Parvatibai Chowgule College of Arts & Science
(Autonomous)
Margao – Goa

MINUTES OF MEETING OF THE BOARD OF STUDIES IN PHYSICS HELD ON 11th June 2022 AT 11:00 am

Vide Chowgule College notice (F.133(C)/256 dated 3rd June, 2022) anonline meeting of this BoS was convened on 11rth June, 2022 at 11:00 am. Since the members present represented the Quorum, the BoS began its proceedings.

Minutes are presented in the format.

Members present:

1. Mrs. Malati Dessai (Chairman)
2. Dr. Ananya Das
3. Mr. Yatin P. Desai
4. Dr. Ashish M. Desai (Member Secretary)
5. Ms. Pearl Oliviera
6. Dr. Tarun Kumar Jha (Academic Council Nominee)
7. Dr. Bholanath Pahari (Academic Council Nominee)
8. Dr. Sudhir Cherukulappurath (Vice-Chancellor Nominee)

Members Absent:

1. Mr. Mangrish Salelkar (Industry Representative)
2. Mr. Harison Cota (Postgraduate Alumni)

Proceedings
The Chairperson welcomed the members of BoS and explained the agenda of the meeting. The board transacted the following business:
Agenda Items:

1. To approve syllabus of Generic Elective Courses (GEC) offered by the Department of Physics.
2. Any Other Business (A.O.B.)

PART A: Resolutions

1. The syllabus of the three new Generic Elective Courses were presented and discussed at the meeting. Following the titles of the GEC courses to be offered by the Department of Physics:

i. Elementary Physics
ii. Physics for Life Sciences
iii. Introduction to Astronomy

The syllabus of the General Elective courses approved by the members of BoS are presented in Annexure I. Also, the revised list of courses offered by the Department of Physics containing the approved General Elective coursesin presented in Annexure II.

2. Syllabi of theory and/or practical component of the following course were revised.
   i. Introduction to Astronomy and Astrophysics

   The revised syllabi approved by the members of BoS are presented in Annexure III.

3. Under A.O.B, the Academic Audit panel approved and passed by the BoS constitutes of the following members:
   i. Dr. Bholanath Pahari, UGC-Assistant Professor of Physics, School of Physical and Applied Sciences, Goa University.
   ii. Dr. Tarun Kumar Jha, Assistant Professor, Department of Physics, BITS Pilani. K. K. Birla Goa Campus.
   iii. Dr. Sudhir Cherukulappurath, UGC-Assistant Professor of Physics, School of Physical and Applied Sciences, Goa University.

4. All the above recommended changes may be implemented from academic year 2022-23 onwards.

PART B: Resolutions/Recommendations of BoS that require consideration / approval of Academic Council:

1. The syllabi of General Elective Courses presented in Annexure I.
2. The revised list of courses offered by the Department of Physics presented in Annexure II.
3. The syllabus of Introduction to Astronomy and Astrophysics presented in Annexure III.
4. The external members of the Academic Audit Panel approved by BoS Physics presented in Annexure IV.

The Chairman thanked the members of Board of Studies in Physics for their valuable contribution and active participation. The meeting ended at 12:20 pm.
The foregoing minutes of the meeting are circulated by the Chairman on 17th June 2022.

Dr. Ashish M. Desai
Member Secretary
BoS (Physics)
Date: 17th June 2022

Mrs. Malati Dessai
Chairman
BoS (Physics)

PART C: The remarks of the Dean of the Faculty:-

a. The minutes are in order

b. The minutes may be placed before the Academic Council with remark, if any.

c. Important points of the minutes which need clear policy decision of the Academic council to be recorded.

Date:

Signature of the Dean: _____
(Faculty of Science) (Dr. Meghana Devli)

Annexure I

Syllabi of the General Elective Courses

Course Title : Elementary Physics

Course Code : PHY-GEC-1

Marks : 75 (Theory) + 25 (Practical)

Credits : 3 (Theory) + 1 (Practical)

Course Objectives : To provide introduction to topics on Mechanics, Properties of Matter, Crystal Physics, Origin of Quantum Physics, Thermodynamics and Nuclear Physics which are essential allied learning components for most of the subjects of Physical, Chemical, and Earth Sciences.

Course Outcomes : At the end of this course, students will be able to:

CLO1: develop qualitative and quantitative understanding of Newtonian mechanics in one and two dimensions and solve the Newton equations for simple configurations.

