LU M.Sc (all subjects) Entrance Exam 2027

Detailed Syllabus · Lucknow University · by LUUPDATE

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Based on the official University of Lucknow Admission Brochure & notices. Final 2027 notification aane par changes ho sakte hain – confirm on lkouniv.ac.in. Full info: luupdate.com/lu-entrance-2027

Exam Pattern — overview

100 objective MCQs · 2 marks each · 90 minutes · generally no negative marking (confirm in official notice). Questions at **graduation (Bachelor) level** of the relevant subject; some papers also include a **common section** of general awareness, English/Hindi comprehension & reasoning. MBA is via CAT score (LUMET for vacant seats).

M.Sc (Science subjects) — detailed

Each M.Sc paper is at the **B.Sc level of the subject**.

Physics: classical mechanics, electromagnetism, waves & optics, thermodynamics & statistical physics, quantum & modern physics, electronics, mathematical physics.

Chemistry: physical (thermodynamics, kinetics, electrochemistry, quantum), organic (reaction mechanisms, stereochemistry, named reactions), inorganic (coordination, organometallics, periodic properties), analytical chemistry.

Mathematics: abstract & linear algebra, real & complex analysis, differential equations, numerical analysis, mechanics, calculus of several variables.

Statistics: probability, distributions, statistical inference, sampling, design of experiments, regression.

Botany / Zoology / Geology / Biochemistry / Microbiology / Environmental Science: respective graduation-level core topics.

🔬 **Official B.Sc. syllabus (read 'Course Outlines / Syllabus' on UDRC):** Physics • Chemistry • Mathematics • Statistics • Botany • Zoology • Biochemistry • Microbiology (Botany dept) • Computer Science • Geology. Other subjects → udrc.lkouniv.ac.in.

M.Sc — Computer Science / AI / Data Science / Cyber Security — detailed

Graduation-level CS/IT core.
Programming: C/C++/Java/Python fundamentals, OOP concepts.
Data Structures & Algorithms: arrays, linked lists, stacks, queues, trees, graphs, sorting & searching, complexity analysis.
DBMS: ER model, relational model, normalization, SQL, transactions.
Operating Systems: processes, scheduling, memory management, deadlocks, file systems.
Computer Networks: OSI/TCP-IP, protocols, routing, network devices.
Computer Organisation & Architecture, Software Engineering, Discrete Mathematics, Theory of Computation basics.
Extra for AI / Data Science: probability & statistics, linear algebra, machine-learning basics, data analytics & visualization.
Extra for Cyber Security: network security, cryptography, information security basics.
Plus: quantitative aptitude & logical reasoning.

M.Sc. Biochemistry — Detailed Syllabus

Detailed unit-wise syllabus compiled by LUUPDATE from the University of Lucknow B.Sc. (NEP) core theory papers, Semesters I–VI. Fourth-year (Sem VII–VIII) and practical papers are excluded. Technical terms are kept in English as used in study material.

Unit 1 — Fundamental Chemistry & Biomolecules
1.1 Chemical Foundations & Biophysical Chemistry
• **Thermodynamics:** The zeroth, first, second and third laws; concepts of enthalpy, entropy and Gibbs free energy (ΔG); how equilibrium and spontaneity decide the direction of biological reactions, and the idea of coupled reactions in living systems.
• **pH & Buffers:** Self-ionisation of water and the ionic product; the Henderson–Hasselbalch relationship; buffering action and buffer capacity; physiologically important buffer systems such as phosphate, bicarbonate and histidine/protein buffers.
• **Electrochemistry:** Oxidation–reduction (redox) reactions, standard reduction potentials, the Nernst equation, and the link between electrochemical cells and cellular bioenergetics.
• **Chemical Bonding & Molecular Interactions:** Covalent and ionic bonds, hydrogen bonding, van der Waals forces and hydrophobic interactions; the contribution of dipole moments and weak forces to the stability of biomolecules.
• **Solutions & Colligative Properties:** Diffusion, osmosis and osmotic pressure, and dialysis — together with their practical relevance in biochemistry.
1.2 Biomolecules — Structure & Function
• **Carbohydrates:** Classification into mono-, di-, oligo- and polysaccharides. Structure of monosaccharides in open-chain and ring (Haworth) forms; stereoisomerism (D/L, α/β anomers), epimers and mutarotation. Important sugars — glucose, fructose, galactose, ribose and deoxyribose. Disaccharides (sucrose, lactose, maltose) with their glycosidic bonds and reducing / non-reducing character. Storage and structural polysaccharides — starch, glycogen, cellulose, chitin — plus glycosaminoglycans (e.g., hyaluronic acid). Glycoconjugates: glycoproteins, glycolipids and proteoglycans.
• **Lipids:** Classification into simple (fats, waxes), compound (phospholipids, glycolipids) and

derived (fatty acids, steroids) lipids. Saturated and unsaturated fatty acids, essential fatty acids and ω-3 / ω-6 nomenclature. Triacylglycerols and their properties (saponification, iodine number). Phospholipids — lecithin, cephalin and sphingolipids. Steroids — structure and function of cholesterol, bile acids and steroid hormones. Eicosanoids: prostaglandins and leukotrienes.
• **Amino Acids & Proteins:** Classification of amino acids on the basis of side chain and nutritional requirement. Amphoteric nature, isoelectric point (pI) and zwitterions. The peptide bond — its characteristics, planarity and cis / trans geometry. Levels of protein organisation: primary (N-/C-terminus, sequencing), secondary (α-helix, β-sheet, turns), tertiary (domains, folding forces) and quaternary (e.g., haemoglobin). Denaturation and renaturation; comparison of fibrous and globular proteins.

Unit 2 — Cell Biology, Microbiology & Physiology
2.1 Cell Biology
• **Cell Structure:** Comparison of prokaryotic and eukaryotic cells; structure and function of organelles — nucleus, mitochondria, endoplasmic reticulum, Golgi apparatus, lysosomes, peroxisomes and the cytoskeleton.
• **Membrane Biology:** The fluid-mosaic model of membranes; modes of transport (passive, active and facilitated); ion channels and membrane receptors.
• **Cell Division:** Mitosis and meiosis; regulation of the cell cycle through checkpoints, cyclins and cyclin-dependent kinases (CDKs).
• **Cell Signalling:** Hormones and their receptors (GPCRs and receptor tyrosine kinases); second messengers such as cAMP, IP3 and Ca^{2+}.
2.2 Microbiology
• **Microbial Diversity:** Bacteria (Gram-positive and Gram-negative), viruses, fungi and archaea.
• **Bacterial Structure:** Cell wall (peptidoglycan), flagella, pili and endospores.
• **Growth & Nutrition:** Culture media, the bacterial growth curve and sterilisation techniques.
• **Microbial Metabolism:** Distinctive metabolic pathways (e.g., Entner–Doudoroff), nitrogen fixation and fermentation.
• **Pathogens & Disease:** An overview of common disease-causing bacteria and viruses (for example, cholera, dengue and the mechanism of COVID-19).
2.3 Human Physiology (Basics)
• **Blood:** Composition, plasma proteins, the coagulation (clotting) process and blood groups.
• **Excretion:** Composition of urine and the basics of renal function.
• **Nerve & Muscle:** Generation of the action potential, neurotransmitters and muscle contraction (sliding-filament theory).
• **Endocrine System:** Pituitary, thyroid, adrenal and pancreatic hormones — their mechanisms of action and related disorders.
• **Nutrition:** Balanced diet, vitamins, and nutritional disorders such as malnutrition and obesity.

Unit 3 — Enzymes, Metabolism & Bioenergetics
3.1 Enzymes
• **Classification & Nomenclature:** The IUBMB system of naming and classifying enzymes.
• **General Properties:** Substrate specificity, the active site, and the role of cofactors and coenzymes.
• **Enzyme Kinetics:** The Michaelis–Menten equation, Km and Vmax, and the Lineweaver–Burk

(double-reciprocal) plot; factors that affect reaction rate such as pH and temperature.
• **Inhibition:** Competitive, non-competitive and uncompetitive inhibition; allosteric regulation.
• **Regulation:** Isozymes and control of enzyme activity through feedback inhibition and covalent modification.
3.2 Bioenergetics
• **High-Energy Compounds:** High-energy phosphates (ATP), redox potentials and the complexes of the electron transport chain (ETC).
• **Oxidative Phosphorylation:** The chemiosmotic theory, ATP synthase, uncouplers and inhibitors of the respiratory chain.
• **Photosynthesis (Basics):** The light reactions and the Calvin cycle.
3.3 Metabolism — Catabolic & Anabolic Pathways
• **Carbohydrate Metabolism:** Glycolysis and its regulation, the amphibolic TCA cycle, gluconeogenesis, glycogen metabolism, the pentose phosphate pathway and the Cori cycle.
• **Lipid Metabolism:** β-oxidation of fatty acids, fatty-acid synthesis, ketone-body formation and cholesterol biosynthesis.
• **Amino-Acid Metabolism:** Transamination and deamination, the urea cycle, and glucogenic versus ketogenic amino acids.
• **Nucleotide Metabolism:** Biosynthesis and degradation of purines and pyrimidines.
• **Integration:** Integration of metabolic pathways, hormonal control by insulin and glucagon, and important metabolic disorders (e.g., diabetes and phenylketonuria).

Unit 4 — Molecular Biology, Genetics & Advanced Techniques
4.1 Molecular Biology & Genetics
• **DNA Replication:** The semi-conservative mechanism and the key enzymes involved — DNA polymerases, helicase and ligase.
• **Transcription:** RNA polymerases, promoters and RNA processing (5′ capping, splicing and poly-A tailing).
• **Translation:** The genetic code, ribosomes and tRNA; the stages of initiation, elongation and termination.
• **Gene Regulation:** Operons (lac and trp) in prokaryotes and regulatory mechanisms in eukaryotes (enhancers, transcription factors).
• **Genome Maintenance:** Mutations, DNA repair pathways and recombination.
4.2 Recombinant DNA Technology & Biotechnology (Basics)
• **Tools & Methods:** Restriction enzymes, vectors (plasmids and bacteriophages), cloning, the polymerase chain reaction (PCR) and gel electrophoresis.
• **Applications:** Recombinant insulin production, genetically modified organisms (GMOs) and an introduction to gene therapy.
4.3 Biochemical Techniques
• **Separation Techniques:** Centrifugation (differential and density-gradient), chromatography (paper, TLC, ion-exchange, gel-filtration, affinity and HPLC) and electrophoresis (PAGE, SDS-PAGE and agarose).
• **Spectroscopy:** UV-Visible and fluorescence spectroscopy, along with the basic principles of NMR and mass spectrometry (MS).
• **Other Methods:** Radioisotope techniques, biosensors and enzyme assays.
4.4 Clinical & Applied Biochemistry (Introductory)

• **Clinical Enzymology:** Diagnostic enzymes and biomarkers — for example, markers of liver and heart disease.
• **Common Disorders:** Jaundice, atherosclerosis, the basics of cancer, and inborn errors of metabolism.
• **Immunology Basics:** Antigens, antibodies and the ELISA technique.

M.Sc. Botany — Detailed Syllabus

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Unit 1 — Microbial Diversity & Lower Plants (Cryptogams)

1.1 Plant Viruses
• **Virology:** Nature, classification and structure of plant viruses (helical and icosahedral symmetry); external and internal symptoms of infected plants; modes of virus transmission; genome organisation and replication of Tobacco Mosaic Virus (TMV); techniques in plant virology — purification, serology and electron microscopy; structure and replication of bacteriophages and viroids.
1.2 Bacteria & Archaea (Prokaryotes)
• **Prokaryotic Biology:** Cell structure and function of prokaryotes; classification (Archaea, Gram-positive and Gram-negative bacteria, Mollicutes); metabolic diversity (phototrophy, chemolithotrophy, autotrophy, heterotrophy, fermentation); bacterial cell division and growth; bacterial genome and plasmids; genetic variability through mutation and recombination; control of microbial growth; culture and staining methods; economic importance of bacteria.
1.3 Fungi & Lichens
• **Mycology:** Eukaryotic (yeast) cell structure; classification, thallus organisation and reproduction in fungi; economic importance; characters and life cycles of representative genera — Albugo, Pythium (Oomycota); Rhizopus (Zygomycota); Synchytrium (Chytridiomycota); Saccharomyces, Aspergillus, Ascobolus (Ascomycota); Ustilago, Puccinia, Agaricus (Basidiomycota); Fusarium (mitosporic fungi).
• **Lichens:** Classification, thallus organisation, reproduction, physiology and role in monitoring environmental pollution.
1.4 Algae
• **Phycology:** General features, range of thallus organisation and classification; ultrastructure of eukaryotic algal and cyanobacterial cells; economic importance; characters and life cycles of representative genera — Microcystis, Oscillatoria (Cyanophyta); Volvox, Hydrodictyon, Oedogonium, Coleochaete, Chara (Chlorophyta); Navicula (Bacillariophyta); Vaucheria (Xanthophyta); Ectocarpus (Phaeophyta); Polysiphonia (Rhodophyta).

Unit 2 — Archegoniates & Palaeobotany

2.1 Bryophytes
• **Bryophytes:** General characters, classification, reproduction and affinities; gametophytic and sporophytic organisation of Pogonatum, Anthoceros, Riccia, Marchantia and Frullania.
2.2 Pteridophytes
• **Pteridophytes:** General characters, affinities, classification and stelar systems; heterospory and

the seed habit; morphology, anatomy, development and reproduction of Rhynia (Psilopsida), Lycopodium and Selaginella (Lycopsida), Equisetum (Sphenopsida), and Adiantum, Nephrolepis, Marsilea (Filicopsida).

2.3 Gymnosperms

• **Gymnosperms:** General characters, affinities and classification; morphology, anatomy, development and reproduction of Cycas (Cycadales), Pinus (Coniferales) and Ephedra (Ephedrales).

2.4 Palaeobotany

• **Palaeobotany:** General account; types of fossils and methods of fossilisation; the geological time scale; an introduction to palynology and continental drift.

Unit 3 — Angiosperms — Taxonomy, Anatomy, Development & Reproduction

3.1 Plant Systematics

• **Classification & Nomenclature:** Principles of classification and nomenclature; comparative study of the systems of Linnaeus, Bentham & Hooker, and Cronquist; herbaria and botanical gardens.

• **Families & Economic Importance:** Taxonomic study and economic importance of major dicot families (e.g., Asteraceae, Brassicaceae, Malvaceae, Solanaceae, Lamiaceae, Euphorbiaceae, Fabaceae/Papilionaceae, Apiaceae, Apocynaceae, Convolvulaceae, Ranunculaceae, Rosaceae, Rubiaceae, Rutaceae, Cucurbitaceae, Nymphaeaceae) and monocot families (Arecaceae, Cyperaceae, Liliaceae, Poaceae).

3.2 Morphology & Anatomy

• **Plant Architecture:** General morphology and development of floral organs; root–shoot transition; plant modifications (phylloclade, phyllode, cladode); meristems — classification, root and shoot apical meristems; growth and differentiation of root, shoot and leaf; cambium, tissue differentiation, secondary growth and its anomalies.

3.3 Reproduction

• **Reproductive Botany:** Structure and development of male and female gametophytes (micro- and megasporogenesis, micro- and megagametogenesis); palynology — pollen morphology, viability and germination; embryo-sac types and development; double fertilisation; endosperm development and its morphological nature; embryogeny; apomixis and polyembryony.

Unit 4 — Ecology, Soil Science & Environment

4.1 Ecology

• **Ecosystem & Communities:** Ecosystem — concept, types and components; food chains, food webs, mineral cycles (N, C, S, P) and ecological pyramids; plant communities and succession (hydrosere, xerosere); ecological groups and their adaptations (hydrophytes, xerophytes, halophytes); population characteristics.

4.2 Phytogeography

• **Plant Distribution:** Static and dynamic phytogeography; principles governing the geographical distribution of plants; phytogeographic regions of the world and India; agro-ecological and floristic zones of India; natural vegetation of India and vegetation types of Uttar Pradesh; endemism.

4.3 Soil Science

• **Soils:** Mineral resources and their conservation; soil formation and profile development; soil

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composition, types and properties (texture, density, temperature, organic matter, pH, ion exchange); soil erosion and conservation; problem soils and their reclamation.

4.4 Environmental Pollution

• **Pollution:** Air, water, soil, radioactive, thermal and noise pollution — their sources, effects and control measures.

Unit 5 — Cytology, Genetics & Plant Breeding

5.1 Cell Biology & Chromosomes

• **Cell Structure:** Organisation and function of cell organelles (nucleus, chloroplast, mitochondria, endomembrane system, peroxisomes, lysosomes); chromosome composition and organisation — nucleosome and solenoid models; special chromosomes (salivary-gland, lampbrush and B-chromosomes); mitosis, meiosis and their significance.

5.2 Genetics

• **Inheritance:** Principles of inheritance; incomplete dominance and co-dominance; gene interactions (complementary genes, epistasis, duplicate genes); linkage and linkage maps.

• **Variation & Mutation:** Extrachromosomal inheritance (variegation in the four-o'clock plant, shell coiling in snails, kappa particles in Paramecium); sex determination; structural chromosomal changes (deletion, duplication, inversion, translocation); numerical changes (euploidy and aneuploidy) and their evolutionary importance; mutations — spontaneous and induced, mutagens, molecular mechanisms and evolutionary significance.

5.3 Plant Breeding & Biostatistics

• **Plant Breeding:** Hybridisation, heterosis, cytoplasmic male sterility and its applications; selection; breeding for disease resistance, drought tolerance and quality traits.

• **Biostatistics:** Classification of data; mean, median and mode; standard deviation, standard error and variance; correlation; the chi-square (χ^2) test.

Unit 6 — Plant Physiology

6.1 Water Relations & Mineral Nutrition

• **Water & Nutrients:** Diffusion and osmosis, osmotic potential, water absorption and ascent of sap; transpiration — significance, affecting factors and the mechanism of stomatal opening and closing; mineral nutrition — essentiality of elements, macro- and micronutrients, their roles and deficiency symptoms, and the mechanism of ion uptake (passive and active).

6.2 Photosynthesis & Respiration

• **Photosynthesis:** Photosynthetic pigments; photochemical reactions, reaction centres, O_2 evolution and photophosphorylation; CO_2 fixation — C_3, C_4 and CAM pathways; photorespiration and glycolate metabolism; factors affecting photosynthesis.

• **Respiration:** Aerobic and anaerobic respiration; respiratory pathways — glycolysis, the Krebs cycle and the pentose phosphate pathway; electron transport, oxidative phosphorylation and cyanide-resistant respiration.

6.3 Nitrogen & Lipid Metabolism

• **Metabolism:** Nitrogen cycle, biological nitrogen fixation, nitrate and nitrite reduction and nitrogen assimilation; fatty-acid synthesis and oxidation (α and β).

6.4 Growth & Development

• **Growth Regulation:** Phases of growth; flowering — photoperiodism, vernalisation and circadian rhythm; seed germination; bud and seed dormancy; abscission and senescence; phytohormones

— auxins, gibberellins, cytokinins, abscisic acid and ethylene (discovery, physiological roles and applications); nastic and tropic plant movements.

Unit 7 — Plant Biochemistry

7.1 Carbohydrates

• **Carbohydrates:** Classification, structure and properties of monosaccharides (aldose and ketose sugars), oligosaccharides (reducing and non-reducing), and polysaccharides (storage — starch, inulin; structural — cellulose, pectin, chitin); aminoglycans, peptidoglycans, glycoproteins and glycolipids.

7.2 Lipids & Vitamins

• **Lipids:** Classification, structure and properties of fatty acids (saturated and unsaturated); simple, compound and derived lipids.

• **Vitamins:** Structure and properties of vitamins.

7.3 Amino Acids & Proteins

• **Amino Acids:** Classification, structure and properties of amino acids; essential and non-essential amino acids.

• **Proteins:** Classification, structural organisation and biological roles of proteins.

7.4 Enzymes & Bioenergetics

• **Enzymes:** Discovery, classification and characteristics of enzymes; general structure, active site, action specificity and mode of action; enzyme kinetics (Michaelis–Menten constant); enzyme inhibition and factors affecting catalytic efficiency.

• **Bioenergetics:** Laws of thermodynamics; the concept of Gibbs free energy in plants; redox reactions; high-energy compounds.

Unit 8 — Economic Botany & Plant Biotechnology

8.1 Economic Botany & Plant Resources

• **Crop Plants & Products:** Centres of diversity, origin and domestication of crop plants; cultivation and uses of cereals (wheat, rice, maize) and legumes; plants yielding fatty/essential oils, spices, beverages (tea, coffee, cocoa) and fibres (cotton, jute, flax, coconut); timber, gums, resins and dye-yielding plants; medicinal plants and the basics of ethnobotany.

• **Conservation:** Conservation of plant resources — in situ (sanctuaries, national parks, biosphere reserves, wetlands, mangroves) and ex situ (field gene banks, seed banks, cryobanks).

8.2 Plant Biotechnology

• **Recombinant DNA:** Isolation of genomic and plasmid DNA; plasmid vectors; restriction digestion and ligation; transformation; selection of recombinants; transgenic plants.

• **Applications:** Genetic engineering in agriculture (Bt cotton, herbicide-resistant crops, Flavr Savr tomato, Golden rice) and in industry and medicine (recombinant enzymes, vaccines, interferon, antibiotics; biosafety concerns).

• **Plant Tissue Culture:** Principles, components and techniques of in vitro culture; callus and cell-suspension cultures; organogenesis and embryogenesis; protoplast isolation, culture and fusion; somatic hybridisation; somaclonal variation; production of plant secondary metabolites.

M.Sc. Chemistry — Detailed Syllabus

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Unit 1 — Inorganic Chemistry

1.1 Atomic Structure & Periodic Properties

• **Atomic Structure:** Quantum-mechanical picture of the atom (in brief); shapes of s, p and d orbitals; Aufbau principle, Pauli's exclusion principle and Hund's rule of maximum multiplicity; electronic configurations of elements; effective nuclear charge.

