UNIVERSITY OF RUHUNA

Faculty of Engineering

End-Semester 5 Examination in Engineering: March 2022

Module Number: CE5252 **Module Name: Remote Sensing and GIS (C-18)**

[Three Hours]

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

Q1. a) Starting from the basics derive the cosine rule of spherical triangles.

[2.0 Marks]

b) An aeroplane is flying from Katunayake international airport (7° 10' 31.20" N, 79° 53' 0.59" E) to Abuja international airport (9° 4' 20.1504" N, 7° 29' 28.6872" E) along the shortest path Assuming that the radius of Earth to be 6,371 km, determine the following:

i. Distance between Katunayake and Abuja in km;

[2.0 Marks]

ii. Most northernly latitude reached on the journey;

[2.0 Marks]

iii. the time taken to reach Abuja if the average ground speed of the flight is 600 km/h ; and

[1.0 Marks]

iv. the heading the fight should follow immediately after taking of from Katunayake.

[1.0 Marks]

c) Assuming that the radius of Earth to be 6,371 km determine the are of coconut triangle enclosed by Puttalam (08°02'03"N 79°50'07"E), Colombo (6°56'04"N 79°50'34"E), and Kurunagala (7°29'04"N 80°22'22"E)

[4.0 Marks]

Q2. a) Star was observed in the northern sky of from a peg station in Oluvil (7.2944° N, 81.8607° E) with a total station at 0:30 am (Early Morning) Sri Lanka standard time on 10th September 2020. Star had a WCB of 298° 11' 20" with respect to true north and a corrected altitude of 78° 34' 17.9". Answer the following using the data given above and referring to Table Q2-1.

i. Construct the 3D view of the celestial hemisphere keeping the observer at the centre and indicate the position of the star, zenith, and pole, and indicate relevant values.

[2.0 Mark]

ii. Determine the declination of the star.

[2.0 Mark]

iii. Determine the hour angle of the star.

[2.0 Marks]

iv. Determine the Sidereal hour angle of the star.

[2.0 Marks]

v. Determine RA of the star in hms units.

[1.0 Marks]

vi. Identify the star using the star maps given in Figure Q2-1, Figure Q2-2 or Table Q2-1.

[1.0 Mark]

b) Determine the Sri Lanka Standard time when the planet Jupiter would have crossed the meridian of Colombo on the September 10th 2020

[2.0 Marks]

Q3. a) A terrestrial photogrammetry exercise was carried out from two peg stations A and B located distance L apart. If the instrument used in the exercise is having focus length of f, and was set up at A and B so that it will make angle α and β with line AB respectively prove that the distance any point C having photo coordinates of x_A, and $-x_B$ on the two photographs will be given by

$$AC = \frac{\sin(\beta - \delta)}{\sin(\alpha + \beta - (\gamma + \delta))}$$

$$BC = \frac{\sin(\alpha - \gamma)}{\sin(\alpha + \beta - (\gamma + \delta))}$$

where,

$$\gamma = \tan^{-1}\left(\frac{x_A}{f}\right) \text{ and } \delta = \tan^{-1}\left(\frac{x_B}{f}\right)$$

[2.0 Marks]

b) On such a terrestrial surveying exercise (stated above in Q3. (a)) top of a 70 m tall tower (C) is appearing in both photographs taken from A and B with photo coordinates of (132.89 mm, 80.10 mm) and (-28.98 mm, 130.80 mm) respectively. If the focal length of the camera is 250 mm, two-survey points A and B are located 525.679 m apart, A is located 230.990 m above mean sea level and whole circle bearing of line AB is 90°20′45″ddetermine the following:

i. Horizontal lengths AC and BC;
ii. Coordinates of point C;
iii. Elevation of points B and C; and
iv. The photo coordinate of the bottom of the tower.

[6.0 Marks]

c) If the tower is 70 m tall what would be the photo coordinate of the bottom of the tower on the photo taken from A.

[2.0 Marks]

d) There is a 50m tall obstruction at the halfway point of AC. If a 60 m tall tower is erected at A determine the lowest point visible on tower C when from the top of tower A.

