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[*University of Choice*]

MASINDE MULIRO UNIVERSITY OF SCIENCE AND TECHNOLOGY [MMUST]

MAIN EXAMINATION

2023/2024 ACADEMIC YEAR

THIRD YEAR FIRST SEMESTER EXAMINATIONS

FOR THE DEGREE

OF

BACHELOR OF SCIENCE IN MECHANICAL AND INDUSTRIAL ENGINEERING

COURSE CODE: **MIE 331**

COURSE TITLE: **FLUID MECHANICS III**

DATE: 07/12/2023 **TIME: 12:00 - 14:00**

INSTRUCTIONS TO CANDIDATES

1. This paper consists of **FOUR** questions
2. Answer Question **ONE [Compulsory]** and any other **TWO** Questions
3. All symbols have their usual meaning

TIME: 2 Hours

MMUST observes ZERO tolerance to examination cheating

This Paper Consists of 4 Printed Pages. Please Turn Over

QUESTION ONE [30 marks]

a] Distinguish between the upstream velocity and the free-stream velocity. For what types of flow are these two velocities equal to each other **[5 marks]**

b] The local atmospheric pressure at a given location is 84 kPa. Air at this pressure and at 20°C flows with a velocity of 6 m/s over a 3-m × 8-m flat plate. Determine the drag force acting on the top surface of the plate if the air flows parallel to the 3-m-long side. The kinematic viscosity to be $\nu = 1.51 \times 10^{-5}$ m²/s. $R_{Air} = 287$ J.kg^{-1}.K^{-1} **[12 marks]**

c] Calculate the stagnation temperature and pressure for helium flowing through a duct at 0.25 MPa, 50°C, and 240 m/s given that $C_P = 5.1926$ kJ/kg.K and k= 1.667 **[4 marks]**

d] What is the driving force for flow in an open channel. How is the flow rate in an open channel established **[5 marks]**

e] Explain when the flow in an open channel is said to be uniform and state the conditions under which the flow will remain uniform **[4 marks]**

QUESTION TWO [20 marks]

a] A circular sign has a diameter of 50 cm and is subjected to normal winds up to 150 km/h at 10°C and 100 kPa. Determine the drag force acting on the sign. Also determine the bending moment at the bottom of its pole whose height from the ground to the bottom of the sign is 1.5 m. Disregard the drag on the pole. The drag coefficient for a thin circular disk is $C_D = 1.1$ **[5 marks]**

b] Products of combustion enter a gas turbine with a stagnation pressure of 1.0 MPa and a stagnation temperature of 750 °C, and they expand to a stagnation pressure of 0.1 MPa. Taking k= 1.33 and R = 0.287 kJ/kg·K for the products of combustion, and assuming the expansion process to be isentropic, determine the power output of the turbine per unit mass flow **[7 marks]**

c] Carbon dioxide enters an adiabatic nozzle at 1250 K with a velocity of 55 m/s and leaves at 450 K. Assuming constant specific heats at room temperature, determine: **[i]** the Mach number at the inlet **[ii]** the nozzle exit velocity **[iii]** the Mach number at the exit. Take R = 0.1889 kJ/kg·K, C_P = 0.8439 kJ/kg·K and k = 1.288 **[8 marks]**

QUESTION THREE [20 marks]

a] Using an illustration, explain the progression of the boundary layer as a fluid flows over a flat plate **[8 marks]**

b] Water flows steadily in a 0.8-m-wide rectangular channel at a rate of 0.7 m^3/s. If the flow depth is 0.25 m, determine the flow velocity and if the flow is subcritical or supercritical. Also determine the alternate flow depth if the character of flow were to change. **[12 marks]**

QUESTION FOUR [20 marks]

Water discharging into an 8-m-wide rectangular horizontal channel from a sluice gate is observed to have undergone a hydraulic jump. The flow depth and velocity before the jump are 1.2 m and 9 m/s, respectively. Determine **[i]** the flow depth and the Froude number after the jump, **[ii]** the head loss **[iii]** the dissipation ratio, and **[iv]** the mechanical energy dissipated by the hydraulic jump. **[20 marks]**

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General information

Standard acceleration: g= 9.81 m/s^2 *Standard atmospheric pressure*: 1 atm=101.325 kPa= 760 mmHg=10.33 mH_2O

1 bar=**10^5** Pa

Specific gas constant of air: R= 0.287 kJ/kg. K

Universal gas constant: R_U = 8.314 kJ/kmol K

Dynamic viscosity μ: **1** $kgm^{-1}s^{-1}$ = **1** N s m^{-2} = **1** Pa.s

Kinematic viscosity: m^{-2} /s

Properties of water

Temperature [°C)	Density ρ, [kg/m^3)	Specific weight γ, [N/m^3)	Viscosity μ, [N.s/m^2)	Kinematic viscosity ν, [m^2/s)	Bulk modulus B, [Pa)	Surface tension σ, [N/m)	Vapor Pressure [kPa)
0	999.9	9809	1.792×10^{-3}	1.792×10^{-6}	204×10^{7}	7.62×10^{-2}	0.610
5	1000	9810	1.519	1.519	206	7.54	0.872
10	999.7	9807	1.308	1.308	211	7.48	1.13
15	999.1	9801	1.140	1.141	214	7.41	1.60
20	998.2	9792	1.005	1.007	220	7.36	2.34
30	995.7	9768	0.801	0.804	223	7.18	4.24
40	992.2	9733	0.656	0.661	227	7.01	7.38
50	988.1	9693	0.549	0.556	230	6.82	12.3
60	983.2	9645	0.469	0.477	228	6.68	19.9
70	977.8	9592	0.406	0.415	225	6.50	31.2
80	971.8	9533	0.357	0.367	221	6.30	47.3
90	965.3	9470	0.317	0.328	216	6.12	70.1
100	958.4	9402	0.284×10^{-3}	0.296×10^{-6}	207×10^{7}	5.94×10^{-2}	101.3

Properties of Air at Atmospheric Pressure

Temperature [°C)	Density ρ, [kg/m^3)	Viscosity μ, [N.s/m^2)	Kinematic viscosity ν, [m^2/s)	Speed of sound c, [m/s)
-30	1.452	1.56×10^{-5}	1.08×10^{-5}	312
-20	1.394	1.61	1.16	319
-10	1.342	1.67	1.24	325
0	1.292	1.72	1.33	331
10	1.247	1.76	1.42	337
20	1.204	1.81	1.51	343
30	1.164	1.86	1.60	349
40	1.127	1.91	1.69	355
50	1.092	1.95	1.79	360
60	1.060	2.00	1.89	366
70	1.030	2.05	1.99	371
80	1.000	2.09	2.09	377
90	0.973	2.13	2.19	382
100	0.946	2.17	2.30	387
200	0.746	2.57	3.45	436
300	0.616	2.93×10^{-5}	4.75×10^{-5}	480