UNIVERSITY OF RUHUNA

Faculty of Engineering

End-Semester 5 Examination in Engineering: August 2018

Module Number: CE5255 **Module Name: Remote Sensing and GIS**

[Three Hours]

[Answer all questions. Each question carries **TWELVE** marks]
All Standard Notations denote their regular meanings

Q1. a) A pipe laying project in a hilly area needs to fabricate pipe bends. They are in need to determine the relationship between the pipe angle (z in the plane of the pipe) and the corresponding horizontal angle (Z) of the bend for a bend having slope of α with the horizontal. Derive the relationship between the parameters as shown below. (*Hint: model this problem as a spherical trigonometric problem*)

$$cos^2(\alpha) = \frac{\cos(z) + 1}{\cos(Z) + 1}$$

[3.0 Marks]

b) Table Q1-1 shows the angle measured on the plane of the pipe bend and the corresponding horizontal angle of a set of pre-made pipe bends. Determine the slope (α) of the pipe for which these bends are suitable for, using a graphical method by adopting the equation stated in Q1. (a).

[3.0 Marks]

c) 'A' and 'B' are two GPS survey stations which have coordinates of ($6° 4'47.62''$N, $80° 11'30.1''$E) and ($6° 12'35.69''$N, $80° 34' 20.78''$E) in order. By using the Earth curvature data of Everest 1830 datum given in Table Q1-2, calculate the following.

i. Mean latitude (φ_m) of points 'A' and 'B'
ii. Correction due to convergence of meridians ($\delta\alpha$)
iii. Length of the $1''$arc of latitude (λ) at the mean latitude
iv. Length of the $1''$arc of longitude (μ) at the mean latitude
v. Azimuth from A to B
vi. The reverse azimuth (i.e. From B to A)

[6.0 Marks]

Q2. a) Regulus (10 hrs 08 min 22.311 sec, +11° 58′ 01.95″), the brightest star in the constellation of Leo was observed from a peg station P1 with a theodolite at local sidereal time of 21hrs 29min 08.97sec. The observed altitude of Regulus was 78° 53′ 15.97″ and the clockwise angle from peg P2 to the star was 124° 34′ 20″. Answer the following using the data given above.

i. Draw the northern celestial hemisphere, as seen by viewer, looking from straight above the north pole and indicate the positions of pole(P), zenith(Z), local meridian(L), first point of Aires (γ) and Regulus (R) with relevant values.

ii. From the above diagram determine the hour angle of the star with the southern arm of the local meridian (angle $Z\hat{P}R$).

iii. If the corresponding Greenwich sidereal time for the observation time is 15hrs 59min 52.97sec determine the longitude of the peg P1 by using the above diagram.

iv. Construct the 3D view of the northern hemisphere zenith as the pole and user at the centre. Indicate the positions of pole, zenith, local meridian, and Regulus with relevant values.

v. Determine the latitude of the point using a spherical triangle in the figure stated in subpartQ2.(a)(iv).

[10.0 Marks]

b) Determine the difference between local time and local standard time (GMT+5:30) at the place of observation stated in Q2(a).

[2.0 Marks]

Q3. a) A pair of terrestrial photographs were taken at two peg stations situated L m horizontally apart, by keeping the telescope axis level and perpendicular to the line made by the two peg stations. A point 'V' appears in both terrestrial photographs with photo coordinates of $(+x_1, +y_1)$ and $(+x_2, +y_2)$ respectively (where $x_1 > x_2$). If the photos were taken using a camera with focus length of f, prove that the horizontal distances to the point 'V' from the first points P_1 and P_2 are given by:

$$P_1V = \frac{\sqrt[2]{(f^2 + x_1^2)}}{(x_1 - x_2)} \times L \quad \text{and} \quad P_2V = \frac{\sqrt[2]{(f^2 + x_2^2)}}{(x_1 - x_2)} \times L \quad \text{respectively.}$$

