Computer Science Stream, Manipal Institute of Technology, Manipal
Department of Computer Applications
Course Structure & Syllabus for B. Tech (Data Science & Engineering) Program from Academic Session 2020-2021

Year	FIRST SEMESTER						SECOND SEMESTER					
	Sub. Code	**Subject Name**	**L**	**T**	**P**	**C**	**Sub. Code**	**Subject Name**	**L**	**T**	**P**	**C**
I	MAT 1151	Engineering Mathematics - I	3	1	0	4	MAT 1251	Engineering Mathematics – II	3	1	0	4
	PHY 1051	Engineering Physics	2	1	0	3	CHM 1051	Engineering Chemistry	2	1	0	3
	CIE 1051	Mechanics of Solids	2	1	0	3	BIO 1051	Biology for Engineers	2	1	0	3
	ECE 1051	Basic Electronics	3	0	0	3	ELE 1051	Basic Electrical Technology	2	1	0	3
	MME 1051	Basic Mechanical Engineering	3	0	0	3	CSE 1051	Problem Solving Using Computers	2	1	0	3
	HUM 1051	Communication skills in English	1	0	3	2	CIE 1052	Environment Studies	1	0	3	2
	PHY 1061	Engineering Physics Lab	0	0	3	1	CHM 1061	Engineering Chemistry Lab	0	0	3	1
	MME 1061	Workshop Practice	0	0	3	1	CSE 1061	PSUC Lab	0	0	3	1
	MME 1161	Engineering Graphics - 1	1	0	2	2	MME 1261	Engineering Graphics - II	1	0	2	2
			15	**3**	**11**	**22**			**13**	**5**	**11**	**22**
	Total Contact Hours (L + T + P)		**29**				**Total Contact Hours (L + T + P)**		**29**			
	THIRD SEMESTER						**FOURTH SEMESTER**					
II	MAT 2157	Mathematical Foundations for Data Science-I	3	0	0	3	MAT 2213	Mathematical Foundations For Data Science-II	3	0	0	3
	HUM 2151	Finance & Econometrics	3	0	0	3	DSE 2252	Database Systems	3	1	0	4
	DSE 2151	Introduction to Data Analytics	3	0	0	3	DSE 2254	Machine Learning	3	1	0	4
	DSE 2153	Object Oriented Programing	3	1	0	4	DSE 2256	Design & Analysis of Algorithms	3	1	0	4
	DSE 2155	Data Structures	3	1	0	4	DSE 2258	Data Communications and Networks	3	0	0	3
	DSE 2157	Computer System Architecture	3	0	0	3	****	Open Elective – I	3	0	0	3
	DSE 2159	Data Analytics Lab	0	0	3	1	DSE 2260	Database Lab	0	0	3	1
	DSE 2161	Object Oriented Programming Lab	0	0	3	1	DSE 2262	Machine Learning Lab	0	0	3	1
	DSE 2163	Data Structures Lab	0	0	3	1	DSE 2264	Design & Analysis of Algorithms Lab	0	0	3	1
			18	**2**	**9**	**23**			**18**	**3**	**9**	**24**
	Total Contact Hours (L + T + P)		**29**				**Total Contact Hours (L + T + P) + OE**		**30**			
	FIFTH SEMESTER						**SIXTH SEMESTER**					
III	MAT 3151	Mathematical Foundations For Data Science-III	3	0	0	3	HUM 3252	Operations Research	3	0	0	3
	DSE 3151	Deep Learning	3	1	0	4	DSE 3252	Artificial Intelligence	3	1	0	4
	DSE 3153	Operating Systems	3	0	0	3	DSE 3254	Parallel Programming	3	1	0	4
	DSE 3155	Natural Language Processing	3	0	0	3	DSE 3256	Big Data Analytics	3	1	0	4
	DSE 3157	Cloud Computing	3	0	0	3	DSE 3258	Data Privacy & Security	3	0	0	3
	****	Open Elective – II	3	0	0	3	****	Open Elective – III	3	0	0	3
	DSE 3159	Deep Learning Lab	0	0	3	1	DSE 3260	Artificial Intelligence lab	0	0	3	1
	DSE 3161	Operating Systems Lab	0	0	3	1	DSE 3262	Parallel Programming Lab	0	0	3	1
	DSE 3163	Web Technologies Lab	0	1	3	2	DSE 3264	Big Data Analytics Lab	0	0	3	1
			18	**2**	**9**	**23**			**18**	**3**	**9**	**24**
	Total Contact Hours (L+T+P) + OE		**29**				**Total Contact Hours (L + T + P) + OE**		**30**			

	SEVENTH SEMESTER						EIGHTH SEMESTER					
	Sub. Code	Subject Name	L	T	P	C	Sub. Code	Subject Name	L	T	P	C
IV	DSE****	Program Elective - I	3			3	DSE 4298	Industrial Training				2
	DSE****	Program Elective - II	3			3	DSE 4299	Project work/ Practice School				12
	DSE****	Program Elective - III	3			3						
	DSE****	Program Elective - IV	3			3						
	DSE****	Program Elective - V	3			3						
	****	Open Elective - IV	3			3						
			18			**18**						**14**
	Total Contact Hours (L + T + P) + OE		**18**				**Total Contact Hours (L + T + P)**		**-**			

PROGRAM ELECTIVES:

Sub. Code	Subject Name	Sub. Code	Subject Name
DSE 4151	Advanced Data Structures and Algorithms	DSE 4152	Software Engineering
DSE 4153	Block chain Technologies	DSE 4154	Internet of Things
DSE 4155	Quantum Computing	DSE 4156	Social Network Analysis
DSE 4157	Data Forensics	DSE 4158	Information Retrieval
DSE 4159	Soft Computing Techniques	DSE 4160	Enterprise Data Architecture
DSE 4161	Computer Vision	DSE 4162	Robotics & Automation
DSE 4163	Finance & Accounting	DSE 4164	Risk Analytics
DSE 4165	Financial Market Analytics	DSE 4166	Business & Economic Analytics
DSE 4167	Fundamentals of Business Analytics	DSE 4168	Digital Marketing
DSE 4169	Supply Chain Management	DSE 4170	Health Informatics
DSE 4171	Bioinformatics	DSE 4172	Medical Image Processing
DSE 4173	Biostatistics	DSE 4174	Algorithmic Trading
DSE 4175	Applied Econometrics		

PROGRAM ELECTIVE BASED MINOR SPECIALIZATION:

1. **Finance & Security Analytics** – DSE 4163, DSE 4164, DSE 4165, DSE 4166
2. **Business Analytics** – DSE 4163, DSE 4167, DSE 4168, DSE 4169
3. **Health Care Analytics** – DSE 4170, DSE 4171, DSE 4172, DSE 4173

FIRST SEMESTER

MAT 1151: ENGINEERING MATHEMATICS – I [3 1 0 4]

Matrices-inverse and rank, solution of linear system of equations, Eigen value problems. Vector entspaces, basis, linear transformations, inner product spaces and Orthogonalization. First and higher order differential equations and their solutions, Lagrange's and divided difference interpolation. Numerical differentiation and integration. Solution of algebraic and transcendental equations, solutions of ordinary differential equations.

Reference Books:

1. B. S. Grewal, Higher Engineering Mathematics, (42e), Khanna Publishers, 2013
2. Kreyzig E., Advanced Engineering Mathematics, (10e), Wiley Eastern, 2011
3. David C. Lay, Linear Algebra and applications, (3e), Pearson Education, 2009
4. Sastry S. S., Introductory methods of Numerical analysis, (4e), PHI, 2007
5. Rainville E. D. and Bedient P.E., A short course in differential equations, (4e), Macmillan Publishers, 1969

PHY 1051: ENGINEERING PHYSICS [2 1 0 3]

Double-slit interference of light, Interference from thin films (Air-wedge, Newton's rings), Michelson interferometer. Single-slit and Double-slit diffraction of light, Circular apertures, Diffraction gratings and applications, Diffraction of X-rays, Polarization of light, Double refraction, Optical activity. Black body radiation and Planck's hypothesis, Photoelectric effect, The Compton effect, Wave packet, phase speed, group speed. Uncertainty principle. One-dimensional wave functions and expectation values, Particle in a box, Boundary conditions on particles in general, The schrodinger equation, Particle in a well of finite height, Tunneling through a potential barrier and its applications, The simple harmonic oscillator. Atomic spectra of gases and Bohr's model of the hydrogen atom, Quantum model of the hydrogen atom, The wave functions for hydrogen, Quantum numbers, X-ray spectra, Spontaneous and stimulated transitions, Lasers and applications. Molecular bonds, Energy states and spectra of molecules, Bonding in solids, Free electron theory of metals, Band theory of solids, Electrical conduction in metals, Insulators and Semiconductors, Superconductivity.

References:

1. Jewett & Serway; PHYSICS for Scientists and Engineers with Modern Physics (7e), Cengage Learning 2008.
2. Halliday, Resnick, Krane, PHYSICS (5e), Volume 2, John Wiley & Sons, Inc 2002.

CIE 1051: MECHANICS OF SOLIDS [2 1 0 3]

Introduction to mechanics of rigid bodies, Resolution of force, Composition of forces, Moment of a force, Varignon's theorem, couple, Conditions of Equilibrium, Space and free body diagrams, Lami's theorem, Types of beams, Support reactions, Types of loading, Friction, Centroid and moment of inertia of simple and composite areas, Introduction to rigid bodies, Normal stress and strain, Mechanical

properties of materials, Hooke's law, Modulus of elasticity, Stress – Strain behaviour of ductile and brittle materials, Factor of safety, Allowable stress, Stresses and deformations in tapered bars, Stepped bars, Poisson's ratio, Shear stress and Shear strain, Modulus of rigidity, Relationship between modulus of elasticity, modulus of rigidity and bulk modulus, Compound bars, stresses due to temperature, Stresses in thin cylinders, Concepts of bending moment & shear force diagrams.

References:

1. Meriam J. L., Kraige L. G., Engineering Mechanics: Statistics (5e), John wiley & sons, 2004.
2. Beer F. P., Johnston Jr. E. R., Dewolf J. T., Mazurek D. F., Sanghi S., Mechanics of Materials (7e), Tata McGraw-Hill, 2017.
3. Pytel A., Singer F.L., Strength of Materials (4e), HarperCollins College Div, 1987.
4. Bhavikatti S. S., Strength of Materials (4e), Vikas Publishers, 2013.
5. Basavarajaiah B. S., Mahadevappa P., Strength of Materials (3e), Universities Press, 2010.

ECE 1051: BASIC ELECTRONICS [3 0 0 3]

Diode Characteristics, Breakdown phenomenon in diodes, Zener diode, Diode rectifier, Zener regulator, Regulated Power supplies, Special purpose diodes, BJT characteristics, CB, CE and CC configurations, Transistor biasing, RC coupled Amplifier, Transistor as a Switch, Block diagram and characteristics of Operational Amplifier, Inverting and noninverting amplifier, Difference amplifier, Op-amp based adder, subtractor, integrator, differentiator, comparator and square wave generator, Number systems and codes, Boolean algebraic theorems, simplification of Boolean expressions, Logic gates, concept of Universal Logic, Flip flops, Fundamentals of analog communication, Introduction to digital communication and communication networks, Introduction to mobile communication.

References:

1. Robert L. Boylestad, Louis Nashelsky., Electronic Devices & Circuit Theory (11e), PHI 2012.
2. Malvino and Leach., Digital Principles & applications (7e), TMH 2010.
3. George Kennedy, Bernad Davis., Electronic Communication Systems, (4e), TMH, 2004
4. Garcia, Widjaja., Communication Networks, McGraw Hill 2006.
5. Raj Pandya, Mobile and Personal Communication Services and Systems, Wiley-IEEE Press, 1999.

MME 1051: BASIC MECHANICAL ENGINEERING [3 0 0 3]

Properties of Steam and Boilers: Steam properties Working principle of Babcock & Wilcox Boiler. Prime Movers: Classification, working principle of steam, gas and water turbines Power plants: Working principle of thermal, nuclear, hydel and solar power plants Refrigeration: Principle and working of vapour compression refrigeration system, I.C. Engines: Classification, Working of 2-stroke, 4 - stroke C.I and S.I Engines Power Transmission: Belt drives, Introduction to rope drive and chain drives, Gear Drives. Machine Tools: Introduction to Lathe, Drilling Machine and operations Casting and Forging: Two box moulding procedure, moulding sand and its desirable properties, Pattern allowances, Introduction to forging. Welding: Principle of Resistance spot welding, Electric arc welding and Oxy-acetylene gas welding, Introduction to soldering and brazing

References:

1. K. R.Gopalakrishna, Text book of elements of Mechanical Engineering, Subhash Publications, Bangalore, 2005.

2. Roy & Choudhury, Elements of Mechanical Engineering, Media Promoters & Publishers Pvt. Ltd, Mumbai, 2000.
3. Mishra B.K., Mechanical Engineering Sciences, Kumar & Kumar Publishers (P) Ltd, Bangalore, 1999
4. Trymbaka Murthy S., A text book of elements of Mechanical Engineering, I. K. International Publishing House Pvt. Ltd, 2010.
5. Rajput R. K., Elements of Mechanical Engineering, Fire Wall Media, 2005.
6. B.S. Raghuvanshi, A course in Workshop Technology, Vol. 1, Dhanpat Rai & sons, New Delhi, 2005.

HUM 1051: COMMUNICATION SKILLS IN ENGLISH [1 0 3 2]

Reading- Analysis of reading passages – Articles, Text, Online reading material; Types of reading- skimming, scanning, critical reading; comprehension, analysis, response; Familiarization- pronunciation, accent, intonation. Writing- Structures- grammar and usage competence, writing a paragraph, writing an evaluative response, writing an argumentative response, writing a creative response, writing a critical response; Composition -editing and writing; Vocabulary building – etymology, words of foreign origin; Sensitivity in communication- Social Networks and Public communication – Etiquette. Speaking – Discussion and debates on contemporary topics – current affairs, scientific enquiry, philosophical debates, literary sensibilities, socio-political awareness and cultural sensitivity; Exploring multiple perspectives- critical reasoning, constructive feedback, persuasive arguments and effective interpersonal communication. Listening - Response to audio/video texts- comprehension, analysis, critical evaluation; Listening to groups and individuals- active listening, feedback and response.

References:

1. Raman, M & Sharma, S., Technical Communication: Principles and Practice. Oxford University Press, New Delhi 2014.
2. Swan, Michael, Practical English Usage, (4e) Oxford University Press, London 2017
3. Lewis, Norman, Word Power Made Easy 2010.
4. Balasubramanian. P., Phonetics for Indian Students, (2e), Mc Milan, Mumbai 2013.

PHY 1061: ENGINEERING PHYSICS LAB [0 0 3 1]

Experiments on interference of mechanical waves, Experiments on interference, diffraction and double refraction of light. Experiments on quantum theory of radiation. Experiments on free-electron theory of metals, band theory of solids, semiconductors. Experiments on resonance circuits, Hall-effect.

References:

1. Jewett & Serway, PHYSICS for Scientists and Engineers with Modern Physics (7e), Cengage Learning 2008.
2. Worsnop & Flint, Advanced Practical Physics for Students (9e), Methuen & Co. Ltd, London 1987.

MME 1061: WORKSHOP PRACTICE [0 0 3 1]

Mechanical Engineering Practices - Sheet metal, Plumbing exercises, Study of Automotive systems like Transmission and Suspension, Demonstration on the working of Lathe and Drilling machine, Civil

Engineering Practices - Material Testing by conducting Tensile test, Shear test and Compression test, Surveying exercises using chain and tape, Prismatic compass, Dumpy level, Electrical and Electronics Engineering Practices – Study of wiring tools, Fuses, Circuit breakers, Lighting sources, Wiring, Electrical energy in Single phase and three phase circuits, Energy tariff calculations. Testing of Electronic components, IC based experiments comprising Digital counter, Buzzer and Musical door bell, Soldering practice, Building a DC regulated power supply.

