E.G.S. PILLAY ENGINEERING COLLEGE

(Autonomous)

Approved by AICTE, New Delhi | Affiliated to Anna University, Chennai |
Accredited by NAAC with 'A'Grade |Accredited by NBA (CIVIL, CSE, ECE, EEE, IT, MECH)
NAGAPATTINAM – 611 002

B.E Mechanical Engineering

FullTimeCurriculum And Syllabus

Third Year – Fifth Semester

Course Code	Course Name	L	T	P	C	Maximum Marks		
						CA	ES	Total
1701MA502	Operations Research	2	2	0	3	40	60	100
1702ME501	Heat andMassTransfer	3	2	0	4	40	60	100
1702ME502	Computer Aided Design	3	0	0	3	40	60	100
1702ME503	Design of Transmission Systems	3	2	0	4	40	60	100
	Elective I	3	0	0	3	40	60	100
	Elective II	3	0	0	3	40	60	100
1702ME551	Heat Transfer Laboratory	0	0	2	1	50	50	100
1702ME552	Computer Aided Design Laboratory	0	0	2	1	50	50	100
1704ME553	Mini Project I (Design and Fabrication)	0	0	2	1	100	-	100
1704GE551	Life Skills: Aptitude I	0	0	2	1	100	-	100
		17	**6**	**8**	**24**	**540**	**460**	**1000**

L – Lecture | T – Tutorial | P – Practical | CA – Continuous Assessment | ES – End Semester

1701MA502	OPERATIONS RESEARCH	L	T	P	C
		2	2	0	3

UNIT I INTRODUCTION TO LINEAR PROGRAMMING (LPP) 9 Hours

Introduction to Applications of Operations Research in functional areas of Management. Linear Programming-Formulation, Solution by Graphical and Simplex methods (Primal - Penalty, Two Phase), Dual simplex method. Principles of Duality.

UNIT II TRANSPORTATION AND ASSIGNMENT MODELS 9 Hours

Transportation Models – Initial Basic feasible solution by N-W Corner Rule, Least cost and Vogel's approximation methods. Solution by MODI-Assignment Models- Solution by Hungarian method-Travelling Salesman problem.

UNIT III NETWORKS AND INVENTORY MODELS 9 Hours

Scheduling by PERT and CPM - Inventory Models – EOQ and EBQ Models (With and without shortages), Quantity Discount Models.

UNIT IV GAME THEORY AND REPLACEMENT MODELS 9 Hours

Game Theory-Two-person Zero sum games-Saddle point, Dominance Rule, Methods of matrices, graphical and LP solutions. Replacement Models-Individuals replacement Models (With and without time value of money) – Group Replacement Models.

UNIT V QUEUING THEORY MODELS 9 Hours

Queuing Theory - single and Multi-channel models – infinite number of customers and infinite calling source. (M/M/1) :(∞/FCFS), (M/M/S) :(∞/FCFS), (M/M/1) :(N/FCFS), (M/M/S) :(N/FCFS)- Simple Problems

TOTAL: 45 HOURS

REFERENCES:

1. Hamdy A Taha, Introduction to Operations Research, Pearson, 9th Edition, 2014.
2. Paneerselvam R., Operations Research, Prentice Hall of India, Fourth Print, 2008.
3. G. Srinivasan, Operations Research – Principles and Applications, PHI, 2007.
4. Kalavathy S, Operations Research, Second Edition, Vikas Publishing House, 2004.
5. N. D Vohra, Quantitative Techniques in Management, Tata McGraw Hill, 2010.
6. nptel.ac.in/courses/112106134/1

Course Outcomes (COs):

CO Number	Competency
CO1	Formulate linear programming problems, interpret the solutions to solve industrial problems. (K2)
CO2	Make use of transportation and assignment techniques for optimization.(K3)
CO3	Use critical path analysis and programming evaluation review techniques to complete the project at minimum cost in short duration. (K3)
CO4	Utilize Inventory models to optimize the inventory cost in business problems. (K3)
CO5	Construct the Game model and replacement model for enhancing operational efficiency. (K3)
CO6	Calculate steady state system performance characteristics for Queuing Models. (K2)

1702ME501 HEAT AND MASS TRANSFER

UNIT I CONDUCTION 12

Basic Concepts – Mechanism of Heat Transfer – Conduction, Convection and Radiation – Fourier Law of Conduction - General Differential equation of Heat Conduction — Cartesian and Cylindrical Coordinates – One Dimensional Steady State Heat Conduction – Conduction through Plane Wall, Cylinders and Spherical systems – Composite Systems – Conduction with Internal Heat Generation – Extended Surfaces – Unsteady Heat Conduction – Lumped Analysis – Use of Heislers Chart.