• **Periodicity:** Classification based on electronic configuration; diagonal relationship; inert-pair effect; atomic, ionic and van der Waals radii; ionisation energy; electron affinity and electronegativity — definitions, determination, periodic trends and their use in predicting chemical behaviour.

1.2 Chemical Bonding

• **Covalent Bonding:** Valence bond theory and its limitations; directional nature of covalent bonds; hybridisation and shapes of simple molecules and ions; VSEPR theory; molecular orbital theory of homonuclear and heteronuclear (CO, NO) diatomics; multi-centre bonding in electron-deficient molecules; bond strength and bond energy; percentage ionic character from dipole moment and electronegativity difference.

• **Weak Interactions:** Hydrogen bonding and van der Waals forces.

1.3 Ionic Solids & Metallic Bonding

• **Solid-State Bonding:** Ionic structures; radius-ratio rule, coordination number and its limitations; lattice defects; lattice energy and the Born–Haber cycle; solvation energy and solubility of ionic solids; polarising power and polarisability of ions and Fajans' rules; metallic bonding — free-electron, valence-bond and band theories.

1.4 Chemistry of s-, p- and Noble-Gas Elements

• **s-Block:** Comparative study; hydrides; solvation and complexation of alkali and alkaline-earth cations and their role in biosystems; introduction to alkyls and aryls of Li and Mg.

• **p-Block:** Comparative study (including diagonal relationship) of groups 13–17; hydrides, oxides, oxyacids and halides; diborane, boron nitride, fullerenes and silicates; structures of oxides and oxyacids of phosphorus and sulphur; interhalogens and polyhalides.

• **Noble Gases:** Chemical properties; discovery of $O_2^+PtF_6^-$; chemistry, structure and bonding of xenon compounds.

1.5 Transition & Inner-Transition Elements

• **d-Block:** Characteristic properties of the first transition series; binary compounds (hydrides, carbides, oxides); relative stability of oxidation states, coordination numbers and geometries. Second and third series — general characteristics and comparative treatment of Zr/Hf, Nb/Ta and Mo/W.

• **Lanthanides & Actinides:** Lanthanides — electronic structure, oxidation states, ionic radii, lanthanide contraction, complex formation, occurrence and isolation, ceric ammonium sulphate. Actinides — electronic configuration, oxidation states, magnetic properties and separation of Np, Pu and Am from U.

1.6 Coordination Chemistry

• **Bonding Theories:** Werner's coordination theory and its experimental verification; Sidgwick's effective atomic number (EAN); polydentate ligands and chelates; nomenclature; isomerism in coordination compounds; valence bond theory — inner- and outer-orbital complexes and its limitations.

• **Crystal Field Theory:** Crystal-field splitting in octahedral, tetrahedral and square-planar complexes; factors affecting CFSE; effect of CFSE on lattice energy and ionic radii.
• **Magnetic Properties:** Types of magnetic behaviour; measurement of magnetic susceptibility; spin-only formula; L–S coupling; spectroscopic ground state; orbital contribution; application of magnetic-moment data to 3d complexes.

1.7 Acids–Bases, Redox & Special Topics

• **Acid–Base Concepts:** Arrhenius, Brønsted–Lowry, Lux–Flood, solvent-system and Lewis concepts; Pearson's HSAB principle — hard and soft acids and bases, symbiosis, applications and limitations.
• **Non-aqueous Solvents & Redox:** Properties and types of solvents; reactions in liquid NH_3 and liquid SO_2; electrode potential, electrochemical series and applications; principles of extraction of elements.
• **Inorganic Polymers:** Silicones and phosphazenes; pseudohalogens and pseudohalides; structure and bonding of NO; nitrosyl complexes and EAN.

Unit 2 — Organic Chemistry

2.1 Structure, Bonding & Reactive Intermediates

• **Electronic Effects:** Resonance, electromeric, inductive and field effects; types of reagents (electrophiles and nucleophiles); homolytic and heterolytic bond fission; generation, structure, stability and reactions of carbenes, nitrenes and arynes, and the factors affecting their stability.

2.2 Stereochemistry

• **Optical Isomerism:** Elements of symmetry, molecular chirality and optical activity; stereogenic centres, enantiomers and diastereomers; threo/erythro forms, meso compounds; resolution, inversion, retention and racemisation; relative and absolute configuration; sequence rules; D/L and R/S nomenclature.
• **Geometrical & Conformational Isomerism:** Determination of configuration, the E/Z system, isomerism in oximes and alicyclic compounds; conformational analysis of ethane, n-butane and cyclohexane; axial and equatorial bonds; sawhorse, Newman, Fischer and flying-wedge projections; conformation versus configuration.

2.3 Hydrocarbons

• **Alkanes & Cycloalkanes:** Methods of formation; physical and chemical properties; Baeyer's strain theory and its limitations; ring strain, theory of strainless rings, the cyclopropane ring and banana bonds.
• **Alkenes & Alkynes:** Alkenes — methods of formation, properties and relative stabilities; dienes (isolated, conjugated, cumulated); allenes and butadiene; 1,2- and 1,4-addition; the Diels–Alder reaction. Alkynes — structure, bonding, formation, reactions and acidity.

2.4 Aromatic Compounds & Halides

• **Arenes & Aromaticity:** Hückel's rule; stability and bond lengths in benzene; resonance and MO picture; aromatic electrophilic substitution — arenium-ion mechanism, nitration, halogenation, sulfonation, mercuration and Friedel–Crafts reactions; activating/deactivating groups, orientation and the ortho/para ratio.
• **Alkyl & Aryl Halides:** Methods of formation and reactions; nucleophilic substitution (SN1 and SN2) with energy-profile diagrams; nuclear and side-chain reactions of aryl halides; nucleophilic aromatic substitution.

2.5 Heterocyclics & Organometallics

• **Heterocyclic Compounds:** MO picture and aromatic character of pyrrole, furan, thiophene and

pyridine; synthesis and reactions, with emphasis on electrophilic and nucleophilic substitution; comparative basicity of pyridine, piperidine and pyrrole; condensed heterocycles — indole, quinoline and isoquinoline (Fischer indole, Skraup and Bischler–Napieralski syntheses).

• **Organometallics:** Grignard reagents — formation, structure and chemical reactions.

2.6 Alcohols, Phenols, Carbonyls & Acids

• **Alcohols & Phenols:** Synthesis and properties of monohydric, dihydric (ethylene glycol) and trihydric (glycerol) alcohols; preparation, acidity and reactions of phenols; comparative acidity of alcohols and phenols; resonance stabilisation of the phenoxide ion.

• **Aldehydes & Ketones:** Synthesis and properties; mechanism of nucleophilic addition to the carbonyl group; reactions at α-hydrogens; reduction, oxidation, condensation and the Wittig reaction.

• **Carboxylic Acids & Derivatives:** Synthesis, properties and acidity; effect of substituents on acid strength; acid chlorides, esters, amides and anhydrides; fats, oils and detergents — rancidity, saponification value, iodine value, acid value, Reichert–Meissl value; cleansing action of soaps and detergents.

2.7 Nitrogen Compounds & Biomolecules

• **Organic Nitrogen Compounds:** Nucleophilic substitution in and reduction of nitroarenes (acidic, neutral and alkaline media); preparation and reactions of amines; separation of primary, secondary and tertiary amines; structural factors affecting basicity.

• **Amino Acids, Peptides & Proteins:** Classification of amino acids; acid–base behaviour, isoelectric point and electrophoresis; preparation and reactions of α-amino acids; peptides and Merrifield solid-phase synthesis; colour tests, biological functions and denaturation/renaturation of proteins.

Unit 3 — Physical Chemistry

3.1 Mathematical Concepts & Gaseous State

• **Mathematical Concepts:** Logarithmic relations, equations of straight lines and slopes, curve tracing, differentiation of simple functions, maxima and minima, partial differentiation and integration; permutations, combinations, factorials and probability; binary numbers and their arithmetic.

• **Gaseous State:** Deviation from ideal behaviour and the van der Waals equation; critical phenomena and PV isotherms of real gases; relationship between critical and van der Waals constants; law of corresponding states; Maxwell distribution of molecular velocities, collision number, mean free path and collision diameter.

3.2 States of Matter

• **Solid State:** Laws of crystallography; X-ray diffraction and Bragg's equation; Laue and powder methods; crystal structures of NaCl, KCl and CsCl.

• **Liquid & Liquid Crystals:** Intermolecular forces and structure of liquids; classification and structure of nematic, smectic and cholesteric liquid crystals; thermography and seven-segment cells.

• **Colloidal State:** Sols — kinetic, optical and electrical properties; stability, protective action, Hardy–Schulze rule and gold number; emulsions and emulsifiers; gels — classification, preparation and applications.

3.3 Chemical Kinetics & Catalysis

• **Kinetics:** Order and molecularity; integrated rate laws (second-order and pseudo-order), half-

life; experimental methods (conductometric, potentiometric, optical, polarimetric, spectrophotometric); effect of temperature and activation energy; collision theory and transition-state theory.

• **Catalysis & Buffers:** Classification and characteristics of catalysed reactions; buffer action and the Henderson–Hasselbalch equation; hydrolysis of salts.

3.4 Thermodynamics & Thermochemistry

• **First Law & Thermochemistry:** Heat capacities (Cv and Cp) and their relationship; Joule's law, Joule–Thomson coefficient and inversion temperature; w, q, ΔU and ΔH for isothermal and adiabatic expansion of ideal gases; Hess's law, heats of reaction, enthalpy of neutralisation, bond dissociation energy and Kirchhoff's equation.

• **Second Law & Entropy:** Statements of the second law; Carnot cycle, efficiency and theorem; thermodynamic temperature scale; Le Chatelier's principle; reaction isotherm and isochore; Clausius–Clapeyron equation; entropy as a state function and its changes; criteria of spontaneity; Gibbs and Helmholtz free-energy functions.

3.5 Electrochemistry

• **Conductance:** Kohlrausch's law; weak and strong electrolytes; Arrhenius theory of dissociation and its limitations; Ostwald's dilution law; Debye–Hückel–Onsager equation; transport number (Hittorf and moving-boundary methods); applications of conductance measurements.

• **Electrodes & Cells:** Types of reversible electrodes; single and standard electrode potentials; reference electrodes (SHE and calomel); Nernst equation and cell EMF; electrochemical series; galvanic and electrolytic cells; thermodynamics of cell reactions; concentration cells with and without transport, liquid-junction potential; pH determination using quinhydrone, calomel and glass electrodes.

3.6 Surface Chemistry

• **Adsorption:** Physical and chemical adsorption; Freundlich and Langmuir adsorption isotherms; multilayer adsorption and the BET isotherm.

Unit 4 — Quantum Chemistry, Spectroscopy & Polymer Chemistry

4.1 Elementary Quantum Mechanics

• **Quantum Theory:** de Broglie's hypothesis; Heisenberg's uncertainty principle; the Hamiltonian operator; Born–Oppenheimer approximation; the Schrödinger wave equation and its significance; physical interpretation of the wave function; postulates of quantum mechanics; particle in a one-dimensional box; the H-atom wave equation, quantum numbers and angular wave functions.

• **Molecular Orbital Theory:** Formation of molecular orbitals from atomic orbitals (LCAO); the H_2^+ ion; bonding and antibonding orbitals; sp, sp^2 and sp^3 hybrid orbitals; comparison of the MO and VB models.

4.2 Molecular Spectroscopy

• **Rotational, Vibrational & Raman:** Rigid-rotor energy levels, selection rules, intensity distribution, bond-length determination and isotope effect; harmonic-oscillator energy levels and selection rules; force constants, anharmonicity and isotope effects; polarisability and the Raman spectra of diatomic molecules.

• **UV-Visible & IR:** Beer–Lambert law and molar absorptivity; types of electronic transitions and the effect of conjugation; chromophores and auxochromes; bathochromic, hypsochromic, hyperchromic and hypochromic shifts; Woodward–Fieser rules; IR — molecular vibrations, Hooke's law, selection rules, fingerprint region and characteristic group frequencies.

• **NMR & Mass Spectrometry:** ^{1}H-NMR — nuclear shielding and deshielding, chemical shift, spin–spin splitting and coupling constants, signal areas and interpretation of simple spectra; mass spectrometry — molecular ion, metastable ion, the nitrogen rule, fragmentation and the McLafferty rearrangement.

4.3 Polymer Chemistry

• **Introduction & Characterisation:** Reactivity of monomers, ring versus chain formation; chain-reaction, free-radical, cationic, anionic and living polymerisation; coordination and copolymerisation; IR, NMR and X-ray study of polymers; thermal, chemical and physical testing (hardness, tensile strength, impact, tear and abrasion resistance).

• **Structure & Properties:** Configuration and crystal structure of polymer chains; morphology; melting temperature (Tm) and glass-transition temperature (Tg); effect of chain flexibility; structure–property relationships.

• **Processing & Applications:** Elastomers, plastics and fibres; compounding and vulcanisation; processing techniques (calendering, casting, injection/blow/extrusion moulding, thermoforming, fibre spinning); commercial and specialty polymers (polyethylene, PVC, polyamides, polyesters, phenolic and epoxy resins, silicones, PTFE; conducting, fire-retardant, liquid-crystal and biomedical polymers).

M.Sc. Computer Science — Detailed Syllabus

Detailed unit-wise syllabus compiled by LUUPDATE from the University of Lucknow B.Sc. (NEP) core theory papers, Semesters I–VI. Fourth-year (Sem VII–VIII) and practical papers are excluded. Technical terms are kept in English as used in study material.

Unit 1 — Programming Fundamentals & Problem Solving

1.1 Programming Methodology

• **Problem Solving:** Concept of problem solving; general, algorithmic and heuristic approaches; steps of problem solving; problem definition; characteristics of a good program; program design; stages of program development; top-down and bottom-up methodologies.

• **Algorithms & Flowcharts:** Algorithm notation and design; pseudocode; flowcharts and flowchart symbols (e.g., Raptor); the program-development cycle — coding, documentation, testing and debugging; modular and structured programming; programming conventions; types of programming languages and translators (assemblers, interpreters, compilers), editors and debuggers.

1.2 Programming with C++

• **Language Basics:** Character set, keywords, variables (declaration and initialisation), constants, data types, operators, precedence and associativity, type conversion and typecasting; basic program structure; input/output statements.

• **Control & Functions:** Selection statements (if, if-else, nested, else-if ladder, switch); iteration (for, while, do-while), nested loops, break and continue; functions and parameter passing, default arguments, call by value and reference, function overloading, recursion; single- and multi-dimensional arrays; file handling (file classes, modes and I/O operations).

1.3 Programming with Python

• **Python Basics:** Features of Python; interpreter and interactive mode; values, types, variables, expressions and statements; operators and precedence; input/output; modules and functions; flow of execution; parameters and arguments.

• **Data Handling:** Control statements (if, if-elif-else, while, for, break, continue, pass); fruitful functions, scope and recursion; strings (slices, immutability, methods); lists, tuples and dictionaries; list comprehension; reading and writing files; errors, exceptions and exception handling; modules and packages.

Unit 2 — Data Structures & Algorithms

2.1 Data Structures

• **Complexity Analysis:** Asymptotic notations and analysis; time-complexity analysis; solving recurrences using recursion trees.

• **Linear Structures:** Arrays; singly, doubly and circular linked lists; stacks as an ADT (array and linked-list implementations) and their applications; queues as an ADT (array and linked-list implementations).

• **Non-linear Structures:** Trees — definitions, properties and traversal algorithms; binary trees and their traversals; linear and binary recursion; binary search trees — insertion, deletion, search and complexity analysis.

2.2 Design & Analysis of Algorithms

• **Design Paradigms:** Basic design and analysis techniques; correctness of algorithms; iterative techniques, divide and conquer, dynamic programming and greedy algorithms.

• **Sorting & Searching:** Bubble, insertion and merge sort; heap and quick sort; linear-time sorting (bucket, radix, count sort); searching techniques; medians and order statistics; complexity analysis.

• **Graphs & Advanced Techniques:** Breadth-first and depth-first search and their applications; minimum spanning trees; string processing; decision trees; balanced and red-black trees; randomised, distributed and heuristic algorithms.

Unit 3 — Computer Organization & Architecture

3.1 Fundamentals of Computers

• **Computer System:** Definition, evolution and generations of computers; characteristics, capabilities and limitations; classification; basic components — control unit, ALU, memory and I/O; hardware and software; memory hierarchy (main, cache, auxiliary; RAM, ROM, SRAM, DRAM); BIOS/UEFI and the booting process; stored-program concept; processor types and the motherboard.

• **Peripherals & Software:** Input devices (keyboard, mouse, scanner), output devices (monitor, printer, plotter), storage devices (magnetic, optical, flash); system, application and open-source/freeware/proprietary software.

• **Number Systems & Boolean Logic:** Binary, octal, decimal and hexadecimal systems and inter-conversion; complements and binary arithmetic; computer codes (BCD, EBCDIC, ASCII, Gray, Excess-3, Unicode); logic gates; Boolean algebra (rules, laws, De Morgan's theorem, simplification); units of memory.

3.2 Digital Logic & Microprocessor

• **Digital Circuits:** Logic gates; flip-flops and characteristic tables; logic simplification using Boolean algebra and Karnaugh maps; don't-care conditions; combinational circuits; sequential circuits; decoders, encoders, multiplexers, de-multiplexers, adders, subtractors, incrementers, registers and memory units.

• **Microprocessor (8086):** Internal architecture, BIU and EU, programming model; addressing

modes; instruction set; bus structure and timings; memory address decoding; cache and controllers; I/O interface, timer, interrupt and DMA controllers; assembly-language programming and program-control instructions.

Unit 4 — Operating Systems

4.1 Operating System Concepts

• **Introduction:** History and evolution; basic functions; resource abstraction; types of operating systems (multiprogramming, batch, time-sharing, real-time, personal and handheld); OS organisation — processor and user modes, kernels, system calls and system programs.

• **Process Management:** Process characterisation and scheduling; pre-emptive and non-pre-emptive scheduling algorithms; inter-process communication and synchronisation; critical section and semaphores; deadlock — characterisation, prevention, avoidance, detection and recovery, and Banker's algorithm.

• **Memory & File Management:** Physical and virtual address space; memory-allocation strategies (fixed and variable partitions, paging, segmentation, virtual memory); file and I/O management — directory structure, file operations and allocation methods, and device management.

Unit 5 — Databases & Web Technologies

5.1 Relational Database Management System

• **Fundamentals:** Database and its characteristics; data models; components of a DBMS; three-schema architecture; data independence; file-system versus database approach.

• **Database Design:** Entity-relationship modelling — entities, attributes, relationships and constraints; ER diagrams; mapping ER diagrams to relational schemas; functional dependencies; normalisation (1NF, 2NF, 3NF) and decomposition.

• **Relational Model & SQL:** Characteristics of a relation; types of keys; relational integrity constraints; relational algebra (selection, projection, Cartesian product, join); SQL — DDL, DML, queries, aggregation, group-by/having clauses, and views.

5.2 Web Development (HTML, CSS, PHP)

• **Web Basics:** History and architecture of the WWW; browsers, websites and portals; static versus dynamic sites; servers and frameworks (WAMP, XAMPP); fundamentals of web design, UI/UX, layouts, navigation and sitemaps.

• **HTML & CSS:** HTML structure, tags, meta tags, forms, tables and frames; HTML5 features (audio/video, semantics); CSS structure and properties (background, colour, fonts, borders, positioning); CSS3 features (opacity, transitions, transforms, animations, web fonts); responsive design and media queries.

• **PHP:** PHP structure and syntax; variables, loops, functions and conditions; arrays, strings and form processing; regular expressions; date/time and file uploads; exception handling; sessions, state management and cookies.

Unit 6 — Computer Networks

6.1 Computer Networks & Data Communication

• **Network Fundamentals:** Network definition, topologies and classifications; network protocols; layered network architecture; the OSI reference model and the TCP/IP protocol suite; networking devices — hubs, switches (managed and unmanaged) and routers.

• **Data Communication:** Analog and digital signals; data-rate limits; digital-to-digital line

encoding; pulse-code modulation; parallel and serial transmission; digital-to-analog modulation; multiplexing (FDM, TDM); transmission media.
• **Switching & Protocol Layers:** Circuit and packet switching (connectionless datagram and connection-oriented virtual circuit); access mechanisms (modems, DSL, cable); multiple-access protocols (CSMA/CD, Ethernet LANs); network-layer functions, IP and routing algorithms; transport-layer services (error and flow control, three-way handshake) and application-layer protocols.

Unit 7 — Software Engineering, Computer Graphics & AI
7.1 Software Engineering
• **Process Models:** Evolving role and characteristics of software; definitions of software engineering; linear/sequential, iterative and incremental development models.
• **Design & Testing:** System models (data-flow, object, inheritance); the design process, methods and quality; architectural design (repository, client-server, abstract-machine and control models); object-oriented and function-oriented design; software reliability and metrics; fault avoidance, tolerance and reuse; white-box and black-box testing; boundary-value analysis; testing strategies and integration (top-down and bottom-up).
7.2 Computer Graphics
• **2-D Graphics:** Graphics systems and applications; raster and random-scan displays; 2-D transformations (translation, scaling, rotation, reflection, shear and composite); the 2-D viewing pipeline and window-to-viewport transformation.
• **3-D Graphics & Clipping:** Line-clipping (Cohen–Sutherland, Cyrus–Beck) and polygon-clipping (Sutherland–Hodgeman) algorithms; 3-D object representation (polygon and quadric surfaces, splines); 3-D transformations, viewing and projection; introduction to virtual reality — components, position trackers, navigation/manipulation interfaces, rendering pipelines (graphical, haptic, OpenGL) and applications.
7.3 Artificial Intelligence
• **Search & Problem Solving:** Definition of AI, the Turing test and a brief history; problem formulation and search space; tree and graph search (BFS, uniform-cost, DFS, depth-limited, iterative deepening); heuristic search (best-first, A*), hill climbing, constraint satisfaction and means-end analysis; game playing (min-max and alpha-beta pruning).
• **Knowledge & Modern AI:** Knowledge representation — propositional and first-order predicate logic, resolution, unification, semantic nets, frames, scripts, production rules and PROLOG; symbolic versus data-driven AI; introduction to machine learning and deep learning; interpretable/explainable AI and the ethics of AI.

