Answers to Homework Problems for Section 2

The homework problems below give those data required for the Law of Cosines, Pub 229, and Nautical Almanac (NASR) sight reduction methods. Each problem should be worked to find the value for Hc, a, Z, and Zn. Compare your answers with those listed below. Your computed answers should agree exactly, providing you have done the problems correctly. If your plotting is accurate, the EPs should agree closely with the listed answers.

Compare the answers found by the Pub 229 and NASR methods with those found by the Law of Cosines method.

Plot the results of all three methods Law of Cosines, Pub 229, and NASR on separate plotting sheets. On the Pub 229 and NASR plots, measure and record the DR to LOP distance. Include the EP with its coordinates on each plotting sheet.

	1	2	3	4	5
Body:	Venus	Kaus Australis	Sun	Mars	Moon
ZT:	0545	1802	0923	2036	0956
DR L	23° 19.6′ S	14° 19.5′ N	32° 15.0′ S	46° 21.0′ S	40° 33.8′ N
DR Lo	67° 14.2′ W	152° 49.8′ E	34° 16.8′ W	126° 52.1′ W	135° 28.6′ E
GHA	43° 56.1′	265° 07.0′	348° 53.6′	167° 09.6′	145° 01.5′
Dec	13° 17.2′ N	34° 26.8′ S	17° 34.3′ N	14° 48.3′ S	14° 04.2′ N
Ho	46° 55.7′	16° 27.8′	23° 56.1′	43° 55.6′	16° 58.1′

Answers: Law of Cosines Method:

Hc	46° 52.1′	16° 30.3′	23° 54.1′	43° 56.4′	17° 00.1′
a[DR]	3.6 T	2.5 A	2.0 T	0.8 A	2.0 A
Z	S 145.7° E	N 133.2° W	S 132.1° E	S 119.7° W	N 85.8° E
Zn	034°	227°	048°	300°	086°

EP:

L	23° 16.6′ S	14° 21.2′ N	32° 13.7′ S	46° 21.4′ S	40° 33.7′ N
Lo	67° 12.0′ W	152° 51.7′ E	34° 15.0′ W	126° 51.1′ W	135° 26.0′ E

Answers: Pub 229 Method:

aL	23° S	14° N	32° S	46° S	41° N
aLo	66° 56.1′ W	152° 53.0′ E	33° 53.6′ W	127° 09.6′ W	135° 58.5′ E
Hc	47° 17.6′	16° 41.3′	24° 18.6′	44° 17.4′	17° 24.5′
a[AP]	21.9 A	13.5 A	22.5 A	21.8 A	26.4 A
KP–LOP	3.7 T	2.7 A	2.0 T	0.9 A	2.0 A
Z	S 145.9° E	N 133.1° W	S 132.3° E	S 119.8° W	N 86.2° E
Zn	034.1°	226.9°	047.7°	299.8°	086.2°

EP:

L	23° 16.6′ S	14° 21.2′ N	32° 13.7′ S	46° 21.4′ S	40° 33.7′ N
Lo	67° 12.0′ W	152° 51.7′ E	34° 15.0′ W	126° 51.1′ W	135° 25.8′ E

Answers: Nautical Almanac Method:

aL	23° S	14° N	32° S	46° S	41° N
aLo	66° 56′ W	152° 53′ E	33° 54′ W	127° 10′ W	135° 58′ E
Hc	47° 18′	16° 42′	24° 18′	44° 17′	17° 24′
a [AP]	22 A	14 A	22 A	21 A	26 A
KP–LOP	3.7 T	2.7 A	2.4 T	0.2 T	2.4 A
Z	S 146.0° E	N 133.5° W	S 132.2° E	S 119.6° W	N 86.6° E
Zn	034°	227°	048°	300°	087°

EP:

L	23° 17′ S	14° 22′ N	32° 13′ S	46° 21′ S	40° 34′ N
Lo	67° 12′ W	152° 52′ E	34° 15′ W	126° 52′ W	135° 26′ E

Answers to Homework Problems

1. Latitude by Polaris

Compute the latitude by the method described in this section (and in the *Nautical Almanac*). Plot on a CLS, determine and record the coordinates of the Estimated Position.

