ENGR361/2 V 2011 Fluid Mechanics I Final Exam

(Total Problems: 6; Total Time: 180 minutes; Total Grade: 100)
December 20th 2011
Instructor: Dr. Liangzhu (Leon) Wang

NOTE:

1. **Write solutions on the examination booklet**
2. **Write your name and ID CLEARLY on the examination booklet**
3. **Material allowed: Yes (one page single-sided crib sheet only)**
4. **Calculator allowed: Yes (ENCS approved calculators only)**
5. **Read each question carefully and answer all questions**
6. **Write down clearly all the intermediate steps**
7. **Submit this problem sheet and your formula sheet with your examination booklet**

Problem 1 (16 Points) – Concepts and Definitions (if you draw graphs or use equations, make sure to explain in words too)

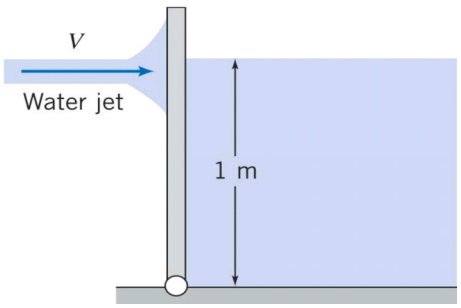
1.1 Define pathlines, streaklines and streamlines. For a given fluid flow, when all these three lines become the same lines? (4 points)

1.2 Define laminar flow and turbulent flow. For flows in pipes, what dimensionless number is used to define laminar, turbulent and transitional flows? What is the range of this number for laminar, turbulent, and transitional flow, respectively? (6 points)

1.3 For flows in pipes, define major losses and minor losses. List four types of common minor losses in pipe flows (no graphs, explain in words). (6 points)

Problem 2 (16 Points)

A gate is 1 m wide and 1.2 m tall and hinged at the bottom. On one side the gate holds back a 1-m-deep body of water as shown in the figure. On the other side, a 5-cm diameter water jet hits the gate at a height of 1 m. What jet speed V is required to hold the gate vertical? What will the required speed be if the body of water is lowered to 0.5 m? What will the required speed be if the water level is lowered to 0.25 m?



Problem 3 (23 Points)

In a wind tunnel study of gaseous pollutant dispersion, independent variables are needed: V (stack gas speed), U (wind speed), ρ (air density), $\rho - \rho_s$ (density difference of air and stack gas), g (acceleration of gravity), v_s (kinematic viscosity of stack gas), D (stack diameter).

3.1 By using FLT system and V, ρ and D as repeating variables, find suitable set of similarity requirements for modeling pollutant dispersion. (15 points)

3.2 Use of a length scale of 1:200 and same fluid in the model and prototype, will the similarity requirement be satisfied? (8 points)

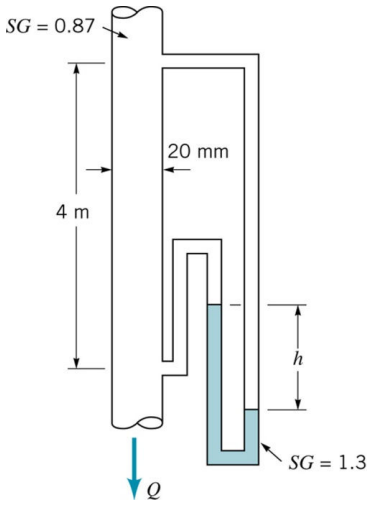
Problem 4 (15 Points)

Oil of SG = 0.87 and a kinematic viscosity $v = 2.2\times10^{-4}\ m^2/s$ flows through the vertical pipe shown in the figure at a rate of $4 \times 10^{-4}\ m^3/s$.

