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GIS in Water Resources Midterm Exam **Fall 2010**

There are 3 questions on this exam. Please do all 3.

1. Basic Concepts and Geodesy

(a) Provide an example for each GIS data type that was used in our exercises. Give the name of a standard GIS data set or data source that provides information using this data type.

- **Raster**

  EX. SAN MARCOS DIGITAL ELEVATION MODEL.
  NATIONAL ELEVATION DATASET FROM SEAMLESS USGS SERVER

- **Polygon**

  EXAMPLE. SAN MARCOS WATERSHED BOUNDARY DATASET.
  NATIONAL WATERSHED BOUNDARY DATASET

- **Polyline**

  EXAMPLE. SAN MARCOS STREAMS.
  STREAMS OR FLOWLINES FROM NATIONAL HYDROGRAPHY DATASET.

- **Point**

  EXAMPLE. USGS GAGES. ALSO GAGES FROM NCDC
  USGS GAGE FEATURES FROM WEB SERVICES ACCESSED IN HYDROGET.

- **Geometric network**

  A GEOMETRIC NETWORK WAS CONSTRUCTED IN EX 4 & PROVIDED IN EX 5 FOR SAN MARCOS STREAMS.
  NHD PLUS CONTAINS INFORMATION TO SUPPORT A GEOMETRIC NETWORK.

- **Imagery**

  THE BASEMAP LAYERS USED IN EX 2 INCLUDE IMAGERY FROM BING OR ESRI. THIS IS A GROWING STD DATA SOURCE.

The remaining parts of this question refer to the specification below that shows the parameters of the State Plane coordinate system for Nebraska.

Name: NAD_1983_StatePlane_Nebraska_FIPS_2600_Feet

Details:

Projection: Lambert_Conformal_Conic
False_Easting: 1640416.666667
False_Northing: 0.000000
Central_Meridian: -100.000000
Standard_Parallel_1: 40.000000
Standard_Parallel_2: 43.000000
Latitude_Of_Origin: 39.833333
Linear Unit: Foot_US (0.304801)

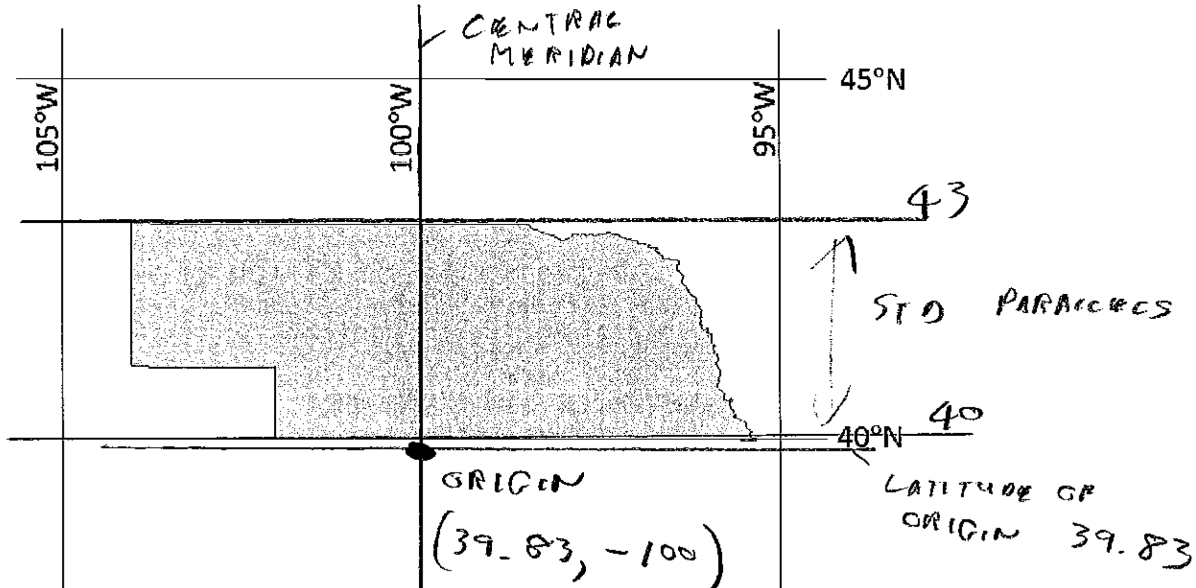
Geographic Coordinate System: GCS_North_American_1983
Angular Unit: Degree (0.017453292519943295)
Prime Meridian: Greenwich (0.000000000000000000)
Datum: D_North_American_1983
Spheroid: GRS_1980

(b) What map projection and earth datum is used in this coordinate system?

