15 Marks

Skill Enhancement Courses

Skill Enhancement Courses (SEC)

a) Selection of Skill enhancement courses

There are two skill enhancement courses (SEC) in 5th semester (PHY-3510 and PHY-3511). For 5th semester, there are four options available. The college has to select any one from the given four options. It is advised that college should not offer elective and skill enhancement course of same theme.

b) Teaching Learning process for Skill Enhancement Courses

Skill base courses are intended to explore the applications of physics knowledge. Learning in skill enhancement courses is largely experience based. The skill enhancement courses may be categorized as knowledge skill or technical skill. For knowledge skill courses one can use the conventional method for teaching along with problem solving, assignments seminars etc. For acquiring the technical skill, the students will get adequate 'hands-on' experience. The teachers may use demonstrations and activity-based learning techniques. On field visits, study tour and mini projects will enrich the learning experience of the students.

c) Assessment methods for skill enhancement courses

Continuous evaluation will be the best method for assessment of skill enhancement courses.

One can use tools like assignments, mini projects or activities, problems, etc and grade the students according to their performance. The internal assessment should have 50 % weightage.

The University examination may be conducted for the remaining 50%.

The University examination question paper should have adequate proportion of objective and subjective question.

d) List of Skill Enhancement Courses:

Semester-Vth	**Semester-Vth**
PHY-3510	**PHY-3511**
PHY-3510(G): Python Programming	PHY-3511(K): Physics Workshop Skill
PHY-3510(H): Energy studies	PHY-3511(L): Biomedical Instrumentation
PHY-3510(I): Introduction to Arduino	PHY-3511(M): Non-destructive Testing Techniques
PHY-3510(J): Sensors and Transducer	PHY-3511(N): Acoustics Applications

T.Y.B.Sc. (Physics) (Sem-V)
PHY-3510 SEC (G): Python Programming

Lectures: 36 **(Credits-02)**

Pre-requisite	: Basic mathematics (XII-Science)
Version of python	: 3.4
Proposed IDE	: Spider, Py Charm or Jupyter

Python Programming:

Python is one of the top ten popular programming languages. Python is a general purpose and high level programming language. You can use Python for developing desktop GUI applications, websites and web applications. Also, Python, as a high level programming language, allows you to focus on core functionality of the application by taking care of common programming tasks. The simple syntax rules of the programming language further makes it easier for you to keep the code base readable and application maintainable. There are also a number of reasons why you should prefer Python to other programming languages.

Advantages of Python Programming

i.) Readable and Maintainable Code
ii.) Multiple Programming Paradigms
iii.) Compatible with Major Platforms and Systems
iv.) Robust Standard Library
v.) Many Open Source Frameworks and Tools
vi.) Simplify Complex Software Development
vii.) Adopt Test Driven Development

Objectives:

i.) To build foundation for understanding Python environment to enhance computational skills.
ii.) Understand variables, input and output functions in python and To Apply computational skill in problem solving approach of Physics
iii.) Get exposure to arithmetic, assignment, relational, logical and Boolean operators.
iv.) Be familiar with Python modules and Libraries

Course outcomes:

After completion of this course student will be able

i.) To write code for complex scientific computational requirement.
ii.) Use Libraries like NumPy for numeric computation
iii.) Use Library SciPy for scientific and technological calculations
iv.) Use Library Matplotlib for plotting of graph and its visualization.
v.) Develop own functions for Physics or mathematics.

Syllabus

a) Python Programming:

Unit No.	Topic	Lectures
1	**Introduction to Python Programming Language**: Introduction to Python Language, • Strengths and Weaknesses, • IDLE, Dynamic Types, • Naming Conventions, • String Values, • String Operations, • String Slices, • String Operators, • Numeric Data Types, • Conversions, • Built In Functions	03
2	**Data Collections and Language Component:** • Introduction, • Control Flow and Syntax, • Indenting, • The if Statement, • Relational Operators, • Logical, • Operators, • True or False, • Bit Wise Operators, • The while Loop, break and continue, • The for Loop, Lists, • Tuples, • Sets, • Dictionaries, • Sorting Dictionaries, • Copying Collections.	05
3	**Functions and Modules :** • Introduction • Defining Your Own Functions Parameters • Function Keyword and Optional Parameters • Passing Collections to a Function • Variable Number of Arguments Scope • Functions Passing Functions to a Function • Mapping Functions in a Dictionary	05

	• Modules • Standard Modules – sys • Standard Modules – math • Standard Modules – time • The dir Function	
4	**Modules and packages in Python :** • NumPy, SciPy • MathPlot etc	**05**

Activity: **any- 6** **[18L]**

Sr. No.	Practical/Demonstration to Communicate Concepts and Application in Physics, Electronics, Statistics and Mathematics
1	Write python program to use basic math and string operations.
2	Write python program to find roots of quadratic equation, prime numbers etc
3	Write python program to store data in list and perform matrix operation
4	Write python program to do numerical methods
5	Write python program involving tuples, dictionaries in problems related to physics or mathematical concepts
6	Write python program to use random number generator as probability density to show expected value is 0.5 to explain quantum mechanical behaviour of particle in one dimensional well.
7	Write python program to use NumPy library for more complex arithmetic operations
8	Write python program to use complex numbers and complex algebra
9	Write python program to use bitwise operation
10	Write python program to plot graphs using mathplotlib or similar library

Reference books:

- Python Programming: Using Problem Solving Approach. By Reema Thareja.
- Think Python By Allen Downey
- Problem Solving and Python Programming By Balguruswami McGrow Hill
- Let Us Python By Aditya Kanetkar
- Learning with Python By Allen Downey
- Data Analytics By Bharti Motwani

T.Y.B.Sc. (Physics) (Sem-V)
PHY-3510 SEC (H): Energy Studies

Lectures: 36 **(Credits-02)**

Objectives:

1. Students understand the comparative aspects, advantages and disadvantages of various sources of energy. They understand the facts and myths regarding the energy sources.
2. Students learn the basic principles involved and technologies developed in the uses of solar energy, biomass energy, wind energy, fuel cells.
3. Students understand the challenges and opportunities in conversion of energy from one form to another, generation of electricity and mechanical work using different energy sources.
4. Students get acquainted with challenges and recent trends in energy storage devices and they learn more about super-capacitors and batteries, electrical vehicles. They can imagine about future road maps in the fields of energy conversion and storage technologies.

Course Outcomes:

1. Students become capable of conducting energy audits and give consultancy in that field.
2. Students can design different types of solar heaters for small domestic as well as large scale community level applications.
3. Students acquire skills to implement solar P-V systems at domestic levels as well as for office premises and educational institutions. Students become able to start their own enterprise in net metering.
4. Students get ideas and hence become self-employed in the field of design , production, commissioning and implementation of bio-mass energy sources , bio-gas plants, gasifiers, wind mills, hybrid systems etc.
5. Students can go for research in the fields of super-capacitors, battery technologies, fuel cells and material synthesis for implementation of these technologies.
6. Students become successful entrepreneurs in the energy field.

Students strive to make the regions where they live and work self-sufficient in generating and fulfilling their own energy needs using different energy solutions.

Syllabus:

Unit No.	Topic	Lectures
1	**An Introduction to Energy Sources:** Classification and comparison of energy sources (hydro, thermal, nuclear, solar, wind, biomass, and fossil fuels) considering environmental, safety, economy, production and distribution aspects. Facts and Myths about various sources of energy, thermal, nuclear sources of energy, Hybrid sources. Energy audit.	3
2	**Solar thermal Applications:** Sun as a source of energy, Solar Constant, Liquid flat plate collector, construction and working, Concentrating collectors, Solar drying, Solar water heating systems.	3
3	**Solar Photovoltaic systems Applications:** Photovoltaic principle, Power output and conversion efficiency, Limitation to photovoltaic efficiency, Basic photovoltaic system for power Generation,	4

	Application of solar photovoltaic systems, Advantages and disadvantages of Solar PV Systems. Configurations of Solar Photovoltaic Systems: Off-grid, Grid-Tied and Grid-Storage, Net metering and steps in installation of a rooftop solar PV System design.	
4	**Biomass and wind energy:** Bio-mass conversion technologies, Bio-gas generation, Working of biogas plant, Bio-gas from plant wastes, Methods for obtaining energy from biomass, Thermal gasification of biomass, Introduction to wind energy, Classification and description of wind machines, Wind energy, Wind data.	4
5	**Energy storage devices and electrical Vehicles :** Recent trends in batteries, super-capacitors, fuel cells. Applications of storage devices: Electrical Vehicles (EV), Converter, Inverter, Controls & Controllers in EV, Future Trends in Electric Cars.	4

Activity: any-6 (At least one activity from each unit) **[18L]**

Unit-I:

1. Energy audit of college campus/public campus/home/building.
2. Comparison of energy sources.
3. Visits to energy generation/distribution sites.

Unit-II:

4. Study of solar water heaters.
5. Study of large scale solar heaters for industrial/cooking/water heating applications.
6. Study of flat plate, parabolic solar concentrators.

Unit-III:

7. Efficiency measurement of PV systems using I-V characteristics of Amorphous Si, Mono-crystalline Si, Polycrystalline Si in individual, series and parallel combinations.
8. Effect of intensity of incident light, incident angle and shading on Solar PV Module on Output power.
9. Study of design of solar lanterns, street lights using solar systems.
10. Study of Installation and commissioning of roof top solar PV systems.
11. Study of net metering systems.

Unit-IV:

12. Visit to bio gas plant
13. Visit to bio diesel plants
14. Study of modified bio mass plants
15. Design and implementation of domestic/small scale biogas plants.
16. Study of different types of gasifiers
17. Study of wind mill / visit to wind mill

Unit-V:

18. Preparation and testing of fuel cell on Laboratory scale
19. Preparation and testing of super capacitors on Laboratory scale
20. Preparation and testing of paper batteries and other types of batteries on Laboratory scale.
21. Design and implementation of battery-operated toys using green technology

Reference books:

1. Non-conventional Energy sources- G. D. RAI (4th edition), Khanna Publishers, Delhi
2. Solar Energy - S. P. Sukhatme (Second Edition), Tata Mc Graw Hill Ltd., New Delhi.
3. Solar Energy Utilisation - G. D. RAI (5th edition), Khanna Publishers, Delhi.
4. Renewable Energy Technology: A practical guides of beginners, Chetan Singh Solanki, PHI Learning Private-Ltd., New Delhi.
5. Solar Photovoltaics: Fundamentals, Technologies and Applications, Chetan Singh Solanki, PHI Learning Private-Ltd., New Delhi

Note :

1. It is expected that students should undertake at least 1 activity from each unit and total 6 activities amounting to 18 lectures time.
2. Out of the total time allotted to each unit, half the time should be utilized for classroom teaching and remaining half for the activity.
3. Students should be encouraged to study this course by using Case–Study approach.

T.Y.B.Sc. (Physics) (Sem-V)
PHY-3510 SEC (I): Introduction to Arduino

Lectures: 36 **(Credits-02)**

Introduction:

Arduino is an open-source electronics platform based on easy-to-use hardware and software. Arduino board designs use a variety of microcontrollers. Boards are equipped with sets of digital and analog input/output (I/O) pins that may be interfaced to various circuits. It has USB that is used for loading programs. Microcontrollers can be programmed using C / Python programming languages. This course will focus on creative thinking and on hands-on project development using Arduino Boards.

Objectives:

- To create general awareness and interest in Arduino Boards.
- To provide knowledge of different Arduino boards and various sensors and actuators.
- The course enables student to understand the basics of interfacing with Arduino Boards.
- To familiarize students with Arduino as IDE, programming language & platform and to Program basic Arduino examples.
- To provide knowledge of different Smart System applications.
- Develop skills to design and implement various smart system application.

Course Outcomes: After successful completion of this course, student will be able to

- Students will be able to understand and use various Arduino Boards, and its various components, Input / Output Pins, Input / Output Devices.
- Understand general concepts of Programming Arduino Boards.
- Apply the knowledge gain to design applications using Arduino in different domains.
- To analyze and evaluate the performance of various Arduino based devices.
- Learn and understand about any new IDE, compiler, and MCU chip in Arduino compatible boards or similar types.

Instructions: This course consists of two parts

- Part I: Theory and Part II: Practical / Project.
- Out of which 1 Credit is for Theory and 1 credit is for Practical work.
- Part II has two sub parts:
- Part II(A) : Practical / Demonstration & Part II(B) : Project. The A or B parts are optional, students can opt any one for 1 credit

Part I: Theory

Unit	Topics	Lectures
I : Introduction to Microcontrollers	• Introduction to Embedded Systems, Block Diagram, Single Board Computers (SBC) and System on Chip (SoC), Single Board Microcontroller (SBM), microprocessor vs microcontrollers, Basic system with microcontroller such as Arduino (SBM), Raspberry Pi (SoC) etc.	04

II : Introduction to Arduino and Arduino Programming	• **Arduino Basics:** What is Arduino, Advantages of Arduino, Arduino Types, Arduino Components, Arduino Uno Architecture • **Arduino Hardware:** Types of Arduino boards, Various components on Arduino Board, Various sensors and actuators: Overview of Sensors working, Analog and Digital Sensors	**06**
III : Introduction to Programming for Arduino	• **Arduino Software:** Integrated Simulation Environment (IDE), Setup the IDE, Arduino Libraries, What is Sketch, Writing Arduino Sketches, Serial Monitor, **Introduction to programming:** Fuctions, Variables & Basic Structure of Arduino (C++) Code, Basics Programs (Hello Word, Blinking of LED), Loading program through USB and Test performance of the System, Integration of Sensors and Actuators with Arduino	08

Part II (A): Arduino Programming (Practical / Demonstration) : **any-6 [18 L]**

Simple Practical using Arduino Uno Board (Software + Hardware): Choose any-3 Practical from group-1 and any-3 practical from group-2. (Total = 6 practical)

Sr No	List of Practical's
	Group 1 : Any-3
1	Demonstration of Arduino Uno Board, Its Various Components, Pins
2	Installation Arduino Software (IDE) on computer, Introduction to Sketch, Loading of Program from computer, Simple programs: Hello Word, Blinking of LED on Arduino board etc.
3	Interfacing external LED (ON & OFF); Fading of LED
4	Analog Read Serial: 1. Read a potentiometer, print its state out to the Arduino Serial Monitor. 2. Read an analog input and prints the voltage to the Serial Monitor.
5	Digital Read Serial: Interfacing a switch, Read a switch, print the state out to the Arduino Serial Monitor.
6	Digital: Interfacing push Button: Use a push button to control an LED or Buzzer
7	Digital : State Change Detection: Count the number of button pushes.
8	Analog In Out Serial: Read an analog input pin, map the result, and then use that data to dim or brighten an LED.
	Group 2 : Any 3
9	Knock: Detect knocks with a piezo element.
10	Interfacing of Ultrasonic Sensor, Detect objects with an ultrasonic range finder.
11	Interfacing of Proximity Sensor

12	Interfacing of Temperature & Humidity Sensor : To interface DHT11 sensor for recording temperature and humidity readings with Arduino.
13	Interfacing LCD display with Arduino
14	Interfacing of Relay Switch and Servo Motor with Arduino
15	Interfacing Bluetooth Module to Arduino
16	Interfacing of Motion (PIR Sensor) or Light Sensor using (LDR & LED) or Gas Sensor (MQ-2) with Arduino

OR

Part II (B): Arduino Programming (Practical / Demonstration)

Project : any-1 (Simple Projects Using Arduino Uno Board) [18 L]

Sr No	List of Simple Projects
1	Line Following Robot with Arduino
2	Obstacle Avoiding Robot with Arduino
3	Weather Station using Arduino
4	Home Automation using Arduino
5	Android Based Air quality Monitor
6	Intelligent automatic irrigation system

References:

1. www.arduino.cc
2. https://www.arduino.cc/en/Tutorial/BuiltInExamples
3. https://create.arduino.cc/projecthub

T.Y.B.Sc. (Physics) (Sem-V)

PHY-3510 SEC (J): Smart Sensors and Transducer Technology

Lectures: 36 **(Credits-02)**

Course Objectives:

- To make students familiar with the constructions and working principle of different types of sensors and transducers.
- To make students aware about the measuring instruments and the methods of measurement and the use of different transducers.

