### SEMESTER-VII

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<th>S. No.</th>
<th>Course Code</th>
<th>Subject</th>
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CA = Class Attendance, TA = Teacher Assessment.
### SEMESTER-VIII

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**TOTAL** | 15 | 16 | 1000 | 38 |

CA = Class Attendance, TA = Teacher Assessment.
SEVENTH SEMESTER

BOP-471

PHARMACEUTICAL CHEMISTRY-VIII
(MEDICINAL CHEMISTRY-III)

Classification, mode of action, uses, recent advances and structure activity relationship of the following classes of drugs (Synthetic procedures of individually mentioned drugs only).

Unit I

Steroidal drugs: Introduction, classification, nomenclature, and stereochemistry of-
- Androgens and anabolic steroids: Testosterone, Stanazolol.
- Estrogens and progestogens: Progesterone, Estradiol.
- Adrenocorticoids: Prednisolone, Dexamethasone.

Unit II

Chemotherapy of microbial infections:
- Antibiotics: Penicillin, Semi-synthetic Penicillins (Ampicillin), Cephalosporins (Cefepime), Chloramphenicol, Tetracyclines (Doxycycline), Aminoglycosides, Macrolides.
- Antifungals: Ketoconazole and Clotrimazole.
- Antiseptics & disinfectants: Chlorhexidine.

Unit III

Chemotherapy of microbial infections:
- Synthetic antibacterials: Sulphonamides (Sulphamethoxazole, Sulphadiazine, Sulphacetamide), Quinolones/Fluoroquinolones (Nalidixic acid, Ofloxacin).
- Antimycobacterial agents: PAS, Ethambutol, Isoniazid, Dapsone.

Unit IV

Chemotherapy of parasitic infections:
- Antimalarials: Chloroquine, Primaquine, Pyrimethamine.
- Antiamoebics: Ornidazole, Diloxanide.
- Anthelmintics: Albendazole.

Unit V

Cancer chemotherapy: Alkylating agents (Chlorambucil, Carmustine), Antimetabolites (Methotrexate, 5-Fluorouracil), Anticancer antibiotics (Doxorubicin).
- Antiviral/Anti-HIV agents: Amantadine, Acyclovir, Zidovudine, Saquinavir, Raltegravir.
BOOKS RECOMMENDED
Unit I

Unit II
Significance of plasma drug concentration measurement.
Compartment models and non-compartment models: Definition and scope.
Pharmacokinetics of drug absorption: Zero order and first order absorption rate constant. Determination of absorption rate constant using Wagner-Nelson and Loo-Reigelman method.

Unit III
Compartment kinetics: One compartment and preliminary information of multicompartment models. Determination of pharmacokinetic parameters from plasma and urine data after drug administration by intra venous (I.V.) bolus and I.V. infusion.

Unit IV
Dosage adjustment in patients with renal and hepatic disease.
Clinical Pharmacokinetics: Definition and scope.

Unit V
Brief introduction to bioavailability and bioequivalence: Definition and significance. Measurement of bioavailability.
Introduction to in-vivo in-vitro correlation (IVIVC) and its significance.
Review of regulatory requirements for conduction of bioequivalence studies.
**BOP-472P**

PHARMACEUTICS-IX
(BIOPHARMACEUTICS & PHARMACOKINETICS) PRACTICAL

1. *In-vitro* drug release study of the any powder, uncoated tablet, capsule, film-coated tablet, sustained release tablet and fast release (M.D, Dispersible etc.) tablet using various dissolution media.
2. To determine the % protein binding of some drugs.
3. To determine the effect of protein binding on drug bioavailability.
4. To calculate various Pharmacokinetic parameters from zero order drug release data, first order drug release data, blood data of *I.V.* bolus injection (one compartment model) and urinary excretion data of *I.V.* bolus. Injection using both methods (Rate of elimination & sigma minus method one compartment model).
5. To study *in-vitro* drug- drug interactions.
6. To study the passive diffusion of a drug using cellophane membrane.
7. To study the passive diffusion of a drug using egg membrane.
8. To determine the various Pharmacokinetic parameters from the given blood data of oral administration of dosage form.
10. Determination of bioequivalence by dissolution method.