References:

1. Hajra Choudhury S. K and Bose S. K, "Elements of Workshop Technology, Vol I", Media Promoters & Publishing Pvt. Ltd., Mumbai, 2012.
2. Raghuvanshi S.S, "Workshop Technology", Dhanpat Rai and Sons, Delhi, 2002.
3. Punmia B. C, "Surveying", Laxmi Publications, Bangalore, 2012
4. Uppal S.L., Electrical Wiring, Estimating and Costing, Khanna Publishers, 1978
5. Bishop Owen, Electronics: A First Course, (2e), NEWNES, An Imprint of Elsevier, 2006.

MME 1161: ENGINEERING GRAPHICS – I [1 0 2 2]

Introduction – Geometrical constructions, Dimensioning and conventions of lines. Projection of points in first Quadrant only. Projection of straight lines inclined to both horizontal and vertical planes, Traces of lines, Application problems on lines. Projection of regular plane when the surface is inclined to both HP and VP. Projection of regular solids like prisms, pyramids cone and cylinder when the axis is inclined to both HP and VP.

References:

1. Gopalkrishna K. R. and Sudhir Gopalkrishna., A textbook of Computer Aided Engineering Drawing, (37 e), Subhas Stores, Bangalore 2012.
2. Bhat N. D. and Panchal V. M., Engineering Drawing, (50 e), Charotar Publishing House, Anand, India 2010.
3. Venugopal K., Engineering Drawing and Graphics + Auto CAD, Newage International Publishers, Delhi 2002.
4. Narayana K. L. and Kannaiah P., Text book on Engineering Drawing, Scitech Publications, Chennai, 2002.
5. Basant Agrawal and Agrawal C. M., Engineering Drawing, Tata McGraw Hill, New Delhi 2010.

SECOND SEMESTER

MAT 1251: ENGINEERING MATHEMATICS – II [3 1 0 4]

Mean value theorems, Taylor and Maclaurin's series expansions, indeterminate forms. Partial differentiation, total derivatives, errors and expansions, Taylor's theorem, maxima and minima, Lagrange's method. Infinite series, tests for convergence of series with positive terms, alternating series, power series. Analytical solid geometry- spheres. Cones and cylinders. Multiple integrals and their applications, beta and gamma functions. Laplace transforms, periodic functions, step functions, inverse transforms, convolution, solution of differential equations and applications.

Reference Books:

1. B. S. Grewal - Higher Engineering Mathematics, Khanna Publishers.
2. N. Piskunov-Differential Calculus, Vol I and II, Mir Pub.
3. Rainville E.D and Bedient P. E., A short course in differential equations, Macmillan Pub., Mumbai.
4. Kreyzig E, Advanced Engineering Mathematics, Wiley Eastern, Delhi.
5. Shanti Narayan, Differential Calculus, Shyam Lal Charitable Trust, Delhi.

CHM 1051: ENGINEERING CHEMISTRY [2 1 0 3]

Principles and applications of electrochemistry, metal finishing. Chemistry of primary and secondary batteries. Working principles of fuels cells and their applications. Concept of corrosion and its importance, types of corrosion, factors affecting corrosion, Corrosion control methods. General methods of chemical analysis, Instrumental methods. Introduction to spectroscopic methods of analysis: Electromagnetic radiation (EMR), Interaction of EMR with matter, Numerical Problems. Concepts of rotational, vibrational and electronic spectra, Laws of spectrophotometry. Classification of Fuels, Gross Calorific value and Net Calorific value. Solid, Liquid and Gaseous fuels. basic principles and classification of materials, Effect of bonding on properties of materials. Classification of advanced materials-polymers, Liquid crystals, Ceramics, composites, bio materials, nanomaterials, thin films and their properties and applications.

References:

1. Kuriacose J. C., Rajaram J., Chemistry in Engineering and Technology, volume I/II Tata McGraw - Hill, New Delhi, 2001
2. Jain P. C., Jain M. Engineering Chemistry, (16e)., Dhanpat Rai and Sons, New Delhi, 2015
3. Fischer T., Materials Science for Engineering Students, Academic Press, London, 2009

BIO 1051: BIOLOGY FOR ENGINEERS [2 1 0 3]

Chemistry of life: Elements of life and their bonding ability, importance of carbon, elemental replacement, different types of bonds and interactions in biological systems, water and phospholipids

as well as their importance in the survival of life, Biomolecules such as carbohydrates and proteins, their structures, enzymes, effect of pH and Bioenergetics. Inheritance of life: Mendelian model and its testing, Location of factors and its mode of inheritance, Morgan concept on location of factors, pedigree analysis. Molecular basis of inheritance: Discovery of DNA, Experimental evidence for the existing theories of molecular biology, structure of DNA, DNA copying mechanism and its proof reading as well as editing, RNA synthesis and processing, Protein synthesis and Genetic code. Case studies: Mechanism of viral replications, Lac operon as an example of biological control system, Concepts of cloning, Recombinant DNA technology, vaccination and ascent of sap. Evolution and origin of life: Darwin's theory, Mechanisms of Evolution, Evidence of evolution, Constraints on evolution

References:

1. Sadava D. E., Hillis D. M., Heller H. C. and Hacker S. D. Life the science of biology, (11e), Macmillan Learning, USA ISBN-10: 1-319- 01016-4, 2107
2. Urry L. A., Cain M. L., Wasserman S. A., Minorsky P. V. and Reece J. B., Campbell Biology, (11e), Pearson ISBN-10: 0134093410, 2017
3. Johnson A. T., Biology for Engineers, CRC Press Inc., USA, ISBN 9781420077636, 2010

ELE 1051: BASIC ELECTRICAL TECHNOLOGY [2 1 0 3]

DC circuits, Independent sources, Resistance, Network reduction techniques, Mesh and Node voltage analysis, Superposition, Thevenin's and Maximum power transfer theorems, Transient behaviour of inductance and capacitance, Series and Parallel magnetic circuits, Self and Mutual inductances, Coupled coils, Dot rule, Average and RMS values of sinusoidal waves, Series and Parallel AC circuits, Power factor improvement, Series and Parallel resonance, Three phase star and delta connected loads, Measurement of power in three phase circuits, Electrical power system, Transformers, DC motors, BLDC, Induction motors, Synchronous motors, Stepper motors, Measurement of energy.

References:

1. Hughes E., Electrical and Electronic Technology (9e), Pearson Education, 2008
2. D. C. Kulshreshtha, Basic Electrical Engineering, McGraw Hill, 2012.
3. Kothari D. P. & Nagarath I. J., Basic Electrical Engineering, TMH 2013
4. http://www.nptel.ac.in/courses/108108076/
5. http://www.nptel.ac.in/courses/WebcourseContent/IIT%20Kharagpur/Basic%20Electrical%20Technology/New_index1.htm

CSE 1051: PROBLEM SOLVING USING COMPUTERS [2 1 0 3]

Introduction to computing, Importance of Problem solving using computers, Algorithms and Flow charts, Introduction to C language, Simple C programs, Syntax and Logical Errors in compilation, Object and executable code, Variable names and declaration, Data types, Sizes and Constants, Various operators, Type conversion and expressions, Precedence and order of evaluation, Statements and blocks, Control flow, Break and continue, 1-D and 2-D Arrays and Strings, Searching and Sorting, Multidimensional Arrays and Matrices, Modular programming and Recursive functions, Structure and Pointers, Defining Structures and Array of Structures, Pointer arithmetic, Pointer to Structures, File Management and Cyber Security.

References:

1. Dromey. R. G, How to solve it by computers, Pearson, 1982.
2. Brian W. Kernighan and Dennis M. Ritchie, The C Programming language (2e), Pearson Education, 1988.
3. Deital. P. J and Deitel. H. M, C: How to program (7e), Pearson Education, 2010.
4. Balagurusamy, E, Computing fundamentals and C programming (1e), McGraw-Hill, 2008.

CIE 1052: ENVIRONMENTAL STUDIES [1 0 3 2]

Meaning, multidisciplinary nature of environmental science, applications in engineering disciplines, environmental ethics, sustainable development, Renewable and non-renewable resources, Resource consumption & conservation methods, different types of energy, Conventional sources & Non-Conventional sources of energy, Types & Structure of Ecosystem, Environmental Pollution and control , Disaster Management meaning, natural disasters especially earthquakes & Manmade disasters, Environmental crisis & legislations , Environmental acts, Laws and Policies, EIA, Case studies of the past related to environmental issues, crisis, disasters, hazard, pollution, climate change & its effects, Practical activity related to environmental problems and its impacts on environment.

References:

1. Mohan kanda, Disaster Management in India evolution of institutional arrangements & operational strategies, 2017.
2. Y.Anjaneyulu, Introduction to Environmental science, 2017.
3. R.K.Trivedy, Handbook of Environmental laws, acts, guidelines, compliances & standards, 3rd edition, 2nd volume, 2017.
4. Benny Joseph, Environmental Studies, Tata McGraw-Hill Publishing Company Ltd., New Delhi , 2008.
5. Aloka Debi, “Environmental Science and Engineering”, Universities Press (India) Pvt. Ltd. 2012.
6. R.J.Ranjit Daniels and Jagadish Krishnaswamy, “Environmental Studies”, Wiley India Private Ltd., New Delhi, 2009.
7. G.Swarajya Lakshmi, Environmental science: A Practical Manual, 2010.
8. Student guide: Environment Reader for Universities, based on UGC syllabus published by Centre for Science and Environment, 2017.

CHM 1061: ENGINEERING CHEMISTRY LABORATORY [0 0 3 1]

Alkalimetric titration; Estimation - Total hardness of water, percentage of copper in brass, weight of iron in haematite, percentage of manganese dioxide in pyrolusite, percentage of ammonia nitrogen in a fer tilizer; pK value of a weak acid by potentiometric titration; Conductometric acidbase ntitrations; Determination of concentration of copper using colorimeter; Determination of coefficient of viscosity of liquid; Chloride content of water; Analysis of lead pigment

References:

1. Vogel A.I. Text book of Quantitative Inorganic Analysis, (5e), ELBS, 1998
2. Laboratory Manual for Engineering Chemistry Laboratory, M.I.T., 2014

CSE 1061: PROBLEM SOLVING USING COMPUTERS LAB [0 0 3 1]

Introduction to Computing, Simple C programming, Branching Control Structures, Looping Control Structures, 1D and 2D Array programming, String programming, Modular and Recursive Function

Programming – Programs using Pointers, Structures and File manipulation – MATLAB Programming with Simulink.

References:

1. Brian W. Kernighan and Dennis M. Ritchie, The C Programming language (2e), Pearson Education, 1988.
2. Deital. P. J and Deitel. H. M, C: How to program (7e), Pearson Education, 2010.
3. Balagurusamy. E, Computing fundamentals and C programming (1e), McGraw-Hill, 2008.
4. Duane Hanselman and Bruce Littlefield, Mastering Matlab 7, Pearson Publication, 2008.
5. Stormy Attaway, Matlab: A practical Introduction to Programming and Problem Solving, Elsevier, ISBN: 978-0-75-068762-1.

MME 1261: ENGINEERING GRAPHICS – II [1 0 2 2]

Introduction to Engineering Graphics, Sections of solids – Drawing sectional views and true shape of section, Development of surfaces using parallel line development for prisms and cylinders, Radial line development for pyramids and cones, Isometric projections of simple and sectioned solids, Combined solids, Simple machine components. Orthographic views of Simple and cut solids, combined solids, Simple machine components.

References:

1. Gopalkrishna K. R. and Sudhir Gopalkrishna., A textbook of Computer Aided Engineering Drawing, (37e), Subhas Stores, Bangalore 2012.
2. Bhat N. D. and Panchal V. M., Engineering Drawing, (50e), Charotar Publishing House, Anand, India 2010.
3. Venugopal K., Engineering Drawing and Graphics + Auto CAD, Newage International Publishers, Delhi 2002.
4. Narayana K. L. and Kannaiah P., Text book on Engineering Drawing, Scitech Publications, Chennai, 2002.
5. Basant Agrawal and Agrawal C. M., Engineering Drawing, Tata McGraw Hill, New Delhi 2010.

THIRD SEMESTER

MAT 2157: MATHEMATICAL FOUNDATIONS FOR DATA SCIENCE-I [3 0 0 3]

Statistics: Measures of central tendency – mean, median, mode, measures of dispersion – mean deviation, standard deviation, quartile deviation, skewness and kurtosis. Correlation coefficient, regression, least squares principles of curve fitting. **Probability:** Introduction, finite sample spaces, conditional probability and independence, Baye's theorem, one dimensional random variable, mean, variance. Two and higher dimensional random variables: mean, variance, correlation coefficient. **Distributions:** Binomial, Poisson, uniform, normal, gamma, Chi-square and exponential distributions, simple problems. Moment generating function, Functions of one dimensional and two dimensional random variables, Sampling theory, Central limit theorem and applications. **Partial Differential Equations**: Numerical solutions of partial differential equations by finite difference methods, five-point formula, Laplace Poisson Equations, Heat equation, Crank Nicolson's method, Wave equation. Application of Finite Difference technique.

References:

1. Meyer P.L. "*Introduction to probability and statistical applications"*, 2nd edn., American Publishing Co
2. Hogg and craig , *Introduction to mathematical statistics*, 6th Edn,2012, Pearson education, New Delhi.
3. Ross Sheldon M, "*Introduction to Probability and Statistics for Engineers and Scientists*", Elseveir, 2010.
4. William J. Stewart, "*Probability, Markov Chains, Queues and Simulation"*.
5. S. Narayanan, T. K. Manicavachagom Pillay, G. Ramanaiah, *Advanced mathematics for engineering students*, S. Viswanathan Pvt.. Ltd., 1985.

HUM 2151 FINANCE & ECONOMETRICS [3 0 0 3]

Basic Economics: Nature and significance, Micro & macro differences, Law of demand and supply, Elasticity & equilibrium of demand & supply. Time value of money, Interest factors for discrete compounding, Nominal & effective interest rates, basics of investment and consumption function. **Mathematics of Finance:** Present and future worth of single, Uniform gradient cash flow. Bases for comparison of alternatives, Present worth amount, Capitalized equivalent amount, Annual equivalent amount, Future worth amount, Capital recovery with the return, Rate of return method. **Financial Investment Companies:** Mutual fund companies, types of mutual funds, Calculation of Net Asset Values, Venture Capital Companies, Investment and Merchant Banking companies. **Accounting:** Concept of Financial Accounting, Difference between financial, cost and management accounting, Depreciation of fixed assets: Physical & functional depreciation, Straight-line depreciation, Declining balance method of depreciation, Sum-of-the years digits method of depreciation, Sinking fund and service output methods, basics of cost accounting methods – Job costing and Process costing, Cost sheet format and its uses. **Financial Statements:** Introduction to balance sheet and profit & loss statement.

Basic financial ratios. **Financial Econometrics:** Nature of Econometrics and Economic Data. Regression Model, General Linear Model, Auto-regressive and distributed Lag Models, Simultaneous Equation Models. Multi-collinearity and Heteroscedasticity, autocorrelation, Qualitative and Limited Dependent Variables Models, Simultaneous Equation Models: Estimation Methods, Panel Data Regression Models and Time Series Econometrics

References:

1. Prasanna Chandra., *Fundamentals of Financial Management*, Tata Mc-Graw Hill Companies, New Delhi, 2005.
2. James L Riggs, David D Bedworth and Sabah U Randhawa., *Engineering Economics*, Tata McGraw – Hill Publishing Company Ltd, New Delhi, 2004.
3. T. Ramachandran., *Accounting and Financial Management*, Scitech Publications Pvt. Ltd. India, 2001.
4. Eugene F. B. & Joel F. H., *Fundamentals of Financial Management*, th 12 ed., Cengage Learning Publisher, 2009.
5. Johnston,J, *Econometric Methods*, McGraw-Hill Book Co., New York.
6. Maddala, G.S, *Econometrics*, McGraw-Hill Book Co., New York, 3rd Rd.
7. Gujarathi, D.N, *Basic Econometrics*, Fourth Edition, Tata McGraw-Hill, New Delhi.

