CENTRAL UNIVERSITY OF PUNJAB, BATHINDA

M.Sc. Life Sciences with Specialization in Human Genetics

2019-21

Department of Human Genetics and Molecular Medicine

Programme Outcome

M.Sc Life Sciences with Specialization in Human Genetics is a two years (4 semesters) post-graduation programme. On successful completion of this programme the student will be able to :

- Understand the mechanisms that underpin human inheritance
- Have an understanding of the role of genetic factors in health and disease
- Identify patients with or at an risk of genetic disease
- Develop knowledge on human molecular genetics, cytogenetics and cell biology
- Develop skills on bioinformatics and biostatical tests commonly used in life sciences
- Communicate scientific findings through presentation and writing articles or reviews
- Familiarize about bioethics, intellectual property rights and research methodology
- Familiarize with the laboratory based research work and practice many different molecular biology techniques
- Successfully compete different aptitude based examinations, such as NET, GATE

This programme will provide students a very exciting avenue to nurture their scientific aptitude to achive their academic goals.

Semester-I

Course Code	Course Title	Course Type	Credit Hours		
			L	T	P
LHG.506	Biostatistics and Research Methodology	Compulsory Foundation Course	4	-	-
LHG.507	Biostatistics and Research Methodology	Compulsory Foundation Course	-	-	1
LHG.508	Cellular and Molecular Biology	Core Course	4	-	-
LHG.509	Cellular and Molecular Biology	Core Course	-	-	1
LHG.510	Basic and Clinical Biochemistry	Core Course	4	-	-
LHG.511	Basic and Clinical Biochemistry	Core Course	-	-	1
LHG.512	Concepts of Genetics	Core Course	4	-	
LHG.513	Concepts of Genetics	Core Course	-	-	1
LHG.514	Human Cytogenetics and Human Biochemical Genetics	Core Course	4	-	-
LHG.515	Basics of Human Genetics	Interdisciplinary Elective Course-I	2	-	-
LHG.516	Introduction to Intellectual Property Rights	Interdisciplinary Elective Course-I	2	-	-
Total Credits			**22**	**-**	**4**

Semester-II

Course Code	Course Title	Course Type	Credit Hours		
			L	T	P
LHG.521	Human Physiology	Core Course	4	-	-
LHG.522	Human Physiology	Core Course	-	-	1
LHG.523	Essentials of Immunology	Core Course	4	-	-
LHG.524	Advanced Techniques in Human Genetics and Molecular Medicine	Core Course	4	-	-
LHG.525	Human Embryology and Developmental Genetics	Discipline Elective - I	4	-	-
LMM.525	Regenerative Medicine	Discipline Elective - I	4	-	-
LHG.526	Population Genetics and Genetic Epidemiology	Discipline Elective - II	4	-	-
LMM.526	Molecular and Cellular Oncology	Discipline Elective - II	4	-	-
LHG.527	Prenatal Diagnosis and Genetic Counseling	Interdisciplinary Elective Course-II	2	-	-
LHG.528	Introduction to Population Genetics	Interdisciplinary Elective Course-II	2	-	-
LHG.542	Seminar-I	Skill Based Course	1	-	-
Total Credits			**23**		**1**

Semester-III

Course Code	Course Title	Course Type	Credit Hours		
			L	T	P
xxx.xxx/ HGL.550	MOOC course (One course) / Bioinformatics and Computational Biology	Compulsory Foundation	4	-	-
LHG.551	Biosafety, Bioethics and Intellectual Property Rights	Core Course	4	-	-
LHG.552	Genetic Disease and Therapies	Core Course	4	-	-
LHG.553	Pharmacogenomics and Nutrigenomics	Core Course	4	-	-
LHG.599	Project –I			-	6
Total Credits			**16**	**-**	**6**

Semester-IV

Course Code	Course Title	Course Type	Credit Hours		
			L	T	P
LHG.571	Recombinant DNA technology and therapeutics	Core Course	4	-	-
LHG.572	Advanced Practical Course in Human Genetics	Core Course	-	-	3
LHG.573	Practice in Life Sciences-I	Discipline Enrichment Course	2	-	-
LHG.574	Practice in Life Sciences-II	Discipline Enrichment Course	2	-	-
LHG.544	Seminar-II	Skill Based Course	1	-	-
LHG.599	Project -II	Skill Based Course	-	-	6
	Two courses need to be chosen from the list of EF/VB courses given by the University	Elective Foundation/Value based Course	1+1	-	-
Total Credits			**11**	**-**	**9**

Semester – I

Course Code: LHG.506
Course Title: Biostatistics and Research Methodology
Total Hours: 60

L	T	P	Cr
4	-	-	4

Learning Outcomes:
On successful completion of the course the student will be able to:

- Analyze and evaluate wide variety of statistical data
- Represent statistical data and summary statistics in graphical and tabular forms
- Apply suitable statistical tools to analyze data
- Write and communicate scientific reports, projects and publications

UNIT I Hours: **15**

Overview of Biostatistics: Basic concepts of statistical data and different types of tables; graphical representation of experimental data for publication; frequency distribution; measurement of central tendency and variation; statistical errors.

UNIT II Hours: **15**

Experimental design and analysis: Basics of sampling in biological studies; different types of sampling techniques; various steps in sampling; concept of data distribution in sampling; graphical representation of data; level of significance; multiple corrections; hypothesis testing.

UNIT III Hours: **15**

Inferential Statistics: Chi-Square test: hypothesis testing, contingency, homogeneity; student's t-test: paired and unpaired, one tailed and two tailed; one-way and two-way analysis of variance (ANOVA); correlation and regression.

UNIT IV Hours: **15**

Study design & Technical writing: Best practices in research and technicality of research design; interpretation and report writing; e-Library; web-based literature search engines; evaluation based development of scientific writing skill: synopsis, research paper, poster preparation and paper presentation and dissertation.

Transactionalal Modes: Lecture**;** Tutorial**;** Problem solving; Self-learning.

Suggested Readings:

1. Norman, G. and Streiner, D. (2008). *Biostatistics: The Bare Essentials.* (with SPSS), 3rd Edition, Decker Inc. USA.
2. Sokal, R.R. and Rohlf, F.J. (1994). *Biometry: The Principles and Practices of Statistics in Biological Research*. W.H. Freeman publishers, USA.
3. Banerjee P.K (2014). *Introduction to Biostatistics*. S.Chand, India
4. Daniel WW (2010). *Biostatistics*: *A Foundation for Analysis in the Health Sciences*. John Wiley and Sons Inc.
5. Bailet NTJ. *Statistical Methods in Biology*. Cambridge Univ. Press.
6. Glaser AN. *High-Yield Biostatistics*. Lippincott Williams & Wilkins.

Course Code: LHG.507
Course Title: Biostatistics and Research Methodology
Total Hours: 30
(Practical)

L	T	P	Cr
-	-	1	1

Learning Outcomes:

On successful completion of the course the student will be able to:

- Use variety of statistical tools to analyze data
- Apply suitable statistical equations to analyze data
- Perform data stratification and representation
- Write and communicate scientific reports, projects and publications

1. Plotting different types of graphs using statistical data, using MS Excel.
2. Plotting normal distribution graph
3. Frequency distribution, SD, SE calculations
4. Chi-square tests
5. Student's t-test
6. ANOVA
7. Regression and Correlation.
8. Scientific writing skill development.

Transactionalal Modes: Laboratory based practicals; Problem solving; Self-learning.

L	T	P	Cr
4	-	-	4

Course Code: LHG.508
Course Title: Cellular and Molecular Biology
Total Hours: 60

Learning Outcomes:
On successful completion of the course the student will be able to:

- Evaluate the structures and functions of the basic components of membranes, and organelles and their related functions
- Conceptualize basic cellular and molecular mechanisms
- Analyze the molecular processes of DNA replication, transcription, and translation
- Apply the knowledge for through insight into basic mechanisms of cellular signal transduction and regulation of gene expression

UNIT I **Hours: 15**

Membrane Structure and Functions: Prokaryotic and eukaryotic cell; membranes of intracellular organelles; membrane transport; protein secretion and sorting: structure and functions of intracellular organelles; intracellular traffic and secretory pathways; endocytosis and exocytosis.

UNIT II **Hours: 15**

The cytoskeleton: Cell cytoskeleton and its organization including extracellular matrix, adhesions and junctions.

Cell-cell communication and cell growth: Overview of cell signaling, cell surface receptors and second messengers.

UNIT III **Hours: 15**

Chemical structure and functions of nucleic acids: Chemical structure of DNA and RNA; Watson- Crick model; different forms of DNA and RNA; organelle DNA; nucleosome assembly.

Gene and genome organization: Eukaryotic gene organization; transposition; mechanism of DNA replication; DNA damage and their repair.

UNIT IV **Hours: 15**

Transcription: Transcription and transcription factors; transcriptional and post-transcriptional gene silencing; mRNA processing: capping, polyadenylation, splicing, editing, mRNA stability.

Translation: Genetic code; translation machinery: mechanisms of chain initiation, elongation and termination; regulation of translation; post-translational modifications of proteins.

Transactionalal Modes: Lecture**;** Demonstration**;** Tutorial**;** Lecture cum demonstration; Problem solving; Self-learning.

