

University of Pretoria
Department of Geography, Geoinformatics and
Meteorology
GMA 220: Remote Sensing
Semester Test

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Instructions

Duration T [minutes]: $60 \leq T \leq 70$

Answer all questions as concisely as possible.

You might find the following equations useful.

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

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

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

$$\frac{gs_w}{2} = \tan\left(\frac{\theta}{2}\right) \times H \quad (4)$$

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

Question 1

An Overview of remote sensing, 15 marks

1. What is the significance of *in situ* measurements in remote sensing? Give a typical example. [3 marks]
2. Explain briefly (*in point form*) the remote sensing process used by scientists when extracting information from a remotely sensed data. [4 marks]
3. Enumerate four advantages and four disadvantages of remote sensing. [4 marks]

Question 2

Principles of electromagnetic radiation, 15 marks

1. All objects with temperature, $T > 0$ K emit electromagnetic energy. What is the relationship between the amount of energy radiated from an object and temperature? What is the significance of *Wiens's displacement law* in the remote sensing system design? [4 marks]
2. Define each the following terms that are used to describe atmospheric Energy-Matter interactions. [3 marks]

Refraction, Scattering, Absorption

3. Though reflectance curves do not provide any information about transmittance and absorption of remote sensing target objects, they provide valuable information that forms the basis for surface description. Figure 1 shows spectral reflectance curves for two earth surface characteristics: Grass and water. What is the ideal portion of the spectrum that one could use to discriminate between water and grass? Describe how a white-and-black image of the terrain could be obtained? [4 marks]
4. The total radiance L_s , recorded by the a sensor onboard a remote sensing system cruising at an orbital and/or suborbital platform is given by:

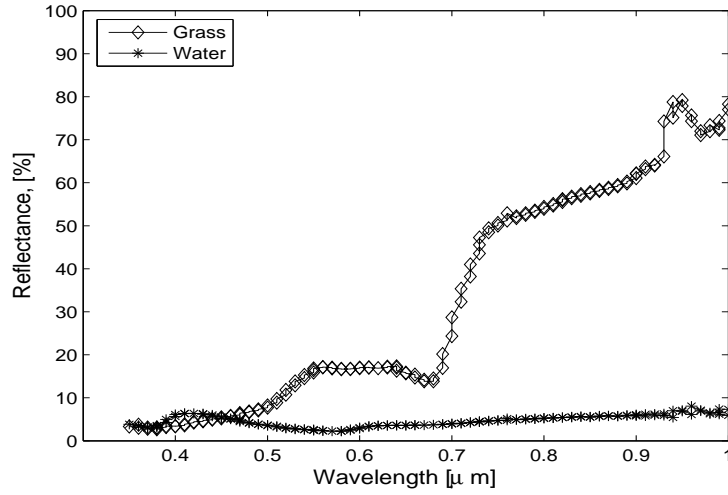


Figure 1: Spectral reflectance [%] of grass and water terrain

$$L_s = L_T + L_P \quad [Wm^2sr^{-1}] \quad (6)$$

where L_T and L_P are the total amount of radiance exiting the target study area and path radiance respectively.

- (a) What constitutes the path radiance, L_p ? **[2 marks]**
- (b) What is the role of *in situ* data in correcting for L_p component present in L_s **[2 marks]**

Question 3

Multi-spectral remote sensing systems, 15 marks

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.

1. What is the importance of the preprocessing stage in the data-to-information conversion process in remote sensing? **[3 marks]**

2. By giving examples, distinguish between multi-spectral and hyper-spectral remote sensing systems. [4 marks]
3. *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? [2 marks]
4. The Moderate Resolution Imaging Spectrometer- MODIS flown on-board NASA's Earth Observation System (EOS), *Terra* and *Aqua* provides long-term observations which are used to derive enhanced knowledge of global dynamics and processes occurring on the surface of the Earth and in the lower atmosphere.
 - Complete Table 1 by filling in three examples each, of variables derived from MODIS data sets [3 marks]

Table 1: Global datasets derived from MODIS

Variable class	MODIS derived global variable
Land ecosystem	a:-
	b:-
	c:-
Atmospheric	a:-
	b:-
	c:-
Ocean variables	a:-
	b:-
	c:-

- What is *temporal*, *spatial* and *radiometric* resolution? What is the significance of *these terms* in the design of the remote sensing system?
One sentence please! [3 marks]

Question 4

Thermal infrared sensing systems: t-IR, 15 marks

1. Interpretation of thermal infrared images requires that the analyst should understand how both the sensor system and terrain introduces noise into the thermal image. List other three considerations that an analyst should bear in mind. **[3 marks]**
2. What are *atmospheric windows*? Why is knowing a remote sensing target object's dominant wavelength important in thermal infrared remote sensing? **[2 marks]**

Case study:

During the summer seasons, cases of fire outbreaks in townships in South Africa are reported in the media. 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 this purpose. Assume that temperature of the fires are measured up to ≈ 820 K. **[3 marks]**

3. 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 : 1.0 milliradian

Total angular field of view, θ : 45°

Maximum scan angle off-nadir: ϕ : 35°

Detector : Mercury Cadmium 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). What is the diameter of the circular ground area, D, viewed at nadir in the TX Thermal Imagery? [**3 marks**]
 - Describe the resolution of the ellipsoidal cell for the scan angle off-nadir given in the metadata. Show all the calculations [**2 marks**]
4. Describe the general shape of a spatial thermal gradient depicting the Urban Heat Island (UHI) effect. Consider the Central Business District (CBD) as the spatial origin. [**2 marks**]