M.Sc. Geology — Detailed Syllabus

Detailed unit-wise syllabus compiled by LUUPDATE from the University of Lucknow B.Sc. (NEP) core theory papers, Semesters I–VI. Fourth-year (Sem VII–VIII) and practical papers are excluded. Technical terms are kept in English as used in study material.

Unit 1 — Physical Geology & Geomorphology
1.1 Earth Processes & Landform Science
• **Science of Landforms:** Endogenic and exogenic processes; the geological time scale; scale in geomorphology (temporal and spatial); models of landscape evolution (Davisian cycle, Penck, King and Büdel models); weathering and associated landforms.

• **Wind, Glacial & Periglacial Landforms:** Aeolian landforms (dunes — morphology and classification); glaciers — characteristics, distribution and classification; glacial surface landforms; periglacial landforms (patterned ground, ground-ice phenomena, asymmetrical valleys).

1.2 Surface & Indian Geomorphology

• **Karst, Coastal & Slope Landforms:** Karst topography; coastal landforms (cliffs, beaches, tidal flats, deltas, coastal dunes, reefs); mass-movement processes and slope systems; landforms of igneous activity; introduction to the geomorphology of the Moon and Mars.

• **Fluvial & Indian Geomorphology:** Fluvial landforms (drainage basins, alluvial channels, floodplains, alluvial fans, river terraces); geomorphology of the Indian subcontinent (the Himalaya, the Indo-Gangetic Plain, the Peninsular regions); introduction to the geomorphology of the Indian Ocean.

Unit 2 — Crystallography & Mineralogy

2.1 Crystallography

• **Crystal Morphology:** Laws of crystallography; crystallographic axes; crystal symmetry and symmetry classes; crystallographic notations and Hermann–Mauguin symbols; clinographic and stereographic projections; crystal forms and aggregates; twinning and twin laws.

• **Crystal Systems:** Symmetry and forms in the cubic (galena, pyrite, tetrahedrite types), tetragonal (zircon type), hexagonal (beryl, calcite types), orthorhombic (barytes type), monoclinic (gypsum type) and triclinic (axinite type) systems.

2.2 Mineralogy

• **Mineral Properties:** Definition of a mineral; atomic bonding; silicate structures; physical properties of minerals (colour, lustre, form, hardness, fracture, cleavage, specific gravity); pseudomorphism and polymorphism; mineral characters based on heat, electricity, magnetism and radioactivity; clay minerals — properties and classification.

• **Rock-Forming Minerals:** Physical properties, chemical composition, occurrence and uses of the feldspathoid, amphibole, pyroxene, olivine, mica, garnet, silica and feldspar families.

Unit 3 — Structural Geology & Tectonics

3.1 Deformation, Stress & Strain

• **Stress & Strain:** Introduction to structural geology; crustal processes and the behaviour of the crust during deformation; basic concepts of stress and strain; estimation of strain in naturally deformed rocks; mechanisms of rock deformation; Mohr diagrams.

• **Primary Structures & Folds:** Study of outcrops; identification of bedding; measurement of dip, strike and thickness; concordant and discordant igneous bodies; unconformities — classification, recognition and significance (onlap, offlap); fold morphology and geometric/genetic classification; mechanics of folding, buckling and superposed folding.

3.2 Faults, Fabrics & Plate Tectonics

• **Faults, Joints & Fabrics:** Geometric and genetic classification of faults (normal, reverse, strike-slip) and joints; recognition and dynamics of faulting and its effect on folded beds; foliation and lineation — terminology, origin and relation to major structures; geometry and rock types of shear zones.

• **Tectonics:** Types of tectonites; recognition of top and bottom beds; sea-floor spreading; basic concepts and causes of plate tectonics; mantle plumes and plume mechanics; structure and

tectonic evolution of the Himalaya; anatomy of mountain belts.

Unit 4 — Palaeontology

4.1 Invertebrate Palaeontology

• **Fundamentals:** Introduction to palaeontology; processes of fossilisation; a preliminary idea of the origin of life; trace fossils and their uses.

• **Invertebrate Groups:** Morphology and geological history of Bivalvia, Brachiopoda, Gastropoda, Cephalopoda, Echinoidea, Anthozoa and Trilobita.

4.2 Plant & Vertebrate Palaeontology

• **Palaeobotany & Vertebrates:** Introduction to palaeobotany; important Lower and Upper Gondwana plant fossils; a brief idea of biostratigraphy, palaeobiogeography and palaeoecology; introduction to the evolution of man, horse and elephant; a brief account of the Siwalik vertebrate fauna.

Unit 5 — Igneous & Metamorphic Petrology

5.1 Igneous Petrology

• **Magma & Classification:** Magma emplacement (volcanic, hypabyssal, plutonic) and evolution; Bowen's reaction series; physical properties of magma (temperature, viscosity, density, volatile content); magma formation in the crust and upper mantle; bases of classification and the IUGS classification; textures of igneous rocks; magmatism in different tectonic settings.

• **Phase Equilibria & Petrogenesis:** Binary and ternary phase systems (diopside–anorthite, forsterite–silica, albite–anorthite, albite–orthoclase, diopside–albite–anorthite, forsterite–diopside–silica, nepheline–kalsilite–silica) and their petrogenetic significance; petrogenesis of granitoids, basalts, anorthosite, komatiites, carbonatite, kimberlite and ophiolite.

5.2 Metamorphic Petrology

• **Processes & Facies:** Definition, agents, types and grades of metamorphism; limits of metamorphism; metamorphic processes; structures, textures and classification of metamorphic rocks; nature of metamorphic reactions; isograds and reaction isograds; metamorphic facies and facies series; metamorphism of pelitic rocks; mineralogical phase rule; ACF, AKF and AFM projections.

• **Advanced Topics:** Metasomatism; origin and structure of migmatites; regional metamorphism and its relation to plate tectonics; paired metamorphic belts; the Pressure–Temperature–time (P–T–t) path; introduction to ultrahigh-pressure (UHP) and ultrahigh-temperature (UHT) metamorphism.

Unit 6 — Sedimentology & Stratigraphy

6.1 Sedimentology

• **Sedimentary Rocks:** Origin of sedimentary rocks; sediment grain parameters; classification of sedimentary rocks; diagenesis and lithification; fluid dynamics (laminar and turbulent flow, Reynolds and Froude numbers, entrainment velocity); bedforms and flow regimes; texture of clastic rocks.

• **Structures & Environments:** Sedimentary structures (physical, chemical and biological); terrigenous clastics and chemically precipitated rocks and their classification; concept of facies and Walther's law; shallow-marine, fluvial, deltaic and deep-sea systems.

6.2 Stratigraphy

• **Principles:** Basic concepts and principles of stratigraphy; lithostratigraphic, chronostratigraphic and biostratigraphic units; concepts of magnetostratigraphy, chemostratigraphy and event stratigraphy.
• **Stratigraphy of India:** Archaean successions (Dharwar Supergroup, Singhbhum and Bundelkhand cratons); Proterozoic successions (Cuddapah and Vindhyan Supergroups, Kaladgi, Kurnool, Bhima, Marwar); Precambrian–Cambrian boundary; Gondwana Supergroup; Palaeozoic and Triassic successions; Jurassic (Kutch) and Cretaceous (Trichinopoly, Deccan Traps) successions; the K–T boundary; Cenozoic stratigraphy (Assam and Siwalik Groups); the Quaternary, Meghalayan Stage and Anthropocene.

Unit 7 — Applied Geology
7.1 Remote Sensing & Engineering Geology
• **Remote Sensing:** Concepts and geological applications of remote sensing; types and acquisition of aerial photographs; scale and resolution; Indian Remote Sensing satellite missions.
• **Engineering Geology:** Introduction to the geotechnical properties of rocks; geological considerations for geo-engineered structures; landslides — classification and mitigation.
7.2 Hydrogeology & Environmental Geology
• **Hydrogeology:** The hydrological cycle; groundwater and its vertical distribution; aquifers and geological considerations; rainwater harvesting; river and groundwater pollution.
• **Environmental Geology:** Concept of environmental geology; geological hazards (earthquakes, floods, tsunamis and cyclones); processes of soil formation, soil types and degradation; environmental change due to anthropogenic activity.

Unit 8 — Economic Geology & Mineral Exploration
(Semester VI optional elective — indicative scope. Refer to the official paper for the exact unit breakdown.)
8.1 Economic Geology
• **Ore Deposits:** Ore, gangue, tenor and grade; processes of formation of mineral deposits (magmatic, hydrothermal, sedimentary, residual and metamorphic); classification of mineral deposits; controls of ore localisation.
• **Indian Mineral Resources:** Distribution, mode of occurrence and uses of important metallic and non-metallic mineral deposits of India; fuel resources — coal and petroleum; an overview of India's mineral wealth.
8.2 Mineral Exploration & Gemmology
• **Exploration Methods:** Principles and stages of mineral exploration; geological, geophysical and geochemical prospecting methods; sampling, ore reserve estimation and an introduction to mining.
• **Gemmology:** Properties, classification and identification of gemstones; precious and semi-precious stones; an overview of the gem industry.

M.Sc. Mathematics — Detailed Syllabus

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Unit 1 — Calculus & Real Analysis

1.1 Differential Calculus

• **Limits & Continuity:** Limit, continuity and differentiability of functions of one variable; Cauchy's and Heine's definitions; uniform continuity; Bolzano's, boundedness, intermediate-value and extreme-value theorems; Darboux's theorem; chain rule; indeterminate forms.

• **Mean-Value Theorems & Expansions:** Rolle's theorem; Lagrange and Cauchy mean-value theorems and higher-order MVTs; Taylor's theorem with remainders; successive differentiation and Leibnitz's theorem; Maclaurin and Taylor series; limit, continuity and differentiability of functions of two variables.

• **Partial Differentiation & Curves:** Partial differentiation; Euler's theorem on homogeneous functions; Schwarz's and Young's theorems; maxima and minima of two variables; Lagrange multipliers; Jacobians; inverse- and implicit-function theorems; tangents, normals, asymptotes, curvature, envelopes and evolutes; concavity, points of inflexion and curve tracing (Cartesian, polar and parametric).

1.2 Integral Calculus

• **Riemann Integration:** Definite integral as the limit of a sum; Riemann integrability of continuous and monotonic functions; fundamental theorem and mean-value theorems of integral calculus; differentiation under the integral sign.

• **Improper Integrals & Special Functions:** Improper integrals — classification and convergence; comparison, μ-, Abel's, Dirichlet's and quotient tests; beta and gamma functions; rectification, volumes and surfaces of revolution; Pappus theorem; multiple integrals, change of order, Dirichlet's and Liouville's theorems.

• **Vector Calculus:** Vector differentiation — gradient, divergence and curl; directional derivative; vector integration; theorems of Gauss, Green and Stokes.

1.3 Sequences & Series

• **Convergence:** Sequences, limits, bounded and monotonic sequences, Cauchy's criterion, limit superior/inferior and subsequences; series of non-negative terms; comparison, Cauchy integral, ratio, root, Raabe's and De Morgan–Bertrand tests; alternating series and Leibnitz's theorem; absolute and conditional convergence; pointwise and uniform convergence of sequences and series of functions.

Unit 2 — Algebra

2.1 Matrices & Linear Systems

• **Matrices:** Elementary operations; rank; echelon and normal forms; inverse by elementary operations; systems of linear (homogeneous and non-homogeneous) equations and consistency; eigenvalues, eigenvectors and the characteristic equation; Cayley–Hamilton theorem.

2.2 Group Theory

• **Groups:** Equivalence relations and partitions; congruence modulo n; groups, subgroups, cyclic groups and generators; coset decomposition; Lagrange's theorem; Fermat and Euler theorems; normal subgroups and quotient groups; homomorphism and isomorphism theorems; permutation groups, the alternating group and Cayley's theorem; group actions, Burnside's lemma, the class equation and Sylow theorems.

2.3 Ring & Field Theory

• **Rings & Fields:** Rings and their types (commutative, with unity, division rings, integral domains,

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fields); subrings; characteristic of a ring; ideals and quotient rings; ring homomorphism; field of quotients; prime and maximal ideals; Euclidean rings, principal ideal rings, polynomial rings, the Eisenstein criterion and unique factorisation domains.

2.4 Linear Algebra

• **Vector Spaces & Transformations:** Vector spaces and subspaces; linear independence; basis and dimension; quotient spaces; linear transformations, direct sums and the algebra of linear transformations; rank–nullity theorem and matrix representation; linear functionals and dual spaces; characteristic values; inner-product spaces, Cauchy–Schwarz inequality, orthonormal sets, Bessel's inequality and the Gram–Schmidt process; bilinear and quadratic forms.

Unit 3 — Complex Analysis

3.1 Analytic Functions

• **Analyticity:** Stereographic projection; continuity and differentiability of complex functions; analytic functions; Cauchy–Riemann equations; harmonic functions.

3.2 Integration, Series & Residues

• **Complex Integration:** Complex integration; Cauchy–Goursat theorem; Cauchy's integral formula and the formulae for derivatives; Cauchy's inequality; Liouville's theorem; elementary functions; conformal mapping and Möbius transformations.

• **Series & Residues:** Taylor and Laurent series; convergence of sequences and series of functions; Weierstrass M-test; radius of convergence; zeros, poles and singularities; residues and the residue theorem; maximum- and minimum-modulus theorems; Schwarz's lemma; Hadamard's three-circle theorem.

Unit 4 — Differential Equations & Mathematical Methods

4.1 Ordinary Differential Equations

• **First-Order ODEs:** Variable-separable, linear and Bernoulli equations; exact equations and integrating factors; equations of the first order and higher degree; Clairaut's equation; singular solutions; orthogonal trajectories.

• **Higher-Order ODEs & Systems:** Linear ODEs with constant coefficients; Wronskian and its applications; second-order equations with variable coefficients (known-solution method, normal form, undetermined coefficients, variation of parameters); systems of first-order equations; phase plane, critical points and stability; Liapunov's direct method; series solutions; Bessel, Legendre and hypergeometric functions.

4.2 Partial Differential & Integral Equations

• **PDEs:** Origin and solution of first-order PDEs — Lagrange's method, Cauchy's method of characteristics and Charpit's method; second- and higher-order PDEs with constant and variable coefficients; classification; Monge's method.

• **Integral Equations:** Definition and classification; special kernels; eigenvalues and eigenfunctions; separable kernels; Fredholm and Volterra equations; Fredholm theorems and the Fredholm alternative; method of successive approximations; resolvent kernel.

4.3 Mathematical Methods

• **Transforms & Calculus of Variations:** Laplace transforms — existence, properties, transforms of derivatives and integrals, convolution theorem, inverse transforms and solution of differential equations; Fourier series and transforms (finite and infinite); Fourier integral; calculus of variations — Euler's equation, extremals, functionals with higher derivatives and several variables, and

variational problems in parametric form.

Unit 5 — Geometry, Differential Geometry & Tensor Analysis

5.1 Analytical Geometry

• **Conics & Conicoids:** General equation of the second degree; system of conics, tracing of conics, confocal and polar conics; three-dimensional coordinates, direction cosines, the plane and the straight line (Cartesian and vector forms); sphere, cone and cylinder; central conicoids, paraboloids, plane sections, generating lines, confocal conicoids and reduction of the second-degree equation.

5.2 Differential Geometry

• **Curves & Surfaces:** Local theory of space and plane curves; tangent, normal and binormal; osculating, normal and rectifying planes; helices; the Serret–Frenet apparatus; involutes, evolutes and Bertrand curves; first fundamental form and arc length; families of curves; geodesics and geodesic curvature; the Gauss–Bonnet theorem; normal, mean and Gaussian curvature; Meusnier's theorem; lines of curvature; Rodrigues' formula and Euler's theorem.

5.3 Tensor Analysis

• **Tensors:** Tensor algebra — vector and dual spaces, tensor products, contraction, inner product and associated tensors; contravariant, covariant and mixed tensors; symmetric and skew-symmetric tensors; the quotient theorem; Christoffel symbols and covariant differentiation; gradient, divergence, curl and Laplacian in tensor form; Riemannian space, the curvature and Ricci tensors, scalar curvature, Einstein space and tensor, and geodesics.

Unit 6 — Mechanics & Numerical Analysis

6.1 Mechanics

• **Statics:** Frame of reference; work–energy principle; forces in three dimensions; Poinsot's central axis; wrenches; null lines and planes; virtual work; stable and unstable equilibrium; catenary and catenary of uniform strength.

• **Dynamics:** Velocities and accelerations in radial–transverse and tangential–normal directions; simple harmonic motion; motion under various laws of force; elastic strings; motion in a resisting medium; constrained motion; motion of varying mass and rocket motion; central orbits and Kepler's laws; motion in three dimensions; rotating frames and the rotating Earth.

6.2 Numerical Analysis

• **Equations & Interpolation:** Solution of equations — bisection, secant, regula-falsi, Newton–Raphson and Newton's method for multiple roots; interpolation — Lagrange and Hermite; difference schemes and divided differences.

• **Integration & Numerical ODEs:** Numerical differentiation and quadrature (Newton–Cotes, Gaussian); systems of linear equations — Gauss elimination, LU and Cholesky decomposition, Jacobi, Gauss–Seidel and relaxation methods; the algebraic eigenvalue problem (Jacobi, Givens and power methods); numerical solution of ODEs (Euler, Runge–Kutta, Milne–Simpson); least-squares and Chebyshev approximation; difference equations.

Unit 7 — Discrete Mathematics, Number Theory & Operations Research

(Semester VI optional electives — any one is chosen in the UG programme; all three are summarised here as they may feature in the entrance.)

7.1 Discrete Mathematics

• **Logic & Boolean Algebra:** Propositional and predicate logic; logical connectives, truth tables, tautologies and normal forms; modus ponens and modus tollens; quantifiers and methods of proof; Boolean algebra, sum-of-products and product-of-sums, duality, logic gates and Karnaugh maps; lattices and their types.
• **Combinatorics & Automata:** Inclusion–exclusion principle; recurrence relations and generating functions; finite automata — DFA, NDFA, Mealy and Moore machines and minimisation.
7.2 Number Theory
• **Number Theory:** Divisibility and the Euclidean algorithm; primes; congruences; Fermat's, Euler's and Wilson's theorems; solutions of congruences and the Chinese remainder theorem; Euler's phi-function; primitive roots; quadratic residues, Legendre and Jacobi symbols and quadratic reciprocity; Diophantine equations and Pythagorean triples; generating functions and recurrence relations.
7.3 Operations Research
• **Linear Programming:** Formulation of LP problems; slack and surplus variables; standard and matrix forms; basic feasible solutions; convex sets; the simplex method; artificial variables, Big-M and two-phase methods; revised simplex; resolution of degeneracy; duality and the dual simplex method; integer programming.
• **OR Applications:** Transportation and assignment problems; queuing theory; Markov chains; PERT and CPM; constrained optimisation using Lagrange multipliers.

M.Sc. Physics — Detailed Syllabus

Detailed unit-wise syllabus compiled by LUUPDATE from the University of Lucknow B.Sc. (NEP) core theory papers, Semesters I–VI. Fourth-year (Sem VII–VIII) and practical papers are excluded. Technical terms are kept in English as used in study material.

Unit 1 — Mechanics, Oscillations & Waves
1.1 Newtonian & Relativistic Mechanics
• **Frames & Relativity:** Galilean transformations and their relation to Newton's laws; strong and weak forms of the third law; inertial and non-inertial frames; Mach's principle; the Michelson–Morley experiment; postulates of special relativity; length contraction, time dilation, relativistic energy and momentum.
• **Vector Fields & Forces:** Gradient, divergence and curl; Gauss's divergence and Stokes's theorems; conservative and non-conservative forces; conservation of energy and linear momentum and their link to symmetry; pseudo-forces in rotating frames and the Coriolis force.
1.2 Rigid-Body Dynamics & Elasticity
• **Collisions & Rotation:** Elastic and inelastic collisions in one and two dimensions; centre-of-mass (zero-momentum) frame; angular momentum and torque; rotational energy and the inertia tensor; moment of inertia of standard bodies; combined translational and rotational motion on planes.
• **Elasticity:** Relations between elastic constants; twisting of hollow and solid cylinders and torsional rigidity; bending moment and flexural rigidity; depression of cantilever and supported beams.
1.3 Gravitation, Oscillations & Waves
• **Central Forces & Gravitation:** Two-body central-force problem and reduced mass; Kepler's laws and planetary/satellite motion; role of the inverse-square law in determining orbits;

geosynchronous and geostationary satellites; elementary GPS; motion of the galaxy under self-gravity.
• **Oscillations & Waves:** Simple harmonic motion (differential equation and complex notation); damped and forced oscillations; sharpness of resonance and quality factor; plane progressive waves and energy transport; reflection and phase change at boundaries; superposition, standing waves and resonance; phase and group velocity.

Unit 2 — Optics
2.1 Interference
• **Coherence & Interference:** Electromagnetic nature of light; superposition; spatial and temporal coherence; division of wavefront (Young's double slit, Fresnel biprism, Lloyd's mirror); division of amplitude (thin films, Newton's rings); Michelson and Fabry–Pérot interferometers and the etalon.
2.2 Diffraction & Resolution
• **Diffraction:** Fresnel diffraction — half-period zones, zone plate, straight edge and narrow wire; Fraunhofer diffraction — circular aperture, single and double slits, diffraction grating, principal maxima and missing orders.
• **Resolving Power:** Rayleigh's criterion of resolution; resolving power of grating and telescope.
2.3 Polarization
• **Polarization:** Polarization by reflection, Brewster's law and Malus's law; dichroism and birefringence; Nicol prism, retardation plates and Babinet compensator; optical activity and Fresnel's explanation; specific rotation; half-shade and biquartz polarimeters; Jones-matrix representation of polarizers, retarders and rotators.

