Structure of ARIES PhD coursework (Total Credit 40)

Lectures - L ; Tutorials -T; Practical – P (hours per week); Credit -1 is atleast 14 hrs

TERM – 1		**L**	**T**	**P**	**Credit**
APC 101	Basic Astronomy	3	1	0	4
APC 102	Mathematical and Statistical Methods	1	1	0	2
APC 103	Electrodynamics and Radiative processes in Astrophysics	2	1	0	3
APC 104	Introduction to Atmospheric Sciences	2	1	0	3
APC 105	Astrophysical Fluid Mechanics	3	1	0	4
	Total	**11**	**5**	**0**	**16**
TERM – 2					
APC 201	Formation, Evolution and atmosphere of stars	1	1	0	2
APC 202	Observational Technique and Methodology – (Optical, IR, Radio, X-ray, Gamma ray)	1	1	0	2
APC 203	Interstellar medium and Stellar Variability	1	1	0	2
E-204/205/206	General Theory of Relativity and Cosmology, / OR Atmospheric Trace Gases and Aerosol, / OR Solar Physics	2	1	0	3
	Total	**5**	**4**	**0**	**9**
TERM – 3	**Research Methodology, Applied Physics & Project**				
Module	**Unit title**	**Teaching hours**			
RPE	**Research and Publication Ethics**	**Credit 2** (30 hours)			
Theory					
RPE01	Philosophy and Ethics	3 (hours)			
RPE02	Scientific Conduct	5 (hours)			
RPE03	Publication Ethics	7 (hours)			
Practice					
RPE04	Open Access Publishing	4 (hours)			
RPE05	Publication Misconduct	4 (hours)			
RPE06	Databases and Research Metrics	7 (hours)			
APC 302	Applied Physics	**Credit 3** (42hours)			

APC PROJ	Credit Reseach	Credit report & literature survey	Credit defence bia seminar	**Credit**
	4	4	2	**10**

Pre-Ph.D. Course work
ARIES, Manora Peak, Nainital

First Term Syllabus

2022-23

APC 101	**Basic Astronomy (Lectures - 38 hrs; 3 credit)**

Coordinate System: (8 hrs)

- Astronomical observations: electromagnetic waves, cosmic rays, gravitational radiation; earth vs. space based observations
- Spherical Trigonometry, Celestial sphere, Equatorial and Ecliptic systems, Coordinate systems
- Astronomical Times - Sidereal time, Solar time, Hour angle, Julian date, Astronomical twilight
- Distance measurements: AU, parsec, standard candles, distance measurement by geometric means (parallax, distances to open clusters)
- Stellar Motions, Planetary motions, Parallax, Precession and Nutation, Astronomical Constants
- Apparent, Absolute and Bolometric magnitudes, Extinction and Optical thickness, Color-index and luminosity of stars
- Distances of Stars, Stellar positions, Proper motion, Occultations and Eclipses,

Fundamentals of radiation and Sun as a star: (5 hrs)

• Radiation: geometric optics, specific intensity, luminosity/flux, radiative transfer equation, extinction and emission of light, opacity, opticallly thick/thin media, black body radiation, local thermal equilibrium between matter and radiation and its connection with black body radiation

• Sun as a star (qualitative): Solar spectrum, effective temperature, luminosity, photospheric absorption lines, limb darkening; energy source: Kelvin time scale, nuclear fusion; energy transport in the sun, Thomson scattering, mean free path, photon diffusion inside the Sun; photosphere, chromosphere, transition region, corona; X-ray emission, magnetic fields, Sunspots

Stars: (7 hrs)

- Velocity dispersion, Stellar temperatures, Spectral Classification of stars, HR diagram.

