Total No. of printed pages = 3

ME 181602

14/6/23

Roll No. of candidate | | | | | | | | | | |

2023

B.Tech. 6th Semester End-Term Examination

Mechanical Engineering

FLUID MECHANICS — II

(New Regulation (w.e.f. 2017 – 18) & New Syllabus (w.e.f. 2018-19))

Full Marks – 70 Time – Three hours

The figures in the margin indicate full marks for the questions.

Answer question No. 1 and any *four* from the rest.

1. Choose the correct option from the following : (10 × 1 = 10)

(i) The compressible flow upstream of a shock is always

(a) Supersonic (b) Subsonic

(c) Sonic (d) None of the above

(ii) When a fluid is subjected to resistance, it undergoes a volumetric change due to

(a) Cohesion (b) Strain

(c) Compressibility (d) Adhesion

(iii) If the Mach number is M=1 then the flow is

(a) Sonic flow (b) Sub sonic flow

(c) Supersonic flow (d) None of the above

(iv) Select the expression that does not give the speed of a sound wave $\left(\gamma = {}^{C_p}/_{Cv}\right)$

(a) $\sqrt{\gamma p/\rho}$ (b) $\sqrt{{}^{\gamma\rho}/_{p}}$

(c) $\sqrt{\gamma RT}$ (d) $\sqrt{{}^{\delta p}/_{\delta\rho}}$

[Turn over

(v) The laminar boundary layer thickness on a flat plate varies as

(a) $x^{(-1/2)}$ (b) $x^{(4/5)}$

(c) $x^{(1/2)}$ (d) x^2

(vi) Flow separation is caused by

(a) Reduction of pressure to vapor pressure

(b) A negative pressure gradient

(c) A positive pressure gradient

(d) The boundary layer thickness reducing to zero

(vii) In the entrance region of a pipe, the boundary layer grows and the inviscid core accelerate. This is accompanied by a

(a) Rise in pressure

(b) Constant pressure gradient

(c) Fall in pressure in the flow direction

(d) Pressure pulse

(viii) At the point of separation

(a) shear stress is zero

(b) velocity is negative

(c) pressure gradient is negative

(d) shear stress is maximum

(ix) If the mean velocity has a gradient, the turbulence is called isotropic

(a) True (b) false

(x) In a turbulent flow in a pipe, the shear stress is

(a) Maximum at the centers and decreases linearly towards the wall

(b) Maximum at the centers and decreases logarithmically towards the wall

(c) Maximum at the wall and decreases to zero value at the center

(d) Maximum midway between center and wall

2. (a) Derive an expression for the speed of sound wave in a compressible fluid. (5)

(b) Air flows steadily and isentropically in a converging- diverging nozzle. At the throat, the air is at 140 kPa (abs), and at 60°C. The throat cross-sectional area is 0.05 m^2. At a certain section in the diverging part of the nozzle, the pressure is 70.0 kPa (abs). Calculate the velocity and area of this section. (10)

3. (a) What is the meaning of "point of separation" of a boundary layer. How will the velocity gradient $\frac{\delta u}{\delta y}$ and the second gradient $\frac{\delta^2 u}{\delta^2 y}$ vary within the boundary layer at the point of separation. Show the variation graphically. Here, u is the velocity along the wall and y is the co-ordinate perpendicular to the wall. (8)

(b) What do you mean by Prandtl mixing length theory? Derive the universal velocity distribution law for turbulent flow using Prandtl's mixing length theory. (7)

4. (a) Discuss the mechanics involved in boundary layer transition. (5)

(b) Air (density, ρ = 1.23 kg/m^3 and kinematic viscosity, v = 1.5 × 10^{-5} m^2/s) is following over a flat plate. The free stream speed is 15 m/s. At a distance 1 m from the leading edge, calculate boundary layer thickness, δ and wall shear stress τ_w for (i) completely laminar flow and (ii) completely turbulent flow for a 1/7th power law velocity profile. (10)

5. (a) An airplane travels 700 km/h at sea level where the temperature is 15°C. How fast would the airplane be flying at the same Mach number at an altitude where the temperature is -50°C? (5)

(b) Derive area -velocity relationship for one dimensional steady adiabatic and frictionless flow of a compressible fluid through a duct and discuss the effect of area variation on flow properties. Draw the different profiles of nozzles and diffuser for subsonic and supersonic flow conditions. (10)

6. (a) What are the characteristics of turbulent flow? Why turbulent flow does not separate readily from a surface? (5)

(b) Why shear stresses at the wall is greater for turbulent flow than the laminar flow? (5)

(c) Discuss the velocity profile diagram of laminar and turbulent flow over a flat plate. (5)

7. (a) Derive the governing equation (Continuity and Navier-Stroke momentum equation) for turbulent flow. (5)

(b) Draw the Fanno line and Rayleigh on T-S diagram and write the assumptions associated with Fanno and Rayleigh line. (5)

(c) A fluid of dynamic viscosity 2 × 10^{-5} kg/ms and density 1 kg/m^3 flows with an average velocity of 1 m/s through a long duct rectangular (25 mm × 15 mm) cross-section. Assuming laminar flow, calculate the pressure drops in the fully developed region per meter length of the duct. (5)
