REVISED SYLLABUS

(Approved vide emergent BPGS meeting held on 12-03-2020, Effective from Session 2020- 2021)

Doctor of Philosophy

in

BIOTECHNOLOGY

Babasaheb Bhimrao Ambedkar University
(A Central University)
Vidya vihar , Raebareli Road
Lucknow -226025

COURSE STRUCTURE FOR Ph. D. BIOTECHNOLOGY

Course Code	Course Title	Credit	Max Marks
DPHBT-101	**Research Methodology**	**04**	**100**
DPHBT -102A	**Advances in Microbial Technology**	**04**	**100**
DPHBT -102B	**Plant Biotechnology**		
DPHBT -102C	**Immunology & Animal Biotechnology**		
DPHBT -102D	**Advances in Enzyme Technology**		
DPHBT -102E	**Advances in Structural Biology**		
DPHBT -103	**Advances in Genetic Modification Technologies [Genetically Modified Organism (GMO) and Living Modified Organism (LMO)]**	**04**	**100**
DPHBT -104	**Advance Course in Bioinformatics and System Biology**	**04**	**100**
CPE-RPE-105	**Research and Publication Ethics (RPE)**	**02**	**100**

Syllabus for Ph. D Course Work
DPHBT-101
Research Methodology

Prof. D. R. Modi, Prof. Sangeeta Saxena,
Dr. G. Sunil Babu, Dr. Anand Prakash,
Dr. Monica Sharma & Dr. Yusuf Akhter
Credit=4
Max Marks: 100
Sessional: 30
End Semester Exam: 70

Unit 1. General Research approach

Definition- defining research problem, Basic and applied research, Approaches and Methodology, Research/ experimental design, Literature collection and documentation. Research report- Writing of research proposal, report and Research paper: Data presentation, Analysis and Interpretation. Documentation: Footnotes and Bibliography. Ethical, legal, social and scientific issues in biological research. Role of Intellectual Property Rights (IPR) in Research and development. A brief idea of funding agencies - DST, DBT, ICMR, CSIR and UGC.

Unit 2: Biophysical methods

Analysis of biomolecules using spectrometric analysis(UV-Vis, IR& FTIR, and Mass spectrometry). Structural determination- NMR& ESR and X-diffraction. Affinity analysis- Equilibrium dialysis, Surface Plasmon Resonance. Radiolabelling- use of radioisotopes used biology, molecular imaging of radioactive materials.

Unit 3: Microscopy and Immunotechniques

Analysis of Biological samples using microscopic techniques. Visualization of cells and subcellular components – Light , Fluorescent and Electron microscopy. Living cells- Phase contrast and confocal microscopy. FISH & GISH.

Principles involved in antigen and antibody reactions (Precipitin & Agglutination). Antibody generation, RIA, ELISA, Western blot and Immunoprecipitation (Chip) and Flow cytometry

Unit 4: Molecular Biology Techniques

Nucleic acid purification - isolation of DNA and plasmids (Plant & animal cells). Amplification of DNA by PCR (simple, nested, Multiplex). Gene expression studies- RT –PCR, Micro array. Cloning – types (Ta cloning), Blue –white screening. Role of RFLP, AFLP and RAPD in Biology.

Unit 5: Bioinformatics and Statistics

Biological databases (NCBI, EBI, JDBD), Sequence analysis (Multiple sequence analysis Local & Global). Algorithms fused for Nucleic acid and protein analysis.

Statistics: Level of significance, Simple Correlation, correlation coefficient, simple linear regression. Student's t' test, Chi square test, Fisher test and Z- test. Analysis of variance: One way & two ways ANOVA.

Books suggested:

1. Biophysical chemistry: Applications to Biochemistry and molecular biology by David Frifelder W H Freeman and company Publishers.
2. Principles and Techniques of practical Biochemistry by K Wilson and K Walker ,Cambridge
3. Molecular Cloning : A laboratory manual J Sambrook & EF Fritsch Cold Spring Harbor Laboratory press
4. Principles of Gene Manipulation by RW Old & SB Prime rose; Blackwell Science Publishers
5. Biochemical calculations by Irwin H Segel, John Wiley & Sons Publishers
6. Biostatistics ,B R Bhatt , New Age Publishers
7. Bioinformatics Sequence and Genome Analysis by David W Mount
8. Essential Bioinformatics by Jin Xiong; Cambridge Publishers

DPHBT-102A
Advances in Microbial Technology

Prof. D. R. Modi
Credit=4
Max Marks: 100
Sessional: 30
End Semester Exam: 70

Unit1: Review of Litrature of revelent topic of research area. National and international status.