Unit 3 — Electricity, Magnetism & Electromagnetic Theory
3.1 Electrostatics & Dielectrics
• **Electrostatics:** Electric charge and charge densities; Coulomb's law; electric field and flux; Gauss's law; divergence and curl of E; electric potential and the field as its negative gradient; potential and field of dipoles and quadrupoles; force and torque on a dipole; electrostatic energy of a charge configuration.
• **Dielectrics:** Polarization and the polarization vector; bound charges; the displacement vector D; susceptibility and dielectric constant; relation between E, P and D; Lorentz local field; Clausius–Mossotti and Debye equations.
3.2 Magnetism & Electromagnetic Induction
• **Magnetostatics:** Biot–Savart and Ampère laws; divergence and curl of B; scalar and vector magnetic potentials; force on a moving charge and a current-carrying wire; torque on a current loop and its dipole moment; magnetization, magnetic intensity, susceptibility and permeability; B–H curve and hysteresis.
• **Induction & EM Waves:** Faraday's and Lenz's laws; non-conservative induced field; self- and mutual inductance; energy stored in a magnetic field; skin effect; Betatron equation and ballistic galvanometer; equation of continuity and displacement current; Maxwell's equations; EM waves in vacuum and dielectrics; transverse nature; energy density and Poynting vector.

Unit 4 — Thermal Physics & Kinetic Theory
4.1 Thermodynamics
• **Laws & Potentials:** Zeroth, first, second and third laws; thermodynamic processes; relation

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between Cp and Cv; work in isothermal and adiabatic processes; reversibility; entropy; Carnot cycle and theorem; Clausius inequality; thermodynamic potentials (enthalpy, Gibbs, Helmholtz, internal energy); Maxwell's relations; Clausius–Clapeyron and TdS equations.

4.2 Real Gases & Kinetic Theory

• **Real Gases:** Deviations from ideal behaviour; the virial equation; Andrews' experiments and critical constants; van der Waals equation of state; law of corresponding states; Joule and Joule–Thomson effects; temperature of inversion.

• **Kinetic Theory:** RMS speed and the kinetic interpretation of temperature; degrees of freedom and the equipartition of energy with applications to specific heats; mean free path; transport phenomena (viscosity, conduction, diffusion); Maxwell's velocity distribution.

4.3 Radiation

• **Black-Body Radiation:** Spectral distribution and energy density; derivation of Planck's law; deduction of Wien's distribution, Rayleigh–Jeans, Stefan–Boltzmann and Wien's displacement laws; the solar constant.

Unit 5 — Quantum Mechanics & Atomic Physics

5.1 Foundations of Quantum Physics

• **Origins of Quantum Theory:** Inadequacy of classical physics; black-body radiation; photoelectric effect; continuous and characteristic X-rays; Compton effect; gravitational red shift; de Broglie waves and the wave function and its interpretation; wave and group velocity; Davisson–Germer experiment; wave–particle duality.

• **Schrödinger Equation:** Heisenberg's uncertainty principle and its applications; the time-dependent Schrödinger equation; eigenvalues and eigenfunctions; probability current; expectation values and Ehrenfest's theorem; boundary conditions and discrete energy levels; particle in a rigid box and the quantum dot; step potential, rectangular barrier and square well.

5.2 Atomic Physics & Spectra

• **Atomic Structure:** Bohr model and the hydrogen spectrum; Franck–Hertz experiment; Sommerfeld elliptic orbits; electron angular momentum and spin; space quantization; Stern–Gerlach experiment; Pauli's exclusion principle; fine structure and spin–orbit coupling; LS and jj coupling schemes; Zeeman effect.

• **Atomic Spectra:** Spin–orbit interaction and doublet separation; term symbols and intensity rules; fine structure of hydrogen lines; optical spectra of alkali and alkaline-earth elements; Hund's rule and Landé interval rule; normal and anomalous Zeeman effect; Paschen–Back effect; hyperfine structure and isotope effect.

Unit 6 — Solid State Physics

6.1 Crystal Structure & Diffraction

• **Crystallography:** Lattice, basis and crystal structure; translation vectors and primitive cells; symmetry operations, point and space groups; 2-D and 3-D Bravais lattices; Miller indices; bcc, fcc, hcp, diamond, NaCl and CsCl structures.

• **Crystal Diffraction:** X-ray diffraction and Bragg's law; Laue, rotating-crystal and powder methods; reciprocal lattice and its relation to the direct lattice; diffraction conditions, Ewald construction and Brillouin zones; atomic form factor and crystal structure factor.

6.2 Bonding, Lattice Vibrations & Electron Theory

• **Binding & Phonons:** Classification of crystal bindings (ionic, covalent, metallic, van der Waals,

hydrogen-bonded); cohesive and Madelung energy; lattice vibrations of monatomic and diatomic chains; dispersion relations and phonons; lattice heat capacity (Dulong–Petit law, Einstein and Debye theories, T^3 law).

• **Electron Theory:** Free-electron theory (Drude model, Wiedemann–Franz law, Fermi energy, density of states, Hall effect); band theory (Bloch theorem, Kronig–Penney model, effective mass, concept of holes, classification of solids).

6.3 Magnetic, Dielectric & Other Properties

• **Material Properties:** Dia-, para-, ferro-, ferri- and antiferromagnetism; Langevin and Weiss theories; domains and hysteresis; dielectric polarization and polarizability; introduction to superconductivity; point defects (Schottky and Frenkel).

Unit 7 — Nuclear & Particle Physics

7.1 Nuclear Properties & Decay

• **Nuclear Properties:** Mass, radii, charge and matter density; binding energy and its variation with mass number; nuclear fission and fusion; the N/Z stability plot; angular momentum, parity and electromagnetic moments; two-nucleon systems (deuteron; N–P, P–P, N–N interactions).

• **Decay & Detectors:** Theory of α-decay; β-decay (neutrino hypothesis, parity violation); γ-decay (internal conversion, nuclear isomerism); compound nucleus and reaction cross-section; interaction of radiation with matter; detectors (GM, proportional, scintillation, semiconductor); accelerators (Van de Graaff, Linac, cyclotron, synchrocyclotron, collider).

7.2 Nuclear Models & Particle Physics

• **Nuclear Models:** Liquid-drop model and the semi-empirical mass formula; single-particle shell model; collective model (vibrational and rotational).

• **Particle Physics:** Particle interactions, types and families; symmetries and conservation laws (energy, momentum, parity, baryon and lepton number, isospin, strangeness); quark model; colour quantum number and gluons; basic idea of the Standard Model.

Unit 8 — Electronics

8.1 Circuits & Devices

• **Circuit Fundamentals:** Transients in LR, RC and LCR circuits; AC circuits, complex impedance and Q-factor; series and parallel resonance; coupled circuits; impedance matching; maximum-power-transfer theorem; AC bridges (Maxwell, Schering, Wien).

• **Diodes:** PN-junction formation and the depletion layer; forward and reverse characteristics; half- and full-wave rectifiers; ripple factor and rectification efficiency; clippers and clampers; Zener diode (avalanche and Zener breakdown); filter circuits and voltage regulation.

8.2 Transistors & Applications

• **Transistors & Amplifiers:** PNP and NPN transistors; CB, CE and CC configurations; current gains; biasing methods; DC load line, Q-point stabilization and thermal runaway; single- and multistage RC-coupled amplifiers and their frequency response.

• **Feedback & Instruments:** Positive and negative feedback; Barkhausen criterion; Hartley oscillator; amplitude modulation and demodulation; multimeter and cathode-ray oscilloscope; component colour codes.

Unit 9 — Molecular Spectroscopy, Lasers, Optoelectronics & Plasma

(Semester V–VI electives — included as they may feature in the entrance.)

9.1 Molecular Spectroscopy

• **Spectroscopy:** Microwave (rotational) spectra of diatomic and polyatomic molecules; infrared (vibrational) spectra and the vibrating rotator; Raman spectroscopy — pure rotational and vibrational Raman spectra, selection rules and P/Q/R branches; electronic spectra of diatomic molecules and the Franck–Condon principle; dissociation energy; ESR, NMR and NQR spectroscopy and their applications.

9.2 Lasers & Optoelectronics

• **Lasers & Non-linear Optics:** Laser theory and light amplification; threshold condition; rate equations (two-, three- and four-level systems); line broadening (natural, collision, Doppler); optical resonators and modes; introduction to non-linear optics — second-harmonic generation, phase matching and self-focusing.

• **Fibre Optics & Devices:** Total internal reflection, acceptance angle and numerical aperture; types of fibre and refractive-index profiles; guided modes and the V-parameter; pulse dispersion and attenuation; LEDs (materials, structures and efficiency); semiconductor lasers and photodetectors.

9.3 Plasma Physics & Space Science

• **Plasma Physics:** Definition and parameters of plasma; Saha's ionization equation; Debye shielding and quasi-neutrality; single-particle drifts; waves in magnetoplasma; kinetic and fluid descriptions; Landau damping; plasma oscillations; applications to nuclear fusion.

• **Space Science:** Atmospheric layers; ionosphere and magnetosphere; structure of the Sun and sunspots; solar wind, flares and coronal mass ejections; space weather; stellar structure and evolution; Chandrasekhar limit; neutron stars and black holes; galaxies; cosmic microwave background and the expansion of the universe.

M.Sc. Statistics — Detailed Syllabus

Detailed unit-wise syllabus compiled by LUUPDATE from the University of Lucknow B.Sc. (NEP) core theory papers, Semesters I–VI. Fourth-year (Sem VII–VIII) and practical papers are excluded. Technical terms are kept in English as used in study material.

Unit 1 — Probability Theory

1.1 Foundations of Probability

• **Basic Concepts:** Random experiment, trial, sample point and sample space; events; mutually exclusive, exhaustive and equally likely events; set theory and algebra of events; classical, relative-frequency and axiomatic definitions of probability and their limitations.

• **Theorems & Bayes' Rule:** Addition theorem of probability for n events; theorem of total probability; Boole's inequality; conditional probability and the multiplication theorem; independent events; Bayes' theorem and its applications.

1.2 Random Variables & Limit Theorems

• **Random Variables:** Discrete and continuous random variables; probability mass and density functions; cumulative distribution function; joint, marginal and conditional distributions; independence of random variables; expectation and its properties; conditional expectation and variance.

• **Limit Theorems:** Moments and the moment-generating function and its properties; continuity theorem for the m.g.f.; Chebyshev's inequality; weak law of large numbers; central limit theorem for i.i.d. random variables and its applications.

Unit 2 — Descriptive Statistics

2.1 Data & Summary Measures

• **Data & Presentation:** Statistical population; attributes and variables; nominal, ordinal, interval and ratio scales; primary and secondary data; questionnaire and schedule design; classification, tabulation and diagrammatic/graphical representation; frequency and cumulative-frequency distributions; histogram, frequency polygon, ogives, stem-and-leaf and box plots.

• **Central Tendency & Dispersion:** Measures of central tendency and dispersion with their merits and demerits; moments and factorial moments; Sheppard's corrections; skewness and kurtosis and their measures; quantile-based measures (quartiles, deciles, percentiles).

2.2 Correlation, Regression & Association

• **Correlation & Regression:** Method of least squares for curve fitting; correlation and regression; correlation for bivariate frequency distributions; rank correlation (Spearman, Kendall); intra-class correlation and correlation ratio; partial and multiple correlation and multiple regression for tri-variate data.

• **Association of Attributes:** Contingency tables, class and ultimate class frequencies; consistency; association and independence of attributes; measures of association for 2×2 tables; Chi-square, Karl Pearson's and Tschuprow's coefficients; contingency tables with ordered categories.

Unit 3 — Probability Distributions & Numerical Methods

3.1 Distribution Theory

• **Univariate Distributions:** Binomial, Poisson, hypergeometric, geometric and negative-binomial; discrete and continuous uniform; normal; exponential, gamma and beta; Cauchy, Laplace, Pareto, Weibull and log-normal distributions; normal and Poisson as limiting cases of the binomial.

• **Sampling Distributions:** Distributions of sums, products and quotients of two variables; χ^2, t and F distributions (central cases), their relationships and limiting forms; bivariate normal distribution and its properties.

3.2 Numerical Analysis

• **Interpolation:** Calculus of finite differences and operators; interpolation formulae with remainder term; Newton's forward, backward, divided-difference and central-difference formulae; Lagrange's interpolation.

• **Numerical Integration:** Derivation of the general quadrature formula for equidistant ordinates; trapezoidal, Simpson's one-third and three-eighth rules; Weddle's rule.

Unit 4 — Statistical Inference

4.1 Estimation

• **Point Estimation:** Characteristics of a good estimator — unbiasedness, consistency, sufficiency and efficiency; method of maximum likelihood and its properties; minimum chi-square, least-squares and method-of-moments estimation; sufficient statistics; Cramér–Rao inequality and MVU estimators.

• **Interval Estimation:** Pivotal quantity and its use in finding confidence intervals; concept of best confidence intervals; variance-stabilizing transformations.

4.2 Testing of Hypotheses

• **Hypothesis Testing:** Simple and composite hypotheses; Type I and Type II errors; significance

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level, p-value and power of a test; Most Powerful (MP), Uniformly Most Powerful (UMP) and UMP Unbiased (UMPU) tests; Neyman–Pearson lemma and its applications; tests based on t, F and χ^2 distributions; likelihood-ratio tests and their reduction to standard tests; large-sample tests.

Unit 5 — Sampling Techniques

5.1 Basic Sampling Methods

• **Simple Random Sampling:** Sampling versus complete enumeration; sampling units and frame; precision and efficiency of estimators; simple random sampling with and without replacement; use of random-number tables; estimation of population mean and proportion and their variances; sample-size determination.

• **Stratified & Systematic Sampling:** Stratified random sampling; proportional and optimum allocation; gain in precision due to stratification; role of cost in allocation; minimization of variance for fixed cost; systematic sampling and estimation of population mean and total.

5.2 Advanced Estimation Methods

• **Ratio, Regression & Cluster Sampling:** Ratio and regression methods of estimation in simple random sampling; cluster sampling with equal and unequal clusters; double sampling in the ratio method; two-stage and multi-stage sampling; non-sampling errors.

Unit 6 — Analysis of Variance & Design of Experiments

6.1 Analysis of Variance

• **ANOVA:** Analysis of variance — one-way and two-way classification with model assumptions; Duncan's multiple-comparison test; analysis of covariance.

6.2 Design of Experiments

• **Basic Designs:** Principles of design — randomization, replication and local control; choice of plot size and type using uniformity trials; completely randomized design (CRD) and randomized block design (RBD); efficiency of a design and comparison of CRD and RBD; Latin square design (LSD), layout and ANOVA; efficiency comparisons; missing-plot technique in RBD and LSD.

• **Factorial Experiments:** General description of factorial experiments; 2^2, 2^3 and 2^n factorial experiments; main effects and interactions in 2^2 and 2^3 experiments; ANOVA by Yates' procedure; estimates and tests for main and interaction effects (analysis without confounding).

Unit 7 — Regression, Multivariate & Non-Parametric Methods

7.1 Multivariate & Regression Analysis

• **Multivariate Normal:** Multivariate normal distribution; marginal and conditional distributions; moment-generating and characteristic functions; maximum-likelihood estimation of the mean vector and covariance matrix; distribution of linear combinations of components.

• **Linear Regression:** Linear regression model of full rank; least-squares theory; OLS and ML estimation of β and tests of hypotheses; R^2 and adjusted R^2; ANOVA table for regression.

7.2 Order Statistics & Non-Parametric Tests

• **Order Statistics:** Distributions of the minimum, maximum and rth order statistic; joint distribution of the rth and sth order statistics; distribution of the sample range and median; confidence intervals for quantiles; tolerance and coverage.

• **Non-Parametric Tests:** Tests for randomness and goodness of fit; one-sample tests (sign test, Wilcoxon signed-rank); two-sample tests (run test, Kolmogorov–Smirnov, median test, Mann–Whitney U, Mood and Sukhatme tests).

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Unit 8 — Statistical Quality Control, Educational & Applied Statistics

8.1 Statistical Quality Control

• **Control Charts & Inspection:** Process control; control charts for variables and attributes; modified, group and CUSUM charts and V-mask; sampling inspection by attributes — single and double sampling plans; producer's and consumer's risk; OC, ASN, ATI, AOQL and LTPD functions; sampling inspection by variables.

8.2 Educational Statistics

• **Test Theory & Scaling:** Scaling procedures — scaling of test items and scores, scaling by the normal curve, percentile, z- and t-scores; test theory, parallel tests and true score; reliability (parallel-test, test–retest, split-half, Kuder–Richardson, Cronbach's α) and validity; tetrachoric, biserial and point-biserial correlation.

8.3 Applied Statistics

• **Time Series & Index Numbers:** Components of a time series; additive, multiplicative and mixed models; trend determination and seasonal indices; index numbers — Laspeyres, Paasche, Fisher and Marshall–Edgeworth; tests for a good index number; consumer price index.

• **Demography:** Sources of demographic data; measurement of fertility (CBR, GFR, ASFR, TFR, GRR, NRR); measurement of mortality (CDR, ASDR, IMR, standardized death rates); life tables and their construction.

Unit 9 — Operations Research, Queueing & Computational Statistics

(Semester V–VI electives — included as they may feature in the entrance.)

9.1 Operations Research

• **Linear Programming & Allocation:** Formulation of LP problems; graphical, simplex, Big-M and two-phase methods; duality; transportation problem (North-West corner, least-cost, Vogel's approximation, stepping-stone, MODI); assignment problem and the Hungarian algorithm.

• **Inventory & Sequencing:** Inventory control and deterministic EOQ models (with and without shortages); job sequencing (n jobs–2/k machines, 2 jobs–n machines); dynamic programming and Bellman's principle of optimality.

9.2 Queueing Theory & Network Analysis

• **Queueing & Networks:** Elements and classification of queueing systems; distributions of arrivals, service and departures; models (M/M/1):(∞/FCFS), (M/M/1):(N/FCFS) and (M/M/C):(∞/FCFS); Little's formula; network analysis — minimum spanning tree, shortest-route and maximal-flow problems; project management (PERT/CPM, floats, time charts).

9.3 Computational Statistics

• **R, SPSS & Programming:** Introduction to computers and number systems; R programming and RStudio — data structures, data input and management; descriptive and inferential statistics, parametric and non-parametric tests, ANOVA, correlation and regression in R and SPSS; introduction to programming with C/C++ (data types, operators, control structures, arrays, functions, pointers and files).

M.Sc. Zoology — Detailed Syllabus

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Unit 1 — Diversity & Biology of Non-Chordates

1.1 Lower Invertebrates

• **Protozoa, Porifera & Cnidaria:** General characters and classification up to order level; type study of Paramecium caudatum; life cycle and pathogenicity of Plasmodium vivax and Leishmania donovani; type study of Sycon, canal system and skeleton in sponges; type study of Obelia geniculata; corals and coral reefs.

• **Helminths & Annelids:** Platyhelminthes — life cycle and pathogenicity of Fasciola hepatica and Taenia solium, parasitic adaptations; Nematoda — life cycle and pathogenicity of Wuchereria bancrofti; Annelida — type study of Nereis and the coelom.

1.2 Higher Invertebrates

• **Arthropoda & Mollusca:** Arthropoda — type study of Palaemon and grasshopper (Schistocerca); Mollusca — type study of Pila globosa and pearl formation in bivalves.

• **Echinodermata & Hemichordata:** Echinodermata — type study of Asterias; Hemichordata — type study of Balanoglossus and its affinities.

Unit 2 — Diversity & Biology of Chordates

2.1 Protochordates & Lower Vertebrates

• **Protochordates:** General characters and classification of Chordata; origin of chordates; Urochordata (Herdmania) and Cephalochordata (Branchiostoma) — type study, affinities and systematic position.

• **Fishes & Amphibians:** Agnatha; Pisces — type study of Scoliodon, accessory respiratory organs and migration; Amphibia — parental care, neoteny and paedogenesis.

2.2 Higher Vertebrates

• **Reptiles & Birds:** Reptilia — affinities of Sphenodon, venomous and non-venomous snakes of India and their biting mechanism, dinosaurs; Aves — Archaeopteryx as a connecting link, types of feathers, flight adaptations and migration.

• **Mammals & Comparative Anatomy:** Mammalia — dentition, affinities of Prototheria and adaptive radiation of locomotory appendages; comparative functional anatomy of vertebrate sense organs.

Unit 3 — Biosystematics & Evolutionary Biology

3.1 Biosystematics & Taxonomy

• **Taxonomy:** Definition, concepts and importance of taxonomy and biosystematics; types and operation of taxonomy; International Code of Zoological Nomenclature (ICZN); Linnaean hierarchy; theories of biological classification; collection and preservation of specimens; process of identification and description; molecular techniques in systematics.

3.2 Evolution

• **Theories & Mechanisms:** Theories of evolution (Lamarckism, Darwinism, modern synthetic theory); mechanisms of evolution — mutation, genetic drift, gene flow, non-random mating, natural selection and molecular drive; Hardy–Weinberg law; biological species concept; modes of speciation (allopatric, parapatric, sympatric).

• **Evidence & Patterns:** Palaeobiological evidence — stratigraphy, the geological timescale, fossil types, formation and dating; anatomical evidence — vestigial, homologous and analogous organs; transitional forms and living fossils; evolutionary patterns (divergent, convergent, parallel).

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Unit 4 — Ecology, Environmental Biology & Toxicology

4.1 Ecology

• **Ecosystem & Populations:** Ecology and ecological hierarchy; ecosystem concept, types and structural components; energy flow and biogeochemical cycles; trophic levels, food chain and food web; population characteristics, growth and regulation; interspecific interactions; ecological succession and niche; r- and K-strategies; ecological adaptations (aquatic, volant, arboreal, cursorial, fossorial, desert).

4.2 Environmental Biology

• **Pollution & Management:** Environmental pollution — causes, consequences and management of air, water, soil, radiation, noise and light pollution; greenhouse effect, ozone depletion and acid rain; environmental footprints; environmental legislation (Environment Protection Act 1986, National Green Tribunal Act 2010) and UNEP; environmental monitoring and waste management (sanitary landfill, composting, incineration, pyrolysis).