Suggested Readings:

1. Alberts, B., Bray, D., Lews, J., Raff, M., Roberts, K. and Watson, J.D. (2010). *Molecular Biology of the cell*. Garland publishers, Oxford.
2. Celis, J.E. (2006). *Cell biology: A laboratory handbook*, Vol 1, 2, 3. Academic Press, UK.
3. Gupta, P.K. (200*8). Cytology, Genetics and Evolution*. Rastogi publications, Meerut, India
4. Karp, G. (2010*). Cell and Molecular Biology: Concepts and Experiments*. John Wiley & Sons. Inc. New Delhi, India.
5. Robertis, (2011). *Cell and Molecular Biology*. Lippincott Williams & Wilkins
6. Fasman, G.D. (1989). *Practical Handbook of Biochemistry and Molecular Biology*. CRC Press, Taylor and Francis Group, UK.
7. Jocelyn, E.K., Elliott, S.G., Stephen, T.K. (2009). *Lewin's Genes X*. Jones & Bartlett Publishers, USA.
8. James,D.W.,http://www.amazon.com/Tania-A. Baker/e/B001H6OS90/ ref=sr_ntt_srch_lnk_1?qid=1311422012&sr=11Baker,http://www.amazon.com/Tania-A.Baker/e/B001H6OS90/ref=sr_ntt_srch_lnk_1?qid= 1311422012&sr=1-1
9. T.A., Bell, S.P., Gann, A. (2009). *Molecular Biology of the Gene*. Benjamin Cummings, USA.
10. Johnson, A., Lewis, J., Raff, M. (2007). *Molecular Biology of the Cell*. Garland Science, USA.
11. Lodish, H.,Berk, A., Chris, A.K. and Krieger, M. (2011). *Molecular Cell Biology*. W.H. Freeman, USA.
12. Sambrook, J., Fritish, E.F., Maniatis, T. (2012). *Molecular cloning: A laboratory manual*. Cold Spring Harbor Laboratory Press, New York.

Course Code: LHG.509
Course Title: Cellular and Molecular Biology (Practical)
Total Hours: 30

L	T	P	Cr
-	-	1	1

Learning Outcomes:

On successful completion of the course the student will be able to:

- Evaluate the structures and functions of the basic components of membranes, and organelles and their related functions.
- Analyze the results of Immunofluroscence and IHC
- Apply the knowledge for the research related to cell biology.

Perform cell or tissue culture

1. Preparation of mitotic & meiotic chromosomes.
2. Study of structure of cell organelles through electron micrographs.
3. Instrumental methods for cell biology-centrifugation, chromatography.
4. Immunofluorescence and fluorescent probes.
5. Sectioning of tissues.
6. Histochemical techniques (Fixing, Processing, Staining).
7. Epifluoresence and Confocal Microscopy.
8. Basics of bacterial/mammalian cell culture

*Practical will be conducted depending upon the faculty/facility available.

Transactionalal Modes: Hands-on practicals; Demonstration**;** Tutorial**;** Problem solving; Self-learning.

L	T	P	Cr
4	-	-	4

Course Code: LHG.510
Course Title: Basic and Clinical Biochemistry
Total Hours: 60

Learning Outcomes:

On successful completion of the course the student will be able to:

- Describe the importance of maintenance of pH, role of vitamins and minerals in metabolic processes
- Evaluate the basic structural features and functions of carbohydrates, lipids, nucleic acids, proteins and vitamins.
- Get knowledge about structural details of proteins and nucleic acids
- Conceptualize the basic features of enzyme catalysis and regulation.

UNIT I **Hours: 15**

Essentials of clinical biochemistry: Molecular structure and physical properties of water; ionization of water; weak acids and weak bases; pH and buffers; interpretation of biochemical tests; clinical hematology; chemical composition of blood, urine and cerebrospinal fluids; water and sodium balance; acid-base balance disorders; potassium, calcium, magnesium and phosphate metabolism and associated diseases; vitamins and trace elements disorders.

UNIT II **Hours: 15**

Biomolecules and metabolic disorders: Structure and functions of carbohydrates, lipids, amino acids, proteins, nucleic acids and vitamins; bioenergetics and thermodynamics; phosphoryl group transfer and ATP; biological oxidation-reduction reactions; glycolysis, citric acid cycle and oxidative phosphorylation; liver function test; jaundice, diabetes mellitus, hypoglycemia, hypertension, hypo- and hyper-thyroidism.

UNIT III **Hours: 15**

Conformation of Biomolecules: Ramachandran plot; protein secondary, tertiary and quaternary structure; domains, motif and folds; protein denaturation and folding; oxygen binding proteins; Hill equation; Bohr effect; nucleic acids: A-, B-, Z-DNA forms, tRNA, micro-RNA, Stability of protein and Nucleic acid structures.

UNIT IV **Hours: 15**

Enzymology: Classification; Principles of catalysis; mechanism of enzyme catalysis; enzyme kinetics; enzyme inhibition; enzyme regulation; isozymes and clinical enzymology.

Transactionalal Modes: Lecture**;** Demonstration**;** Tutorial**;** Lecture cum demonstration; Problem solving; Self-learning.

Suggested Readings:

1. Berg, J.M., Tymoczko, J.L. and Stryer, L. (2010). *Biochemistry.* W.H.
2. Freeman & Company. USA.
3. Brown, T.A. (2006). *Gene Cloning and DNA analysis: In Introduction*.
4. Blackwell Publishing Professional. USA.
5. Haynie, D.T. (2007). *Biological thermodynamics*. Cambridge University. UK.
6. Mathews, C.K., Van Holde, K.E. and Ahern, K.G. (2000). *Biochemistry*.Oxford University Press Inc. New York.
7. Nelson, D. and Cox, M.M. (2008). *Lehninger Principles of Biochemistry*.BI publications Pvt. Ltd. Chennai, India.
8. Ochiai, E. (2008). *Bioinorganic Chemistry: A survey.* Academic Press. Elsevier, India.
9. Randall, D. J., Burggren, W. and French, K. (2001). *Eckert animal physiology*. W.H. Freeman & Company. USA.
10. Raven, P.H., Johnson, G.B. and Mason, K.A. (2007). *Biology*. Mcgraw-Hill. USA.

11. Shukla AN (2009). *Elements of Enzymology*. Discovery Publishing. New Delhi, India.
12. Voet, D. and Voet, J.G. (2008). *Principles of Biochemistry*. CBS Publishers &Distributors. New Delhi, India.
13. R Swaminathann. (2011). Handbook of clinical biochemistry. 2 edition, World Scientific Publishing Company, New Jersey, USA
14. Martin A Crook et al. (2012). Clinical Biochemistry and metabolic medicine. CRC press, Taylor & Francis Group, USA

L	T	P	Cr
-	-	1	1

Course Code: LHG.511
Course Title: Basic and Clinical Biochemistry (Practical)
Total Hours: 30

Learning Outcomes:
On successful completion of the course the student will be able to:

- Perform preparation of regular biochemical reagents, i.e, buffers.
- Appreciate the importance of chemical safety and precautions in the biochemistry laboratory
- Practice the separation through electrophoresis technique

Analyze various experiments like blood group typing, counting of RBCs and WBCs and identification of blood cells

1. Preparation of solutions, buffers, pH setting etc.
2. Amino acid and carbohydrate separations by paper & thin layer chromatography.
3. Quantitative Estimation of Proteins, Sugars, total lipids and amino acids.
4. Assay and estimation of different enzymes e.g. invertase, amylases, acid and alkaline phosphatases.
5. Principle and application of electrophoresis, Native, SDS PAGE.
6. Estimation of total phenolic compounds.
7. Extraction and estimation of vitamins.
8. Basic clinical tests like Urea, lipid profiling, SGOT, SGPT etc.

*Practical will be conducted depending upon the faculty/facility availabile.

Transactionalal Modes: Hands-on practicals; Demonstration**;** Tutorial**;** Self-learning.

Course Code: LHG.512
Course Title: Concepts of Genetics
Total Hours: 60

L	T	P	Cr
4	-	-	4

Learning Outcomes:
On successful completion of the course the student will be able to:

- Evaluate the Mendelian and Non-Mendelian inheritance patterns
- Gather knowledge about gene expression regulation and sex determination
- Evaluate different chromosomal aberrations and ploidies

Know the details of extra chromosomal inheritance patterns

UNIT I **Hours: 15**

Basics of Inheritance: Mendel's laws of inheritance; concept of segregation; independent assortment and dominance; locus concept; alleles and multiple alleles; epistasis; crossing over and recombination; application of Mendel's laws of population studies; Hardy-Weinberg principle.

UNIT II **Hours: 15**

Chromosomal mutations and gene concept: Chromosomal aberrations: deletions, duplications, inversions, translocations; change in chromosome number: trisomy and polyploidy; evolutionary history of bread wheat; aneuploids–nullisomics, monosomics, and trisomics; somatic aneuploids; changes in chromosome structure; properties of chromosomes for detection of structural changes; mutations: spontaneous and induced mutations; somatic vs germinal mutation; pedigree analysis.
Gene concept: Fine structure of gene; and analysis – Benzer's experiments, complementation and recombination.

UNIT III **Hours: 15**

Sex determination: Sex determination and sex linked inheritance; sex determination in *Caenorhabditis elegans*, humans, *Drosophila*; sex linked genes and dosage compensation in human, *Drosophila* and *C. elegance*.
Linkage analysis and gene mapping: Monohybrid and dihybrid cross.

UNIT IV **Hours: 15**

Extra-chromosomal inheritance: Chloroplast: variegation in Four O' Clock plants; mutations in *Chlamydomonas*; mitochondrial inheritance: poky in neurspora, petites in yeast; molecular organization and gene products of chloroplast and mitochondrial DNA; infectious heredity: Kappa in *Paramecium*: Infective particles in *Drosophila*; endosymbiont theory.