Unit2: Systematicsof microbial taxonomy: Systematics and Taxonomy; Modern approaches to bacterial taxonomy, polyphasic classification; Ribosomal DNA sequencing, General characteristics of primary domains and of taxonomics groups belonging to Bacteria, Archea and Eukarya. Nomenclature and outline of bacterial classification as per Bergey's manual. Bacterial genetic system: Transformation, conjugation, Transduction.

Unit 3: Techniques in Microbiology: Theory and practice of sterilization, pure culture techniques; culture collection, preservation and maintenance of microbial cultures.

Unit 4: Industrial Microbiology: Microbial products- Industrial production of chemicals: alcohol (ethanol), acids (citric, acetic), solvents (glycerol, acetone), antibiotics (penicillin, streptomycin), amino acids (lysine, glutamic acid).

Unit 5: Applied Microbiology: Industrial production of glucose from starch and cellulose. Production of glucose-fructose syrup from sucrose. Use of lactase in dairy industry. Use of proteases in food, detergent and leather industries, Sterilization and pasteurization of food products. Technology of typical food /food products (bread, cheese) Food preservation. Current status of genetically modified microorganism in industries.

DPHBT-102 B

Plant Biotechnology

Prof. Sangeeta Saxena
Credit=4
Max Marks: 100
Sessional: 30
End Semester Exam: 70

Unit I: Review of Literature : Review of literature related to research area including research papers relevant to the topic of research, current International and national status of the topic of research.

Unit II: Plant Genome : An introduction to genome size and organisation. Gene structure and expression of plant genes, examples of promoter elements used to derive transgene expression, protein targeting. Molecular dissection of genome , Molecular markers for genome analysis - kinds of molecular markers DNA markers Application of molecular markers in characterisation, DNA Fingerprinting, Application of molecular markers in other fields of molecular biology e.g. transgenic crops, Fingerprinting of cultivars, fungi, plants.

Unit III: Plant Biotechnology and Genetic Engineering: Plant Tissue culture, Culture types, Plant regeneration, Plant transformation techniques. Current state of transgenic crops, role of genetic engineering in stress management. Manipulation of plant development, Genetic Engineering of metabolic pathway in medicinal plants.

Unit IV: Biotechnological approaches to Disease Resistance: Plant pathogen interactions, Plant virology/mycology etc. Diagnostic development, Natural disease resistance pathways. The transgenic approach - PDR, RNAi, siRNA, miRNA. Engineering resistance / tolerance, Improvement of crop yield and quality. Viral disease resistance genes - coat protein genes, movement protein genes, ribozymes, defective genomes, antisense RNA technology etc.

Unit V: Bioinformatics in disease management and IPR issues:- Major bioinformatics resources, Sequence and structure databases; Sequence analysis (sequence alignment, phylogeny); Genomics and Proteomics sequence and data bases, sequence analysis, scoring matrices, sequence-bases database searches, Pair wise sequence alignments and multiple sequence alignments, designing of degenerate primers and siRNA based on multiple sequence alignment data, taxonomy and phylogeny, sequence pattern and profile , Intellectual property rights - Patent laws at national and international level, Ethical issues, Public awareness and perception of biotechnology.

Books suggested:

1. Molecular Biology of the Cell.
By: Bruce Alberts, Bray D, Lewis J, Raff M, Roberts K and Watson J D. Garaland Publishing Inc. New York.

2. Molecular Cloning: a Laboratory Manual.
By: Sambrook J, Fritsch E F and Maniatis T. Cold Spring Harbor laboratory Press. New York.

3.**Plant Biotechnology.**
By: Adrian S, Nigel S and Mark F. Oxford University Press.