UNIT II CONVECTION 12

Basic Concepts –Heat Transfer Coefficients – Boundary Layer Concept – Types of Convection – Forced Convection – Dimensional Analysis – External Flow – Flow over Plates, Cylinders and Spheres – Internal Flow – Laminar and Turbulent Flow – Combined Laminar and Turbulent – Flow over Bank of tubes – Free Convection – Dimensional Analysis – Flow over Vertical Plate, Horizontal Plate, Inclined Plate, Cylinders and Spheres.

UNIT III PHASE CHANGE HEAT TRANSFER AND HEAT EXCHANGERS

12

Nusselts theory of condensation-pool boiling, flow boiling, correlations in boiling and condensation. Types of Heat Exchangers – Heat Exchanger Analysis – LMTD Method and NTU - Effectiveness – Overall Heat Transfer Coefficient – Fouling Factors.

UNIT IV RADIATION

12

Basic Concepts, Laws of Radiation – Stefan Boltzman Law, Kirchoffs Law –Black Body Radiation –Grey body radiation -Shape Factor Algebra – Electrical Analogy – Radiation Shields

UNIT V MASS TRANSFER 12

Basic Concepts – Diffusion Mass Transfer – Fick's Law of Diffusion – Steady state Molecular Diffusion – Convective Mass Transfer – Momentum, Heat and Mass Transfer Analogy – Convective Mass Transfer Correlations

Text / Reference Books

Sl. No.	Title of the Book	Author(s)	Publisher
TEXT BOOKS			
T1	Fundamentals of Engineering Heat and Mass Transfer	Sachdeva R C.	New Age International, 1995.
T2	"Fundamentals of Heat and Mass Transfer		McGraw-Hill Book Co., 1994
REFERENCES			
R1	Heat and Mass Transfer	. Yadav R	Central Publishing House, 1995
R2	Heat Transfer	Ozisik M.N	McGraw-Hill Book Co., 1994

After successful completion of the course, students will be able to

	Competency	Cognitive level
CO1	Calculate heat transfer rate in steady and unsteady state of heat conduction.	K3
CO2	Calculate convective heat transfer rate for external and internal flow.	K3
CO3	Determine heat transfer rate for boiling and condensation process and heat exchangers.	K3
CO4	Calculate the emissivity and radiation heat transfer .	K3
CO5	Estimate mass transfer rate for diffusive mass transfer.	K2
CO6	Estimate mass transfer rate for convective mass transfer.	K2

1702ME502 COMPUTER AIDED DESIGN L T P C
3 0 0 3

UNIT I FUNDAMENTALS OF COMPUTER GRAPHICS 9

Product cycle, Sequential and Concurrent Engineering, CAD - Architecture, Tools, applications - Coordinate systems - Two and Three Dimensional Transformations - Translation - Scaling - Rotation, Windowing - clipping and Viewing.

UNIT II GEOMETRIC MODELING 9

Representation of curves - Hermite, Bezier, B-Spline and rational curves - Surface Modeling - surface patch - Bezier and B spline surface. Solid Modelling - Boundary representation and Constructive Solid Geometry.

UNIT III VISUAL REALISM 9

Hidden line removal algorithm - Priority and Area oriented algorithms. Hidden Surface removal algorithm - Depth buffer and Warnock's algorithms. Hidden solid removal algorithm, Ray Tracing algorithm, Shading and Coloring - types.

UNIT IV ASSEMBLY OF PARTS 9

Assembly modeling - Interference of Positions and orientations - CAD Tolerance Analysis - geometrical Mass Properties - degree of freedom - Constraints and Simulation concepts.

UNIT V DATA EXCHANGE FORMATS 9

Database Management System - CAD Standards File types - IGES, PDES, Database – Structures - Types, STEP Files. Communication Standards - File Transfer between CAD and CAM package.