Projection: LAMBERT CONFORMAL CONIC

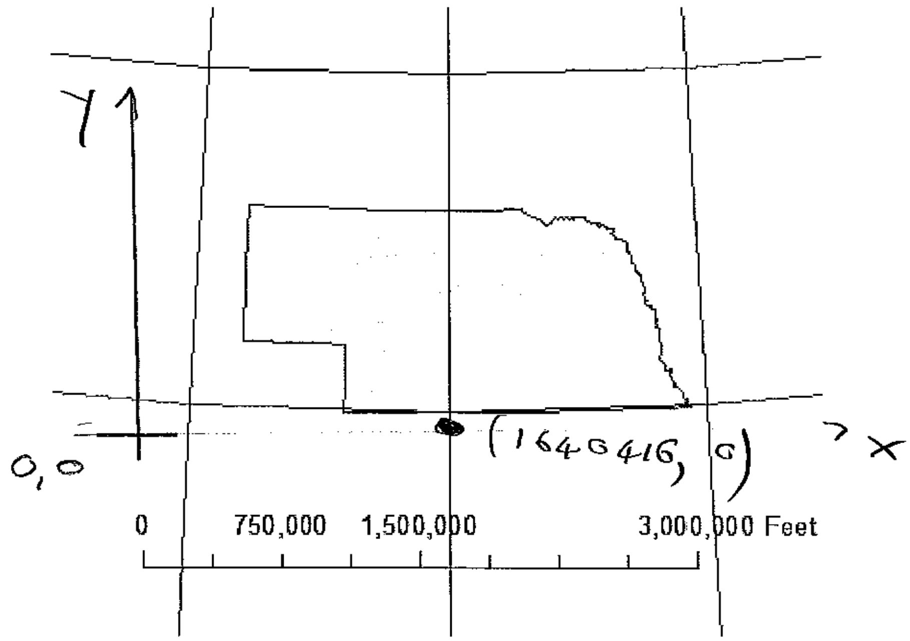
Earth Datum: NORTH AMERICAN DATUM OF 1983

(c) Sketch on the diagram below the locations of the Standard Parallels, the Central Meridian and the Latitude of Origin. What is the significance of the standard parallels? Put a large dot at the location of the origin of this coordinate system and label it with its (latitude, longitude coordinates)

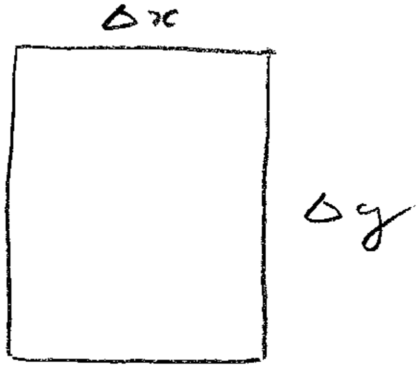


THE STANDARD PARALLELS ARE WHERE THE PROJECTION CONE INTERSECTS THE GLOBE.

(d) The map below shows same map of Nebraska redrawn in its state plane coordinate system. Redraw the dot in this map that you drew in Part (c) and label it with its Easting and Northing coordinates. Draw the Easting-Northing, or X-Y, axes of this coordinate system. Label the (0,0) point.