Course Outcomes: At the end of the course, a student will be able to:

- Use concepts in common methods for converting a physical parameter into an electrical quantity
- Classify and explain with examples of transducers, including those for measurement of temperature, strain, motion, position and light
- Choose proper sensor comparing different standards and guidelines to make sensitive measurements of physical parameters like pressure, flow, acceleration, etc
- Predict correctly the expected performance of various sensors
- Locate different type of sensors used in real life applications and paraphrase their importance
- Set up testing strategies to evaluate performance characteristics of different types of sensors and transducers and develop professional skills in acquiring and applying the knowledge outside the classroom through design of a real-life instrumentation system.

Syllabus: **[18 L]**

Unit-I: Mechanical and Electromechanical sensor:

Definition, principle of sensing & transduction, classification. Resistive (potentiometric type): Forms, material, resolution, accuracy, sensitivity. Strain gauge: Theory, type, materials, design consideration, sensitivity, gauge factor, variation with temperature, adhesive, rosettes. LVDT: Construction, material, output input relationship, I/O curve, discussion.

Unit-II: Capacitive sensors:

Variable distance-parallel plate type, variable area- parallel plate, serrated plate/teeth type and cylindrical type, variable dielectric constant type, calculation of sensitivity. Stretched diaphragm type: microphone, response characteristics..

Unit-III: Thermal sensors:

Material expansion type: solid, liquid, gas & vapor Resistance change type: RTD materials, tip sensitive & stem sensitive type. Thermo emf sensor: types, thermoelectric power, general consideration, Junction semiconductor type IC and PTAT type.

Unit-IV: Magnetic sensors:

Sensor based on Villari effect for assessment of force, torque, proximity, Wiedemann effect for yoke coil sensors, Thomson effect, Hall effect, and Hall drive, performance characteristics. Radiation sensors: LDR.

Activity: any-6 (At least one activity from each unit) **[18 L]**

Unit-I:

1) Linear displacement measurement using potentiometric sensor.
2) Displacement/pressure measurement using strain gauge sensor.
3) Linear displacement measurement using LVDT.

Unit-II:

1) Capacitive type transducer measure small displacement/force varying plate area/distance of plate/dielectric constant.
2) Displacement/pressure measurement using microphone.
3) Liquid pressure measurement using pressure sensor

Unit-III:

1) Measurement of temperature using RTD .
2) Measurement of temperature using Thermocouple transducer.
3) Silicon diode as temperature sensor

Unit-IV:

1) Magnetic sensor/Hall effect/proximity sensor based measurement magnetic susceptibility magnetisation
2) LDR based measurement light intensity etc.

Reference books:

1) R Sensor & transducers, D. Patranabis, 2nd edition, PHI
2) Instrument transducers, H.K.P. Neubert, Oxford University press.
3) Measurement systems: application & design, E.A.Doebelin, Mc Graw Hill
4) Sensor & transducers, D. Patranabis, 2nd edition, PHI
5) Instrument transducers, H.K.P. Neubert, Oxford University press.
6) Measurement systems: application & design, E.A.Doebelin, Mc Graw Hill

T.Y.B.Sc. (Physics) (Sem-V)

PHY-3511 SEC (K): Physics Workshop Skill

Lectures: 36 **(Credits-02)**

Objectives:

This course is to get exposure with various aspects of instruments and their usage through hands-on mode.

Course outcomes:-

After completion of this course students will able to handle and test various instruments.

Syllabus:

Unit-1. Basic of Measurement: 4L

- Accuracy, precision, sensitivity, resolution, range etc.
- Errors in measurements and loading effects.
- Principle and working of digital meters. Comparison of analog & digital instruments. Characteristics of a digital meter.

Multimeter:

- Block diagram and working of a digital multimeter.
- Principles of measurement of dc voltage and dc current, ac voltage, ac current and resistance.
- Specifications of a multimeter and their significance.

Unit-2. Electronic Voltmeter: 4L

- Principles of voltmeter, Construction (block diagram only).
- Specifications of an electronic Voltmeter and their significance.
- AC Milli Voltmeter: Type of AC Milli Voltmeters
- Block diagram ac Milli Voltmeter,
- Specifications and their significance.

Unit-3. Cathode Ray Oscilloscope: 5L

- Block diagram of basic CRO.
- Construction of CRT, Electron gun, electrostatic focusing and acceleration (Explanation only-no mathematical treatment),
- Brief discussion on screen phosphor, visual persistence & chemical composition.
- Time base operation, synchronization. Front panel controls.
- Specifications of a CRO and their significance.
- Use of CRO for the measurement of voltage (dc and ac frequency, time period.
- Special featuresof dual trace oscilloscope.
- Introduction to digital oscilloscope, Block diagram and principle and working.

Unit-4. Signal Generators and Analysis Instruments: 2L

- Block diagram, explanation and specificationsof low frequency signal generators.
- Pulse generator, and function generator.

- Brief idea for testing, specifications. Distortion factor meter, wave analysis.

Unit-5. Impedance Bridges and Q-Meters: 3L

- Block diagram of bridge.
- Working principles of basic (balancing type) RLC bridge.
- Specifications of RLC bridge. Block diagram & working principles of a Q- Meter.
- Digital LCR bridges.

Activity: any-6 (18 L)

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

Reference Books:

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 Mc Graw Hill. Logic circuit design, Shimon P. Vingron, 2012, Springer.
4) Electronic Devices and circuits, S. Salivahanan & N. S.Kumar, 3, 2012, Tata Mc-Graw Hill
5) Electronic circuits: Handbook of design and applications, U.Tietze, Ch.Schenk, 2008, Springer Electronic Devices, 7/e Thomas L. Floyd, 2008, Pearson India

T.Y.B.Sc. (Physics) (Sem-V)

PHY-3511 SEC (L): Biomedical Instruments

Lectures: 36 **(Credits-02)**

Objectives

- Introduction to various bio-signals and their origin
- Understanding of electrode theory
- Use of transducers in biomedical instrumentation
- Patient safety while using biomedical instrumentation
- Instruments handling and analysis of the recorded data

Course Outcomes

- Students will acquire basic knowledge of biomedical instrumentation.
- Students can handle and operate different equipment's like ECG, Oxymeter, and Glucometer.
- Students will be able to record the different health parameters using it.
- Student will also able to analyze and interpret the recorded data.

Syllabus:

Unit-I: Physiological transducers **(7L)**

- Introduction to physiological transducers
- Classification of Transducer
- Performance characteristic of transducer.
- Displacement, position and motion transducer.
- Pressure transducer for blood pressure measurement
- Transducer for Body temperature measurement
- Biosensors

Unit-II: Bioelectric signals and cardiovascular system: **(7L)**

- Basics of signal measuring system
- Basic and essentials of biomedical instrumentation system.
- Heart and Cardiovascular system
- Resting and action potential, propagation of action potential, Passive and active conduction.
- Electro-conduction system of heart
- Blood Pressure measurement
- Heart Sounds, Phonocardiography
- Pulse oximetry

Unit-III: Electrocardiography: **(4L)**

- Introduction and Principle
- Interpretation of Electrocardiogram
- Block diagram of electrocardiograph, ECG machine maintenance and trouble shooting
- The ECG leads
- Effect of artifacts on ECG recording

- Types of ECG recorders

Activities: any-6 (3 Lecture hours each) (18L)

1. Study of ECG machine(Voltage gain , chart speed etc) and EEG placement of electrodes
2. ECG recording and analysis (Calculation of heart rate, measurement of peak amplitude and period of waves)
3. Study of anolog sphygmomanometer and digital BP monitor – Measurement of SBP, DBP and pulse rate
4. Measurement of pulse parameter using pulse oxymetry /pulse measuring instrument
5. Use of biosensor (sugar level measurement / skin resistance).
6. To study Infrared sensor/ temperature gun and measuring values
7. Study of BMI/ body composition monitor and measurement of physiological parameters (BMI, % Body fat,
8. First aid for heart patient – study and practice
9. Study of Spirometer and practice for increasing lung capacity
10. Visit to established hospital

Reference Books:

1. Biomedical Instrumentation and Measurements (Second edition) - Leslie Cromwell, Fred J. Weibell, Erich A. Pfeiffer Pearson education.
2. Handbook of Biomedical Instrumentation (Second Edition) - R. S. Khandpur (Tata McGraw Hill).
3. Biomedical Instrumentation and Measurement by Carr and Brown-Pearson.
4. Biomedical instruments and measurements (Second edition) - R. Ananda Natarajan Eastern economy edition
5. A textbook of Biomedical engineering edited - R.M. Kenedi, blackie (Glasgow & London)
6. Medical instrumentation: Application and design (Third edition)- John G. Webster, Willey India Education

Required Equipment with Probable cost:

1. Electro Cardiogram- ECG machine- analog- Rs. 30000/-
2. SPO_2 meter- Analog- Rs. 3000/-
3. Fat Meter- Digital- Rs. 4000/-
4. Sphygmomanometer – Digital and analog: Rs. 3000/- each
5. Glucometer- Digital: Rs.2000 each.

T.Y.B.Sc. (Physics) (Sem-V)
PHY-3511 SEC (M): Nondestructive Testing Techniques

Lectures: 36 **(Credits-02)**

Objective:

- To study and understand the various non-destructive testing (NDT) methods, and their industrial and scientific applications.

Outcomes:

- After completion of this course the students will be able to use NDT methods for defects and characterization of industrial components.

Syllabus:

Unit No.	Topics	Lectures
I	Definition and objectives of NDT, introduction to materials testing, purpose of testing and properties of materials, classification of material testing, destructive testing and its examples only, Definition, Characteristics detected, principle, advantages, limitation and applications of various methods like Visual inspection, liquid penetrant testing, magnetic particle testing, thermography testing, eddy current testing, ultrasonic testing, acoustic emission testing, radiography testing,	6
II	What are the discontinuities, Types of discontinuities in materials? Processing the discontinuity, service induced discontinuity, factors for selection of NDT method in different cases of discontinuity, brief description of equipment used in visual testing method, Principles of liquid penetrant method, stages of liquid penetrant process, liquid penetrant process flow chart, chemical and solvent cleaning methods of surface preparation, how to apply and removal of excess penetrant?, application of developer, and observation of defects, penetrant, their types and properties, role of developer, their types, Magnetic particle testing method, procedure of Magnetic particle testing methods, portable magnetization equipment and stationary magnetization equipment, dry and wet particle inspection techniques and stages involved in it and its applications	6
III	Thermography testing, basics of infrared theory, range characteristics, wavelength, frequency, emission, convection, conduction, reflection, transmission, emissivity of infrared, basic principles of thermography testing, elements of infrared detection system, thermography testing active and passive approach, basics of eddy current testing, working principles of eddy current testing, stages in eddy current testing, factors influencing in eddy current testing, Ultrasonic testing and its methods (transmission and pulse echo method), Acoustic emission testing, factors influencing acoustic wave propagation and data acquisition, instrumentation of acoustic	6

	emission testing, Radiography testing, principle, various stages in testing, gamma ray radiography testing, SWSI and DWSI techniques in X ray testing, Fluoroscopy testing arrangement and working principle, Computed tomography in NDT	

Activity: any-6 (each activity will be equivalent to 3-hrs) **[18L]**

1. Video demonstration of any two NDT techniques
2. Study of different X ray photograph and MRI scan photographs in medicine
3. Study of NDT by acoustic method
4. Surface visual study of defects of various objects provided
5. Study of surface defects by liquid penetration method
6. Study of surface defects by liquid leak method
7. Study of surface defects by liquid spray method
8. Study of surface defects by using UV light and fluorescent liquid method
9. Visit to any industry and observing NDT method live (equivalent to two demonstrations)
10. Audio visual expert lecture of industrialist who is using NDT method for quality control.

Reference Books:

1. Non- destructive testing of materials, Dr V. Jaykumar, Dr. K. Elangovan, Lakshmi Publications, Tamilnadu, India.
2. Practical non-destructive testings, Baldev Raj, T. Jaykumar, M. Thavasimuthu, Narosa Publications
3. Basics of non-destructive testings, Lari and Kumar, S.K. Kataria& Sons publications
4. Non-destructive testing techniques, Ravi Prakash, New Age International Private Limited
5. Non-destructive test and evaluation of materials, J. Prasad, C.G.K. Nair, McGraw Hill Education

T.Y.B.Sc. (Physics) (Sem-V)
PHY-3511 SEC (N): Acoustics Applications

Lectures: 36 **(Credits-02)**

Objective:

To study and understand about sound physics, properties and their applications.

Outcomes:

After completion of this course the students will be able to use sound detection and characterization of sounds.

Syllabus:

Unit-1: Environmental Acoustics (3 L)

1.1 Environmental Noise: sonic boom, aircraft flyover, foot-fall noise, slammed door
1.2 Weighted sound levels: Sound level meters, A-weighted & C-weighted sound level, Phon, Sone,
1.3 Noise rating: Community noise: Highway noise, Aircraft noise
1.4 Noise induced hearing loss: Chronic, Trauma.
1.5 Mufflers: Automobile, Silencers, Transmission loss,

Unit-2: Sound Reinforcement Systems (5 L)

2.1 Microphones- Types, selection criteria, Professional grade, sensitivity, FM microphones
2.2 Loudspeakers- Direct Radiator type, Horn- Folded and Flared horn, Woofer, Squawker, Tweeter, Loudspeaker Cabinets- Enclosed cabinet, Open Cabinet, Bass Reflex Cabinet,
2.3 Amplifiers: Public Address systems, Gain and Bandwidth
2.4 Headphones- Noise cancellation features
2.5 Acoustic Delays
2.6 Synthesizers, Graphic equalizers, mixers
2.8 Basics of Audio Signal Processing
2.9 Monophonic and Stereophonic Systems

Unit-3: Musical Acoustics **(**4 L)

3.1 Pitch, timbre, rhythm, intensity, loudness, consonance, dissonance, Bass, Treble, Harmonics and Overtones
3.2 Standing waves, interference, beats, harmony, melody
3.3 Octave: Musical Scales
3.4 Types of Musial Instruments: String - violin, guitar, Wind - Brass, Reed instruments, organ, Percussion - Drums, Tabla
3.5 MIDI - Musical Instruments Digital Interface
3.6 Audio file formats: MP 3 and MP 4 systems

Unit-4: Room Acoustics (2 L)

4.1 Growth and decay of sound in live rooms
4.2 Sabine Equation, Reverberation time measurement methods
4.3 Room modes, Sound absorption materials
4.2 Speech Intelligibility: Articulation Test, Articulation Score

Unit-5: Acoustics in Medicine and Ultrasound (2 L)

5.1 Audiometry and Hearing loss

5.2 Ultrasonography

5.3 Ultrasonic Transducers

5.4 Ultrasonic cleaning, Non Destructive Testing (NDT)

Unit-6. Underwater Acoustics (2 L)

