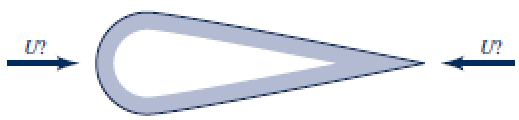
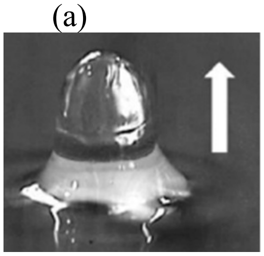
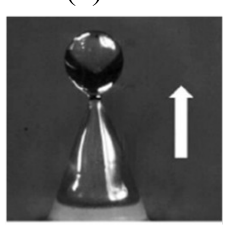
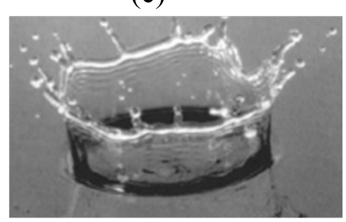
Name:

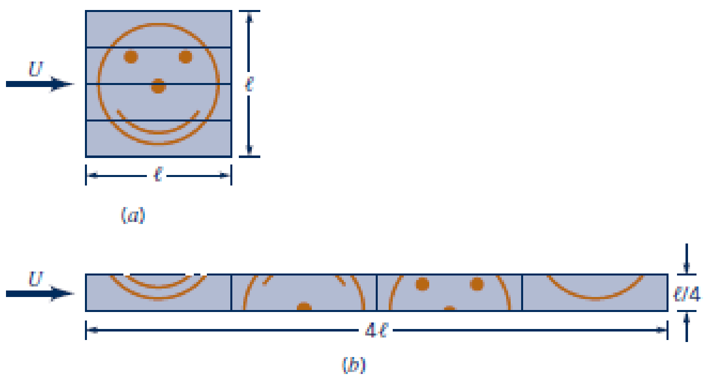
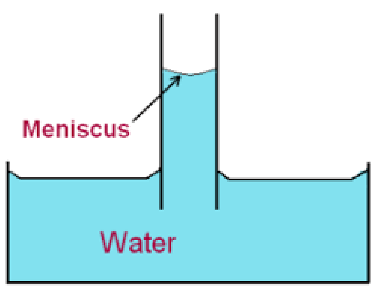
Enrolment No:

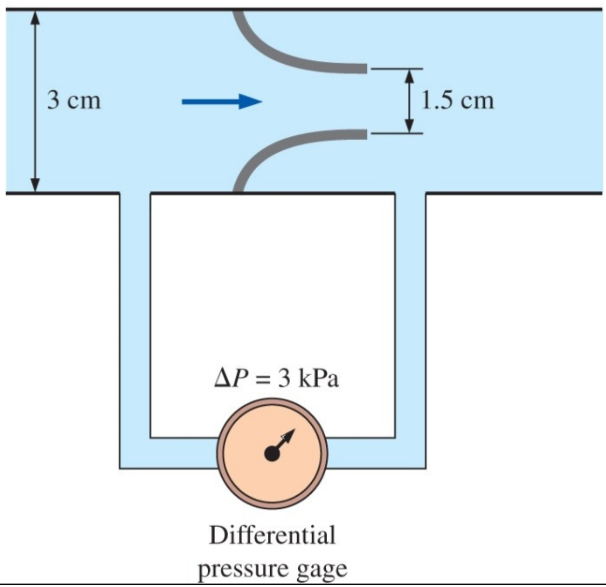
UNIVERSITY OF PETROLEUM AND ENERGY STUDIES
End Semester Examination, December 2018

Course: MECH2007 (Fluid Mechanics) **Semester: III**
Programme: B. Tech Mechanical Engineering
Time: 03 hrs. **Max. Marks: 100**
Instructions:

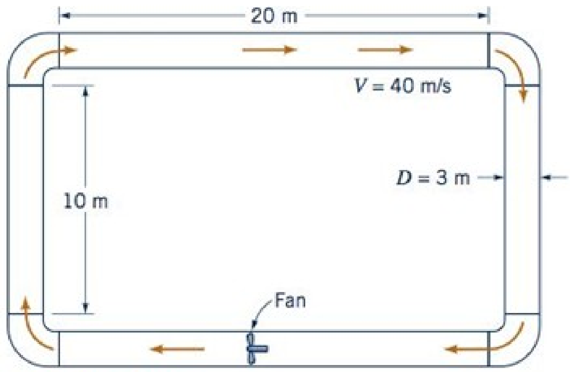
SECTION A **5 Questions x 4 Marks = 20 Marks**

