

Homework #2 Solution

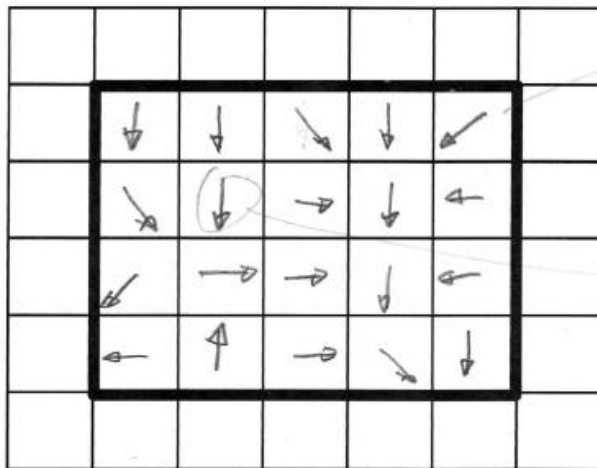
Watershed Delineation from a Digital Elevation Model

Following is a grid of elevations in a 30 m digital elevation model.

21	21	21	21	21	21	21
21	24	24	24	24	24	21
21	18	18.4	19.2	15.9	19.5	19.5
21	24	18	18.3	16.2	18.3	18
15	21	19.8	18.6	16.2	16.8	16.5
15	19.5	21	21	21	15	14.7

18.3
 16.2
 18.3

- On the above grid, determine **which grid cells are pits** and indicate the elevation to which they need to be raised to **fill** them.
- For the inner block of 4 x 5 grid cells indicated by the box determine the **D8 flow direction** and indicate this using an arrow on the diagram below. Use pit filled elevation values.



$$\left(\frac{24 - 16.2}{30.56} \right) = 0.183$$

$$\frac{24 - 19.5}{30} = 0.15$$

AMBIGUOUS.
 COULD GO LEFT
 OR DOWN.

Note. Flow directions are not evaluated along the edges because they may depend on data outside the domain. Indicate any grid cells where there is ambiguity and flow direction needs to be arbitrarily chosen. Comment on how it may be good for the computer to evaluate flow direction in these cases.

3. Calculate the D8 slope for the two cells indicated below. Use pit filled elevation values.

21	21	21	21	21	21	21
21	24	24	24	24	24	21
21	18	18.4	19.2	18.9	19.5	19.5
21	24	18	18.3	16.2	18.3	18
15	21	19.8	18.6	16.2	16.8	16.5
15	19.5	21	21	21	15	14.7

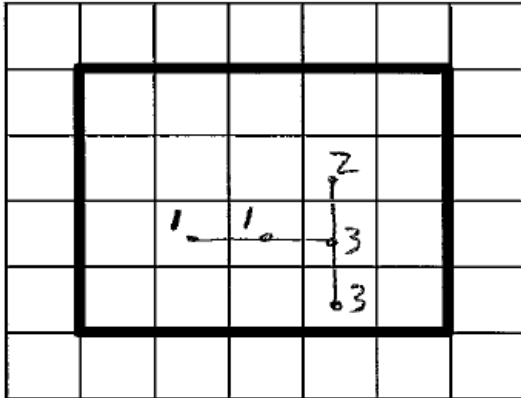
$$\frac{24 - 16.2}{30\sqrt{2}} = 0.183$$

$$\frac{19.2 - 16.2}{30} = 0.1$$

4. Calculate the **flow accumulation** for all grid cells in the inner 4 x 5 block indicated by the bold box. Write your answers (reported in terms of the number of grid cells flowing into each grid cell) in the diagram below. On this diagram also indicate the watershed draining to the grid cell labeled A by drawing a line around it.

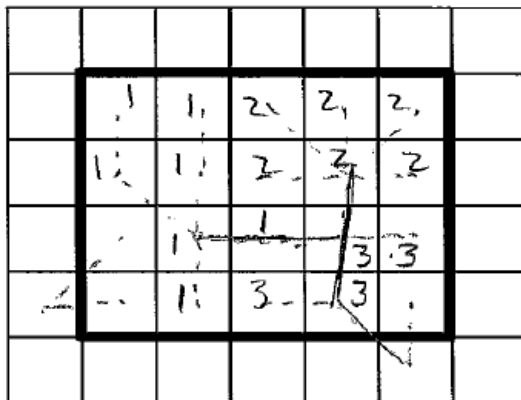
	0	0	0	0	0	
	1	1	0	3	0	
	0	5	6	14	0	
	0	10	0	16	0	
				A		

5. Determine a stream network using a **flow accumulation** threshold of 3 grid cells and indicate the grid cells that comprise the stream network. Identify each segment of your stream network using a unique number in the diagram below. You should only fill in stream segment numbers for grid cells on the stream network.



NETWORK IS FROM
 CELL CENTER TO
 CELL CENTER

6. Determine the grid cells belonging to the catchment draining to each stream segment and fill in numbers in the diagram below indicating the catchment grid.



7. Prepare a table giving the length of each stream segment and the drainage area of the corresponding catchment. Also indicate the total area and total length of the stream network draining to grid cell A. Report the drainage density for this stream network. Drainage density is Length/Area.