**BOOKS RECOMMENDED**

5. Gibaldi, M., Biopharmaceutics & Clinical Pharmacokinetics, Pharma Book Syndicate, Hyderabad.
PHARMACOLOGY-III
(PHARMACOLOGY & PHARMACOVIGILANCE)

Unit I
Pharmacology of endocrine system: Hypothalamic and pituitary hormones, thyroid hormones and thyroid drugs. Parathormone, Calcitonin and Vitamin D, Insulin, oral hypoglycemic agents and Glucagon. Corticosteroids, androgens and anabolic steroids, Estrogens, Progesterone and oral contraceptives, drugs acting on the uterus.

Unit II
Chemotherapy: General principles of chemotherapy. Sulfonamides, Quinolones, Beta-lactam antibiotics, Chloramphenicol, Tetracyclines, Macrolides and Aminoglycosides.
Chemotherapy of parasitic infections: Tuberculosis, leprosy, malaria, fungal infections, viral diseases.

Unit III
Naturopathy: History, definitions, mechanism and its effect on various systems, hydrotherapy, mud therapy, chromotherapy, acupressure, aromatherapy and therapeutic massage.

Unit IV
Pharmacovigilance: Scope, definition and aims of pharmacovigilance and pharmacoepidemiology, therapeutic index- LD₅₀ and ED₅₀, drug interactions.
Adverse drug reactions: Classification, mechanism, predisposing factors and causality assessment. Role of clinical pharmacist in reporting, evaluation, monitoring, prevention and management of ADR, drug induced diseases affecting different organ systems.
Fixed dose drug combinations (FDDCs): Rational and irrational combinations, FDDCs in Indian scenario.

Unit V
Epidemiological methods: Case control study: Selection of cases, selection of controls, matching, measurements of exposure, analysis, odds ratio, bias in case control study, advantages, disadvantages.
Cohort study: Concept, framework, combination of prospective and retrospective cohort study, relative risk, attributable risk, advantages, disadvantages.
PHARMACOLOGY-III
(PHARMACOLOGY & PHARMACOVIGILANCE) PRACTICAL

1. To calculate the pA$_2$ value of Atropine and Chlorpheniramine.
2. Bioassay of Ach, Histamine and Oxytocin on suitable isolated preparations using matching assay, bracketing assay, interpolation, three point assay and four point assay.
3. Bioassay of histamine and acetylcholine using matching and interpolation method on rat and guinea pig.

The experiments should be conducted using software, wherever possible.

BOOKS RECOMMENDED:
20. Pizzorno J. E., Murray M. T., The Encyclopedia of Natural Medicine, Simon & Schuster, New York, USA.
PHAMACOGNOSY-IV

Unit-1
Systematic study of source, cultivation, collection, processing, commercial varieties, chemical constituents, substitutes/adulterants, uses, diagnostic macroscopic and microscopic features and specific chemical tests of following alkaloid containing drugs-

**Pyridine-piperidine:** Tobacco, Areca and Lobelia.

**Tropane:** Belladona, Hyoscyamus, Datura, Coca and Withania.

**Quinoline and isoquinoline:** Cinchona, Ipecac and Opium.

**Indole:** Ergot, Rauwolfia, Catharanthus and Nux-vomica.

Unit II

**Imidazole:** Pilocarpus.

**Steroidal:** Veratrum and Kurchi.

**Alkaloidal amine:** Ephedra and Colchicum.

**Glycoalkaloid:** Solanum.

**Purines:** Coffee and Tea

**Quinazoline:** Vasaka.

Unit III

**Production and utilization of phytoconstituents:** Calcium sennosides, Diosgenin, Solasodine, Podophyllotoxins, Tropane alkaloids, Isoquinoline alkaloids and Quinoline alkaloids.

Unit IV

**Plant tissue culture:** Historical development of plant tissue culture, type of culture, nutritional requirements, growth and maintenance, factors affecting plant tissue culture.

Applications of plant tissue culture in pharmacy.

Unit V

Introduction to herbal fingerprinting using HPTLC technique.

Introduction to herbal drug interactions.

