UNIVERSITY OF JOHANNESBURG

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| **PROGRAM** | : | NATIONAL DIPLOMA<br>*ENGINEERING : CIVIL* |
| **SUBJECT** | : | **HYDRAULICS 2A** |
| **CODE** | : | **CEW2A11** |
| **DATE** | : | MAIN EXAMINATION<br>29 MAY, 2019 |
| **DURATION** | : | (Z-PAPER) 16:30 - 18:30 |
| **WEIGHT** | : | 40 : 60 |
| **TOTAL MARKS** | : | 100 |

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| **EXAMINER** | : | MR LF SHIRLEY |
| **MODERATOR** | : | DR AM CASSA |
| **NUMBER OF PAGES** | : | 4 PAGES, 1 FORMULAE SHEET AND 4 ANNEXURES |

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| **INSTRUCTIONS** | : | CLOSED BOOK |
| **REQUIREMENTS** | : | NONE |

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**HAND IN THE QUESTION PAPER WITH YOUR SCRIPT.**

**INSTRUCTIONS TO CANDIDATES:**

ANSWER ALL THE QUESTIONS.

## QUESTION 1

1.1 Define an ideal fluid. (1)

1.2 State two differences between liquids and gases. (2)

1.3 Who invented the mercury barometer? (1)

1.4 What property quantifies the compressibility of a liquid? (1)

**[5]**

## QUESTION 2

Determine the terminal velocity with which the 500g mass will slide along the inclined surface. See Figure 1. Take g = $10m/s^2$.

$$\tau = \frac{F}{A} = \mu\frac{U}{t}$$

State whether the 500g mass will slide up or down the inclined surface.

**[10]**

## QUESTION 3

Determine the pressure difference in $N/m^2$ between points 1 and 2 of the venture meter shown in Figure 2. Work from first principles. Take g = $9{,}81m/s^2$.

**[10]**

## QUESTION 4

Calculate the foundation stresses in $kN/m^2$ underneath the toe and heel of the concrete weir shown in Figure 3. Assume water seeps through underneath the structure and exits at the toe into the atmosphere. Analyze the forces and moments acting on the structure per metre run of weir into the paper. **[25]**

$$f_1; f_2 = \frac{W}{A} \pm \frac{My}{I}$$

$$I_{rect} = \frac{1}{12}bd^3$$

## QUESTION 5

Figure 4 shows a circular butterfly valve that can rotate about a horizontal shaft through its centre.

5.1 Calculate the torque required to keep the valve closed against the hydrostatic pressure. (10)

5.2 Prove that the torque required under 5.1 does not depend on the depth of the valve. (5)

$$F = \gamma \bar{y} A$$
$$\bar{h} = \frac{k^2}{\bar{y}} \sin^2 \Theta + \bar{y}$$
$$I = Ak^2$$
$$I_{circle} = \frac{\pi}{64} d^4$$

**[15]**

## QUESTION 6

The depth of flow in a triangular concrete channel with sides sloping as shown in Figure 5 is d.

6.1 Derive a mathematical expression for the cross-sectional area of flow in the channel in terms of d; (5)

6.2 Derive a mathematical expression for the wetted perimeter of the flow in the channel in terms of d; (3)

6.3 Write down a mathematical expression for the hydraulic radius of the flow in the channel in terms of d; (2)

6.4 Calculate the average flow velocity in the channel using Manning's formula taking n = 0,0150 and d = 1,250m. The channel falls 1m over a horizontal distance of 2km; (3)

6.5 Calculate the flow in the channel in $m^3/s$ for the conditions given under Question 6.4. (2)

$$v = \frac{1}{n} m^{\frac{2}{3}} i^{\frac{1}{2}}$$
$$m = \frac{A}{P}$$
$$Q = Av$$

**[15]**

## QUESTION 7

Water is pumped from a well 2,50m lower than the pump to a nozzle which is 17,50m higher than the pump and is discharged vertically upwards into the atmosphere. The pipes have a diameter of 100mm and the nozzle diameter is 25mm. The pump develops a total pressure head of 50m. See Figure 6. Ignoring all losses determine:

7.1 The velocity of the water when it leaves the nozzle; (5)

7.2 The height that the water will reach above the nozzle. (5)

[10]

## QUESTION 8

The thrust of a rocket engine is 5MN. The velocity of the issuing jet relative to the rocket is 3000m/s. At what rate in kg/s is fuel consumed?

$$F = \rho Q(v_2 - v_1) = \dot{m}\,(v_2 - v_1)$$

[5]

## QUESTION 9

A mixture of two liquids of equal volume is made, the one has a relative density of 0,80 and the other a density of 980kg/m$^3$. What will the weight of 2500ℓ of the mixture be?

