

CENTRAL UNIVERSITY OF PUNJAB, BATHINDA

CENTRAL UNIVERSITY OF PUNJAB BATHINDA

Course Scheme

For

M.Sc. (Food Science and Technology)

1st to 4th SEMESTER

Session 2016-18

Syllabi Applicable For Admissions in 2016

Centre for Applied Agriculture

School of Basic and Applied Sciences

CENTRAL UNIVERSITY OF PUNJAB, BATHINDA

FIRST SEMESTER

Course No.	Course Title	Credits			Total Credits
		L	T	P	
FST.501	Advanced Food Chemistry	3	-	-	3
FST.502	Advanced Food Processing Technology	2	-	-	2
FST.503	Food Process Engineering	3	-	-	3
FST.504	Technology of Cereals Processing	3	-	-	3
FST.505	Modern Food Microbiology	2	-	-	2
FST.506	Nutrition Science, Nutraceuticals & Health Foods	2	-	-	2
FST.507	Food Biotechnology-Molecular Biology	2	-	-	2
FST.508	Experiments in Food Chemistry	-	-	1	1
FST.509	Experiments in Cereals Processing	-	-	1	1
FST.510	Experiments in Food Microbiology	-	-	1	1
Total Credits		17	-	3	20

SECOND SEMESTER

Course No.	Course Title	Credits			Total Credits
		L	T	P	
FST.511	Advanced Food Analysis Techniques	2	-	-	2
FST.512	Legumes and Oil Seeds Processing	2	-	-	2
FST.513	Advanced Fruits and Vegetables Processing	2	-	-	2
FST.514	Application of Enzymes in Food Processing	2	-	-	2
FST.515	Equipment Design and Process Control	3	-	-	3
FST.516	Food Engineering Operations	2	-	-	2
FST.517	Genetic Engineering in Food Technology	2	-	-	2
FST.518	Management, New Product Development and International Trade	2	-	-	2
FST.519	Experiments in Legumes and Oil Seeds Processing	-	-	1	1
FST.520	Experiments in Fruits and Vegetables Processing	-	-	1	1
FST.521	Experiments in Food Engineering-I	-	-	1	1
FST.522	Experiments in Genetic Engineering	-	-	1	1
Total		17	-	4	21

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THIRD SEMESTER

Course No.	Course Title	Credits			Total Credits
		L	T	P	
FST.523	Advanced Food Packaging	2	-	-	2
FST.524	Food business Management	2	-	-	2
FST.525	Poultry, Meat and Fish Processing	2	-	-	2
FST.526	Sensory Evaluation and Quality Control in Food Industry	2	-	-	2
FST.527	Renewable Energy in Food Processing	2	-	-	2
FST.528	Advanced Food Engineering	3	-	-	3
FST.529	Fermentation Science in Food Processing	2	-	-	2
FST.530	Experiments in Food Packaging	-	-	1	1
FST.531	Experiments in Food Engineering-II	-	-	1	1
FST.532	Seminar/ Synopsis for Research Project	-	2	-	2
Total Credits		15	2	2	19

FOURTH SEMESTER

Course No.	Course Title	Credits			Total Credits
		L	T	P	
	Research Methodology and Computer Applications	2	-	-	2
	Seminar	-	1	-	1
	Research Project	-	20	-	20
Total Credits		2	21		23
Gross Credits (Sem. I-IV) (20+21+19+23)		83			

CENTRAL UNIVERSITY OF PUNJAB, BATHINDA

Semester I

Course Name: Advanced Food Chemistry

L	T	P	Credits	Marks
3	-	-	3	100

Course Code: FST. 501

- **Water relationships in foods:** Water activity and its relevance to deteriorative processes in foods (chemical, enzymic, physical and microbial changes).
- **Food Carbohydrates:** Structure, analytical, physicochemical, nutritional and functional aspects of carbohydrates (mono, oligo and poly-saccharides of plant origin).
- **Proteins:** Occurrence, amino acids, physical & chemical properties, determination, peptides, proteins & their properties, sequence of amino acids, structure of protein denaturation, major source of protein.
- **Oils and Fats:** Introduction, occurrence, composition, classification, physical and chemical properties, rancidity and flavor, reversion. Processing of oil bearing materials.
- **Pigments:** Myoglobin, chlorophyll, anthocyanins and carotenoids, occurrence, structure, chemistry and changes during processing.
- **Pectic Substances:** Occurrence, structure, properties and uses in foods.
- **Fragrance and flavouring compounds:** essential oils, terpenoids-oleoresins biochemical Pathways for the production of volatile compounds in specific plant species; Chemical structure, distribution, diurnal and seasonal fluctuations; Intraspecific differences in volatiles oil production, differentiation between geographical origins; Turpentine and terpene industry and, biological Interactions among food components and flavours.
- **Antioxidants:** Chemistry and mechanisms of action, techniques of evaluation of antioxidant activity, uses. Natural antioxidants, mechanisms of action and their evaluation techniques. Free radical chemistry, reactive oxygen, photosensitized oxidation, metal catalyzed reactions.
- **Toxic substances:** Natural toxicants in foods and their elimination.

Suggested readings:

- Food Chemistry by O.R. Fennema
- Aurand LW, Woods A & Wells MR. 1987. *Food Composition and Analysis*. AVI Publ.
- Kumar A & Gaonkar G. 1995. *Ingredient Interaction: Effect on Food Quality*. Marcel Dekker.

CENTRAL UNIVERSITY OF PUNJAB, BATHINDA

**Course Name: Advanced Food Processing
Technology**

L	T	P	Credits	Marks
2	-	-	2	100

Course Code: FST. 502

- Principles of food processing. Causes of food spoilage. Types of preservation techniques and their principles.
- Irradiation in Food processing: Sources and Mechanism of action of ionization irradiations, Doses and Effects on foods.
- Membrane Technology: Introduction to pressure activated membrane processes: micro-filtration, UF, NF and RO and their industrial application. Supercritical fluid extraction: Concept, property of near critical fluids NCF and extraction methods.
- Microwave in food processing: Advantages, mechanism of heat generation, application in food processing.
- High Hydrostatic Pressure Processing: Concept, equipments, mechanism of microbial inactivation and effects on food constituents, and its application in food processing.
- Ultrasonic processing: Properties of ultrasonic, applications in food processing.
- Application of newer techniques in food processing: high intensity light, pulse electric fields, ohmic heating, IR heating and pulsed X-rays in food processing and preservation.
- Hurdle technology: Concept of hurdle technology and its application.

