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GIS in Water Resources Midterm Exam **Fall 2018**

There are four questions on this exam. Please do all of them.

Question 1

(a) Figure 1 shows the extent of the Digital Elevation Model used as input to Exercise 4. Assuming an earth radius of 6371 Km, calculate the lengths of the lines AB, BC, CD and DA in Km, and the earth surface area covered by this DEM (Km^2). $\pi = 3.1416$.

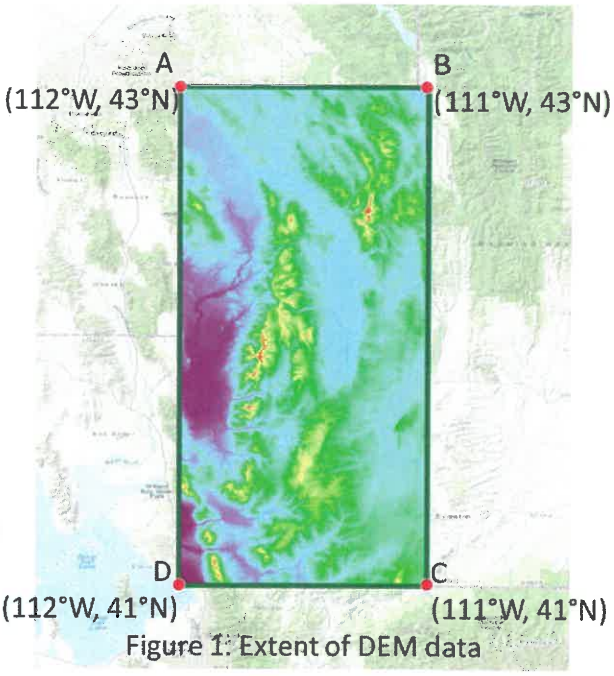


Figure 1: Extent of DEM data

(i) $AD = BC = R_e \Delta\phi$; $R_e = 6371$

$\Delta\phi = 2° = 2 \times \pi/180$ rad $= 0.03491$ rad

$\therefore AD = BC = 6371 \times 0.03491$

$= 222.4$ Km

(ii) $AB = R_e \cos\phi \Delta\lambda$

$\Delta\lambda = 1° = 1 \times \pi/180 = 0.01745$ rad

$\phi = 43° = 43 \times \pi/180 = 0.75049$ rad

$\cos\phi = \cos(0.75049) = 0.73135$

$\therefore AB = 6371 \times 0.73135 \times 0.01745 = 81.32$ Km

(iii) Similarly for CD, $\Delta\lambda = 0.01745$ rad

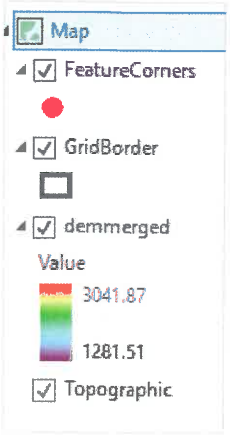
$\phi = 41° = 41 \times \pi/180 = 0.71585$ rad

$\cos\phi = \cos(0.71585) = 0.75471$

$\therefore CD = 6371 \times 0.75471 \times 0.01745 = 83.92$ km

(iv) Average of AB & CD $= (81.32 + 83.92)/2 = 82.62$ km

$\therefore$ area ABCD $= 82.62 \times 222.4 = 18374$ km^2



Length AB (Km)	Length BC (Km)	Length CD Km)	Length DA (Km)	Area ABCD (Km^2)
81.32	222.4	83.92	222.4	18374

(b) Figure 1 contains rasters and feature classes. What is the fundamental difference between these two types of geographic information?

Rasters provide continuous coverage over a geographic space

Feature classes contain points, lines or polygons that are discrete spatial objects not covering a whole space

Question 2

The following coordinate system is commonly used in mapping the United States

Coordinate System Details

Projected Coordinate System	USA Contiguous Albers Equal Area Conic
Projection	Albers
WKID	102003
Authority	Esri
Linear Unit	Meters (1.0)
False Easting	0.0
False Northing	0.0
Central Meridian	-96.0
Standard Parallel 1	29.5
Standard Parallel 2	45.5
Latitude Of Origin	37.5
Geographic coordinate system	GCS North American 1983
WKID	4269
Authority	EPSG
Angular Unit	Degree (0.0174532925199433)
Prime Meridian	Greenwich (0.0)
Datum	D North American 1983
Spheroid	GRS 1980
Semimajor Axis	6378137.0
Semiminor Axis	6356752.314140356
Inverse Flattening	298.257222101

(a) What Earth Datum is used?