4.3 Toxicology

• **Toxicants & Effects:** Routes, frequency and duration of exposure; dose–response relationship; selective toxicity; toxicity tests (bioassay, acute and chronic), MATC and safe concentration; toxic effects of xenobiotics (local/systemic, reversible/irreversible); bioconcentration, bioaccumulation and biomagnification; biotransformation; toxic effects on body systems; mutagenicity, teratogenicity, carcinogenicity and toxicogenomics.

Unit 5 — Animal Physiology & Behaviour

5.1 Animal Physiology

• **Nutrition, Respiration & Circulation:** Physiology of digestion and absorption of proteins, carbohydrates and lipids; role of gastrointestinal hormones; respiratory pigments, oxygen-dissociation curve and Bohr effect; respiratory volumes and transport of O_2 and CO_2; composition of blood, blood groups and Rh factor; mechanism of blood coagulation; cardiac cycle.

• **Excretion, Nerve, Muscle & Endocrine:** Structure of the nephron, urine formation and osmoregulation; structure of the neuron, conduction of the nerve impulse, synapse and neurotransmitters; types of muscle and the mechanism of skeletal-muscle contraction; structure and function of endocrine glands (pituitary, pineal, thyroid, parathyroid, pancreas, adrenal, gonads); physiology of reproduction.

5.2 Animal Behaviour & Chronobiology

• **Behaviour & Biological Rhythms:** Types of animal behaviour; innate behaviour, learning and conditioning; social behaviour and communication; biological rhythms and the concept of the biological clock; circadian rhythms and their significance.

Unit 6 — Cell Biology, Genetics & Cytogenetics

6.1 Cell Biology

• **Cell Structure & Division:** Plasma membrane and cell–cell interactions (adhesion molecules, cellular junctions); endomembrane system and protein targeting; cytoskeleton (microtubules, microfilaments, intermediate filaments); mitochondria, peroxisome and ribosome; nucleus and chromatin structure; chromosome types (polytene, lampbrush), heterochromatin and euchromatin; cell cycle, cell division (mitosis and meiosis) and its regulation.

6.2 Genetics

• **Mendelian & Beyond:** Mendel's laws of inheritance; complete and incomplete dominance and codominance; linkage and crossing over; sex determination, sex-linked inheritance and dosage compensation; sex-influenced and sex-limited traits; multiple alleles and gene–gene interactions; cytoplasmic inheritance and genomic imprinting; inheritance of continuous and threshold characters; chromosomal and gene mutations; pedigree analysis and hereditary diseases of man.

Unit 7 — Molecular Biology & Biotechnology

7.1 Molecular Biology

• **Nucleic Acids & Gene Expression:** Structure and types of DNA and RNA; DNA replication; the central dogma and the genetic code; transcription, translation and RNA processing; gene regulation.

7.2 Biotechnology

• **Recombinant DNA Technology:** Concept and scope of biotechnology; recombinant DNA technology; cloning vectors (plasmid, cosmid, lambda bacteriophage); restriction enzymes; construction of genomic and cDNA libraries; transformation techniques; PCR, RFLP, RAPD, AFLP and DNA fingerprinting; DNA microarray and sequencing; Southern, northern and western blotting.

• **Applications:** Animal cell culture and expression of cloned genes; molecular diagnosis of genetic diseases (cystic fibrosis, sickle-cell anaemia); recombinant insulin and human growth hormone; gene therapy; production of cloned and transgenic animals (nuclear transplantation, retroviral method, DNA microinjection); applications of transgenic animals; the Human Genome Project.

Unit 8 — Developmental Biology & Immunology

8.1 Developmental Biology

• **Embryonic Development:** Gametogenesis (spermatogenesis and oogenesis); fertilization (external and internal); egg structure and types; morphogenesis and morphogens; cleavage, blastulation, fate maps and gastrulation; stem cells and cell lineage; chick-embryo development up to primitive-streak formation; embryonic induction and organizers; extra-embryonic membranes; placenta (types and physiology); modes and mechanisms of regeneration.

8.2 Immunology

• **Immune System:** Concept and types of immunity; cells and organs of the immune system; immunoglobulins (types and structure of the different classes); antigen–antibody interactions; autoimmunity; major histocompatibility complex; cytokines (properties and functions); hybridoma technology and monoclonal antibodies.

M.Sc. Applied Geology — Detailed Syllabus

Detailed unit-wise syllabus compiled by LUUPDATE from the University of Lucknow B.Sc. (NEP) core theory papers, Semesters I–VI. Fourth-year (Sem VII–VIII) and practical papers are excluded. Technical terms are kept in English as used in study material.

Unit 1 — Physical Geology & Geomorphology

1.1 Earth Processes & Landform Science

• **Science of Landforms:** Endogenic and exogenic processes; the geological time scale; scale in geomorphology (temporal and spatial); models of landscape evolution (Davisian cycle, Penck,

King and Büdel models); weathering and associated landforms.
• **Wind, Glacial & Periglacial Landforms:** Aeolian landforms (dunes — morphology and classification); glaciers — characteristics, distribution and classification; glacial surface landforms; periglacial landforms (patterned ground, ground-ice phenomena, asymmetrical valleys).
1.2 Surface & Indian Geomorphology
• **Karst, Coastal & Slope Landforms:** Karst topography; coastal landforms (cliffs, beaches, tidal flats, deltas, coastal dunes, reefs); mass-movement processes and slope systems; landforms of igneous activity; introduction to the geomorphology of the Moon and Mars.
• **Fluvial & Indian Geomorphology:** Fluvial landforms (drainage basins, alluvial channels, floodplains, alluvial fans, river terraces); geomorphology of the Indian subcontinent (the Himalaya, the Indo-Gangetic Plain, the Peninsular regions); introduction to the geomorphology of the Indian Ocean.

Unit 2 — Crystallography & Mineralogy
2.1 Crystallography
• **Crystal Morphology:** Laws of crystallography; crystallographic axes; crystal symmetry and symmetry classes; crystallographic notations and Hermann–Mauguin symbols; clinographic and stereographic projections; crystal forms and aggregates; twinning and twin laws.
• **Crystal Systems:** Symmetry and forms in the cubic (galena, pyrite, tetrahedrite types), tetragonal (zircon type), hexagonal (beryl, calcite types), orthorhombic (barytes type), monoclinic (gypsum type) and triclinic (axinite type) systems.
2.2 Mineralogy
• **Mineral Properties:** Definition of a mineral; atomic bonding; silicate structures; physical properties of minerals (colour, lustre, form, hardness, fracture, cleavage, specific gravity); pseudomorphism and polymorphism; mineral characters based on heat, electricity, magnetism and radioactivity; clay minerals — properties and classification.
• **Rock-Forming Minerals:** Physical properties, chemical composition, occurrence and uses of the feldspathoid, amphibole, pyroxene, olivine, mica, garnet, silica and feldspar families.

Unit 3 — Structural Geology & Tectonics
3.1 Deformation, Stress & Strain
• **Stress & Strain:** Introduction to structural geology; crustal processes and the behaviour of the crust during deformation; basic concepts of stress and strain; estimation of strain in naturally deformed rocks; mechanisms of rock deformation; Mohr diagrams.
• **Primary Structures & Folds:** Study of outcrops; identification of bedding; measurement of dip, strike and thickness; concordant and discordant igneous bodies; unconformities — classification, recognition and significance (onlap, offlap); fold morphology and geometric/ genetic classification; mechanics of folding, buckling and superposed folding.
3.2 Faults, Fabrics & Plate Tectonics
• **Faults, Joints & Fabrics:** Geometric and genetic classification of faults (normal, reverse, strike-slip) and joints; recognition and dynamics of faulting and its effect on folded beds; foliation and lineation — terminology, origin and relation to major structures; geometry and rock types of shear zones.
• **Tectonics:** Types of tectonites; recognition of top and bottom beds; sea-floor spreading; basic

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concepts and causes of plate tectonics; mantle plumes and plume mechanics; structure and tectonic evolution of the Himalaya; anatomy of mountain belts.

Unit 4 — Palaeontology

4.1 Invertebrate Palaeontology

• **Fundamentals:** Introduction to palaeontology; processes of fossilisation; a preliminary idea of the origin of life; trace fossils and their uses.

• **Invertebrate Groups:** Morphology and geological history of Bivalvia, Brachiopoda, Gastropoda, Cephalopoda, Echinoidea, Anthozoa and Trilobita.

4.2 Plant & Vertebrate Palaeontology

• **Palaeobotany & Vertebrates:** Introduction to palaeobotany; important Lower and Upper Gondwana plant fossils; a brief idea of biostratigraphy, palaeobiogeography and palaeoecology; introduction to the evolution of man, horse and elephant; a brief account of the Siwalik vertebrate fauna.

Unit 5 — Igneous & Metamorphic Petrology

5.1 Igneous Petrology

• **Magma & Classification:** Magma emplacement (volcanic, hypabyssal, plutonic) and evolution; Bowen's reaction series; physical properties of magma (temperature, viscosity, density, volatile content); magma formation in the crust and upper mantle; bases of classification and the IUGS classification; textures of igneous rocks; magmatism in different tectonic settings.

• **Phase Equilibria & Petrogenesis:** Binary and ternary phase systems (diopside–anorthite, forsterite–silica, albite–anorthite, albite–orthoclase, diopside–albite–anorthite, forsterite–diopside–silica, nepheline–kalsilite–silica) and their petrogenetic significance; petrogenesis of granitoids, basalts, anorthosite, komatiites, carbonatite, kimberlite and ophiolite.

5.2 Metamorphic Petrology

• **Processes & Facies:** Definition, agents, types and grades of metamorphism; limits of metamorphism; metamorphic processes; structures, textures and classification of metamorphic rocks; nature of metamorphic reactions; isograds and reaction isograds; metamorphic facies and facies series; metamorphism of pelitic rocks; mineralogical phase rule; ACF, AKF and AFM projections.

• **Advanced Topics:** Metasomatism; origin and structure of migmatites; regional metamorphism and its relation to plate tectonics; paired metamorphic belts; the Pressure–Temperature–time (P–T–t) path; introduction to ultrahigh-pressure (UHP) and ultrahigh-temperature (UHT) metamorphism.

Unit 6 — Sedimentology & Stratigraphy

6.1 Sedimentology

• **Sedimentary Rocks:** Origin of sedimentary rocks; sediment grain parameters; classification of sedimentary rocks; diagenesis and lithification; fluid dynamics (laminar and turbulent flow, Reynolds and Froude numbers, entrainment velocity); bedforms and flow regimes; texture of clastic rocks.

• **Structures & Environments:** Sedimentary structures (physical, chemical and biological); terrigenous clastics and chemically precipitated rocks and their classification; concept of facies and Walther's law; shallow-marine, fluvial, deltaic and deep-sea systems.

6.2 Stratigraphy

• **Principles:** Basic concepts and principles of stratigraphy; lithostratigraphic, chronostratigraphic and biostratigraphic units; concepts of magnetostratigraphy, chemostratigraphy and event stratigraphy.

• **Stratigraphy of India:** Archaean successions (Dharwar Supergroup, Singhbhum and Bundelkhand cratons); Proterozoic successions (Cuddapah and Vindhyan Supergroups, Kaladgi, Kurnool, Bhima, Marwar); Precambrian–Cambrian boundary; Gondwana Supergroup; Palaeozoic and Triassic successions; Jurassic (Kutch) and Cretaceous (Trichinopoly, Deccan Traps) successions; the K–T boundary; Cenozoic stratigraphy (Assam and Siwalik Groups); the Quaternary, Meghalayan Stage and Anthropocene.

Unit 7 — Applied Geology

7.1 Remote Sensing & Engineering Geology

• **Remote Sensing:** Concepts and geological applications of remote sensing; types and acquisition of aerial photographs; scale and resolution; Indian Remote Sensing satellite missions.

• **Engineering Geology:** Introduction to the geotechnical properties of rocks; geological considerations for geo-engineered structures; landslides — classification and mitigation.

7.2 Hydrogeology & Environmental Geology

• **Hydrogeology:** The hydrological cycle; groundwater and its vertical distribution; aquifers and geological considerations; rainwater harvesting; river and groundwater pollution.

• **Environmental Geology:** Concept of environmental geology; geological hazards (earthquakes, floods, tsunamis and cyclones); processes of soil formation, soil types and degradation; environmental change due to anthropogenic activity.

Unit 8 — Economic Geology & Mineral Exploration

8.1 Economic Geology

• **Ore Deposits:** Ore, gangue, tenor and grade; processes of formation of mineral deposits (magmatic, hydrothermal, sedimentary, residual and metamorphic); classification of mineral deposits; controls of ore localisation.

• **Indian Mineral Resources:** Distribution, mode of occurrence and uses of important metallic and non-metallic mineral deposits of India; fuel resources — coal and petroleum; an overview of India's mineral wealth.

8.2 Mineral Exploration & Gemmology

• **Exploration Methods:** Principles and stages of mineral exploration; geological, geophysical and geochemical prospecting methods; sampling, ore reserve estimation and an introduction to mining.

• **Gemmology:** Properties, classification and identification of gemstones; precious and semi-precious stones; an overview of the gem industry.

M.Sc. Biostatistics — Detailed Syllabus

Detailed unit-wise syllabus compiled by LUUPDATE from the University of Lucknow B.Sc. (NEP) core theory papers, Semesters I–VI. Fourth-year (Sem VII–VIII) and practical papers are excluded. Technical terms are kept in English as used in study material.

Unit 1 — Probability Theory

1.1 Foundations of Probability

• **Basic Concepts:** Random experiment, trial, sample point and sample space; events; mutually exclusive, exhaustive and equally likely events; set theory and algebra of events; classical, relative-frequency and axiomatic definitions of probability and their limitations.

• **Theorems & Bayes' Rule:** Addition theorem of probability for n events; theorem of total probability; Boole's inequality; conditional probability and the multiplication theorem; independent events; Bayes' theorem and its applications.

1.2 Random Variables & Limit Theorems

• **Random Variables:** Discrete and continuous random variables; probability mass and density functions; cumulative distribution function; joint, marginal and conditional distributions; independence of random variables; expectation and its properties; conditional expectation and variance.

• **Limit Theorems:** Moments and the moment-generating function and its properties; continuity theorem for the m.g.f.; Chebyshev's inequality; weak law of large numbers; central limit theorem for i.i.d. random variables and its applications.

Unit 2 — Descriptive Statistics

2.1 Data & Summary Measures

• **Data & Presentation:** Statistical population; attributes and variables; nominal, ordinal, interval and ratio scales; primary and secondary data; questionnaire and schedule design; classification, tabulation and diagrammatic/graphical representation; frequency and cumulative-frequency distributions; histogram, frequency polygon, ogives, stem-and-leaf and box plots.

• **Central Tendency & Dispersion:** Measures of central tendency and dispersion with their merits and demerits; moments and factorial moments; Sheppard's corrections; skewness and kurtosis and their measures; quantile-based measures (quartiles, deciles, percentiles).

2.2 Correlation, Regression & Association

• **Correlation & Regression:** Method of least squares for curve fitting; correlation and regression; correlation for bivariate frequency distributions; rank correlation (Spearman, Kendall); intra-class correlation and correlation ratio; partial and multiple correlation and multiple regression for tri-variate data.

• **Association of Attributes:** Contingency tables, class and ultimate class frequencies; consistency; association and independence of attributes; measures of association for 2×2 tables; Chi-square, Karl Pearson's and Tschuprow's coefficients; contingency tables with ordered categories.

Unit 3 — Probability Distributions & Numerical Methods

3.1 Distribution Theory

• **Univariate Distributions:** Binomial, Poisson, hypergeometric, geometric and negative- binomial; discrete and continuous uniform; normal; exponential, gamma and beta; Cauchy, Laplace, Pareto, Weibull and log-normal distributions; normal and Poisson as limiting cases of the binomial.

• **Sampling Distributions:** Distributions of sums, products and quotients of two variables; χ^2, t and F distributions (central cases), their relationships and limiting forms; bivariate normal distribution and its properties.

3.2 Numerical Analysis

• **Interpolation:** Calculus of finite differences and operators; interpolation formulae with remainder

term; Newton's forward, backward, divided-difference and central-difference formulae; Lagrange's interpolation.
• **Numerical Integration:** Derivation of the general quadrature formula for equidistant ordinates; trapezoidal, Simpson's one-third and three-eighth rules; Weddle's rule.

Unit 4 — Statistical Inference
4.1 Estimation
• **Point Estimation:** Characteristics of a good estimator — unbiasedness, consistency, sufficiency and efficiency; method of maximum likelihood and its properties; minimum chi- square, least-squares and method-of-moments estimation; sufficient statistics; Cramér–Rao inequality and MVU estimators.
• **Interval Estimation:** Pivotal quantity and its use in finding confidence intervals; concept of best confidence intervals; variance-stabilizing transformations.
4.2 Testing of Hypotheses
• **Hypothesis Testing:** Simple and composite hypotheses; Type I and Type II errors; significance level, p-value and power of a test; Most Powerful (MP), Uniformly Most Powerful (UMP) and UMP Unbiased (UMPU) tests; Neyman–Pearson lemma and its applications; tests based on t, F and χ^2 distributions; likelihood-ratio tests and their reduction to standard tests; large-sample tests.

Unit 5 — Sampling Techniques
5.1 Basic Sampling Methods
• **Simple Random Sampling:** Sampling versus complete enumeration; sampling units and frame; precision and efficiency of estimators; simple random sampling with and without replacement; use of random-number tables; estimation of population mean and proportion and their variances; sample-size determination.
• **Stratified & Systematic Sampling:** Stratified random sampling; proportional and optimum allocation; gain in precision due to stratification; role of cost in allocation; minimization of variance for fixed cost; systematic sampling and estimation of population mean and total.
5.2 Advanced Estimation Methods
• **Ratio, Regression & Cluster Sampling:** Ratio and regression methods of estimation in simple random sampling; cluster sampling with equal and unequal clusters; double sampling in the ratio method; two-stage and multi-stage sampling; non-sampling errors.

Unit 6 — Analysis of Variance & Design of Experiments
6.1 Analysis of Variance
• **ANOVA:** Analysis of variance — one-way and two-way classification with model assumptions; Duncan's multiple-comparison test; analysis of covariance.
6.2 Design of Experiments
• **Basic Designs:** Principles of design — randomization, replication and local control; choice of plot size and type using uniformity trials; completely randomized design (CRD) and randomized block design (RBD); efficiency of a design and comparison of CRD and RBD; Latin square design (LSD), layout and ANOVA; efficiency comparisons; missing-plot technique in RBD and LSD.
• **Factorial Experiments:** General description of factorial experiments; 2^2, 2^3 and 2^n factorial experiments; main effects and interactions in 2^2 and 2^3 experiments; ANOVA by Yates' procedure; estimates and tests for main and interaction effects (analysis without confounding).

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Unit 7 — Regression, Multivariate & Non-Parametric

7.1 Multivariate & Regression Analysis

• **Multivariate Normal:** Multivariate normal distribution; marginal and conditional distributions; moment-generating and characteristic functions; maximum-likelihood estimation of the mean vector and covariance matrix; distribution of linear combinations of components.

• **Linear Regression:** Linear regression model of full rank; least-squares theory; OLS and ML estimation of β and tests of hypotheses; R^2 and adjusted R^2; ANOVA table for regression.

7.2 Order Statistics & Non-Parametric Tests

• **Order Statistics:** Distributions of the minimum, maximum and rth order statistic; joint distribution of the rth and sth order statistics; distribution of the sample range and median; confidence intervals for quantiles; tolerance and coverage.

• **Non-Parametric Tests:** Tests for randomness and goodness of fit; one-sample tests (sign test, Wilcoxon signed-rank); two-sample tests (run test, Kolmogorov–Smirnov, median test, Mann–Whitney U, Mood and Sukhatme tests).

Unit 8 — Statistical Quality Control, Educational &

8.1 Statistical Quality Control

• **Control Charts & Inspection:** Process control; control charts for variables and attributes; modified, group and CUSUM charts and V-mask; sampling inspection by attributes — single and double sampling plans; producer's and consumer's risk; OC, ASN, ATI, AOQL and LTPD functions; sampling inspection by variables.

8.2 Educational Statistics

• **Test Theory & Scaling:** Scaling procedures — scaling of test items and scores, scaling by the normal curve, percentile, z- and t-scores; test theory, parallel tests and true score; reliability (parallel-test, test–retest, split-half, Kuder–Richardson, Cronbach's α) and validity; tetrachoric, biserial and point-biserial correlation.

8.3 Applied & Biostatistical Methods

• **Time Series & Index Numbers:** Components of a time series; additive, multiplicative and mixed models; trend determination and seasonal indices; index numbers — Laspeyres, Paasche, Fisher and Marshall–Edgeworth; tests for a good index number; consumer price index.

• **Demography & Vital Statistics:** Sources of demographic data; measurement of fertility (CBR, GFR, ASFR, TFR, GRR, NRR); measurement of mortality (CDR, ASDR, IMR, standardized death rates); life tables and their construction.

Unit 9 — Operations Research, Queueing &

9.1 Operations Research

• **Linear Programming & Allocation:** Formulation of LP problems; graphical, simplex, Big-M and two-phase methods; duality; transportation problem (North-West corner, least-cost, Vogel's approximation, stepping-stone, MODI); assignment problem and the Hungarian algorithm.

• **Inventory & Sequencing:** Inventory control and deterministic EOQ models (with and without shortages); job sequencing (n jobs–2/k machines, 2 jobs–n machines); dynamic programming and Bellman's principle of optimality.

9.2 Queueing Theory & Network Analysis

• **Queueing & Networks:** Elements and classification of queueing systems; distributions of arrivals,

service and departures; models (M/M/1):(∞/FCFS), (M/M/1):(N/FCFS) and (M/M/C):(∞/ FCFS); Little's formula; network analysis — minimum spanning tree, shortest-route and maximal- flow problems; project management (PERT/CPM, floats, time charts).

9.3 Computational Statistics

• **R, SPSS & Programming:** Introduction to computers and number systems; R programming and RStudio — data structures, data input and management; descriptive and inferential statistics, parametric and non-parametric tests, ANOVA, correlation and regression in R and SPSS; introduction to programming with C/C++ (data types, operators, control structures, arrays, functions, pointers and files).

