University of Mumbai

No. UG/ 88 of 2021

CIRCULAR:-

Attention of the Principals of the Affiliated Colleges and Directors of the recognized Institutions in Faculty of Science & Technology.

They are hereby informed that the recommendations made by the Ad-hoc Board of Studies in **Architecture** at its meeting held on 27th June, 2020 and subsequently approved by the Board of Deans at its meeting held on 20th July, 2020 **vide** item No. **3** have been accepted by the Academic Council at its meeting held on 23rd July, 2020 **vide** item No. **4.142** and subsequently approved by the Management Council at its online meeting held on 28th August, 2020 **vide** item No. **2** and that in accordance therewith, in exercise of the powers conferred upon the Management Council under Section 74(4) of the Maharashtra Public Universities Act, 2016 (Mah. Act No. VI of 2017) the Ordinance **6609 & 6610** Regulations **9353 & 9353-A** and the syllabus of **Master in Architecture in Landscape (Sem I to IV)** has been introduced and the same have been brought into force with effect from the academic year **2020-21**, (The said course might be introduced from the academic year 2021-2022 in the wake of prolonged Covid-19 pandemic situation in the country and subsequent delay in the commencement of the new academic year) accordingly. (The same is available on the University's website www.mu.ac.in).

MUMBAI – 400 032
25th January, 2021

(Dr. B.N.Gaikwad)
I/c. REGISTRAR

To,

The Principals of the affiliated Colleges and Directors of the recognized Institutions in Faculty of Humanities. (Circular No. UG/334 of 2017-18 dated 9th January, 2018.)

A.C/4.142/23/07/2020
M.C/2/28/08/2020

****

No. UG/88-A of 2021 MUMBAI-400 032 25th January, 2021

Copy forwarded with Compliments for information to:-

1) The Dean Faculty of Science & Technology,
2) The Chairman, Ad-hoc Board of Studies in Architecture,
3) The Director, Board of Examinations and Evaluation,
4) The Director, Board of Students Development,
5) The Co-ordinator, University Computerization Centre,

(Dr. B.N.Gaikwad)
I/c. REGISTRAR

Copy to :-

1. **The Director of Board of Student Development.,**
2. **The Deputy Registrar (Admissions, Enrolment, Eligibility and Migration Department (AEM)**
3. **The Director of Students Welfare,**
4. **The Executive Secretary to the to the Vice-Chancellor,**
5. **The Pro-Vice-Chancellor**
6. **The Registrar and**
7. **The Assistant Registrar, Administrative sub-centers, Ratnagiri, Thane & Kalyan**
8. **The Deputy Registrar Research Administration & Promotion Department (RAPC) for information.**

1. **The Director of Board of Examinations and Evaluation**
2. **The Finance and Accounts Officers**
3. **Record Section**
4. **Publications Section**
5. **The Deputy Registrar, (Admissions, Enrolment, Eligibility and Migration Department (AEM)**
6. **The Deputy Registrar (Accounts Section), Vidyanagari**
7. **The Deputy Registrar, College Affiliation & Development Department (CAD).**
8. **The Professor-cum- Director, Institute of Distance and Open Learning Education,**
9. **The Director University Computer Center (IDOL Building), Vidyanagari,**
10. **The Deputy Registrar (Special Cell),**
11. **The Deputy Registrar, (PRO)**
12. **The Deputy Registrar, Academic Authorities Meetings and Services (AAMS) (1 copy) and**
13. **The Deputy Registrar, Executive Authorities Unit**

They are requested to treat this as action taken report on the concerned resolution adopted by the Academic Council referred to in the above circular and that on separate Action Taken Report will be sent in this connection.

1. **The Assistant Registrar Constituent Colleges Unit**
2. **BUCTU**
3. **The Deputy Accountant, Unit V**
4. **The In-charge Director, Centralize Computing Facility**
5. **The Receptionist**
6. **The Telephone Operator**
7. **The Secretary MUASA**
8. **The Deputy Registrar Research Administration & Promotion Department (RAPC)**

for information.

University of Mumbai

Proposal for

Master of Science in

Material Science

(M. Sc. in Material Science)

(Choice Based and Credit System)

with effect from the Academic year 2020-21onwards

Semesters-I to IV

Cover Page

AC__________

Item No. ______

UNIVERSITY OF MUMBAI

Syllabus for Approval

Sr. No.	Heading	Particulars
1	Title of the Course O.6594	M.Sc. in Material Science
2	Eligibility for Admission O.6595	Bachelor of Science degree with Physics, or Chemistry, as a major subject (i.e. upto the third year B. Sc. level), or Bachelor of Engineering degree (BE / BTech) examination or an examination of another University recognized as equivalent thereto.
3	Passing Marks	55%
4	Ordinances / Regulations (if any)	
5	No. of Years / Semesters R.9341	4 semesters
6	Level	P.G. / ~~U.G./ Diploma / Certificate~~ **(Strike out which is not applicable)**
7	Pattern	~~Yearly~~ / Semester **(Strike out which is not applicable)**
8	Status	New / ~~Revised~~ **(Strike out which is not applicable)**
9	To be implemented from Academic Year	From Academic Year: 2020-2021

Date: 24.04.2020 Signature :

Dr. AnuradhaMisra
Name of BOS Chairperson

Dr. AnuradhaMajumdar
Dean, Science and Technology

(i) Necessity to start to this course?

Importance of Material Science

Architecting novel and advance materials has been a source of inspiration since ancient times. Materials have transformed civilization beyond the wildest imagination of our predecessors. These days, like food, air, water and shelter, one cannot survive without materials and thus it is always in news. The world's long-term economic development depends on the existence of efficient, innovative and smart materials and their industries. These in turn rely on individuals who possess a sound grasp of their legal, economic, technical and policy backgrounds.

Materials science is multidisciplinary and covers everything from the production of aluminum, steel and silicon - to the development of new materials. The materials have wide application, and they can be used in petroleum activities, energy technology or for more everyday products such as knives. Material technology is therefore an important focus area for Indian industry. The right choice of materials can save companies a lot of money and work! Today, materials technologists face exciting challenges such as environmentally friendly metal production and recycling, advanced material use in the oil and gas operations, as well as the development of new materials based on nanotechnology for environmentally friendly and efficient utilization of our national energy resources.

Why Study Master in Material Science?

Student Perspective

1. **Prospect to study Interdisciplinary area:**

Today's most of the challenging global problems can be solved by integrating the knowledge of various disciplines which can analytically and creatively embrace new idea. This material science course contains elements of basic science (physics, mathematics, biology and chemistry) blended with emerging technology and engineering aspects and all these will be taught in a cohesive and self-contained way during the course. This makes for a varied and stimulating experience, giving you the tools to make a real difference in industry and research.

Having understanding of various disciplines will also provide flexibility to choose and switch different fields during the course of your career. Most importantly by multidisciplinary perception one develop skill of critical thinking to look a problem beyond disciplinary boundaries to consider other viewpoints and, to compare and generate concepts across subject areas.

2. **Employment opportunities in Material Science field:**

The ability to create new materials and to make existing materials perform better is the key to many advances in areas of science and engineering, be it in industry or research organizations. The world's long-term economic development depends on the existence of efficient, innovative and smart materials and their industries. These in turn rely on individuals who possess a sound grasp of their legal, economic, technical and policy backgrounds. This course provides expertise in areas that are important to India as an industrial nation, both today and in the future. As a material science student, you will benefit from this expertise and receive an education that is both relevant and career-enhancing in a later job situation.

With expertise in materials science a student can choose from range of sectors like aerospace,armed forces and defence, automotive, material manufacturing, nuclear industry, oil and gas, pharmaceuticals, telecommunications, utilities,renewable energy, environmental and biomedical. Not constrained to the industrial jobs one can also have shinning career in research and academics. As per the report in journal of "*Nature*" the total share of material science based research articles is in range of 20-40 % in all the developed countries and this is growing each year by substantial amount, thus offering more career opportunity in research and academics.