DSE 2151 INTRODUCTION TO DATA ANALYTICS [3 0 0 3]

Steps in Data Analytics Projects, Data Analytics tasks and methods, Data Gathering and Preparation: Data Formats, Parsing and Transformation, Scalability and Real-time Issues; **Data Cleaning**: Consistency Checking, Heterogeneous and Missing Data, Data Transformation and Segmentation; **Exploratory Analysis**: Descriptive and comparative statistics, Hypothesis testing, **Statistical Inference**. **Association rule mining:** Apriori, FP Growth, Partitioning, measures of pattern interestingness. **Clustering:** Partitioning, Hierarchical, Density based approaches. Recommender Systems, Anomaly Detection. **Visualization**: Visual Representation of Data, Gestalt Principles, Information Overloads; Creating Visual Representations: Visualization Reference Model, Visual Mapping, Visual Analytics, Design of Visualization Applications; **Classification of Visualization Systems**: Interaction and Visualization Techniques, Visualization of One, Two and Multi-Dimensional Data, Text and Text Documents; **Visualization of Groups**: Trees, Graphs, Clusters, Networks, Software, Metaphorical Visualization; **Visualization of Volumetric Data**: Vector Fields, Processes and Simulations, Visualization of Maps, Geographic Information, GIS systems, Collaborative Visualizations, Evaluating Visualizations; **Recent Trends in Various Perception Techniques:** Various Visualization Techniques, Data Structures used in Data Visualization.

References:

1. Glenn J. Myatt, Wayne P. Johnson, *Making Sense of Data I: A Practical Guide to Exploratory Data Analysis and Data Mining*, 2nd Edition, John Wiley & Sons Publication, 2014.
2. Glenn J. Myatt, Wayne P. Johnson, *Making Sense of Data II: A Practical Guide to Data Visualization, Advanced Data Mining Methods, and Applications*, John Wiley & Sons Publication, 2009.
3. E. Tufte. *The Visual Display of Quantitative Information*, (2e), Graphics Press, 2007.
4. Jules J., Berman D., *Principles of Big Data: Preparing, Sharing, and Analyzing Complex Information*, (2e), 2013.

5. Matthew Ward and Georges Grinstein, *Interactive Data Visualization: Foundations, Techniques, and Applications*, (2e), A K Peters/CRC Press, 2015.
6. Jurgen Kai-Uwe Brock, *Data Design: The Visual Display of Qualitative and Quantitative Information*, (1e), Consulting Press, 2017.
7. Edward R. Tufte, *The Visual Display of Quantitative Information*, (2e), Graphics Press USA, 2001.
8. Cole Nussbaumer Knaflic, *Storytelling With Data: A Data Visualization Guide for Business Professionals*, (1e), John Wiley and Sons, 2015.

DSE 2153 OBJECT-ORIENTED PROGRAMMING [3 1 0 4]

Introduction: Object-oriented Paradigm and Pillars such as Abstraction, Encapsulation, Inheritance and Polymorphism; **Java Basics:** Compilation and Execution of a Java Program, Access Modifiers; Class and Objects: Class Definition, Creating Objects, Role of Constructors, Method Overloading, Argument Passing, Objects as Parameters, Access Control; **I/O Basics**: Reading Console Input, Writing Console Output; Array and Strings: Arrays in Java, 1-D, 2-D and Dynamic Arrays, String Basics, String Comparison and Manipulation; **Inheritance:** Inheritance and its Types, Abstract Class, Inner and Outer Class, Super, Final, Static Keywords; **Package and Interface**: In-Built Packages and User Define Packages, Role of Interface, Polymorphism via Inheritance; **Collection Framework & Generics**: List, Set, Map, Generic Classes; Exception Handling: Errors and Exceptions, Types of Exceptions, Handling Exceptions, Multithreading: Thread Class, Runnable, Thread Life Cycle, Synchronization, Thread Priority; **Event Handling and GUI Programming**: Events, Action Listener, Important Swing Package Classes.

References:

1. Schildt H, *Java: The Complete Reference*, (10e), Tata McGraw-Hill Education Group, 2017.
2. Balagurusamy E, *Programming with Java*, (5e), Tata McGraw Hill, 2017.
3. Daniel Liang Y, *Introduction to Java Programming*, (10e), Pearson Education, 2018.
4. Horstmann CS, *Big Java: Early Objects*, (5e), Wiley's Interactive Edition, 2015.

DSE 2155 DATA STRUCTURES [3 1 0 4]

Introduction - Pointers and Pointer Application, Accessing variables through pointers, pointers to pointers, pointer arithmetic and arrays, pointers and functions, **Recursion-** definition, recursive programs, efficiency of recursion, **Stacks, queues,** evaluation of expressions, multiple stacks and queues and its application, **Linked lists representations**- Singly, doubly, header node, circular along with the applications, **Trees**-Binary trees, representation, recursive/ non recursive inorder, preorder and post order tree traversal, level order traversal, Binary search tree, creation, insertion deletion operations on binary search tree, Additional Binary Tree Operations, Threaded Binary Tree and applications and Introduction to the concepts of Optimal Binary Search Trees.

References:

1. Behrouz A. Forouzan, Richard F. Gilberg, *A Structured Programming Approach Using C*, (3e), Cengage Learning India Pvt. Ltd, India, 2007

2. Ellis Horowitz, Sartaj Sahni, Susan Anderson and Freed, *Fundamentals of Data Structures in C*, (2e), Silicon Press, 2007
3. Richard F. Gilberg, Behrouz A. Forouzan, Data structures, *A Pseudocode Approach with C*, (2e), Cengage Learning India Pvt. Ltd, India , 2009
4. Tenenbaum Aaron M., Langsam Yedidyah, Augenstein Moshe J., *Data structures using C*, Pearson Prentice Hall of India Ltd., 2007
5. Debasis Samanta, *Classic Data Structures*, (2e), PHI Learning Pvt. Ltd., India, 2010

DSE 2157 COMPUTER SYSTEM ARCHITECTURE [3 0 0 3]

Number Representation and Arithmetic Operations, Character Representation, Memory locations and addresses, Memory operations, Addressing modes, CISC and RISC. Hardware for addition and subtraction, Multiplication, Hardware implementation, Booth's algorithm, Division, Floating point representation, IEEE standard floating point representation, Floating point arithmetic. Bus organization, comparison of hardwired and micro-programmed approach, hardwired control design, Booths multiplier design, Micro-programmed multiplier control unit. Internal organization of memory chips, Structure of Larger Memories, Cache mapping functions, Replacement algorithms, Virtual memories. Accessing I/O devices, Interrupts, Enabling and Disabling Interrupts, DMA. Pipeline Organization, Data Dependencies, Handling Data Dependencies, Hardware Multithreading, SIMD Processing, Graphics Processing Units (GPUs), Shared Memory Multiprocessors, Interconnection Networks, Cache Coherence, Write-Through Protocol, Write-Back protocol, Directory-Based Cache Coherence.

References:

1. Carl Hamacher, ZvonkoVranesic and SafwatZaky, *Computer Organization and Embedded Systems*, (6e), McGraw Hill Publication, 2012
2. William Stallings, *Computer Organization and Architecture – Designing for Performance*, (9e), PHI, 2015
3. Mohammed Rafiquzzaman and Rajan Chandra, *Modern Computer Architecture*, Galgotia Publications Pvt. Ltd., 2010
4. D.A. Patterson and J.L.Hennessy, *Computer Organization and Design-The Hardware/Software Interface*, (5e), Morgan Kaufmann, 2014
5. J.P.Hayes, *Computer Architecture and Organization*, McGraw Hill Publication, 1998

DSE 2159 DATA ANALYTICS LAB [0 0 3 1]

Tutorial on tools for Data Analytics & Visualization. Suggested tools are R, MATLAB, WEKA, RapidMiner. Experiments with datasets to be defined in lab manual, to implement concepts of data preprocessing, exploratory analysis, comparative statistics, statistical inference, Association and clustering. Creating Visual Representations- Suggested tools are MSExcel, Power BI, Tableau. MSExcel Pivot Tables and charts, Visualization of Groups, Volumetric Data, Case Studies in Various Perception Techniques.

References:

1. Glenn J. Myatt., *Making sense of Data: A practical Guide to Exploratory Data Analysis and Data Mining*, (2e), Wiley Press, 2006.
2. Gareth James, Daniela Witten, Trevor Hastie, Robert Tibshirani, “An Introduction to Statistical Learning with Applications in R”, Springer Science, 2017

3. E. Tufte. *The Visual Display of Quantitative Information*, (2e), Graphics Press, 2007.
4. Cole Nussbaumer Knaflic, *Storytelling with Data: A Data Visualization Guide for Business Professionals*, (1e), John Wiley and Sons, 2015.
5. Brian R. Hunt, Ronald L. Lipsman, Jonathan M. Rosenberg, Kevin R. Coombes, John E. Osborn, Garrett J. Stuck , *Guide to MATLAB: For Beginners and Experienced Users*,(2e), Cambridge University Press, 2011.

DSE 2161 OBJECT ORIENTED PROGRAMMING LAB [0 0 3 1]

Class and Objects: Class Definition, Creating Objects; Array and Strings: Programs Based Upon 1-D, 2-D and Dynamic Arrays, String Comparison and Manipulation; Inheritance: Inheritance and Its Types, Abstract Class, Inner and Outer Class, Super, Final, Static Keywords; Collection Framework & Generics: Using Collection Classes such as Array Lists and Linked Lists Writing Generic Classes; Exception Handling: Errors and Exceptions, Types of Exceptions; Multithreading: Thread Class, Runnable, Synchronization, Thread Priority; Event Handling and GUI Programming: Action Listener, Swing Package.

References:

1. Schildt H, *Java: The Complete Reference*, (10e), Tata McGraw-Hill Education Group, 2017.
2. Balagurusamy E, *Programming with Java*, (5e), Tata McGraw Hill Education Group, 2017.
3. Daniel Liang Y, *Introduction to Java Programming*, (10e), Pearson Education India, 2018.
4. Horstmann CS, *Big Java: Early Objects*, (5e), Wiley's Interactive Edition, 2015.

DSE 2163 DATA STRUCTURES LAB [0 0 3 1]

Reviewing the concepts of pointers, structures and recursion, Studying the operation of stacks and queues and the associated application programs, Creating dynamic allocation of memory for linked list and applying it to examples using singly, doubly and circular linked list and their applications, Creation of binary trees and the application associated with the trees.

References:

1. Behrouz A. Forouzan, Richard F. Gilberg, *A Structured Programming Approach Using C*, (3e), Cengage Learning India Pvt. Ltd, India, 2007
2. Ellis Horowitz, Sartaj Sahni, Susan Anderson and Freed, *Fundamentals of Data Structures in C*, (2e), Silicon Press, 2007
3. Richard F. Gilberg, Behrouz A. Forouzan, *Data structures, A Pseudocode Approach with C*, (2e), Cengage Learning India Pvt. Ltd, India, 2009
4. Tenenbaum Aaron M., Langsam Yedidyah, Augenstein Moshe J., *Data structures using C*, Pearson Prentice Hall of India Ltd., 2007
5. Debasis Samanta, *Classic Data Structures*, (2e), PHI Learning Pvt. Ltd., India, 2010

FOURTH SEMESTER

MAT 2213: MATHEMATICAL FOUNDATIONS FOR DATA SCIENCE-II [3 0 0 3]

Stochastic Process: Markov chains with stationary transition probabilities, properties of transition functions, classification of states, Stationary distribution of a Markov chain, existence and uniqueness, convergence to the stationary distribution. Methods based on Markov chains for simulation of random vectors. MCMC algorithm. Random Walks, queueing processes, branching processes. Gambler's ruin problem, transient states. **Multivariate Analysis**: Multivariate distributions: multivariate normal distribution and its properties, distributions of linear and quadratic forms, tests for partial and multiple correlation coefficients and regression coefficients and their associated confidence regions. Data analytic illustrations. Wishart distribution (definition, properties), construction of tests, union-intersection and likelihood ratio principles, inference on mean vector, Hotelling's T^2. MANOVA-Inference on covariance matrices. Classification methods: Discriminant analysis, principal component analysis and factor analysis, Canonical Correlation analysis, Correspondence Analysis, Multidimensional Scaling, Cluster analysis. Nonparametric and robust methods of multivariate analysis. Graphical representation of multivariate data.

References:

1. W. Feller: An Introduction to Probability Theory and its Applications, Vol.-II.
2. S. Karlin and H. M. Taylor, A First Course in Stochastic Processes.
3. William J. Stewart, Probability, Markov Chains, Queues and Simulation.
4. P. G. Hoel, S. C. Port and C. J. Stone, Introduction to Stochastic Processes.
5. S. Ross, Introduction to Probability Models.
6. T. W. Anderson, An Introduction to Multivariate Statistical Analysis.

DSE 2252 DATABASE SYSTEMS [3 1 0 4]

Introduction: Database System Applications, View of data, Database languages, Database users and Administrator. **Introduction to Relational Model**: database schema, keys, schema diagrams, Relational Query Languages, Relational Operations. **Introduction to SQL**: Data Definition, Basic structure of SQL queries, Basic operations, Set operations, Null values, Aggregate Functions, Nested subqueries, Modification of the database. **Intermediate SQL**: Join expressions, Views, Transactions, Integrity Constraints, SQL Data types and schemas, Authorization, Advanced SQL-PL/SQL, Cursors, Functions, Procedures, Triggers, recursive queries, advanced aggregation features. **Database Design and Entity-Relationship Model:** Design Process, ER Model, Reduction to Relational schema. **Relational Database design:** Functional dependencies, Normal forms, Closure, Canonical cover, Lossless joins , dependency preserving decomposition, Storage and File structure, Indexing & Hashing. Query Processing, Overview, Measure of query cost, selection, Join operation, sorting, Evaluation of expressions. **Query Optimization**: Overview, Estimating statistics of expression results, Materialized Views. **Transactions**: Concepts, Simple transaction model, Transaction atomicity and durability,

Transaction Isolation, Serializability, Transaction Isolation Levels. Concurrency Control- Lock based protocols, Deadlock Handling, Multiple granularity, Timestamp-based Protocols, Validation-based Protocols. **Recovery System**: Failure classification, Storage, Recovery algorithm, Buffer Management. **Unstructured database**: Introduction to NoSQL, Basics of document-oriented database, MongoDB.

References:

1. Abraham Silberschatz, Henry Korth, S. Sudarshan, *Database System Concepts*, 6th Edition, McGraw Hill, 2010.
2. Ramez Elmasri, Shamkant Navathe, Fundamentals of Database System, 6th Edition, Addison Wesley Publications Co., 2010.
3. Raghu Ramakrishnan, Johannes Gehrke, *Database Management System*, 3rd Edition, WCB/McGraw Hill Publisher, 2014.
4. Ivan Bayross, *SQL, PL/SQL-The Programming Language of Oracle*, 4th Edition, BPB Publications, 2010.
5. Shashank Tiwari, *Professional NoSQL*, Wiley, 2015.