4.Biotechnology in crop Improvement.
By: Chawla H S. International Book Distributing Company

5.Practical Application of Plant molecular Biology.
By:Henry R J. Chapman and Hall

Websites provided:

www.ncbi.nlm.nih.gov.in, www.qiagen.com, www.nature.com, www.arabidopsis.com, www.tigr.org, www.bioresearch.ac.uk, www.royalsoc.ac.uk, www.plantprotection.org, www.geo-pie.edu/traits/herbes.html, www.pioneer.com, www.dupont.com, www.bio.org/foodag, www.ers.usda.gov, www.monsanto.com, www.ejb.org, www.florigene.com, www.bio.org, www.cals.cornell.edu,www.newscientist.com

DPHBT-102C
Immunology and Animal Biotechnology

Dr. G. Sunil Babu
Credit=4
Max Marks: 100
Sessional: 30
End Semester Exam: 70

Review of literature relevant to the Research topics.

1. Immune system in Health and Disease: overview of the immune system, Humoral and cellular responses and their role in controlling the infectious diseases. Immune response alleviation and immunological disorders. Genetic predisposition of diseases. Role of MHC in disease susceptibility and resistance. Polymorphisms- SNPs, Role of SNPs in Human diseases.

2. Cancer biology: Mechanism of Carcinogenesis, Proto oncogenes and Oncogenes. Sarcoma and Carcinoma, Tests related to malignancy. Cancer therapy- Chemo and radiation therapies. Immune surveillance in Cancer. Mutations: Types and their role in Cancer. Detection of mutations.

3. Animal cell culture: Primary and established cell cultures. Role of serum in culture. Development of serum free media. Maintaining of cell lines and cryopreservation. Continuous cell lines used in the production of Vaccines and mAbs (CHO, Vero and Sp2/0). Cell synchronization and cell cloning. Transformation and differentiation. Stem cell culture, Nuclear Transfer experiments (Roslin & Honolulu techniques).

4. RNAi - regulation of genome by double stranded RNA. si RNA and miRNA. miRNA biogenesis and maturation. mirTRons, miRNA and mRNA interactions, Orthologous/homologous/paralogous nature of miRNAs. Role of miRNA in prognosis and pathogenesis of diseases. Bioinformatic tools used in the Identification and prediction of miRNAs.

5. Immunoinformatics- introduction, immunology databases, IMGT databases, (IMGT/LIGM_DB; IMGT/3D structure-DB; IMGT/MHC_DB; IMGT/PRIMER-DB, IMGT-GENE-DB). IMGT Web resources. Immunoinformatics in transplantation. Human immune disease- gene identification, RIKEN database, FANTOM3 .

Books suggested:

1. Molecular Cloning : A laboratory manual J Sambrook & EF Fritsch Cold Spring Harbor Laboratory press
2. Culture of Animal cells 4th Edi by Freshney, R.I.
3. Kuby's Immunology. 6th Edition Richard A Goldsby,Thomas J Kindt, Barbara S Osborne ;W.H.Freeman & Coy publishers
4. Animal cell culture- practical approach by Edi. Jhon R.W. Masters ; Oxford
5. Bioinformatics Sequence and Genome Analysis by David W Mount, CSHL press
6. Essential Bioinformatics by Jin Xiong; Cambridge
7. RNAi – a guide to gene silencing by Gregory J . Hannon; CSHL Press
8. Immunoinformatics: bioinformatics strategies for better understanding of immune function, Novartis Foundation,ISBN 0-470-85356-5

DPHBT-102D
Advances in Enzyme Technology

Dr. Monica Sharma
Max Marks: 100
Sessional: 30
End Semester Exam: 70

UNIT I:
Advances in Microbial Technology-Microbial growth: Continuum and Stochastic models, mathematical expression of growth, growth curve, measurement of growth and growth yields; synchronous growth; continuous culture, feb batch cultures, microbial bioenergetics, design, analysis and stability of bioreactors.

UNIT II:
Metagenomics-Introduction, scope of metagenomics, bioinformatics tools, data analysis, next generation sequencing methods, insilico analysis of enzymes, protein ligand interaction, molecular docking and related software tools.

UNIT III:
Enzymes kinetics- Modes and types of enzyme catalysis, Steady state and equilibrium hypotheses of enzyme catalysis, Michaelis-Menten and Brigg's Haldane equations, determination of K_m & V_{max}, meaning and significance of k_{cat}/K_m.

UNIT IV:
Enzyme inhibition kinetics and enzyme regulation, principles of enzyme assays. Medium Engineering-enzyme kinetics in biphasic reactions; stabilization of biphasic aqueous- organic systems, equilibria in biphasic aqueous- organic systems. Enzyme engineeringby directed evolution and rational approach, immobilization kinetics of enzymes and their application, Synzymes/Artificial enzymes.

