INSTITUTE OF AERONAUTICAL ENGINEERING

(Autonomous)

Dundigal, Hyderabad - 500 043

AERONAUTICAL ENGINEERING

COURSE DESCRIPTION FORM

Course Title	**AERODYNAMICS – II**			
Course Code	**A52107**			
Regulation	**R15-JNTUH**			
Course Structure	**Lectures**	**Tutorials**	**Practical's**	**Credits**
	4	-	-	4
Course Coordinator	Mr. N V Raghavendra, Associate Professor			
Team of Instructors	Mr. N V Raghavendra, Associate Professor, Ms. Farheen Sana, Associate Professor			

I. COURSE OVERVIEW

Aerodynamic is the study of the flow of air about a body. In this case, the body will be an airplane. It gives a complete picture of the aerodynamic forces behavior of the airplane. Aerodynamics extends fluid mechanic concepts to the aerodynamic performance of wings and bodies in sub/supersonic regimes. Aerodynamics-II is a basic course that deals with the flow characteristics subjected to various types of force problems, usually the objectives of aerodynamic force analysis are the determination of the lift, drag, thrust and weight produced by wing surfaces. Classroom lectures are supplemented with physical demonstrations. The course includes a laboratory where students have an opportunity to build an appreciation for the phenomenon being discussed in lecture. The course has four components: (i) thermodynamics in fluid motion (ii) one dimensional flows; (iii) oblique shock and expansion waves; (iv) supersonic flow regimes.

II. PREREQUISITE(S)

Level	Credits	Periods	Prerequisite
UG	4	5	Knowledge of basic physics, fluid mechanics & engineering mechanics

III. MARKS DISTRIBUTION

Sessional Marks	University End Exam Marks	Total Marks
Mid Semester Test There shall be two midterm examinations. Each midterm examination consists of subjective type and objective type tests. The subjective test is for 10 marks of 60 minutes duration. Subjective test of shall contain 4 questions; the student has to answer 2 questions, each carrying 5 marks. The objective type test is for 10 marks of 20 minutes duration. It consists of 10 Multiple choice and 10 objective type questions, the student has to answer all the questions and each carries half mark. First midterm examination shall be conducted for the first two and half units of syllabus and second midterm examination shall be conducted for the remaining portion.	75	100

Assignment Five marks are marked for assignments. There shall be two assignments in every theory course. Marks shall be awarded considering the average of two assignments in each course		

IV. EVALUATION SCHEME

S No	Component	Duration	Marks
1	I Mid examination	80 minutes	20
2	I Assignment	--	05
3	II Mid examination	80 minutes	20
4	II Assignment	--	05
5	External examination	3 hours	75

V. COURSE OBJECTIVES:

I. **Discuss** and revise the basic thermodynamics concepts.
II. **Understand** the characteristics of quasi one-dimensional compressible flows through nozzles. in subsonic and supersonic regimes.
III. A**nalyze** how the aerodynamics affects the aircraft design and operation.
IV. **Knowledge** of oblique shock waves and expansion waves.
V. **Understand** one dimensional inviscid compressible flows.
VI. **Knowledge** of flow in transonic regime.
VII. **Discuss** the effect of presence of airfoil, wing and cone section in supersonic flows.

VI. COURSE OUTCOMES

At the end of the course the students are able to:

1. **Apply** knowledge and understand the essential facts, concepts and principles of thermodynamics.
2. **Apply** the basic knowledge in mathematics, science and engineering.
3. **Apply** the basic knowledge to design a mathematical system or a Mechanical system or a process that meets desired specifications and requirements.
4. **Analyze** the characteristics of quasi one-dimensional flows through nozzles.
5. **Analyze** how the aerodynamics affects the aircraft design and operation
6. **Analyze** the concept of oblique shock waves and expansion waves.
7. **Evaluate** the one dimensional inviscid compressible flows.
8. **Analyze** flow in transonic regime.
9. **Analyze** the effect of presence of airfoil, wing and cone section in supersonic flows.