TOTAL: 45 Periods

Comp	Competency	Cognitive level
CO1	Use various concepts of CAD, computer graphics and transformations.	Apply
CO2	Prepare various geometric models using curves, surfaces and solids.	Apply
CO3	Use various visual realism methods (shading, colouring and animation).	Apply
CO4	Do assembly modeling and tolerance analysis.	Apply
CO5	Use various computer graphics standards.	Apply
CO6	Use various Data Exchange Formats.	Apply

Text / Reference Books

Sl. No.	Title of the Book	Author(s)	Publisher
TEXT BOOKS			
T1	"Mastering CAD/CAM"	Ibrahim Zeid,	Tata McGraw- Hill, 2008.
T2	"Computer Graphics",	Amarendra N Sinha and Arun D Udai,	second reprint, Tata McGraw Hill Education (P) Ltd., 2009.
REFERENCES			
R1	Geometric Modeling	Michael E. Mortenson,	Third edition, Industrial Press, 2006.
R2	Mathematical Elements for computer Graphics	Rogers,	Tata Mcgraw Hill Education Private Limited, 2009.
R3	"Computer Graphics: A Practical Approach, Concepts, Principles, Case Studies"	Rajiv Chopra,	First Edition, S.Chand and Company Ltd., 2011.
REFERENCE WEBSITES			
1	http://nptel.ac.in/courses/Webcoursecontents/IITDelhi/Computer%20Aided%20Design%20&%20ManufacturingI/index.htm		
2	http://ocw.mit.edu/courses/mechanical-engineering/2- 158j-computational-geometry-spring-2003/calendar/		

1702ME503		DESIGN OF TRANSMISSION SYSTEMS	L	T	P	C
			3	2	0	4

UNIT I	DESIGN OF FLEXIBLE ELEMENTS (12)	
Design of Flat belts and pulleys - Selection of V belts and pulleys – Selection of hoisting wire ropes and pulleys – Design of Transmission chains and Sprockets.		
UNIT II	**SPUR GEARS AND PARALLEL AXIS HELICAL GEARS (12)**	
Speed ratios and number of teeth-Force analysis -Tooth stresses - Dynamic effects – Fatigue strength - Factor of safety - Gear materials – Design of straight tooth spur & helical gears based on strength and wear considerations – Pressure angle in the normal and transverse plane- Equivalent number of teeth-forces for helical gears		
UNIT III	**BEVEL, WORM AND CROSS HELICAL GEARS (12)**	
Straight bevel gear: Tooth terminology, tooth forces and stresses, equivalent number of teeth. Estimating the dimensions of pair of straight bevel gears. Worm Gear: Merits and demerits- terminology. Thermal capacity, materials-forces and stresses, efficiency, estimating the size of the worm gear pair. Cross helical: Terminology-helix angles-Estimating the size of the pair of cross helical gears.		
UNIT IV	**GEAR BOXES (12)**	
Geometric progression - Standard step ratio - Ray diagram, kinematics layout -Design of sliding mesh gear box - Design of multi speed gear box for machine tool applications - Constant mesh gear box - Speed reducer unit. – Variable speed gear box, Fluid Couplings, Torque Converters for automotive applications.		
UNIT V	**CAMS, CLUTCHES AND BRAKES (12)**	
Cam Design: Types-pressure angle and under cutting base circle determination-forces and surface stresses. Design of plate clutches –axial clutches-cone clutches-internal expanding rim clutches- Electromagnetic clutches. Band and Block brakes - external shoe brakes – Internal expanding shoe brake.		
FOR FURTHER READING – SEMINAR – CPS	**Total:**	**60 Hrs**

Reference(s)

1. Bhandari V, “Design of Machine Elements”, 3rd Edition, Tata McGraw-Hill Book Co, 2010.
2. Joseph Shigley, Charles Mischke, Richard Budynas and Keith Nisbett “Mechanical Engineering Design”, 8th Edition, Tata McGraw-Hill, 2008.
3. Prabhu. T.J., “Design of Transmission Elements”, Mani Offset, Chennai, 2000.
4. C.S.Sharma, Kamlesh Purohit, “Design of Machine Elements”, Prentice Hall of India, Pvt. Ltd., 2003.
5. Bernard Hamrock, Steven Schmid, Bo Jacobson, “Fundamentals of Machine Elements”, 2nd Edition, Tata McGraw-Hill Book Co., 2006.
6. http://nptel.ac.in/courses/108102047/