3. **Studying Material Science at University of Mumbai (UoM):**

Material science being one of the most prominent area of research in most of the science and technology departments of UoM, thus give us the prospect to gather highly expertise and prolific teachers from various departments to teach this course. Within these different departments specialized research laboratories will be used for the practical classes where one will get the real feel of the research equipment. This will give a student an interesting experience and greater understanding of the area along with networking with different departments of UoM for Future Avenue. At the same time this study program will have small classes with approx. 30 students, which makes it easy to get acquainted with their fellow students and with the faculty teachers from the various department. This makes the material science study completely unique, and distinguishes the study from other university courses. All modules are heavily contextualized and draw on the wide network of expert staff of UoM in delivering a cutting edge programme of the highest quality and relevance to students. In addition, the collaboration of UoM with reputed material research institutes (BARC, TIRF, IIT Bombay, ICT) and R&D labs of industries (Reliance, Pidilite, Tata etc.) will allow each student to explore the possibility to execute their project work in these reputed institutions for the master thesis. UoM being one of the biggest and oldest university of India we have large network of alumni who can guide and support the students in the area of their choice for the career. Therefore, one should choose to study materials science at Mumbai University.

4. **Studying Material Science can lead to International Career:**

World over materials Science is a key aspect of most companies, universities and research institutes. In the race to make things stronger, cheaper, lighter, more functional and more sustainable, the manipulation of materials, their properties and processes is crucial for these institutions. This means graduates in this area can work, or do research in most countries of the world, and many of our alumni have done just that. As per "Material Research Society" website there about 42 types of scholarship and grants available for the admission in PhD degree across the top ranked universities of world. Proper guidance to successfully achieve these international scholarship and grants will also be provided by our experienced teachers having international collaboration.

<u>University Perspective</u>

1. **Integration of the departments of Science and Technology discipline:**

Out of 11 departments of science & technology of UoM distinguish faculty members of 8 of these departments are actively involved in various research areas of Material Science. Thus through this course these teachers will get opportunity to teach their expertise field in material science. This will also offer prospect for these faculty members to gel with the teachers from other departments and explore the possible avenue for the multidisciplinary research and extend the research network for the high impact output.

2. **Academia-Industry collaboration:**

Since the present course is a professional course with more exposure towards the industries so the teachers involved in the course will have possibility to explore the future collaboration with industries through the students involved in this course. Students will be encourage to take-up the industrial problem for the master thesis which will also generate financial benefits to the university through consultancy projects. There are shining examples of fruitful collaboration between universities, industry partners and start-ups. Many ideas from research in universities are put to use through collaboration between universities and firms. Others reach the market through licensing or start-up companies.

Goals

It is well known that material sector has its own impact on the progress and development of any nation. The availability of various material resources and in house capability to use it in the appropriate manner for productive development of a nation is the key factor in the economic growth of the country. Keeping this long term need in mind at department of Physics, University of Mumbai, we would like open a new branch as material Science.

The main goal would be to promote interdisciplinary research, development and teaching activities in the field of materials. The major objective of this effort will be to bring and to bear, the expertise and facilities that are available in the various science departments on the university campus, for purpose of teaching and solving some of the frontline problems, both of basic and applied nature.

We hereby proposed to start a 2 years MSc program in “Material Science”. The main aim is to train the students so that they can take the field of Materials as their future career and lead in solving the global problems in this area by scientific research. All modules are heavily contextualized and draw on the wide network of expert staff in delivering a cutting edge programme of the highest quality and relevance to students.

(ii) Whether UGC has recommended to start the said course?

UGC recommendation:

UGC in its public notice dated 23rd December 2013 with reference number F.No.14-9/2013(CPP-II) have recommended and approved post graduate course in "Material Science and Technology" as a professional course of 2 years for the affiliated University and Colleges. https://www.ugc.ac.in/pdfnews/3527528_DraftRegulationsonTechnicalEducation.pdf

(iii) Whether this course have commenced from the academic year 2020-21?

(iv) This course will be self-financed, whether adequate number of eligible permanent faculties are available?

Yes we have adequate number of eligible permanent faculties to teach this course. Material Science course is an interdisciplinary course and contains elements of basic science (physics, mathematics, biology and chemistry) blended with engineering aspects and all these will be taught in a cohesive manner by the permanent faculties, having expertise, from various Science & Technology departments of University of Mumbai.

(v) To give details regarding the duration of the course and is it possible to compress the course?

M. Sc. in Material Science Program is two years full-time course for the candidates who have passed the B.Sc. degree (Physics, or Chemistry or Biology, as a major subject)or BE/BTechdegree. As per the guidelines from UGC (https://www.ugc.ac.in/pdfnews/4380302_English.pdf) a candiadate is eligible to receive M.Sc.

degree only after completion of minimum two years of the course with earned the minimum number of credits prescribed by the University for the master programme.

(vi) **<u>The intake capacity of each course and no. of admission given in the current academic year (2020-21)?</u>**

The intake capacity of the “Material Science” course is maximum30 candidates

(vii) **<u>Opportunities of Employability/Employment available after undertaking these courses.</u>**

The ability to create new materials and to make existing materials perform better is the key to many advances in areas of science and engineering, be it in industry or research organizations. The world's long-term economic development depends on the existence of efficient, innovative and smart materials and their industries. These in turn rely on individuals who possess a sound grasp of their legal, economic, technical and policy backgrounds. This course provides expertise in areas that are important to India as an industrial nation, both today and in the future. As a material science student, you will benefit from this expertise and receive an education that is both relevant and career-enhancing in a later job situation.

With expertise in materials science a student can choose from range of sectors like aerospace, armed forces and defence, automotive, material manufacturing, nuclear industry, oil and gas, pharmaceuticals, telecommunications, utilities, renewable energy, environmental and biomedical. Not constrained to the industrial jobs one can also have shinning career in research and academics. As per the report in journal of “*Nature*” the total share of material science based research articles is in range of 20-40 % in all the developed countries and this is growing each year by substantial amount, thus offering more career opportunity in research and academics.

Introduction:

Architecting novel and advance materials has been a source of inspiration since ancient times. Materials have transformed civilization beyond the wildest imagination of our predecessors. These days, like food, air, water and shelter, one cannot survive without materials and thus it is always in news. The world's long-term economic development depends on the existence of efficient, innovative and smartmaterials and their industries. These in turn rely on individuals who possess a sound grasp of their legal, economic, technical and policy backgrounds.

Materials science is multidisciplinary and covers everything from the production of aluminum, steel and silicon - to the development of new materials. The materials have wide application, and they can be used in petroleum activities, energy technology or for more everyday products such as knives. Material technology is therefore an important focus area for Indian industry. The right choice of materials can save companies a lot of money and work! Today, materials technologists face exciting challenges such as environmentally friendly metal production and recycling, advanced material use in the oil and gas operations, as well as the development of new materials based on nanotechnology for environmentally friendly and efficient utilization of our national energy resources.

1. Why study Materials Science?

Materials Science is the study for those who are curious about why different materials are used for different purposes, how they are made and assembled and how they can be developed and improved. The study provides expertise in areas that are important to India as an industrial nation, both today and in the future. As a material science student, you will benefit from this expertise and receive an education that is both relevant and career-enhancing in a later job situation.

There are many different companies that need people with expertise in materials science, and students as a material scientist will have many opportunities after graduation in field industry, research and academics.

At the same time this study program will have small classes with approx. 30 students, which makes it easy to get acquainted with their fellow students. The sense of class, the unity and the personal contact with the faculty teachers from the various department make the material science study completely unique, and distinguishes the study from other university studies. Therefore, one should choose to study materials science at Mumbai University.

2. Goals

It is well known that material sector has its own impact on the progress and development of any nation. The availability of various material resources and in house capability to use it in the appropriate manner for productive development of a nation is the key factor in the economic growth of the country. Keeping this long term need in mind at department of Physics, University of Mumbai, we would like open a new branch as material Science.

The main goal would be to promote interdisciplinary research, development and teaching activities in the field of materials. The major objective of this effort will be to bring and to bear, the expertise and facilities that are available in the various science departments on the university campus, for purpose of teaching and solving some of the frontline problems, both of basic and applied nature.

We hereby proposed to start a 2 years MSc program in "Material Science". The main aim is to train the students so that they can take the field of Materials as their future career and lead in solving the global problems in this area by scientific research. All modules are heavily contextualized and draw on the wide network of expert staff in delivering a cutting edge programme of the highest quality and relevance to students.