CLO2: comprehend the phenomenon of elasticity, surface tension and their application.

CLO3: identify different types of crystal systems and determine structural parameters like unit cell of crystal lattices.

CLO4: derive and apply Bragg's law to determine crystal structure.

CLO5: discuss and interpret experiments that reveal the particle properties of waves and wavelike properties of matter.

CLO6: understand the uncertainty principle and its applications.

CLO7: understand different types of temperature scales and relationship between different scales of temperature.

CLO8: able to comprehend the first law of thermodynamics to represent the relationship between heat and mechanical work.

CLO9: able to comprehend the second law of thermodynamics to depict the manner in which thermodynamic changes take place.

CLO10: understand the basic properties of the nucleus and explain the process of radioactivity.

CLO11: gain knowledge on basic concept of nuclear force and Meson theory of nuclear force.

Theory:

Unit I: **[18 h]**

Elements of Newtonian Mechanics
Mechanics an exact science, Brief description of classical view of Space and Time. Kinematics, the description of motion. Dynamics, the concept of Mass and Force. Newton's First and Second Laws; Inertial frames. Equations of motion. Interpretation of Newton's third Law as Conservation of Momentum. Units and dimensions, Some elementary problems in Mechanics (Applications of Newton's Laws) - Atwood Machine, Forces acting on a brick sliding down an inclined plane.
[Symon 1.1,1.2,1.3,1.4,1.6,1.7, Taylor 1.1-1.7, Kleppner 2.4]

Properties of Matter
Elasticity: Hooke's Law, Types of Elasticity: Young's Modulus, Bulk Modulus and Modulus of rigidity. Poisson's ratio. Determination of Young's Modulus for a wire. Torsion in a string-couple per unit twist, Torsional Pendulum.
[Mathur: Section 8.8, 8.9, 8.12, 8.13, 8.14, 8.15, 8.16, 8.18, 8.19, 8.22, 8.26, 8.30]

Surface Tension: Brief review of molecular theory of surface tension. Relation between surface tension and surface energy. Angle of contact. Capillarity-rise of liquid in a capillary tube.
[Mathur: Section 14.1, 14.2, 14.3, 14.4 14.6, 14.8, 14.14, 14.15 and 14.17]

Crystal Physics and Crystal Diffraction
Introduction, Space Lattice, Unit cell, Lattice Parameter of unit cell, Bravais lattices, Crystal Stacking sequences in metallic crystal structure, SC, BCC, FCC and HCP structures. Introduction, Bragg's law, Bragg's X-ray Spectrometer.
[Pillai: 4.I – 4.VI, 4.XIV – 4.XV, 5.VII – 5.IX]

Unit II: **[18 h]**

Particle Properties of waves:
Concepts of Blackbody Radiation, The Photoelectric effect, Compton Effect.
[Beiser: 3.1,3.2, 3.5]

Wave Properties of Particles:
De Broglie's hypothesis. Davisson-Germer Experiment. Interference pattern of bullets, waves and electrons. Wave Particle duality. The Uncertainty principle and its application.
[Beiser 4.1-4.8, Feynman 1.1-1.8. Singh: 2.6, 3.1, 3.2, 3.5]

Principle of Thermometry
Review of concept of heat and temperature, Thermometry, Types of thermometers, Centigrade, Fahrenheit, Rankine Scales and relations between them, Platinum resistance thermometer, Thermocouple, Seebeck effect.
[Brij Lal: 13.1 – 13.5, 13.15, 13.17]

Laws of Thermodynamics:
Thermodynamic system, zeroth law of thermodynamics, concept of heat, Thermodynamic equilibrium, Concept of internal energy and external work done, First law of thermodynamics, reversible and irreversible processes, heat engine, Definition of efficiency, Carnot ideal heat engine, Carnot's cycle, Second law of thermodynamics.
[Brij Lal: 4.1-4.7, 4.20-4.24, 4.28]

Unit III: **[9 h]**

Nuclear Physics:

Basic Properties of the nucleus and nuclear model: Discovery of the nucleus, Composition of the nucleus. Particles of nuclei of atoms. Classification of nuclei. Nuclear size, Nuclear mass, Nuclear density, Nuclear spin. Nuclear magnetic dipole moment. Mass defect and packing fraction. Binding energy. Nuclear stability. Liquid drop model.
[Ilangovan: 1.3.1 – 1.8.3] [Eisberg: 15.5]

Radioactivity: Properties of radioactive rays, The law of radioactive Decay, Mean Life, Half-life and Decay Constant. Radioactive series, Artificial Radioactivity. Carbon dating.
[Patel: 2.2-2.3, 2.9, 2.11-2.13]

Nuclear forces: Main characteristics of the nuclear force. Meson theory of nuclear force, Estimation of mass of the meson using uncertainty principle, Yukawa potential.
[Patel: 8.6] [Ilangovan: 1.9]

Experiments: (Minimum Six)
1. Atwood Machine
2. Verification of Newton's Second Law using Air Track
3. Conservation of linear momentum using Air Track
4. Spring Mass System: Determining the Spring Constant
5. Simple Pendulum
6. Photoelectric effect.

