Université d’Ottawa
Faculté de genie

Départment de
Génie civil

University of Ottawa
Faculty of Engineering

Department of
Civil Engineering

uOttawa

L’Université canadienne
Canada’s university

CVG 3109
SOIL MECHANICS - I
MIDTERM EXAMINATION

Length of Examination: 1 hr 15 mins **7th Nov, 2017 (08:30 to 09:45)**
Course Instructor: Sai Vanapalli

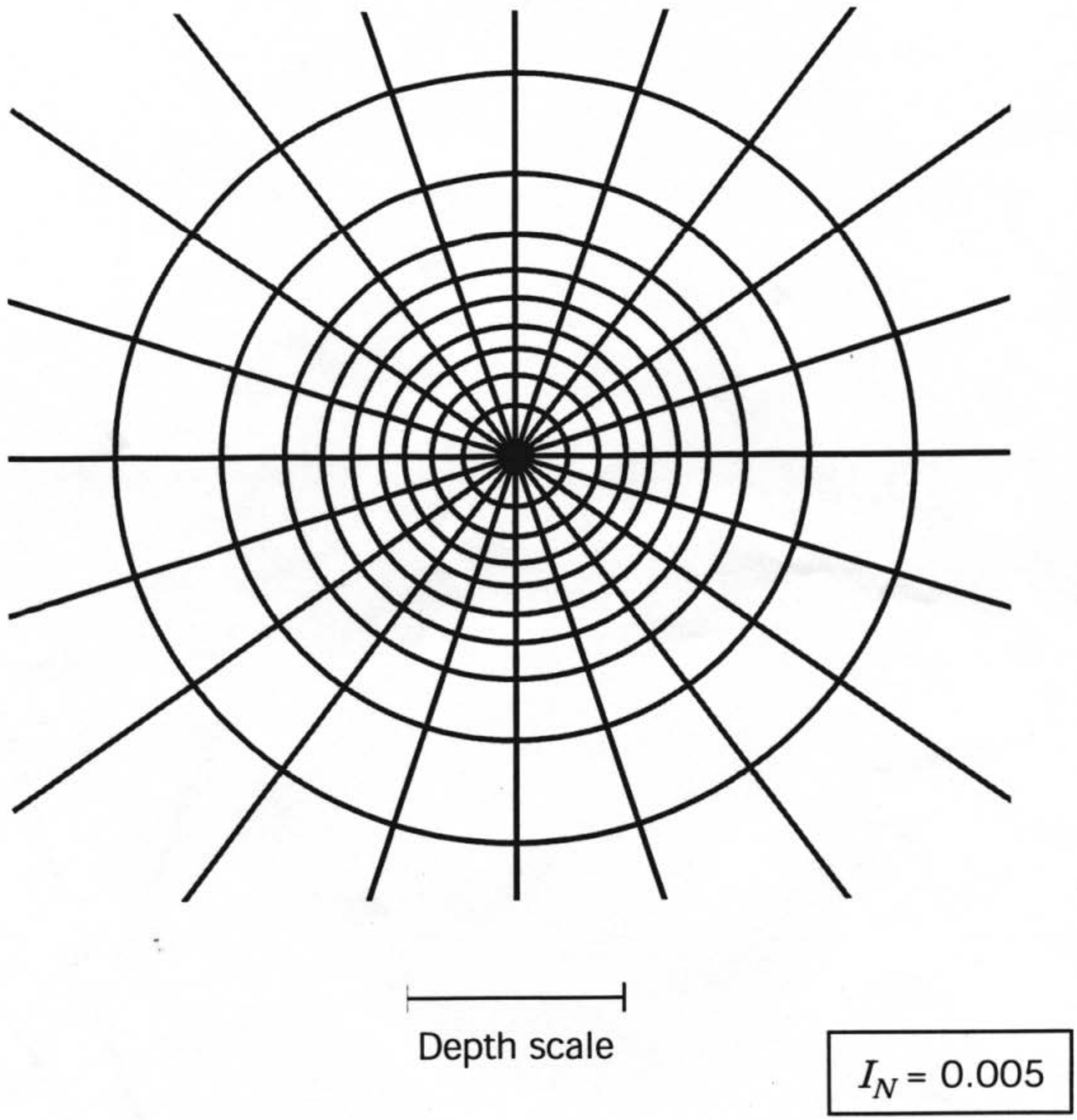
First Name: ____
Last Name: ____
Student Number: ___________
Signature ____________________________