COURSE OUTCOMES:

	Competency	**Cognitive level**
CO1	Design the belt drives (flat belt, V- belt), chain drive, rope drives, belt drive, pulleys and chain sprockets.	K3
CO2	Solve the problem of spur and straight helical gear based on strength and wear consideration.	K3
CO3	Solve the problem of bevel and worm gear based on strength and wear consideration.	K3
CO4	Construct the various gear boxes (sliding mesh, constant mesh, multispeed) through geometric progression, standard step ratio, ray diagram, kinematics layout.	K3
CO5	Design of cam using basic knowledge acquired earlier studies.	K3
CO6	Design of Clutches and internal - external shoe brakes from using basic knowledge acquired earlier studies.	K3

K1-Remember K2- Understanding K3-Apply K4-Analyze K5-Evaluate K6-Create

1703ME001 NON - TRADITIONAL MACHINING PROCESSES

UNIT I INTRODUCTION

Introduction - Need - Classification - Energies employed in the processes - Brief overview of Abrasive jet machining(AJM), Water jet machining(WJM), Ultrasonic machining(USM), Electric discharge machining(EDM), Electro-chemical machining(ECM), Electron beam machining(EBM), Laser beam machining(LBM), Plasma arc machining(PAM).

UNIT II MECHANICAL ENERGY BASED PROCESSES

Abrasive Jet Machining, Water Jet Machining and Ultrasonic Machining - Working Principles, Equipment, Process parameters, Material removal rate, Applications

UNIT III ELECTRICAL ENERGY BASED PROCESSES

Hours Electric Discharge Machining - Working Principles, Equipment, Process Parameters, Material removal rate, Electrode / Tool, Power Circuits, Tool Wear, Dielectric, Flushing, Wire cut EDM - Applications.

UNIT IV CHEMICAL AND ELECTRO-CHEMICAL ENERGY BASED PROCESSES

Chemical machining - Etchants, Maskants - techniques. Electro-chemical machining - Working principle, Equipment, Process Parameters, Material removal rate, Electrical circuit. Electro-chemical grinding - Electro-chemical honing - Applications.

UNIT V THERMAL ENERGY BASED PROCESSES

Laser Beam machining, Plasma Arc Machining - Principles, Equipment. Electron Beam Machining - Principles, Equipment, Types, Beam control techniques, Material removal rate - Applications.

FOR FURTHER READING/SEMINAR/CBS

Abrasive water jet machining, Electric discharge grinding and drilling, Electro-stream drilling, Electro-chemical deburring. Mechanical Contour machining, Whirling jet machining. Ion beam machining and Hot chlorine machining

REFERENCES:

1. P. K. Mishra, Non Conventional Machining, Narosa Publishing House, New Delhi, 2007.
2. P. C. Pandey and H.S. Shan, Modern Machining Processes, Tata McGraw Hill Publishing Company Pvt Ltd., New Delhi, 2008.
3. Joao Paulo Davim, Nontraditional Machining Processes: Research Advances, Springer, New York,2013.

After completion of the course students will be able to

	Competency	**Cognitive level**
CO1	Explain the basics and needs of NTM	K2
CO2	Describe mechanical energy based machining process	K2
CO3	Elaborate electrical energy based machining process	K2
CO4	Describe chemical and electro chemical energy based machining process	K2
CO5	Explain thermal energy based machining process	K2
CO6	Explain the recent trends in non traditional maching process	K2

1703ME006 WELDING TECHNOLOGY

L	T	P	C
3	0	0	3

Course Objectives

- To study working principle of gas and arc welding processes.
- To provide knowledge on resistance welding processes.
- To study working of solid state welding processes.
- To introduce the special welding processes.
- To learn about the design of welding joints and testing of weldments.

UNIT I GAS AND ARC WELDING PROCESSES: 9 Hours

Fundamental principles – Air Acetylene welding, Oxyacetylene welding, Carbon arc welding, Shielded metal arc welding, Submerged arc welding, TIG & MIG welding, Plasma arc welding and Electroslag welding processes - advantages, limitations and applications.

UNIT II RESISTANCE WELDING PROCESSES: 9 Hours

Spot welding, Seam welding, Projection welding, Resistance Butt welding, Flash Butt welding, Percussion welding and High frequency resistance welding processes - advantages, limitations and applications.