Q1	It is often assumed that "sharp objects can cut through the air better than blunt ones." Based on this assumption, the drag on the object shown in Figure should be less when the wind blows from right to left than when it blows from left to right. Experiments show that the opposite is true. Interpret the results. 	**4**	**CO5**
Q2	A drop is being released from a syringe upon a Teflon surface and three resulting cases are shown below: (a)  (b)  (c)  Categorize these three cases of drop impacts in the increasing order of Weber number. Explain the physical significance of it.	**4**	**CO3**
Q3	For the following 2D flow fields: $\vec{V}=(u,v)=u(x,y)\vec{i}+v(x,y)\vec{j}$ or $\Psi(x,y)$ $(a)\, Couette\ flows: u=y, v=0$ $(b)\, \Psi=x^2-y^2$ For each case, determine if the flow is incompressible, if it is irrotational and if it can be treated as potential flows.	**4**	**CO4**
Q4	Why are dimples made on the golf ball surface?	**4**	**CO5**
Q5	Describe the physical significance of kinematic viscosity? What are its units?	**4**	**CO1**

SECTION B	**5 Questions x 8 Marks = 40 Marks (2 Choice)**		
Q6	The square, flat plate shown in first figure is cut into four equal-sized pieces and arranged as shown in the second figure. Determine the ratio of the drag on the original plate [case **(a)**] to the drag on the plates in the configuration shown in **(b)**. Assume laminar boundary flow. Explain your answer physically? 	**8**	**CO5**
Q7	A washing machine agitator is to be designed. The power, $\boldsymbol{P}$, required for the agitator is to be correlated with the amount of water used (indicated by the depth, $\boldsymbol{H}$, of the water). It also depends on the agitator diameter, $\boldsymbol{D}$, height, $\boldsymbol{h}$, maximum angular velocity, $\boldsymbol{\omega}_{max}$, and frequency of oscillations, $\boldsymbol{f}$, and water density, $\boldsymbol{\rho}$, and viscosity, $\boldsymbol{\mu}$. Determine the number of independent Π groups (dimensionless groups) in this problem using Buckingham Π theorem and the dependence of power upon other relevant parameters. **OR** Using Buckingham Pi Theorem, find the dependence of capillary rise upon other parameters. 	**8**	**CO3**
Q8	A 30 cm diameter horizontal pipe terminate in a nozzle with the exit diameter of 7.5 cm. if the water flows through at a rate of 0.15 m^3/s, what force will be exerted by fluid on the nozzle? OR A tornado can be approximated by a free vortex of strength Γ for $r > R_c$, where R_c is the radius of the core. Velocity measurements at points A and B indicate that $V_A = 125$ ft/s and	**8**	**CO2**

	V_B=60 ft/s. Determine the distance from point A to the center of the tornado. Why can the free vortex model not be used to approximate the tornado throughout the flow field $(r \geq 0)$?		
Q9	A flow nozzle equipped with a differential pressure gauge is used to measure the flow rate of water at 10°C (ρ=999.7 kg/m^3 and μ=1.307×10^{-3} kg/m·s) through a 3-cm-diameter horizontal pipe. The nozzle exit diameter is 1.5 cm, and the measured pressure drop is 3 kPa. Determine the average velocity through the pipe, and the head loss. 	**8**	**CO3**
Q10	The potential flow a blunt body can be approximated by combining a uniform flow in the positive x direction and a source located at the origin. Let $\boldsymbol{U}$=20 m/s and $\boldsymbol{m}$=120 m^2/s (source strength) (a) Obtain expression for the velocity potential, and velocity field for the combined flow. (b) Determine the stagnation points in the flow where the velocity is zero.	**8**	**CO4**
SECTION-C	**2 Questions x 20 Marks = 40 Marks (1 Choice)**		
Q11 4. 5.	Consider steady, incompressible, parallel, laminar flow of a liquid flowing between two parallel plates. The liquid has a density, ρ, and dynamic viscosity, μ. The distance between the plates is *'h'*. The gravitational force acts downward. (a) Write down the continuity equation and NS equations of this problem, and simplify the equations by making appropriate assumptions. Please list your assumptions. Hint: Treat the flow as 2D. (b) What is the velocity boundary condition at the free surface. (c) Find the velocity profile. (d) Calculate the shear stress at the wall.	**20**	**CO4**

<table>
<tr><td></td><td>(e) Find the discharge in the pipe as a function of pressure drop over a length L.</td><td></td><td></td></tr>
<tr><td>Q12</td><td>A fan is to produce a constant air speed of 40 m/s throughout the pipe loop shown in the Figure below. The 3-m diameter pipes are rough and each of the four 90° elbows has a loss coefficient of 0.3. Determine the power that the fan adds to the air when:
a) The pipes have a surface roughness of the order of 3 mm.
b) The pipes are smooth.