	1a	1b
Date	16 September	24 June
WT	18–03–23	04–42–26
WE	0–27 f	0–10f
IC	– 1.2′	+ 1.2′
HE	56 ft	30 ft
hs	42° 49.1′	24° 15.5′
DR L	43° 06.6′ N	23° 36.0′ N
DR Lo	69° 22.8′ W	165° 08.9′ E

Answer

EP L 43° 05.1′ N
Lo 69° 22.8′ W

EP L 23° 34.9′ N
Lo 165° 08.9′ E

2. Latitude by Meridian Transit

Compute the latitude by the method described in this section. Plot on a CLS, determine and record the latitude and longitude of the EP. HE 27 ft, IC –0.8′.

Body: Sun LL	2a	2b	2c
Date	24 December	24 December	30 June
ZT	11–46–25	12–13–01	12–17–30
hs	36° 07.2′	21° 47.7′	37° 03.1′
DR L	30° 22.0′ N	44° 39.2′ N	29° 38.0′ S
DR Lo	161° 37.2′ W	161° 37.3′ E	63° 28.0′ W

Answer

EP L 30° 19.5′ N
Lo 161° 37.2′ W

EP L 44° 38.8′ N
Lo 161° 37.3′ E

EP L 29° 39.5′ S
Lo 63° 28.0′ W

Body: Moon UL	2d	2e
Date	7 May	7 May
ZT	07–07–05	06–33–30
hs	69° 19.2′	54° 06.0′
DR L	31° 03.4′ S	46° 37.2′ S
DR Lo	18° 40.0′ W	18° 29.9′ E

Answer

EP L 30° 58.8′ S
Lo 18° 40.0′ W

EP L 46° 34.2′ S
Lo 18° 29.9′ E

3. Sight Data Averaging

Find the average WT and hs of the following data using the method described in Section 3, Part 3. Include all data in your work.

Sight No.	WT	hs
10	18–56–02	40° 18.0′
11	18–57–10	40° 17.2′
12	18–58–18	40° 15.8′
13	18–59–43	40° 14.6′
14	19–01–01	40° 13.8′

Answer

Average WT 18–58–27 Average hs 40° 15.9′

Answers to Homework Problems

In the problems that follow, use the JN-N Course Nautical Almanac Excerpts provided with the course material as Appendix G, supplemented with a current *Nautical Almanac.*

1. The marine sextant on a natural horizon. Determine Ho.

	Date	Body	hs	IC	HE	Temp	Barom
a.	16 Aug	Sun UL	15° 15.2′	–1.0′	20 ft	50° F	29.83 in
b.	16 Aug	Sun UL	15° 15.2′	–1.0′	20 ft	18° F	30.47 in
c.	20 Apr	Enif	12° 16.8′	+1.2′	8 ft	16° F	30.18 in
d.	25 Sep	Mars	2° 12.0′	0.0′	24 ft	0° F	29.51 in
e.	16 Aug	Moon UL	0° 04.5′	0.0′	22 ft	100° F	30.00 in

This observation was made at UT 2000.

Answer	**1a**	**1b**	**1c**	**1d**	**1e**
Ho	**14° 50.6′**	**14° 50.3′**	**12° 10.4′**	**1° 47.2′**	**0° 09.4′**

2. The marine sextant on a dip short of the horizon. Use the Appendix F USPS Dip Short Tables provided. Determine Ho.

	Date	Body	hs	IC	HE	Dist
a.	29 June	Sun LL	65° 00.2′	–1.0′	6.0 ft	1.5 nm
b.	21 Oct	Mars	22° 35.0′	0.0′	11.5 ft	170 yds
c.	18 Aug	Moon LL	29° 06.4′	+0.2	8.25 ft	350 yds

This observation was made at UT 0600.

Answer	**2a**	**2b**	**2c**
Ho	**65° 11.8′**	**21° 15.1′**	**29° 40.3′**

Instructor Note
Double interpolation of the Dip Short of the Horizon Tables (and other tables) will sometimes produce different results if the "vertical" interpolation is done before the "horizontal" or after. Example 2c illustrates such a situation. Caution the class of the possibility. It is of no practical significance.

3. Back sights (over the shoulder) with a marine sextant. Determine Ho.

Date		Body	hs	IC	HE
a.	19 Mar	Sun LL	122° 14.0′	0.0′	101 ft
b.	11 Mar	Mars	117° 56.2′	–0.4′	12 ft
c.	9 May	Moon UL	118° 20.2′	+0.2′	21 ft

This observation was made at UT 1100.

