# UNIVERSITY OF GREATER MANCHESTER

# OFF CAMPUS DIVISION

# WESTERN INTERNATIONAL COLLEGE, RAS AL KHAIMAH

## BENG (HONS) CIVIL ENGINEERING

## SEMESTER TWO EXAMINATION 2024/2025

## SOIL MECHANICS AND HYDRAULICS

## MODULE NO: CIE4020

**Date: Saturday, 24 May 2025** **Time: 10:00 am – 12:00 pm**

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**INSTRUCTIONS TO CANDIDATES:**

**This is an open book examination. You are allowed to bring one A4 sheet, written on both sides.**

**There are SIX (6) questions on this paper. Answer any FIVE (5) questions.**

**Answer SECTION A and SECTION B in separate answer books.**

**Marks for parts of questions are shown in brackets.**

**This examination paper carries a total of 100 marks.**

**Formula sheet/ supplementary information is provided at the end of exam paper for each section, and additional data and graph sheets will be provided at the time of examination.**

**All working must be shown. A numerical solution to a question obtained by programming an electronic calculator will not be accepted.**

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## SECTION A - SOIL MECHANICS

### QUESTION 1

a) Explain the concept of a Phase Diagram. Differentiate between a two-phase diagram and a three-phase diagram. Illustrate your answer with neat sketches and describe the significance of each phase in the analysis.

**(8 marks)**

b) A soil sample has a mass of 2290 g and a volume of $1.15\ x\ 10^{-3} m^3$. After being completely dried in an oven, the mass of the sample is 2035g. The value of specific gravity $G_s$ for the soil is 2.68. Determine the bulk density, unit weight, water content, void ratio, porosity, degree of saturation and air content**.**

**(8 marks)**

c) The moist unit weight of a soil sample is 19.2 kN/m³. Given that the specific gravity is 2.69 and the water content is 9.8%, determine the dry unit weight, void ratio, porosity, and degree of saturation.

**(4 marks)**

**[TOTAL 20 MARKS]**

**Please turn the page**

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**QUESTION 2**

a) Using a diagram, explain the concept of Atterberg limits and illustrate the different states of soil based on moisture contents.

**(8 marks)**

b) A clay sample has a plasticity index of 30, a liquidity index of 0.45, and a plastic limit of 28. Calculate:

(i) Water content of the clay

**(4 marks)**

(ii) Degree of saturation

**(4 marks)**

(iii) Bulk unit weight of the clay if its specific gravity is 2.68 and void ratio is 1.05.

**(4 marks)**

**[TOTAL 20 MARKS]**

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**QUESTION 3**

a) Explain the significance of water content in the compaction of soils and describe how optimum moisture content (OMC) is determined using the Standard Proctor Test.

**(8 marks)**

b) **Table 1** shows a set of light compaction test results where bulk densities were recorded for soil samples compacted at different moisture contents. Consider specific gravity, $G_s$ = 2.68.

**Table 1: COMPACTION TEST RESULT**

| **Moisture Content (%)** | **Bulk Density ($kg/m^3$)** |
|---|---|
| 10 | 1760 |
| 12 | 1890 |
| 14 | 2040 |
| 16 | 2105 |
| 18 | 2080 |
| 20 | 2025 |

Using the data provided in the above table, plot the compaction curve in the **graph sheet** to obtain the maximum dry density and the optimum water content. **Attach the Graph sheet along with the answer script.**

**(12 marks)**

**[TOTAL 20 MARKS]**

**END OF SECTION A**

**PLEASE TURN THE PAGE FOR SECTION B**

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## SECTION B- HYDRAULICS

**QUESTION 4**

a) Name three devices which can be used to measure water pressure in pipelines and specify the unit of pressure measurement for each device.

**(5 marks)**

b) The pressure at a point in a pipeline is measured by means of a piezometer tube. Determine the height, h, of the column of liquid if the liquid is water and the pressure is 12.5 KN/$m^{2.}$

**(5 marks)**

c) A rectangular pontoon 13.5m x 5.4m x 3.0m high floats in water with the 3.0m side vertical. The pontoon weighs 420KN and its centre of gravity is 1.5 m above the base of the pontoon. Calculate the metacentric height of the pontoon if it is floating in fresh water and comment on its stability condition.

**(10 marks)**

**[TOTAL 20 MARKS]**

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**QUESTION 5**

a) Explain the Continuity equation used in the analysis of fluid flow. Illustrate using appropriate diagrams and equations.

**(5 marks)**

b) Determine the loss of head due to friction in a cast iron pipe 400m long and 150mm in diameter, which carries 43 l/s. Use the Darcy equation with $\lambda = 0.02$.

**(5 marks)**

c) A spun bitumen-lined metal pipe 450 mm in diameter and 2km in length connects two reservoirs A & B having water levels 150m AOD and 120m AOD, respectively. Determine the flow rate in the pipeline, taking only frictional losses into account (**Table of recommended roughness values** and **HRS Tables** are provided in additional data pages)

**(10 marks)**

**[TOTAL 20 MARKS]**

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**QUESTION 6**

a) A canal has a bottom width of 3m and sides with a slope of 1 vertical to 2 horizontal. The depth of water is 1.2m when the discharge is 3.51$m^3$/s. Using the Manning formula with n = 0.022, calculate the slope of the channel bed.

**(8 marks)**

b) Water flows from a storage tank along a 250mm diameter pipe, 50m long, at a rate of 0.25$m^3$/s. The pipe includes two 90° bends ($k_L$ = 0.7), a fully open gate valve ($k_L$ = 0.25) and a partially shut valve ($k_L$ = 6). If the pipe entrance is sharp and the flow discharges to the atmosphere at the end of the pipe, calculate the necessary difference in level between the tank water level and the outlet. Take the pipe friction factor, λ = 0.04

**(12 marks)**

**[TOTAL 20 MARKS]**

**END OF QUESTIONS**

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## Formulae Sheet for Section A

$$n = \frac{e}{1+e}$$

$$a = n(1-S)$$

$$LL = \frac{w - PL}{PI}$$

**PLEASE TURN THE PAGE FOR SECTION B FORMULAE SHEET**

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## Formulae Sheet for Section B

$$P = \rho g h$$

$$Q = AV$$

$$Q = \frac{A}{n} R^{\frac{2}{3}} S_0^{\frac{1}{2}}$$

$$R = \frac{A}{P}$$

$$\frac{P_1}{\rho g} + \frac{{V_1}^2}{2g} + Z_1 = \frac{P_2}{\rho g} + \frac{{V_2}^2}{2g} + Z_2 + h_f + h_L$$

$$h_f = S_0 . L \; h_f = \frac{\tau L v^2}{2gd} = \frac{\tau L Q^2}{12.1 d^5}$$

$$h_L = k_L . \frac{v^2}{2g}$$

$K_{L\ entry\ to\ pipe}$ = 0.5 ; $K_{L\ exit\ from\ a\ pipe}$ = 1

$$A = By + zy^2$$

$$P = B + 2y\sqrt{1 + z^2}$$

$$Q = \frac{2}{3} C_d \, L \sqrt{2g} H^{\frac{3}{2}}$$

**END OF PAPER**