6.1 Speed of sound in sea water, Transmission loss

6.2 Sonar: Active and Passive Sonar

Activities: Any-6 **[18L]**

1. Frequency response of loudspeaker
2. Polar characteristics of a microphone
3. Study of Graphic Equalizer
4. Estimation and measurement of reverberation time
5. Online calculators for Room Modes
6. Speaker response of a direct radiator loudspeaker
7. Transmission loss (TL) of an expansion chamber muffler.
8. Acoustic power output of direct radiator loudspeakers
9. Verification using an online mode calculator

Reference Books:

1. Fundamentals of Acoustics, L.E. Kinsler and A. R. Frey, Wiley Eastern
2. Audio and Video Systems, R. G. Gupta, Tata McGraw Hill, 2010
3. Acoustics, W.W. Seto, Schaum's Outline
4. Handbook of Sound Engineers, G.M. Ballou, Academic Press
5. Basic Acoustics, D.E. Hall, Oxford University Press
6. Design for good Acoustics and Noise Control, J.E. Moore, University Press

Semester-VI

T.Y.B.Sc. (Physics) (Sem-VI)
PHY-361: Solid State Physics

Lectures: 36 **(Credits-02)**

1: The Crystalline Structures **(10 L)**

Lattice, Basis, Translational Vectors, Primitive Unit Cell, Symmetry Operations, Different types of lattices: 2D and 3D (Bravais lattices) Miller indices, Inter Planer Distances, SC, BCC and FCC structures, Packing Fraction, Crystal structures NaCl, diamond, CsCl, ZnS, HCP, Concept of Reciprocal Lattice and its properties, Problems

2: X ray Diffraction and Experimental Methods **(9 L)**

Bragg's Diffraction, Bragg's Law, Experimental X-ray diffraction Methods: The Laue Method, Bragg's Spectrometer, The Powder Crystal Method, Analysis of cubic structure by Powder Method, Ewald's Construction, Bragg's Diffraction condition in direct and reciprocal lattice, Problems

3: Free Electron and Band Theory of Metals **(9L)**

Assumptions of Classical and Somerfield Free Electron model, Energy levels and Density of States (One and Three Dimensions), Nearly free electron model, Fermi energy, Fermi level, Hall Effect, Mobility, Hall Angle

Band Theory of Solids: Origin of energy gap, Energy bands in Solids, Distinction between metal, semiconductor and insulator, Problems

4: Magnetism **(8L)**

Diamagnetism, Langevin theory of Diamagnetism, Paramagnetism, Langevin theory of Paramagnetism, Ferromagnetism, Antiferromagnetism, Ferromagnetic Domains, Hysteresis, Curie temperature, Neel temperature, **Superconductivity**, Day to day applications of Magnetism, Problems

Reference books:

1. Solid State Physics S.O.Pillai, 6th Edition, New Age International (P) Ltd, Publisher, (2010).
2. Solid State Physics – Kakani S.L. and Hemrajani C, 4th Edition, S. Chand Publication (2005).
3. Fundamentals of Solid State Physics – B.S.Saxena, R.C.Gupta and P.N.Saxena, Pragati Prakashan, Meerut , Uttar Pradesh
4. Introduction to Solid State Physics- Charles Kittel, John Wiley and Sons, 7th Edition.
5. Solid State Physics- A.J.Dekker, Macmillan India Ltd, (1998).
6. Solid State Physics- R.K. Puri, V.K. Babbar, S. Chand Publication.
7. Elementary Solid State Physics Principles and Applications, M Ali Omar, Pearson Education, Inc. and Dorling Kindersley Publishing, Inc.(2006)
8. Problems and Solution in Solid State Physics-S.O. Pillai, New Age International (P) Ltd.
9. Solid State Physics, P.K. Palanisamy, Scitech Publications(India) Pvt Ltd, Chennei, 1st Edition (2004)
10. Solid State Physics: Essential Concepts, David W. Snoke, 2nd Edition, Cambridge University Press

T.Y.B.Sc. (Physics) (Sem-VI)
PHY-362: Quantum Mechanics

Lectures: 36 **(Credits-02)**

1: Origin of Quantum Mechanics (08 L)

1. Historical Background: Black body radiation, photoelectric effects.
2. Matter waves - De Broglie hypothesis. Davisson and Germer experiment.
3. Wave particle duality
4. Concept of wave function, wave packet, phase velocity, group velocity and relation between them
5. Heisenberg's uncertainty principle with Electron diffraction experiment, different forms of uncertainty.
6. Different fields of applications of quantum mechanics
7. Problems

2: The Schrodinger equation (10 L)

1. Physical interpretation of wave function
2. Schrodinger time dependent equation.
3. Schrodinger time independent equation.(Steady state equation).
4. Requirements of wave function.
5. Probability current density, equation of continuity, and its physical significance.
6. An operator in Quantum mechanics, Eigen function and Eigen values.
7. Expectation value, Ehrenfest's theorem (Only statements)
8. Problems

3: Applications of Schrodinger Steady state equation (14 L)

1. Free particle.
2. Step potential.
3. Potential barrier. (Qualitative discussion). Barrier penetration and tunnelling effect.
4. Particle in infinitely deep potential well (one - dimension).
5. Schrodinger's equation in spherical polar co-ordinate system.
6. Rigid rotator (free axis).
7. Problems

4: Operators in Quantum Mechanics (4 L)

1. Hermitian operator.
2. Position, Momentum operator, angular momentum operator, and total energy operator (Hamiltonian).
3. Commutator brackets- Simultaneous Eigen functions.
4. Commutator Algebra
5. Commutator bracket using position, momentum and angular momentum operator
6. Concept of parity according to quantum mechanics, parity operator and its Eigen values.
7. Applications of Operators in Quantum Mechanics
8. Problems

Reference books:

1. Eisberg, Robert M., and Robert Resnick. *Quantum Physics of Atoms, Molecules, Solids, Nuclei, and Particles*. Wiley, 1985. ISBN: 9780471873730.
2. Liboff, Richard L. *Introductory Quantum Mechanics*. Addison Wesley, 2002. ISBN: 9780805387148.
3. Griffiths, David J. *Introduction to Quantum Mechanics*. Upper Saddle River, Pearson Prentice Hall, 2005. ISBN: 9780131118928
4. Feynman, Richard P., Robert B. Leighton, and Matthew L. Sands. *The Feynman Lectures on Physics*. Addison Wesley, 1989. ISBN: 9780201500646.
5. P M Mathews and K Venkatesan, *A Textbook of Quantum Mechanics*, Tata McGraw Hill publication, *ISBN*. : 9780070146174
6. N. Zettili, *Quantum Mechanics- Concepts and applications*, Wiley publication, *ISBN*: 978-0-470-02679-3
7. Ajoy Ghatak, S. Lokanathan, *Quantum Mechanics: Theory and Applications*, Springer Publication, *ISBN* 978-1-4020-2130-5
8. G Aruldhas, *Quantum Mechanics*, Phi Learning Private Ltd., *ISBN* : 97881203363
9. Shankar, Ramamurti. *Principles of Quantum Mechanics*. Springer, 2008. ISBN: 9780306447907.
10. Gupta, Kumar & Sharma, *Quantum Mechanics*, Jai Prakash Nath Publications.

T.Y.B.Sc. (Physics) (Sem-VI)
PHY-363: Thermodynamics and Statistical Physics

Lectures: 36 **(Credits-02)**

1: **Transport phenomenon and Maxwell's relations:** **(9L)**

Mean free path, Transport phenomenon, Viscosity, Thermal conductivity and diffusion.
Thermodynamic functions: Internal Energy, Enthalpy, Helmholtz function, Gibb's function,
Derivation of Maxwell Relations, Specific heat and latent heat equations, Joule Thomson effect (Throttling Process), Problems

2: Elementary Concepts of Statistics: **(9L)**

Probability, distribution functions, Random Walk and Binomial distribution, Simple random walk problem, Calculation of mean values, Probability distribution for large-scale N, Gaussian probability distributions, Problems

3: Statistical Distribution of System of Particles and Ensembles: **(12L)**

Specification of state of system, Statistical ensembles, Basic Postulates, Probability calculations, Behaviors of density of states, Thermal, Mechanical and general interactions
Micro canonical Ensemble (Isolated System), Canonical ensembles, simple application of canonical ensemble, Molecules in Ideal gas, Calculation of mean values in canonical ensemble.
Problems.

4: **Introduction to Quantum Statistics**: **(6L)**

Quantum distribution function, Maxwell-Boltzmann's statistics, Bose-Einstein Statistics, Fermi-Dirac Statistics, Comparison of the distributions. Applications of Quantum Statistics, Problems.

Reference books:

1) Lokanathan, R.S. Gambhir, Statistical and Thermal physics
2) F. Reif, Fundamentals of statistical and thermal physics
3) A. Beiser, Perspectives of modern physics
4) B.B. Laud, Fundamental of Statistical Mechanics
5) R.B. Singh, A primer of Statistical Mechanics
6) Gupta, Kumar, Statistical Mechanics

T.Y.B.Sc. (Physics) (Sem-VI)
PHY-364: Nuclear Physics

Lectures: 36 **(Credits-02)**

1: Nuclear Structure, Properties and Radioactivity: (12 L)

a) Basic Concept of Nucleus:

- Composition, charge, size, density of nucleus(Revision)
- Nuclear Angular momentum,
- Nuclear magnetic dipole moment
- Electric quadrupole moment, Parity & symmetry,
- Mass defect and Binding energy, packing fraction,
- Classification of nuclei,
- Stability of nuclei (N Vs Z Curve)
- Day to day applications of Nuclear Physics
- Problems.

b) Radioactivity:

- Radioactivity disintegration (concept of natural and artificial radioactivity, Properties of α, β, γ-rays, Laws of radioactive decay, half-life, mean life, Specific activity and its units (Revision)
- Successive disintegration and equilibriums and radioisotopes.
- Radiocarbon dating
- Application of radioactivity (Agricultural, Medical, Industrial, Archaeological).
- Problems

Ref.(1) Ch.(2,3), Ref.(3) Ch.(3, 6)

2: Particle Accelerator and Radiation Detectors: (06 L)

a) Particle Accelerators:

- Introduction and Classification
- Linear Accelerator (electron/proton LINAC)
- Cyclic Accelerator (Cyclotron)
- Particle Accelerators In India (Discussion only)

Ref.(1) Ch.(12)

b) Nuclear Detector:

- Classification of Nuclear Detectors
- Gas filled Detectors (G. M. counter)
- Solid state detectors (scintillation counter)
- Problems:

Ref.(2) Ch.(4), Ref.(3) Ch.(7, 15)

3: Nuclear forces and Nuclear Models: (09 L)

a) Nuclear Forces:

- Classification of Nuclear Forces

- Meson theory of nuclear forces,
- Properties Of nuclear forces, properties of deuteron system,
- Elementary particles,

b) Nuclear Models:

- Quarks model for elementary particles
- Shell Model: Assumptions, Evidences, and Spin and Parity limitations.
- Liquid drop model: Assumptions
- Semi-empirical B.E. formula
- Problems:

Ref.(1) Ch.(9, 17, 18), Ref.(3) Ch.(18)

4: Nuclear Reactions and Reactor Theory: (09 L)

a) Introduction to Nuclear reactions:

- Nuclear Reaction, Conservation laws (Revision)
- The Q-value equation, Exothermic and Endothermic reaction
- Compound nucleus
- Threshold energy
- Nuclear cross-section
- Nuclear fission , nuclear fusion stellar energy, chain reaction and critical mass,

b) Reactor Theory:

- Nuclear reactor and its basic components, homogeneous and heterogeneous reactors, power reactor, fast breeders
- Nuclear Reactors In India (Discussion only)
- Problems.

Ref.(1) Ch.(14, 15), Ref.(3) Ch.(11, 13, 14)

Reference books:

1. Dr. S. N. Ghoshal, Nuclear Physics, Revised Edition, S. Chand Publication, 2014
2. D. C. Tayal, Nuclear Physics, Revised Enlarged Edition, Himalaya Publishing House.
3. K.S. Krane, Introductory Nuclear Physics, Wiley, India, 1988
4. B. L. Cohen, Concepts of Nuclear Physics, Tata McGraw Hill
5. I. Kaplan, Nuclear Physics, 2nd Edition, Narosa, New Delhi, 1989
6. S.B. Patel, Nuclear Physics: An Introduction, New Age International, 1991

T.Y.B.Sc. (Physics) (Sem-VI)
PHY-365 (A): Electronics-II

Lectures: 36 **(Credits-02)**

1: Semiconductor Devices: **(9L)**

a. LED and Photodiode, Optocoupler. (Working Principles) Problems. Ref. 1.
b. BJT: Transistor amplifier classifications - Class A, B, C and AB (working only), Differential amplifier (transistorized), Problems. Ref. 1.
c. Field Effect Transistor: JFET (Introduction, classification, principle, working and IV characteristics) MOSFETs (DE-MOSFET and E only MOSFET). Problems. Ref. 1

2: Applications of Semiconductor Devices: **(9L)**

a. Three Pin Regulators: Block diagram of 3-pin IC regulator, study of IC-78XX, 79XX. Dual Power Supply using IC-78XX, 79XX. Ref. 1
b. Switching Regulators (SMPS): Introduction, Block diagram, Advantages and Disadvantages. Ref. 4
c. Modulation and Demodulation : Concept of Carrier Wave, Need of Modulation and Demodulation, Methods of Modulation like AM, FM, PM (Concepts Only),
d. Concept of Modulation Index, Upper and Lower Side Band Frequencies in AM. Problems, Ref.3

3: Integrated Circuits: **(9L)**

a. Integrated Circuits: Introduction, Scale of Integration, Advantages and drawbacks of IC Ref.4
b. OP-AMP Applications as Integrator, Differentiator, Comparator. Ref. 1
c. Timer IC-555: Block diagram, Astable, monostable multivibrator (working and design). Problems, Ref. 1

4: Combinational and Sequential Circuits: **(9L)**

a. Combinational Circuits: Introduction to SOP and POS equation. Concept of Standard SOP and POS equation. Concept of K-map and their use in reduction of Boolean expressions, design of half adder, full adder, half subtract, Study of binary to gray and gray to binary code conversion. Problems. Ref. 2
b. Sequential Circuits: RS flip flop using NAND/NOR, clocked RS, D, JK and T-flip flops. Application of flip flops in Sequential Circuits as Counters and Registers. Asynchronous and Synchronous Counters. (3-bit Counter), Shift Registers and their types of operation -SISO, SIPO, PISO, PIPO (Concepts only). Ref. 2

Reference books:

1. Malvino, Electronic Principles (6th Ed.), Tata McGraw Hill, New Delhi
2. R. P. Jain, Modern Digital Electronics (3rd Ed.), Tata McGraw Hill, New Delhi
3. B. L. Theraja, Basic Electronics - Solid State, S. Chand and Company, New Delhi
4. K. R. Botkar, Integrated Circuits, Khanna Publishers, Delhi

T.Y.B.Sc. (Physics) (Sem-VI)
PHY-365 (B): Advanced Electronics

Lectures: 36 **(Credits-02)**

(Important Note: This course is designed for the student who has offered Electronics as one of the subjects at S.Y.B.Sc. level**)**

1: Sensors: **(9L)**

Introduction to Sensors: Revision of temperature measurement and Pressure Measurement.

Motion sensors: Types of motions, Accelerometers' principles, Types of accelerometers, applications.

Optical sensors:

Photo detectors, Photo detector characteristics, photoconductive detectors, photo voltaic detectors, Photodiode detectors, photo emissive detectors.

Pyrometry: Thermal radiation, Broadband pyrometers, Narrowband pyrometers.

