



# Module 10

## Modern Navigation Systems

### Solving for Time

#### Module 10D

### Celestial Data of the Lewis and Clark Expedition



# Summary of Module 10

- Students will learn how to determine time from celestial measurements, and about the relationship between index and time offset errors for sextant and GPS observations, respectively. (10A)
- Students will learn how to read and use Nevil Maskelyne's 1804 Nautical Almanac, the predecessor to today's modern Nautical and Air Almanacs. (10B)
- Students will use Newton's method to determine latitude, learn how to relate the lunar distance to GHAY in order to determine GMT/UTC time and longitude, and learn how to compute the corrections for parallax using Richharia's equations. (10C)
- **Students will use these new skills to analyze actual celestial observation data from the Lewis and Clark expedition. (10D)**



## Read the article from the journal *Measure*

- Using the attached spread sheet *Moon Angles Rev 5a*, re-compute the lunar distances for June 2, 1804 for two or three samples of data that you select from the *Measure* article. Include the effects of parallax and semi-diameter following the directions from the Nautical Almanac.
- Compute latitude from the Lewis and Clark data using the noon measurement of the elevation of the sun. Include the effects of declination and index error. (see the next slide)
- Using Google Earth or other online resources, look up details of the confluence of the Osage and Missouri Rivers.



# From the Kindle version of the Lewis & Clark Journals

informed us that the Countrey on both Sides of muddy river's to the hill called by the french \_\_\_\_\_ 3 ms. below this place, a Small Praries below the hill, 4 Deer Killed to day I assend a hill &. after measuring the river &c. &c. &c.

[Clark, June 2, 1804]

June 2nd Satturday Cap Lewis Took the Time & Distance of suns & moons nearest limbs, the Sun East- and Meridean altitude of Suns U. L. with Octant, back observation gave for altitude  $37^{\circ} 28'' 00''$ .

Error of Octant  $2^{\circ} 00' 00''$  +. made Several other observations- I made an angle for the Wedth of the two rivers. The

Missourie from the Point to the N. Side is 875 yards wide the Osage River from the point to the S. E Side is 397 yards wide, the distance between the two rivers at the pt. of high Land (100 foot above the bottom) and 80 poles up the Missouries from the point is 40 poles, on the top of this high land under which is a limestone rock two Mouns or graves are raised- from this pt. which Comds both rivers I had a delightful prospect of the Missouries up & down, also the Osage R. up. George Drewyer & John Shields who we had Sent with the horses by Land on the N Side joined us this evening much worsted, they being absent

Amazon provides a free download of the Kindle edition of the Lewis & Clark journals, along with a free reading APP for a PC. You do not need to purchase a Kindle E-reader to use this resource.

# Table 3 from the *Measure* article

Hypothetical chronometer time for (-6:03:01) offset from UT	91° 37'	91° 47'	91° 57'	92° 07'	92° 17'	L&C lunar measurement	L&C chronometer time used to calculate (-6:03:01) offset
13:30	74.567	74.555	74.543	74.478	74.465		
13:45	74.442	74.476	74.457	74.441	74.424	74.429	13:45:13
14:00	74.345	74.322	74.346	74.325	74.353	74.321	14:03:11
14:15	74.259	74.277	74.246	74.264	74.235		
14:30	74.166	74.130	74.137	74.146	74.154	74.145	14:29:22
14:45	74.042	74.086	74.082	74.082	74.038	74.088	14:46:10
15:00	73.988	73.977	73.963	73.998	73.989		
Relative $\Delta t$ for (-6:03:01) offset from UT	-80	-40	0	40	80		

**Table 3.** The time/longitude search bin for a presumed latitude of 38° 36'. If the presumed latitude is correct, knowledge of the delta times between the noon latitude measurement and the lunar measurements is adequate for determining both UT and longitude.



# Assignment 10.4

1. Using the attached spread sheet *Moon Angles Rev 5a*, re-compute the lunar distances for June 2, 1804 for two or three samples of data that you select from Table 3 of the Measure article. Include the effects of parallax and semi-diameter following the directions from the Nautical Almanac. This will require some experimenting in order to get the correct data from either the Nautical Almanac or the USNO web tool. Comment on how to use the semi-diameter data properly when computing a lunar distance.
2. Compute latitude from the Lewis and Clark data using the noon measurement of the elevation of the sun from the Kindle page included in a previous slide. Include the effects of declination and index error. Draw a sketch that shows the angles involved, and illustrates why the declination of the sun is required.
3. Using Google Earth or other online resources, look up details of the confluence of the Osage and Missouri Rivers. Comment on your observations and conclusions.



# End of Mod 10D