- Stellar evolution, end product of stars: White dwarfs, Neutron Stars, Black holes. Observational signatures like supernovae, GRBs and classification of such events. Basics of accretion phenomena, its efficiency, continuum spectra
- Binary star evolution, effective potential in rotating frame, Lagrange points, Roche lobe,
- Mass overflow, Type Ia supernovae

Galaxies: (8 hrs)

- Galaxy morphology, Galactic dynamics, Spiral structure, Density wave theory, galaxies classification schemes, Morphology and properties of different class of galaxies.
- Galaxy luminosity functions. Stellar relaxation, Dynamical friction, Random velocity and random curves, Tully Fischer Relation, Galaxy rotation curve and dark matter;
- Milky Way components: gas, stars, magnetic field and cosmic rays, satellites, 21cm line, HII regions, phases and components of interstellar medium, cosmic rays
- Active galactic nuclei (AGN) and classifications, Quasars emission and absorption line physics. AGN emission model, AGN surveys.
- Cluster of galaxies and super clusters.

Special and General relativity (10 hrs)

- Salient features of Special Relativity; Postulates, obtaining the Lorentz transformation from the postulates, space time diagram and consequences of special relativity. EM theory, hydrodynamics in STR.
- Basics of Newtonian mechanics and gravity.
- General Theory of Relativity - Principle of Equivalence; Principle of general covariance.
- General Tensors; Maxwell's Equations in curved space-time; Ideal fluids: Equations of motion
- Einstein field equations; Schwarzschild line elements and its consequences

Suggested Readings:

1. Fundamental Astronomy: Karttunnen, Kroger, Oja, Poutanen, Donner (Springer press)
2. The Physical Universe: an Introduction to Astronomy by Frank H. Shu (Univ. Sci. Books)
3. An Introduction to Modern Astrophysics: B. W. Carrol & D. A. Ostlie
4. Astrophysical Concepts: M. Harwit
5. Spherical Astronomy: W. M. Smart
6. An Introduction to Active Galactic Nuclei: B. M. Peterson (Cam. Univ. Press)
7. Quasars and Active Galactic Nuclei: Ajit Kembhavi, J. V. Narlikar (Cam. Univ. Press)

APC 102	**Mathematical and Statistical Methods (Lectures 20 hrs 1 credit)**

Errors Analysis and uncertainties Statistical distributions Probability distributions, statistics and expectations, Statistical description of data, Moments of a distribution, Mean, Variance, correlatoin, Random numbers. **(5 hrs)**

Interpolation and extrapolation, Method of least squares, Testing the fit, Curve of growth, Linear and non-linear models, Marquardt method, Errors in estimated parameters, Robust estimation, Random processes in Astrophysics. **(6hrs)**

Monte Carlo Techniques, Fourier Analysis, periodogram analysis, wavelet analysis, Bayesian analysis and Basic programming **(9 hrs)**

Suggested Readings:

1. Practical statistics for Astronomers: J. V. Wall and C. R. Jenkins
2. Numerical Recipes-the art of scientific computing: W. H. Press et al.
3. Data reduction and Error analysis for the Physical Sciences: P. R. Bevington and D. K. Robinson
4. Astrophysical Concepts: Martin Harwit
5. Computer Programming in FORTRAN 90/95: V. Rajaraman

APC 103	**Electrodynamics and Radiative Processes in Astrophysics (Lectures 28 hrs; 2 credit)**

Radiation Transfer- Radiative flux, specific intensity and equation of radiative transfer, solution to the equation of radiative transfer.
Thermal radiation, characteristic temperatures related to the Planck spectrum, Einstein coefficients. **(5 hrs)**

Radiation fields- Maxwell's equations, polarization and stokes parameters.
Electromagnetic potentials, radiation from moving charges, The Lienard-Wiechart potentials.
Velocity and radiation fields, radiation from non-relativistic systems of particles, Larmor's formula, dipole approximation. **(6 hrs)**

Relativistic Effects- Lorentz transformations, emission from relativistic particles, relativistic Larmor's formula. **(3 hrs)**
Bremsstrahlung- Bremsstrahlung radiation from a single speed electron, thermal bremsstrahlung emission and absorption. **(2 hrs)**
Synchrotron radiation- total emitted power, spectrum of synchrotron radiation, spectral index for power law distribution of electrons, transition from cyclotron to synchrotron radiation, synchrotron self-absorption. **(6 hrs)**
Compton scattering- Energy transfer from electrons at rest; Inverse Compton scattering; Scattered power and spectrum; Inverse Compton loss time scale; Comptonization; Basics of Sunyaev-Zeldovich effect; maximum brightness temperature **(6 hrs)**

