Name: Key

GIS in Water Resources Midterm Exam **Fall 2012**

There are five questions on this exam. Please do all five.

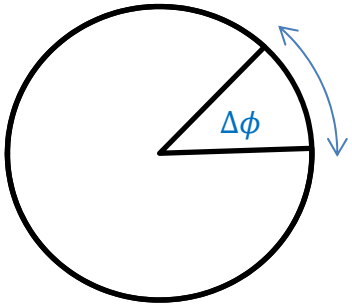
Question 1

(a) You have worked with the location of Utah State University in Logan in Geographic Coordinates (41° 44' 54"N, 111° 48' 30"W). If a line is drawn directly South from Logan, it will eventually cross the Equator. Calculate the length of this line in km assuming a spherical earth with a radius of 6371 km. $\pi = 3.1416$.

Utah State University

41°44'54"N, 111°48'30"W

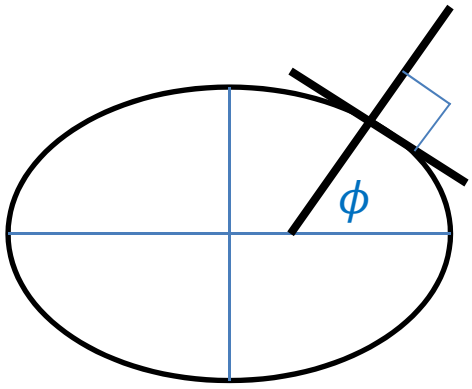
$41°44'54" = 41 + 44/60 + 54/3600 = 41.748$



$$L = 2\pi R \frac{\Delta\phi}{360}$$
$$= 2\pi \times 6371 \times \frac{41.748}{360}$$
$$= 4642.2 \text{ km}$$

(b) Define the term **Latitude** and use a diagram to illustrate your definition recognizing that the earth is represented as a rotated ellipsoid.

In terms of the spheroid or rotated ellipsoid latitude is the angle between the surface normal and equatorial plane (not center of the earth)



Eccentricity exaggerated

Question 2

(a) In this class, we have used several national datasets. Briefly describe the content of the these datasets and give the form of geographic data (vector or raster) that each uses.

Dataset	Contents	Form
National Hydrography Dataset	Stream lines, Water bodies, Canals and other flow paths. Stream gage locations	Vector
National Elevaton Dataset	Topographic elevation values	Grid
Watershed Boundary Dataset	Watershed divides demarcating the nation into hydrologic units or HUCs	Vector
SSURGO Soil Dataset	Soil classes and their properties	Vector

(b) The properties of a feature class examined in ArcMap indicate the following information.

		Labels
Projected Coordinate System:	NAD_1983_Albers	
Projection:	Albers	
False_Easting:	0.00000000	X_o
False_Northing:	0.00000000	Y_o
Central_Meridian:	-96.00000000	λ_o
Standard_Parallel_1:	29.50000000	
Standard_Parallel_2:	45.50000000	
Latitude_Of_Origin:	37.50000000	φ_o
Linear Unit:	Meter	

(i) Label the rows of this description with the coordinates **(φ_o,λ_o)** and **(X_o,Y_o)** in the column to the right above.

(ii) What earth datum does this projection use?

NAD 1983 (North american datum of 1983)

(iii) Give a brief explanation of the following terms:

Feature Class

A geographic representation of vector objects such as points, lines and polygons used in GIS

