Annexure-116
12

Item-55
09-01-2020

कुलपति सचिवालय
डायरी सं. 682
दिनांक 06.01.2020

Diary No.: PHY/05
Date: 06/01/2020

To,

Date: 06/01/2020

The Controller of Examination,
Central University of South Bihar,
Gaya

Sub: Regarding Commencement of new Courses in the School of Physical & Chemical Sciences.

Ref: Minutes of the meeting with HoD with honorable Vice Chancellor held on 4th December, 2019.

Dear Ma'am,

With reference to the requested information during the meeting held on 4th December, 2019 in honorable Vice Chancellor office, hereby, please find the details of new courses for the B. Sc. Honours with Physics and Two specializations offered in M. Sc. (Physics) from the Department of Physics in the coming academic session 2020-21 and the same is approved by their Departmental Council.

The Department of Chemistry is also proposing a new course for the B. Sc. Honours with Chemistry in the coming session 2020-21 and the same is also approved by their Departmental Council.

Kindly do the needful and necessary action and allow us to run the above proposed courses from the mentioned session.

Thanking you

With best regards,

06.01.2020

Dean
School of Physical and Chemical Sciences
CUSB, Gaya

Take it to Academic Council.

9/1/2020

DR(Acad)

9.1.2020

C.O.(Acad)

Enclosure: **1)** Copy of DC meeting held on January 03, 2020.

2) Copy of the HoDs meeting with the Honorable VC, CUSB dated December 4, 2019.

3) VC, CUSB, Gaya for kind information

Sh. Manish

09/1/20

कुलसचिव कार्यालय
डायरी सं० 106
दिनांक 08.01.20

Diary No.: PHY/04
Date: 06/01/2020

COE-2296
08/01

To,

Date: 06/01/2020

The Controller of Examination,
Central University of South Bihar,
Gaya

Sub: Regarding Commencement of new Courses in the School of Physical & Chemical Sciences.

Ref: Minutes of the meeting with HoD with honorable Vice Chancellor held on 4th December, 2019.

Dear Ma'am,

With reference to the requested information during the meeting held on 4th December, 2019 in honorable Vice Chancellor office, hereby, please find the details of new courses for the B. Sc. Honours with Physics and Two specializations offered in M. Sc. (Physics) from the Department of Physics in the coming academic session 2020-21 and the same is approved by their Departmental Council.

The Department of Chemistry is also proposing a new course for the B. Sc. Honours with Chemistry in the coming session 2020-21 and the same is also approved by their Departmental Council.

Kindly do the needful and necessary action and allow us to run the above proposed courses from the mentioned session.

May like to see for further directives. 8/1

VC Take it to Academic Council

8/1/2020

Thanking you

With best regards,

08.01.2020

Dean,
School of Physical and Chemical Sciences
CUSB, Gaya

Reg

Enclosure: 1) Copy of DC meeting held on January 03, 2020.

2) Copy of the HoDs meeting with the Honorable VC, CUSB dated December 4, 2019.

3) VC, CUSB, Gaya for kind information

Date: 06/01/2020

To,
The Controller of Examination,
Central University of South Bihar,
Gaya

Sub: Regarding Commencement of new Courses in the Department of Physics.

Ref: Minutes of the meeting with HoD with honorable Vice Chancellor held on 4th December, 2019.

Dear Ma'am,

With reference to the requested information during the meeting held on 4th December, 2019 in honorable Vice Chancellor office, hereby, please find the details of new courses for the B. Sc. Honours in Physics and Two specializations offered in M. Sc. (Physics) in the Department of Physics from the coming academic session 2020-21.

Kindly do the needful and necessary action.

Thanking you and with best regards,

06.01.2020

Head,
Department of Physics
CUSB, Gaya

Head
Department of Physics
Central University of South Bihar,Gaya

Enclosure: **1)** Copy of DC meeting held on January 03, 2020.

2) Copy of the HoDs meeting with the Honorable VC, CUSB dated December 4, 2019.

3) VC, CUSB, Gaya for kind information

Minutes

Physics Department's Teacher's Council
Central University of South Bihar
Friday, 3rd January, 2020 - (11:00 - 12:00 Hours)

Meeting Starts: 11:03 Hrs

A meeting of teacher's council of department of Physics in the Central University of South Bihar was held on 3rd January, 2020 at head's chamber. It began at 11:00 AM and was presided over by Prof. Venktesh Singh, with Dr. Budhendra Singh as member secretary.

In attendance:

Member's of Teacher's Council : Dr. Vijay Raj Singh, Dr. A. Kumar, Dr. N. Chandra, Dr. R. R. Sahi, Dr. Puneet Mishra, Dr. Lakhwinder Singh

Agenda

- Modification of syllabus for Post Graduate and proposal to start Undergraduate program in Physics

Teacher's Council :

- All members unanimously agreed upon putting up a proposal to start M.Sc. specialization modules i.e. Condensed Matter Physics and Nuclear & Particle Physics. In addition, to improve academic standard and quality, all members suggested to modify the present course content.
- A proposal to start 3 year undergraduate B.Sc. (Honors) program with physics was unanimously accepted by all the member and it was decided to follow the course structure according to the UGC approved course contents as per CBCS guidelines.
- All members suggested to submit the proposal and modification to the competent authority for further action.

Closing remarks were given by Prof. Venktesh Singh, the Chairman of Teacher's council, who directed the respective members to prepare the complete structure of the respective course modules for specialization including core and elective papers. In addition, it is instructed to initiate the necessary action to implement modified PG programme and new UG program with Physics as per UGC guidelines.

Meeting Closed: 12:10 Hrs

03.01.2020

Prof. Venktesh Singh
Chairman,

Dr. Budhendra Singh
Secretary,

Members Teacher's council:

03/01/2020

Dr. A. Kumar

03/01/2020

Dr. P. Mishra

Dr. R. R. Sahi

Dr. N. Chandra

Dr. L. Singh

Dr. Vijay Raj Singh

दक्षिण बिहार केन्द्रीय विश्वविद्यालय
CENTRAL UNIVERSITY OF SOUTH BIHAR
SH-7, Gaya – Panchanpur Road, Village – Karhara, Post-Fatehpur
P.S. – Tekari, District – Gaya (Bihar) PIN- 824236

MINUTES OF THE MEETING WITH HEADS OF ALL DEPARTMENTS

DATE - 04/12/2019 **TIME - 4:00 PM**

The meeting of the Heads of all Departments under the Chairmanship of Hon'ble Vice-Chancellor was held on 04/12/2019 at 04:00 PM in the conference room at CUSB to discuss various issues pertaining to academic matters.

The Vice Chancellor welcomed all Head of Departments specially those who have joined the University recently after last recruitment drive. After the opening remarks of Hon'ble Vice Chancellor, the Controller of Examinations briefed the issues to be discussed in the meeting.

The following points were discussed :-

1. ***To discuss the list of Holidays & Academic Calendar for 2020.***

   The Controller of Examinations conveyed that suggestion have been received from faculty members to keep the Academic Calendar 2020 in line with Holidays notified by Government of India and do away the practice of closing of the University during Deepawali and Chhatha and adjacent days of Holi festival and in lieu opening of the University on Saturdays. The matter was discussed at length and it was agreed upon to carry on the practice being followed by the University for Academic Calendar 2020. It was decided to keep the University open on Saturdays in lieu of extra holidays to compensate the teaching loss and to fulfil the minimum requirement of teaching days.

2. ***To discuss the status of updation of student's marks on ERP portal.***

   All Head of Departments briefed about the status of entries of students' marks of Continuation Evaluation and Semester Examination on ERP portal made by their respective Departments.

3. ***Evaluated answer scripts shown to students as per Ordinance Clause 14.6.1.***

   The Controller of Examinations informed that in the recent past few grievances from the students have been received regarding evaluation of answer scripts. The concerned students had approached to the office with the grievance that the evaluated answer script was not shown to them. In this regard, the Hon'ble Vice Chancellor invited the attention of Heads of all Departments to clause No.-14.6.1 of Ordinance and instructed them to follow the provision scrupulously and to show the evaluated answer script to the students. It was decided that each faculty should notify the dates to the students well in advance.

8. ***Online Result Publication has been started.***

The Controller of Examinations informed that from Academic Year 2018-19, the Semester results are being declared on ERP Portal and semester grade report can be downloaded by the students from ERP Portal directly.

9. ***To apprise about CUCET-2020 and preparation of Prospectus 2020 - requirement of School / Department content, Photograph and course structure. Any new courses to be launched in the existing Departments.***

The Controller of Examinations informed that alike previous year, the University shall be a part of CUCET-2020. The process of inviting application for admission in Academic Year 2020 shall be started in the month of February 2020. She requested all Heads of Departments to send the content about the Schools/Departments, programmes of studies offered by their respective Department along with course structure so that the same may be incorporated in the Prospectus 2020 and uploaded on University website. She also informed if the Departments intend to start new programme in forthcoming session, the details should be sent to office at the earliest but not later than 6th January, 2019. It was agreed upon to offer the PhD programmes in Department of History, Chemistry, and Commerce etc. where eligible faculty members are available. Accordingly it was decided to take admission in PhD in January 2020 twice a year.

10. ***Ph.D. Admission***

The Hon'ble Vice Chancellor on request of certain new department directed that from January 2020, Ph.D. admission may be carried out twice a year, i.e. through CUCET for NET/JRF/Non-NET students in July every year and in January only for NET /JRF students directly through walk in interview process.

All Head of Departments desirous of admitting Ph.D. Students in January 2020 may conduct their DC meeting and submit their consent/ denial latest by 18th December, 2019 to the office of Controller of Examinations.

The meeting ended with Vote of Thanks to the Chair.

(Rashmi Tripathi)
Controller of Examinations

(Prof. H.C.S. Rathore) 13/12/19
Vice-Chancellor

2. SCHOOL OF PHYSICAL & CHEMICAL SCIENCES

2.1 Department of Physics

The Department of Physics, under the umbrella of School of Physical & Chemical Sciences, has been providing support to the undergraduate programs of Central University of South Bihar (CUSB) since its inception. The M.Sc. Degree Program in Physics was launched from the academic session 2018-19 with the intake of 35 students and from academic session 2019-20, the Department is running the Ph.D. programme in various frontier areas of physics such as experimental nuclear and high energy physics, theoretical high energy physics, experimental condensed matter physics and material science, and theoretical superconductivity and nanoscience. In addition, from the upcoming session 2020-21, the Department is going to start one major undergraduate programme namely B. Sc. Honours with Physics – a three year degree course as per UGC CBCS norms. From the same academic session, Physics Department is going to offer two specializations in postgraduate programmes such as Condensed Matter Physics, and Nuclear & Particle Physics.

The Department of Physics is committed to engage in high quality research and in the pursuit of excellence in teaching. The faculty members of the Department are actively involved in cutting-edge theoretical and experimental research in challenging areas as mentioned above. To promote interdisciplinary research for solving grand challenges facing our society, the Department is highly involved with the various innovation centres of the country. The faculty members of the Department of Physics are significantly contributing in the National and International research collaborations.

2.1.1 Ph.D. in Physics

The broad areas of research in the Department of Physics are hard/soft condensed matter physics, spectroscopy, nanoscience and nanotechnology, materials science, and high energy physics, nuclear and astroparticle physics. In due course, we will also open research areas related to computational physics, theoretical biophysics, and space physics. All the students will be required to successfully complete the course work before beginning the research towards their Ph.D. thesis. The tentative course work structure, subjected to the approval from the Board of Studies, is as follows:

Course Code	Course Title	Credits
Core	Research Methodology	4
Core	Theoretical and Experimental Techniques of Physics Research	4
Core	Review, Report and Seminar	2
Core	Research and Publication Ethics (RPE)	2

2.1.2 M.Sc. in Physics

The objectives of this program are to cater and to meet the needs and aspirations of contemporary M.Sc. Physics students. It is tailored to incorporate the essential ingredients of multifaceted education and research for this rapidly changing world. This program aims to provide the much needed and strong foundation in Physics so that students can (i) develop the ability to apply the knowledge of Physics in any allied fields, (ii) develop the programming proficiency with high-end software for both computation and automation, (iii) get acquainted with cutting-edge scientific equipment, (iv) obtain a platform to kicks start their innovative ideas for future applied research career, (v) improve soft skills to build their professional career. In addition to these, specialised courses in nuclear and particle physics will train them to understand the basic, fundamental and somewhat advanced concepts about radiation safety and nuclear & particle physics making them ready to contribute towards the country's nuclear energy and safety programmes. Over all these courses are designed in such a way that it will help them to contribute towards societal development and to make their life better.

List of Courses in M.Sc. Physics from Academic Session 2020-2021 (96 Credits)

Course Code	Course Title	Credit		
Semester - I		**L**	**T**	**P**
MSPHY1001C04	Mathematical Physics	4	0	0
MSPHY1002C04	Classical Mechanics	4	0	0
MSPHY1003C04	Quantum Mechanics	4	0	0
MSPHY1004C04	General Physics Lab. – I	0	0	4
MSPHY1005E04	Electronics	4	0	0
MSPHY1006E04	Experimental Techniques	4	0	0
MSPHY1007E02	Biography of Indian Scientists	2	0	0
	Elective – I (From other department)	4	0	0
Total Credits		**30**		
Semester - II		**L**	**T**	**P**
Course Code	**Course Title**	**Credit**		
MSPHY2001C04	Thermodynamics and Statistical Physics	4	0	0
MSPHY2002C04	Classical Electrodynamics and Relativity	4	0	0
MSPHY2003C04	General Physics Lab. – II	0	0	4
MSPHY2004C04	Atomic and Molecular Physics	4	0	0
MSPHY2005C02	Elementary Solid State Physics	2	0	0

MSPHY2006C02	Elementary Nuclear & Particle Physics	2	0	0
MSPHY2007E04	Advanced Quantum Mechanics	4	0	0
MSPHY2008E04	Advanced Mathematical Physics	4	0	0
MSPHY2009E04	Introduction of Ancient Indian Sciences	4	0	0
Total Credits		**32**		
Semester-III (Specialization in Condensed Matter Physics)		**L**	**T**	**P**
Course Code	**Course Title**	**Credit**		
MSPHY3001C04	Condensed Matter Physics	4	0	0
MSPHY3002C04	Solid State Devices	4	0	0
MSPHY3003C04	Solid State Physics Lab - I	0	0	4
MSPHY3004E04	Materials Science	4	0	0
MSPHY3005E04	Crystal Growth and Characterizations	2	0	2
MSPHY3006E04	Crystallography Crystal Structure and Diffraction Techniques	2	0	2
MSPHY3007E04	Fundamentals of nanoscience and nanotechnology	4	0	0
MSPHY3008E02	Physics of Dielectric and Ferroelectric Materials	2	0	0
MSPHY3009E02	X-ray Spectroscopy	2	0	0
MSPHY3010E02	Diffusion in Solids	2	0	0
MSPHY3011E04	Fundamentals of Scanning Probe Microscopy	4	0	0
	Elective - III (from other Department)	4	0	0
Total Credits		**42**		
Semester-IV (Specialization in Condensed Matter Physics)		**L**	**T**	**P**
Course Code	**Course Title**	**Credit**		
MSPHY4001C04	Advanced Condensed Matter Physics	4	0	0
MSPHY4002C04	Dissertation	4	0	0
MSPHY4003C04	Solid State Physics Lab - II	0	0	4
MSPHY4004E04	Physics of Magnetism and Spintronics	4	0	0
MSPHY4005E04	Alloy Design and Development	2	0	2

MSPHY4006E04	Material Synthesis and Processing	2	0	2
MSPHY4007E04	Renewable Energy	4	0	0
MSPHY4008E04	Carbon Nano-structures and Their Properties	2	0	2
MSPHY4009E04	Biomedical Instrumentation	4	0	0
MSPHY4010E04	Industrial Process Control	4	0	0
MSPHY4011E04	Nanoscale Characterization Techniques	4	0	0
MSPHY4012E04	Nanoelectronics	4	0	0
Total Credits		**48**		
Semester-III (Specialization in Nuclear and Particle Physics)		**L**	**T**	**P**
Course Code	**Course Title**	**Credit**		
MSPHY3101C04	Advanced Nuclear Physics	4	0	0
MSPHY3102C04	Nuclear & Particle Physics Lab. – I	0	0	4
MSPHY3103C04	Advanced Particle Physics	4	0	0
MSPHY3104E04	Introduction of Astrophysics	4	0	0
MSPHY3105E04	Nuclear Reactor Physics	4	0	0
MSPHY3106E04	Statistical Analysis Techniques in Nuclear and Particle Physics	4	0	0
MSPHY3107E02	Radiation Safety	2	0	0
MSPHY3108E02	Neutrino Physics	2	0	0
	Elective – I (from other department)	4	0	0
Total Credits		**32**		
Semester - IV (Specialization in Nuclear and Particle Physics)		**L**	**T**	**P**
Course Code	**Course Title**	**Credit**		
MSPHY4101C04	Experimental Techniques in Nuclear and Particle Physics	4	0	0
MSPHY4102C04	Dissertation	0	0	4
MSPHY4103C04	Nuclear & Particle Physics Lab. – II	0	0	4
MSPHY4104E04	Particle Accelerator Physics	4	0	0
MSPHY4105E04	Data Analysis and Simulation in particle Physics	4	0	0

MSPHY4106E04	General Theory of Relativity	4	0	0
MSPHY4107E02	High Energy Cosmic Rays	2	0	0
MSPHY4108E02	Dark Matter Physics	2	0	0
Total Credits		**28**		

2.1.3 B.Sc. Honours with Physics

The objectives of this programme are to create bright brain to cater and meet, the needs and aspirations of contemporary B.Sc. Honours with Physics students. This programme will boost up Departmental ongoing postgraduate and doctorate programmes. The Central University of South Bihar is the first in the Bihar state that started B.Sc. Honours with Physics. This program aims to (i) provide the much needed and strong foundation in Physics so that students can develop the ability to apply the knowledge of Physics in any allied fields, (ii) give students an opportunity to use advanced laboratory equipment to get acquainted with them and make their carrier in advanced higher education in physics, and (iii) present a platform to the students for advance training and in depth physics knowledge.

List of Courses in B.Sc. Honours with Physics from Academic Session 2020-2021
(140 Credits Based on Choice Based Credit System (CBCS))

Course Code	Course Title	Credit		
Semester-I		**L**	**T**	**P**
BSPHY1001C06	Mathematical Physics - I	4	0	2
BSPHY1002C06	Mechanics	4	0	2
BSPHY1003AECC02	Environmental Science / (English / MIL Communication)	2	0	0
	GE-1*	4/5	0/1	2/0
Minimum Required Credits		**20**		
Semester - II		**L**	**T**	**P**
Course Code	**Course Title**	**Credit**		
BSPHY2001C06	Electricity and Magnetism	4	0	2
BSPHY2002C06	Wave and Optics	4	0	2
BSPHY2003AECC02	Environmental Science / (English / MIL Communication)	2	0	0

	GE – II*	4/5	0/1	2/0
Minimum Required Credits		**20**		
Semester-III		**L**	**T**	**P**
Course Code	**Course Title**	**Credit**		
BSPHY3001C06	Mathematical Physics - II	4	0	2
BSPHY3002C06	Thermal Physics	4	0	2
BSPHY3003C06	Digital Systems and Applications	4	0	2
BSPHY3004SEC02	Computational Physics Skills	2	0	0
BSPHY3005SEC02	Basic Instrumentation Skills	2	0	0
	GE – III*	4/5	0/1	2/0
Minimum Required Credits		**26**		
Semester-IV		**L**	**T**	**P**
Course Code	**Course Title**	**Credit**		
BSPHY4001C06	Mathematical Physics - III	4	0	2
BSPHY4002C06	Elements of Modern Physics	4	0	2
BSPHY4003C06	Analog Systems and Applications	4	0	2
BSPHY4004SEC02	Radiation Safety	2	0	0
BSPHY4005SEC02	Renewable Energy and Energy Harvesting	2	0	0
	GE – IV*	4/5	0/1	2/0
Minimum Required Credits		**26**		
Semester-V		**L**	**T**	**P**
Course Code	**Course Title**	**Credit**		
BSPHY5001C06	Quantum Mechanics and Applications	4	0	2
BSPHY5002C06	Solid State Physics	4	0	2
BSPHY5003DSE06	Advanced Mathematical Physics - I	5	1	0
BSPHY5004DSE06	Physics of Devices and Communication	4	0	2
BSPHY5005DSE06	Astronomy and Astrophysics	5	1	0

BSPHY5006DSE06	Nano Materials and Applications	4	0	2
Minimum Required Credits		**24**		
Semester - VI		**L**	**T**	**P**
Course Code	**Course Title**	**Credit**		
BSPHY6001C04	Electromagnetic Theory	4	0	2
BSPHY6002C04	Statistical Mechanics	4	0	2
BSPHY6003DSE06	Experimental Techniques	4	0	2
BSPHY6004DSE06	Advanced Mathematical Physics - II	5	1	0
BSPHY6005DSE06	Classical Dynamics	5	1	0
BSPHY6006DSE06	Nuclear and Particle Physics	4	0	2
BSPHY6007DSE06	Dissertation	6		
Minimum Required Credits		**24**		
Grand Total Credits		**140**		

* GE papers may be chosen from the currently running courses in the Department of Chemistry. Students may also opt the previous semester paper of the Chemistry Department according to the running semester.

Puneet Mishra 06.01.2020

06.01.2020

6/1/20

06/01/2020

06.01.2020

Nitin Chandra

6.1.20

S. N.	Programme	Intake	Eligibility
1	B.Sc. Honours Chemistry (3 year)	15	10+2 or equivalent examination in Science stream from any recognized Board/University with a minimum of 50% marks for General / OBC and 45 % marks for SC/ST candidates.
2	B.Sc. Honours Physics (3 year)	15	10+2 or equivalent examination in Science stream including Physics and Mathematics from recognized Board/University with a minimum of 50% marks for General / OBC and 45 % marks for SC/ST candidates.

Nitin Chaudhary

Puneet Mishra
06.01.2020

06.01.2020

Prof. L-

06/01/2020

06/01/2020

6.1.20

6/01/2020

Department of Chemistry
Central University of South Bihar

Ref No. CUSB/CHE/2020/01 Date: 06/1/2020

To

The COE

Central University of South Bihar,

Gaya

Subject: Regarding starting of BSc (Honours) with Chemistry programme in the Department of Chemistry and modifications in the Prospectus for 2020-21

Respected Madam,

In reference to minutes of meeting of all the head of the Department dated 04-12-2019, Kindly find enclosed a proposal for starting BSc (Hons) with Chemistry programme and modifications in the Prospectus for 2020-21 from department of Chemistry. I would like to submit that we have adapted the course structure and syllabus for the programme as suggested by the University Grant commission for the BSc (Honours) in Chemistry. Recommendation of the department council, course structure and syllabus are enclosed for your kind information and perusal please. Some modifications for the Prospectus 2020-21 are also enclosed.

Submitted for necessary action please.

Sincerely

Faculty members

Dr. Vinod Kumar
Professor

Dr. Amiya Priyam
Associate Professor

Dr. Jagannath Roy
Associate Professor

Girish Chandra 6/1/2020
Dr. Girish Chandra
Assistant Professor

Dr. Angad Kumar Singh
Assistant Professor

Dr. K Mahender
Assistant Professor

Vinod Kumar
Professor and Head
Department of Chemistry
CUSB

Copy to

Vc office

Department of Chemistry
Central University of South Bihar

Ref No.....CUSB/CHE/2020/02 Date: 06/9/2020

Subject: Regarding starting of BSc (Honours) with Chemistry programme from academic session 2020-21

A meeting of the department council was held on Jan. 3, 2020 regarding discussion on starting of an undergraduate programme, BSc (Hons) with Chemistry. It was realized that quality of the students we are getting for postgraduate programme in the department is not up to the mark. Hence it was proposed that an undergraduate programme may be started in the department so that we can get well trained students for the master programme.

It was unanimously proposed that:

1. An undergraduate programme, BSc (Honours) with Chemistry may be started in the department from academic session 2020-21
2. The course structure and syllabus for the programme will be adapted from the UGC

Submitted for kind approval please.

Sincerely

Faculty members

Dr. Vinod Kumar
Professor

Dr. Amiya Priyam
Associate Professor

Dr. Jagannath Roy
Associate Professor

Dr. Girish Chandra 3/1/2020.
Assistant Professor

Dr. Angad Kumar Singh
Assistant Professor

Dr. K Mahender
Assistant Professor

Vinod Kumar
Professor and Head
Department of Chemistry
CUSB

2.2.3 B.Sc. Honours with Chemistry

S.No	Programme	Intake	Eligibility
1	BSc (Honours) with Chemistry	15	10+2 or equivalent examination with chemistry as one of the subjects from any recognized Board/university with atleast 50 % marks for general/OBC and 45 % marks for SC/ST candidates

The objective of this programme is to groom young mind and inspire them to take Chemistry as career. The programme is designed to meet the needs and aspirations of contemporary students opting for undergraduate programme with chemistry. This programme will also help in providing well trained, and motivated students for the ongoing master and doctorate programmes of the Department. This program aims to (i) provide the student a strong foundation and skills so that they can apply the knowledge in the advancement of chemistry and related fields, (ii) Train the students with the help of state in art laboratory equipment to get them acquainted with technical skills required in the field (iii) present a platform to the students for advance training and in-depth chemistry knowledge and (iv) equip the students with required skills and knowledge so that they can compete at the International level.

List of Courses in B.Sc. Honours with Chemistry from Academic Session 2020-2021
(140 Credits Based on Choice Based Credit System (CBCS))

Semester-I				
Paper Code	**Course Title**	**Credits**		
		L	**T**	**P**
BSCHE1001C06	Inorganic I: Atomic Structure & Chemical Bonding-I	**4**	**0**	**2**
BSCHE1002C06	Physical I: States of Matter & Ionic Equilibrium	**4**	**0**	**2**
BSCHE1003AECC02	English / MIL Communication	**2**	**0**	**0**
	*GE-1	**4/5**	**0/1**	**2/0**
	Total Credits	**20**		
Semester-II				
		L	**T**	**P**
BSCHE2001C06	Organic I: Basics & Hydrocarbons	**4**	**0**	**2**
BSCHE2002C06	Physical II: Chemical Thermodynamics & its Applications	**4**	**0**	**2**
BSCHE2003AECC02	Environmental Science/ (English/MIL Communication)	2	**0**	0
	GE-2	4/5	**0/1**	2/0
	Total Credits	20		
Semester-III				
			T	P

BSCHE3001C06	Inorganic II: *s* and *p*-Block Elements	4	0	2
BSCHE3002C06	Organic II: Oxygen Containing Functional Groups	4	0	2
BSCHE3003C06	Physical III: Phase Equilibria & Chemical Kinetics	4	0	2
BSCHE3004SEC02	Basic Analytical Chemistry	2	0	0
BSCHE3005SEC02	Pharmaceutical Chemistry	2	0	0
	GE-3	4/5	0/1	2/0
Minimum Required Credits		26		
Semester-IV				
		L	**T**	**P**
BSCHE4001C06	Inorganic III: Coordination Chemistry	4	0	2
BSCHE4002C06	Organic III: Heterocyclic Chemistry	4	0	2
BSCHE4003C06	Physical IV: Electrochemistry	4	0	2
BSCHE4004SEC02	Green Methods in Chemistry	2	0	0
BSCHE4005SEC02	Intellectual Property Rights	2	0	0
	GE-4	4/5	0/1	2/0
Minimum Required Credits		26		
Semester-V				
		L	**T**	**P**
BSCHE5001C06	Organic IV: Biomolecules	4	0	2
BSCHE5002C06	Physical V: Quantum Chemistry & Spectroscopy	4	0	2
BSCHE5003DSE06	Novel Inorganic Solids	4	0	2
BSCHE5004DSE06	Green Chemistry	4	0	2
BSCHE5005DSE06	Analytical Methods in Chemistry	4	0	2
BSCHE5006DSE06	Polymer Chemistry	4	0	2
Minimum Required Credits		24		
Semester-VI				
		L	T	P
BSCHE6001C06	Inorganic IV: Organometallic Chemistry	4	0	2
BSCHE6002C06	Organic Chemistry V: Spectroscopy	4	0	2
BSCHE6003DSE06	Instrumental Methods of Analysis	2	0	0
BSCHE6004DSE06	Inorganic Materials of Industrial Importance	4	0	2

BSCHE6005DSE06	Dissertation	6	0	0
BSCHE6006DSE06	Research Methodology for Chemistry	5	1	0
Minimum Required Credits		24		

*Students may opt for GE I to GE IV courses from the GE or core courses offered for BSc (Honours) with Physics by the Department of Physics.

Manish Kumar Raj (LDC) <manishraj@cub.ac.in>

Fwd: BoS Meeting Invitation

1 message

CoE, CUSB <coe@cub.ac.in> Tue, Feb 4, 2020 at 10:23 AM
To: Dheerendra Singh <dheerendra@cub.ac.in>, Manish Raj UDC <manishraj@cub.ac.in>

Keep record in file

---------- Forwarded message ---------
From: **Department of Physics (PHY)** <hod.phy@cusb.ac.in>
Date: Tue, 4 Feb, 2020, 9:48 AM
Subject: BoS Meeting Invitation
To: <ranjanksingh65@rediffmail.com>
Cc: <pstoregistrar@cub.ac.in>, CoE, CUSB <coe@cub.ac.in>

To,
Prof. Ranjan Kumar Singh
Physics Department, Institute of Science,
Banaras Hindu University, Varanasi

Dear Sir,

I would like to inform you that the incoming Board of Studies Meeting of Physics Department, School of Physical & Chemical Sciences, Central University of South Bihar (CUSB), Gaya is scheduled on February 19, 2020 at 10:00 am in the office of HoD, Physics.

In this regard, I would like to invite you for the above mentioned meeting as external subject expert of BoS.

University will take care of your visit related grievance according to the GoI rules and regulations.

Let us know your travel schedule.

Looking for your visit to CUSB, Gaya.

With regards,
venktesh

--
(Dr. Venktesh Singh)
Professor & Head
Department of Physics
Central University of South Bihar (CUSB)
Gaya - 824236, India

Diary NO PHY/12, Date 14/01/2020

Department of Physics

School of Physical & Chemical Sciences

Central University of South Bihar, Gaya - 824236

To,
The Controller of Examination,
Central University of South Bihar,
Gaya

Date: 14/01/2020

Sub: Revised Budget for the BoS meeting is to be held on 12/02/2020 in the Department of Physics.

Dear Ma'am,

We would like to hold a BoS meeting on the proposed date as on 12/02/2020. In this regard, Two External members (**Prof. Ranjan Kumar Singh**, BHU & **Prof. Prabhakar Singh**, IIT-BHU) of Department of Physics have confirmed for their presence in the BoS meeting. The revised budget for the proposed BoS meeting is as follows.

1.	Travel Ticket By Flight (Prof. Ranjan Kr. Singh & Prof. Prabhakr Singh)	1 Person @ 10,000	Rs. 20,000.00
2.	Reserve Transportation	Gaya Airport to Hotel Bodhgaya and BodhGaya to CUSB, Gaya (To & Fro)	Rs. 4000.00
3.	Accommodation	1 person @ 3000/- (including breakfast and Dinner)	Rs. 6000.00
5.	Lunch	For 12 Persons @ 500/-	Rs. 6000.00
6.	Honorarium	1 person @ Rs. 2500/-	Rs. 5000.00
		Total	**Rs. 41000.00**
		Adv. Required.	**Rs. 41000.00**

In view of conducting the BoS meeting the amount of Rs. 41000/- (Forty one Thousand Only) may be provided as advance. If any mentioned amount seems to be inflated you are requested to modify accordingly.