7. Cantilever: Determination of Young's modulus by vertical vibrations of a cantilever.
8. Torsional Pendulum: Determination of Rigidity Modulus of the material of a wire.
9. Bending of beams: determination of Young's modulus
10. Capillarity: determination of Surface tension
11. Rigidity Modulus of Brass.
12. Constant volume air thermometer.
13. Calculation of lattice constant by of Copper – X-ray diffraction pattern is given and student calculates: d-spacing, miller indices and lattice constant.
14. X-ray Emission (characteristic lines of copper target)- Calculation of wavelength and Energy.
15. Tutorial on Basic properties of nucleus.
16. Tutorial on Radioactivity.

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1. Symon Keith, 2016, Mechanics, Pearson Education
2. Kleppner, Kolenkow, 2013, Introduction to Mechanics, Cambridge University Press, UK
3. Taylor J. R., 2005, *Classical Mechanics*, University Science Books, USA
4. Mathur D. S., 2010, *Elements of Properties of Matter*, S. Chand and Company, New Delhi.
5. Pillai S. O., 2018, *Solid State Physics*, 8th Multi Colour Edition, New Age International Publisher.
6. Beiser, A. 1969, *Perspectives of Modern Physics*, McGraw-Hill Book Company, Singapore.
7. Feynman, R. 2012, *Feynman Lectures on Physics: Quantum Mechanics (Volume - 3)*, Pearson Education, India.
8. Singh, K. And Singh, S. 2013, *Elements of Quantum Mechanics*, S. Chand, New Delhi.
9. Brij Lal, Subramanyam N., Hemne P.S. 2007, *Heat Thermodynamics and Statistical Physics*, S. Chand & Company Ltd., New Delhi
10. Ilangovan, K. 2012, *Nuclear Physics*, MJP Publishers, Chennai.
11. Patel, S. 2011, *Nuclear Physics: An Introduction*, 2nd Edition. New Age International Limited, New Delhi.
12. Eisberg, R. And Resnick, R. 2010, *Quantum Physics of Atoms, Molecules, Solids, Nuclei and particles*, 2nd Edition, Wiley India Pvt Ltd.

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1. Krane, K. 1987, *Introductory Nuclear Physics*, 3rd Edition. Wiley, New Jersey.

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1. https://ocw.mit.edu/courses/physics/8-01sc-classical-mechanics-fall-2016/
2. https://www.youtube.com/playlist?list=PL2ub1_oKCn7qTH_D11rqL-kAXfJv43J0-
3. https://hcverma.in/QuantumMechanics
4. http://www.zytemp.com/infrared/thermometry_history.asp
5. https://ocw.mit.edu/courses/chemistry/5-60-thermodynamics-kinetics-spring-2008/video-lectures/lecture-1-state-of-a-system-0th-law-equation-of-state/
6. https://ocw.mit.edu/courses/materials-science-and-engineering/3-091sc-introduction-to-solid-state-chemistry-fall-2010/
7. https://www.youtube.com/playlist?list=PLF15670EECA944A13

Course Title : Physics for Life Sciences

Course Code : PHY-GEC-2

Marks : 75 (Theory) + 25 (Practical)

Credits : 3 (Theory) + 1 (Practical)

Course Objectives : To provide introduction to topics on Thermodynamics, Properties of Matter, Waves and Sound, Ultrasonics, Electrostatics, Magnetostatics, Nuclear Physics and Optics which are essential allied learning components for most of the subjects of biological sciences.

Course Outcomes : At the end of this course, students will be able to:

CLO1: comprehend the first law of thermodynamics to represent the relationship between heat and mechanical work.

CLO2: comprehend the second law of thermodynamics to depict the manner in which thermodynamic changes take place.

CLO3:comprehend the phenomenon of surface tension, viscosity and their application.