Transactionalal mode: Lecture**;** Demonstration**;** Tutorial**;** Lecture cum demonstration; Problem solving; Self-learning.

Suggested Readings:

1. Klug WS and Cummings MR. Concepts of Genetics. Prentice-Hall.2014
2. Anthony, J.F. Miller, J.A. Suzuki, D.T., Richard, R.C., Gilbert, W.M. (1998). *An introduction to Genetic Analysis*. W.H. Freeman publication, USA.
3. Pierce BA. Genetics: A Conceptual approach. Freeman Publishers.
4. Hartle DL and Jones EW. Genetics: Analysis of Genes and Genomes. Jones & Bartett.
5. Atherly, A.G., Girton, J.R., Mcdonald, J.F. (1999).*The science of Genetics*. Saundern College publication.
6. Snusted, D.P., Simmons, M. J. (2010). *Principles of Genetics*. John Wiley & Sons, New
7. Griffith AF et al. An Introduction to Genetic Analysis. John Wiley & Sons.

Course Code: LHG.513
Course Title: Concepts of Genetics (Practical)
Total Hours: 30

L	T	P	Cr
-	-	1	1

Learning Outcomes:

On successful completion of the course the student will be able to:

- Analyze genetic linkage and epistasis
- Evaluate different mutants of *Drosophila*

Demonstrate X inactivation in females

1. Monohybrid and dihybrid ratios, Multiple alleles, Epistasis – Problems.
2. Inheritance patterns in Human– Numericals on Pedigree analysis-
3. Autosomal patterns, X–linked patterns, Y–linked patterns.
4. Segregation analysis in Drosophila (Monohybrid, Dihybrid)
5. Analysis on Linkage
6. Identification of inactivated X chromosome as Barr body and drumstick
7. Studies of a Model organism: *E. coli*, *C.elegans, D. melanogaster* and *D. rerio*.

* Practical will be conducted depending upon faculty/facilities availibile.

Transactionalal Modes: Hands-on practicals; Demonstration**;** Tutorial**;** Self-learning.

L	T	P	Cr
2	-	-	2

Course Code: **LHG.515**
Course Title: **Basics of Human Genetics**
Total Hours: **30**

Learning Outcomes:
On successful completion of the course the student will be able to:

- Know about cell division and genetic transmissions
- Know about patterns of inheritance
- Gather knowledge about different human genetic diseases

Evaluate different chromosomal aberrations and ploidies

UNIT I **Hours: 7**

Chromosomal analysis: Classification of human chromosomes; human chromosomes; the life cycle of a somatic cell: mitosis, meiosis, gametogenesis.

UNIT II **Hours: 8**

Genetic assessment: Medical applications of chromosomes; Symbols used in a pedigree drawing of a pedigree; terminology, consanguinity**,**

UNIT III **Hours: 7**

Common chromosomal disorders: Aneuploidy, Down syndrome, Edwards syndrome, Patau's syndrome and other trisomies ; structural aberration

UNIT IV **Hours: 8**

Patterns of inheritance: Autosomal and sex chromosomal inheritance patterns with examples; multiple, Uniparental disomy,, multifactorial disorders.

Transactional mode: Lecture**;** Demonstration**;** Tutorial**;** Lecture cum demonstration; Problem solving; Self-learning.

Suggested Readings:

1. Emery and Rimoin's, et aI., 2007. Principles and Practice of Medical Genetics. Fifth Edition.Volume - II, Churchill Livingstone Elsevier.
2. Emery and Rimoin's, Principles and Practice of Medical Genetics e-dition: 3-Volume.Set, Churchill Livingstone Elsevier
3. De Grouchy & Turleau.1984.Clinical atlas on Human Chromosomes.
4. Jankowski &Polak, 1996.*Clinical Gene Analysis and Manipulation.*
5. Robinson and Linden, Clinical Genetics Handbook. (latest edition)
6. F Vogel A.G. Motulusky. Human Genetics: Problems and Approaches. Second Completely Revised Edition, Springer-Verlag. (latest edition)
7. Golder N. Wilson, M.D., Ph.D.Clinical Genetics-A Short Course. A John Wiley and Sons. Inc., Publication. (latest edition)

Course Code: LHG.516
Course Title: Introduction to Intellectual Property Rights
Total Hours: 30

L	T	P	Cr
2	-	-	2

Learning Outcomes:
On successful completion of the course the student will be able to:

- Gather knowledge about different forms of intellectual property rights
- Differentiate between patentable and nonpatentable invention/innovation
- Familiar with the various patent filing routes
- Be more aware about the protection of indigenous intellectual propert

UNIT I **Hours: 8**

Intellectual Property Rights (IPRs): Various forms of IP – patents, industrial designs, trade secrets, geographical indications and plant breeder's right; copyright.

UNIT II **Hours: 8**

Patent system in India: Patent filing in India and abroad: determination of patentability of inventions; filing a patent application in India: timeline, procedure involved in the granting of a patent; gene patent; patenting of living organisms.

UNIT III **Hours: 7**

Various routes of filing international patent application: Different phased of Patent co-operation treaty (PCT) application

UNIT IV **Hours: 7**

Protection of indigenous intellectual property: Traditional Knowledge Digital Library (TKDL).

Transactional mode: Lecture**;** Demonstration**;** Tutorial**;** Lecture cum demonstration; Problem solving; Self-learning.

Suggested Readings:

1. Dutfield G. (2003*). Intellectual Property Rights and the Life Science Industries: A Twentieth Century History* (Globalization and Law).Routledge.
2. Mahop, M.T. (2010). *Intellectual Property, Community Rights and Human Rights: The Biological and Genetic Resources of Developing Countries.*Routledge.
3. Martin Khor (2002). Intellectual Property, Biodiversity and Sustainable Development: Resolving the Difficult Issues. Zed Books limited.

Semester – II

Course Code: LHG.521
Course Title: Human Physiology
Total Hours: 60

L	T	P	Cr
4	-	-	4

Learning Outcomes:
On successful completion of the course the student will be able to:

- Know about the anatomical structures and explain the physiological functions of body systems.
- Evaluate the interrelationships between physiological systems of the human body.
- Recognize the principle of homeostasis and control mechanisms of physiological systems in the human body.

Make a connection between knowledge of anatomy and physiology and real-world situations, including healthy lifestyle decisions

UNIT I **15 Hours**

Cardiovascular System: Heart; cardiac cycle; blood constituents; groups and hematopoiesis; blood pressure; blood pressure and its neural and chemical regulation.

Excretory System: Kidney; urine formation; urine concentration; waste elimination; micturition; regulation of water balance; electrolyte and acid-base balance.

UNIT II **15 Hours**

Digestive System: Digestion; absorption; energy balance; BMR; epithelial barrier function; regulation of swallowing and gastric emptying and small/large bowel; gastro-intestinal secretions and accessory glands.

Muscle Physiology: Types of muscles: skeletal, cardiac and smooth muscles; properties; contractile force.

UNIT III **15 Hours**

Nervous System: Neuron; action potential; central and peripheral nervous system; neural control of muscle tone and posture; vision; hearing and tactile response.

Thermoregulation and stress adaptation: Comfort zone; body temperature – physical, chemical; neural regulation; acclimatization.

UNIT IV **15 Hours**

Respiratory System: Anatomical considerations; transport of gases; exchange of gases; waste elimination; neural and chemical regulation of respiration; alveolar ventilation; diffusion across alveoli; and respiration under stress: altitude, hypoxia.

Reproduction: Males and female reproductive system.

Transactional mode: Lecture**;** Seminar**;** Tutorial**;** Problem solving; Self-learning; group discussion.

Suggested Readings:

1. Brody, T. (1998). *Nutritional biochemistry*. Academic Press, USA.
2. Devlin, T.M. (2005). *Textbook of Biochemistry with clinical correlations*. John Wiley & Sons Inc. USA.
3. Guyton. (2007). *Textbook of medical physiology*. 11th Edition. Elsevier India Pvt. Ltd. New Delhi.
4. Hill, R.W, Wyse, G. A. and Anderson, M. (2008). *Animal physiology*. Sinauer Associates Inc. USA.
5. Khurana. (2006). *Textbook of medical physiology*. Elsevier India Pvt. Ltd.
6. Murray, R.K. (2009). *Harper's illustrated biochemistry*.Jaypee Publishers, New Delhi, India.
7. Tyagi, P. (2009). *A textbook of Animal Physiology*.Dominant Publishers and distributors, New Delhi, India.
8. Silverthorn D, (2011) *Human Physiology*, Pearson; 6th edition.
9. Sherman V. (2013) *Vander's Human Physiology*. McGraw-Hill 13th edition.

Course Code: LHG.522
Course Title: Human Physiology (Practical)
Total Hours: 30

L	T	P	Cr
-	-	1	1

Learning Outcomes:

On successful completion of the course the student will be able to:

- Perform key hands-on experiments on human physiology
- Demonstrate several biophysical techniques regularly used in health sciences

Get familiar with the basic principles of physiological experiments

1. Equipment in the laboratory - maintenance and use.
2. Sensory physiology practicals.
3. Determination of hemoglobin in the blood by various methods.
4. Identificaiton of formed elements in blood.
5. RBC and WBC count in whole blood.
6. Determination of blood group.
7. Measurement of Blood pressure and Pulse rate.
8. Studying characteristics of ECG.
9. Blood glucose estimation.
10. Determination of Respiratory function: Breathing rate, Breath holding capacity.
11. Distinguish different types of muscles and Observation of types of muscular contraction.
12. Urinalysis from simulated urine sample.

*Practical will be conducted depending upon the faculty/facilities available.