Yours faithfully,

14.01.2020

(Dr. Venktesh Singh)
Professor & Head

Head
Department of Physics
Central University of South Bihar, Gaya

Diary No. PHY/08, Dated 09/01/2020

Department of Physics

School of Physical & Chemical Sciences

Central University of South Bihar, Gaya - 824236

To,
The Controller of Examination,
Central University of South Bihar,
Gaya

Date: 09/01/2020

Sub: Tentative Budget for the BoS meeting is to be held on 12/02/2020 in the Department of Physics.

Dear Ma'am,

We would like to hold a BoS meeting on the proposed date as on 12/02/2020. In this regard, Two External members (**Prof. Ranjan Kumar Singh**, BHU & **Prof. Prabhakar Singh**, IIT-BHU) of Department of Physics have confirmed for their presence in the BoS meeting. The tentative budget for the proposed BoS meeting is as follows.

1.	Travel Ticket By Flight (Prof. Ranjan Kr. Singh & Prof. Prabhakr Singh)	1 Person @ 10,000	Rs. 20,000.00
2.	Reserve Transportation	Gaya Airport to Hotel Bodhgaya and BodhGaya to CUSB, Gaya (To & Fro)	Rs. 5000.00
3.	Accommodation	1 person @ 3000/-	Rs. 6000.00
4.	Dinner & Breakfast	1 person @ 3000/-	Rs. 6000.00
5.	Lunch	For 12 Persons @ 600/-	Rs. 7200.00
6.	Honorarium	1 person @ Rs. 3000/-	Rs. 6000.00
		Total	**Rs. 50200.00**
		Adv. Required.	**Rs. 50200.00**

In view of conducting the BoS meeting the amount of Rs. 500200.00/- (Fifty Thousand two Hundred Only) may be provided as advance.

Yours faithfully,

09.01.2020

(Dr. Venktesh Singh)
Professor & Head

Head
Department of Physics
Central University of South Bihar, Gaya

Acad-55
09-01-2020

कुलपति सचिवालय
आवक सं. 682
दिनांक 06.01.2020

Diary No.: PHY/05
Date: 06/01/2020

To,

Date: 06/01/2020

The Controller of Examination,
Central University of South Bihar,
Gaya

Sub: Regarding Commencement of new Courses in the School of Physical & Chemical Sciences.

Ref: Minutes of the meeting with HoD with honorable Vice Chancellor held on 4th December, 2019.

Dear Ma'am,

With reference to the requested information during the meeting held on 4th December, 2019 in honorable Vice Chancellor office, hereby, please find the details of new courses for the B. Sc. Honours with Physics and Two specializations offered in M. Sc. (Physics) from the Department of Physics in the coming academic session 2020-21 and the same is approved by their Departmental Council.

The Department of Chemistry is also proposing a new course for the B. Sc. Honours with Chemistry in the coming session 2020-21 and the same is also approved by their Departmental Council.

Kindly do the needful and necessary action and allow us to run the above proposed courses from the mentioned session.

Thanking you

With best regards,

06.01.2020

Dean,
School of Physical and Chemical Sciences
CUSB, Gaya

Take it to Academic Council.

9/1/2020

DR (Acad)

9.1.2020

C.C (Acad)

Enclosure: **1)** Copy of DC meeting held on January 03, 2020.

2) Copy of the HoDs meeting with the Honorable VC, CUSB dated December 4, 2019.

3) VC, CUSB, Gaya for kind information

S.P. Mandal

09/01/20

Date: 06/01/2020

To,
The Controller of Examination,
Central University of South Bihar,
Gaya

Sub: Regarding Commencement of new Courses in the Department of Physics.

Ref: Minutes of the meeting with HoD with honorable Vice Chancellor held on 4th December, 2019.

Dear Ma'am,

With reference to the requested information during the meeting held on 4th December, 2019 in honorable Vice Chancellor office, hereby, please find the details of new courses for the B. Sc. Honours in Physics and Two specializations offered in M. Sc. (Physics) in the Department of Physics from the coming academic session 2020-21.

Kindly do the needful and necessary action.

Thanking you and with best regards,

06.01.2020

Head,
Department of Physics
CUSB, Gaya

Head
Department of Physics
Central University of South Bihar, Gaya

Enclosure: 1) Copy of DC meeting held on January 03, 2020.

2) Copy of the HoDs meeting with the Honorable VC, CUSB dated December 4, 2019.

3) VC, CUSB, Gaya for kind information

Minutes

Physics Department's Teacher's Council
Central University of South Bihar
Friday, 3rd January, 2020 - (11:00 - 12:00 Hours)

Meeting Starts: 11:03 Hrs

A meeting of teacher's council of department of Physics in the Central University of South Bihar was held on 3rd January, 2020 at head's chamber. It began at 11:00 AM and was presided over by Prof. Venktesh Singh, with Dr. Budhendra Singh as member secretary.

In attendance:

Member's of Teacher's Council : Dr. Vijay Raj Singh, Dr. A. Kumar, Dr. N. Chandra, Dr. R. R. Sahi, Dr. Puneet Mishra, Dr. Lakhwinder Singh

Agenda

- Modification of syllabus for Post Graduate and proposal to start Undergraduate program in Physics

Teacher's Council :

- All members unanimously agreed upon putting up a proposal to start M.Sc. specialization modules i.e. Condensed Matter Physics and Nuclear & Particle Physics. In addition, to improve academic standard and quality, all members suggested to modify the present course content.
- A proposal to start 3 year undergraduate B.Sc. (Honors) program with physics was unanimously accepted by all the member and it was decided to follow the course structure according to the UGC approved course contents as per CBCS guidelines.
- All members suggested to submit the proposal and modification to the competent authority for further action.

Closing remarks were given by Prof. Venktesh Singh, the Chairman of Teacher's council, who directed the respective members to prepare the complete structure of the respective course modules for specialization including core and elective papers. In addition, it is instructed to initiate the necessary action to implement modified PG programme and new UG program with Physics as per UGC guidelines.

Meeting Closed: 12:10 Hrs

03.01.2020

Prof. Venktesh Singh
Chairman,

Dr. Budhendra Singh
Secretary,

Members Teacher's council:

03/01/2020

Dr. A. Kumar

03/01/2020

Dr. P. Mishra

Dr. R. R. Sahi

Dr. N. Chandra

दक्षिण बिहार केन्द्रीय विश्वविद्यालय
CENTRAL UNIVERSITY OF SOUTH BIHAR
SH-7, Gaya – Panchanpur Road, Village - Karhara, Post-Fatehpur
P.S. – Tekari, District – Gaya (Bihar) PIN - 824236

MINUTES OF THE MEETING WITH HEADS OF ALL DEPARTMENTS

DATE - 04/12/2019 **TIME - 4:00 PM**

The meeting of the Heads of all Departments under the Chairmanship of Hon'ble Vice-Chancellor was held on 04/12/2019 at 04.00 PM in the conference room at CUSB to discuss various issues pertaining to academic matters.

The Vice Chancellor welcomed all Head of Departments specially those who have joined the University recently after last recruitment drive. After the opening remarks of Hon'ble Vice Chancellor, the Controller of Examinations briefed the issues to be discussed in the meeting.

The following points were discussed :-

1. ***To discuss the list of Holidays & Academic Calendar for 2020.***

   The Controller of Examinations conveyed that suggestion have been received from faculty members to keep the Academic Calendar 2020 in line with Holidays notified by Government of India and do away the practice of closing of the University during Deepawali and Chhatha and adjacent days of Holi festival and in lieu opening of the University on Saturdays. The matter was discussed at length and it was agreed upon to carry on the practice being followed by the University for Academic Calendar 2020. It was decided to keep the University open on Saturdays in lieu of extra holidays to compensate the teaching loss and to fulfil the minimum requirement of teaching days.

2. ***To discuss the status of updation of student's marks on ERP portal.***

   All Head of Departments briefed about the status of entries of students' marks of Continuation Evaluation and Semester Examination on ERP portal made by their respective Departments.

3. ***Evaluated answer scripts shown to students as per Ordinance Clause 14.6.1.***

   The Controller of Examinations informed that in the recent past few grievances from the students have been received regarding evaluation of answer scripts. The concerned students had approached to the office with the grievance that the evaluated answer script was not shown to them. In this regard, the Hon'ble Vice Chancellor invited the attention of Heads of all Departments to clause No.-14.6.1 of Ordinance and instructed them to follow the provision scrupulously and to show the evaluated answer script to the students. It was decided that each faculty should notify the dates to the students well in advance.

8. ***Online Result Publication has been started.***

The Controller of Examinations informed that from Academic Year 2018-19, the Semester results are being declared on ERP Portal and semester grade report can be downloaded by the students from ERP Portal directly.

9. ***To apprise about CUCET-2020 and preparation of Prospectus 2020 - requirement of School / Department content, Photograph and course structure. Any new courses to be launched in the existing Departments.***

The Controller of Examinations informed that alike previous year, the University shall be a part of CUCET-2020. The process of inviting application for admission in Academic Year 2020 shall be started in the month of February 2020. She requested all Heads of Departments to send the content about the Schools/Departments, programmes of studies offered by their respective Department along with course structure so that the same may be incorporated in the Prospectus 2020 and uploaded on University website. She also informed if the Departments intend to start new programme in forthcoming session, the details should be sent to office at the earliest but not later than 6th January, 2019. It was agreed upon to offer the PhD programmes in Department of History, Chemistry, and Commerce etc. where eligible faculty members are available. Accordingly it was decided to take admission in PhD in January 2020 twice a year.

10. ***Ph.D. Admission***

The Hon'ble Vice Chancellor on request of certain new department directed that from January 2020, Ph.D. admission may be carried out twice a year, i.e. through CUCET for NET/JRF/Non-NET students in July every year and in January only for NET /JRF students directly through walk in interview process.

All Head of Departments desirous of admitting Ph.D. Students in January 2020 may conduct their DC meeting and submit their consent/ denial latest by 18th December, 2019 to the office of Controller of Examinations.

The meeting ended with Vote of Thanks to the Chair.

(Rashmi Tripathi)
Controller of Examinations

(Prof. H.C.S. Rathore)
Vice-Chancellor

2. SCHOOL OF PHYSICAL & CHEMICAL SCIENCES

2.1 Department of Physics

The Department of Physics, under the umbrella of School of Physical & Chemical Sciences, has been providing support to the undergraduate programs of Central University of South Bihar (CUSB) since its inception. The M.Sc. Degree Program in Physics was launched from the academic session 2018-19 with the intake of 35 students and from academic session 2019-20, the Department is running the Ph.D. programme in various frontier areas of physics such as experimental nuclear and high energy physics, theoretical high energy physics, experimental condensed matter physics and material science, and theoretical superconductivity and nanoscience. In addition, from the upcoming session 2020-21, the Department is going to start one major undergraduate programme namely B. Sc. Honours with Physics – a three year degree course as per UGC CBCS norms. From the same academic session, Physics Department is going to offer two specializations in postgraduate programmes such as Condensed Matter Physics, and Nuclear & Particle Physics.

The Department of Physics is committed to engage in high quality research and in the pursuit of excellence in teaching. The faculty members of the Department are actively involved in cutting-edge theoretical and experimental research in challenging areas as mentioned above. To promote interdisciplinary research for solving grand challenges facing our society, the Department is highly involved with the various innovation centres of the country. The faculty members of the Department of Physics are significantly contributing in the National and International research collaborations.

2.1.1 Ph.D. in Physics

The broad areas of research in the Department of Physics are hard/soft condensed matter physics, spectroscopy, nanoscience and nanotechnology, materials science, and high energy physics, nuclear and astroparticle physics. In due course, we will also open research areas related to computational physics, theoretical biophysics, and space physics. All the students will be required to successfully complete the course work before beginning the research towards their Ph.D. thesis. The tentative course work structure, subjected to the approval from the Board of Studies, is as follows:

Course Code	Course Title	Credits
Core	Research Methodology	4
Core	Theoretical and Experimental Techniques of Physics Research	4
Core	Review, Report and Seminar	2
Core	Research and Publication Ethics (RPE)	2

2.1.2 M.Sc. in Physics

The objectives of this program are to cater and to meet the needs and aspirations of contemporary M.Sc. Physics students. It is tailored to incorporate the essential ingredients of multifaceted education and research for this rapidly changing world. This program aims to provide the much needed and strong foundation in Physics so that students can (i) develop the ability to apply the knowledge of Physics in any allied fields, (ii) develop the programming proficiency with high-end software for both computation and automation, (iii) get acquainted with cutting-edge scientific equipment, (iv) obtain a platform to kicks start their innovative ideas for future applied research career, (v) improve soft skills to build their professional career. In addition to these, specialised courses in nuclear and particle physics will train them to understand the basic, fundamental and somewhat advanced concepts about radiation safety and nuclear & particle physics making them ready to contribute towards the country's nuclear energy and safety programmes. Over all these courses are designed in such a way that it will help them to contribute towards societal development and to make their life better.

List of Courses in M.Sc. Physics from Academic Session 2020-2021 (96 Credits)

Course Code	Course Title	Credit		
	Semester - I	L	T	P
MSPHY1001C04	Mathematical Physics	4	0	0
MSPHY1002C04	Classical Mechanics	4	0	0
MSPHY1003C04	Quantum Mechanics	4	0	0
MSPHY1004C04	General Physics Lab. – I	0	0	4
MSPHY1005E04	Electronics	4	0	0
MSPHY1006E04	Experimental Techniques	4	0	0
MSPHY1007E02	Biography of Indian Scientists	2	0	0
	Elective – I (From other department)	4	0	0
	Total Credits	30		
	Semester - II	L	T	P
Course Code	Course Title	Credit		
MSPHY2001C04	Thermodynamics and Statistical Physics	4	0	0
MSPHY2002C04	Classical Electrodynamics and Relativity	4	0	0
MSPHY2003C04	General Physics Lab. – II	0	0	4
MSPHY2004C04	Atomic and Molecular Physics	4	0	0
MSPHY2005C02	Elementary Solid State Physics	2	0	0

MSPHY2006C02	Elementary Nuclear & Particle Physics	2	0	0
MSPHY2007E04	Advanced Quantum Mechanics	4	0	0
MSPHY2008E04	Advanced Mathematical Physics	4	0	0
MSPHY2009E04	Introduction of Ancient Indian Sciences	4	0	0
Total Credits		32		
Semester-III (Specialization in Condensed Matter Physics)		L	T	P
Course Code	Course Title	Credit		
MSPHY3001C04	Condensed Matter Physics	4	0	0
MSPHY3002C04	Solid State Devices	4	0	0
MSPHY3003C04	Solid State Physics Lab - I	0	0	4
MSPHY3004E04	Materials Science	4	0	0
MSPHY3005E04	Crystal Growth and Characterizations	2	0	2
MSPHY3006E04	Crystallography Crystal Structure and Diffraction Techniques	2	0	2
MSPHY3007E04	Fundamentals of nanoscience and nanotechnology	4	0	0
MSPHY3008E02	Physics of Dielectric and Ferroelectric Materials	2	0	0
MSPHY3009E02	X-ray Spectroscopy	2	0	0
MSPHY3010E02	Diffusion in Solids	2	0	0
MSPHY3011E04	Fundamentals of Scanning Probe Microscopy	4	0	0
	Elective - III (from other Department)	4	0	0
Total Credits		42		
Semester-IV (Specialization in Condensed Matter Physics)		L	T	P
Course Code	Course Title	Credit		
MSPHY4001C04	Advanced Condensed Matter Physics	4	0	0
MSPHY4002C04	Dissertation	4	0	0
MSPHY4003C04	Solid State Physics Lab - II	0	0	4
MSPHY4004E04	Physics of Magnetism and Spintronics	4	0	0
MSPHY4005E04	Alloy Design and Development	2	0	2

MSPHY4006E04	Material Synthesis and Processing	2	0	2
MSPHY4007E04	Renewable Energy	4	0	0
MSPHY4008E04	Carbon Nano-structures and Their Properties	2	0	2
MSPHY4009E04	Biomedical Instrumentation	4	0	0
MSPHY4010E04	Industrial Process Control	4	0	0
MSPHY4011E04	Nanoscale Characterization Techniques	4	0	0
MSPHY4012E04	Nanoelectronics	4	0	0
Total Credits		48		
Semester-III (Specialization in Nuclear and Particle Physics)		L	T	P
Course Code	Course Title	Credit		
MSPHY3101C04	Advanced Nuclear Physics	4	0	0
MSPHY3102C04	Nuclear & Particle Physics Lab. – I	0	0	4
MSPHY3103C04	Advanced Particle Physics	4	0	0
MSPHY3104E04	Introduction of Astrophysics	4	0	0
MSPHY3105E04	Nuclear Reactor Physics	4	0	0
MSPHY3106E04	Statistical Analysis Techniques in Nuclear and Particle Physics	4	0	0
MSPHY3107E02	Radiation Safety	2	0	0
MSPHY3108E02	Neutrino Physics	2	0	0
	Elective – I (from other department)	4	0	0
Total Credits		32		
Semester - IV (Specialization in Nuclear and Particle Physics)		L	T	P
Course Code	Course Title	Credit		
MSPHY4101C04	Experimental Techniques in Nuclear and Particle Physics	4	0	0
MSPHY4102C04	Dissertation	0	0	4
MSPHY4103C04	Nuclear & Particle Physics Lab. – II	0	0	4
MSPHY4104E04	Particle Accelerator Physics	4	0	0
MSPHY4105E04	Data Analysis and Simulation in particle Physics	4	0	0

MSPHY4106E04	General Theory of Relativity	4	0	0
MSPHY4107E02	High Energy Cosmic Rays	2	0	0
MSPHY4108E02	Dark Matter Physics	2	0	0
Total Credits		28		

2.1.3 B.Sc. Honours with Physics

The objectives of this programme are to create bright brain to cater and meet, the needs and aspirations of contemporary B.Sc. Honours with Physics students. This programme will boost up Departmental ongoing postgraduate and doctorate programmes. The Central University of South Bihar is the first in the Bihar state that started B.Sc. Honours with Physics. This program aims to (i) provide the much needed and strong foundation in Physics so that students can develop the ability to apply the knowledge of Physics in any allied fields, (ii) give students an opportunity to use advanced laboratory equipment to get acquainted with them and make their carrier in advanced higher education in physics, and (iii) present a platform to the students for advance training and in depth physics knowledge.

List of Courses in B.Sc. Honours with Physics from Academic Session 2020-2021
(140 Credits Based on Choice Based Credit System (CBCS))

Course Code	Course Title	Credit		
Semester-I		L	T	P
BSPHY1001C06	Mathematical Physics - I	4	0	2
BSPHY1002C06	Mechanics	4	0	2
BSPHY1003AECC02	Environmental Science / (English / MIL Communication)	2	0	0
	GE-1*	4/5	0/1	2/0
	Minimum Required Credits	20		
Semester - II		L	T	P
Course Code	Course Title	Credit		
BSPHY2001C06	Electricity and Magnetism	4	0	2
BSPHY2002C06	Wave and Optics	4	0	2
BSPHY2003AECC02	Environmental Science / (English / MIL Communication)	2	0	0

	GE – II*	4/5	0/1	2/0
Minimum Required Credits		20		
Semester-III		L	T	P
Course Code	Course Title	Credit		
BSPHY3001C06	Mathematical Physics - II	4	0	2
BSPHY3002C06	Thermal Physics	4	0	2
BSPHY3003C06	Digital Systems and Applications	4	0	2
BSPHY3004SEC02	Computational Physics Skills	2	0	0
BSPHY3005SEC02	Basic Instrumentation Skills	2	0	0
	GE – III*	4/5	0/1	2/0
Minimum Required Credits		26		
Semester-IV		L	T	P
Course Code	Course Title	Credit		
BSPHY4001C06	Mathematical Physics - III	4	0	2
BSPHY4002C06	Elements of Modern Physics	4	0	2
BSPHY4003C06	Analog Systems and Applications	4	0	2
BSPHY4004SEC02	Radiation Safety	2	0	0
BSPHY4005SEC02	Renewable Energy and Energy Harvesting	2	0	0
	GE – IV*	4/5	0/1	2/0
Minimum Required Credits		26		
Semester-V		L	T	P
Course Code	Course Title	Credit		
BSPHY5001C06	Quantum Mechanics and Applications	4	0	2
BSPHY5002C06	Solid State Physics	4	0	2
BSPHY5003DSE06	Advanced Mathematical Physics - I	5	1	0
BSPHY5004DSE06	Physics of Devices and Communication	4	0	2
BSPHY5005DSE06	Astronomy and Astrophysics	5	1	0

BSPHY5006DSE06	Nano Materials and Applications	4	0	2
	Minimum Required Credits	**24**		
	Semester - VI	L	T	P
Course Code	Course Title	Credit		
BSPHY6001C04	Electromagnetic Theory	4	0	2
BSPHY6002C04	Statistical Mechanics	4	0	2
BSPHY6003DSE06	Experimental Techniques	4	0	2
BSPHY6004DSE06	Advanced Mathematical Physics - II	5	1	0
BSPHY6005DSE06	Classical Dynamics	5	1	0
BSPHY6006DSE06	Nuclear and Particle Physics	4	0	2
BSPHY6007DSE06	Dissertation	6		
	Minimum Required Credits	**24**		
	Grand Total Credits	**140**		

* GE papers may be chosen from the currently running courses in the Department of Chemistry. Students may also opt the previous semester paper of the Chemistry Department according to the running semester.

06.01.2020

06/01/2020

06.01.2020

06/01/2020

6/1/20

S. N.	Programme	Intake	Eligibility
1	B.Sc. Honours Chemistry (3 year)	15	10+2 or equivalent examination in Science stream from any recognized Board/University with a minimum of 50% marks for General / OBC and 45 % marks for SC/ST candidates.
2	B.Sc. Honours Physics (3 year)	15	10+2 or equivalent examination in Science stream including Physics and Mathematics from recognized Board/University with a minimum of 50% marks for General / OBC and 45 % marks for SC/ST candidates.

06.01.2020

Parneet Mishra
06.01.2020

06/01/2020

06/01/2020

Nitin Chauhan
6/1/20

6.1.20

Department of Chemistry
Central University of South Bihar

Ref No...CUSB/CHE/2020/01 Date: 06/01/2020

To

The COE

Central University of South Bihar,

Gaya

Subject: Regarding starting of BSc (Honours) with Chemistry programme in the Department of Chemistry and modifications in the Prospectus for 2020-21

Respected Madam,

In reference to minutes of meeting of all the head of the Department dated 04-12-2019, Kindly find enclosed a proposal for starting BSc (Hons) with Chemistry programme and modifications in the Prospectus for 2020-21 from department of Chemistry. I would like to submit that we have adapted the course structure and syllabus for the programme as suggested by the University Grant commission for the BSc (Honours) In Chemistry. Recommendation of the department council, course structure and syllabus are enclosed for your kind information and perusal please. Some modifications for the Prospectus 2020-21 are also enclosed.

Submitted for necessary action please.

Sincerely

Faculty members

Dr. Vinod Kumar
Professor

Dr. Girish Chandra
6/1/2020
Assistant Professor

Dr. Amiya Priyam
Associate Professor

Dr. Angad Kumar Singh
Assistant Professor

Dr. Jagannath Roy
Associate Professor

Dr. K Mahender
Assistant Professor

Vinod Kumar
Professor and Head
Department of Chemistry
CUSB

Copy to
VC office

Dept. of Chemistry

Ref No... CUSB/CHE/2019/02 Date: 06/01/2020

Subject: Regarding starting of BSc (Honours) with Chemistry programme from academic session 2020-21

A meeting of the department council was held on Jan. 3, 2020 regarding discussion on starting of an undergraduate programme, BSc (Hons) with Chemistry. It was realized that quality of the students we are getting for postgraduate programme in the department is not up to the mark. Hence it was proposed that an undergraduate programme may be started in the department so that we can get well trained students for the master programme.

It was unanimously proposed that:

1. An undergraduate programme, BSc (Honours) with Chemistry may be started in the department from academic session 2020-21
2. The course structure and syllabus for the programme will be adapted from the UGC

Submitted for kind approval please.

Sincerely

Faculty members

Dr. Vinod Kumar
Professor

Dr. Amiya Priyam
Associate Professor

Dr. Jagannath Roy
Associate Professor

Dr. Girish Chandra 7/1/2020.
Assistant Professor

Dr. Angad Kumar Singh
Assistant Professor

Dr. K Mahender
Assistant Professor

Vinod Kumar
Professor and Head
Department of Chemistry
CUSB

2.2.3 B.Sc. Honours with Chemistry

S.No	Programme	Intake	Eligibility
1	BSc (Honours) with Chemistry	15	10+2 or equivalent examination with chemistry as one of the subjects from any recognized Board/university with atleast 50 % marks for general/OBC and 45 % marks for SC/ST candidates

The objective of this programme is to groom young mind and inspire them to take Chemistry as career. The programme is designed to meet the needs and aspirations of contemporary students opting for undergraduate programme with chemistry. This programme will also help in providing well trained, and motivated students for the ongoing master and doctorate programmes of the Department. This program aims to (i) provide the student a strong foundation and skills so that they can apply the knowledge in the advancement of chemistry and related fields, (ii) Train the students with the help of state in art laboratory equipment to get them acquainted with technical skills required in the field (iii) present a platform to the students for advance training and in-depth chemistry knowledge and (iv) equip the students with required skills and knowledge so that they can compete at the International level.

List of Courses in B.Sc. Honours with Chemistry from Academic Session 2020-2021
(140 Credits Based on Choice Based Credit System (CBCS))

Semester-I				
Paper Code	Course Title	Credits		
		L	T	P
BSCHE1001C06	Inorganic I: Atomic Structure & Chemical Bonding-I	4	0	2
BSCHE1002C06	Physical I: States of Matter & Ionic Equilibrium	4	0	2
BSCHE1003AECC02	English / MIL Communication	2	0	0
	*GE-1	4/5	0/1	2/0
	Total Credits	20		
Semester-II				
		L	T	P
BSCHE2001C06	Organic I: Basics & Hydrocarbons	4	0	2
BSCHE2002C06	Physical II: Chemical Thermodynamics & its Applications	4	0	2
BSCHE2003AECC02	Environmental Science/ (English/MIL Communication)	2	0	0
	GE-2	4/5	0/1	2/0
	Total Credits	20		
Semester-III				
		L	T	P

BSCHE3001C06	Inorganic II: *s* and *p*-Block Elements	4	0	2
BSCHE3002C06	Organic II: Oxygen Containing Functional Groups	4	0	2
BSCHE3003C06	Physical III: Phase Equilibria & Chemical Kinetics	4	0	2
BSCHE3004SEC02	Basic Analytical Chemistry	2	0	0
BSCHE3005SEC02	Pharmaceutical Chemistry	2	0	0
	GE-3	4/5	0/1	2/0
	Minimum Required Credits	26		
	Semester-IV			
		L	T	P
BSCHE4001C06	Inorganic III: Coordination Chemistry	4	0	2
BSCHE4002C06	Organic III: Heterocyclic Chemistry	4	0	2
BSCHE4003C06	Physical IV: Electrochemistry	4	0	2
BSCHE4004SEC02	Green Methods in Chemistry	2	0	0
BSCHE4005SEC02	Intellectual Property Rights	2	0	0
	GE-4	4/5	0/1	2/0
	Minimum Required Credits	26		
	Semester-V			
		L	T	P
BSCHE5001C06	Organic IV: Biomolecules	4	0	2
BSCHE5002C06	Physical V: Quantum Chemistry & Spectroscopy	4	0	2
BSCHE5003DSE06	Novel Inorganic Solids	4	0	2
BSCHE5004DSE06	Green Chemistry	4	0	2
BSCHE5005DSE06	Analytical Methods in Chemistry	4	0	2
BSCHE5006DSE06	Polymer Chemistry	4	0	2
	Minimum Required Credits	24		
	Semester-VI			
		L	T	P
BSCHE6001C06	Inorganic IV: Organometallic Chemistry	4	0	2
BSCHE6002C06	Organic Chemistry V: Spectroscopy	4	0	2
BSCHE6003DSE06	Instrumental Methods of Analysis	2	0	0
BSCHE6004DSE06	Inorganic Materials of Industrial Importance	4	0	2

BSCHE6005DSE06	Dissertation	6	0	0
BSCHE6006DSE06	Research Methodology for Chemistry	5	1	0
Minimum Required Credits		24		

*Students may opt for GE I to GE IV courses from the GE or core courses offered for BSc (Honours) with Physics by the Department of Physics.

Central University of South Bihar

Department of Chemistry, School of Physical and Chemical Sciences

Panchanpur, Gaya-824236, Bihar

Brief Profile of Faculty Members:

S.No.	Name	Designation	Academic Qualification	Specialisation	Achievement/ Special Award	Photograph
1.	Dr. Vinod Kumar	Professor and Head	PhD, IHBT Palampur	Organic and Medicinal Chemistry	UGC-JRF/SRF Postdoctral fellowship from Siena University Italy and Bath University England Visiting fellowship-Innsbruck Medical University, Austria	
2.	Dr. Amiya Priyam	Associate Professor	Ph.D., Jadavpur University, Kolkata	Inorganic Chemistry	Postdoctoral Fellow, Florida State University and National University of Singapore	
3.	Dr. Jagannath Roy	Associate Professor	Ph.D., University of Calcutta , Kolkata	Inorganic Chemistry	Editorial board member and reviewer of international and national journals	

4.	Dr. Girish Chandra	Assistant Professor, Head (I/C)	Ph.D., IIT Bombay	Organic Chemistry	Postdoctoral Fellow, Ewha Womans University, Seoul, South Korea	
5.	Dr. Angad Kumar Singh	Assistant Professor	Ph.D., Banaras Hindu University, Varanasi	Organic Chemistry, Coordination Chemistry/ Material Chemistry	NET(CSIR), GATE Young Scientist (SERB) DSK-PDF (UGC) Research Associate (CSIR)	
6.	Dr. Mahender Khatravath	Assistant Professor	Ph.D., University of Hyderabad, Hyderabad	Organic Chemistry, Medicinal Chemistry	Senior Research Fellow (SRF), by CSIR-India Junior Research Fellow (JRF), by CSIR-India SERB-National Post-Doctoral Fellowship (N-PDF), DST-SERB India	

6/1/2020

Prof. Vinod Kumar, Head
Professor, Department of Chemistry
Central University of South Bihar, Panchanpur
Gaya, Bihar

Minutes

Board of Studies, Physics Department, CUSB, Gaya
Wednesday, February 19, 2020 (10:00 - 17:00 Hours)

Meeting Starts: 10:00 AM

A meeting of Board of Studies of the department of Physics of Central University of South Bihar was held on 19th February, 2020 at 10:00 AM in the HoD chamber. The following members were present:

1	**Prof. Venktesh Singh** Head, Department of Physics, CUSB, Gaya	Chairman	19.02.2020
2	**Prof. Prabhakar Singh,** Department of Physics, IIT (BHU) Varanasi	External Member	19/2/2020
3	**Prof. Ranjan Kumar Singh** Department of Physics, Institute of Science, BHU Varanasi	External Member	19/2/2020
4	**Dr. Amiya Priyam** Department of Chemistry, CUSB	Cognate Member	Amiya Priyam
5	**Dr. Girish Chandra** Department of Chemistry, CUSB	Cognate Member	Girish Chandra 19/2/20
6	**Dr. Budhendra Kumar Singh** Department of Physics, CUSB	Member	19/2/2020
7	**Dr. Vijay Raj Singh** Department of Physics, CUSB	Member	VRS 19.2.20
8	**Dr. Akhilananda Kumar** Department of Physics, CUSB	Member	A. K 19/02/2020
9	**Dr. Rohit R. Shahi** Department of Physics, CUSB	Member	Rohit 19.02.2020
10	**Dr. Nitin Chandra** Department of Physics, CUSB	Member	Nitin Chandra 19.02.2020
11	**Dr. Puneet Mishra** Department of Physics, CUSB	Member	Puneet Mishra 19.02.2020
12	**Dr. Lakhwinder Singh** Department of Physics, CUSB	Special Invitee	Lakhwinder Singh 19/02/2020

Agenda

- B.Sc. Physics (Honors) course structure and syllabi.
- M.Sc. Physics with specialization domain of Nuclear & Particle and condensed matter physics.
- Ph.D course structure and syllabi.