[2.0 Marks]

Q4. a) With neat sketches explain how remote sensing ce applied to "Tax Mapping".

[3. 0 Marks]

b) A farmer is claiming insurance for his crops stating that the Irrigation Department failed to supply an adequate amount of water to his crops. Assuming that remote sensing data is available for the farm area for the

entire area with reasonable temporal resolution. Explain how you can verify this claim based on remote sensing data.

[3. 0 Marks]

c) Define the following terms in terms of remote sensing
   i. Active remote sensing
   ii. Spectral signature
   iii. Atmospheric window
   iv. Temporal resolution

[2.0 Marks]

d) PH value of a water body in terms of normalized difference water index (NDWI) and normalized difference moisture index (NDMI) can be given by the following equation.

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

Figure Q4-1 shows the part of the raster data obtained, for bands 3,4, and 5 of Landsat-8 (refer to Table Q4-1), over a waterbody Rajarata area. 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. Determine raw NDWI and NDMI for the individual pixels of the raster given in Figure Q4-1(each number indicates a pixel).
   iii. Based on a 3×3 regional average of NDWI and NDMI, determine the average PH value of the water body represented by the pixel at the centre of Figure Q4-1.

[4.0 Marks]

Q5. a) Briefly explain the roles of a control segment of a GNSS.

[1.5 Marks]

b) Explain the principle of differential GNSS as required for high standards of accuracy on a surveying site.

[2.5 Marks]

c) Explain how GPS solves two of the problems associated with traverse surveying.

[2.0 Marks]

d) With neat sketches, explain how real-time kinematic (RTK) GNSS surveying.

[3.0 Marks]

e) Briefly explain the difference between GNSS and GIS.

[3.0 Marks]