Answer	**3a**	**3b**	**3c**
Ho	**58° 11.3′**	**62° 07.1′**	**61° 55.5′**

Answers to Homework Problems

Note: It is suggested that the sheet with the blank diagrams at the end of student manual Section 5 be removed and duplicated for use as needed.

1. Meridian Diagram

Solve the following problems by means of the meridian diagram. Label all the parts of the navigational triangle that are used in celestial navigation, and measure their values.

a.	Given:	L 25° N,	Lo 70° W,	GHA 128°,	Dec 28° S.	Find h and Zn.
b.	Given:	L 35° N,	Lo 170° E,	GHA 300°,	Dec 60° N.	Find h and Zn.
c.	Given:	L 28° S,	Lo 60° E,	GHA 265°,	Dec 20° N.	Find h and Zn.
d.	Given:	L 46° S,	h 28°,	Zn 332°.		Find LHA and Dec
e.	Given:	L 30° N,	h 43°,	Zn 270°.		Find LHA and Dec
f.	Given:	L 32° N,	h 0°,	Dec 16° S,	body is rising.	Find LHA and Zn.
g.	Given:	L 32° N,	h 0°,	Dec 16° S,	body is setting.	Find LHA and Zn.

Answer

a.	**h 11°**	**Zn 231°**	**co-L 65°**	**z 79°**	**p 118°**	**t 58°W**	**Z N 129° W**
b.	**h 25°***	**Zn 329°**	**co-L 55°**	**z 65°**	**p 30°**	**t 110°W**	**Z N 31° W**
c.	**h 31°**	**Zn 037°**	**co-L 62°**	**z 59°**	**p 110°**	**t 35°E**	**Z S 143° E**
d.	**LHA 26°**	**Dec 11°N**	**co-L 44°**	**z 62°**	**p 101°**	**t 26°W**	**Z S 152° W**
e.	**LHA 50°**	**Dec 20°N**	**co-L 60°**	**z 47°**	**p 70°**	**t 50°W**	**Z N 90° W**
f.	**LHA 281°**	**Zn 109°**	**co-L 58°**	**z 90°**	**p 106°**	**t 79°E**	**Z N 109° E**
g.	**LHA 79°**	**Zn 251°**	**co-L 58°**	**z 90°**	**p 106°**	**t 79°W**	**Z N 109° W**

* due to high declination ‘h’ will not agree with sight reduction (approx. 4°)

It would be very useful for several of the preceding problems to be solved using the Three View Graphical Diagram Method. See Figure 5–7 on page 5–12 of the student manual. When drawing Meridian Diagrams exact agreement with NASR or Law of Cosines methods results is not to be expected but should be within the limits of accuracy of the graphical method (usually not more than 4° difference).

2. Time Diagram.

On the given time diagram in the SM, measure and record the following:

a. Longitude at M.
b. UT.
c. LMT.
d. ZT (compute).
e. GHA of the star.
f. LHA of the star.
g. LHA of Aries.
h. GHA of Aries.
i. SHA of the star.
j. Meridian angle (t) of the star.
k. If the date at Greenwich is 5 April, what is the local date at M?

Answer

a. 145° E	**e. 260°**	**i. 135°**
b. 1920	**f. 45°**	**j. 45° W**
c. 0500 next day	**g. 270°**	**k. 6 Apr**
d. 0520 next day	**h. 125°**	

Answers to Homework Problems

1. Convert into hours, minutes, and seconds (arithmetic).

   a. 46° 24.5´ b. 65° 21.4´ c. 139° 03.3´ d. 204° 47.9´

Answer

a. 3h 05m 38s b. 4h 21m 26s c. 9h 16m 13s d. 13h 39m 12s

2. Convert into degrees, minutes and tenths of minutes of arc (arithmetic).

   a. 5h 35m 09s b. 7h 26m 23s c. 10h 50m 10s d. 16h 41m 17s

Answer

a. 83° 47.3´ b. 111° 35.8´ c. 162° 32.5´ d. 250° 19.3´

3. a. For an observer at the ZT and longitude indicated, find LMT in each of the following. Draw a time diagram for each problem.