Optical sources: Conventional light sources, Laser light sources and principles.

Applications: Label inspection, Turbidity, Ranging.

2: Analog Signal Conditioning: **(11L)**

Introduction to analog and digital signals: Analog Multiplexer and De-Multiplexer using Ic-4051, Ideal & Practical characteristics of Low Pass, High Pass, band pass and band reject filters. 2nd order active low pass and high pass filter using op-amp. Instrumentation amplifier using 3-OP-AMP, Application of Instrumentation Amplifier as thermocouple signal conditioning. Interpretation of integrator and differentiator as low pass and high pass filters respectively.

3: Digital signal conditioning: **(10L)**

Digital Multiplexer and De-Multiplexer using NAND gate, Priority encoder using Ic-74148, Decoders: 2 to 4 decoder and 3 to 8 Decoder.

Signal Converters:

DAC: R-2R ladder type DAC, Binary weighted DAC.

ADC: Single slope ADC, Successive Approximation ADC, Flash ADC.

Data Acquisition System using 3-channels

4: Introduction to Process Control: **(6L)**

Block diagram of Process control, Process control using ON-OFF controller, Op-amp and temperature sensor, Process control using Proportional Control Logic, Definition of Process LAG, and Problems.

Reference books:

1. C.D. Johnson, Process Control Instrumentation Technology, Pearson Education, 8th edition.
2. Krishna Kant, Computer Based Industrial Control, Eastern Economic Edition
3. Rangan, Mani, Sharma, Instrument of Device System
4. B. C. Nakra, K. K. Chaudhari, Instrument measurement and analysis

PHY-356: Elective-II

T.Y.B.Sc. (Physics) (Sem-VI)
PHY-366 Elective-II (O): Medical Electronics

Lectures: 36 **(Credits-02)**

1: Introduction: **(9L)**

1. 1 Terminology of medical instrumentation,
1.2 Physiological system of body
1.3 Sources of bioelectric signals,
1. 4 Origin of bioelectric signals,
1.5 Analysis of ECG pattern
1.6 Nernst equation
1.7 Various types of bioelectric signals,
1.8 Basic medical instrumentation system,
Problems
Ref: 1

2: Bio potential Electrodes and sensors: **(9L)**

2.1 Electrode-electrolyte interface,
2.2 Polarizable and non-polarizable electrodes,
2.3 Electrodes for ECG, EEG, EMG,
2.4 Resistive sensor
2.5 Capacitive sensor
2.6 Inductive sensor
2.7 Piezoelectric sensor
2.8 Temperature sensor
Problems
Ref: 2

3: Amplifiers and Signal Processing: **(9L)**

3.1 Introduction
3.2 Basic amplifier requirements
3.3 The Differential amplifier
3.4 Common mode rejection
3.5 Instrumentation amplifier
3.6 Isolation amplifier
3.7 Pateint safety
3.8 Cardiac monitor
Problems
Ref: 2

4: Measurements of Pressure and Volume Flow of Blood: **(9L)**

4.1 Direct measurements of blood pressure,
4.2 Indirect measurements of BP.
4.3 Heart sounds,

4.4 Phonocardiography,

5.4 Ultrasonic blood flow meter

5.5 Laser Doppler blood flow meter

Ref: 1

Reference books :

1. Handbook of Biomedical Instrumentation, R.S. Khandpur
2. Medical Instrumentation application design, John G Webster, Houghon Mifflin Co.
3. Clinical Biophysics, P. Narayanan
4. Introduction to biomedical equipment technology J. Carr and John M. Brown
5. Introduction to Biomedical Electronics, Joseph DfuBovy, Mc Graw Hill.

List of Experiments: (Any Two)

1. Measurement of BP using Mercury sphygmomanometer and digital BP monitor
2. Study of ECG machine. Gain, chart speed arrangements and positioning electrodes
3. Recording of ECG and its analysis.
4. Absorbance using calorimeter/ Absorption spectra using Spectrophotometer.
5. Pulse oximetry. Measurement of SpO2
6. Use of thermal scanner/Thermal gun
7. Study of glucometer as a sensor and measurement of BSL

T.Y.B.Sc. (Physics) (Sem-VI)
PHY-366 Elective-II (P): Physics of Nanomaterials

Lectures: 36 **(Credits-02)**

1: Introduction to nanomaterials: **(10 L)**

- Introduction to Nano-sized materials and Structures
- Significance of Nano-size
- Properties of Nanomaterials: Mechanical, Electrical, Thermal and Optical properties
- Classification of nanostructured materials

2: Methods for Synthesis of Nanomaterials: **(08 L)**

- Bottom-up and Top-down approaches
- Classification of Synthesis Techniques: Vapour phase and Liquid phase approach.
- Synthesis Methods: Thermal Evaporation, Sputter deposition, Colloidal method, Sol-gel Method, Chemical Vapour deposition and Electrochemical Deposition.

3: Characterization techniques: **(08 L)**

- Over view of structural characterization of nanomaterials by XRD
- Microstructural characterization and elemental analysis of nanomaterials using Scanning electron microscopy (SEM)and Energy Dispersive Spectroscopy (EDS)
- Structural characterization of nanomaterials using Transmission electron microscopy (TEM)
- Optical characterization of nanomaterials using UV- visible spectroscopy

4: Special nanomaterials: **(04 L)**

- Carbon nanotubes, their types and properties
- Quantum dots and their properties

5: Applications: **(06L)**

- Nanomaterials for application in Nano-electronics, Cosmetics, Medical, Biosensors Automobiles, Space, Sports, Cloth industry etc.
- Nanomaterials for environmental pollution monitoring and reduction etc.
- Nanomaterials for energy generation and storage

Reference books :

1. Nanotechnology: Principles and Practices by Sulbha Kulkarni, Capital Publishing Co. New Delhi.
2. Introduction to nanotechnology, by C. P. Poole Jr. and F. J. Ownes, Willey Publications.
3. Origin and development of nanotechnology by P. K. Sharma, Vista International publishing house.
4. Nanostructure and nanomaterials synthesis, Properties and applications, by G. Cao, Imperials College Press, London.
5. The chemistry of nanomaterials: Synthesis, properties and applications, C. N. R. Rao, A. Muller, A. K. Cheetham (Eds) Wiley VCH Verlag Gmbh& Co, Weinheim, 2004.

List of experiments: (Any Two)

1. Synthesis of metallic nanoparticles by wet chemical method.
2. Synthesis of Metal Oxide Nanoparticle using different techniques.
3. Synthesis of silver nanoparticles from silver nitrate by colloidal solution method.
4. Study of optical absorption of nanoparticles.
5. Determination of crystallite size from X-ray diffraction spectra.

T.Y.B.Sc. (Physics) (Sem-VI)
PHY-366 Elective-II (Q): Microcontrollers

Lectures: 36 **(Credits-02)**

1: 8051-Architecture: **[10L]**

1.1 Comparison of Microprocessor and Microcontroller,

1.2 Intel 8051 Microcontroller: Block Diagram and Functions of each block, Pinout details, A and B CPU registers, Program status word (PSW) register, Program Counter, Data Pointer, Stack and Stack Pointer.

1.3 Memory Organization of 8051, Internal RAM, Register Banks, Special function registers, Internal ROM, I/O Ports and their functions, Oscillator and Clock.

2: 8051-Assembly Language Programming: **[16L]**

2.1 Introduction to 8051 Assembly programming, 8051 data types and assembler directives, Different Addressing modes, Concept of Unsigned and Signed numbers.

2.2 Instruction Set of 8051 microcontroller: Data Transfer instructions, Arithmetic Instructions, Logic and compare instructions, rotate instructions, Branch (Jump, Call RET) instructions.

2.3 Use of Instruction Set in Assembly Language Programming.

3: 8051-Interrupts, Timers/Counters and Serial Communication: **[10L]**

3.1 Interrupts and their vector structure, IE register, Interrupt priority in the 8051

3.2 Timers and Counters: Use of Basic Registers in Programming 8051 timers, Timer/ Counter Operation modes. Problems on Timer clock frequency and its Period.

3.3 Basics of Serial Data Communication, Types of Serial Data Communication, Concept of Baud Rate, RS 232 Standards, 8051 connection to RS 232, Functions of SBUF and SCON Registers.

Reference Books:

1. 8051 Microcontroller by Kenneth J. Ayala.
2. 8051 Microcontroller and Embedded Systems using Assembly and C by Mazidi and D Mac Kinlay, 2006 Pearson Education Low Price Edition.
3. 8051 Microcontroller – Hardware, Software and Applications by V Udayashankara, M S Mallikarjunaswamy, McGraw Hill Education (India) Pvt.Ltd, New Delhi.
4. Microprocessor and Microcontroller by R. Theagarajan, Sci Tech Publication, Chennai
5. Programming customizing the 8051 Microcontroller by Myke Predko, Tata McGraw Hill

List of Experiments: (Any Two)

Use Keil / Pinacle software for:

1. Addition of two 16 bit numbers
2. Multiplication of two 8 bit numbers.
3. Write a program to find largest/smallest number of N numbers in given block.
4. Memory block transfer from one location to another.
5. Find one's and two's complement of given number.
6. Subtraction two 8 bit numbers using two's complement method.

T.Y.B.Sc. (Physics) (Sem-VI)
PHY-366 Elective-II (R): Lasers

Lectures: 36 **(Credits-02)**

1: Introduction to Lasers: **(8 L)**

Brief history of Lasers, Interaction of radiation with matter, Energy levels, Population density, Boltzmann distribution, Stimulated Absorption, Spontaneous Emission and Stimulated Emission, Einstein's Coefficients, Einstein's relations.

Characteristics of Laser: Directionality, Mono-chromaticity, Coherence,

2: Laser Action: **(6 L)**

Population inversion, Condition for light amplification, Gain coefficient, Active medium, metastable states.

Pumping schemes: three level and four level

3: Laser Oscillator: **(6 L)**

Optical feedback, round trip gain, critical population inversion, Optical resonator, condition for steady state oscillations, cavity resonance frequencies.

4: Laser Output: **(3 L)**

Line-shape broadening: Lifetime broadening, Collision broadening

5: Types of Lasers: **(7 L)**

Solid State Lasers – Ruby Laser, Diode Laser, Gas Lasers – HeNe Laser, CO_2 Laser

6: Applications of Lasers: **(6 L)**

Industrial: welding, cutting, drilling

Nuclear Science: laser isotope separation, laser fusion,

Medical: eye surgery

Reference books:

1. An introduction to Lasers - Theory and applications, M.N. Avadhanulu, S. Chand and Co. New Delhi
2. Experiments with He-Ne Laser by Sirohi
3. Optical fibre and Laser - Principle and applications, Anuradha De, New Age International Publishers,

List of Experiments: (Any Two)

1. Determination of wavelength of He-Ne Laser by transmission grating
2. Determination of Angle of prism (Pin and drawing paper)
3. Study of Lissajous figures using diode Laser and mirrors
4. Beam divergence of a Diode Laser.
5. Determination of the diameter of a thin wire using a laser.
6. Measurement of wavelength of Laser beam using Michelson Interferometer.
7. To study the interference of light using optical fibers
8. Measurement of the focal length of a given convex lens using a laser.

T.Y.B.Sc. (Physics) (Sem-VI)

PHY-366 Elective-II (S): Astronomy and Astrophysics-II

Lectures: 36 **(Credits-02)**

1: Astronomical Scales: **(10 L)**

Measurement of Astronomical Quantities, Astronomical Distances, Stellar Radii, Masses of Stars, Stellar Temperature, Measurement of Time, Sidereal Time, Apparent Solar Time, Mean Solar Time, Equation of Time, Astronomical Coordinate system (only introduction)

2: The Milky Way and Universe: **(8 L)**

Basic Structure and Properties of the Milky Way, Active Galaxies, Quasars and Radio Galaxies, Hubble's law with equation, its significance, Concept of space time, fate of our universe, Multiverse (only introduction)

3: The Stellar Phenomenon: **(10 L)**

Basic Composition of Interstellar Medium, Sun: Solar Cycle, Activity, Butterfly diagram, Photospheric phenomenon, Stars as distance estimators, Hydrostatic Equilibrium of a Star, Stellar models (only introduction).

4: Non-optical Astronomy: **(8 L)**

Basic parameters of an antenna, various types of antennas. UV, IR, X-ray and Gamma ray Telescopes, Detectors for optical and infrared regions. Orbiting space based telescopes: HST, Chandra.

List of Reference Books:

1. Astronomy structure of the Universe, A. E. Roy and D. Clarke, Adam Hilger Pub.
2. Source Book of Space Sciences, Samuel Galsstone; D.Van Nostrand Co. Inc
3. Astrophysics - Stars and Galaxies, K.D. Abhyankar, Tata McGraw Hill Pub.
4. Textbook of Astronomy and Astrophysics with elements of cosmology, V.B. Bhatia, Narosa Pub.
5. Structure of the Universe, J.V. Narlikar
6. Astrophysics, Baidyanath Basu.
7. Astrophysical Techniques, third Edition, C. R. Kitchin
8. Fundamentals of Astronomy, Michael Seed
9. Telescopes and techniques, C. R. Kitchin (Springer)

List of experiments: (Any Two)

1. To determine the temperature of an artificial star.
2. To observe the Fraunhofer lines in sunlight and determine the elements present.
3. To obtain the solar image on the screen and trace out the existing sunspots.
4. To locate and observe the various stars, constellation, planets. (At least 2 observation of each)
5. To polar Align an astronomical telescope.
6. To study the solar limb darkening effect.

T.Y.B.Sc. (Physics) (Sem-VI)

PHY-366 Elective-II (T): Renewable Energy Sources-II

Lectures: 36 **(Credits-02)**

1: Bioenergy and Biofuels: **(10L)**

Bioenergy:

1. Introduction to Bioenergy
2. Basic Routs: Biochemical, Thermochemical, Transesterification
3. Biochemical- Biogas generation/methanation
4. Biogas plant: Floating gas holder and fixed dome type biogas plant, construction and working
5. Factors affecting on bio-digestion (list of factors).
6. Thermochemical: Pyrolysis, Gasification, Carbonization
7. Transesterification:
8. Comparative study of floating gas holder and fixed dome type biogas plant.
9. Working of downdraft gasifier.
10. Various methods to obtain energy from biomass.

Biofuel:

1. Introduction to Biofuels
2. Production of Biofuels (Jatropa and Sugar cane bagasse)

Ref 1: 7.1, 7.2, 7.2.1, 7.2.2, 7.4, 7.5, 7.6, 7.7, 7.8, 7.11, 7.23, 7.24.1

Ref 2: 10.3 (page no 374 to 380)

2: Wind Energy **(08L)**

1. Introduction to wind energy.
2. Principles and components of wind energy conversion system.
3. Classification of wind machines: Horizontal axial machine and vertical axial machine.
4. Advantages and disadvantages of wind energy.
5. Wind data

Ref -1: 6.1, 6.2, 6.3, 6.5, 6.7, 6.8

3: Other Energy Sources: **(08L)**

1. Introduction to tidal and geothermal energy.
2. Tidal energy: methods of utilization of tidal energy.
3. Advantages and disadvantages of tidal power generation.
4. Geothermal energy: Geothermal sources and energy conversion.
5. Advantages and disadvantages of geothermal energy.
6. Introduction to Thermocell

Ref -1 (9.3), pages from 510-532),

Ref -1 (8), pages from 443, 470-476, 477) Ref -1 (11), pages from 609-657)

4: Energy Management: **(10L)**

1. Introduction to Energy Management (Definition, Principles etc)
2. Need of Energy Saving and Management
3. Different strategies of Energy Management
4. Role of Energy Managers and Auditors,

5. Energy Audit Measurements and Instruments, and Preparation of Energy Audit Report (in brief).
6. Case studies of Energy Audit & Management (e.g. Industries & Green Buildings, Boilers, Furnaces, Refrigeration and Air conditioning, Cogeneration, Waste Heat recovery, Electric motors, Pumping systems, Fans and blowers, Cooling Towers,
   Industrial/Commercial Lighting system, BEE Star rated equipment) any one.