CLO4: understand the dependence of velocity of sound waves on various factors like temperature, pressure, density and humidity.

CLO5: understand the production and detection techniques of ultrasonic waves and its applications.

CLO6: apply the principles of electrostatics to solve problems relating to electric field and electric potential.

CLO7: apply the principles of magnetostatics to solve problems relating to magnetic field.

CLO8:comprehend the basic phenomenon of radioactivity.

CLO9: understand the basics of optical instruments.

Theory:

Unit I: **[15 h]**

Thermodynamics

Thermodynamic system, Thermodynamic variables, Thermodynamic equilibrium, and Thermodynamic processes, Zeroth law of thermodynamics, Concept of work and internal energy, First law of thermodynamics, Isothermal and adiabatic changes, Work done in isothermal and adiabatic changes, Relation between pressure, volume and temperature in adiabatic process, Reversible and irreversible processes, Carnot Heat engine, Carnot cycle for perfect gas, efficiency, Second law of thermodynamics (Kelvin – Planck Statement, Clausius Statement).

[Brij Lal: 4.1, 4.4 – 4.7, 4.10.4, 4.11 - 4.13, 4.20 – 4.24, 4.28]

Properties of Matter

Surface Tension: Brief review of molecular theory of surface tension. Relation between surface tension and surface energy. Angle of contact. Capillarity-rise of liquid in a capillary tube. **[Mathur: Section 14.1, 14.2, 14.3, 14.4 14.6, 14.8, 14.14, 14.15 and 14.17]**

Viscosity: Streamline flow, turbulent flow, Critical velocity, Coefficient of viscosity, Poiseuille's formula for flow of liquid through a capillary tube.
[Mathur: Section 12.1 - 12.12 (12.8 upto equation b)]

Unit II: **[15 h]**

Waves and Sound

Transverse vibrations in strings. Velocity of longitudinal waves in gases. Newton's formula for velocity of sound. Velocity in a homogeneous medium. Laplace’s correction. Kundt’s tube-determination of velocity of sound in a gas and in solids. Intensity level and Bel and Decibel.
[Khanna 4.2, 5.3-5.5, 11.1, 11.3, 12.1-12.4, 19.6 and Subrah.: 11.23 11.25,11.27]

Ultrasonics

Production and detection of Ultrasonic waves. Magnetostriction method and piezo-electric generator method. Detection of velocity of ultrasonic waves. Detection and application os ultrasonic waves.
[Subrah: 11.23 11.25, 11.27]

Unit III: **[15 h]**

Electrostatics:

Electric charge, Coulomb’s law, Electric field, Lines of electric force, Electric potential, Electric potential due to a point charge, Relation between electric field and electric potential, Gauss’s law and its applications.
[H. C. Verma Vol. II: 29.1 – 29.8, 30.3, 30.4]

Magnetostatics:
Definition of magnetic field, Relation between electric and magnetic fields, Motion of a charged particle in a uniform magnetic field, Biot-Savart law, Magnetic field due to a current in a straight wire.
[H. C. Verma Vol. II: 34.2 – 34.4, 35.1, 35.2]

Radioactivity:
Properties of radioactive rays, The law of radioactive Decay, Mean Life, Half-life and Decay Constant. Radioactive series, Artificial Radioactivity. Carbon dating.
[Patel: 2.2-2.3, 2.9, 2.11-2.13]

Optics:
Laws of reflection and refraction. Size of an object, The simple magnifier, Objective andEyepiece. Huygens's eyepiece. Ramsden's eyepiece.
[Subrahmanyam N.: 1.5, 10.4,10.5,10.8,10.10,10.11]

Experiments: (Minimum Six)

1. Viscosity of a liquid by Poiseuille's method
2. Capillarity: determination of Surface tension
3. To determine the velocity of Sound using Helmholtz resonator
4. Velocity of Sound using CRO.
5. To determine the frequency of AC mains using Sonometer.
6. Experiment on reflection and refraction
7. Single Slit Diffraction using LASER source.
8. Newtons rings
9. Focal length of the lens system.
10. Crystal oscillator.

References:

1. Brij Lal, Subramanyam N., Hemne P.S. 2007, *Heat Thermodynamics and Statistical Physics*, S. Chand & Company Ltd., New Delhi
2. Mathur D. S., 2010, *Elements of Properties of Matter*, S. Chand and Company, New Delhi.
3. Khanna, D., Bedi, R. 1992, *A Textbook of Sound*, Atma Ram and sons, Delhi.
4. Patel, S. 2011, *Nuclear Physics: An Introduction*, 2nd Edition. New Age International Limited, New Delhi.
5. Verma, H. C. *Concepts of Physics-Part II*. Bharati Bhawan Publisher, Noida.