DSE 2254 MACHINE LEARNING [3 1 0 4]

Machine Learning Basics: Types of Machine Learning, Supervised vs. Unsupervised Learning, Parametric vs. non-parametric models., **Instance Based learning** – k-nearest neighbors, **Simple Regression Models**: Linear, Logistic, Cost functions, Gradient Descent, Batch Gradient Descent, Overfitting, Model Selection, No free lunch theorem, bias/variance trade-off, union and Chernoff bounds, VC dimensions. **Bayesian Models:** Bayesian concept learning, Bayesian Decision Theory, Naïve Bayesian, Laplacian Correction, Bayesian Belief Networks. **Tree Models:** information theory, decision tree induction, tuning tree size, ID3,C4.5, CHAID, Decision Stump. **Support Vector Machines**: kernel functions,. **Regression Models**: Ridge and Lasso Regression, GLM and the exponential Family. Bagging algorithm, Random Forests, Grid search and randomized grid search, Partial dependence plots. **Ensembling and Boosting Algorithms**: Concept of weak learners, Adaptive Boosting, Extreme Gradient Boosting (XGBoost). **Artificial Neural Networks**: Perceptron, Back propagation, Hopfield Network. **Curse of Dimensionality**: Factor Analysis, Principal Component Analysis (PCA), Difference between PCAs and Latent Factors,

References:

1. K. Murphy, *Machine Learning: A Probabilistic Perspective*, MIT Press, 2012.
2. G. James, D. Witten, T Hastie, R Tibshirani, *An introduction to statistical learning with applications in R*, Springer, 2013.
3. J. Han, M. Kamber, J. Pei, *Data Mining concepts and techniques*, (2e), Morgan Kaufmann-Elsevier, 2011.
4. T. Hastie, R. Tibshirani, J. Friedman, *The Elements of Statistical Learning*, (2e), Springer, 2009.
5. T. M. Mitchell, *Machine Learning*, (Indian Edition), MacGraw Hill, 2017.
6. C. Bishop, *Neural Networks for Pattern Recognition*, Oxford University Press, 2019

DSE 2256 DESIGN & ANALYSIS OF ALGORITHMS [3 1 0 4]

Fundamentals of Algorithms, Important Problem Types, Analysis of algorithm efficiency. Analysis Framework: Asymptotic Notations and Basic Efficiency Classes, Mathematical Analysis of

Nonrecursive and Recursive Algorithms. Brute force Techniques, Divide and Conquer, Decrease and Conquer: Insertion Sort, Depth First Search, Breadth First Search, Topological Sorting. Transform and Conquer: Presorting, BST, Heapsort. Space and Time tradeoffs: Input Enhancement in String Matching. Dynamic Programming: Warshall's and Floyd's Algorithms, The Knapsack Problem. Greedy Techniques: Prim's, Kruskal's and Dijkstra's Algorithm, Huffman Trees. Coping with limitations of algorithmic power, P, NP,and NP-complete Problems, Backtracking: n-Queens problem, Hamiltonian Circuit Problem, Subset-Sum Problem. Branch and Bound: Assignment Problem, Knapsack Problem, TSP.

References:

1. Anany Levitin, *Introduction to the Design and Analysis of Algorithms*, (3e), Pearson Education, 2011

2. Ellis Horowitz and Sartaj Sahni, *Computer Algorithms/C++*, (2e), University Press, 2007.

3. Thomas H. Cormen, Charles E. Leiserson, Ronal L, Rivest, Clifford Stein, *Introduction to Algorithms*, (2e), PHI, 2006

DSE 2258 DATA COMMUNICATION AND NETWORKS [3 0 0 3]

Basic concepts of computer networks, Layered architecture and comparison between ISO/OSI, TCP/IP layered models. Significance of Datalink layer and protocols. Network layer functionalities, classful, classless IP addressing, address allocation and role of forwarding module in forwarding the packet using routing table. Roles played by IP, ARP, RARP, ICMP & IGMP protocols in network layer. Inter-domain and intra-domain routing algorithms for routing tables. Importance of transport layer in achieving process-to-process communication. Insight of connection oriented protocol TCP and connectionless protocol UDP. Features of TCP in achieving flow control, error control and congestion control. Requirement of different timers in TCP. Drawbacks of IPv4 addressing and new IP addressing scheme IPv6. Migrating from IPv4 to IPv6. Introduction to application layer, a client/server application program and a case study. Client-server application program-Dynamic Host Configuration Protocol (DHCP).

References:

1. Behrouz A. Forouzan, *TCP/IP Protocol Suite*, 4th Edition, Tata McGraw Hill, 2010.
2. Tannenbaum, A.S, *Computer Networks*, 5th Edition, Prentice Hall of India EE Edition, 2011.
3. Behrouz A. Forouzan, *Data Communications and Networking*, 5th Edition, Tata McGraw Hill, 2013.
4. Leon Garcia and Widjala, *Communication Networks*, 5th Edition, Tata McGraw Hill, 2017.

DSE 2260 DATABASE LAB [0 0 3 1]

Introduction to SQL, Integrity Constraints in SQL, Simple and complex queries, PL/SQL Basics, Exception Handling, Cursors, Transactions, Procedures, Functions and Packages, Triggers, Exercises on NoSQL MongoDB, MsAccess. Mini Project.

References:

1. Silberschatz, Korth, Sudarshan, *Database System Concepts*, (6e), McGraw-Hill, 2011

2. Ivan Bayross, *SQL, PL/SQL*, (2e/3e), BPB Publications

3. G. Reese, *Database Programming with JDBS and Java*, (2e), O'Reilly, 2000

DSE 2262 MACHINE LEARNING LAB [0 0 3 1]

Tutorial on tools for Machine Learning. Python suggested. Experiments with datasets to be defined in lab manual to perform preprocessing and deploy classifiers such as Bayesian, Decision Trees, Support Vector Machines, k-nearest neighbor, Regression Models. Classification accuracy measures, improving classifier performance through ensembling, boosting etc.

References:

1. Hans Peter Langtangen, *Python Scripting for Computational Science*, (3e), Springer Publishers, 2014
2. Naomi R. Ceder, *The Quick Python Book*, (2e), Manning Publications Co., 2010
3. Wesley J. Chun, *Core Python Applications Programming*, (3e), Prentice Hall Publishers, 2012
4. G. James, D. Witten, T Hastie, R Tibshirani, *An introduction to statistical learning with applications in R,* Springer, 2013.

DSE 2264 DESIGN & ANALYSIS OF ALGORITHMS LAB [0 0 3 1]

Exercises to implement doubly linked list & Binary Search Tree, GCD Techniques. Sorting algorithms. String Matching, DFS, BFS, Topological sorting, AVL tree, 2-3 tree, Horspool algorithm, Open hash table, Floyd's algorithm, Warshall's algorithm, Greedy Techniques, Dijkstra's algorithm, Backtracking.

References:

1. Anany Levitin, *Introduction to the Design and Analysis of Algorithms*, (3e), Pearson Education, India, 2011.

2. Ellis Horowitz and Sartaj Sahni, *Computer Algorithms*/C++, (2e), University Press, 2007

3. Thomas H. Cormen, Charles E. Leiserson, Ronal L, Rivest, Clifford Stein, *Introduction to Algorithms*, (2e), PHI, 2006

FIFTH SEMESTER

MAT 3151: MATHEMATICAL FOUNDATIONS FOR DATA SCIENCE –III [3 0 0 3]

Propositional and predicate logic. Number Theory- Divisibility, Euclidean algorithm, prime numbers, Fundamental Theorem of Arithmetic, greatest common divisors, Fermat's little theorem, Congruences, solution of congruences, Chinese remainder theorem, Euler's phi function, Quadratic residues and reciprocity, Jacobi Symbol, binary quadratic forms, equivalence and reduction of binary forms, sums of two squares, greatest integer function, arithmetic functions, Combinatorial number theory, the inclusion-exclusion principle, Techniques of numerical calculation, Public key Cryptography. **Graph Theory**- Introduction to graphs. Order, size, degree. Walks, paths, cycles. Complements. Subgraphs, cliques. Isomorphism. Connectedness and connected components. Trees and spanning trees. Distance, radius, diameter, girth. Vertex connectivity, edge connectivity. Eulerian and Hamiltonian graphs. Measures of centrality – degree centrality, closeness centrality, betweenness centrality. Matrices associated with graphs – adjacency, incidence, Laplacian, and distance matrices. Eigenvalues and eigenvectors. Directed graphs. Graph algorithms – spanning tree algorithm, Dijkstra's algorithm, Floyd-Warshall algorithm.

References :

1. Chartrand, Lesniak, and Zhang. *Graphs and Digraphs*, Fifth Edition. CRC Press. 2010.
2. D. Jungnickel. Graphs, *Networks and Algorithms*, Fourth Edition. Springer. 2013.
3. Douglas B. West. *Introduction to Graph Theory*, Second Edition. Prentice Hall. 2001.
4. *An Introduction to theory of numbers* (fifth edition), I. Niven, H.S. Zuckerman, H. L. Montgomery, John Wiley & Sons, Inc.
5. *A course in Number theory and Cryptography* (second edition), Neal Koblitz, Springer-Verlag.

DSE 3151 DEEP LEARNING [3 0 0 3]

Introduction, Neural Network Basics: Multi-layer perceptron, Back propagation algorithm, training procedures, **Shallow Neural Networks:** Review, Gradient descent and Activation Function **Deep Feed Forward Networks**: Forward and Backward Propagation, Hidden units, architecture design, Dimensionality reduction, learning time. **Regularization for Deep Learning:** Parameter Norm Penalties, Regularization and Under-Constrained Problems, Dataset Augmentation, Noise-Robustness, Bagging and Other Ensemble Methods, Dropout, Adversarial Training. **Optimization for Training Deep Models**: Challenges in Neural Network Optimization. Deep Neural Networks and the Brain**. Convolutional Networks:** convolution operation, pooling Object detection and Face recognition **Sequence Modeling:** Recurrent and Recursive Networks, **Stacked Auto Encoders**: Under complete, Regularized, sparse, de-noising, Monte Carlo Methods. Markov Models, **Hidden Markov models**: evaluation problem, finding the state sequence, HMM as graphical model. **Deep Generative Models:**

Boltzmann Machines-the physics, randomness, impact on cognitive learning. Deep Boltzmann Machines, **Deep Belief Networks**-its relationship to Boltzmann Machines, concept of greedy networks, application to drug discovery. **Generative Adversarial Networks, Auto-regressive Networks**. **Practical Methodology:** Performance Metrics, Default Baseline Models, Selecting hyper parameters, Debugging Strategies. **Case Studies in:** Large Scale Deep Learning, Computer Vision, Speech Recognition, Economics, Fraud detection, Crime detection.

References:

1. Ian Goodfellow, Yoshua Bengio and Aaron Courville, *Deep Learning*, MIT Press 2016.
2. Alpaydin Ethem, *Introduction to Machine Learning*, 3rd Edition, PHI Learning Private Limited, 2018.
3. Kevin P. Murphy, *Machine Learning: A Probabilistic Perspective*, MIT Press, 2012.
4. Simon Haykin, *Neural Networks and Learning Machines*, PHI, 2008
5. Andrew Ng's Notes on Machine Learning from CS229.
6. Rajasekaran S., and Pai G. A. V., *Neural Networks, Fuzzy Logic and Genetic Algorithms*, PHI Learning, 2010.

DSE 3153 OPERATING SYSTEMS [3 1 0 4]

Operating System Structure and Operations, Process Management, Memory Management, Storage Management, Operating System Services, User Operating System Interfaces, Types of System Calls, System Programs, Operating System Structure, System Boot ,Overview, Process Scheduling, Operations on Processes, Inter-process Communication, Multithreaded Models, Thread Libraries, Scheduling Algorithms, Thread Scheduling, Linux scheduling, Critical Section Problem, Peterson's Solution, Synchronization Hardware, Semaphores, Logical Versus Physical Address Space, Segmentation, Contiguous Memory Allocation, Paging, Structure of Page Table, Segmentation, Demand Paging, Copy-On-Write, Page Replacement, Allocation of Frames, Thrashing, Disk Scheduling, Swap-Space Management, System Model, Deadlock: Deadlock prevention, Avoidance, Detection, Recovery, File Concept, Protection.

References:

1. Silberschatz, P. B. Galvin and G. Gagne, *Operating System Concepts*, (9e), Wiley and Sons (Asia) Pvt Ltd, 2013.

2. Milan Milenkovic, *Operating systems: Concepts and Design*, McGraw Hill, New York, 1987

3. H. M. Dietel, *An Introduction to Operating Systems*, Addison Wesley, 1990.

4. Andrew S. Tannebaum, *Operating System: Design and Implementation*, (3e), Prentice Hall of India, 2008

5. Maurice J Bach, *Design of UNIX Operating System*, Prentice Hall of India, 1988

DSE 3155 NATURAL LANGUAGE PROCESSING [3 0 0 3]

Basics of Finite State Automata, Knowledge in Speech and Language Processing, Ambiguity, Models and Algorithm. Survey of English Morphology, Finite-State Morphological Parsing, Building a Finite-State Lexicon, FSTs for Morphological Parsing, Lexicon-Free FSTs. Words and sentence tokenization,

Detecting and Correcting Spelling Errors. Case study: Normalizing Text, Segmentation. N-Grams, Unsmoothed N-Grams, Smoothing, Interpolation, and Backoff. English Word Classes, Tag-sets for English, Part-of-Speech Tagging, The Noisy Channel Model for Spelling. Case study: Automatic Tagging. Constituency, Some Grammar Rules for English, The Penn Treebank project, Dependency Grammar. Parsing with Context Free Grammars, CKY algorithm, Statistical Parsing.

References:

1. J.E.Hopcroft, R.Motwani & J.D.Ullman , *Introduction to Automata Theory Languages, and Computation*, (3rd Edition) , Pearson Education.
2. Daniel Jurafsky & James H. Martin, *Speech and Language Processing*, (2e), Pearson, 2009.
3. Steven Bird, Ewan Klein and Edward Loper, *Natural Language Processing with Python*, (1e), O'Reilly Media, 2009
4. Akshar Bharati, Rajeev Sangal and Vineet Chaitanya, *Natural Language Processing: A Paninian Perspective*, Prentice-Hall of India, New Delhi, 1995
5. Steven Bird, Ewan Klein, Edward Loper, *Natural Language Processing with Python – Analysing Text with natural language toolkit*, O'Reilly Media, 2009
6. Chris Manning, Hinrich Schutze, *Foundations of Statistical Natural Language Processing*, MIT Press, Cambridge, 1999

DSE 3157 CLOUD COMPUTING [3 0 0 3]

Introduction to Cloud Computing, Virtualization and Infrastructure as a service, Hyper converged Infrastructure, Virtual Machines Provisioning and Migration Services, Services and Service Oriented Architectures, Message-Oriented Middleware, Portals and Science Gateways, Cloud Programming and Software Environments: Features of Cloud and Grid Platforms, Parallel and Distributed Programming Paradigms, Sla Management, SLA Management in Cloud, Automated Policy-based Management. Cloud Security Fundamentals, Vulnerability Assessment, Security and Privacy, Cloud Computing Security Architecture. AWS, AWS Solution, AWS Services (IAM, VPC, etc.).

References:

1. Rajkumar Buyya, James Broberg, Andrzej Goscinski, *Cloud Computing Principles and Paradigm*, Wiley Publications, 2013.
2. Matthew Portnoy *Virtualization Essentials*, John Wiley and Sons Publication, 2012
3. Thomas Erl, *Service oriented Architecture*, Pearson publications, 2016
4. Scott D Lowe, *Hyper converged Infrastructure implementation strategies,* Actual Tech media, 2015
5. George Reese, *Cloud application architectures: building applications and infrastructure in the cloud*, O'Reilly Media, Inc., 2009.
6. Kai Hwang,Geoffrey Fox, JackDongarra,Todd Green, *Distributed and Cloud Computing: Clusters, Grids, Clouds and The Future Internet*, Morgan Kaufmann Publishers, 2011

DSE 3159 DEEP LEARNING LAB [0 0 3 1]

Tutorial on tools for Machine Learning. Tensorflow, Python-Keras suggested. Experiments with datasets to be defined in lab manual to deploy deep learning algorithms. Case studies or mini projects in topics such as Sentiment Analysis, Anomaly Detection, Recommender Systems.

