University of Pretoria
Department of Geography, Geoinformatics and Meteorology
GMA 320: Remote Sensing
Semester Test

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Instructions

Duration T [minutes]: $60 \leq \mathrm{T} \leq 110$

Answer all questions as concisely as possible.
You might find the following equations useful.

$$H = \frac{D}{\beta} \quad (1)$$

$$H = \frac{D^{b}_{phi}}{\beta \times \sec\phi} \quad (2)$$

$$H = \frac{D^{a}_{phi}}{\beta \times \sec^{2}\phi} \quad (3)$$

$$\frac{gsw}{2} = \tan(\frac{\theta}{2}) \times H \quad (4)$$

$$\lambda_{max} \times T = \kappa; \qquad [\kappa = 2898 \mu m K] \quad (5)$$

$$T_{rad} = \epsilon^{0.25} \times T_{kinetic} \quad (6)$$

$$M = \epsilon\sigma T^{4}; \qquad [\sigma = 5.6697 \times 10^{-8} W m^{-2} K^{-4}] \quad (7)$$

$$BV_{i,j,k} = \frac{1}{N} \sum_{i=1}^{N} BV_i \tag{8}$$

$$BV_{i,j,k} = \frac{1}{2} \left[BV_{i-1,j,k} + BV_{i+1,j,k} \right] \tag{9}$$

$$\mu_k = \frac{1}{n} \sum_{i=1}^{n} BV_{i,k} \tag{10}$$

$$var_k = \frac{1}{n} \sum_{i=1}^{n} \left(BV_{i,k} - \mu_k \right)^2 ; s_k = \sqrt{var_k} \tag{11}$$

$$\tag{12}$$

Question 1
An Overview of remote sensing, (13 marks)

1. Name three possible sources of bias in *in situ* measurements in remote sensing? [**3 marks**]

2. With examples, outline three important aspects/forms of data collection during remote sensing process. [**6 marks**]

3. What are *Hybrid variables* and *collateral* data. Give an example of each. [**4 marks**]

Question 2
Remote sensing data collection, (17 marks)

1. Name two ways through which digital imagery can be obtained [**1 mark**]:

2. How would a remote sensing analyst assign a DN to an hyper-spectral data set with i rows, j columns and k bands? [**1 mark**]

3. Digital remotely sensed data are transformed to useful information, possibly via the conversion of an analog electrical signal data recorded by the remote sensing sensor to a digital value.

   (a) What is the importance of the preprocessing stage in the data-to-information conversion process in remote sensing? [**1 mark**]

   (b) By giving examples, distinguish between multi-spectral and utra-spectral remote sensing systems.[**1 mark**]

   (c) *Pushbroom* sensors are thought to yield accurate measurement of the reflected radiant flux from a specific portion of the terrain. Give two reasons for this? [**1 mark**]

      i. In the winter seasons of South Africa, Western Cape region has experienced flooding which adversely affected the infrastructure, health, Agriculture and loss of life. As a remote sensing analyst, you have been asked to suggest the most suitable thermal infrared detector's operating wavelength region

to be placed on a remote sensing suborbital system that is being designed for monitoring the damage that these weather systems cause. Assume that the average kinetic temperature of flooded terrain is $\approx 17^{\circ}$ and the emissivity, ϵ is ≈ 0.91. [**5 marks**]

ii. Most thermal infrared scanning systems introduce geometric errors. General swath width, spatial ground resolution cell size, radial displacement and tangential scale distortions ought to be considered in the analysis. You are provided with the following metadata:

ImageInfo:
Residential Area, TX Thermal Imagery
Sensor : Daedalus DS-1230 Quantitative Thermal Infrared Scanning System
IFOV : 2.5 milliradian
Total angular field of view, θ: 48°
Maximum scan angle off-nadir: ϕ: 37°
Detector : Mercury Cadium Telluride (Hg-Cd-Te) operating in the region 8 - 14 μm
Acquired : January 10, 1980
Altitude : 250 m above ground level (AGL)
Time over Target : 6:45
Air Temp at Ground Level : 12 degrees C

You are required to:

- Compute the ground swath width (gsw). [**3 marks**]
- Describe the resolution of the ellipsoidal cell for the scan angle off-nadir given in the metadata. Show all the calculations [**4 marks**]

Question 3
Digital Image Processing considerations (7 marks)

- Enumerate any four important Digital Image Processing (DIP) system considerations. [**2 marks**]

- Name any three main features that an ideal remote sensing storage media should have. [**3 marks**]
- What are the attributes required of a good (remote scientist) digital image processing analyst? *state atleast two*[**2 marks**]

Question 4
Image quality assessment and statistical evaluation (7 marks)

1. Name any two possible causes of low Signal-to-Noise ratio: S/N in the Brightens Values (BV) of a remotely sensed data? [**1 marks**]

2. How can a digital remote sensing analyst assess the quality and statistical characteristics of a remote sensed data? *any two ways*[**1 marks**]

3. Univariate statistics do not provide information on the covariance of spectral measurements. Table 4 shows the correlation matrix derived from a sample multi-spectral data set.

Table 1: Correlation matrix derived the multi-spectral data set recorded from vegetated terrain

Band	**1**	**2**	**3**	**3**
1	-			
2	0.40	-		
3	0.90	0.50	-	
4	0.94	0.20	0.80	-

- What do the high correlation between bands 1, 3 and 4 signify? [**1 marks**]
- Which band provides unique information not found in the other bands? [**2 marks**]
- What is the proportion of total variation in the brightness values of band 4 that can be explained by a linear relationship with values of the random variation in band 1 ? [**2 marks**]

Question 5
Principles of electromagnetic radiation, (16 marks)

1. All objects with temperature, T>0 K emit electromagnetic energy. Table 1 is a record of temperature taken from a wet soil surface (i.e $\epsilon \approx 0.95$).

Table 2: *Stefan-Boltzmann law*: T_{kin} - Kinetic temperature, T_{rad}- Radiant temperature and M-total radiant exitance

$T_{kin}[^{\circ}]$	15	18	21	25
$T_{rad}[K]$				
M $[Wm^{-2}]$				

You are required to:

- Complete Table 2 above [**5 marks**]
- If the average kinetic temperature of a vegetated portion ($\epsilon \approx 0.89$) of the terrain measured simultaneously was 28°. What could be the appropriate spectral resolution in order to discriminate the two surface types? Show all your calculations. [**6 marks**]