Suggested Readings

- Food Science by N.N. Potter.
- Barbosa-Canovas 2002. *Novel Food Processing Technologies*. CRC Press.
- Dutta AK & Anantheswaran RC. 1999. *Hand Book of Microwave Technology for Food Applications*.
- Frame N.D. (Ed.). 1994. *The Technology of Extrusion Cooking*. Blackie.
- Gould GW. 2000. *New Methods of Food Preservation*. CRC.
- Shi J. (Ed) 2006. *Functional Food Ingredients and Nutraceuticals: Processing Technologies*. CRC.

CENTRAL UNIVERSITY OF PUNJAB, BATHINDA

Course Name: Food Processing Engineering

L	T	P	Credits	Marks
3	-	-	3	100

Course Code: FST. 503

- Heat Transfer: Conduction-Fourier's law, applications of steady-state heat transfer i.e. conductive heat transfer in a rectangular slab, tubular pipe, composite rectangular wall (in series), composite cylindrical tube (in series) and sphere. Critical thickness of insulation. Convection-Free convection and forced convection. Estimation of convective heat transfer coefficient and overall heat transfer coefficient. Heat exchangers-Steam injection, steam infusion, Plate heat exchanger, Scraped surface and Tubular heat exchanger. Design of a tubular heat exchanger by LMTD and NTU-Effectiveness method. Radiation-stefan-Boltzmann law, Black body. Emissivity. Grey body. Application of radiation in food drying.
- Evaporation: Heat transfer in evaporation, operation methods and types of evaporators-Batch type pan evaporator, Natural circulation evaporator, Rising film evaporator, Falling film evaporator, Rising Falling film evaporator, Forced circulation type evaporator, Agitated thin film evaporator. Thermal recompression and Mechanical vapour recompression systems.
- Refrigeration: Refrigeration system and its components. Selection of a refrigerant.
- Freezing: Food Freezing systems: Indirect contact systems- Plate freezers, Air blast freezers and Freezers for liquid foods; and direct contact systems – air blast and immersion freezing systems. Calculation of freezing time by Plank's equation and other modified methods.
- Drying: Theory of drying, free moisture content, bound moisture content, critical moisture content, equilibrium moisture content, constant rate drying period, falling rate drying period, heat transfer in drying; types of driers- tray drier, tunnel drier, roller or drum drier, fluidized bed drier, spray drier, pneumatic drier, rotary drier, trough drier, bin drier, vacuum drier and freeze drier.
- Distillation: Vapour liquid equilibrium relations, Raoult's law, boiling point diagram, classification of distillation Equilibrium or Flash distillation, Simple batch or Differential distillation, Simple steam distillation and Distillation with reflux.
- Leaching: Rates of leaching, types of leaching equipment – Fixed bed leaching, Moving bed leaching, Agitated solid leaching.
- Crystallisation: Solubility, types of crystallizers- tank crystallizer, scraped surface crystallizer, circulation-liquid evaporator-crystallizer, circulating-magma vacuum crystallizer, Nucleation theories.

Suggested readings:

- Introduction to Food Engineering (3rd Edition) by R Paul Singh and Dennis R Heldmann; Academic Press, London, UK, 1993
- Fundamentals of Food Process Engineering by R.T. Toledo, 1993.
- Transport Processes and Unit Operations (3rd Edition) by Christie J Geankoplis, Prentice-Hall of India Pvt Ltd, New Delhi, 1999.
- Unit Operations of Chemical Engineering (5th Edition) by Warren L McCabe, Julian C Smith, Peter Harriott; McGraw-Hill, Inc., New Delhi, 1998.

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- Fundamentals of Food Engineering by Radha Charan Verma and Sanjay Kr Jain; Himanshu Publications, Udaipur, 2002.

CENTRAL UNIVERSITY OF PUNJAB, BATHINDA

Course Name: Technology of Cereals Processing

L	T	P	Credits	Marks
3	-	-	3	100

Course Code: FST. 504

- Structure, production and composition of cereals of usage (wheat, rice, corn, oats, and millets).
- Wheat: Classification, types, Wheat milling-conditioning and milling, air fractionation of flours, treatment, physicochemical and rheological tests (Farinograph, Falling Number value, Amylograph, Mixograph, Rapid Visco-analyser, and Alveograph) for wheat flour analysis. Production of wheat starch and vital wheat-gluten.
- Manufacture of bakery and pasta product-bread, biscuits/ cookies, cake, crackers, noodles, spaghettis, macaronis, etc. Role of ingredients in bakery products.
- Rice: Rice quality (physical, chemical and cooking quality). Changes during aging of rice. Methods for accelerated aging of rice. Rice milling technology- operation and by-product utilization. Parboiling: methods, nutritional advantages and effect on rice quality. Rice product: quick cooking rice, rice flakes, puffed rice and alcoholic beverage and beer.
- Corn: Types. Dry and Wet milling of corn and products. Corn-based syrups and sweeteners. Corn products –processing of alkaline cooked/ Nixtamalized corn products i.e. flour, tortillas and tortilla chips; processing of cornflakes. Corn germ oil- composition, processing and utilization.
- Barley: Composition, malting and brewing of barley.
- Oats: Composition, processing of rolled oats.

Suggested Readings

- Wheat Chemistry and Technology by Yashajahu Pomeranz & F.H. Websten
- Oats Chemistry and Technology by F.H. Websten
- Corn Chemistry and Technology by S.A. Watsan and P.E. Ramsat
- Rice Chemistry and Technology by B.O. Juliano
- Technology of Cereals by N.L. Kent

CENTRAL UNIVERSITY OF PUNJAB, BATHINDA

Course Name: Modern Food Microbiology

L	T	P	Credits	Marks
2	-	-	2	100

Course Code: FST. 505

- Microbial growth in food: intrinsic, extrinsic and implicit factors, Microbial interactions, Inorganic, organic and antibiotic additives. Effects of enzymes and other proteins, Combination systems, Adaptation phenomena and stress phenomena, Effect of injury on growth or survival, Commercial available databases. Growth curves. Physical and chemical factors influencing the destruction of microorganisms including thermal death time, Z, F and D values.
- Food poisoning, Food borne infections, Food borne intoxications and Mycotoxins.
- Microbial behaviour against the newer methods of food processing, Adoption and resistance development, Microbes as test organisms, as sensors and as tools for future applications in energy production and food and non food industrial products.
- Modern methods of cell culture: synchronous and co-cell culture, continuous cell culture in liquid and solid media, Cell immobilization and applications, Pre and probiotics cultures.
- Single cell proteins.