   1) ZT 05–43–40, Lo 81° 37.5´ W
   2) ZT 05–43–40, Lo 98° 22.5´ E

Answer

a. 1) 05–17–10 2) 05–17–10

b. At sunset for an observer at the LMT and longitude indicated, find ZT in each of the following. Draw a time diagram for each problem

   1) LMT 18–22–37, Lo 112° 24.8´ W
   2) LMT 19–21–55, Lo 112° 24.8´ E

Answer

b. 1) 18–52–16 2) 18–52–16

4. A sundial is installed at longitude 82° 34.0´ W, positioned to indicate LAT accurately. What will be the maximum error of the sundial on ZT? On what date will this maximum occur? Use the JN-N Course Nautical Almanac Excerpts. NOTE: For this problem the EqT reaches a maximum of minus (–) 14m 19s on 12 February and a maximum of plus (+) 16m 25s on 3 November.

Answer

46m09s Error Date 3 Nov

5. In the following problems, find: (a) UT and date, (b) LMT, (c) Dec of the sun, (d) GAT, (e) LHA of the sun, (f) meridian angle t of the sun, (g) LAT. Solve (d) & (g) by both the GHA and the EqT methods. Draw a time diagram for each problem. Use the JN-N Course Nautical Almanac Excerpts.

Date	WT	WE	Lo
1) 20 March	08–19–51	0m 36s slow	46° 24.5′ W
2) 30 June	16–11–18	1m 24s fast	162° 32.5′ W
3) 17 August	07–02–46	2m 57s fast	125° 21.4′ E
4) 24 December	14–53–32	0m 39s slow	83° 47.2′ E

Answer

1) 20 Mar
(a) UT 11–20–27, 20 March
(b) LMT 08–14–49
(c) Dec 0° 01.0′ S
(d) GAT 11–12–58
(e) LHA 301° 49.9′
(f) t 58° 10.1′ E
(g) LAT 08–07–20

2) 30 Jun
(a) UT 03–09–54, 1 July
(b) LMT 16–19–44
(c) Dec 23° 06.8′ N
(d) GAT 03–06–11
(e) LHA 64° 00.1′
(f) t 64° 00.1′ W
(g) LAT 16–16–01

3) 17 Aug
(a) UT 22–59–49, 16 Aug
(b) LMT 07–21–15
(c) Dec 13° 28.6′ N
(d) GAT 22–55–43
(e) LHA 289° 17.2′
(f) t 70° 42.8′ E
(g) LAT 07–17–09

4) 24 Dec
(a) UT 08–54–11, 24 Dec
(b) LMT 14–29–20
(c) Dec 23° 25.0′ S
(d) GAT 08–54–32
(e) LHA 37° 25.2′
(f) t 37° 25.2′ W
(g) LAT 14–29–41

6. On 7 May, at Lo 70° 00.0 W, the ZT 2200 (ZD +5), radio time signal from station WWV was received. At that instant, the ship's comparing watch read 22–01–45. A few minutes later, the watch was compared with the ship's three chronometers with results as follows:

WT	C 'A'	C 'B'	C 'C'
22–31–12	3–32–00		
22–32–21		3–30–30	
22–33–38			3–32–00

a. What is the error of the comparing watch and the error of each chronometer?

b. On 16 May , the same vessel was at Lo 4° W. A radio time signal was received at ZT 2200.
The chronometers had errors as follows:
CE 'A': 2m 35s fast CE 'B': 0m 12s slow CE 'C': 0m 10s fast.
Required: Find the rate of each chronometer.

Answer

a. WE 1m 45s fast
CE 'A' 2m 33s fast
CE 'B' 0m 06s slow
CE 'C' 0m 07s fast

b. 'A' 0.2s gaining
'B' 0.7s losing
'C' 0.3s gaining

Answers to Homework Problems

1. Using *Bowditch* Table 20 (25):

(a) On the morning of 17 August, find the approximate WT of PV crossing for the sun to the nearest minute. DR L 25° 17.5´ N, Lo 64° 50.0´ W. WE is 4m 00s slow on ZT.

(b) On the afternoon of 2 March, find the approximate ZT of PV crossing for the sun to the nearest minute. DR L 25° 25.0´ S, Lo 103° 24.0´ W.

