Rosh Chodesh Calculation - Calculation of Lunar Month
Ref: Sefer Zemanim, Hilchot Kidush Hachodesh, Chapters 1-17

ROSH CHODESH CALCULATION – CALCULATION OF LUNAR MONTH

How to *practically* work out *Rosh Chodesh time*

- *Direct vision in sky*
- *Approximate calculation* (chapter 6–chapter 10)

This involves pure addition from a given starting point with units of Days, Hours, Units and Moments

- *Precise calculation* (chapter 11–chapter 17)

Involves measuring of true positions and movements of sun and moon.

Done by addition of Degrees, Minutes, Seconds, Thirds etc.

> **Reminder:**
> Astronomy Definitions (IN APPENDIX)

DIRECT VISION IN SKY

- Look for New Moon on western horizon (near where the sun sets)
- Is the latitude to the north or south of the sun?
- Is the crescent wide or narrow? (crescent grows as it moves further away from the sun)
- Which direction are corners of moon pointing?
- How high is the moon in the sky?

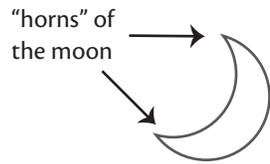Moon sets in west with sun, or slightly north, or slightly south

Western amplitude

S .... N

Western Horizon

Moon setting
south of the Sun

Sun's setting
point
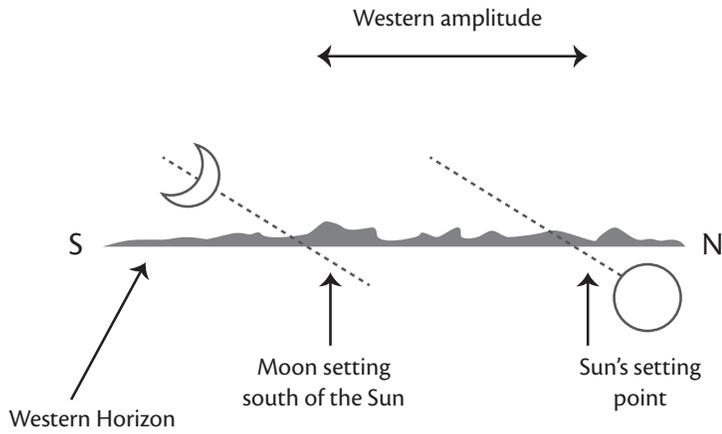
Western amplitude discussed
further in Chapter 19
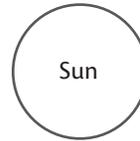
Elongation

S .... N

Western Horizon
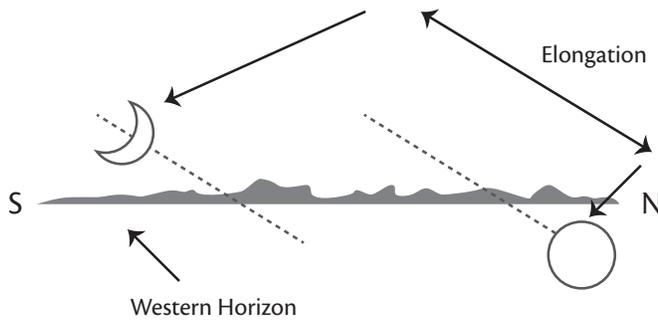
(Angular separation between
sun and moon)
See Chapter 16, 17
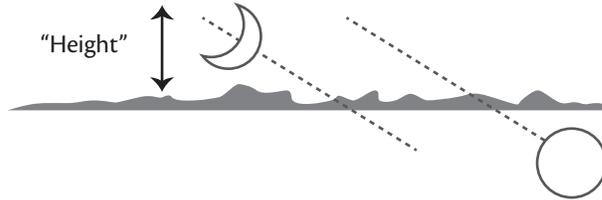i.e. Moon position in relation
to horizon