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1. https://ocw.mit.edu/courses/chemistry/5-60-thermodynamics-kinetics-spring-2008/video-lectures/lecture-1-state-of-a-system-0th-law-equation-of-state/

2. https://www.youtube.com/playlist?list=PL9jo2wQj1WCPHwLSQIPlMLASX07YVBkua
3. https://ocw.mit.edu/courses/physics/8-03sc-physics-iii-vibrations-and-waves-fall-2016/part-i-mechanical-vibrations-and-waves/
4. https://www.youtube.com/watch?v=NK-BxowMIfg&list=PLD07B2225BB40E582
5. https://www.youtube.com/playlist?list=PLF15670EECA944A13
6. http://www.ilectureonline.com/lectures/subject/PHYSICS/6/70

Course Title: Introduction to Astronomy

Course Code: PHY-GEC-3

Marks: 75 (Theory) + 25 (Practical)

Credits: 3 (Theory) + 1 (Practical)

Course Objectives: This is an introductory course with the goal of giving students insights into the field of astronomy.

Course Learning Outcomes: At the end of the course, students will be able:

CLO1: to locate objects in the sky using coordinate systems.

CLO2: to understand the working of various tools used to observe celestial bodies.

CLO3: to understand how different stellar parameters are measured

CLO4: to understand various techniques used by astronomers to determine distances to remote galaxies.

Theory:

UNIT I: INTRODUCING ASTRONOMY [15 h]

Chapter 1: Knowing the Heavens [9 h]

Introduction; The Age and Origin of the Solar System; Positional Astronomy; Constellations; Motions of the sky-Diurnal motion and Earth's rotation, Yearly motion and the Earth's orbit; The Celestial Sphere-Motions of the Celestial Sphere, the Origin of the Seasons, Motion of the Sun on the Celestial Sphere, Equinoxes and Solstices; Precession, Time and Timekeeping; Phases of the Moon; The Moon's Rotation- Synchronous rotation, Sidereal and synodic months; Eclipses and the lines of nodes; Lunar Eclipses; Solar Eclipses

[Freedman, R. A. & Kaufmann III: Chapter 1:1.2-1.4; Chapter 8:8.1-8.4; Chapter 2:2.1-2.7; Chapter 3:3.1-3.5]

Chapter 2: Gravitation and the Waltz of the Planets [6 h]

Geocentric models-the Greek Geocentric model, Ptolemaic system; Copernicus and Heliocentric models; Tycho Brahe's Observations; Kepler and the Orbits of Planets; Galileo and the Telescope- Phases of Venus, Moons of Jupiter; Newton's Law of Motion; Newton and Gravity

[Freedman, R. A. & Kaufmann III: Chapter 4: 4.1-4.7]

UNIT II: ASTRONOMICAL INSTRUMENTS [15 h]

Chapter 1: Nature of Light [5 h]

Blackbody Radiation; Wien's law and Stefan Boltzmann Law; Kirchoff's Laws; Spectral lines and the Bohr Model, Doppler Effect

[Freedman, R. A. & Kaufmann III: Chapter5: 5.3-5.4, 5.6, 5.8-5.9]

Chapter 2: Optics and Telescopes [10 h]

Refracting and Reflecting telescopes- Light gathering power, Magnification, Aberrations; Angular resolution – Limits to Angular resolution, Active and Adaptive Optics, Interferometry, Light Pollution; CCD; Spectrographs; Radio telescopes; Telescopes in Space.

[Freedman, R. A. & Kaufmann III: Chapter 6: 6.1-6.7]

UNIT III: STARS AND GALAXIES [15 h]

Chapter 1: Nature of Stars [8 h]

Thermonuclear Energy; Angular Sizes; Astronomical Distances; Stellar Distances and Parallax,; Apparent Brightness and Luminosity; The Magnitude Scale- Apparent and Absolute magnitude; Star Colors and Temperatures- UBV Photometry; Spectral Classes, Stellar Radii; The Hertzsprung-Russell Diagram- Main Sequence stars, Giants, Supergiants, White Dwarfs, Brown Dwarfs, Spectroscopic Parallax