References:

1. Hans Peter Langtangen, *Python Scripting for Computational Science*, (3e), Springer Publishers, 2014
2. Naomi R. Ceder, *The Quick Python Book*, (2e), Manning Publications Co., 2010
3. Ahmed Menshawy, Md. Rezaul Karim, Giancarlo Zaccone , *Deep Learning with TensorFlow,* Packt Publishing
4. Introduction to Tensorflow, https://www.tensorflow.org/learn

DSE 3161 OPERATING SYSTEMS LAB [0 0 3 1]

Linux basic commands shell concepts and file filters, shell scripting-1,shell scripting-2, linux system calls ,thread programming, inter-process communication, process synchronization, cpu scheduling algorithms, deadlock algorithms, memory management schemes, page replacement algorithms, disk scheduling algorithms

References:

1. Maurice Bach, *Design of Unix Operating System*, Prentice Hall India Learning Private Limited, 2015
2. Graham Glass, *Unix for Programmers and Users- A complete guide*, (3e), Prentice Hall India Learning Private Limited, 2003
3. Sumitabha Das, *Unix concepts and applications*, (4e), McGraw Hill Education, 2017
4. Neil Matthew, Richard Stones, *Beginning Linux Programming*, (4e), Wiley Publication, 2007
5. A. Silberschatz, P. B. Galvin and G. Gagne, *Operating System Concepts*, (9e), Wiley and Sons (Asia) Pte Ltd, 2013
6. Rachel Morgan- *Unix System*, McGraw Hill Education, 2007

DSE 3163 WEB TECHNOLOGIES LAB [0 1 3 2]

Introduction to HTML, CSS AND Javascript. Web applications using any technology stack or frameworks. MVC Architecture, Web forms and web controls, State management, validation, themes and master page. Working with databases, XML, AJAX. Content Management Systems. Developing mini project using web concepts.

References:

1. Randy Connolly, Ricardo Hoar, *Fundamentals of Web Development*, 1st Edition, Pearson Education India, 2015.
2. Luke Welling, Laura Thomson, *PHP and MySQL Web Development*, 5th Edition, Pearson Education, 2016.
3. Nicholas C Zakas, *Professional JavaScript for Web Developers*, 3rd Edition, Wrox/Wiley India, 2012.
4. Danny Goodman, Michael Morrison, Paul Novitski, Tia Gustaff Rayl, *JavaScript Bible*, 7th Edition, Wiley, 2010.
5. John Kocer, "*Angular 7: By Example* (Part One Book 1)", 2019.
6. Nate Murray, Felipe Coury, Ari Lerner, Carlos Taborda, *The Complete Book on Angular*, 2019.

SIXTH SEMESTER

HUM 3252 OPERATIONS RESEARCH [3 0 0 3]

Introduction: Definition, Phases, Applications, Advantages and Limitations of Operations Research. Linear Programming problems: Assumptions, Formulation of LPP for business and non-business applications. Graphical solutions, Special cases – Degeneracy, Infeasible Solution, Unbalanced and Multiple optimal solutions. Minimization and Maximization cases. Simplex algorithm, Concept of dual, Sensitivity analysis with respect to objective function coefficients and R.H.S. values. Transportation problem: Formulation, North-West Corner (NWC) Method, Least Cost (LC) Method, Vogel's Approximation Method (VAM). Testing the solution by Stepping stone, Modified Distribution (MODI) Method. Maximization, Multiple optimal solutions, Degeneracy and Unbalanced problems. Post optimality analysis. Assignment problem: Solution algorithm for Assignment Problems. Unbalanced, multiple optimal solutions, Maximization and Application problems. Travelling salesman / Job sequencing problem: Solution algorithm for Travelling Salesman Problem, Application to job sequencing problem Game theory: Introduction to game theory, Two person- zero sum games, Pure and Mixed Strategies, Solution methods for 2 x 2 games, Graphical method (2 x n games; m x 2 games), Simulation of queuing system - Steps in simulation, Application and Limitations, Monte- Carlo technique-Problems involving Waiting line situations and Selection of crew members. Critical Path Method (CPM): General frame work, Introduction to elements of network, conventions adapted in drawing network, analyzing the network. Calculation of event and Activity times, Total Float, Free Float, Independent float, Critical path, Determination of project duration, Project Crashing. Applications and Limitations of CPM. Project Evaluation and Review Technique (PERT): Calculation of Probabilistic/Expected event and Activity times, Variance of activity duration, Determination of critical path, probability/expectation of project completion.

References:

1. Taha H. A., *Operations Research*, Pearson Education (7e), 2002.
2. W.L. Winston, *Operations Research*, Thomson Asia, 2003.
3. Vohra N. D., *Quantitative Techniques in Management*, 2007.
4. Sharma S. D., *Operations Research* (14e), Kedar Nath Ramnath Publications, 2005
5. Kanthiswaroop, Gupta and Manmohan, *Operations Research*, Sultan Chand and Sons, 2003.

DSE 3252: ARTIFICIAL INTELLIGENCE [3 1 0 4]

History of AI- Aristotle to the Dartmouth AI Conference. **Foundations of AI**- Philosophy, Mathematics, Psychology, Computing, Linguistics, Neurosciences, Controls, and Economics. **AI Approaches** - Cognitive Modeling. The Turing Test, Rational thinking - Logic. **Computing streams of AI**- NLP, Machine Learning, Knowledge Representation, Automated Reasoning, Computer Vision and Robotics. **Intelligent Agents and Environments**- the concept of Rationality, Classification, working of agents, Single and Multi-Agent System, Performance Evaluation of Agents, Architecture of

Intelligent Agents. **AI Problems**: Problem Space, Problem analysis. **Problem Solving Techniques;** Heuristic Search, Uninformed Search, Adversarial Search- games, Constraint Satisfaction Problems. **Games:** Optimal decision in games, Alpha Beta Pruning Knowledge based agents, The Wumpus World. **Knowledge and Reasoning, Representation:** Logical Agents, First order logic and inference, Classical Planning. **Propositional logic:** Propositional Theorem Proving, Representation. Classical Planning, Fuzzy Logic. Ontological Engineering, Semantic Web, RDF data models, RDFS, Querying Semantic Web: SPARQL, filters, Ontology and Information Systems, OWL, Ontology Reasoning: Monotonic rules, Rule interchange format, Semantic web rules languages, RuleML. Quantifying Uncertainty, Probabilistic Reasoning, Making Simple & Complex Decisions. **Reinforcement learning**: Passive, Active, Generalization, Policy Search, Markov Decision Process, Bellman equations, value and policy iteration, Linear Quadratic Regulation, Linear Quadratic Guassian, Q-learning, policy search, POMDPs. **Applications:** NLP, Parsing, Machine translation, speech recognition, **Perception:** Image formation, Image Processing, Object Recognition, Robotics: software agents, Hardware, perception, software architectures. **Future of AI :** Cognitive Modeling approach, Layers of Mental Activities, Layered Knowledge Representation, Cognitive Architectures. **Quantum Computing**: Quantum mechanics and its impact, **Brain –Machine Convergence**.

References:

1. Russell S., and Norvig P., *Artificial Intelligence A Modern Approach* (3e), Pearson 2010.
2. Marvin Minsky, *Society of Mind*. Simon & Schuster, 1998
3. Marvin Minsky, *The Emotion Machine: Commonsense Thinking, Artificial Intelligence, and the Future of the Human Mind*. Simon & Schuster, 2007.
4. Rich E., Knight K., Nair S.B., *Artificial Intelligence* (3e), Tata McGraw Hill, 2008.
5. Grigoris Antoniou, Paul Groth, Frank van vanHarmelen and Rinke Hoekstra, *A Semantic Web Primer*, MIT Press, 2012.
6. Ray Kurzweil, *The Age of Spiritual Machines: When Computers Exceed Human Intelligence*, Penguin (USA) , 2000.
7. Douglas R.Hofstadter, *Godel, Escher, Bach: An Eternal Golden Braid*, Penguin (UK), 2000.

DSE 3254 PARALLEL PROGRAMMING [3 1 0 4]

\Introduction: Traditional Systems, Processor Architectures, Performance Metrics and enhancement, Laws of Parallel Programming, Bottlenecks, Parallel Programming. Multicore Systems: Uniprocessor Systems, Multiprocessor Systems, Introduction to OpenMP; Overview of OpenMP: Creating threads, threads synchronization, performance considerations; OpenMP language features: Parallel Construct, sharing work among threads, clauses to control parallel and work-sharing constructs If Clause, Num_threads Clause, Ordered Clause, Reduction Clause, Copyin Clause, Copy private Clause, Advanced OpenMP Constructs, Nested Parallelism, Flush Directive, Thread private Directive; Open MP Case studies. Many Core Systems: Heterogeneous Parallel Computing, Introduction to Data Parallelism; Data parallelism and CUDA C: Data Parallelism ,CUDA Program Structure , Device Global Memory and Data Transfer, Kernel Functions and Threading; Data-Parallel Execution

Model: CUDA Thread Organization, Mapping Threads to Multidimensional Data, Matrix-Matrix Multiplication, Synchronization and Transparent Scalability, Assigning Resources to Blocks, Thread Scheduling and Latency Tolerance; CUDA Memories: Importance of Memory Access Efficiency, CUDA Device Memory Types Strategy for Reducing Global Memory Traffic, Tiled Matrix, Memory as a Limiting Factor to Parallelism; Performance Considerations: Warps and Thread Execution, Global memory bandwidth, Dynamic partitioning of execution resources; CUDA Case Studies.

References:

1. D. Kirk, W. Hwu, "*Programming Massively Parallel Processors*", 2nd Edition, Elsevier Inc. 2012.
2. A. Grama et al., "*Introduction to Parallel Computing*", 2nd Edition, Addison Wesley 2003.
3. E. Stotzer, C. Terboven," *Using OpenMP – The Next Step*", 1st Edition, MIT Press, 20017.
4. S. Cook, "*CUDA Programming: A Developer's Guide to Parallel Computing with GPUs*", 1st edition, Morgan Kaufmann, 2012.
5. J. Sanders, E. Kandrot, "*CUDA by example: an introduction to general-purpose GPU programming*", Addison-Wesley Professional, 2010.

DSE 3256 BIG DATA ANALYTICS [3 1 0 4]

Introduction to Big Data: evolution, structuring, elements, big data analytics, distributed and parallel computing for big data, Hadoop, Cloud computing and big data, in-memory computing technology for big data, Big Data Stack, Virtualization and Big Data, Hadoop: ecosystem, Hadoop Distributed File System (HDFS), MapReduce: MapReduce Framework, optimizing MapReduce jobs, MapReduce Applications, Understanding YARN architecture, HBase, Exploring Hive, Analyzing data with Pig, Using Oozie, Introduction to Mahout, role of HBase in Big Data Processing, RHadoop: Data Analysis Using the MapReduce Technique in RHadoop, Spark: Core Concepts, Spark's Python and Scala shells, Programming with RDD: RDD Operations, Passing Functions to Spark, Common Transformations and Actions, Mining Data Streams: Streams Concepts, stream Data Model and Architecture, stream computing, filtering Streams, estimating Moments, decaying window, Real time Analytics Platform (RTAP) Applications, Case studies: Real Time Sentiment Analysis, Stock Market Predictions.

References:

1. Vignesh Prajapathi, *Big Data Analytics with R and Hadoop*, Packt Publishing, 2013.
2. Holden Karau, Andy Konwinski , Patrick Wendell, Matei Zaharia, *Learning Spark: Lightning-Fast Big Data Analysis,* 1st Edition, O'Reilley Media Inc, 2015.
3. Michael Minnelli, Michele Chambers, *Big Data Big Analytics: Emerging Business Intelligence and Analytic Trends for Today's Businesses*, Wiley India Pvt. Ltd., 2013.
4. Arvind Sathi, *Big Data Analytics*, MC Press, LLC, 2012.

DSE 3258 DATA PRIVACY AND SECURITY [3 0 0 3]

Introduction to Data Privacy, types of privacy attacks, Data linking and profiling, access control models, role based access control, privacy policies, their specifications, privacy policy languages, privacy in different domains-medical, financial, etc. Mathematical model for comparing real-world data sharing practices, computing privacy and risk measurements. Demographics and Uniqueness. Protection Models-Null-map, k-map, Wrong map. Survey of Techniques-Protection models (null-map, k-map, wrong map), Disclosure control, Inferring entity identities, entry specific databases. Computation systems for protecting delimited Data-Min Gen, Datafly, Mu-Argus, k-Similar.

Introduction to Security: The OSI Security Architecture, Security Attacks, Services and Mechanisms, Model for Network Security, Number theory, Cryptographic Hash Functions, Digital Signatures, System Security, Symmetric Encryption and Message Confidentiality, Substitution ciphers, Stream ciphers, Public-key cryptography and Message Authentication, Key Distribution and Authentication, Transport Layer Security, Wireless Network Security, E-mail Security, IP Security, Security Management Systems, Need for IT Security, Intrusion Prevention and Detection Systems, Cyber Security. **Security metrics**: Design, Data sources, Analysis of security metrics data, Measuring security cost and value, Different context for security process management. **Acquisition and Duplication**: Sterilizing Evidence Media, Acquiring Forensics Images, Acquiring Live Volatile Data, Data Analysis, Metadata Extraction, and File System Analysis.

References:

1. Ronald Leenes , Rosamunde van Brakel , Serge Gutwirth , De Hert, Paul, *Data Protection and Privacy: The Age of Intelligent Machines (Computers, Privacy and Data Protection)*, Hart Publishing (December 28, 2017)
2. B. Raghunathan, *The Complete Book of Data Anonymization: From Planning to Implementation*, Auerbach Pub, 2016.
3. L. Sweeney, *Computational Disclosure Control: A Primer on Data Privacy Protection*, MIT Computer Science, 2017
4. William Stallings, *Cryptography and Network Security: Principles and Practice*, 7th Edition, Pearson Education, 2017.
5. William Stallings, *Network Security Essentials: Applications and Standards*, 6th Edition, Pearson Education, 2014.
6. Atul Kahate, *Cryptography and Network Security*, 3rd Edition, Tata McGraw-Hill Publishing Company Limited, 2013.
7. Lance Hayden, IT Security Metrics, Tata McGraw Hill, 2016.

DSE 3260 ARTIFICIAL INTELLIGENCE LAB

Intelligent Agents and case study, AI Problems- Problem Space: Heuristic search Techniques; Constraint satisfaction problems, Semantic Networks, Propositional and Predicate Logic: Propositional and Predicate calculus, semantics for predicate calculus, theorem prover, inference rules, unification,

Resolution, Refutation in predicate logic; Communicating, Perceiving, and Acting case study, Genetic Algorithm and its use cases. Fuzzy Logic and its case study.

References:

1. E. Rich, K. Knight, and S.B. Nair, "*Artificial Intelligence*", 3rd Ed., Tata McGraw Hill, 2009.
2. S. Russell, and P. Norvig, "*Artificial Intelligence: A Modern Approach*", Prentice Hall, 2011.

DSE 3262 PARALLEL PROGRAMMING LAB

Communications in MPI, Collective communications in MPI, Error Handling in MPI, OpenCL introduction and programs on vectors, OpenCL programs on strings and to check the execution time in OpenCL, OpenCL programs on matrix, OpenCL programs on sorting and searching, CUDA Programs on arrays and matrices, CUDA programs on strings.

References:

1. D. Kirk, W. Hwu, "*Programming Massively Parallel Processors*", 2nd Edition, Elsevier Inc. 2012.
2. A. Grama et al., "*Introduction to Parallel Computing*", 2nd Edition, Addison Wesley 2003.
3. E. Stotzer, C. Terboven," *Using OpenMP – The Next Step*", 1st Edition, MIT Press, 20017.
4. S. Cook, "*CUDA Programming: A Developer's Guide to Parallel Computing with GPUs*", 1st edition, Morgan Kaufmann, 2012.
5. J. Sanders, E. Kandrot, "*CUDA by example: an introduction to general-purpose GPU programming*", Addison-Wesley Professional, 2010.

DSE 3264 BIG DATA ANALYTICS LAB

Tutorial on tools for Big Data tools and technologies. Cloudera Distribution for Hadoop, Apache Cassandra, MongoDB suggested. Experiments with big datasets to be defined in lab manual, to deploy big data implementations of machine learning algorithms. Case studies or mini projects to be defined for big data.

References:

1. Vignesh Prajapathi, *Big Data Analytics with R and Hadoop*, Packt Publishing, 2013.
2. Holden Karau, Andy Konwinski , Patrick Wendell, Matei Zaharia, *Learning Spark: Lightning-Fast Big Data Analysis*, 1st Edition, O'Reilley Media Inc, 2015.
3. Michael Minnelli, Michele Chambers, *Big Data Big Analytics: Emerging Business Intelligence and Analytic Trends for Today's Businesses*, Wiley India Pvt. Ltd., 2013.
4. Arvind Sathi, *Big Data Analytics*, MC Press, LLC, 2012.