Board of Studies :

1. Course structure and syllabi of B.Sc. Physics (Honors) was discussed at length. The structure and syllabi were modified as per the need and requirement. The same were approved and recommended by the BoS for further consideration and approval at the competent committee/authority.
2. Course structure and syllabi of M.Sc. Physics with specialization in Nuclear & Particle Physics and condensed matter physics was discussed at length. The structure and syllabi were modified as per the need and requirement. The same were approved and recommended by the BoS for further consideration and approval at the competent committee/authority.
3. Course structure and syllabi of Ph.D in Physics was discussed at length. The structure and syllabi were modified as per the need and requirement. The same were approved and recommended by the BoS for further consideration and approval at the competent committee/authority.

The BoS meeting was concluded with vote of thanks to the chair.

Meeting Closed: 16:15 Hrs

19/02/2020 19/2/2020 19.2.20 19.02.2020

19/02/2020 19/2/2020 19.02.2020

Puneet Mishra 19/02/2020 19/2/2020 19.02.2020

A.K 19/02/2020 Lachander Singh 19/02/2020

Anuja 19.2.2020

Rajesh Chandra 19/2/20

CENTRAL UNIVERSITY OF SOUTH BIHAR

ORDINANCE AND REGULATIONS GOVERNING

Master of Science (M.Sc.) Physics
Degree Programme

(Effective from the Academic Session 2020-2021)

Department of Physics
School of Physical and Chemical Sciences

TABLE OF CONTENTS

ORDINANCE AND REGULATIONS GOVERNING

MASTER OF SCIENCE (M.Sc.) PHYSICS DEGREE PROGRAMME OF CENTRAL UNIVERSITY OF SOUTH BIHAR UNDER CHOICE BASED CREDIT SYSTEM

(Effective from Academic Session 2018-19)

Under the powers conferred by The Central Universities Act, 2009- section 28(1) (b)], as amended, Central University of South Bihar, hereby, institutes the four semester Post Graduate Degree Programme for the Award of Master of Science (M.Sc.) Degree by the Department of Physics under the School of Physical and Chemical Sciences of the University under the choice based credit system. The following ordinance for governing admission, course of study, examinations and other matters relating to M.Sc. Degree under Department of Physics of the Central University of South Bihar are hereby laid to come in force w.e.f. the Academic Session 2018-19 onwards till further amended.

1. **Definitions of Key Words:**

1.1 **'Choice-Based Credit System (CBCS)':** The CBCS provides choice for the students to select course from the prescribed courses (Elective or Soft-skill courses). It provides a 'cafeteria' approach in which the students can take courses of their choice, learn at their own pace, study additional courses and acquire more than the minimum required credits, and adopt an inter-disciplinary approach to learning.

1.2 **'Academic Year'**: Two consecutive (one odd + one even) semesters shall constitute one academic year.

1.3 **'Course'**: Course, usually referred to as paper having specific title and code number, is a component of a Programme. It consists of a list of topics /points /concepts /theories /principles etc. which a student has to learn and master during the Programme of study. Each Course generally shall be of 04 credits. Each course should define the learning objectives/ learning outcomes. A course may be designed to be delivered through lectures/tutorials/laboratory work/field work/outreach activities/project work/vocational training/viva/seminars/ term papers/assignments /presentations / self-study work etc., or a combination of some of these.

1.4 **'Course Teacher'**: The course teacher generally will be the teacher who has primarily conceived the course, developed its contents, taken up the responsibility of teaching it and evaluating the performance of the students in that course.

1.5 **'Credit'**: A unit by which the course work is measured. It determines the number of hours of instructions required per week. One credit is equivalent to one hour of teaching (lecture or tutorial) or two hours of practical work/field work per week.

1.6 **'Credit Point'**: It is the product of the grade point and the number of credits for a course.

1.7 **'Grade Point'**: It is a numerical weight allotted to each letter grade on a 10-point scale.

1.8 **'Letter Grade'**: It is an index of the performance of students in a said course. Grades are denoted by letters O, A+, A, B+, B, C, P and F. A letter grade is assigned to a student on the basis of evaluation of her/his performance in a course on a ten point scale.

1.9 **'Programme'**: An educational Programme leading to the award of a Degree, Diploma or Certificate.

1.10 **'Credit-Based Semester System (CBSS)'**: Under the CBSS, the requirement for awarding a degree or diploma or certificate is prescribed in terms of number of credits to be completed by the students.

1.11 **'Semester':** Each Semester shall consist of 15-18 weeks of academic work equivalent to 90 actual teaching days. The odd semester may be scheduled from July to December and even semester from January to June. The credit-based semester system provides flexibility in designing curriculum and assigning credits based on the course content and hours of teaching.

1.12 **'Semester Grade- Point Average (SGPA)'**: It is a measure of performance of the work done in a semester. It is ratio of total credit points secured by a student in various courses registered in a semester and the total course credits taken during that semester. It shall be expressed up to two decimal places.

1.13 **'Cumulative Grade Point Average (CGPA)'**: It is a measure of overall cumulative performance of a student over all semesters. The CGPA is the ratio of total credit points secured by a student in various courses in all semesters and the sum of the total credits of all courses in all the semesters. It shall be expressed up to two decimal places.

1.14 **'Transcript'/ 'Grade Card' 'or Certificate'**: Based on the grades earned, a grade certificate shall be issued to all the registered students after every semester. The grade certificate will display the course details (code, title, number of credits, grade and/or marks secured) along with SGPA of that semester.

1.15 **'The University'**: 'The University' in this Ordinance means the Central University of South Bihar.

2. Admission and Other General Provisions:

2.1 The Programme of study leading to Master of Science (M.Sc.) Degree of Central University of South Bihar shall be of two year (Four Semesters) duration which may be completed in a maximum duration of four years (Eight Semesters).

2.2 The intake to the said PG Programme (M.Sc.) shall be as decided by the UATEC/Academic Council of the University from time to time.

2.3 The admission to the M.Sc. Programme shall be governed by the provisions as laid down by UATEC/Academic Council of the University from time to time.

2.4 Reservation of seats for admission to the M.Sc. Programme shall be as per the policy of Government of India (GOI) and as notified by the GOI/UGC from time to time.

2.5 In accordance to the rules of GOI for admission to the Central Higher Education Institutions, reservations of seats for M.Sc. Programme are as follows:

S. No.	Category	Reservation
1	SC Candidates	15 % of the intake
2	ST Candidates	7.5% of the intake
3	OBC Candidates	27% of the intake
4	Divyang Candidates	5% of the intake *(on horizontal reservation basis)*
5	Dependents/Wards of Defence Personnel and Kashmiri Migrants/NCC cadets	As per the GOI rules

(a) The candidates seeking admission under the above categories shall be required to fulfill the prescribed eligibility conditions of the admission of the programme and shall submit requisite documents in support of their claim, as prescribed by the GOI from time to time

(b) The SC/ ST/OBC candidates must enclose attested copy of the latest caste certificate as per GOI norms along with their Admission Form/Enrolment form stating that the candidate belongs to SC/ST/OBC Category.

The following are empowered to issue SC/ST/OBC Certificates:

(i) District magistrate/ Additional District Magistrate/ Collector/ Deputy Commissioner/ Addl. Deputy Commissioner/Deputy Collector /Ist Class Stipendiary Magistrate/City Magistrate/Sub Divisional magistrate/ Taluka Magistrate/ Executive Magistrate /Extra Assistant Commissioner.

(ii) Chief Presidency Magistrate/ Addl. Chief Presidency Magistrate/ Presidency Magistrate.

(iii) Revenue Officer not below the rank of Tehsildar.

(iv) Sub - Divisional Officer of the area where the candidate and/or his family normally resides.

(v) Administrator/Secretary to the Administrator/ Development Officer (Lakshadweep Islands).

(vi) Candidate must note that certificate from any other person/authority shall not be accepted generally.

(c) 5% seats on horizontal reservation basis shall be reserved for Divyang Candidates (Benchmark Category) and shall be further sub-divided into different categories of Divyangs as per the GOI rules.

A candidate applying under Divyang category must attach a certificate by CMO, District Hospital. However, she/he shall be considered under Divyang category only after verification from the University Medical Board, if necessary.

(d) Vacant seats reserved for SC/ST/OBC candidates, if any, may be filled up as per the GOI/UGC rules. In case in any one of the two categories of candidates viz., SC/ST, the required number of candidates for admission is not available (i.e., the list of respective category has been exhausted), then candidates belonging to the other category (SC or ST as the case may be, if available), shall be called for admission in order of merit so as to make up the deficiency in the required number in any of the aforesaid two categories. This provision shall be applicable to candidates belonging to SC & ST categories only.

(e) If sufficient number of candidates are not available in OBC category (i.e., OBC category list has been exhausted), such vacant seats shall be transferred to the general category.

2.6 Mere appearance in the admission test shall not entitle a candidate to be considered for admission to the Programme unless she/he fulfills the eligibility conditions. Applicants must fully satisfy themselves about their eligibility before filling the application form.

2.7 Provisional admission shall be offered to the candidates in order of merit list and the availability of seat in the Programme on the date of admission.

2.8 In case there is more than one candidate securing equal ranks as obtained by the last candidate in order of merit in the list of candidates to be called for admission, the following *inter-se* ranking rules of the University shall be applicable.

In case the candidates have equal/tie ranks then the marks obtained in the qualifying examination shall be the deciding factor and if, that is also same or result of both the candidates is not declared, then a senior candidate on the basis of date of birth shall be given preference. However, in a case of tie rank, if the result of qualifying examination of one candidate is declared then she/he will be given preference, provided she/he fulfills other eligibility conditions. In case of any dispute the decision of the Chairman, UATEC shall be final.

2.9 If the result of the qualifying examination is not declared by a university/board till the date of admission, the mark-sheet of the qualifying examination by a candidate can be submitted on or before 30th September of the admission year. In exceptional cases, further extension may be given by the Competent Authority on cogent reason(s). However, it may be noted that this clause cannot be extended to the candidate(s) whose result is being withheld or not declared by the university/board due to some specific reasons particularly related to the candidate(s). Furthermore, if the result of qualifying examination is not declared by a university/board in general then the aggregate percentage of marks/grades of the completed semesters/years of the qualifying examination (e.g. two years/five semesters of B.Sc. with Physics Honours) must be not less than the required percentage of marks/grades in the qualifying examination.

2.10 At the time of reporting for admission, the candidates are required to be present in person and bring the documents in original as well as a set of photocopy duly attested as notified by the Admission Committee/Controller of Examinations (CoE) from time to time.

2.11 A candidate provisionally selected for admission shall be required to fill the prescribed form, submit the required documents, collect her/his admit card or any other equivalent document for admission to the Programme from the office of the Department/School/University after paying the fees on or before a date fixed for the purpose, otherwise the offer made to her/him will automatically stand cancelled.

2.12 In case any provisionally selected candidate fails to deposit the fee by the date prescribed, her/his provisional admission shall be cancelled and the seat thus falling vacant shall be offered to the next candidate in order of merit under the specified category.

2.13 Notwithstanding anything contained in this ordinance, a candidate who is qualified under the foregoing ordinance for admission to the University, and who is a student of some other Indian University/Institution, shall not be admitted to the University without the production of a Leaving or Transfer Certificate and/or Migration Certificate (as the case may be) issued by the last college/university attended and certifying to the satisfactory conduct of the student mentioning the highest examination she/he has passed. However, in certain cases if the candidates are not in position to submit the Leaving or Transfer Certificate and/or Migration Certificate and the character certificate at the time of admission, they should submit the same as early as possible, but not later than 30th September of the year of admission in M.Sc. failing which the University reserves the right to cancel their admission. In exceptional cases, further extension may be given by the Competent Authority on cogent reason(s). However, it may be noted that this clause cannot be extended to the candidate(s) whose result is being withheld or not declared by the university/board due to some specific reasons particularly related to the candidate(s).

2.14 A waitlisted candidate shall be offered admission strictly on the basis of ranking, provided there is a vacancy in the Programme. Such waitlisted candidates shall have to deposit their fees latest by the date fixed by the Admission Committee/ Competent Authority.

2.15 The candidates enjoying employed status and selected for admission to M.Sc. Programme in the University, are required to produce Leave Sanction /Relieving Order at the time of Admission/Registration from their employer for the duration of the Programme permitting them to pursue their studies at the University, failing which the offer of admission may stand withdrawn. In case of any dispute the decision of the competent authority shall be final.

2.16 The admission of any candidate is liable to be cancelled without giving any further notice forthwith or at any time during the period of the concerned Programme of Study, if it is detected that the candidate has /had produced fake / forged certificate(s) /document(s), or indulged in any act of misconduct/indiscipline or has /had concealed any other relevant information at the time of admission.

2.17 The admission of the candidate to the M.Sc. Programme shall be subject to such ordinances, rules and regulations as may be framed from time to time by the University.

2.18 Foreign students shall be admitted as per the rules of the University.

2.18 Only the High Court of Patna shall have jurisdiction in case of any dispute relating to the provisional admission in the Programme.

19/02/2020

3. Eligibility Conditions

The eligibility conditions for admission into the M.Sc. Physics Degree Programme shall be as follows:
B.Sc. with Physics Honours with a minimum of 55 % marks for General / OBC candidates and 50% marks for SC/ST candidates from any recognised University

However, the eligibility conditions for admission into M.Sc. Physics Programme and intake of the Programme shall be decided by the University Admission, Teaching and Evaluation Committee (UATEC) from time to time.

4. Medium of Instruction of the Programme:

The medium of instruction and examination shall be English for M.Sc. Physics Programme.

5. Programme Fee:

5.1 The semester-wise fee structure of M.Sc. Physics Programme is given below:

One Time Fee	
Admission	500
Enrolment	1000
Identity Card	100
Development Fee	1000
Security Deposit (Refundable)	1000
Semester Fee	
Tuition Fee	3000
Laboratory Fee	1000
Computer Lab	500
Evaluation Fee	500
Academic / Extension Activity Fee	0
Addt. Professional Enrichment Fee	0
Field Visit	0
Library/Magazine/News Letter	500
Cultural Activities	500
Games/Athletics	500
Total Fee	10100
Vidyarthi Medi-claim (Annual Fee)	618
Total Fee (with VMC)	**10718**
Hostel Fee : Rs. 9000/- per semester	
Transportation Fee : As per actual, if provided	

5.2 The mode and schedule of payment of fees shall be decided by the university from time to time.

5.3 The fee structure of M.Sc. Programme under Department of Physics may be changed by the University prospectively. Such changed fee structure shall be declared in the admission prospectus of the concerned academic session.

6. Conduct of the Programme:

6.1 To qualify for the M.Sc. (Physics) Degree, a candidate must earn 96 credits as contained in the Programme structure/Syllabus of M.Sc. (Physics) Degree as annexed with this ordinance. This Programme structure/Syllabus is subject to update/change/modify from time to time as prescribed by the Board of Studies (BoS) of the Department and need not to follow the procedure prescribed for updating the ordinances.

6.2 A student of the M.Sc. (Physics) Programme shall not be permitted to seek admission concurrently to any other equivalent or higher degree or diploma examination in this University or any other University, subject to rules/regulations of UGC or equivalent body in this regard and adoption of the same by the University.

6.3 The maximum period allowed to complete the M.Sc. (Physics) Programme will be four years (Eight Semesters).

6.4 The Department shall offer courses as per its schedule and available resources and can decide to offer or not to offer a particular course in a particular semester. To earn additional or lesser credits in a semester from the Department than the prescribed in the syllabus and to earn credits from other Departments/Schools shall be the sole responsibility of the student. S/he has to choose the courses in such a way that it becomes feasible for her/him to earn the credits.

7. Type of Courses:

The M.Sc. (Physics) Programme of the University has three types of courses, viz,. Core courses, Elective courses, and Self-study/Skill-based courses.

7.1 Core courses:

7.1.1. The core courses are those courses whose knowledge is deemed essential for the students registered for the M.Sc. (Physics) Programme. Where feasible and necessary, two or more Programmes (like, degree, diploma and certificate etc.) may prescribe one or more common core

courses.

7.1.2 All the core courses prescribed for M.Sc. (Physics) Degree Programme offered by the Department of Physics under the School of Physical and Chemical Sciences shall be mandatory for all the students registered in the M.Sc. (Physics) Programme.

7.1.3 A core course of the Programme may be an elective course for any other Programme.

7.2 Elective courses:

7.2.1 The elective courses can be chosen from a pool of courses (papers). These courses are intended to:

- allow the student to specialize in one or more branches of the broad subject area;
- help the student to acquire knowledge and skills in a related area that may have applications in the broad subject area;
- help the student to bridge any gap in the curriculum and enable acquisition of essential skills (e.g. statistical, computational, language or communication skills etc.); and
- help the student to pursue an area of interest.

7.2.2 Along with the elective courses prescribed for the M.Sc. Degree Programme offered by the Department of Physics, a student has to register herself/himself in different elective courses in such a way that she/he ensures earning of minimum eight credits as elective from the other Departments/Schools.

7.2.3 The student may also choose additional elective courses offered by the University to enable her/him to acquire extra credits from the discipline, or across the disciplines. However, up to only 16 credit courses with best grades completed from the other Departments/Schools shall be considered for calculating CGPA of the Programme of study.

7.3 Self-study/Skill-based Courses:

The self-study/skill-based courses are optional, not mandatory. Being non-credit courses, the performance of students in these courses shall be indicated either as "satisfactory" or as "unsatisfactory", instead of the Letter Grade and this shall not be counted for the computation of SGPA/CGPA. These courses may also be taken by a student from other Departments/Schools.

Moreover, if the BoS of the Department feels that the Programme of study of M.Sc. requires certain academic backgrounds to pursue the Programme effectively, it may recommend some course(s) without credit(s) to meet the purpose as compulsory part of the syllabus.

Note: A course (Core/Elective/Self-study/Skill-based) may also be offered by the department in the form of a Dissertation, Project work, Practical training, Field work or Internship/Seminar etc.

8. **Mobility Options and Credit Transfers:**

The students shall be permitted to opt inter-disciplinary and horizontal mobility and can take courses of their choice, learn at their paces, enroll for additional courses, acquire more than the required credits, and adopt an interdisciplinary approach to learning, subject to the provisions made in this ordinance.

8.1. A student may be allowed to take course/courses of any other University/Organization/Institution, the courses of whom are duly accredited by the Department of Physics/School of Physical and Chemical Sciences under MoU or otherwise and approved by the Academic Council. (Note: The Department of Physics/School of Physical and Chemical Sciences shall try to ensure accreditation of relevant courses of other Universities/Organizations/Institutions including MOOCs and increase the choice basket of M.Sc. (Physics) Programme).

8.2. A student availing inter-university mobility shall continue to be a bonafide-student of the University where she/he initially got admission and in case she/he earns credits from a different university, the credits so earned shall be transferred to her/his parent University.

8.3. It shall be the responsibility of the student to assess the feasibility and practicality of vertical mobility (across universities), as it doesn't entitle a student to be exempted or relaxed from any of the requisites (sessional, attendance, assignments, end-semester examinations and Programme duration etc.) for the completion of the Programme.

8.4. The mobility option should not be interpreted as inter-university migration.

8.5. The mobility across the disciplines is also subject to availability of desired elective course, faculty, infrastructure and number of students (as fixed by the University/Department from time to time) opting for that elective course.

8.6. The mobility shall be permissible from the Regular Mode Programme to the Regular Mode Programme of learning only, and cannot be replaced by Open/Distance/Online Programme.

8.7 A student of some other University shall in any case be admitted only at the beginning of the particular Programme/Course which she/he proposes to take in the University subject to the fulfillment of other conditions.

9. **Credits:**

A credit defines the quantum of contents/syllabus prescribed for a course and determines the number of hours of instruction required per week. Thus, in each course, credits are assigned on the basis of the number of

lectures/tutorials/laboratory work/field work and other forms of learning required for completing the contents in 15-18 week schedule. 2 hours of laboratory work/field work is generally considered equivalent to 1 hour of lecture.

(i) 1 credit = 1 hour of instruction per week (1 credit course = 15 contact hours of instruction per semester)

(ii) 4 credits = 4 hours of instruction per week (4 credit course = 60 contact hours of instruction per Semester)

(iii) 1 credit = 1 hour of tutorial per week (1 credit course = 15 contact hours of instruction per semester)

(iv) 1 credit = 2 hours of laboratory work/field work per week (1 credit course = 30 hours of laboratory work/field)

Number(s) of credit(s) assigned to a particular course are mentioned in the detailed syllabus of the courses.

10. Course Coding:

Each course offered by the Department of Physics is identified by a unique course code comprising of twelve letters/numbers indicating Programme/level of Programme (first two letters in uppercase), Discipline/Subject (Next three letters in uppercase), Semester (next digit ranging from 1 to 4), Course Number (next three digits starting from 001 for each semester), Nature of Course for the Programme (next letter in uppercase i.e. C = Core Course; E = Elective Course, S = Self-study/Skill course), total number of credits for the course (next two digits starting from 00), respectively.

For example, the course code for second core course of the M.Sc. Physics Programme in the Third semester in the Department carrying 4 credits shall be ***MSPHY3002C04***.

Every time when a new course is prepared by the BoS of the Department (merely changing minor content and not the course title shall also be considered as a new course) it shall be assigned a new course code.

However, the University may decide a different course codification pattern for any Programme in future as per the demand of the situation.

11. Duration of the Programme:

The minimum duration for completion of M.Sc. (Physics) Programme shall be four consecutive semesters (two odd and two even semesters). *The maximum period for completion shall be eight semesters.*

Provided that (i) a semester or a year may be declared by the Controller of Examinations as a zero semester or a zero year for a student if she/he could not continue with the academic work during that period due to terminal illness and hospitalization of longer duration, or due to accepting a scholarship/fellowship, with due permission of the University, subject to the fulfillment of requirements laid down in this respect by the rules or regulations of the University. Such a zero semester/year shall not be

counted for calculation of the duration of the Programme in the case of such a student.

(ii) Hostel and other related facilities shall not be given to a student after completion of minimum duration, i.e., four semesters required for M.Sc. (Physics) Programme.

12. **Student Mentor:**

The Department shall appoint a Mentor for each student from amongst the faculty members of the Department. All faculty members of the Department shall function as Student Mentors and shall generally have more or less equal number of students. The Student Mentor shall advise the student in choosing courses and render all possible support and guidance to her/him.

13. **Course Registration:**

13.1. The registration for courses shall be the sole responsibility of the student. No student shall be allowed to do a course without registration, and no student shall be entitled to any credits in the course, unless she/he has been registered for the course by the scheduled date fixed by the Department/School/University.

13.2. Every student has to register in each semester (in consultation with her/his Student Mentor) for the courses she/he intends to undergo in that semester by applying in the prescribed proforma in triplicate (one copy each for student, for the student's file to be maintained in the departmental office and for the office of the Controller of Examinations), duly signed by her/him, the Student Mentor, the concerned Course Teacher and finally approved by the Head/In charge of the Department of Physics, within the deadline notified for the purpose by the Department/School/University.

13.3. Registration done in different courses within the stipulated period of time by a student shall not ordinarily be permitted to be changed. However, in exceptional cases, a student may be allowed by the Head/In charge of the Department of Physics to add a course, substitute a course for another course of the same type (elective or self-study/skill-based) or withdraw from a course, for valid reasons by applying on prescribed proforma (in triplicate as mentioned above in 13.2) with the consent of the Student Mentor not later than one week from the last date of course registration in a particular semester. Further, withdrawal from a course shall be permitted only if the courses registered after the withdrawal shall enable the student to earn a minimum of 20 credits. This duly approved change/withdrawal shall be notified by the office of the Department of Physics to all concerns like Controller of Examinations, both the Course Teachers etc.

13.4. A student shall register for a minimum of 20 credits and can register for a maximum of 32 credits in a semester unless specified otherwise by the University for a Programme of study.

13.5. If a student registers herself/himself for more elective courses than the prescribed in the Programme, while calculating the Cumulative Grade Point Average (CGPA), only the prescribed number of elective courses for the Programme of study shall be included in the descending order of the grades obtained by her/him ensuring the presence of minimum 8 and maximum 16 credits from the electives of other Departments/Schools.

13.6. A student shall have the option to choose an elective course from other Departments/Schools irrespective of the semester in which the course is offered, remaining other conditions same subject to the condition that the course is offered by a particular Department in that semester. For example; a student of third Semester can opt a course of other Department offered in any first/third Semester provided the course is offered by the particular Department.

14. **Examination and Promotion:**

(A) The examination of all the courses required for the M.Sc. (Physics) degree shall be internal in nature and generally consisting of Continuous Internal Assessment and End-Semester Examination. For the preparation of final grade in a particular course, the Continuous Internal Assessment (Formative in nature) and the End-Semester Examination (Summative in nature) shall have the weightage of 30% and 70%, respectively.

(B) Each course, irrespective of credits assigned to it, shall be evaluated out of 100 points. These points should not be confused with traditional system of marks. The points obtained by a student in a course are indicator of percentage of marks and not the raw marks. Since, the University has adopted the system of grading, hence, the marks shall not be reflected in a grade sheet of a student. However, for wider uses, and if required, the students or the prospective employer or end user may take the following reference for calculating maximum marks and obtained marks for a Programme/Course:

For Maximum Marks –

1 Credit Course = 25 marks course

2 Credit Course= 50 marks course

3 Credit Course= 75 marks course

4 Credit Course= 100 marks course

and so on.

For obtained marks –

The obtained points may be converted into marks by taking them as percentage of marks. For example:

(i) If a student has obtained 80 points in a 4 Credit Course, then it may be converted as: *80 marks out of 100.*

(ii) If a student has obtained 80 points in a 2 Credit Course, then it may be converted as: *40 marks out of 50.*

(iii) If a student has obtained 80 points in a 1 Credit Course, then it may be converted as: *20 marks out of 25.*

In such course(s), where direct numerical grades are awarded in place of points, these numerical grades shall be converted into marks by using the following formula:

Points in the Course = Numerical grade in the Course x 10

However, any change may be recommended in this pattern by the UATEC, from time to time.

14.1. Continuous Internal Assessment:

14.1.1 The Continuous Internal Assessment of the students' learning and performance shall be carried out by the Course Teacher(s). Considering the nature of the course, the teacher(s) shall decide the mode of Continuous Internal Assessment, which may include one or more assessment tools, such as student's class performance, assignments, class tests, take-home tests, term paper(s), presentations, oral-quizzes, case studies and laboratory work etc.

14.1.2 Each Course Teacher shall design the Continuous Internal Assessment system for the course she/he offers with the approval of the Departmental Committee (DC). This approved design of Continuous Internal Assessment shall be announced to the students of the respective courses at the beginning of each semester by the concerned teacher.

14.1.3 Generally, each course shall be taught by one teacher only, who shall maintain all the records related to attendance, teaching and assessment in a systematic manner. In an exceptionally rare case, if a teacher is assisted in teaching by other teacher, the teacher (in-charge of the course) shall be responsible for coordinating teaching and assessment, including award of final grade.

14.1.4 In case a student fails to appear in any Continuous Internal Assessment, it will be taken care by the concerned Course Teacher at her/his level.

14.2. End-Semester Examination:

14.2.1 Generally, End-Semester theory question paper shall include a limited number of very short answer type questions followed by short and long questions covering the entire syllabus in such a way that the question paper ensures assessing students' knowledge, understanding, application and analysis-synthesis/reflection of the subject. Thus, a standard model format of the End-Semester Examination paper consisting of 70 points shall be as under –

Section-A: 15 very short questions of 02 points each = 30 points
(Short specific questions covering the entire syllabus to be given which should be answered in approximately 50 words by the examinee).

Section-B: 04 short questions of 05 points each = 20 points
(05 short questions to be given out of which 04 questions are to be attempted in approximately 200 words by the examinee).

Section-C: 02 long questions of 10 points each = 20 points
(03 long questions to be given out of which 02 questions are to be attempted in approximately 500 words by the examinee).

However, a different format of the End-Semester question paper for some particular course (e.g., project, dissertation or laboratory/field work etc.) may be prescribed by the Board of Studies (BoS) of the Department which shall come into force only after the approval of the competent authority of the University.

14.2.2 The duration of the End-Semester theory examination generally shall be of three hours.

14.2.3 The DC shall appoint one or more team(s), as per the need, of preferably three faculty members in each team for moderation of question papers of End-Semester Examinations and communicate the same to the Controller of Examinations. The task of moderation shall be organized by the Controller of Examinations.

The paper setter and the moderator(s) shall ensure and certify that question paper is comprehensive to cover all important topics/themes/course and fit for assessing the mastery of the entire course. They shall also ensure and certify that not more than 10% questions from the previous year question paper have been repeated.

14.3 In exceptional cases, depending upon the nature of a particular course, a totally different mode of assessment and evaluation may be prescribed by the BoS of the Department for the course, which shall come into force only after the approval of the competent authority of the University. However, it must be reflected in the detailed syllabus of the course and be available to the students at the beginning of the semester.

14.4 Any partial or complete change in the system of examination (Assessment & Evaluation) may be recommended by the UATEC which shall be implemented only after the approval of the competent authority.

14.5 A student is required to secure a minimum of 'P' grade in the Continuous Internal Assessment and in the End-Semester Examination, taking together, in a course.

14.6 Making Evaluated Answer-scripts Available to the Students:

14.6.1 All the examination answer-scripts shall be made available to the students after evaluation by the respective teachers as per the schedule decided by the concerned teachers or the University. In case of the End-Semester Examination, the evaluated answer scripts shall be made available to the students within 7 days of the last examination for the semester. Thereafter, within a week, all the answer books along with the statement of marks shall be sent by the concerned teacher through her/his Department to the Office of the Controller of Examinations for declaration of the results.

14.6.2 If a student is not satisfied with the evaluation of her/his answer script, s/he must submit a written objection to the concerned Head of the Department (offering the course) within 8 days from the last examination for the semester. Such complaint shall be looked after by a panel of three faculty members, including the concerned teacher, to be

nominated by the concerned Head of the Department, whose decision shall be final. The revised points, if any, shall be submitted by the panel to the concerned Head of Department who shall further submit it to the Controller of Examinations. This complete process of grievance redressal by the panel and the further submission of marks by the Head of Department, generally, should not take more than 7 days from the date of receipt of the grievance. However, in case of any controversy, the matter shall be referred to the Vice-Chancellor for final decision and action.

14.6.3 Once evaluated answer books are submitted to the Controller of Examinations, there shall be no re-evaluation/re-totaling thereafter.

14.7 Letter Grades and Grade Points:

An absolute grading system shall be adopted to grade the students.

14.7.1. Under the absolute grading system, points shall be converted to grades based on pre-determined class intervals.

14.7.2. In the End-Semester theory or practical examinations, the examiner shall award the points and these points after adding the points of Continuous Internal Assessment shall be further converted into Grades/Grade points in accordance with the provisions of this ordinance.

14.7.3. Detail Grade Sheet issued by the Controller of Examinations office at the end of the semester shall carry points /percentage and equivalent grades (numerical and letter) both.

14.7.4. The 10-point Grading System, with the Letter Grades as given under shall be followed:

Letter Grade	Numerical Grade Point	Class Interval (in %)
O (Outstanding)	10	Above 90 and ≤ 100
A+ (Excellent)	9	Above 80 and ≤ 90
A (Very Good)	8	Above 70 and ≤ 80
B+ (Good)	7	Above 60 and ≤ 70
B (Above Average)	6	Above 50 and ≤ 60
C (Average)	5	Above 45 and ≤ 50
P (Pass)	4.5	40 to 45
F (Fail)	0	< 40
Ab (Absent)	0	Absent

Note:

(i) F= Fail, and the students graded with 'F' in a Programme or Course shall be required to re-appear in the examination.