[Freedman, R. A. & Kaufmann III: Chapter1: 1.5, 1.7; Chapter 16:16.1; Chapter 17: 17.1-17.8]

Chapter 2: Galaxies [7 h]

Distances to Galaxies; Classifying Galaxies- Spiral Galaxies, Elliptical Galaxies, Irregular Galaxies; The Distance Ladder- Standard Candles: Variable Stars and Type Ia Supernovae, Distance Determination without Standard Candles (Tully Fisher Relation), Hubble Law

[Freedman, R. A. & Kaufmann III: Chapter 24: 24.1-24.5]

Experiments: (Minimum six)

1. Resolving power of telescope.
2. Study of scattering of light (Diameter of Lycopodium powder).
3. To find radius of curvature of a convex lens using optical lever
4. Measurement of the solar constant.
5. Draw constellation map of a) Orion b) Auriga c) Taurus d) Ursa Major (Big Dipper) marking of pole star.
6. To determine the elements in sun using Frauhoffer spectra.
7. To estimate Astronomical Unit using Venus transit data by parallax method.
8. Determine the period of revolution of sun using virtual laboratory
9. To become familiar with the astronomical objects visible to naked eye in the night sky using the software Stellarium
10. To become familiar with the Constellations in the night sky using the software Stellarium
11. To identify the retrograde motion of Mars with respect to the Background stars using Stellarium
12. To identify some of the prominent spectral lines in the spectrum of our sun
13. To get familiar with the spectra of different stars using Stellarium
14. To extract coordinates of a star assuming a telescope in equatorial mount using Stellarium
15. To measure astronomical distances using Cepheid variables using Stellarium
16. To measure the Proper Motion of Barnard's Star using Stellarium
17. To identify a Circumpolar Star using Stellarium
18. To determine the distance and age of cluster using Colour Magnitude Diagram using Stellarium
19. To determine orbital inclination of the planet Mars using Stellarium
20. To measure planetary distances using Stellarium
21. To measure distance to Moon using Stellarium
22. To determine observer’s location by means of the stars using Stellarium

References:

1. Freedman, R. A. & Kaufmann III, W. J., 2008. *Universe*, Eighth Edition. New York: Clancy Marshall
2. Shu, F. H., 1982. *The Physical Universe An Introduction to Astronomy*. Sausalito, California: University Science Books.
3. Kutner, M. L., First published in 2003. *Astronomy A Physical Perspective*. Second ed. New York: Cambridge University Press.

Additional References:

1. Roy A.E., Clarke D., 1989, *Astronomy structure of the Universe*, Adam Hilger Pub.
2. Glasstone S., 1965, *Source book on the Space Sciences*, Van Nostrand Reinhold Inc., U.S
3. Narlikar J.V., 1976, *Structure of the Universe*, Oxford Paperbacks.
4. Sule, A., 2013. *A Problem Book in Astronomy and Astrophysics.* [Online]
5. Palen, S. E., 2002. *Schaum's Outline Series, Astronomy*. United States of America: McGraw Hill.

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2. https://youtu.be/vDv3iSMdYyc
3. https://youtu.be/Upy-jNpQW_0
4. https://youtu.be/nzmFc2gjUo4
5. https://youtu.be/0b7-4tfx3J4
6. https://ocw.mit.edu/courses/physics/8-282j-introduction-to-astronomy-spring-2006/
7. https://www.youtube.com/watch?v=nzmFc2gjUo4&list=PLA011BE74F1B54629

Annexure II

Revised list of courses

SEMESTER	CORE		ELECTIVE				
I	PHY-I.C-1 Introduction to Mathematical Physics	PHY-I.C-2 Mechanics-I	PHY-GEC-1 Elementary Physics	PHY-GEC-2 Physics for Life Sciences	PHY-GEC-3 Introduction to Astronomy	-------	-------
II	PHY-II.C-3 Heat and Thermodynamics	PHY-II.C-4 Electricity and Magnetism	PHY-GEC-1 Elementary Physics	PHY-GEC-2 Physics for Life Sciences	PHY-GEC-3 Introduction to Astronomy	-------	-------
III	PHY-III.C-5 Electromagnetic Theory-I	-------	PHY-E1 *Optics	PHY-E2 Modern Physics	PHY-E3 Oscillations, Waves and Sound	PHY-E17 Introduction to Astronomy and Astrophysics	PHY-SEC.1 Basics of Visualization and Scientific word processing.
IV	PHY-IV.C-6 Quantum Mechanics	-------	PHY-E5 *Electronics-I	PHY-E18 Introduction to Error Analysis	PHY-E4 Properties of Matter and Acoustics	PHY-E7 Computational Physics	PHY-SEC.2 Instrumentation
V	PHY-V.C-7 Electromagnetic Theory-II	-------	PHY-E9 *Solid State Physics	PHY-E10 Thermodynamics and Statistical Mechanics	PHY-E11 Electronics-II	PHY-E12 Mathematical Physics	PHY-E6 Solid State Devices
VI	PHY-VI.C-8 Atomic and Molecular Physics	-------	PHY-E13 *Mechanics II	PHY-E14 Nuclear and Elementary Particle Physics	PHY-E15 Introduction to Special Theory of Relativity	PHY-E16 Introduction to Material Science	