3. Eligibility.

M. Sc. in "Material Science" Program will be open to a candidate passed the Bachelor of Science degree examination with Physics, or Chemistry, as a major subject (i.e. upto the third year B. Sc. level), or Bachelor of Engineering degree (BE / BTech) examination or an examination of another University recognized as equivalent thereto.

4. Intake Capacity. R.9340

Intake capacity- 30 maximum, with minimum- 20 candidates

5. Course Structure & Distribution of Credits.

M. Sc. in Material Science Program is 2 years full-time course which will consists of total 12 (twelve) theory courses, total 6 (six) practical lab courses and 1 (one) project (thesis based) in the last semester. Each theory course will be of 4 (four) credits, a practical lab course will be of 4 (four) credits and a project will be of 24 (twenty four) credits. A student earns 24 (twenty four) credits per semester and total 96 (ninety six) credits in four semesters. The course structure is as follows,

Theory Courses

	Paper-1	Paper-2	Paper-3	Paper-4
Semester-I	Applied Mathematics and Basic Quantum Mechanics	Thermodynamics and Statistical Mechanics	Fundamental Material Science	Properties of Solids
Semester-II	Types of Materials	Thin Film, Crystal and Solid Growth	Advance Material Characterization	Computational Material Science
Semester-III	Nanoscience & Nanomaterials	Materials for Energy& Environment	Materials for sensor, electronics and Photonoics	Soft condense matter and Biomaterials

Practical Lab courses

Semester-I	Material Science Lab-I	Material Science Lab-2
Semester-II	Characterization of Materials Lab	Material Designing and synthesis Lab
Semester-III	Nanomaterial & Functional MaterialLab	Applied Materials Lab

One Semester Project:

Semester-IV	Dissertation based R&D Project

Semester I

M.Sc. in Material ScienceProgram for Semester-I consists of four theory courses and two practical courses. The details are as follows:

Theory Courses (4): 16 hours per week (One lecture of one week duration)

Theory Paper	Subject	Lectures (Hrs)	Credits
PSMS101	Applied Mathematics and Basic Quantum Mechanics	60	04
PSMS102	Thermodynamics and Statistical Mechanics	60	04
PSMS103	Fundamental Material Science	60	04
PSMS104	Properties of Solids	60	04
	Total	**240**	**16**

Practical lab courses (2): 16 hours per week

Practical Lab Course	Practical Lab Sessions (Hrs)	Credits
PSMSP101 Material Science Lab-I	120	04
PSMSP102 Material Science Lab-II	120	04
Total	**240**	**08**

Semester II

M.Sc. in Material ScienceProgram for Semester-II consists of four theory courses and two practical courses. The details are as follows:

Theory Courses (4): 16 hours per week (One lecture of one week duration)

Theory Paper	Subjects	Lectures (Hrs)	Credits
PSMS201	Types of Materials	60	04
PSMS202	Thin Film, Crystal and Solid Growth	60	04
PSMS203	Advance Material Characterization	60	04
PSMS204	Computational Material Science	60	04
	Total	**240**	**16**

Practical lab courses (2): 16 hours per week

Practical Lab Course	Practical Lab Sessions (Hrs)	Credits
PSMSP201 Characterization of Materials Lab	120	04
PSMSP202 Material Designing and synthesis Lab	120	04
Total	**240**	**08**

Semester III

M.Sc. in Material Science Program for Semester-III consists of four theory courses,and twopractical course. The details are as follows:

Theory Courses (4): 16 hours per week (One lecture of one week duration)

Theory Paper	Subjects	Lectures (Hrs)	Credits
PSMS301	Nanoscience & Nanomaterials	60	04
PSMS302	Materials for Energy & Environment	60	04
PSMS303	Materials for Sensor, electronics and Photonoics	60	04
PSMS304	Soft condense matter and Biomaterials	60	04
	Total	**240**	**16**

Practical lab courses (2): 16 hours per week

Practical Lab Course	Practical Lab Sessions (Hrs)	Credits
PSMSP301 Nanomaterial & Functional MaterialLab	120	04
PSMSP302 Applied Materials Lab	120	04
Total	**240**	**08**

Semester IV: PSMSP401 Project Work

M.Sc. in Material Science Program for Semester-IV consists of full time dissertation based research project of 24 credits. Every student will have to complete a separate project in Semester IV with twenty four credits (600 marks). Students have to prepare and submit a Master level thesis and the final evaluation will be done by external field expert on the bases of the quality of the thesis and Viva-Voce examination.

The candidate shall be awarded the degree of Master of Science in Material Science (M. Sc. in Material Science) after completing the course and meeting all the evaluation criteria.

6. Scheme of Examination and Passing:

1. This course will have 40% Term Work (TW) / Internal Assessment (IA) and 60% external (University written examination of 2.5 Hours duration for each course paper and practical examination of 4 Hours duration for each practical). All external examinations will be held at the end of each semester and will be conducted by the University as per the existing norms.
2. Term Work / Internal Assessment - IA (40%) and University examination (60%)- shall have separate heads of passing. For Theory courses, internal assessment shall carry 40 marks and Semester-end examination shall carry 60 marks for each Theory Course.
3. To pass, a student has to obtain minimum grade point E and above,separately in the IA and external examination.
4. The University (external) examination for Theory and Practical shall be conducted at the end of each Semester and the evaluation of Project work i.e. Dissertation, at the end of the forth Semester by the external field expert.
5. The candidates shall appear for external examination of 4 theory courses each carrying 60 marks of 2.5 hours duration and 2 practical courses each carrying 100 marks at the end of each semester.
6. The candidate shall prepare and submit for practical examination a certified Journal based on the practical course carried out under the guidance of a faculty members with minimum number of experiments as specified in the syllabus for each group.

7. Standard of Passing for University Examinations:

As per ordinances and regulations prescribed by the University for semester based credit and grading system

8. Standard point scale for grading:

Grade	Marks	Grade Points
O	80 & above	10
A+	70 to 79.99	9
A	60 to 69.99	8
B+	55 to 59.99	7
B	50 to 54.99	6
C	45 to 49 .99	5
D	40 to 44 .99	4
F (Fail)	39.99 & below	0

9. Justification:

Materials Science has been a strength of the University Department of Physics with several faculty members working in the broad areas of thin films, condensed matter physics, surface physics, solid-state device physics, nanosynthesis, nanocatalysts and photocatalysts. The group has been involved in basic research, teaching, developing technologies, and in some cases transferring them to industry. In the past 8 years, the Department strength has increased from a total of 8 faculty members to 16 at present and many of the newly appointed faculty members also have expertise in Materials Science and Soft Condensed Matter Physics.We have developed a comprehensive laboratory for training and research in the field of "Advance Materials".

In addition, there is a lot expertise in the area of Material Science available in Mumbai due to proximity to eminent institutions like IIT, Bombay, BARC, TIFR and ICT, Mumbai. Guest lectures from eminent material scientist from these institutions and persons from industry, a dedicated strong core group comprising of faculty members of Kalina campus and opportunity to perform industry based projects will make it a unique program.

10. Fee Structure:

Details of the Fees for the M.Sc. course for the **1st Year**is given below.

Note: The Fees may be upwardly revised by the University and the revisedFees applicable at the time of admission will be charged.

Sr. No	Description of Fees Charged	Amounts (Rupees)
1	Tuition	20000/-
2	Other fees/Extracurricular activities	250/-
3	Registration fee for M Sc Part I only	850/-
4	Registration form fee	25/-
5	Laboratory fee	15000/-
6	Laboratory deposit	1000/-
7	Library	2000/-
8	Gymkhana	200/-
9	Admission processing fee	200/-
10	Vice chancellors fund	20/-
11	Magazine	100
12	Identity card	70/-
13	Group insurance	40/-
14	Student welfare	50/-
15	University sports and cultural activity	30/-
16	Development fee	1000/-
17	Utility	250/-
18	Computer/internet	1000/-
19	e suvidha	50/-
20	e charges	20/-
21	Disaster relief fund	10/-
22	Cultural Activity	6/-
	Total	**42,171/-**

Details of the Fees for the M.Sc. course for the **2nd Year** is given below.