VII. HOW PROGRAM OUTCOMES ARE ASSESSED

Program outcomes		Level	Proficiency assessed by
PO1	**General knowledge:** An ability to apply the knowledge of mathematics, science and Engineering for solving multifaceted issues of Aeronautical Engineering	H	Exercises
PO2	**Problem Analysis**: An ability to communicate effectively and to prepare formal technical plans leading to solutions and detailed reports for Aeronautical systems	H	Assignments
PO3	**Design/Development of solutions**: To develop Broad theoretical knowledge in Aeronautical Engineering and learn the methods of applying them to identify, formulate and solve practical problems involving Aerodynamics	S	Exercises

PO4	**Conduct investigations of complex problems**: An ability to apply the techniques of using appropriate technologies to investigate, analyze, design, simulate and/or fabricate/commission complete systems involving complex aerodynamics flow situations.	H	
PO5	**Modern tool usage**: An ability to model real life problems using different hardware and software platforms, both offline and real-time with the help of various tools along with upgraded versions.	S	Assignments
PO6	**The engineer and society**: An Ability to design and fabricate modules, control systems and relevant processes to meet desired performance needs, within realistic constraints for social needs		Exercises
PO7	**Environment and sustainability**: An ability To estimate the feasibility, applicability, optimality and future scope of power networks and apparatus for design of eco-friendly with sustainability		Exams, Discussions
PO8	**Ethics**: To Possess an appreciation of professional, societal, environmental and ethical issues and proper use of renewable resources		Exercises
PO9	**Individual and team work**: An Ability to design schemes involving signal sensing and processing leading to decision making for real time Aeronautical systems and processes at individual and team levels.	S	Assignments
PO10	**Communication**: an Ability to work in a team and comprehend his/her scope of work, deliverables, issues and be able to communicate both in verbal, written for effective technical presentation	S	Exercises
PO11	**Project management and finance**: To be familiar with project management problems and basic financial principles for a multi-disciplinary work		Assignments
PO12	**Life-long learning**: An ability to align with and upgrade to higher learning and research activities along with engaging in life-long learning.	H	Exercises

S – Supportive **H – Highly Related**

VIII. HOW PROGRAM SPECIFIC OUTCOMES ARE ASSESSED

Program Specific Outcomes		Level	Proficiency assessed by
PSO1	**Professional skills:** Able to utilize the knowledge of aeronautical/aerospace engineering in innovative, dynamic and challenging environment for design and development of new products	H	Lectures, Assignments
PSO2	**Problem solving skills:** imparted through simulation language skills and general purpose CAE packages to solve practical, design and analysis problems of components to complete the challenge of airworthiness for flight vehicles	S	Tutorials
PSO3	**Practical implementation and testing skills:** Providing different types of in house and training and industry practice to fabricate and test and develop the products with more innovative technologies	S	Seminars and Projects
PSO4	**Successful career and entrepreneurship:** To prepare the students with broad aerospace knowledge to design and develop systems and subsystems of aerospace and allied systems and become technocrats		

S – Supportive **H – Highly Related**

IX. SYLLABUS

Unit I

Thermodynamics in Fluid motion:

Definition of compressibility of flow, measure, flow regimes. Review of thermodynamics –concept of equilibrium, thermodynamic systems, variables of state, the first law of thermodynamics, Reversible & Irreversible processes, Perfect gases, internal energy and enthalpy, specific heats, adiabatic reversible process, relations for thermally & calorically perfect gas, First law applied to irreversible processes, the throttling process or Joule-Thompson process(considered most important for application to fluid mechanics), Entropy and second law, Entropy change relations, isentropic relations.

Unit II

One Dimensional Flows:

One dimensional approximation, continuity equation for 1-D flows, Energy equation – incorporation of kinetic energy in Joule-Thompson process, reservoir conditions, 1-D momentum equation for inviscid flow, Bernoulli equation for compressible flow, Mach number, 1-D area velocity relation, convergent divergent channel and throat, relations between stagnation pressure/density and mach number, local reservoir and actual reservoir, sonic variables and reservoir variables, different forms of energy equation, constant area duct as a special case of 1-D flow, continuity and momentum equations for constant area ducts, experimental flow visualization of a bluff body in a supersonic flow and picture of a normal shock constant area ducts formed but streamlines entering and leaving perpendicular to the shock, Normal shock waves: basic equations, relations across a normal shock, calculation of normal shock wave properties, measurement of air speed in compressible subsonic and supersonic flows, entropy rise across normal shock and its relation to pressure rise, numerical exercises with normal shock tables.