* BoS Physics recommendsthese elective courses to be taken by students as a prerequisite to the M.Sc. (Physics) Program.

Annexure III

Course Title: Introduction to Astronomy and Astrophysics

Course Code: PHY-E17

Marks: 75 (Theory) + 25 (Practical)

Credits: 3 (Theory) + 1 (Practical)

Prerequisites: Classical Mechanics, Optics, Modern Physics, Quantum Mechanics, Electromagnetic Theory - I

Course Objectives: The course aims to introduce the students to the Exciting World of Extragalactic Universe.

Course Learning Outcomes: At the end of the course, students will be able:

CLO1: Understand the various Extra-galactic objects.

CLO2: Understand the construction, working and mounting of modern telescopes.

CLO3: Understand co-ordinate system of Celestial Objects.

CLO4: Understand different spectral classes of stars, galaxies and the very early universe.

Theory:

UNIT I: FUNDAMENTALS OF ASTRONOMY [15 h]

1. The Celestial Sphere and Mechanics: [7 h]

The Greek tradition: The geocentric universe; The Copernican revolution: Bringing Order to the Planets; Positions on the Celestial Sphere: The Altitude- Azimuth Coordinate system, The Equatorial Coordinate System, Precession, Measurement of time

Elliptical orbits: Kepler's Laws of Planetary Motion, Geometry of Elliptical Motion

[**Carroll &Ostlie: Chapter 1: 1.1-1.3; Chapter 2: 2.1]**

2. Continuous Spectrum of Light [8 h]

Stellar Parallax; The Magnitude Scale: Apparent Magnitude, Flux, Luminosity and Inverse Square Law, Absolute Magnitude, Distance Modulus; Blackbody Radiation: Connection between color and temperature, Stefan Boltzmann Equation; Planck function and Astrophysics; Color Index: UBV Wavelength filters, Color indices and the Bolometric Correction, The Color-Color diagram;

Interaction of Light and Matter: Spectral lines, Kirchoff's laws, Applications of Stellar Spectra Data, Spectrographs

[**Carroll &Ostlie: Chapter 3: 3.1-3.2, 3.4-3.6; Chapter 5: 5.1]**

UNIT II: ASTRONOMICAL TOOLS, THE SOLAR SYSTEM AND THE NATURE OF STARS [15 h]

1. Astronomical Instruments: [4 h]

Optical telescopes: Refracting and reflecting telescopes, Telescope mounts, Large Aperture telescopes, Adaptive optics, Space based observatories, Electronic detectors; Radio telescopes: Spectral flux density, Improving resolution – Large apertures and Interferometry

[**Carroll &Ostlie: Chapter 6: 6.2-6.3]**

2. The Solar Sytem: [6 h]

Brief survey: General characteristics of the planets, Moons of the planets, Asteroid belt, Comets and Kuiper belt objects, Meteorites, Solar system formation – a brief overview; Tidal forces: Physics of tides, Effects of tides, Synchronous rotation, Additional tidal effects from the sun, Roche limit

[**Carroll &Ostlie: Chapter 19: 19.1-19.2]**

3. Classification of Stellar Spectra: [5 h]

Formation of spectral lines: Spectral types of stars, The Maxwell Boltzmann velocity distribution, The Boltzmann equation, Saha equation; The Hertzsprung Russell Diagram: An enormous range in stellar radii

[**Carroll &Ostlie: Chapter 8: 8.1-8.2]**

UNIT III: STAR FORMATION, GALAXIES AND THE UNIVERSE [15 h]

