UNIVERSITY OF JOHANNESBURG

PROGRAM	:	**NATIONAL DIPLOMA** *ENGINEERING: MECHANICAL*
SUBJECT	:	**HYDRAULIC MACHINES III**
CODE	:	**MHM 301**
DATE	:	SUMMER EXAMINATION 2015 7 NOVEMBER 2015
DURATION	:	(SESSION 2) 12:30 - 15:30
WEIGHT	:	40 : 60
TOTAL MARKS	:	101
FULL MARKS	:	100

EXAMINER	:	MR. T MILLER
MODERATOR	:	MR P SENDA
NUMBER OF PAGES	:	5 PAGES (Including cover page and one Annexure)

REQUIREMENTS : 1 SHEET OF GRAPH PAPER

INSTRUCTIONS:

- PLEASE ANSWER ALL QUESTIONS.
- NUMBER ALL YOUR QUESTIONS CLEARLY AND UNDERLINE YOUR FINAL ANSWER.
- ANSWERS WITHOUT UNITS WILL BE PENALIZED.
- MAKE REASONABLE ASSUMPTIONS WHERE DATA IS MISSING.

QUESTION 1

A centrifugal pump was tested in a laboratory of a mining facility running at its operating speed and the following results were obtained from the test.

Q (m^3/s)	0.00	0.030	0.060	0.075	0.100	0.125
H_{avail} (m)	35.6	34.07	31.33	29.50	25.23	17.92
Efficiency (%)	0	50	65	68	70	65

The pipe used in the test is 100 m in length with a diameter of 200 mm and has a Darcy friction factor f = 0.035. Water is sucked from a dam and delivered directly into a large reservoir below water level through a potential head of 17 m.
The following data can be considered for minor losses;

$K_{entrance}$ = 0.4 (pipe entrance), K_{valve} = 15(valve), $K_{elbow\ 90°}$ = 0.92 (each elbow—there are 5), $K_{elbow\ 45°}$ = 0.45 (each elbow—there are 2), K_{exit} = 1.00 (pipe exit),

Plot the characteristic curves of the pump and pipe and at the point of curve intersection, determine:

1.1 the discharge in m^3/s at the operating point;

1.2 the operating head and

1.3 the breaking power required to drive the pump in kW at the operating point.

[28]

QUESTION 2

A centrifugal pump has impeller inlet and outlet radii of r_1 = 120 and r_2 = 200 mm respectively. The impeller inlet and outlet blade widths are b_1= 55 mm and b_2 = 35 mm. The pump is to deliver 0.3 m^3/s of the liquid at a net head of 14.5 m when the impeller rotates at 1720 rpm. Design the blade shape inI such a way that (V_{1t} = 0,) for the pump. Calculate:

2.1 angles β_1 and β_2; (11)

2.2 the breaking power and (2)

2.3 the pump efficiency (2)

[15]

QUESTION 3

The following design data is available for a hydroelectricity plant:

Gross head	520 m
Flow rate	2 m^3/s
Number of identical turbines	15
Total mechanical losses	4%
Generator efficiency	94.5%

Estimate the total electrical power output from the generator.

[9]

QUESTION 4

The frictional losses for a pelton wheel are Cv = 0.94 and Cd = 0.9. The rotational speed of the pelton wheel is 450 rpm and has an average diameter of 1.5 m with a bucket deflecting angle of 159 deg. The nozzle jet diameter is 80 mm and the pressure exerted behind the nozzle is 850 kN/m^2. Determine;

4.1 the breaking power for the wheel, (10)

4.2 the theoretical maximum power for the wheel and (5)

4.3 the overall efficiency under the conditions in 4.1. (3)

[18]

QUESTION 5

A centrifugal fan has a fan total pressure of 400 Pa and a manometric efficiency of 55%. The rotational speed is 1500 rpm. The fan delivers 1.2 m^3/s air of density 1.2 kg/m^3. The inner diameter of the impeller is 0.8 of the outer diameter and the width of the impeller is constant at 0.2 of the outer diameter. The whirl velocity at the inlet is zero and the exit whirl velocity is twice the exit peripheral velocity, calculate;

5.1 the peripheral velocity at inlet and (10)

5.2 the outlet blade angle. (8)

[18]

QUESTION 6

Determine the bed width and bed depth of the best trapezoidal channel to meet the following specifications:

Flow rate	120 m^3/s
Slope	1:1300
Construction	Brickwork

[13]

FULL MARKS: 100

TOTAL MARKS: 101

USEFUL HYDRAULIC MACHINES FORMULAE

$$H_E = \frac{\omega}{g}(r_2V_{2t} - r_1V_{1t})$$

$$Q = 2\pi r_1 b_1 V_{1,n} = 2\pi r_2 b_2 V_{2,n} \qquad V_t = \omega r - \frac{V_n}{tan\beta} \text{ (1 or 2)}$$

$$V_t = V_n tan\alpha \text{ (1 or 2)}$$

$$bp = \omega T_{shaft} = \rho\omega Q(r_2V_{2,t} - r_1V_{1,t})$$

$$wp = \rho g Q H$$

$$H_L = \frac{8fLQ^2}{\pi^2 g D^5}$$ Darcy equation for major losses

$$\frac{8k_{total}Q^2}{\pi^2 g D^4}$$ Minor losses

$$P_{Peltonwhed} = \rho\omega r Q(V_j - \omega r)(1 - \cos\beta)$$

From Chow (1959).

Wall Material	n
A. Artificially lined channels	
Glass	0.010
Brass	0.011
Steel, smooth	0.012
Steel, painted	0.014
Steel, riveted	0.015
Cast iron	0.013
Concrete, finished	0.012
Concrete, unfinished	0.014
Wood, planed	0.012
Wood, unplaned	0.013
Clay tile	0.014
Brickwork	0.015
Asphalt	0.016
Corrugated metal	0.022
Rubble masonry	0.025

$$V_{jet} = C_v\sqrt{2gH}$$

$$\boldsymbol{P_T = P_s + P_v}$$

$$\boldsymbol{P_E = \rho\omega(r_2V_{2t} - r_1V_{1t})}$$

$$\boldsymbol{\eta_{\ manomatric} = \frac{P_T}{P_E}}$$

$$\boldsymbol{P_m = \rho_m RT}$$

$$\left(\frac{Q}{ND^3}\right)_P = \left(\frac{Q}{ND^3}\right)_m \; ; \; \left(\frac{H}{N^2D^2}\right)_P = \left(\frac{H}{N^2D^2}\right)_m \; ; \; \left(\frac{P}{D^5N^3}\right)_P = \left(\frac{P}{D^5N^3}\right)_m$$

$$\text{Re} = \frac{\rho V R_h}{\mu}; \; \text{Fr} = \frac{V}{\sqrt{g y_n}}$$