SEGMENT	LENGTH (m)	AREA (cells)	AREA (m ²)
1	60	7	6300
2	30	6	5400
3	30	4	3600

$$1 \text{ cell} = 30 \times 30 = 900 \text{ m}^2$$

$$\text{TOTAL AREA} = \frac{15300 \text{ m}^2}{}$$

$$\text{TOTAL LENGTH} = \frac{120 \text{ m}}{}$$

$$\text{DRAINAGE DENSITY} = \frac{120}{15300}$$

$$= 0.0078 \text{ m}^{-1}$$

B Slope

The following is a grid of elevations in meters in a digital elevation model with 50 m cell size.

50	45	40
46	42	38
42	40	37

(a) Determine the **Hydrologic Slope** of the **center cell** with elevation 42

$$\text{To right } \frac{42-38}{50} = 0.08$$

$$\text{To bottom right } \frac{42-37}{50\sqrt{2}} = 0.070$$

The slope to the right is largest, so select it
Hydrologic slope = 0.08

(b) What D8 Flow Direction encoding does this cell have using the ESRI direction encoding?

1. The encoding of right or east is 1

(c) Use the ArcGIS slope method to determine the x and y components of **Terrain Slope** of this grid.

X-Component, **dz/dx**

$$\frac{50 + 46 \times 2 + 42}{8 \times 50} - \frac{40 + 38 \times 2 + 37}{8 \times 50} = \mathbf{0.0775}$$

Y-Component, **dz/dy**

$$\frac{42 + 40 \times 2 + 37}{8 \times 50} - \frac{50 + 45 \times 2 + 40}{8 \times 50} = \mathbf{-0.0525}$$

(d) Determine the overall Terrain Slope

$$\sqrt{0.0775^2 + 0.0525^2} = \mathbf{0.0936}$$

(e) Briefly explain how the Hydrologic Slope and Terrain Slope are different from one another.

Terrain slope is an average considering all surrounding cells. Its formulae can be justified based on fitting a smooth surface to all 9 points. Hydrologic slope only considers adjacent grid cells that are lower in elevation and is the slope towards the grid cell in the single steepest downwards direction.

A. Line Measure and Slope Question:

1. A line is defined by a sequence of vertices A, B, C, D, whose (X, Y) coordinates are given in the table. If the line exists on a topographic surface defined by the equation $Z = 100 - 0.01(X + Y)$, compute the *Z-coordinate* of each of these points. All values are in meters. Determine the *length* and *slope* of each of the line segments AB, BC, and CD, and determine the *absolute measure* value, M_a , in meters of the vertices B, C, D assuming that location A has measure 0. Determine the *relative measure* value, M_r , of these vertices assuming A is 0% and D is 100% of the length of the line.

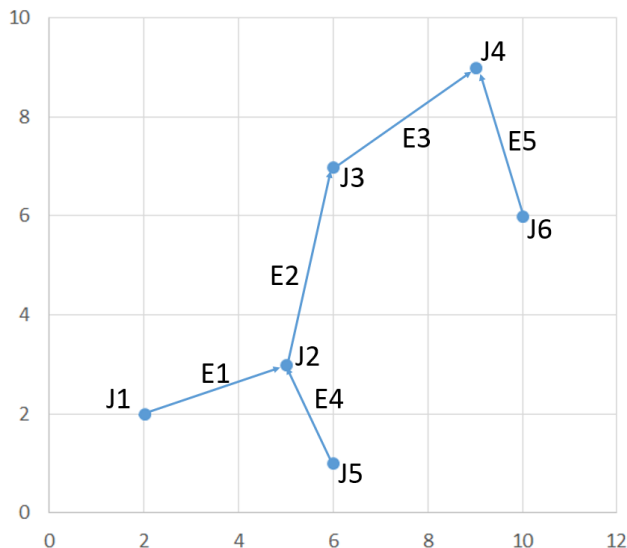
Point	X	Y	Length	Measure	Relative Measure
A	20	20		0	0.0%
B	50	30	31.62	31.62	29.0%
C	60	70	41.23	72.85	66.9%
D	90	90	36.06	108.91	100.0%

B. Network Topology Question:

2. Suppose we have a set of line segments with the beginning “from” points (labelled 1) and ending “to” points (labelled 2).

Segment	From Point		To Point	
	X1	Y1	X2	Y2
1	2	2	5	3
2	5	3	6	7
3	6	7	9	9
4	6	1	5	3
5	10	6	9	9

- a) Make a drawing to scale that shows these five line segments.



Suppose, now, that these lines have been built into a geometric network which has Edge-Junction topology.

- b) How many Junctions are there in this network? (Remember that all Edges begin and end at a Junction). Label the Junctions J1, J2, etc in your drawing.

6 Junctions (include end points)

- c) How many Edges are there in this network? Label them in your drawing E1, E2, ... etc.

5 Edges

- d) Build a network topology table that shows how the Edges are connected through the Junctions.

Network Topology			
Junction	Edge,Junction	Edge,Junction	Edge,Junction
J1	E1,J2		
J2	E1,J1	E4,J5	E2,J3
J3	E2,J2	E3,J4	
J4	E3,J3	E5,J6	
J5	E4,J2		
J6	E5,J4		

- e) Do a “Trace Upstream” from the location (6,7) and identify which Edges and Junctions are selected.

E2, E1, E4

J3, J2, J1, J5 (Note that the junction where the trace originates is included)

- f) Do a “Trace Downstream” from the location (2,2) and identify which Edges and Junctions are selected.

E1, E2, E3

J1, J2, J3, J4 (Again the junction where the trace originates is included)