Introduction to bioactive compounds enhancing bioavailability such as- Piperine, Vitamin K.
PHARMACOGNOSY-IV PRACTICAL

1. To study the morphology and microscopy of Datura and Withania.
2. To study the morphology and microscopy of Ipecac and Rauwolfia.
3. To study the morphology and microscopy of Catharanthus and Nux-vomica.
4. To study the morphology and microscopy of Ephedra and Kurchi.
5. To study the morphology and microscopy of Solanum and Vasaka.
    b) Transverse section of Catharanthus leaf and Kurchi bark.
7. To study the TLC profile of Catharanthus leaf.
8. To study the TLC profile of Withania root.
9. Chemical test of Tea, Tobacco, Datura and Withania.
11. Preparation of different callus cultures using various parts of plants.
13. Effect of various plant hormones on micopropogation.

BOOKS RECOMMENDED

8. Sukh Dev, A Selection of Prime Ayurvedic Plant Drugs, Anamaya Publisher New Delhi.
10. Indian Ayurvedic Pharmacopoeia, Govt. of India.
UNIT I

**Ultra violet and visible spectroscopy:** Principle and origin of spectra, quantitative laws, chromophores and auxochromes, factors affecting absorption, instrumentation—single and double beam spectrophotometer, Woodward-Fieser rule, applications.

**Infra-red spectroscopy:** Principle, effect of hydrogen bonding and conjugation on absorption band, instrumentation, interpretation of IR spectra of simple compounds (Ethanol, Benzaldehyde). FTIR, applications of IR spectroscopy in pharmaceutical analysis.

UNIT II

**NMR spectroscopy:** Principle of $^1$H-NMR, chemical shift and factors affecting it, shielding and deshielding, spin-spin coupling and coupling constant, spin-spin splitting, instrumentation, NMR active compounds and study of $^1$H-NMR spectra of Ethanol, Benzaldehyde. Introduction to $^{13}$C-NMR.

UNIT III

**Mass spectrometry:** Principle, fragmentation pattern in relation to molecular structure and functional groups including McLafferty rearrangement, ionization techniques (CI, FAB, ESI, MALDI), instrumentation, applications, mass spectra of some simple compounds (Ethanol, Benzaldehyde).

UNIT IV

**Miscellaneous techniques:** Principle, instrumentation and applications of atomic absorption spectroscopy, fluorimetry and flame photometry. Introduction to gel electrophoresis, scanning electron microscopy (SEM) and transmission electron microscopy (TEM).

UNIT V

**Quality Assurance:** Basic concept of quality, difference between QC and QA, quality audit, types of quality audits, concept of TQM, ISO 9000 series. Elementary study of WHO guidelines. Different documents prepared by QA department (batch manufacturing record, master formula record, validation master plan). Basic concept of validation, types of validation, different validation parameters, protocols for process validation.
PHARMACEUTICAL ANALYSIS-III
(PHARMACEUTICAL ANALYSIS & QUALITY ASSURANCE) PRACTICAL

1. Determination of $\lambda_{\text{max}}$ of different compounds by UV-visible spectrophotometry.
2. Verification of Beer’s law.
3. Determination of unknown concentration of some drugs by UV-visible spectrophotometry.
5. Determination of factors which affect $\lambda_{\text{max}}$ by UV-visible spectrophotometry.
6. Interpretation of IR, Mass and NMR spectra.
7. Assay of official formulations containing single and more active ingredients using instrumental techniques.
10. Formation and maintenance of different documents/records formed by QA department.

BOOKS RECOMMENDED

1. Pharmacopoeia of India, Ministry of Health, Govt. of India.
Delhi.


HOSPITAL TRAINING-II

Training of students at a hospital establishment for a minimum duration of 45 days. The hospital training shall include: First aid (wound dressing, artificial respiration etc.), different routes of injection, study of patient observation charts, prescriptions and dispensing, simple diagnostic reports etc.

May be performed at the end of the 6th semester.
EIGHTH SEMESTER

BOP-481

PHARMACEUTICAL CHEMISTRY-IX
(CHEMISTRY OF NATURAL PRODUCTS)

Unit I
General methods of isolation and separation of plant constituents, qualitative tests for the detection of plant constituents. Application of spectral techniques in the structure determination of natural products.
Biogenetic investigations and basic metabolic pathways (Alkaloids, Terpenes, Steroids). Brief introduction to biogenesis of secondary metabolites of pharmaceutical importance (Atropine, Quinine, Papaverine, Morphine and Reserpine).