Suggested Readings:

1. Radiative Processes in Astrophysics: Rybicki & Lightman
2. Radiation: F. Shu
3. Electrodynamics: Jackson

APC 104	Introduction to Atmospheric Sciences (Lecture 31 hrs; 2 credit)

Atmospheric science and classifications- Components of meteorology and climatology, Composition of the Earth's atmosphere, Thermal structure of the Atmosphere, Introduction to Ionosphere, Atmospheric boundary layer and mountain meteorology. **(4 hrs)**

Observational techniques of meteorological parameter: Instruments for meteorological observations, Balloon soundings (RS/RW, pilot balloon etc.) **(3 hrs)**

Atmospheric Thermodynamics- Hydrostatic equation, Hypsometric equation, Concept of parcel-Potential temperature, virtual potential temperature, Lapse rate, Static stability **(3 hrs)**

Radiative transfer- Solar and terrestrial radiation, Absorption, emission, transmission, Beer's law, surface radiation budget, effective temperature of earth, Greenhouse effect. **(3 hrs)**

Meteorological processes and weather systems- Winds and air-mass trajectories, General circulation model, sea breeze, land breeze, clouds, fogs/smog, precipitation, fronts, cyclones and anticyclones, tropical cyclones, thunderstorms, monsoon. **(3 hrs)**

Dynamic meteorology- Fundamental forces, Basic conservation laws, Applications of the basic equations, Scale analysis, Circulations and vorticity, Synoptic scale motions, Quasi geostrophic analysis. **(4 hrs)**

Atmospheric oscillations- Baroclinicity, barotropicity and instability, Mesoscale circulations, El-Nino, La-Nina, ENSO, Polar vortex, Inter tropical convergence zone (ITCZ), Rossby waves **(3 hrs)**

Radar principle- Classical radar equation and return signal, distributed targets, Doppler velocity measurements, Signal processing and detection, Application of radars to study atmospheric phenomenon, Lidar and its applications. Estimations of radiative forcing, Lidar equation, types of Lidar, Applications of Lidar. **(4 hrs)**

Introduction to Trace Gases and Stratospheric Processes (4 hours): Stratospheric ozone, Production and Loss processes of stratospheric ozone, Ozone loss and

Production at the North pole and South Pole, Polar Stratospheric Clouds, Changes in CFCs, HCFCs, HFCs

Suggested Readings:

1. Aeronomy of the middle atmosphere: G. Brasseur and S. Solomon
2. Atmospheric chemistry and climate change: Brasseur et al.
3. Meteorology for Scientist and Engineers: R. Stull
4. Atmospheric Science: J. M. Wallace and P. V. Hobbs
5. An introduction to dynamic meteorology: J. R. Holton
6. Meteorology for Scientist and Engineers: R. Stull
7. Tropical meteorology: G. C. Asnani (Vol I, II, III)
8. Introduction to radar systems: Skolnik
9. Radar Meteorology: S. Raghvan
10. Radar for Meteorologist: R. E. Rinehart

APC 105	**Astrophysical Fluid mechanics (Lectures 43 hrs; 3 credit)**

Hydrodynamics (HD):

- Equations of motion of fluid - Euler and Navier Stokes equations, basic discussion; **(1 hr)**
- Kinetic Theory approach to obtain the equations of motion (Boltzmann equations to HD equations); **(2 hrs)**
- Acoustic waves, shock waves; **(2 hrs)**
- Kelvin's circulation theorem, laminar flow, turbulent boundary layers **(2 hrs)**
- Fluid instabilities Convective, rotational, Rayleigh Taylor; gravitational, and Kelvin-Helmholtz Instabilities; **(3 hrs)**
- Convection