M.Sc. Biotechnology — Detailed Syllabus

Detailed unit-wise syllabus compiled by LUUPDATE from the University of Lucknow B.Sc. (NEP) core theory papers, Semesters I–VI. Fourth-year (Sem VII–VIII) and practical papers are excluded. Technical terms are kept in English as used in study material.

Unit 1 — Biomolecules & Cell Biology

1.1 Biomolecules — Structure & Function

• **Carbohydrates:** Classification into mono-, di-, oligo- and polysaccharides; open-chain and ring (Haworth) forms; stereoisomerism (D/L, α/β anomers), epimers and mutarotation; important sugars; disaccharides and their glycosidic bonds; storage and structural polysaccharides (starch, glycogen, cellulose, chitin); glycosaminoglycans and glycoconjugates (glycoproteins, glycolipids, proteoglycans).

• **Lipids:** Simple, compound and derived lipids; saturated/unsaturated and essential fatty acids; ω-3 / ω-6 nomenclature; triacylglycerols (saponification, iodine number); phospholipids and sphingolipids; steroids (cholesterol, bile acids, steroid hormones); eicosanoids — prostaglandins and leukotrienes.

• **Amino Acids & Proteins:** Classification of amino acids; amphoteric nature, isoelectric point (pI) and zwitterions; the peptide bond; levels of protein organisation (primary, secondary, tertiary, quaternary); denaturation and renaturation; fibrous versus globular proteins.

• **Vitamins & Biophysical Chemistry:** Structure and properties of vitamins; pH and buffers (Henderson–Hasselbalch relationship, physiological buffers); thermodynamics and Gibbs free energy in biological systems; weak interactions stabilising biomolecules.

1.2 Cell Biology

• **Cell Structure:** Comparison of prokaryotic and eukaryotic cells; structure and function of organelles — nucleus, mitochondria, endoplasmic reticulum, Golgi apparatus, lysosomes, peroxisomes and the cytoskeleton (microtubules, microfilaments, intermediate filaments); endomembrane system and protein targeting.

• **Membrane Biology:** The fluid-mosaic model; modes of transport (passive, active and facilitated); ion channels and membrane receptors; cell–cell interactions (adhesion molecules, cellular junctions).

• **Cell Division & Signalling:** Mitosis and meiosis; regulation of the cell cycle through checkpoints, cyclins and CDKs; hormones and their receptors (GPCRs and receptor tyrosine kinases); second messengers (cAMP, IP3 and Ca^{2+}).

Unit 2 — Microbiology & Microbial Technology

2.1 Microbial Diversity & Structure

• **Microbial Diversity:** Bacteria (Gram-positive and Gram-negative), viruses, fungi and archaea; bacterial cell structure — cell wall (peptidoglycan), flagella, pili and endospores; eukaryotic (yeast) cell structure.

• **Growth & Nutrition:** Culture media; the bacterial growth curve; sterilisation techniques; culture and staining methods; control of microbial growth.

2.2 Microbial Metabolism & Genetics

• **Microbial Metabolism:** Metabolic diversity (phototrophy, chemolithotrophy, autotrophy, heterotrophy, fermentation); distinctive pathways (e.g., Entner–Doudoroff); nitrogen fixation; fermentation.

• **Bacterial Genetics & Pathogens:** Bacterial genome and plasmids; genetic variability through mutation and recombination; economic importance of bacteria; overview of common disease-causing bacteria and viruses (cholera, dengue, mechanism of COVID-19).

Unit 3 — Enzymes, Metabolism & Bioenergetics

3.1 Enzymes

• **Classification & Properties:** IUBMB system of naming and classifying enzymes; substrate specificity, the active site, and the role of cofactors and coenzymes.

• **Kinetics & Regulation:** The Michaelis–Menten equation, Km and Vmax, and the Lineweaver– Burk plot; factors affecting reaction rate (pH, temperature); competitive, non-competitive and uncompetitive inhibition; allosteric regulation; isozymes; feedback inhibition and covalent modification.

3.2 Bioenergetics

• **Energy & Oxidative Phosphorylation:** High-energy phosphates (ATP), redox potentials and the electron transport chain (ETC); chemiosmotic theory, ATP synthase, uncouplers and respiratory-chain inhibitors; basics of photosynthesis (light reactions and the Calvin cycle).

3.3 Metabolism

• **Carbohydrate & Lipid Metabolism:** Glycolysis and its regulation; amphibolic TCA cycle; gluconeogenesis; glycogen metabolism; pentose phosphate pathway; Cori cycle; β-oxidation and fatty-acid synthesis; ketone-body formation and cholesterol biosynthesis.

• **Amino-Acid, Nucleotide & Integration:** Transamination and deamination; the urea cycle; glucogenic versus ketogenic amino acids; biosynthesis and degradation of purines and pyrimidines; integration of metabolic pathways; hormonal control (insulin and glucagon); metabolic disorders (diabetes, phenylketonuria).

Unit 4 — Molecular Biology & Genetics

4.1 Molecular Biology

• **DNA Replication:** Structure and types of DNA and RNA; the semi-conservative mechanism and key enzymes (DNA polymerases, helicase and ligase); the central dogma.

• **Transcription & Translation:** RNA polymerases, promoters and RNA processing (5′ capping, splicing, poly-A tailing); the genetic code, ribosomes and tRNA; initiation, elongation and termination.

• **Gene Regulation & Genome Maintenance:** Operons (lac and trp) in prokaryotes; regulatory mechanisms in eukaryotes (enhancers, transcription factors); mutations, DNA repair pathways and recombination.

4.2 Genetics

• **Mendelian & Beyond:** Mendel's laws; complete/incomplete dominance and codominance; gene interactions (complementary, epistasis, duplicate genes); linkage and crossing over; sex determination and sex-linked inheritance; multiple alleles; cytoplasmic inheritance and genomic imprinting; chromosomal and gene mutations; the Hardy–Weinberg law; pedigree analysis and hereditary diseases of man.

Unit 5 — Genetic Engineering & Recombinant DNA

5.1 Tools & Methods

• **rDNA Toolkit:** Concept and scope of biotechnology; isolation of genomic and plasmid DNA; restriction enzymes; cloning vectors (plasmids, cosmids, lambda bacteriophage); ligation and transformation; selection of recombinants.

• **Cloning & Analysis:** Construction of genomic and cDNA libraries; the polymerase chain reaction (PCR), RFLP, RAPD, AFLP and DNA fingerprinting; DNA microarray and sequencing; Southern, northern and western blotting.

5.2 Transgenics & Applications

• **Plant & Animal Systems:** Plant tissue culture (callus and cell-suspension cultures, organogenesis, embryogenesis, protoplast isolation, culture and fusion, somatic hybridisation, somaclonal variation); transgenic plants; animal cell culture and expression of cloned genes; production of cloned and transgenic animals (nuclear transplantation, retroviral method, DNA microinjection).

• **Genetic Engineering Applications:** Bt cotton, herbicide-resistant crops, Flavr Savr tomato and Golden rice; recombinant insulin, human growth hormone, vaccines, interferon and antibiotics; gene therapy; the Human Genome Project; biosafety concerns.

Unit 6 — Analytical & Biochemical Techniques

6.1 Separation & Spectroscopy

• **Separation Techniques:** Centrifugation (differential and density-gradient); chromatography (paper, TLC, ion-exchange, gel-filtration, affinity and HPLC); electrophoresis (PAGE, SDS-PAGE and agarose).

• **Spectroscopy:** UV-Visible and fluorescence spectroscopy; basic principles of NMR and mass spectrometry (MS).

6.2 Other Methods

• **Assays & Detection:** Radioisotope techniques, biosensors and enzyme assays; basics of statistical handling of biological data (mean, standard deviation, standard error, correlation and the chi-square test).

Unit 7 — Applied Biotechnology & Immunology

7.1 Clinical & Applied Biotechnology

• **Clinical Applications:** Diagnostic enzymes and biomarkers (markers of liver and heart disease); molecular diagnosis of genetic diseases (cystic fibrosis, sickle-cell anaemia); common disorders — jaundice, atherosclerosis, basics of cancer and inborn errors of metabolism.

7.2 Immunology

• **Immune System:** Concept and types of immunity; cells and organs of the immune system; antigens, antibodies and the ELISA technique; immunoglobulins (types and structure); antigen–

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antibody interactions; autoimmunity; the major histocompatibility complex; cytokines (properties and functions); hybridoma technology and monoclonal antibodies.

M.Sc. Artificial Intelligence & Machine Learning — Detailed Syllabus

Detailed unit-wise syllabus compiled by LUUPDATE. Based on the B.Sc. Computer Science / Mathematics / Statistics UG curriculum, Semesters I–VI. Fourth-year and practical/lab papers are excluded; technical terms are kept in English as used in study material.

Unit 1 — Programming & Problem Solving

• **Problem Solving & Algorithms:** Algorithmic and heuristic approaches; problem definition; characteristics of a good program; algorithm notation, pseudocode, flowcharts; the program-development cycle (coding, documentation, testing, debugging); modular and structured programming; translators (assemblers, interpreters, compilers).
• **C++:** Character set, keywords, variables, constants, data types, operators, precedence and type conversion; control statements (if/else, switch, loops, break/continue); functions and parameter passing, default arguments, call by value/reference, overloading, recursion; arrays; file handling.
• **Python:** Interpreter and interactive mode; values, types, variables, expressions; operators and precedence; control statements; fruitful functions, scope and recursion; strings, lists, tuples and dictionaries; list comprehension; file I/O; errors, exceptions; modules and packages.

Unit 2 — Data Structures & Algorithms

• **Data Structures:** Asymptotic notations and time-complexity analysis; recurrences via recursion trees; arrays; singly, doubly and circular linked lists; stacks and queues as ADTs and their applications; trees, binary trees and traversals; binary search trees (insertion, deletion, search, complexity).
• **Algorithm Design:** Iterative techniques, divide and conquer, dynamic programming and greedy algorithms; sorting (bubble, insertion, merge, heap, quick, and linear-time bucket/radix/ count); searching; medians and order statistics; BFS/DFS and applications; minimum spanning trees; balanced and red-black trees; randomised and heuristic algorithms.

Unit 3 — Mathematical Foundations

3.1 Linear Algebra & Calculus

• **Matrices & Linear Algebra:** Elementary operations, rank, echelon and normal forms; systems of linear equations and consistency; eigenvalues, eigenvectors and the characteristic equation; Cayley–Hamilton theorem; vector spaces, linear independence, basis and dimension; linear transformations; inner-product spaces and the Gram–Schmidt process.
• **Calculus:** Limits, continuity and differentiability; partial differentiation and Euler's theorem; maxima and minima of several variables and Lagrange multipliers; gradient, divergence and curl; basics of integration.

3.2 Discrete Mathematics

• **Logic & Combinatorics:** Propositional and predicate logic; truth tables, tautologies and normal forms; methods of proof; Boolean algebra and Karnaugh maps; inclusion–exclusion principle; recurrence relations and generating functions; graphs and trees.

Unit 4 — Probability & Statistics for ML

• **Foundations:** Random experiment, sample space and events; mutually exclusive, exhaustive and equally likely events; classical, relative-frequency and axiomatic definitions; addition and multiplication theorems; total probability; conditional probability and independence; Bayes' theorem and its applications.
• **Random Variables & Limit Theorems:** Discrete and continuous random variables; pmf, pdf and cdf; joint, marginal and conditional distributions; expectation, conditional expectation and variance; moments and the moment-generating function; Chebyshev's inequality; weak law of large numbers; central limit theorem. Probability Distributions
• **Univariate Distributions:** Binomial, Poisson, hypergeometric, geometric and negative- binomial; discrete and continuous uniform; normal; exponential, gamma and beta; Cauchy, Laplace, Pareto, Weibull and log-normal; normal and Poisson as limiting cases of the binomial.
• **Sampling Distributions:** Distributions of sums, products and quotients of two variables; χ^2, t and F distributions and their relationships and limiting forms; bivariate normal distribution and its properties.
4.3 Inference & Regression
• **Estimation & Testing:** Maximum likelihood and method-of-moments estimation; confidence intervals; hypothesis testing; tests based on t, F and χ^2.
• **Regression & Correlation:** Method of least squares; simple and multiple linear regression; correlation, rank correlation; R^2 and adjusted R^2; ANOVA table for regression.

Unit 5 — Databases & Computer Fundamentals
5.1 Computer Organization
• **Fundamentals:** Basic components (control unit, ALU, memory, I/O); memory hierarchy (RAM, ROM, cache); number systems and inter-conversion; computer codes (BCD, ASCII, Gray, Unicode); logic gates and Boolean algebra; combinational and sequential circuits.
5.2 Database Management
• **RDBMS:** Database characteristics and data models; three-schema architecture; ER modelling and ER diagrams; functional dependencies and normalisation (1NF, 2NF, 3NF); relational algebra; SQL — DDL, DML, queries, aggregation, group-by/having and views.

Unit 6 — Artificial Intelligence
• **Search & Problem Solving:** Definition of AI, the Turing test and a brief history; problem formulation and search space; tree and graph search (BFS, uniform-cost, DFS, depth-limited, iterative deepening); heuristic search (best-first, A*), hill climbing, constraint satisfaction and means-end analysis; game playing (min-max and alpha-beta pruning).
• **Knowledge Representation:** Propositional and first-order predicate logic; resolution, unification, semantic nets, frames, scripts, production rules and PROLOG; symbolic versus data- driven AI.

Unit 7 — Machine Learning & Modern AI
7.1 Foundations of ML
• **Learning Paradigms:** Introduction to machine learning and deep learning; supervised, unsupervised and reinforcement learning; training, validation and testing; bias–variance trade-off; overfitting and regularisation; evaluation metrics.
• **Core Algorithms:** Linear and logistic regression; decision trees; k-nearest neighbours; clustering

(k-means); dimensionality reduction; introduction to neural networks; interpretable/ explainable AI and the ethics of AI.

M.Sc. Cyber Security & Cyber Forensics — Detailed Syllabus

Detailed unit-wise syllabus compiled by LUUPDATE. Based on the B.Sc. Computer Science UG curriculum, Semesters I–VI. Fourth-year and practical/lab papers are excluded; technical terms are kept in English as used in study material.

Unit 1 — Programming & Problem Solving

• **Problem Solving & Algorithms:** Algorithmic and heuristic approaches; problem definition; characteristics of a good program; algorithm notation, pseudocode, flowcharts; the program-development cycle (coding, documentation, testing, debugging); modular and structured programming; translators (assemblers, interpreters, compilers).
• **C++:** Character set, keywords, variables, constants, data types, operators, precedence and type conversion; control statements (if/else, switch, loops, break/continue); functions and parameter passing, default arguments, call by value/reference, overloading, recursion; arrays; file handling.
• **Python:** Interpreter and interactive mode; values, types, variables, expressions; operators and precedence; control statements; fruitful functions, scope and recursion; strings, lists, tuples and dictionaries; list comprehension; file I/O; errors, exceptions; modules and packages.

Unit 2 — Data Structures & Algorithms

• **Data Structures:** Asymptotic notations and time-complexity analysis; recurrences via recursion trees; arrays; singly, doubly and circular linked lists; stacks and queues as ADTs and their applications; trees, binary trees and traversals; binary search trees (insertion, deletion, search, complexity).
• **Algorithm Design:** Iterative techniques, divide and conquer, dynamic programming and greedy algorithms; sorting (bubble, insertion, merge, heap, quick, and linear-time bucket/radix/ count); searching; medians and order statistics; BFS/DFS and applications; minimum spanning trees; balanced and red-black trees; randomised and heuristic algorithms.

Unit 3 — Computer Organization & Architecture

3.1 Fundamentals of Computers
• **Computer System:** Evolution and generations; basic components (control unit, ALU, memory, I/O); memory hierarchy (RAM, ROM, SRAM, DRAM, cache); BIOS/UEFI and the booting process; stored-program concept; peripherals and software types.
• **Number Systems & Boolean Logic:** Binary, octal, decimal and hexadecimal systems and inter-conversion; complements and binary arithmetic; computer codes (BCD, EBCDIC, ASCII, Gray, Excess-3, Unicode); logic gates; Boolean algebra and De Morgan's theorem.
3.2 Digital Logic & Microprocessor
• **Digital Circuits:** Flip-flops; logic simplification using Boolean algebra and Karnaugh maps; combinational and sequential circuits; decoders, encoders, multiplexers, adders, registers and memory units.
• **Microprocessor (8086):** Internal architecture (BIU and EU); addressing modes; instruction set; bus structure and timings; memory address decoding; I/O interface, interrupt and DMA controllers; assembly-language programming.

Unit 4 — Operating Systems

4.1 Operating System Concepts

• **Introduction & Processes:** Types of operating systems; OS organisation (processor/user modes, kernels, system calls); process characterisation and scheduling (pre-emptive and non- pre-emptive); inter-process communication and synchronisation; critical section and semaphores; deadlock (prevention, avoidance, detection, Banker's algorithm).

• **Memory & File Management:** Physical and virtual address space; memory-allocation strategies (paging, segmentation, virtual memory); file and I/O management; directory structure, file operations and allocation methods; device management.

Unit 5 — Databases & Web Technologies

5.1 Relational Database Management System

• **RDBMS:** Database characteristics and data models; three-schema architecture; ER modelling and ER diagrams; functional dependencies and normalisation (1NF, 2NF, 3NF); relational algebra; SQL — DDL, DML, queries, aggregation, group-by/having and views.

5.2 Web Development

• **Web Basics & Languages:** Architecture of the WWW; static versus dynamic sites; servers and frameworks; HTML structure, forms and HTML5; CSS and CSS3; PHP — syntax, arrays, strings, form processing, regular expressions, file uploads, sessions, state management and cookies.

Unit 6 — Computer Networks

6.1 Networks & Data Communication

• **Network Fundamentals:** Topologies and classifications; network protocols; layered architecture; the OSI reference model and the TCP/IP protocol suite; networking devices (hubs, switches, routers).

• **Data Communication & Protocol Layers:** Analog and digital signals; line encoding; pulse- code modulation; multiplexing (FDM, TDM); transmission media; circuit and packet switching; multiple-access protocols (CSMA/CD, Ethernet); IP and routing algorithms; transport-layer services (error/flow control, three-way handshake) and application-layer protocols.

Unit 7 — Software Engineering & Applied Computing

7.1 Software Engineering

• **Process & Testing:** Characteristics of software; software engineering definitions; linear/ sequential, iterative and incremental models; system models; architectural design; software reliability and metrics; fault avoidance, tolerance and reuse; white-box and black-box testing; boundary-value analysis; testing strategies and integration.

7.2 Applied Topics

• **Foundations for Security & Forensics:** Knowledge representation and logic; introduction to AI, machine learning and deep learning; ethics of computing; data integrity and the role of OS, network and database fundamentals in security and digital-forensics workflows.

M.Sc. Data Science & Data Analytics — Detailed Syllabus

Detailed unit-wise syllabus compiled by LUUPDATE. Based on the B.Sc. Computer Science / Statistics UG curriculum, Semesters I–VI. Fourth-year and practical/lab papers are excluded;

technical terms are kept in English as used in study material.

Unit 1 — Programming & Problem Solving

• **Problem Solving & Algorithms:** Algorithmic and heuristic approaches; problem definition; characteristics of a good program; algorithm notation, pseudocode, flowcharts; the program-development cycle (coding, documentation, testing, debugging); modular and structured programming; translators (assemblers, interpreters, compilers).

• **C++:** Character set, keywords, variables, constants, data types, operators, precedence and type conversion; control statements (if/else, switch, loops, break/continue); functions and parameter passing, default arguments, call by value/reference, overloading, recursion; arrays; file handling.

• **Python:** Interpreter and interactive mode; values, types, variables, expressions; operators and precedence; control statements; fruitful functions, scope and recursion; strings, lists, tuples and dictionaries; list comprehension; file I/O; errors, exceptions; modules and packages.

Unit 2 — Data Structures & Algorithms

• **Data Structures:** Asymptotic notations and time-complexity analysis; recurrences via recursion trees; arrays; singly, doubly and circular linked lists; stacks and queues as ADTs and their applications; trees, binary trees and traversals; binary search trees (insertion, deletion, search, complexity).

• **Algorithm Design:** Iterative techniques, divide and conquer, dynamic programming and greedy algorithms; sorting (bubble, insertion, merge, heap, quick, and linear-time bucket/radix/ count); searching; medians and order statistics; BFS/DFS and applications; minimum spanning trees; balanced and red-black trees; randomised and heuristic algorithms.

Unit 3 — Databases & Data Management

3.1 Relational Databases

• **Fundamentals & Design:** Database characteristics; data models; three-schema architecture and data independence; ER modelling and ER diagrams; mapping to relational schemas; functional dependencies and normalisation (1NF, 2NF, 3NF).

• **Relational Model & SQL:** Types of keys; integrity constraints; relational algebra (selection, projection, Cartesian product, join); SQL — DDL, DML, queries, aggregation, group-by/having clauses and views.

3.2 Computational Tools

• **R, SPSS & Programming:** Number systems; R programming and RStudio — data structures, data input and management; descriptive and inferential statistics, parametric and non- parametric tests, ANOVA, correlation and regression in R and SPSS; basics of C/C++.

Unit 4 — Probability & Distribution Theory

• **Foundations:** Random experiment, sample space and events; mutually exclusive, exhaustive and equally likely events; classical, relative-frequency and axiomatic definitions; addition and multiplication theorems; total probability; conditional probability and independence; Bayes' theorem and its applications.

• **Random Variables & Limit Theorems:** Discrete and continuous random variables; pmf, pdf and cdf; joint, marginal and conditional distributions; expectation, conditional expectation and variance; moments and the moment-generating function; Chebyshev's inequality; weak law of

large numbers; central limit theorem. Probability Distributions

• **Univariate Distributions:** Binomial, Poisson, hypergeometric, geometric and negative- binomial; discrete and continuous uniform; normal; exponential, gamma and beta; Cauchy, Laplace, Pareto, Weibull and log-normal; normal and Poisson as limiting cases of the binomial.