Suggested readings

- Adams M. 2006. *Emerging Food-borne Pathogens*. Woodhead Publ.
- Yousef AE. 2002. *Food Microbiology: A laboratory Manual*. A VI.
- James MJ, Loessner MJ & David A. 2005. *Modern Food Microbiology*. 7th Ed. Golden Food Science Text Series.
- Food Microbiology by Frazier

CENTRAL UNIVERSITY OF PUNJAB, BATHINDA

Semester I

Course Name: Nutrition Science, Nutraceuticals and Health Foods

L	T	P	Credits	Marks
2	-	-	2	100

Course Code: FST. 506

- Definition and scope, History of Nutrition, Functions of Food, Water Balance, Energy Balance.
- Recommended daily allowances and requirement of infants, children, adults, old people, expectant and nursing mothers.
- Genetic disorders and nutritional requirements.
- Appetite suppressants, phytosterols, polyphenols, phytoestrogens, ω -fatty acids, glucosinolates. Glycemic index and its role in human nutrition. Starch digestibility. Nutritional importance of dietary fibre and gums. Non-digestible oligosaccharides. Prebiotics and probiotics. Alkaloids, Flavonoids and other Phenolics.
- Introduction to nutraceuticals: definitions, synonymous terms, basis of claims for a compound as a nutraceutical. Concept of angiogenesis and the role of nutraceuticals/functional foods; Nutraceuticals for cardiovascular disease, cancer, diabetes, cholesterol management, obesity, joint pain, immune enhancement, age-related macular degeneration, endurance performance and mood disorders-compounds and their mechanisms of action, dosage levels, contraindications if any etc.
- Manufacturing aspects of selected nutraceuticals such as lycopene, isoflavonoids, prebiotics and probiotics, glucosamine, phytosterols etc; formulation of functional foods containing nutraceuticals-stability and analytical issues.

Suggested readings

- Food and nutrition volume I and II By Swaminathan
- Brigelius- Flohe, J & Joost HG. 2006. *Nutritional Genomics: Impact on Health and Disease*. Wiley VCH.
- Cupp J & Tracy TS. 2003. *Dietary Supplements: Toxicology and Clinical Pharmacology*. Humana Press.
- Gibson GR & William CM. 2000. *Functional Foods- Concept to Product*.
- Goldberg I. 1994. *Functional Foods: Designer Foods, Pharma Foods*.
- Robert EC. 2006. *Handbook of Nutraceuticals and Functional Foods*. 2nd Ed. Wildman.
- Shi J. (Ed) 2006. *Functional Food Ingredients and Nutraceuticals: Processing echnologies*. CRC.
 - Webb GP. 2006. *Dietary Supplements and Functional Foods*. Blackwell Publ.

CENTRAL UNIVERSITY OF PUNJAB, BATHINDA

**Course Name: Food Biotechnology-Molecular
Biology**
Course Code: FST. 507

L	T	P	Credits	Marks
2	-	-	2	100

- DNA & RNA chemical structure & base composition and type of nucleic acids, T-DNA
- DNA replication, repair and recombination in prokaryotes & eukaryotes, gene amplification, mobile genetic elements (transposons).
- Transcription mechanisms in Prokaryotes & Eukaryotes: transcription unit, promoters, constitutive and inducible, initiation, termination, transcription factors, regulatory elements & mechanism of transcription regulation.
- Prokaryotes & eukaryotes translation: the translation machinery, wobble hypothesis, mechanism of initiation, elongation & termination.
- Post transcriptional and Post-translational modification in genes: processing of hnRNA, rRNA & tRNA; 5' cap formation, 3'-end processing, polyadenylation and splicing of RNA. Post translation modification and cellular localization of proteins.
- Regulation of gene expression in Prokaryotes and Eukaryotes: operon concept; LAC, TRP and ARA operons. RNA interference, Molecular mechanism of antisense molecules, ribozymes, applications of antisense & ribozyme technologies in Food security.

Suggested Reading

- Nelson, D.L. & Cox, M.M. (2005). Lehninger Principles of Biochemistry, 4th ed., Worth Publishers, New York.
- Stryer, L. (1995). Biochemistry, 4th ed., W.H. Freeman and Co., New York.
- Damal, J., Lodish, H., and Baltimore, D. (1990). Molecular Cell Biology, 2nd ed., Scientific American Books, Distributed by W.H. freeman and Co., New York.
- Watson J., Baker T., Bell S., Gann A, Levine M and Loscik R. (2008). Molecular Biology of the Gene. 6th Ed. Pearson Education.

CENTRAL UNIVERSITY OF PUNJAB, BATHINDA

Course Name: Experiments in Food Chemistry

L	T	P	Credits	Marks
-	-	1	1	100

Course Code: FST. 508

Determination of moisture content by drying method, moisture meters, distillation and Karl Fischer titration methods. Determination of ash content and Mineral Matter: Total ash, acid soluble and insoluble ash, alkalinity of ash. Determination of protein Content by Kjeldhal and Formal titration of Folin-ciocalteries methods. Qualitative tests for estimation of reducing and non-reducing sugars and starch. Lipid estimation by soxhlet method. Determination of saponification, iodine value, acid value, Free Fatty acid content.

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Course Name: Experiments in Cereals Processing

L	T	P	Credits	Marks
-	-	1	1	100

Course Code: FST. 509

- Physicochemical testing of cereal grains-wheat, rice, corn and millets.
- Laboratory milling of wheat and rice.
- Determination of content of un-milled/head/broken rice and degree of milling.
- Parboiling and evaluation of quality of parboiled rice.
- Evaluation of cooking quality of rice.
- Parboiling of rice.
- Amylose content determination in starches.
- Rheological testing of wheat flour dough.
- Baking of bread, cookies/biscuits and cakes.
- Processing of paste products and evaluation of their quality.
- Determination of germination capacity and husk content of barley.
- Experimenting malting of barley and other cereals.

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Course Name: Experiments in Food Microbiology

L	T	P	Credits	Marks
-	-	1	1	100

Course Code: FST. 510

Preparation of nutrient media and techniques of inoculation. Staining techniques- Monochrome staining negative staining, gram staining, acid-fast staining, spore staining, capsule staining. Evaluation of microorganism in raw and processed products by using various techniques. Study of factors influencing growth of microorganisms. Determination of effects of various preservatives including antibiotics on the suppression of microbial growth.

