MACHAKOS UNIVERSITY

University Supplementary Examinations 2023/2024

SCHOOL OF ENGINEERING AND TECHNOLOGY
DEPARTMENT OF MECHANICAL AND MANUFACTURING ENGINEERING
THIRD YEAR FIRST SEMESTER EXAMINATIONS FOR THE DEGREE OF BACHELOR OF SCIENCE IN MECHANICAL ENGINEERING

EMM 312: FLUID MECHANICS III

DATE: **TIME: 2 HOURS**

INSTRUCTIONS
This paper contains FIVE questions
Question ONE is **compulsory** and carries 30 Marks.
Questions TWO – FIVE carries 20 Marks each.
Answer question **ONE** and any other **TWO** questions**.**

QUESTION ONE (COMPULSORY) (30 MARKS)

a) Define the following terms with respective to open channel flow.

i) Specific energy **(4 Marks)**

ii) Critical depth **(4 Marks)**

b) i) Show that for an open rectangular channel, the critical velocity is realised when the critical depth (D_c) is;

$$\mathbf{D_c = \frac{2}{3}H}$$ **(6 Marks)**

Where H is the specific energy

ii) Show that the critical depth occurs when Froude's Number = 1. **(8 Marks)**

c) Water id flowing through a rectangular channel 1.25 m wide at a depth of 5 m at a rate of 3.2 m^3/sec. Determine;

i) Specific Energy **(2 Marks)**

ii) Critical depth **(2 Marks)**

d) A block 37.5 mm thick is placed across the bed of a rectangular horizontal channel 375 mm wide to form a broad crested weir. The depth of the liquid just upstream of weir is 68.75 mm. Calculate the rate of flow assuming that flow conditions over the block are critical . **(4 Marks)**

QUESTION TWO (20 MARKS)

a) Derive the Chezy Formula for uniform flow in open channels. Work from first principles and explain the meaning of all symbols used. **(8 Marks)**

b) An irrigation channel has a gradient of 1 in 2000, a bottom width of 4.8 m and side slopes of 1 vertical to 2 horizontal. The depth of water is 1.2 m and value of C = 50. Calculate the:

i) Mean velocity in m/sec. **(8 Marks)**

ii) Discharge in m^3/sec. **(4 Marks)**

QUESTION THREE (20 MARKS)

a) Show that the Bernoulli's equation for a compressible fluid under adiabatic conditions is given by:

$$\left(\frac{\gamma}{\gamma-1}\right)\frac{P}{\rho}+\frac{V^2}{2}=constant$$ **(10 Marks)**

Where; v – velocity of the gas immediately in front of the orifice

γ - Adiabatic index of compression/expansion

P – pressure

ρ – mass density

b) A venturimeter having an inlet diameter of 75 mm and throat diameter 25 mm is used for measuring the rate of flow of air through a pipe. The U-gauge mercury manometer registers gauge pressures of 250 mm and 150 mm of mercury at inlet and throat respectively.

Determine the volumetric flow rate of air in the pipe in m^3/sec.

Assume that the: Flow is adiabatic at inlet and $\gamma = 1.4$

Mass density of air at inlet = 1.602 kg/m^3.

Barometric pressure corresponds to 760 mm of mercury

Specific gravity of mercury = 13.6 **(10 Marks)**

QUESTION FOUR (20 MARKS)

a) Show that for a circular culvert of diameter (d), the velocity of flow will be maximum when the depth of flow (h) at the centre is 0.81d. **(10 Marks)**

b) Concisely explain the meaning of all the term "optimum shape of a cross-section" with specific reference to uniform flow in open channels. **(3 Marks)**

c) The depth of water in a circular brick lined conduit 1.8 m in diameter is to be 1.5 m and its capacity of 227300 m^3/day. The water surface subtends an angle of $96^0 20'$ at the axis of the conduit. Determine the gradient of the conduit.
Assume C = 51. **(7 Marks)**

QUESTION FIVE (20 MARKS)

a) Air from a large reservoir discharges into the atmosphere through a small orifice at its side of cross-section area a. Show that the discharge/mass flow rate is given by;

$$\dot{m} = C_d a \rho_1 \sqrt{2\left(\frac{\gamma}{\gamma - 1}\right)\frac{\rho_1}{e_1}\left[1 - r_p{}^{\frac{\gamma-1}{\gamma}}\right] r_p{}^{\frac{2}{\gamma}}}$$

Where; C_d - coefficient of discharge

a - cross sectional area of the orifice

γ - Adiabatic index of expansion

P – pressure in the vessel

ρ_1 – mass density of air the vessel

P_1 – pressure in the vessel

$= \frac{Patm}{P_1}$ **(10 Marks)**

b) Air from a large reservioir discharges into the atmosphere through an orifice of diameter 25 mm. Tthe temperature and pressure in the reservoir are 206.931 kN/m^2 and 15^0C respectively.

Assume: R = 287 J/KgK

γ = 1.4

Atmospheric pressure = 101.396 kN/m^2. **(10 Marks)**