• **Sampling Distributions:** Distributions of sums, products and quotients of two variables; χ^2, t and F distributions and their relationships and limiting forms; bivariate normal distribution and its properties.

Unit 5 — Statistical Inference & Regression

• **Estimation:** Unbiasedness, consistency, sufficiency and efficiency; maximum likelihood and its properties; minimum chi-square, least-squares and method-of-moments estimation; Cramér–Rao inequality and MVU estimators; confidence intervals and pivotal quantities.

• **Testing of Hypotheses:** Simple and composite hypotheses; Type I and Type II errors; significance level, p-value and power; MP, UMP and UMPU tests; Neyman–Pearson lemma; tests based on t, F and χ^2; likelihood-ratio and large-sample tests.

5.3 Regression & Multivariate Analysis

• **Linear Regression:** Linear regression model of full rank; least-squares theory; OLS and ML estimation of β and tests of hypotheses; R^2 and adjusted R^2; ANOVA table for regression.

• **Multivariate Normal:** Multivariate normal distribution; marginal and conditional distributions; ML estimation of the mean vector and covariance matrix; distribution of linear combinations of components.

Unit 6 — Descriptive Statistics & Sampling

6.1 Descriptive Statistics

• **Data & Summary Measures:** Types of data and scales of measurement; classification, tabulation and graphical representation (histogram, ogive, box plot); measures of central tendency and dispersion; moments, skewness and kurtosis; quantile-based measures.

• **Correlation & Association:** Correlation and regression; rank correlation (Spearman, Kendall); partial and multiple correlation; association of attributes; Chi-square and contingency tables.

6.2 Sampling Techniques

• **Sampling Methods:** Simple random sampling (with/without replacement); stratified, systematic and cluster sampling; ratio and regression estimation; two-stage and multi-stage sampling; non-sampling errors; sample-size determination.

Unit 7 — Machine Learning & Artificial Intelligence

• **Search & Problem Solving:** Definition of AI, the Turing test and a brief history; problem formulation and search space; tree and graph search (BFS, uniform-cost, DFS, depth-limited, iterative deepening); heuristic search (best-first, A*), hill climbing, constraint satisfaction and means-end analysis; game playing (min-max and alpha-beta pruning).

• **Knowledge Representation:** Propositional and first-order predicate logic; resolution, unification, semantic nets, frames, scripts, production rules and PROLOG; symbolic versus data- driven AI.

7.3 Machine Learning

• **Foundations:** Supervised, unsupervised and reinforcement learning; training/validation/testing; bias–variance trade-off; overfitting and regularisation; evaluation metrics; linear and logistic

regression; decision trees; k-NN; clustering (k-means); dimensionality reduction; introduction to neural networks and deep learning.

M.Sc. Environmental Science — Detailed Syllabus

Detailed unit-wise syllabus compiled by LUUPDATE. Based on the B.Sc. Science UG curriculum — Botany, Zoology & Geology core, Semesters I–VI. Fourth-year and practical/lab papers are excluded; technical terms are kept in English as used in study material.

Unit 1 — Ecology & Ecosystems

1.1 Ecosystem & Communities

• **Ecosystem:** Concept, types and structural components; energy flow and biogeochemical cycles (N, C, S, P); trophic levels, food chains, food webs and ecological pyramids; plant communities and ecological succession (hydrosere, xerosere); the niche concept.

• **Populations & Adaptations:** Population characteristics, growth and regulation; interspecific interactions; r- and K-strategies; ecological groups and adaptations (hydrophytes, xerophytes, halophytes; aquatic, arboreal, fossorial, desert).

Unit 2 — Environmental Pollution & Management

2.1 Pollution & Management

• **Pollution:** Air, water, soil, radioactive, thermal, noise and light pollution — sources, effects and control measures; greenhouse effect, ozone depletion and acid rain; environmental footprints.

• **Legislation & Waste Management:** Environmental legislation (Environment Protection Act 1986, National Green Tribunal Act 2010) and UNEP; environmental monitoring and waste management (sanitary landfill, composting, incineration, pyrolysis).

Unit 3 — Soil Science & Natural Resources

3.1 Soils & Resources

• **Soil Science:** Soil formation and profile development; composition, types and properties (texture, density, temperature, organic matter, pH, ion exchange); soil erosion and conservation; problem soils and their reclamation.

• **Mineral & Fuel Resources:** Mineral resources and their conservation; an overview of metallic, non-metallic and fuel resources (coal and petroleum) and the need for sustainable use.

Unit 4 — Environmental Geology & Hazards

4.1 Hazards & Hydrogeology

• **Environmental Geology:** Concept of environmental geology; geological hazards (earthquakes, floods, tsunamis and cyclones); environmental change due to anthropogenic activity.

• **Hydrogeology:** The hydrological cycle; groundwater and its vertical distribution; aquifers and geological considerations; rainwater harvesting; river and groundwater pollution.

Unit 5 — Environmental Toxicology

5.1 Toxicants & Effects

• **Toxicology:** Routes, frequency and duration of exposure; dose–response relationship; selective toxicity; toxicity tests (bioassay, acute and chronic), MATC and safe concentration; bioconcentration, bioaccumulation and biomagnification; biotransformation; toxic effects on

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body systems; mutagenicity, teratogenicity, carcinogenicity and toxicogenomics.

Unit 6 — Biodiversity, Phytogeography & Conservation

6.1 Distribution & Conservation

• **Phytogeography:** Static and dynamic phytogeography; principles of plant distribution; phytogeographic and floristic zones of India; natural vegetation of India and Uttar Pradesh; endemism.

• **Conservation:** In situ conservation (sanctuaries, national parks, biosphere reserves, wetlands, mangroves) and ex situ conservation (field gene banks, seed banks, cryobanks); conservation of plant and animal resources.

Unit 7 — Environmental Microbiology & Biotechnology

7.1 Microbiology

• **Microbial Diversity:** Bacteria, viruses, fungi and archaea; bacterial structure, growth and nutrition; microbial metabolism (nitrogen fixation, fermentation); role of microbes in nutrient cycling and pollution control.

7.2 Environmental Biotechnology

• **Applications:** Recombinant DNA technology basics; transgenic plants and microbes for environmental use; bioremediation concepts; plant tissue culture and conservation biotechnology; biosafety concerns.

M.Sc. Food Processing & Food Technology — Detailed Syllabus

Detailed unit-wise syllabus compiled by LUUPDATE. Based on the B.Sc. Science UG curriculum — Biochemistry, Botany & Zoology core, Semesters I–VI. Fourth-year and practical/lab papers are excluded; technical terms are kept in English as used in study material.

Unit 1 — Food Chemistry & Biomolecules

1.1 Carbohydrates, Lipids & Proteins

• **Carbohydrates:** Classification (mono-, di-, oligo- and polysaccharides); reducing and non-reducing sugars; important sugars; storage and structural polysaccharides (starch, glycogen, cellulose, pectin, chitin, inulin); glycoconjugates.

• **Lipids:** Simple, compound and derived lipids; saturated and unsaturated fatty acids; essential fatty acids and ω-3 / ω-6 nomenclature; triacylglycerols and their properties (saponification value, iodine number, acid value, rancidity).

• **Proteins & Vitamins:** Classification and structural organisation of amino acids and proteins; isoelectric point; denaturation and renaturation; structure and properties of vitamins.

Unit 2 — Enzymes & Bioenergetics in Food

2.1 Enzymes

• **Enzymes:** Classification and characteristics; active site, cofactors and coenzymes; Michaelis–Menten kinetics (Km, Vmax); enzyme inhibition; factors affecting catalytic efficiency (pH, temperature) — relevant to food processing and spoilage.

2.2 Bioenergetics & Metabolism

• **Energy & Pathways:** Laws of thermodynamics and Gibbs free energy; high-energy compounds (ATP); glycolysis, the TCA cycle and oxidative phosphorylation; fermentation pathways relevant to

food production.

Unit 3 — Food Microbiology

3.1 Microbial Diversity & Growth

• **Microbiology:** Bacteria (Gram-positive and Gram-negative), viruses, fungi (including yeasts) and archaea; bacterial structure; culture media; the bacterial growth curve; sterilisation techniques; control of microbial growth.

• **Fermentation & Pathogens:** Microbial metabolism and fermentation; food fermentation principles; spoilage organisms; common food-borne pathogens and an overview of disease-causing bacteria and viruses.

Unit 4 — Nutrition & Human Physiology

4.1 Nutrition

• **Nutrition:** Balanced diet; vitamins and their roles; nutritional disorders (malnutrition, obesity); macro- and micronutrients.

• **Digestion & Absorption:** Physiology of digestion and absorption of proteins, carbohydrates and lipids; role of gastrointestinal hormones; basics of human metabolism.

Unit 5 — Food Crops & Plant Resources

5.1 Economic Botany

• **Crop Plants & Products:** Centres of diversity, origin and domestication of crop plants; cultivation and uses of cereals (wheat, rice, maize) and legumes; plants yielding fatty/essential oils, spices and beverages (tea, coffee, cocoa); fibres and timber; medicinal plants and the basics of ethnobotany.

Unit 6 — Food Biotechnology

6.1 Recombinant DNA & Tissue Culture

• **Plant Biotechnology:** Recombinant DNA technology basics; restriction enzymes, vectors, cloning and transformation; transgenic plants; genetic engineering in agriculture (Bt cotton, Flavr Savr tomato, Golden rice); plant tissue culture and production of secondary metabolites.

Unit 7 — Food Analysis & Quality

7.1 Analytical Techniques

• **Separation & Spectroscopy:** Centrifugation; chromatography (paper, TLC, ion-exchange, gel-filtration, affinity, HPLC); electrophoresis (PAGE, SDS-PAGE); UV-Visible and fluorescence spectroscopy; basics of NMR and mass spectrometry; enzyme assays and biosensors.

7.2 Quality Control

• **Statistical Quality Control:** Process control; control charts for variables and attributes; sampling inspection by attributes (single and double sampling plans); producer's and consumer's risk; basics of OC and AOQL functions applied to food quality.

M.Sc. Forensic Science — Detailed Syllabus

Detailed unit-wise syllabus compiled by LUUPDATE. Based on the B.Sc. Science UG curriculum — Chemistry, Zoology & Physics core, Semesters I–VI. Fourth-year and practical/lab papers are excluded; technical terms are kept in English as used in study material.

Unit 1 — Forensic Chemistry & Analytical Techniques

1.1 Spectroscopy & Separation

• **Spectroscopy:** Beer–Lambert law; UV-Visible spectroscopy and types of electronic transitions; IR — molecular vibrations, fingerprint region and group frequencies; ^{1}H-NMR — chemical shift, spin–spin splitting; mass spectrometry — molecular ion, fragmentation and the nitrogen rule.

• **Separation Techniques:** Chromatography (paper, TLC, ion-exchange, gel-filtration, affinity, HPLC); electrophoresis; centrifugation — applied to the analysis of trace and questioned samples.

Unit 2 — General & Organic Chemistry Foundations

2.1 Organic Chemistry

• **Reactive Intermediates & Stereochemistry:** Electronic effects; electrophiles and nucleophiles; optical isomerism, chirality and R/S nomenclature; functional groups — alcohols, phenols, aldehydes, ketones, carboxylic acids and amines; biomolecules (amino acids, peptides, proteins).

2.2 Inorganic & Physical Basics

• **Foundations:** Atomic structure and periodicity; chemical bonding; acid–base concepts; chemical kinetics and reaction rates; basics of electrochemistry and the colloidal state relevant to trace analysis.

Unit 3 — Forensic Biology & Serology

3.1 Blood, Body Fluids & Immunology

• **Serology:** Composition of blood, plasma proteins, blood groups and the Rh factor; mechanism of blood coagulation; identification of body fluids.

• **Immunology:** Antigens, antibodies and antigen–antibody interactions; the ELISA technique; immunoglobulins; the major histocompatibility complex; monoclonal antibodies and hybridoma technology.

Unit 4 — Molecular Forensics & DNA Profiling

4.1 Molecular Biology & DNA Fingerprinting

• **Nucleic Acids:** Structure and types of DNA and RNA; DNA replication; the central dogma; transcription and translation.

• **DNA Techniques:** Recombinant DNA technology; restriction enzymes; PCR, RFLP, RAPD, AFLP and DNA fingerprinting; DNA microarray and sequencing; Southern, northern and western blotting — applied to identification and paternity analysis.

Unit 5 — Forensic Toxicology

5.1 Toxicants & Effects

• **Toxicology:** Routes, frequency and duration of exposure; dose–response relationship; selective toxicity; toxicity tests (bioassay, acute and chronic), MATC and safe concentration; toxic effects of xenobiotics (local/systemic, reversible/irreversible); biotransformation; mutagenicity, teratogenicity and carcinogenicity.

Unit 6 — Forensic Physics & Instrumentation

6.1 Optics & Electronics

• **Optics:** Interference, diffraction and polarization; resolving power; refractive index and

birefringence; principles of the microscope — applied to examination of glass, fibres and trace evidence.
• **Electronics & Instruments:** Diodes and transistors; basic instrumentation; cathode-ray oscilloscope; principles of detectors and measuring instruments used in forensic laboratories.

Unit 7 — Cell Biology & Genetics Foundations
7.1 Cell & Genetics
• **Cell Biology:** Prokaryotic and eukaryotic cells; organelles; cell cycle and division (mitosis and meiosis); chromatin and chromosome structure.
• **Genetics:** Mendel's laws; sex determination and sex-linked inheritance; multiple alleles; pedigree analysis and hereditary diseases of man — relevant to forensic identification.

M.Sc. Microbiology — Detailed Syllabus

Detailed unit-wise syllabus compiled by LUUPDATE. Based on the B.Sc. (NEP. Fourth-year and practical/lab papers are excluded; technical terms are kept in English as used in study material.

Unit 1 — Microbial Diversity
1.1 Bacteria, Archaea & Viruses
• **Prokaryotic Biology:** Cell structure and function of prokaryotes; classification (Archaea, Gram-positive and Gram-negative bacteria, Mollicutes); bacterial cell wall (peptidoglycan), flagella, pili and endospores; bacterial cell division; economic importance of bacteria.
• **Virology:** Nature, classification and structure of viruses (helical and icosahedral symmetry); genome organisation and replication; structure and replication of bacteriophages; viroids; an overview of disease-causing viruses (e.g., dengue and the mechanism of COVID-19).
1.2 Fungi, Algae & Lichens
• **Mycology:** Eukaryotic (yeast) cell structure; classification, thallus organisation and reproduction in fungi; economic importance; representative genera across Oomycota, Zygomycota, Ascomycota and Basidiomycota.
• **Phycology & Lichens:** General features and classification of algae; ultrastructure of eukaryotic algal and cyanobacterial cells; lichens — thallus organisation, reproduction and role in monitoring environmental pollution.

Unit 2 — Microbial Physiology, Growth & Metabolism
2.1 Growth & Nutrition
• **Growth & Control:** Culture media; the bacterial growth curve; sterilisation techniques; culture and staining methods; control of microbial growth.
• **Microbial Metabolism:** Metabolic diversity (phototrophy, chemolithotrophy, autotrophy, heterotrophy, fermentation); distinctive pathways (e.g., Entner–Doudoroff); nitrogen fixation; fermentation.

Unit 3 — Biomolecules, Enzymes & Bioenergetics
3.1 Biomolecules
• **Macromolecules:** Classification and structure of carbohydrates, lipids, amino acids and proteins; isoelectric point; levels of protein organisation; vitamins.
3.2 Enzymes & Bioenergetics

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• **Enzymes:** Classification; active site, cofactors and coenzymes; Michaelis–Menten kinetics (Km, Vmax); inhibition; allosteric regulation.
• **Bioenergetics & Metabolism:** High-energy compounds (ATP); the electron transport chain and oxidative phosphorylation; glycolysis, the TCA cycle and the pentose phosphate pathway.

Unit 4 — Cell Biology
4.1 The Microbial & Eukaryotic Cell
• **Cell Structure:** Comparison of prokaryotic and eukaryotic cells; organelles — nucleus, mitochondria, endoplasmic reticulum, Golgi apparatus, lysosomes, peroxisomes and the cytoskeleton; the fluid-mosaic membrane model and transport.
• **Cell Division & Signalling:** Mitosis and meiosis; cell-cycle regulation (checkpoints, cyclins, CDKs); receptors and second messengers (cAMP, IP3, Ca^{2+}).

Unit 5 — Molecular Biology & Microbial Genetics
5.1 Molecular Biology
• **Gene Expression:** Structure of DNA and RNA; DNA replication and key enzymes; transcription, RNA processing and translation; the genetic code; gene regulation — operons (lac and trp); mutations, DNA repair and recombination.
5.2 Microbial Genetics
• **Variability:** Bacterial genome and plasmids; genetic variability through mutation and recombination (transformation, transduction, conjugation).

Unit 6 — Recombinant DNA & Microbial Biotechnology
6.1 Tools & Applications
• **rDNA Technology:** Restriction enzymes; vectors (plasmids, cosmids, lambda bacteriophage); cloning, ligation and transformation; selection of recombinants; PCR and gel electrophoresis; Southern, northern and western blotting; DNA sequencing.
• **Applications:** Recombinant insulin and vaccines; interferon and antibiotics; genetically modified organisms; bioremediation; biosafety concerns.

Unit 7 — Immunology & Applied Microbiology
7.1 Immunology
• **Immune System:** Concept and types of immunity; cells and organs of the immune system; antigens, antibodies and antigen–antibody interactions; the ELISA technique; immunoglobulins; the major histocompatibility complex; cytokines; hybridoma technology and monoclonal antibodies.
7.2 Medical & Applied Microbiology
• **Pathogens & Disease:** Overview of common disease-causing bacteria and viruses (e.g., cholera, dengue); host–pathogen interactions; basics of clinical and industrial microbiology.

M.Sc. Molecular & Human Genetics — Detailed Syllabus

Detailed unit-wise syllabus compiled by LUUPDATE. Based on the B.Sc. (NEP. Fourth-year and practical/lab papers are excluded; technical terms are kept in English as used in study material.

Unit 1 — Cell Biology & Chromosomes

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1.1 Cell Structure & Division

• **Cell Organisation:** Plasma membrane and cell–cell interactions; endomembrane system and protein targeting; cytoskeleton; mitochondria, peroxisome and ribosome; nucleus and chromatin structure; heterochromatin and euchromatin.

• **Chromosomes & Division:** Chromosome types (polytene, lampbrush, B-chromosomes); nucleosome and solenoid models; mitosis, meiosis and their significance; regulation of the cell cycle.

Unit 2 — Classical & Mendelian Genetics

2.1 Inheritance

• **Mendelian & Beyond:** Mendel's laws; complete and incomplete dominance and codominance; gene interactions (complementary genes, epistasis, duplicate genes); linkage, crossing over and linkage maps.

• **Sex & Extrachromosomal Inheritance:** Sex determination, sex-linked inheritance and dosage compensation; sex-influenced and sex-limited traits; multiple alleles; cytoplasmic inheritance and genomic imprinting; inheritance of continuous and threshold characters.

Unit 3 — Cytogenetics & Mutation

3.1 Chromosomal Variation

• **Structural & Numerical Changes:** Structural chromosomal changes (deletion, duplication, inversion, translocation); numerical changes (euploidy and aneuploidy) and their evolutionary importance.

• **Mutation:** Spontaneous and induced mutations; mutagens; molecular mechanisms and evolutionary significance; chromosomal and gene mutations.

Unit 4 — Molecular Biology

4.1 Nucleic Acids & Gene Expression

• **Replication & Central Dogma:** Structure and types of DNA and RNA; semi-conservative DNA replication and key enzymes (DNA polymerases, helicase, ligase); the central dogma and the genetic code.

• **Transcription, Translation & Regulation:** RNA polymerases, promoters and RNA processing (5′ capping, splicing, poly-A tailing); ribosomes and tRNA; gene regulation (operons; enhancers and transcription factors); DNA repair and recombination.

Unit 5 — Genetic Engineering & rDNA Technology

5.1 Tools & Methods

• **Recombinant DNA:** Cloning vectors (plasmid, cosmid, lambda bacteriophage); restriction enzymes; construction of genomic and cDNA libraries; transformation techniques; PCR, RFLP, RAPD, AFLP and DNA fingerprinting; DNA microarray and sequencing; Southern, northern and western blotting.

• **Transgenics:** Animal cell culture and expression of cloned genes; production of cloned and transgenic animals (nuclear transplantation, retroviral method, DNA microinjection); applications of transgenic animals.

Unit 6 — Human Genetics & Genetic Disorders

6.1 Human Inheritance

• **Pedigree & Disorders:** Pedigree analysis and hereditary diseases of man; molecular diagnosis of genetic diseases (cystic fibrosis, sickle-cell anaemia); recombinant insulin and human growth hormone; gene therapy; the Human Genome Project.

Unit 7 — Evolution & Population Genetics

7.1 Evolutionary Genetics

• **Mechanisms:** Theories of evolution (Lamarckism, Darwinism, modern synthetic theory); mutation, genetic drift, gene flow, non-random mating, natural selection and molecular drive; the Hardy–Weinberg law; biological species concept; modes of speciation (allopatric, parapatric, sympatric).

• **Statistical Tools:** Mean, variance and standard deviation; correlation; the chi-square (χ^2) test applied to genetic ratios.

M.Sc. Renewable Energy — Detailed Syllabus

Detailed unit-wise syllabus compiled by LUUPDATE. Based on the B.Sc. Physics / Electronics UG curriculum with allied Chemistry, Semesters I–VI. Fourth-year and practical/lab papers are excluded; technical terms are kept in English as used in study material.

Unit 1 — Mechanics, Oscillations & Waves

1.1 Mechanics & Energy

• **Newtonian Mechanics:** Inertial and non-inertial frames; conservative and non-conservative forces; conservation of energy and momentum; the work–energy principle; rigid-body dynamics, moment of inertia and rotational energy.

• **Oscillations & Waves:** Simple harmonic motion; damped and forced oscillations; resonance and quality factor; plane progressive waves and energy transport; superposition and standing waves; phase and group velocity.