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Semester II

Course Name: Advanced Food Analysis Techniques

L	T	P	Credits	Marks
2	-	-	2	100

Course Code: FST. 511

- Basic Techniques: Fundamentals of Acids, Bases, pH. pKa, buffers, Methods for cell disintegration and disruption, Dialysis, Ultrafiltration and other membrane techniques.
- Spectroscopy Technique: UV, Visible, Fluorescence Spectroscopy/ and Raman Spectroscopy, FTIR, Plasma Emission Spectroscopy, Isothermal Calorimetry (ITC), NMR.
- Chromatography Techniques: TLC, Macromolecule separation Techniques: Ion exchange, Hydrophobic, Reverse-phase and Affinity chromatography; FPLC, HPLC: 2D and 3D HPLC, and UPLC, HPLC-Gel permeation Chromatography (HPLC-GPC).
- Centrifugation: Relative Centrifugal Force (RCF) and Sedimentation coefficient. Centrifuge: Types and applications.
- Electrophoretic Techniques: Cappillary electrophoresis; Polyacrylamide and Agarose gel electrophoresis; 2D-PAGE Electrophoresis.
- Advanced Techniques: Theory and methods: Amino Acid Analysis, Atomic emission spectroscopy (AES), Mass spectrometry: Electrospray Ionization (ESI) and MALDI-TOF.

Suggested Readings

- Keith Wilson and John Walker, Principles and Techniques of Practical Biochemistry. 5th Edition, Cambridge University Press, 2000.
- Freifelder D., Physical Biochemistry, Application to Biochemistry and Molecular Biology, 2nd Edition, W. H. Freeman & Company, San Fransisco, 1982.
- Walker, John M. (Ed.) The Proteomics Protocols Handbook, Publisher Humana Press.
- Peter C. Uden, Element-specific Chromatographic Detection by Atomic Emission Spectroscopy, Volume 479, American Chemical Society, 1992.
- Wallace Woon-Fong Leung, Industrial Centrifugation Technology, McGraw Hill Profseeional, 1998.
- KenzoHiraoka, Fundamentals of Mass Spectrometry, Springer-Verlag New York, 2013.
- Juggen H, Gross, Mass Spectrometry A Textbook, Springer-Verlag Berlin Heidelberg, 2011.

CENTRAL UNIVERSITY OF PUNJAB, BATHINDA

Course Name: Legumes and Oil Seeds Processing

L	T	P	Credits	Marks
2	-	-	2	100

Course Code: FST. 512

- Legumes: Production, structure, classification, composition, processing and cooking methods, and utilization.
- Legumes in Human Nutrition: Nutrient composition of raw and cooked/canned and germinated/sprouted legumes. Anti-nutritional factors in different legume seeds and their elimination.
- Processing: Pulse Milling, Technology of protein flours, isolates and concentrates- preparation uses nutritional value, their physicochemical and functional properties. Preparation of processed soyabean products-soy milk, tofu, flour, concentrate and isolate.
- Oilseeds: Composition, oil extraction- mechanical and solvent extraction processes, renderization, purification and hydrogenation, winterization and processing for oils.

Suggested readings

- Pulse Chemistry and Technology by Tiwari and Singh
- Legumes: Chemistry and Technology
- Chakrabarty MM. 2003. Chemistry and Technology of Oils and Fats.
- Prentice Hall.
- Hamilton RJ & Bhati A. 1980. Fats and Oils- Chemistry and Technology.
- App. Sci. Publ.
- Chemistry and Technology of Edible Fats and Oils by P.N. Williams & J. Devine

CENTRAL UNIVERSITY OF PUNJAB, BATHINDA

Course Name: Advanced Fruits and Vegetables Processing

L	T	P	Credits	Marks
2	-	-	2	100

Course Code: FST. 513

- Modern storage of fresh fruits and vegetables: Evaporative cool and modified/controlled atmosphere storages.
- Modern post-harvest handling of fruits and vegetables: Washing, sorting/grading, peeling blanching and coring, Edible Coatings.
- Fresh-Cut Fruits and Vegetables: Fruits and Vegetables for the Fresh-Cut Processing, Treatments to Ensure Safety, Additives to preserve quality.
- Juice Processing: Method of juice extraction, equipment and preservation. Enzymatic maceration, Juice concentration- Processing, equipment and flavor retention. Freeze concentration applications in fruit processing.
- Processing of jams and jellies: Pectin and related compounds, theories of gel formation preparation of dietetic jellies.
- Processing of tomato products: Puree, paste, ketchup and soup.
- Processing of potato products: Flour, chips, fries, acrylamide in potato products and nutritional value.

Suggested readings:

- Hand Book of Analysis and Quarterly Control of Fruits & Vegetables Products-S. Ranganna Tata McGrawHill, New Delhi.
- Commercial Vegetable Processing- Woods Roof & Lue.
- Commercial Fruit & Veg. Processing- W.V. Cruses.
- Advances in Fresh-Cut Fruits and Vegetable Processing Olga Martin-Belloso, Robert Soliva-Fortuny
- Advances in Fruit Processing Technology by Rodrigues Fernandes

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Course Name: Application of Enzymes in Food Processing

L	T	P	Credits	Marks
2	-	-	2	100

Course Code: FST. 514

- Enzymes: classification, properties, characterization, kinetics and immobilization; fermentative production of enzymes used in food industry (amylases, proteases, cellulases, pectinases, xylanases, lipases).
- Role and utilization of enzymes: milk-chese making and whey processing, lactose hydrolysis; fruit juices- cell wall degradation for liquefaction, clarification, peeling, debittering, decolourization of very dark coloured juices such as anthocyanases; baking-fungal α -amylase from bread making; maltogenic α -amylases for anti-staling; xylanases and pentosanases as dough conditioners; lipases or dough conditioning; meat tenderization; gluten-free bakery foods-transglutaminase, glucose oxidase, etc.
- Enzyme-aided extraction of plant materials for production of flavours. Enzymatic production of flavour enhancers such as nucleotides. Enzymatic approach to tailor- made fats.
- Enzymatic modification of proteins: Enzymes for production of protein hydrolysates and bioactive peptides.
- Enzymes in starch industry: Production of modified starches, corn syrups containing glucose, maltose, glucose and fructose etc.

