The University of Melbourne

Semester 1 Exam 2018

Student number ....

Department	Infrastructure Engineering
Subject number	GEOM90008
Subject title	Foundations of Spatial Information
Exam duration	2 hours
Reading time	15 mins
This paper has	7 pages including this title page.

Authorized materials

The following items are authorized: Pens and pencils, compass and rulers, and a Casio FX82 (any suffix) pocket calculator.

Instructions to invigilators

Students have to hand in their examination papers together with their script books.

Instructions to students

Answer all questions. The answers to the multiple answer questions (Questions 1-5) must be given by circling the correct answers **on the examination paper**. All other questions must be answered in the script books. The examination paper must be handed in together with the script books. **In total you can earn 100 points**.

Paper to be archived in Baillieu Library? No

Questions 1-5: Multiple answer questions [25 points total; 5 points each]

Circle all correct answers **on this sheet**. Note that a question can have none, one or multiple correct answers. Do not give any comments or explanations.

Q1: Topological relations between to simple regions can be represented by:

a) a matrix of three intersection sets;

b) a matrix of four intersection sets;

c) a matrix of six intersection sets;

d) a matrix of eight intersection sets.

Q2: In normal cylindrical projections, lateral circles are mapped to:

a) equidistant parallel lines;

b) ellipses;

c) circles;

d) straight lines.

Q3: Which of the following phenomena form a partition:

a) the water catchments in Victoria;

b) the waterways in Victoria;

c) the bird habitats in Victoria;

d) the natural parks in Victoria.

Q4: Which of the following phenomena form a planar graph:

a) the complete graph of ten nodes, K_{10};

b) the graph of an irregular triangular network;

c) the graph of 'friends' in Facebook;

d) the waterways in Victoria.

Q5: What are the properties of topological transformations:

a) preserving distances;

b) preserving neighbourhood;

c) preserving directions;

d) preserving proportions.

Question 6 [18 points]

The 4-intersection model uses binary notations of empty ($\emptyset$) or non-empty ($\neg\emptyset$) intersection sets of points to characterise topological relationships between simple regions.

a) How many intersection sets are formed for this purpose? [2 points]

b) What are these intersections sets representing? [2 points]

c) What are the defining characteristics of a topological relationship? [2 points]

d) How many topological relations between simple regions can be distinguished by the 4-intersection model? [2 points]

e) Give an example: Sketch a topological relation between two simple regions, and provide the corresponding 4-intersection matrix. [2 points]

f) How many topological relations between a point and a region can be distinguished by the 4-intersection model? [3 points]

g) Now consider 1D space. How many topological relations can be distinguished by the 4-intersection matrix between two line segments in 1D space? [3 points]

h) Which topological relations cannot be distinguished by the 4-intersection matrix between two line segments in 1D space? [2 points]

Question 7 [20 points]

The four height points below are extracted from a digital elevation model (DEM).

a) Suggest an algorithm to re-sample the height at the grid point of (100, 100), and explain the algorithm in one sentence. [4 points]

b) Compute the height at this grid point by applying your suggested algorithm. [4 points]

c) Discuss the quality of your algorithm in terms of smoothness. [4 points]

d) Given the four points, how many triangulations can you create? Provide a number, and a sketch for each triangulation. [2 points]

e) Which of your triangulations has Delauney properties? [2 point]

f) Explain what the Delauney properties are. [4 points]

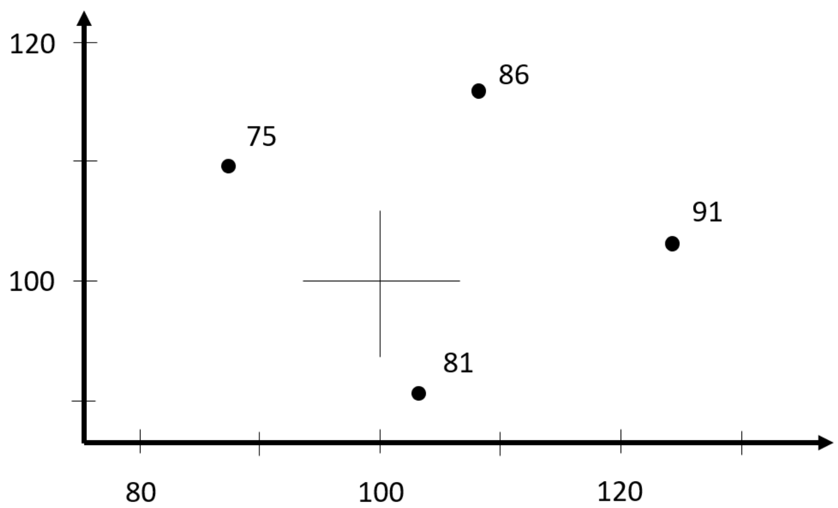

Figure 1: Known heights in a digital elevation model.

