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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 TECHNOLOGY EDUCATION [MECHANICAL TECHNOLOGY]

COURSE CODE: TEM 331

COURSE TITLE: FLUID MECHANICS I

DATE: 07/12/2023 **TIME: 15:00 - 17:00**

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] Explain the difference between normal stress and tangential stress **[4 marks]**

b] Does the absolute pressure in a liquid of constant density double when the depth is doubled. Explain using relevant formulas **[3 marks]**

c] Briefly explain why it is extremely difficult to push a ball under water? **[4 marks]**

d] In a hydraulic press, the input force is multiplied by 7 times in order to lift a 3000 N weight with the output piston. By how many times must the radius of the output piston be greater than the radius of the input piston for this output force to be achieved **[4 marks]**

e] A hose pipe is used to empty a 40 L bucket. The inner diameter of the pipe is 0.8cm at the bucket outlet (pipe inlet) and increases by 150% at the pipe outlet. If it takes 1 min to empty the bucket, determine the percentage change in average velocity of water as result of pipe area change **[6 marks]**

f] State and explain any four assumptions made in the applicability of Bernoulli's equation **[4 marks]**

g] Show that the friction factor in laminar region of flow is given by $f = 64/Re$ **[5 marks]**

QUESTION TWO [20 marks]

a] A fluid of constant density $\rho=980$ kg/m^3 is flowing through a horizontal tube. The diameters upstream and downstream of the tube are 100 mm and 80 mm respectively while the gauge pressure and velocity upstream of the tube are 200 kPa and 5m/s respectively. Determine the gauge pressure downstream of the tube **[10 marks]**

b] Explain the significance of Reynolds number. Dominance of which forces leads to laminar or turbulent flows? **[4 marks]**

c] Determine the minor head loss that will occur as 0.0045 m^3/s water flows from a 40-mm pipe diameter into a 100-mm pipe diameter through a sudden expansion. Take the minor loss coefficient to be 0.7 **[6 marks]**

QUESTION THREE [20 marks]

Determine the flowrate through the Venturi meter shown in **Fig. Q3** if ideal conditions exist **[20 marks]**

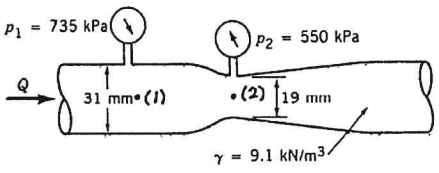


Fig. Q3

QUESTION FOUR [20 marks]

a] The tank of a leaky air compressor originally holds 90 L of air at 33 °C and 2.25 bar. During a compression process, 4 grams of air is lost. The remaining air occupies 42 L at 5.5 bar. Determine the temperature of the remaining air **[8 marks]**

b] Water is flowing through an 80 m long plastic pipe, 50 mm in diameter at the rate of 2 dm^3/s. Given that the pipe surface roughness is 0.032 mm and the dynamic viscosity of water is 1.5×10^{-3} Pa.s, determine the head loss **[12 marks]**

.....The End.....