Suggested readings:

- Enzymes in Food Processing by Tilak Nagodainthana and Gerald Reed.
- Enzymes in Food Processing by G.A. Tucker and LFJ Woods.
- *Enzymes in Food Technology* by Whitehurst R & Law B.

CENTRAL UNIVERSITY OF PUNJAB, BATHINDA

Course Name: Equipment Design and Process Control

L	T	P	Credits	Marks
3	-	-	3	100

Course Code: FST. 515

- Basic Scientific and Engineering principles of equipment design and process control, Properties of substances, chemical equation and stoichiometry, phases and phases rule, material and energy balances, energy balance and open system. Engineering properties of food materials and their significance in equipment design. Principles of CAD and its simple application.
- Design of Vessels: Codes and regulations, Materials of construction, Design for pressures, Design pressure and temperature loadings, allowable stresses, minimum thickness after forming, corrosion mechanism, corrosion control, Design for internal and external pressure, cylindrical and spherical shell, formed heads, re-enforcement openings.
- Design of food storage tank, horizontal and vertical silos, insulated and uninsulated, process plant piping: codes and regulations, testing, fabrication requirements, overall economic and safety considerations, heat exchangers: shell and tube heat exchangers, construction codes, genera design considerations, clad tube sheet, plate type exchangers. Air cooled heat exchangers, heat exchangers cost economics.
- Instrument terminology and performance system accuracy, flow sheet symbols, instrument evaluation, electrical, mechanical, magnetic and optical transducers for measurement of process variables like temperature, pressure, flow, level, consistency and humidity, indicating and recording devices: direct acting and servo operated systems, digital indicators, strip and circular chart recorders, electronic data loggers, principle of automatic process control.
- Process characteristics, controller characteristics, controller characteristics, closed loop system, pneumatic and electric controllers, final controlling elements, control valves, valve sizing, electronic actuators, motor drives and controls, introduction to programmable logic controllers (PLC): internal structure, inter facing with sensors and actuators, binary logic diagrams and ladder diagrams, choosing a PLC system.

Suggested readings:

- Process Instrument and Controls. Mc-Graw-Hill by Considine DM.
- *Automatic Process Control*. Wiley Eastern by Eackman DP.
- Equipment Design Hand Book. Vol. II Gulf Publ. Evans FL.
- Kempe's Engineers Year Book 1996. Miller Information Services, UK.
- Process Heat Transfer. McGraw-Hill by Kern DQ.
- Process Measurement and Analysis. Butterworth- Heinmann by Liptak BG.
- McCabe WL, Smith JC & Harriott P. McGraw Hill.

CENTRAL UNIVERSITY OF PUNJAB, BATHINDA

Course Name: Food Engineering Operations

L	T	P	Credits	Marks
2	-	-	2	100

Course Code: FST. 516

- Pumping in Food Industry: Introduction, general consideration for pipeline selection, factors influencing the choice of a pump, types of pumps, design of pumps.
- Mixing and Emulsification: Mixing theory, measurement of mixing, rates of mixing, types of mixers-Mixers for liquids for low or moderate viscosity, mixers for high viscosity pastes and plastic solids, Mixers for dry solids. Emulsification theory, equipments and applications.
- Filtration: Filtration theory, constant rate and constant pressure filtration. Classification of filtration equipments-bed filters, plate-and-frame filter press, leaf filters, continuous rotary filters. Filter media and filter aids.
- Centrifugation: Theory, rates of setting in centrifuges. Centrifuge equipment- Liquid-liquid centrifuges, Centrifugal clarifiers, Desludging and dewatering centrifuges.
- Extrusion: Introduction, functions, advantages and terminology of extrusion, types of extruders-single screw extruder, twin screw extruder, their classification and applications in food industry.

Suggested readings:

- Introduction to Food Engineering by R.P Singh & D.R. Heldman.
- Fundamentals of Food Process Engineering by R.T. Toledo.
- Food Engineering Operations by J.G. Brennan, J.R. Butters, N.D Cowell & A.E.V.Lilley.
- Unit operations of Chemical Engineering by W.L. McCabe, J.C Smith & P.Harriott.
- Transport Processes and Unit Operations by C.J.Geankoplis
- The Technology of Extrusion Cooking by N.D. Frame.
- Extruders in Food Applications by M.N. Riaz.

CENTRAL UNIVERSITY OF PUNJAB, BATHINDA

Course Name: Genetic Engineering in Food Technology

L	T	P	Credits	Marks
2	-	-	2	100

Course Code: FST. 517

- Restriction & Ligation Enzymes: klenow enzyme, polynucleotide Kinase&Alkaline Phosphatase, T4 DNA ligation and Labeling methods.
- Polymerase Chain Reaction:Primer design, Fidelity of thermostable enzymes (Taq&Pfu polymerases), Types of PCR – multiplex, nested, reverse transcriptase, real time PCR, touchdown PCR, hot start PCR, colony PCR, PCR in gene recombination.
- Vectors and Cassettes: Plasmids, Phagemids, Cosmids, YACs & BACs, Expression vectors; pMal; GST;pET-based vectors, Genetic transformation vectors.
- Linkers&Adaptors:Tools for Markers-assisted plant breeding (RAPD, AFLP, SSR etc.)Homopolymeric tailing, cDNA libraries;Phase display-expression libraries, cloning of PCR products, Gateway Technology.
- Techniques in Genetic Engineering: DNA; RNA labeling; detection andquantification, Northern, Southern and Colony hybridization, Southwestern and Far-western, Transformation.
- Cell and tissue culture: Concepts & basic techniques in Micrpropagation, Organogenesis & somatic embryogenesis, somaclonal and gametoclonal variations, Initiation and maintenance of callus and suspension cultures.

Suggested Reading

- J. Sambrook and D.W. Russel; Molecular Cloning: A Laboratory Manual, Vols 1-3, CSHL,2001.
- Brown TA, Genomes, 3rd ed, Garland Science 2006.
- S.B. Primrose, R.M. Twyman and R.W.Old; Principles of Gene Manipulation. 6th Edition, S.B.University Press,2001.
- Literature from Technology providers like Stratagene, Promega, Novagen, New England Biolab etc.
- Razdan, M.K.(1994). An Introduction to Plant Tissue Culture. Oxford & IBHPublishing Co., New Delhi.
- Bhojwani, S.S.and Razdan, M.K.(1996). Plant Tissue Culture. Theory and Practice, Elsevier
- Research Papers from referred Journals.

