UNIVERSITY OF JOHANNESBURG

PROGRAM	:	BACCALAUREUS INGENERIAE *CIVIL ENGINEERING*
SUBJECT	:	**Hydraulic Engineering 3A**
CODE	:	**HMG3A11**
DATE	:	SSA EXAMINATION JUNE 2018
DURATION	:	3 Hours
WEIGHT	:	50 : 50
TOTAL MARKS	:	100

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NUMBER OF PAGES	:	3 PAGES AND 1 ANNEXURE

FILE NO: HMG3A11 2018

INSTRUCTIONS	:	QUESTION PAPERS MUST BE HANDED IN
REQUIREMENTS	:	2 ANSWER BOOKLETS

INSTRUCTIONS TO STUDENTS

- PLEASE ANSWER ALL QUESTIONS
- PROVIDE SHORT AND PRECISE ANSWERS FOR THE THEORETICAL PART
- SHOW ALL THE STEPS FOR CALCULATIONS CLEARLY

QUESTION 1 [26 Marks]

1.1. Suppose the selected centrifugal pump for our use is not available in the market. Discuss how we can select another pump available in the market and how we can utilize that pump. (5)

1.2. Write the reasons for throttling a pump. What do we do if we do not use throttling? (5)

1.3. Explain how pressure surges affects water quality in water supply systems. (5)

1.4. Discuss the occurrences of cavitation phenomenon in pipe systems, its effects, detection and control mechanisms. (6)

1.5. Sketch the EGL (solid line) and HGL (dash line) for Fig. 1. (5)

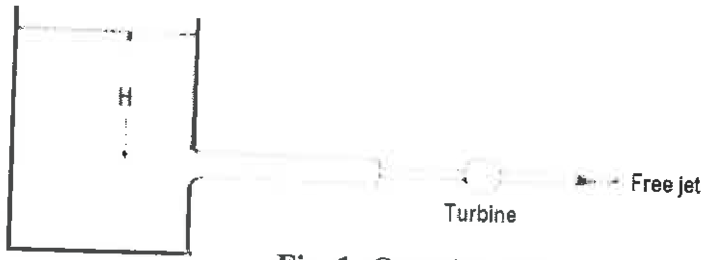

Fig. 1: Question 1.5

QUESTION 2 [16 Marks]

2.1 Derive Darcy Weisbach headloss equation using the first principles of flow. (6)

2.2 Derive an equation for the available NPSH for a submersible centrifugal pump. Support your derivation by drawing. (8)

QUESTION 3 [18 Marks]

Given: three reservoirs connected at a single junction (Fig. 2). The length (L), diameter (D), friction factor f and minor loss coefficient (K) of each pipe are given in Tabular form.

Calculate:

a) the correct flow in each pipe (14)

b) The reading of a pressure gauge attached to the junction J. (4)

[Hint: Start assuming pressure head at J = 130m]

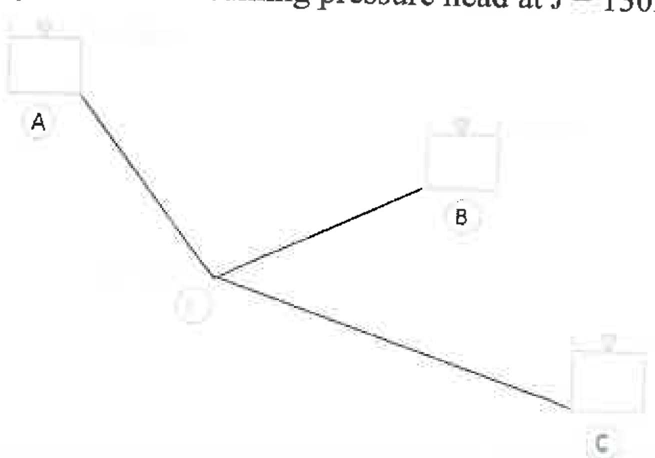

Table 1

	JA	JB	JC
L (m)	1400	1800	2200
D (m)	0.30	0.25	0.20
f	0.016	0.018	0.022
K	40	25	50

Fig. 2. Three reservoirs problem **(Question 3)**

FORMUAL SHEET

$$P_w = \gamma Q H_t \qquad \frac{Q_1}{Q_2} = \left(\frac{D_1}{D_2}\cdot\frac{N_1}{N_2}\right) \qquad \frac{H_1}{H_2} = \left(\frac{D_1}{D_2}\cdot\frac{N_1}{N_2}\right)^2 \qquad \frac{P_1}{P_2} = \left(\frac{D_1}{D_2}\cdot\frac{N_1}{N_2}\right)$$

$$R_e = \frac{\rho V D}{\mu} \qquad \frac{NPSHR_1}{NPSHR_2} = \left(\frac{N_1}{N_2}\right)^2 \qquad P = A\left[\frac{1-(1+i)^{-n}}{i}\right] \qquad c = \sqrt{\frac{K}{\rho}}$$

$$\frac{1}{\sqrt{f}} = -2\log\left(\frac{\varepsilon}{3.7D} + \frac{2.51}{Re\sqrt{f}}\right) \qquad \frac{1}{\sqrt{f}} = 2\log\left(\frac{3.7D}{\varepsilon}\right)$$