Unit II
Extraction, isolation and structure elucidation of alkaloids: Tropanes (Atropine); Phenanthrenes (Morphine); Quinolines (Quinine); Isoquinolines (Papaverine); Indoles (Reserpine).

Unit III
Extraction, isolation and structure elucidation of-
Glycosides: Digoxin.
Flavonoids: Quercetin.
Lignans: Podophyllotoxin.
Purines: Caffeine.

Unit IV
Extraction, isolation and structure elucidation of-
Terpenoids: Camphor, Menthol, Citral.
Carotenoids: β-Carotene.
Vitamins: α-Tocopherol.
Quassinoids: Quassin.

Unit V
Natural allergens, photosensitizing agents and fungal toxins.
Role of natural products in drug discovery and development.
Recent developments of natural products used as anticancer agents, antidiabetics, antimalarials and immunomodulators.
1. Laboratory experiments on extraction (conventional/microwave assisted), isolation, separation and purification of various groups of chemical constituents of pharmaceutical significance.
2. Exercises on paper and thin layer chromatographic evaluation of herbal drug constituents.
3. Isolation of volatile oils and their chromatographic profiles.

SUGGESTED EXPERIMENTS
1. Isolation of Caffeine from tea leaves.
2. Isolation of Piperine from black pepper.
3. Isolation of Hesperidin from orange peel.
4. Isolation of Clove oil from clove.
5. Isolation of Caraway oil from caraway.
6. Isolation of Cumin oil from cumin.
7. To study the TLC profile of extracted oils.
8. To perform the column chromatography of any available herb.
9. To study the paper chromatographic profile of glycone portion separated from senna.
10. To isolate the active constituent of any available drug with the help of preparative TLC.
11. Quantitative determination of Ascorbic Acid present in amla.

BOOKS RECOMMENDED
10. Indian Herbal Pharmacopoeia, Indian Drug Manufacturers Association and Regional Research Laboratory, Jammu.
Unit I
**Immunology and immunological preparations:** Principles, antigen and haptens, immune system, cellular and humoral immunity, immunological tolerance, antigen-antibody reactions and their applications, standardization and storage of vaccine.

Unit II
**Recombinant DNA technology:** A brief introduction to genetic engineering and techniques, production of r-DNA and their application, development of hybridoma for monoclonal antibodies and their application, protoplast fusion and biotechnological production of products such as Insulin and Somatotropin.

Unit III
Antibiotics: Screening of soil for organisms producing antibiotics.
Fermentor: Basic design, control of different parameters and application.
Isolation of mutants and factors affecting mutation.

Unit IV
**Microbial transformation:** Introduction, types of reactions mediated by microorganisms, selection of organisms, methodology of biotransformation, process improvements with special reference to steroids.

Unit V
**Enzyme immobilization:** Sources of enzymes, techniques of immobilization of enzymes and cell, advantages and limitation of immobilization, application of immobilization in pharmacy. Biotechnological production and pharmaceutical application of enzymes such as penicillinase, α-galactosidase, amylases and proteases.
1. Estimation of protein in given sample.
2. Production of protoplast fused cells by chemical method.
3. Production of protoplast fused cells by mechanical method.
4. Estimation of immunological reaction (blood group etc.).
5. Assay of antibiotics.
6. Screening of soil for antibiotic producing microorganisms.
7. Immobilization of drug.
8. Immobilization of enzyme.
9. Immobilization of cell.
10. Protein estimation by gel electrophoresis.
11. Isolation of enzymes from natural sources.

BOOKS RECOMMENDED
1. Prescott and Dunn’s Industrial Microbiology, CBS Publishers and Distributors, New Delhi.
Unit I

**Concepts of management:** Definition, administrative management (planning, organizing, staffing, directing and controlling). Entrepreneurship development, introduction to operative management (personnel, materials, production, financial management).

Unit II

**Principles of management:** Coordination, communication, motivation, decision making, leadership, innovation and creativity.

**Production management:** A brief study of the different aspects of production management, methodology of activities: performance evaluation, review technique, maintenance management.

Unit III

**Pharmaceutical marketing:** Introduction to pharmaceutical marketing. Functions, buying, selling, transportation, storage and finance. Feedback information, channels of distribution, wholesale, retail, department store. Introduction to e-commerce (online shopping, online banking, pretail, marketing to prospective and established customers) and start up business.

