

Name:	 UPES UNIVERSITY WITH A PURPOSE
Enrolment No:	

UNIVERSITY OF PETROLEUM AND ENERGY STUDIES
End Semester Examination, December-January 2021

Course: Computational Gas Dynamics
Program: M. Tech. CFD
Course Code: ASEG 7020

Semester: I
Time: 03 hrs.
Max. Marks: 100

SECTION A

Instructions: This Section has 05 questions and all questions are compulsory. Scan and upload all the correct answer(s).

S. No.		Marks	CO
Q 1	<p>For a one-dimensional flow of a perfect gas a compression wave is a region in the flow where</p> <ul style="list-style-type: none"> i. The speed of acoustic waves increases monotonically ii. The speed of acoustic waves decreases monotonically iii. The speed of entropy waves increases monotonically iv. The speed of entropy waves increases monotonically v. Pressure decreases monotonically 	04	CO1
Q 2	<p>The one dimensional unsteady Euler equations for a supersonic flow can be approximated as three wave equations. Which of the following statements are true for these waves?</p> <ul style="list-style-type: none"> i. All the waves travel towards in the direction of flow ii. Two waves travel downstream while one wave travels upstream iii. Two waves travel upstream while one wave travels downstream iv. All waves travel upstream v. Speeds of all waves is higher than the local speed of sound. 	04	CO1
Q 3	<p>Roe's approximate Riemann solver (three wave approximation)</p> <ul style="list-style-type: none"> i. Yields exact solution for a single shock ii. Yields exact solution for a single contact iii. Yields exact solution for a single expansion wave iv. Allows expansion shock 	04	CO2

	v. Yields inaccurate solution for a single compression wave		
Q 4	<p>For Roe's approximate Riemann solver</p> <ul style="list-style-type: none"> i. The Roe averaged velocity at the interface is a linear average of the left and right velocities ii. The Roes averaged enthalpy at the interface is a linear average of the left and right enthalpies iii. The Roes averaged density at the interface is a linear average of the left and right densities iv. The Roes averaged speed of sound at the interface is a linear average of the left and right speeds of sound v. The Roe averaged velocity at the interface is a geometric mean of the left and right velocities 	04	CO3
Q 5	<p>The interface flux for the Godunov's first order upwind scheme is</p> <ul style="list-style-type: none"> i. $f(u_L)$ for $u_L > 0$ and $u_R > 0$ ii. $f(u_L)$ for $u_L < 0$ and $u_R < 0$ iii. $f(u_R)$ for $u_L > 0$ and $u_R > 0$ iv. $f(u_R)$ for $u_L < 0$ and $u_R < 0$ v. $f(u_L)$ for $u_L < 0$ and $u_R > 0$ 	04	CO4
<p>SECTION B</p> <p>Instructions: This Section has 04 questions and all questions are compulsory. Scan and upload the answers. The answer should be of short type (up to 200 words or equivalent numbers).</p>			
Q 6	<p>Consider the non-conservation form of Euler equation, given as</p> $\frac{\partial U}{\partial t} + A \frac{\partial U}{\partial x} = 0$ <p>If matrix T^{-1}, which the concatenation of the left eigenvector of Jacobian matrix A is found to be</p>	10	CO1

$$T^{-1} = \begin{pmatrix} 1 - \frac{(\gamma - 1) u^2}{2 a^2} & (\gamma - 1) \frac{u}{a^2} & -\frac{(\gamma - 1)}{a^2} \\ \frac{(\gamma - 1) u^2}{4 a^2} - \frac{1 u}{2 a} & -\frac{(\gamma - 1) u}{2 a^2} + \frac{1}{2 a} & \frac{(\gamma - 1)}{2 a^2} \\ \frac{(\gamma - 1) u^2}{4 a^2} + \frac{1 u}{2 a} & -\frac{(\gamma - 1) u}{2 a^2} - \frac{1}{2 a} & \frac{(\gamma - 1)}{2 a^2} \end{pmatrix}$$

Find the elements the vector dV , which represents changes in characteristic variables for the wave form of 1 D Euler equations.

Q 7 Suppose that the solution to the Riemann problem produces only a shock. Using conservation principles derive an expression for the change in internal energy across the shock wave in terms of p_R, p_L, ρ_R , and ρ_L , where the subscripts L and R represent the left and right state respectively

10

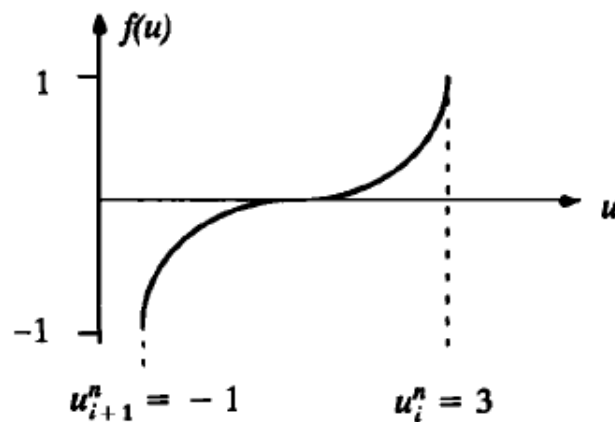
CO1

Q 8 Discuss a Flux Vector Splitting technique in context to the solution of 1D unsteady Euler equations.

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CO4

Q 9 Consider the scalar flux function illustrated below. Find the conservative numerical flux $f_{i+1/2}^n$ of Godunov's and Roe's first order upwind method.



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CO4

SECTION-C

Instructions: This Section has 02 questions and all questions are compulsory. Scan and upload the answer. The answer should be of long type (up to 500 words or equivalent numbers).

Q 10	<p>Find the Roe's approximate solution to the Riemann problem for 1 D Euler equation at $t = 0.01$ s if $p_L = 50,000$ N/m², $\rho_L = 1$ kg/m³, $u_L = 100$ m/s and $p_R = 10,000$ N/m², $\rho_R = 0.125$ kg/m³, $u_R = -20$ m/s.</p>	20	CO3
Q 11	<p>Find the exact solution of the following Riemann problem for 1 D Euler equation at $t = 0.01$ s if $p_L = 25,000$ N/m², $\rho_L = 1$ kg/m³, $u_L = 100$ m/s and $p_R = 5,000$ N/m², $\rho_R = 0.125$ kg/m³, $u_R = -50$ m/s.</p> $\frac{\partial \mathbf{u}}{\partial t} + A \frac{\partial \mathbf{u}}{\partial x} = 0$ <p>where</p> $\mathbf{u}(x, 0) = \begin{cases} \mathbf{u}_L & x < 0 \\ \mathbf{u}_R & x > 0 \end{cases}$	20	CO2