Crescent

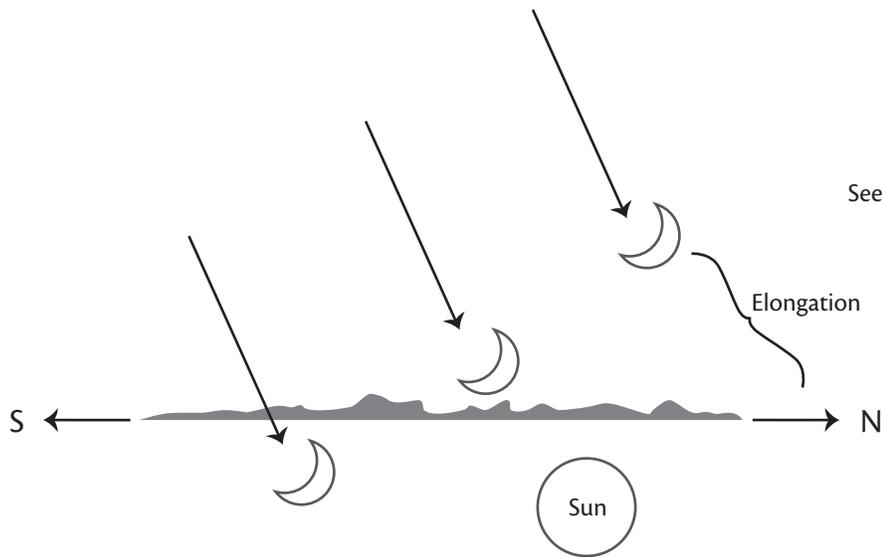"horns" of
the moon

(Always point away from sun)
Width varies

See Chapter 19

Sun

Height

"Height"

See Chapter 18

Latitude

See Chapter 16

Elongation

S ← → N

Sun

Western Horizon

R

Units for calculation are

Days, Hours, Units, Moments

i.e. 10 days, 21 hours, 204 units and 70 moments = 10d 21h 209u 70m

1 Day = 12 hours (and 1 night = 12 hours)

1 Hour = 1080 units

1 Unit = 60 moments

1 Lunar Month = 29d 12h 793u

1 Lunar year = 354d 8h 876u

1 Leap year = 383d 21h 589u

1 Solar year = 365d 6h

Difference between a lunar and solar year = 10d 21h 204u

19-year cycle = 7 leap years + 12 ordinary years

(Leap years are at 3, 6, 8, 11, 14, 17 and 19)

Difference between solar calendar and lunar calendar in 19-year cycle is 0d 1h 485u

To allow us to determine which day of week the next month, year, or leap year will occur we also need *7-day groupings*

• Remainder for Lunar month = 1d 12h 793u

• Remainder for Lunar year = 4d 8h 876u

• Remainder for Leap year = 5d 21h 589u

• Remainder for 19-year cycle = 2d 16h 595u

There are 2 methods of calculation

1. Perek ט׳

Based on

• Solar year 365¼ days

• 91 days and 7½ hours between seasons

• First spring (vernal) Equinox of Creation 7d 9h 642u

• Equinox falls at exact same time every 28 years

• Difference in equinox from 1 year to next = 1 day and 6 hours

2. Perek י׳

Based on

Solar year of 365d 5h 997u 48m i.e. assumes a slightly shorter solar year.

• Difference between solar and lunar year = 10d 21h 12u 48m

• Difference between each 19-year cycle = 0

• Difference between seasons = 91d 7h 519u 31m

• First Vernal Equinox of creation = 0d 9h 642u

This is the calculation favoured by the Sages of *Yisrael*, and is the more accurate.

Besides these 2 different starting points, the actual calculations are the same, as follows:

- Starting points is 2d 5h 204u (First Year of Creation)
- Work out multiples of 19-year cycles
- Therefore, can work out how many leap years and how many ordinary years have passed.
- Add this all up
- Result will be conjunction of *Tishrei*
- For any other month add on multiples of 29d 12h 793u