2 NAD 83 - North American Datum of 1983

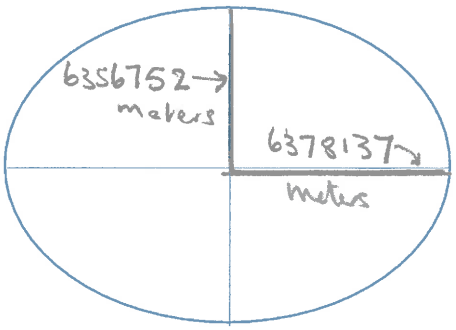
(b) What spheroid is used?

2 GRS 80 - Geodetic Reference System of 1980

(c) What map projection is used?

2 USA Contiguous Albers Equal Area Conic

(d) Use the diagram below to indicate the dimensions in meters of the axes of the spheroid used in this coordinate system.



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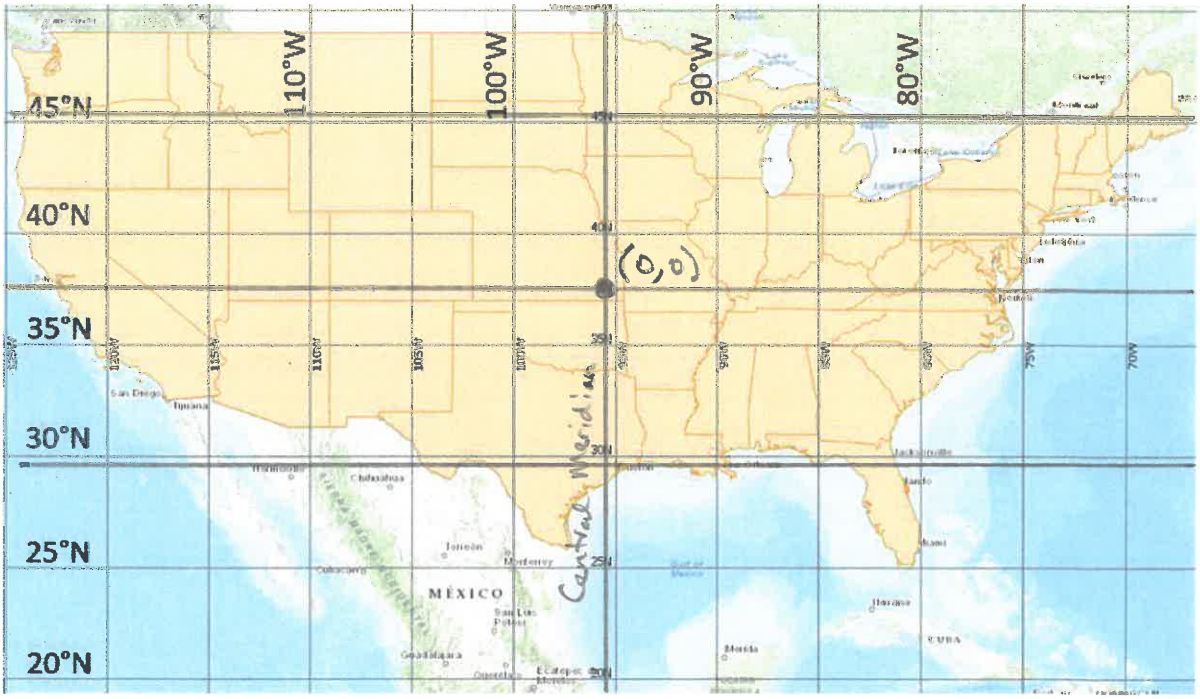
7 (e) Draw on the map below lines which show the Central Meridian, Latitude of Origin, and the Standard Parallels of this coordinate system.



(f) Put a large dot at the origin of this coordinate system and label it with its (X_o, Y_o) coordinates

2 See diagram

According to Wikipedia, the geographic coordinates for Washington DC are: 38°54'17"N, 77°00'59"W.

(g) To 5 figures after the decimal point what are the latitude and longitude of Washington DC in decimal degrees?

Latitude in DD = $38 + 54/60 + 17/3600 = 38.90472°$

4 Longitude in DD = $-(77 + 0/60 + 59/3600)$

$= -77.01639°$

∴ Washington DC is $(\phi, \lambda) = (38.90472, -77.01639)$

(h) In what UTM zone is Washington DC located?

