UNIVERSITY OF SOUTH AUSTRALIA

DIVISION OF
INFORMATION TECHNOLOGY, ENGINEERING AND THE ENVIRONMENT

School of Geoinformatics, Planning and Building

Semester 1, 2002

Spatial Systems 2N : GEOE 3007 (10226)

Time Allowed : 3 hours + 10 minutes reading time

General Instructions to Candidates

Total marks = 100
Attempt **questions 1 and 2** and **any other four questions.**
Marks (percentages) for each question are as indicated.
Programmable calculators are permissible.
Please ensure the front of answer books are completed with your name, student ID number, program, and course.

Additional Instructions

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

NOTATION

GIS	Geographic Information System
MGA	Map Grid of Australia

QUESTION 1 (18 marks (18%))

(x) Describe and compare the affine, similarity and projective transformations available in the ARC/INFO vector based GIS software for transforming a digitized map into mapping system coordinates.

(y) Select, giving reasons, the transformation that would be applied to an aerial photograph and an orthophoto to convert those documents into mapping system coordinates.

(z) Explain the term *Root Mean Square* (RMS) error associated with these transformations.

What is an acceptable value for the RMS error?

What are the possible causes of a large RMS error and what remedial action may be taken to reduce it to an acceptable value?

(aa) From the following (incomplete) data resulting from the application of the ARC/INFO affine transformation, compute the RMS error and comment on whether it is acceptable. (i.e., compute the values for the fields represented by # in the table below)

```
Arc: TRANSFORM INCHCOV STATECOV AFFINE
Transforming coordinates for coverage INCHCOV

Scale (X,Y) = (1452.317,1508.433)    Skew (degrees) = (0.416)
Rotation (degrees) = (0.218)         Translation =
(2124994.654,317664.385)
RMS Error (input,output) = (#.###,##.###)

Affine      X = Ax + By + C
            Y = Dx + Ey + F

A =      1452.230       B =       -5.526        C =   2124994.654
D =        15.858       E =     1508.462        F =    317664.385

tic id        input x           input y
             output x          output y         x error         y error

1               2.000            16.946
          2127791.000        343183.000          14.463          75.499
2              12.764            16.821
          2143469.000        343326.000          ##.###          ##.###
3               2.052             1.976
          2128000.000        320680.000         -36.290          -2.353
4              12.922             2.013
          2143729.000        320912.000          20.245          -6.163
5               2.082             9.442
          2127944.000        332015.000          22.016         -74.699
6              12.662             9.442
          2143320.000        332015.000          10.609          93.079
Arc:
```

QUESTION 2 (18 marks (18%))

(bb) Describe what is meant by a *buffering* operation and give some examples of where it may be used.

(cc) Explain, giving an example, whether island polygons could result from a buffering operation.

(dd) Within the context of the ARC/INFO vector based GIS, the *fuzzy* and *weed* tolerances may be defined as follows:

> *The fuzzy tolerance is the minimum distance between **all arc coordinates** (nodes and vertices) in a coverage; i.e., coordinates within the fuzzy tolerance of each other are considered equal – at the same location.*
>
> *The weed tolerance is the minimum distance between any two vertices **along an arc.***

Why may the application of fuzzy and weed tolerances be of importance in digitizing and buffering operations?

(ee) A certain planning criterion requires that a particular development may not occur within 100 metres of the roads of a given road network nor outside of a certain maximum distance from the roads, depending on the type of road.

The road network represented in an ARC/INFO vector based GIS consisting of three different types of roads is described in the following table together with the development exclusion and inclusion specifications:

Type	Road Description	Exclusion Width metres	Maximum Inclusion Width metres
1	Dual carriageway sealed highways	100	1000
2	Single carriageway sealed highways	100	700
3	Single carriageway unsealed roads	100	250

A *lookup table* may be defined as follows:

> *"A special tabular data file containing additional attributes for features stored in an associated feature attribute table"*

Suppose the buffering operation of the ARC/INFO GIS software is able utilise a lookup table and that the following operations are also available:

Operation	Description
UPDATE	Merge new features using a cut-and-paste operation
CLIP	Cut out a piece of a coverage
SPLIT	Split a coverage into a number of smaller coverages
ERASE	Remove part of the inside of a coverage

Describe, with the aid of diagrams, how the required buffer area would be extracted from the GIS data. What attribute data would appear in the attribute table of the buffer?

QUESTION 3 (16 marks (16%))

(ff) Describe the vector data model that may be used to represent geographic features similar to the way maps do.

(gg) Define the term *topology* as it applies to a GIS based on the vector data model and illustrate how this definition may be applied to spatial vector data.

(hh) What are the advantages of using a topologically structured vector GIS compared to one which is not so structured?

(ii) Discuss whether a GIS based on the raster data model has or needs a topological structure.

QUESTION 4 (16 marks (16%))

A GIS is to be established over a small township for which there are three existing paper maps at different scales *which overlap in some localities.* One of the maps covering about half the town is in good condition based on the MGA with a sufficient number of control points or tics able to be identified on it for digitizing purposes. The other two maps are in poor condition in that they are fairly old, have been folded a number of times and are even torn along some of the folds. They are based on arbitrarily oriented local plane coordinate systems in feet and each contain six points for which the MGA coordinates have been determined from field surveys. The GIS software to be used for digitizing the three maps to cover the township area is able to have a file of tic ids and associated MGA coordinates established prior to any digitizing being performed.

(jj) Describe the procedure for digitizing the three separate map sheets to form a homogeneous set of spatial data covering the said township in MGA coordinates. Identify the kinds of digitizing errors that could occur and suggest preventative action that should be taken prior to or during digitizing to minimize the amount of subsequent editing which may need to be performed.

(kk) Outline the procedure for performing the editing (if necessary), processing and inclusion of the township land parcel numbers up to the stage where land parcel attribute data may then be included.

QUESTION 5 (16 marks (16%))

(ll) What is a relational database?

(mm) Define the operations *relate* and *relational join*.

What is *a relate key* and, in particular, *a primary key* and a *foreign key*?

(nn) Discuss the advantages and disadvantages of using the *relate* or *relational join* operations in establishing a relational database.

(oo) It is proposed that a large number of cadastral land parcels currently held in the form of paper records is to be stored in a vector based GIS. The attributes of the land parcels consist of owner details, locality, valuation information, zoning classification for planning purposes, improvements and survey plan number.

Allotment ownership is found to be of the following types:

- Some allotments have one owner;
- Some allotments have more than one owner;
- Multiple allotments are owned by one owner; and
- Multiple allotments are owned by more than one owner.

Show how the attribute data may be constructed.

QUESTION 6 (16 marks (16%))

A *topological overlay* may be defined as:

"An analysis procedure for determining the spatial coincidence of geographic features"

With the aid of examples and diagrams, demonstrate the ARC/INFO implementation of topological overlays. In addition, for each overlay, devise the appropriate Venn diagrams and boolean expressions.

QUESTION 7 (16 marks (16%))

(pp) Describe the raster data model that may be utilised in a GIS.

(qq) What is one of the critical factors in converting vector data into raster data?

(rr) Discuss whether vector to raster conversion followed by raster to vector conversion would result in the retrieval of the original vector layer.

(ss) Using some examples show how spatial analysis may be performed using raster data.

(tt) Review the characteristics and uses of the raster and vector GIS data models and compare their relative strengths and weaknesses.