Answer
(a) WT 0819 (b) ZT 1706

2. Using the Law of Cosines method, verify 1(a) and (b).

Answer
(a) WT 0819 (b) ZT 1707

3. Compute the azimuth by Law of Cosines sight reduction method and determine the compass deviation using the following data:

(a)
Lat	20° 36.0´ N
LHA (sun)	292° 48.0´
Dec (sun)	10° 45.0´ N
Var	18° E
Compass Bearing	072°

(b)
Lat	54° 42.0´ N
LHA (sun)	283° 18.0´
Dec (sun)	3° 24.0´ S
Var	3° E
Compass Bearing	098°

Answer
(a) Zn = 087.4°
Dev 2.6° W = 3° W

(b) Zn = 102.9°
Dev 1.9° E = 2° E

4. The date is 10 May. Your DR position is L 42° 48.1´ N and Lo 82° 29.0´ W. Variation is 4° W. You wish to swing ship for a compass Deviation Table in late afternoon.
   Note: The latitude is considerably greater than in the example used in the text. Because of this, the rate of change of sun azimuths will be greater, about 1° in 6 minutes, and the range of azimuths will have a somewhat wider spread.

   (a) By the Law of Cosines, compute the time of PM PV.
   (Use ZT 1500 data for Dec to compute t and round to whole degrees.)
   (b) By the Law of Cosines method, compute the Zn for that time.
   (c) Using the method described in this section, develop a Time Zn (RMB) series.
   (d) For the times listed below, what RMB (whole degrees) would you use?

   16-43-02 16-53-48 17-09-32 17-31-56

Answer

(a) 1706 (b) Zn 270.2°

(c)

Time (EST)	t	Zn	(rnd)	Var	MB	RMB	(rnd)	Time (EDT)
1618	58°W	261.6°	262°	4°W	265.6°	085.6°	086°	1718
1626	60°W	263.1°	263°	4°W	267.1°	087.1°	087°	1726
1634	62°W	264.6°	265°	4°W	268.6°	088.6°	089°	1734
1642	64°W	266.0°	266°	4°W	270.0°	090.0°	090°	1742
1650	66°W	267.4°	267°	4°W	271.4°	091.4°	091°	1750
1658	68°W	268.8°	269°	4°W	272.8°	092.8°	093°	1758
1706	70°W	270.2°	270°	4°W	274.2°	094.2°	094°	1806
1714	72°W	271.5°	272°	4°W	275.5°	095.5°	096°	1814
1722	74°W	272.9°	273°	4°W	276.9°	096.9°	097°	1822
1730	76°W	274.2°	274°	4°W	278.2°	098.2°	098°	1830
1738	78°W	275.5°	276°	4°W	279.5°	099.5°	100°	1838
1746	80°W	276.8°	277°	4°W	280.8°	100.8°	101°	1846
1754	82°W	278.1°	278°	4°W	282.1°	102.1°	102°	1854

In the above tabulation both Zn and reciprocal magnetic bearing have been shown with one decimal and rounded to whole degrees. Although it may seem to be unnecessary plotting to tenth degrees for Zn it does make a better curve. It is no easier to plot to rounded degrees and then “smooth” the curve.

Values for RMB or Zn would be taken from the curve only to the nearest whole degree.

(d) RMB at selected times

Time (EST)	RMB	Time (EST)	RMB
16–43–02	090°	17–09–32	095°
16–53–48	092°	17–31–56	099°

5. The DR latitude of your ship is 47° 17.4´ N. Variation is 20° W. A compass bearing on the sun, whose center is on the visible horizon, is 073°. The sun’s declination is 21° 16.3´ N. Compute amplitude by *Bowditch* Table 22 (27) and 23 (28) and by the Law of Cosines method. Find the azimuth of the sun and the deviation of the compass.

Answer

Zn Sun—Table 27 & 28 = 056.6° Zn Sun—Law of Cosines = 056.8°
Dev 3.6° E = 4° E Dev 3.8° E = 4° E

Answers to Homework Problems

Solve the following problems to the nearest minute of time, using the JN-N Course Nautical Almanac Excerpts:

1. Determine the ZT of the beginning of morning twilight (nautical and civil) and sunrise, and give the duration of nautical twilight, for the following dates and positions:
   a. 2 March, L 38° 15.5′ N, Lo 67° 32.2′ W.
   b. 17 August, L 8° 40.2′ S, Lo 141° 19.0′ E.