  Thermal diffusivity and its effect on the entropy equation. Conductive and convective transport of heat equation. Mixing length theory and transport of heat, application to plane-parallel atmospheres and stars. **(2 hrs)**
- Bernoulli's theorem; deLaval Nozzle; Bondi Flow, Parker wind; **(2 hrs)**

- Jean’s mass- self gravitating spherical masses; Application of hydrostatics: Virial theorem **(2 hrs)**
- Accretion discs: example (i) Transonic accretion discs – Eq. Of motion, method to solve, solutions (ii) Sakura-Sunyaev disc - equations of motion and continuum spectra **(2 hrs)**
- Method of characteristics and Riemann Problem, building blocks of CFD **(3 hrs)**

Magneto Hydrodynamics (MHD):

- Plasma Orbit theory, motion of charged particles in EM field, Drift currents, guiding centre approach. Magnetic mirror, curvature drifts, Landau damping, plasma oscillation, **(3 hrs)**
- Basic Kinetic equation of collisionless plasma, Kinetic theory eqs to Vlassov Equations, Two fluids and its applications. **(3 hrs)**
- MHD Equations from two fluid equations, flux freezing, MHD waves e.g., slow, fast and Alfven waves. **(3 hrs)**
- Magnetostatics and Parker instability, Magnetic virial theorem. **(3 hrs)**
- Weber Davis model of Solar wind; **(3 hrs)**
- Hydromagnetic shocks: jump conditions. Rotational discontinuities. **(3 hrs)**
- Magnetic reconnection, basics of dynamo**(4 hrs)**

Suggested Readings:

1. Gas Dynamics: F. H. Shu
2. The Physics of Fluids and plasma: A. Rai Choudhuri
3. Fluid Mechanics: Landau and Liftshitz
4. Physics of fully Ionized Gases: L. Spitzer Jr.
5. Solar Magneto-hydrodynamic Priest

Second Term Syllabus

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2022-23

APC 201	Formation, Evolution and atmosphere of stars (Lectures 16 hrs; Credit 1)

- Molecular clouds, fragmentation and collapse, Isothermal sphere and Jeans criteria, Rotating configuration, Collapse of Dense Cores **(2 hrs)**
- Hydrostatic equilibrium, Thermal equilibrium, Virial theorem, stellar structure, Mass-luminosity relation **(2 hrs)**
- Opacities, Convective zones, Convective instability, Energy transport, Lithium problem, Energy generation in stars. Radiative equilibrium **(2 hrs)**
- Evolution of stars, Thermal and non-thermal distributions, Spectral energy distributions, Continuum, Emission and absorption spectra, Chandrasekhar limit **(3 hrs)**
- Model atmospheres, Eddington-Milne approximation, Chandrasekhar solution model atmospheres, Equation of state, Saha's ionization equation, Local thermodynamic equilibrium models, Convective equilibrium, Non-LTE models, Spectral line analysis, Chemical composition, Mass-loss/transfer **(4 hrs)**
- Atomic structure: Selection rules, Milne relation for recombination coefficients; Line broadening, Doppler broadening, natural broadening, collisional broadening and Voigt profile; curve of growth **(1 hr)**
- Stellar winds, Circumstellar envelopes. **(1 hr)**
- Atmosphere of Sun and sunlike stars. **(1 hr)**

Suggested Readings:

1. An Introduction to the Study of Stellar Structure: S. Chandrasekhar; Dover Pub, 1967
2. Principles of Stellar Evolution and Nucleosynthesis, by D. D. Clayton: University of Chicago Press, 1983
3. Stellar Structure and Evolution: Kippenhahn and Weigert
4. Stellar Atmospheres, 2nd ed.: W.H. Freeman, 2006.
5. Gray, D., Observation and Analysis of Stellar Photosphere, 3rd ed.,:Cam. Univ. Press, 2005

APC 202	**Observational Technique and Methodology – (Optical, IR, Radio, X-ray, Gamma ray) (Lectures 16 hours ; credit 1)**