Transactionalal Modes: Hands-on practicals; Demonstration**;** Tutorial**;** Self-learning.

Course Code: LHG.523
Course Title: Essentials of Immunology
Total Hours: 60

L	T	P	Cr
4	-	-	4

Learning Outcomes:

On successful completion of the course the student will be able to:

- Evaluate basic concepts of immune system and to understand the concept of immune-based diseases as either a deficiency of components or excess activity as hypersensitivity.
- Apply the knowledge how immune system is involved in diseases caused by internal or external factors.

UNIT I **15 Hours**

Immune System: The cells and organs of immune system;cells of immune system; humoral immunity-immunoglobulin basic structure, classes and subclasses; structural and functional relationships; nature of antigen; antigen-antibody reaction; antibody diversity; class switching; B and T cell development.

UNIT II **15 Hours**

Immune Effectors: Complement system; their structure, functions and mechanisms of activation by classical, alternative and lectin pathway; Th1 and Th2 response; cytokines; chemokines; interferons; interlukins.

UNIT III **15 Hours**

Mechanisms of immune system diversity: Structure and functions of major histocompatibility complex (MHC) and human leukocyte antigen (HLA) system; polymorphism, distribution, variation and their functions.

UNIT IV **15 Hours**

Immune system in health and diseases: Inflammation; hypersensitivity and autoimmunity; immunity to microbes; immunity to tumors; AIDS and immunodeficiencies; hybridoma technology and vaccine development associated challenges for chronic and infectious diseases; immunotoxins.

Transactionalal Modes: Lecture**;** Demonstration**;** Tutorial**;** Lecture cum demonstration; Problem solving; Self-learning.

Suggested Readings:

1. Kindt, T.J., Osborne, B.A. and Goldsby, R.A. (2007). *Kuby Immunology* 7th Edition. W.H. Freeman, USA.
2. Abbas. (2008). *Cellular and Molecular immunology*. CBS Publishers & Distributors, India.
3. Charles, A. and Janeway, J.R. (1994). *Immunobiology: The immune system in health and disease.* Blackwell Publishing, USA.
4. Delves, P.J., Roitt, I.M. and Seamus, J.M. (2006). *Roitt's essential immunology (Series–Essentials).*Blackwell Publishers, USA.
5. Elgert, K.D. (2009). *Immunology: Understanding the immune system.* Wiley-Blackwell, USA.
6. Paul, W.E. (1993). *Fundamental immunology.* Raven Press, SD, USA.
7. Sawhney, S.K. and Randhir, S. (2005). *Introductory practical biochemistry*. Alpha Science International Ltd. New Delhi, India.
8. Tizard. (2008). *Immunology: An Introduction.* Cengage Learning, Thompson, USA.

L	T	P	Cr
4	-	-	4

Course Code: LHG.524
Course Title: Advanced Techniques in Human Genetics
Total Hours: 60

Learning Outcomes:
On successful completion of the course the student will be able to:

- Analyze various cellular processes technically.
- Apply the knowledge to decipher the mechanisms of molecular and cell biology.
- Know specific technical aspects for variety of techniques used in biological experiments
- Conceptualize principles of different techniques used in life sciences

UNIT I **15 Hours**

Biochemical Techniques: Sterilization techniques; spectrometry; colorimetry;Mass, UV, IR, NMR and atomic absorption spectrophotometery; centrifugation: principle and applications; ultracentrifugation; chromatography: principle, procedure and applications of thin layer chromatography (TLC), gel filtration and ion exchange, affinity chromatography, GC, GLC, HPLC, dHPLC and FPLC.

UNIT II **15 Hours**

Microscopy: Light microscopy; phase contrast microscopy; fluorescent microscopy; scanning electron microscopy (SEM/FESEM); transmission electron microscopy (TEM); micrometry and photomicrography; histochemistry; scanning-probe microscopy; atomic force microscopy; CLSM.

UNIT III **15 Hours**

Nucleic acids: Isolation, purification and analysis of nucleic acids; electrophoresis: principle of gel electrophoresis, polyacrylamide gel electrophoresis (PAGE and SDS-PAGE), agarose gel electrophoresis, pulse field gel electrophoresis (PFGE) and 2-Dimensional gel electrophoresis; polymerase chain reaction (PCR): principle, types and applications; PCR based markers: RAPDs, SNPs; blotting techniques: southern, northern, western, dot blotting and hybridization; DNA fingerprinting.

UNIT IV **15 Hours**

Flow Cytometry: Cell sorting; hybridoma technology: production of antibodies; histochemical and immunotechniques; immunochemical techniques; developing monoclonal and polyclonal antibodies; immunocytochemistry,

radioimmunoassay (RIA); enzyme linked immunosorbent assay (ELISA) and autoradiography. **Mutation analyses techniques:** Restriction mapping, SSCP analyses, DNA sequencing-manual and automated methods. **Cell and tissue culture techniques:** Plants and animals.

Transactionalal Modes: Lecture**;** Demonstration**;** Tutorial**;** Lecture cum demonstration; Problem solving; Self-learning.

Suggested Readings:

1. Brown, T.A. (2010). *Gene cloning and DNA analysis: An Introduction*. 6th Edition, Wiley-Blackwell Publisher, New York.
2. Goldsby, R.A., Kindt, T.J. and Osborne, B.A. (2008). *Kuby Immunology.* 6th Edition, W. H. Freeman & Company, San Francisco.
3. Gupta, P.K. (2005). *Elements of biotechnology*.Rastogi Publications, Meerut.
4. Gupta, S. (2005). *Research methodology and statistical techniques*, Deep & Deep Publications (P) Ltd.New Delhi.
5. Kothari, C.R. (2008.) *Research methodology(s)*. New Age International (P) Ltd., New Delhi
6. Lewin, B. (2010). *Genes X*, CBS Publishers & Distributors. New Delhi.
7. Mangal, S.K. (2007). *DNA Markers In Plant Improvement.*Daya Publishing House,New Delhi.
8. Nelson, D. and Cox, M.M. (2009). *Lehninger Principles of Biochemistry*. W.H. Freeman and Company, New York.
9. Primrose. S.B. and Twyman, R. (2006). *Principles of Gene Manipulation and Genomics*.Blackwell Publishing Professional, U.K.
10. Sambrook, J. (2006). *The Condensed Protocols from Molecular Cloning: A Laboratory Manual.*Cshl Press. New York.
11. Sambrook, J. and Russell, D.W. (2000). *Molecular Cloning: A Laboratory Manual* (3 Vol-set). 3rd Edition, CSHL Press, New York.
12. Sawhney, S.K. and Singh, R. (2005). *Introductory Practical Biochemistry*.Narosa Publishing House, New Delhi .
13. Slater, A., Scott, N.W. and Fowler, M.R. (2008). *Plant Biotechnology: The Genetic Manipulation of Plants*. Oxford University Press, USA.
14. Wilson, K. and Walker, J. (2006). *Principles and Techniques of Biochemistry and Molecular biology*. 6th Edition, Cambridge University Press India Pvt. Ltd., New Delhi.

L	T	P	Cr
4	-	-	4

Course Code: LHG.525
Course Title: Human Embryology and Developmental Genetics
Total Hours: 60

Learning Outcomes:
On successful completion of the course the student will be able to:

- Get familier with basic concepts in reproductive physiology
- Correlate genetic regulation in different embryonic developmental stages
- Evaluate the role of biomolecules in embryonic development

Know different genetic and environmental triggers for post-natal development, ageing and senescence

UNIT I **15 Hours**

Reproductive Physiology: Structure and functions of adult human reproductive organs; reproductive endocrinology; gametogenesis; comparisons between female and male gametes; embryogenesis: fertilization; gastrulation and implantation of embryo; fetal membrane and placenta; lactation.
Concept of non-disjunction: Origin and cause of non-disjunction.

UNIT II **15 Hours**

Basic concepts of development: Post-zygotic cell division and cellular biology; different stages of development; potency, commitment, specification, induction, competence, determination and differentiation; morphogenetic movements; fate map and cell lineages.

UNIT III **15 Hours**

Gene expression regulation during development: Basics of gene expression regulation during early embryogenesis; role of key developmental genes: polycomb gene, P granules, *SOX*, *BMP*, *HOX* and *PAX*.

UNIT IV **15 Hours**

Post-natal Development, Aging and senescence: Environmental and genetic factors during maturations, Sex linked changes, Deciduous and primary teeth, Cognitive development ageing: its causes and regulation; Clinical death.
Teratology: Teratogens, introduction to toxicogenomis.

Transactionalal Modes: Lecture**;** Demonstration**;** Tutorial**;** Lecture cum demonstration; Problem solving; Self-learning.

Suggested Readings:

1. Gilbert, S.F. (2013). Developmental Biology. Tenth Edition.
2. Slack, J.M.W. (2012). Essentiel Developmental Biology. Third Edition.
3. Moody, A.A. (2014). Principles of Developmental Genetics. Second Edition.
4. Slack, J.M.W. (2018). The Science of Stem Cells. First Edition.
5. Milunsky, J. & Milunsky, A. (2010). *Genetic Disorders and the Fetus: Diagnosis, Prevention & Treatment*. Willey Blackwell India, New Delhi.
6. Prakash, G. (2007). *Reproductive Biology*. Narosa Publication House Pvt. Ltd., New Delhi.
7. Sadler, T.W., Tosney, K., Chescheir, N.,C., Imseis, H., Leland, J. and Sadler-Redmond, S.,L. (2011).*Langman's Medical Embryology (Longmans Medical Embryolgy).* Lippincott Williams and Wilkins.

