1-1) Festivals would be held twice per year
as at latitudes \(-23.5^\circ \leq \theta \leq 23.5^\circ\) sun passes
directly overhead twice per year at noon.

• Latitude of Tahiti is \(-17.37^\circ\). The sun passes
  this declination in early February (Feb 1) and
  early November (Nov 2).

• Latitude of Oahu is \(21.28^\circ\). Sun passes
  this latitude at end of May (May 31) and
  mid July (July 15).
b) southernmost latitude at which all stars of long duration can be seen is determined by the latitude at which 
Northeast star Dubhe (α Ursae Majoris) is seen at lower transit.

For an observer with \( L = 8 \) min \( \Rightarrow 90^\circ - 90 - 8 \) = 78.10° > 72°, see figure 1.4

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(3) Range of latitudes for which no stars of big dipper
are above horizon: is that for which the southernmost
star at upper transit cannot be seen.
This range of latitudes must be in the
southern hemisphere.

\[ |\ell| < 90 - \delta_R = 90 - 49.19' \]

\[ = 40.41' \]

or \[ |\ell| < -40.41' \] where
no stars of big dipper
are seen.

1.4) Last week of September, sun is in front
of constellation Virgo at right ascension \( \alpha = 13^h \)
and Pisces is at 0 hr (vernal equinox, set as 0 point for r.a.)
Annual equinox occurs in 3rd week of September.
and must be near \( \alpha = 12^h \) \((= 1/2 \times 24\,\text{hr})\).
The sun moves \( \frac{360^\circ}{52\,\text{weeks}} = \frac{\alpha}{7/\text{week}} = \frac{7^\circ}{360^\circ} \times 24' = 0.46\,\text{hr} \)
so its only about 0.5 hr on sky from star in Virgo
so one has to look in broad daylight! Much better
to look toward Pisces at r.a. = 0. The star in
Pisces would be observable at
1-6) Two points on Earth surface separated by 1 arc sec.

\[ R \theta = d \]

\[ R = R_e = 6.378 \text{ km} \]

\[ \theta = 1'' = \frac{1^\circ}{3600} \cdot \frac{2\pi \text{ rad}}{360^\circ} = \frac{1}{206265} \text{ rad} \]

\[ d = \frac{(6378 \text{ km})}{206265} = 0.031 \text{ km} \]

or 31 meters

b) Physical distance for \( \theta = 1 \) sec of time:

\[ \frac{1 \text{ sec}}{3600 \text{ sec}} \times \frac{2\pi \text{ rad}}{24 \text{ hr}} = 7.3 \times 10^{-5} \text{ rad} \]

\[ d = R_e \theta = (6378 \text{ km})(7.3 \times 10^{-5} \text{ rad}) \]

\[ = 0.464 \text{ km} = 464 \text{ m} \]
1.8) a) In this case, the declination remains fixed at 0°. There is still deviation around mean solar time because of the elliptical orbit.

The analemma is a straight line in this case. The sun traverses this line as seen from Earth since Earth moves in an elliptical orbit around sun. At the closest approach, the apparent time lags behind the mean time, when sun moves slower in its orbit, apparent time exceeds mean time. See fig 1.11 and note.
c) From the figure of Mars, we can infer that its orbit is a slightly inclined ellipse. The tilt of Mars's spin axis is about 35°.

Our objective is to determine the equation of time (UTC) for Mars, using the diagram provided in figure 1.2. Since Mars is a symmetrical figure, we can deduce the approximate position of the line in the diagram.