Note: The Fees may be upwardly revised by the University and the revisedFees applicable at the time of admission will be charged.

Sr. No	Description of Fees Charged	Amounts (Rupees)
1	Tuition	20000/-
2	Other fees/Extracurricular activities	250/-
3	Registration fee for M Sc Part I only	850/-
4	Registration form fee	25/-
5	Laboratory fee	15000/-
6	Project Component	5000/-
7	Laboratory deposit	1000/-
8	Library	2000/-
9	Gymkhana	200/-
10	Admission processing fee	200/-
11	Vice chancellors fund	20/-
12	Magazine	100
13	Identity card	70/-
14	Group insurance	40/-
15	Student welfare	50/-
16	University sports and cultural activity	30/-
17	Development fee	1000/-
18	Utility	250/-
19	Computer/internet	1000/-
20	e suvidha	50/-
21	e charges	20/-
22	Disaster relief fund	10/-
23	Cultural Activity	6/-
	Total	**47,171/-**

Other Charges:	Amounts (Rupees)
Document verification (wherever applicable)	400/-
Form and Prospectus fee	100/-
University Exam fee	600/-
Mark sheet	50/-
Project fee(wherever applicable)	2000/-
Convocation fee only for M Sc part II	250/-
Refundable deposits:	
Caution money	150/-
Library deposit	250/-

Formand prospectus fees will be collected at the time of the purchase of prospectus. In addition,Railway concession fee, Cultural activity fee and library smart card fee will be collected atthe time of admission for students taking admission, asprescribed by the University. Any additional applicable fees may be charged by University on recommendation of the University authorities.

NB: Foreign students will have to pay five times of prescribed fees.

Complete Syllabus:

Semester 1: Theory Courses

PSMS101: Applied Mathematics and Basic Quantum Mechanics (60 lectures, 4 credits)

Unit-1: Vector Calculus and Differential Equations

(A) Review of vector addition and multiplication – dot product, cross product, scalar and vector triple products, concept of vector derivative (del operator) - gradient, divergence, curl and Laplacian operators, convective derivative and Maxwell's equations as examples

(B) Ordinary differential equations (ODE), first order ODE, second and higher order homogenous linear ODE, ODE with inhomogeneous term, methods of solution, radioactive decay and damped, driven harmonic oscillator as examples

(C) Partial Differential equations (PDE), linear homogeneous PDE, boundary conditions and initial conditions, methods of solution, wave equation and Poisson/Laplace equation as examples

Unit 2: Matrices and Integral Transforms

(A) Matrices, revision of matrix addition and multiplication, algebraic properties of matrices, their trace and their determinant, minimal concepts of linear algebra, the matrix eigenvalue problem, diagonalisation of matrices

(B) Fourier series (basic introduction only), Fourier transform and properties, applications of Fourier transform, Laplace transform and properties, applications of Laplace transform

Unit 3: Introduction to Quantum Mechanics and the 1-D Schrodinger equation

(A) Brief historical review (revision only), Postulates of QM, Observables and operators, measurement, the state function and expectation values, Dirac notation

(B) The time-dependent Schrodinger equation, time development of state functions, time-independent Schrodinger equation, one-dimensional infinite well, finite well, barrier as examples.

(C) Superposition principle and its implications, Commutator relations, Heisenberg's uncertainty principle (HUP), emphasis on HUP as a tool for order-of-magnitude estimates

Unit 4: The 3-D Schrodinger equation and some approximation methods

(A) 2-D and 3-D Schrodinger equation in cartesian coordinates, particle in a 3-D box

(B) Schrodinger equation in spherical polar coordinates (3-D), the angular momentum problem and the hydrogen atom as examples (direct quoting of the eigen-solutions, followed by physical interpretation)

(C) Concept of variational method to obtain ground state energies, Helium atom and Hydrogen molecular ion as minimal examples

References:

[1] "Mathematical Methods for Physicists, 7th ed." – G. Arfken, H. Weber, F. E. Harris

[2] "Mathematical Methods in the Physical Sciences, 3rd ed." – M. L. Boas

[3] "Introduction to Quantum Mechanics, 2nd ed." – D. J. Griffiths

[4] "Quantum Mechanics: Concepts and Applications, 2nd ed." – N. Zettilli

PSMS102: Thermodynamics and Statistical Mechanics (60 lectures, 4 credits)

Unit 1: Thermodynamics

(A) [Revision] Concept of temperature, Zeroth law of thermodynamics, types of processes, PV diagram as a tool for analysis

(B) [Revision] Concepts of internal energy, work and heat, First law of thermodynamics, thermodynamic state of a system, specific heat

(C) Second law of thermodynamics, efficiency of a thermodynamic cycle, irreversibility, concept of entropy, TS diagram and it use

(D) Thermodynamic potentials: comparative analysis of Enthalpy, Helmholtz free energy and Gibbs free energy, first order phase transitions and the Clausius-Clapeyron equation

Unit 2: Classical Equilibrium Statistical Mechanics

(A) Statistical description of a system of particles, Phase space and number of accessible microstates for a given the macrostate; Statistical definition of entropy; Gibb's paradox and correct counting of microstates

(B) Phase space density and ergodic hypothesis; Liouville theorem, Microcanonical ensemble, classical ideal gas as an example

(C) Canonical ensemble: Equilibrium between a system and an energy reservoir, Canonical partition function (Z) and derivation of thermodynamics; Energy fluctuations

(D) Grand canonical ensemble: Equilibrium between a system and a particle-energy reservoir; Grand partition function and derivation of thermodynamics; Fluctuations

Unit 3: Quantum Statistics and examples of Ideal Bose and Fermi systems

(A) Counting particle states for Bose and Fermi gases, Comparison to Boltzmann gas, Calculation of partition function and thermodynamic variables

(B) Thermodynamics of an ideal Bose gas, Calculation of number density of particles, total internal energy, equation of state and thermodynamic variables, Bose-Einstein condensation temperature and number density; Debye theory of specific heat as an example

(C) Thermodynamics of an ideal Fermi gas, Calculation of number density of particles, total internal energy, equation of state and thermodynamic variables, Concept of Fermi energy and degenerate Fermi gas; free electron gas in metals and thermionic emission as examples

Unit 4: Critical Phenomena and Transport Phenomena

(A) Gibbs density for spin systems with interaction, Ising and Heisenberg Hamiltonians with quantum mechanical interaction between electric/magnetic dipoles. Calculating partition function for a finite number of interacting spins, Solution of 1-D Ising model, Illustration of critical phase transition in 2-D Ising model (no detailed treatment)

(B) First order and second order phase transitions. Thermodynamic potentials and derivatives. Universality of second order phase transitions. Transition temperature, critical exponents

(C) Random walk, Binomial distribution, Brownian motion,Kinetic theory of diffusion; Langevin equation, Mean square velocities, mean square displacements, autocorrelation functions for random variables, Fluctuation-dissipation theorem

References:

[1] "Heat and Thermodynamics, 7th ed." – M. W. Zemansky, R. H. Dittman

[2] "Statistical Mechanics, 2nd ed." – K. Huang

[3] "A Modern Course in Statistical Physics, 4th ed." – L. E. Reichl

[4] "Statistical Mechanics, 3rd ed." – R. K. Pathria, P. D. Beale

PSMS103: Fundamentals of Materials Science (60 lectures, 4 credits)

Unit 1: Crystallography

Crystal Structures and Crystal Geometry, The Space Lattice and Unit Cells, Crystal Systems and Bravais Lattices, Principal Metallic Crystal Structures, Atom Positions in Cubic Unit Cells, Directions in Cubic Unit Cells, Miller Indices For Crystallographic Planes In Cubic Unit Cells, Crystallographic Planes and Directions In Hexagonal Unit Cells, Comparison of FCC,HCP, and BCC Crystal Structures, Volume, Planar, and Linear Density Unit Cell Calculations, Polymorphism or Allotropy, Crystal Structure Analysis, Point group, Space group, Crystalline Imperfections, point defects, dislocations and stacking faults.