[5]

**[TOTAL =100]**

**HAND IN THE QUESTION PAPER WITH YOUR SCRIPT.**

# Formulae

$$p = \rho g h = \gamma h$$

$$p = \frac{F}{A}$$

$$\gamma = \rho g$$

$$\tau = \frac{F}{A} = \mu \frac{dv}{dy}$$

$$\nu = \frac{\mu}{\rho}$$

$$I_{rect} = \frac{1}{12} b d^3$$

$$I_{circle} = \frac{\pi d^4}{64}$$

$$I_{triangle} = \frac{b h^3}{36}$$

$$F = \gamma A \bar{y}$$

$$\bar{h} = k^2 \frac{\sin^2 \theta}{\bar{y}} + \bar{y}$$

$$F_h = \gamma A_p \bar{y}$$

$$F_v = \rho g V = \gamma V$$

$$R = \sqrt{F_h{}^2 + F_v{}^2}$$

$$\tan^{-1} \Theta = \frac{F_v}{F_h}$$

$$BM = \frac{I}{V}$$

$$I = A k^2$$

$$z_1 + \frac{p_1}{\rho g} + \frac{v_1^2}{2g} + h_p \quad = \quad z_2 + \frac{p_2}{\rho g} + \frac{v_2^2}{2g} + h_l$$