Unit - III

Oblique Shock And Expansion Waves:

Oblique shock relations, supersonic flow over wedges with attached shock, large wedge angle and shock detachment, oblique shock charts: strong shock and weak shock boundary, pressure, density and entropy rise, oblique shock of vanishing strength and mach wave, mach line, mach angle, supersonic compression by turning, smooth nearly isentropic turn, numerical exercises with oblique shock charts, regular reflection from solid wall, pressure deflection diagrams, phenomenological description of shock boundary layer interaction at the wall, intersection of shocks, mach reflection and slip stream. Numerical exercises with shock reflection and shock intersection, detached shock wave in front of a bluff 2-D body-variation of its strength starting from normal shock, strong oblique shock, weak oblique shock to mach wave, shock wave in front of a 3-d body (phenomenological description only), supersonic expansion by turning, Prandtl-Meyer function and expansion fan, shock expansion theory-application to supersonic aerofoils. Supersonic flows-over a flat plate at angle of attack, over a diamond aerofoil at angle of attack, determination of the slip stream angle, wave drag and lift, numerical exercises with Prandtl-Meyer function tables. Numerical exercises determining shock expansion slip stream configuration and force calculation on aerofoils.

Unit – IV

More One Dimensional Flows And Subsonic And Transonic Airfoils:

Adiabatic flow in straight, variable area channels- nozzles, diffusers. Governing equations, area-velocity relation. Mass flow rate, effect of stagnation conditions, back pressure. Choked flow- isentropic flow, ideally expanded, over-expanded, under-expanded flows- appearance of normal shock- flow losses. Wave reflection from free boundary, brief outline of operation of supersonic wind tunnels employing convergent-divergent nozzles, 1-D piston motion in a constant area tube, jump start, propogation of shock wave in front and expansion wave behind, x-t diagram, particle velocity, pressure density and temperature relations.

SUBSONIC FLOW: The velocity potential, perturbation potential, linearised governing equation in 2-D, The pressure coefficient-Prandtl-Glauert compressibility correction, application to swept wings, critical Mach no., drag divergence Mach no.

TRANSONIC FLOW: the sound barrier. Supercritical airfoils, swept wings at transonic speeds, second order equation for transonic flow, wing-body combinations, Whitcomb’s, transonic area rule, application to transonic aircraft.

Unit -V: Airfoil, Wing and Cone in Supersonic Flow: Point mass in stationary air moving in subsonic speed and moving in supersonic speed and propagation of wave front, in supersonic case influence zone limited within mach lines/wave /cones, principle of limited upstream influence in supersonic flow, brief outline of method of characteristics-statement (without proof) of compatibility relations, application to supersonic nozzle design.

Linearized supersonic flow-governing equations, boundary conditions. Pressure coefficient, application to supersonic airfoils. Lift, drag, pitching moment. Wedge, flat plate, diamond and biconvex aerofoils at small angle of attack.

Air loads over flat rectangular wings of finite span, Delta wing with supersonic leading edge and subsonic leading edge, Cone at zero angle of attack with attached conical shock: Limited upstream influence in supersonic flow-comparison of finite cone and semi-infinite cone, dimensional analysis and dimensionless conical variable, ordinary differential equation for conical flow, mention of availability of computed solution, how to use the standard computed chart, comparison of pressure rise for wedge and cone of equal semi-angle.

Qualitative aspects of hypersonic flow, Newtonian flow model: windward surface and Lee surface, Lift and drag of flat plate wings at hypersonic speeds.

TEXT BOOKS:

1. Liepmann, H.W., and Roshko, A., "Elements of Gas Dynamics", John Wiley, 1957
2. Bertin, J.J., "Aerodynamics for Engineers", 4th edn., Indian reprint, Pearson Education, ISBN: 81-297-0486-2, 2004
3. Radhakrishnan E., "Gas Dynamics", Prentice-Hall of India.
4. Anderson, J.D., "Modern Compressible Flow with Historical Perspective", 3rd edn., McGraw-Hill, ISBN: 0- 07-112161-7, 2003

REFERENCES:

1. McCormick, B.W., "*Aerodynamics, Aeronautics & Flight Mechanics*", 2nd edn., John Wiley, ISBN: 0-471-57506-2, 1995
2. Shapiro, A.H., "*The Dynamics and Thermodynamics of Compressible Fluid Flow*", *Vols. I and II*, John Wiley, 1953.
3. Landau, L.D., &Lifshitz, E.M., "*Fluid Mechanics*", 2nd edn., Course of Theoretical Physics, vol. 6, Maxwell Macmillan International Edition, Pergamon, ISBN: 0-02-946234-7, 1989

X. COURSE PLAN:

The course plan is meant as a guideline. There may probably be changes.

