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

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Total: 100 Marks

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Instructions

Duration: 3 hours
Answer all questions.

Formulae

$$R = \beta \times DN + \epsilon$$

$$T = \frac{K_2}{ln\left[\frac{K_1}{R} + 1\right]}$$

$$R = \frac{\{R_{max} - R_{min}\}\{DN - DN_{min}\}}{\{DN_{max} - DN_{min}\}} + R_{min}$$

$$\text{eigenvalue}[\%] = \frac{\text{eigenvalue}}{\sum_{PC} \text{eigenvalue}}$$

$$var_k = \frac{1}{n}\sum_{i=1}^{n}(BV_{i,k} - \mu_k)^2$$

$$s_k = \sqrt{var_k}$$

Question 1 [16 marks]

1. Explain briefly the following concepts as used in remote sensing [**4 marks**]
   (a) Radiometric correction [1 marks]
   (b) A pixel [1 marks]
   (c) Spectral signature [2 marks]
2. (a) What is radiometric resolution? [**2 marks**]
   (b) How does changing radiometric resolutions influence image interpretation? [**2 marks**]
3. Name three examples of common application of remote sensing. [**3 marks**]
4. Name the five main stages of *the remote sensing process.* [**5 marks**]

Question 2 [14 marks]

1. One important characteristic to describe a satellite sensor is its data collection capabilities. Name two spectral and two non-spectral char-

acteristics of a sensor [**4 marks**]

2. 12 [Wm^{-2}] of light falls on a surface which transmits 33 % and absorbs 25% of the light. What is the amount of light reflected by this surface in Wm^{-2}? What assumption is made while solving this problem? [**4 marks**]

3. You are provided with spectral radiances (minimum (R_{min}) and maximum (R_{max})for each band at maximum (DN_{min}) and minimum (DN_{max}) digital numbers respectively of a thermal band of landsat 7 imagery acquired before and after July 2000 and in Table 1 and the pre-launch calibration constants in Table 2. Determine the effective at-satellite temperature in [° K] for a pixel with DN value of 136 for an landsat 7 high gain band acquired in February 2002 given that the gain (β) and bias (ϵ) are 0.037040[Wm^{-2}ster$^{-1}\mu$m^{-1}] and 3.16 [Wm^{-2}ster$^{-1}\mu$m^{-1}] respectively. [**6 marks**]

Table 1: ETM+ Spectral Radiance Range [Wm^{-2}ster$^{-1}\mu$m^{-1}] before and after July 1, 2000

	Before	July	2000		After	July	2000
Low	Gain	High	Gain	Low	Gain	High	Gain
R_{min}	R_{max}	R_{min}	R_{max}	R_{min}	R_{max}	R_{min}	R_{max}
0.0	17.04	3.2	12.65	0.0	17.04	3.2	12.65

Table 2: ETM+ Thermal constants constant value units

Constant	Value	Unit
K_1	666.09	[Wm^{-2}ster$^{-1}\mu$m^{-1}]
K_2	1282.71	[°K]

Question 3 [17 marks]

1. Using an example, state the difference between systematic and random distortions in a remote sensing imagery. [**5 marks**]

2. Describe briefly the two methods of geometric correction that can be done on a remote sensing image [**6 marks**]

3. Write short notes on the following spatial-based enhancement techniques

   (a) Sharpening [**3 marks**]

   (b) Edge detection [**3 marks**]

Question 4 [13 marks]

1. Name two ways through which digital imagery can be obtained [**2 mark**]:

2. Multispectral sensors typically acquire images by sensing reflected radiation in the visible, near and mid infrared wavelengths. Can we use these images to directly map things like vegetation species or crop types? If not, what sort of a process can we use to derive a map of vegetation species or crop type? [**6 mark**]

3. How might the spatial and spectral resolution of images acquired by different multispectral remote sensing systems influence the potential precision and accuracy of a landcover map derived from these images? [**5 marks**]

Question 5 [12 marks]

1. What is supervised and unsupervised classification [**6 marks**]

2. Name at least three classification training tools [**3 marks**]

3. What is spatial ratioing? [**3 marks**]

Question 6 [8 marks]

1. What is the difference between convolution and correlation as used in digital image analysis? [**2 marks**]

2. You are provided with the following image subset (I) and mask K. Determine the output pixel value at the location $\{i, j\} = \{2, 3\}$ after convolution and correlation. [**6 marks**]

$$\mathbf{I} = \begin{bmatrix} 45 & 24 & 34 & 28 & 55 \\ 23 & 51 & 47 & 31 & 36 \\ 44 & 46 & 53 & 40 & 52 \\ 40 & 52 & 39 & 61 & 53 \end{bmatrix}$$

$$\mathbf{K} = \begin{bmatrix} 109 & 128 & 131 \\ 123 & 11 & 142 \\ 144 & 140 & 153 \end{bmatrix}$$

Question 7 [20 marks]

1. Table 3 shows part of the variance-covariance matrix derived from a sample multi-spectral data set.

Table 3: Variance-covariance matrix derived from a sample multi-spectral data set

Band	**1**	**2**	**3**	**4**
1	56.50			
2	135.00	264.80		
3	718.75	275.25	1007.50	
4	537.50	64.00	663.75	570.00

   (a) Complete Table 4 by calculating the correlation matrix based on the values in Table 3.[**3 marks**]

Table 4: Correlation matrix derived from covariances in Table 3

Band	**1**	**2**	**3**	**4**
1	1.00			
2	0.35	1.00		
3		0.53	1.00	
4	0.94			1.00

(b) Comment on the significance of the correlation between band 1 and bands 3 and 4? [**3 marks**]

(c) Which band provides unique information not found in the other bands? [**3 marks**]

(d) What is the percentage 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 2? [**3 marks**]

2. You are provided with the following sample covariance matrix and corresponding eigen values(see Table 5) from image analysis.

Table 5: Covariance matrix and eigen values for bands $1 \rightarrow 6$

	1	2	3	4	5	6	Eigen value
1	1423.44	1285.58	1324.69	1455.73	2010.68	1349.20	9782.80
2	1285.58	1175.56	1225.84	1317.50	1843.92	1249.63	336.86
3	1324.69	1225.84	1342.04	1300.68	1962.05	1386.25	130.32
4	1455.73	1317.50	1300.68	1712.95	2113.74	1340.94	29.21
5	2010.68	1843.92	1962.05	2113.74	3113.93	2124.28	12.47
6	1349.20	1249.63	1386.24	1340.94	2124.28	1526.88	3.13

(a) Calculate the sum of variance. [**3 marks**]

(b) Calculate the proportion of the total information content explained by each principal component. [**3 marks**]

(c) What percentage of the total information content is explained by the 1st three principal components? [**2 marks**]