Unit 2 — Thermal Physics & Solar Radiation

2.1 Thermodynamics

• **Laws & Potentials:** Zeroth, first, second and third laws; thermodynamic processes; relation between Cp and Cv; reversibility; entropy; Carnot cycle and theorem; thermodynamic potentials and Maxwell's relations; Clausius–Clapeyron equation.

2.2 Kinetic Theory & Radiation

• **Kinetic Theory:** RMS speed and kinetic interpretation of temperature; degrees of freedom and equipartition; mean free path; transport phenomena (viscosity, conduction, diffusion); Maxwell's velocity distribution.

• **Black-Body Radiation:** Spectral distribution and energy density; Planck's law; Wien's, Rayleigh–Jeans, Stefan–Boltzmann and Wien's displacement laws; the solar constant.

Unit 3 — Electricity, Magnetism & Electromagnetic

3.1 Electrostatics & Magnetism

• **Fields:** Coulomb's law; electric field, flux and Gauss's law; electric potential; dielectrics and polarization; Biot–Savart and Ampère laws; magnetic materials; B–H curve and hysteresis.

3.2 Induction & EM Waves

• **Induction:** Faraday's and Lenz's laws; self- and mutual inductance; energy stored in a magnetic field; displacement current; Maxwell's equations; EM waves in vacuum and dielectrics; energy density and the Poynting vector.

Unit 4 — Electronics & Power Devices

4.1 Circuits & Diodes

• **Circuits:** Transients in LR, RC and LCR circuits; AC circuits, complex impedance and Q-factor; series and parallel resonance; maximum-power-transfer theorem.

• **Diodes:** PN-junction formation and the depletion layer; forward and reverse characteristics; half- and full-wave rectifiers; ripple factor and rectification efficiency; Zener diode and voltage regulation.

4.2 Transistors & Applications

• **Transistors:** PNP and NPN transistors; CB, CE and CC configurations; biasing; DC load line and Q-point stabilization; RC-coupled amplifiers; positive and negative feedback; oscillators; amplitude modulation and demodulation.

Unit 5 — Solid-State & Semiconductor Physics

5.1 Crystal Structure & Electron Theory

• **Crystallography:** Lattice, basis and crystal structure; Bravais lattices; Miller indices; X-ray diffraction and Bragg's law; reciprocal lattice and Brillouin zones.

• **Electron Theory:** Free-electron theory (Drude model, Fermi energy, density of states, Hall effect); band theory (Bloch theorem, Kronig–Penney model, effective mass, holes); classification of solids — conductors, semiconductors and insulators.

5.2 Material Properties

• **Properties:** Lattice vibrations and phonons; lattice heat capacity (Einstein and Debye theories); dia-, para-, ferro- and antiferromagnetism; dielectric polarization; introduction to superconductivity; point defects (Schottky and Frenkel).

Unit 6 — Optoelectronics & Modern Physics

6.1 Quantum Foundations

• **Quantum Physics:** Photoelectric effect; de Broglie waves and the wave function; Heisenberg's uncertainty principle; the Schrödinger equation; particle in a box; energy quantization — foundations for photovoltaic and semiconductor devices.

6.2 Lasers, Fibre Optics & Photodetectors

• **Devices:** Laser theory and light amplification; optical resonators; total internal reflection, acceptance angle and numerical aperture; types of optical fibre; LEDs (materials, structures and efficiency); semiconductor lasers and photodetectors; plasma physics and applications to nuclear fusion.

Unit 7 — Energy Chemistry & Materials

7.1 Electrochemistry

• **Electrochemical Energy:** Conductance and Kohlrausch's law; types of reversible electrodes; standard electrode potentials; the Nernst equation and cell EMF; the electrochemical series; galvanic and electrolytic cells — relevant to batteries and fuel cells.

7.2 Materials & Polymers

• **Functional Materials:** Surface chemistry and adsorption (Freundlich, Langmuir, BET isotherms); polymer chemistry — polymerisation, structure–property relationships, conducting and specialty polymers used in energy applications.

M.Sc. Wildlife Sciences — Detailed Syllabus

Detailed unit-wise syllabus compiled by LUUPDATE. Based on the B.Sc. Zoology / Life Sciences UG curriculum, Semesters I–VI. Fourth-year and practical/lab papers are excluded; technical terms are kept in English as used in study material.

Unit 1 — Diversity & Biology of Non-Chordates

1.1 Lower Invertebrates

• **Protozoa to Annelids:** General characters and classification; type study of Paramecium; life cycles and pathogenicity of Plasmodium and Leishmania; type study of Sycon, Obelia; corals and coral reefs; helminths (Fasciola, Taenia, Wuchereria) and parasitic adaptations; Annelida — type study of Nereis and the coelom.

1.2 Higher Invertebrates

• **Arthropoda to Hemichordata:** Type study of Palaemon and grasshopper; Mollusca — type study of Pila and pearl formation; Echinodermata — type study of Asterias; Hemichordata — type study of Balanoglossus and its affinities.

Unit 2 — Diversity & Biology of Chordates

2.1 Protochordates & Lower Vertebrates

• **Protochordates & Fishes:** General characters, classification and origin of chordates; Urochordata (Herdmania) and Cephalochordata (Branchiostoma); Agnatha; Pisces — type study of Scoliodon, accessory respiratory organs and migration; Amphibia — parental care, neoteny and paedogenesis.

2.2 Higher Vertebrates

• **Reptiles to Mammals:** Affinities of Sphenodon; venomous and non-venomous snakes of India; dinosaurs; Aves — Archaeopteryx as a connecting link, flight adaptations and migration; Mammalia — dentition, affinities of Prototheria and adaptive radiation; comparative anatomy of vertebrate sense organs.

Unit 3 — Biosystematics & Evolution

3.1 Taxonomy & Evolution

• **Biosystematics:** Concepts and importance of taxonomy; the International Code of Zoological Nomenclature (ICZN); Linnaean hierarchy; collection and preservation of specimens; molecular techniques in systematics.

• **Evolution:** Theories of evolution (Lamarckism, Darwinism, modern synthetic theory); mechanisms (mutation, genetic drift, gene flow, natural selection); the Hardy–Weinberg law; modes of speciation; palaeobiological and anatomical evidence; evolutionary patterns.

Unit 4 — Ecology & Wildlife Habitats

4.1 Ecosystems & Populations

• **Ecology:** Ecosystem concept, types and structural components; energy flow and biogeochemical cycles; trophic levels, food chains and food webs; population characteristics,

growth and regulation; interspecific interactions; ecological succession and niche; r- and K-strategies.
• **Adaptations:** Ecological adaptations (aquatic, volant, arboreal, cursorial, fossorial, desert); ecological groups and habitat types.

Unit 5 — Environmental Biology & Conservation
5.1 Environment & Management
• **Environmental Biology:** Environmental pollution (air, water, soil, noise) — causes, consequences and management; greenhouse effect, ozone depletion and acid rain; environmental legislation (Environment Protection Act 1986, National Green Tribunal Act 2010) and UNEP.
5.2 Biodiversity & Conservation
• **Conservation:** In situ conservation (sanctuaries, national parks, biosphere reserves, wetlands, mangroves) and ex situ conservation (gene banks, seed banks, cryobanks); conservation of plant and animal resources; endemism.

Unit 6 — Animal Physiology & Behaviour
6.1 Physiology
• **Body Systems:** Digestion and absorption; respiratory pigments, the oxygen-dissociation curve and the Bohr effect; composition of blood and coagulation; the cardiac cycle; nephron structure and osmoregulation; nerve impulse and synapse; muscle contraction; endocrine glands and reproduction.
6.2 Behaviour & Chronobiology
• **Behaviour:** Types of animal behaviour; innate behaviour, learning and conditioning; social behaviour and communication; biological rhythms and the biological clock; circadian rhythms and their significance.

Unit 7 — Wildlife Toxicology & Health
7.1 Toxicology
• **Toxicants & Effects:** Routes, frequency and duration of exposure; dose–response relationship; toxicity tests (bioassay, acute and chronic); bioconcentration, bioaccumulation and biomagnification; biotransformation; toxic effects on body systems; mutagenicity, teratogenicity and carcinogenicity — relevance to wildlife health.

M.A./M.Sc. Anthropology — Detailed Syllabus

Detailed unit-wise entrance syllabus compiled by LUUPDATE from the University of Lucknow B.A./B.Sc. (NEP) core theory papers, Semesters I–VI. Fourth-year and practical papers are excluded.

Unit 1 — Introduction to Socio-Cultural Anthropology
Social Institutions
• **Scope & Institutions:** Anthropology and its branches; meaning and scope of social-cultural anthropology; marriage — definition, types, forms and payments (dowry, bride-price); family — nature, types and the joint family system; kinship terms and usages, descriptive and classificatory systems.
• **Political & Religious Life:** Social order in stateless political systems and state formation;

economic, political and religious institutions; theories of the origin of religion (animism, animatism, naturism); magic, religion and science; totemism and taboo.

Unit 2 — Theoretical Principles in Socio-Cultural Anthropology

Concepts & Theories

• **Culture & Schools:** Concept, definition, characteristics and components of culture; cultural evolutionism — classical (Tylor, Morgan) and neo-classical (White); functionalism (Malinowski's theory of needs) and structural-functionalism (Radcliffe-Brown); the Culture and Personality school (Benedict).

Unit 3 — Biological Anthropology

Human Evolution

• **Primates & Fossils:** Scope and branches of biological anthropology; the primates — evolutionary tendencies and classification; comparative anatomy and the evolution of the human foot; fossils and fossilization; geological time scale and dating methods; early hominid fossils (Ramapithecus and others); races and species of fossil man. M . A. / M . S c . A n t h ro p o l o g y E n t r a n c e S y l l a b u s — U n i v e r s i t y o f Lu c k n o w

Unit 4 — Human Genetics, Variation, Growth & Nutrition

Human Genetics & Race

• **Inheritance & Variation:** Scope of human genetics; Mendel's laws and their application to man; modes of inheritance (autosomal dominant/recessive); polygenic inheritance and dermatoglyphics; multiple alleles and the ABO, MNS and Rh blood groups; concept and genetic basis of race; the major human races and ethnic elements in India.

Growth & Nutrition

• **Nutritional Anthropology:** Meaning, scope and applications of nutritional anthropology; longitudinal, semi-longitudinal and cross-sectional methods; growth status and somatometry; nutritional requirements for normal growth and common nutritional disorders.

Unit 5 — Archaeological Anthropology

Prehistory

• **Dating & Cultures:** Meaning and scope of archaeological anthropology; short- and long- range dating methods; Quaternary climatic changes and the Great Ice Age; West European Palaeolithic cultures; the Indian Palaeolithic (Soanian, Acheulean) and Middle Palaeolithic; microlithic phase; the Mesolithic and the Neolithic Revolution and complex in India.

Unit 6 — Anthropology in the Indian Context

Tribes & Castes

• **Indian Society:** Origin and growth of Indian anthropology; Indological, anthropological and historical approaches to Indian society and civilization; ethnographic profiles of Indian tribes — racial, linguistic and socio-economic; tribal problems and development; constitutional provisions regarding the Scheduled Tribes and Scheduled Castes; the role of anthropology in tribal development.

Unit 7 — Applied & Action Anthropology

Practising Anthropology & Development

• **Applied Fields:** Applied and action anthropology — meaning, scope and historical development; anthropology of tourism and in the census; planning and development of Indian populations and human rights; development anthropology — sustainable development, poverty alleviation, planning, social exclusion and rural development (land reforms, CDP, Panchayati Raj).

Disaster Management

• **Disasters:** Definition and classification of disasters (natural and man-made); anthropological and cultural perceptions of disasters; the disaster management cycle — preparedness, prevention and mitigation; act, policy and institutional framework. M . A. / M . S c . A n t h ro p o l o g y E n t r a n c e S y l l a b u s — U n i v e r s i t y o f Lu c k n o w

Unit 8 — Medical & Business Anthropology

Medical Anthropology

• **Health & Disease:** Development of medical anthropology; basic concepts — illness, sickness and disease; biological and socio-cultural factors in health; genes and disease, disease ecology and the concept of healing; healthcare in tribal and rural communities.

Business Anthropology

• **Consumer & Organisation:** History and growth of business and corporate anthropology; anthropology and consumer behaviour; anthropology in organisational and industrial contexts; globalization, international trade and anthropology.

M.A./M.Sc. Geography — Detailed Syllabus

Detailed unit-wise entrance syllabus compiled by LUUPDATE from the University of Lucknow B.A./B.Sc. (NEP) core theory papers, Semesters I–VI. Fourth-year and practical papers are excluded.

Unit 1 — Fundamentals & Geographical Thought

Nature of the Discipline

• **Concepts & Approaches:** Meaning, definition, nature, scope and approaches of geography; basic concepts and branches; dualism in geography; the physical and human dimensions; recent trends, modern concepts and applied geography; career opportunities.

• **Evolution of Thought:** Geography as a natural and social science; contributions of the Greeks, Romans and Indians; the modern German, French, British and American schools; Humboldt, Ritter and Ratzel.

Unit 2 — Physical Geography

Earth Systems

• **Lithosphere:** Origin of the earth; internal structure based on seismic evidence; plate tectonics and associated features; the fluvial cycle of erosion (Davis and Penck).

• **Atmosphere & Hydrosphere:** Composition and structure of the atmosphere, heat budget, cyclones, monsoon and Koppen's climatic classification; the hydrological cycle, ocean-bottom relief, tides and currents.

Unit 3 — Human Geography

Society & Settlement

• **People & Culture:** Definition, nature, subfields and approaches; space and society — cultural regions, race, religion and language; population growth, distribution and composition; the demographic transition theory.

• **Settlements:** Types and patterns of rural settlements; classification of urban settlements; trends and patterns of world urbanization. M . A . / M . S c . G e o g r a p h y E n t r a n c e S y l l a b u s — U n i v e r s i t y o f Lu c k n o w

Unit 4 — Economic & Regional Geography

Economic Geography

• **Resources & Activities:** Meaning, concepts and approaches; classification of resources; power resources and principal crops; agricultural regions of the world (Whittlesey); Weber's theory of industrial location; major industries (iron and steel, sugar).

Regional Planning & Development

• **Planning Regions:** Concept, need and types of regional planning; delineation of planning regions; regionalisation of India (agro-ecological zones); growth-pole theory and the core-periphery model; backward regions and special area development plans in India.

Unit 5 — Environmental Geography & Disaster Management

Environment

• **Ecosystem & Management:** Concepts and approaches of environmental geography; ecosystem structure; human-environment relationships in equatorial, desert, mountain and coastal regions; environmental problems and management (air pollution, biodiversity loss, waste); environmental programmes and policies in India and abroad.

Disaster Management

• **Hazards & Response:** Hazard, risk, vulnerability and disaster; natural disasters in India (flood, landslide, drought) and human-induced disasters — causes, impact and mapping; mitigation and preparedness; NDMA and NIDM; community-based and indigenous disaster management.

Unit 6 — Geography of India & the Southern Hemisphere

Geography of India

• **India's Setting & Economy:** Physical setting — location, structure, relief, drainage and climate; population size and growth; rural and urban settlement systems; resource base (livestock, power, minerals); agriculture and major industries.

Regional Geography

• **Southern Hemisphere:** Physiographic regions, climate, soil, vegetation, people and economy of South America and Africa (and their islands).

Unit 7 — Political & Urban Geography

Political Geography

• **State & Geopolitics:** Nature and scope of political geography and geopolitics; the state as a politico-territorial phenomenon — location, size and shape; global strategic views of Mackinder, Spykman, Seversky and Mahan.

Urban Geography

• **Urban Systems:** Regional urban patterns; central place theory (Christaller and Losch) and

growth-pole theory; contemporary urban issues — poverty, housing, slums and master plans. M . A. / M . S c . G e o g r a p h y E n t r a n c e S y l l a b u s — U n i v e r s i t y o f Lu c k n o w

Unit 8 — Social Geography & Geography of Tourism

Social Geography

• **Social Space:** Concept, nature and social space; elements of social geography — ethnicity, tribe, dialect, language, caste and religion; socio-cultural and linguistic regions of India.

Geography of Tourism

• **Tourism:** Concepts, nature and scope; recent trends — international, regional and domestic; eco- and sustainable tourism; impacts on economy, environment and society; tourism infrastructure and the National Tourism Policy.

M.A./M.Sc. Home Science — Detailed Syllabus

Detailed unit-wise entrance syllabus compiled by LUUPDATE from the University of Lucknow B.A./B.Sc. (NEP) core theory papers, Semesters I–VI. Fourth-year and practical papers are excluded.

Unit 1 — Human Physiology

Body Systems

• **Cell to Systems:** Cell structure and function; tissues (epithelial, connective, muscular, nervous) and the skeletal system; the cardiovascular and respiratory systems; the excretory and endocrine systems; the gastrointestinal system and digestive glands.

• **Nervous & Reproductive:** The nervous system and sense organs (eye and ear); the reproductive system; the menstrual cycle; and the physiology of pregnancy, parturition, lactation and menopause.

Unit 2 — Food & Nutrition

Nutrients & Foods

• **Basic Nutrition:** Definition of nutrition and health; functions of food; energy in human nutrition (energy balance, BMR, PAL, SDA); classification of nutrients — carbohydrates, lipids, proteins, fat- and water-soluble vitamins, minerals and trace elements; nutritional composition of food groups; importance and methods of cooking.

Unit 3 — Nutrition: A Life-Cycle Approach

Nutrition Through Life

• **Life Stages:** Nutritional needs and concerns across the life cycle — infancy, childhood, adolescence, adulthood, pregnancy, lactation and old age; balanced diet, meal planning and the prevention of malnutrition at each stage. M . A. / M . S c . H o m e S c i e n c e E n t r a n c e S y l l a b u s — U n i v e r s i t y o f Lu c k n o w

Unit 4 — Human Development I: The Childhood Years

Childhood Development

• **Growth & Domains:** Domains, stages, contexts and principles of growth and development; prenatal development and factors affecting it; the new-born; physical and motor, social and

emotional, and cognitive and language development through infancy and childhood.

Unit 5 — Human Development II: Adolescence & Adulthood
Later Development
• **Adolescence to Adulthood:** Developmental tasks of adolescence; self and identity, family and peer relationships; cognitive development, intelligence and creativity; the transition from adolescence to adulthood and the concept of adulthood.

Unit 6 — Family Resource Management & Housing
Resource Management
• **Management & Money:** Introduction to the family and to management; determinants of management — goals, values, standards and decision making; the management process (planning, controlling, evaluation); resources in the family; money, time and energy management and work simplification.
Housing & Interior Design
• **Housing:** Principles of design and the factors of fine personal and interior design; selection and planning of housing and interior spaces.

Unit 7 — Textiles & Apparel
Textiles
• **Fibres & Fabrics:** Textile fibres — classification and chemical, physical and microscopic properties; yarns and fabric construction.
Apparel Designing & Construction
• **Garment Construction:** Basics of cutting, stitching and designing; selection of fabric and calculation of fabric requirements; elements and principles of art in dress designing; pattern designing and garment construction.

Unit 8 — Extension Education & Communication
Extension
• **Concepts & Methods:** Basic concepts and principles of extension education; adult learning and Home Science extension; extension methods, approaches and audio-visual/teaching aids; extension programme planning; communication — definition, elements and scope; extension and development programmes. M . A. / M . S c . H o m e S c i e n c e E n t r a n c e S y l l a b u s — U n i v e r s i t y o f Lu c k n o w

M.Sc. Nutritional Sciences — Detailed Syllabus

Detailed unit-wise entrance syllabus compiled by LUUPDATE from the University of Lucknow B.A./B.Sc. (NEP) core theory papers, Semesters I–VI. Fourth-year and practical papers are excluded.

Unit 1 — Fundamentals of Human Nutrition
Nutrition & Macronutrients
• **Concepts & Energy:** Concept of nutrition, health and nutritional status; the balanced diet; energy — units, basal metabolic rate (BMR) and energy requirements.

• **Macronutrients:** Carbohydrates, proteins and fats — classification, functions, food sources, requirements and the effects of deficiency and excess.

Unit 2 — Micronutrients & Water

Vitamins, Minerals & Water

• **Vitamins:** Fat-soluble (A, D, E, K) and water-soluble (B-complex and C) vitamins — functions, sources and deficiency disorders.

• **Minerals & Water:** Macro- and micro-minerals (calcium, phosphorus, iron, iodine, zinc); water and electrolyte balance; fluid requirements.

Unit 3 — Biochemistry of Nutrition

Metabolism

• **Digestion & Absorption:** Digestion, absorption and transport of carbohydrates, proteins and fats; the role of enzymes and hormones.

• **Metabolic Pathways:** Outlines of carbohydrate, protein and lipid metabolism; energy metabolism and nutrient interactions.

Unit 4 — Food Science & Food Microbiology

Foods & Safety

• **Food Science:** Composition and properties of food groups — cereals, pulses, milk, fruits and vegetables; methods of cooking and the effect on nutrients.

• **Preservation & Microbiology:** Food spoilage, preservation and food safety; food adulteration; food microbiology and food-borne illnesses.

Unit 5 — Community & Public Health Nutrition

Nutrition in the Community

• **Assessment & Problems:** Assessment of nutritional status (anthropometry, clinical, dietary and biochemical methods); common nutritional problems — PEM, anaemia, vitamin-A and iodine-deficiency disorders.

• **Programmes & Education:** National nutrition programmes and policy; nutrition education and intervention.

Unit 6 — Clinical & Therapeutic Nutrition

Diet Therapy

• **Principles:** Principles of diet therapy; therapeutic modifications of the normal diet; routine hospital diets.

• **Dietary Management:** Dietary management of diabetes, cardiovascular, renal, gastrointestinal and liver disorders, and obesity.

Unit 7 — Life-Cycle Nutrition & Research Methods

Life Stages & Methods

• **Nutrition Through Life:** Nutrition during pregnancy, lactation, infancy, childhood, adolescence, adulthood and old age.

• **Food Service & Research:** Food-service management; basics of nutrition research methods and

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