Course Code: LMM.525
Course Title: Regenerative Medicine
Total Hours: **60**

L	T	P	Cr
4	-	-	4

Learning Outcomes:

On successful completion of the course the student will be able to:

- Synthesize the ideas for research in stem cell biology
- Apply the knowledge for translational research as well as industrial aspects of the tissue engineering and regenerative medicine
- Get in depth knowledge about tissue engineering

Conceptualize regenerative medicine

UNIT I **15 Hours**

Stem Cells: Stem cells, their properties and classification, adult stem cells, iPSCs, methods of isolation, identification and characterization of stem cells, special features of stem cell culture.

UNIT II **15 Hours**

Adult Stem Cells: Stem cells of various organs specially; Hematopoietic, mesenchymal and neural stem cells: their signaling and applications, cancer stem cells.

UNIT III **15 Hours**

Tissue Engineering: Principles of tissue culture, tissue and organ culture, extracellular matrices, bioreactors.

UNIT IV **15 Hours**

Regenerative Medicine: Regeneration of bone and cartilage, lung, liver, spinal cord and heart, Islet transplantation and bio-artificial pancreas.

Transactionalal Modes: Lecture**;** Demonstration**;** Tutorial**;** Lecture cum demonstration; Problem solving; Self-learning.

Suggested Readings:

1. Lanza, R., Gearhart,J. (2009). *Essential of Stem Cell Biology*. Elsevier Academic Press.
2. Lanza, R., Klimanskaya, I. (2009). *Essential Stem Cells Methods*. Academic Press.
3. Mao, J. J., Vunjak-Novakovic (2008). *Translational Approaches in Tissue Engineering & Regenerative Medicine*.Artech House INC Publications.
4. Lanza, R. (2007). *Principles of Tissue Engineering, 3rd Edition*. Academic Press.
5. Stein. (2011). *Human Stem Cell Technology and Biology: A Research Guide and Laboratory Manual.* Wiley-Blackwell.
6. Lanza, R. (2004). *Handbook of Stem Cells, Two-Volume Set: Volume 1-Embryonic Stem Cells; Volume 2-Adult & Fetal Stem Cells*. Academic Press.

Related Weblinks:

1. www.stemcells.wisc.edu
2. http://stemcells.nih.gov/info/scireport/Pages/2006report.aspx
3. *stemcells.nih.gov/*
4. http://instem.res.in/

L	T	P	Cr
4	-	-	4

Course Code: LHG.526
Course Title: Population Genetics and Genetic Epidemiology
Total Hours: 60

Learning Outcomes:

On successful completion of the course the student will be able to:

- Conceptualize the basic concepts in population genetics and apply statistics relevant to the study of genomic diversity
- Examine the major genetic and ecological processes underlying evolution and explain the process driving speciation

- Perform different epidemiological studies to identify the cause-effect relationship in variety of human traits/diseases
- Design genetic studies and perform association and linkage analysis on any relevant data.

UNIT I **15 Hours**

Population dynamics and basics of epidemiology: Dynamics and conditions of the Hardy-Weinberg law; selection co-efficient and fitness; heterozygous advantages; inbreeding and its consequences; mutation pressure and estimation of rates; genetic load; selection co-efficient and fitness; dynamics of migration and genetic drifts; construction of pedigree and pedigree analysis.

UNIT II **15 Hours**

Evolution and Speciation: Emergence of evolutionary thoughts Lamarck; Darwinism – concepts of variation, adaptation, struggle, fitness and natural selection; Mendelism; spontaneity of mutations; the evolutionary synthesis.

Mechanism of evolution: Adaptive radiation; isolating mechanisms; speciation; allopatricity and sympatricity; convergent evolution; sexual selection; co-evolution.

UNIT III **15 Hours**

Fundamentals of epidemiological studies: Experimental and observational studies; basic parameters of epidemiology: frequency, occurrence, prevalence, incidence; association; causation, variation; Cohort studies: cross sectional and longitudinal; Association studies: candidate gene association and genome-wide association studies (GWAS);concept of heritability; systematic review and meta-analysis.

UNIT IV **15 Hours**

Genetic variation and complex trait inheritance: Basics of genetic variations; genetic markers – SNP, CNV, Ins/dels, VNTR, STR, microsatellite; concepts of tag markers and haplotypes, linkage disequilibrium; quantitative genetic analysis; QTL and eQTL.

Genetic variation and complex trait inheritance: Next-generation sequencing; DNA micro -array.

Transactionalal Modes: Lecture**;** Demonstration**;** Tutorial**;** Case study; seminar presentation; Problem solving; Self-learning.

Suggested Readings:

1. Bhasker, H.V. and Kumar S (2008). *Genetics*. Campus Books International, New Delhi, India.

2. Cavalli-Sforza, L.L. and Bodmer, W.F. (2013). *The Genetics of Human Populations.* Dover Publications.
3. Hamilton M.B. (2009). *Population Genetics*. Wiley-Blackwell, UK.
4. Hedrick P.W.(2011). *Genetics of Populations*. Jones and Bartlett Publishers, Massachusetts.
5. Jobling, M., Hollox, E., Hurles, M., Kivisild, T. and Tyler-Smith, C. (2013). *Human Evolutionary Genetics*. Garland Science.
6. Knight, J.C. (2009). *Human Genetic Diversity –Functional consequences for Health and Disease*. Oxford University Press, USA.
7. Krebs, J.E, Goldstein, E.S. and Kilpatrick, S.T. (2013) *Lewin's Essential Genes*. Jones and Bartlett learning, USA.
8. Nielsen, R. and Slatkin, M. (2013). An Introduction to Population Genetics: Theory and Applications. Sinauer Associates, Inc.
9. Relethford, J.H. (2012). *Human Population Genetics.* John Wiley & Sons.
10. Snusted, D.P., Simmons, M. J. (2010). *Principles of Genetics*. John Wiley & Sons, New York.
11. Palmer LJ, Burton PR & Smith GD (2011). *An introduction to genetic epidemiology* (Policy Press, University of Bristol)
12. Dawn TM (2011). *Genetic Epidemiology* (Springer)
13. Austin M (2013). *Genetic Epidemiology: Methods and Applications*, 1st Edition (CABI Publishing)

L	T	P	Cr
4	-	-	4

Course Code: LMM.526
Course Title: Molecular and Cellular Oncology
Total Hours: 60

Learning Outcomes:
On successful completion of the course the student will be able to:

- Conceptualize basic aspects of oncobiology
- Evaluate comprehensive analysis to cope up with the ever-expanding role of molecular biology in basic cancer research as well as clinical oncology
- Apply the knowledge to modern diagnostic and therapeutics approaches function at molecular level
- Synthesize the ideas about novel cancer therapeutic approaches

UNIT I **15 Hours**

Fundamentals and Genetics of Cancer: History, hallmarks of cancer research, cancer classification, Mutagens, carcinogens and gene mutations and genetic arrangements in progenitor cells. Chromosomal aberrations, tumor viruses and discovery of oncogenes, Mechanism of activation of oncogenes. Transcription factors as tumor suppressors and oncogenes, Familial cancer

syndromes, telomere regulation in cancer, micro RNA profiling in cancer, cancer stem cells.

UNIT II **15 Hours**

Signal transduction in cancer progression: Role of growth factors and receptors in carcinogenesis, Interaction of cancer cells with variety of immune cells. Deregulation of Cell cycle in cancer. Role of p53 and pRb in cell cycle, Apoptosis and tumor suppressor p53, mitochondrial signaling, RAS signaling in cancer, cancer metabolism, hypoxia and metastasis, angiogenesis, tumor microenvironment. DNA damage and repair mechanisms, DNA repair defects and their relation to cancer.

UNIT III **15 Hours**

Cancer Detection: General and organ specific symptoms associated with cancer, techniques for cancer detection, biomarkers for cancer detection of various stages of cancer, population genetics based screening methods, *In-vitro* assays to detect angiogenesis, metastasis, cell proliferation, mice models to study cancer (transgenic, knock-out, knock-in, xenografts and patient derived xenografts), genomic and proteomic approaches to develop better cancer markers.

UNIT IV **15 Hours**

Cancer Therapies and Recent Advances in Cancer Research : Traditional Chemotherapies, radiotherapy, Onco-surgery, Bone marrow transplantation, stem cell therapies, Immunotherapy, combinational therapies, natural products as therapeutics, cancer vaccines, gene therapies and delivery vehicles, targeted anticancer therapies, monoclonal antibody & adjuvant therapies. System biology approaches, Application of new technologies in prevention, assessing risk, diagnostics and treatment.

Transactionalal Modes: Lecture**;** Demonstration; Tutorial; Seminar presentation; Lecture cum demonstration; Problem solving; Self-learning.

Suggested Readings:

1. Airley, R. (2010). *Cancer Chemotherapy: basics to clinic.* Willey-Blackwell publishing, New Jersey.
2. DeVita, V. T., Hellman, S., Rosenberg, S. A. (2011). *Cancer: principles and practice of oncology.* Lippincot Williams and Wilkins publishers, Philadelphia.
3. Enders, G. H. (2010). Cell *cycle deregulation in cancer.* Humana Press, Springer science, New York.

