# ASTRON USER NOTES

## INTRODUCTION

Astron (Aστρον – Greek for Star) is an Excel spreadsheet for sextant users. Its objective is to combine almanac calculations, apparent body position calculations and sight reduction into an easy to use single page utility.

* As an almanac, Astron will, for an entered date and time, calculate the GHA, Dec, HP, SD and Magnitude of a body selected from a list of the 57 navigational stars, Polaris, Sun, Moon, Mercury, Venus, Mars, Saturn and Jupiter. Although intended for practical use in the present era, dates between 2000BC and 3000AD may be entered. (Dates entered before 1752AD are assumed to be on the Julian calendar.)
* If an assumed position is also entered, Astron will also calculate the Azimuth and Altitude of the selected body. (If the body is unidentified, a sidebar utility can identify it given its approximate azimuth and altitude.)
* If a sextant altitude is also entered, together with instrument error, height of eye, temperature, pressure and observed limb, Astron will also calculate the Azimuth and Intercept from the assumed position.

Astron was written using Excel 2016. It has backward compatibility to at least Excel 2010. It has not yet been tested on Open Office Calc, nor on operating systems other than Windows 8/10. It is a large spreadsheet and, on account of the many calculations, will probably run very slowly on older machines. In fact, it was the predominance of Greek characters in the many formulae used that inspired the name.

## GENERAL NOTES

1. Ensure that ALL input fields are correct before using result. Other fields cannot be changed. Fields coloured  are intermediate calculations for information only, whilst results are coloured 

2. There are two working sheets, selected by the tabs on the bottom left of the sheet.

A. The COMPUTER ALMANAC that handles both the process of calculating the geographic position of the body at the instant of observation and the subsequent sight reduction.

B. The MANUAL ALMANAC that asks you to enter the body’s geographic position from elsewhere (typically from a printed almanac) and only performs the sight reduction.

Note: A third sheet, for reference purposes only, gives permanent star data sorted in various orders.

3. There are several other sheets for intermediate processes. These are all protected and hidden, but can be revealed individually by the curious. {Home/Review/Unprotect workbook/Home/Format/Hide & Unhide}. A password is not required to unprotect sheets nor workbook. If you wish to view or change any hidden data, it is suggested that you make a copy of Astron.xlsx, rename it and ONLY delve around with your copy. Some parts of the visible sheets are also hidden for clarity – these also contain only intermediate working data.

## CALCULATION NOTES

**Cell Rounding:** If answer is (say) 12° 59.96', Excel will (alas) round this to 12° 60.0'. Interpret this as 13° 00.0'. If anyone has a fix for this, (without recourse to undesirable macros), please speak up!

**Division by zero:** Rare cases may occur (usually involving interim values of exactly 0 or 90 degrees) which give a #NUM! error. Work around by changing input by 0.1 minutes.

**Numbers:** These are displayed rounded to 0 or 1 decimal place; however, all calculations are carried out using 15 significant figures. In some instances, optional entries of greater accuracy are permitted (and used, but not displayed). (EG 0.14' can be entered as Sun horizontal parallax on the Manual Almanac sheet, but will be displayed as 0.1')

## NOTES when using the COMPUTER ALMANAC

**Enter Time and Date**: Always enter GMT time and date. See paragraph “Time Zones” below. (Strictly speaking, the term Universal Time (UT) should be used, but GMT is so well established that it is used in this worksheet.)

**Select Body:** Click on the current body name. Then click on the arrow that appears on the right of that cell and use the pick list to select the required body. Sun. moon and planets are first on the list, then stars in alphabetical order. Stars whose names are in UPPER CASE are all brighter than magnitude 1.6. (Depending on your system, you may need to use the up/down arrows beside the pick list if mouse scrolling doesn’t work.) Alternatively, just enter in the (correctly spelled) name of the body.

**Moon Phase:** Indicated as a percentage of full moon. A “+” sign indicates the moon is waxing, a “-“ sign indicates waning.

**Planets:** Computer Almanac calculates semi diameter for planets – normally use "C" and observe centre of planet. However, Venus’ phase aspect (like the moon) is rarely vertical and the apparent centre is not necessarily the true centre.

**Polaris:** Treat as any other star and plot intercept. GHA may be up to 1.5' in error due meridian convergence near the pole. Azimuth and intercept calculation accuracy remains <0.1'/0.1nm unless Ass Lat is North of 75N. Note that 1 second error in time (hardly avoidable) equals 0.25nm in position. Observation inaccuracies are greater than calculation inaccuracies,

**Rigil Kent.:** For this star, do not expect GP precision from this software better that 0.3 minutes for current epoch and much less for distant epochs. This is under investigation – possibly due to its published proper motion including (varying) double star orbital motion.

## NOTES when using the MANUAL ALMANAC

**Entering Data for Sun, moon or a planet**: Enter the GHA and Declination from the Almanac for the exact time of observation. Enter 0.0 in the SHA fields.