   Answer a. NT 0504, CT 0534, SR 0600, Duration 0h 56m
   b. NT 0457, CT 0522, SR 0543, Duration 0h 46m

2. Determine the ZT of sunset and the end of evening civil twilight and nautical twilight, and give the duration of nautical twilight, for the following dates and positions:
   a. 20 March, L 34° 26.8′ S, Lo 47° 12.6′ W.
   b. 30 June, L 29° 14.0′ N, Lo 158° 47.9′ W.

   Answer a. SS 1820, CT 1846, NT 1914, Duration 0h 54m
   b. SS 1838, CT 1905, NT 1938, Duration 1h 00m

3. Determine the ZT of sunrise on 9 May at L 58° 40′ S, Lo 14° 22′ E.
   Note: It will be necessary to interpolate between daily pages of the *Nautical Almanac* to obtain an answer to the nearest minute of time.

   Answer ZT of SR 0755

4. Determine the ZT of moonrise and moonset for the following dates and positions:
   a. 19 April, L 18° 15.1′ N, Lo 139° 06.5′ E.
   b. 24 December, L 51° 32.2′ S, Lo 6° 12.8′ W.

   Answer a. ZT Moonrise 1007 ZT Moonset 2345
   b. ZT Moonrise 2302 ZT Moonset 0911

5. On 17 August, the 0400 DR position of a vessel is L 39° 10′ N, Lo 144° 06′ E. Course is 105° T; speed is 18 knots. The current as determined by the Fix of the previous evening (ZT 1900) has a set of 000° and a drift of 0.5 knots. Determine the ZT of sunrise. If necessary, use 1st and 2nd estimates.

   Answer ZT SR 1st estimate 0537
   2nd estimate 0536

6. Work out problem 1a. above (sunrise only) using the calculator with the Law of Cosines method. Show all computations.

   Answer SR 0601

Answers to Homework Problems

1. On 17 August enroute to Yokohama, the navigator computed the time of the end of civil twilight as ZT 1930. The DR position at that time will be L 34° 15.0´ N, Lo 145° 16.0´ E. Using the USPS Star Finder, prepare and record a list of the first magnitude stars and planets that will be available for observation. List the moon, if available. The list should show the name, azimuth, altitude, and magnitude of each body. If the moon is listed, do not show its magnitude. Arrange the list in order of increasing azimuths.

Answer

Body	Zn	h	Mag
Deneb	058°	46°	1.3
Vega	071°	69°	0.1
Altair	112°	43°	0.9
Jupiter	164°	30°	–2.0
Antares	187°	29°	1.2
Moon	199°	29°	
Spica	238°	22°	1.2
Arcturus	258°	52°	0.2

Instructor Note
The values shown for the Zn and h of the bodies were obtained from the USPS Star Finder using LHA Aries of 253.6° and the 35° template. Those obtained by students should compare favorably.

2. During evening twilight on 30 June, through a break in the clouds a celestial body was observed at ZT 17–35–10. The hs was 35° 22.1´ and an approximate azimuth of 038° was noted. The 1735 DR position at the time of observation was L 25° 48.5´ S, Lo 136° 19.0´ W. Using either one of the two methods discussed in this section, identify the observed body.

Answer

The unknown body is identified as Arcturus.

LHA Aries		=	181.7°		
By Star Finder:	t	=	32° E	Dec	= 19° N
By Law of Cosines:	t	=	32° 05´ E	Dec	= 19° 03.3´ N
SHA Arcturus		=	146.4°		

Answers to Homework Problems

1. Draw four time diagrams, one for each equinox and one for each solstice, showing the relationship between the sun and Aries. Omit the Greenwich meridian. Assume LMT to be 1000. What is the relationship between LST and LMT on the following dates? Draw Time Diagrams to illustrate.

   a. 23 September b. 22 December c. 21 March d. 21 June

   Answer **a. 23 Sep LST = LMT** **b. 22 Dec LST = LMT + 6 hrs (or – 18 hrs)**
   c. 21 Mar LST = LMT + 12 hrs (or – 12 hrs) **d. 21 Jun LST = LMT + 18 hrs (or – 6 hrs)**

2. Assume meridian angle t of Aries is 90° E.

   a. What is LST? b. If LMT is 1200, what is the date?

   Answer **a. LST = 1800** **b. Date: 22 Dec (approx.)**

3. You are at sea on 23 September, UT 1720 (Autumnal Equinox). Fomalhaut overhead, sky cloudless. EqT = 0. Star data below. Use only protractor, compass, ruler, paper & pencil (no Star Finder, books, tables).