Lecture No	Course Learning Outcomes	Topics to be covered	Reference
1	**Explain** basic concept of thermodynamics	**UNIT– I - Thermodynamics in Fluid motion**	T1.1
2	**Define** compressibility of flow	Definition of compressibility of flow	T1.1
3	**Define** measure, flow regimes	Measure, flow regimes	T1.1
4	**Discuss** concept of equilibrium, thermodynamic systems, variables of state	Review of thermodynamics –concept of equilibrium, thermodynamic systems, variables of state	T1.1
5	**Discuss** the first law of thermodynamics, Reversible & Irreversible processes	The first law of thermodynamics, Reversible & Irreversible processes	T1.1
6	**Define** perfect gases, internal energy and enthalpy	Perfect gases, internal energy and enthalpy	T2.2
7	**Discuss** Specific heats, adiabatic reversible process,	Specific heats, adiabatic reversible process	T2.2
8	**Derive** relations for thermally & calorically perfect gas	Relations for thermally & calorically perfect gas	T2.2
9	**Define** first law applied to irreversible processes	First law applied to irreversible processes	T2.2
10	**Discuss** the throttling process or Joule-Thompson process	The throttling process or Joule-Thompson process(considered most important for application to fluid mechanics)	T1.17
11	**Discuss** Entropy and second law	Entropy and second law	T1.17
12	**Explain** Entropy change relations	Entropy change relations	T1.17

13	**Justify** the isentropic relations	isentropic relations	T1.17
14	**Discuss** One dimensional approximation, continuity equation for 1-D flows	**Unit II – One Dimensional Flows:** One dimensional approximation, continuity equation for 1-D flows	T1.2
15	**Discuss** Energy equation – incorporation of kinetic energy in Joule-Thompson process,	Energy equation – incorporation of kinetic energy in Joule-Thompson process	T1.4
16	**Explain** Reservoir conditions, 1-D momentum equation for inviscid flow	Reservoir conditions, 1-D momentum equation for inviscid flow	T1.2
17	**Derive** Bernoulli equation for compressible flow	Bernoulli equation for compressible flow	T1.3
18	**Explain** Mach number, 1-D area velocity relation	Mach number, 1-D area velocity relation,	T1.3
19	**Explain** convergent divergent channel and throat	convergent divergent channel and throat	T1.3
20	**Discuss and analyze** Local reservoir and actual reservoir	Local reservoir and actual reservoir	T1.3
21	**Discuss and analyze** Sonic variables and reservoir variables	Sonic variables and reservoir variables	T1.3
22	**Analyze** different forms of energy equation	Different forms of energy equation,	T1.3
23	**Discuss** constant area duct as a special case of 1-D flow	Constant area duct as a special case of 1-D flow	T1.3
24-25	**Explain** continuity and momentum equations for constant area ducts	Continuity and momentum equations for constant area ducts	T1.3
26	**Discuss** the experimental flow visualization of a bluff body in a supersonic flow	Experimental flow visualization of a bluff body in a supersonic flow	T1.3
27	**Explain** picture of a normal shock - constant area ducts formed by streamlines entering and leaving perpendicular to the shock	Picture of a normal shock - constant area ducts formed by streamlines entering and leaving perpendicular to the shock	T1.3
28-29	**Define** Normal shock waves: basic equations, relations across a normal shock	Normal shock waves: basic equations, relations across a normal shock	T1.4
30	**Explain** calculation of normal shock wave properties	Calculation of normal shock wave properties	T1.4
31	**Discuss** the measurement of air speed in compressible subsonic and supersonic flows	Measurement of air speed in compressible subsonic and supersonic flows	T1.4
32	**Resolve** the entropy rise across normal shock and its relation to pressure rise	Entropy rise across normal shock and its relation to pressure rise	T1.4
33	**Discuss** numerical exercises with normal shock tables	Numerical exercises with normal shock tables	T1.4
34	**Explain** Oblique shock relations, pressure, density and entropy rise	**UNIT– III - Oblique Shock And Expansion Waves:** Oblique shock relations, pressure, density and entropy rise	T1.17
35	**Define** supersonic flow over wedges with attached shock	Supersonic flow over wedges with attached shock,	T1.17
36	**Explain** Large wedge angle and shock detachment	Large wedge angle and shock detachment	T1.17
37-38	**Discuss** Oblique shock charts: strong shock and weak shock boundary	Oblique shock charts: strong shock and weak shock boundary	T2.4
39	**Discuss** the oblique shock of vanishing strength and mach wave, mach line, mach angle	Oblique shock of vanishing strength and mach wave, mach line, mach angle	T2.4
40	**Discuss** the supersonic compression by turning, smooth nearly isentropic turn	Supersonic compression by turning, smooth nearly isentropic turn	T2.4
41	**Discuss** numerical exercises with oblique shock charts, regular reflection from solid wall, pressure deflection diagrams ,	Numerical exercises with oblique shock charts, regular reflection from solid wall, pressure deflection diagrams	T2.4