SOLAR

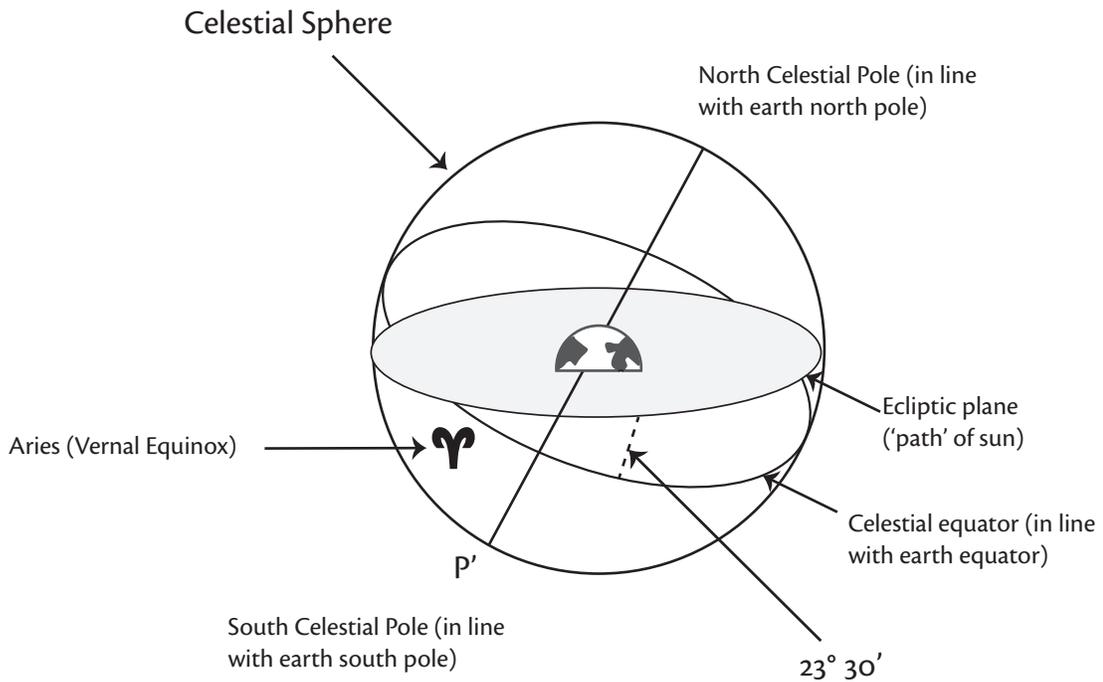Same, using figures of Season calculation i.e. equinox and solstices

PRECISE CALCULATION (Perek 11–Perek 17)

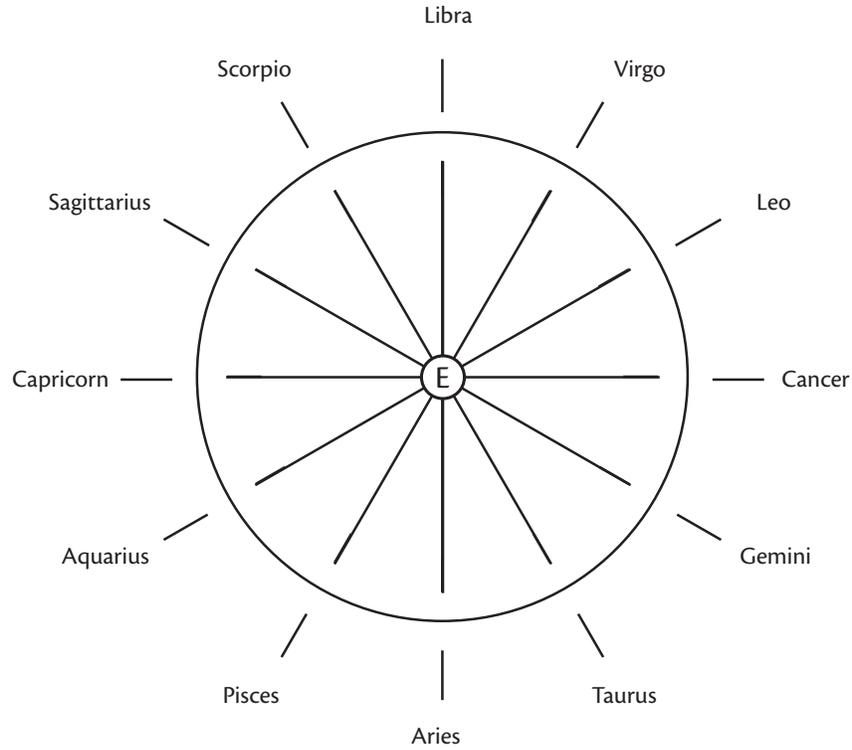This calculation results from combining the following
- Basis of calculations (Perek 11)
- Distance moved by sun within constellations – Mean of sun (Perek 12)
- True position of sun (Perek 13)
- Distance moved by moon – Mean of moon (Perek 14)
- True position of moon (Perek 15)
- Moons latitude (Relation of orbits of sun and moon) (Perek 16)
- Moons longitudes and other adjustments due to incongruities of moons orbit) (Perek 17)

