NATIONAL UNIVERSITY OF SCIENCE AND TECHNOLOGY

FACULTY OF INDUSTRIAL TECHNOLOGY

DEPARTMENT OF INDUSTRIAL AND MANUFACTURING ENGINEERING

Bachelor of Engineering Honours Degree Industrial and Manufacturing Engineering

Fluid Mechanics

TIE 2202

Second Semester Main Examination Paper

April/May 2015

This examination paper consists of 4 pages

Time Allowed: **3 hours**

Total Marks: **100**

Special Requirements:

Examiner's Name: **Eng. Davison. Zimwara**

INSTRUCTIONS AND INFORMATION TO CANDIDATE:

1. **Answer any five (5) questions**
2. **Each question carries 20 marks**
3. **Use of calculators is permissible**

Question 1

(a) Explain the major differences between a fluid and a solid. [4]

(b) Show that for three dimensional incompressible flow the continuity equation is given by

$$\frac{\delta v_x}{\delta x} + \frac{\delta v_y}{\delta y} + \frac{\delta v_z}{\delta z} = 0$$ [16]

Question 2

(a) Water flows through a pipe diameter AB 1.2m at 3m/s and then passes through a pipe BC that is 1.5m in diameter. At C the pipe forks, branch CD is 0.8m in diameter and carries one third of the flow in AB. The velocity in branch CE is 2.5m/s

Find:

i) The volume rate of flow in AB [2]
ii) The velocity in BC [3]
iii) The velocity in CD [2]
iv) The diameter of CE [3]

(b) Derive from first principles Bernoulli's equation for frictionless and incompressible flow through a pipe. Explain the terms involved. [10]

Question 3

Show that in a fully developed laminar flow a pipe of radius r and length L, the velocity profile and the flow rate are given by:

$$u = -\frac{R^2}{4\mu}\left(\frac{\partial p}{\partial x}\right)\left[1-\left(\frac{r}{R}\right)^2\right]$$

$$Q = \frac{\prod \Delta p\, D^4}{128\mu L}$$

Question 4

(a) Water flows through a pipe line which contracts from 400 diameters at A to 300 mm diameter at B and then forks, one branch being 150 mm diameter discharging at C and the other branch 200mm diameter discharging at D. If the velocity at A is 1.8m/s and the velocity at D is 3.6 m/s. What will be the discharge at C and D and the velocities at B and C? [12]

(b) A centrifugal pump has an impeller with dimensions r_1=75mm, r_2=150mm, b_1=50mm, b_2=30mm, $\beta_1=\beta_2=30°$. For a discharge of 70 litres per second and without shock entry to vanes, calculate

b) The speed
c) The head, and
d) The power.

Neglect losses ($\alpha_1=90°$) take the speed as 1450 r.p.m. [8]

Question 5

Water flows at U=1m/s part a flat plate with L=1m in the flow direction. The boundary layer is tripped so that it becomes turbulent at the leading edge.

Evaluate i) the disturbance thickness δ [4]
ii) The displacement thickness δ [4]
iii) The wall shear stress at the location X= L [4]
vi. Compare with the values that would be found if laminar flow could be maintained to the same position. Assume a 1/7 power law for turbulent velocity profile [8]
[20]

(a) A vertical venture-meter measures the flow of oil of specific gravity 0.82 and has an entrance of 125mm diameter and a throat of 50mm diam. There are pressure gauges at the entrance and at the throat, which is 300mm above the entrance,if the coefficient for the meter is 0.97. Find the flow rate in m^3/s when the pressure difference is 27.5 KN/m^2. [10]

(b) Show that Stodola's slip factor

$$SF = 1 - \frac{\pi Sin\beta_2}{z[1 - \left(\frac{V_{f_2}}{U_2}\right)Cot\beta_2}$$

For impeller pumps [10]

Question 7

Hot water is to be pumped by means of high pressure from a large reactor at ground-level, through a heat exchanger to an open tank of the second floor. The inlet to the open tank is 14m above the ground floor. The tubes are made of cast iron.

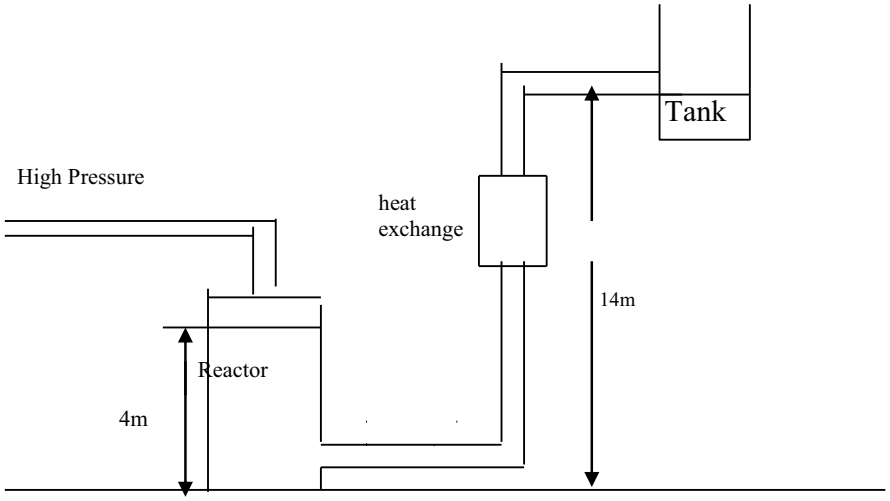
Calculate: The needed pressure in the rector to pump 30 tones of water in 10 mins. [20]

Data:			
	Tube	length	20 m
		Diameter	200 mm
	Hot water	viscosity	10^{-3} Ns/m^2
		Density	1050 kg/m^3

Friction losses the coefficient of friction losses K ($\Delta p = Ku^2/2g$)

90 bend	0.7
sharp inlet	0.45
valve	4
heat exchanger	16

Take f as = 0.006
The water level in the reactor can be regarded as constant.



End of Exam