ANNEX: Figures, Tables and Equations

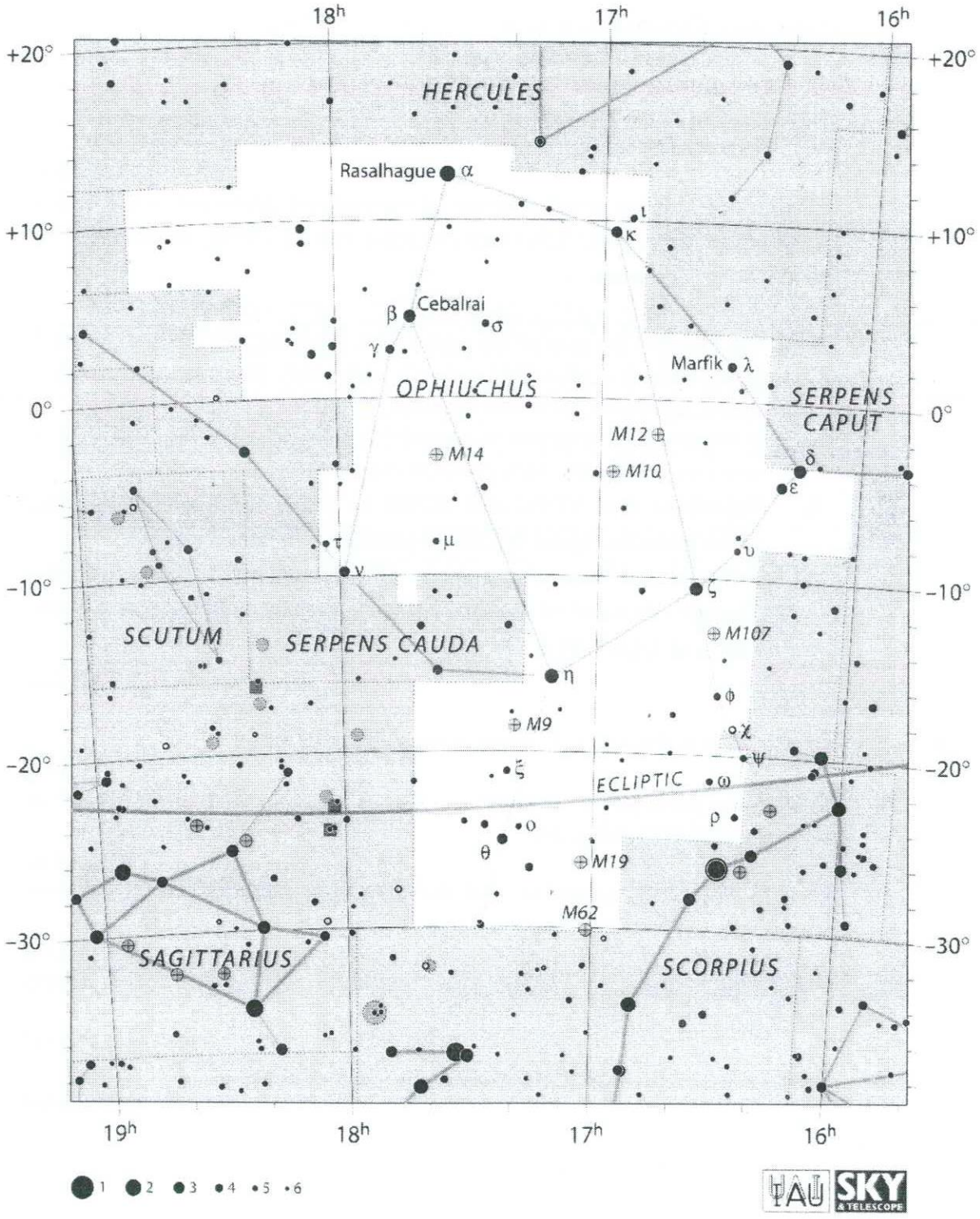

Figure Q2-1 Star Map of Ophiuchus Constellation

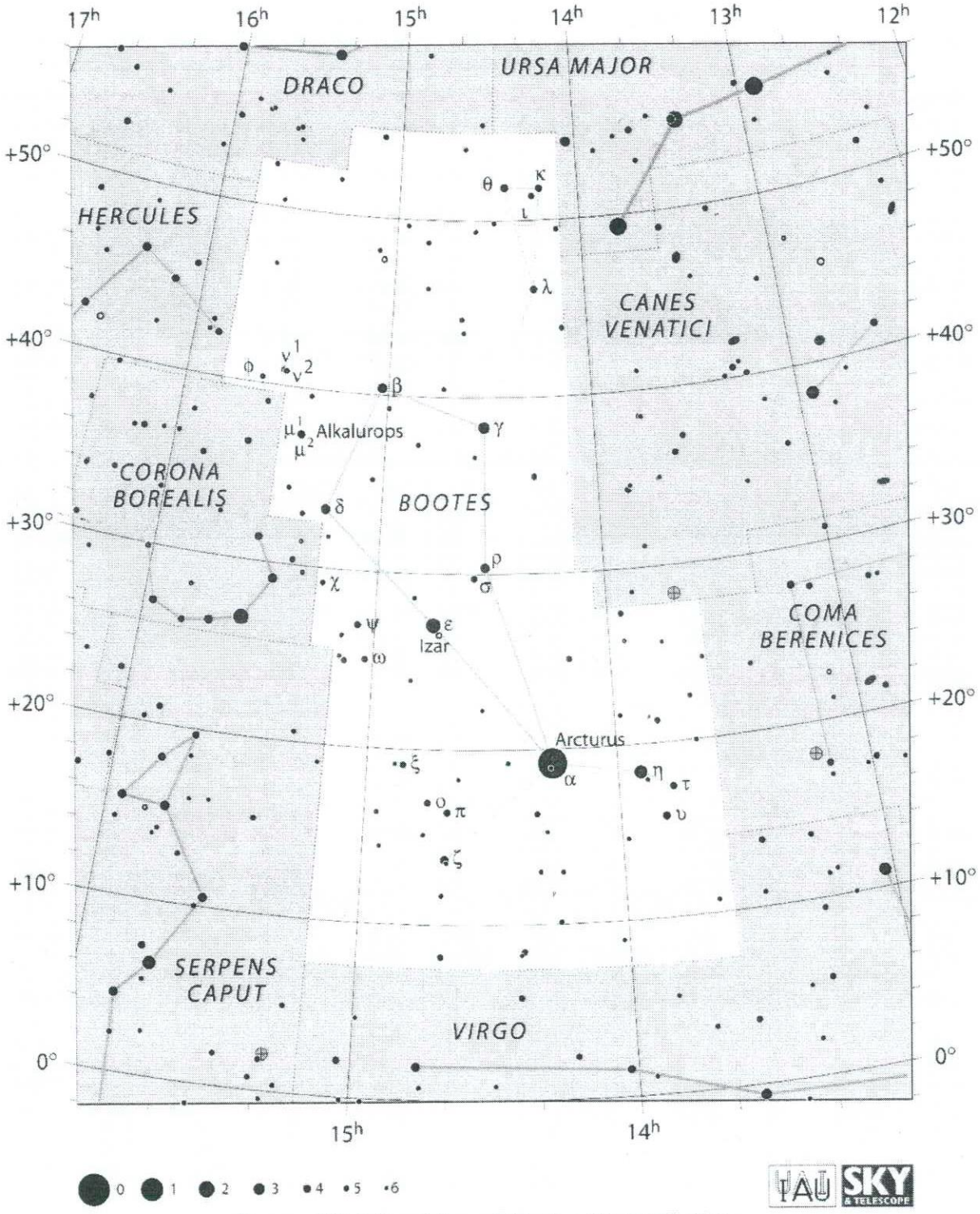

Figure Q2-2 Star Map of Bootes Constellation

Table Q2-1 Extracts from Star Almanac

September 09, 10, 11 (Wed., Thu., Fri.)

	Aries	Venus		Mars		Jupiter		Saturn	
Wed	GHA	GHA	Dec	GHA	Dec	GHA	Dec	GHA	Dec
0	348°29.8	223°34.8	N18°14.3	320°50.3	N06°50.6	59°32.7	S22°42.9	50°47.5	S21°17.8
1	3°32.2	238°34.4	13.9	335°52.7	50.7	74°35.2	42.9	65°50.1	17.8
2	18°34.7	253°34.0	13.5	350°55.2	50.7	89°37.7	42.9	80°52.6	17.8
3	33°37.2	268°33.6	·· 13.0	5°57.6	·· 50.7	104°40.2	·· 42.9	95°55.2	·· 17.8
4	48°39.6	283°33.2	12.6	21°00.0	50.7	119°42.7	42.9	110°57.7	17.8
5	63°42.1	298°32.9	12.1	36°02.5	50.8	134°45.2	42.9	126°00.3	17.9
6	78°44.6	313°32.5	N18°11.7	51°04.9	N06°50.8	149°47.7	S22°42.9	141°02.8	S21°17.9
7	93°47.0	328°32.1	11.2	66°07.4	50.8	164°50.2	42.9	156°05.4	17.9
8	108°49.5	343°31.7	10.8	81°09.8	50.8	179°52.7	42.9	171°07.9	17.9
9	123°52.0	358°31.3	·· 10.4	96°12.3	·· 50.9	194°55.2	·· 42.9	186°10.5	·· 17.9