**Entering Data for a star**: Enter the GHA of Aries from the Almanac for the exact time of observation. Enter the Almanac SHA and Declination for the star in the appropriate fields.

**Entering Horizontal Parallax**: For the **moon,** all almanacs list HP which must be entered. For the **sun,** normally enter 0.14 minutes. (Your almanac may list sun HP values in the notes section.) For **Venus** and **Mars**, most almanacs list this as a single entry on each multi day page. For **other planets** and **stars**, enter 0.0.

**Entering Semi Diameter**: For the **sun** and **moon,** all almanacs list semi diameter which must be entered. For planets and stars, normally enter 0.0 and observe centre of any discernible shape.

## SIGHT REDUCTION NOTES (both worksheets)

**Index Error:** An on scale reading is deemed positive. (H1 = Hs - IE). (Do not confuse with oft used Index Correction (IC) which is of opposite sign.)

**Correction for parallax:** This also includes a further latitude correction to HP to allow for oblateness. (Reducing earth radius as latitude increases. For the moon, this is 0' at the equator, decreasing to -0.2' at the poles. The latitude correction to HP is negligible for other bodies)

**Correction for semi diameter:** In addition to SD correction, for a moon sight only, a further correction for augmentation is included. This is 0' on the horizon increasing to + 0.26' at the zenith.

**Artificial horizon:** If bottom of double reflected image touches top of image seen in mirror or liquid, this is a LOWER limb sight. Either way, subtract index error, then half result to get Hs. Set IE and HoE to 0.

## UNIDENTIFIED BODY (On Computer Almanac sheet only)

First enter Date, Time and Ass Lat/Lng.

Then enter Observed Altitude and TRUE bearing in the fields near the right edge of the screen.

Note that only the listed bodies can be identified. (Sun, moon, Mercury, Venus, Mars, Jupiter, Saturn, the 57 navigational stars and Polaris). Other bright stars (EG Castor and Becrux) will not be found.

## CONVERSIONS

This software uses metres, °C and hPa for height of eye, temperature and pressure respectively. If you normally work in feet, °F or Inches of Mercury, use the converter at lower right of the screen.

## TIME ZONES (On Computer Almanac sheet only)

A sub section on the right of the Computer Almanac sheet allows you to enter Time Zone offset (+E/-W) and Daylight saving hour(s) if applicable. It calculates ship’s time from the GMT that you have entered. The purpose is solely to allow you to cross check that the correct GMT has been entered. Note that Time Zones not only affect the hour, they can also affect the day, the month and possibly even the year. Time Zones are positive East of Greenwich. For simplicity, only whole hours are accepted – sorry India, Marquesas Islands and parts of Australia! Be aware that high seas sailors often use Zone Descriptions (ZD) which are strictly longitude dependant and of opposite sign.

## INDIRECT USES (see note at end)

**1. Calculate time of rise or set of any body at any location.**

* Input Year, Month, Day, approximate GMT, chosen body, Location Lat & Long, Hs=0, IE = 0, Act HoE, Temp, Press & Limb (☉ ☾).
* Then adjust Hour, Minute and eventually Second to give an intercept value of 0.0nm. This is GMT. Local time (and date) is also given, provided time zone and daylight saving time are correctly entered.
* If azimuth <180, this is body rising time. Otherwise, it is setting time.

**2. Compass check at rise or set of any body.**

* Record pelorus bearing of event. Input body, exact time of rise or set, Act Lat & Long, Hs=0, IE = 0, Act HoE, Act Temp, Act Press, Limb = "U" (☉ ☾ only). (Intercept should be near to zero,)
* Compare Azimuth with recorded bearing, allowing for variation and deviation (unless a gyro compass).

**3. Latitude from Local Upper Meridian Passage of any body.** (IE body at maximum altitude)

* Traditionally a separate procedure is used to calculate Latitude from an observation of a body at its maximum altitude, usually on the grounds that it is simpler than calculating and plotting a standard sight reduction. However, a separate procedure is unnecessary with Astron. Enter Hs, GMT, assumed position and other parameters as for a normal sight.
* The azimuth will be near to 180° (body S of observer) or 000°. Plot azimuth/intercept to obtain a position line as normal, which, in this case, will be nearly East/West.
* Alternatively, adjust your assumed Longitude to give a **LHA** of exactly 000/180, then adjust assumed Latitude to give an intercept of zero. This is your Latitude.
* NOTE 1. In theory, the adjusted assumed longitude is also your true longitude, but this is unlikely to be accurate as the exact time of maximum altitude is difficult to observe.
* NOTE 2. If the GMT of maximum altitude is more accurately determined by the median time of bracketed observations of equal altitude, then the adjusted assumed longitude will, indeed, be your true longitude. This will need refining for ship’s run and (except for star observations) change of body declination between the bracketed observations. The author suggests that, with Astron, it is easier just to take two or more observations at opportune times and plot the resulting position lines.
* NOTE 3. The maximum altitude is also difficult to observe when bodies are within 20 degrees of overhead.