- Telescopes and their properties **(1 hr)**
- Adaptive/Active Optics and Interferometry, Optical detectors **(1 hr)**
- Concept of Photometry, Spectroscopy and Polarimetry, Interstellar absorption law, Photometric measurements, Effects of bandwidth, Relationship between color indices and gradients, Balmer discontinuity, Q parameter of UBV system, Intermediate and narrow band photometry **(4 hrs)**
- Astronomical spectrograph, Wavelength resolution, Prism, Gratings, Slit spectrograph, Stability of spectrograph, Image slicer, Comparison spectra, Calibration spectra. **(3 hrs)**
- Radio signals and their emission mechanisms, Astronomical radio telescopes, Single dish aperture, Interferometry, Aperture synthesis Detection, Correlators, Calibration, Polarization measurement, Radio observations - continuum, HI 21cm-line, molecular lines **(3hrs)**
- X-ray & Gamma-ray observational techniques **(2 hrs)**
- **Hands on session on data reduction techniques (2 hrs; TAs can be included).**

Suggested Readings:

1. Handbook of CCD Astronomy: S. B. Howell
2. Astrophysical Techniques: C. R. Kitchin
3. Telescopes and Techniques: C. R. Kitchin
4. Astronomy Method: Hale Bradt
5. Astronomical Polarimetry: Jaap Tinbergen
6. Observational Astrophysics: Pierre Lena
7. Astronomical Photometry: M. Golay
8. X-ray Astronomy: R. Giacconi
9. Frontiers of X-ray Astronomy edited: A. C. Fabian et al.
10. X-ray Detectors in Astronomy: G. W. Fraser

APC 203	Interstellar medium and Stellar Variability (Lectures 18 hours; credit 1)

- Interstellar medium (ISM), Galactic gas and its detection, Phases of the interstellar medium **(2 hrs)**
- Interstellar dust: Extinction and thermal emission, properties of Grains **(2 hrs)**
- young stellar systems **(1 hr)**
- effect of massive stars, H II regions, induced star formation **(2 hrs)**
- Local and large scale distribution of stars and interstellar matter, Diffuse Matter, Inter galactic Medium(IGM), Diffuse matter in Universe **(2 hrs)**
- Stellar populations, Stellar variability **(1 hr)**
- Classification of variable stars, Binary stars, Transiting exoplanets, Stellar pulsation **(2 hrs)**
- Pulsating variables, Kappa mechanism, Period-luminosity relationship **(1 hr)**
- Characteristics of Cepheids, RR Lyrae stars, Delta-Scuti, Gamma-Doradus, Hybrid stars, Ap, Am and roAp stars, Mira variables **(1 hr)**
- Solar-like oscillations, White dwarf variability, Supernovae **(1 hr)**
- Variable stars as distance indicators, PMS variables, T Tauri stars, Be stars, RCB stars, Eruptive variables-Flare stars, Wolf-Rayet stars **(1 hr)**
- Inter-night and Intra-night variability, Asteroseismology **(2 hrs)**

Suggested Readings:

1. Fundamental Astronomy: Karttunnen, Kroger, Oja, Poutanen, Donner; Springer press
2. Challenges in Stellar Pulsation: L. A. Balona; Bentham Publishers
3. Understanding of variable stars: John R. Percy
4. Physical Processes in the Interstellar Medium: Lyman Spitzer Jr.
5. The Physics of the Interstellar Medium: J. E. Dyson, D. A. Williams
6. The Interstellar Medium: James Lequeux, Edith Falgarone, Ch Ryter
7. Star formation: Stahler and Palla
8. An introduction to Star formation: Derek Ward-Thomson and Anthony P. Whitworth

E 204	**Special & General Theory of Relativity and introduction to Cosmology (Lectures 32 hours; 2 credits)** **Elective**