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

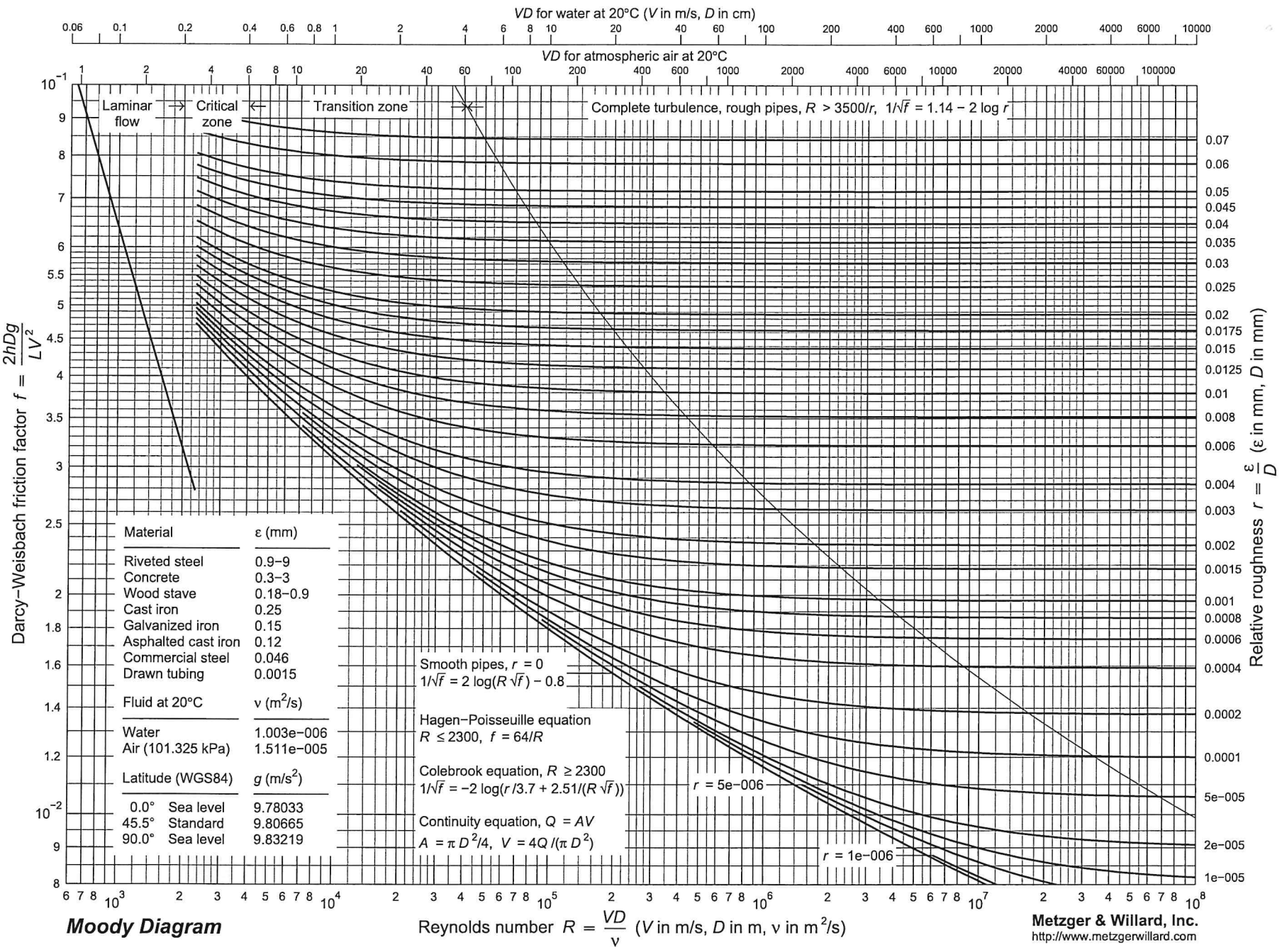
Kinematic viscosity: m^{-2} /s

Properties of water

Temperature [°C]	Density ρ, [kg/m³]	Specific weight γ, [N/m³]	Viscosity μ, [N.s/m²]	Kinematic viscosity ν, [m²/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/m³]	Viscosity μ, [N.s/m²]	Kinematic viscosity ν, [m²/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


VD for water at 20°C (V in m/s, D in cm)
VD for atmospheric air at 20°C
Laminar flow
Critical zone
Transition zone
Complete turbulence, rough pipes, R > 3500/r, 1/√f = 1.14 − 2 log r
Darcy–Weisbach friction factor f = 2hDg/LV²
Relative roughness r = ε/D (ε in mm, D in mm)
Material | ε (mm)
Riveted steel 0.9–9
Concrete 0.3–3
Wood stave 0.18–0.9
Cast iron 0.25
Galvanized iron 0.15
Asphalted cast iron 0.12
Commercial steel 0.046
Drawn tubing 0.0015
Fluid at 20°C | ν (m²/s)
Water 1.003e−006
Air (101.325 kPa) 1.511e−005
Latitude (WGS84) | g (m/s²)
0.0° Sea level 9.78033
45.5° Standard 9.80665
90.0° Sea level 9.83219
Smooth pipes, r = 0
1/√f = 2 log(R √f) − 0.8
Hagen–Poisseuille equation
R ≤ 2300, f = 64/R
Colebrook equation, R ≥ 2300
1/√f = −2 log(r/3.7 + 2.51/(R √f))
Continuity equation, Q = AV
A = π D²/4, V = 4Q/(π D²)
r = 5e−006
r = 1e−006
Moody Diagram
Reynolds number R = VD/ν (V in m/s, D in m, ν in m²/s)
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