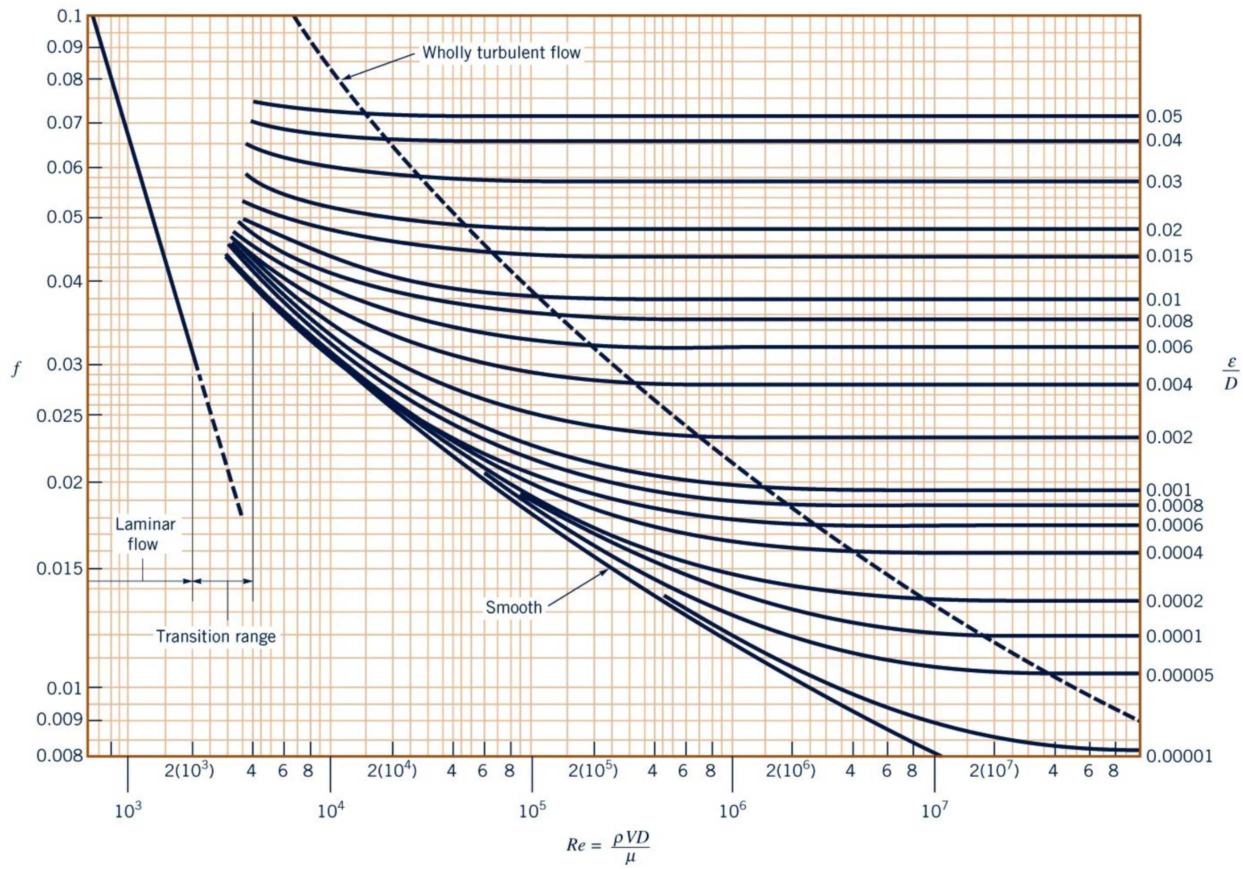


OR

Consider these cases of external flow situations and answer the questions:

a) A plate of length 500 mm and width 250 mm has been placed longitudinally in a stream of crude oil which flows with a velocity of 6 m/s. if the oil has specific gravity 0.9 and viscosity 1 stoke calculate 1) Boundary layer thickness at the middle of the plate. 2) Shear stress and the middle of the plate 3) Friction drag on one side of the plate.

b) Experiments were conducted in a wind tunnel with wind speed of 50 km/hr on a flat plate 2 m long and 1 m wide. The mass density of air is 1.15 kg/m^3, and plate is kept at such an angle that the coefficients of lift and drag are 0.75 and 0.15 respectively. Determine the lift force, drag force, resultant force and power exerted by the air stream on the plate.</td><td>20</td><td>CO3</td></tr>
</table>



Wholly turbulent flow
Laminar flow
Transition range
Smooth
f
0.1
0.09
0.08
0.07
0.06
0.05
0.04
0.03
0.025
0.02
0.015
0.01
0.009
0.008
0.05
0.04
0.03
0.02
0.015
0.01
0.008
0.006
0.004
0.002
0.001
0.0008
0.0006
0.0004
0.0002
0.0001
0.00005
0.00001
$\frac{\varepsilon}{D}$
$2(10^3)$ 4 6 8 $2(10^4)$ 4 6 8 $2(10^5)$ 4 6 8 $2(10^6)$ 4 6 8 $2(10^7)$ 4 6 8
10^3 10^4 10^5 10^6 10^7
$Re = \frac{\rho V D}{\mu}$