- Basics of Newtonian mechanics and gravity, General Theory of Relativity - Principle of Equivalence; Principle of general covariance **(2 hrs)**
- General Tensors; Maxwell's Equations in curved space-time; Ideal fluids: Equations of motion **(4 hrs)**
- Einstein field equations; Schwarzschild line elements and its consequences **(4 hrs)**
- Stellar structure of relativistic stars, gravitational collapse. Neutron Stars, blackholes **(4 hrs)**
- Kerr metric and its consequences **(3 hrs)**
- Relativistic Accretion discs. Some of the outflow models **(4 hrs)**
- The basic framework of relativistic cosmology: FRW metric, Cosmological redshift, Hubble constant, Friedmann models; thermal history of the universe; phase space distribution function; thermodynamics in early universe, CMBR **(11 hrs)**

Suggested Readings:

1. Gravitation and Cosmology: Weinberg
2. Problem book on relativity and gravitation: Priest et. Al.
3. Classical theory of Field: Landau and Lifshitz
4. A first course in general theory of relativity – Bernard Schutz
5. Classical Mechanics: H. Goldstein
6. Structure formation in the Universe: T. Padmanabhan
7. Cosmological Physics: J. A. Peacock
8. Introduction to Cosmology: J. V. Narlikar
9. Principle of Physical Cosmology: P. J. E. Peebles

E 205	**Atmospheric Trace Gases and Aerosol (Lectures 29 hours; 2 credits)** **Elective**

- **Introduction to Trace Gases and Stratospheric Processes (4 hours):** Stratospheric ozone, Production and Loss processes of stratospheric ozone, Ozone loss and Production at the North pole and South Pole, Polar Stratospheric Clouds, Changes in CFCs, HCFCs, HFCs
- **Trace Gases in the Troposphere (6 hours):** Tropospheric Ozone, Oxidizing power of the troposphere, Role of different trace gases (including ozone precursor gases) and their Budget, Production and loss processes of tropospheric ozone, Greenhouse gases, Role of Meteorology and Dynamics in Trace Gases Evolution, Different motion of air-masses, Transport of pollutants, Back-air trajectory and its modelling, Role of the boundary layer dynamics,
- **Chemical Kinetic (2 hours):** Rate expression for gas phase reactions, Photolysis rate, Lifetime, Role of meteorology in reaction rates (stratosphere and troposphere)
- **Observational Techniques and Modelling (5 hours):** Surface-Balloon-Satellite based observational techniques, Classification of satellite orbits (Geostationary and Polar) and payload planning, different space-borne sensors and their application/data analysis, Box model, Regional and Global models,
- **Introduction to Aerosols (3 hours):** Classification and properties of aerosols, Production and removal mechanisms, Concentrations and size distribution, Radiative and health effects, Secondary Organic Aerosols
- **Observational Techniques (3 hours):** Physical and optical methods, Techniques for the chemical analysis of aerosols,
- **Radiations (3 hours):** Absorption and scattering of solar radiation, Rayleigh scattering and Mie scattering Bouguert-Lambert law, Principles of radiometry, Optical phenomena in atmosphere Modeling for aerosols
- **Air Pollutants and Climate Change Impact (3 hours):** Sources of various anthropogenic emissions, forest fire and biomass burning, impact of emissions in

tropospheric chemistry, long-term changes in trace gases and aerosols, impact on human health and vegetation

Suggested Readings:
1. Atmospheric chemistry and climate change: Brasseur et. al.
2. Atmospheric Science: J. M. Wallace and P. V. Hobbs
3. Fundamental of Atmospheric Modeling: M. Z. Jacobson
4. Atmospheric chemistry and climate change: Brasseur et al.
5. Introduction to Atmospheric Chemistry: D. J. Jacob