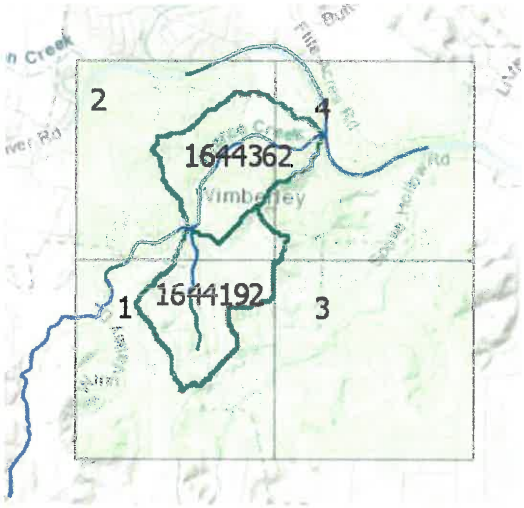
UTM zones are 6° wide, starting at 180° W. Washington is ~77° W

4 $\therefore (180 - 77)/6 = 17.16$

So 17 zones to the west and Washington DC is located in Zone 18 of UTM

Question 3

In the map below four hypothetical National Water Model Grid Cells are shown overlaying two NHDPlus Catchments in Part of the San Marcos Basin. Each grid cell is 2 Km x 2 Km and numbered 1 to 4 (CellNumber). The Catchments are numbered by their grid code.



Below is the attribute table of the feature class created by intersecting the National Water Model grid cells with NHDPlus catchments. Shape_area_m2 gives the area of each polygon in the intersection in m^2.

CatchGridIntersect

Field: Add Delete Calculate Select

GRIDCODE	CellNumber	Shape_Area_m2
1644192	1	1062667
1644192	2	306233
1644192	3	957
1644192	4	26043
1644362	2	1221750
1644362	4	256950

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for catchment 1644192

area = 1062667 + 306233 + 957 + 26043

= 1395900 m^2

= 1.396 Km^2

for catchment 1644362

area = 1221750 + 256950

= 1478700

= 1.479 Km^2

a) Determine the area of each catchment Km^2.

Catchment	Area (Km^2)
1644192	1.396
1644362	1.479

Below is the attribute table of National Water Model precipitation over each grid cell in mm for a storm of interest.

NWM2kmGrid

Field: Add Delete Calculate Selectic

CellNumber	Precip_mm	Shape_Area_m2
1	21	4000000
2	22	4000000
3	23	4000000
4	26	4000000

b) For catchment 1644362 determine the NWM grid cells that it intersects with and the fraction of area overlapping with each of these grid cells.

Catchment 1644362 intersects with

Cell No. 2, fraction area = 1221750 / 1478700 = 0.826

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Cell No. 4, fraction area = 256950/1478700 = 0.174

1.000

c) For catchment 1644362 determine the Area weighted precipitation input from the National Water Model in mm.

area-weighted precip = 0.826 × 22 + 0.174 × 26

= 22.7 mm

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Question 4

a) Following is a grid of elevation values in meters in a digital elevation model with 10 m cell size. Identify any pits by shading them, and indicate the elevation to which grid cells need to be raised to fill the pits so that the DEM is hydrologically conditioned. Write the elevation values for the resulting hydrologically conditioned DEM in the template to the right.

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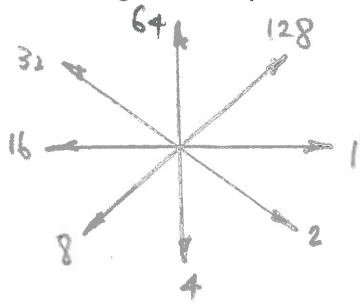
17	13.5	16	15	18
18	13 (13.5)	15.5	16	17
19	12.5 (13.5)	16	16.5	17
20	19	20	19	21

17	13.5	16	15	18
18	13.5	15.5	16	17
19	13.5	16	16.5	17
20	19	20	19	21

b) For the six inner grid cells determine their D8 flow direction. Indicate D8 flow directions using arrows in the diagram below. Also indicate the numerical values of the flow direction encoding as used by ArcGIS.