CENTRAL UNIVERSITY OF PUNJAB, BATHINDA

Course Name: Management, New Product Development and International Trade

L	T	P	Credits	Marks
2	-	-	2	100

Course Code: FST. 518

- Managerial Roles, Activities, Skills, Knowledge and Competencies; Basic management modal; Market-meaning, concepts, scope, types, structure; Marketing- concepts, elements and functions; Concepts and scope of marketing management; Marketing of food products in India; Consumer behaviour and consumerism. Four Ps of market- Price, Product, Packaging and Promotion; Advertising - how advertising works? Deciding advertising objectives, advertising budget and advertising message, Media Planning, Personal Selling, Publicity
- Concept of product development-product success and failure, factors for success, managing for product's success. New product development process- strategy, product design and process development, commercialization, and launch. Role of consumers in product development-consumer behaviour, food preferences, avoiding acceptance, integration of consumer needs in product development and sensory needs.
- International Marketing and International Trade, Salient features of International Marketing, Composition & direction of Indian exports; International marketing environment; Deciding which & how to enter international market; Exports- Direct exports, indirect exports, Licensing, Joint Ventures, Direct investment & internationalization process; World Trade Organization (WTO).

Suggested Readings

- Chhabra T.N & Suria RK. 2001. *Management Process and Perspectives*. Kitab Mahal.
- Clarke & Wright W. 1999. *Managing New Product and Process Development*. Free Press.
- Earle and Earle 2001. *Creating New Foods*. Chadwick House Group.
- Earle R, Earle R & Anderson A. 2001. *Food Product Development*. Woodhead Publ.
- Fuller 2004. *New Food Product Development - from Concept to Market Place*. CRC.
- Mamoria and Joshi- *Principle and Practice of Marketing in India*
- Kotler P. 2000. *Marketing Management*. Prentice-Hall.
- Jhingan ML. 2005. *International Economics*. 5th Revised and Enlarged Ed. Virnda Publ.

CENTRAL UNIVERSITY OF PUNJAB, BATHINDA

**Course Name: Experiments in Legumes and Oil
Seeds Processing**

L	T	P	Credits	Marks
-	-	1	1	100

Course Code: FST. 519

Experimental expeller processing and solvent extraction of oil seed. Quality evaluation of oil extracted from oil seeds. Experimental Milling of Legumes seeds. Separation and evaluation of starch and protein from different legumes. Preparation of soya milk/tofu. Cooking quality, textural evaluation and physico-chemical testing of legumes. Preparation of edible flours, protein concentrates and isolates.

CENTRAL UNIVERSITY OF PUNJAB, BATHINDA

Course Name: Experiments in Fruits and Vegetables Processing

L	T	P	Credits	Marks
-	-	1	1	100

Course Code: FST. 520

Examination of fresh fruits and vegetables for processing. Experimental coating of fresh fruits and vegetables. Canning of fruits and vegetables. Testing of can, cut out test Preparation and analysis of syrups and Brines. Preparation of fruit and vegetable juice. Concentration of fruit and vegetable juice. Drying of juice (normal and freeze drying). Manufacture of squash, RTS, Jam, Jellies, marmalade, Preserve and Candied Fruit. Preparation of wine and potato chips.

CENTRAL UNIVERSITY OF PUNJAB, BATHINDA

Course Name: Experiments in Food Engineering-I

L	T	P	Credits	Marks
-	-	1	1	100

Course Code: FST. 521

- Determination of viscosity of liquid food.
- Determination of Reynolds number and nature of fluid flow in a pipe.
- Determination of pressure drop using manometer.
- Study the working principle and operation of various types of grinders.
- Study the working principle and operation of various types of crushers.
- Study of particle size distribution and determination of average particle size.
- Study of a belt conveyor, screw conveyor and bucket elevator-working and design calculation.
- Determination of freezing time of selected food materials.
- Study of an evaporator.
- Determination of thermal conductivity of food materials.
- Determination of heat transfer coefficient in free and forced convection.

CENTRAL UNIVERSITY OF PUNJAB, BATHINDA

Course Name: Experiments in Genetic Engineering

L	T	P	Credits	Marks
-	-	1	1	100

Course Code: FST. 522

- 1) DNA & RNA Isolation and Separation.
- 2) Plasmid Isolation and Separation.
- 3) Restriction of DNA and Separation
- 4) Cloning of foreign DNA insert in plasmid
- 5) Transformation of *E.coli* Cells
- 6) Expression and validation of gene cloning

Suggested Readings:

- Maniatis, T., Fritsch, E.F. and Sambrook, J. (2001). Molecular cloning 3rd ed.: Laboratory manual, 1st edition. Cold Spring Harbour Laboratory, Cold Spring Harbour, New York.

CENTRAL UNIVERSITY OF PUNJAB, BATHINDA

Semester III

Course Name: Advanced Food Packaging

L	T	P	Credits	Marks
2	-	-	2	100

Course Code: FST. 523

- Definitions. Functions of package.
- Aseptic processing of food products.
- Retortable pouch technology.
- Active and intelligent packaging, Active packaging techniques, Intelligent packaging technique, Oxygen, ethylene and other scavengers-oxygen scavenging packaging, Ethylene scavenging packaging, Carbon dioxide and other scavengers,
- Novel MAP applications for fresh produce
- Antimicrobial food packaging: Constructing an antimicrobial packaging system, Factors affecting the effectiveness of antimicrobial packaging.
- Non-migratory bioactive polymers (NMBP) in food packaging, Advantages of NMBP, limitations, inherently bioactive synthetic polymers: types and applications, Polymers with immobilized bioactive compounds.
- Modern packaging systems: Green plastics for food packaging. The problem of plastic packaging waste. The range of biopolymers. Developing novel biodegradable materials. Current applications, role of packaging in the supply chain,
- Recycling packaging materials: The recyclability of packaging plastics, improving the recyclability of plastics packaging. Testing the safety and quality of recycled material, Use of recycled plastic in packaging.
- Edible films and coatings.
- Nano-science in food Packaging.