[3.0 Marks]

b) If the instrument height at the point P_1 is HI_1, prove that the elevation of point 'V' with respect that of point P_1 is given by:

$$\Delta h = HI_1 + \frac{y_1}{x_1 - x_2} \times L.$$

[2.0 Marks]

c) A photogrammetric survey was carried out around a volcano to assess the current height of the summit from two stations P_1 and P_2 located 400 m apart and lying on a line having whole circle bearing of 94° 43′ 54′. Further, P_1 (70,000 mE, 30,000 mN) is located westward of the P_2. Table Q3-1 shows photo coordinates of the summit (V) on the two terrestrial photographs taken from the two peg stations using a photo-theodolite having a focus length of 150 mm. When photos were taken theodolite was kept perpendicular to the line P_1P_2 and telescope horizontal.

i. Determine the horizontal distance P_1V and P_2V.
ii. Determine the whole circle bearing of line P_1V.
iii. Determine the coordinates of point V.
iv. Determine the coordinates of point P_2.
v. If the instrument height at P_1 is 1.720 m and P_1 is located at 120.980 m above datum, determine the elevation of summit V.
vi. There is a doubt that whether the theodolite was kept horizontal when the second photo was taken fromP_2. If P_2 is located 2.520 m below P_1 and the instrument height at P_2 is 1.750 m, show that the theodolite's telescope is not level when the second photo was taken.
vii. Determine the angle of telescope with the horizontal for the case in Q3. (c)(vi).

[7.0 Marks]

Q4. Photogrammetry has been used to assess the level of deforestation in the past, however, photogrammetry is a sub-discipline of remote sensing. Some wave length regions in the electromagnetic spectrum are left by remote sensing satellites. Many remote sensing satellites had 8-bit radiometric resolution in the past however, they are now upgraded to 12-bit resolution. Usually analysis of remote sensing data is done by calculating indexes. For example, 'Normalized Difference Vegetation Index' (NDVI) is used to detect changes in vegetation cover.

a) Briefly explain following terms or phrases appearing in the above passage related to remote sensing.

i. Photogrammetry is a sub discipline of remote sensing
ii. Normalized Difference Vegetation Index

iii. Some wave length regions in the electromagnetic spectrum are not used in the bands of remote sensing satellites.

iv. Upgrading radiometric resolution from 8 bits to 12 bits.

[4.0 Marks]

b) A study carried out in Iraq has validated the following equation to determine the PH value of a water body in terms of Normalized difference water index (NDWI) and Normalized difference moisture index (NDMI).

$$PH = 8.396 + 2.622 \times \text{NDWI} - 4.295 \times \text{NDMI}$$

Figure Q4-1 shows the part of the raster data obtained, for bands 3,4 and 5 of Landsat-8 (refer Table Q4-1), over a waterbody. Answer the following questions based on the data provided.

i. If the ground resolution of Lansat-8 bands 1 to 5 is 30 m, what is the area covered by the data given in Figure Q4-1?

ii. Explain, with reference to spectral reflection curves of clear and turbid water, how NDWI can help to detect clear and turbid water.

iii. Determine raw NDWI and NDMI for the part of the raster given in Figure Q4-1.

iv. Based on 3×3 regional average of NDWI and NDMI, determine the PH value of water body represented by the pixel at the centre of Figure Q4-1.

[6.0 Marks]

c) List six applications of remote sensing, other than the applications mentioned in Q4. (a) and (b).

[2.0 Marks]

Q5. a) Explain using suitable equations, how the clock bias in the GPS positioning is eliminated by observing four satellites.

[3.0 Marks]

b) Explain the processes in 'static' and 'kinematic' GPS surveying.

[2.0 Marks]

c) Briefly explain the three segments in GPS.

[1.5 Marks]

d) List five applications of GIS software.

[2.5 Marks]

e) "Students' G.C.E.(A/L) Z scores are inversely proportional to the n^{th} power of the distance from their residence, during school time, to the school ($Z = C\frac{1}{D^n}$)" is a claim which needs to be tested. If GIS is suggested as the tool, explain how to test the claim giving special references to the data need, and process in the GIS.