42	**Describe** phenomenological description of shock boundary layer interaction at the wall	Phenomenological description of shock boundary layer interaction at the wall	T2.4
43	**Discuss** the importance and effects of surface roughness for internal and external flows	Intersection of shocks, mach reflection and slip stream	T2.4
44	**Discuss** Numerical exercises with shock reflection and shock intersection	Numerical exercises with shock reflection and shock intersection	T2.4
45	**Explain** Detached shock wave in front of a bluff 2-D body- variation of its strength starting from normal shock	Detached shock wave in front of a bluff 2-D body- variation of its strength starting from normal shock	T2.4
46	**Derive** Strong oblique shock, weak oblique shock to mach wave	Strong oblique shock, weak oblique shock to mach wave,	T2.4
47	**Define** Shock wave in front of a 3-d body(phenomenological description only)	Shock wave in front of a 3-d body(phenomenological description only),	T2.4
48	**Describe** Supersonic expansion by turning	Supersonic expansion by turning,	T1.5
49-50	**Explain** Prandtl-Meyer function and expansion fan ,	Prandtl-Meyer function and expansion fan,	T1.5
51	**Discuss** Shock expansion theory-application to supersonic aerofoils.	Shock expansion theory-application to supersonic aerofoils	T1.5
52	**Discuss** Supersonic flows-over a flat plate at angle of attack, over a diamond aerofoil at angle of attack	Supersonic flows-over a flat plate at angle of attack, over a diamond aerofoil at angle of attack	T1.5
53	**Explain** Determination of the slip stream angle	Determination of the slip stream angle,	T1.5
54	**Derive** the wave drag and lift	Wave drag and lift	T1.5
55	**Discuss** Numerical exercises with Prandtl-Meyer function tables.	Numerical exercises with Prandtl-Meyer function tables.	T1.5
56-57	**Discuss** Numerical exercises determining shock expansion slip stream configuration and force calculation on aerofoils.	Numerical exercises determining shock expansion slip stream configuration and force calculation on aerofoils.	T1.5
58	**Define** Adiabatic flow in straight, variable area channels- nozzles, diffusers	**Unit - IV: More One Dimensional Flows And Subsonic And Transonic Airfoils:** Adiabatic flow in straight, variable area channels- nozzles, diffusers	R2.17
59	**Discuss** Governing equations, area-velocity relation	Governing equations, area-velocity relation.	R2.17
60	**Discuss** Mass flow rate, effect of stagnation conditions, back pressure	Mass flow rate, effect of stagnation conditions, back pressure.	R2.17
61	**Discuss** Choked flow- isentropic flow, ideally expanded, over-expanded, under-expanded flows- appearance of normal shock- flow losses	Choked flow- isentropic flow, ideally expanded, over-expanded, under-expanded flows- appearance of normal shock- flow losses.	R2.17
62	**Define** Wave reflection from free boundary, brief outline of operation of supersonic wind tunnels employing convergent-divergent nozzles	Wave reflection from free boundary, brief outline of operation of supersonic wind tunnels employing convergent-divergent nozzles,	R2.17
63	**Discuss** and **Explain** the 1-D piston motion in a constant area tube, jump start, propagation of shock wave in front and expansion wave behind	1-D piston motion in a constant area tube, jump start, propagation of shock wave in front and expansion wave behind	R2.17
64	**Define** x-t diagram, particle velocity, pressure density and temperature relations	x-t diagram, particle velocity, pressure density and temperature relations.	R2.17
65	**Discuss** the velocity potential, perturbation potential, linearised governing equation in 2-D .	SUBSONIC FLOW: The velocity potential, perturbation potential, linearised governing equation in 2-D	R2.17
66	**Define** the pressure coefficient-Prandtl-Glauert compressibility correction	The pressure coefficient-Prandtl-Glauert compressibility correction	T3.2

