The University of Melbourne

Semester 1 Exam 2016

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

Authorized materials

The following items are authorized: Pens and pencils, compass and rulers, faculty-approved pocket calculators.

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 answers must be written in the script books. The examination paper must be handed in together with the script books. **In total you can earn 115 points**.

Paper to be archived in Baillieu Library? Yes

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: Is a Delauney Triangulation any of the following:

a) a simplicial 3-complex;

b) a general 3-complex;

c) a simplicial 2-complex;

d) a general 2-complex.

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: Which of the following are operators of cartographic generalization:

a) selection;

b) displacement;

c) projection;

d) enrichment.

Question 6 [26 points]

Your company plans to develop a new mobile location-aware game application: a multi-player game of an urban orienteering race. From experience you think the following estimates are realistic:

- Estimated personnel costs:
  Year 1: $120k (salary of a software engineer for the game development), and from then on $10k per year (for game maintenance and updates). Estimated map licence costs: $10k per year. All other costs are negligible.
- Each time players play the game they will pay 50 cents.
- Estimated market:
  Year 1: 0 plays (game under development), Year 2: 150,000 plays, and from then on 250,000 plays of the game per year.

Now you apply your economic knowledge:

a) Define the notions of *direct benefit* and *indirect benefit* for a company. [4 points]

b) For this specific game development, name one example for a *direct benefit*, and one for an *indirect benefit*. [4 points]

c) Define the notion of *break-even*. [4 points]

d) In which month do you reach realistically break-even in this game development? [4 points]

e) But you are concerned of the risks with all these estimates. You guess that software development can easily run 50% over the budgeted time. Would you still reach break-even within three years in this case? [5 points]

f) You also expect more competition in the market than ever before, and decide to consider additionally market variations of $\pm$ 30%. Would your company break-even in the worst case before Year 5? [5 points]

Question 7 [23 points]

The grid shown below represents a digital elevation model (DEM), with a marked location of unknown terrain elevation. The grid size of the DEM is 100m, and the unknown location is 70m to the East and 60m to the North of the bottom left grid point.

a) Explain how a grid is represented by the raster data structure [4 points].

b) Determine the elevation at the marked location by nearest neighbourhood interpolation [4 points]. Explain in one sentence this interpolation method. [2 points]

c) Determine the elevation at the marked location by bilinear interpolation [6 points]. Explain this interpolation method [3 points].

d) Name one advantage and one disadvantage of bilinear interpolation compared to nearest neighbourhood interpolation [4 points].

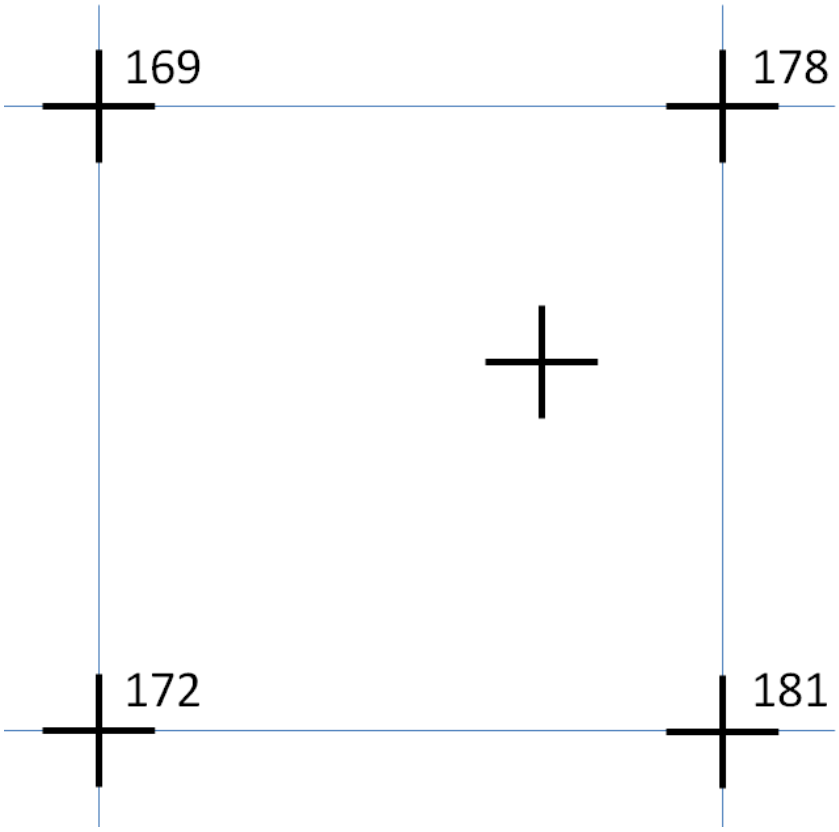

Figure 1: A grid-based digital elevation model.

Question 8 [21 points]

The 4-intersection model uses binary notations ($\emptyset$, $\neg\emptyset$) to characterise topological relationships between simple regions in a schema of four intersection sets.

a) In this context, what is a 'simple' region? [2 points]

b) What is each of the four intersection sets representing? [4 points]

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

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

e) How many distinct 4-intersection matrices can be constructed in theory? [2 points]

f) Can you provide one example of a 4-intersection matrix that does not correspond to a topological relationship between two simple regions [2 points]?

g) How many topological relations exist between a point and a region? [3 points]

Now consider a one-dimensional space: the time axis. 'Regions' on the time axis are temporal intervals, or durations.

a) Along the time axis, sketch all topological relations between two temporal intervals you can think of. How many relations can you distinguish [4 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:

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

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

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 linear 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 $\mathbf{p}$, $\mathbf{q}$, $\mathbf{r}$:

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

with:

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

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

End of exam paper.