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

UNIVERSITY OF PETROLEUM AND ENERGY STUDIES

End Semester Examination, May 2019

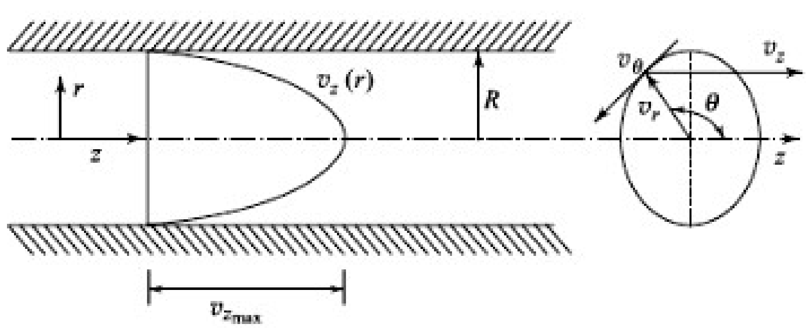
Course: Aerodynamics I **Semester: IV**
Program: B. Tech ASE & ASE +AVE **Time 03 hrs.**
Course Code: ASEG 2002 **Max. Marks: 100**
Nos. of page(s): 03
Instructions: Make use of sketch/plots to elaborate your answer. All sections are compulsory. Q 9 and 11 have internal choice.

SECTION A

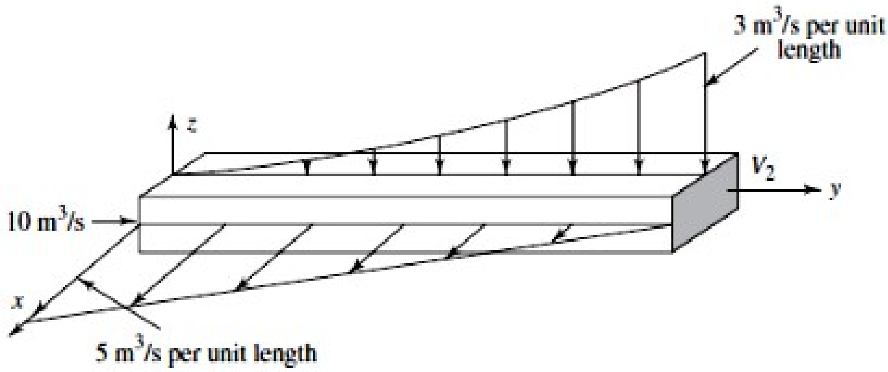
S. No.		Marks	CO
Q 1	What is meant by Magnus effect? Mention a few applications of this effect.	**[04]**	**CO2**
Q 2	An airplane travels at 800 km/h at sea level where the temperature is 15ºC. How fast would the airplane be flying at the same Mach number at an altitude where the temperature is -40ºC.	**[04]**	**CO3**
Q 3	State the continuity equation for compressible flow in the polar coordinates.	**[04]**	**CO1**
Q 4	Define the properties of a boundary layer. Why is turbulent boundary layer preferred for flow over spheres and cylinders?	**[04]**	**CO1**
Q 5	Explain the physical meaning of divergence of velocity? Also, write down the relation between line integrals, surface integrals, and volume integrals.	**[04]**	**CO2**

SECTION B

Q 6	Define coefficient of pressure and plot the variation of coefficient of pressure for the circular cylinder kept in uniform flow for both real and inviscid flows. Explain the cause of variation in the plots.	**[10]**	**CO2**
Q 7	Derive the Euler's equation of motion for a 3-d incompressible, steady flow. Show how Bernoulli's equation and hydrostatic equation can be deduced from Euler's equation.	**[10]**	**CO3**
Q 8	Kerosene at 10ºC flows steadily at 20 lit/min through a 150 m long horizontal length of 5.5 cm diameter cast iron pipe. Compare the pressure drop of the kerosene with that of the same flow rate of benzene at 10ºC through the same pipe. For kerosene at 10ºC, $\rho = 820$ kg/m^3 and $\mu = 0.0025$ Ns/m^2 and for benzene $\rho = 899$ kg/m^3 and $\mu = 0.0008$ Ns/m^2. Why do you obtain greater pressure drop for benzene?	**[10]**	**CO4**

Q 9	Derive the equations of the following for a Blasius flow over a flat plate. (a) The velocity field within the boundary layer, (b) The boundary layer thickness, (c) The shear stress distribution on the plate, (d) The frag force on the plate. **OR** Air moves over a flat plate with a uniform free stream velocity of 10 m/s. At a position 15 cm away from the front edge of the plate, what is the boundary layer thickness? Use a parabolic profile in the boundary layer. For air, $\upsilon = 1.5 \times 10^{-5}$ m^2/s and $\rho = 1.23$ kg/m^3	**[10]**	**CO4**
	SECTION-C		
Q 10	(a) State and prove Kutta-Joukowski's theorem for a two-dimensional incompressible steady flow around a body of any shape. (b) A circular cylinder of 2 m diameter and 12 m length is rotated at 300 rpm about its vertical axis when it is kept in air stream of 40 m/s, with its axis perpendicular to the flow. Determine (i) circulation around the cylinder (ii) theoretical lift (iii) position of stagnation points actual drag, lift and resultant force on the cylinder, Take $C_d = 0.52$, $C_L = 1.0$ and $\rho = 1.208$ kg/m^3	**[20]**	**CO 4, 5**
Q 11	Applying the Navier-Stokes equation, derive the governing equation for a fully developed laminar flow through a straight tube of circular cross-section as shown in the figure. Explain the assumptions considered to derive the axial, maximum and average velocity inside the pipe. Find the equation for the discharge and the skin friction coefficient for the flow. Also find the radial distance from the pipe axis at which the velocity equals the average velocity.  **OR** (a) Derive the governing equation for a parallel flow in a straight channel.	**[20]**	**CO5**