Unit 2: Metallurgy

Solidification of Metals, Solidification of Single Crystals, Metallic Solid Solutions, Rate Processes in Solids, Diffusion In Solids, Industrial Applications of Diffusion Processes, Effect of Temperature on Diffusion In Solids. Phase Diagrams, Phase Diagrams of Pure Substances, Gibbs Phase Rule, Binary Isomorphous Alloy Systems, The Lever Rule, Nonequilibrium Solidification of Alloys, Binary Eutectic Alloy Systems, Binary Peritectic Alloy Systems, Binary

Monotectic Systems, Invariant Reactions, Phase Diagrams With Intermediate Phases and Compounds, Ternary Phase Diagrams

Unit 3: Mechanical Properties of Solids

Mechanical Properties of Metals, the Processing of Metals and Alloys, Stress and Strain In Metals, The Tensile Test and The Engineering Stress-Strain Diagram, Hardness and HardnessTesting, Plastic Deformation of Metal Single Crystals, Plastic Deformation of PolycrystallineMetals, Solid-Solution Strengthening of Metals, Recovery and Recrystallization of PlasticallyDeformed. Metals, Fracture of Metals, Fatigue of Metals, Creep and Stress Rupture of Metals. Tribology: wear of metals–mechanisms, factors influencing wear, wear resistance-protection against wear

Unit 4: Degradation of Metals

Corrosion, Electrochemical Corrosion of Metals, Galvanic Cells, Corrosion Rates (Kinetics), Types of Corrosion, Oxidation of Metals, Corrosion Control.

Prevention of degradation: Alloying environment, environment conditioning, design modification, Cathodic and anodic protection, organic and inorganic coating, inhibitors and passivators, Wear resistant coating.

PSMS104: Properties of Solids (60 lectures, 4 credits)

Unit-1: Lattice vibrations and thermal properties

Vibrations of Monoatomic Lattice, normal mode frequencies, dispersion relation; Lattice with two atoms per unit cell (diatomic linear chain), normal mode frequencies, dispersion relation, Quantization of lattice vibrations: Phonons, phonon momentum,

Inelastic scattering of neutrons by phonons, Surface vibrations, Inelastic Neutron scattering, Complementarity between X-ray and Neutron Diffraction methods

Thermal Energy of a harmonic oscillator (Specific Heat models of Einstein and Debye; review), Anharmonic Crystal Interaction. Thermal conductivity – Lattice Thermal Resistivity, Phonon collision: Normal and Umklapp Processes, Effects due to anharmonicity: Thermal Expansion

Unit-2: Electric and Dielectric properties

Electric properties of metals, classical free electron theory of metals, Fermi Dirac statistic and electron distribution in solids, Density of energy states and Fermi energy, Free electron gas in one and three dimensional box, Motion of electrons and effective mass, The

Boltzmann equation and relaxation time, Electrical conductivity of metals and alloys, Mathiessen's rule, Thermo-electric effects, Wiedmann-Franz Law, Lorentz number, ac conductivity,

Maxwell's equations in dielectric medium, Polarization, Theory of Local Electric field at an atom, Clausius-Mossotti relation, Electronic polarizability, Frequency dependence of polarizability, Polarization Catastrophe Ferroelectricity, Antiferroelectricity, Piezoelectricity, ferroelasticity with suitable examples.

Unit 3: Magnetic and Superconductive Properties

Diamagnetism and Paramagnetism, Langevin theory of diamagnetism, Hund's rules to determine ground state of ions with partially filled shell, Temperature dependence of paramagnetism: Curie Law, Magnetic ordering in solids: Ferromagnetic, antiferromagnetic and ferrimagnetic, Magnetic hysteresis and ferromagnetic domains, Examples of magnetic materials for various applications

Superconductivity: Occurrence of superconductivity, Meissner effect, Isotope effect, Critical fields: Type I and Type II behavior

Theoretical survey: London equations, Outline of BCS theory, Josephson superconducting effect (DC and AC), Superconducting materials: Conventional and High-Tc and some applications

Unit 4: Semiconductor Properties

Band theory of Soilds, Formation of bands in solids, Density of states, Bloch theorem, Kronig Penny Model, Nearly free electron approximation, Gaps at Brillouin Zones boundaries, electron states, Classification into conductors, semiconductors, and insulators, Effective mass and concept of holes, Fermi surface

Elementary theory of semiconductors, conductivity of semiconductors, simplified model of an intrinsic semiconductor and insulator, carrier statistics in intrinsic and extrinsic crystals, electrical conductivity, mobility of charge carriers, Hall effect, direct and indirect, law of mass action and chemical potential of semiconductors, advantages and applications of semiconductor devices.

Semester 1: Laboratory Courses

PSMSP101:Material Science Lab-I (Practical Lab session 120 hrs and 4 credits)

Students have to perform minimum of 8 experiments from the list given below:

List of Experiments

1. Susceptibility measurement by Guoy's balance method
2. Study of Hall effect and estimation of Hall coefficient R, carrier density (n) and carier mobility of Semiconductor material
3. Measurement of Magneto resistance of Bi specimen
4. Michelson Interferometer
5. Study of variation of dielectric constant of a ferro electric material with temperature (barium titanate)
6. Ultrasonic Interferometer – Young's modulus and elastic constant of solids
7. Study of Thermal properties of given crystal (specific heat, thermal expansion, thermal conductivity)
8. Study of variation of magnetic properties with composition of a ferrite Specimen using BH loop tracer
9. Study of colourcentres and thermo luminance of alkali halides (Metal Oxides)
10. Resistivity & Energy band gap by four probe method

PSMSP102:Material Science Lab-II (Practical Lab session 120 hrs and 4 credits)

Students have to perform minimum of 8 experiments from the list given below:

List of Experiments

1. Rockwell and Brinnels Hardness testing of Materials
2. Studying the corrosion properties of coatings
3. Determine Dielectric Constant of Ferroelectric Material using LCR bridge
4. Resistivity of Ge sample by van der Pauw method at different temp and determination of band gap
5. Grain Size measurement Ferrous alloys and Non-ferrous Alloys using optical microscope
6. Image analysis, finding defects, particle size analysis from SEM and TEM images
7. Investigating Crystal structure and miller indices of the given XRD Pattern
8. Non-Destructive Technique – Ultrasonic flaw detector
9. Laser Experiments – Wavelength and Particle Size Determination
10. Refractive index of Material using He-Ne laser
11. Thermo-emf of bulk samples of metals (aluminium or copper)

Semester 2: Theory Courses

PSMS201: Types of Material (60 lectures, 4 credits)

Unit 1: Engineering Alloys

Engineering Alloys, Production of Iron and Steel, The Iron-Iron Carbide Phase Diagram, Heat Treatment of Plain-Carbon Steels, Low-Alloy Steels, stainless steel, cast irons Aluminum Alloys, Copper Alloys, Magnesium, Titanium, and Nickel Alloys

Unit 2: Polymeric material

Polymeric Materials, Polymerization Reactions, Industrial Polymerization Methods, Crystallinity and Stereoisomerism In Some Thermoplastics, Processing of Plastic Materials, General-Purpose Thermoplastics, Engineering Thermoplastics, Thermosetting Plastics (Thermosets), Elastomers(Rubbers), Deformation and Strengthening of Plastic Materials, Creep and Fracture of Polymeric Materials Application of polymers: Polymer additives, as coating materials, fillers, plasticizers, stabilizers, lubricants, colorants, flame retardants, Conducting polymers as gas sensors, and biosensors. Optical sensors.

Unit 3: Ceramic and Composite material

Ceramic Materials, Simple Ceramic Crystal Structures, Silicate Structures, Processing of Ceramics, Traditional and Technical Ceramics, Electrical Properties of Ceramics, Mechanical Properties of Ceramics, Thermal Properties of Ceramics, Glasses.

Composite Materials, Fibersfor Reinforced-Plastic Composite Materials, Fiber-Reinforced-Plastic Composite Materials,Open-Mold Processes for Fiber-Reinforced-Plastic Composite Materials, Closed-Mold Processesfor Fiber-Reinforced-Plastic Composite Materials, Concrete, Asphalt and Asphalt Mixes, Wood,Sandwich Structures

Unit 4: Advance Materials

Electrets - properties and applications - Metallic glasses - Properties and applications - SMART materials - Piezoelectric, magnetostrictive, electrostrictive materials - Shape memory alloys - Rheological fluids – CCD device materials and applications, Ferrofuilds, spintronics material, Metamaterials, Graphene, superalloy, Spinel materials, Perovskites, MEMS, NEMS, Material for Quantum technology.