**4. Latitude from Local Lower Meridian Passage of any circumpolar body.** (IE body at minimum altitude)

* As 3. above, enter Hs, GMT, Ass Lat/Lng and other parameters as for a normal sight.
* The azimuth will be near to 000° (body N of observer) or 180°. Plot azimuth/intercept as normal.
* Alternatively, adjust your assumed Longitude to give a **LHA** of exactly 180/000, then adjust Assumed Latitude to give intercept of zero. This is your Latitude.
* Notes 1 and 2 to the previous paragraph apply, with some context reversed.

**5. Sextant damaged or overboard!**

* Observe rise or set of any body to obtain a position line. Input body, exact time of rise or set, Ass Lat & Long, Hs=0, IE = 0, Act HoE, Act Temp, Act Press, Limb = "U" (☉ ☾ only).
* Plot position line from Azimuth/Intercept result. Repeat with other bodies, transferring position lines for ship's movement.
* Choose bodies with maximum possible difference in declination for best accuracy.
* For sun or moon rise / set observation, also note time of rise/set of LOWER limb. Useful as a cross check (rise) and/or in case subsequent upper limb event is obscured (set).

**6. Exact time of full or new moon.**

* Select “Moon”.
* Enter approximate date.
* Adjust day, hour, minute and eventually second whilst watching the waxing/waning +/- indicator. When this changes from + to – with a tiny time increment, this is the time of full moon. (From – to + is new moon.) (Using the +/- is more accurate than using the change in phase from 99% to 100%)

**Notes to above indirect uses.**

1. These are indirect ways of using Astron for purposes other than its design objective. All of them can be accomplished more easily with other dedicated software, but are listed here just in case you do not have such software handy.
2. Some of the uses refer to ‘adjusting’ an entry. This is best done by ‘guessing and halving’ as the following example shows. Changes on each iteration are shown in RED. The example below is to find the GMT of the rise of the planet Mercury on 1st January 2016 at a position 6 miles North West of Norfolk Island. (S 29 00.0 E168 00.0) The answer is 19:21:20 GMT on 1st Jan 2016. (Setting Time Zone to +11 gives a local time of 06:21:20 on 2nd January – a useful reminder that you may have chosen the wrong start date!) As it is mid- summer, the sun will be well up and, alas, after all your efforts, the rise of Mercury will not be visible!

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| **INITIAL SETTINGS** |  |  |  |  |  |  |  |
| BODY | ALAT | ALNG | Hs | IE | HoE | T | P | Limb |
| MERCURY | S 29 00.0 | E 168 00.0 | 0 | 0 | 5.5 | 28 | 1025 | C |
|  |  |  |  |  |  |  |  |  |
| **YEAR** | **MONTH** | **DAY** | **HOUR**  | **MIN** | **SEC** | **AZIMUTH** | **INTERCEPT** | **COMMENT** |
| 2016 | 1 | 1 | 0 | 0 | 0 | 083.0 | 3561.2 A | Initial time guess. Long way off. Add 12 hours. |
|  |  |  | 12 |  |  | 209.5 | 2017.0 T | Still long way off. Add 6 hours. |
|  |  |  | 18 |  |  | 125.6 | 925.9 T | Now 900 off. At least 1 hour. |
|  |  |  | 19 |  |  | 117.0 | 252.5 T | Now 200 off. Try 30 minutes. |
|  |  |  | 19 | 30 |  | 113.2 | 104.1 A | Too far. Try 15 mins. |
|  |  |  |  | 15 |  | 115.1 | 75.5 T | Not enough. Try 22 mins. |
|  |  |  |  | 22 |  | 114.2 | 8.0 A | Getting closer. Just a little too far. Try 21 mins. |
|  |  |  |  | 21 |  | 114.3 | 4.0 T | 21 mins not enough, 22 too many. Try 30 seconds. |
|  |  |  |  | 21 | 30 | 114.3 | 2.0 A | Too much. Halve it. Try 15 secs. |
|  |  |  |  |  | 15 | 114.3 | 1.0 T | Too little. Halve the difference. Try 22 secs. |
|  |  |  |  |  | 22 | 114.3 | 0.4 A | Too much. Try 19 secs. |
|  |  |  |  |  | 19 | 114.3 | 0.2 T | Nearly there. Add 1 sec. |
|  |  |  |  |  | 20 | 114.3 | 0.0 A | QED. |

PS. “Why Norfolk Island?” Read “Alone over the Tasman Sea” by Sir Francis Chichester. A wonderful example of navigation to find this tiny island in 1931 in a Gipsy Moth biplane using only a sextant, no fuel left to go anywhere else and no autopilot. He practiced by taking sun sights whilst riding a bicycle!