Unit IV

**Salesmanship:** Principle of sales promotion, advertising, ethics of sales, merchandising, literature, detailing, recruitment, training, performance appraisal of sales force.

Unit V


**BOOKS RECOMMENDED**

Unit I
Introduction to food technology.

**Food Processing:** Freezing, changes in food during refrigerated storage, progressive freezing, Ice crystal damage, effect of dehydration, microwave heating and drying methods on food products.

Unit II

**Food packaging and preservation:** Properties of packaging material used for food packaging, influence of packaging material on changes of food stuffs, brief description of packaging of frozen, dried products and thermally processed foods.

Brief description of food preservation and its methods.

Unit III

**Neutraceuticals:** Introduction, classification, categories and rational of use of neutraceuticals.

Brief description to dietary supplements, fortified foods, functional foods and phytoneutraceuticals.

Unit IV

**Development and marketing of neutraceutical products:** Supercritical fluid extraction technology-basics and application for extraction of neutraceuticals from various sources, Packaging, label claims. Regulatory aspects of neutraceutical products in India.

Unit V

**Testing of neutraceuticals and food products:** Testing of microbial load, nutritional value, heavy metals, calorific value and neutraceutical label claim test.

Brief introduction to Agmark, Bureau of Indian Standards (BIS) and Food Safety and Standards Authority of India (FSSAI).
PHARMACEUTICS-XII
(FOOD & NEUTRACEUTICALS) PRACTICAL

1. Preparation of traditional health products e.g. Gulkand, Amla syrup
2. Formulation of health drinks.
3. Preparation and testing of some food products.
5. Preparation and testing of some neutraceuticals.

BOOKS RECOMMENDED

ELECTIVE

*BOP-485(A)*

**COMPUTATIONAL METHODS IN DRUG DESIGN**

**Unit I**
Introduction to drug design concept, rational approaches of drug design, role of computational chemistry in drug design. The concept of drug likeness and druggability.

**Chemometrics:** Introduction to multivariate analysis, linear (PCA, MLR, PLS) and non-linear methods, validation tools. Introduction to some statistical softwares (such as; SPSS, Graph Pad Prism etc.).

**Unit II**
**Molecular Modeling:** Introduction to the principles of molecular mechanics, quantum mechanics, molecular dynamics and their applications in drug design.

**Unit III**
**Quantitative structure activity relationship (QSAR):** Basic concepts of QSAR, molecular descriptors (2D and 3D parameters), biological parameters, tools and techniques, quantitative models, validation of models, introduction to 2D and 3D QSAR methodologies.

**Unit IV**
**Virtual screening:** Introduction to some molecule databases. Ligand based and structure based virtual screening. Similarity searching, various methods of similarity searching and their applications in virtual screening: QSAR modeling, pharmacophore modeling, shape based screening, fingerprint based screening etc.

**Unit V**
**Structure based drug design:** Protein Data Bank, molecular graphics, design of enzyme inhibitors, receptor based drug design, molecular docking and protein homology modeling.
Introduction to bioinformatics and some drug design softwares (free and commercially available).
**BOP-485P (A)**

**COMPUTATIONAL METHODS IN DRUG DESIGN PROJECT**

1. To perform the Hansch and Free-Wilson analysis for the given dataset.
2. To develop and validate a 3D-QSAR model on a given dataset.
3. To develop and validate a 3D-Pharmacophore model on a given dataset.
4. To create a 3D-QSAR based hypothesis for virtual screening on a small molecule dataset.
5. To create a shape-based pharmacophore query on a set of aligned molecules and perform a virtual screening on a small molecule dataset.
6. To perform the virtual screening on a small molecule dataset using different fingerprint methods.
7. To perform molecular docking simulation and study various non-covalent interaction in protein-ligand complex.
8. To perform a homology modeling for a given target using modeler.
9. To perform the structure based virtual screening on a small molecule dataset.
10. To perform the different machine learning methods on a given dataset.
11. To perform the drug-likeness (ADMET) for small molecules.

**BOOKS RECOMMENDED**

BOP-485 (B)

GOOD MANUFACTURING PRACTICES

Unit I
Introduction to good manufacturing practices (GMP), good clinical practices (GCP) and good laboratory practices (GLP). Schedule M.
Standard operating procedure (SOP): Introduction, preparation, validation and revision.