$$v = \frac{1}{n} m^{\frac{2}{3}} i^{\frac{1}{2}}$$

$$F = \rho Q (v_2 - v_1)$$

$$f_1 ; f_2 = \pm \frac{F}{A} \pm \frac{My}{I}$$

$$P = \rho g Q H$$

$$Q = av$$

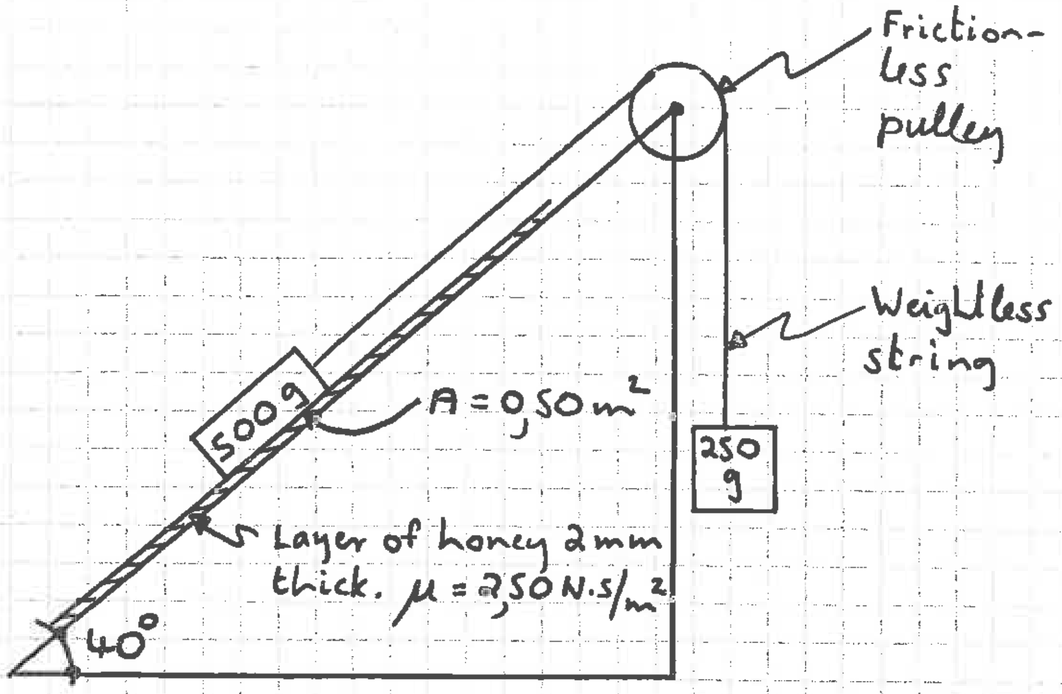



Figure 1

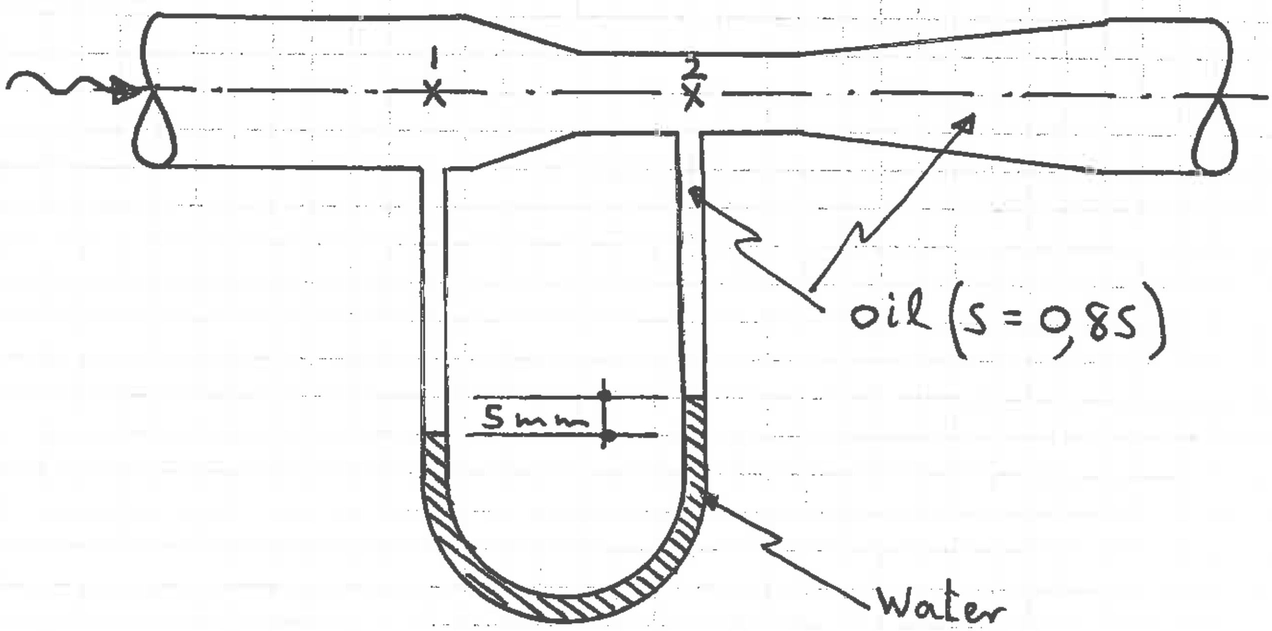
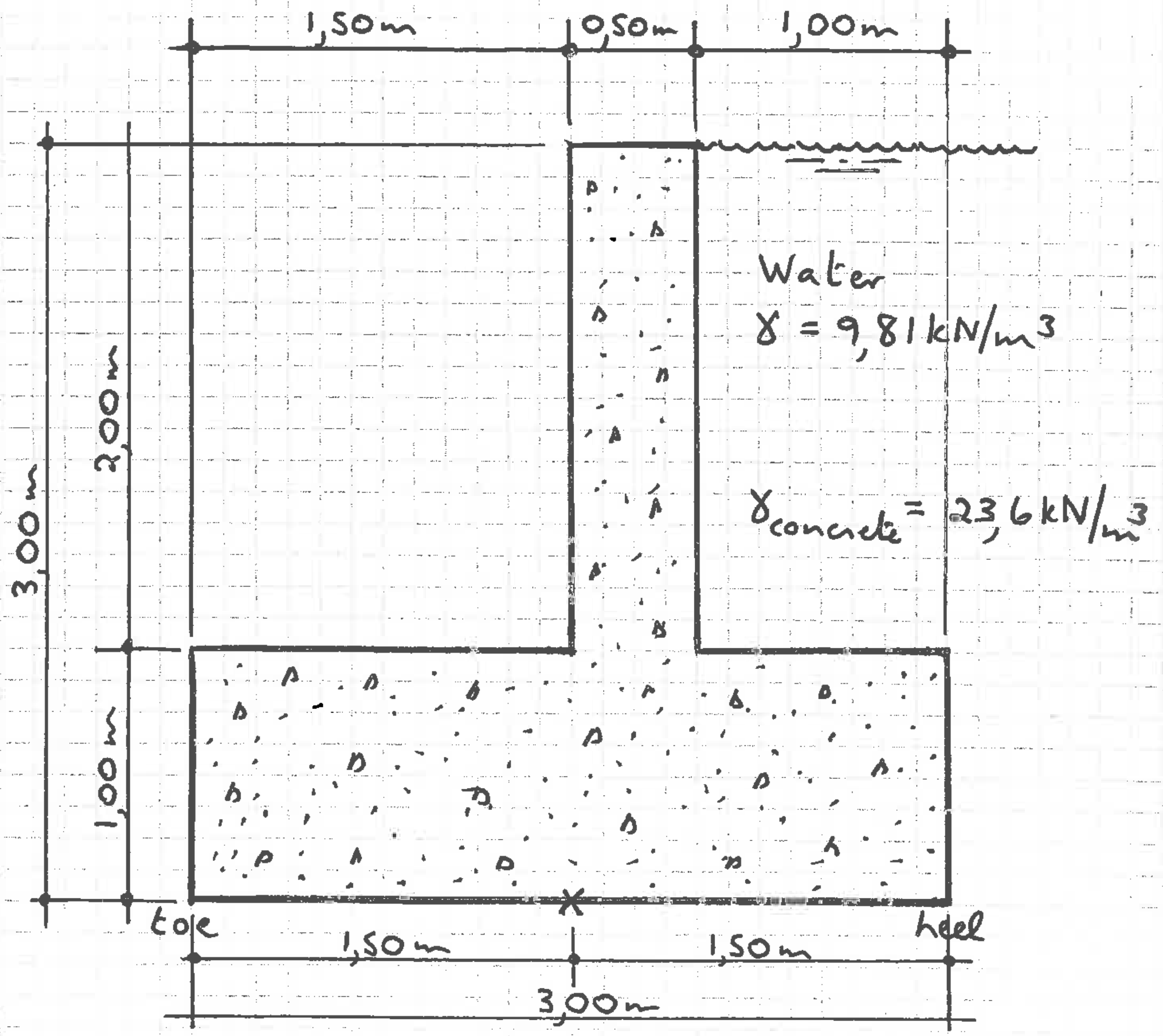