UNIT III SOLID STATE WELDING PROCESSES: 9 Hours

Cold welding, Diffusion bonding, Explosive welding, Ultrasonic welding, Friction welding, Forge welding, Roll welding and Hot pressure welding processes - advantages, limitations and applications.

UNIT IV OTHER WELDING PROCESSES: 9 Hours

Thermit welding, Atomic hydrogen welding, Electron beam welding, Laser Beam welding, Friction stir welding, Under Water welding, Welding automation in aerospace, nuclear and surface transport vehicles.

UNIT V DESIGN OF WELD JOINTS, WELDABILITY AND TESTING OF WELDMENTS 9 Hours

Various weld joint designs – Welding defects – causes and remedies - Weldability of Aluminium, Copper, and Stainless steels. Destructive and non destructive testing of weldments.

FOR FURTHER READING – SEMINAR – CPS Total: 45 Hours

Case studies- Application of underwater welding and explosive welding.

Course Outcome

Co1: Do Various Gas and Arc Welding Processes.

Co2: Do Various Resistance Welding Processes.

Co3: Do Solid State Welding Processes.

Co4: Do Special Welding Processes.

Co5: Describe Weld ability, Design of weld joints

Co6: Describe the Testing of Weldments

Reference(s)

1. Little R.L., “Welding and welding Technology”, Tata McGraw Hill Publishing Co., Ltd., New Delhi, 34th reprint, 2008.
2. R. S. Parmer, Welding Processes & Technology, Khanna Publishers, New Delhi, 2008.
3. O. P. Khanna, A text book of Welding Technology, Dhanpatrai publications, Second Edition - New Delhi, 2002.
4. Metals Hand Book, Volume 6, American Society for Metals, 2005.
5. Sindokou, Welding metallurgy, A Jhon wiley & sons,Inc. Publication, Second Edition-New Jersey, 2003.
6. www.weldingtypes.net .

1702ME551 HEAT TRANSFER LABORATORY

L	T	P	C
0	0	2	1

LIST OF EXPERIMENTS:

1. Determination of thermal conductivity of insulating powder. **4 Hours**
2. Determination of thermal conductivity of guarded hot plate. **4 Hours**
3. Determination of thermal conductivity of materials in lagged pipe. **4 Hours**
4. Determination of heat transfer co-efficient through composite wall. **2 Hours**
5. Determination of heat transfer co-efficient by natural convection. **2 Hours**
6. Determination of heat transfer co-efficient by forced convection. **2 Hours**
7. Determination of heat transfer co-efficient in a parallel and counter flow heat exchanger. **2 Hours**
8. Determination of heat transfer co-efficient and effectiveness from Pin-Fin by natural convection. **2 Hours**
9. Determination of heat transfer co-efficient and effectiveness from Pin-Fin by forced convection. **2 Hours**
10. Determination of Stefan-Boltzmann constant. **2 Hours**
11. Determination of emissivity using emissivity apparatus. **2 Hours**
12. Determination of performance in a fluidized bed cooling tower **2 Hours**

Total: 30 Hours

At the end of the course students will be able to

	Competency	Cognitive level
CO1	Measure the heat transfer phenomena predict the relevant coefficient.	Applying
CO2	Experiment with mechanisms of heat transfer under steady and transient conditions.	Applying
CO3	Make use of thermal analysis and sizing of heat exchangers and also understand the basic Concepts of mass transfer.	Applying
CO4	Do experimentation heat exchanger, conduction heat transfer apparatus.	Applying
CO5	Do experimentation heat exchanger, convection and radiation heat transfer apparatus.	Applying
CO6	Perform the concepts and to design of heat transfer through extended surfaces.	Applying

1702ME552 COMPUTER AIDED DESIGN LABORATORY

L	T	P	C
3	2	0	4

3D GEOMETRIC MODELLING

List of Experiments

1. Introduction of 3D Modelling software
2. Create the part model of mechanical components

Creation of 3D assembly model of following machine elements using 3D Modelling software

1. Flange Coupling
2. Plummer Block
3. Screw Jack
4. Universal Joint
5. Machine Vice
6. Stuffing box
7. Safety Valves
8. Non-return valves
9. Connecting rod
10. Piston
11. Crankshaft

* Students may also be trained in manual drawing of some of the above components

Total: 30 Hours

Course Outcomes (COs):