E 206	**Solar Physics (Lectures 32; Credit 2)** **Elective**

- **Solar interior** : Core, radiative zone, convection zone (2 hrs)
- **Energy Generation inside Sun**: PP Chain , CNO cycle, Solar neutrino problem (2 hrs)
- **Amplification of magnetic field inside Sun**: Anti-dynamo theorems, Solar dynamo, mean field dynamo, Parker's dynamo wave solution (4 hrs)
- **Solar atmosphere**: Photosphere, Chromosphere, Transition region, and Corona. Multiwavelength view of solar atmosphere (3 hrs)
- **Features in the solar photosphere**: Granulation, super-granulation pattern, magneto-convection, magnetic buoyancy, formation, evolution and disappearance of sunspots, sunspot cycle, solar cycle (4 hrs)
- **Features in Chromosphere**: Filaments, prominences, fibrils, mottles, RBEs, RREs, Plages, long term evolution of these structures (4 hrs)
- **Features in the corona**: coronal loops, coronal holes, bright points, their properties and evolution (3 hrs)
- **Solar wind**: Parker's solution for thermal winds, Observations of solar wind, solar wind speed anisotropy (3 hrs)
- **MHD waves and magnetic reconnection**: Application in the solar atmosphere, coronal heating, acceleration of the solar wind (3 hrs)
- **Sun and space weather**: Solar flares, coronal mass ejections, interplanetary coronal mass ejections, Geomagnetic disturbances, DST index and auroras (4 hrs)

Suggested Readings:
1. The Sun: An Introduction by M. Stix
2. Magnetohydrodynamics of the Sun by Eric Priest
3. Physics of the Solar Corona by M.J Aschwanden
4. Physics of Plasmas and Fluids by A. R. Choudhuri

Third Term

RPE	Research and Publication Ethics

Theory:

- **RPE 01: Philopsophy and Ethics (3hrs)**
  (1) Introduction to philosophy: definition, nature and scope, concept, branches
  (2) Ethics: definition, moral philosophy, natureof moral judgements and reactions
- **RPE 02: Scientific Conduct (5hrs)**
  (1) Ethics with respect to science and research Publication
  (2) Intellectual honesty and science integrity
  (3) Scientific misconducts: Falsification, Fabrication and Plagiarism (FFP)
  (4) Redundant publications: dulicate and overlapping publications, salami slicing
  (5) Selective reporting and misrepresantation of data
- **RPE 03: Publication Ethics (7hrs)**
  (1) Publication Ethics: definition, introduction and importance
  (2) Best practices/standards setting initiatives and guidelines: COPE, WAME etc
  (3) Conflicts of interest
  (4) Publication misconduct: definitions, concept, problems that lead to unethical behavoiur and vice versa, types
  (5) Violation of publicatins ethics, authorship and contributorship
  (6) Identification of publication misconduct, complaints and appeals
  (7) Predatory publishers and journals
- **RPE 04: Open access publishing (4 hrs)**
  (1) Open access publications and initiatives
  (2) SHERPA/RoMEO online resource to check publisher copyright and self archiving policies
  (3) Software tools to identify predatory publications developed by SPPU
  (4) Journal finder/journal siggestion tools viz. JANE, Elsevier Journal Finder, Springer Journal Suggester etc
- **RPE 05: Publication misconduct (4 hrs)**
  A. Group Discussion (2 hrs)
  1. Subject specific ethical issues, FFP, authorship
  2. Conflicts of interest
  3. Complaints and appeals: examples and fraud in India and abroad

  B. Software tools (2hrs)
  Use of plagiarism software like Turnitin, Urkund and other open source software tools
- **RPE 06: DATABASES and Research metric**
  A. Databases (4hrs)
  1. Indexing data bases
  2. Citation databases: Web of Science, Scopus etc

B. Research Metricc (3hrs)

1. Impact factor of journals as per Journal Citation Report, SNIP, SJR, IPP, Cite Score
2. Metrics: h-index, g index, i 10 index, altmetrics

References:

1. Bird, A., (2006), Philosophy of Science, Routledge
2. MacIntyre, Alasdair, (1967) A Short History of Ethics, London
3. P. Chaddah, (2018) Ethics in Competitive Research: Do not get scooped, do not get plagiarized, ISBN: 978-9387480865
4. National Academy of Sciences, National Academy of Engineering and Institute of Medicine, On Being a Scientist: A guide to responsible conduct in research: Third Edition. National Academies Press
5. Resnik D. B. (2011), What is ethics in research & why is it important. National Institute of Environmental Health Sciences, Retrieved from https://www.niehs.nih.gov/research/resources/bioethics//whatis/index.cfm
6. Bcal J. (2012), Predatory publishers are corrupting open access. Nature, 489(7415), 179-179. https://doi.org/10.1038/489179a
7. Indian National Science Academy (INSA), Ethics in Science Education, Research and Governance (2019), ISBN: 978-81-939482-1-7. http://www.insaindia.res.in/pdf/Ethics_Book.pdf