Feature Dataset

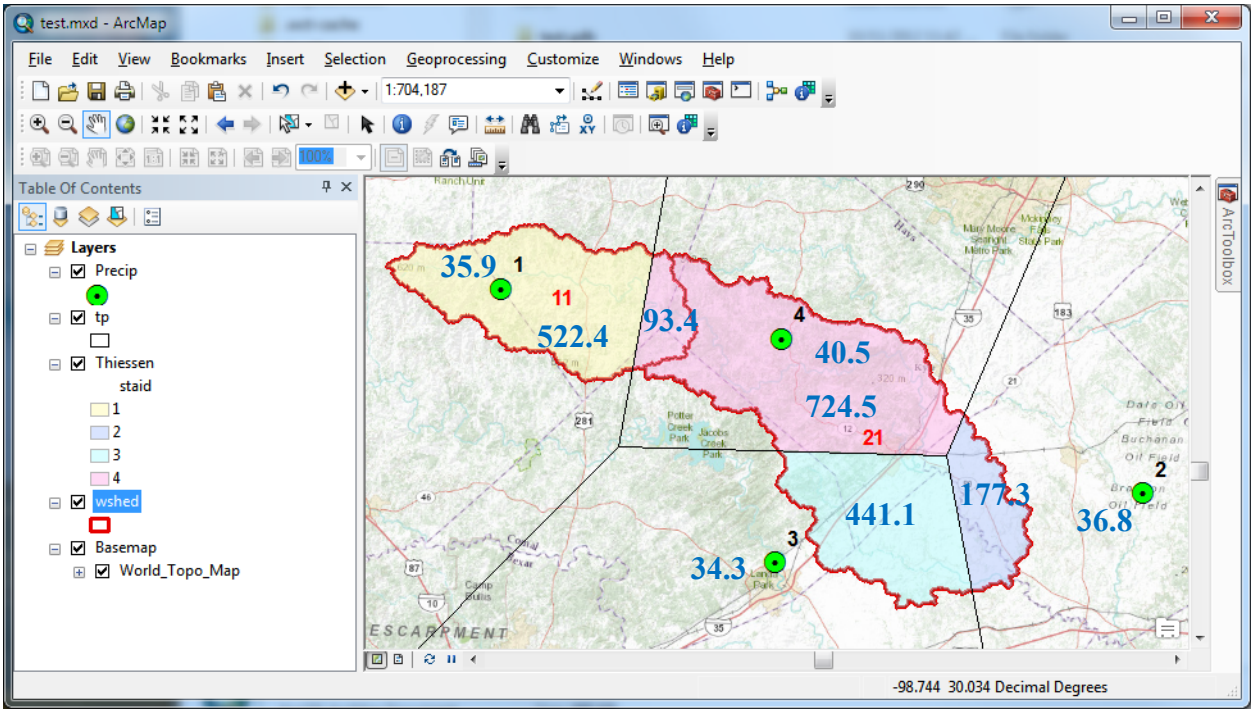
A collection of feature classes all with the same spatial reference (or coordinate system)

Geodatabase

A relational database holding geographic data including feature classes and feature datasets

Question 3

The following ArcMap screen shot illustrates Precipitation stations labeled (single digit) with their station identifier **staid** and subwatersheds labeled (double digit) with their **HydroID**



Following are the attribute tables for

1. **Precip**. Annual precipitation (AnnPrecip_in) in inches at precipitation stations identified by the field **staid**
2. **Wshed**. Subwatersheds identified by the field **HydroID**, with area in square kilometers.
3. **Thiessen**. The result from application of the Thiessen, then Intersection tools giving the intersection of Thiessen Polygons with subwatersheds, with the area in square kilometers.

Precip

OBJECTID	Shape *	staid	AnnPrecip_in
1	Point	1	35.9
2	Point	2	36.8
3	Point	3	34.3
4	Point	4	40.5

wshed

OBJECTID_1	Shape *	HydroID	AreaSqKm
1	Polygon	11	615.8
2	Polygon	21	1342.9

Thiessen

OBJECTID	Shape *	staid	HydroID	AreaSqKm
1	Polygon	1	11	522.4
2	Polygon	2	21	177.3
3	Polygon	3	21	441.1
4	Polygon	4	11	93.4
5	Polygon	4	21	724.5

(a) In the **map**, **label each gage** with its annual precipition and **label each of five polygons** of the Intersected Subwatershed and Thiessen coverage with its area in square kilometers.

(b) Describe the join operation that would be required to obtain a field in the Thiessen table containing AnnPrecip_in for each Thiessen Polygon. Your description should indicate the tables and key fields involved.

Join the Precip table on to the Thiessen table using staid as the key field for both tables.