(e) The National Elevation Dataset has grid cells that are 1" x 1" in size. Suppose that this grid is projected into the Nebraska State Plane coordinate system. If a DEM cell is located at Lincoln, NE, whose lat-long coordinates in decimal degrees are (40.8144, -96.7078), determine the **surface area (ft^2)** of the earth (square feet) that a 1" x 1" cell would cover. Assume that the radius of the earth is 20,925,392 feet. What would be the **cell size (ft)** of an equivalent square DEM cell that covers the same area?



$$\Delta y = \frac{1}{3600} \times \frac{\pi}{180} \times r$$

$$= \frac{1}{3600} \times \frac{\pi}{180} \times 20925392$$

$$= 101.45 \text{ ft}$$

$$\Delta x = \Delta y \cos(\text{Lat})$$

$$= \Delta y \cos(40.8144)$$

$$= 76.78 \text{ ft}$$

SURFACE AREA $= 7789.3 \text{ ft}^2$

EQUIVALENT SQUARE $= \sqrt{7789.3} = 88.26 \text{ ft}$

2. Hydrology and Digital Elevation Models

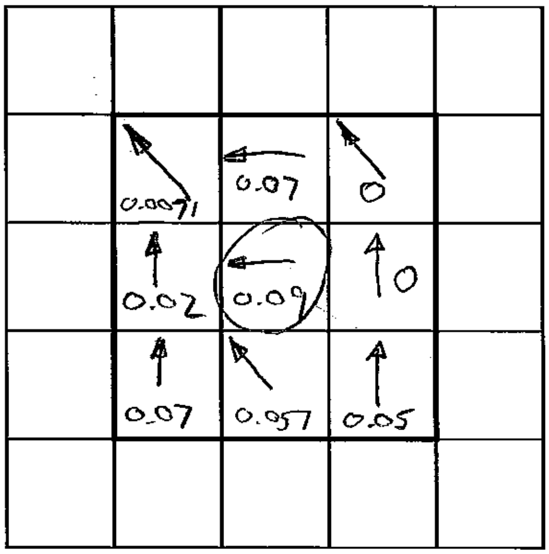
Following is a grid of elevations in a 100 m digital elevation model.

44	46	51	57	58
45	45	52	50 / 51	55
46	47	56	48 / 51	58
52	54	55	56	54
51	53	52	54	53

PITS

a) On the above grid, for the cells within the boldface highlighted box, determine **which grid cells are pits** and indicate the elevation to which they need to be raised to **fill** them.

b) For the inner block of 3 x 3 grid cells indicated by the bold box determine the **D8 flow direction** and indicate this using an arrow on the diagram below.



STRAIGHT $\frac{\Delta H}{100}$

DIAGONAL $\frac{\Delta H}{100\sqrt{2}}$

STEEPEST

Calculate the **D8 slope** for each cell within the bold box and label it by its flow direction arrow. **Circle the cell** with the highest slope.

d) Calculate the **flow accumulation** for all grid cells in the inner 3 x 3 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. In this calculation do not consider inflow from any cells outside the boldface box.

			D	C
	5	0	(2)	B
	3	0	(1)	A
	0	0	0	

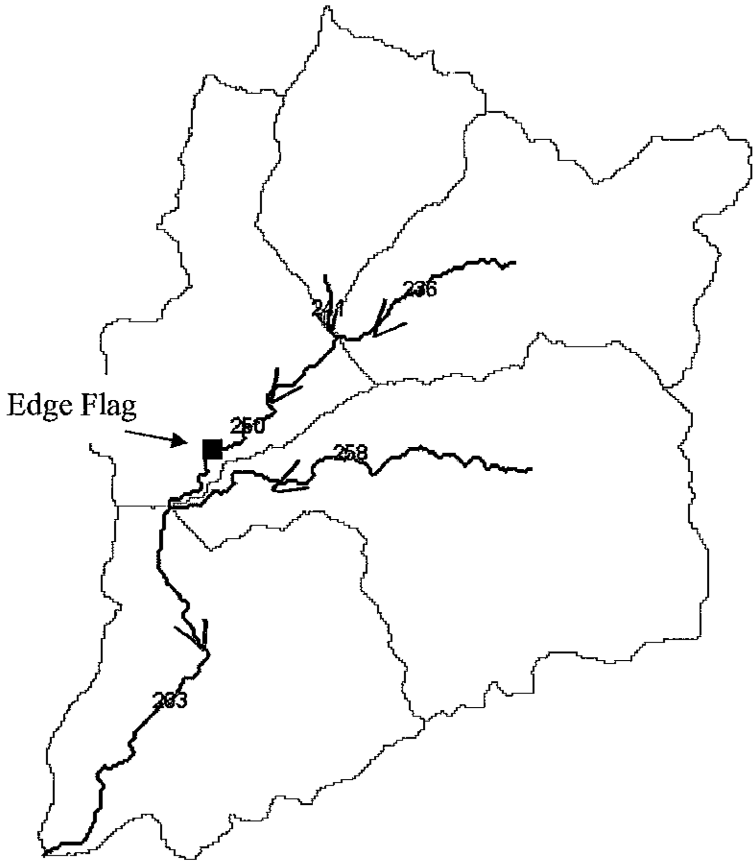
MAY GET FLOW FROM B, C, D AND A VIA CELL BELOW.