(ii) The minimum qualifying points for a course shall be 45% (i.e., 'P' grade).

(iii) The students shall have to qualify in the Continuous Internal Assessment and the End-Semester examinations taking together.

(iv) Before awarding numerical grade to the points obtained in a course, only the total of Continuous Internal Assessment and End-Semester Examination shall be rounded off to remove the decimal point. Thus, no separate rounding off shall be done of the points obtained in different components of Continuous Internal Assessment and End-Semester Examination.

(v) There shall be rounding off of SGPA/CGPA up to two decimal points.

(vi) The SGPA/CGPA obtained by a student shall be out of a maximum of 10 points.

(vii) In order to be eligible for the award of the M.Sc. (Physics) Degree of the University, a student must obtain CGPA of 4.50 at the end of the Programme.x

(viii) Provided that the student who is otherwise eligible for the award of the M.Sc. (Physics) Degree but has secured a CGPA of less than 4.50 at the end of the minimum permissible period of semesters may be allowed by the Department to reappear or repeat as the case may be the same course(s) or other courses of the same type in lieu thereof in the extra semesters provided in Clause 11 related to the duration of Programme.

(ix) The Cumulative Grade Point Average (CGPA) obtained by a student shall be classified into the following division/Class:

CGPA	Class/ Division
Above 9	Outstanding
Above 8 to 9	First Class (With Distinction)
6 to 8	First Class
5.5 to < 6	High-Second Class
5 to < 5.5	Second Class
4.5 to < 5	Third Class

14.8. Re-appear in the End-Semester Examination:

14.8.1 Once a student has fulfilled the attendance requirements in a course as per the provisions mentioned in this ordinance but has failed to score minimum grade required to qualify the Course or failed to appear in the

End-Semester Examination of the course, may be allowed to re-appear in the End-Semester Examination, in such course, in the extra semesters provided under the Clause 11 on duration of Programme.

14.8.2. Such student may avail the chance to re-appear only within the maximum duration of the Programme. The re-appearance shall be permitted only in the End-Semester Examination of the concerned course(s) and the marks obtained by the student in the Continuous Internal Assessment conducted earlier for the particular course(s) shall be carried forward to be added with the marks obtained by her/him in the latest End-Semester Examination of the respective course(s).

14.8.3. The re-appear examination of even semesters shall be conducted along with the End-Semester Examinations of even semesters. Similarly, the re-appear examinations of odd semesters shall be conducted along with the End-Semester Examinations of odd semesters.

14.8.4. The re-appear examination shall be based on the syllabi of the course in force at the time of initial registration to the course.

14.8.5 A student who is re-appearing for the End-Semester Examination as per the clause 14.8.1 above; can re-appear in the subsequent semester(s), whenever the examination of a particular course is held, on payment of Rs. 2000/- (may be revised time to time by the University) per course in addition to the prescribed semester fee of the semester in which she/he has been promoted/provisionally promoted, if applicable, within the maximum permissible duration for the Programme.

14.8.6 A student who has got the Migration/Transfer Certificate issued from the University shall not be allowed to re-appear in the End-Semester Examination.

14.9 Re-appear in the End-Semester Examination for Improvement of Grade(s):

14.9.1 If a student wishes to improve her/his grade(s) in any course (s), s/he can re-appear in the End-Semester Examination in the subsequent odd/even semester(s), whenever the examination of the particular course(s) is held, on payment of Rs. 2000/- (may be revised time to time by the University) per course in addition to the prescribed semester fee of the semester in which she/he has been promoted/provisionally promoted, if applicable, within the maximum permissible duration for the Programme of study of the student.

14.9.2 A student may improve her/his points/grade by reappearing In the End-Semester Examination of a course as per the provisions of reappearing mentioned above. In such cases points obtained by the student in the Continuous Internal Assessment of the particular course shall be carried forward to the subsequent End-Semester Examination of the course. However, in such case, the points/grades obtained on the basis of latest appeared End-Semester Examination shall be considered for calculation of final CGPA of the Programme.

14.9.3 The re-appear examination of a course for improvement of grade shall be based on the syllabi of the course in force at the time of initial registration to the course.

14.9.4 A student who has got the Migration/Transfer Certificate issued from the University shall not be allowed to re-appear in any examination for improvement of grade.

14.10 Repeating course(s):

14.10.1 A student having attendance shortage in any course may repeat the course by taking re-admission in that course in subsequent odd/even semester(s), whenever the course is being offered, within the maximum permissible duration of the Programme.

14.10.2 If a student repeats a course she/he has to fulfill all the desired requirements afresh including attendance, Continuous Internal Assessment and the End-Semester Examination. In such case the course content shall be based on the syllabi of the course in force at the time of repeat of the course. However, at the time of repeating, if the same course is not being offered by the Department due to any reason, the student may choose any other course of similar nature and credits from the available courses on recommendation of the Mentor and approval of the concerned Head of Department.

14.10.3 If a student repeats a course, she/he has to submit a fee of Rs. 3000/- (may be revised time to time by the University) per course in addition to the prescribed semester fee of the semester in which she/he has been promoted/provisionally promoted, if applicable.

14.11 Promotion Rules:

14.11.1 A student shall be declared as **'Promoted'** to the next semester when s/he earns 'P' Grade or above in the last concluded semester examination, maintaining the spirit and pattern of semester system and covering the mandatory components, such as Continuous Internal Assessment and End-Semester Examinations in all the courses for which s/he was registered till date.

14.11.2 A student shall be **'Provisionally Promoted'** to the next semester if she/he secures less than 'P' grade in **maximum three courses** out of the total courses registered by her/him till date.

14.11.3 A student shall be deemed as **'Failed'** in a semester when she/he gets below 'P' Grade in **more than three courses** or does not appear in the End-Semester Examination of **more than three courses**, after fulfilling the attendance requirements as per this ordinance, out of the total courses registered by her/him till date. In such case(s), a student has to re-appear in the End-Semester Examination of the course(s) in subsequent odd/even semester(s) within the maximum permissible duration of the Programme on payment of Rs. 2000/- (may be revised

time to time by the University) per course. Since, such student does not need to attend the classes of the course(s) again; the marks of Continuous Internal Assessment obtained by her/him in the course(s) earlier shall be carried forward to be added with the marks obtained by her/him in the latest End-Semester Examination of the respective course(s).

14.11.4 A student shall also be deemed as 'Failed' in a semester when she/he failed to appear in the End-Semester Examinations of more than three courses due to the attendance criteria mentioned in 18.4 of this ordinance. Such student has to repeat the courses in the subsequent odd/even semester(s), whenever the courses are being offered, within the maximum permissible duration of the Programme, on payment of the prescribed fees as per the clause 14.10.3.

14.11.5 Under no circumstances, any student shall be permitted to register in a new course if she/he is having less than 'P' Grade in more than three courses.

14.11.6 A student shall be declared to have passed the Programme of study and award of the degree if she/he has secured the required credits with at least 'P' grade.

14.11.7 The re-examination of End-Semester Examination of the failed or provisionally promoted students shall be as per the clauses/sub-clauses under 14.8 above. However, only in a case where a student of final semester (within the minimum prescribed duration of the Programme) fails to appear or to achieve 'P' grade in maximum three courses including all backlogs after the result declaration of final semester, the Department may ask the concerned course Teacher(s) to conduct re-examination of End-Semester Examinations of such course(s) within a month from commencement of the next semester relaxing the condition of odd/even semester as given in 14.8.3 the student shall have to pay a fee of Rs. 2000/- per course.

14.11.8 If a candidate is repeating a course in an academic session, whatever may be the reason, it shall not be counted in the total number of seats and shall not affect the fresh intake of the M.Sc. (Physics) Programme in that academic session.

14.12 **Minimum Credit Requirements:**

For a two-year M.Sc. (Physics) Degree Programme, the credit requirements shall be 96 credits, including core and elective courses as prescribed in the detailed syllabus attached with this ordinance and regulations. A minimum of 8 credits and maximum of 16 credits shall be in the form of elective courses from the core/elective courses

offered by other Department(s).

15. Computation of SGPA and CGPA:

The University shall follow the following procedure to compute the Semester Grade Point Average (SGPA) and Cumulative Grade Point Average (CGPA):

15.1. The SGPA is the ratio of sum of the product of the number of credits with the grade points scored by a student in all the courses taken by a student in a particular semester and sum of the number of credits of all the courses undergone by a student in that semester, i.e.,

$$SGPA\ (Si) = \sum (Ci \times Gi)/\sum Ci$$

Where, Ci is the number of credits of the i^{th} course and Gi is the grade point scored by the student in the i^{th} course.

15.2. The CGPA is also calculated in the same manner taking into account all the considerable courses as per the provision laid down in this ordinance out of the total courses undergone by a student over all the semesters of a Programme, i.e.,

$$CGPA = \sum (Ci \times Gi)/\sum Ci$$

Where, Ci is the number of credits of the i^{th} course (which is to be considered for the award of the PG Degree) and Gi is the grade point scored by the student in the i^{th} course.

15.3. The SGPA and CGPA shall be rounded off to 2 decimal points.

15.4 Since, the calculation of CGPA is not based on all the courses undergone by the student, rather it is governed by other provisions laid down in this ordinance like, clause 7.2.3, 13.5 etc., the CGPA may differ from the corresponding calculations based on SGPA only.

16. Illustration of Computation of SGPA and CGPA:

16.1. Illustration for computing SGPA:

Course	Credit	Grade Letter	Grade Point	Credit Point
Course I	3	A	8	3 x 8 = 24
Course II	4	B+	7	4 x 7 = 28
Course III	3	B	6	3 x 6 = 18
Course IV	3	O	10	3 x 10 =30
	Total credits for the semester = 13			Total Credit points Earned = 100

Thus, SGPA = 100/13 = 7.69

16.2 **Illustrations for computing CGPA:**

Courses Considered for the Award of the Degree	Completed In the month (Year)	Credit	Grade Letter	Grade Point	Credit Point
Course I	Dec 2018	4	A	8	4 x 8 = 32
Course II	Dec 2018	4	B+	7	4 x 7 = 28
Course III	June 2019	4	B	6	4 x 6 = 24
Course IV	June 2020	4	o	10	4 x 10 = 40
		Total credits for the semester =16			Total Credit points earned= 124

Thus, CGPA= 124/16= 7.75

Note: Formula to calculate percentage from CGPA/SGPA= CGPA or SGPA x 10; and formula to calculate percentage to CGPA or SGPA = Percentage/10,

e.g., In case of example mentioned in Table 16.2, the percentage of CGPA = 7.75 x 10 = 77.50%

16.3. Transcript (Format): Based on the above, letter grades, grade points, and the SGPA, the Transcripts/Detail Grades Certificates (DGCs) shall be issued to the candidates for each semester and a consolidated transcript on completion of the Programme indicating the performance in all the courses considered for calculating the CGPA. Along with the CGPA, the percentage of marks obtained in the Programme shall be reflected in this consolidated transcript on the basis of the CGPA. However, this system may be changed by the University at any point of time without prior notice to the stakeholders as per the need.

17. Removal of Student Name from the Programme:

The name of a student falling under any one of the following categories shall automatically stand removed from the rolls of the University:

(a)A student who has failed to fulfill the minimum grade point requirements prescribed for the Programme during the maximum duration of the Programme.

(b)A student who has already exhausted the maximum duration allowed for

completion of the Programme and has not fulfilled the requirements for the award of the degree.

(c)A student who is found to be involved in misconduct, forgery, indiscipline or any other objectionable conduct, upon recommendation of the Disciplinary Committee/ Proctorial Board or any other procedure deemed fit by the University.

(d)A student who has failed to attend the classes as stipulated under the clause of attendance requirements in this ordinance.

18. Attendance Rules:

18.1 A student is required to attend 100% of the classes held in a course in the specific semester in order to be eligible to appear in the End-semester examination of that particular course.

18.2 Waiving of attendance-deficit up to a maximum of 25% is permissible to accommodate following situations:

(a) Representing the University in any inter-collegiate, inter-University, local, national or international events; (b) Participating in an activity of the University with prior permission of the Competent Authority; (c) Participation in NCC/NSC/NSS Camps duly supported by certificate. (d) Participation in Educational Excursions, which form a part of teaching in any subject, conducted on working days duly certified by the concern Course Teacher/ Head of Department /Dean; and (e) to cover all unforeseen reasons like illness, hospitalization, personal engagements elsewhere or other personal reasons which compel a student to absent herself/himself from attending the classes.

18.3 Hence, it shall be mandatory/compulsory to every student to have attendance in 75% classes held in particular course. No waiver, for whatsoever reason, shall be given. Accordingly, no application requesting waiver below 75% attendance shall be entertained by the University. However, a further relaxation up to 10% or the days spent (whichever is lesser) on the basis of situations mentioned under a, b & c of Clause 18.2 above (not on the basis of d of Clause 18.2) may be considered by the Vice-Chancellor on the recommendation of the Head/In charge of the Department. In any other situation no appeal can be made for this purpose even to the Vice-Chancellor.

18.4 A student, however, shall not be allowed to appear in the End-Semester Examination of the courses which are not covered under above mentioned clauses 18.1, 18.2 and 18.3. Such a student shall be permitted to repeat the courses in the subsequent odd/even semester(s), whenever the courses are being offered, within the maximum permissible duration of the Programme, on payment of the prescribed

fees as per the clause 14.10.3. However, in the first semester, for repeating the courses, it shall be mandatory for a student to have minimum 40% attendance in aggregate (taken together all the courses registered by her/him in the semester). If a student does not put in at least 40% of aggregate attendance in the first semester, she/he shall have to leave the Programme without claiming refund of any fees, and her/his admission shall be treated as cancelled.

18.5 The attendance of a newly admitted candidate shall be counted from the date of her/his admission/registration or date of beginning of classes, whichever is later. In the case of promoted candidates, attendance shall be counted from the date on which respective class begins. However, if a new student is admitted late after the commencement of the classes, s/he must get herself/himself registered in the desired courses following the due procedure within 5 working days after the admission failing which her/his attendance shall be counted after 5 working days from the date of admission.

18.6 In a case of changed registration as per the clause 13.3 of this ordinance the total classes held for calculating percentage of attendance in the newly registered course for a particular student shall be counted from the fresh registration in that particular course.

18.7 Monthly records of attendance of students in each of the courses taught by a teacher is to be prepared and submitted by the concerned teacher to the Office of the Head/In charge of the Department (HoD) and the Controller of Examinations' (CoE) office by the 10th day of the next month after displaying it to the students in the course and taking their signatures. The teacher will keep the original record of attendance with her/him and submit it finally to both the offices with her/his remarks regarding the eligibility of a student for appearing in the end semester examination within three working days after the last class or teaching day in the semester, whichever is later. Any failure in compliance in this matter must be informed by the concerned teacher to the Head of Department and the Controller of Examinations with justification.

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18.8 There shall be an Attendance Monitoring Committee in the Department under the Chairmanship of the Head or her/his nominee for proper monitoring of attendance records and taking suitable action(s) as per the requirements.

19. Programme Structure:

The M.Sc. (Physics) Programme shall be of two year duration divided into four semesters. A student is required to earn at least 96 credits within the stipulated time as per the details given in Annexure-1.

(ANNEXURE WILL CONTAIN THE FOLLOWING ALONG WITH THE DETAILED SYLLABUS)

The Courses and Credit Load (in the provided format along with specific scheme of examination, if any):

Semester-wise Distribution of Courses:

20. Power to Relax and Amendments

20.1 All the above clauses are subject to the amendments, as and when required, as per the decisions pertaining to rules, regulations and norms of the University Statutory Bodies and other Regulatory Bodies etc. (e.g., National Council for Teacher Education (NCTE)), from time to time.

20.1.1 Notwithstanding what is contained in the foregoing clauses of this ordinance, the Academic Council may, in exceptional circumstances consider at its discretion and for reasons to be recorded, relax any of the provisions except those prescribing CGPA requirements.

20.2 Notwithstanding anything stated in this ordinance, for any unforeseen issues arising, and not covered by this ordinance, or in the event of differences of interpretation, the Vice-Chancellor may take a decision, after obtaining the opinion/advice, if required, of UATEC. The decision of the Vice-Chancellor shall be final.

CENTRAL UNIVERSITY OF SOUTH BIHAR

Master of Science (M.Sc.) Physics Programme

Syllabus

(Effective from Academic Session 2020-2021)

Department of Physics

SCHOOL OF PHYSICAL AND CHEMICAL SCIENCES

SCHOOL OF PHYSICAL & CHEMICAL SCIENCES

Department of Physics

Department of Physics, under the umbrella of School of Physical & Chemical Sciences, has been providing support to the undergraduate programs of Central University of South Bihar (CUSB) since its inception. The M.Sc. Degree Program in Physics was launched from the academic session 2018-19 with the intake of 35 students and from academic session 2019-20, the department is running the Ph.D. programme in various frontier areas of physics such as Nuclear & Particle, High Energy Physics, Astroparticle Physics, Low energy neutrino Physics, Dark Matter, Detector development and Data Acquisition System (DAQ), Experimental condense matter Physics and Material Science, Superconductivity (Theory), Nano-science and technology (Theory), Metallic glasses (Experimental), Molecular Motors, Molecular Spintronics, Two-dimensional superconductivity, Material synthesis, crystal growth and characterization (Piezo, ferro, semiconductor and NLO), Synthesis & Characterization of Nano material, magnetic and hydrogen storage properties, Noncommutativity and deformed special relativity. In addition, from the upcoming session 2020-21, the department is going to start one major undergraduate programme namely B. Sc. Honours in Physics – a three year degree course as per UGC CBCS norms. From the same academic session department is going to offer two specializations in postgraduate programmes such as Material Science, and Nuclear & Particle Physics.

The Department of Physics is committed to engage in high quality research and in the pursuit of excellence in teaching. The faculty members of the department are actively involved in cutting-edge theoretical and experimental research in challenging areas as mentioned above. To promote interdisciplinary research for solving grand challenges facing our society, the department has established both intra-university as well as inter-institutional collaborations with laboratories in India and overseas. The department of physics has active national and international research collaborations.

Ph.D. in Physics

The broad areas of research in the department of Physics are hard/soft condensed matter physics, spectroscopy, nanoscience and nanotechnology, materials science, and Nuclear and Astroparticle Physics. In due course we will also open research areas related to computational physics, theoretical biophysics, and space physics. All the students will be required to successfully complete a course work before beginning the research towards their Ph.D. thesis. The tentative course work structure, subjected to the approval from the Board of Studies, is as follows:

Course Code	Course Title	Credits
Core	Research Methodology	4
Core	Theoretical and Experimental Techniques of Physics Research	4
Core	Review, Report and Seminar	2
Core	Research and Publication Ethics (RPE)	2

Course Title: Research Methodology			
Course Code	PHDPHY1001C04	Credits	4
L + T + P	4 + 0 + 0	Contact Hours	60 (L)

Unit :1

Research objectives: Types of research, Development of a research question; Science, pseudoscience and rationalism; Physical science and metaphysics; Literature survey, Identification of knowledge gaps and a research problem; Concept of novelty, Formulation and implementation of a research plan; Serendipity, creativity, discovery and innovation.

Research process and tools: Design of experiments, testing and characterization; Measurement - Standardization, calibration and sampling; Primary and secondary data; Computer programming, theory, modelling and simulation; Data acquisition, processing, observation, critical analysis and interpretation; Presentation of data; Reliability and reproducibility.

(15 Lectures)

Unit:2

Computer applications and tools: Software for documentation, graphs, graphics, drawing and presentation.

Search engines and databases: Web literature search; International standards, reference data and constants.

Library system: Physical cataloguing of books and journals; Online catalogue search; Subscribed books and journals.

Good laboratory practices: Organization and cleanliness; Maintenance of laboratory records; Biological, chemical, electrical and fire safety; Safe disposal of hazardous materials; Upholding environmental and human concerns in planning and conducting experiments; Government regulations.

(15 Lectures)

Unit :3

Communicating research results: Journal paper – types of available publishing services; Research proposal, Report, Thesis; Presentation in Seminar and conference; Journal abbreviations, Bibliography standards; Indices of quality assessment of publications.

Statistical techniques: Mathematical tools for analysis, Statistical data treatment and evaluation; Probability and probability distributions; Sampling and sampling designs, Data analysis, Testing of hypothesis, statistical tests and analysis, Data interpretation, multivariate analysis, Model building.

(15Lectures)

Unit:4

Analytical and numerical techniques: Mean deviation, Root mean square deviation, Histogram, Skewness, Kurtosis, Moments, Variance, Chi-square, Correlation, Factor analysis, Mean square weighted deviation, Regression, Time series analysis

Statistical and graphical packages: MS Excel, MATLAB, Microcal Origin / Sigma plot, gnu plot, xmgr – Key Features; Developing algorithms and applications, Tex.

(15 Lectures)

Text Books:

1. Research Methodology: The Aims, Practices and Ethics of Science, P. Pruzan, Springer, 2016
2. Research Methods for Science, M. P. Marder, Cambridge University, 2011
3. Fundamentals of Research Methodology and Statistics, Y.K. Singh, New Age, 2006

Reference Books:

1. Research Methodology: An Introduction for Science and Engineering Students; Melville
2. and Goddard, Juta, 1996
3. Research Methods in Science and Engineering, Scott A. Gold, CRC Press, 2016

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Course Title: Theoretical and Experimental Techniques of Physics Research			
Course Code	PHDPHY1002C04	Credits	4
L + T + P	4 + 0 + 0	Contact Hours	60 (L)

Unit: I

Quantum Mechanics: Schrödinger Picture, **Time independent perturbation theory**: Theory and an example; **Scattering theory**: Quantum theory, Partial wave analysis (one example), Born Approximation and its validity (One example); **Path integral formulation**: propagator, Schrödinger wave equation from path integral, eg: free particles; Introduction to second quantization; **Quantum field theory**: quantization of scalar field and Dirac field.

Condensed Matter Physics: **Electronic Structure Calculation:** Hartree-Fock Theory, Introduction to Density Functional Theory; **Correlated Electron States:** Mott Transition, Hubbard Model, Magnetic impurities and Kondo Model; **Quantum Hall effect:** Integer and fractional Hall Effect, Laughlin wave function; **Magnetism:** Mean field approximation for Heisenberg Hamiltonian model for Ferromagnetism.

(15 Lectures)

Unit: II

High Energy Physics: Introduction to relativistic kinematics, Review of Experimental methods: fixed target and collider experiments, Introduction of four forces and interactions, Feynman diagrams Basics of quantum electrodynamics: Glashow-Salam-Weinberg model,
Standard Model Physics.

Nonlinear Optics: Nonlinear wave propagation in Anisotropic media; Second Harmonic Generation (SHG); Phase Matching Techniques; Three-Wave Interactions; Third Harmonic Generation (THG); Density Matrix and Perturbation approach to Nonlinear susceptibility.

(15 Lectures)

Unit: III

Vacuum Generation and Measurement Techniques: Introduction to vacuum, gas law; Rotary vane pump, Turbomolecular pump, Cryo pump; Pirani gauge, Penning gauge.

Fundamentals of Synthesis and Fabrication of Materials: Classification of powders; Synthesis of powders: Sol-gel, Hydrothermal, Combustion techniques; Synthesis of thin films: Spincoating, Dip coating, Thermal and electron beam evaporation, Pulsed laser deposition; General concept of lithography, Photolithography, Electron beam lithography; Clean room. **Introduction to Basic Measurements and Characterization Techniques:** ***Study of Crystal Structure:*** X-ray diffraction (XRD), Transmission Electron diffraction (TED), ***Microscopic Techniques:*** Optical Microscopes (Bright field, Confocal, Super-resolution), Scanning Electron Microscope, Transmission Electron Microscope, Scanning Probe Microscopes.

(15 Lectures)

Unit: IV

Spectroscopic Techniques: UV-Vis, Fluorescence, IR and FTIR, Photo-Acoustic, Laser Induced Breakdown, Raman, Twyman-Green interferometer as a special case of Michelson Interferometer for testing of optical components, Lateral shearing interferometers and its applications such as testing. Collimation of a lens, laser speckle techniques and its applications. **Surface and Compositional Analysis Methods**: EDAX, XPS. **Dielectric Characterization**: Complex impedance spectroscopy, Analysis of Nyquist plot, Various RC network schemes, Analysis of CV curves, ac conductivity, Charging-discharging cycle of capacitors. **Electrochemical Measurements**: Different potentiometric /galvanometric techniques. Methods for studying electrical, magnetic, thermal properties. **Accelerator and Fusion Techniques:** Pelletron, Linear accelerator, Cyclotron, Synchrotron, Tokamac; Applications in High energy physics, Materials science and Particle therapy. **Low Temperature Methods** : Temperature measurement and control; Cryostats and cooling methods.

(15 Lectures)

Text Books:

1. Handbook of Vacuum Science and Technology; Hoffman, Singh and Thomas; Academic Press, 1998.
2. Nanostructures and Nanomaterials - Synthesis, Properties and Applications; Guozhong Cao, World Scientific, 2004
3. Thin Film Phenomena; Chopra; McGraw-Hill; 1969
4. ASM Handbook: Volume 10: Materials Characterization; Crankovic; ASM International;1986
5. Surface Characterization Methods: Principles, Techniques and Applications; Milling; CRC Press; 1999

Course Title: Review, Report and Seminar			
Course Code	PHDPHY1003C02	**Credits**	2
L + T + P	2 + 0 + 0	**Contact Hours**	30 (L)

Course Title: Research and Publication Ethics (RPE)			
Course Code	PHDPHY1003C02	**Credits**	2
L + T + P	2 + 0 + 0	**Contact Hours**	30 (L)

Research ethics: Ethics code of American Psychological Association; Collaboration, cooperation and teamwork; Research outcome; Intellectual property right, Copy-right, patent, fundamentals of patent filing; Usage of pirated version of literatures and software; Plagiarism – Case Studies, Web based verification.

References:

1. Research Methods for Science, M. P. Marder, Cambridge University, 2011
2. Fundamentals of Research Methodology and Statistics, Y.K. Singh, New Age, 2006

19/02/2020

Nitin Chandra 19.02.2020

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M.Sc. in Physics

The objectives of this program are to cater and to meet the needs and aspirations of contemporary M.Sc. Physics students. It is tailored to incorporate the essential ingredients of multifaceted education and research for this rapidly changing world. This program aims to (i) provide the much needed and strong foundation in Physics so that students can develop the ability to apply the knowledge of Physics in any allied fields, (ii) help students to develop programming proficiency with high end software for both computation and automation, (iii) give students an opportunity to use advanced laboratory equipment to get acquainted with them, (iv) present a platform to students for training in both mechanical and electronic hardware for basic and applied research, (v) offer necessary soft skills to the students to build their professional career, (vi) to make the students well aware about the radiation safety and precautions that will help the society to make their life better, (vii) to enhanced their knowledge in the area of nuclear and particle physics that will help in making their contribution in country's nuclear energy and national security and safety programmes.

List of Courses in M.Sc. Physics from Academic Session 2020-2021 (96 Credits)

Course Code	Course Title	Credit		
	Semester-I	L	T	P
MSPHY1001C04	Mathematical Physics	4	0	0
MSPHY1002C04	Classical Mechanics	4	0	0
MSPHY1003C04	Quantum Mechanics	4	0	0
MSPHY1004C04	General Physics Lab. - I	0	0	4
MSPHY1005E04	Electronics	4	0	0
MSPHY1006E04	Experimental Techniques	4	0	0
MSPHY1007E04	Biography of Indian Scientists	2	0	0
	Elective – I (From other department)	4	0	0
	Total Credit	**30**		
	Semester - II	L	T	P
Course Code	**Course Title**	**Credit**		
MSPHY2001C04	Thermodynamics and Statistical Physics	4	0	0
MSPHY2002C04	Classical Electrodynamics and Relativity	4	0	0
MSPHY2003C04	General Physics Lab. – II	0	0	4
MSPHY2004C04	Atomic and Molecular Physics	4	0	0
MSPHY2005C04	Elementary Solid State Physics	2	0	0
MSPHY2006C04	Elementary Nuclear & Particle Physics	2	0	0
MSPHY2007E04	Advanced Quantum Mechanics	4	0	0
MSPHY2008E04	Advanced Mathematical Physics	4	0	0
MSPHY2009E04	Introduction of Ancient Indian Sciences	4	0	0
	Total Credit	**32**		
	Semester-III (Specialization in Condensed Matter Physics)	L	T	P
Course Code	**Course Title**	**Credit**		
MSPHY3001C04	Condensed Matter Physics	4	0	0
MSPHY3002C04	Solid State Devices	4	0	0
MSPHY3003C04	Solid State Physics Lab - I	0	0	4
MSPHY3004E04	Materials Science	4	0	0
MSPHY3005E04	Crystal Growth and Characterizations	2	0	2
MSPHY3006E04	Crystallography Crystal Structure and Diffraction Techniques	2	0	2

MSPHY3007E04	Fundamentals of nanoscience and nanotechnology	4	0	0
MSPHY3008E02	Physics of Dielectic and Ferroelectric Materials	2	0	0
MSPHY3009E02	X-ray Spectroscopy	2	0	0
MSPHY3010E02	Diffusion in Solids	2	0	0
MSPHY3011E04	Fundamentals of Scanning Probe Microscopy	4	0	0
	Elective - III (from other Department)	4	0	0
	Total Credit	42		

Semester-IV (Specialization in Condensed Matter Physics)		L	T	P
Course Code	Course Title	Credit		
MSPHY4001C04	Advanced Condensed Matter Physics	4	0	0
MSPHY4002C04	Dissertation	4	0	0
MSPHY4003C04	Solid State Physics Lab - II	0	0	4
MSPHY4004E04	Physics of Magnetism and Spintronics	4	0	0
MSPHY4005E04	Alloy Design and Development	2	0	2
MSPHY4006E04	Material Synthesis and Processing	2	0	2
MSPHY4007E04	Renewable Energy	4	0	0
MSPHY4008E04	Carbon Nanostructres and Their Properties	2	0	2
MSPHY4009E04	Biomedical Instrumentation	4	0	0
MSPHY4010E04	Industrial Process Control	4	0	0
MSPHY4011E04	Nanoelectronics	4	0	0
	Total Credit	44		

Semester-III (Specialization in Nuclear and Particle Physics)		L	T	P
Course Code	Course Title	Credit		
MSPHY3101C04	Advanced Nuclear Physics	4	0	0
MSPHY3102C04	Nuclear & Particle Physics Lab. – I	0	0	4
MSPHY3103C04	Advanced Particle Physics	4	0	0
MSPHY3104E04	Introduction of Astrophysics	4	0	0
MSPHY3105E04	Nuclear Reactor Physics	4	0	0
MSPHY3106E04	Statistical Analysis Techniques in Nuclear and Particle Physics	4	0	0
MSPHY3107E04	Radiation Safety	2	0	0
MSPHY3108E04	Neutrino Physics	2	0	0
	Elective – I (from other department)	4	0	0
	Total Credit	32		

Semester - IV (Specialization in Nuclear and Particle Physics)		L	T	P
Course Code	Course Title	Credit		
MSPHY4101C04	Experimental Techniques in Nuclear and Particle Physics	4	0	0
MSPHY4102C04	Dissertation	0	0	4
MSPHY4103C04	Nuclear & Particle Physics Lab. – II	0	0	4
MSPHY4104E04	Particle Accelerator Physics	4	0	0
MSPHY4105E04	Data Analysis and Simulation in particle Physics	4	0	0
MSPHY4106E04	General Theory of Relativity	4	0	0
MSPHY4107E04	High Energy Cosmic Rays	2	0	0
MSPHY4108E04	Dark Matter Physics	0	0	0
	Total Credit	26		

Master of Science (M.Sc.) Physics Programme

Detailed Syllabus

(Effective from Academic Session 2020-2021)

SEMESTER - I

Methods of Content Interaction	Mainly: Lectures and Tutorials; Additionally: Group discussion; self-study, seminar, presentations by students, individual and group drills, group and individual field based assignments followed by workshops and seminar presentation.
Assessment and Evaluation	• 30% - Continuous Internal Assessment (Formative in nature but also contributing to the final grades) • 70% - End Term External Examination (University Examination)

Course Title: Mathematical Physics			
Course Code	MSPHY1001C04	Credits	4
L + T + P	4 + 0 + 0	Contact Hours	60 (L)

UNIT I:
Linear vector spaces and operators: Vector spaces and subspaces, Linear dependence and independence, Inner product, Orthogonality, linear operators, Matrix representation, Similarity transformations, Characteristic polynomial of a matrix, Eigen values and eigenvectors, Self adjoint and Unitary transformations, Eigen values and eigenvectors of Hermitian and Unitary transformations, diagonalization.