10	138°54.4	13°30.9	09.9	111°14.7	50.9	209°57.7	42.9	201°13.0	17.9
11	153°56.9	28°30.5	09.5	126°17.2	50.9	225°00.2	42.9	216°15.6	18.0
12	168°59.3	43°30.1	N18°09.0	141°19.6	N06°50.9	240°02.7	S22°42.9	231°18.1	S21°18.0
13	184°01.8	58°29.7	08.6	156°22.1	51.0	255°05.1	42.9	246°20.7	18.0
14	199°04.3	73°29.3	08.1	171°24.6	51.0	270°07.6	42.9	261°23.2	18.0
15	214°06.7	88°28.9	·· 07.7	186°27.0	·· 51.0	285°10.1	·· 43.0	276°25.8	·· 18.0
16	229°09.2	103°28.5	07.2	201°29.5	51.0	300°12.6	43.0	291°28.3	18.1
17	244°11.7	118°28.1	06.8	216°31.9	51.0	315°15.1	43.0	306°30.8	18.1
18	259°14.1	133°27.7	N18°06.3	231°34.4	N06°51.1	330°17.6	S22°43.0	321°33.4	S21°18.1
19	274°16.6	148°27.3	05.9	246°36.9	51.1	345°20.1	43.0	336°35.9	18.1
20	289°19.1	163°26.9	05.4	261°39.3	51.1	0°22.6	43.0	351°38.5	18.1
21	304°21.5	178°26.6	·· 04.9	276°41.8	·· 51.1	15°25.1	·· 43.0	6°41.0	·· 18.1
22	319°24.0	193°26.2	04.5	291°44.3	51.1	30°27.6	43.0	21°43.6	18.2
23	334°26.5	208°25.8	04.0	306°46.7	51.2	45°30.1	43.0	36°46.1	18.2
Mer.pass.:00:46		v-0.4 d-0.4 m-4.1		v2.4 d0.0 m-2.0		v2.5 d-0.0 m-2.4		v2.5 d-0.0 m0.3	