Star	SHA	Dec	Mag.	
				a) What is your Latitude?
Markab	14°	15° N	2.6	b) What is the LHA Aries?
Eltanin	91°	51° N	2.4	c) What is your Longitude?
Sabik	103°	16° S	2.6	d) What is the ZT and date?
Fomalhaut	16°	30° S	1.3	e) What star is about due north of you?
Bellatrix	279°	6° N	1.7	f) Is Altair east or west of you?
Altair	63°	9° N	0.9	g) What is the second brightest star listed?
Spica	159°	11° S	1.2	h) Is Sabik visible?
Hamal	329°	23° N	2.2	i) What stars, if any, are not visible?

Answer

a) 30° S **b) 344°** **c) 84° E** **d) 2320 23 Sep**
e) Markab **f) West** **g) Spica** **h) Yes** **i) Bellatrix, Eltanin, Spica**

Answers to Homework Problems

Great Circle Problems

1. Plot a course line on the great-circle chart, N.O. 17, from Le Stiff Light, France to Cape Hatteras Light, North Carolina. Transpose it to Mercator chart, N.O.15 by the method described in the text. (Take the latitude and longitude of points on the great circle track at whole multiples of 5° of longitude. Using the points obtained, transfer the course line to the Mercator chart.) Plot the resulting incremental rhumb line tracks and determine the sum of the rhumb line distances as an approximation of the true great circle distance. Determine course for the first rhumb line leg as an approximation of the initial great circle course (Cn_i). Compare these results with the initial course and distance determined by the procedures described on the great circle chart, N.O. 17, and by graphical solution of the navigational triangle on a terrestrial meridian diagram.

   From Le Stiff Light — L 48° 28´ N, Lo 5° 03´ W
   To Cape Hatteras Light — L 35° 15´ N, Lo 75° 31´ W

   Answer **Plot; distance = 3140.6 m_i, Cn_i = 281.2°**
   Terrestrial meridian diagram; DLo = 70° 28´ W, dist = 52 × 60 = 3,120 mi Cn_i = 285°

2. Compute the great circle distance and initial course between the positions listed below. Work each problem by the Law of Cosines method and by construction of a diagram on the plane of the terrestrial meridian.

	Departure	Destination
a.	Charleston, S.C. L 32° 47´ N, Lo 79° 55´ W	Funchal, Ilha Da Madeira L 32° 38´ N, Lo 16° 55´ W
	Answer Law of Cosines:	**D = 3129.8 mi** **Cn 071.8°**
b.	Sydney, Australia L 33° 53´ S, Lo 151° 12´ E	Acapulco, Mexico L 16° 51´ N, Lo 99° 56´ W
	Answer Law of Cosines:	**D = 6884.5 mi** **Cn 085.7°**
c.	Punta Panual Lt, Chile L 33° 34´ S, Lo 71° 38´ W	Hilo, Hawaii, HI L 19° 44´ N, Lo 155° 04´ W
	Answer Law of Cosines:	**D = 5734.0 mi** **Cn 290.0°**
d.	Cape Arago Lt, Oregon L 43° 20´ N, Lo 124° 22´ W	Tokyo, Japan L 35° 40´ N, Lo 139° 45´ E
	Answer Law of Cosines	**D = 4209.0 mi** **Cn 300.8°**

Answers to Homework Problems

1. List the items you deem necessary for a small, adequate lifeboat navigation kit.

   Answer **Consult 12–1 and 12–2 or the student manual and lead the class in a discussion concerning what is best for them in the area that they boat.**

2. A lifeboat is maintaining a compass course of 000°. The relative bearings of the sun were 115° at sunrise and 235° at sunset. Find the compass error for the heading.

   Answer **5° E**

3. A lifeboat at L 30° 21´ N and Lo 40° 18´ W is maintaining a CC of 273°. On 17 August 199X at ZT 08–28–32, a relative bearing of 194° is obtained on the sun. Using the Analemma Curve and the NASR Tables find the compass error and the true heading.

   Note: Due to the nature of the way the Analemma Curve has been drawn and reprinted, differences in the precise value of the EqT and Dec may vary from one person to another.

   Answer **From Analemma Curve:** **Dec Sun 13° 30´ N, EqT (–) 4m 12s**
   TB 099° CE 8° W CB 107° TH = 265°

4. A navigator aboard a lifeboat drew a circle the radius of the length of a nail. He then placed the nail in the center of the circle. What was the altitude of the sun when the shadow from the nail reached the circumference of the circle?