Ref- 4 to 12 - Use any book for reference

Reference books:

1. Non-conventional Energy Sources, G. D. RAI (4th edition), Khanna Publishers, Delhi.
2. Solar Energy, S.P. Sukhatme (second edition), Tata Mc Graw Hill Ltd, New Delhi.
3. Solar Energy Utilisation**,** G. D. RAI (5th edition), Khanna Publishers, Delhi.
4. Energy Management: W.R.Murphy, G.Mckay (Butterworths).
5. Energy Management Principles: C.B.Smith (Pergamon Press).
6. Efficient Use of Energy: I.G.C.Dryden (Butterworth Scientific)
7. Energy Economics -A.V.Desai (Wieley Eastern)
8. Industrial Energy Conservation: D.A. Reay (Pergammon Press)
9. Energy Management Handbook – W.C. Turner (John Wiley and Sons, A Wiley Inter science publication)
10. Industrial Energy Management and Utilisation –L.C. Witte, P.S. Schmidt, D.R. Brown (Hemisphere Publication, Washington)
11. Hand book of Energy Audit by Sonal Desai (Publisher Tata McGraw Hill.)
12. Energy Management and Conservation Handbook, Frank Kreith and Yogi Goswami, (CRC Press)

List of Experiments: (Any Two)

1. Fuel value of wood/charcoal.
2. Study of sensible heat storage using liquid.
3. Selective and Non-selective coatings – Determination of Selectivity ratio.
4. To do energy audit of home/society/college/industry and prepare a detail audit report.
5. Study and analysis of home Electricity Bill
6. Study of Power consumption of conventional tube light vs LED fitting

T.Y.B.Sc. (Physics) (Sem-VI)
PHY-367: Physics Laboratory-4A

Lectures: 36 **(Credits-02)**

(General Physics, Thermodynamics and Statistical Physics, Nuclear Physics and Quantum Mechanics)

(Any Eight)

GROUP-I: GENERAL PHYSICS (any FOUR)

1. Surface Tension of Mercury by method of Ripples.
2. Viscosity of Liquid by rotating cylinder method.
3. Coefficient of sound absorption
4. 'Y' by Cornu's Method
5. Hall Effect: To measure the Hall coefficient
6. Energy gap of a semiconductor
7. Study of XRD spectrum of any material.
8. Resistivity by Four probe method
9. Platinum resistance thermometer

GROUP-II: THERMODYNAMICS AND STATISTICAL PHYSICS (any TWO)

1. Determination of pressure coefficient of air by constant volume thermometer.
2. Verification of Stefan's fourth power law by bulb filament
3. Thermal conductivity by Forbes Method.
4. Thermal conductivity of rubber tube.
5. Thermal diffusivity of Brass.
6. Thermal and Electrical conductivity of Cu.

GROUP-III: NUCLEAR PHYSICS AND QUANTUM MECHANICS (any TWO)

1. Characteristics of G.M. tube
2. Inverse square law (γ-rays)
3. e/m by Thomson method
4. Determination of Planck's constant
5. Study of Gaussian distribution by G. M. tube.

Additional Activities (Any ONE)

- Demonstrations: Any 2 demonstrations equivalent to 2 experiments
- Study tour with report equivalent to 2 experiments
- Mini project equivalent to 2 experiments
- Computer aided demonstrations (simulations or animations)
  (Any 2 demonstrations equivalent to 2 experiments)

Note: *Students have to perform* ***ten*** *experiments or* ***one*** *additional activities in addition to* ***eight*** *experiments mentioned above. Total laboratory work with additional activities should be equivalent to* ***ten*** *experiments.*

T.Y.B.Sc. (Physics) (Sem-VI)
PHY-368: Physics Laboratory-4B

Lectures: 36 **(Credits-02)**

(Electronics (Essential) or Advanced Electronics, acoustics and Lasers, Optional Courses)

(Any Eight)

GROUP-I: ELECTRONICS (ESSENTIAL) (any TWO)

(For the students not offering advance electronics in theory courses)

1. Characteristics of JFET
2. Design and built astable multivibrator using IC 555/IC 741
3. Half adder /Full adder
4. Integrator and differentiator using IC 741
5. IC 723 as regulated power supply

GROUP-I: ADVANCED ELECTRONICS (any TWO)

(For the students offering advance electronics in theory courses)

1. Instrumental amplifier using three op-amps
2. Temperature controller using PT 100 / thermocouple /thermistor temperature sensors
3. Object counter (two digit)
4. Schmitt trigger
5. Study of LVDT

GROUP-II: ACOUSTICS AND LASERS (any FOUR)

1. Frequency response of loudspeaker (twitter, woofer, mid-range)
2. Study of interference by Quinck's method
3. Use of Ultrasonic interferometer to measure velocity of sound in liquids
4. Transmission loss using expansion chamber muffler.
5. Study of diffraction using a transmission/reflection grating (metal ruler)
6. Study of the characteristics of a laser beam.
7. Determination of the diameter of a thin wire using a laser beam.
8. 'μ' By total internal reflection of light

GROUP-III: PRACTICAL FROM OPTIONAL COURSE (Any-2)

Additional Activities (Any ONE)

- Demonstrations: Any 2 demonstrations equivalent to 2 experiments
- Study tour with report equivalent to 2 experiments
- Mini project equivalent to 2 experiments
- Computer aided demonstrations (simulations or animations)
  (Any 2 demonstrations equivalent to 2 experiments)

Note: *Students have to perform* ***ten*** *experiments or* ***one*** *additional activities in addition to* ***eight*** *experiments mentioned above. Total laboratory work with additional activities should be equivalent to* ***ten*** *experiments.*

T.Y.B.Sc. (Physics) (Sem-VI)
PHY-369: Physics Project-II

Lectures: 36 **(Credits-02)**

Guidelines:

It is expected that,

1. The student does work equivalent to about 10 laboratory experiments throughout the semesters in the third year.
2. One bears in mind that the project work is a practical course and it is intended to develop a set of skills pertaining to the laboratory work apart from the cognition of students. Therefore, the guides should not permit projects that involve no contribution on part of student.
3. The project must have a clear and strong link with the principles of basic physics and/or their applications.
4. The theme chosen should be such that it promotes better understanding of physics concepts and brings out the creativity in the students.
5. The evaluation of the project work must give due credit to the amount of the project work actually done by a student, skills shown by the student, understanding of the physics concepts involved and the presentation of the final report at the time of viva voce.
6. The viva voce should be conducted at the time of evaluation of project work at least for twenty minutes per student. Extra care must be taken in the evaluation of projects done in a pair or group. Delegation of the work done by individuals must be sought from the students in such cases.
7. Any ready-made material used in the report (such as downloaded pages from the web) must be clearly referred to and acknowledged.
8. It is also recommended that a teacher will look after 4 projects at one time.
9. Any non-adherence to this norm should attract a penalty by way of deduction in the marks awarded to a student. It is recommended that the College will provide consumables/contingencies for every project, to the tune of Rs. 750 /- each. (*If the students paid extra fee other than laboratory fee then college will provide financial assistance for the Project work.)

The Project work shall consist of the following Criterions.

1) Working model (Experimental or Concept based simulation/Demonstration Related to Physics).
2) Understanding of the project.
3) Experimental Details.
4) Data collection and Data Analysis.
5) Innovation.
6) Outcomes/Result.
7) Conclusion.

Note: At the time of project practical examination, the candidate must submit the certified project report by the project in-charge and HOD. A candidate will be allowed to appear for the Project practical examination only if the candidate submits a project completion report duly certified by the project in-charge and Head of the department.

The Project work shall include:

Models based / Demonstrated Applications / Review articles / Simulation on PC on any concept in Physics / Comparative & differentiative study / Improvement in the existing experiment (Design and fabrication concept) / Extension of any regular experiments / Attempt to make experiment open-ended / Thorough survey of existing active components / devices, ICs, methods, means, technologies, generations, applications etc. / any innovative projects using the concept of Physics / Interdisciplinary areas.

Evaluation weightage:

- Semester End University Examination : 35 Marks
- Internal Examination: 15 Marks

Skill Enhancement Courses

Skill Enhancement Courses (SEC)

a) Selection of Skill enhancement courses

There are two skill enhancement courses (SEC) in 6th semester (PHY-3610 and PHY-3611). For 6th semester, there are four options available. The college has to select any one from the given four options. It is advised that college should not offer elective and skill enhancement course of same theme.

b) Teaching Learning process for Skill Enhancement Courses

Skill base courses are intended to explore the applications of physics knowledge. Learning in skill enhancement courses is largely experience based. The skill enhancement courses may be categorized as knowledge skill or technical skill. For knowledge skill courses one can use the conventional method for teaching along with problem solving, assignments seminars etc. For acquiring the technical skill, the students will get adequate 'hands-on' experience. The teachers may use demonstrations and activity-based learning techniques. On field visits, study tour and mini projects will enrich the learning experience of the students.

c) Assessment methods for skill enhancement courses

Continuous evaluation will be the best method for assessment of skill enhancement courses.

One can use tools like assignments, mini projects or activities, problems, etc and grade the students according to their performance. The internal assessment should have 50 % weightage.

The University examination may be conducted for the remaining 50%.

The University examination question paper should have adequate proportion of objective and subjective question.

d) List of Skill Enhancement Courses:

Semester-VIth	**Semester-VIth**
PHY-3610	**PHY-3611**
PHY-3610(U): Scientific Data Analysis using Python	PHY-3611(Y): Microcontrollers
PHY-3610(V): Solar PV System: Installation, Repairing and Maintenance	PHY-3611(Z): Instrumentation for Agriculture
PHY-3610(W): Applications of Internet of things (IOT)	PHY-3611(AA): Radiation Physics
PHY-3610(X): Calibration Techniques	PHY-3611(AB): Photography

T.Y.B.Sc. (Physics) (Sem-VI)

PHY-3610 SEC (U): Scientific Data Analysis using Python

Lectures: 36 **(Credits-02)**

Pre-requisite	: Basic knowledge of computer programming (Python/c)
Mode of internal Assessment	: A small project analysing scientific data for visualization
Data sets may include	: Pollution Data, Rain data, Astronomical data, any scientific data Related to Physics or science in general
Sources of Data sets	: MERI, Nashik, AIUCAA Pune, NASA or similar 1. Website for competition: https://www.kaggle.com/ 2. Google dataset: https://datasetsearch.research.google.com/ 3. Data for visualization and dataset resources: https://dev.to/aspittel/my-favorite-data-visualization-and-dataset-resources-35kp Other potentially useful searches: 1. https://bigdata-madesimple.com/70-amazing-and-free-data-sources-for-data-visualization/ 2. https://eduinpro.com/blog/data-sets-for-data-visualization-projects-datascience/

Learn how to analyses data using Python. This course will take you from the basics of Python to exploring many different types of data. You will learn how to prepare data for analysis, perform simple statistical analyses, create meaningful data visualizations, predict future trends from data, and more

Student will learn how to:

- Import data sets, access different elements of data frames.
- Understand the functions available in existing Python modules.
- Understand the utility of functions available in NumPy and Pandas library.
- Clean and prepare data for analysis
- Manipulate pandas Data Frame
- Understand awareness with different types of basic charts and functions in matplotlib library
- Get exposure to visualization techniques from seaborn library
- Build data pipelines

  Data Analysis with Python is delivered through lecture, hands-on labs, and assignments. It includes following parts:
- Data Analysis libraries: will learn to use Pandas Data Frames, Numpy multi-dimensional arrays, and SciPy libraries to work with a various datasets. We will introduce you to pandas, an open-source library, and we will use it to load, manipulate, analyze, and visualize cool datasets. Then we will introduce you to another open-source library, scikit-learn, and we will use some of its machine learning algorithms to build smart models and make cool predictions.

Outcome of the course

- Know basic notions and definitions in data analysis.
- Know standard methods of data analysis and information retrieval.
- Be able to formulate the problem of knowledge extraction as combinations of data filtration, analysis and exploration methods.
- Be able to translate a real-world problem into mathematical terms.

Syllabus:

Unit No.	Topics	Lectures
I	**Data Structures, modules and Importing Datasets** Lists: Creating list, accessing list elements, functions for lists, programming with lists Tuples: Creating Tuples, accessing list elements, functions for Tuples, programming with Tuples Dictionary: Creating Dictionary, accessing list elements, functions for Dictionary, programming with Dictionary. In Built modules : Math module, random Module, Array module, string Module etc	6
II	**Core libraries in Python** NumPy Library for Arrays Pandas Library for Data Processing Basics of data frames, create, adding/ deleting of rows, columns to data frames Import of data, functions of data frames Data Normalization Sets, data extraction using relational, logical operators. Group by functionality, missing values	6
III	**Summarizing the Data Frame and visualization** Matplotlib Library for visualization: Pie chart, violin plot, scatter plot, histogram, bar chart, area plot. Seaborn Library for Visualization: Box plot, point plot, line plot, count plot, bar plot, strip plot, scatter plot and Regression Plot	6

Activity: Hands on data Analysis and Visualization with Pandas [18L]

Note: For Internal assessment students will either do **any-6 activities** related to data analysis and visualization on particular dataset or will carry out small project on analysis or visualization using science (preferably physics) related dataset.

Reference Books:

- Python Programming: Using Problem Solving Approach - Reema Thareja.
- Let us Python - Aditya Kanetkar
- Learning with Pythob - Allen Downey
- Data Analytics - Bharti Motwani

T.Y.B.Sc. (Physics) (Sem-VI)

PHY-3610 SEC (V): Solar PV System: Installation, Repairing and Maintenance

Lectures: 36 **(Credits-02)**

Objectives:

1. In this skill oriented course, student will study basics of solar photovoltaic (PV) cells, modules, and system components.
2. Design and sizing of off-grid PV system for homes, apartments as well as commercial offices.
3. Understanding energy conversion from sunlight to electricity, and working with solar conversion equipment.
4. This Course will hands on experience needed to become self-employed.

Outcomes:

1. Learn basics of light conversion in electricity.
2. Hands on training will motivate to use Solar PV system.
3. Become entrepreneur / self-employed.
4. Analyzed of MSEB electricity bill and design and sizing of off-grid PV system
5. Participants will learn about solar PV module and batteries used in solar PV plant.

Syllabus:

Unit-1: Introduction **(6L)**

The Sun, Earth, and Renewable Energy, Photovoltaic Effect, Working of Solar cell, Types of solar cell, PV Modules and Arrays, Module Parameters, Sunshine and Shadow, tracking mechanism, aligning the Array.

Unit-2: Solar Radiations and Measurement **(6L)**

Introduction, Solar constant, Solar radiation at the earth surface, Need of solar radiation measurement, Instruments for the measurement of solar Radiation, Pyrheliometer, Pyranometer, Sunshine Recorder, Sun Meter or Lux Meter

Unit-3: Basics Solar PV Systems **(6L)**

Basics types of PV Systems on grid and off grid, DC to AC conversion, Building-integrated Photovoltaics, Engineering and Architecture, Balancing of PV system. System Components, Batteries, Charge controllers, Inverters, Hybrid systems, System sizing, Applications of off grid PV System.

