Hall Ticket No | | | | | | | | | | | Question Paper Code: AAE008

INSTITUTE OF AERONAUTICAL ENGINEERING

(Autonomous)

Dundigal, Hyderabad - 500 043

MODEL QUESTION PAPER - I

B.Tech V Semester End Examinations, November - 2019

Regulations: R16

HIGH SPEED AERODYNAMICS

(AERO)

Time: 3 hours **Max. Marks: 70**

Answer ONE Question from each Unit
All Questions Carry Equal Marks
All parts of the question must be answered in one place only

UNIT – I

1.	a)	With the help of neat sketch derive the equations for the conservations of momentum in integral form.	**[7M]**
	b)	Consider the flow properties at the point in the flow where the temperature is 320 k and velocity is 100m/s. Calculate the Mach number at this point?	**[7M]**
2.	a)	What do you understand by supersonic flow and write down its relation with speed of sound?	**[7M]**
	b)	Calculate the ratio of kinetic energy to internal energy at a point in the flow where the Mach number is M=2 and M=20.	**[7M]**

UNIT – II

3.	a)	Derive the expression for pressure relationship for normal shock for a perfect gas in terms of Mach number.	**[7M]**
	b)	Consider an infinitesimally thin flat plate at an angle of attack in a Mach 2.3 flow. Calculate the lift and wave drag co- efficient for an angle of attack α=50.	**[7M]**
4.	a)	Define total pressure. Derive the expression for total pressure change across a normal shock.	**[7M]**
	b)	For a flow with M=2, P=1atm and T=288k, this flow is deflected at a compression corner through 200. calculate M,P,T.	**[7M]**

UNIT – III

5.	a)	Give a brief outline of operation of supersonic wind tunnels employing convergent - divergent nozzles?	**[7M]**
	b)	Calculate the mass flow through the nozzle assuming that reservoirs temperature is 288K and throat area is 0.3 m^2	**[7M]**

6. a) Explain about choked flow, ideally expanded, over-expanded, under expanded flows in detail. **[7M]**

b) A pitot tube at the exit of a supersonic nozzle reads, $8.92X\ 10^4\ N/m^2$. If the reservoir pressure is $2.02\ X\ 10^5$ N/m2, calculate the area ratio of the nozzle (Ae/A*). **[7M]**

UNIT – IV

7. a) Derive the equation for determining characteristic lines for two dimensional irrotational flows. **[7M]**

b) Write short notes on "Elements of the Method of Characteristics". High light the internal points and wall points. **[7M]**

8. a) Define Method of characteristics. Explain the supersonic nozzle design using method of characteristics. **[7M]**

b) Calculate theoretical lift co-efficient for above airfoil is in an incompressible flow is $c_l = 2.\pi.a$ for $M\infty = 0.8$. **[7M]**

UNIT – V

9. a) What are the uses of flow visualization? Write the working principle of Schlieren techniques with the suitable diagram. **[7M]**

b) Explain the dynamic similarity between a wind tunnel model and the prototype to be flight-tested. What are the essential conditions to be satisfied for the results to be carried from the model to the prototype? Are there any limitations or preconditions involved? **[7M]**

10. a) Write short note about Laser Doppler and Particle Image Velocimetry technique with the neat sketch. **[7M]**

b) List industrial domain where wind and fluid tunnels are used. Explain its applications in their respective domain. **[7M]**

COURSE OBJECTIVES:

The course should enable the students to:

I	Understand the effect of compressibility at high-speeds and the ability to make intelligent design decisions.
II	Explain the dynamics in subsonic, transonic and supersonic flow regimes in both internal and external geometries.
III	Analyze the airfoils at subsonic, transonic and supersonic flight conditions using the perturbed flow theory assumption.
IV	Formulate appropriate aerodynamic models to predict the forces and performance of realistic threedimensional configurations.

COURSE OUTCOMES (COs):

CO 1	Explain a brief review of thermodynamics and fluid mechanics in relation to compressible flows
CO 2	Demonstrate different types of shock waves and expansion waves and its properties across different situations.
CO 3	Demonstrate different types of shock waves and expansion waves and its properties across different situations.
CO 4	Illustrate the concepts of method of characteristics and its applications in nozzle designs.
CO 5	Understand the experimental methods and their characteristics of various wind tunnels.