SEVENTH SEMESTER

There are five program electives and one open elective with total of 18 credits to be taught in this semester.

EIGHTH SEMESTER

DSE 4298: INDUSTRIAL TRAINING

Each student has to undergo industrial training for a minimum period of 8 weeks. This may be taken in a phased manner during the vacation starting from the end of third semester. Student has to submit to the department a training report in the prescribed format and also make a presentation of the same. The report should include the certificates issued by the industry.

DSE 4299: PROJECT WORK/PRACTICE SCHOOL

The project work may be carried out in the institution/industry/ research laboratory or any other competent institutions. The duration of the project work shall be a minimum of 16 weeks which may be extended up to 24 weeks. A mid-semester evaluation of the project work shall be done after about 8 weeks. An interim project report on the progress of the work shall be submitted to the department during the mid-semester evaluation. The final evaluation and viva-voice will be conducted after submission of the final project report in the prescribed form. Student has to make a presentation on the work carried out, before the department committee as part of project evaluation.

PROGRAM ELECTIVES

DSE4151 ADVANCED DATA STRUCTURES [3 0 0 3]

Advanced Search Trees: Review of Binary Search Trees, AVL Tree, R-B Trees and Splay Trees, Advanced Search Data Structures Like- Treaps, Skip Lists, Finger Search Trees, Biased Search Trees; Data Structures For External Storage: Review of 2-3-4 Trees and 2-3 Trees, B-Tree, B+ Trees, Priority Queues and Concatenable Queues Using 2-3 Trees; Advanced Heaps: Review of Heaps, Binomial Trees, Implementing Binomial Heaps and its Operations, Structure of Fibonacci Heaps, Mergeable Heap Operations, Decreasing Key and Deleting a Node, Bounding the Maximum Degree, Amortized Analysis of Fibonacci Heaps; Dictionaries and Hashing: Review of Dictionaries and Implementation, Review of Hashing- The Bucket Approach, Index File Approach, Universal Hashing, Perfect Hashing, Locality-Sensitive Hashing, Collision Resolution Techniques in Hashing, Separate Chaining, Open Addressing, Quadratic Probing, Double Hashing, Rehashing, Extendible Hashing, Synopses, Fingerprints, Fault Tolerant Data Structures; Graph Theory And Sorting Network: Review Of Graph Representation and Basic Algorithms, Algorithms for Connectedness, Finding all Spanning Trees in a Weighted Graph, Bipartite Graphs: Maximum Matching, the Hungarian Algorithm, Maximum Flow in a Transport Network - the Ford–Fulkerson Algorithm; Sorting Network: Comparison Network, Zero-One Principle, Bitonic Sorting and Merging Network Sorter.

References:

1. Cormen, T. H., Leiserson, C. E., Rivest, R.L., and Stein, C. *Introduction to Algorithms*, (3e), MIT Press, 2009.
2. Aho, V., Hopcroft, J. E. and Ullman, J. D. *The Design and Analysis of Computer Algorithms*, (1e), Fourth Impression, Pearson Education, 2009.
3. Horowitz, E., Sahni, S. and Rajasekaran, S, *Computer Algorithms*, (2e), University Press, 2007.
4. Weiss, M. A, *Data Structures and Algorithm Analysis in C++*, (2e), Pearson Education India, 2004.
5. Goodrich, M. T., Tamassia, R., *Algorithm Design*, (1e), John Wiley, 2002.

DSE4152 SOFTWARE ENGINEERING [3 0 0 3]

Introduction: The software engineering discipline-evaluation and impact, Programs vs. software products, Changes in software development practice, System engineering, handling complexity through Abstraction and Decomposition. **Software life cycle: W**aterfall model, Iterative waterfall model, Prototype model, Evolutionary model, Spiral model, RAD model, Agile models, comparison of different life cycle models. **Software project management:** Responsibilities of project manager, Project planning, Metrics for project size estimation techniques, Empirical estimation techniques, COCOMO, Halstead's software science, Staffing level estimation, Scheduling, Organization and team structure, Staffing, Risk management, Software configuration management. **Requirements analysis and specification:** Requirements gathering and analysis, Software requirement specification (SRS), Traceability, Characteristics of a Good SRS Document, IEEE 830 guidelines, overview of formal system

development techniques. **Software design:** Good Software Design, Cohesion and coupling, Control Hierarchy: Layering, Control Abstraction, Depth and width, Fan-out, Fan-in, Software design approaches, object oriented vs. function oriented design. **Function-oriented and Object Oriented software design:** Overview of SA/SD methodology, structured analysis, Data flow diagram, Extending DFD technique to real life systems, Structured design, Detailed design, Design review. Unified Modeling Language (UML), UML Diagrams: Static and Dynamic **User interface design:** Characteristics of a good user interface, User Guidance and Online Help, Mode-based Vs Mode-less Interface, Types of user interfaces, Component-based GUI development, User interface design methodology: GUI design methodology, Task and object modeling, Selecting a metaphor, Interaction design and rough layout, User interface inspection. **Coding and testing:** Coding, Code testing, Test driven development, testing tools, Introduction to Agile software development and DevOps. **Software reliability and quality management:** Software reliability, Statistical testing, Software quality and management, ISO 9000, SEI capability maturity model, Personal software process (PSP), Six sigma, Software quality metrics **Computer aided software engineering:** Case and its scope, Case environment, Case support in software life cycle, Other characteristics of case tools, Towards second generation case tool, Architecture of a case environment. Legal Aspects of Software Engineering, Business Aspects of Software Engineering. **Software maintenance and reuse:** Characteristics of software maintenance, Software reverse engineering, Software maintenance processes model, Estimation maintenance cost. Basics issues in any reuse program, Reuse approach, Reuse at organization level.

References:

1. Rajib Mall, "*Fundamentals of Software Engineering*", PHI.
2. Richard Fairley, "*Software Engineering Concepts*", Tata McGraw Hill.
3. Jalote Pankaj, "*An integrated approach to Software Engineering*", Narosa.
4. Pressman R, "*Software Engineering- Practitioner Approach*", McGraw Hill.

DSE4153 BLOCK CHAIN TECHNOLOGIES [3 0 0 3]

Introduction, Structure of a Block, The Genesis Block, Linking Blocks in the Blockchain, Merkle Trees, Simplified Payment Verification, Using hash functions to chain blocks, for Proof-of-Work, Digital Signatures to sign transactions, Distributed Ledger, Byzantine Agreement, Eventual Consistency & Bitcoin Consistency- Availability and Partitions, Bitcoin, Smart Contracts, Weak Consistency, Distributed Storage, Consistent Hashing, Hypercubic Networks, Mining and Consensus: Decentralized Consensus, Independent Verification of Transactions Mining Nodes, Aggregating Transactions into Blocks, Constructing the Block Header, Successfully Mining the Block, Validating a New Block, Assembling and Selecting Chains of Blocks, Consensus Attacks, Changing the Consensus Rules, Soft Fork Signaling with Block Version, Consensus Software Development, Ethereum and Bitcoin, block format,

mining algorithm, proof-of-stake (PoS) algorithm, account management, contracts and transactions, Solidity language, account management, contracts and transactions, Applications of Blockchain :Case studies

References:

1. Andreas M. Antonopoulos, "*Mastering Bitcoin: unlocking digital cryptocurrencies*", O'Reilly Media, (1e) 2014
2. Roger Wattenhofer, "*Distributed Ledger Technology, The science of the Blockchain*", Inverted Forest Publishing, (2e), 2017.
3. Antonopoulos, Andreas M. and Wood, Gavin. "*Mastering Ethereum*", O'Reilly Media, 2018.
4. George Icahn, "*Blockchain:the complete guide to understanding blockchain technology*", Amazon publishers, 2017.

DSE4154 INTERNET OF THINGS [3 0 0 3]

Introduction to internet of things, IoT in global context, Design Principles, IoT Technology Fundamental- Devices and gateways, Local and wide area networking, Data management, Business processes in IoT, IoT reference Architecture, IoT Domain Model, Functional Model. Information Model, Communication Model, Deployment and Operational View, IoT Prototyping- Prototyping Embedded Devices, Electronics, Sensors, Actuator, Embedded Computing Basics, Arduino, Raspberry Pi, BeagleBone Black, IoT Use Cases - Industrial Automation, Smart Home, Smart City, Commercial Building Automation.

References:

1. McEwen A., *Designing the Internet of Things*, Wiley, 2014

2. Holler J., From *Machine-to-Machine to the Internet of Things: Introduction to a New Age of Intelligence*, Academic Press, 2014.

3. Francis daCosta, *Rethinking the Internet of Things: A Scalable Approach to Connecting Everything*, Apress Publications, 2013

4. Pethuru R., *The Internet of Things: Enabling Technologies, Platforms, and Use Cases*, CRC Press, 2017

5. Vijay M., *Internet of Things (A Hands-on-Approach)*, Universities Press, 2014

6. Daniel M., *Building the Internet of Things with IPv6 and MIPv6: The Evolving World of M2M Communications*, Wiley, 2013.

DSE4155 QUANTUM COMPUTING [3 0 0 3]

Introduction, Fundamental concepts. Quantum bits, Quantum computation, Quantum algorithms, Quantum Information, Introduction to Quantum Mechanics, Liner algebra, Postulates of quantum mechanics, Quantum Computation, Quantum circuits, Controlled operations, Measurement, Universal quantum gates, The Quantum Fourier Transform, The quantum Fourier transform, Phase estimation, Applications, Quantum Search Algorithms, Quantum counting, Speeding up the solution of NP-Complete problems, Quantum Information,

Classical noise and Markov processes, Quantum Operations, Quantum Error Correction, The Shor code, Theory of quantum error correction, Entropy and Information, Shannon entropy, Basic properties of entropy, Von Neumann entropy, Quantum Information Theory, Distinguishing quantum states and the accessible information, Data compression, Classical information versus noisy quantum channels, Quantum information versus noisy quantum channels, Entanglement as a physical resource, Quantum cryptography.

References:

1. Michael A Nielsen, and Isaac L. Chuang "*Quantum Computation & Quantum Information"*, (10e), Cambridge University Press, 2011.
2. F. Benatti, M. Fannes, R. Floreanini, and D. Petritis, "*Quantum Information, Computation and Cryptography"* Springer, 2010.
3. Mika Hirvensalo, "*Quantum Computing",* (2e), Springer-Verlag New York, 2004.
4. Jozef Gruska, "*Quantum Computing"*, McGraw Hill, 1999.
5. Phillip Kaye, Raymond *Laflamme* and Michele Mosca, "*An Introduction to Quantum Computing*", Qxford University Press, 2006.

DSE4156 SOCIAL NETWORK ANALYSIS [3 0 0 3]

Introduction to Social Web, Nodes, Edges and Network Measures, Describing Nodes and Edges, Describing Networks, Layouts, Visualizing network features, The role of Tie strength, Measuring Tie strength and its network structures, network propagation, Link prediction, entity resolution, Case study, Introduction to community discovery, communities in context, quality functions, The Kernighan-Lin algorithm, Agglomerative algorithms, spectral algorithms, multi-level graph partitioning, Markov clustering, Other approaches, Introduction to social influence, Influence related statistics, social similarity and influence, Homophily, Existential Test for social influence, Influence and actions, Influence and interactions, influence maximization in viral marketing.

References:

1. Jennifer Golbeck., *Analysing the Social Web*, Morgan Kaufmann publications, 2013
2. Charu C. Aggarwal, *Social Network Data Analytics*, Springer publications, 2011
3. John Scott, *Social Network Analysis*, (3e), Sage publications limited, 2013
4. Jay Goldman, *Facebook Cookbook*, O'Reilly, 2009
5. Shamanth Kumar, Fred Morstatter, Huan Liu, *Twitter Data Analytics*, Springer publications, 2013

DSE4157 DATA FORENSICS [3 0 0 3]

Introduction, the history of forensics, the objectives of computer forensics, computer forensics flaws and risks, computer forensics- rules, procedures and legal issues, computer forensics lab, essential laboratory tools. Forensics investigation process: Introduction, investigating computer crime, conducting a computer forensics investigation, Recovering Deleted Files and

Deleted Partitions, Data Acquisition and Duplication. Hard disk and file systems: Introduction, file systems and hard disks, digital media devices, image file forensics, boot process-windows, linux and macintosh. Advanced forensics: Operating system forensics, Network forensics, Database forensics, Mobile forensics; cloud forensics, Malware forensics, investigating web and email attacks. Forensics analysis, validation and Report writing: Determine what data to collect and analyze, validating forensics data, addressing data hiding techniques, understanding the importance of reports, guidelines for writing reports, generating report findings with forensics software tools.

References:

1. Nelson, Phillips Enfinger, Steuart, Computer Forensics and Investigations, CENGAGE Learning, 2013.
2. Dave Kleiman, The official CHFI study guide , Syngress publishing, 2017
3. Chris Pogue, Unix and Linux forensic analysis DVD toolkit, Syngress publishing, 2008.
4. John R. Vacca, Charles, Computer Forensics, Computer Crime Investigation, River Media, 2005.
5. Eoghan Casey, Handbook of digital forensics and investigation, Elsevier Academic press, 2010.
6. Harlan Cavery, Windows forensic analysis DVD toolkit, Syngress Publishing, 2009.
7. Keith J. Jones, Richard Bejtiich, Curtis W. Rose, Real Digital Forensics, Addison Wesley Pearson Education, 2005.

DSE4158 INFORMATION RETRIEVAL [3 0 0 3]

Introduction to Information Retrieval: Mathematical Basics, Vector spaces and Similarity, Probabilities and Statistics, Text Analysis; Pre-processing: Document processing, Stemming, String Matching, Basic NLP tasks – POS Tagging Shallow Parsing; Overview of Text Retrieval Systems: System Architecture, Boolean Models, Inverted Indexes, Document Ranking, IR Evaluation; Retrieval Models and Implementation: Vector Space Models, TF-IDF Weighting, Retrieval Axioms, Implementation Issues, Probabilistic Models; Statistical Language Models: Okapi/BM25, Language Models, KL-divergence, Smoothing; Query Expansion and Feedback: Query Reformulation, Relevance feedback, Pseudo-Relevance Feedback, Language Model Based, Feedback; Web Search Engines: Models of the Web, Web Crawling; Static Ranking: Page Rank HITS, Query Log Analysis, Adversarial IR, Information Filtering: Adaptive Filtering, Collaborative Filtering, User Interfaces, Text Classification, Naïve Bayes, K-nearest neighbors, Feature selection, Semi-supervised Learning; Text Clustering: Vector-space Clustering; K-means, EM algorithm, Text shingling; Graph-Based Methods: WordNet, Document and Word Graphs, Network Analysis, Random Walks, Harmonic Functions.

References:

1. Christopher D. Manning, Prabhakar Raghavan and Hinrich Schütze, Introduction to Information Retrieval", (2e), Cambridge University Press, 2015.

2. B. Croft, D. Metzler, T. Strohman, Search Engines: Information Retrieval in Practice, (3e), MIT Press, 2016.

3. Chengxiang Zhai, Statistical Language Models for Information Retrieval (Synthesis Lecture Series on Human Language Technologies), (2e), Morgan & Claypool Publishers, 2017.

DSE4159 SOFT COMPUTING TECHNIQUES [3 0 0 3]

Introduction to Soft Computing: Concept of Computing Systems, Soft Computing Versus Hard Computing, Characteristics of Soft Computing, Some Applications of Soft Computing Techniques; Fuzzy Logic: Introduction to Fuzzy Logic- Fuzzy Sets and Membership Functions, Operations on Fuzzy Sets, Fuzzy Relations, Rules, Propositions, Implications and Inferences, Defuzzification Techniques - Fuzzy Logic Controller Design, Some Applications of Fuzzy Logic; Artificial Neural Networks: Biological Neurons and its Working, Simulation of Biological Neurons to Problem Solving, Different ANNs Architectures, Training Techniques for ANNs, Applications of ANNs to Solve Some Real Life Problems; Nature Inspired Algorithms: Genetic Algorithms, Concept of "Genetics" and "Evolution" and its Application to Probabilistic Search Techniques, Basic GA Framework and Different GA Architectures, GA Operators- Encoding, Crossover, Selection, Mutation, etc., Solving Single-Objective Optimization Problems Using GAs, Particle Swarm Optimization- Implementation, Operators, Case Studies, Ant Bee Colony Optimization- Implementation, Operators, Case Studies; Multi-Objective Optimization: Problem Solving Concept of Multi-Objective Optimization Problems (MOOPs) and Issues of Solving Them. Multi-Objective Evolutionary Algorithm (MOEA), Non-Pareto Approaches to Solve MOOPs, Pareto-Based Approaches to Solve MOOPs, Some Applications with MOEAs.