Activity: any-6 **(18L)**

1. Estimate the value of the Solar Constant.
2. Study of intensity variation on the performance of PV module.
3. Study of series and parallel combination of the PV modules.
4. Measurement of Solar radiation measurement using Sunmeter and Pyranometer.
5. Analysis of MSEB electricity bill.
6. Energy Farm/PV Plant visit report.
7. Study of intensity variation using Sun Meter or Lux Meter.
8. Study of I-V characteristics and working of solar cell.
9. Study of different types of solar cell.
10. Study of Hybrid systems.

Reference books:

1. Solar Energy, S.P. Sukhatme (second edition), Tata Mc.Graw Hill Ltd, New Delhi.
2. Solar Energy Utilisation, G. D. RAI (5th edition), Khanna Publishers,Delhi.
3. Electricity from Sunlight, An Introduction to Photovoltaics, Paul A. Lynn, John Wiley & Sons, Ltd.
4. Solar Electricity, 2nd edition, T. Markvart, John Wiley & Sons, Ltd.
5. Solar Photovoltaic Basics, White Sean, Taylor & Francis Ltd.

T.Y.B.Sc. (Physics) (Sem-VI)

PHY-3610 SEC (W): Applications of Internet of Things (IOT)

Lectures: 36 **(Credits-02)**

Objectives:

- To introduce the terminology, technology and its applications
- To introduce the concept of M2M (machine to machine) with necessary protocols
- To introduce the C# Language which is used in many IoT devices
- To introduce the Raspberry PI platform, that is widely used in IoT applications
- To introduce the implementation of web based services on IoT devices

Learning Outcomes :

a) IOT concepts
b) IOT Standards
c) Components of IOT System.
d) Relevance of IOT for the future.
e) IOT Applications.
f) IOT for smart cities (Case study Smart city Barcelona)
g) IOT in Indian Scenario
h) Challenges in IOT implementation.

This subject does not have the intention of being a comprehensive course about the technologies involved in IOT. The focus will be more on the possibilities offered by the different technologies, and on the creative thinking techniques to find innovative applications of combinations of such technologies in real-life scenarios. Some presentations will also be scheduled in which people from industry will make presentations about selected topics related to the IoT. The Internet of Things (IoT) is a course about the new paradigm of objects interacting with people, with information systems, and with other objects. The course will focus on creative thinking and on hands-on project development. The duration of the course is 30 hours. Will be a mix of 75 minutes session and 2 hours session. Lab will be for 5 hours.

Future Scope:

It is a system of interrelated computing devices, digital machines, objects, animals or people that are provided with unique identifiers and the ability to transfer data over a network without requiring human-to-human or human-to-computer interaction. Internet of Things

What Internet of Things can do?

3. Medical Check-up Health Devices Operational Efficiency Medical Report Health Sector
4. Advanced Kitchen Automatic Parking Remote Home Control Security System Smart Home
5. Wi-Fi Connectivity Traffic Control Security System Advanced Parking System Smart City
6. Advanced Power Supply Manufacturing Bill Payment Planning Industrial Automation
7. Let's Take an Example of Internet of Things

● Renewal Energy Source. ● Automatic wearing suit. ● Next Gen way to fly. ● Speech Recognition. ● Perfect example of AI. ● Advanced GPS.

Syllabus:

Unit-1: Introduction to Internet of Things **[4L]**

Definition and Characteristics of IoT, Physical Design of IoT – IoT Protocols, IoT communication models, IoT Communication APIs IoT enabled Technologies – Wireless Sensor Networks, Cloud Computing, Big data analytics, Communication protocols,

Unit-2: IOT Concepts and introduction **[5L]**

Technologies that led to evolution of IOT, IOT and SCADA, IOT and M2M, IOT and Big Data Requirement of international standard (case study), IOT standards in practice, Operating platforms /systems

Unit-3: IOT Applications (case study)**.** **[4L]**

Lighting as a service, Intelligent Traffic systems, Smart Parking, Smart water management, IOT in Indian Scenario

Unit-4: Introduction to C# **[5L]**

Language features, commands, functions of C#, Data types, data structures, Control of flow, functions, modules, Packaging, file handling, data/time operations, classes, Exception handling.

Activity: Any -6 (each case study will be 3-hrs) **[18 L]**

1) Lighting as a service (case study)
2) Intelligent Traffic systems (case study)
3) Smart Parking (case study)
4) Smart water management (case study)
5) IoT for smart cities (Case study-Smart city Barcelona)
6) Requirement of international standard (case study)
7) Study different functions of C#
8) Study how to control of flow of C# program
9) Study different data types of C#
10) Study various commands used in C#

Reference books:

1. Internet of Things – A Hands-on Approach, Arshdeep Bahga and Vijay Madisetti, Universities Press, 2015, ISBN: 9788173719547
2. Getting Started with Raspberry Pi, Matt Richardson & Shawn Wallace, O'Reilly (SPD), 2014, ISBN: 9789350239759
3. The Internet of Things: How Smart TVs, Smart Cars, Smart Homes, and Smart Cities Are Changing the World Paperback – 26 March 2015 by Michael Miller.

T.Y.B.Sc. (Physics) (Sem-VI)
PHY-3610 SEC (X): Calibration Techniques

Lectures: 36 **(Credits-02)**

Objective:

- To make students familiar with the constructions and working principle of different types of Instruments
- To make students aware about the measuring instruments and Calibration of Instrument

Course Outcomes: At the end of the course, a student will be able to:

- Calibrate hydraulic, pneumatic and mechanical measuring and control equipment: setting, adjustment, validation or verification of mechanical, pneumatic, hydraulic, measuring and control instruments using reference standards in accordance with predetermined procedures.
- Calibrate electrical and electronic measuring and control equipment: setting, adjustment, validation or verification of electrical, electronic measuring and control instruments using reference standards in accordance with predetermined procedures.
- Carryout maintenance activities on instrumentation and control panel.

Syllabus:

Unit-1: Principles of Calibration [4 L]

1. Introduction and Importance of Calibration
2. Traceability in Calibration
3. Calibration Uncertainty
4. Various Calibration Methods
5. Factors Affect Calibration
6. Instrument Classification and Instrument Identification

Unit-2: Pressure Calibration [6L]

1. Introduction to pressure calibration
2. Pressure unit conversion standards
3. Types of Pressure Gauges
4. Calibration of Pressure Gauges
   a. Accuracy
   b. Pressure Media
   c. Contamination
   d. Height Difference
   e. Leak test of Piping
   f. Adiabatic Effect
   g. Torque Force
   h. Calibration Position
   i. Generating Pressure
   j. Pressurizing the Gauge
   k. Reading the Pressure Value
   l. Number of Calibration Points
   m. Hysteresis (deviation of calibration points)
   n. Number of Calibration cycles
5. Instruments required for calibration:
   a. Pressure comparator
   b. Master Gauge
6. Pressure Calibration with Example

Unit-3: Calibration of Electronic Instruments [4L]

1. Identification of Components
2. Equipment required for calibration
3. Procedure of Calibration
   a. Read operational Specifications
   b. Sequence of events
   c. Identification of common Faults
4. Electronic Calibration with Examples (Oscilloscopes, Multimeters, Function Generators, Signal Generators)

Unit-4: Temperature Calibration [4L]

1. Temperature units and Conversions
2. Temperature Sensors
3. Calibration of temperature sensors
   a. Handling temperature sensor
   b. Preparations
   c. Temperature sources
   d. Reference Temperature Sensor
   e. Immersion Depth
   f. Stabilization
   g. Temperature sensor handle
   h. Calibrated temperature range
   i. Calibration Points
   j. Adjusting/trimming a temperature sensor
4. Examples:

Activity: any-6 **[18L]**

Calibration of a dial thermometer

1) RTD calibration check
2) Temperature controller loop
3) Calibration of pressure Transmitters
4) Calibration of pressure switch
5) Level calibration Instrument
6) Liquid head measurement
7) Calibrating a differential pressure level transmitter
8) Calibration of top pan balance
9) Calibration of digital balance
10) Calibration of PH/Conductivity meter
11) Calibration of Volt meter
12) Calibration of Current meter
13) Calibration of Oscilloscopes
14) Calibration of Function Generators

Reference Books :

1) **Calibration:** A Technician's Guide - Mike Cable
2) Measurement and Control Basics -Thomas A. Hughes
3) Measurement and Control of Liquid Level - Chun H. Cho
4) A Practical Book On Calibration Of Analytical Instruments - Dr S Jain ,
5) Calibration Handbook of Measuring Instruments - Alessandro Brunelli

T.Y.B.Sc. (Physics) (Sem-VI)
PHY-3611 SEC (Y): Microcontroller

Lectures: 36 **(Credits-02)**

Objective:

- To make students familiar with the constructions and working principle of microprocessor
- To make students aware about microprocessor

Outcome: After successful completion of this course students are supposed to develop their own applications/ mini/ tiny projects using microcontroller.

Syllabus:

Unit-1. ARCHITECTURE OF 8051: **[05]**

Microprocessor and Microcontrollers a short comparison, Overview of the 8051 family, Block diagram of Microcontroller, Functions of each block, Pin details of 8051, A and B CPU registers, Flags and Program status word (PSW), Program Counter (PC) and Data Pointer register (DPTR), Internal RAM, Stack and Stack Pointer, Special function registers, Memory Organization of 8051, Internal ROM, I/O Ports, Oscillator and Clock

Unit-2. 8051 ASSEMBLY LANGUAGE PROGRAMMING: **[05]**

Introduction to 8051 Assembly programming, Assembling and running an 8051 program, 8051 data types and directives, Jump, loop, and call instructions, 8051 I/O programming, Addressing modes, arithmetic and logical instructions and programs, Signed number concepts and arithmetic operations, Logic and compare instructions, Rotate instructions, BCD, ASCII, and other application programs.

Unit-3. TIMERS/ COUNTERS AND INTERRUPT PROGRAMMING: **[04]**

Timers of 8051, TMOD and TCON registers, Programming timers 0 and 1 in 8051, counter programming**,** 8051 interrupts, Interrupt priority in the 8051, and Application programs using interrupts.

Unit-4. INTERFACING TECHNIQUES **[04]**

Key/ keyboard (push button) interfacing, interfacing a LCD display, interfacing an ADC and LM35 temperature sensor.

Activity: any-6 **[18L]**

1. Addition of two 16 bit numbers using of Kiel/ Pinnacle
2. Multiplication of two 8 bit numbers using of Kiel/ Pinnacle
3. Write a program to find largest/smallest number of N numbers in given block using of Kiel/ Pinnacle
4. Memory block transfer from one location to another using of Kiel/ Pinnacle
5. Find one's and two's complement of given number using of Kiel/ Pinnacle
6. Subtraction two 8 bit numbers using two's complement method using of Kiel/ Pinnacle
7. To run basic programs using IDE/Software
8. Single key / Keyboard Interfacing.
9. ADC/DAC Interfacing.
10. Mini Project (Water level controller, Electronic Thermometer etc.)

Reference Books:

1. 8051 Microcontroller by Kenneth J. Ayala.
2. 8051 Microcontroller and Embedded Systems using Assembly and C - Mazidi, Mazidi and D MacKinlay, 2006 Pearson Education Low Price Edition.
3. Microprocessor and Microcontroller by R.

T.Y.B.Sc. (Physics) (Sem-VI)
PHY-3611 SEC (Z): Instrumentation for Agriculture

Lectures: 36 **(Credits-02)**

Objectives:

After completion of this course students can

1. Get knowledge of sensors used in agriculture field
2. Learn continuous and batch process
3. Learn greenhouse automation schemes
4. Learn Instrumentation in Irrigation

Course Outcomes:

After completion of this course student will

1. Able to test soil and water parameters.
2. Able to develop their own juice extract plant.
3. Able to developed their own green house

Syllabus:

Unit-1: Introduction **[02L]**

Necessity of instrumentation and control for agriculture, sensor requirement, remote sensing, bio sensors in agriculture.

Unit-2: Soil Properties & Sensing **[04L]**

Properties of soil: fundamentals definitions and relationship, index properties of soil, permeability & seepage analysis, shear strength, Mohr's circle of stress, active & passive earth pressures, stability & slopes,

Sensors: introduction to sonic anemometers, hygrometers, fine wire thermocouples, open & close path gas analyzers

Unit-3: Instrumentation in Continuous & Batch process **[04L]**

Flow diagram of sugar plant, sensors & instrumentation setup, Flow diagram of fermenter & control (batch process), flow diagram of dairy industry & instrumentation setup for it, Juice extraction control process & instrumentation setup.

Unit-4: Instrumentation in Irrigation **[04L]**

Water distribution and management control, Auto drip and sprinkler irrigation system, upstream & downstream control concept, SCADA for DAM parameters &control.

Unit-5: Greenhouse Parameters & Instrumentation **[04L]**

Greenhouse effect, Concept and construction of greenhouse, merits & demerits, ventilation, cooling & heating, wind speed, temperature & humidity, soil moisture, rain gauge, carbon dioxide enrichment measurement & control, Leaf area length *evapotranspiration*, temperature, wetness & respiration measurement & data logging, electromagnetic radiations photosynthesis.

Activity : any-6 **[18L]**

1) Measurement of water holding capacity of soil.
2) Measurement of soil texture.
3) Measurement of moisture contain in soil.
4) Micronutrients analysis of soil.
5) Measurement of physical properties of soil. (Color, odder, texture etc.)

6) Measurement of Chemical properties of soil (pH, chloride, Oxygen, Sulphur etc. contain in soil)
7) Measurement of Biological properties of soil (Fungi, Bacteria)
8) Air quality measurement.
9) Analysis of Residues in fruits.
10) Visit to green house.
11) Visit to Sugar industry/Juice extract plant/ dairy industry

Reference books:

1. Industrial instrumentation, "Patranabis", TMH.
2. Instrumentation handbook-process control, "B.G. Liptak", Chilton.
3. Process control and instrumentation technology, "C.D. Johnson", PHI
4. Wills B.A., " Mineral Processing Technology", 4th Ed., Pergamon Press
5. Principle of Farm Machinery, R.A Kepner, Roy Bainer;: CBS Publication
6. Agricultural Engineering; Radhey Lal: Saroj Publication
7. Environmental Engineering, Peary. II. S. and others

T.Y.B.Sc. (Physics) (Sem-VI)
PHY-3611 SEC (AA): Radiation Physics

Lectures: 36 **(Credits-02)**

Course Objectives:

1. Students should understand the mechanism of interaction of various types of radiations with matter.
2. Students should get acquainted with principles of Measurement radiation levels, design principles and and actual implementation of variety of radiation detectors.
3. Students should learn about standards regarding safety levels laid down by National and International agencies, methods adapted to maintain safety standards in various places and methods of shielding.
4. Students should study the applications of radiations in various fields.

Course outcomes:

1. Students can use the knowledge in the applications of Radiation Physics in the fields like radio carbon dating, medical diagnostic tools.
2. Students acquire skill in operating different types of radiation detectors to detect and measure radiation levels in different places.
3. Students can work as advisers in maintenance of radiation safety standards and following of strict protocols at various places like Hospitals, Industry, and Laboratories etc.
4. Students become able to employ their skills to develop applications of radio activity in the fields like agriculture, industry, hospitals etc.