Suggested readings:

- Ahvenainen R. 2001. *Novel Food Packaging Technique*. CRC.
- Crosby NT. 1981. *Food Packaging Materials*. App. Sci. Publ.
- Painy FA. 1992. *A Handbook of Food Packaging*. Blackie.
- Sacharow S & Griffin RC. 1980. *Principals of Food Packaging*. AVI Publ.
- Stanley S & Roger CG. 1998. *Food Packaging*. AVI Publ.
- Food Packaging Principles by Gordon Robertson, 2005.
- Food Packaging by Takashi Kadoya, 1990.

CENTRAL UNIVERSITY OF PUNJAB, BATHINDA

Course Name: Food Business Management

L	T	P	Credits	Marks
2	-	-	2	100

Course Code: FST. 524

Food/Agribusiness- meaning and scope; Agricultural And Food Marketing: Traditional markets, market functions; Government Initiatives and reforms in markets and food business, Role of the middlemen

Food Business Models: understanding supply chain, procurement, distribution, retailing of agri-inputs and food products.

Marketing strategy, planning and control; new product development, Food marketing research, Food product management and pricing decisions. E-trading in food business. Channel management.

Entrepreneurship in food business, role of cooperatives and producer companies.

CENTRAL UNIVERSITY OF PUNJAB, BATHINDA

Course Name: Poultry, Meat and Fish Processing

Course Code: FST. 525

L	T	P	Credits	Marks
2	-	-	2	100

- Eggs: Structure, composition, nutritive value and functional properties of eggs. Internal quality evaluation, grading, preservation and maintenance of internal quality microbial spoilage, products-Egg powders, frozen eggs, egg foams, factors influencing foaming, packaging and transportation of eggs.
- Poultry: Types, factors affecting quality, chemical composition and nutritive value of poultry Meat. Poultry dressing-methods of stunning, slaughter, scalding & dressing. Grading and packaging of poultry meat. Preservation of poultry meat-chilling, freezing, curing, smoking, dehydration, canning, irradiation.
- Meat: types of microscopic structure of meat tissue. Chemical composition and nutritive value of meat. Muscle concentration and relaxation. Postmortem biochemical changes. Properties of fresh meat. Preservation of meat-chilling, freezing, curing, smoking, dehydration, canning, irradiation, freeze drying, microwave. Meat tenderization. Cooking, palatability and eating quality of meat. Microbial spoilage of meat. Sausage-types and other comminuted meat products and other processing steps.
- Fish processing: preservation method of fish and other sea foods-cold storage, freezing pickling. Fish paste and sauces. By product of fish processing industry.
- Utilization of poultry, meat and fish industry by-products.

Suggested readings

- Govindan TK. 1985. *Fish Processing technology*. Oxford and IBH.
- Hui YH. 2001. *Meat science and applications*. Marcel Dekker.
- Principal of Meat Science by Forrest et al.
- Processed Meat by Pearson
- Fish Processing Technology by George M. Hall

CENTRAL UNIVERSITY OF PUNJAB, BATHINDA

Course Name: Sensory Evaluation and Quality Control in Food Industry

L	T	P	Credits	Marks
2	-	-	2	100

Course Code: FST. 526

- Concept and quality: Quality attributes – size and shapes. Color and glass, Texture-Visual and objectively measureable attributes. Their measurements and evaluation. Sampling and specification of raw materials and finished products.
- Concepts and quality managements: Objective, importance and functions of quality control; Quality management system in India; Sampling procedures and plans; Food safety and standards Act, 2006; Domestic regulations. Quality assurance, Total Quality Management; GMP; GLP, GAP; sanitary and hygienic practices; HACCP. Indian and international quality system and standards- ISO and Food Codex.
- Various organization dealing with inspection, traceability and authentication, certification and quality assurance (PFA, FPO, MMPO, MPO, AGMARK, BIS).
- Instrumental analysis in quality control: HPLC, GC calorimeter, spectrophotometers etc.
- Sensory evaluation introduction, requirements, panel screening selection. Consumer acceptance. Different tests for sensory evaluation-discrimination, descriptive effective; Flavour profile and tests; Ranking tests; Methods of sensory evaluation of different food products.

Suggested readings

- Sensory evaluation practices by Stone, 2004.
- Principle of sensory evaluation of foods by M.A. Amerine, R.M. Rangborn and E.B. Roessler.
- Quality Control in Food Industry by Hershoerfer, 1972.
- Quality Control in Food Industry by Kramer and Tuig.
- Amerine MA *et al* 1965. *Principle of Sensory Evaluation of Foods*. Academic press.
- Early R. 1995. *Guide to Quality Management systems for Food industries*. Blackie Academic. Jellinek G. 1985.
- *Sensory Evaluation of Food – Theory and Practice*. Ellis Horwood.
- Krammer A & Twigg BA. 1973. *Quality Control in Food Industry*. Vol. I, II. AVI Publ.
- Piggot JR. 1984. *Sensory Evaluation of Foods*. Elbview Applied Science.
- Ranganna S. 2001. *Handbook of Analysis and Quality Control for Fruit and Vegetable Products*. Tata-McGraw-Hill.

CENTRAL UNIVERSITY OF PUNJAB, BATHINDA

Course Name: Renewable Energy in Food Processing

L	T	P	Credits	Marks
2	-	-	2	100

Course Code: FST. 527

- Energy in Food Processing: Steam generation. Steam tables. Steam utilization. Fuel utilization. Electric power utilization. Electric motors. Electrical controls and lighting.
- Renewable Energy Utilization, desirability, feasibility and the niches: Integrated renewable energy sources for process heat availability.
- Solar energy resources, solar thermal and solar photovoltaic technology for electricity and process heat, Solar cell technologies for decentralized energy generation.
- Elements of passive solar architectural and solar-active system for refrigeration and cooling, Solar drying of fruits and vegetables, Hybrid solar dryer for industrial applications, solar furnaces and concentrators.
- Overview of wind energy developments, wind turbine technology & its utilization for process heat and electricity generation.
- Bio-energy resource, Biomass conversion sources viz Gasification systems for process heat, biogas for electricity and other industrial energy, ethanol fermentation, liquid fuel from biomass (process, chemistry and technologies), complete combustion technology, improved cook stoves & furnace technology.

Suggested readings:

- Introduction to Food Engineering by R.P. Singh & D.R. Heldman.
- Hordeski MF. 2004. *Dictionary of Energy Technologies*. CRC Press.
- Kreith F & Goswami D. 2007 . *Handbook of Energy Efficiency and Renewable Energy*. CRC Press.
- NIIR Board. 2001. *Modern Technology of Agro Processing & Agricultural Waste Products*. National Institute of Industrial Research Publ.
- Rathore NS & Panwar NL. 2007. *Renewable Energy for Sustainable Development*. New India Publ. Agency.
- Teri 1993. *Rays of Hope: Renewable Energy for Sustainable Development*. Tata Energy Research Institute, New Delhi.