(c) In the table that results from this join, an annual precipitation is associated with each of the five subareas. Fill in the resulting values in the table below and calculate the **Product** of the AreaSqKm and AnnPrecip_In fields

ObjectID	Staid	HydroID	AreaSqKm	AnnPrecip_In	Product
1	1	11	522.4	35.9	18754
2	2	21	177.3	36.8	6524
3	3	21	441.1	34.3	15130
4	4	11	93.4	40.5	3783
5	4	21	724.5	40.5	29342

(d) Calculate the areally averaged annual precipitation in inches in each subwatershed

Subwatershed 11

$$\frac{18754 + 3783}{615.8} = 36.6\ in$$

Subwatershed 21

$$\frac{6524 + 15130 + 29342}{1342.9} = 38.0\ in$$

(e) Suppose you were interested in the health of the vegetation in these subwatersheds. Describe how you would use remote sensing to determine a grid of Normalized Difference Vegetation Index (NDVI) values over this region.

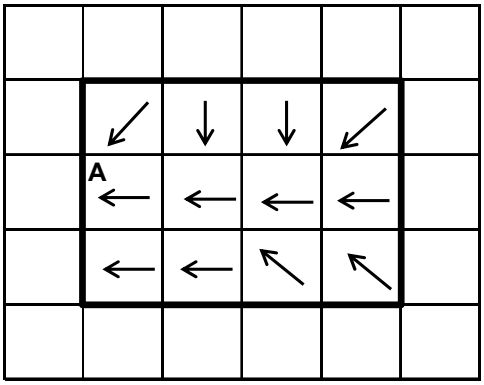
Use the appropriate bands from Landsat in the NDVI formula (below) in a raster calculation

$$NDVI = \frac{NIR - RED}{NIR + RED}$$

NIR = Near Infra Red

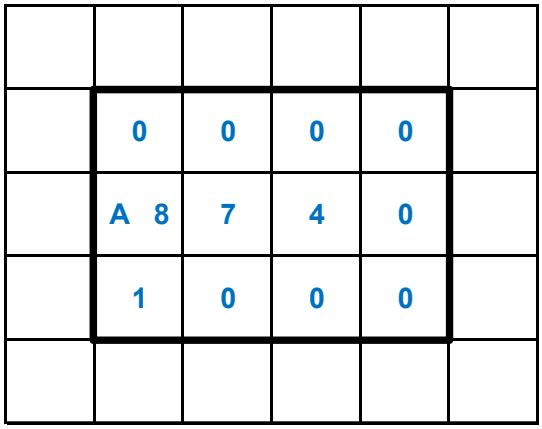
Question 4

The following diagram illustrates a set of flow directions evaluated in a digital elevation model with cell size 50 m.

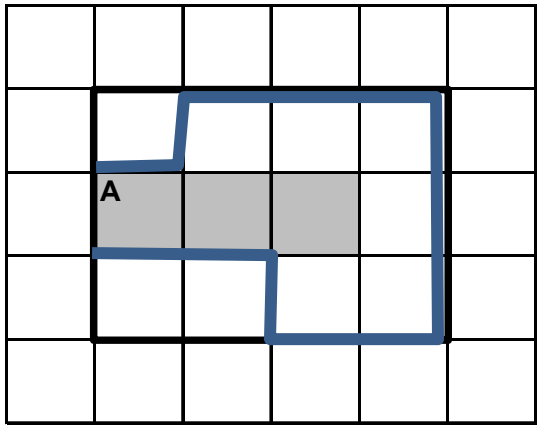


(a) Calculate the **flow accumulation** for all grid cells for which flow direction is given (in the inner block). Write your answers in the left hand side grid below.

Flow Accumulation



Watershed and Stream Cells



(b) Determine the **stream cells** draining to and including grid cell A using a threshold contributing area of 4 grid cells. Shade these cells in the right hand grid above.

(c) In the right hand grid above, draw a **border around the watershed** draining to and including grid cell A. What is the **area** of this watershed (square meters)?

Area = 9 x 50 x 50 = 22,500 m^2

Question 5
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

To right $\frac{42-38}{50} = 0.08$
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 ArcGIS Flow Direction does this cell have? **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 forumlae 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.