Syllabus:

Unit No.	Title and Contents	Lectures
I	**Interaction of Radiation with Matter** Interaction of different types of radiation with matter-Ionizing & Nonionizing radiations, excitation, ionization, radioactive losses-Energy loss by collision, range energy relation, Bethe-Bloch formula collision stopping power, radiation stopping power, Straggling.	3
II	**Radiation Detectors** Characteristic curve of Gas-filled detectors. Ionization chamber, Proportional counter, Gas filled detectors (G. M. counter), Characteristics of organic and inorganic scintillation detectors, Scintillator detector, Semiconductor detector.	3
III	**Radiation units and Measurement of radiation exposure** Units for radiation exposure- Roentgen, Becquerel, Gray, Sievert, RAD, REM, KERMA. Radiation exposure, Absorbed Dose, Equivalent Dose, Effective Dose, Ambient and directional equivalent dose, Relative biological effective dose, Quality factor, Personal dosimeters, Film badge dosimeters, Thermo luminescent dosimeter.	3
IV	**Radiation Sources and Radiation Shielding** Natural & Artificial radioactive sources, Alpha, Beta, Gamma Sources, Basic concept of radiation shielding, linear and mass absorption coefficient, stopping power, materials for shielding of gamma and neutron, shielding interaction cross section.	3

V	**Radiation Protection:** Time, Distance, Shielding, Radiation Protection and Safety rules as per the regulatory guidelines of the Government of India, Safety codes for handling radioactive sources. Monitoring of radiation levels around an open radioactive source, ICRP, NCRP, AERB recommended limit.	3
VI	**Radiation Applications:** Radioactive pharmaceuticals and labelled compounds. Radioactive nuclei used in diagnostic applications. Applications of gamma-rays in sterilization of medical instruments, medication items and preservation of food.	3

Activity: any-6 [18L]

1. Study the different types of radio isotopes and their applications in medical field.
2. Study use of isotopes in radiocarbon dating.
3. Study of working of G. M. Counter.
4. Study of G. M. Counter characteristics – Dead Time and End point energy.
5. Study of commercially available portable, handy radiation detectors.
6. Survey of various places to measure radiation levels
7. Visit to hospitals and other such locations for measuring radiation exposure.
8. Visit to industrial areas to measure radiation exposure levels
9. Study of various shielding materials and their stopping power.
10. Study of dependence of radiation stopping power of materials on physical properties of materials
11. Study of protocols followed by various units to follow safety measures
12. Visit to food industry using preservation techniques using nuclear radiations.
13. Visit to pharmacy industry producing radioactive compounds.
14. Visit to diagnostic centres which employ radiation sources

Reference books:

1. Nuclear and Radiation Physics in Medicine. Tony Key. World Scientific. 2014
2. Introduction to Radiological Physics and Radiation dosimetry. Frank H. Attix. Wiley. 1986
3. Medical Physics by Glasser O, Vol 1, 2, 3 Year Book Publisher Inc Chicago.
4. Radiation Protection and Health Science. Marilyn E. Noz. World Scientific. 2007.
5. Introduction to Radiation Protection. Grupen C. Springer. 2008.
6. Radiation Physics for Medical Physicists. Podgorsak Ervin B. Springer. 2005.
7. Techniques for Nuclear and Particle Physics experiments. Leo. W. R. Springer. 2005.

T.Y.B.Sc. (Physics) (Sem-VI)
PHY-3611 SEC (AB): Photography

Lectures: 36 **(Credits-02)**

Objectives:

- To create general awareness and interest in photography process.
- To make students familiar with the Photographic equipment and handling techniques.
- To help students to learn basic photographic and image processing skills.

Course Outcomes: After successful completion of this course, student will be able to

- Understand the basic principle, structure and handling techniques in digital photography.
- Students will be able to develop and apply photographic skills using digital photography tools including digital editing, saving, sizing, and posting of the images
- Student gets proficient at the technical aspect of photographing with a digital camera.
- Students can identify and apply appropriate business practices specific to the self-employed professional photographer

Syllabus:

Unit No.	Topics	Lectures
I	**Introduction of Photography:** **Introduction:** History & Development of photography, Principles, functions and structure of camera, Indoor and outdoor lighting techniques; Background selection; Flash and its features. Black & White v/s Digital camera (Limitation & advantages) **Types of Camera:** Pinhole camera, Box camera, SLR camera, Studio camera, Digital camera.	6
II	**Camera Control and Exposure:** **Camera Controls:** Need for camera controls. Apertures, Depth of field and depth of focus. Shutters (Ideal, leaf and focal plane shutter). Shutter speed (slow and fast). Auto focus, Manual focus and Image stabilization **Camera lenses & Exposure:** Normal, Wide angle, Telephoto and Zoom range, Incident and reflected light, Exposure triangle, Exposure and equivalent exposures, Brief idea of exposure meter (TTL and Flash meter).	6
III	**Colour Theory & Digital Camera:** **Colour Theory:** Classification and use of colours in photography, Construction of colour enlarger, Colour Head, sources of light and filters used in a colour enlarger **Digital Camera:** Types of Digital Camera and its features, Memory Chip card, Creative shots, Settings in the Digital Camera - Handling methods; White balance, Maintenance of camera. Digital camera sensors and its types.	6

Activity: any-6 (Practical/Demonstration) **[18L]**

Sr No	List of Practical's
1	To study the effect of aperture on depth of field
2	To study and recognize the use of slow and fast shutter speed
3	To study the effect of Exposure for different colour temperatures
4	To identify and determine the focal length of the different types of lenses
5	To study the Image Mixing, Image Cutting and Text Building Effect
6	To study Blurr Effect and Transformation Tools
7	To understand the effect of clip mask, photo filter and stamping Tool
8	To study the effect of natural light, tungsten light and fluorescent light on Photograph.
9	Lighting for still life (Earthen ware, Metal ware, Glass ware, Fruits, Crockery, Jewelry, Flowers, Food etc.)
10	Indoor shooting using three point lighting set up
11	Image processing 1: (Lightroom techniques 1): Brightness, saturation etc
12	Image processing 2: (Lightroom techniques 2): Exporting, contact sheet, print
13	Nature photography
14	Wild life photography
15	Night photography
16	Event Photography
17	News photography and preparing a photo story
18	Cover page design for a magazine

Reference books:

1. Basic Photography- M.J. Langford, Focal Press.
2. The basic book of Photography – Fifth edition – by Tom Gri
3. Beginner's guide to photographic lighting: Techniques studio or on Location-Dom Marr
4. Photography its principles & practice: A manual of the photography – Carroll.
5. Photography for the 21st century by Katic Millar
6. Advanced Photography (Vol.-I & Vol.-II) - M.J. Langford, Focal Press.
7. Applied Photographic Optics- Sidney F. Ray; Focal Press
8. The Practical Guide to Photographic Lighting, John Tarrant, Focal Press

SAVITRIBAI PHULE PUNE UNIVERSITY
(SPPU)
(Formerly University of Pune)

CREDIT SYSTEM (CS)
For
SEMESTER PATTERN
Post Graduate Programs

Handbook

(Updated Version)

Prepared by
Professor Vilas Kharat **Dr. V. B. Gaikwad**

MESSAGE FROM
HON. VICE CHANCELLOR, SPPU

The world of today is full of competition in each and every field. In order to cop-up with the needs of the time it has become necessary to prepare ourselves in tune with the norms and practices accepted and implemented across the globe. As such, one of the important aspects is to add a value to a postgraduate degree by imparting a knowledge based and hands-on experience training to the students. This very aspect demands the choice based credit system for the PG programs. The Credit System (CS) not only nurtures a student to put his best efforts for touching the heights of excellent education based knowledge but also allows carrying the credits earned from one University to the other in India and abroad as well. In fact, there are as many aspects that are of great importance in the CS but CONTINUOUS ASSESSMENT is the backbone and so it has to be handled with care so as to visualize a student with potential for excellence. Our University has jumped into this well of 21st century education with a firm footing of CS from the academic year 2013-14 for the PG programs conducted at affiliated colleges also. I am confident that the teachers involved in the implementation part would shoulder the responsibility & add values to it.

This handbook of CS is prepared to facilitate the aims and objectives of the system and the teachers as well as students would testimony the lucidity and essence of it.

Dr. W. N. Gade

PREAMBLE

In pursuance of the decision to implement Credit System at the Post Graduate level and ensure continuous assessment, the SPPU has decided to incorporate the Credit System (CS) under Semester Pattern in all its affiliated colleges and recognized institutions where postgraduate programs are conducted.

The Hon. Vice-Chancellor and the authorities of University of Pune, namely, the members of the Management Council, the

Deans of Faculties, the Members of the Academic Council, and the chairmen of the board of studies are the pillars in shaping the system for the cause of the benefit to the students.

Of course, all the teachers are committed to handle the credit system for the better and result oriented output in the enhancement of knowledge level of each and every student.

Down the line of every 2/3 years, the University is keen to inculcate the system and observe the overall development of its students.

CONTENTS

1. General administration
2. Conduct of the Credit System
3. Examination Rules
4. Assessment and Grade point average
5. Modus Operandi of Evaluation under Credit System- 2 years programs
6. Modus Operandi of Evaluation under Credit System- 3 years programs

1. Generaladministration

1.1 These rules and regulations shall be applicable for the conduct of CS for the Departments on the Campus of SPPU (implemented in AY 2001-02) as well as for the affiliated colleges and institutes (implemented in AY 2013-14).

1.2 As per the UGC directives, 10 point scale is applicable from the academic year AY 2015-16 (not applicable to the students admitted before the AY 2015-16).

1.3 CS Coordination Committee.

1. *Director, BCUD – Chairman*
2. *Deans of faculties - Members*
3. *HoD s from Campus(02) - Members*
4. *Professors from Campus(02) - Members*

This Committee shall take all decisions arising pertain to these rules and the implementation of CS.

2. Conduct of the Credit System

2.1 The Post-Graduate Degree will be awarded to those students who earn the minimum number of credits as follows:

Name of the Faculty	Total credits	Average credits per semester
Science, Engineering, Pharmacy, Management, Technology	100	25
Arts & Fine Arts, Social Sciences, Commerce, Law, Education, Physical Education**	64	16

(* - will be as per the directives of Education Council)

- In a case, where the PG program duration is of one year, such a program shall consist of minimum 40 credits.
- Except the credits for practical courses, wherever applicable, a student can register for less number of courses in a semester subject to the condition that such a student will have to complete the degree in a maximum of four (five) years for 2 years (3 years) program. This facility will be available subject to the availability of concerned courses in a given semester and with a maximum variation of 25 % credits (in case of fresh credits) per semester.

2.2 The proportion of Laboratory courses shall be around 40 % of the total credits of a PG program. Project work, if included, shall consist of NOT more than 10 % of the total number credits for PG programs in Science, Engineering, Technology, Management, Pharmacy and 05 % of the total number of credits for other PG programs.

2.3 One credit will be equivalent to 15 clock hours of teacher-student classroom contact in a semester. There will be no mid-way change allowed from Credit System to Non-credit (external) System or vice versa.

2.4 A post graduate teacher in a subject shall be affiliated to only ONE post graduate center at any given time and for only one subject.

2.5 For the routine conduct of the CS in a PG Department on the campus of SPPU, HoD will be the Chairperson and the teachers (employees of SPPU) in the Department will be the members.

While for a PG Department in colleges/institutes, Dean of the concerned faculty shall be the Chairperson and the constitution of faculty wise committee shall be as follows:

1. *Dean of the Faculty – Chairman*
2. *Two HoD's of the Post Graduate centers from the respective faculty nominated by the Hon. Vice Chancellor*
3. *One HoD/Professor/Subject expert from the Post Graduate Department of the University Campus nominated by the Hon. Vice Chancellor*
4. *Director, BCUD - Coordinator*

2.6 Among the minimum number of credits to be earned by a student to complete a Post Graduate Degree program (100/64 credits), the student will have to earn minimum 75% credits from the parent Department (subject) and the remaining up to 25 % credits could be earned from the parent Department (subject) or any subject/s of any faculty conducted at other PG Department/ PG Center. In any case, a student will have to earn compulsory credits from the parent Department (subject) over and above.

3. Examination Rules

3.1 Assessment shall consist of CA-Continuous assessment and ESE(ETE)-End of Semester(Term) Examination with an equal weightage of 50%.

3.2 The concerned teacher is responsible for conduct and evaluation towards CA and shall announce at the beginning of the course about the mechanisms under which CA would take place. However, the ESE (ETE) shall cover the entire syllabus prescribed for that course.

3.3 The CA towards 50% marks will be a continuous activity and at least two written tests (for 60-80% marks out of CA marks) must be conducted in addition to at least two following mechanisms (for 20-40% marks out of CA marks) for a full course of 4/5 credits.

Journal/Lecture/Library notes, Short Quizzes, Seminar presentation, Assignments, Extension Work, An Open Book Test (book to be decided by the concerned teacher), Mini Research Project by an individual student or a group of students

A teacher may devise a mechanism other than written test in addition to above in order to flourish the course contents.

a) It is mandatory for a teacher to hand over the assessed answer sheets to the respective students well before the commencement of the ESE (ETE).

b) It is also mandatory to declare the score gained by all the students in a course towards CA on the notice board duly signed by the concerned teacher of the course and the HoD/Principal/Director.

3.4 ESE (ETE) for the remaining 50% marks will be conducted by SPPU.

3.5 A student has to obtain 40 % marks taken together of CA and ESE (ETE) with a minimum of 30% in each of these separately.

3.6 A student will have to obtain a minimum aggregate of 40% marks in each course to be counted for the minimum number of credits required for the completion of the program.

3.7 If a student misses an internal assessment examination he/she will have a second chance with the endorsement of the HoD/Principal/Director in consultation with the concerned teacher. Such a second chance shall not be the right of the student.

3.8 a) If a student is declared as "PASS" in a course (Grade other than F), then the student cannot choose/reappear that course unless appearing under "CLASS/GRADE IMPROVEMENT" for ESE (ETE) only.

CA is not available for a course in which the student has been declared as "PASS".

b) If a student is declared as "FAIL" (Grade F) in a course, then the student is allowed to choose such a course, with CA and ESE (ETE) both, only in a semester in which the course is conducted, irrespective of the previous score in CA.

Otherwise, the student may appear only for ESE (ETE) in that course in any of the following/forthcoming semester, provided that the student has scored at least 15% of the total 100% (or 30% of the 50% of the total marks) in CA.

Explanation:

X = 100%

CA score	ESE/ ETE Score	CA+ ESE/ETE	Result
≥15% of X	≥15% of X	≥40% of X	PASS/Earned Credits with Grade
≥15% of X	≥15% of X	<40% of X	FAIL/No Credits Earned

Y = Course,
Odd-Sem = First Half/Semester of an Academic Year
Even-Sem = Second Half/Semester of an Academic Year

Semester in which Y is conducted	Status of the Y for a student	Future scope for improvement in Y
Odd-Sem	PASS	Under CLASS IMPROVEMENT only
	FAIL	The student can appear for ESE (ETE) in any subsequent semester, provided the student has scored ≥ 15% of X. OR The student can choose/register Y with CA and ESE (ETE) both in an Odd-Sem.
Even-Sem	PASS	Under CLASS IMPROVEMENT only
	FAIL	The student can appear for ESE (ETE) in any subsequent semester, provided the student has scored ≥ 15% of X. OR The student can choose/register Y with CA and ESE (ETE) both in an Even-Sem.

c) In case of 3.8(b), the maximum duration available to register/reappear for a course will be as follows.

2 years PG Program – Up to 4 (four) years
(i.e. if a student is registered/admitted for first semester in 2013-14, then the student is allowed to register/reappear up to second semester in 2016-17)

3 years PG Program – Up to 5 (five) years
(i.e. if a student is registered/admitted for first semester in 2013-14, then the student is allowed to register/reappear up to second semester in 2017-18)

d) In the case of 3.8(b), the number of attempts (excluding registered for first time) available to register/reappear for the course would be 3(three) only, subject to 3.8(c).

e) In an exceptional case, if there are sufficient number of students who wish to register for a course for CA and ESE (ETE) both in which they are failed, then such a course can be conducted in the immediate following semester only, in addition to the courses conducted in that semester. However, there cannot be more than two such courses at a time in that semester.

