Register Number:……..

KUMARAGURU
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B.E DEGREE EXAMINATIONS: NOV/DEC 2022

(Regulation 2018)

Fifth Semester

AERONAUTICAL ENGINEERING

U18AET5101**:** High Speed Aerodynamics

COURSE OUTCOMES

CO1:	Use Basic Principles of the compressible gas flows.
CO2:	Calculate the parameters of compressible flow through variable area duct.
CO3:	Solve the Problems on one dimensional flow with Normal Shock, Rayleigh and Fanno flows and apply method of characteristics.
CO4:	Examine the flow with Oblique shocks and Expansion waves.
CO5:	Apply Linearized flow theory for streamlined bodies.

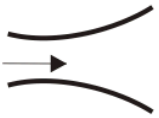
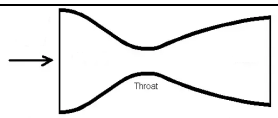
Time: Three Hours **Maximum Marks: 100**

Instruction: Gas Tables may be permitted

Answer all the Questions:-

PART A (10 x 1 = 10 Marks)

1. Identify the corresponding shape of the given nozzle/diffuser. CO2 [K_3]

Nozzle/Diffuser	Shape
A. Subsonic Nozzle B. Subsonic Diffuser	i. 
C. Supersonic Nozzle D. Supersonic Diffuser	ii. 
E. Subsonic to Supersonic Nozzle F. Supersonic to Subsonic Diffuser	iii. 

		A	B	C	D	E	F			
	a)	ii	i	iii	i	iii	ii			
	b)	i	iii	ii	i	iii	ii			
	c)	ii	i	iii	i	ii	iii			
	d)	i	ii	ii	i	iii	iii			

2. Compressibility effects are taken into account when the velocity is CO1 [K_1]

	a)	Less than 100 m/s	b)	Greater than 100 m/s
	c)	Less than 200 m/s	d)	Greater than 200 m/s

3. Which of the following statements are true for flow across a stationary normal shock wave? CO3 [K_3]

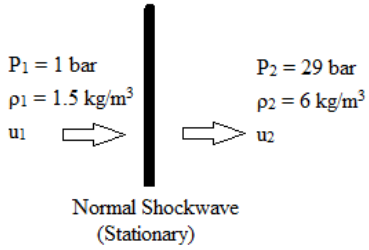
P. Stagnation temperature remains constant.

Q. Stagnation pressure decreases

	R. Entropy increases S. Stagnation pressure increases T. Stagnation temperature increases					
	a)	P,Q,R	b)	R,S,T		
	c)	Q,R,S	d)	S,T,P		
4.	For a flow across an oblique shock which of the following is true?				CO4	[K_3]
	a)	Component of velocity normal to shock decreases while tangential component increases.	b)	Component of velocity normal to shock increases while tangential component decreases.		
	c)	Component of velocity normal to shock is unchanged while tangential component decreases.	d)	Component of velocity normal to shock decreases while tangential component is unchanged.		
5.	Determine the correctness or otherwise of the following statements, [a] and [r]: Assertion [a]: The downstream of a stationary normal shockwave is always subsonic. Reason [r]: The Prandtl relation in terms of Mach number shows that when upstream Mach number is supersonic, the downstream Mach number will be subsonic.				CO3	[K_2]
	a)	Both [a] and [r] are true and [r] is the correct reason for [a].	b)	Both [a] and [r] are true but [r] is not the correct reason for [a].		
	c)	Both [a] and [r] are false.	d)	[a] is true but [r] is false.		
6.	In a closed-circuit supersonic wind tunnel, the convergent-divergent (C-D) nozzle and test section are followed by a C-D diffuser to swallow the starting shock. Here, we should have				CO3	[K_3]
	a)	diffuser throat larger than the nozzle throat and the shock located just at the diffuser throat.	b)	diffuser throat larger than the nozzle throat and the shock located downstream of the diffuser throat.		
	c)	diffuser throat of the same size as the nozzle throat and the shock located just at the diffuser throat.	d)	diffuser throat of the same size as the nozzle throat and the shock located downstream of the diffuser throat.		
7.	Order the given terms (from lowest Mach number to Highest Mach number) I. Drag Divergence Mach number II. Lower Critical Mach number III. Upper Critical Mach number IV. Sonic boom				CO5	[K_2]
	a)	III-I-IV-II	b)	III-IV-I-II		
	c)	II-I-IV-III	d)	II-IV-III-I		
8.	Prandtl-Meyer expansion function is valid only for				CO4	[K_1]
	a)	Calorically perfect gas	b)	Ideal gas		
	c)	Real gas	d)	Perfect gas		
9.	Determine the correctness or otherwise of the following statements, [a] and [r]: Assertion [a]: A Pitot tube cannot be used to measure the speed of supersonic flow. Reason [r]: The Pitot tube in a supersonic flow measures stagnation pressure behind the shock wave.				CO3	[K_2]
	a)	Both [a] and [r] are true and [r] is the	b)	Both [a] and [r] are true but [r] is not the		