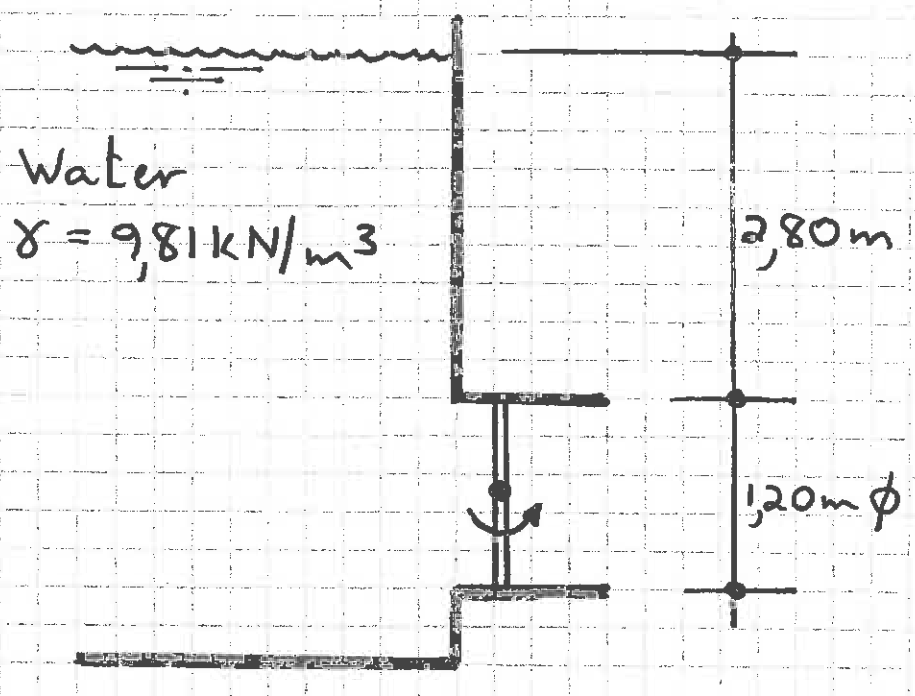

Figure 2




Cross-section through weir

Scale : 1 in 25

Figure 3




Vertical cross-section through tank with butterfly valve

Figure 4

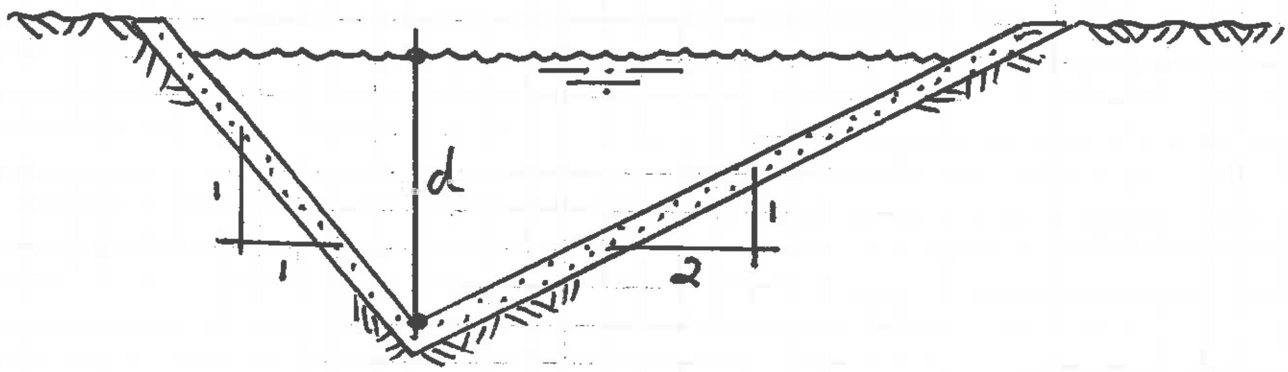



Figure 5

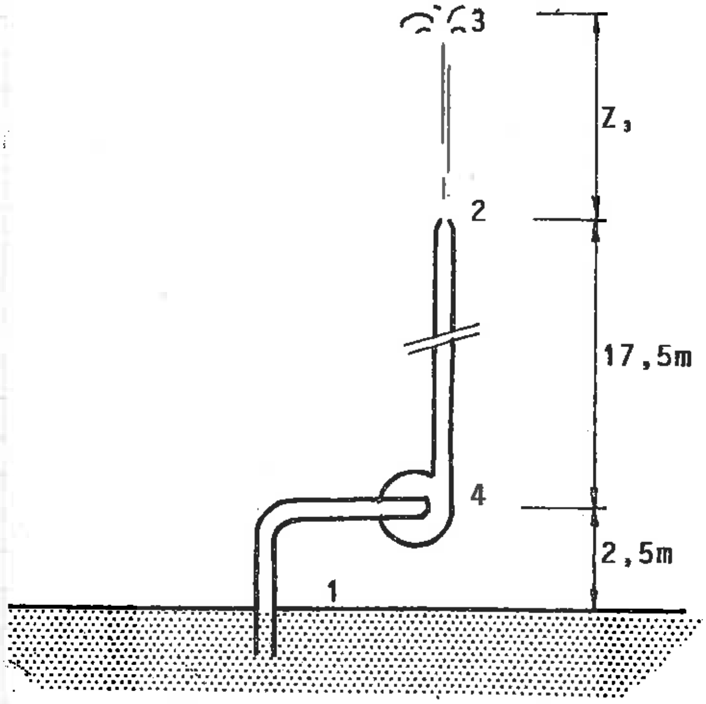



Figure 6