Thu	GHA	GHA	Dec	GHA	Dec	GHA	Dec	GHA	Dec
0	349°28.9	223°25.4	N18°03.6	321°49.2	N06°51.2	60°32.6	S22°43.0	51°48.7	S21°18.2
1	4°31.4	238°25.0	03.1	336°51.7	51.2	75°35.1	43.0	66°51.2	18.2
2	19°33.8	253°24.6	02.7	351°54.2	51.2	90°37.5	43.0	81°53.8	18.2
3	34°36.3	268°24.2	·· 02.2	6°56.6	·· 51.2	105°40.0	·· 43.0	96°56.3	·· 18.2
4	49°38.8	283°23.8	01.7	21°59.1	51.2	120°42.5	43.0	111°58.8	18.2
5	64°41.2	298°23.4	01.3	37°01.6	51.3	135°45.0	43.0	127°01.4	18.3
6	79°43.7	313°23.0	N18°00.8	52°04.1	N06°51.3	150°47.5	S22°43.0	142°03.9	S21°18.3
7	94°46.2	328°22.6	18°00.3	67°06.6	51.3	165°50.0	43.0	157°06.5	18.3
8	109°48.6	343°22.2	17°59.9	82°09.0	51.3	180°52.5	43.0	172°09.0	18.3
9	124°51.1	358°21.8	·· 59.4	97°11.5	·· 51.3	195°55.0	·· 43.0	187°11.6	·· 18.3
10	139°53.6	13°21.4	58.9	112°14.0	51.3	210°57.4	43.0	202°14.1	18.3
11	154°56.0	28°21.0	58.5	127°16.5	51.3	225°59.9	43.1	217°16.6	18.4
12	169°58.5	43°20.6	N17°58.0	142°19.0	N06°51.4	241°02.4	S22°43.1	232°19.2	S21°18.4
13	185°01.0	58°20.2	57.5	157°21.5	51.4	256°04.9	43.1	247°21.7	18.4
14	200°03.4	73°19.8	57.1	172°24.0	51.4	271°07.4	43.1	262°24.3	18.4
15	215°05.9	88°19.4	·· 56.6	187°26.5	·· 51.4	286°09.9	·· 43.1	277°26.8	·· 18.4
16	230°08.3	103°19.0	56.1	202°29.0	51.4	301°12.4	43.1	292°29.4	18.4
17	245°10.8	118°18.6	55.7	217°31.5	51.4	316°14.8	43.1	307°31.9	18.5
18	260°13.3	133°18.2	N17°55.2	232°34.0	N06°51.4	331°17.3	S22°43.1	322°34.4	S21°18.5
19	275°15.7	148°17.8	54.7	247°36.5	51.4	346°19.8	43.1	337°37.0	18.5
20	290°18.2	163°17.4	54.2	262°39.0	51.4	1°22.3	43.1	352°39.5	18.5
21	305°20.7	178°17.0	·· 53.8	277°41.5	·· 51.4	16°24.8	·· 43.1	7°42.1	·· 18.5
22	320°23.1	193°16.6	53.3	292°44.0	51.5	31°27.3	43.1	22°44.6	18.5
23	335°25.6	208°16.2	52.8	307°46.5	51.5	46°29.7	43.1	37°47.1	18.6
Mer.pass.:00:42		v-0.4 d-0.5 m-4.1		v2.5 d0.0 m-2.0		v2.5 d-0.0 m-2.4		v2.5 d-0.0 m0.4	

