UNIVERSITY OF SWAZILAND

MAIN EXAMINATION PAPER

PROGRAMMES:

BSc. ABE 3,

COURSE CODE: ABE 303

TITLE OF PAPER: FLUID AND SOIL MECHANICS

TIME ALLOWED: TWO (2) HOURS

SPECIAL MATERIAL REQUIRED: NONE

INSTRUCTIONS: ANSWER QUESTION ONE AND ANY TWO OTHER QUESTIONS

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QUESTION 1

a. Water is flowing over a sharp-crested rectangular weir of width 35cm into a cylindrical tank of diameter 75 cm. In 20 seconds the depth of water in the tank rises 1.2m. Assuming a discharge coefficient of 0.9, determine the height of the water above the weir in mm. **[10 marks]**

b. Soil from a borrow pit is to be used for a constructed fill in the construction of a storage lagoon. The construction details call for the fill to be placed and compacted to 95% Proctor density. The material to be used for the fill comes from a borrow pit with a void ratio of 0.60.

(i) Describe what '95% Proctor density' means. **[5 marks]**

(ii) What volume of material from the borrow pit will need to be removed to make up the required 1000 m^3 of in-place material? **[10 marks]**

(iii) Plot the relationship between water content and bulk density for a soil undergoing a standard compaction effort. **[5 marks]**

(iv) Show on the same graph as used for (iii), the effects of increasing or decreasing the compaction effort. **[5 marks]**

(v) Suggest ways that the required compaction might be achieved in the construction. **[5 marks]**

QUESTION 2

a. A retaining wall 5 m high supports a backfill consisting of 2 m of sandy clay overlying 3m of sand. The gravimetric water level water level coincides with the upper surface of the sand. Given that the soil constants are;

Sandy clay	**sand**
$\rho = 1840 kg/m^3$	$\rho = 1930 kg/m^3$
$c = 11.5 kN/m^2$	$c = 0 kN/m^2$
$\phi = 10^o$	$\phi = 35^o$

(i) Determine the total active thrust on the retaining wall and its point of action, assuming tension cracks have developed. **[10 marks]**

(ii) If it were possible to lower the water level by 2m, without altering the soil properties, what then would be the active thrust on the wall? Again, assume tension cracks would develop. **[10 marks]**

b. Explain why the velocity measured by the Pitot-static tube is higher than that measured by the venturimeter? **[10 marks]**

QUESTION 3

a. Derive an expression for the bulk density of a partially saturated soil in terms of specific gravity of the particle, G_s, the void ratio, e, the degree of saturation, S_r, and the density of water, ρ_w. **[10 marks]**

b. Starting with the Bernoulli and Continuity equations derive the following expression that can be used to measure flow rate with a venturi meter.**[10 marks]**

$$Q_{actual} = c_d A_1 A_2 \sqrt{\frac{2g\left[\frac{p_1 - p_2}{\rho g} + z_1 - z_2\right]}{A_1^2 - A_2^2}}$$

c. Show that when the pressure difference is measured using a manometer the following expression can be used; **[10 marks]**

$$Q_{actual} = c_d A_1 A_2 \sqrt{\frac{2gh\left(\frac{\rho_{man}}{\rho} - 1\right)}{A_1^2 - A_2^2}}$$

QUESTION 4

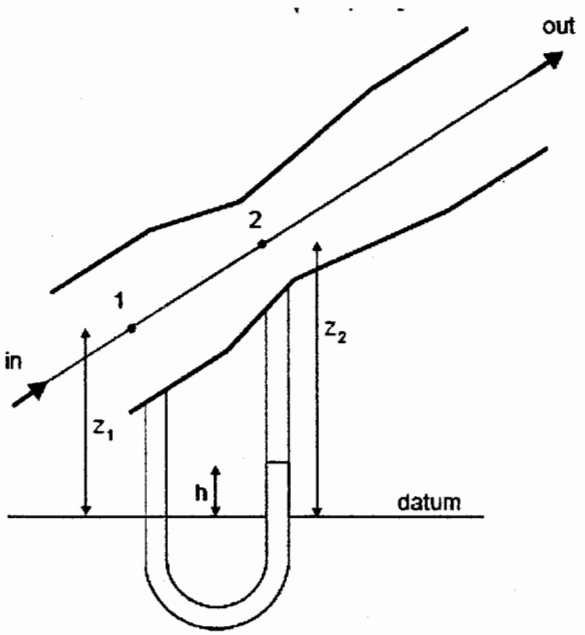
a. A concrete-lined trapezoidal channel with uniform flow has a normal depth a normal depth of 2 m. The base width is 5 m and the side slopes are equal at 1:2. Taking Manning's $n = 0.015$ and the bedslope $S = 0.001$, and viscosity $\mu = 1.14 \times 10^{-3}$ Ns/m^2, calculate;

(i) Discharge **[5marks]**

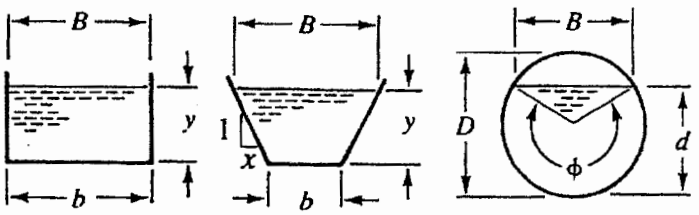
(ii) Mean velocity **[5marks]**

(iii) Reynolds number **[5marks]**

b. A venturimeter (see figure) is used to measure the flow of water in a pipe of diameter 100mm. The throat diameter *(2)* of the venturimeter is 60mm and it has a coefficient of discharge of 0.9. When a flow of 100 litres/second is flowing the attached manometer shows a head difference of 60cm, what is the density of the manometric fluid of the manometer? **[15marks]**



APPENDIX



	Rectangle	Trapezoid	Circle
area, A	by	$(b+xy)y$	$\frac{1}{8}(\phi-\sin\phi)D^2$
wetted perimeter, P	$b+2y$	$b+2y\sqrt{1+x^2}$	$\frac{1}{2}\phi D$
top width, B	b	$b+2xy$	$\left(\sin\frac{\phi}{2}\right)D$
hydraulic radius, R	$\frac{by}{b+2y}$	$\frac{(b+xy)y}{b+2y\sqrt{1+x^2}}$	$\frac{1}{4}\left(1-\frac{\sin\phi}{\phi}\right)D$
hydraulic mean depth, D_m	y	$\frac{(b+xy)y}{b+2xy}$	$\frac{1}{8}\left(\frac{\phi-\sin\phi}{\sin(1/2\phi)}\right)D$

$$p_a = k_a \gamma z$$

$$p_a = k_a \gamma z - 2c\sqrt{k_a}$$

$$p_a = \gamma z \frac{1}{N_\varphi} - 2c\frac{\sqrt{N_\varphi}}{N_\varphi}$$

$$k_a = \frac{1-\sin\phi}{1+\sin\phi} = \tan^2\left(45-\frac{\phi}{2}\right)$$

$$p_a = k_a \gamma' z$$