PSMS202: Thin film and Crystal Growth (60 lectures, 4 credits)

Unit I – Vacuum Techniques

Fundamental processes at low pressures, Mean Free Path, Time to form monolayer, Number density, Materials used at low pressure, vapour pressure Impingement rate, Flow of gases, Production of low pressures; High Vacuum Pumps and systems, Ultra High Vacuum Pumps and System, Measurement of pressure, Leak detections

Unit 2--Thin film deposition techniques

Preparation of Thin Films: Thermal evaporation, e-beam deposition, Cathode Sputtering, DC sputtering, Magentron sputtering, Chemical vapor Deposition, Laser Ablation, Molecular Beam epitaxy, electro-plating, sol-gel method (Spin and Dip coatings), Langmur-Blochet Films

Unit 3 Crystal Growth phenomena

The historical development of crystal growth – significance of single crystals - the chemical physics of crystal growth Crystal growth: Phase equilibria and Crystallization Techniques, phase diagrams and solubility curves, Kinetics of Nucleation, Rate equation, Heterogeneous and secondary nucleation, Crystal surfaces, growth mechanisms, mass transport, crystal morphology,, influence of supersaturation, temperature, solvents, impurities; Polymorphism – phase transition and kinetics.

Unit 4: Crystal Growth Technology

Silicon, Compound semiconductors, CdTe, CdZnTe, Czochralski technique, Bridgman technique, Float zone Process, Liquid Phase expitaxy, Molecular Beam epitaxy. Growth of Oxide & Halide crystals- Techniques and applications,

PSMS203: Advance Material Characterization: (60 lectures, 4 credits)

Unit I: Microscopy

Optical microscopy, Fluorescence microscopy, Scanning electron microscopy (SEM), Transmission electron microscopy (TEM), Scanning Transmission electron microscopy (STEM), Atomic Force microscopy (AFM), Scanning Tunneling microscopy (STM), Electron Probe micro-analyzer (EPMA).

Unit 2: Electromagnetic Radiation Spectroscopy

UV-Vis Spectroscopy, X-Ray Fluorescence (XRF) Spectroscopy, Fourier-Transform Infrared Spectroscopy (FTIR), Raman Spectroscopy, Photoluminescence Spectroscopy (PL), Rotational Spectroscopy, X-Ray Diffraction (XRD)

Unit 3: Particle Spectroscopy

X-Ray photoelectron Spectroscopy (XPS), Auger electron Spectroscopy (AES), Neutron diffraction, Rutherford Backscattering Spectroscopy (RBS), Mass Spectroscopy, Nuclear magnetic resonance Spectroscopy (NMR), Inductive Couple Plasma mass Spectroscopy (ICPMS), Electron spin resonance Spectroscopy

Unit 4: Thermal and electrical characterization techniques

Differential Scanning Calorimetry (DSC), Thermo Gravimetric Analysis (TGA), Differential Thermal Analysis (DTA), Two and Four probe method, Van der Pauw method, Hall probe method, Electrochemical (IV, CV, Impedance, Capacitance) Measurements, BET-Surface area measurement.

PSMS204: Computational Material Science (60 lectures, 4 credits)

Unit – I – Basic Concepts and Theoretical Background

Introduction and basic concepts: Theoretical background, basic equations for interacting electrons and nuclei, Coulomb interaction in condensed matter, Independent electron approximations, periodic solids and electron bands, structures of crystals: lattice + basis, the reciprocal lattice and Brillouin zone, excitations and the Bloch theorem.

The quantum theory of bonding: The Hamiltonian formulation, Dirac notation, electronic wave function, Schrödinger equation.

Unit – 2 – Quantum Mechanics of Materials

Central field approximation, Hamiltonian of the solid, Born-Oppenheimer approximation, hydrogen atom and molecule.

Hartree-Fock method: Coulomb and exchange operator, Fock operator, the HartreeFock Hamiltonian, basis set, charge density, the self-consistent field (SCF) procedure,expectation value.

Density functional theory: Exact formulation, approximations, choice of basisfunctions, essential machinery of a place-wave DFT code, energy minimization anddynamics.

Semi-empirical tight binding methods: Linear combination of atomic orbitals(LCAO), Hamiltonian and overlap matrices, Slater-Koster parameters for two-centerintegral, tight binding to empirical atomistic models.

Unit – 3 – Molecular Statics

The potential energy landscapes.

Energy minimization: Generic nonlinear minimization, steepest descent, lineminimization, conjugate method, Newton-Raphson method.

Saddle points and transition paths: Nudged elastic band methodImplementing molecular statics: Neighbor list, periodic boundary condition,applying stress and pressure, boundary conditions on atoms.Application to crystals and crystalline defects: Cohesive energy of an infinitecrystal, crystal defects (vacancies, surfaces, interfaces, dislocations).

Unit – 4 – Modelling and Simulations of Materials

Model systems and interatomic potentials,

Molecular Dynamics: Equations of motion for atomic systems, the basic machineryand finite difference methods, time integration algorithm, starting a simulation,simulation of microcanonical (NVE) and canonical ensemble (NVT), controlling thesystem (temperature, pressure), thermostats and barostats, equilibration, running,measuring and analyzing MD simulation data, measurement of statistical quantities,estimating errors.

References:
1. Condensed Matter in a Nutshell, G. D. Mahan, Princeton University Press, Princeton and Oxford (2011).
2. Modern Quantum Chemistry – Introduction to Advanced Electronics Structure Theory, A Szabo and N. S. Oslund, Dover Publications Inc., Mineola, New York, (1989).
3. Electronic Structure Calculations for Solids and Molecules – Theory and Computational Methods, Jorge Kohanoff, Cambridge University Press, 1 edition (2006).
4. Modelling materials – Continuum, Atomistic, Multiscale Techniques, E. B. Tadmor and R. E. Miller, Cambridge University Press, New York (2011).
5. Computer Simulation of Liquids, M. P. Allen and D. J. Tildesley, Clarendon Press – Oxford, (1991).
6. Understanding Molecular Simulations, D. Frenkel and B. Smit, Academic Press, (2002).

Semester 2: Laboratory Courses

PSMSP201:Characterization of Materials Lab (Practical Lab session 120 hrs and 4 credits)

Students have to perform minimum of 8 experiments from the list given below:

List of Experiments

1. Strain analysis and Particle size determination by XRD and Phase determination by JCPDS.
2. Finding type of molecules and vibration levels using FTIR and Raman Spectra.
3. Study of optical properties of material by using UV-Vis spectroscopy
4. Finding the BET surface area of given material using nitrogen absorption-desorption.
5. Study Luminance material using Photo-Luminance (PL) spectroscopy
6. Indexing of Selected Area Electron Diffraction (SAED) pattern to crystal structure.
7. Determining the elements and its composition by XRF measurement.
8. XPS data analysis: Finding chemical states and chemical shift from XPS spectra.
9. Study crystallization of solids using DSC technique.
10. Mössbauer Spectra analysis of Fe-based specimen: Determination of isomer shift, hyperfine field, estimation of oxidation state in ferrite samples.
11. Thickness and Refractive index measurement using Elipsometery.

PSMSP202:Material Designing and synthesis Lab (Practical Lab session 120 hrs and 4 credits)

Students have to perform minimum of 8 experiments from the list given below:

List of Experiments

1. Handling of Vacuum system and finding pumping characteristic of vacuum pumps.
2. Deposition of metal thin film using thermal evaporation system.
3. Deposition of non-conducting material thin film using RF-magnetron sputtering system.
4. Synthesis of thin film by sol-gel method (Spin-coating & Dip-coating).
5. Constructing material by solid state method
6. Synthesis of Spinel or Perovskites material by chemical methods
7. Designing of material by Computational tools - 1.
8. Designing of material by Computational tools - 2.
9. Studying material properties by Computational tools - 1.
10. Studying material properties by Computational tools - 2.