Fri	GHA	GHA	Dec	GHA	Dec	GHA	Dec	GHA	Dec
0	350°28.1	223°15.8	N17°52.3	322°49.0	N06°51.5	61°32.2	S22°43.1	52°49.7	S21°18.6
1	5°30.5	238°15.4	51.8	337°51.5	51.5	76°34.7	43.1	67°52.2	18.6
2	20°33.0	253°15.0	51.4	352°54.0	51.5	91°37.2	43.1	82°54.8	18.6
3	35°35.4	268°14.6	·· 50.9	7°56.5	·· 51.5	106°39.7	·· 43.1	97°57.3	·· 18.6
4	50°37.9	283°14.3	50.4	22°59.1	51.5	121°42.1	43.1	112°59.8	18.6
5	65°40.4	298°13.9	49.9	38°01.6	51.5	136°44.6	43.1	128°02.4	18.7
6	80°42.8	313°13.5	N17°49.4	53°04.1	N06°51.5	151°47.1	S22°43.1	143°04.9	S21°18.7
7	95°45.3	328°13.1	48.9	68°06.6	51.5	166°49.6	43.1	158°07.5	18.7
8	110°47.8	343°12.7	48.5	83°09.1	51.5	181°52.1	43.1	173°10.0	18.7
9	125°50.2	358°12.3	·· 48.0	98°11.6	·· 51.5	196°54.5	·· 43.1	188°12.5	·· 18.7
10	140°52.7	13°11.9	47.5	113°14.2	51.5	211°57.0	43.2	203°15.1	18.7
11	155°55.2	28°11.5	47.0	128°16.7	51.5	226°59.5	43.2	218°17.6	18.7
12	170°57.6	43°11.1	N17°46.5	143°19.2	N06°51.5	242°02.0	S22°43.2	233°20.2	S21°18.8
13	186°00.1	58°10.7	46.0	158°21.8	51.5	257°04.4	43.2	248°22.7	18.8
14	201°02.6	73°10.3	45.5	173°24.3	51.5	272°06.9	43.2	263°25.2	18.8
15	216°05.0	88°09.9	·· 45.0	188°26.8	·· 51.5	287°09.4	·· 43.2	278°27.8	·· 18.8
16	231°07.5	103°09.5	44.5	203°29.3	51.5	302°11.9	43.2	293°30.3	18.8
17	246°09.9	118°09.1	44.0	218°31.9	51.5	317°14.4	43.2	308°32.9	18.8
18	261°12.4	133°08.7	N17°43.6	233°34.4	N06°51.5	332°16.8	S22°43.2	323°35.4	S21°18.9
19	276°14.9	148°08.3	43.1	248°37.0	51.5	347°19.3	43.2	338°37.9	18.9
20	291°17.3	163°07.9	42.6	263°39.5	51.5	2°21.8	43.2	353°40.5	18.9
21	306°19.8	178°07.5	·· 42.1	278°42.0	·· 51.5	17°24.2	·· 43.2	8°43.0	·· 18.9
22	321°22.3	193°07.1	41.6	293°44.6	51.5	32°26.7	43.2	23°45.5	18.9
23	336°24.7	208°06.7	41.1	308°47.1	51.5	47°29.2	43.2	38°48.1	18.9
Mer.pass.:00:38		v-0.4 d-0.5 m-4.1		v2.5 d0.0 m-2.1		v2.5 d-0.0 m-2.4		v2.5 d-0.0 m0.4	