UNIT V:
Recombinant expression, vector engineering, types of vector, codon usage, Transcriptome analysis, enzymes in genetic engineering, Construction of cDNA, cloning: mRNA enrichment, reverse transcriptase, DNA primers, linkers, adaptors and their chemical synthesis; genomic libraries and screening of libraries for selection of desired clones using nucleic acid hybridization techniques.

Suggested Books:

1. Bioprocess Engineering Principles by Pauline M. Doran
2. Metagenomics for Microbiology- Jacques Izard Maria Rivera. eBook ISBN: 9780124105089 Paperback ISBN: 9780124104723. Academic Press.
3. Enzyme Kinetics: Behavior and Analysis of Rapid Equilibrium and Steady-State Enzyme Systems by Irwin H. Segel. I SBN-13: 978-0471303091. ISBN-10: 0471303097.
4. Fundamentals of Enzyme Engineering. Yoo, Y.J., Feng**,** Y., Kim**,** Y.-H., Yagonia, C. ISBN 978-94-024-1026-6.
5. Molecular Cloning : A laboratory manual J Sambrook & EF Fritsch Cold Spring Harbor Laboratory press
6. Recombinant Protein Production with Prokaryotic and Eukaryotic Cells. ... A Comparative View on Host Physiology:Selected articles from the Meeting of the EFB Section on Microbial Physiology, Semmering,Austria, 5th–8th October 2000.

DPHBT-102E
Advances Structural Biology

Dr. Yusuf Akhter
Credit=4
Max Marks: 100
Sessional: 30
End Semester Exam: 70

Course Contents:

UNIT -I:INTRODUCTION

Overview of Structural Biology:Basic structural principles, conformational principles, Ramachandran diagram, forces involved in macromolecular interaction, building blocks of proteins, Proteins-Primary Structure, Chemistry And Covalent Modifications, motifs of protein structures:Protein Secondary and Supersecondary Structure , alpha domain structures, alpha/beta structures, Macromolecular crystallography-concepts.

UNIT -II:

Structural Classification of Proteins, Profiles and Protein Families, DNA structures, DNA recognition in prokaryotes and eukaryotes, specific transcription factors, enzyme catalysis and structure. Membrane proteins, signal transduction, proteins of the immune system. Structure of Spherical viruses, DNA – Protein Interactions,RNA – Protein Interactions.

UNIT -III:

Protein Folding and flexibility, Protein Misfolding, Disease, in vivo Folding and Degradation, Prediction, Engineering and design of protein structures. Methods toidentify secondary structural elements, Macromolecular Machines in Protein Folding and Unfolding.

UNIT-IV

Determination of protein structures by X-ray and NMR methods. Prediction of secondary structure-PHD and PSI-PRED methods. Tertiary Structure : homology and comparative modelling, fold recognition and ab-initio approaches. Structures of oligomeric proteins and study of interaction interfaces.

UNIT- V

Introduction to Molecular Graphics, *In silico* study of biological structures. Structural genomics- concepts and significance, Structural databases**,** Protein Quaternary Structure and Cooperativity, Metalloenzymes – Structure & Mechanism, Carbohydrate Binding Proteins: Structure and Function.

Prescribed Text Books:

1. Introduction to Protein Structure by Carl-Ivar Branden, John Tooze
2. Proteins: Structures and molecular properties. Freeman, New York. Second edition by Creighton, T. E.
3. Introduction to Protein Architecture Arthur M. Lesk (2001) Oxford University Press

Additional Reading:

1. Voet & Voet. (2011). Biochemistry, (4^{th} edition), Wiley
2. Nelson & Cox, Lehninger. (2008). Principles of Biochemistry 4th edition, W. H. Freeman Publications.
3. Foundations of Structural Biology by Leonard J. Banaszak

DPHBT-103

Advances in Genetic Modification Technologies [Genetically Modified Organism (GMO) and Living Modified Organism (LMO)]

Prof. D. R. Modi, Prof. Sangeeta Saxena, Dr. G. Sunil Babu, Dr. Anand Prakash, Dr. Monica Sharma & Dr. Yusuf Akhter