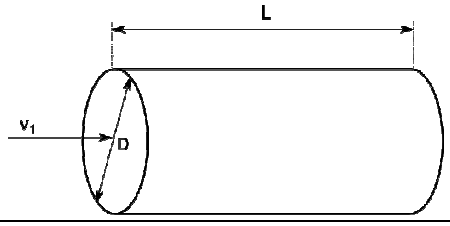
		correct reason for [a].		correct reason for [a].		
	c)	Both [a] and [r] are false.	d)	[r] is true but [a] is false.		
10.	One of the criteria for high-speed airplane is that critical Mach number should be as high as possible. Therefore, high-speed subsonic airplanes are usually designed with				CO5	[K_2]
	a)	thick airfoils	b)	laminar flow airfoils		
	c)	thin airfoils	d)	diamond airfoils		

Answer any TEN Questions:- PART B (10 x 4 = 40 Marks)
(Answer not more than 80 words)

11.	An Airplane is flying at standard sea level condition. The temperature at a point on the wing is 250K. What is the pressure at this point?	CO1	[K_3]
12.	A plane travels at a speed of 2400km/hr in an atmosphere of 5^{o}C. Represent the disturbance propagation with the Mach angle value and mention zone of silence and zone of action.	CO1	[K_3]
13.	Consider the 1D, adiabatic, inviscid, compressible flow of air (R=287 J/kg-K, C_v=718 J/kg-K) through a duct of constant cross sectional area A=1 m^2. If the volume flow rate Q=680 m^3/s and stagnation temperature is T_o=580.05 K, then calculate the air temperature inside the duct.	CO2	[K_3]
14.	Consider one-dimensional isentropic flow at a Mach number of 0.5. If the area of cross-section of a streamtube increases by 3% somewhere along the flow, Find the corresponding percentage change in density.	CO2	[K_4]
15.	A student needs to find velocity across a stationary normal shock. He measures density and pressure across the shock as shown in the figure below. Help him to find the velocity (u_2). [1bar = 10^5Pa]  	CO3	[K_4]
16.	The entropy increase across a normal shock wave is 199.5 J/(kg.K). What is the upstream Mach number?	CO3	[K_5]
17.	A fighter aircraft travels at a speed of 2160 kmph at std sea-level condition. What is the pressure recorded by the Pitot probe mounted on the nose of the aircraft?	CO3	[K_4]
18.	Draw the variation plot of θ,β,M.	CO4	[K_1]
19.	Compare supersonic flow over a wedge and cone with neat sketches.	CO4	[K_2]
20.	Differentiate like reflection and unlike reflection with neat sketches.	CO4	[K_2]
21.	Consider flow over a thin aerofoil at Mach number, M_∞ = 0.5 at an angle of attack, α. Calculate the lift coefficient (C_l) using the Prandtl-Glauert rule for compressibility correction.	CO5	[K_4]
22.	Represent the nomenclature of "Super Critical Aerofoil".	CO5	[K_2]

Answer any FIVE Questions:- PART C (5 x 10 = 50 Marks)
(Answer not more than 250 words)

23.		Obtain the expression for speed of sound in gas medium (in terms of ratio of	10	CO1	[K_3]

		specific heats and local temperature) from the one dimensional continuity and momentum equations.			
24.	a)	Derive the one dimensional momentum equation for steady, inviscid, compressible flows.	5	CO2	[K_3]
	b)	An airplane flying at 2000 kmph at an altitude where the pressure and temperature are $3x10^4$ N/m^2 and 20^oC respectively. Calculate the pressure, density and temperature at the leading edge of the wing.	5	CO2	[K_5]
25.	a)	Derive the Rankine-Hugoniot pressure density relationship for the shock and explain its significance.	5	CO3	[K_3]
	b)	Consider two flows, one of helium and one of air. Denoting the strength of a normal shock by the pressure ratio across the shock P_2/P_1, which gas will result stronger shock? For a monatomic gas such as helium, γ=1.67, and for a diatomic gas such as air, γ=1.4. Assume equal velocities of 1700 m/s and temperature of 288 K for both gas flows.	5	CO3	[K_4]
26.		Air at P_o=10 bar, T_o=400K is supplied to a 50mm diameter pipe. The friction factor for the pipe surface is 0.002. If the Mach number changes from 3.0 at the entry to 1.0 at the exit determine, i. The length of the pipe, and ii. The mass flow rate. 	10	CO3	[K_4]
27.	a)	Consider an oblique shock wave with a wave angle of 30 degree, where the upstream flow Mach number is 2.4. Calculate the following: i. Flow turning angle, ii. Pressure ratio across the shock, iii. Temperature ratio across the shock, and iv. Mach number behind the wave.	5	CO4	[K_5]
	b)	A supersonic flow with M_1=1.5, P_1=1 atm, T_1=288K is expanded around a sharp corner through a deflection angle of 15°. Calculate M_2, P_2, and T_2.	5	CO4	[K_5]
28.	a)	Interpret about the Transonic area Rule.	5	CO5	[K_2]
	b)	Illustrate the characteristics of swept backward wing.	5	CO5	[K_2]

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