Stars

	SHA	Dec
Alpheratz	357°38.0	29°12.2
Ankaa	353°10.3	-42°11.6
Schedar	349°34.4	56°38.9
Diphda	348°50.5	-17°52.3
Achernar	335°22.5	-57°07.8
Hamal	327°54.9	23°33.5
Polaris	315°21.9	89°20.7
Acamar	315°14.3	-40°13.2
Menkar	314°09.6	4°10.2
Mirfak	308°33.0	49°55.8
Aldebaran	290°43.6	16°33.0
Rigel	281°07.2	-8°10.6
Capella	280°27.1	46°00.9
Bellatrix	278°26.7	6°22.1
Elnath	278°06.3	28°37.4
Alnilam	275°41.3	-1°11.3
Betelgeuse	270°55.9	7°24.7
Canopus	263°54.1	-52°42.1
Sirius	258°29.5	-16°44.5
Adhara	255°08.8	-28°59.8
Procyon	244°54.7	5°10.4
Pollux	243°21.8	27°58.5
Avior	234°16.5	-59°34.3
Suhail	222°49.2	-43°30.7
Miaplacidus	221°39.6	-69°47.9
Alphard	217°51.5	-8°44.7
Regulus	207°38.5	11°52.1
Dubhe	193°46.1	61°38.5
Denebola	182°28.9	14°27.6
Gienah	175°47.5	-17°39.2
Acrux	173°04.5	-63°12.7
Gacrux	171°56.0	-57°13.6
Alioth	166°16.7	55°51.2
Spica	158°26.2	-11°15.9
Alkaid	152°55.2	49°13.0
Hadar	148°41.3	-60°28.3
Menkent	148°02.0	-36°28.2
Arcturus	145°51.4	19°04.8
Rigil Kent.	139°45.4	-60°55.2
Kochab	137°20.6	74°04.6
Zuben'ubi	137°00.1	-16°07.5
Alphecca	126°06.9	26°39.1
Antares	112°20.2	-26°28.6
Atria	107°17.5	-69°04.0
Sabik	102°06.8	-15°44.9
Shaula	96°15.1	-37°07.1
Rasalhague	96°01.8	12°33.0
Eltanin	90°43.7	51°29.5
Kaus Aust.	83°37.0	-34°22.5
Vega	80°35.4	38°48.5
Nunki	75°52.0	-26°16.2
Altair	62°03.2	8°55.6
Peacock	53°10.9	-56°40.2
Deneb	49°27.8	45°21.4
Enif	33°41.9	9°58.3
Al Na'ir	27°36.9	-46°51.7
Fomalhaut	15°18.1	-29°30.7
Scheat	13°48.2	28°11.7
Markab	13°33.0	15°19.0

Sep 09 Wed	SHA	Mer.pass
Venus	235°05.0	09:06
Mars	332°20.5	02:36
Jupiter	71°02.9	19:58
Saturn	62°17.8	20:33

Sep 10 Thu	SHA	Mer.pass
Venus	233°56.4	09:07
Mars	332°20.3	02:32
Jupiter	71°03.6	19:55
Saturn	62°19.7	20:29

Sep 11 Fri	SHA	Mer.pass
Venus	232°47.8	09:07
Mars	332°20.9	02:28
Jupiter	71°04.2	19:51
Saturn	62°21.6	20:25

Horizontal parallax	
Venus:	0.2
Mars:	0.3

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	The improved moisture content of soil and vegetation and thin cloud penetration
Band 8 - Panchromatic	0.50 - 0.68	The 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	The 100-meter resolution, thermal mapping and estimated soil moisture
Band 11 – TIRS 2	11.5 - 12.51	The 100-meter resolution, Improved thermal mapping and estimated soil moisture

Band 3-Green

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

Band 4-Red

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

Band 5-NIR

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

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

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

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

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

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

$$\delta\alpha = \Delta\mathrm{L}\sin(\varphi_m)$$

$$H = H_o + r$$

$$GSrT = RA - \lambda_E$$

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

$$\mathrm{BC}^2 = \mathrm{AB}^2 + \mathrm{AC}^2 - 2\mathrm{AB} \times \mathrm{AC}\,\mathrm{CosA}$$

$$\boldsymbol{Sin(A+B) = Sin(A)Cos(B) + Cos(A)Sin(B)}$$

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

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