References:

1. Martin, F., Neill, Mc. and Thro, E., *Fuzzy Logic: A Practical approach*, AP Professional, 2000.
2. Ross, T, J., *Fuzzy Logic with Engineering Applications*, (3e), Willey India, 2010.
3. Kasabov, N. K., *Foundations of Neural Networks, Fuzzy Systems, and Knowledge Engineering*, MIT Press, 1998.
4. Ibrahim, A. M., *Fuzzy Logic for Embedded Systems Applications*, Elsevier Press, 2004.
5. Mitchell, M., *An Introduction to Genetic Algorithms*, MIT Press, 2000.
6. Goldberg, D. E., *Genetic Algorithms In Search, Optimization And Machine Learning*, Pearson Education India, 2002.
7. Rajasekaran, S. and Vijayalakshmi Pai, G. A., *Neural Networks, Fuzzy Logic and Genetic Algorithms: Synthesis, and Applications*, Prentice Hall India, 2007.
8. Pratihar, D. K., *Soft Computing*, (1e), Narosa Publishing, 2008.
9. Jang, J.-S. R., Sun, C.-T. and Mizutani, E., *Neuro-Fuzzy and Soft Computing*", (1e), PHI Learning, 2009.
10. Haykin, S., *Neural Networks and Learning Machines*, (3e), Prentice Hall India, 2011.

DSE4160 ENTERPRISE DATA ARCHITECTURE [3 0 0 3]

Enterprise Architecture- Overview, core elements, Structure of enterprises. Introduction to Enterprise Data Architecture (EDA). Developing an EDA- structured vs. unstructured data, analysis and planning approaches, data governance, security, privacy, value and risk, implementation methodology, components and artifacts, Developing Current Architect Views, Repository and Support Tools. Data

Quality Management – Concepts and Implementation. Enterprise Data models - performance requirements and rendering, performance testing and monitoring; Disaster Recovery strategies, Fault Tolerance and Recovery, data-sharding , de-duplication in-memory computing, Effective Metadata modeling, design and management. Enterprise Architectural frameworks – Open-Source Frameworks, MEGAF, India Enterprise Architecture (IndEA) , National Institute of Standards and Technology (NIST), IndiaStack, Praxeme. TOGAF framework – modular structure, content framework, extended guidance, architectural styles. Application architecture- Open source components, API and micro-services, building UX layer. Hardware for EDA- Data warehousing, Enterprise Big Data Storage Models, , Cloud and edge-computing, Polyclouds and data interchange, Case studies. Mini project on creating a EDA for a specific enterprise using open-source technologies.

References:

1. Andy Graham, *The Enterprise Data Model: A framework for enterprise data architecture*, Koios Associates Ltd, 2nd edition, 2012 .
2. Charles D. Tupper, *Data Architecture: From Zen to Reality*, Morgan Kaufmann, 1 edition, 2011.
3. Len Silverston, *The Data Model Resource Book*, Volume 1and 2: A Library of Universal Data Models for All Enterprises, Wiley, Revised edition, 2001.
4. https://dama.org/content/body-knowledge , DAMA-DMBOK: Data Management Body of Knowledge.
5. John Ladley, *Data Governance: How to Design, Deploy and Sustain an Effective Data Governance Program* , Morgan Kaufmann, 1st edition, 2012.
6. Scott A. Bernard , An Introduction to Enterprise Architecture, AuthorHouse, 3rd edition.
7. https://www.opengroup.org/togaf, TOGAF, The Open Group

DSE4161 COMPUTER VISION [3 0 0 3]

Introduction : Image Processing, Components of Image processing system, Image formation and digitization concepts, Neighbours of pixel adjacency connectivity, regions and boundaries, Distance measures, Image processing operations, Arithmetic, Logical, Geometrical, Convolution and Correlation Operations, Applications: Document Image Analysis, Biometrics, Object Recognition, Tracking, Medical Image Analysis, Content-Based Image Retrieval, Video Data Processing, Multimedia, Virtual Reality and Augmented Reality, Image Formation, Image representations (continuous and discrete) , Image pre-processing Techniques, Feature Extraction-Point, Line and Edge Detection, Color, Texture, Shape and structure Features in spatial and frequency domains, Corner Detection, Hough Transform , Image Segmentation: Boundary detection based techniques, Point, line detection, Edge detection, Edge linking, local processing, regional processing, Hough transform, Thresholding, Iterative thresholding, Otsu's method, Moving averages, Multivariable thresholding, Region-based segmentation, Watershed algorithm, Use of motion in segmentation, Computer Vision: Computer Vision, What is Computer Vision - Low-level, Mid-level, High-level , Overview of Diverse Computer Vision Applications,

Fundamentals of object recognition, Low-level computer vision-Edges, contours, textures, shapes, and colors , Motion, optical flow, and tracking Local features, invariance, bag-of-words models, Fisher vector, Middle-level representations of objects: parts, attributes, embedding.

References:

1. David A forsyth & Jean ponce "Computer vision – A modern Approach, Prentice Hall, Pearson Education India; Edition: Second, ISBN-13: 978-9332550117, 2015.
2. R. C. Gonzalez, R. E. Woods. "Digital Image Processing". Pearson, Inc., Edition-Fourth, ISBN. 978-0131687288, 2017.
3. A. K. Jain. "Fundamentals of Digital Image Processing. Prentice-Hall, Pearson; Edition: First, ISBN-13: 978-0133361650, 1994.
4. David A forsyth & Jean ponce , "Computer vision – A modern Approach" , Prentice Hall ,2002.
5. Bernd Jahne and Horst HauBecker, "Computer vision and Applications" Academic press, 2000.

DSE4162 ROBOTICS AND AUTOMATION [3 0 0 3]

Introduction: Definition, Applications of mobile robotics, History of mobile robotics. **Design of system and navigation architecture:** Reference control scheme of a mobile robotics environment, Temporal decomposition of architecture, Control decomposition, Hybrid architecture, Mobile architecture, Perception, Representation and the mapping process. **Locomotion:** Issues for locomotion, Legged mobile robots, Wheeled mobile robots. **Kinematics:** Kinematics introduction, Forward and reverse kinematics, Wheeled kinematics and its constraints, Mobile system locomotion, Human biped locomotion as a rolling polygon, Representation of robot position through the reference frame**. Power Sources and Sensors:** Hydraulic, pneumatic and electric drives, determination of HP of motor and gearing ratio, variable speed arrangements, path determination, micro machines in robotics, machine vision, ranging, laser, acoustic, magnetic, fiber optic and tactile sensors. **Manipulators, Actuators and Grippers:** Construction of manipulators, manipulator dynamics and force control, electronic and pneumatic manipulator control circuits, end effectors, U various types of grippers, design considerations. **Navigation:** Localization overview, Path planning. **Computational intelligence:** Swarm intelligence, Evolutionary computation, Artificial immune system, Ant algorithm. **Mobile robot programming:** This chapter is included to provide hands on introduction to the field of mobile robotics and various issues in designing and planning of robot work environment. It includes construction and programming of robotic agents using robotic kits and microcontrollers applying concepts of locomotion, perception, navigation and computational intelligent algorithms.

Text Books:

1. Ronald Siegwart, Illah R. Nourbakhsh, "*Introduction to Autonomous Mobile Robots*", MIT Press,
2. Andries P. Engelbrecht , "*Computational Intelligence: An Introduction*", Wiley 2nd Edition, 2007
3. Ronald C. Arkin , "*Intelligent Robotics and Autonomous Agents*", MIT Press, 1997
4. Ulrich Nehmzow, "*Mobile Robotics: A practical Introduction*", Springer-Verlag London, 2003

5. Robin R. Murphy, "*Introduction to AI Robotics*", MIT Press, 2000
6. Leandro N. de Castro and Jonathan Timmis, "*Artificial Immune system: A new Computational Intelligence Approach*", Springer-Verlag, Germany 2002.

MINOR SPECIALIZATION IN FINANCE & SECURITY ANALYTICS

DSE 4163 FINANCE & ACCOUNTING [3 0 0 3]

Understanding the Financial Data: Financial Statements, Type of Accounting and finance data, Nature and behavior of financial and accounting data. Preparation of financial statements in excel, Calculation, projection of various reports with finance and accounting data, Understanding data in finance, sources of data, cleaning and pre-processing data, Understanding stock price behaviour, Time series analysis in finance . **Review of Financial Statements:** Sources for Financial Statement Information, Types of financial statements: Income statement, Balance Sheet, Cash flow and funds flow statement, Ratio Analysis, DuPont Analysis, Profitability and Turnover Ratios, Liquidity Ratios, Forecasting of ratios and future financial statements, Preparation financial reports using MS Excel. **Valuation of Equity and Firm/Business:** Free Cash Flow to Equity (FCFE), Free Cash Flow to the firm (FCFF), Discounted cash flow approach to equity and business valuation, Relative Valuation approach to valuation, non-financial performance metrics affecting company valuations. **Investment Analysis:** Capital Budgeting Techniques – Pay Back Method, Discounted Pay Back Method, Accounting Rate of Return, Net Present Value Method, Internal Rate of Return and Profitability Index. Risk Analysis in Capital Budgeting – Nature of risk, Statistical Techniques for risk analysis, Conventional techniques of risk analysis and Sensitivity Analysis. Capital Rationing. **Capital Structure and Valuation:** Meaning. Operating Leverage. Financial Leverage, EBIT-EPS Analysis. Combined Leverage. Meaning of Capital Structure. Capital Structure Theories – Definitions, Net Income Approach, Net Operating Income Approach, Modigliani Miller Approach, and Traditional Approach. Practical Considerations in Determining Capital Structure. **Working Capital Analysis:** Meaning, Need and Nature of Working Capital [Concept and Definitions]. Determinants of Working Capital. Trade-off between Profitability and Risk. Determining Financing Mix. Computation/Estimation of Working Capital. Cash Management and Receivables and payables management.

References:

1. Principles Corporate Finance 9th Edition, by Richard A. Brealey, Stewart C. Myers, Franklin Allen
2. Dr. John Robertson - Financial ratio analysis - John Robertson publishers
3. Khan M. Y. and Jain P. K. - Financial Management - Tata McGraw-Hill Publishing
4. Pandey I. M. - Financial Management - Vikas Publishing House Pvt Ltd.
5. James C. Van Horne and John M. Wachowicz, Jr. - Fundamentals of Financial Management- Pearson Education Limited
6. ACCA F3 Financial Accounting - Kaplan's publishing.

DSE 4164 RISK ANALYTICS [3 0 0 3]

Introduction to risk analysis: Nature of risk and uncertainty; Why do a risk analysis?; Management's responsibility with regard to risk; Discuss risk management; Upside and downside risk; Handling big data; Cost and benefits associated with investing in information systems; Recommended techniques for the Boards to manage risks. **Quantification of risk:** Quantification of risk using expected values, standard deviations and probability tables; Calculating Beta & Capital Asset Pricing Model; Decision trees; Decision models to deal with uncertainty in decision making-Max-min, Max-max, and Min-max regret criteria; Payoff tables. **Probability mathematics and simulation:** Types of risks; Types of market risks; Market risk measurement, Value at Risk (VaR); VaR as a key parameter to measure market risk; Elements of VaR system; Stress testing; VaR Methods- An overview of VaR methods; VaR local and full valuation; Delta normal methods; Historical simulation; Monte Carlo simulation; Examples of VaR applications. **Financial risk analysis modelling:** Introduction to credit risk; Credit risk management; Settlement risk; Measuring credit risk; Measuring Credit VaR; Types of credit derivatives. **Forecasting with uncertainty:** Properties of a Time Series Forecast; Common Financial Time Series Models; Autoregressive Models; Time Series Projection of Events Occurring Randomly in Time; Time Series Models with Leading Indicators. **Hedging Techniques:** Hedging- Hedging linear risk; Optimal hedging; Hedge ratio as regression coefficient; Duration hedging; Beta hedging; Non-linear risk hedging; Delta and dynamic hedging.

References:

1. Quantitative Financial Risk Management, Wiley publications, by Michael B. Miller
2. Vose David, Risk Analysis: A Quantitative Guide, John Wiley & Sons Inc, 2018.
3. Hull John C., Risk Management and Financial Institutions, John Wiley & Sons Inc, 2018.
4. Risk Management - CIMA official study text, Kaplan Publishing
5. Value at Risk: The New Benchmark for Managing Financial Risk, 3rd Edition, by Philippe Jorion

DSE 4165 FINANCIAL MARKET ANALYTICS [3 0 0 3]

Money and Capital market, Fundamental Analysis: Economic analysis, Industry Analysis, Company analysis. Technical Analysis, chart formations, Moving average analysis, Relative strength analysis, Technical indicators. Merits and demerits of technical analysis. **Random Walk Hypothesis:** Efficient market theory, weak form, semi-strong form, strong form, Implications for investment analysis. **Equity valuation:** Balance sheet valuation, Dividend discount model, Earnings multiplier approach, Earnings to price ratio, Expected return, and growth. **Analysis and Valuation of debt:** Bond pricing, Bond yield, Risk in debt. **Portfolio Analysis:** Risk and Return analysis, Markowitz Theory. Portfolio Theories –CAPM. Markowitz Theory, Single Index Model, Two Factor Model Theory, Arbitrage Pricing Theory**.**

References:

1. Donald Fischer and Jordan - Security Analysis and Portfolio Management - PHI, New Delhi
2. William F. Sharpe - Investments

DSE 4166 BUSINESS & ECONOMIC ANALYTICS [3 0 0 3]

Consumers, producers & production: Consumer Behavior, Production, cost & revenue analysis. **Price and Output determination under different market structure:** Perfect competition, Price and output determination under Monopoly, monopolistic competition, oligopoly. **National Income Accounting:** Circular flow of income model; methods and concepts in national income accounting and limitations, Inflation: Types, causes, effects and control measures for Inflation. **Macro policies:** Meaning, objectives and tools and effects of monetary and fiscal policies. **External Sector:** Economic openness, Balance of Payments, BoP crisis, exchange rate concepts, foreign capital flow.

References:

1. Soumyen Sikdar., Principles of Macroeconomics, OXFORD University Press.
2. Robert Pindycik & Daniel Rubinfeld., Microeconomics, 8TH ed., Pearson India Education services Pvt Ltd.
3. Gujarathi, D.N, Basic Econometrics, Fourth Edition, Tata McGraw-Hill, New Delhi.

MINOR SPECIALIZATION IN BUSINESS ANALYTICS

DSE 4163 FINANCE & ACCOUNTING [3 0 0 3]

Given earlier

DSE 4167 FUNDAMENTALS OF BUSINESS ANALYTICS [3 0 0 3]

Data-Analytic Thinking for Business: The Ubiquity of Data Opportunities, Data Science as a strategic asset, data analytic thinking, Business Enterprise and its functions, Enterprise Applications – ERP, CRM, MIS. Difference between Business Intelligence and Business Analytics. **Database systems for Business**: OLTP and OLAP systems for business overview and architecture overview. **Business Problems and Data Science Solutions using CRISP-DM Approach**: Business Understanding, preparation, modeling, evaluation, deployment. **Performance Metrics in Analytics -** Key performance Indicators (KPIs), KPI based balanced score card, KPIs on Dashboards. **Project Management -** Project Management, phases, tools, techniques and methodologies in project management, Agile Framework and Scrum Approach. **Quality Management -** quality management philosophy, concepts and tools, Statistical Quality Control methods, Lean and Six Sigma, SERVQUAL model of service quality. **Case studies** – Human Capital Analytics, IT Analytics, Sales and Marketing Analytics, Analytics in telecom, Retail, healthcare, financial markets, social media, sports and other related business fields.