4.1 Is the flow in the pipe laminar or turbulent? (5 points)

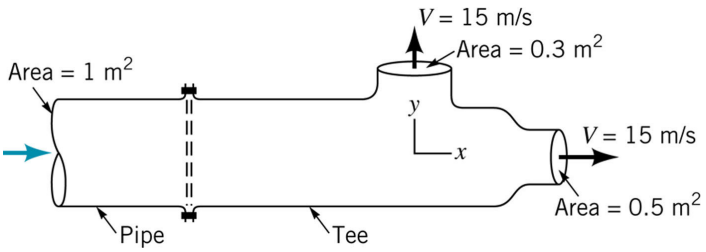
4.2 Determine the manometer reading, h (10 points)

Hint: $$Q = \frac{\pi(\Delta p + \gamma l)D^4}{128\mu l}$$



Problem 5 (15 Points)

Water flows as two free jets from the tee attached to the pipe shown in the figure. The exit speed is *15 m/s*. If viscous effects and gravity are negligible, determine the x and y components of the force that the pipe exerts on the tee.

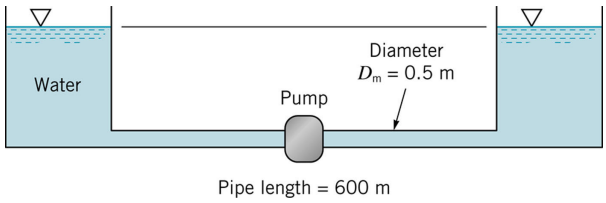


Problem 6 (15 Points)

Water is pumped between two large open tanks as shown in the figure. The pump power is 50 kW.

7.1 List the minor losses, which may exist for the flow between the tanks? (5 points)

7.2 If we neglect these minor losses and the friction factor is equal to 0.02, what is the flowrate passing between the tanks? (10 points)



Properties and Constants

$\rho_{air} = 1.23\ kg/m^3$
$\mu_{air} = 1.79 \times 10^{-5}\ N{\cdot}s/m^2$
$\gamma_{air} = 12.066\ N/m^3$
$g = 9.81\ m/s^2$

$\rho_{water} = 999\ kg/m^3$
$\mu_{water} = 1.12 \times 10^{-3}\ N{\cdot}s/m^2$
$\gamma_{water} = 9.81 \times 10^{3}\ N/m^3$

Systems of Dimensions

Dimensions Associated with Common Physical Quantities

	FLT System	*MLT* System
Acceleration	LT^{-2}	LT^{-2}
Angle	$F^0L^0T^0$	$M^0L^0T^0$
Angular acceleration	T^{-2}	T^{-2}
Angular velocity	T^{-1}	T^{-1}
Area	L^2	L^2
Density	$FL^{-4}T^2$	ML^{-3}
Energy	FL	ML^2T^{-2}
Force	F	MLT^{-2}
Frequency	T^{-1}	T^{-1}
Heat	FL	ML^2T^{-2}
Length	L	L
Mass	$FL^{-1}T^2$	M
Modulus of elasticity	FL^{-2}	$ML^{-1}T^{-2}$
Moment of a force	FL	ML^2T^{-2}
Moment of inertia (area)	L^4	L^4
Moment of inertia (mass)	FLT^2	ML^2
Momentum	FT	MLT^{-1}
Power	FLT^{-1}	ML^2T^{-3}
Pressure	FL^{-2}	$ML^{-1}T^{-2}$
Specific heat	$L^2T^{-2}\Theta^{-1}$	$L^2T^{-2}\Theta^{-1}$
Specific weight	FL^{-3}	$ML^{-2}T^{-2}$
Strain	$F^0L^0T^0$	$M^0L^0T^0$
Stress	FL^{-2}	$ML^{-1}T^{-2}$
Surface tension	FL^{-1}	MT^{-2}
Temperature	Θ	Θ
Time	T	T
Torque	FL	ML^2T^{-2}
Velocity	LT^{-1}	LT^{-1}
Viscosity (dynamic)	$FL^{-2}T$	$ML^{-1}T^{-1}$
Viscosity (kinematic)	L^2T^{-1}	L^2T^{-1}
Volume	L^3	L^3
Work	FL	ML^2T^{-2}