   Answer **45°**

5. After abandoning ship on 23 December 199X, a lifeboat navigator without a sextant wished to check his position by taking a sun sight at sunrise. The estimated position at the time of the sinking was L 31° 43´ S, Lo 169° 14´ E. As the UL of the sun touched the visible horizon on 24 December, he read a WT of 04–38–32. WE was 1m 20s fast. Ho = (–) 0° 52´. Using the JN-N Course Nautical Almanac Excerpts and the NASR method, reduce the sight and record the a, Zn, and EP coordinates. Check your answer by the Law of Cosines method. Note: Review special notes in Section 1 of the student manual on reduction of negative altitude sights by NASR tables.

   Answer **NASR a = 39 mi A Law of Cosines a = 17.3 mi A EP: L 31° 35´ S**
   Zn = 118° Zn = 118° Lo 168° 56´ E

6. A navigator is at sea at an unknown position on 19 April199X. Due to the time of sunrise it is determined that the position is in west longitude. At UT 20–40–20 the hs of the sun's lower limb is measured to be 64° 54.0´. The sun is rising rapidly. A Nautical Almanac is not available until part (f). IC is 0.0´; Dip is (–) 1.5´; and you will estimate the main correction. In mid-April the semidiameter of the sun appears from earth to be a nominal 16.0´. It is just past mid-April so use an S.D. of 15.9´.

   (a) Determine the sun's declination either graphically or by formula. Note that 199X is a leap year!

   Answer **Dec (formula) 11° 22.8´ N** **Dec (graphically) 11° 44´**

   (b) A compass bearing of the sun at the time of the sight was 121°. Determine the hemisphere of the position.

   Answer **Northern hemisphere**

   (c) Is the latitude larger or smaller than the sun's declination?

   Answer **Latitude is greater**

   (d) LAN is determined by a series of sights to be UT 21–01–41 and the hs is 73° 42.0´ . Compute the approximate latitude.

   Answer **Using refraction of 0.2´ (an estimate) and Dec of 11° 23´ N (formula)**
   L 27° 26.6´ N = 27° 27´ N

   (e) Determine the approximate EqT from the Analemma Curve and compute the approximate Lo.

   Answer **EqT (from Analemma) (+) 00m 45s approx.**
   Lo 135° 36.5´ W = 135° 37´ W

   (f) Using the JN-N Course Nautical Almanac Excerpts, recalculate the position and note the difference between actual values and the ones you estimated. Use an HE of 3 feet.

   Answer **L 27° 30.2´ N Lo 135° 40.1´ W (using GHA method)**
   A similar answer may be obtained by Law of Cosines and plotting.

Answers to Homework Problems

There are no Homework Problems for Section 13.

For Section 14, answers to the Homework Problems are included in the Student Manual, and the answer to Problem 18 is **Jupiter.**

Section 15

Review

Answers To Homework Problems

1. Lower branch of local celestial meridian
   Hour circle of apparent sun
   West
2. North, South
   Vertical circle
   East, West
3. Local celestial meridian
   Hour circle
   East, West
4. Hour circle vernal equinox (Aries)
   Hour circle
   West
5. Celestial equator
   Parallel of declination
   North, South
6. Poles
   Parallel
   North, South
7. Z, N, M
8. ZM
9. N M
10. AOH
11. BEX
12. AOS
13. SOH
14. # 1
15. OBE
16. 8° W
17. 281° (by diagram)
18. S 74° E (by diagram)
19. 52° (by diagram)
20. 83° (by diagram)
21. 090°
22. 318° (by diagram)
23. 000°
24. S 63° W (by diagram)
25. 255° (by diagram)
26. 81° E (by computations)
27. 15° N
28. 149° W (by computations)
29. 135° (by computations)
30. 253° (by computations)
31. Procyon and Sirius
32. 0448
33. Fomalhaut
34. Brightest Vega, 2nd Brightest Altair
35. Altair
36. 100° E
37. 0120, 19 September
38. 0820
39. 80° W
40. 250°
41. (+) 15m 23s
42. 4860 Mi
43. 18° 04.8´
44. 13–12–19
45. 13–08–40
46. 09–45–14
47. 10–08–02
48. 1 day, 17h, 55m