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(University of Choice)

MASINDE MULIRO UNIVERSITY OF SCIENCE AND TECHNOLOGY (MMUST)

MAIN CAMPUS

UNIVERSITY EXAMINATIONS

2023/2024 ACADEMIC YEAR

SECOND YEAR FIRST SEMESTER EXAMINATIONS

FOR THE DEGREE

OF

BACHELOR OF SCIENCE IN ELECTRICAL AND COMMUNICATIONS ENGINEERING

COURSE CODE: ECE 207

COURSE TITLE: FLUID MECHANICS FOR ELECTRICAL ENGINEERS

DATE: 7th December 2023 **TIME:** 15:00-17:00

INSTRUCTIONS TO CANDIDATES

a) This paper consists of FOUR questions
b) Answer Question ONE **(compulsory)** and any other TWO Questions
c) The Moody chart is provided
d) All symbols have their usual meaning

TIME: 2 Hours

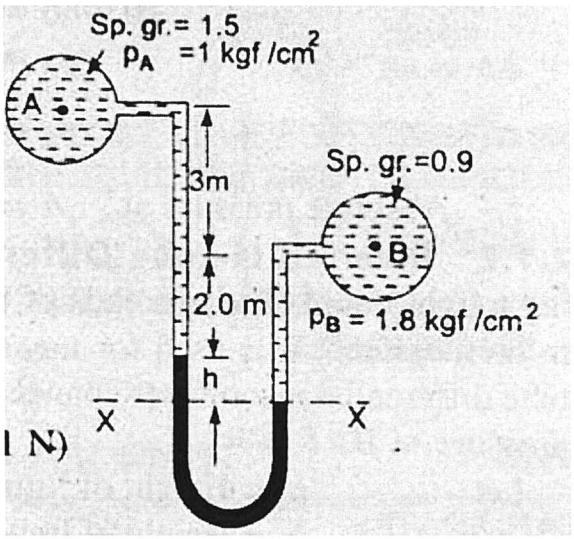
QUESTION ONE **(30 marks)**

a) Calculate the specific weight, density and specific gravity of one litre of a liquid which weighs 7N **(6 marks)**

b) A flat plate of area $1.5x10^6$ mm^2 is pulled with a speed of 0.4 m/s relative to another plate located at a distance 0.15 m from it. Find the force and Power required to maintain this speed if the fluid separating them has a viscosity of 0.1 Pa.s **(5 marks)**

c) Calculate the capillary rise in a glass tube of 2.5mm diameter when immersed vertically in water and when immersed in Mercury. Take surface tensions $\sigma = 0.0725N/m$ for water and $\sigma = 0.52N/m$ for mercury. The contact angles for water and mercury are 0 and 130 degrees respectively **(4 marks)**

d) A differential Manometer is connected at the two points A and B of two pipes as shown below. The pipe A contains a liquid of specific gravity 1.5 while pipe B contains a liquid of specific gravity 0.9.The pressures at A and B are 1kgf/cm^2 and 1.80 kgf/cm^2 respectively. Find the difference in mercury level in the differential manometer (1kgf=9.81) **(9 marks)**



e) A crude oil of kinematic viscosity 0.4x 10-4 m2/s is flowing through a pipe of diameter 300 mm.at the rate of 300 litres per second. Find the head lost due to friction for a length of 50m of the pipe **(6 marks)**

QUESTION TWO (20 marks)

a) Find the minimum size of glass tube that can be used to measure water level if the capillary rise in the glass tube is to be restricted to 2mm.Consider surface tension of water in contact with air to be 0.073575 N/m and the contact angle to be 0 degrees. **(4marks)**

b) The diameters of a pipe at section 1and 2 are 10cm and 15cm respectively. Find the discharge through the pipe if the velocity of water flowing through the pipe at section 1 is 5m/s. Determine also the velocity at section 2. **(4marks)**

c) Explain the Phenomenon of Capillarity and Derive an expression for capillary rise or drop for a liquid **(5marks)**

d) A pipe through which water is flowing, is having diameters 20cm and 10cm at crossections 1 and 2 respectively. The velocity of water at section 1 is given as 4m/s. Find the velocity head at sections 1and 2 and also the rate of discharge **(7marks)**