After successful completion of the course, the students will be able to

	Competency	Cognitive level
CO1	Prepare the 3D assembly model of flange coupling and Plumber block	Apply
CO2	Prepare the 3D assembly model of screw jack and universal joint.	Apply
CO3	Prepare the 3D assembly model of machine vice and stuffing box	Apply
CO4	Prepare the 3D assembly model of safety valve and non return valve.	Apply
CO5	Prepare the 3D assembly model of connecting rod and piston.	Apply
CO6	Prepare the 3D assembly model of crank shaft.	Apply

1704GE551	LIFE SKILLS: APTITUDE – I	L	T	P	C
		0	0	2	1

PREREQUISITE :

Technical English – I and II

COURSE OBJECTIVES:

1. To brush up problem solving skill and to improve intellectual skill of the students
2. TobeabletocriticallyevaluatevariousreallifesituationsbyresortingtoAnalysisOf key issues and factors
3. To be able to demonstrate various principles involved in solving mathematical problems And thereby reducing the time taken for performing job functions.
4. To enhance analytical ability of students
5. To augment logical and critical thinking of Student

COURSE OUTCOMES:

After completion of the course, Student will be able to

CO 1 - Understand about number system.

CO2 - Gather information about ratio and proportion, averages

CO3 - Discuss about percentages, profit and loss

CO4 –Describe about coding and decoding, direction sense

CO5 – Understand the number and letter series number

UNIT I INTRODUCTION TO NUMBER SYSTEM, BASIC SHORTCUTS OF ADDITION, MULTIPLICATION,DIVISION **6 Hours**

Classification of numbers – Types of Numbers - Divisibility rules - Finding the units digit - Finding remainders in divisions involving higher powers - LCM and HCF Models - Fractions and Digits – Square, Square roots – Cube, Cube roots – Shortcuts of addition, multiplication, Division.

UNIT II RATIO AND PROPORTION, AVERAGES **6 Hours**

Definition of Ratio - Properties of Ratios - Comparison of Ratios - Problems on Ratios - Compound Ratio - Problems on Proportion, Mean proportional and Continued Proportion Definition of Average - Rules of Average - Problems on Average - Problems on Weighted Average - Finding average using assumed mean Method.

UNIT III PERCENTAGES, PROFIT AND LOSS **6 Hours**

Introduction Percentage - Converting a percentage into decimals - Converting a Decimal into a percentage - Percentage equivalent of fractions - Problems on percentages - Problems on Profit and Loss percentage- Relation between Cost Price and Selling price - Discount and Marked Price - Two different articles sold at same Cost Price - Two different articles sold at same Selling Price - Gain% / Loss% on Selling Price.

UNIT IV CODING AND DECODING, DIRECTION SENSE **6 Hours**

Coding using same set of letters - Coding using different set of letters - Coding into a number - Problems on R-model - Solving problems by drawing the paths - Finding the net distance travelled - Finding the direction - Problems on clocks - Problems on shadows - Problems on direction sense using symbols and Notations.

UNIT V NUMBER AND LETTER SERIES NUMBER AND LETTER ANALOGIES, ODD MAN OUT **6 Hours**

Difference series - Product series - Squares series - Cubes series - Alternate series - Combination series - Miscellaneous series - Place values of letters - Definition of Analogy - Problems on number analogy - Problems on letter analogy - Problems on verbal analogy - Problems on number Odd man out - Problems on letter Odd man out - Problems on verbal Odd man out

Total: 30 Hours

REFERENCES:

1. ArunSharma,„HowtoPrepareforQuantitativeAptitudefortheCAT‟,7th edition,McGrawHills publication,2016.
2. Arun Sharma, „How to Prepare for Logical Reasoning for CAT‟, 4th edition, McGraw Hills publication,2017.
3. R S Agarwal, „A modern approach to Logical reasoning‟, revised edition, S. Chand publication, 2017.
4. RSAgarwal,QuantitativeAptitudeforCompetitiveExaminations‟revisededition,S.Chand publication, 2017.
5. Rajesh Verma, "Fast Track Objective Arithmetic", 3rd edition, Arihant publication,2018.
6. B.S. Sijwalii and InduSijwali, "A New Approach to REASONING Verbal & Non-Verbal", 2nd edition, Arihnat publication,2014.