4. Grutzmann, R., Pilarsky, C. (2010). *Cancer gene profiling: methods and protocols*. Humana Press, Springer science, New York.
5. Gusev, Y. (2010). *Micro RNA profiling in cancer.* Pan Standford publishing pvt.Ltd.,Singapore.
6. Hiem, S., Mitelman, F. (2009). *Cancer cytogenetics*. IIIrd edition. Willey-Blackwell publishing, New Jersey.
7. Jocelyn, E. K., Elliot, S. G., Stephen, T. K. (2009). *Lewin's Gene X.* Jones &Barlett.
8. Wang, E. (2010). *Cancer systems biology*. CRC press, Taylor & Francis group, New York.
9. Weinberg, Robert A. (2007). *The Biology of Cancer*. New York: Garland Science
10. Prasad, K. N. (2009). Bio-Shield, *Antioxidants against Radiological, Chemical and Biological Weapons,* Strategic Book Publishing, USA.
11. Washington, C. M. and Leaver D. T. (2009). *Principles and Practice of Radiation Therapy*, Elsevier Health Sciences, USA.

Course Code: LHG.527
Course Title: Prenatal Diagnosis and Genetic Counseling
Total Hours: 30

L	T	P	Cr
2	-	-	2

UNIT I **8 Hours**

Prenatal screening & diagnosis: Indications for prenatal diagnosis; preliminaries to prenatal diagnosis; procedures for obtaining fetal tissue; ultrasonography; laboratory studies; psychosocial issues.

UNIT II **7 Hours**

Techniques used in prenatal diagnosis: Amniocentesis, Chorionic villus sampling, fetoscopy, cordocentesis, maternal serum screening.

UNIT III **8 Hours**

Genetic Counseling: History taking; examination; genetic counseling in clinical genetics; determining recurrence risks; population screening for genetic diseases; reproductive decision making.

UNIT IV **7 Hours**

Indications for prenatal diagnosis: Advanced maternal age, previous child with a chromosome abnormality, family history of a chromosomal abnormality, family history of a single gene disorder, family history of neural tube defect

Transactionalal Modes: Lecture; Case study, Demonstration**;** Tutorial**;** Lecture cum demonstration; Problem solving; Self-learning.

Suggested Readings:

1. Peter Snustad and Michael J Simmons(2009). Principles of Human Genetics. Fifth Edition. John Wiley & Sons, Inc.
2. Strachan T and Read A 2010 Human Molecular Genetics, Fourth Edition. Taylor and Francis
3. Ricki Lewis (2009) Human Genetics-Concepts and Application. Ninth Edition. McGraw-Hill College Publishers

Course Code: LHG.528
Course Title: Introduction to Population Genetics
Total Hours: 30

L	T	P	Cr
2	-	-	2

Learning Outcomes:

On successful completion of the course the student will be able to:

- Know about attributes of a population and it's dynamics
- Explore different causes for population diversity and heterogeneity

Examine and analyze causes of population diversity

UNIT I **8 Hours**

Hardy-Weinberg Equilibrium: Historical emergence; subdivisions of human population; dynamics and conditions of the Hardy-Weinberg law and its application for autosomal locus with two alleles and multiple alleles; testing of Hardy-Weinberg proportion.

UNIT II **8 Hours**

Heterozygosity: heterozygous advantages, inbreeding and its consequences, Selection co-efficient and fitness, heterozygous advantages.

UNIT III **7 Hours**

Kinetics of changes of gene frequencies: dynamics of migration and genetic drifts; equilibrium between mutation and selection.

UNIT IV **7 Hours**

Genetic load: Non-recurrent and recurrent mutation, mutation pressure and estimation of rate of mutation.

Transactionalal Modes: Lecture**;** Demonstration**;** Tutorial**;** Lecture cum demonstration; Problem solving; Self-learning.

Suggested Readings:

1. Bhasker, H.V. and Kumar S (2008). *Genetics*. Campus Books International, New Delhi, India.
2. Cavalli-Sforza, L.L. and Bodmer, W.F. (2013). *The Genetics of Human Populations.* Dover Publications.
3. Hamilton M.B. (2009). *Population Genetics*. Wiley-Blackwell, UK.
4. Hedrick P.W.(2011). *Genetics of Populations*. Jones and Bartlett Publishers, Massachusetts.
5. Jobling, M., Hollox, E., Hurles, M., Kivisild, T. and Tyler-Smith, C. (2013). *Human Evolutionary Genetics*. Garland Science.
6. Knight, J.C. (2009). *Human Genetic Diversity –Functional consequences for Health and Disease*. Oxford University Press, USA.
7. Krebs, J.E, Goldstein, E.S. and Kilpatrick, S.T. (2013) *Lewin's Essential Genes*. Jones and Bartlett learning, USA.
8. Nielsen, R. and Slatkin, M. (2013). An Introduction to Population Genetics: Theory and Applications. Sinauer Associates, Inc.
9. Relethford, J.H. (2012). *Human Population Genetics.* John Wiley & Sons.
10. Snusted, D.P., Simmons, M. J. (2010). *Principles of Genetics*. John Wiley & Sons, New York.

Course Code: LHG.542
Course Title: Seminar-I
Total Hours: 15

L	T	P	Cr
-	-	-	1

Learning Outcomes:

On successful completion of the course the student will be able to:

- Improve communication aptitude
- Learn presenting paper or data in scientific forum

Evaluation criteria: The detailed assessment criteria are as per University policy. The students will be assessed based on presentation and report submitted on the topics assigned by seminar coordinator.

Semester – III

Course Code: xxx.xxx
Course Title: MOOC course
Total Hours: 60

L	T	P	Cr
4	-	-	4

Learning Outcomes:
On successful completion of the course the student will be able to:
Acquire knowledge on specific topics and will be able to apply it to real data or experiments.

MOOC course of 4 credits may be chosen by a student from the list provided by Swayam to the
Head of the concerned Department. The student is required to submit the pass certificate of
MOOC course before the declaration of result. The link for selection of MOOC course is:
http://ugcmoocs.inflibnet.ac.in/course.php

Course Code: LHG.550
Course Title: Bioinformatics and Computational Biology
Total Hours: 60

L	T	P	Cr
4	-	-	4

Learning Outcomes:
On successful completion of the course the student will be able to:
- Analyze publicly available and experimental genomics data
- Perform *in-silico* prediction of protein structures and protein-protein interaction
- Perform in silico functional annotation of genetic findings
- Demosntrate physical property of biomolecules in silico

UNIT I **15 Hours**

Biological databases: Nucleotide Sequence Databases, GenBank, DDBJ, EMBL, Sequence Flatfile and submission process, Protein sequence databases, UniProt in detail, Mapping databases, Genomic databases, Data mining.

UNIT II **15 Hours**

Sequence analysis: Gene Prediction methods and programs, Promoter analysis, RNA secondary structure thermodynamics, Refining multiple sequence alignment based on RNA secondary structure predictions, SNP

discovery methods and databases, Genotyping, International haplotype map project, 1000 genomes project.

Analysis for protein sequences: Predicting features of individual residues, Predicting function, Neural networks, Protein structure prediction, Protein structure databases, PDB in detail, 3D visualization softwares, Pathway and molecular interaction databases.

UNIT III **15 Hours**

Inferring relationships: Global Vs. local sequence alignments, Dotplots, Scoring matrices, Pairwise sequence alignment, BLAST, Position-Specific scoring and PSI-BLAST, MegaBLAST, BL2SEQ, BLAT, FASTA Vs BLAST, Protein multiple sequence alignments, Multiple structural alignments, Shotgun sequencing, Sequence assembly and finishing.

UNIT IV **15 Hours**

Modelling and structure: From protein sequence to structure, theoretical and practical aspects of protein sequence alignments, secondary, tertiary structure prediction, comparative modeling, Docking, protein-protein and protein-ligand docking. Techniques for 3-D structure determination like X-ray, NMR, MS/MS analysis.

Computational drug designing: Structure-based drug design, virtual screening, quantitative structure activity relations, Cheminformatics and pharmacophore mapping in therapeutic development.

Transactionalal Modes: Lecture**;** Demonstration**;** Tutorial**;** Lecture cum demonstration; Problem solving; Case study; Self-learning.

Suggested Readings:

1. Baxevanis, A.D. and Ouellette, B.F.F. (2005). *Bioinformatics: A Practical guide to the Analysis of Genes and Proteins*. Wiley-Interscience, USA.
2. Hall, B.G. (2011). *Phylogenetic Trees Made Easy: A How-To Manual*. Sinauer Associates, Inc. USA.
3. Lesk, A.M. (2008). *Introduction to Bioinformatics*. Oxford University Press, UK.
4. Zvelebil, M. and Baum, J. (2007). *Understanding Bioinformatics*, Garland Science, New York, USA.
5. Ramsden, J. (2010). *Bioinformatics: An Introduction* (*Computational Biology*). Springer, India.
6. Ye, S.Q. (2008). *Bioinformatics: A Practical approach*. Chapman & Hall/CRC, UK.
7. Mount, D. (2012). Bioinformatics: Sequence and Genome Analysis. Cold Spring Harbor Laboratory Press.
8. Graur, D., Li, W. H. (2000). Fundamentals of Molecular Evolution. Sinauer Associates.
9. Tisdall, J. (2001). Beginning Perl for Bioinformatics. O'Really Publishers.

Course Code: LHG.551

Course Title: Biosafety, Bioethics and Intellectual Property Rights
Total Hours: 60

L	T	P	Cr
4	-	-	4

Learning Outcomes:
On successful completion of the course the student will be able to:

- Identify the philosophical components of the *bioethical* issues concerning biotechnological advancements like recombinant DNA technology, cloning, gene manipulation.
- Define the components of a biological risk assessment, will understand the importance of choosing appropriate Biosafety Levels for reducing risk and importance of containment
- Getting in-depth knowledge about different forms of intellectual property rights, will able to differentiate between patentable and nonpatentable invention/innovation
- Get familiar with the various patent filing routes and the ways of protection of indigenous intellectual property

UNIT I **15 Hours**

Biosafety: Good laboratory practices; gene pollution; biological invasion; risk and safety assessment from genetically engineered organisms; special procedures for r-DNA based products; biological containment (BC) and physical containment (PC); CDC biosafety levels; biohazard management.