We need to visualise the celestial sphere around the earth (Zodiac) and the paths of celestial bodies within the sphere (mainly the sun and moon)

To site a point on the celestial sphere, there are a few co-ordinate systems.

Celestial Sphere

North Celestial Pole (in line with earth north pole)

Ecliptic plane ('path' of sun)

Aries (Vernal Equinox)

Celestial equator (in line with earth equator)

P'

South Celestial Pole (in line with earth south pole)

23° 30'

Point O represents a celestial object on the celestial sphere. The following are its coordinates:

a. *Equatorial coordinates:* (Independent of geographic location)
- Declination   OC (Perpendicular [to equator] angular distance; 0–90°)
- Right ascension   γC (eastward from Aries, 0–360°)

b. *Ecliptic coordinates:* (Independent of geographic location)
- Latitude   OA (Perpendicular to ecliptic, 0–90°)
- Longitude   γA (Counter clockwise from Aries, 0–360°)
   – Latitude refers to a N – S separation
   – Longitude refers to an E – W separation

c. *Horizon coordinates:* (Varies according to geographic location)
- Altitude   OB (Perpendicular angle above horizon, 0–90°)
- Azimuth   NB (Clockwise from N, 360°)

BASICS OF CALCULATIONS

Heavenly Sphere divided into 360° (degrees)

There are 12 Constellations

Therefore, each Constellation = 30°

1° = 60′ (minutes)

1' = 60″ (seconds)

1" = 60‴ (thirds)

R

Libra

Scorpio   Virgo

Sagittarius   Leo

Capricorn ——   E   —— Cancer

Aquarius   Gemini

Pisces   Taurus

Aries

For reference, the start of the Zodiac is Aries.

The Earth (E) is at the centre of the Zodiac, but not at the centre of sun (or other planets). C is centre of orbit of say the sun. This position against the background of the Zodiac, varies from day to day.

So, if one looks up into the sky we see the celestial sphere of the Zodiac and imagine the plane of orbit of say sun or moon within the sphere.
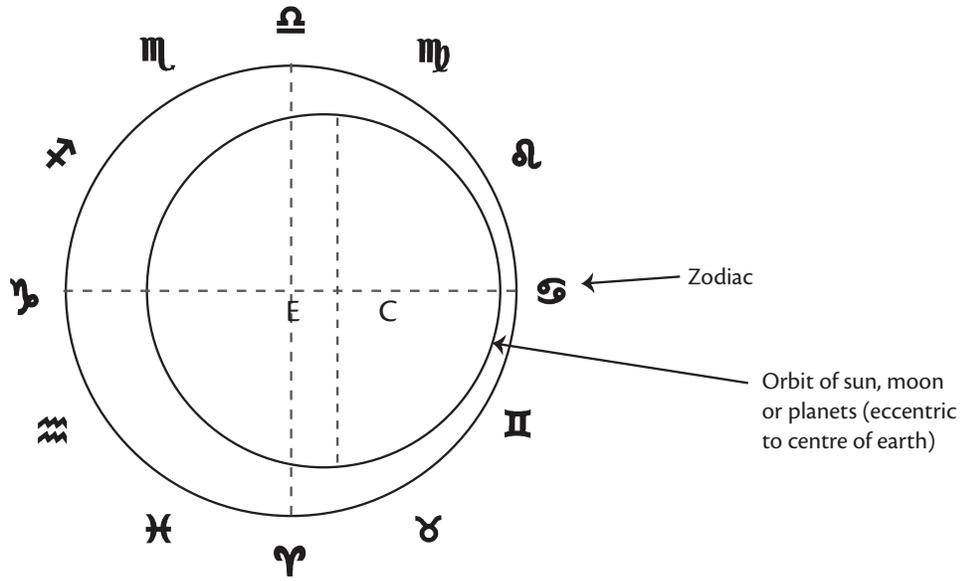
If we looked at the sun or moon against the Zodiac (position H) it would appear to be at point 1. If viewed from centre of planets orbit, it would appear at 2 on the Zodiac.