(20 Lectures)

UNIT II:
Vector analysis and curvilinear co-ordinates: Gradient, Divergence and Curl operations, Vector Integration, Gauss' and Stokes' theorems, Curvilinear co-ordinates, Gradient, Curl, divergence and Laplacian in spherical polar and cylindrical polar co-ordinates. Definition of tensors, contravariant and covariant components of tensors.

(20 Lectures)

UNIT III:
Ordinary differential equations and Special Functions: Linear ordinary differential equations, Series solutions – Frobenius' method, Series solutions of the differential equations of Bessel, Legendre, Leguerre and Hermite polynomials.

(20 Lectures)

References

1. Mathematical Methods of Physics - J. Mathews and R. L. Walker, Second Edition,
2. Addison-Wesley.
3. Mathematical Methods for Physicists – G. B. Arfken and H. Weber, Seventh Edition, Academic Press, 2012
4. Matrices and Tensors in Physics - M. R. Spiegel, Schaum Series
5. Linear Algebra – Seymour Lipschutz, Schaum Outlines Series
6. Matrices and Tensors in Physics - A.W. Joshi, Wiley Eastern Ltd, 1975
7. Vector Analysis - M. R. Spiegel, Schaum Series
8. Introduction to Dynamics – I. Percival and D. Richards, Cambridge University Press.

Course Title: Classical Mechanics			
Course Code	MSPHY1002C04	Credits	4
L + T + P	4 + 0 + 0	Contact Hours	60 (L)

UNIT I:

System of particles: Center of mass, total angular momentum and total kinetic energies of a system of particles, conservation of linear momentum, energy and angular momentum. Lagrangian Formulation: Constraints and their classification, degrees of freedom, generalized co-ordinates, virtual displacement, D'Alembert's principle, Lagrange's equations of motion of the second kind, uniqueness of the Lagrangian, Simple applications of the Lagrangian formulation: 1. Single free particle in (a) Cartesian co-ordinates, (b) plane polar co-ordinates; 2. Atwood's machine; 3.bead sliding on a uniformly rotating wire in a forcefree space; 4. Motion of block attached to a spring ; 5. Simple pendulum. Symmetries of space time: Cyclic coordinate, Conservation of linear momentum, angular momentum and energy.

(15 Lectures)

UNIT II:

Central forces: Reduction of two particle equations of motion to the equivalent one-body problem, reduced mass of the system, conservation theorems (First integrals of the motion), equations of motion for the orbit, classification of orbits, conditions for closed orbits, the Kepler problem (inverse square law force).

Scattering in a central force field: general description of scattering, cross-section, impact parameter, Rutherford scattering, center of mass and laboratory co-ordinate systems, transformations of the scattering angle and cross-sections between them. Motion in non-central reference frames: Motion of a particle in a general non-inertial frame of reference, notion of pseudo forces, equations of motion in a rotating frame of reference, the Coriolis force, deviation due east of a falling body, the Foucault pendulum.

(15 Lectures)

UNIT III:

Rigid body dynamics: Degrees of freedom of a free rigid body, angular momentum and kinetic energy of a rigid body, moment of inertia tensor, principal moments of inertia, classification of rigid bodies as spherical, symmetric and asymmetric, Euler's equations of motion for a rigid body, Torque free motion of a rigid body, precession of earth's axis of rotation, Euler angles, angular velocity of a rigid body, notions of spin, precession and nutation of a rigid body.

Small oscillations: Types of equilibria, quadratic forms for kinetic and potential energies of a system in equilibrium, Lagrange's equations of motion, normal modes and normal frequencies, examples of (i) longitudinal vibrations of two coupled harmonic oscillators, (ii) Normal modes and normal frequencies of a linear, symmetric, triatomic molecule, (iii) oscillations of two linearly coupled plane pendula.

(15 Lectures)

UNIT IV:

Hamiltonian formulation: Generalized momenta, canonical variables, Legendre transformation and the Hamilton's equations of motion, Examples of (a) the Hamiltonian of a particle in a central force field, (b) the simple harmonic oscillator, cyclic co-ordinates and conservation theorems, derivation of Hamilton's equations from variational principle. Canonical transformation: Generating functions (four basic types), examples of canonical transformations, the harmonic oscillator in one dimension, Poisson brackets, equations of motion in terms of Poisson brackets, properties of Poisson brackets (antisymmetry, linearity and Jacobi identity), Poisson brackets of angular momentum, The Hamilton-Jacobi equation, Linear harmonic oscillator using Hamilton-Jacobi method

(15 Lectures)

References

1. Classical mechanics, H. Goldstein, C. Poole, J. Safico, 3rd edition, Pearson Education Inc. (2002).
2. Classical mechanics, K. N. Srinivasa Rao, University Press (2003).
3. Classical mechanics, N. C. Rana and P. S. Joag, Tata McGraw-Hill (1991).
4. Classical dynamics of particles and systems, J. B. Marian, Academic Press (1970)
5. Introduction to classical mechanics, Takwale and Puranik, Tata McGraw-Hill (1983).
6. Classical mechanics, L. D. Landau and E. M. Lifshitz, 4th edition, Pergamon press (1985).

Course Title: Quantum Mechanics			
Course Code	MSPHY1003C04	**Credits**	4
L + T + P	4 + 0 + 0	**Contact Hours**	60 (L)

UNIT I: Introductory concepts of Quantum Mechanics

Wave-particle duality, electron diffraction, Wave packets, Gaussian wave packet, Spreading of Gaussian wave packet, Heisenberg uncertainty principle for position and momentum, Schrodinger equation, conservation of probability, probability interpretation of wave function, expectation values, Ehrenfest theorem, measurement in quantum theory, time independent Schrodinger equation, stationary states, momentum space representation.

(15 Lectures)

UNIT II: One Dimensional and Three Dimensional Problems

One Dimensional: Particle in a box – simple harmonic oscillator - Square well potential – Barrier penetration.

Orbital angular momentum and spherical harmonics, Orbital angular momentum commutation relations, Eigen values and eigen functions, General operator algebra of angular momentum operators J_x, J_y, J_z. Ladder operators, Eigen values and eigenkets of J^2 and Jz, Matrix representations of angular momentum operators, Pauli matrices, Addition of angular momentum, Clebsch-Gordan coefficients, computation of Clebsch-Gordan coefficients in simple cases ($j_1 = j_2 = 1/2$).

Three Dimensional: Central potential, separation of variables in the Schrodinger equation, Particle in a Spherical well, the radial equation. The Hydrogen atom.

(15 Lectures)

UNIT III: General formalism of quantum theory

Operator formalism: Hilbert space and observables, linear operators and observables, Dirac notation, degeneracy and simultaneous observables, generalized uncertainty principle for two non-commuting observables, Unitary dynamics, projection operators and measurements, time-dependence of observables: Schrodinger, Heisenberg and interaction pictures, Simple harmonic oscillator by operator method.

Identical particles: Exchange degeneracy, Symmetrization Postulate, Constructing symmetric and antisymmetric states, system of identical non-interacting particles, the Pauli's exclusion principle and the Periodic table

(15 Lectures)

UNIT-IV: Approximation methods

Time-independent perturbation theory for non- degenerate and degenerate levels - Application to ground state of an harmonic oscillator and Stark effect in Hydrogen - Variation method -Application to ground state of Helium atom - WKB approximation - WKB quantization rules, Applications in the theory of alpha-decay and field emission of electrons.

(15 Lectures)

References:

1. Introduction to Quantum Mechanics – David J. Griffiths, Second Edition, Pearson Prentice Hall 2005.
2. Quantum Mechanics Concepts and Applications- Nouredine Zettile, Second Edison, John Wiley and Sons. 2009
3. Quantum Mechanics Vol I & II – C. Cohen-Tannoudji, B. Diu and F. Laloe, Second Edition, Wiley Interscience Publication, 1977.
4. Quantum Mechanics – E. Merzbacher, John Wiley and Sons, 1998.
5. Quantum Mechanics – B.H. Bransden and C.J. Joachain, Second Edition, Pearson Education, 2007.
6. Modern Quantum Mechanics – J.J. Sakurai, Revised Edition, Addison-Wesley, 1995.
7. Principles of Quantum Mechanics - R. Shankar, Second Edition, Springer, 1994.
8. Quantum Mechanics- L.I. Schiff, Third Edition, Mc Graw Hill Book Company, 1955.
9. Quantum Physics – S. Gasiorowicz, John Wiley and Sons.

Course Title: General Physics Lab – 1			
Course Code	MSPHY1004C04	**Credits**	4
L + T + P	0 + 0 + 4	**Contact Hours**	120 (P)

❖ List of Experiments:

1. To study Hydrogen spectrum and determine Rydberg's constant with the help of spectrometer diffraction grating and a Hydrogen spectrum tube.
2. To determine wavelength of sodium light by Fresnel's Biprism method.
3. To determine specific rotation of sugar using polarimeter.
4. To measure radius of curvature of a Plano-convex lens using Newton's ring apparatus.
5. Determination of wavelength of sodium light using Newton's ring apparatus.
6. To determine wavelength of sodium light by diffraction grating using spectrometer.
7. To verify Norton's Theorem and to find equivalent current source circuit.
8. To verify Theivenin's theorem and to find equivalent voltage source circuit.
9. To verify superposition and maximum power transfer theorem.
10. To study transient response in R-C circuit.
11. Measurement of frequency and phase using Lissajous figure.
12. To study applications of operational amplifier as adder, substractor and buffer.
13. Construction and verification of Up / Down, synchronous/ asynchronous, ripple decade counters and 4 bits universal shift register.
14. To measure the charge to mass ratio (e/m) of the electron.
15. To find speed of sound using resonance column.
16. To study and construct different type of holographic photographs.
17. To verify Faraday and Lenz's law of induction by measuring the induced voltage as function of time.
18. To determine the speed of light in air.

❖ Any experiment can be added / deleted at any time during the course in / from the list of the experiments.

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Course Title: Electronics			
Course Code	MSPHY1005E04	Credits	4
L + T + P	4 + 0 + 0	Contact Hours	60 (L)

UNIT I:

Physics of devices: p-n junction, abrupt junction, band structure, thermal equilibrium, depletion region, depletion capacitance, current and voltage characteristics, **Bipolar Junction Transistor (BJT):** band structure - transistor action – static characteristics. **Field Effect Transistors:** JFET structure, working, characteristics; MOS structure; MOSFET working, MOSFET characteristics, width of depletion region, junction capacitance-threshold voltage. Metal semiconductor contacts – ohmic and Schottky contacts. **Photo-electronic Devices:** Principle of operation, photoconductor – efficiency, current gain, response time. Effect of light on I-V characteristics of a junction photo device, principle and working of a photodiode, Light emitting devices, principle , working and factors affecting the efficiency of LED.

(15 Lectures)

UNIT II:

Boolean Expressions: Boolean laws and theorems, simplification of SOP equations, Simplification of POS equations, Simplification using Karnaugh Map technique (4 variables)- conversion of binary to Grey code. **Flip flops:** Latch using NAND and NOR gates- RS flip flop , clocked RS flip flop, JK flip flop, JK master slave flip flop - racing –Shift Registers basics - Counters: Ripple counters truth table-timing diagram, Synchronous counters-truth table-timing diagram, Decade counter. **Visual displays:** Single-element displays, seven-segment displays, decoder logic. **Digital to Analog converters:** ladder and weighted resistor types. Analog to digital Converters-counter method, successive approximation and dual slope converter. Application of DACs and ADCs.

(15 Lectures)

UNIT III:

Digital Data Communication Standards: Serial communications: RS232, handshaking implementation of RS232 on PC; Universal Serial Bus (USB) – USB standards, types and elements of USB transfers.

Parallel communications: General purpose interface bus (GPIB), GPIB signals and lines, handshaking and interface management, implementation of a GPIB on a PC; basic idea of sending data through a COM port. **Digital pulse modulation:** Need for digital transmission, pulse code modulation, digital carrier modulation techniques, sampling, quantization and encoding; concept of amplitude shift keying (ASK), frequency shift keying (FSK), phase shift keying (PSK), and binary phase shift keying (BPSK); comparison with analog pulse modulation.

(15 Lectures)

UNIT IV:

Architecture of Microprocessors: General definitions of mini computers, microprocessors, micro controllers and digital signal processors. Overview of 8085 microprocessor. Overview of 8086 microprocessor. Signals and pins of 8086 microprocessor. **Assembly language of 8086:** Description of Instructions. Assembly directives. Assembly software programs with algorithms. **Architecture of Micro controllers:** Overview of the architecture of 8051 microcontroller.

(15 Lectures)

References

1. Semiconductor Devices Physics and Technology, S M Sze, (Second Edition, 2002), John Wiley and Sons Inc. Asia.
2. Solid State Electronic Devices, Ben G Streetman, Sanjay Banerjee, (Fifth edition, 2000),
3. Pearson Education, Asia.
4. Semiconductor Optoelectronic Devices, Pallab Bhattacharya, (Second Edition, 1997), Pearson education, Asia.
5. Electronic Principles, A P Malvino, (Sixth Edition, 1999), Tata McGraw Hill, New Delhi.
6. Digital principles and applications, Donald P Leach and Albert Paul Malvino, (Fifth Edition, 2002), Tata McGraw Hill.
7. Digital systems, Principles and applications, Ronald J Tocci and Neal S Widmer, (Eighth Edition, 2001), Pearson Education.
8. PC Based Instrumentation: Concepts & Practice – N. Mathiavanan.
9. PC Based Instrumentation and Control – Mike Tooley
10. Microprocessor Architecture Programming & Applications – R.S. Gaonkar.
11. Microprocessor 8085: Architecture, Programming, & Interfacing – A. Wadhwa.

Course Title: Experimental Techniques			
Course Code	MSPHY1006E04	**Credits**	4
L + T + P	4 + 0 + 0	**Contact Hours**	60 (L) Hours

Unit I

Vacuum Techniques: Introduction, flow regimes (Knudsen's number, Reynold's number, turbulent, laminar, viscous, molecular), different ranges of vacuum (low, medium, high), pumps (rotary, diffusion, turbo molecular), pressure gauges (pirani, penning, ion).

Digital Instruments: Principle and working of digital meters, comparison of analog & digital instruments, characteristics of a digital meter.

(15 Lectures)

Unit II

Optical Microscopy; Scanning Electron Microscopy; Scanning Tunneling Microscopy; Atomic Force Microscopy; X-ray diffraction, Neutron diffraction

(15 Lectures)

Unit III

Transmission Electron Microscopy; Low Energy Electron Diffraction; Reflection of High Energy Electron Diffraction; Electron Spectroscopy for chemical analysis; Auger Electron spectroscopy; Secondary ion mass spectroscopy; Electron Energy Loss Spectroscopy, Molecular spectroscopies including Microwave, FTIR, Raman and surface enhanced Raman Spectroscopy.

(15 Lectures)

Unit IV

X-ray Fluorescence; Rutherford back scattering; UV-VIS-NIR spectro-photometer, Ellipsometry; Deep Level Transient Spectroscopy; Thermally Simulated Current; C-V and Admittance Spectroscopy; Hall effect and Time of Flight methods for charge carriers, Differential scanning calorimeter; Differential Thermal Analyzer.

(15 Lectures)

Reference Books

1. Sayer, M., Mansingh, A., Measurement, Instrumentation and Experiment Design in Physics and Engineering, PHI (2000).
2. Nanotechnology-Molecularly Designed Materials : G.M. Chow & K.E. Gonsalves (American Chemical Society), 1996.
3. Nanoparticles and Nanostructured Films–Preparation, characterization and Application : J.H. Fendler (Wiley), 1998

Course Title: Biography of Indian Scientists			
Course Code	MSPHY1007E02	Credits	2
L + T + P	2 + 0 + 0	Contact Hours	30 (L) Hours

Unit I

Historical Accounts of Ancient Indian Scientists: Baudhaayana, Aaryabhata, Brahmagupta, Bhaaskaraachaarya, Mahaaviiraachaarya, Kanaad, Varaahamihira, Naagaarjuna, Sushruta, Charak, Vaagbhatta, Patanjali, PaNini, Chaanakya; Pingala, Lagaadha, Bharata Muni, Madhvaachaarya, Dhanvantari, Kapila Muni, Bhaaradwaj Muni.

(15 Lectures)

Unit: II

Biographical Sketch of Modern Indian Scientists: Sir J C Bose, Prafulla Chandra Roy, Srinivas Ramanujan, Sir C Venkata Raman, Meghnad Saha, S N Bose, Shanti Swarup Bhatnagar, Homi Jehangir Bhabha, S Chandrashekhar, Vikram Sarabhai, C R Rao, K V Chandrashekhar, Har Govind Khurana, G N Ramachandra, Harish Chandra, M K Vainu Bappu, M Visvesvaraya, Subhash Mukhopadhyay, Raja Ramanna, A P J Abdul Kalam, Vashishtha Narayan Singh

(15 Lectures)

References

1. Biography of Indian Scientist - A Chattopadhyay
2. Bharat Ke Mahan Vaigyanik Famous Indian Scientists And Their Biographies - Arvind Gupta
3. The golden age of Indian mathematics - S Parameswaran; Swadeshi Science Movement Kerala
4. The history of ancient Indian mathematics - C N Srinivasiengar; The World Press Private Limited
5. आचायरजगदीश चन बसु: १५०वी जयनी पर शदाजिल - ठिनताई चन मणल (अनुवादक - डॉ. वीरेन कु मार ठिसंह)
6. भारत के प्रमुख गणितज्ञाचार्य - डॉ. देवी प्रसाद वर्मा, श्रीराम चौथाईवाले, देवेन्द्रराव देशमुख; विद्या भारती संस्कृति शिक्षा संस्थान

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Master of Science (M.Sc.) Physics Programme

Detailed Syllabus

(Effective from Academic Session 2020-2021)

SEMESTER - II

Course Title: Thermodynamics and Statistical Mechanics			
Course Code	MSPHY2001C04	**Credits**	4
L + T + P	4 + 0 + 0	**Contact Hours**	60 (L) Hours

UNIT I: Thermodynamics
Postulates of equilibrium thermodynamics, Intensive and extensive variables, Thermodynamic definition of Entropy –Calculation of entropy changes in reversible processes, Equilibrium between two thermodynamic systems, Thermodynamic potentials –Enthalpy, Helmholtz and the Gibbs functions, The Maxwell relations, Variational principles in thermodynamics

(15 Lectures)

UNIT II: Classical statistical mechanics
Basic postulates of statistical mechanics, Macro-and micro states – Statistical equilibrium- Phase space, Ensemble: microcanonical, canonical, grand canonical; Density function- Liouville's theorem, Canonical distribution function: Evaluation of mean values in a canonical ensemble, Partition function--connection with thermodynamics; Statistical definition of entropy—Boltzmann equation and its significance; Ideal monoatomic gas, Gibbs' paradox, Equipartition theorem, specific heat of solids.

(15 Lectures)

UNIT III: Quantum statistical mechanics
Basic concepts – Quantum ideal gas, Identical particles and symmetry requirements, Quantum distribution functions, Bose-Einstein statistics, Ideal Bose gas, black body radiation, Bose- Einstein condensation, specific heat, Fermi-Dirac statistics, Ideal Fermi gas, properties of simple metals, Pauli paramagnetism, electronic specific heat, Quantum statistics in the classical limit.

(15 Lectures)

UNIT IV: Irreversible processes and fluctuations
Random walk in one dimension, Brownian motion, Langevin equation, Fluctuation dissipation theorem, Einstein relation, Fourier analysis of random functions, Wiener- Khintchine relations Nyquist's theorem, Fluctuations and Onsagar relations.

References

1. K. Huang, Statistical Mechanics, Wiley Eastern Limited, New Delhi, (1963).
2. F. Reif, Fundamentals of Statistical and Thermal Physics, McGraw Hill, Singapore (1985).
3. R.K. Pathria, Statistical Mechanics, Bufferworgh Heinemann (2nd Edition)
4. Silvio R A Salinas, Introduction to Statistical Physics, Springer, (2001)
5. B.B.Laud, Fundamentals of Statistical Mechanics, New Age International Publication(2003)

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Course Title: Classical Electrodynamics and Relativity			
Course Code	MSPHY2002C04	**Credits**	4
L + T + P	4 + 0 + 0	**Contact Hours**	60 (L) Hours

UNIT I: Electrostatics

Coulomb's law, Electric field, Gauss's law, applications of Gauss's law, Electric Potential, Poisson's equation and Laplace's equation, Work and energy in electrostatics, Techniques for calculating potentials: Laplace's equation in one, two and three dimensions, boundary conditions and uniqueness theorems, Method of Images, Multipole expansion Electrostatic fields in matter: Dielectrics, Polarization, Field inside a dielectric, Electric displacement, Linear dielectrics.

(9 Lectures)

UNIT II: Magnetostatics

Lorentz Force law, Biot-Savart Law, Divergence and Curl of B, Ampere's law and applications of Ampere's law, Magnetic vector potential, Multipole expansion. Magnetostatic fields in Matter: Magnetization, field of a magnetized object, magnetic field inside matter, linear and non linear magnetic media .

(9 Lectures)

UNIT III: Electrodynamics

Time dependent fields, Faraday's law, Maxwell's displacement current, Differential and integral forms of Maxwell's equations. Scalar and vector potentials, gauge transformations, Coulomb and Lorentz Gauge; Maxwell's equations in terms of potentials. Energy and momentum in electrodynamics.

(9 Lectures)

UNIT IV: Electromagnetic waves

Electromagnetic waves in non conducting media: Monochromatic plane waves in vacuum, propagation through linear media; Boundary conditions; Reflection and transmission at interfaces. Fresnel's laws, interference, coherence transmission line and wave guides; Electromagnetic waves in conductors: Modified wave equation, monochromatic plane waves in conducting media Dispersion: Dispersion in non conductors, free electrons in conductors and plasmas. Guided waves.

(12 Lectures)

UNIT V: Electromagnetic Radiation

Retarded potentials, Electric dipole radiation, magnetic dipole radiation. Radiation from a point charge: Lienard-Wiechart potentials, fields of a point charge in motion, Power radiated by a point charge.

(9 Lectures)

UNIT VI: Relativity

Electrodynamics and Relativity: Review of special theory of relativity, Lorentz transformations, Minkowski four vectors, energy-momentum four vector, covariant formulation of mechanics Transformation of electric and magnetic fields under Lorentz transformations, field tensor, invariants of electromagnetic field, Covariant formulation of electrodynamics, Lorentz force on a relativistic charged particle.

(12 Lectures)

References

1. Introduction to Electrodynamics – David J. Griffiths, Fourth Edition, Pearson, 2013.
2. Classical Electrodynamics – J.D. Jackson, Fourth Edition, John Wiley & Sons, 2005.
3. Classical Electromagnetic Radiation – M.A. Heald and J.B. Marion, Saunders, 1983.

Course Title: General Physics Lab – II			
Course Code	MSPHY2003C04	**Credits**	4
L + T + P	0 + 0 + 4	**Contact Hours**	120 (P)

List of Experiments:

1. To observe the dependence of the high frequency response of the analog link on D.C. Current passing through the photo transmitter.
2. To determine Bohr magneton and specific charge (e/m) of electron using Zeeman apparatus.
3. To determine Verdet's constant from the relation between rotation angle and magnetic flux using Faraday Effect apparatus.
4. To determine wavelength of laser using Michelson interferometer.
5. To study drain and transfer characteristics of JFET.
6. To study drain and transfer characteristics of MOSFET.
7. To study input, output and transfer characteristics of PNP / NPN transistor in CB mode.
8. To study input, output and transfer characteristics of PNP / NPN transistor in CE mode.
9. Application of IC- 555 as Pulse Generator Sequential Timer and pulse with modulator.
10. Construction and verification of half adder, full adder, half substractor, and full substractor using combinational circuits.
11. To construct and study JK, JKMS and T Flip flops.
12. Determination of ρ (rho) the resistance per unit length of a Carey Foster's bridge and find the melting point of given substance using Platinum resistance thermometer.
13. To study NAND gate as universal gate.
14. To study and verify binary storage counter, type t Flip – Flop, Up, Down and Decimal counter.
15. Construction and verification of Up / Down, synchronous/ asynchronous, ripple decade counters and 4 bits universal shift register.
16. Construction of Divide -by- N counters (6 or 60) using IC-7493 & IC-7490.

❖ Any experiment can be added / deleted at any time during the course in / from the list of the experiments.

Course Title: Atomic and Molecular Physics			
Course Code	MSPHY2004C04	**Credits**	4
L + T + P	4 + 0 + 0	**Contact Hours**	60 (L) Hours

UNIT I

Atomic Structure and Atomic Spectra: One Electron Atom: Vector model of a one electron atom, Quantum states of an electron in an atom, Hydrogen atom spectrum, Spin-orbit coupling, Relativistic corrections for energy levels of hydrogen atom, Hydrogen fine structure, Spectroscopic terms, Hyperfine structure and isotopic shift.

(15 Hours)

UNIT II

Two valance Electron Atom: Vector model for two valance electrons atom, LS coupling, Pauli exclusion principle, Interaction energy for LS coupling, Lande interval rule, JJ coupling, interaction energy for JJ coupling. Inner shell vacancy, X-rays and Auger transitions: chemical shift. Frank-Condon principle. Atom in Magnetic Field: Zeeman effect, Magnetic moment of a bound electron, Magnetic interaction energy in weak field. Paschen-Back effect, Magnetic interaction energy in strong field.

(15 Hours)

UNIT III

Molecular Structure and Molecular Spectra :Types of molecules, Electronic, rotational, vibrational and Raman spectra of diatomic molecules, selection rules. Born-Oppenheimer approximation. Morse potential energy curve, Molecules as vibrating rotator, Vibration spectrum of diatomic molecule, PQR branches. Elementary discussion of Raman, ESR and NMR spectroscopy, chemical shift.

(15 Hours)

UNIT IV

Infrared spectroscopy: The vibrating diatomic molecule. The diatomic vibrating-rotator spectra of diatomic molecules Raman Spectroscopy: Introduction, Pure rotational Raman spectra, Vibrational Raman Spectra, Nuclear Spin and intensity alternation in Raman spectra, Isotope effect, Raman Spectrometer.

(15 Hours)

Text Books:

1. Concepts of Modern Physics by Arthur Beiser (McGraw-Hill Book Company, 1987).

Reference Books:

1. Atomic spectra & atomic structure, Gerhard Hertzberg: Dover publication, New York.
2. Molecular structure & spectroscopy, G. Aruldhas; Prentice – Hall of India, New Delhi.
3. Fundamentals of molecular spectroscopy, Colin N. Banwell & Elaine M. McCash, Tata McGraw –Hill publishing company limited.
4. Introduction to Atomic spectra by H.E. White,
5. Spectra of diatomic molecules by Gerhard Herzberg

Course Title: Elementary Solid State Physics			
Course Code	MSPHY2005C02	Credits	2
L + T + P	2 + 0 + 0	Contact Hours	30 (L) Hours

Unit 1

Crystal structure: Periodic arrangement of atoms-lattice translation vectors, The basis and crystal structure, primitive and non-primitive lattice cell-fundamental types of lattice, -2D and 3-D Bravias lattice and crystal systems. Elements of symmetry operations points and space groups-nomenclature of crystal directions and crystal planes-miller indices, Bonding of solids, Defects and dislocations, Quasi crystals. Superfluidity. Ordered phases of matter: translational and orientational order, kinds of liquid crystalline order **X-ray diffraction:** Scattering of x-rays, Laue conditions and Bragg's law, atomic scattering factor, geometrical structure factor, Reciprocal lattice and its properties.

(15 Lectures)

Unit 2

Properties of Solids: Elastic properties, phonons, lattice specific heat. Free electron theory and electronic specific heat. Response and relaxation phenomena. Drude model of electrical and thermal conductivity. Hall effect and thermoelectric power. Electron motion in a periodic potential, Introduction to band theory of solids: metals, insulators, Elementary ideas of quantum Hall effect, Cyclotron resonance and magnetoresistance, Introduction to superconductivity. Josephson junctions.

(15 Lectures)

Reference Books:

1. Solid State Physics- A. J. Dekker.
2. Solid State Physics- C. Kittel.
3. Elementary Solid state physics, M.A. Omar.
4. Introduction of Solids: L.V. Azaroff.
5. Solid State Physics: N.W. Ashcroft and N.D. Mermin.
6. Crystallography Applied to Solid State Physics: A.R. Verma and O.N. Srivastava

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Course Title: Elementary Nuclear & Particle Physics			
Course Code	MSPHY2006C02	**Credits**	2
L + T + P	2 + 0 + 0	**Contact Hours**	30 (L) Hours

UNIT I

Static properties of nuclei : Rutherford scattering, Nuclear radius and charge distribution, nuclear form factor, Nuclear binding energy (review), Angular momentum, parity and symmetry, Magnetic dipole moment and electric quadrupole moment.

(6 Lectures)

UNIT II

Radioactive decays : Review of alpha decay, Beta decays, Gamma decay Fermi theory, Conservation laws, Allowed and forbidden transitions, Experimental evidence for parity-violation in beta decay, Electron capture probabilities, Double beta decay, Neutrino Detection of neutrinos, Internal conversion process, Production of nuclear orientation, Angular distribution of gamma rays from oriented nuclei. Nuclear reactions and mechanism, Compound nuclei and direct reactions.

(10 Lectures)

UNIT III

Nuclear Detectors : Interaction of radiation with matter (qualitative idea), Basics of Solid state detectors, Scintillation and gaseous detectors for particles and electromagnetic radiation detection. Idea of Calorimeter, Hybrid detectors and arrays.

(6 Lectures)

UNIT IV

Basic Concept of Particle Physics : Classification of fundamental forces. Elementary particles and their quantum numbers (charge, spin, parity, isospin, strangeness, etc.). Gellmann-Nishijima formula. Quark model, baryons and mesons. C, P, and T invariance. Application of symmetry arguments to particle reactions. Parity non-conservation in weak interaction.

(8 Lectures)

References :

1. Nuclear and Particle Physics B. R. Martin, John Wiley & Sons Ltd
2. Nuclear Physics : Irving Kaplan (Narosa)
3. Basic Ideas and Concepts in Nuclear Physics : K. Hyde (Institute of Physics)
4. Introduction to Nuclear Physics ; Herald Enge (Addison-Wesley)
5. Nuclei and Particles : E. Segre (W.A. Benjamin Inc)
6. Introductory Nuclear Physics, Samuel S. M. Wong, Wiley-VCH Verlag GmbH & Co. KGaA

Course Title: Advanced Quantum Mechanics			
Course Code	MSPHY2007E04	**Credits**	4
L + T + P	4 + 0 + 0	**Contact Hours**	60 (L) Hours

UNIT I: Scattering Theory

Kinematics of Scattering Process: differential and total cross-section -Asymptotic from of scattering wave function. Scattering amplitude by Green's method. Born approximation method and screened potential and square well potential as examples - Partial wave analysis and phase shift-Optical Theorem- Relationship between phase shift and Potential. Scattering by Hard sphere.

