



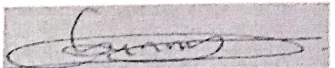
ELIZADE UNIVERSITY, ILARA-MOKIN,
ONDO STATE, NIGERIA

DEPARTMENT OF MECHANICAL ENGINEERING

SECOND SEMESTER EXAMINATIONS

2017/2018 ACADEMIC SESSION

COURSE: MEE 502 – Fluid Dynamics (3 Units)
CLASS: 500 Level Mechanical & Automotive Engineering
TIME ALLOWED: 3 Hours
INSTRUCTIONS: Answer any 4 questions


HOD'S SIGNATURE

Date: July/August, 2018

Question 1

- (a) Air is flowing through a duct and a normal wave is formed at a cross-section at which the Mach number is 2.0. If the upstream pressure and temperature are 105 bar and 15 °C, respectively, find the Mach number, pressure and temperature immediately downstream of the shock waves. Take $\gamma = 1.4$ (4 Marks)
- (b) Calculate the maximum mass flow possible through a frictionless, heat-insulated, convergent nozzle if the entry or stagnation conditions are 5 bar and 15 °C and the throat area is 6.5 cm². Also calculate the temperature of the air at the throat. Take $C_p = 1.00 \text{ kJ kg}^{-1} \text{K}^{-1}$ (4 Marks)
- (c) Show that for maximum discharge from a reservoir through a convergent-divergent duct, the throat velocity is $\bar{v} = \sqrt{\left(\frac{\gamma P_t}{\rho_t}\right)}$, where P_t is the throat pressure, ρ_t is the throat density (5 Marks)
- (d) How do the temperature and the pressure at the stagnation point in isentropic flow compare with reservoir conditions? (2 Marks)

Question 2

- (a) Write short note on the following:
(i) Under-expanded nozzle (ii) Over-expanded nozzle (iii) Oblique shock wave
(iv) Normal shock wave (4 Marks)
- (b) At a point upstream of the throat of a converging-diverging nozzle, the properties are $V_1 = 190 \text{ m/s}$, $T_1 = 305 \text{ K}$ and $P_1 = 120 \text{ kPa}$. If the exit flow is supersonic, Compute, from isentropic theory, mass flow rate and inlet area. The throat area is 35 cm². (4 Marks)
- (c) Air flows along a circular pipe with a diameter d of 50 mm. Assuming that conditions are adiabatic and that the Mach number at the entrance to the pipe is 0.2, calculate the distance

- from the entrance of the pipe to the section at which the Mach number will be (a) 1.0. (b) 0.5
 Take $f = 0.00375$ (4 Marks)
- (d) List and explain four (4) factors affecting transition from laminar to turbulent flow regimes (3 Marks)

Question 3

- (a) Consider a supersonic flow of air through a stationary duct wherein a stationary shock is present. The Mach number ahead of the shock is 2.1 and the pressure and temperature are 101.3 kPa absolute and -37°C . What is the velocity of propagation of the shock relative to the air ahead of the shock? (4 Marks)
- (b) Show that Bernoulli's equation $P + 0.5\rho U^2 + \rho g z$ constant, satisfies steady inviscid flow when the flow is irrotational. Note that P is the pressure, U is velocity and ρ is density (4 Marks)
- (c) State four (4) characteristics of inviscid flow. (4 Marks)
- (d) Determine whether these flows are rotational or irrotational:
- $u = -2y, v = 3x$
 - $u = 0, v = 3xy$
 - $u = 2x, v = -2y$
- (3 Marks)

Question 4

- (a) What do you understand by the term "turbulent modeling"? (2 Marks)
- (b) Differentiate between K-Omega ($K - \omega$) and K-epsilon ($K - \epsilon$) in relation to turbulent modelling. (4 Marks)
- (c) Oil with a free stream velocity of 3.0 m/s flows over a thin plate 1.25 m wide and 3 m long. Determine the boundary layer thickness and the shear stress at the mid-length and calculate the total, double-sided resistance of the plate. ($\rho = 850 \frac{\text{kg}}{\text{m}^3}$, kinematic viscosity, $\nu = 10^{-5} \text{ m}^2 \text{ s}^{-1}$) (5 Marks)
- (d) A flow is defined by $u = 2x$ and $v = -2y$. Find the stream function and potential flow function for this flow. (4 Marks)

Question 5

- (a) Consider a uniform flow, $\Phi = U_0 \left(r + \frac{R^2}{2} \right) \cos\theta$ past a circular cylinder, where U_0 is velocity, R is the radius and Φ is the potential function. Obtain velocity components and pressure on the cylinder. (4 Marks)
- (b) A supersonic wind tunnel consists of a large reservoir containing gas under high pressure which is discharged through a convergent-divergent nozzle to a test section of constant cross-sectional area. The cross-sectional area of the throat of the nozzle is 500 mm² and the Mach number in the test section is 4. Calculate the cross-sectional area of the test section assuming $\gamma = 1.4$ (3 Marks)
- (c) A smooth flat plate 3 m wide and 30 m long is towed through still water at 20 °C at a speed of 8 m/s. Determine the total drag on the plate and the drag on the first 3 m of the plate. (4 Marks)
- (d) Show that Blasius equation for boundary layer thickness, δ in a laminar flow is given by $\frac{\delta}{x} = \frac{4.91}{\sqrt{Re_x}}$ (4 Marks)