67	**Discuss** application to swept wings, critical Mach no., drag divergence Mach no.	Application to swept wings, critical Mach no., drag divergence Mach no.	T3.3
68	**Discuss** the sound barrier. Supercritical airfoils, swept wings at transonic speeds, second order equation for transonic flow	TRANSONIC FLOW: the sound barrier. Supercritical airfoils, swept wings at transonic speeds, second order equation for transonic flow	T3.2
69	**Discuss** wing-body combinations, Whitcomb's, transonic area rule, application to transonic aircraft	Wing-body combinations, Whitcomb's, transonic area rule, application to transonic aircraft	T3.3
70	**Discuss** Point mass in stationary air moving in subsonic speed and moving in supersonic speed and propagation of wave front	**Unit -V: Airfoil, Wing and Cone in Supersonic Flow:** Point mass in stationary air moving in subsonic speed and moving in supersonic speed and propagation of wave front	T3.3
71	**Discuss** in supersonic case influence zone limited within mach lines/wave /cones	In supersonic case influence zone limited within mach lines/wave /cones	T3.3
72	**Discuss** principle of limited upstream influence in supersonic flow, brief outline of method of characteristics-statement (without proof) of compatibility relations	Principle of limited upstream influence in supersonic flow, brief outline of method of characteristics-statement (without proof) of compatibility relations	T3.3
73	**Discuss** application to supersonic nozzle design. Linearized supersonic flow-governing equations,	Application to supersonic nozzle design. Linearized supersonic flow-governing equations	T3.2
74	**Explain** boundary conditions. Pressure coefficient, application to supersonic airfoils. Lift, drag, pitching moment.	Boundary conditions. Pressure coefficient, application to supersonic airfoils. Lift, drag, pitching moment.	T4.2
75	**Define** Wedge, flat plate, diamond and biconvex aerofoils at small angle of attack.	Wedge, flat plate, diamond and biconvex aerofoils at small angle of attack.	T4.2
76	**Discuss** Air loads over flat rectangular wings of finite span, Delta wing with supersonic leading edge and subsonic leading edge,	Air loads over flat rectangular wings of finite span, Delta wing with supersonic leading edge and subsonic leading edge	T3.2
77	**Discuss** Cone at zero angle of attack with attached conical shock: Limited upstream influence in supersonic flow-comparison of finite cone and semi-infinite cone,	Cone at zero angle of attack with attached conical shock: Limited upstream influence in supersonic flow-comparison of finite cone and semi-infinite cone	T3.2
78	**Define** dimensional analysis and dimensionless conical variable,	Dimensional analysis and dimensionless conical variable	T4.2
79	**Explain** ordinary differential equation for conical flow, mention of availability of computed solution	Ordinary differential equation for conical flow, mention of availability of computed solution	T4.2
80	**Discuss** how to use the standard computed chart, comparison of pressure rise for wedge and cone of equal semi-angle.	How to use the standard computed chart, comparison of pressure rise for wedge and cone of equal semi-angle.	T4.2
81	**Define** Qualitative aspects of hypersonic flow, Newtonian flow model: windward surface and Lee surface,	Qualitative aspects of hypersonic flow, Newtonian flow model: windward surface and Lee surface,	T4.2
82	**Explain** Lift and drag of flat plate wings at hypersonic speeds.	Lift and drag of flat plate wings at hypersonic speeds.	T3.4

XI. MAPPING COURSE OBJECTIVES LEADING TO THE ACHIEVEMENT OF THE PROGRAM OUTCOMES AND PROGRAM SPECIFIC OUTCOMES

Course Objectives	Program Outcomes												Program Specific Outcomes			
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3	PSO4
I	H					S		S				H		S	S	
II		S					H			S			H			H
III				H				S			S					
IV			H		S				S			H				
V	H					S						S				S
VI		S			S		H		H	S						
VII				H							S	H		S	S	

S – Supportive **H - Highly related**

XII. MAPPING COURSE OUTCOMES LEADING TO THE ACHIEVEMENT OF PROGRAM OUTCOMES AND PROGRAM SPECIFIC OUTCOMES

Course Outcomes	Program Outcomes												Program Specific Outcomes			
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3	PSO4
1	H		H					S			S	H		S	S	
2					S											S
3												H				
4								S		S	S					H
5																
6			H	H						S						S
7	H															
8													H			
9		H												S		

S – Supportive **H - Highly related**

Prepared by: Mr. N V Raghavendra, Associate Professor

HOD, AE