(12 Lectures)

UNIT II: Time Dependent Perturbation Theory

Time dependent perturbation theory - Constant and harmonic perturbations - Transition probabilities - Fermi's-Golden rule - Selection rules for dipole radiation - Adiabatic approximation - Sudden approximation - The density matrix - spin density matrix and magnetic resonance - Semi classical treatment of an atom with electromagnetic radiation.

(12 Lectures)

UNIT III: Many Electron Atom and Molecules

Thomas -Fermi atom – Self consistent method. Hartee – Fock method. Constants of motion in central field approximation-Corrections to the central field approximation. Born-Oppenheimer method-Molecular orbital theory. Valance bond theory. H2+ ion- Hydrogen molecule.

(12 Lectures)

UNIT-IV: Relativistic Quantum Mechanic

Klein –Gordon Equation, Plane wave solution and Equation of continuity, Probability density- Dirac Equation, alpha, beta- matrices, Plane wave solution, significance of negative energy states. Spin of Dirac particle Relativistic particle in central potential –Total Angular Moment, Particle in a magnetic field – Spin Magnetic moment, properties of gamma matrices- Dirac's equation in covariant form.

(12 Lectures)

UNIT V: Field Quantization

Lagrangian density and equation of motion for field, Symmetries and conservation laws, Noether's theorem, cononical quantization of scalar field, Complex scalar field, electromagnetic field and Dirac field, Problem in quanitizing electromagnetic field, Gupta & Bleuler method, Feynman rules (without derivation), Feynman diagrams.

(12 Lectures)

References:

1. Introduction to Quantum Mechanics – David J. Griffiths, Second Edition, Pearson Prentice Hall 2005.
2. Quantum Mechanics Concepts and Applications- Nouredine Zettile, Second Edison, John Wiley and Sons. 2009
3. Quantum Mechanics – B.H. Bransden and C.J. Joachain, Second Edition, Pearson Education, 2007.
4. Modern Quantum Mechanics - J.J. Sakurai, Revised Edition, Addison-Wesley, 1995.
5. Relativistic Quantum Mechanics: J.D. Bjorken and S.D. Drell.
6. Relativistic Quantum Fields: J.D. Bjorken and S.D. Drell.
7. A First Book on Quantum Field Theory: Amitabha Lahiri and P.B. Pal.
8. An Introduction to Quantum Field Theory: M. E. Peskin and V. Schroeder; Persues Book
9. Introduction to QFT: F. Mandle and G. Shaw
10. Advance Quantum Mechanics- J. J. Sakurai

Course Title: Advanced Mathematical Physics			
Course Code	MSPHY2008E04	Credits	4
L + T + P	4 + 0 + 0	Contact Hours	60 (L) Hours

UNIT I:

Fourier and Laplace transforms: Fourier Series, Fourier transform, Convolution theorem, Parseval's theorem, Laplace transform and its properties, convolution theorem, inverse Laplace transforms, solution of differential equations using Laplace transforms, Fourier transform & Laplace transform of Dirac Delta function.

(30 Lectures)

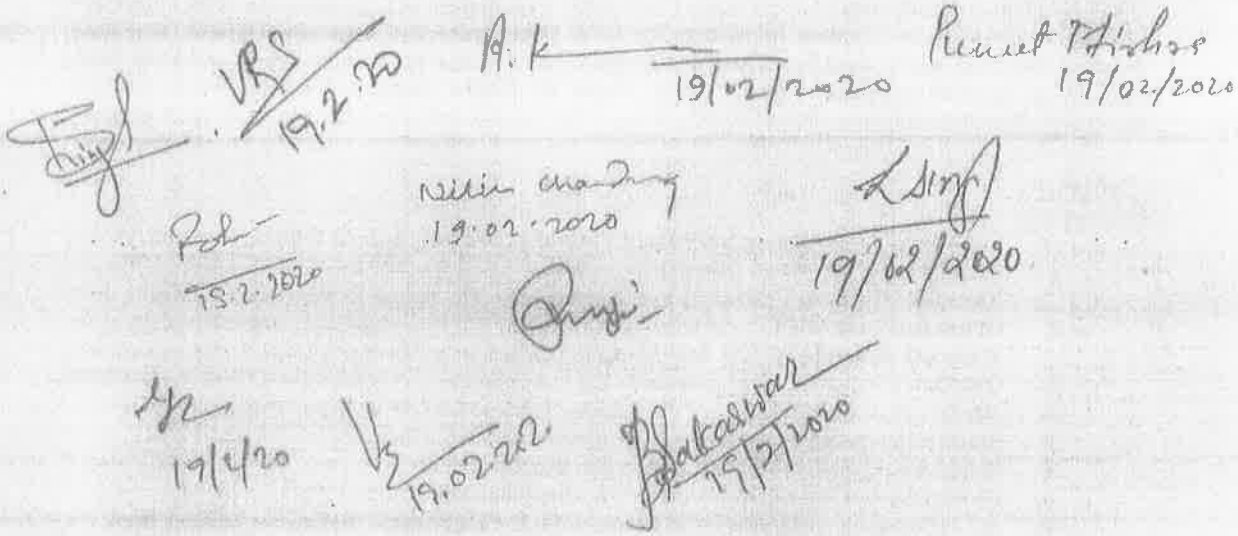
UNIT II:

Complex analysis and Group theory: Functions of a complex variable, Analytic functions, Cauchy-Riemann relations, Cauchy's theorem, Cauchy's integral formula, Taylor and Laurent expansions, residue theorem, Evaluation of definite integrals, elementary idea of group theory.

(30 Lectures)

References

1. Mathematical methods of physics - J. Mathews and R. L. Walker, Second Edition, Addison-Wesley.
2. Mathematical methods for Physicists – G. B. Arfken and H. Weber, Seventh Edition, Academic Press, 2012.
3. Complex functions – M. R. Spiegel, Schaum Series.
4. Mathematical Physics - P.K.Chattopadhyay, Wiley Eastern Ltd.1990.
5. Linear Algebra and Group theory for Physicists – K. N. Srinivasa Rao.



Course Title: Introduction of Ancient Indian Sciences			
Course Code	MSPHY2009E04	Credits	4
L + T + P	4 + 0 + 0	Contact Hours	60 (L) Hours

Unit I

Basic Concepts: Some essential definitions; Classification of Indian Knowledge Systems; The objects of human pursuit; Fundamental basis for all Indian knowledge systems; The prescriptive nature of Indian discourses; The causal nature of universe; Means of acquiring knowledge; Prevalent social practice as source of knowledge - in view of modern statistical studies; Two way flow of knowledge; Vedas and Vedaangas; Evolution of Indian Science; Popularising Science among masses; Concept of cyclic time

(15 Lectures)

Unit II

Formal Structure of different Sciences:

Ancient Indian Mathematics: Definition of GaNita; Importance and all pervading nature of GaNita; Prescriptive nature of GaNita; Concept of zero; Decimal System; Arithmetics; Algebra;

Negative numbers; Trigonometry; GaNita in Vedaangas; Early Geometry; Concept π, $\sqrt{2}$, $\sqrt{3}$ etc.; Shulba-Sootra - Geometrical Calculations; GaNita Jyotisha; GaNita in prosody; GaNita in language; GaNita in music (Hemchandra Series); Binary system; Permutations and Combinations; Kerala school; Early Calculus; Upapatti - Indian version of proof; Similarities and contrast from modern mathematics

Ancient Indian Astronomy: Jyotisha - the science of time-keeping; Importance of Jyotisha; GaNita Jyotisha; Panchaanga; Phalita Jyotisha; Phalita Jyotisha and the causal nature of universe; works of different ancient scientists in the field of Jyotisha

Physics: Use of GaNita as prescription in contrast to use of mathematics as description; Motion; Gravitation; Concept of Paramaanu - Vaisheshik darshana; Syaatvaada and probabilistic interpretation of quantum mechanics; Cosmology; Causality; Physics in Jain and Bauddha darshana; Aprasiddha entities and its relevance in policy making of Indian science;

The science of Language: Meaning of Bhasha; Evolution of language; Praakrita and Sanskrita; Grammar of Sanskrita - Ashtadhyaayii by Paaniinii; Sanskrit as world's most mathematical human language; Sanskrit for technical discourse; Basic knowledge of Sanskrita (Dhaatu, Pratyaya, Vibhakti, Vachana, Linga, Purusha; Lakaara, Sandhi, Samaasa); Order of words in Sanskrita; Rules to make new words; Falsification of word-to-word translation; Language as vehicle of culture and civilisation; Science in Sanskrita literature

The science of well-being: Definition of Ayurveda; Swaasthya in contrast to health; Importance of being healthy; Ayurveda as a way of life; Vaata, Pitta, Kapha; Quality of a good medicine; Yoga and Praanaayaama - definition and its importance as a method for well-being; Air, Water, Soil, Oil, Ghee, Cloth as a tool to heal; Mantra-healing; Surgery in ancient India; Healthy diet; Indian kitchen - a medicine store; Contribution of homemaking women in evolution of Ayurveda

Social and Economic Sciences: Expansion of self as family; Human body as a prototype of social structure; Family as a prototype for social administration; Gandhi's idea of Swaraajya; Sharing as a way of life; Economic system based on sharing; Sanskaaras - Prescription for proper distribution; Jaati as an economical unit; Village as an independent economic unit; Arthashaastra; Concept of virtual money in today's world and its absence in ancient Indian economic systems; Evolution of modern economic system based on virtual money, banks and markets; Comparative study of modern economic system with the ancient one; The Angus Maddison report

Other topics: Science of preservation of knowledge (Indian Education System); Comparative study of the oral and the scriptural traditions; Agricultural Sciences; Metallurgical Sciences; Computer Science; Civil Engineering; Architecture; Chemistry; Mechanical Engineering; Darshana in contrast to Philosophy; Indian systems as a solution to environmental problems; Role and π, 2, 3 status of women in Indian systems; Dharma in the root of all Indian sciences; Discussion on modern concept of patent/copyright in view of ancient practices

(45 Lectures)

References

1. Indian Science and Technology in the Eighteenth Century: Some Contemporary European Accounts - Dharampal; Other India Press
2. The History of ancient Indian mathematics - C N Srinivasiengar; The World Press Private Limited

3. GaNita Yuktibhaasha: Rationales in mathematical astronomy of Jyeshthadeva (Volume I & II) - Malayalam text critically edited with English translation by K V Sharma (with explanatory notes by K Ramasubramanian, M D Srinivas & M S Sriram); Culture and History of Mathematics; Hindustan Book Agency
4. The golden age of Indian mathematics - S Parameswaran; Swadeshi Science Movement Kerala
5. पाचीन भारत मेिवजान एवं पौदोिगकी; िवजान भारती
6. Science in Samskrita; Samskrita Bharati
7. Pride of India: A glimpse into India's scientific heritage; Samskrita Bharati
8. भारत मेिवजान की उजल परमरा - सुरेश सोनी
9. The Wonder that is Sanskrit - Sampad & Vijay; Auro Publications
10. गृहअथरशास; पुनरतान पकाशन सेवा टस
11. अथरशास - कौिटल
12. अषाङ्गहृदयम् - वागट
13. चरक संिहता - चरक
14. सुशुत संिहता - सुशुत

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Master of Science (M.Sc.) Physics Programme

Detailed Syllabus

(Effective from Academic Session 2020-2021)

SEMESTER - III

Specialization
Condensed Matter Physics

Course Title: Condensed Matter Physics			
Course Code	MSPHY3001C04	Credits	4
L + T + P	4 + 0 + 0	Contact Hours	60 (L) Hours

Unit-1
Ewald's method, Lorentz field, Phonons in perfect-crystals: General theory of lattice dynamics of non-primitive lattice, normal coordinate description, quantization of lattice vibrations, phonon concept, ionic crystals, shell model. Inelastic scattering of slow neutrons by crystals for study of phonons. Kramer-Kronig relation.

(15 Lectures)

Unit-2
Dielectric constant of ionic crystals. Static polarizability, polarizability in variable field, placzek's approximation, first order Raman scattering, second-order Raman scattering, elementary ideas of the study of phonons by Raman scattering Plasmons, interaction of electromagnetic waves with phonons and polaritons.

(15 Lectures)

Unit-3
Excitation in imperfect crystals: Definition of classical Green functions, application to one dimensional harmonic oscillator, principle of causality. Double-time quantum Green functions, correlation functions, and spectral density. Static Green function (Fourier transform), application to lattice vibrations and Electron energy states. Point defect in one dimensional lattice, localized, gap and resonance modes. Elementary ideas of extension to impurity electron energy states, gap states.

(15 Lectures)

Unit-4
Transport Theory: Phenomenological coefficient Lij and their physical interaction. General Boltzmann equation and its linearization Entropy production. Relaxation time solution of Boltzmann equation. Electronic contributions of thermal and electrical conductivities and to Peltier, Seeback coefficient for metals and electronis semiconductors. Relationship between electrical and ideas about lattice contribution to thermal conductivity.

(15 Lectures)

Reference Books:

1. Solid State Physics- A. J. Dekker.
2. Solid State Physics- C. Kittel.
3. B.E.Warren – X-ray Diffraction.
4. A. Maradudin – Solid State Physics (Supplement 3) (Academic Press).
5. O. Madelung – Introduction of Solid State Theory (Springer).
6. J.M. Ziman: Principles of the theory of solids

Course Title: Solid State Devices			
Course Code	MSPHY3002C04	Credits	4
L + T + P	4 + 0 + 0	Contact Hours	60 (L) Hours

Unit-I:
Classification of Semiconductors; Crystal structure with examples of Si, Ge & GaAs semiconductors; Energy band structure of Si, Ge & GaAs; Extrinsic and compensated Semiconductors; Temperature dependence of Fermi-energy and carrier concentration. Drift, diffusion and injection of carriers; Carrier generation and recombination processes- Direct recombination, Indirect recombination, Surface recombination, Auger recombination; Applications of continuity equation-Steady state injection from one side, Minority carriers at surface, Haynes Shockley experiment, High field effects. Hall effect; Four – point probe resistivity measurement; Carrier life time measurement by light pulse technique. Introduction to amorphous semiconductors, Growth of semiconductor crystals.

(18 Lectures)

Unit-II:
Fabrication of p-n junction by diffusion and ion-implantation; Abrupt and linearly graded junctions; Thermal equilibrium conditions; Depletion regions; Depletion capacitance, Capacitance – voltage (C-V) characteristics, Evaluation of impurity distribution, Varactor; Ideal and Practical Current-voltage (I-V) characteristics; Tunneling and avalanche reverse junction break down mechanisms; Minority carrier storage, diffusion capacitance, transient behavior; Ideality factor and carrier concentration measurements; Carrier life time measurement by reverse recovery of junction diode; p-i-n diode; Tunnel diode, Introduction to p-n junction solar cell and semiconductor laser diode.

(18 Lectures)

Unit-III:
Schottky barrier – Energy band relation, Capacitance- voltage (C-V) characteristics, Current-voltage (I-V) characteristics; Ideality factor, Barrier height and carrier concentration measurements; Ohmic contacts. Bipolar Junction Transistor (BJT): Static Characteristics; Frequency Response and Switching. Semiconductor heterojunctions, Heterojunction bipolar transistors

(10 Lectures)

Unit-IV:
Junction Field Effect Transistor (JFET) - Construction, Characteristic parameters, Transfer Characteristics, applications; Introduction to ideal MOS device; MOSFET fundamentals, Measurement of mobility, channel conductance etc. from I_{ds} vs V_{ds} and I_{ds} vs V_g characteristics; Metal-semiconductor field effect transistor (MESFET)- Device structure, Principles of operation, Current voltage (I-V) characteristics, High frequency performance.

(14 Lectures)

References:

1. S.M. Sze; Semiconductor Devices: Physics and Technology, 2nd edition, John Wiley, New York, 2002.
2. B.G. Streetman and S. Benerjee; Solid State Electronic Devices, 5th edition, Prentice Hall of India, NJ, 2000.
3. W.R. Runyan; Semiconductor Measurements and Instrumentation, McGraw Hill, Tokyo, 1975.
4. Adir Bar-Lev; Semiconductors and Electronic devices, 2nd edition, Prentice Hall, 1984.
5. Donald A. Neamen; Semiconductor Physics and Devices: Basic Principles, 3rd edition, Tata McGraw-Hill, New Delhi, 2002.
6. M. Shur; Physics of Semiconductor Devices, Prentice Hall of India, New Delhi, 1995.

Course Title: Solid State Physics Lab – I			
Course Code	MSPHY3003C04	Credits	4
L + T + P	0 + 0 + 4	Contact Hours	120 (P)

❖ **List of Instruments:**

1. To study the relationship between temperature of given samples (1&2) and its time of cooling by plotting a cooling curve and identify the samples.
2. To study Hall Effect in semiconductor and determine Hall coefficient (Rh) &charge career density.
3. Characterization of Nano-fluids like Ag/Au & ferrofluids.
4. To evaluate modest nano-particles concentrations in the fluid for significant enhancement of its property.
5. Study of phase transition and to detect/assess weak and strong molecular interactions in nano-fluids.
6. To determine the Stefan's constant by using an incandescent lamp and Photovoltaic cell.
7. To demonstrate Hysteresis curve of hard magnet.
8. To determine Dielectric constant of specimen at high frequency by Lecher wires.
9. To study the dispersion relation for mono-atomic lattice and determine the cut of frequency.
10. To determine heat capacity of solids
11. Measurement of Planck's constant using LED.
12. Measurement of Planck's constant using photo voltaic cell.

❖ Any experiment can be added / deleted at any time during the course in / from the list of the experiments.

Course Title: Materials Science			
Course Code	MSPHY3004E04	Credits	4
L + T + P	4 + 0 + 0	**Contact Hours**	60 (L) Hours

Unit-I

Formation and structure of materials: Introduction to Materials Science- Engineering materials - structure - property relationship, Review of ionic, covalent and molecular bindings, bond angle, bond length and bond energy, lattice energy - Madelung constant cohesive energy, van der Waal's Interaction- Lennard- Jones Potential, closed packed structure-packing efficiency and density of materials. Crystal imperfections: Review of crystalline imperfection, Schottky and Frenkel defects- Equilibrium concentrations, edge and screw dislocations, surface imperfections.

(15 Lectures)

Unit -II

Elastics and plastics behavior of materials:

Atomic model of elastic behavior-rubber like Elasticity- anelastic behavior, viscoelastic behavior, fracture of materials-Ductile and brittle fracture – Ductile brittle transition, protection against fracture Plastic deformation by slip-shear strength of perfect and real crystals- CRSS ratio, maximum stress to move dislocation, methods of strengthening crystalline materials against plastic deformation-strain hardening, grain refinement, solid solution strengthening, precipitation strengthening.

(15 Lectures)

Unit- III

Composite materials: Classification of composite materials, matrix materials- polymer, metals, ceramics, reinforcing materials- fibers, particles, concrete-concrete making materials, structure, composition, properties and applications, polymer-concrete composites, fabrication, structure, application of polymer matrix composites, metal matrix composites, ceramic-matrix composites, carbon-fibre composites, fibre reinforce, particle reinforce composites with properties and applications.

(15 Lectures)

Unit -IV

Elements of polymer science: Monomers- Polymers- classification polymers, synthesis of polymers-chain polymerization, step polymerization, Industrial polymerization methods, Average molecular weight- weight, number & viscosity, size of polymer molecule. Microstructure of polymers- chemical, geometric, random, alternating and block polymers. Phase transition-Polymer melting and glass transition, stereo isomerism, degree of crystallinity. Process of plastic materials: Moulding- compression, injection, blow, extrusion, spinning.

(15 Lectures)

Reference Books

1. Elements of Materials Science and Engineering: Lowrence H. Van Vlack, Addison
2. Wesley, (1975).
3. Introduction to Ceramics: W D Kingery, H K Bower and VR'uhlman, John Wiley, (1960)
4. Foundations of Materials Science and Engineering-William F. Smith, McGraw Hills International Edition, (1986)
5. Materials Science and Engineering, V. Ragharan, Prentice Hall (1993)
6. Structure & Properties of materials-vol I-IV Rose, Shepard and Wulff (1987)
7. Polymer Science, V. R Gowariker, N.V. Vishwanathan, Joydev Shreedhar, Wiley Eastern(1987)
8. Text of Polymer Science, Fred. W.Billmeyer, John Wiley and Sons, Inc. (1984)
9. Materials Science and Engineering W.D. Callister Wiley

Course Title: Crystal Growth and Characterization			
Course Code	MSPHY3005E04	Credits	4
L + T + P	2 + 0 + 2	Contact Hours	30 (L) 60(P) Hours

Unit – I: Fundamentals of Crystal Growth

Importance of crystal growth – Classification of crystal growth methods – Basic steps: Generation, transport and adsorption of growth reactants – Nucleation: Kinds of nucleation –Classical theory of nucleation: Gibbs Thomson equations for vapour and solution – Kinetic theory of nucleation – Becker and Doring concept on nucleation rate – Energy of formation of a spherical nucleus – Statistical theory on nucleation: Equilibrium concentration of critical nuclei, Free energy of formation.

(10 Lectures)

Unit – II: Crystal Growth Techniques

Melt Growth : Basics of melt growth – Heat and mass transfer – Conservative growth processes: Bridgman-Stockbarger method – Czochralski pulling method – Kyropolous method – Nonconservative processes: Zone-refining – Vertical and horizontal float zone methods – Skull melting method – Vernueil flame fusion method.

Solution Growth : Growth from low temperature solutions: Selection of solvents and solubility – Meir's solubility diagram – Saturation and supersaturation – Metastable zone width – Growth by restricted evaporation of solvent, slow cooling of solution and temperature gradient methods– Crystal growth in Gel media: Chemical reaction and solubility reduction methods – Growth from high temperature solutions: Flux growth Principles of flux method – Choice of flux – Growth by slow evaporation and slow cooling methods.

Vapour Growth : Basic principles – Physical Vapour Doposition (PVD): Vapour phase crystallization in a closed system – Gas flow crystallization – Chemical Vapour Deposition (CVD): Advantageous and disadvantageous

(20 Lectures)

Practical :- Growth and Characterization

- Growth of crystals
- Characterization and analysis using
  - Single crystal X-Ray Diffraction
  - Powder X-Ray Diffraction,
  - FT-IR spectroscopy,
  - UV-Vis spectroscopy,
  - Raman Spectroscopy,
  - Dielectric, Non Linear
  - Optical (NLO) Studies

(60 Practical Hours)

References:

1. J.C. Brice, Crystal Growth Processes, John Wiley and Sons, New York, 1986,
2. J.W. Mullin, Crystallization, , Elsevier Butterworth-Heinemann, London, 2004
3. Ichiro Sunagawa, Crystals: Growth, Morphology and Perfection, Cambridge University Press, Cambridge, 2005.
4. B.R. Pamplin, Crystal Growth, Pergamon Press, Oxford, 1975
5. Characterization of Materials (Materials Science and Technology:A Comprehensive treatment,Vol 2A & 2B, VCH (1992).
6. S Zhang, L. Li and Ashok Kumar, Materials Characterization Techniques, CRC Press (2008)
7. P.E. J. Flewitt and R K WildPhysical methods for Materials Characterization, , IOP Publishing (2003)

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Course Title: Crystallography, Crystal Structures and Diffraction Techniques			
Course Code	MSPHY3006E04	Credits	4
L + T + P	2 + 1 + 1	Contact Hours	30 (L)++15(T)+30(P) Hours

Unit-I

Close packing of spheres. Structure of common metals, alloys, ionic, covalent and molecular crystals, Production and properties of x-rays: Continuous and characteristic spectrum. Interaction of X-rays with matter. Laue equations. Bragg's law. Reciprocal lattice concept and its applications to rotation, Laue and Debye Scherrer techniques. Powder diffractometry. Space group symmetries.

(15 Lectures)

Unit –II

General procedure for working out the details of space groups with illustrations from triclinic, monoclinic and orthorhombic systems. Wyckoff positions. Principles of crystal structure analysis. Structure factor calculations. Space group extinctions. Electron density functions. Phase problem. Patterson functions. Direct methods in crystallography. Debye Scherrer, Guinier and Bragg-Brentano geometries for powder diffractometers. General intensity expression for powder diffraction. Rietveld refinement technique. Quantitative phase analysis and microstructure determination. Limitations of powder method. Single crystal diffractometers. Indexing of electron diffraction patterns

(15 Lectures)

List of Experiments

1. Phase problem and determination of crystal structures.
2. Indexing of X-Ray powder diffraction patterns.
3. Atomic scattering factor and structure factor determination.
4. Experimental determination of space group and inversion symmetry.
5. Structure Refinement procedures

Reference Books

1. X-ray Diffraction B.D. Culty
2. Crystallography Verma and Srivastava
3. B.E.Warren – X-ray Diffraction.
4. Maradudin – Solid State Physics (Supplement 3) (Academic Press).
5. O. Madelung – Introduction of Solid State Theory (Springer).
6. J.M. Ziman: Principles of the theory of solids

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Course Title: Fundamental of Nanoscience and Nanotechnology			
Course Code	MSPHY3007E04	**Credits**	4
L + T + P	4	**Contact Hours**	60 (L) Hours

Unit I:

Metal nanoclusters: Magic numbers, Geometric Structure, Electronic Structure, Bulk-to-Nano transition; **Semiconducting nanoparticles:** Optical properties; Rare-gas and molecular clusters: Inert gas clusters, Superfluid clusters, Molecular clusters, **Methods of synthesis:** RF plasma, Chemical methods, Thermolysis, Pulsed-Laser method **Cohesive Energy:** Ionic solids, Defects in Ionic solids, Covalently bonded solids, Organic crystals, Inert-gas solids, Metals **Quantum wells, wires and dots:** Fabricating techniques for Quantum Nanostructures, effect of size and dimension on conduction electrons, Applications

(15 Lectures)

Unit II:

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, Phase transitions.

Electronic Properties: 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.

(15 Lectures)

Unit III:

Mechanical Properties: 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, Methods of Fabrication of Nanosized Devices.

(15 Lectures)

Unit IV:

Magnetism in Nanostructures : Basics of Ferromagnetism; Behavior of Powders of Ferromagnetic Nanoparticles : Properties of a single Ferromagnetic Nanoparticles, Effect of nanosized grain structure on magnetic properties, Magnetoresisitive materials;

Spintronics: Definition and examples of spintronic devices, Magnetic storage and spin valves, Dilute magnetic semiconductors; Molecular switches and electronics: Molecular switches, Molecular electronics, Mechanism of conduction through a molecule; Photonic crystals.

(15 Lectures)

References:

1. The Physics and Chemistry of Nanosolids, Frank J. Owens and Charles P. Poole, Wiley- Interscience, 2008.
2. Frank J. Owens, Physics of Magnetic Nanostructures, Wiley- Interscience, 2015.

Course Title: Physics of Dielectric and Ferroelectric Materials			
Course Code	MSPHY3008E02	Credits	2
L + T + P	2+0+0	Contact Hours	30 (L) Hours

Unit I:

Introduction to Dielectrics: Polarisation mechanisms in dielectrics: induced, orientational, electronic, ionic, interfacial and lattice polarizations; combined mechanisms. Classical and quantum theory of polarization, Dielectric Relaxation mechanism, Applications of dielectrics

Macroscopic electric field – Local electric field at an atom – Dielectric constant and polarizability – Clausius-Mossotti equation, The complex impedance method, calculations of permittivity and dielectric losses, cole-cole plots.

Spontaneous polarization and ferroelectrics, Phase Transitions of the first and second order. Ferroelectric Liquid Crystals. Fundamental of piezoelectricity, Search method for ferroelectric and piezoelectric materials, Material processing for ferroelectric and piezoelectric materials, Characterization technique of piezoelectricity, Defect studies of ferroelectric and piezoelectric materials, Application of ferroelectric and piezoelectric materials.

(20 Lectures)

Unit II

Case Studies:

- Study of the ferroelectric properties of thin films by using sawyer tower circuit
- Study of dielectric relaxation phenomena,
- Study of the temperature dependence of permittivity in ferroelectrics
- Study of the RLC circuit with nonlinear capacitor,
- Determination of field-dependence of permittivity in ferroelectrics,
- Study of the piezoelectric effect by the method of resonance impedance.

(10 Lectures)

References:

1. Gerald Burns, Solid State Physics, Academic Press, 1990.
2. Kwan Chi Kao, Dielectric Phenomena in Solids, Elsevier Academic Press (2004)
3. J.D. Livingston, Electronic Properties of Engineering Materials, Wiley, 1999
4. L.L. Hench and J.K. West, Principles of Electronic Ceramics, Wiley, 1990
5. J. Grindlay, An introduction to the phenomenological theory of ferroelectricity, Pergamon Press, Oxford, 1970
6. Karin M. Rabe, Charles H. Ahn, Jean-Marc TrisconePhysics of Ferroelectrics: A Modern Perspective, Springer (2007)

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Course Title: X-Ray Spectroscopy			
Course Code	MSPHY3009E02	Credits	2
L + T + P	2+0+0	Contact Hours	30 (L) Hours

UNIT I

Source of X-rays (classic and synchrotron radiation), Interaction of x-rays with matter (photoeffect, Compton effect, elastic scattering, Auger effect), Detectors for X-rays, Optical elements for X-rays (mirrors, monochromators, (micro)focusing elements) , X-ray diffraction, small angle scattering, X-ray fluorescence, X-ray absorption spectroscopy, Introduction to analysis of atomic and molecular structure with x-ray spectroscopic methods; Micro-spectroscopy (combination of XAS and micro focusing of SR X-ray beam) and 2D elemental mapping with sub-micron resolution, In-situ in in-operando spectroscopic techniques with X-rays

(20 Lectures)

UNIT II

Photoemission Electron Microscopy - X-ray Absorption Spectroscopy - X-ray Magnetic Linear Dichroism (XMLD) - X-ray Magnetic Circular Dichroism (XMCD) - Temperature and angle dependence of X-ray Magnetic Dichroism.

(20 Lectures)

References:

1. G. Bunker, "Introduction to XAFS: A Practical Guide to X-ray Absorption Fine Structure Spectroscopy", Cambridge University Press, 2010
2. X-ray absorption spectroscopy (principles, applications, techniques of EXAFS, SEXAFS and XANES), edited by D.C. Konnigsberger and R. Prins, John Wiley and Sons, NY (1988)
3. D. A. Skoog, F. J. Holler, T. A. Nieman, Principles of Instrumental analysis, Saunders Colege Publishing, Philadelpia, 1998

Course Title: Diffusion in Solids			
Course Code	MSPHY3010E02	Credits	2
L + T + P	2 + 0 + 0	Contact Hours	30 (L) Hours

Unit I

Laws of diffusion. Solution of Fick's diffusion equation under simple boundary conditions. Types of diffusion. Diffusion and concentration gradient. Compositional dependence of diffusion. Diffusion in metals and alloys.

(15 Lectures)

Unit II

Methods of determining diffusion coefficients. Diffusion in ionic solids. Diffusion and conductivity. Point defects. Interaction of point defects. Analysis of typical binary compounds. Diffusion in ternary compounds, ferrites, oxides, sulfides, silicates etc. Diffusion and solid state reactions.