CENTRAL UNIVERSITY OF PUNJAB, BATHINDA

Course Name: Advanced Food Engineering

L	T	P	Credits	Marks
2	-	-	2	100

Course Code: FST. 528

- Engineering properties of foods, their significance in equipment design, processing and handling of food and food products, steady state and unsteady state transfer, Numerical graphical and analog methods in the analysis of heat transfer. Solution of unsteady state equations, solar radiation.
- Mass transfer, molecular diffusion and diffusivity, equilibrium stage process, convective mass transfer, simultaneous momentum, Separation by equilibrium stages, immiscible phases, distillation of binary mixtures and multi-component separations.
- Aerodynamics and hydrodynamic characteristics, drag coefficient, terminal velocity and Reynold's --number, application of aerodynamic properties to the separation, pneumatic handling and conveying of food products, material and energy balance. Concept of viscosity and its measurement-capillary tube viscometer, rotational viscometer. Flow measurement tube, Orifice meter, Venturimeter. Pressure and its measurement-Simple and Differential manometers.
- Thermodynamic properties of moist air, kinetics of water absorption, evaporation and dehydration of foods, design of single and multi-effects evaporators, machines of movement of air through Stationary bed, thin Layer and Thick layer bed drying, simulation models, Freeze bed drying, cyclic pressure freeze drying. Microwave drying and vacuum drying, efficient drying systems, infrared heating, Freezing of foods, freeze concentration and frying, freezing point curves, phase diagrams, methods of freeze concentration, design problems.
- Theory of ultra-filtration and reverse osmosis, selection and types of membranes and properties, concentration, polarization, mathematical description of flow through membrane, application and use in food industry.

Suggested readings

- Charm SE. 1971. *Fundamental of Food Engineering*. AVI Publ.
- Cheryan M. 1998. *Ultra-filtration and Micro-filtration Handbook*. Technomic Publ.
- Heldman DR & Singh RP.1984. *Food Process Engineering*. AVI Publ.
- Watson EL & Harper JC.1989. *Elements of Food Engineering*. **AVI Publ**

CENTRAL UNIVERSITY OF PUNJAB, BATHINDA

Course Name: Fermentation Science in Food processing

L	T	P	Credits	Marks
2	-	-	2	100

Course Code: FST. 529

- Types in fermentation- Alcohol, lactic acid, acetic acid.
- Fermenter design: Model of fermenter, measurement of process variables and their control.
- Microbial production of amino acids, vitamins antibodies, enzymes, algae, baker's yeast and food yeast, lactic acid, citric acid, industrial alcohol.
- Down stream processing.
- Fermented food products: milk curds, yogurt, acidophilus milk, Bulgarian milk, butter milk, kefir, Kumiss & Vegetables-pickles, Sauerkraut, cucumbers; meats; legume/cereal products, Soya sauce, miso, temph, idli, dhokla, etc.; beverages: Beer, Wine, Vinegar.

Suggested readings:

- The technology of wine marketing by M.A. Amerine, H.N. Berg, W.V. Gruers.
- Indigenous fermented food by Stoin Karm.
- Industrial Microbiology by Proscott & Dun, 2009

CENTRAL UNIVERSITY OF PUNJAB, BATHINDA

Course Name: Experiment in Food Packaging

L	T	P	Credits	Marks
-	-	1	1	100

Course Code: FST. 530

Identification of different types of packaging material. Physical and chemical properties of packaging films. Chemical resistance of packaging material. Determination of WVTR and OTR in different packaging materials. Uniformity and amount of wax determination. Shelf life studies of packaged food. Puncture resistance of corrugated boxes. Determination of tin coating weight and porosity. Determination of continuity of lacquer coating. Determination of tensile strength and heat seal strength of packaging material. To conduct drop test.

CENTRAL UNIVERSITY OF PUNJAB, BATHINDA

Course Name: Experiment in Food Engineering II

L	T	P	Credits	Marks
-	-	1	1	100

Course Code: FST. 531

Design of short, intermediate length and long cylindrical vessels, Design of spherical vessels, Design of shell and tube, double pipe, scraped surface and spiral tube heat exchangers, design of jacketed vessels-insulation thickness, corrosion allowance, study of various transducers for measurement of pressure, flow level, humidity, temperature, Study of controllers in constant temperature water baths, make ladder diagrams and flow sheet diagrams for control logics, programme a PLC, design a computer interface of a PLC, visit a food processing plant to study data acquisition and process control system.

CENTRAL UNIVERSITY OF PUNJAB, BATHINDA

Seminar

Synopsis for Research Project

CENTRAL UNIVERSITY OF PUNJAB, BATHINDA

Semester IV

Course Name: **Research Methodology and Computer Application**

L	T	P	Credits	Marks
2	-	-	2	100

Course Code: **FST.**

- Measurement of central tendency: mean, medium, mode, dispersion, deviation, standard error, coefficient of variation, coefficient of determination, coefficient of non-determinant, moments, and distribution of data, skewness and kurtosis.
- Regression analysis: reciprocal, double reciprocal, logistic regression analysis, monomolecular regression. Regression analysis of exponential curve, Gompertz growth function and Gompertz decay function,
- Sampling and test of hypothesis: testing of hypothesis, Error, Probability, Distribution, chi-square (X^2) test, student 't' test, 'F' test,
- Analysis of variance: ANOVA, Non parametric statistics.
- Software: User and application of statistical software, SigmaStat, SPSS, Minitab.
- Computer Application: Introduction to MS Office and associated tools, graphical and histograms etc. tools in Office.
- Bioinformatics: Biological databases, tool for DNA and protein sequence and structure analysis

Suggested readings:

- Jerrold H. Zar, Biostatistical Analysis, Tan Prints (I) Pvt. Ltd., New Delhi, 2003.
- P.S.S. Sundar Rao, P.h. Richard, An Introduction to Biostatistics, Prentice Hall of India (P.) Ltd. New Delhi 2003.
- Mount D. W. (2004). Bioinformatics & Genome Analysis. *Cold Spring Harbor Laboratory press.*

CENTRAL UNIVERSITY OF PUNJAB, BATHINDA

Seminar –on research work

Research project