Unit II
**Documentation:** Protocols, forms and maintenance of records in pharmaceutical industry, preparation of document for investigational new drug (IND), new drug application (NDA), abbreviated new drug application (ANDA) and export registration.

Unit III
Introduction to 21-Code of federal regulations. Current good manufacturing practices (c-GMP) guidelines according to United States Food and Drug Administration (USFDA), difference between GMP and c-GMP.

Unit IV
**Pharmaceutical product recall:** Recall classification, strategy for effective recall, FDA requested recall, firm initiated recall, recall status reports, termination of recall.
Introduction to finished product reprocessing and salvaging.

Unit V
**Sampling:** Introduction, WHO guidelines, sampling plans and techniques, operating characteristics curves, maintenance of sampling records of finished product and packaging material.
GOOD MANUFACTURING PRACTICES PROJECT

1. Study the steps to generate SOP.
2. Generation and validation of SOP for Autoclave.
5. Generation and validation of SOP for Balance (electronic and dispensing).
7. Generation and validation of SOP for Hot air oven.
10. Generation and validation of SOP for Incubator.

BOOKS RECOMMENDED

2. Garfield, Quality Assurance Principles for Analytical Laboratories, Published by Oxford University Press, USA.
5. Florey, Analytical Profile of Drugs (All volumes), Academic Press, United States.
6. Indian Pharmacopoeia.
**BOP-485 (C)**

**CLINICAL PHARMACY**

**Unit I**


**Unit II**

**Data analysis and compiling:** The patient’s case history, communication skills including patient medication history interview, patient counseling. Pharmacoeconomics. Medical writing: Regulatory and educational medical writing. Literature review and meta-analysis: Process, methods and application, research, report and paper / thesis writing. Pharmacovigilance programme of India (PvPI) and Geneva (UPSALA).

**Unit III**

**Daily activities of clinical pharmacists:** Drug therapy monitoring (medication chart view, clinical review), therapeutic drug monitoring, ward round participation, drug utilization evaluation/ review (DUE)/ (DUR). Quality assurance of clinical pharmacy services.

**Unit IV**

**Research design and conduct of clinical trials:** Research support including planning and execution of clinical trials. Schedule Y, GLP, GCP and ICH Guidelines, trial master file and ethical requirements. Various phases of clinical trials. Categories of Phase IV studies. Bioavailability (BA) and bioequivalence (BE) studies and the estimation with the help of plasma-concentration profile curve. Statistical analysis plan (SAP) and its importance in clinical research.

**Unit V**

**Data collection and biostatistical analysis:** Statistical principles underlying clinical trials, data handling and role of biostatistician. Sample size calculation, types of variables, Type I error and type II errors, application of parametric and non-parametric tests, confidence intervals, outliers. Data analysis with the help of bio-statistical software.
BOP-485P (C)

CLINICAL PHARMACY PROJECT

Epidemiological survey and comparison of prescribed therapeutic agents/diagnostic reports on different diseases such as- Cardiovascular disorders, central nervous system disorders, gastrointestinal tract disorders, hormonal disorders, pathogenic diseases.

BOOKS RECOMMENDED
1. Scott L.T., Basic skills in interpreting laboratory data, American Society of Health System Pharmacists Inc., USA.
2. Rowland and Tozer, Clinical Pharmacokinetics, Williams and Wilkins Publication, Philadelphia, USA.
6. Herfindal E.T. and Hirashman J.L., Clinical Pharmacy and Therapeutics Williams and Wilkins, Philadelphia, USA.
STANDARDIZATION OF HERBAL DRUGS

Unit I
Commerce and quality control of natural medicinal plants products, organoleptic, microscopical, physical and chemical evaluation of crude drugs.

Unit II
Standardization of plant material as per WHO guidelines.

Unit III
Methods of extraction and modern techniques for the isolation, purification, separation estimation and characterization of active plant constituents.

Unit IV
Analysis of official formulations derived from crude drugs, including some ayurvedic preparations.

Unit V
General methods of screening of natural products for following biological activity:

a) Anti-inflammatory  b) Hypoglycaemic  c) Antibacterial

d) Antifertility  e) Psychopharmacological.
STANDARDIZATION OF HERBAL DRUGS PROJECT

Projects based on-
1. Standardization of Ayurvedic liquid formulations on the basis of the following parameters—viscosity, pH, loss on drying, foaming index, chromatography.
2. Standardization of Ayurvedic powdered formulations on the basis of following parameters—extractable matter by using various solvents, ash value, stomatal and stomatal index, trichomes and their types, loss on drying, foaming index, fiber content, chromatography.
3. Stability studies of herbal products as per WHO guidelines.