(b) Water enters a rectangular duct at a rate of 10 m^3/s as shown in the figure. Two of the faces are of the duct are porous. On the upper surface, water is added at a rate shown by the parabolic curve, while on the front face water laves at the rate determined linearly by the distance from the end. The maximum values of both rates are given in the figure. What is the average velocity leaving the duct if it is 1 m long and has a cross section of $0.1m^3$?



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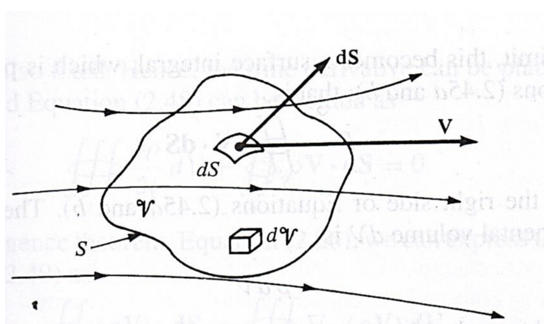
SECTION A

S. No.		Marks	CO
Q 1	Write notes on Newton's law of viscosity, kinematic viscosity and aerodynamic heating.	**[04]**	**CO1**
Q 2	State and explain Kutta condition for a flow over a body.	**[04]**	**CO1**
Q 3	The x and y velocity components of a fluid flow are given by $u=2xy+4y+6x$ and $v=3y+2x^2+6xy$ Is the flow irrotational? Is it a physically possible flow?	**[04]**	**CO2**
Q 4	Write down the Navier-Stokes equations for a three dimensional steady flow.	**[04]**	**CO1**
Q 5	An object is immersed in an air flow with a static pressure of 200 kPa (abs), a static temperature of 20ºC, and a velocity of 200 m/s. What is the pressure and temperature at the stagnation point?	**[04]**	**CO3**

SECTION B

Q 6	Derive the Prandtl's boundary layer equations by the simplification of the Navier-Stokes equations.	**[10]**	**CO3**
Q 7	Show that the combination of a doublet flow and uniform flow is equivalent to a non-lifting flow over a circular cylinder. Obtain expressions for the velocity potential, stream function and the location of stagnation points.	**[10]**	**CO4**
Q 8	Consider the flow over a small flat which is 8 cm long in the flow direction and 1 m wide. The free stream conditions correspond to standard sea level, and the flow velocity is 120 m/s. Assuming laminar flow, calculate the boundary layer thickness at the downstream edge and the drag force on the plate. For the same flow over the	**[10]**	**CO3**

	same plate, assume that the boundary layer is now completely turbulent. Calculate the boundary layer is now completely turbulent Calculate the boundary layer thickness at the trailing edge and the drag force on the plate		
Q 9	Derive the continuity equation in Polar coordinates and explain the concept of source flow. **OR** For an irrotational flow show that Bernoulli's equation is valid between any points in the flow, not just along a streamline.	**[10]**	**CO3**
	SECTION-C		
Q 10	For a flow between two parallel plates, the upper plate has a velocity of 60 m/s while thelower plate is stationary. The two plates are separated by a distance of 0.025 mm. The fluid between the plates is air. Assume incompressible flow. The temperature of both plates is 288 K. Calculate: (a) the velocity in the middle of the flow, (b) the shear stress (c) the maximum temperature in the flow (d) the heat transfer to either wall, (e) If the lower wall is suddenly made adiabatic, calculate its temperature.	**[20]**	**CO5**
Q 11	Derive the momentum equation in the integral form by applying the basic principle of Newton's second law of motion on a volume as shown in fig. 1.  Fig. 1 Finite control volume fixed in space. Once derived, convert the integral form into differential form using the appropriate integral relation. **OR** Modify the integral form of the continuity equation when applied to quasi-one-	**[20]**	**CO3,4**

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dimensional flow in a duct as shown in the fig. 2.

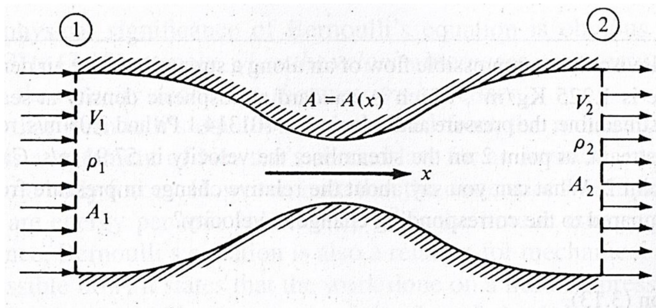

Fig. 2 Quasi-one-dimensional flow in duct.

Consider a low-speed subsonic wind tunnel with a 12/1 contraction ration for the nozzle. If the flow in the test section is at standard sea level conditions with a velocity of 50 m/s, calculate the height difference in a U-tube mercury manometer with one side connected to the nozzle inlet and the other to the test section.

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