UNIT II **15 Hours**

Bioethics: Ethical considerations during research; Animal testing; xenotransplantation; embryonic and adult stem cell research; assisted reproductive technologies; cloning; ethical issues of the human genome project; the element of informed consent; ethical issues in MTP and euthanasia.

UNIT III **15 Hours**

Intellectual Property Rights (IPRs): Various forms of IP – patents, industrial designs, trade secrets, geographical indications and plant breeder's right; copyright: fair use, plagiarism and open access publishing; criticism of intellectual property; protection of indigenous intellectual property.

UNIT IV **15 Hours**

Patent system in India: Patent filing in India and abroad: Determination of patentability of inventions, filing a patent application in India: timeline, procedure involved in the granting of a patent, various routes of filing patent application abroad, patent co-operation Treaty (PCT);Gene patent, Patenting of Living Organisms.

Transactionalal Modes: Lecture**;** Demonstration**;** Tutorial**;** Lecture cum demonstration; Problem solving; Case study; Self-learning.

Suggested Readings:

1 Clarke, A (2012). *Genetic Counseling: Practice and Principles*. Taylor & Francis

2 Fleming, D.O. and Hunt, D.L. (2006). *Biological Safety: Principles and Practices*. American Society for Microbiology, USA.

3 Mahop, M.T. (2010). *Intellectual Property, Community Rights and Human Rights: The Biological and Genetic Resources of Developing Countries*.Routledge.

4 Shannon, T.A. (2009). *An Introduction to Bioethics*. Paulist Press, USA.

5 Thompson J and Schaefer, B.*D (2013).Medical Genetics: An Integrated Approach*. McGraw Hill.

6 Vaughn, L. (2009). *Bioethics: Principles, Issues, and Cases*. Oxford University Press, UK.

7 WHO. (2005). *Laboratory BiosafetyManual*. World Health Organization.

Course Code: LHG.552
Course Title: Genetic Diseases and Therapies
Total Hours: 60

L	T	P	Cr
4	-	-	4

Learning Outcomes:

On successful completion of the course the student will be able to:

- Develop knowledge of the mechanism human genetic disorders caused due to genomic imprinting and numerical chromosomal aberrations
- Develop knowledge about monogenic and multifactorial diseases
- Apply the principal of genetics and biostatistics for genetic disorders risk assessment
- Conceptualization about genetic imprinting and correlate with human diseases

UNIT I **15 Hours**

Monogenic Disorders: Cystic fibrosis**;** Huntington's disease; Duchenne Muscular dystrophy; X-linked rickets.

Multifactorial Diseases: Diabetes type 2; Cancers; Hypertension; Obesity; Neurodegenerative diseases.

UNIT II **15 Hours**

Genomic Imprinting and Human Diseases: Uniparental disomy & genomic imprinting: Prader-Willi & Angelman syndrome; Beckwith-Wiedeman syndrome & Silver Russell Syndrome; Imprinting and brain and behaviour; imprinting and Cancer.

Neurofibromatosis I; X/Y linked human syndromes due to numerical chromosomal anomalies.

UNIT III **15 Hours**

Genetic Screening: Risk calculations, Population screening for genetic disease-adult, Clinical utilization of presymptomatic and predispositional testing, Presymptomatic testing for genetic diseases and malignancy, carrier detection; prenatal and postnatal screening; Assisted reproductive techniques and Pre-implantation diagnosis and Genetic Counseling.

UNIT IV **15 Hours**

Therapies for genetic disorders and multifactorial diseases: Stem cell therapies**:** stem cell types, cord blood cells, bone marrow transplantation; current stem cell therapies; gene therapies: methods; diseases suitable for gene therapies: hemoglobinopathies, cystic fibrosis, muscular dystrophies, cancer; challenges in gene therapy; regulatory requirements.

Transactionalal Modes: Lecture**;** Demonstration**;** Tutorial**;** Lecture cum demonstration; Problem solving; Self-learning.

Suggested Readings:

1. Brown, S.M., (2009). *Essentials of Medical Genomics*. Wiley-Blackwell.
2. Jocelyn, E. K., Elliot, S. G., Stephen, T. K. (2009), *Lewin's Gene X*. Jones & Barlett.
3. Krebs, J.E., Goldstein, E.S. and Kilpatrick, S.T. (2014). *Lewin's Genes XI*. Jones and Bartlet India Pvt. Ltd.
4. Lodish, H., Berk, A., Chris, A. K., Krieger, M. (2008), *Molecular Cell Biology*. W.H. Freeman, USA.
5. MilunskyA,Milunsky J (2009). *Genetic Disorders and the Fetus: Diagnosis, Prevention and Treatment*, 6th Edition. Wiley-Blackwell publishers.

Course Code: LHG.553
Course Title: Pharmacogenomics and Nutrigenomics
Total Hours: 60

L	T	P	Cr
4	-	-	4

Learning Outcomes:
On successful completion of the course the student will be able to:

- Define pharmacogenomics and will understand its application in clinical setting. The students will be aware about the challenges in the field on account of different ethnic background.
- Have an understanding about the nutritional requirements and the role of gut microbiota in human nutrition.
- Be aware of the effect of genetic polymorphisms in variable response to micronutrients and will understand the regulation of transcription factors by the nutrients.
- Get aware of the genetic markers involved in the regulation of metablomics and the role of these markers in health and disease.

UNIT I **15 Hours**

Pharmacogenomics: Pharmacokinetics and pharmacodynamics; drug-metabolizing enzymes: cytochrome P450s, VKORC1 and TPMT; personalized treatment: example of warfarin, anti-epileptic and anti-cancer drugs like methotrexate and tamoxifen, trastuzumap; heredity disorders with altered drug response: porphrriavariegata, hemoglobinopathies, grigler-najjar syndrome; concept of pharmacogenomics; progress in understanding the genomic basis for adverse drug reactions; ethnic diversity in pharmacogenomics studies and challenges posed by ethnicity.

UNIT II **15 Hours**

Nutritional Biochemistry: Essential and non-essential nutrients; micro and macro nutrients; measurement of calorie values of foods; recommended dietary allowances; basal metabolic rate (BMR); malnutrition; malabsorption and interventional strategies. Concept of gut microbiota in human nutrition.

UNIT III **15 Hours**

Nutrigenomics vs Nutrigenetics: Diet and gene expression; nutrients as regulators of activity and transcription factors; nutritionalstatusin early life and metabolic programming; gene polymorphisms and differential responses to micronutrients: examples related to obesity, vitamin D deficiency and folic acid deficiency.

UNIT IV **15 Hours**

Biomarkers and recent advances in Nutrigenomics: Risk/benefit biomarker; genetic and nutritional control of lipid metabolism, metabolomics; effect of diet on epigenetic processes, concept of gut microbiome and its implications in health and disease.

Transactionalal Modes: Lecture**;** Demonstration**;** Tutorial**;** Lecture cum demonstration; Problem solving; Self-learning.

Suggested Readings:

1. Altman RB, Flockhart D and Goldstein DB (2012). Principles of Pharmacogenetics and Pharmacogenomics.Cambridge University Press.
2. Ferguson, L,R.(2013) *Nutrigenomics and Nutrigenetics in Functional Foods and Personalized Nutrition.* CRC Press.
3. Tollefsbol T (2011). *The New Molecular and Medical Genetics*. Elsevier Inc
4. Simopoulos A.P. and Ordovas J.M. (2004). Nutrigenetics and Nutrigenomics Karger Publishers
5. Rimbach, G and Fuchs, J (2005) *Nutrigenomics (Oxidative Stress and Disease*). CRC press

Course Code: LHG.599
Course Title: Project-I
Total Hours: 180

L	T	P	Cr
-	-	6	6

Learning Outcomes:

On successful completion of the course the student will be able to:

- Get hands-on training on several genetic and genomics techniques
- Learn study designing and report writing
- Interpretation of results and discussion
- Improve communication skills

The objective of this course would be to ensure that the student learns the nuances of the scientific aptitude, presentation and writing. Herein the student shall have to write his/her synopsis including an extensive review of literature with simultaneous identification of scientifically sound (and achievable) objectives backed by a comprehensive and detailed methodology.

Synopsis will be evaluated as per the University policy.

Semester – III

L	T	P	Cr
4	-	-	4

Course Code: LHG.571
Course Title: Recombinant DNA Technology and Therapeutics
Total Hours: 60

Learning Outcomes:
On successful completion of the course the student will be able to:

- Demonstrate cloning and expression vectors in E.Coli in recombinant DNA techniques
- Get familiar with vectors for Eukaryotes
- Learnconventional methods used in recombinant DNA technology
- Learn therapeutics aspect of recombinant DNA technologies

UNIT I **15 Hours**

Basics of Genetic Engineering: Isolation and purification of nucleic acids; gene manipulation;restriction and DNA modifying enzymes; restriction modification systems;cloning vectors: plasmids, phages, lambda vectors, cosmids, PAC, BAC, YAC; selection and screening of clones.

UNIT II **15 Hours**

Construction of DNA libraries: Genomic and cDNA libraries; screening of genomic and expression libraries.