BOOK RECOMMENDED
4. Pharmacopial Standards for Ayurvedic Formulations, CCRAS, Delhi.
5. Dhavan B.N. and Srimal R.C., The Use of Pharmacological Techniques for Evaluation of Natural Products. CDRI, Lucknow.
11. Sukh Dev, A Selection of Prime Ayurvedic Plant Drugs, Anamaya Publisher New Delhi.
12. Indian Ayurvedic Pharmacopoeia, Govt. of India.
14. Mukherjee P.K., Quality Control of Herbal Drugs, Business Horizones Pharmaceutical Publisher, New Delhi.
RESEARCH METHODOLOGY

Unit I

Fundamentals of research: Meaning and objective of research, types of research (basic, applied and patent oriented), defining research problem, research design including various methods, research process and steps involved.

Literature survey and documentation: Methods of literature survey, use of library, books, journals, e-journals, thesis, chemical abstracts and patent database, importance of documentation, documentation techniques, use of computer programs/packages (online resources such as scientific search engines and online servers) in literature survey and documentation.

Unit II

Data collection and data analysis: Execution of the research, observation and collection of data, types of data (primary and secondary), methods of data collection, sample size, sampling procedure and methods. Data processing and analysis strategies. Research hypothesis (experimental and non-experimental), hypothesis testing (parametric and non-parametric tests), types of errors and their control, generalization and interpretation of results. Use of statistical softwares/packages in data analysis (SPSS, Graph Pad Prism).

Unit III

Technical writing and reporting of research: Types of research report: Dissertation and thesis, research paper, review article, short communication, conference presentation, meeting report etc. Structure and organization of research reports: Title, abstract, key words, introduction, methodology, results, discussion, conclusion, acknowledgement, references, footnotes, tables and illustrations. Use of reference managing softwares (such as- Mendeley, EndNote). Impact factor, rating, indexing and citation of journals.

Detailed study of ‘Instruction to Authors’ of any ACS or ScienceDirect journal, a thorough understanding of steps involved in submitting articles electronically to any ACS or ScienceDirect journal (registration, new article submission, tracking process, submitting revised articles).

Unit IV

Research ethics, ethical consideration during animal experimentation including CPCSEA guidelines, impact of research on environment and society, commercialization of research, intellectual ownership, plagiarism and use of plagiarism detection softwares such as Turnitin,
VIPER etc., responsibility and accountability of the researchers. Academia-Industry interface and research.

**Project cost management:** Cost analysis of the project, cost incurred on raw materials, procedure, instrumentation and biological testing.

**Unit V**

**Funding agencies and research grants:** Introduction to various research funding agencies such as-DST, DBT, AICTE, UGC, CSIR, ICMR, AAYUSH, and DRDO along with their functions in India. Writing a research project and procurement of research grant.
RESEARCH METHODOLOGY PROJECT

Projects based on -

1. Literature survey, data collection, formulation and testing of hypothesis, interpretation of results on a particular research project.
2. Use of statistical packages/ programs (such as SPSS, Graph Pad Prism) in data analysis.
3. Collection, compilation and execution of computational programs for research benefits.
4. Manuscript preparation, communication and follow-up of a research paper/review article.
5. Writing a research project for the procurement of research grant/travel grant from any funding agency.
6. Preparation and presentation of a research report (Oral and Poster presentations using Microsoft PowerPoint Package, Microsoft Publisher etc.).

BOOKS RECOMMENDED

Visit of students to an industrial establishment or an approved research laboratory. The industrial/research laboratory visit shall include: in case of industry- visit to different sections and subsections of the industry, an idea about the functioning of the industry, product range of the industry and various approvals of the industry; in case of research laboratory- visit to different departments of the laboratory, an idea about the interdisciplinary coordination, contribution of the laboratory to the society and various approvals of the laboratory. A proper report of the same shall be submitted by the students, which shall be subsequently evaluated to assess the impact of the visit.

**May be performed at the end of the 7th semester.**