Semester 3: Theory Courses

PSMS301: Nanoscience and Nanotechnology (60 lectures, 4 credits)

Unit 1:

1. Nanomaterials and Nanotechnologies: An Overview, Why Nanomaterials? Scale, Structure, and Behavior, A Brief History of Materials, Nanomaterials and Nanostructures in Nature.
2. Nanomaterials: Classes and Fundamentals, Classification of Nanomaterials Size Effects, Surface to Volume Ratio Versus Shape, Magic Numbers, Surface Curvature, Strain Confinement
3. Synthesis and Characterization, Synthesis of Nanoscale Materialsand Structures, Methods for Making 0D Nanomaterials, Methods for Making 1D and 2D, Nanomaterials, Methods for Making 3D Nanomaterials, Top-Down Processes, Intermediate Processes, Bottom Up Processes, Methods for Nanoproflling, Characterization of Nanomaterials
4. Cohesive Energy: Ionic solids, Defects in Ionic solids, Covalently bonded solids, Organic crystals, Inert-gas solids, Metals, Conclusion
5. Quantum effect: Quantum wells, wires and dots: Fabricating Quantum Nanostructures: Solution fabrication, Size and dimensionality effects: Size effects, Size effects on conduction electrons, Conduction electrons and dimensionality, Fermi gas and density of states, Potential wells, Partial confinement, Properties dependent on density of states; Excitons, Single electron Tunneling; Applications: Infrared detectors, Quantum dot lasers

Unit 2:

1. Vibrational Properties: The finite One-dimensional monoatomic lattice, Ionic solids, Experimental Observations: Optical and acoustical modes; Vibrational spectroscopy of surface layers of nanoparticles – Raman spectroscopy of surface layers, Infrared Spectroscopy of surface layers; Photon confinement, Effect of dimension on lattice vibrations, Effect of dimension on vibrational density of states, effect of size on Debye frequency, Melting temperature, Specific heat, Plasmons, Surface-enhanced Raman Spectroscopy, Phase transitions.
2. Mechanical Properties of Nanostructured: Materials : Stress-Strain Behavior of materials; Failure Mechanism of Conventional Grain-Sized Materials; Mechanical Properties of Consolidated Nano-Grained Materials; Nanostructured Multilayers; Mechanical and Dynamical Properties of Nanosized Devices: General considerations, Nanopendulum, Vibrations of a Nanometer String, The Nanospring, The Clamped Beam, The challenges and Possibilities of Nanomechanical sensors, Methods of Fabrication of Nanosized Devices

Unit 3:

1. Magnetism in Nanostructures: Basics of Ferromagnetism; Behavior of Powders of Ferromagnetic Nanoparticles : Properties of a single Ferromagnetic Nanoparticles, Dynamic of Individual Magnetic Nanoparticles, Measurements of Superparamagnetism and the Blocking Temperature, Nanopore Containment of Magnetic Particles; Ferrofluids; Bulk nanostructured Magnetic Materials: Effect of nanosized grain structure on magnetic properties, Magnetoresisitive materials, Antiferromagnetic nanoparticles.
2. Electronic Properties: Ionic solids, Covalently bonded solids; Metals: Effect of lattice parameter on electronic structure, Free electron model, The Tight-Binding model; Measurements of electronic structure of nanoparticles: Semiconducting nanoparticles, Organic solids, Metals.
3. Nanoelectronics: N and P doping and PN junctions, MOSFET, Scaling of MOSFETs; Spintronics: Definition and examples of spintronic devices, Magnetic storage and spin valves, Dilute magnetic semiconductors; Molecular switches and electronics: Molecular switches, Molecularelectronics, Mechanism of conduction through a molecule; Photonic crystals.

Unit 4:

1. An introduction to nanochemistry concepts: Nanochemistry introduction, Surface, Size, Shape, Self-assembly, Defects, The bio-nano interface, Safety.
2. Gold nanoparticles: Introduction, Surface, Size, Shape, Self-assembly, Defects,
3. Cadmium Selenide nanoparticles: Introduction, Surface, Size, Shape, Self-assembly, Defects,
4. Iron Oxide: Introduction, Surface, Size, Shape, Self-assembly, Bio-nano, Iron Oxide-Nano.
5. Carbon: Introduction, Surface, Size, Shape, Self-assembly, Bio-nano, Conclusion,
6. Carbon Allotropy: Nature of the carbon bond, New Carbon clusters: Small Carbon clusters, Buckyball, The structure of molecular C60, Crystalline C60, Larger and smaller Buckyballs, Buckyballs of other atoms; Carbon nanotubes: Fabrication, Structure, Electronic properties, Vibrational properties, Functionalization, Doped Carbon Nanotubes, Mechanical properties; Nanotube Composites: Polymer-carbon nanotube composites, Metal-Carbon nanotube composites; Graphene nanostructures.

Main References:

[1] The Physics and Chemistry of Nanosolids, Frank J. Owens and Charles P. Poole, Wiley-Interscience, 2008.

[2] Nanomaterials, Nanotechnologies and Design: An Introduction for Engineers and Architects, Daniel L. Schodek, Paulo Ferreira, Michael F. Ashby, Publisher: Butterworth-Heinemann Ltd.

[3] Concepts of Nanochemistry, LudovicoCademartiri and Geoffrey A. Ozin, Wiley-VCH, 2009.

PSMS302: Materials for Energy and Environmental applications (60 lectures, 4 credits)

Unit 1: Material for Energy conversion

Introduction to energy conversion, Photovoltaic: Solar energy, semiconductor physics,p-n junction, and photovoltaic cells, Design of Solar Cells, Photovoltaic device fabrication and characterization, silicon based solar cells, design of new generation solar cells (hybrid, quantum dot, dye-sensitized and perovskite solar cells),

Fuel Cells and its applications: Fuel Cells, components of fuel cells, difference between batteries and fuel cells, principle of working of fuel cell, Types of fuel cells, Acid/alkaline fuel cells, polymer electrolyte fuel cell, phosphoric acid fuel cell, molten carbonate fuel cell, solid oxide fuel cell.

Thermoelectric Materials: Fundamentals of thermoelectricity (Seebeck, Peltier and Thomson effects), Thermoelectric Effects and Transport Properties, Basics of Thermoelectric devices, Heat Conduction in Bulk Thermoelectric Materials (Heat Conduction by Phonons, Heat Conduction by Electrons), Progress in Thermoelectric Materials (Bulk Thermoelectric Materials, Nanostructured Thermoelectric Materials), Reduction of Thermal Conductivities in Bulk and Nanostructured Materials), Thermoelectric Devices.

Unit 2: Materials for Energy Storage

Batteries and Super capacitors for electrochemical energy storage:Batteries – primary and secondary batteries, Lithium, Solid-state and moltensolvent batteries; Lead acid batteries; Nickel Cadmium Batteries; AdvancedBatteries, Super capacitors for energy storage. Role of carbon nanomaterials aselectrodes in batteries and super capacitors. Cell characterization: (Charging/discharging cycles, overpotential, battery capacity, state of charge, state of health, impedance spectroscopy)

Hydrogen energy – merits as a fuel – production of hydrogen – fossil fuels, electrolysis, thermal decomposition, photochemical and photocatalytic methods. Hydrogen storage – metal hydrides, metal alloy hydrides, carbon nanotubes, sea as source of deuterium.

Applications of Superconductors in Energy Superconducting wires and their characteristics, High field magnets for production of energy by magnetic fusion, Energy generation-Magnetohydrodynamics (MHD), energy storage, electric generators and role of superconductors. Large scale applications of superconductors Electric power transmission, Applications of superconductor in medicine - Magnetic Resonance Imaging (MRI), Superconducting Quantum Interference Devices (SQUID).

Material for Composite for wind energy: Wind Turbine Rotor Blades: Construction, Loads and Requirements, carbon fibers, thermoplastic.

<u>Unit 3: Catalysis and Photocatalysis</u>

Introduction to catalysis: Physical and Chemical adsorption, adsorption isotherms, chemisorption on metals and metal oxides. Catalysis: concept of activity, selectivity, poisoning, promotion and deactivation. Types of catalysis: homogeneous, heterogeneous, electrocatalyst, photocatalyst, biocatalyst. Thermodynamics and kinetics of Heterogeneous catalysis, concept of Langmuir-Hinshelwood kinetics.