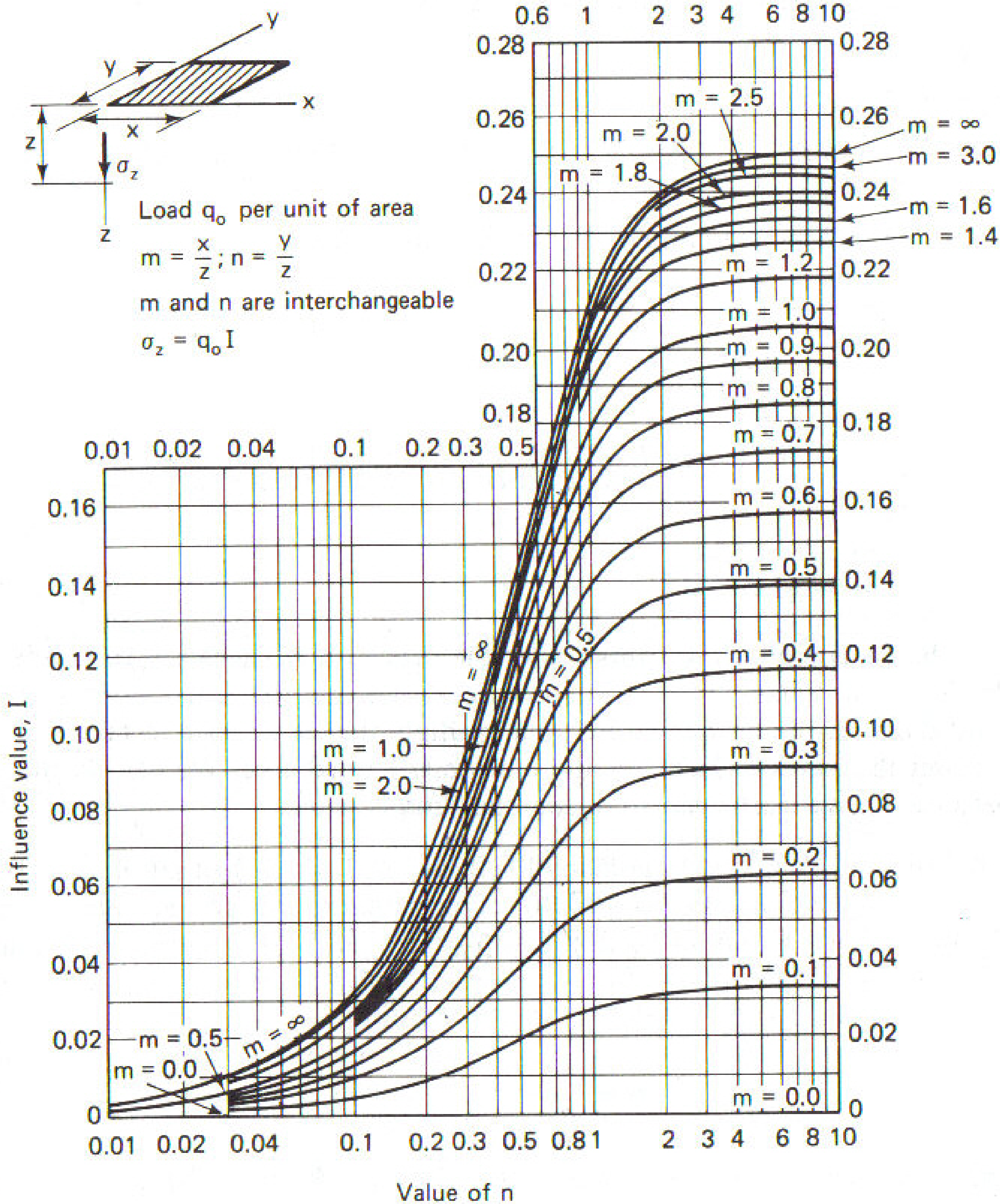
(i) This is a closed book exam. No textbooks are allowed
(ii) **Formula sheet** is available on the last page of this question paper
(iii) If you do not understand a question, clearly state an assumption and proceed.
(iv) Non programmable calculators are permitted
(v) Questions have the values shown next to the questions.
(vi) Marks will be taken out for missing units and labels.
(vii) Answers should be succinct.

At the end of the exam, when time is up:

- Stop working and turn your exam upside down.
- Please remain silent.
- Do not move or speak until ALL exams have been picked up, and a TA or the Professor gives the go-ahead to leave.