MAY GET FLOW FROM A

Circle the cells whose flow accumulation values reported above are uncertain due to the possibility of being impacted by flow from outside the boldface box.

3. Stream Networks

The image below shows a stream network and catchments delineated from a digital elevation model. Each edge in the stream network has been labeled with the grid_code. Also shown are attribute tables for the stream and catchment feature classes. **Map units are meters.**



Stream attribute table

OBJECTID *	Shape *	grid_code	from_node	to_node	Shape_Length
1	Polyline	241	239	247	809.558441
2	Polyline	236	236	247	2609.92424
3	Polyline	250	247	263	3396.761902
4	Polyline	258	260	263	5329.995667
5	Polyline	263	263	289	5564.406922

Catchment attribute table

OBJECTID *	Shape *	grid_code	Shape_Length	Shape_Area
1	Polygon	236	19860	9269999.9999
2	Polygon	241	13560	5024700.0000
3	Polygon	250	19380	7711200
4	Polygon	258	24360	14699700.000
5	Polygon	263	20160	11446199.999

Note. In the data presented above from ArcGIS data is displayed with many significant figures. In the calculations you are asked for below you do not need to retain more than 3 significant figures of precision.

An edge flag has been placed on edge 250 as indicated.

a) Indicate (with arrows on the diagram above) the **direction of flow** along each stream edge

DIRECTIONS INDICATED. DETERMINED FROM VISUAL GEOMETRY OR FROM & TO NODES

b) List below the **grid_code attribute** of the edges that would be selected by a **Trace Upstream** operation and calculate the **total drainage area (m^2)** of the network so selected. Remember that a trace operation always includes the edge on which the edge flag is located.

GRID CODES = 241, 250, 236

AREA = $(5.025 + 7.711 + 9.27) \times 10^6$

TOTAL = 22.03×10^6 m^2

c) List below the grid_code attribute edges that would be selected by a **Trace Downstream** operation and calculate the **total length (m)** of the flow path selected

GRID CODES : 250, 263

LENGTH = 3397 + 5564

TOTAL = 8961 m

d) Assume a mean annual rainfall of 30 in/yr over these watersheds and a runoff coefficient of 0.15, calculate the **mean annual flow rate (ft^3/s)** at the downstream end of edge 250. Note that $1\ m^2 = 10.763\ ft^2$.

$$\text{Area} = 22.03 \times 10^6\ m^2$$

$$= 22.03 \times 10^6 \times 10.763$$

$$= 237.14 \times 10^6\ ft^2$$

$$\text{VOL RAIN} = \frac{30}{12} \times 237.14 \times 10^6$$

$$= 592.8 \times 10^6\ ft^3$$

$$\text{VOL RUNOFF} = 0.15 \times 592.8 \times 10^6$$

$$= 88.92 \times 10^6\ ft^3$$

SECONDS IN YEAR — FOR LEAP YR ON AVERAGE

$$365.25 \times 24 \times 3600$$

$$= 31557600$$

MEAN ANNUAL FLOW RATE

$$= \frac{88.92 \times 10^6}{31557600}$$

$$= 2.818\ ft^3/s$$