KISII UNIVERSITY

UNIVERSITY EXAMINATIONS

FIRST YEAR EXAMINATION FOR THE AWARD OF THE DEGREE OF MASTER OF SCIENCE IN APPLIED MATHEMATICS
SECOND SEMESTER 2022/2023
[MAY, 2023]

MATH 854: FLUID MECHANICS III

STREAM: Y1 S2 **TIME: 3 HOURS**

DAY: WEDNESDAY, 2:00 – 5:00 P.M. **DATE: 03/05/2023**

INSTRUCTIONS

1. Do not write anything on this question paper.
2. Answer Question ONE Compulsory and any other TWO (2) Questions.

QUESTION ONE (30 MARKS)

a) Describe briefly the term dimensional homogeinity. (2marks)

b) Find an expression for the drag force on smooth sphere of diameter D, moving with uniform velocity V in a fluid density ρ and dynamic viscosity μ. (7marks)

c) State the Buckingham's π-theorem. (3marks)

d) The resistance R experienced by a partially submerged body depends upon the velocity V, length l, viscosity of the fluid μ, density of the fluid ρ and gravitational acceleration g. Obtain a dimensionless expression for R. (7marks)

e) Briefly explain the following concepts in terms of Mach number:

i) Subsonic flow
ii) Sonic flow
iii) Supersonic flow (3marks)

f) Air at a pressure of 240 kN/m^2 and temperature 30^0C is moving at a velocity of 200 m/s. Calculate the stagnation pressure if:

i) Compressibility is neglected.
ii) Compressibility is accounted for.

Take $R = 287287J/kgK, \gamma = 1.4$ (8marks)

QUESTION TWO (15 MARKS)

a) Derive the differential equation of a perfect gas given by the equation $\frac{dp}{p} - \frac{d\rho}{\rho} - \frac{dT}{T} = 0$ (3marks)

b) Briefly explain the THREE basic thermodynamic processes involved in compressible fluid flow. (6marks)

c) A gas is flowing through a horizontal pipe. On a section where cross-section area is $100cm^2$, the pressure and temperature are found to be 4 bar (gauge) and 40^0C respectively. At another section where the area of the cross-section is $50cm^2$ the pressure is recorded 3 bar (gauge). If the mass rate of flow of gas through the pipe is $0.6kg/s$, find the velocities of the gas at these sections, assuming an isothermal change. Take $R = 287J/kgK$ and atmospheric pressure= 1 bar.

(6marks)

QUESTION THREE (15 MARKS)

a) A gas with a velocity of $400\ m/s$ is flowing through a horizontal pipe at a section where pressure is $80kN/m^2$ absolute and temperature 50^0C. The pipe changes in diameter and at this section, the pressure is $120kN/m^2$ absolute. Find the velocity of the gas at this section if the flow of the gas is adiabatic. Take $R = 287J/kgK$ and $\gamma = 1.4$. (10marks)

b) An aeroplane is flying at a height of 15 km where temperature is -40^0C. The speed of the plane is corresponding to $M = 2$. Find the speed of the plane if $R = 287J/kgK$ and $\gamma = 1.4$

(5marks)

QUESTION FOUR (15 MARKS)

a) A supersonic aircraft flies at an altitude of 3.6 km where temperature is 4^0C. Determine the speed of the aircraft if its sound is heard 4 seconds after its passage over the head of an observer. Take $R = 287J/kgK$ and $\gamma = 1.4$ (7marks)

b) An aeroplane is flying at 900 km/hr through still air having a pressure of 78.5 kN/m^2 (absolute) and temperature -10^0C. Calculate on the stagnation point on the nose of the plane:
i) Stagnation pressure
ii) Stagnation temperature
iii) Stagnation density

Take $R = 287J/kgK$ and $\gamma = 1.4$

(8marks)