(15 Lectures)

Reference Books:

1. Elements of Materials Science and Engineering: Lowrence H. Van Vlack, Addison
2. Wesley, (1975).
3. Introduction to Ceramics: W D Kingery, H K Bower and VR`uhlman, John Wiley, (1960)
4. Foundations of Materials Science and Engineering-William F. Smith, McGraw Hills
5. International Edition, (1986)
6. Materials Science and Engineering, V. Ragharan, Prentice Hall (1993)
7. Structure & Properties of materials-vol I-IV Rose, Shepard and Wulff (1987)
8. Materials Science and Engineering W.D. Callister Wiley

Course Title: Fundamentals of Scanning Probe Microscopy			
Course Code	MSPHY3011E04	Credits	4
L + T + P	4 + 0 + 0	Contact Hours	60 (L) Hours

Unit I: Tip-Surface Interaction

Non-contact regime Intra-molecular Interactions, Electric Dipoles, Inter-molecular interactions: Physical models, ion-dipoles, Keesom forces, Dispersion Force, ***Contact regime*** Hamaker theory, surface energies, Dejaugin approximation, contact mechanics, Hertz model, JKR model, DMT model

(12 Lectures)

Unit II: Atomic Force Microscope (AFM)

AFM components, AFM calibration, Contact Mode Scans

Force Spectroscopy Cantilever mechanics, Approach-retract curves, Processing Force curves, Modulus and adhesion Maps, Lateral Force Microscopy, Conducting Atomic Force Microscopy, Nano-indentation

(12 Lectures)

Unit III: Dynamic AFM methods

Point Mass Model of Dynamic AFM, frequency response, conservative and dissipative interaction forces, interacting with the surface, ***Analytical theory of Dynamic AFM*** : Excited probe interacting with sample (linear theory), Amplitude and Frequency modulation AFM, Non-linear/dissipative interactions, Attractive and Repulsive Regimes and Phase Contrast Modualtion AFM, ***Reconstructing Surface Forces*** Relationship between Frequency shift and Potential Energy, reconstruction of interaction force from frequency shift in FM-AFM, Experimental details of FM-AFM measurements

(12 Lectures)

Unit IV: Dynamic AFM for Electrostatics/Magnetic/Biology

Measuring Electrostatic Forces, Measuring Magnetic Forces, Dynamic AFM in Liquids, Specialized dynamic-AFM based techniques for physical property measurements: Piezo-response force microscopy, Scanning non-linear dielectric microscopy, Magnetic exchange force microscopy

(12 Lectures)

Unit-V: Scanning Tunneling Microscopy

Quantum tunneling, WKB approximation for field emission, STM instruments and its components, Scanning tunneling spectroscopy, Inelastic electron tunneling spectroscopy; Atomic/molecular manipulations, spin-polarized STM, radio-frequency STM

(12 Lectures)

References:

1. Scanning Probe Microscopy and Spectroscopy: Methods and Applications, Roland Wiesendanger, Cambridge University Press, 1994
2. Fundamentals of Scanning Probe Microscopy, V. L. Mironov, The Russian Academy of Sciences, Institute for Physics of Microstructures, 2004
3. Scanning Probe Microscopy: Electrical and Electromechanical Phenomena at the Nanoscale, Sergei V. Kalinin, Alex Gruverman, Springer-Verlag New York, 2007
4. Scanning Probe Microscopy: Atomic Force Microscopy an Springer-Verlag Berlin Heidelberg, 2015.
5. Springer Handbook of Nanotechnology, Ed. Bharat Bhushan, Springer-Verlag Berlin Heidelberg, 2010

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Master of Science (M.Sc.) Physics Programme

Detailed Syllabus

(Effective from Academic Session 2020-2021)

SEMESTER - IV

Specialization
Condensed Matter Physics

Course Title: Advanced Condensed Matter Physics			
Course Code	MSPHY4001C04	Credits	4
L + T + P	4 + 0 + 0	Contact Hours	60 (L) Hours

UNIT: I

Magnetism: Classical and Semi Classical Theories : Failure to explain large internal fields. Exchange interaction. Ising Model. Bragg William Approximation. Explanation of large external fields. Non-existence of ferromagnetism in two-dimensional Ising Model. Two sublattice Model and classical theories of antiferromagnetic and ferrimagnetism, Ferrites and garnets.

(15 Lectures)

UNIT: II

Second Quantized Theory: Ferromagnetic Heisenberg Hamiltonian, Holstein Primak off transformations and their application to Heisenberg Hamiltonian for small fractional spin reversal. Ferromagnetic magnons, Magnon heat capacity and saturation magnetization at small temperatures. Antiferromagnetic Hamiltonian and its reduction using Holstein Primak off transformation, Antiferromagnetic magnons. Zero point sub-lattice magnetization. The Magnetic Phase Transition :Order parameter, Landau's theory of second order phase Transitions. Fluctuations of the order parameter. Elementary qualitative ideas about critical exponents and scaling.

(15 Lectures)

UNIT: III

Many Electron Systems: Second quantization for Fermions, field operators, electron density operator, Hamiltonian for two particle interactions in second quantized form: Columbian interaction and screened Colombian interaction. Linear Response Theory: Dielectric response analysis, dielectric constant for electron gas in self-consistent approximation, Lindhard formula, dielectric constant. Dielectric screening of a point charge impurity

(15 Lectures)

UNIT: IV

Electron-Phonon Interaction: Long wavelength limit, deformation potential interaction, Born approximation, deformation potential perturbation Hamiltonian, Normal processes, polaron. Number of phonons accompanying electron. Electron-electron interaction via phonons, Attractive interaction, Cooper pairs, Reduced Hamitonian for superconducting state. Bogoliubo-Valatin tranformation, Diagonal and non-diagonal terms, superconducting ground state energy, nature of ground state, excited states, Temperature dependence of energy gap, Transition temperature, Simple treatment of Meissner effect and flux quantization.

(15 Lectures)

Reference Books:

1. Solid State Physics- A. J. Dekker.
2. Solid State Physics- C. Kittel.
3. Introduction of Solids: L.V. Azaroff.
4. olid State Physics: N.W. Ashcroft and N.D. Mermin.
5. Solid State Physics: Mattis
6. Electron Paramagnetic Resonance: Pake
7. Molecular spectroscopy: Banwell.

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Course Title: Solid State Physics Lab – II			
Course Code	MSPHY4003C04	Credits	4
L + T + P	0 + 0 + 4	Contact Hours	120 (P)

❖ **List of Experiments:**

1. To study characteristics of a solar cell.
2. To measure the charge Q on a plate capacitor as a function of the applied voltage E.
3. To determine the capacitance C as a function of areas A of plates.
4. To determine the capacitance C with different dielectrics between the plates.
5. To determine the capacitance C as a function of the distances d between the plates.
6. To determine resistivity of a given semiconductor by Four probe.
7. To draw the characteristics of a P-N junction diode for reverse saturation current and temperature.
8. To determine the Band gap in a semiconductor using a junction diode.
9. To study Hall effect in semiconductor and determine Hall coefficient (Rh), mobility ,Hall angle tan (θ) & conductivity .
10. Crystallographic measurements using XRD.

❖ Any experiment can be added / deleted at any time during the course in / from the list of the experiments.

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Course Title: Physics of Magnetism & Spintronics			
Course Code	MSPHY4004E04	Credits	4
L + T + P	4 + 0 + 0	Contact Hours	60 (L) Hours

UNIT I:

Magnetism in metals: Free electron model, Pauli paramagnetic, Spontaneously spin-split bands, Landau levels, Landau diamagnetism, Magnetism of the electron gas, Excitations in the electron gas, Spin density waves, Kondo effect, The Hubbard model.

Magnetic anisotropy: Shape anisotropy, Magneto-crystalline anisotropy and its origin, Induced anisotropy Competing interactions and low dimensionality: Magnetic frustration, Spin glasses, Superparamagnetic, One and two-dimensional magnets, Spin chain, Spin-Peierl's transition, Spin ladders

(15 Lectures)

UNIT II

Introduction- overview of development of Spintronics and its future scope, Magnetic multilayers, Magnetic Anisotropy of thin films, Interlayer Exchange Coupling and Exchange Bias, Spin dependent transport - Anisotropic magnetoresistance, Giant Magneto Resistance (GMR) effect - Phenomenological theory, Microscopic theory for current in plane (CIP) and current perpendicular to plane (CPP) GMR, Effects of spin-flip scattering Spin tunneling, Tunnel Magnetoresistance (TMR), Effects of Fermi surface, Effect of interfacial states, diffusive tunneling, Spin flip tunneling, Bias voltage dependence of TMR, Magnetic tunnel Junctions (MTJ), Tunnel Junctions with Half Metals

(15 Lectures)

UNIT III

Introduction to thin films, Technology as a drive and vice versa, Basics of vacuum science and technology, Vacuum pumps and gauges. Physical vapor deposition, Raoult's law of evaporation, evaporation rate, evaporation of elements, compounds and alloys, Hertz Knudsen equation; Knudsen cell, Film Thickness Uniformity and Purity

(15 Lectures)

UNIT IV

Molecular beam epitaxy (effusion cell, growth rate, growth of GaAs/AlGAs and GSMBE), Role of Kinetics of Adsorption and Desorption, Surface reconstruction, In-situ film characterization of MBE films by LEED and RHEED, & RHEED Oscillations, Pulsed Laser deposition (PLD process steps, congruent evaporation, advantages and disadvantages of PLD). CVD advantages, CVD Reaction types, Thermodynamics of CVD, Gas Transport, Viscous flow, Close-Spaced Vapor Transport (CSVT), Convection, Film Growth Kinetics, Axial and radial film thickness uniformity, Classification of CVD systems, APCVD, LPCVD & MOCVD and Examples of CVD growth.

(15 Lectures)

References

1. S. Blundell, Magnetism in Condensed Matter, 1st edition, Oxford University Press, 2001.
2. R. C. O' Handley, Modern Magnetic Materials, John Wiley & Sons, Inc., 2000.
3. T. Shinjo (Ed.) Nanomagnetism and Spintronics, 1st edition, Elsevier, 2009.
4. E. Y. Tsymbal and I Zutic, Handbook of Spin Transport and Magnetism, CRC Press, 2012.
5. Materials Science of Thin Films Deposition and Structure, Milton Ohring.
6. Thin Film Solar Cells, Chopra and Das
7. Thin Film Deposition: Principles and Practice, Donald Smith.
8. Handbook of Thin Film Deposition (Materials and Processing Technology), Krishna Seshan.
9. Handbook of Physical Vapor Deposition, D. M. Mattox.

Course Title: Alloy Design and Development			
Course Code	MSPHY4005E04	Credits	4
L + T + P	2 + 0 + 2	Contact Hours	30 (L) + 60(P) Hours

Unit-I

Concept and of alloy design, Steps in alloy design, Significance of alloy design. Single phase, dual phase and multiphase materials, Effect of size, shape and distribution of second phase on mechanical and magnetic properties of alloys. Precipitation and particle coarsening, re-crystallization and grain growth. Solid/Liquid phase transformation in pure metals, single phase alloys, constitutional super cooling and eutectic alloys.

(15 Lectures)

Unit-II

Standards in alloy steels – Study of a few selected standards. Quasicrystalline alloys, Alloy steel design for better tensile strength, ductility, toughness, fatigue strength, creep strength, wear resistance and elevated temperature strength. Alloy design of lightweight, high strength, corrosion resistance Non Ferrous alloys, Magnetic alloys, Multicomponent alloys and their Applications. Different synthesis routes and their effect on properties of Alloys.

(15 Lectures)

List of Experiments

- Synthesis of alloys through different synthesis routes e.g. mechanical alloying, solid state synthesis, arc melting, and induction melting.
- Effect annealing temperature on phase revolution and properties of different alloys.
- Effect annealing condition on phase revolution and properties of different alloys.
- Mechanical, Magnetic and corrosion behaviors of different alloys.
- Development of important Alloys.

Reference Books

1. ASM Handbook, Vol.1 & 2, Properties and Selection: Metals Park, Ohio.
2. Boyer, H.E.(ed.), Selection of Materials for component Design: Source Book, American Society for Metals, Metals Park, Ohio
3. Ashby, M.F. Materials Selection in Mechanical Design, New York: Pergamon, 1992.
4. Ranganathan S., Arunachalam V.S. and Cahn R.W. (Eds.), Alloy Design, Indian Academy of Science, Bangalore,1981.
5. Tien John K. and Ansell George S. (Eds.), Alloy and Micro structural Design, Academic Press.
6. Structure & Properties of Alloys – Robert M. Brick, Robet B. Gordon & Arthur Phillips, Eurasia Publishing House (private) Ltd., New Delhi
7. Metals Hand Book Ninth Edition – Vol 1

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Nitin Upadhyay 19.02.2020 19/4/20 19.02.2020 19/02/2020

Course Title: Materials Synthesis and Processing			
Course Code	MSPHY4006E04	Credits	4
L + T + P	4 + 0 + 0	Contact Hours	60 (L) Hours

Unit I

Introduction: Materials processing science with special emphasis on processing of polymers and ceramics and metals

(2 Lectures)

Unit II

Polymer processing: Rheology of polymeric materials, Compounding of plastics, processing techniques: Compression, Transfer, injection, blow molding, Extrusion, Calendaring, Thermoforming, Rotational molding, Compounding and processing of rubber (both latex and dry rubber) with different formulations: Casting, rubber extrusion, Dip coating (gloves, balloons etc.), fibre spinning and manufacturing processes.

(12 Lectures)

Unit III

Ceramic processing: Processing of traditional ceramics- spray granulation, Pressing, Slurry processing, Slip casting, Pressure casting, Tape casting, Gel casting, Injection molding, Extrusion; Rapid prototyping through Additive manufacturing, Electrophoretic deposition, Production of ceramic fibres, Electro-spinning; Drying, Binder burnout, Green machining, Sintering; Sol-gel processing, Thermal and plasma spraying, Thick and thin film coatings- PVD and CVD techniques; Vapor infiltration techniques

(18 Lectures)

Unit IV

Metallic processing: Casting process- major casting techniques, Solidification and volume shrinkage, Casting design and defects, Fundamentals of deformation processing, Deformation work, Hot and cold working, Few forming processes and defects; Metal removal process- Mechanical machining methods, Single and multiple point machining, Introduction to non-traditional machining, Metal joining process- Concepts of Fusion and solid state welding processes, Brazing and soldering, Welding defects; Introduction to powder Metallurgy Design aspects: General principles of materials selection and design based on requirements of function, Property, Processability and cost; Quantitative methods of materials selection, Normalization of properties, Weighting factors, Materials performance index; Design of engineering structures from the atomic- and nano-scales to macroscopic levels; Case studies- modern metallic, ceramic, polymeric and biomaterials devices and components

(16Lectures)

Unit V

Design aspects: General principles of materials selection and design based on requirements of function, Property, Processability and cost; Quantitative methods of materials selection, Normalization of properties, Weighting factors, Materials performance index; Design of engineering structures from the atomic- and nano-scales to macroscopic levels; Case studies- modern metallic, ceramic, polymeric and biomaterials devices and components

(12Lectures)

References:

1. P. Boch, J-C. Nièpce, Ceramic Materials: Processes, Properties, and Applications, WileyISTE, 2007.
2. J-H. He, ElectrospunNanofibres and Their Applications, SmithersRapra Technology, 2008.
3. Z. Tadmor, C.G. Gogos, Principles of Polymer Processing, 2nd ed., Wiley International, 2006.
4. T.A.Osswald, Polymer Processing Fundamentals, HanserPublcations, 1998.
5. M.N. Rahaman, Ceramic Processing and Sintering, 2nd ed.,, CRC press
6. F.C. Campbell, Elements of Metallurgy and Engineering Alloys, ASM International, 2008.
7. J. Beddoes, M.J. Bibby, Principles of Metal Manufacturing Processes, Elsevier, 2003.
8. G.E. Dieter, Mechanical Metallurgy,McGraw-Hill,3rd ed.,1986.
9. E. Degarmo, J.T. Black and R.A. Kohser, Materials and Processes in Manufacturing, 9th ed., Wiley, 2002.
10. S. Kalpakjian, S.R. Schmid, Manufacturing Engineering and Technology, 6th ed., Pearson,2009.

Course Title: Renewable Energy			
Course Code	MSPHY4007E04	Credits	4
L + T + P	4 + 0 + 0	Contact Hours	60 (L) Hours

Unit-1

Solar Energy: Fundamental and Material Aspects:

Fundamentals of photovoltaic Energy Conversion Physics and Material Properties, Basic to Photovoltaic Energy Conversion: Optical properties of Solids. Direct and indirect transition semiconductors, interrelationship between absorption coefficients and band gap recombination of carriers.

(15 Lectures)

Unit-2

Solar Energy: Different Types of Solar Cells:

Types of Solar Cells, p-n junction solar cell, Transport Equation, Current Density, Open circuit voltage and short circuit current, Brief description of single crystal silicon and organic and Polymer Solar Cells, Elementary Ideas of Advanced Solar Cells e.g. Tandem Solar cells, Solid Liquid Junction Solar Cells, Nature of Semiconductor, Principles of Photoelectrochemical Solar Cells.

(15 Lectures)

Unit-3

Hydrogen Energy: Fundamentals, Production and Storage:

Relevance in relation to depletion of fossil fuels and environmental considerations. Solar Hydrogen through Photoelectrolysis, Physics of material characteristics for production of Solar Hydrogen. Brief discussion of various storage processes, special features of solid hydrogen storage materials, Structural and electronic characteristics of storage materials. New Storage Modes.

(20 Lectures)

Unit-4

Hydrogen Energy: Safety and Utilization:

Various factors relevant to safety, use of Hydrogen as Fuel, Use in Vehicular transport, Hydrogen for Electricity Generation, Fuel Cells, Various type of Fuel Cells, Applications of Fuel Cell, Elementary concepts of other Hydrogen- Based devices such as Hydride Batteries.

(10 Lectures)

Reference Books:

1. Solar Cell Devices-Physics :Fonash
2. Fundamentals of Solar Cells Photovoltaic Solar Energy :Fahrenbruch & Bube
3. Phoptoelectrochemical Solar Cells: Chandra
4. Hydrogen as an Energy Carrier Technologies Systems Economy : Winter & Nitch (Eds.)
5. Hydrogen as a Future Engery Carrier : Andreas Zuttel, Andreas Borgschulte and Louis Schlapbach

19/02/2020

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Course Title: Carbon Nanostructures and Their Applications			
Course Code	MSPHY4008E04	Credits	4
L + T + P	2 + 0 + 2	Contact Hours	30 (L) +60(P) Hours

Unit-I

Introduction to nanomaterials Size Dependent properties. Bulk to Nano Transitions. Method of Synthesis: Thermal and ultrasound decomposition methods. Reduction methods. Coprecipitation, spray drying, sol-gel and hydrothermal methods. Capped semiconductor nanoparticles. High energy ball milling and mechanical attrition. Thermal evaporation. Sputtering. Laser ablation. Chemical vapour deposition. Molecular beam epitaxy. Thermal spraying. Electro and electroless deposition. Brief description of OD,1D,2D nanomaterials e.g. Quantum wells, wires and dots. Size and dimensionality effects. Excitons. Single electron tunneling. Applications in infrared detectors and quantum dot lasers. Magnetic properties of nanocrystalline materials. Nanostructured ferroelectric materials and their properties.

(15 Lectures)

Unit-II

Carbon Nanostructures: Nature of Carbon Clusters, Discovery of C60, Structure of C60 and its Crystal, Superconductivity in C60, Carbon Nanotubes: Synthesis, Structure, Electrical and Mechanical Properties. Graphene: Discovery, Synthesis and Structural Characterization through TEM, Elementary Concept of its applications. Properties of carbon nanotubes. Inorganic nanotubes and nanorods, nanoporous materials.

(15 Lectures)

List of Experiments

1. Synthesis of nanomaterials through different methods Mecahnical-milling, Sol-gel etc
2. Characterizations of nanomaterial through XRD TEM SEM AFM and other techniques.
3. Synthesis of Carbon Nanotubes through CVD.
4. Characterizations through XRD/TEM
5. Synthesis of Graphene through different methods
6. Characterizations of Graphene through XRD TEM.
7. Different properties of carbon nanostructures.

Reference Books:

1. Introduction to Nanotechnology: Poole and Owners
2. Nano Essentials: T. Pradeep
3. Quantum Dots : Jacak, Hawrylak and Wojs
4. Handbook of Nanostructured Materials and Nanotechnology : Nalva (editor)
5. Nano Technology/ Principles and Practices: S.K. Kulkarni
6. Carbon Nanotubes: Silvana Fiorito 6. Nanotechlongy: Richard Booker and Earl Boysen

Course Title: Biomedical Instrumentation			
Course Code	MSPHY4009E04	**Credits**	4
L + T + P	4 + 0 + 0	**Contact Hours**	60 (L) Hours

Unit - I:
Basic principles of biomedical electronics. Distribution of electrical potentials in different parts of the body. Their magnitude and relationship to the physical status. Physical anatomy and its relation to bi-electric signals. Processing of bio-electronic signals and different types of transducers for acquisition. Recording systems, general consideration of electronic recording amplifier. Pre-amplifier, main amplifier and driver amplifier. Consideration of noise. Different types of digital recorder.

(15 Lectures)

Unit - II:
Need for imaging the human body. Imaging techniques, computer assisted tomography (CATSCAN); Basic principles and overall design. Nuclear resonance techniques; full body nuclear magnetic resonance scanners (NMR);Design of NMR scanner and its applications; Ultrasound instrumentation and its applications; thermography and applications. Case studies of typical instrumentation requirements in Electroencephalography (EEG), Electrocardiography, photo cardiograph, and Electromyography (EMG); Different techniques of displaying information. Display systems. Use of oscilloscope, cardioscope, and multichannel displays. Patient safety, electronic shock hazards in biomedical instrumentation. Leakage current and their merits. Instrumentation grounding techniques and patient monitoring systems.

(15 Lectures)

Unit - III :
Computer based imaging : Computer applications in medical imaging : Basics; Computers in nuclear medicine; nuclear medicine computer systems; software in nuclear medicine; digital subtraction radiography; computerised ultrasonography; X-ray computerised tomography; computerised emission tomography; nuclear magnetic resonance.

(15 Lectures)

Unit - IV :
Therapeutic equipments; cardiac pace makers; defibrillators; surgical diathermy;lasers and biomedical electronics; short-wave and microwave diathermy.Computeres in medical research : Signal processing; model building and simulation; Monte Carlo technique; cell kinetics; operational research; statistical research; multivariate analysis; numerical taxonomy; risk profiles; Framingham study; computer networking.

(15 Lectures)

References:

1. R.S. Khandpur, Handbook of Biomedical instrumentation, McGraw-Hill Education, 1987
2. Leslie Cromwell, Biomedical instrumentation and measurements, Prentice-Hall, 2011
3. R.D. Lele, Computers in medicine, Tata McGraw-Hill Pub., 1988

Course Title: Industrial Process Control			
Course Code	MSPHY4010E04	**Credits**	4
L + T + P	4 + 0 + 0	**Contact Hours**	60 (L) Hours

Unit - I:

Transducer and Instrumentation Basics: Principles of transduction, resistive, capacitive, inductive, piezoelectronic, digital etc. temperature, strain, pressure and flow transducers mounting, characteristics and responses.Digital transducers, digital encoders rotating optical transducer, level transducer.Signal conditioning system, offsetting linerization, linear variable differential transducer (LVDT). Instrumentation amplifiers, differential input and DC instrumentation amplifiers. Data Acquisition and Conversion Systems : Microprocessor bases data acquisition system S/H circuits, Analog multiplexers, DAC & ADC converters, signal channel and multichannel IC's, successive approximation register (SAR), converter specifications, resolution, accuracy and speed, recorders, display systems.

(15 Lectures)

Unit - II :

Industrial Process Control : Basic process elements, process model identification, feedback control system, feedback and feed forward and cascade control, Analog controllers, Proportional Integral derivative (PID) controller, Turning of analog controllers.

(15 Lectures)

Unit - III :

Micro Controllers : Logic control systems, Programmable Logic Controller (PLD), basic functions of PIC, basic architecture, ladder diagram, programming, mirocontroller8031/8051, a elements of 16 bit microcontroller (8097).Alarm signal generation for a process (e.g. heating etc.,) Direct digital control (DDC) algorithm.

(15 Lectures)

Unit - IV:

Interfacing - Standards for Instrumentation : Analog signal transmission, 4.20 mA current loop, Digital transmission, synchronous/asynchronous (8251 USART), parallel data transmission (PPI 8255), control parallel printer prot. Bus standards : 222 C, Rs-422, IEF 802.4, General purpose interfaced bus (GPIB), IEE 488. Interfacing with stepper motor. Interfacing with DAC & ADC.

(15 Lectures)

References :

1. D.V.Hall, Microprocessors and Interfacing, Tata McGraw Hill Education Private Limited, 2005
2. Barry E. Jones, Instrumentation measurement and feedback, Tata McGraw Hill Education Private Limited, 1977

Course Title: Nanoelectronics			
Course Code	MSPHY4011E04	Credits	4
L + T + P	4 + 0 + 0	Contact Hours	60 (L) Hours

UNIT I:

Nanoelectronics: Device scaling, Moore's law, limitations, role of quantum mechanics, Nanostructures: Impact, technology and physical consideration; Mesoscopic observables

Preliminaries : Basic Quantum mechanics and Fermi statistics, Metals, Insulators and Semiconductor, Density of states (DOS) in 0D, 1 D, 2D and 3D, DOS in disordered materials, Physics of organic semiconductors: concept of HOMO and LUMO, band gap etc. Novel molecules (Pentacene, carbon nanotube, Fullerenes and its derivatives etc.) and conjugated polymers (Polyacetylene, P3HT, PEDOT:PSS etc.).

(15 Lectures)

UNIT II:

Semi-classical theory of transport in nanostructures: *Modification of Ohm's law*: elastic resistor, ballistic and diffusive transport, conductivity, quantum capacitance, diffusion equation for ballistic transport, Nanotransistor. Voltage-drop, Quasi-Fermi levels, Landauer formula, electrostatic potential versus electrochemical potential, Boltzmann transport equation. Spin voltages.

Entropy driven processes in electrical transport, Seebeck effect, Peltier effect, Heat current, second law of thermodynamics, entropy.

(15 Lectures)

UNIT III:

Two terminal quantum dot and quantum wire devices: Equilibrium in two terminal devices, Current flow in the presence of a bias, numerical technique for self-consistent estimation of V-I ,Current flow, quantum of conductance.

Three-terminal devices: Field Effect Transistors (FETs): Ballistic quantum wire FETs, conventional MOSFETs, CMOS, short channel and narrow width, hot electron effect, punch-through and thin gate oxide breakdown, OFET;

Spintronics: Spin, propagation, detection, spinFETs.

(15 Lectures)

UNIT IV:

Nano-fabrication techniques: Top-down and bottom-up strategies, advantages/disadvantages/ limitations, e-beam lithography, Focussed Ion beam milling, self-organized structures, laser nano-patterning, nano-imprint, electrochemical synthesis, Fabrication of OEDs etc.

(15 Lectures)

References

1. David Ferry , Transport in Nanostructures Cambridge University Press (1995)
2. M. Baldo, Introduction to Nanoelectronics (Lecture Notes; May 2011 MIT).
3. S. Datta, Electronic Transport in Mesocopic Systems; Cambridge University Press (1995).
4. S. Datta, Quantum Transport: Atom to Transistor; Cambridge University Press (2005).
5. M. Lundstrom and J. Guo, Nanoscale Transistors; Physics, Modeling, and Simulation, Springer (2006).
6. P.W. Atkins and R.S. Friedman, Molecular Quantum Mechanics; Oxford University Press, 3rd edition (1997).
7. M. Stepanova and S. Dew, Nanofabrication: Techniques and Principles; Springer-Verlag (2012)

Master of Science (M.Sc.) Physics Programme

Detailed Syllabus

(Effective from Academic Session 2020-2021)

SEMESTER - III

Specialization
Nuclear and Particle Physics

19/02/2020

Nitin Chaudhary
19.02.2020

Puneet Mishra
19/02/2020

19/02/2020

Course Title: Advanced Nuclear Physics			
Course Code	MSPHY3101C04	Credits	4
L + T + P	4 + 0 + 0	Contact Hours	60 (L) Hours

UNIT I

Two-body bound state : Properties of deuteron, Schrodinger equation and its solution for ground state of deuteron, spin dependence of nuclear forces, electromagnetic moment and magnetic dipole-moment of deuteron and the necessity of tensor forces.

(8 Lectures)

UNIT II

Nuclear models and stability : Mean potential, Bethe-Weizsäcker binding energy/mass formula, Fermi gas model, Shell model, Magic Numbers, Collective model, β-instability, α-instability, Nucleon emission, production of super-heavy elements.

(12 Lectures)

UNIT III

Nuclear reactions : Cross-sections, Classical scattering on a fixed potential, Quantum mechanical scattering on a fixed potential, Particle-particle scattering, Nucleon-nucleus and nucleon-nucleon scattering, Resonance scattering and reactions–Breit-Wigner dispersion relation; Compound nucleus formation and break-up, Coherent scattering and the refractive index, Statistical theory of nuclear reactions. Optical model for nuclear reactions at low energies, comparison with experiments.

(16 Lectrures)

UNIT IV

Experimental Techniques : Charge particle, neutron, and gamma-ray Spectroscopy, methods for charge and mass identification : δE-E, TOF, mass spectrometer, Neutron: TOF and n-discrimination, Gamma-rays : Coincidence technique, Detector array, Multiplicity, Doppler shift and Doppler broadening, Methods for life time measurements: Delay coincidence, pulse beam, recoil distance and Doppler shift attenuation, isomeric shift and lamb shift.

(14 Lectrures)

UNIT V

Application of Nuclear Techniques : Mossbaurer effect and its applications, Activation method, Biological effect of radiation, Industrial and Analytical application, nuclear medicine.

(10 Lectrures)

References Books:

1. *Introduction to Nuclear Physics*, Kenneth Krane, Wiley India Pvt. Ltd.
2. *Introduction to Nuclear Physics*, H. A. Enge, Eddison Wesley
3. *Nuclei and Particle*, E. Segre, W. A Benjamin,
4. *Concepts of Nuclear Physics*, B. L. Cohen
5. *Nuclear Physics, Experimental and Theoritical*, H. S. Hans, New Age International
6. *Introduction to Nuclear and Particle Physics*, A. Das & T. Ferbel, World Scientific
7. *Nuclear and Particle Physics*, W. E. Burcham and M. Jobes, Addison Wesley
8. *Nuclear Physics*, S. N. Ghoshal, *Nuclear Physics*- D. C. Tayal
9. *Nuclear Physics*- An Introduction, S. B. Patel, New Age International

Course Title: Nuclear and Particle Physics Lab. – I			
Course Code	MSPHY3102C04	Credits	4
L + T + P	0 + 0 + 4	Contact Hours	120 (P)

❖ List of experiments :

1. **G. M. Counters – characteristics, dead-time and counting statistics**
   Apparatus:- Geiger Muller Detector, Geiger Muller Counter (G. M Counter), G. M. Detector Stand, Desktop and Cable
2. **Verify the inverse square relationship between the distance and intensity of radiation using GM Counter.**
   Apparatus:- Geiger Muller Detector, Geiger Muller Counter (G. M Counter), G. M. Detector Stand, Desktop and Cable
3. **Spark counter-characteristics and range of x-particles in air**
   Apparatus:- Spark counter whole Setup
4. **NaI(Tl) – Calibration and characteristic study, resolution and determination of gamma ray energy**
   Apparatus:- NaI Detector, Scintillation Preamplifier, NIM Crate, NIM High Voltage, Multichannel analyzer, Desktop and Cables
5. **Setup the coincidence circuit in the a cosmic muon test bench**
   Apparatus:- Plastic Scintillator Panel, NIM Crate, NIM High Voltage, NIM Discriminator, NIM Counter, NIM Coincidence unit, NIM Gate generator and Cables
6. **Alpha spectroscopy using a Si surface-barrier detector:**
   Energy response & Energy resolution measurements. (b) Its characteristics and applications. (c) Measurement of stopping power of an alpha particle
   Apparatus:- Si surface-barrier detector attached with Vacuum chamber, Pre-amplifier, MAC, Counter, Si surface-barrier detector High Voltage Setup, Multichannel analyzer, Desktop and Cables
7. **Identification of unknown gamma ray source using known gamma emitter sources with the help of NaI(Tl) detector.**
   Apparatus:- NaI Detector, NIM Crate, NIM High Voltage, Multichannel analyzer, Desktop and Cables
8. **Angular correlation ratio using NaI(Tl) detector.**
   Apparatus:- Two NaI Detector, NIM Crate, NIM High Voltage, NIM Discriminator, NIM Counter, NIM Co-Incident unit, NIM Gate generator, a Goniometer to orient the detector system and Cables
9. **Design the simple geometry of give detector setup and visualize in Gcant4.**
   Apparatus:- Desktop
10. **Absorption of γ - rays – Determination of the Half-value Thickness of Absorber Materials (Pb, Al, Fe)**
    Apparatus:- Geiger Muller Detector, Geiger Muller Counter (G. M Counter), G. M. Detector Stand, Desktop, Lead, Aluminum Absorber and Iron Set of absorbers and Cable.