QUESTION THREE (20 marks)

a) Water is flowing through a pipe of 5cm diameter under a pressure of 29.43 N/cm2 and with a mean velocity of 2m/s. Find the total head or the total energy per unit weight of the water at the crossection, which is 5m above the datum **(6 marks)**

b) A 25cm diameter pipe carries oil of specific gravity 0.9. at a velocity of 3m/s .At another section, the diameter is 20cm. Find the velocity at this section and also the mass flow rate of oil **(6 marks)**

c) Air at 30 °C and atmospheric pressure flows with a velocity of 6.5 m/s through a 75-mm- diameter pipe (absolute roughness = 0.002 mm) . Calculate the friction head loss in 30 m of pipe. **(8 marks)**

QUESTION FOUR (20 marks)

a) The diameters of a small piston and a large piston of a hydraulic Jack containing water as the fluid medium are 3cm and 10cm respectively. A force of 80N is applied on the small piston. Find the load lifted by the large piston when **(6marks)**

   i. The pistons are at the same level
   ii. The small piston is 40cm above the large piston

b) A 30 cm diameter pipe conveying water branches into two pipes of diameters 20 cm and 15 cm respectively ,if the average velocity in the 30cm pipe is 2.5m/s, find the discharge in this pipe Determine also the velocity in the 15cm pipe if the average velocity in the 20cm pipe is 2m/s **(7 marks)**

c) Derive an expression for Bernoulli's theorem from first principles and state the assumptions made for such a derivation **(7marks)**

General information

Standard acceleration: g= 9.81 m/s^2

Standard atmospheric pressure: 1 atm=101.325 kPa= 760 mmHg=10.33 mH_2O

Universal gas constant: R_U = 8.314 kJ/kmol K

Composition of air:

Comp	Mol. Mass(kg/kmol)	%
N_2	28	78.09
O_2	32	20.95
Ar	39.95	0.93
CO_2	44	0.03

***Properties of air*:**

Molar mass/molecular weight: M= 28.96 kg/kmol

Specific gas constant: R= 0.287 kJ/kg K

Specific heat capacity at const pressure: C_P= 1.005 kJ/kg K

Specific heat capacity at const volume: C_v= 0.718 kJ/kg K

Specific heat ratio: $\frac{C_P}{C_V} = 1.4$

Unit conversion factors

Pressure: **1** bar=$\mathbf{10^5}$ Pa

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

Kinematic viscosity ν: **1** m^2s^{-1} = $\mathbf{10^4}$ stokes

Energy: **1** kJ=$\mathbf{10^3}$ N.m

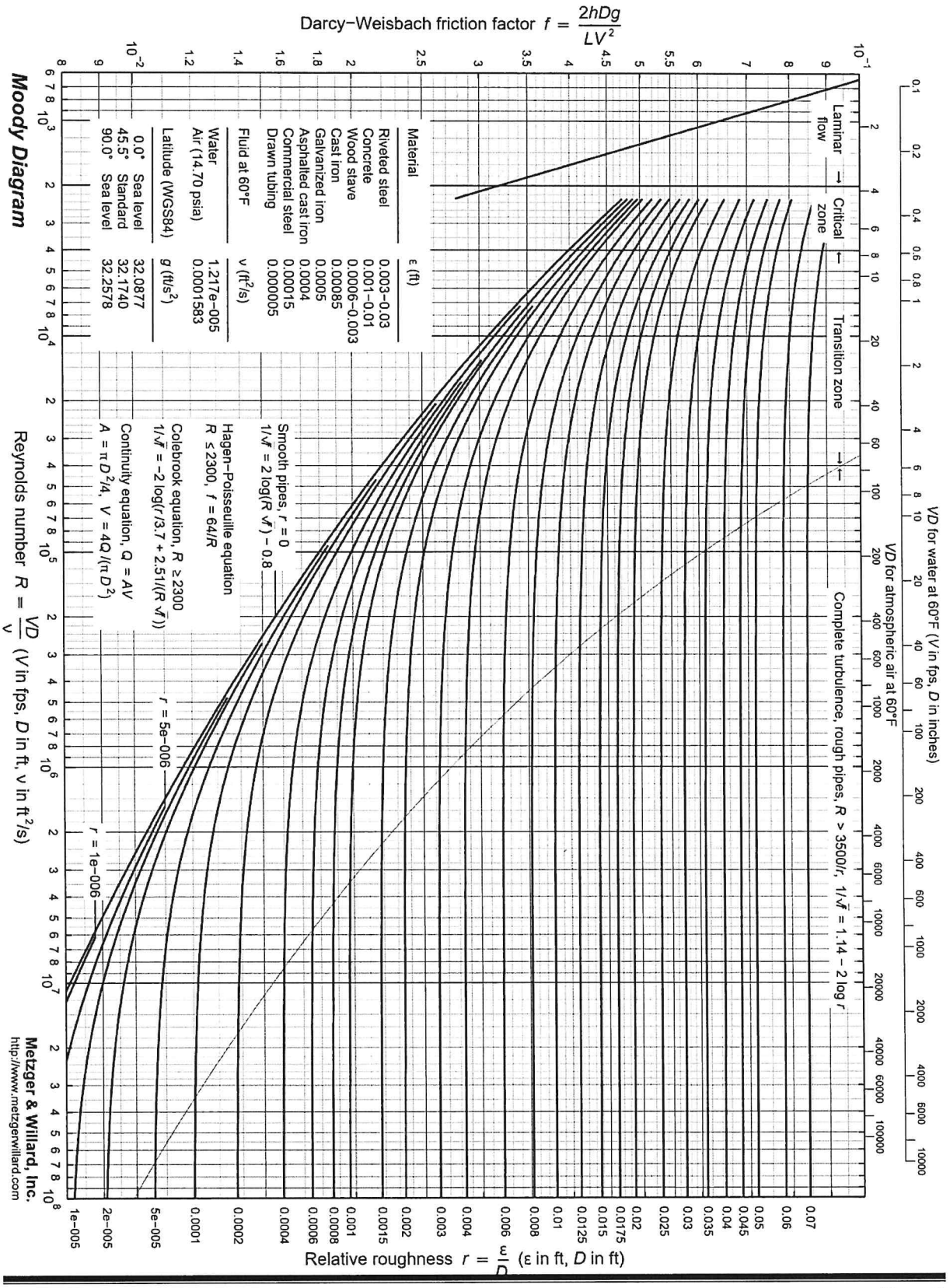
Power: **1** kW= **1** kJ/s

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


Moody Diagram
Darcy–Weisbach friction factor $f = \frac{2hDg}{LV^2}$
Laminar flow
Critical zone
Transition zone
Complete turbulence, rough pipes, $R > 3500/r$, $1/\sqrt{f} = 1.14 - 2 \log r$
VD for water at 60°F (V in fps, D in inches)
VD for atmospheric air at 60°F
Material
ε (ft)
Riveted steel 0.003–0.03
Concrete 0.001–0.01
Wood stave 0.0006–0.003
Cast iron 0.00085
Galvanized iron 0.0005
Asphalted cast iron 0.0004
Commercial steel 0.00015
Drawn tubing 0.000005
Fluid at 60°F
ν (ft²/s)
Water 1.217e-005
Air (14.70 psia) 0.0001583
Latitude (WGS84)
g (ft/s²)
0.0° Sea level 32.0877
45.5° Standard 32.1740
90.0° Sea level 32.2578
Hagen–Poisseuille equation
$R \leq 2300$, $f = 64/R$
Smooth pipes, $r = 0$
$1/\sqrt{f} = 2 \log(R\sqrt{f}) - 0.8$
Colebrook equation, $R \geq 2300$
$1/\sqrt{f} = -2 \log(r/3.7 + 2.51/(R\sqrt{f}))$
Continuity equation, $Q = AV$
$A = \pi D^2/4$, $V = 4Q/(\pi D^2)$
r = 5e-006
r = 1e-006
Reynolds number $R = \frac{VD}{\nu}$ (V in fps, D in ft, ν in ft²/s)
Relative roughness $r = \frac{\varepsilon}{D}$ (ε in ft, D in ft)
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