Question	**Max Marks**		**Marks Awarded**
1	Conceptual Questions:	**20 %**	
2	Chp. 1: Fundamentals/Review:	**20 %**	
3	Chp. 2: Seepage and Effective Stress:	**35 %**	
4	Chap. 3: Elastic theory/Stress Distribution :	**25 %**	
Total	**Maximum**	**100%**	


Depth scale
$I_N = 0.005$


Load q_o per unit of area
$m = \frac{x}{z}$; $n = \frac{y}{z}$
m and n are interchangeable
$\sigma_z = q_o I$
Influence value, I
Value of n
m = ∞
m = 3.0
m = 2.5
m = 2.0
m = 1.8
m = 1.6
m = 1.4
m = 1.2
m = 1.0
m = 0.9
m = 0.8
m = 0.7
m = 0.6
m = 0.5
m = 0.4
m = 0.3
m = 0.2
m = 0.1
m = 0.0

Formulae Sheet

Phase relationships:

Unit weight of soil:

$$\gamma = \frac{W}{V} = \frac{(Se + G_S)}{1+e}\gamma_w$$

Submerged unit weight: $\gamma_{sub} = \frac{(G_s - 1)}{1+e}\gamma_w$

Dry unit weight:

$$\gamma_d = \frac{W_s}{V} = \frac{G_s}{1+e}\gamma_w = \frac{\gamma}{1+w}$$

$$Se = wG_s$$

Elastic Theory (Stress Distribution theory)

Boussinesq's equation for determining vertical stress due to a point load

$$\sigma_z = \frac{3Q}{2\pi z^2}\left\{\frac{1}{1+\left(\frac{r}{z}\right)^2}\right\}^{5/2}$$

Determination of vertical stress due to a rectangular loading: $\sigma_z = q I_c$ (Charts also available)

$$I_c = \frac{1}{4\pi}\left[\frac{2mn\sqrt{m^2+n^2+1}}{m^2+n^2+m^2n^2+1}\left(\frac{m^2+n^2+2}{m^2+n^2+1}\right) + \tan^{-1}\frac{2mn\sqrt{m^2+n^2+1}}{m^2+n^2+m^2n^2+1}\right]$$

m = B/z and n = L/z (both *m* and *n* are interchangeable)

Approximate method to determine vertical stress,

$$\sigma_z = \frac{qBL}{(B+z)(L+z)}$$

Vertical stress determination using Newmarks Chart

$\sigma_z = q I_c$ (No. of sectors)

Permeability & Effective Stress

Total head= Pressure head + Elevation head + Velocity head

$$h = \frac{u}{\gamma_w} + \frac{v^2}{2g} + z$$

Hydraulic gradient: $i = \frac{\Delta h}{L}$

Darcy's law:

$$v = ki$$

$$q = vA$$

$$Q = kiAt = k \cdot \frac{\Delta h}{L} \cdot At$$

Equivalent hydraulic conductivity:

$$k_{H(eq)} = \frac{k_{H_1}H_1 + ... + k_{H_n}H_n}{H_1 + ... + H_n}$$

$$k_{V(eq)} = \frac{H_1 + ... + H_n}{\left(\frac{H_1}{k_{V_1}}\right) + ... + \left(\frac{H_n}{k_{V_n}}\right)}$$

Seepage in a flow net:

$$q = k \cdot h_w \cdot \frac{N_f}{N_d}$$

Pore-water pressure (kPa):

$$u_P = \gamma_w\left[h_P - (-z_P)\right] = \gamma_w(h_P + z_P)$$

Total seepage force = $i\gamma_w V$

Seepage per unit volume = $i\gamma_w$

Effective stress: $\sigma' = \sigma - u_w$

Effective stress on downward seepage:

$$\sigma' = \gamma_{sub}z + jz = \gamma_{sub}z + iz\gamma_w$$

Effective stress on upwards seepage:

$$\sigma' = \gamma_{sub}z - jz = \gamma_{sub}z - iz\gamma_w$$

Critical hydraulic gradient:

$$\sigma' = 0 = \gamma_{sub}z - iz\gamma_w \Leftrightarrow i_c = \frac{\gamma_{sub}}{\gamma_w}$$

$$i_c = \frac{(G_s - 1)\gamma_w}{1+e} \cdot \frac{1}{\gamma_w} = \frac{(G_s - 1)}{1+e}$$