Analysis of gene expression: Northern blotting; RT-PCR; digital PCR; EST analysis; promoter analysis; TSS mapping; cDNA and oligos array; serial analysis of gene expression (SAGE).

UNIT III **15 Hours**

Expression Vectors: Animal virus derived vectors-Sv-40, caccinal/bacculo& retroviral vectors. Expression vectors; pMal, GST, PET – based vectors. Protein purification; His-tag, GST-tag, MBP-tag. Restriction proteases, intein-based vectors. Inclusion bodies methodologies to reduce formation of inclusion bodies, *baculovirus* and pichia vectors system.Site Directed Mutagenesis.

UNIT IV **15 Hours**

Techniques and Applications of recombinant DNA technology: Sites specific mutagenesis; Gene Editing through RNA based therapeutics, CRISPR/CAS system, Genetically modified microbes (Recombinant bacteria) for the production of commercial scale production of proteins, pharmaceuticals; transgenic animals.

Transactionalal Modes: Lecture**;** Demonstration**;** Tutorial**;** Lecture cum demonstration; Problem solving; Self-learning.

Suggested Readings:

1. R.W. Old & S.B. Primrose (2007) *Principles of Gene Manipulation* 7th Edition Blackwell science.
2. Bernard R. Glick & Jack J. Pasternak. (2010) *Molecular Biotechnology* 4th Edition ASM Press Washington.
3. James Watson, Micheal Gilman Jan Witkowsk (2007) *Recombinant DNA* 3rdedition . CSHL, New York.
4. CokinRateldge and Bjorn Christiansen, (2006) *Basic Biotechnology* 3rdEdition Cambridge University press.
5. John E. Smith. (2009) *Biotechnology* 5th Edition by Cambridge University press.
6. *Molecular Biology* of Gene 6th Edition by Watson CSHL Press New York.
7. Sambrook& Russell *Molecular cloning* , CSHL Press, New York.
8. David &Freifelder John &Barlett (2008) *Molecular biology* 2ndEdition ,Narosa publishing , New Delhi.

Related Weblinks:

1. http://www.genengnews.com/ontheweb.asp
2. http://www.ige-india.com/
3. http://www.icgeb.org/~bsafesrv/
4. http://www.livescience.com/32648-whats-genetic-engineering.html

Course Code: LHG.572
Course Title: Advanced Practical Course in Human Genetics
Total Hours: 45

L	T	P	Cr
-	-	3	3

Learning Outcomes:

On successful completion of the course the student will be able to:

- Get hands-on training on several techniques in human genetics research
- Familier with laboratory management

UNIT I **20 Hours**

Molecular genetic techniques: PCR and RFLP; cDNA library preparation; qPCR; analysis of qPCR data (delta CT and delta delta CT method); PBMC culture; chromosome banding: G-banding; Identification of chromosomes based on G-banding; karyotyping; fluorescence in situ hybridization (FISH).

UNIT II **15 Hours**

Bioinformatics: PCR and RT-PCR primer designing; global and local sequence alignment, Sanger sequencing data analysis;data mining, comparative modeling; docking; protein-ligand; structure-based drug design; virtual screening, molecular phylogenetics.

*Practical will be conducted depending upon the faculty/facility.

Transactionalal Modes: Hands-on trainings; Demonstration**;** Tutorial**;** Lecture cum demonstration; Problem solving; Self-learning.

Suggested Readings:

Laboratory specific modified protocols will be followed, however below mentioned reference books can be read to develop overall concepts.

1 Laboratory Protocols. Third Edition. 2005. CIMMYT Applied Molecular Genetics Laboratory.

2 Koliantz, G & Szymanski, D.B. Genetics A Laboratory Manual. Second Edition. 2009. American Society of Agronomy, Crop Science Society of America.

3 Sambrook, J & Green, M.R. Molecular Cloning: A laboratory manual. Fourth Edition. 2013. Cold Spring Harbor Laboratory Press, U.S.

4 Pazos, F & Chagoyen, M. Practical protein bioinformatics.2015. Springer International Publishing, Switserland.

5 Agostino, M. Practical Bioinformatics. 2012. Garland Science. Taylor & Francis Group. New York and London.

Course Code: LHG.573
Course Title: Practice in Life Sciences-I
Total Hours: 30

L	T	P	Cr
2	-	-	2

Learning Outcomes:

On successful completion of the course the student will be able to:

- Improve their knowledgebase required for competitive examinations
- Improve student's aptitude for research and development
- Revise several key topics of life sciences

UNIT I **8 Hours**

Molecules and their interaction relavent to biology: Structure of atoms, molecules and chemical bonds, composition, structure and function of biomolecules, stablizing interactions, principles of biophysical chemistry, bioenergetics, glycolysis, oxidative phosphorylation, coupled reaction, group transfer, biological energy transducers, principles of catalysis, enzymes and

enzyme kinetics, enzyme regulation, mechanism of enzyme catalysis, isozymes, conformation of proteins (ramachandran plot, secondary structure, domains, motif and folds), conformation of nucleic acids stability of proteins and nucleic acids, metabolism of carbohydrates, lipids, amino acids nucleotides and vitamins.

UNIT II **7 Hours**

Cellular organization: Membrane structure and function, structural organization and fu nction of intracellular organelles, organization of genes and chromosomes, cell division and cell cycle, dna replication, repair and recombination, rna synthesis and processing, protein synthesis and processing, control of gene expression at transcription and translation level, cell communication and cell signaling.

UNIT III **8 Hours**

Innate and ada ptive immune system: cells and molecules involved in innate and adaptive immunity, antigens, antigenicity and immunogenicity. B and t cell epitopes, structure and function of antibody molecules, MHC molecules, antigen processing and presentation, activation and differentiation of B and T cellshumoral and cell - mediated immune responses, primary and secondary immune modulation, the complement system, toll - like receptors, cell - mediated effector functions, inflammation, hypersensitivity and autoimmunity, immune response during bacterial (tuberculosis), parasitic (malaria) and viral (HIV) infections, congenital and acquired immunodeficiencies, vaccines.

UNIT IV **7 Hours**

Developmental biology: Basic concepts of development, gametogenesis, fertilization and early development, programmed cell death, aging and senescence

Transactionalal Modes: Lecture**;** Demonstration**;** Tutorial**;** Lecture cum demonstration; Problem solving; Self-learning; MCQ practice.

L	T	P	Cr
2	-	-	2

Course Code: LHG.574
Course Title: Practice in Life Sciences-II
Total Hours: 30

Learning Outcomes:
On successful completion of the course the student will be able to:

- Improve their knowledgebase required for competitive examinations
- Improve student's aptitude for research and development
- Revise several key topics of life sciences

UNIT I **7 Hours**

System physiology – animal: Blood and circulation, cardiovascular system, respira tory system, nervous system, sense organs, excretory system, thermoregulation, stress and adaptation, digestive system, endocrinology and reproduction

UNIT II **7 Hours**

Inheritance biology: Mendelian genetics, concept of gene, extensions of mendelian principles, gene mapping methods, extra chromosomal inheritance, microbial genetics, human genetics, quantitative genetics, mutation, structural and numerical alterations of chromosomes, recombination.

UNIT III **8 Hours**

Evolution and behaviour: Emergence of evolutionary thoughts- lamarck; darwin, origin of cells and unicellular evolution, origin of basic biological molecules; abiotic synthesis of organic monomers and polymers; concept of oparin and haldane; experiement of miller (1953); the first cell; evol ution of prokaryotes; origin of eukaryotic cells; evolution of unicellular eukaryotes; anaerobic metaboli sm, photosynthesis and aerobic metabolism, paleontology and evolutionary history, molecular evolution, mechanisms of evolution, population genetics, brain, behavior and evolution.

UNIT IV **8 Hours**

Applied biology: Application of immunological principles, vaccines, diagnostics. Tissue and cell culture methods for plants and animals, transgenic animals, molecular approaches to diagnosis, genomics and its application to health, molecular biology and recombinant dna methods, histochemical and immunotechniques, biophysical method, statisitcal methods, radiolabeling techniques, microscopic techniques, electrophysiological methods, methods in field biology.

Transactionalal Modes: Lecture**;** Demonstration**;** Tutorial**;** Lecture cum demonstration; Problem solving; Self-learning; MCQ practice.

Course Code: LHG.544
Course Title: Seminar-II
Total Hours: 15

L	T	P	Cr
-	-	-	1

Learning Outcomes:
On successful completion of the course the student will be able to:
- Improve communication aptitude
- Learn presenting paper or data in scientific forum

Evaluation criteria: The detailed assessment criteria are as per University policy. The students will be assessed based on presentation and report submitted on the topics assigned by seminar coordinator.

L	T	P	Cr
-	-	6	6

Course Code: LHG.599
Course Title: Project-II
Total Hours: 180

Learning Outcomes:
On successful completion of the course the student will be able to:
- Get hands-on training on several genetic and genomics techniques
- Learn study designing and report writing
- Interpretation of results and discussion
- Improve communication skills

The final result of the project will be on a five point scale and evaluated as **excellent, very good, good, average** and **unsatisfactory**.

Thesis will be evaluated as per the University policy.

Evaluation Criteria for Theory Courses
A. Continuous Assessment: [25 Marks]
i. Surprise Test (minimum three) - Based on Objective Type Tests (10 Marks)
ii. Term paper (10 Marks)
iii. Assignment(s) (5 Marks)
B. Mid Semester Test: Based on Subjective Type Test [25 Marks]
C. End-Term Exam: Based on Subjective Type Test [25Marks]
Based on Objective Type Tests [25 Marks]
Evaluation Criteria for Practical Course (to be given by Department)