Thus the position of the sun relative to the Zodiac, will vary at different times of the year.

Mean Motion

Sun's orbit

E   C

H

♈

True Motion

Zodiac

E   C

H
A

♈
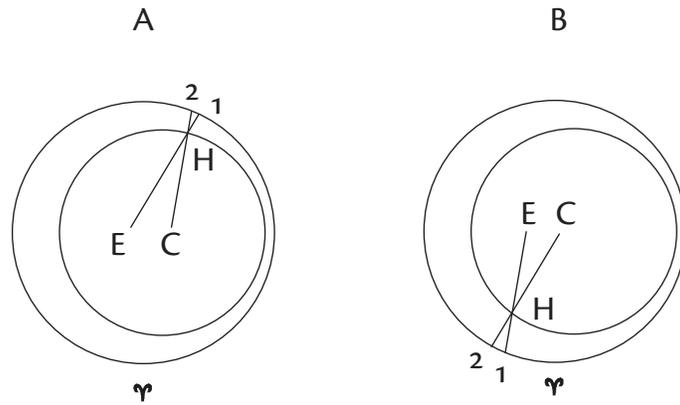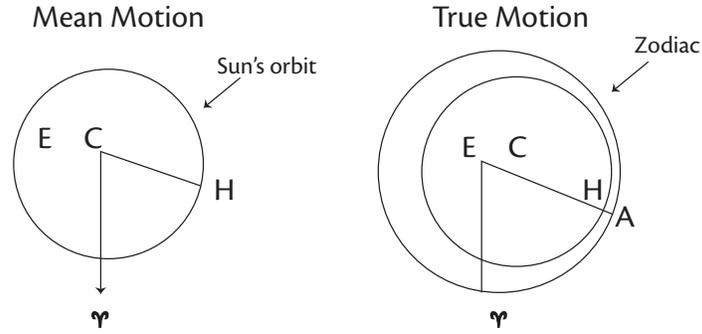
The steady motion of sun or planets in their orbit is called the *mean motion*.

The mean position of say sun (mean longitude) is measured in relation to first point in Aries, and is the angle γCH.

*True motion* of sun or planets is the movement as observed on the outer Zodiac circle.

True position of sun or planet is as it is seen against Zodiac i.e. A (*true longitude*) Similarly it is measured in relation to Aries, and is the angle γEA.

In the following chapters (12–16), the Rambam will be calculating when the moon will first be seen i.e. moon relative to sun (east west relation)

At conjunction the earth, moon and sun are in line.

Thereafter one gets angular separation (*elongation*) To know when this happens one needs to calculate the *true position of sun* and *true position of moon* (longitude)

There is also a north-south separation and this will be discussed in chapters 16 (Latitude)

Node

Orbit of moon

E

Node

Orbit of Sun
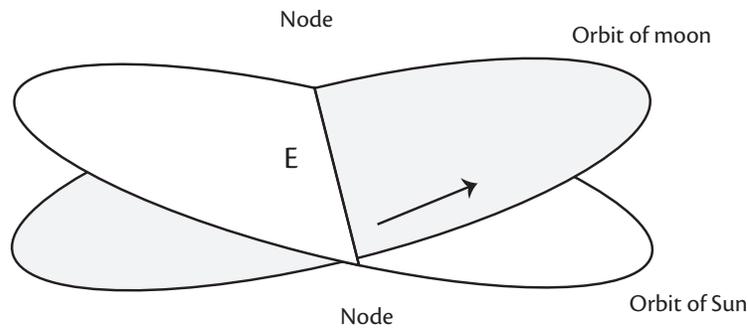
Moon relative to Horizon discussed in chapter 17