❖ Any experiment can be added / deleted at any time during the course in / from the list of the experiments.

Course Title: Advanced Particle Physics			
Course Code	MSPHY3103C04	Credits	4
L + T + P	4 + 0 + 0	Contact Hours	60 (L) Hours

UNIT I

A Preview of Particle Physics : Fundamental Building Blocks and their nature of Interactions, Classification of elementary particles by masses, Conservation Laws: Energy, Angular Momentum, electromagnetic Charge, Lepton flavor and Baryon Numbers. Natural units system, Relativistic kinematics.

(5 Lectrures)

UNIT II

Symmetries and Quarks : Symmetries in Physics, Symmetries and Groups (Brief Introduction), Group SU(2), Combining Representations, Finite Symmetry Groups: P and C, SU(2) of Isospin, Isospin for Antiparticles, Group SU(3), Example of an SU(3) Group: Isospin and Strangeness, Quark-Antiquark States : Mesons, Three-Quark States: Baryons, Magnetic Moments, Heavy Quarks: Charm and Beyond, Hadron Masses, Color Factors.

(10 Lectrures)

UNIT III

QUANTUM ELECTRODYNAMICS (QED) : Structure of the QED Lagrangian, gauge invariance and conserved current, scalar electrodynamics, Feynman rules for QED, phase space integration, Casimir's Trick and the Trace Theorems, Miller and Bhabha scattering, polarisation vectors, Compton scattering and pair creation/annihilation, Klein Nishina formula, Higher Orders in QED: Concept of multi–loop diagrams (no computation), momentum integral, UV and IR singularities, idea of regularisation, running coupling constant.

(15 Lectures)

UNIT IV

QUARK PARTON MODEL : Isospin and strangeness, introduction to unitary groups, generators, Casimir invariants, fundamental and adjoint representations, root and weight diagrams, meson and baryon octets, baryon decuplet, Gell– Mann–Nishijima formula. symmetry group, Young tableaux, quark model, Deep Inelastic Scattering, Elastic scattering off a point particle, Rosenbluth formula, Breit frame, inelastic scattering, structure functions, dimensionless variables. Bjorken scaling, parton model, structure functions in terms of PDFs, Callan–Gross relation, kinematic regions, valence and sea quarks, gluons.

(15 Lectures)

UNIT V

WEAK INTERACTIONS : Fermi theory of Beta decay, Fermi and Gamow –Teller transitions, current–current form of weak interactions, Fermi constant, universality, unitarity violation at high energies. Intermediate vector bosons, unitarity, requirement of conserved currents, muon decay, pion decay, Parity violation, experiments of Wu et al and of Goldhaber et al, maximal parity violation, CP Violation.

(10 Lectures)

UNIT VI

Particle detectors and accelerators : Cloud and bubble chambers, emulsion techniques, electronic detectors, proportional counters, fixed target and collider experiments, basic idea of cyclotron, synchrotron and linac.

(10 Lectures)

References :

1. Introduction to Elementary Particles by D. Griffiths (2nd Ed., Wiley-VCH, 2008).
2. Quarks and Leptons, by F. Halzen and A.D. Martin (Wiley 1984).
3. Particle Physics, by B.R. Martin and G. Shaw (Wiley 2008).
4. Elementary Particle Physics by S. Gasiorowicz (John Wiley, 1966)
5. Elementary Particles and the Laws of Physics by R. P. Feynman and S. Weinberg (Cambridge University Press, 1999)
6. Introduction to Elementary Particle Physics by A. Bettini (Cambridge University Press, 2008)

Course Title: Introduction of Astrophysics			
Course Code	MSPHY3104E04	**Credits**	4
L + T + P	4 + 0 + 0	**Contact Hours**	60 (L) Hours

UNIT I

Stellar Structure and Evolution : Stellar Structure and Evolution: Virial Theorem, Formation of Stars, Hydrostatic Equilibrium, Integral Theorems on pressure, density and temperature, Homologous Transformations, Polytropic gas spheres Lane Emden Equation and its solution, Energy generation in stars, P-P and C-N cycles, Radiative and Convection transport of energy, Equations of stellar structure and their solution, Evolution of stars of different masses, pre- and post main- sequence evolution.

(20 Lectures)

UNIT II

Gravitational Collapse and relativistic Astrophysics : Newtonian theory of stellar equilibrium, White Dwarfs, Electron degeneracy and equation of States, Chandrasekhar Limit, Mass-Radius relation of WD. Neutron Stars, Spherically symmetric distribution of perfect fluid in equilibrium. Tolman-Oppenheimer-Volkoff (TOF) equation, Mass-Radius relations of NS. Pulsars, Magnetars, Gamma ray bursts. Black holes, Collapse to a black hole (Oppenheimer and Snyder), event horizon, singularity.

(10 Lectures)

UNIT III

Galaxies : The milky way Galaxy, Distribution of stars, Morphology, Kinematics, Interstellar medium, Galactic center. Classification of galaxies, Hubble sequence, Ellipticals, Lenticularsand spiral galaxies and their properties, distribution of light and mass in galaxies.

(10 Lectures)

UNIT IV

Overview of Modern Astronomy : 21-cm hydrogen line, cosmic radio sources, quasars, gravitational lensing, Expansion of the Universe and determination of Hubbles constant, gamma ray bursters. Sources of Gravitational Waves.

(10 Lectures)

UNIT V

Experimental methods in Nuclear Astrophysics : Coulomb dissociation, Trojan Horse Method, ANC method, recent applications using Radioactive beams.

(5 Lectures)

References:

1. Stellar Interiors - Physical Principles, Structure, and Evolution by C. J. Hansen, S. D. Kawaler, V. Trimble (Springer, 2004)
2. Stellar Structure and Evolution by R. Kippenhahn and A. Weigert (Springer, 1996)
3. Basics of Astronomy – IGNOU course book PHE-15 Astronomy and Astrophysics, 2006
4. Modern Astrophysicsby Carrol & Ostlie (Addison Wesley, 1996)
5. The Physical Universe by F. Shu (University Science Books, 1982)
6. Principles of Stellar Structure Vol. I & II by J. P. Cox & R. T. Giuli (Gordon & Breach, 1968)
7. An Introduction to the Study of Stellar Structure by S. Chanrdrasekhar (Dover, 1968)
8. Stellar Interiors by D. Menzel, P. L. Bhatnagar & H. K. Sen (Chapman & Hall, 1963)
9. Galactic Astronomy by J. Binney & M. Merrifield (Princeton Univ. Press, 1998)
10. Textbook of Astronomy & Astrophysics by V. B. Bhatia (Narosa, 2001)

Course Title: Nuclear Reactor Physics			
Course Code	MSPHY3105E04	Credits	4
L + T + P	4 + 0 + 0	Contact Hours	60 (L) Hours

UNIT I

Nuclear energy and Neutron diffusion : Binding energy - Nuclear reactions - Nuclear cross sections, Macroscopic cross sections, Mechanism of fission, Products of fission - Energy release from fission - Reactor power - Fuel burn up, Consumption - Multiplication factor - neutron balance and conditions for criticality - Conversion and breeding Classification of reactors.

(10 Lectures)

UNIT II

Diffusion of neutrons : Flux and current density - Equation of continuity - Fick's law - Diffusion equation – Boundary conditions and solutions - Diffusion length - Reciprocity theorem.

(10 Lectures)

UNIT III

Neutron moderation : Energy loss in elastic collision - moderation of neutrons in Hydrogen - Lethargy - Moderation of neutrons - Fermi's age theory - Moderation with absorption. Fermi theory of Bare thermal reactor : Criticality of an infinite reactor - One region finite thermal reactor - Critical equation - Optimum reactor shape.

(10 Lectures)

UNIT IV

Reactor kinetics : Infinite reactor with and without delayed neutrons - Stable period - Prompt jump - Prompt criticality - Negative reactivity - Changes in reactivity - Temperature coefficient - Fission poisoning.

(10 Lectures)

UNIT V

Control and shielding : Control Rod , Fuel management, Natural reactors, Thermal reactors - Intermediate reactors, Fast reactors Breeding, The Thorium converter Light water.

(10 Lectures)

UNIT VI

Reactors : Heavy water Reactors Heat generation and removal Radiation shielding and reactor safeguards Evolution of reactors -Reactor properties over life - core life estimation.

(10 Lectures)

References:

1. John.R Lamarsh, Introduction to Nuclear Reactor Theory, Addison Wesley Publishing Company 2nd printing (1992)
2. Paul .F. Zweifel, Reactor Physics, McGraw Hill Book Company (1973) India.
3. Richard Stepheson, Introduction to nuclear Engineering, McGraw Hill Book Company (1974) New York.
4. Suresh Gard, Feroz Ahmed and L. S Kothari, Physics of Nuclear Reactors, Tata McGraw Hill Pub. Co. Ltd, London.
5. Samuel Glasstone and Edmund , Nucleaar reactor theory

Course Title: Statistical Analysis Techniques in Nuclear and Particle Physics			
Course Code	MSPHY3106E04	Credits	4
L + T + P	4 + 0 + 0	**Contact Hours**	60 (L) Hours

UNIT I

Probability theory: Classical probability, Frequentist probability, Subjective (Bayesian) probability, Komogorov axiomatic approach, Probability distributions, PDFs in more dimensions, Mean, variance and covariance, General Properties of Distributions Binomial Distribution, Poisson Distribution, Gaussian Distribution, Chi-Square (χ^2) Distribution, Gamma Distribution, Commonly used distributions, Conditional probability, Bayes theorem, The likelihood function.

(15 Lectures)

UNIT II

Inference : Review: Random Errors, Error Propagation, Systematic Errors, Basic Estimators, Maximum Likelihood, Inference: Bayesian inference, Error propagation with Bayiesian inference, Choice of the prior, Frequentist inference, Maximum likelihood estimates, Estimate of Gaussian parameters, Estimator properties, Neymans confidence intervals, Binomial intervals, Approximate error evaluation for maximum likelihood estimates, Two-dimensional uncertainty contours, Likelihood function for binned samples, Combination of measurements, Hypothesis tests

(15 Lectures)

UNIT III

Essential Statistics for Data Analysis : Measures of Centrality, Measure of Dispersion, LEAST SQUARES, Fitting Binned Data, Linear Least Squares and Matrices, Chi-Square (χ^2) Test, Students t Test, Simple Linear Regression, Nonlinear Regression, Correlation, Time Series Analysis, Frequency Domain Analysis, Counting Statistics.

(15 Lectures)

UNIT IV

Hypothesis tests and Discoveries Level : The Neyman Pearson lemma, Projective likelihood ratio, Fisher discriminant, Artificial Neural Net-work, Boosted Decision Trees, Overtraining, Upper limits and Discoveries level: Poisson upper limit, Feldman Cousins intervals, Upper limits for event counting experiments, The modified frequentist approach, Treatment of nuisance parameters, Profile likelihood, Variations on test statistics, Random Number generator, Review of Monte Carlo Monte Carlo technique.

(15 Lectures)

References:

1. Statistics for Nuclear and Particle Physicists, Louis Lyons, Cambridge University Press (2018)
2. Statistical Methods in Experimental Physics, Frederick Jame, World Scientific Publishing Co. Pre. Ltd (2nd Edition).
3. Data Analysis in High Energy Physics: A Practical Guide to Statistical Methods, edited by Olaf Behnke, Kevin Kröninger, Grégory Schott, Thomas Schörner-Sadenius, Wiley & sons
4. Statistical Methods for Data Analysis in Particle Physics, Luca Liste, Springer.

Course Title: Radiation Safety			
Course Code	MSPHY3107E02	**Credits**	2
L + T + P	2 + 0 + 0	**Contact Hours**	30 (L) Hours

UNIT I

Interactions of Radiation with Matter : Interaction of charged particles with matter, bremsstrahlung, range of charged particles, interaction of photon with matter (photoelectric effect, Compton scattering and pair production), absorption, scattering and attenuation of photons, Half Value Thickness (HVT) and Tenth Value Thickness (TVT), interaction of neutrons with matter.

(10 Lectrures)

UNIT II

Radiation Quantities and Units : Activity (Becquerel and Curie), energy, exposure (C/kg and Roentgen), air kerma, absorbed dose (Gray and rad), radiation weighting factors, tissue weighting factors, equivalent dose (Siever and rem), effective dose (Sievert and rem) Biological Effects of Radiation Introduction to cell, direct and indirect interactions, effects of radiation on living cells, chromosomal aberration, somatic and genetic effects, deterministic and stochastic effects, acute and chronic exposure, partial body and whole body exposures.

(10 Lectrures)

UNIT III

Radiation Hazard Evaluation and Control : Internal and external hazard and their perspective, evaluation and control of hazard due to external radiation: individual and work place monitoring, application of time, distance and shielding; shielding material, exposure rate constant, types of radiography installations: enclosed installation, opentop, open field; planning of radiography enclosure, controlled areas and supervised areas, shielding calculation for enclosed installations, scattering, Albedo, skyshine, calculation of cordon-off distance, safety in radiography installations: enclosed, open top and field radiography, tracking of lost sources, source storage facilities, safe work practices, safety aspects of high energy accelerators.

(10 Lectrures)

References

1. Radiation Safety: Management and Programs, Haydee Domenech , Springer 2017 edition .
2. Radiation Safety Procedures and Training for the Radiation Safety Officer: Guidance for Preparing a Radiation Safety Program, by John R Haygood, iUniverse (17 September 2013).
3. Radiation Safety in Nuclear Medicine, A Practical, Concise Guide, Gopal B. Saha, Springer.
4. Physics for Radiation Protection, James E. Martin, Wiley-VCH Verlag GmbH & Co. KGaA .
5. Applied Physics of External Radiation Exposure, Dosimetry and Radiation Protection, Antoni, Rodolphe, Bourgois, Laurent, Springer.

Course Title: Neutrino Physics			
Course Code	MSPHY3108E02	Credits	2
L + T + P	2 + 0 + 0	Contact Hours	30 (L) Hours

UNIT I

Important historical experiments : Birth of the neutrino, Nuclear recoil experiment by Rodeback and Allen, Discovery of the neutrino, solar neutrino detection parity violation in weak interactions, helicity of the neutrino, Discovery of weak neutral currents, Discovery of the weak gauge bosons W and Z Observation of neutrinos from SN 1987A, Number of neutrino flavours from the width of the Z bosons. Dirac and Majorana mass terms, Experimental status of lepton number violation.

(10 Lectrures)

UNIT II

Neutrino oscillations : General formalism, C P and T violation in neutrino oscillations, Oscillations with two neutrino flavours, The case for three flavours, Experimental considerations, Nuclear reactor experiments, Experimental status, Accelerator-based oscillation experiments: LSND, KARMEN, Future test of the LSND evidenceMiniBooNE Searches at higher neutrino energy: CHORUS and NOMAD Neutrino oscillations in matter, C P and T violation in matter, Possible future beams: Off-axis beams and experiments, Beta beams, Superbeams, Muon storage rings neutrino factories.

(10 Lectrures)

UNIT III

Important historical experiments : Direct neutrino mass searches, Fundamentals of -decay: Matrix elements, Phase space calculation, Kurie plot and ft values, Searches for m_{ν} : General considerations, Searches using spectrometers Cryogenic searches, Kinks in -decay, m_{ν_i} determination from pion-decay Mass of the ν_τ from tau-decay, Electromagnetic properties of neutrinos: Electric dipole moments, Magnetic dipole moments, Neutrino Radiative decay.

(10 Lectrures)

References

1. K. Zuber,"Neutrino Physics", IoP Publishing 2004.
2. C. Giunti and C.W.Kim, "Fundamentals of Neutrino Physics and Astrophysics", Oxford University Press, 2007.
3. R. N. Mohaptara and P. B. Pal, "Massive Neutrinos in Physics and Astrophysics", World Scientific (2ndEdition), 1998
4. H.V. Klapdor-Kleingrothaus & K. Zuber, "Particle Astrophysics",IoP Publishing, 1997.
5. Scientific American articles:"Detecting Massive Neutrinos", E. Kearns, T. Kajita, Y. Totsuka, Scientific American, August 1999."Solving the Solar Neutrino Problem", A.B. McDonald, J.R. Klein, D.L. Wark, Scientific American, April 2003.

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Master of Science (M.Sc.) Physics Programme

Detailed Syllabus

(Effective from Academic Session 2020-2021)

SEMESTER - IV

Specialization
Nuclear and Particle Physics

Course Title: Experimental Techniques in Nuclear and Particle Physics			
Course Code	MSPHY4101C04	Credits	4
L + T + P	4 + 0 + 0	Contact Hours	60 (L) Hours

UNIT I

Detection of radiations : Interaction of gamma-rays, electrons, heavy charged particles, neutrons, neutrinos and other particles with matter. General properties of Radiation detectors, energy resolution, detection efficiency and dead time. Statistics and treatment of experimental data. Gas-filled detectors, Proportional counters, space charge effects, energy resolution, time characteristics of signal pulse, position-sensitive proportional counters, Multiwire proportional chambers, Drift chamber, Time projection chamber. Organic and inorganic scintillators and their characteristics, light collection and coupling to photomultiplier tubes and photodiodes, description of electron and gamma ray spectrum from detector, phoswich detectors, Cherenkov detector. Semiconductor detectors, Ge and Si(Li) detectors, Charge production and collection processes, detector structures and fabrication aspects, semiconductor detectors in X- and gamma-ray spectroscopy, Pulse height spectrum, Compton-suppressed Ge detectors, Semiconductor detectors for charged particle spectroscopy and particle identification, Silicon strip detectors, Radiation damage. Electromagnetic and Hadron calorimeters. Motion of charged particles in magnetic field, Magnetic dipole and quadrupole lenses, beta ray spectrometer. Detection of fast and slow neutrons - nuclear reactions for neutron detection. General Background and detector shielding.

(20 Lectrures)

UNIT II

Electronics associated with detectors : Electronics for pulse signal processing, CR-(RC) n and delay-line pulse shaping, pole-zero cancellation, baseline shift and restoration, preamplifiers (voltage and charge-sensitive configurations), overload recovery and pileup, Linear amplifiers, single-channel analyser, anolog-to-digital converters, multichannel analyzer. Basic considerations in time measurements, Walk and jitter, Time pickoff methods, time-to-amplitude converters, Systems for fast timing, fast-slow coincidence, and particle identification, NIM, VMI and PXI instrumentation standards and data acquisition system.

(20 Lectures)

UNIT III

Experimental methods : Detector systems for heavy-ion reactions : Large gamma and charge particle detector arrays, multiplicity filters, electron spectrometer, heavy-ion reaction analysers, nuclear lifetime measurements (DSAM and RDM techniques), production of radioactive ion beams. Detector systems for high energy experiments : Collider physics (brief account), Particle Accelerators (brief account), Secondary beams, Beam transport, Modern Hybrid experiments-CMS and ALICE.

(20 Lectures)

References

1. Introduction to Experimental Particle Physics by Richard Fernow (Cambridge University Press), 2001.
2. Radiation detection and measurement by Glenn F. Knoll (Wiley), 2010.
3. Techniques in Nuclear and particle Experiments by W.R. Leo (Springer), 1994.
4. Detectors for particle radiation by Konrad Kleinknecht (Cambridge University Press), 1999.

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Course Title: Nuclear and Particle Physics Lab. – II			
Course Code	MSPHY4103C04	Credits	4
L + T + P	0 + 0 + 4	Contact Hours	120 (P)

❖ List of experiments :

1. **Determination of the Muon Lifetime**
   Apparatus:- Plastic Scintillator Panel, NIM Crate, NIM High Voltage, NIM Discriminator, NIM Counter, NIM Co-Incident unit, NIM Gate generator , Oscilloscope and Cables
2. **Relative efficiency of beta and gamma rays using GM counter and feather comparison method to find range of unknown beta source.**
   Apparatus:- Geiger Muller Detector, Geiger Muller Counter (G. M Counter), G. M. Detector Stand, Sliding bench for G. M. Detector, Desktop and Cables
3. **Measurement of the half-life of meta-stable Barium-137**
   Apparatus:- Geiger Muller Detector, Geiger Muller Counter (G. M Counter), G. M. Detector Stand, Desktop and Cable
4. **To study absorption of beta rays in Al and deduce end-point energy of a beta emitter.**
   Apparatus:- Geiger Muller Detector, Geiger Muller Counter (G. M Counter), G. M. Detector Stand, Aluminum Absorber, Desktop and Cable
5. **Study of angular distribution of Compton scattered gamma rays using scintillation spectrometer.**
   Apparatus:- NaI detector with amplifier and accessories, Scatterers of aluminum, copper and steel, Lead bricks , A rotational stage to move the detector at various angles with respected to collimated beam, Multichannel analyzer system, Desktop and Cable
6. **Proportional counter, its energy response and low energy X-ray measurements**
   Apparatus:- Proportional counter, Proportional Preamplifier, NIM Crate, NIM High Voltage, Multichannel analyzer, Desktop and Cables
7. **Measurement of the Cosmic Ray Flux**
   Apparatus:- Plastic Scintillator Panel, NIM Crate, NIM High Voltage, NIM Discriminator, NIM Counter, NIM Co-Incident unit, NIM Gate generator, Oscilloscope and Cables
8. **Study of passage of particle through matter using Geant4**
   Apparatus:- Geant4 simulation package, and Desktop
9. **$LaBr_3$ – Calibration and characteristic study, resolution and determination of gamma ray energy**
   Apparatus:- $LaBr_3$- Detector, NIM Crate, NIM High Voltage, Multichannel analyzer, Desktop and Cables
10. **Simulation and characterization of silicon detectors.**
    Apparatus:- Silicon- Detector, NIM Crate, NIM High Voltage, Multichannel analyzer, Desktop and Cables

❖ Any experiment can be added / deleted at any time during the course in / from the list of the experiments.

Course Title: Particle Accelerator Physics			
Course Code	MSPHY4104E04	Credits	4
L + T + P	4 + 0 + 0	Contact Hours	60 (L) Hours

UNIT I

Charged Particle Dynamics : Particle motion in electric and magnetic fields, Beam transport system, Beam pulsing and bunching techniques, microbeams, Particle and ion sources, secondary beams, Measurement of beam parameters.

(10 Lectures)

UNIT II

Radiofrequency Accelerators : Linear accelerators - Resonance acceleration and phase stability, electron and proton Linacs. Circular accelerators- Cyclotron, Frequency Modulated Synchrocyclotron, AVF Cyclotron, Alternating-gradient accelerators.

(15 Lectures)

UNIT III

Electrostatic and Heavy Ion Accelerators : Van de Graaff voltage generator, Cockcroft-Walton voltage generator, insulating column, voltage measurement, Acceleration of heavy ions, Tandem electrostatic accelerator, Production of heavy negative ions, Pelletron and Tandetron, Cluster beams, Superconducting Heavy Ion Linear Accelerators.

(15 Lectures)

UNIT IV

Synchrotron Radiation Sources : Electromagnetic radiation from relativistic electron beams, Electron synchrotron, dipole magnet, multipole wiggler, noncoherent and coherent, Undulator, Characteristics of synchrotron radiation.

(10 Lectures)

UNIT V

Radioactive ion beams : Production of Radioactive ion beams, Polarized beams, Proton synchrotron, Colliding accelerators. Applications : Use of accelerators and Ion-beam Analysis Techniques.

(10 Lectures)

References

1. Particle Accelerator Physics, Vol I and II, H.J. Wiedman, (Springer Verlag), 1998.
2. Particle Accelerators, M.S. Livingston and J.P. Blewel, (McGraw-Hill Book Press), 1962.
3. Nuclear Spectroscopy and Reactions Part-A, Ed. J. Cerny, (Academic Press), 1974.
4. Theory of Resonance Linear Accelerators by I.M. Kapchenkey, (Harwood Academic Publishers).

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Course Title: Data Analysis and Simulation in particle Physics			
Course Code	MSPHY4105E04	Credits	4
L+T+P	4+0+0	Contact Hours	60 (L) Hours

UNIT I

C/C++ Programming concepts : Overview- Fundamentals of computer architecture and operation - Programming inC and C++ languages - Data types, int, char, float etc. - C expressions, arithmetic operations, relational and logic operations - Concepts of variables, statements and function calls - Assignment statements, extension of assignment to the operations - primitive input output and print functions – conditional execution using if, else. switch and break statements- Concepts of loops, for, while and do-while-Arrays and pointers- One/Two dimensional arrays and example of iterative programs using arrays- Matrix computations- Sub-programming, functions- Strings -Structure and unions.- Defining C structures, passing structures as arguments- File 1 /0-Simple programs.

(15 Lectures)

UNIT II

Data Analysis : Reconstruction of raw detector data, Charged-particle trajectories, Energy reconstruction, Quark jets, Stable-particle identification, Displaced vertices, unstable-particle reconstruction, Monte Carlo event generators, detector response, Beyond the detector, Multivariate techniques.

(15 Lectures)

UNIT III

Software for Data Analysis : Standard Analysis Packages, Cern Root, Basic idea of ROOT: Histogram, Graph, fitting to Pseudo Data, A Little C++, Math Libraries in ROOT, Linear Algebra in ROOT Trees:Data Handling, Organization, Storage, Data Analysis Capabilities.

(15 Lectures)

UNIT IV

GEANT4 Simualtion : Geant4 Scope of Application, Overview of Geant4 Functionality including tracking, geometry, physics models and hits. Examples: nuclear physics and medical physics.

(15 Lectures)

References

1. E. Balgurusamy : Programming in ANSI C, Tata McGraw Hill
2. V Rajaraman, Computer Oriented Numerical Methods, 3rd Ed. (Prentice-Hall, New Delhi, 1993).
3. https://root.cern.ch/guides/users-guide
4. https://geant4.web.cern.ch/support/user_documentation

Course Title: General Theory of Relativity			
Course Code	MSPHY4107E02	Credits	2
L + T + P	2 + 0 + 0	Contact Hours	30 (L) Hours

UNIT I

Equality of gravitational and intertial masses. Equivalence principle. Principle of general covariance.

(5 Lectures)

Unit II

Tensor Analysis : covariant and contravariant tensors. Tensors of arbitrary rank. Metric tensor. Parallel transport and covariant differentiation. Affine connection and its relation to metric tensor. Curvature tensor and its symmetries. Bianchi identities. Weyl tensor and conformal invariance.

(10 Lectures)

Unit III

Geodesics: Equation of motion of particles. Weak fields and Newtonian approximation. Time and distance in general theory, gravitational red and blue shifts, experimental verification, Einstein's field equation - Newtonian gravity as an approximation, Schwarzschild solution, Radial motion towards centre. Nature of singularities, black holes, even horizon, Kruskal co-ordinates.

(15 Lectures)

Unit IV

General orbits, constants of motion, deflection of light, precession of perihelion and radar echo. Standard, isotropic and harmonic coordinates. Parametrized post-Newtonian formalism and status of observational verification. Mach's principle.

(15 Lectures)

Unit V

Energy momentum tensor for a perfect fluid, equation of motion from field equation for equation for dust. Action principle for field equations. Conservation laws in curved space and pseudo energy tensor for gravitational field .

(15 Lectures)

References

1. Introducing Einstein's Relativity by Ray D'Inverno (Clarendon Press, 1992)
2. Principles of Gravitation and Cosmology, by M. Berry (Cambridge University Press, 1976)
3. Introduction to General Relativity & Cosmology, by Steven Weinberg (John Wiley & Sons, 1972)
4. The Classical Theory of Fields by L.D. Landau and E. M. Lifshitz (Pergamon, 1975)
5. Classical Fields: General Relativity and Gauge Theory by Moshe Carmeli (World Scientific, 2001)
6. General Theory of Relativity by P.A. M. Dirac (John Wiley, 1975)
7. Gravity, Black Holes and the Very Early universe: An Introduction to General Relativity and Cosmology by Tai L. Chow (Springer, 2008)

Course Title: High Energy Cosmic Ray			
Course Code	MSPHY4107E02	Credits	2
L + T + P	2 + 0 + 0	Contact Hours	30 (L) Hours

UNIT I

The Birth of Cosmic Ray: Stellar evolution, the pp chain, Supernova explosions, Supernova neutrinos, Supernova remnants, Acceleration of cosmic rays: stochastic acceleration of charged particles, particle acceleration at astrophysical shocks, acceleration with energy loss.

(10 Lectures)

UNIT II

Cosmic Ray Interaction : Strong, electromagnetic and weak interaction and weak interactions, Units of energy and interaction, Electromagnetic process in matter: Coulomb scattering, Ionization loss, Cherenkov light, Compton scattering, Bremsstrahlung, creation of electron-positron scattering, Synchrotron radiation, Inverse Compton effect, kinematics variables and invariant cross-section.

(10 Lectures)

UNIT III

Ultra High Energy Cosmic Ray (UHECR) : Cosmic microwave background, UHECR interactions on the microwave background, Propagation of UHE protons and nuclei, Possible astrophysical sources of UHECR, GZK cutoff, current status of the field, High energy neutrino and gamma-ray astronomy (review).

(10 Lectures)

References

1. High Energy Cosmic Rays , Todor stanev, Springer
2. Cosmic Rays and Particle Physics, By Thomas K. Gaisser, Cambridge University Press.
3. High Energy Radiation from Black Holes: Gamma Rays, Cosmic Rays, and Neutrinos, By Charles D. Dermer, Charles Dermer, Govind Menon, Princeton University Press.
4. Ultra-high Energy Particle Astrophysics, By Shigeru Yoshida, Nova Science Publishers, Inc. New York.

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Course Title: Dark Matter Physics			
Course Code	MSPHY4108E02	Credits	2
L + T + P	2 + 0 + 0	Contact Hours	30 (L) Hours

UNIT I

Dark Matter Evidences: Coma Cluster, Galaxy rotation curves, Halo models, Gravitational Lensing, Bullet Cluster, Massive, Astrophysical Compact Halo Objects (MACHOs), Cosmological: Cosmic Microwave Background Radiation, Big Bang Nucleosynthesis (BBN), Large scale structure formation, Baryon acoustic oscillation (BAO)

(10 Lectures)

UNIT II

Dark Matter candidates: WIMP miracle, sterile neutrinos, Axions, Supersymmetric candidates, Particles from extra dimensions, Wimpzillas, Primordial black holes, Searches for WIMPs: Direct detection of dark matter, Collider searches of dark matter Indirect detection of dark matter. Current experimental status (review).

(10 Lectures)

UNIT III

Direct detection of WIMP: Signal Rate of WIMP, Velocity Distribution, Correction: , Nuclear Form Factor, Detector response corrections, quenching factor, Spin-independent ('coherent') interactions, Spin-dependent interactions, Annual modulation.

(10 Lectures)

References

1. Dark Matter: An Introduction , Debasish Majumdar , CRC Press; 1 edition (2014)
2. Review of mathematics, numerical factors, and corrections for Dark Matter experiments based on elastic nuclear recoil. J. D. Lewin , P. F. Smith , Particle Physics Department, Rutherford Appleton Laboratory Chilton, Didcot, Oxon, OX11 0QX, UK (1996)
3. Particle Dark Matter: Observations, Models and Searches, edited by Gianfranco Bertone, Cambridge University Press.
4. Dark Matter: A Primer, Katherine Garrett and Gintaras Duda, (https://www.hindawi.com/journals/aa/2011/968283/).
5. Dark Matter, http://pdg.lbl.gov/2019/reviews/rpp2019-rev-dark-matter.pdf