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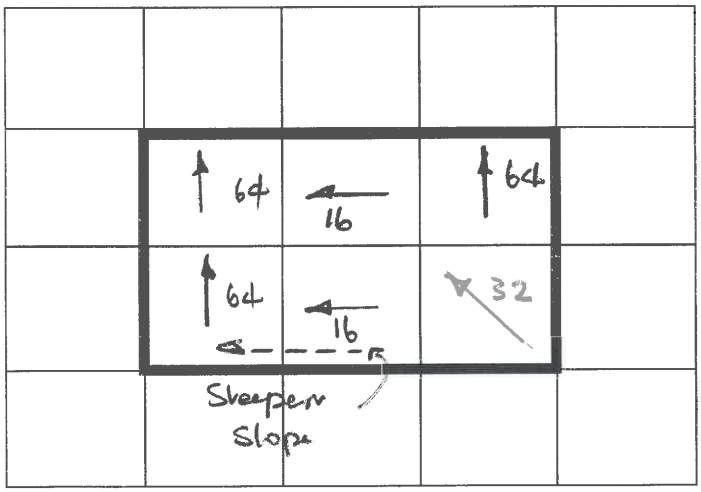

For cell 16.5:

16.5 → 16 ⇒ slope = $0.5/10 = 0.05$

16.5 → 15.5 ⇒ slope = $1/10\sqrt{1} = 0.0707$

(c) Calculate the Hydrologic (D8) slope of the grid cell with the steepest slope among the six inner grid cells. Indicate which grid cell this is.

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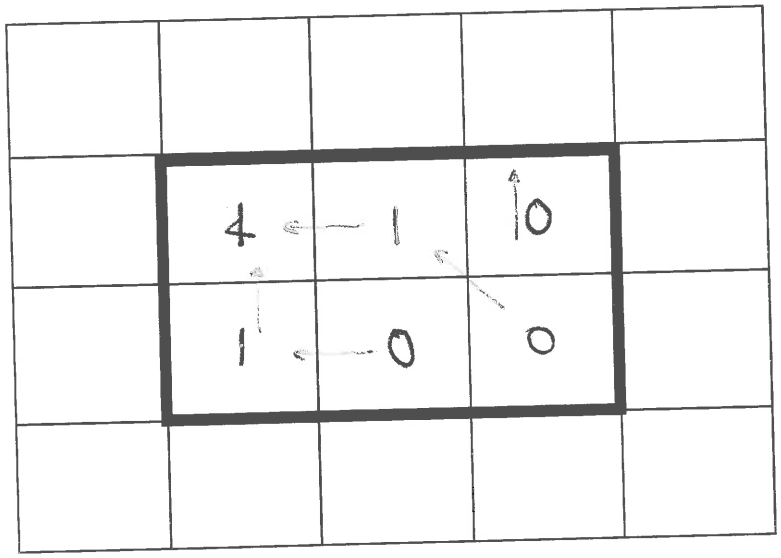
Largest drop = 16 → 13.5

$$\text{Slope} = \frac{16 - 13.5}{10} = \frac{2.5}{10} = 0.25$$

d) For the six inner grid cells determine their D8 flow accumulation. Indicate flow accumulation values in the diagram below. In evaluating these flow accumulation values you may disregard any flow from outside the bold box of six inner grid cells.



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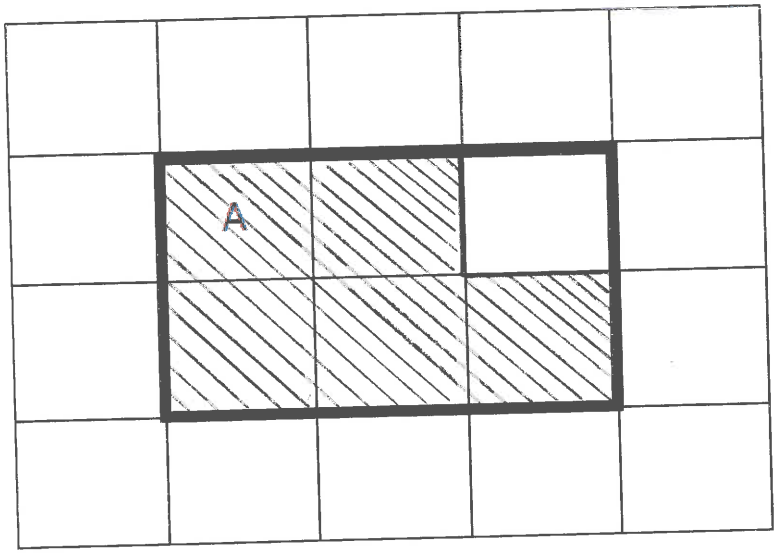
e) Indicate the watershed draining to and including grid cell A by shading the cells included in it. Calculate the area of this watershed in m^2. Note that you do not need to consider grid cells outside the block of six inner grid cells in calculating the watershed area.



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Area of watershed = 5 x 10 x 10 = 500 m^2