References:

1. Prasad, R, N. and Acharya, Seema (2016) Fundamentals of Business Analytics. Wiley India Pvt, Ltd, New Delhi
2. Provost and Fawcett (2013). Data Science for Business, O'Reilly
3. Shmueli, Patel, and Bruce (2009) Data Mining for Business Intelligence, Concepts, Techniques and Applications. Wiley

4. Clifford F. Gray, Erik W. Larson, Gautam V. Desai (2014) - Project Management - Tata McGraw Hill
5. Schwaber Ken (2004). Agile project management with scrum, WP Publishers and Distributors, Bangalore
6. Sridhar Bhatta (2015). Total Quality Management, concepts and cases-Himalaya Publishing House.

DSE 4168 DIGITAL MARKETING [3 0 0 3]

Introduction: Online Market space- Opportunities for building Brand, Digital eco system and channels, Market and customer segmentation, Digital Marketing Strategy Components, Combining digital and traditional media. Search Engine Optimization: How Search Engine works, SEM components, PPC advertising with Google ad words, Display Advertisement. Search Engine Optimization: SEO success factors (On-Page and Off-Page Techniques), Google analytics. Display Advertising: Real time bidding ,Executing display advertising, E-commerce Models. Social Media Marketing: Social Media Channels. Facebook, Twitter, Linkedin, Instagram, other Soc. Media channels. Leveraging Social media for brand conversations and buzz, Successful /benchmark Social media campaigns. Social Media Marketing: Promoting/advertising brand in Social media, Social Media Feedback, Measuring Social media impact. E- Mail Marketing: Types of E- Mail Marketing , Email Automation, Lead Generation, Integrating Email with Social Media and Mobile, Digital Marketing for B2B,Measuring and maximizing email campaign effectiveness. Online Reputation Management: Combining digital and traditional media, Power of Social Media, Monitoring SM, Proactive and reactive reputation management. Creating a Digital Marketing Strategy: Elements of strategy, Operational aspects of strategy, Digital Marketing plans .Mobile Marketing: Mobile Inventory/channels, Location based, Context based, Coupons and offers, Mobile Apps, Mobile Commerce, SMS Campaigns ,Profiling and targeting. Web Analytics and Channel Attribution Strategies: Social Media Analytics, Website Analytics, Channel attribution model.

References:

1. Maity, Moutusy (2017), Internet Marketing: A Practical Approach in the Indian Context, Oxford University Press (ISBN: 9780199469550)
2. Richard Gay, Alan Charlesworth and Rita Esen (2013), Online Marketing- a customer led approach, Oxford University Press, New York. 3. Alan Charlesworth (2014), Digital Marketing: A Practical Approach
4. Avinash Kaushik, Web Analytics 2.0 (2009): The Art of Online Accountability

DSE 4169 SUPPLY CHAIN MANAGEMENT [3 0 0 3]

Introduction and objectives of supply chain, Decision phases in a supply chain, Purchasing tools and techniques,Value analysis, Project planning and control techniques, Pricing and revenue management,Costing fundamentals, Types of costing, Managing inventory in a supply chain, Economic order quantity, EOQ determination with instantaneous delivery and without shortages, Effect of quantity discount, safety stock, reorder level & lead time. Facility decisions in supply chain:, Factors influencing network design in supply chain, Models for facility location and capacity allocation, Transportation decisions in a supply chain, Routing and scheduling in transportation, Multistage

transportation problems, Truck allocation problem, Travelling salesman problem, Vehicle routing problems, Financial evaluation of supply chain Decisions, The impact of financial factors on supply chain decisions, Discounted cash flow analysis, Evaluating supply chain decisions using decision trees.

References:

1. Chopra and Meindl.,Supply Chain Management – Strategy, Planning and Operation, (3e), Pearson Education, New Delhi, 2009.
2. Raghuram and Rangaraj, Logistics and Supply Chain Management: Cases and Concepts, Macmillan, New Delhi, 2000.
3. Simchi-Levi and Kaminski, Designing and Managing the Supply Chain: Concepts, Strategies and Case Studies , McGraw-Hill, 2003.
4. Shapiro J., Modelling the Supply Chain, Duxbury Thomson Learning, U.S.A., 2009.
5. Krajewski Lee J. and Ritzman Larry P., Operations Management, Pearson Education (Singapore) Pte. Ltd., Delhi, 2005.

MINOR SPECIALIZATION IN HEALTH CARE ANALYTICS

DSE 4170 HEALTH INFORMATICS [3 0 0 3]

Introduction to Health care and Information Technology-HealthCare Data – Types of HealthCare Data – HealthCare Databases & Applications – Healthcare Informatics Vs Clinical Informatics-EMR, HER and EPR. Interoperability Standards in Healthcare – Introduction to healthcare standards-need for such standards-HL7-Digital Image Communication in Medicine (DICOM)- Picture Archival and Communication System (PACS)- Clinical Document Architecture (CDA)- Integrating the Healthcare Enterprise . Imaging Systems in Healthcare – Imaging Modalities- Xray, CT, MRI, US- Radiology Information Systems-PACS. Ethics in Healthcare – Protected Healthcare Information-HIPPA-Mobile in Healthcare. Clinical Data Interchange Standards Consortium (CDISC). Telehealth-Telemedicine-Tele Radiology-Data Compression Techniques- IT for rural healthcare. Drug development life cycle, Basics of Drug discovery process, Overview of Clinical Trials, Analytics in Pharmaceutical Industry, Clinical Trails and drug development.

References:

1. Health Informatics: An Interprofessional Approach - Ramona Nelson and Nancy Staggers.
2. Healthcare Informatics - WIlliam Hanson - McGraw-Hill Education.
3. “Principles of Medical Imaging” by K. Kirk Shung, Michael B. Smith, Benjamin M.W. Tsui
4. “Digital Imaging and Communication in Medicine(DICOM)” by Oleg S Pianykh, Springer.
5. “HIMSS Dictionary of Healthcare Information Technology Terms, Acronyms and Organizations”, Second Edition, HIMSS, ISBN 13978-1-938904-03-5
6. “Telemedicine and Telehealth 2.0: A Practical Guide for Medical Providers and Patients” by Victor Lyuboslavsky, Paperback.
7. “Textbook of Healthcare Ethics” 2nd Edition Erich H. Loewy, M.D. , Roberta Springer Loewy, Ph.D. University of California, Davis School of Medicine Sacramento, California, Kluwer Academic Publishers New York.

DES 4171 BIOINFORMATICS [3 0 0 3]

Introduction to Bioinformatics, Central dogma of biology, Digital code of life, database sequence search & Alignment, The evolutionary basis of sequence alignment, The modular nature of proteins, Optimal alignment methods, Substitution scores and gap penalties, Statistical significance of alignments, Structure file formats; Visualizing structural information, Motifs and Pattern, Protein structure prediction, Searching for trees, Rooting trees, Evaluating trees and Data, Phylogenetic software, Phylogenetics on the web, Some simple practical considerations. Introduction to Genomics, Genome annotation, Comparative genomics, Genome compression.

References:

1. Arthur M. Lesk. *Introduction to Bioinformatics*, Oxford University Press, 2002
2. Stuart M. Brown. *BIOINFORMATICS: A biologists guide to biocomputing and the internet*, NYU Medical Center, 2000

DSE 4172 MEDICAL IMAGE PROCESSING [3 0 0 3]

Review of signals, systems & transforms; 2D signals & systems; Medical Imaging: Imaging modalities and their applications; Computed tomography (CT): mathematical basis, the Radon transform & the central slice theorem; Image reconstruction from projections: the Direct Fourier Method, convolution back projection (CBP) algorithm, Algebraic Reconstruction Techniques (ART); reconstruction from fan-beam projections; Extension to 3D – cone-beam CT, spiral CT. Tomosynthesis; X-rays: utility, generation and detection; X-ray CT systems. Emission CT: principles, Positron emission tomography (PET); attenuation correction in ECT; Ultrasound in clinic: benefits/risks, Basics of Ultrasound - review, Ultrasound imaging; Contrast enhanced ultrasound imaging; Motion artifacts in ultrasound imaging. Clutter filtering; elastography, plane wave imaging; Magnetic resonance imaging: Principles of data-generation, resolving the tissues, resolving the spatial locations, and extension to 2D. Resolution & Field of View; Data sampling and the concept of bandwidth.

References:

1 R.C Gonzalez and R.E. Woods, *Digital Image Processing*, (4e), Pearson Education Inc., 2017.
2 A.K. Jain, *Fundamentals of Digital Image Processing*, Prentice- Hall, 1989, Fourth Indian Reprint.
3 A.C. Kak and M. Slaney, *Principles of Computerized Tomographic Imaging*, SIAM's Classics in Applied Mathematics, Philadelphia, SIAM, 2001.
4 Kline Jacob, *Handbook of Biomedical Engineering*, Academic Press, 1988.
5. Carol M. Rumack, Deborah Levine, Diagnostic Ultrasound, (5e), Elsevier, 2017

DSE 4173 BIOSTATISTICS [3 0 0 3]

Review of descriptive statistics, Sampling techniques, Summarizing Quantitative Data, Summarizing Categorical Data. Distributions- Binomial, Negative binomial , Poisson, Continuous Outcomes, Normal Distributions, Population, Sample, Central Limit Theorem, Standard Error, Confidence Intervals. Sampling Distributions, Confidence Intervals estimates. Role of probability in decision making. p-values and statistical inference, Inferential statistics – Hypothesis tests, Chi-square, ANOVA, ANCOVA. Comparative statistics – correlation tests. Non parametric tests. Survival analysis- survival

function, survival curve, Cox Propotional Hazards Regression Analysis-Linear, GLM, stepwise logistic and model selection via AIC and BIC. Prevalence, Incidence, Relative Risk, Risk Difference, Sampling Bias. Study Design – observational , randomized, Randomized Block design, Latin Square design. crossover and parallel arm design. Introduction to factorial designs, 2k factorial design, main effects. Screening designs- Fractional factorial designs, Plackett-Burmann screening designs. Model reduction interaction effects. Clinical Trials, Model assumption checking, residual plots. Optimization designs- Response surface methodology concepts & methods, central composite designs and Box-Behnken design. Probability & Screening; Power and Sample Size determination.

References:

1. Sullivan, L.M., Essentials of biostatistics for the health sciences, 3rd edition, Jones & Bartlett Learning, 2018.
2. Machin, Campbell and Walters, Medical Statistics, 4th edition, Wiley, 2007.
3. Motulsky, H., *Intuitive Biostatistics: A nonmathematical guide to statistical thinking*, 3rd edition, Oxford University Press, New York, 2014.
4. Utts, J and Heckard, R., *Mind on statistics*, 5th edition, Cengage Learning, USA.
5. Stephen S. Senn , *Statistical issues in drug development*, 2nd edition, Wiley Publication.
6. David S. Moore , William I. Notz, Michael A. Fligner , *Statistics in practice* , W. H. Freeman publication, 1st edition, 2014.

DSE4174 ALGORITHMIC TRADING [3 0 0 3]

Basic Trading strategies- Discretionary, Algorithmic Trading, Hybrid. Algorithmic vs. High-Frequency/Low Latency Trading. **Industry Overview**- Alternatives, Hedge Funds, Commodity Trading Advisor Funds, Quant Funds. Tracking Funds, Tracking Benchmarks, Basic Portfolio Strategies. **Mathematics for algorithmic trading-** Prediction of prices, Risk calculation, Capital Allocation, locking in Options & Futures **Review of Time Series, Capital Allocation, Momentum, Options and futures**- trend, seasonal, cyclical and irregular components, white noise, Brownian motion, Auto covariance, autocorrelation and criteria. ARIMA models, Autoregressive Models, Moving Average Models, ARMA Models. Box-Jenkins method, characteristic polynomials, Sharpes and Skewness , Stationary vs. Non-stationary processes, criteria (AIC, BIC) for model choice, Cross Validation, Bootstrap and Stochastic Differential Equations (SDE)s., Kalman Filters. **Algorithmic Trading Basics**- Back testing, Automated Execution, Momentum, Mean Reversion, Carry, Value, Basic Portfolio Strategies, Over fitting. **Mean Reversion Strategies** - Mean Reversion of Stocks, ETFs, Currencies and Futures, Timescales/horizons associated with MR, Momentum and Value, Volume and Mean Reversion Liquidity, Unit Root Tests, Augmented Dickey Fuller Tests. KPSS Tests, Variance Ratio Tests. Co-integration and Johansen Test. **Momentum/Trend Following**- properties and tradeoffs, Inter-day and Intraday Momentum Strategies, Risk Management. Skewness over horizon results, momentum modelling. **Filters, Change points** - sequential binary segmentation, switching Kalman filters, Carry, Value, P vs. Q-measure.

Over fitting- p-hacking, lack of reproducibility, holdout over fitting. Adjusted Sharpe Ratios. Multiple Hypothesis Testing – Holm-Bonferroni . BHY adjustments. ML for Algorithmic trading, pitfalls and future opportunities. **Case Studies**: Introduction to Quantopian, Mini project using open source technologies to build and test simple algorithmic models

References:

1. Earnest Chan, *Algorithmic Trading: Winning Strategies and Their Rationale*, John Wiley & Sons , 1st edition, 2013.
2. Ernie Chan, *Quantitative Trading: How to Build Your Own Algorithmic Trading Business*, John Wiley & Sons;, 1 edition , 2008
3. Rishi K. Narang, *Inside the Black Box: The Simple Truth about Quantitative Trading*, John Wiley & Sons , 1st edition, 2009.
4. Barry Johnson, *Algorithmic Trading and DMA: An introduction to direct access trading strategies*, 4Myeloma Press, 2010.
5. David J. Leinweber, Theodore R. Aronson, *Nerds on Wall Street: Math, Machines and Wired Markets* , John Wiley & Sons, 1st edition, 2009.
6. Alex Kuznetsov, *The Complete Guide to Capital Markets for Quantitative Professionals (McGraw-Hill Library of Investment and Finance)* . McGraw-Hill Education, 1 edition, 2006.

DSE 4175 APPLIED ECONOMETRICS [3 0 0 3]

Financial Econometrics: Nature of Econometrics and Economic Data. Time Series Econometrics. **The Experimental Ideal:** selection problem, random assignment, regression analysis of experiments. **Regression Modeling**: Linear regression modeling, properties of regression, omitted varaibles, decomposition techniques, regression and causality, heterogeneity and nonlinearity. Logit and probit models, problems of inference. **Causal Modeling:** Panel data, Instrumental variables**. Instrumental variables in action:** Causality, asymptotic 2SLS Inference, Two sample, Split Sample Instrumental variables, IV with heterogeneous potential outcomes. Individual Fixed Effects. Differences-in-differences, Fixed effects versus lagged dependent variables**. Regression discontinuity:** designs, sharp and fuzzy regression discontinuity. **Quantile regression model**: estimation of quantile treatment effects, nonstandard standard error issues, bias of robust standard error estimates, clustering and serial correlation in panels. **Methods from Statistical Learning:** Cross validation and k-fold, Shrinkage methods (Ridge and LASSO), Basis functions, Tree models.

References:

1. Joshua D. Angrist and Jorn-Steffen Pischke, *Mostly Harmless Econometrics- An Empircist's Companion*, Princeton University Press, 1 edition, 2009.
2. Jeffrey M. Woolridge, *Introductory Econometrics: A Modern Approach*, CENGAGE Learning Custom Publishing; 5th edition , 2012.
3. Maurice DeGroot, Mark J Schervish, *Probability and Statistics*, Pearson Publications, 4 edition ,2011.
4. Gareth James, Daniela Witten, Trevor Hastie, Robert Tibshirani, *An Introduction to Statistical Learning with Applications in R*, Springer Science, 2017.