Role of catalyst in Energy generation such as in hydrocarbon fuel generation, in fine chemicals, in hydrogen generation, and in biofuel.

Role of catalyst in Environmental purification: Catalyst for vehicle auto-exhaust, VOC removal, Ozone decomposition. Photocatalyst: Concept and mechanism of photocataysis in semiconductor. Photocatalytic applications: removal of organic pollutant from water and air, antibacterial, self-cleaning, antifogging.

<u>Unit 4: Microporous and Mesoporous Materials</u>

Types of porous materials, Order and disordered microporous and mesoporous structure, Zeolites, metallosilicates, silicalites and related microporous materials, Mesoporous silica, metal oxides, Metal-organic Framework, porous organic polymers, Synthesis of microporous and mesoporous Materials;

Applications of microporous and mesoporous Materials in energy and environment: Biofuels generation, sensing, adsorption and gas storage, support for catalyst, CO2 sequestration and storage, separation technology, environmental protection, electrochemistry, membranes, sensors, and optical devices

PSMS303: Materials for Electronics, Photonics and Sensors (60 lectures, 4 credits)

Unit 1: Materials for Electronics-I

p-n junction : Fabrication of p-n junction by diffusion and ion-implantation; Abrupt and linearly graded junctions; p-i-n diode; Tunnel diode, Introduction to p-n junction solar cell and semiconductor laser diode Metal – Semiconductor Contacts: Schottky barrier, Ohmic contacts, Bipolar Junction Transistor (BJT): Static Characteristics; Frequency Response and Switching. Semiconductor heterojunctions, Heterojunction bipolar transistors, Quantum well structures

Unit 2: Materials for Electronics-II

Metal-semiconductor field effect transistor (MESFET)- Device structure, Principles of operation, Current voltage (I-V) characteristics, High frequency performance.

Modulation doped field effect transistor (MODFET); Introduction to ideal MOS device; MOSFET fundamentals, Introduction to Integrated circuits.

Modern Semiconductor (III-V and III-N compounds, II-VI and I-III-VI_2 binary, ternary, and Quaternary semiconductors), Spintronics materials, Dilute magnetic semiconductors, Magnetites, Giant-magneto resistance

Unit 3: Materials for Photonics

Lasers: Population inversion for laser action, resonant cavities, types of resonators, Gas lasers, soild state lasers, Semiconductors lasers. LEDs, Photodetectors,Photodiode, PIN photodiode. Integrated Optoelectronics materialsOptical processes in quantum wells: Interbandand Intraband transitions in quantum wells. Introduction to non-linear optics (ONL), ONL materials,

Waveguides, Resonators and Components: Rectangular waveguides, Circular and other waveguides, Waveguide coupling, matching and attenuation. Quasicrystals, Photonics swtiches

Unit 4: Materials for Sensors

Piezoelectric Smart Materials: Background, Electrostriction, Pyroelectricity, Piezoelectricity, Industrial piezoelectric materials

Shape memory (SM) materials: shape memory effect and martensitic transformation, SME and Superelasticity. Ti-Ni SM Alloys, Cu-based SM Alloys. Ferrous SM alloys. Shape memory ceramics and polymers.

Temperature sensors: resistance thermometers, thermoemf, thermisters, radiation pyrometers, thermography

PSMS304: Soft Condense Matter and Biomaterials (60 lectures, 4 credits)

Unit 1: Liquid Crystal Material

Classification of liquid crystals and different types of mesophases, Calamitic liquid crystals, Polymeric liquid crystals, Chiral liquid crystals, Lyotropic liquid crystals, Polymer Dispersed Liquid Crystals (PDLC), and Liquid Crystal Elastomers (LCE).

Properties: dielectric properties, optical properties, viscoelastic properties, Electro optical Properties: Cholesteric, Ferroelectric, Antiferroelectric, Electric and magnetic anisotropy. Survey over flat panel technologies. Liquid crystal displays, Applications of liquid crystals, Future scope of PDLCs and LCEs

Unit 2: Advance Polymer Materials

Recent advancement in polymers and their applications: Smart polymers, stimuli sensitive polymers, hydrogels, smart polymers as sensors, conducting polymersPolymeric resins, magnetic polymers, polymers for space, nonlinear optical polymers, Importance of polymer blends/composites. Polymeric biomaterials: Introduction, preparation, hydrogel biomaterials, Bioconjugation techniques

Unit 3: Biomaterial-I

Introduction to biomaterials; need for biomaterials; Property requirement of biomaterials; Concept of biocompatibility; Assessment of biocomatibility of biomaterials, Chemicalstructure and property of biomaterials, Degradation of biomaterials,Bioceramic materials: bioactive calcium phosphates, bioglass and glass ceramics Processing and properties of different bioceramic materials; Biomaterials used in bone and joint replacement: metals and alloys – Stainless steel, cobalt based alloys, titanium based materials

Unit 4: Biomaterial-II

Metallic implant materials, ceramic implant materials, polymeric implant materials, composites as biomaterials; Orthopedic, dental and other applications

iomaterials for drug delivery, timed release materials; biodegradable polymers; Bloodcompatible materials; Biomimetics; Bone biology: bone architecture, collagen, osteoblasts,osteoclasts, etc; Protein mediated cell adhesion;

Introduction to tissue engineering; Applications of tissue engineering;Biomaterials in ophthalmology – Viscoelastic solutions, contact lenses, intraocularlens materials – Tissue grafts – Skin grafts

Semester 3: Laboratory Courses

PSMSP301:Nanomaterial and Functional Materials Lab(Practical Lab session 120 hrs and 4 credits)

Students have to perform minimum of 8 experiments from the list given below:

List of Experiments

1. Synthesis of Nano-metals (Ag, Au, Cu) and studying its optical properties.
2. Fabrication of Nano-Semiconductor or quantum dots (CdS, Si) and determine its band gap.
3. Synthesis of Catalyst Material.
4. Fabrication ofphotocatalyst Material (TiO2 and ZnO).
5. Studying the properties of 2D Graphene material.
6. Investigating the properties of shape memory alloy material.
7. Studying Antibacterial effect by Ag nanoparticles
8. Realizing conducting polymer and measuring its electrical properties.
9. Synthesis of porous materials such as mesoporous silica.
10. Synthesis of Pizoelectric material (Barium Titanate)
11. Examining the properties of Liquid crystal.

PSMSP302:Applied Materials Lab (Practical Lab session 120 hrs and 4 credits)

Students have to perform minimum of 8 experiments from the list given below:

List of Experiments

1. Finding the characteristics of Solar-cell.
2. Studying the properties of thermoelectric material.
3. Organic pollutant removal from water using photocatalyst material.
4. Determining the bio-compatibility of Bio-materials
5. Tracking of first and second order transition by resistivity measurement in shape memory (NiTi) alloy

6. Optical fibers- Attenuation and dispersion measurements.
7. Electrochemical characterization of Battery material
8. Experiments on spectral response of solar panel.
9. Catalyst application for H2 production by water splitting.
10. Measurement of thermo-emf of Iron-Copper (Fe-Cu) or chromel-alumel thermocouple as a function of temperature.
11. Voltage-Temperature characteristics of a Silicon diode sensor

Semester 4: Project Work

PSMSP401: Dissertationbased Project work

Introduction

In the project courses, the student can perform an experimental/computational project based on material Science under supervision of one or more faculty members. As a part of the project, the student is expected to learn the basics of the topic chosen, learn how to do literature survey and learn and set up the basic experimental /computational techniques needed for the project. Students are expected to counter novel research problems and define the objectives of the project till the mid SEM. The student can do an industry based project and/or a project in collaboration with other institutes like UM-DAE CBS, TIFR, BARC, ICT, IIT, SAMEER, IIG or any other institute. The necessary research funding upto certain limit will be provided by university. Students have to prepare and submit a Master level thesis and the final evaluation will be done by external field expert on the bases of the quality of the thesis and Viva-Voce examination. Students participation in conference presentations and publishing papers in peer reviewed journals will be appreciatedand rewarded.