[3.0 Marks]

ANNEX: Equations Figures, and Tables

$$L = \frac{\lambda\delta\phi}{\text{Cos}\left(\alpha_m + \frac{\delta\alpha}{2}\right)}$$

$$\varphi_m = \frac{\varphi_A + \varphi_B}{2}$$

$$r = -58\cot(H_o)$$

$$\alpha_m = \text{Tan}^{-1}\left[\frac{\mu\Delta L}{\lambda\delta\phi}\right]$$

$$\delta\alpha = \Delta L \sin(\varphi_m)$$

$$H = H_o + r$$

$$GSrT = RA - \lambda_E$$

$$\text{Cos}A = \frac{\text{Cos}\,a - \text{Cos}(b) \times \text{Cos}(c)}{\text{Sin}(b) \times Sin(c)}$$

$$BC^2 = AB^2 + AC^2 - 2AB \times AC\ \text{Cos}A$$

$$Sin(A+B) = Sin(A)Cos(B) + Cos(A)Sin(B)$$

$$NDWI = \frac{Green - NIR}{Green + NIR}$$

$$NDMI = \frac{Red - NIR}{Red + NIR}$$

Table Q1-1 True value of angle and the average observed value

No	Horizontal Angle	Angle in the plane
1	120°	120°02′25″
2	100°	100°30′31″
3	90°	90°04′11″
4	70°	70°06′59″
5	60°	60°07′15″

Table Q1-2 Earth curvature data based on Everest 1830 datum

At Latitude	Length of 1" of Longitude (m)	Length of 1" of Latitude (m)
6° 00′ 00″	30.71845	30.75381
6° 20′ 00″	30.71883	30.73461

Table Q3-1 Photo coordinates of Summit

Photo taken at	Point in the photo	x (mm)	y (mm)
P1	Summit	30.23	40.54
P2	Summit	-25.87	35.33

Table Q4-1 Bands of Landsat-8 Operational Land Imager (OLI) and Thermal Infrared Sensor (TIRS)

Band	Wavelength (μm)	Useful for mapping
Band 1 – Coastal Aerosol	0.43 - 0.45	Coastal and aerosol studies
Band 2 – Blue	0.45 - 0.51	Bathymetric mapping, distinguishing soil from vegetation, and deciduous from coniferous vegetation
Band 3 - Green	0.53 - 0.59	Emphasizes peak vegetation, which is useful for assessing plant vigour
Band 4 - Red	0.64 - 0.67	Discriminates vegetation slopes
Band 5 - Near Infrared (NIR)	0.85 - 0.88	Emphasizes biomass content and shorelines
Band 6 - Short-wave Infrared (SWIR) 1	1.57 - 1.65	Discriminates moisture content of soil and vegetation; penetrates thin clouds
Band 7 - Short-wave Infrared (SWIR) 2	2.11 - 2.29	Improved moisture content of soil and vegetation and thin cloud penetration
Band 8 - Panchromatic	0.50 - 0.68	15-meter resolution, sharper image definition
Band 9 – Cirrus	1.36 - 1.38	Improved detection of cirrus cloud contamination
Band 10 – TIRS 1	10.60 – 11.19	100-meter resolution, thermal mapping and estimated soil moisture
Band 11 – TIRS 2	11.5 - 12.51	100-meter resolution, Improved thermal mapping and estimated soil moisture

Band 3-Green

$$\begin{bmatrix} \ddots & & & \\ & 25 & 26 & 27 \\ & 23 & 30 & 28 \\ & 28 & 25 & 29 & \ddots \end{bmatrix}$$

Band 4-Red

$$\begin{bmatrix} \ddots & & & \\ & 10 & 11 & 12 \\ & 12 & 10 & 10 \\ & 14 & 12 & 10 & \ddots \end{bmatrix}$$

Band 5-NIR

$$\begin{bmatrix} \ddots & & & \\ & 1 & 2 & 2 \\ & 1 & 2 & 2 \\ & 2 & 1 & 1 & \ddots \end{bmatrix}$$

Figure Q4-1 Parts of 8-bit raster data for different bands (values indicate raw reflectance values)