Name: **Enrolment No:**	UPES UNIVERSITY WITH A PURPOSE

UNIVERSITY OF PETROLEUM AND ENERGY STUDIES
End Semester Examination, January-February 2020

Course: Computational Gas Dynamics **Semester: I**
Program: M. Tech. CFD **Time: 03 hrs.**
Course Code: ASEG 7020 **Max. Marks: 100**

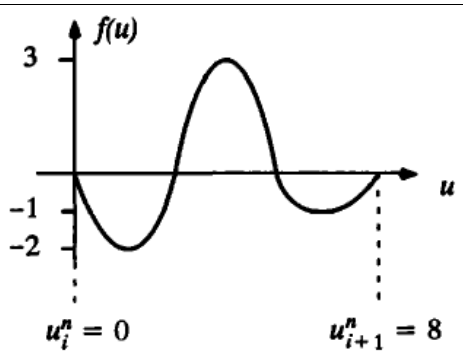
SECTION A

Instructions: This Section has 06 questions and all questions are compulsory. Select all the correct answer(s).

S. No.		Marks	CO
Q 1	For a one-dimensional flow of a perfect gas an expansion wave is a region in the flow where 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	**05**	**CO1**
Q 2	Across a contact discontinuity i. The speed of entropy waves increases ii. The speed of entropy waves remains constant iii. The entropy increases iv. The pressure remains constant v. The temperature remains constant	**05**	**CO1**
Q 3	Roe's approximate Riemann solver 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 v. Yields inaccurate solution for a single compression wave	**05**	**CO2**

Q 4	In context to the solution of 1D unsteady Euler equation, which of the following statements are true? i. For subsonic flow FTFS violates stability criteria ii. For subsonic flow FTBS satisfy stability criteria for all waves iii. For subsonic flow FTBS satisfy stability criteria for at least one family of waves iv. FTBS satisfies stability criteria for supersonic right-running flow v. FTBS violates stability criteria for supersonic left-running flow	**05**	**CO3**
Q 5	The one dimensional unsteady Euler equations can be approximated as three waves, these waves may travel at i. Speeds higher than the flow speed for subsonic flow ii. Speeds lower than the flow speed for subsonic flow iii. Speeds equal to the flow speed iv. Speeds higher than the flow speed for supersonic flow v. Speeds lower than the flow speed for supersonic flow	**05**	**CO3**
Q 6	At an expansive sonic point i. The flow velocity is equal to the speed of sound ii. The velocity magnitude goes to zero iii. The wave speed value goes to zero iv. The wave speed changes direction from right to left v. The wave speed changes direction from left right	**05**	**CO3**
SECTION B **Instructions: This Section has 05 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).**			
Q 7	Deduce the eigenvalues of the Jacobian Matrix $\boldsymbol{A}$, for the one dimensional Euler Equations given by $$\frac{\partial \mathbf{u}}{\partial t} + A\frac{\partial \mathbf{u}}{\partial x} = 0,$$ where $$\boldsymbol{u} = \begin{bmatrix} \rho \\ \rho u \\ \rho E \end{bmatrix} \text{ and } A = \frac{\partial \boldsymbol{f}}{\partial \boldsymbol{u}}$$ with	**10**	**CO1**

	$$\boldsymbol{f} = \begin{bmatrix} \rho u \\ \rho u^2 + p \\ (\rho E + p)u \end{bmatrix}$$		
Q 8	Consider the Riemann problem for the following system of linear equations: $$\frac{\partial u_1}{\partial t} + \frac{\partial u_2}{\partial x} = 0,$$ $$\frac{\partial u_2}{\partial t} + \frac{\partial u_3}{\partial x} = 0,$$ $$\frac{\partial u_3}{\partial t} + 4\frac{\partial u_1}{\partial x} - 17\frac{\partial u_2}{\partial x} + 8\frac{\partial u_3}{\partial x} = 0.$$ Write the system of equations in the form: $$\frac{\partial \vec{u}}{\partial t} + A\frac{\partial \vec{u}}{\partial x} = 0.$$ Thus find the left eigenvectors of the Jacobian matrix *A*.	**10**	**CO1**
Q 9	Write down the expressions for the conservative numerical fluxes for the following numerical schemes for the solution of 1D scalar wave equation: a) FTBS b) FTCS	**10**	**CO3**
Q 10	Discuss following techniques in context to the solution of 1D unsteady Euler equations. a) Flux Vector Splitting b) Wave Speed Splitting	**10**	**CO4**
Q 11	Consider the scalar flux function illustrated below. Find the conservative numerical flux $f^n_{i+1/2}$ of Godunov's and Roe's first order upwind method.	**10**	**CO4**

SECTION-C

Instructions: This Section has 02 questions and only 01 question needs to be answered. Scan and upload the answer. The answer should be of long type (up to 500 words or equivalent numbers).

Q 12	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/m^2, ρ_L = 1 kg/m^3, u_L = 100 m/s and p_R = 5000 N/m^2, ρ_R = 0.125 kg/m^3, u_R = 0 m/s. **OR** Roe's approximate Riemann problem for the Euler problem is given as $$\frac{\partial \boldsymbol{u}}{\partial t} + A_{RL}\frac{\partial \boldsymbol{u}}{\partial x} = 0$$ where $$\boldsymbol{u}(x,0) = \begin{cases} \boldsymbol{u}_L & x < 0 \\ \boldsymbol{u}_R & x > 0 \end{cases}$$ Calculate the Roe-average velocity at the cell interface in terms of the velocities and densities on the left and right of the cell interface.	**20**	**CO2**