Credit=4
Max Marks: 100
Sessional: 30
End Semester Exam: 70

UNIT I: Principles of Genetic Manipulation

1. Molecular tools and their application: Nucelic Acid purifications, amplification, yield analysis and applications .Restriction endonucleases, polymerase nucleases, kinases, topoisomerases, gyrases, methylases and ligases Homologous Recombination: Holliday junction, FLP/FRT and Cre/ Lox recombination RecA and other recombinases. Restriction mapping of DNA fragments and Map construction .Nucleic Acid sequencing. Gene Cloning vectors, plasmids, bacteriophages, cosmids, phagemids , artificial chromosomes.
2. Construction of cDNA, cloning: mRNA enrichment, reverse transcriptase ,DNA primers, linkers, adaptors and their chemical synthesis; genomic libraries and screening of libraries for selection of desired clones using nucleic acid hybridization techniques. Polymerase chain reaction: Principles, variations and applications. Microarray: Printing of oligonucleotides and PCR products on glass slides, nitrocellulose paper. Genome analysis for global patterns of gene expression using fluorescent –labelled DNA or end labelled RNA probes. Analysis of single nucleotide polymorphism using DNA chips.

15 hrs

UNIT II: Genetic Manipulations in Animals

Vector engineering and codon optimization, host engineering, in vitro transcription, and translation, expression in bacteria, yeast, insect, mammalian cells and plants. Chromosome. Engineering Gene therapy: Vector engineering, strategies of gene delivery, gene replacement/ augmentation, gene editing, gene regulation and silencing.

15 hrs

UNIT III: Genetic Manipulations in Plants

Genetic manipulation of plants and GM crops. Crown gall disease: genetic engineering in nature. Using *Agrobacterium tumefaciens* to genetically modify plant cells. Chloroplast Transformation. From infected cells to transgenic plants. Common traits introduced by GM. BT Cotton. Insect resistance. Herbicide tolerance. Golden Rice: a case study.

15 hrs

UNIT IV: Genetic Manipulations in Microbes

Microbial Biotechnology: Genetic Manipulation. CRISPER CAS9 system. Engineering Microbes for the Production of Antibiotics and Enzymes. Engineering Microbes for the Production of Insulin, Growth Hormones and Monoclonal Antibodies. Engineering Microbes for Clearing Oil Spills.

15 hrs

Suggested Readings:

1. J Sambrook & EF Fritsch, *Molecular Cloning: A laboratory manual*, Cold Spring Harbor Laboratory press, U.S.A.
2. S.B Primerose, R M Twyman, *Principles of Gene Manipulation and Genomics*, Blackwell Science (Asia Pvt Ltd).
3. Richard J.Reece, *Analysis of gene and genome*, John Wiley and sons (Asia Pvt Ltd).
4. H.K.Das,*Textbook of Biotechnology*, Wiley Dreamtech India Pvt. Ltd.
5. T.A.Brown, *Principles of Gene Manipulation and Genomics*, Wiley Blackwell Publishers (Asia Pvt Ltd)
6. *Bernard R. R. Glick, Jack J. Pasternak, Jack J. Pasternak, Jack J. Pasternak, Molecular Biotechnology: Principles and Applications of recombinant DNA,* ASM Press, U.S.A.

DPHBT-104

Advance Course in Bioinformatics and System Biology

Dr. Monica Sharma &
Dr. Yusuf Akhter
Credit=4
Max Marks: 100
Sessional: 30
End Semester Exam: 70

UNIT I:

Bioinformatics basics, Historical developments, Biological Databases: Primary and Secondary Databases; Nucleotide and protein sequence Databases; mappings and sequence retrieval. **12 hrs**

UNIT II:

Sequence alignment algorithms, Scoring matrices, BLAST and FASTA, Multiple Sequence Alignments databases, Hidden Markov models and Statistical methods in MSA, Molecular evolution; Phylogenetic Analysis: Phylogenetic Trees and Dendrograms; Phylogenetic reconstructions methods. **12 hrs**

UNIT III:

Fundamentals of System Biology; Transcription networks and their regulation, network motifs in signalling networks. Gene expression paradigms, Gene Control, Genetic switches- noise based and gene amplifiers; System-Quorum Sensing. **12 hrs**

UNIT IV:

Kinetics -Biochemical reactions and biomolecular networks; Michaelis Menten kinetics and equilibrium binding and concept of co-operatively; Metabolic and regulatory network integration. **12 hrs**

UNIT V:

Graph theory and biological networks; drug development; developmental system biology. **12 hrs**

Text Books:

1. Eberhard Voit (2017) A First Course in Systems Biology.2nd Edition. Garland Science (ISBN 9780815345688)
2. Axel Kowald, Christoph Wierling, Edda Klipp, Hans Lehrach, Ralf Herwig, and Wolfram Liebermeister (2009) *Systems Biology*- A Text Book. Wiley.
3. David Mount (2004) Bioinformatics: Sequence and Genome Analysis, Cold Spring Harbor Laboratory Press.
4. Arthur M Lesk (2009) Introduction to Bioinformatics, 3rd Edition, Oxford University Press, USA (ISBN-13: 9780199580798)
5. Andreas D. Baxevanis, B.F. Francis Ouellette (2009) Bioinformatics : A Practical Guide to the Analysis of Genes and Proteins, 3rd Edition, Wiley (ISBN-13: 9788126521920)

Additional readings:

1. Higgs PG, Attwood TK (2009) Bioinformatics and molecular evolution, Wiley-Blackwell.
2. Andrzej Polanski MK. (2007) Bioinformatics. Springer.
3. *Oleg Demin*, Igor Goryanin (2009) *Kinetic Modelling in Systems Biology*. CRC press (ISBN-13: 978-1584886679)
4. **Alberghina**, Lilia, **Westerhoff**, Hans V. (Eds.) (2005) Systems Biology: Definitions and Perspectives. Springer-Verlag Berlin Heidelberg (978-3-540-74269-2)

CPE-RPE-105

Research and Publication Ethics (RPE)

Prof. D. R. Modi, Prof. Sangeeta Saxena,
Dr. G. Sunil Babu, Dr. Monica Sharma
& Dr. Yusuf Akhter

Credit=02
Max Marks: 100
Sessional: 30
End Semester Exam: 70

Course Structure

- **The course comprises of six modules listed in table below. Each module has 4-5 units.**

Modules	**Unit Title**	**Teaching Hours**
Theory		
RPE 01	Philosophy and Ethics	04
RPE 02	Scientific Conduct	04
RPE 03	Publication Ethics	07
Practice		
RPE 04	Open Access Publishing	04
RPE 05	Publication Misconduct	04
RPE 06	Databases and Research Metrics	07
	Total	**30**

Syllabus in detail:

THEORY

- **RPE 01: PHILOSOPHY AND ETHICS (03 hrs)**

1. Introduction to philosophy: definition, nature and scope, concept, branches
2. Ethics: definition, moral philosophy, nature of normal judgments and reactions

- **RPE 02: SCIENTIFIC CONDUT (5hrs).**

1.Ethics with respect to science and research
2.Intellectual honesty and research integrity
3.Scientific misconducts: Falsification, Fabrication, and Plagiarism (FFP)
4.Redundant publication: duplicate and overlapping, publication, salami slicing
5.Selective reporting and misrepresentation of data

- **RPE 03: Publication Ethics (7hrs.)**

1.Publication Ethics: definition, introduction and importance
2.Best practice/standard setting initiatives and guidelines: COPE, WAME, etc.
3.Conflicts of interest
4.Publication misconduct: definition, concept, problems that lead to unethical behavior and vice versa, types
5.Violation of publication misconduct, complaints and appeals
6.Identification of publication misconduct, complaints and appeals
7.Predatory publishers and journals

PRACTICE

- **RPE 04: OPEN ACCESS PUBLISHING (4hrs.)**

1.Open access publications and initiatives
2. SHERPA/RoMEO online resource to check publisher copyright & self-archiving policies.
3. Software tool to identify predatory publications developed by SPPU.
4. Journal finder/journal suggestion tools viz. JANE, Elsevier Journal Finder, Springer journal Suggested etc.

- **RPE 05: PUBLICATION MISCONDUCT (4hrs.)**

A. Group Discussion (2hrs.)

1.Subject specific ethical issues, FFP, authorship
2.Conflicts of interest
3.Complaints and appeals: examples and fraud from India and abroad

B. Software tools (2hrs.)

Use of plagiarism software like Turnitin, Urkund and other open source software tools

- **RPE 06: DATABASES AND RESEARCH METRICS (7hrs.)**

A. Database (4hrs.)

1. Indexing databases
2. Citation databases: Web of Science, Scopus etc.

B. Research Metrics (3hrs.)

1. Impact factor of journal as per Journal Citation Report, SNIP, SJR, IPP, Cite Score
2. Metrics: h-index, g index, i10 index, altmetrics