UNIVERSITY OF SOUTH AUSTRALIA

DIVISION OF
INFORMATION TECHNOLOGY, ENGINEERING AND THE ENVIRONMENT

School of Geoinformatics, Planning and Building

Semester 2, 2002

Geographical Information Systems 4 : GEOE 2018 (13044)

Time Allowed : 3 hours + 10 minutes reading time

General Instructions to Candidates

Total marks = 100
Attempt **question 1** and **any other five questions.**
All questions are of equal value.
Programmable calculators are permissible.
Please ensure the front of answer books are completed with your name, student ID number, program, and course.

Additional Instructions

Read this examination question paper ***very carefully***.
Clearly state any assumptions made.
Use examples and diagrams, where appropriate, in answering the questions.
Start a new question on a new page in the answer book.
Insert the number of the question at the top left hand margin **on each page**.
Use both sides of the paper in the answer book.

NOTATION

DEM	Digital Elevation Model
GIS	Geographic Information System
TIN	Triangulated Irregular Network

QUESTION 1

(a) Consider a typical 2x2 window in a raster in which the four points forming a local (x,y) or (E,N) coordinate system have height or z coordinates z_1, z_2, z_3 and z_4 as follows:

$(-1,1)\ z_3$ $(1,1)\ z_4$

$(-1,-1)\ z_1$ $(1,-1)\ z_2$

A plane with the equation $z = a + bx + cy$ is to be fitted "as closely as possible" through the four points. What is meant by the phrase "as closely as possible" in this context?

Since the four points are evenly spaced with respect to the centre of the 2x2 window, the coefficients in the equation of the "best fit" plane are given by:

$$a = (z_1 + z_2 + z_3 + z_4)/4$$

$$b = (-z_1 + z_2 - z_3 + z_4)/4$$

$$c = (-z_1 - z_2 + z_3 + z_4)/4$$

If the elevations of the four points in metres are as below, compute the coefficients of the equation of the plane and write down the equation of the plane.

10.12 10.25

10.00 10.08

(b) Using the equation of the plane, compute the z coordinates on the plane at the four points of the 2x2 window.

(c) Compute the sum of the deviations of the original z coordinates from the corresponding values on the plane as determined in part (b) followed by the sum of the squares of these deviations. What properties do these sums possess?

(d) By differentiating the equation of the plane in the x and y directions, determine the corresponding numerical values of the slopes (in percentages) of the plane representing the 2x2 window.

(e) The increase in elevation for a unit distance horizontally in the direction of steepest slope is given by $(b^2 + c^2)^{-}$ and the orientation of the line of steepest slope measured anticlockwise from the x or E-axis is arc tan(c/b).

For the 2x2 window, compute

i) The slope as an angular value in degrees and minutes to the nearest 10 minutes; and

ii) The bearing of the aspect in degrees and minutes to the nearest 10 minutes.

QUESTION 2

(f) Explain what is meant by the term "Triangulated Irregular Network" or TIN.

(g) Discuss the data sets that may be used to formulate a TIN.

(h) Describe the following procedures involved in the creation of a TIN:

i. How the points to be used in the TIN are selected; and

ii. How the selected points are connected to form the triangle vertices.

(i) Using examples, describe and compare two structures for the storage of TINs.

QUESTION 3

(j) What is a "Digital Elevation Model" or DEM?

(k) Briefly highlight the similarities and differences between the following terms:

i. Digital Elevation Model;

ii. Digital Terrain Model;

iii. Grid;

iv. Lattice; and

v. Raster.

(l) Describe the sources of data and the methods available for the formulation of DEMs.

(m) Use a table to compare the properties of TINs and DEMs.

QUESTION 4

(n) In constructing a TIN, what are the merits or otherwise of using digitized contours as the input height data?

(o) What is the ideal shape of a triangle in a TIN and why is such a shape desirable?

(p) What is a "flat" triangle? Describe the difficulties associated with flat triangles.

If digitized contours are used as input height data, explain why large numbers of flat triangles may occur and how their incidence may be minimised.

(q) Sometimes, the inclusion of breaklines in the formulation of a TIN may cause a large number of "skinny" triangles to be formed. Does this have a detrimental effect on the TIN? How can the number of skinny triangles be minimised?

(r) In relation to surface representation, it has been stated that:

"A TIN of 100 points will do as well as a DEM of several hundred".

Discuss this statement.

QUESTION 5

(s) Using diagrams where necessary, make a comprehensive appraisal of the application of breaklines in the generation of a TIN.

(t) What are the differences between "soft" and "hard" breaklines and in what circumstances should each be applied?

(u) Explain whether breaklines must have z coordinates associated with them. If required, how can such z coordinates be assigned to breaklines?

QUESTION 6

(v) List eight surface analysis operations that may be performed on a TIN or DEM which represent a surface.

(w) Select and explain in some detail, three of these operations giving some examples of their application.

QUESTION 7

"Spatial interpolation", or simply "interpolation" is the procedure of estimating the value of properties at unsampled sites within the area covered by existing observations.

(x) Define the terms:

vi. Global interpolator;

vii. Local interpolator;

viii. Exact interpolator; and

ix. Approximate interpolator.

(y) Classify the following "Point Based Interpolation" methods into either a "global" or "local" interpolator and an "exact" or "approximate" method by placing ticks in the appropriate boxes of the table below. The table is repeated on the last page of this examination paper which should be filled out, detached and submitted with the script.

Point Based Interpolation				
Method	Global	Local	Exact Method	Approx Method
Proximal				
Trend Surface Analysis				
Moving average/ Distance-weighted average				
Fourier Series				
Manual Interpolation				
B-Splines				
Kriging				

(z) In particular, give an outline of how the B-spline and trend surface analysis methods would be applied to randomly positioned height or z data to enable a grid to be interpolated from the data.

(aa) Explain whether the quintic interpolation used in the Arc/info GIS software is of the B-spline or trend surface type.

WORKING SHEET FOR QUESTION 7

Student's Name: . . . . . .

Student's ID: . . . . . .

Point Based Interpolation				
Method	Global	Local	Exact Method	Approx Method
Proximal				
Trend Surface Analysis				
Moving average/ Distance-weighted average				
Fourier Series				
Manual Interpolation				
B-Splines				
Kriging				