COURSE LEARNING OUTCOMES (CLOs):

AAE008.01	Demonstrate the concept of supersonic flow, how it is different from incompressible flow.
AAE008.02	Understand governing equations of supersonic flow in various form and thermodynamics properties.
AAE008.03	Describe the governing equations required for compressible flows.
AAE008.04	Illustrate the impact of supersonic flow in the presence of compression and expansion corner.
AAE008.05	Demonstrate supersonic aircraft design and applications to aircrafts, supersonic wind tunnel, shock tubes.
AAE008.06	Understand the concepts of shock wave boundary layer interaction.
AAE008.07	Illustrate the concepts of quasi one dimensional flow for compressible flows.
AAE008.08	Describe isentropic flow in nozzles, area Mach relations, choked flow, under and over expanded nozzles, slipstream line.
AAE008.09	Understand the impact of heat and Friction in duct flow and fanno flow.
AAE008.10	Describe small perturbation equations for subsonic, transonic, supersonic and hypersonic flow.
AAE008.11	Understand experimental characteristics of airfoils in compressible flow, supercritical airfoils and area rule.
AAE008.12	Explain supersonic nozzle design using method of characteristics.
AAE008.13	Illustrate working principle of subsonic wind tunnels, supersonic wind tunnels, shock tunnels.

AAE008.14	Explain free-piston shock tunnel, detonation-driven shock tunnels, and expansion tubes and characteristic features, their operation and performance.
AAE008.15	Demonstrate flow visualization techniques for compressible flows.

MAPPING OF SEMESTER END EXAMINATION - COURSE OUTCOMES

SEE Question No		Course Learning Outcomes		Course Outcomes	Blooms Taxonomy Level
1	a	AAE008.03	Describe the governing equations required for compressible flows.	CO 1	Understand
	b	AAE008.03	Describe the governing equations required for compressible flows.	CO 1	Understand
2	a	AAE008.02	Understand governing equations of supersonic flow in various form and thermodynamics properties.	CO 1	Remember
	b	AAE008.03	Describe the governing equations required for compressible flows.	CO 1	Remember
3	a	AAE008.05	Demonstrate supersonic aircraft design and applications to aircrafts, supersonic wind tunnel, shock tubes.	CO 2	Remember
	b	AAE008.04	Illustrate the impact of supersonic flow in the presence of compression and expansion corner.	CO 2	Understand
4	a	AAE008.06	Understand the concepts of shock wave boundary layer interaction.	CO 2	Remember
	b	AAE008.06	Understand the concepts of shock wave boundary layer interaction.	CO 2	Understand
5	a	AAE008.07	Illustrate the concepts of quasi one dimensional flow for compressible flows.	CO 3	Remember
	b	AAE008.08	Describe isentropic flow in nozzles, area Mach relations, choked flow, under and over expanded nozzles, slipstream line.	CO 3	Understand
6	a	AAE008.08	Describe isentropic flow in nozzles, area Mach relations, choked flow, under and over expanded nozzles, slipstream line.	CO 3	Understand
	b	AAE008.07	Illustrate the concepts of quasi one dimensional flow for compressible flows.	CO 3	Remember
7	a	AAE008.12	Explain supersonic nozzle design using method of characteristics.	CO 4	Remember
	b	AAE008.11	Understand experimental characteristics of airfoils in compressible flow, supercritical airfoils and area rule.	CO 4	Understand
8	a	AAE008.12	Explain supersonic nozzle design using method of characteristics.	CO 4	Remember
	b	AAE008.11	Understand experimental characteristics of airfoils in compressible flow, supercritical airfoils and area rule.	CO 4	Remember
9	a	AAE008.15	Demonstrate flow visualization techniques for compressible flows.	CO 5	Remember
	b	AAE008.13	Illustrate working principle of subsonic wind tunnels, supersonic wind tunnels, shock tunnels.	CO 5	Remember
10	a	AAE008.15	Demonstrate flow visualization techniques for compressible flows.	CO 5	Understand
	b	AAE008.13	Illustrate working principle of subsonic wind tunnels, supersonic wind tunnels, shock tunnels.	CO 5	Remember

Signature of Course Coordinator **HOD, AE**