Name:

Enrolment No:

UNIVERSITY OF PETROLEUM AND ENERGY STUDIES

End Semester Examination, December 2022

Course: Advanced fluid mechanics and aerodynamics
Semester: First
Program: M.Tech. Advanced Vehicle
Time : 03 hrs.
Course Code: MEAV7001 **Max. Marks: 100**

Instructions: All questions are mandatory

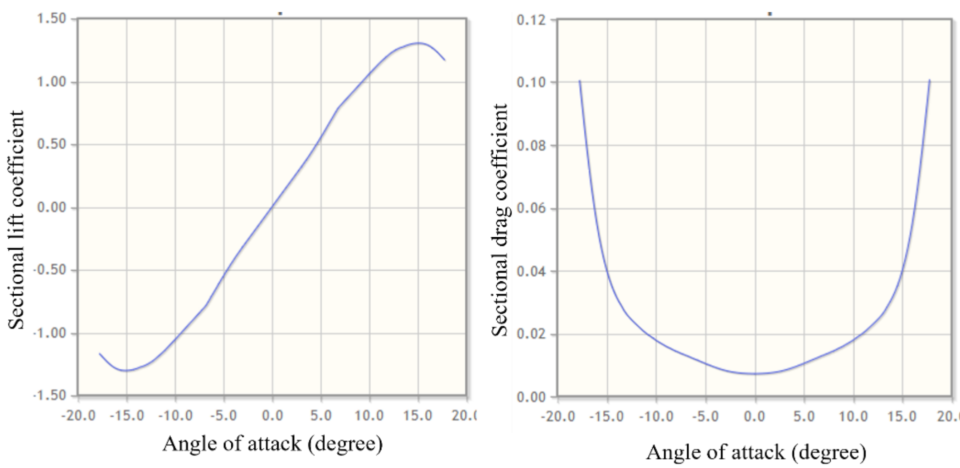
SECTION A
(5Qx4M=20Marks)

S. No.		Marks	CO
Q1	Oil in hydraulic cylinder (cylinder fitted with a piston) is compressed from its initial volume of 2 m^3 to 1.96 m^3. If the pressure inside the cylinder changes from 40 MPa to 80 MPa during this process of compression. Calculate the bulk modulus of elasticity of the oil.	**4**	**CO1**
Q 2	A journal bearing has shaft diameter of 40 mm and a length of 40 mm. The shaft is rotating at 20 rad/s and the viscosity of the lubricant is 0.020 Pa-s. The clearance is 0.020 mm. Calculate the loss of torque due to the viscosity of the lubricant is approximately.	**4**	**CO1**
Q3	Briefly describe the flow separation and separation bubble.	**4**	**CO3**
Q4	Using appropriate sketch, discuss the development of the boundary layer flow over a flat plate, and the different flow regimes.	**4**	**CO3**
Q5	Discuss the different types of drag acting on an aircraft wing.	**4**	**CO3**

SECTION B
(4Qx10M= 40 Marks)

Q1	Consider a Boeing 747 airliner cruising at a velocity of 800 km/hr at a standard altitude of 10 km, where the freestream pressure and temperature are 26 kPa and -50°C (223K), respectively. A one-fiftieth (1/50) scale model of the aircraft is to be tested in a wind tunnel where the temperature is 30°C. Calculate the required velocity and pressure of the test airstream in the wind tunnel such that the lift and drag coefficients measured for the wind-tunnel model are the same as for free flight. Assume that both Air viscosity (μ) and speed of sound (a) are proportional to $T^{1/2}$.	**10**	**CO1**

Q2	Derive the continuity equation for a compressible flow. Also, write the continuity equation for an incompressible flow.	**10**	**CO2**
Q3	Define displacement thickness and momentum thickness for a boundary layer flow. Find the displacement thickness and momentum thickness for the flow over a horizontal flat plate. The velocity distribution in the boundary layer is given by $\frac{u}{U} = 3\left(\frac{y}{\delta}\right) - 2\left(\frac{y}{\delta}\right)^2$, where δ is the thickness of the boundary layer.	**10**	**CO3**
Q4	a) For the flow over circular cylinder, plot and describe the variation in drag coefficient with Reynolds number. [4 marks] b) Draw the Strouhal number vs Reynolds number curve for the flow over a circular cylinder. [2 marks] c) A smoke stake (chimney) of chemical plant is 120 meter tall. The average diameter of the chimney is 10 meters. The natural frequency of the structure (chimney) is 2Hz. Calculate the wind speed at which the resonance in the structure is likely to occur due to vortex-induced vibration. [4 marks]	**10**	**CO4**
SECTION-C (2Qx20M=40 Marks)			
Q1	Using potential flow theory for an inviscid and incompressible flow, derive the equations for stream function, and velocity field for the non-lifting flow over a circular cylinder and obtain the coordinates of the stagnation points. Comments on lift and drag forces acting on the cylinder for the inviscid flow and compare these with the forces acting on the cylinder in a real flow (viscid flow). [20 marks] Or [14 + 6 marks] a) Using potential flow theory, derive the expression for the stream function, velocity field and stagnation point for an inviscid, incompressible flow over a semi-infinite oval body (half Rankine oval). b) For a source flow, write the expression for stream and potential function and show that the equipotential lines and streamlines are perpendicular to each other.	**20**	**CO2**

Q2	Consider a drone's wing (NACA 0012) with a chord of 0.5m and span 2m, in an airstream at standard sea level conditions (air density = 1.2 kg/m^3). Using the experimental data shown in figure, solve the following problems. The figure shows the sectional lift and drag coefficients for a NACA 0012 airfoil at different angles of attack. Take the approximate values of the required data from the given figure. [10 + 10 marks] a) If the lift produced by the wing at the wind speed of 30 m/s is 300N, find out the angle of attack of the wing and calculate the total drag force acting on it. Also, calculate the maximum amount of lift the wing can produce at 30 m/s. In this case, neglect the end effect and assume that the flow over the entire wing is two-dimensional. b) Taking the end effect into consideration (assuming a finite wing), calculate the value of lift and drag coefficients for the wing at 10° angle of attack. Also, calculate the value of lift induced drag.  	**20**	**CO4**