Question 8 [Total 17 points]

Assume that the Euclidean coordinates of the points shown in Figure 1 are projected.

a) Which geometric properties between the points can be affected by the projection? [3 points]

b) Which geometric property is preserved by a conformal projection? [3 points]

c) Is the Universal Transversal Mercator projection a conformal projection (y/n)? [3 points]

d) The Universal Transversal Mercator projection is a cylindrical projection: sketch the idea of a cylindrical projection. [5 points]

e) The Universal Transversal Mercator projection is a *transversal* cylindrical projection: what means *transversal* here? [3 points]

Question 9 [20 points]

Time geography provides concepts to represent and analyse movements, which is fundamental for today's applications in tracking goods, vehicles, and people.

a) Name two concepts of time geography. [4 points]

b) Explain both of them by a sketch. [4 points]

c) Sketch (with concepts of time geography) a case where two people meet in a cafe. Which concepts of time geography did you deploy here, if any? [4 points]

d) Sketch a case where two people meet on a bus. What is different in this case? [4 points]

e) Name two different application areas where the time geographic analysis might be relevant. Explain why, in one sentence each. [4 points]

Appendix - Formulas

F1 Solving determinants:

$$\begin{vmatrix} a & b \\ c & d \end{vmatrix} = ad \quad bc$$

$$\begin{vmatrix} a & b & c \\ d & e & f \\ g & h & i \end{vmatrix} = a(ei \quad hf) \quad b(di \quad fg) + c(dh \quad eg)$$

F2 Position of a point $\mathbf{r}$ with respect to a line defined by $\mathbf{p}$ and $\mathbf{q}$:

$$\det(\mathbf{p}, \mathbf{q}, \mathbf{r}) = \begin{vmatrix} 1 & x_p & y_p \\ 1 & x_q & y_q \\ 1 & x_r & y_r \end{vmatrix}$$

- $\mathbf{r}$ is linearly dependent of $\mathbf{pq}$ if $\det = 0$
- $\mathbf{r}$ is on the right of $\mathbf{pq}$ if $\det < 0$
- $\mathbf{r}$ is on the left if $\det > 0$

F3 Center of the circumcircle of three points $\mathbf{p}$, $\mathbf{q}$, $\mathbf{r}$:

$$\begin{aligned} \mathbf{m} &= \mathbf{p} + \lambda(\mathbf{q} \quad \mathbf{p}) + \mu(\mathbf{r} \quad \mathbf{p}) \\ &= \mathbf{p} + \lambda\mathbf{v} + \mu\mathbf{w} \end{aligned}$$

with:

$$\begin{aligned} \lambda &= 0.5 \frac{\begin{vmatrix} \mathbf{v}^T\mathbf{v} & \mathbf{v}^T\mathbf{w} \\ \mathbf{w}^T\mathbf{w} & \mathbf{w}^T\mathbf{w} \end{vmatrix}}{\begin{vmatrix} \mathbf{v}^T\mathbf{v} & \mathbf{v}^T\mathbf{w} \\ \mathbf{v}^T\mathbf{w} & \mathbf{w}^T\mathbf{w} \end{vmatrix}} \\ \mu &= 0.5 \frac{\begin{vmatrix} \mathbf{v}^T\mathbf{v} & \mathbf{v}^T\mathbf{v} \\ \mathbf{v}^T\mathbf{w} & \mathbf{w}^T\mathbf{w} \end{vmatrix}}{\begin{vmatrix} \mathbf{v}^T\mathbf{v} & \mathbf{v}^T\mathbf{w} \\ \mathbf{v}^T\mathbf{w} & \mathbf{w}^T\mathbf{w} \end{vmatrix}} \end{aligned}$$

End of exam paper.