1. Star formation [6 h]

Formation of protostars- Jeans criterion; Pre-Main Sequence- Formation of Brown Dwarfs, The Zero Age Main Sequence (ZAMS); Evolution of the Main Sequence- Schönberg-Chandrsekhar limit; Late Stages of Stellar Evolution- Subgiant branch, Red Giant branch, Horizontal branch; Stellar Clusters- Globular and Galactic clusters

[**Carroll &Ostlie: Chapter 12: 12.2-12.3, Chapter 13: 13.1-13.3]**

2. The Milky Way and the Nature of Galaxies [5 h]

Morphology of the Milky Way Galaxy; Galactic Center; The Hubble Sequence: Classification of galaxies

[**Carroll &Ostlie: Chapter 24: 24.2, 24.4, Chapter 25: 25.1]**

3. The Early Universe [4 h]

Fundamental particles, Hot and Cold Dark matter, Planck's limits on time, mass and length, Unification and spontaneous symmetry breaking, Problems with the standard theory of the Big Bang, Inflation

[**Carroll &Ostlie: Chapter 30: 30.1]**

Experiments: (Minimum six)

1. Resolving power of telescope
2. Study of scattering of light (Diameter of Lycopodium powder)
3. To find radius of curvature of a convex lens using optical lever
4. Measurement of the solar constant
5. Draw constellation map of a) Orion b) Auriga c) Taurus d) Ursa Major (Big Dipper) marking of pole star.
6. To determine the elements in sun using Frauhoffer spectra
7. To estimate Astronomical Unit using Venus transit data by parallax method
8. Determine the period of revolution of sun using virtual laboratory
9. To become familiar with the astronomical objects visible to naked eye in the night sky using the software Stellarium
10. To become familiar with the Constellations in the night sky using the software Stellarium
11. To identify the retrograde motion of Mars with respect to the Background stars using Stellarium
12. To identify some of the prominent spectral lines in the spectrum of our sun
13. To get familiar with the spectra of different stars using Stellarium
14. To extract coordinates of a star assuming a telescope in equatorial mount using Stellarium
15. To measure astronomical distances using Cepheid variables using Stellarium

16. To measure the Proper Motion of Barnard's Star using Stellarium
17. To identify a Circumpolar Star using Stellarium
18. To determine the distance and age of cluster using Colour Magnitude Diagram using Stellarium
19. To determine orbital inclination of the planet Mars using Stellarium
20. To measure planetary distances using Stellarium
21. To measure distance to Moon using Stellarium
22. To determine observer's location by means of the stars using Stellarium

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6. Kutner, M. L., First published in 2003. *Astronomy A Physical Perspective*. Second ed. New York: Cambridge University Press.
7. Carroll, B. W. &Ostlie, D. A., n.d. *An Introduction to Modern Astrophysics*. Second ed. San Francisco: Addison Wesley.

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7. Glasstone S., 1965, *Source book on the Space Sciences*, Van Nostrand Reinhold Inc., U.S
8. Bhatia V. B., 2001, *Textbook of Astronomy and Astrophysics* with Elements of Cosmology, Narosa Publishers, New Delhi.
9. Narlikar J.V., 1976, *Structure of the Universe*, Oxford Paperbacks.
10. Badyanath and Basu, 2010, *An Introduction to Astrophysics*, 2nd Edition, Prentice Hall India Learning Private Limited
11. Abhyankar K.D., 2001, *Astrophysics - Stars and Galaxies*, Tata McGraw Hill, New Delhi
12. Sule, A., 2013. *A Problem Book in Astronomy and Astrophysics.* [Online]
13. Palen, S. E., 2002. *Schaum's Outline Series, Astronomy*. United States of America: McGraw Hill.

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5. https://youtu.be/0b7-4tfx3J4
6. https://ocw.mit.edu/courses/physics/8-282j-introduction-to-astronomy-spring-2006/
7. https://ocw.mit.edu/courses/physics/8-901-astrophysics-i-spring-2006/
8. https://ocw.mit.edu/courses/physics/8-902-astrophysics-ii-fall-2004/

Annexure IV

The Academic Audit panel approved and passed by the BoS constitutes of the following members:

1. Dr. Bholanath Pahari, UGC-Assistant Professor of Physics, School of Physical and Applied Sciences, Goa University.

2. Dr. Tarun Kumar Jha, Assistant Professor, Department of Physics, BITS Pilani. K. K. Birla Goa Campus.

3. Dr. Sudhir Cherukulappurath, UGC-Assistant Professor of Physics, School of Physical and Applied Sciences, Goa University.