3.9 The student will be finally declared as failed if the minimum numbers of credits are not earned within a total period of Four and Five years respectively for 2 years PG Program and 3 years PG Program. After that, such a student will have

to seek fresh admission as per the admission rules prevailing at that time.

3.10 A student cannot register for the third/fourth semester, if she/he fails to complete 50% credits of the total credits expected to be ordinarily completed within two semesters.

3.11 There shall be a revaluation of the answer scripts of ESE (ETE) as per Ordinance No.134 A & B, but not of CA.

3.12 While marks will be given for all examinations, they will be converted into grades. The Semester End Grade sheets will be generated by using marks and grades and the final grade sheets and transcripts shall have grade points average and total percentage of marks (up to two decimal points). The final grade sheet will also indicate the PG Department/Center to which the candidate is registered.

4. Assessment and Grade Point Average

4.1 The system of evaluation will be as follows: Each CA and ESE (ETE) will be evaluated in terms of marks. The marks for CA and ESE (ETE) will be added to convert into a grade and later a grade point average. There is no grade independently for CA or ESE (ETE).

4.2 Result of a student will be declared for each semester after the ESE (ETE) only.

4.3 The student will get a Grade Sheet with total grades earned and a Grade Point Average, after earning the minimum number of credits towards the completion of a PG program (subject to 3.9).

4.4 Marks/Grade/Grade Point w.e.f. AY 2015-16 (10 Point Scale):

Marks	Grade	Grade Point
80-100	O: Outstanding	10
70-79	A+: Excellent	9
60-69	A: Very Good	8
55-59	B+: Good	7
50-54	B: Above Average	6
45-49	C: Average	5
40-44	P: Pass	4
0-39	F: Fail	0
-	Ab: Absent	0

Following will be applicable for all those who are admitted before the AY 2015-16 till they complete the PG program (subject to 3.9).

Marks	Grade	Grade Point
100 to 75	O: Outstanding	06
74 to 65	A: Very Good	05
64 to 55	B: Good	04
54 to 50	C: Average	03
49 to 45	D: Satisfactory	02
44 to 40	E: Pass	01
39 to 0	F: Fail	00

4.5 Final Grade w.e.f. the AY 2015-16 (10 Point Scale):

Grade Point Average	Grade
09.00 – 10.00	O
08.50 – 08.99	A+
07.50 – 08.49	A
06.50 – 07.49	B+
05.50 – 06.49	B
04.25 – 05.49	C
04.00 – 04.24	P
00.00 – 03.99	F

Remark: B+ is equivalent to 55% marks and B is equivalent to 50% marks.

Following will be applicable for all those who are admitted before the AY 2015-16 till they complete the PG program (subject to 3.9).

Grade Point Average	Grade
05.00-6.00	O
04.50-04.99	A
03.50-04.49	B
02.50-03.49	C
01.50-02.49	D
00.50-01.49	E
00.00-00.49	F

4.7 'B' Grade is equivalent to atleast 55% of the marks as per circular No.UGC- 1298/[4619]UNI-4. (Not applicable for 10 point scale)

4.8 A seven point grade system [guided by the Government of Maharashtra Resolution No. NGV-1298/[4619]/UNI.4 and the University regulations] will he followed uniformly for Science, Arts, Mental, Moral and Social Sciences. The corresponding grade table is detailed above.(not appplicale for 10 point scale)

4.9 If the GPA is higher than the indicated upper limit in the three decimal digit, then higher final

grade will be awarded (e.g. a student getting GPA of 4.492 may be awarded 'A' grade). (Not applicable for 10 point scale)

4.10 There will be only final compilation and moderation at GPA (Final) level done at the Department. While declaring the result, the existing relevant ordinances are applicable. There is also a provision for verification and revaluation, subject to the applicable rules at that point of time.

4.11 For grade improvement, 2 year program student will have to reappear for ESE (ETE) only in the courses comprising a minimum of 30 credits in case of Science, Engineering, Technology, Management and Pharmacy; 20 credits for other faculties and 12 credits in case of one year degree program. These courses will be from the parent Department only in which the student has earned the credits. A student can opt for the Grade Improvement Program only after the declaration of earning minimum number of credits and completion of the PG Program (subject to 3.9) within the period of two years from the completion of program.

4.12 The formula for GPA will be based on Weighted Average. The final GPA will not be printed unless a student passes courses for the minimum 100 credits, 80 credits or 64 credits as the case may be.

4.13 The description for the grades is as follows:

O: Outstanding: Excellent analysis of the topic, (80% and above)

Accurate knowledge of the primary material, wide range of reading, logical development of ideas, originality in approaching the subject, Neat and systematic organization of content, elegant and lucid style;

A+ : Excellent : Excellent analysis of the topic (70 to 79%) Accurate knowledge of the primary material, acquaintance with seminal publications, logical development of ideas, Neat and systematic organization of content, effective and clear expression;

A: Very Good: Good analysis and treatment of the topic (60 to 69%) Almost accurate knowledge of the primary material, acquaintance with seminal publications, logical development of ideas, Fair and systematic organization of content, effective and clear expression;

B+: Good: Good analysis and treatment of the topic (55 to 59%)
Basic knowledge of the primary material, logical development of ideas, Neat and systematic organization of content, effective and clear expression;

B: Above Average: Some important points covered (50 to 54%)

Basic knowledge of the primary material, logical development of ideas, Neat and systematic organization of content, good language or expression;

C: Average: Some points discussed (45 to 49%)

Basic knowledge of the primary material, some organization, acceptable language or expression;

P: Pass: Any two of the above (40 to 44%)

F: Fail: None of the above (0 to 39%)

4.14 One credit is equivalent to 20-25 marks for evaluation purpose.

4.15 There will be an evaluation of each course by students at the end of every semester. (Sample format enclosed for course evaluation by students)

Relevant circulars from which these rules are compiled and modified

· 187/2001 (12-7-2001) for both M. A. and M. Sc.

· 168/2002 (14-6-2002) & CBH/5422 of 29-8-2002 in continuation of 168/2002 for Social sciences and Humanities

· 125/2004 (22-3-2004) addition to 168 of 2002

· 296/ 2006 (5-8-2006) for all departments

- UGC D.O. No. F. 1-1/2014(Secy) Dated 12th Nov. 2014

5. Modus Operandi of Evaluation under Credit System-2 years programs

5.1 Each regular student will normally appear for all the 25% credits in a semester out of the minimum number of credits required to obtain a degree.

5.2 A student who wishes to register to the third /fourth semester should have gained at least 50% credits out of the total number of credits offered at the first and second semester of the first year.

5.3 Evaluation of each credit will be in two parts, namely CA and ESE (ETE).

5.4 A course may be of 1 or 2 or 3 or 4 or 5 credits.

5.5 The evaluation of a course means the evaluation of total number of credits of that course. As such, all the credits taken together of a particular course will be evaluated in two parts CA and ESE (ETE).

5.6 Weightage for CA would be 50% and for ESE (ETE) would be 50%.

5.7 A course will be evaluated in the form of 50 marks for CA and 50 marks for ESE (ETE).

5.8 A student will gain all the credits of a course after having obtained minimum 40 marks from CA (minimum 15 out of 50) and ESE (ETE) (minimum 15 out of 50) taken together and will get the

respective grade and grade points in the respective course. Otherwise, a student will get grade F (Fail) in that respective course and will not gain any credits or grade points towards that course.

5.9 **CA**: The teacher would evaluate a student towards a course through interaction throughout the semester which would include one or more (but not less than 4 including compulsory written test/s) of the following mechanisms with their maximum weightage out of 50 marks and this essentially enables the teacher to get positive feedback about a student's overall understanding/ability and in nutshell enhances the teaching-learning process.

a. Written test – Max 2 with not more than 15 marks for each
b. Assignment – Max 2 with not more than 5 marks for each
c. Seminar presentation – 5 marks (not for all the students)
d. Group discussion – 5 marks (not for all the students)
e. Extension work – 5 marks (not for all the students)
f. An open book test – 10 marks (to be conducted in a classroom for not more than 3 questions)
g. Report/Note on research paper/s or study tours – 5 marks (not for all the students and to be presented in the respective class)

- A teacher may propose any other mean towards CA (other than written test) that may suit for a particular course and implement only after the approval of the Departmental Committee constituted and approved by the HoD/Principal/Director.

5.10 If a student could not attend the CA written test due to some unavoidable reasons then the teacher may consider a request for retest in writing with furnishing the reason of absence.

5.11 If a student failed to gain the credits of any course (declared F grade in that course) then the student can reattempt the course with CA (if the course is conducted in that semester) and ESE (ETE) both or with ESE (ETE) only (if one has scored 15 in CA) in the subsequent ESEs (ETEs) (max. two such attempts) within a period of 4 years (5 for 3 years programs) from the date of admission for the first semester (subject to 3.9).

5.12 In case a student failed to earn the minimum number of credits required for obtaining a degree within the stipulated period of 4 years (5 years for 3 years programs) then such a student will be declared **INCOMPLETE EXIT** and in such a case the student can seek a fresh admission as per the admission rules prevailing at that time.

5.13 The policies and procedures determined by the SPPU from time to time will be followed for the

conduct of examinations and declaration of the result of a candidate.

5.14 **ESE** (ETE): Each credit will be evaluated for a maximum period of 45 minutes. The following would be an outline for setting the question paper for ESE(ETE).

Credits	Duration	Questions to be attempted	Number of Subquestions	Marks for subquestions
1	45 min	1 out of 2	3 (for 2 questions)	4+3+3 or 5+3+2 or 4+4+2
2	90 min	3 out of 5	3 (for 3 questions)	4+3+3 or 5+3+2 or 4+4+2
			2 (for 2 questions)	5+5
3	150 min	4 out of 6	2 (for 4 questions)	4+3+3 or 5+3+2 or 4+4+2
			2 (for 2 questions)	5+5
4/5	180 min	5 out of 8	3 (for 6 questions)	4+3+3 or 5+3+2 or 4+4+2
			2 (for 2 questions)	5+5

Note: A question paper for PG program course of 3/4/5 credits under any Faculty other than Science, Engineering, Technology, Management and Pharmacy may contain a question of 10 marks(1 out of 2) without a subquestion.

5.15 **PRACTICAL EXAMINATION**:

a. The duration for the conduct of ESE (ETE) of a practical course would be same as stipulated in 5.13.

b. The outline of the distribution of maximum marks for various aspects/mechanisms towards CA is as follows:

- *Journal – 10 marks*
- *Viva-voce at the time of submission of each practical – 20 marks*
- *Group discussion of 5/6 students for testing the understanding level of a student – 10 marks*
- *Attendance – 5 marks*
- *Additional practical work of indisciplinary approach – 5 marks*

c. At least three experiments should be asked for the full course of 4/5 credits and at least two for 2/3 credits.

d. Certified Journal would be compulsory to appear for the ESE (ETE) practical course.

e. There shall be two experts from the parent Department and two examiners (one of which will be external) per batch.

5.16 If a student failed to obtain a grade other than F in a course then such a course will not be taken into account for calculating GPA and overall grade. In fact, all the courses in which a student has passed will be taken into account for calculating the GPA and overall grade.

6 Modus Operandi of Evaluation under Credit System-3 years programs

MCA/MSc(IMCA)/3-year Programs:

6.0 All the points other than 5.1 and 5.2 above are applicable to these programs also.

6.1 Each regular student will normally appear for all the 25 credits in a semester. (For the program of 150 credits in Six semesters)

6.2 A student who wishes to register to the third semester/fourth semester should have gained at least 25 credits. (In case 50 credits offered per year)

6.3 A student will be considered to have “Completed” the Internship/Industrial Training upon the submission of certificate of completion, duly signed and sealed, from the Organization where the candidate worked during the Internship period. In case a student failed to submit the required certificate of completion duly signed by mentor/Organization then the student will be considered to have “Not Completed” the required internship/industrial training at the time of the declaration of the result. And hence such student will have to undergo the complete training.

Savitribai Phule Pune University

Three Year B.Sc. Degree Program in B.C.A. (Faculty of Science & Technology

F.Y.B.C.A. Choice Based Credit System Syllabus

To be implemented from Academic Year 2019-2020

Title of the Course: Bachelor of Computer Applications (BCA)

Preamble of the syllabus

The B.C.A. program is a combination of computer and applied courses from science stream. The computer related courses introduce techniques of programming, databases, web designing, system analysis, design tools and different computing environments. The applied courses include mathematics, statistics and electronics that provide theoretical foundation for the learner.

Objectives:

• To produce knowledgeable and skilled human resources that is employable in IT and ITES.

• To impart knowledge required for planning, designing and building Complex Application Software Systems as well as to provide support for automated systems or applications.

• To produce entrepreneurs

Introduction

The Program is of Three Years duration with six semesters. It is a Full Time Degree Program. The program will be based on Choice-based credit system comprising 140 credit points.

Lateral Entry to SYBCA

Any candidate who has passed three Year Diploma course in Computer Engineering/Technology/Information Technology/Electronics Communication/ Electronics Telecommunications/ Electronics approved by the DTE, Maharashtra State or Equivalent authority is eligible for admission to direct second year (SYBCA) of this program

TABLE 1 Structure for FYBCA (Semester_1)

Semester 1

Course Code	Course	Teaching Scheme Hours / Week			Examination Scheme and Marks			Credit	
		Theory	Tutorial	Practical	CE	End-Sem	Total	TH	PR
BCA111	Fundamentals of Computers	04	--	--	30	70	100	04	--
BCA112	Problem Solving and C Programming	04	--	--	30	70	100	04	--
BCA113	Applied Mathematics	04	--	--	30	70	100	04	--
BCA114	Business Communication	04	--	--	30	70	100	04	--
BCA115	Fundamentals of Computers Laboratory	--	--	03	15	35	--	50	1.5
BCA116	C Programming Laboratory	--	--	03	15	35	--	50	1.5
BCA117	Applied Mathematics Laboratory	--	--	03	15	35	--	50	1.5
BCA118	Business Communication Laboratory	--	--	03	15	35	---	50	1,5
							Total Credits	**16**	**06**
Total		**16**	**--**	**12**	**180**	**420**	**600**		**22**

Abbreviations:

TW : Term Work **TH :** Theory **OR :** Oral **TUT:** Tutorial **PR :** Practical

TABLE 1 Structure for FYBCA (Semester_2)

Semester 2

Course Code	Course	Teaching Scheme Hours / Week			Examination Scheme and Marks			Credit	
		Theory	Tutorial	Practical	CE	End-Sem	Total	TH	PR
BCA121	Computer Organization	04	--	--	30	70	100	04	--
BCA122	Advanced C Programming	04	--	--	30	70	100	04	--
BCA123	Operating Systems Concepts	04	--	--	30	70	100	04	--
BCA124	Database Management Systems - I	04	--	--	30	70	100	04	--
BCA125	Computer Organization Laboratory	--	--	03	15	35	050	--	1.5
BCA126	Advanced C Programming Laboratory	--	--	03	15	35	050	--	1.5
BCA127	Operating Systems Laboratory	--	--	03	15	35	050	--	1.5
BCA128	Database Management Systems - I Laboratory	--	--	03	15	35	050	--	1.5
								16	**06**
		16	**--**	**12**	**180**	**420**	**600**		**22**