APC 302	**Review of applied physics**	**(Lectures 42, Credit 3)**

- Introduction to Naonomaterials, discussion between materials and molecules, nanoparticles and bulk according to the number of atoms in cluster, magic numbers, length scale
- Surface effect and physical properties of naonmaterials, quantum confinement of materials, low dimensional nanomaterials (two dimensional, one dimensional and zero dimensional nanomaterials), density of states bulk 2D, 1D and 0D
- Basic interactions existing in nature, classification of elementary particles, basic properties, important modes of interactions and decay modes of leptons, mesons, baryons conservation laws governing elementary particle interaction, parity, isospin, hypercharge, strangeness, invariance under CPT, basics understanding of quark physics
- Basics of nuclear emulsion technique, nuclear track parameters, measurement of range, range energy relations, ionization measurements, grain density measurement, blob gap method, delta rays angle measurement-projectile angle, dip angle and space angle measurements
- Traditional microscopy (IR, Ramn), Electronic microscopes of higher resolution (SEM, TEM)
- Elementary quantum chemstry, Hartee fock approximation and electron correlation, electorn density as basic variable, early attempts, density functional theory

References:

(1) Nuclei & Particles – Emilio Serge
(2) Concepts of Nuclear Physics: Bernard L. Cohen
(3) Solid state physics: M. A Wahab
(4) Inrtoduction to Nanotechnology: C. P. Poole, Wiler Interscience
(5) A chemist's guide to density functional theory: W. Koch, Max C. Holthausen

APC PROJ	**Three months project on research topic chosen by the student and offered by an ARIES faculty.**

(i) Actual hands on research in which all that are taught in RPE course is applied. The topic of research is chosen by the mutual agrrement of the student and the supervisor. Research includes topic selection, literature survey, data collection for observers and/or solving governing equations for theoretician, validation, analysis and drawing relevant scientific conclusion. Many a times it is regeneration of published paper and on occassions it leads to publication of a scientific paper in a reputed journal.

(ii) Preparing a project report using latex based on the research conducted in three months. This is a hands on training on paper/thesis writing.

(iii) Dissertation: Defending the research conducted and evaluation by the Academic committee and other experts
(iv) **Submission of Literature Survey report and the dissertation.**

Grading the course work

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Qualification marks is overall 67% (CGPA 7)
For individual subjects the passing marks is 67%;
In our pre-PhD course work, 1 credit is 1 hour lecture per week and total 14 lectures in the course
We will follow the grading system as below:

Table 1: Ranges for grades using statistical method

Lower Range of Marks	Grade	Upper range of Marks
	A+	$> X+1.5\,\sigma$
$X+1.0\,\sigma <$	A	$\leq X+1.5\,\sigma$
$X+0.5\,\sigma <$	B+	$\leq X+1.0\,\sigma$
X	B	$\leq X+0.5\,\sigma$
$X-0.5\,\sigma <$	C+	$\leq X$
$X-1.0\,\sigma <$	C	$\leq X-0.5\,\sigma$
$X-1.5\,\sigma <$	D	$\leq X-1.0\,\sigma$
	F	$\leq X-1.5\,\sigma$

Table 2: Suggested ranges of grades based on absolute mark system

The award of grades on absolute marks system may be made as follows

Marks	Grades	Marks
91 ≤	A+	≤ 100
82 ≤	A	≤ 90
73 ≤	B+	≤ 81
64 ≤	B	≤ 72
55 ≤	C+	≤ 63
46 ≤	C	≤ 54
35 ≤	D	≤ 45
	F	≤ 34