$$N_S = 51.64 N \frac{Q^{0.5}}{H^{0.75}}$$

$$H_t = h_d + h_{f_d} + \sum h_{m_d} + \frac{v_d^2}{2g} \pm \left[h_s - h_{f_s} - \sum h_{m_s} - \frac{v_s^2}{2g} + \frac{v_s^2}{2g}\right]$$

$$b_1.Q^2 + b_2.Q + b_3 = H$$

$$H = n\left(b_1.Q^2 + b_2.Q + b_3\right)$$

$$(NPSH)_A = \pm h_S - h_{fS} - \sum h_{mS} + \frac{P_{atm}}{\gamma_{air}} - \frac{P_{Vapor}}{\gamma_{vapor}} \qquad Dh = \frac{4A}{P}$$

$$Q = AV \qquad a_1.Q^2 + a_2. = H$$

$$H_t = h_d + h_{f_d} + \sum h_{m_d} + \frac{v_d^2}{2g} \pm \left[h_s - h_{f_s} - \sum h_{m_s}\right] \qquad b_1\left(\frac{Q}{n}\right)^2 + b_2\left(\frac{Q}{n}\right) + b_3 = H \qquad Q = \sqrt{\frac{H - a_2}{a_1}}$$

$$z_1 + \frac{P_1}{\gamma} + \frac{v_1^2}{2g} + H_P = z_2 + \frac{P_2}{\gamma} + \frac{v_2^2}{2g} + H_L \qquad \eta_p = \frac{P_o}{P_a} = \frac{\gamma Q H}{P_a} \qquad y_v = 14\frac{D}{R_e\sqrt{f}}$$

$$y_t = 184\frac{D}{R_e\sqrt{f}}$$

$$Q = AV \qquad V = \frac{Ku}{n} R^{2/3} S_o^{1/2} \qquad h_f = f\frac{L}{D}\frac{V^2}{2g}$$

$$h_s = K\frac{V^2}{2g} \qquad Q = \sqrt{\frac{h_f}{L}\frac{\pi^2 g}{8f} D^5} \qquad \Delta Q = \frac{\sum hf}{\sum h_f / Q_o} \qquad A = \frac{1}{KQ_o} \qquad C_e = \sqrt{\frac{1}{\rho\left[\frac{1}{K} + \frac{C_1 D}{TE}\right]}}$$

$$\frac{1}{\sqrt{f}} = -2\log\left(\frac{\varepsilon/D}{3.7} + \frac{2.51}{\mathrm{Re}\sqrt{f}}\right) \qquad f = \frac{0.25}{\left[\log\left(\frac{\varepsilon/D}{3.7} + \frac{5.74}{\mathrm{Re}^{0.9}}\right)\right]^2} \qquad Q_1 = 0.5Q_o + 0.5A\left(H_{begin} - H_{end}\right)$$

$$H = V\sqrt{\frac{AL}{ag}} \qquad N = \frac{\rho L u_o}{P_o t_c} \qquad \Delta P = P_o\left[\frac{N}{2} + \sqrt{\frac{N^2}{4} + N}\right] \qquad c_1 = 1 - \frac{\eta}{2}$$

$$c_1 = 1 - \eta^2 \qquad c_1 = \frac{5}{4} - \eta \qquad h_f = 10.64\frac{L}{C^{1.85}D^{1.85}}Q^{1.85} \qquad \Delta h = \frac{L}{g}\frac{U_o}{\Delta t}$$

QUESTION 4 [20 Marks]

Two reservoirs (A and B) are at a distance of 12 km apart and are connected by a steel pipeline (Poisson's ratio = 0.35). The pipeline is built with a steel pipe (modulus of elasticity = 210 GPa) of 500 mm diameter and 5 mm thickness. There is a valve at the middle of the two reservoirs. Under standard operating conditions, water (density = 988 kg m^{-3}, bulk modulus = 2.2 GPa) flows through the pipe at a steady flow rate of 300 L/s. The valve is closed gradually and the pipeline has no expansion joints.

Calculate the following:

3.1. wave celerity, transient pressure and pressure increase at point C (3 km u/s of the valve) and D (3 km d/s of the valve) by assuming: (a) rigid pipe, (b) elastic pipe. (17)

3.2. time required for the surge wave to travel from the valve to the reservoir. (3)

QUESTION 5 [20 Marks]

At a test speed of 2370 rpm, the required NPSH of a pump is determined as 7.2 m. A site measurement indicates that the available NPSH is 9.8 m at a water temperature of 10 °C.

5.1. Would the available NPSH be adequate if a 20% safety margin is required? Assume the pump is running at 2 600 rpm and the water temperature is 35 °C. (8)

5.2. A pump test provides the following three measurements: 67 m at no flow; 60 m at 150 ℓ/s; and 45 m at 350 ℓ/s. Calculate the following:

a. the constants b_1, b_2 and b_3 to describe the pump curve mathematically. (4)

b. the constants a_1 and a_2 to describe the system curve mathematically. (3)

c. the equivalent pump curve and duty point for two pumps arranged in parallel. (5)

Table 2. Density, viscosity and vapour pressure as function of temp.

T (°C)	ρ (kg/m3)	μ (kg/m.s)	V.P (Kpa)
5	1000.0	1. 521E -3	0.9
10	999.7	1.307E -3	1.2
15	999.1	1.138E -3	1.7
20	998.2	1.002E -3	2.3
25	997.1	0.891E -3	3.2
30	995.7	0.798E -3	4.3
35	994.0	0.719E -3	5.6