MERCHANT SHIPPING SECRETARIAT
GOVERNMENT OF SRI LANKA
CERTIFICATE OF COMPETENCY EXAMINATION

GRADE : OFFICER IN CHARGE OF A NAVIGATIONAL WATCH ON SHIPS OF 500 GT OR MORE (UNLIMITED)

SUBJECT : PRINCIPLES OF NAVIGATION

DATE : 19/04/2024 Time : 1300 to 1600 hrs

Time allowed **THREE hours** Total marks : 120

ANSWER ALL QUESTIONS Pass marks : 50%

Formulae and all intermediate steps taken in reaching your answer should be clearly shown. You may draw sketches wherever required. Electronic devices capable of storing and retrieving are **not** allowed.

1) Define the following with the help of diagrams;

a) i) GHA ii) SHA iii) Declination iv) Magnitude (10 marks)

b) With the aid diagrams derive the followings

i) LHA* = GHAγ + SHA* + Long (E)

ii) LHA* = GHAγ + SHA* - Long (W) (05 marks)

c) Calculate the LHA of a star whose RA is 75°, for an observer in longitude 50°E, when GHAγ is 200°. (05 marks)

2) a) Why does the duration of the Moon's Synodic Period is longer than Sidereal Period? (06 marks)

b) With an aid of a sketch describe lunar eclipse. (06 marks)

c) Describe with diagram the phases of the moon. (08 marks)

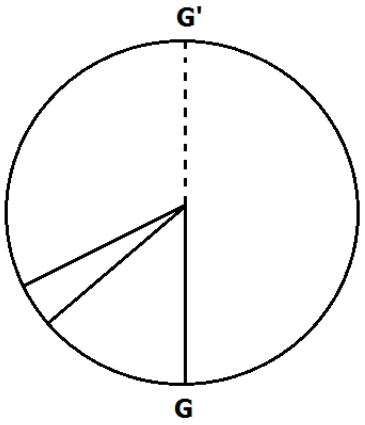
3) a) Explain the Kepler's three laws of planetary motion. (10 marks)

b) Describe difference of Inferior and Superior conjunctions. (5 marks)

c) With add of a diagram explain Apparent motion of planet "Jupiter". (5 marks)

4). a) What is Equation of time and describe two components E1 and E2 of Equation of time. (09 marks)

b) Fill below diagram with details and show the Equation of time. (06 marks)



c) Describe how you find Equation of time from Almanac. (05 marks)

5) a) Sketch the PZX triangle and mark the parts in the triangle. (10 marks)

b) States the Napier's rules for right angled spherical triangle with clear diagram. (05 marks)

c) List corrections to be applied to Sextant Altitude to get True Altitude. (05 marks)

6) a) State the three common chart projections. (06 marks)

b) Describe the use of gnomonic charts for plotting a great circle track between two points and describe the procedure of transferring the great circle track to a Mercator chart. (08 marks)

c) List the advantages of Mercator charts. (06 marks)

Answer Sheet :

1.

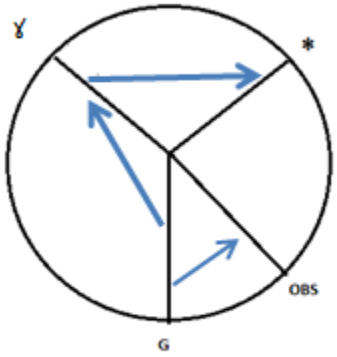
a) i) .GHA of a celestial body is the arc of the Equinoctial or the angle at the celestial poles contained between the celestial meridian of Greenwich and the celestial meridian of the body, measured westward from Greenwich.

ii). SHA of a celestial body is the arc of the Equinoctial or the angle at the celestial pole contained between the celestial meridian of the First point of Aries and the celestial meridian through the body, measured westward from First point of Aries

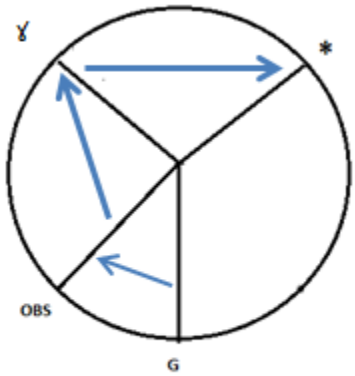
iii). Declination of a celestial body is the arc of a celestial meridian or the angle at the center of the Earth contained between the Equinoctial and the parallel of declination through that body. Declinations are measured from 0^0 to 90^0 N or S of the Equinoctial.

iv). Magnitude in astronomy, measure of the brightness of a **star** or other celestial body. The brighter the object, the lower the number assigned as a **magnitude**. Magnetitude with minus bodies are more suitable for observation.

b). Candidate should describe with diagram.



(i)



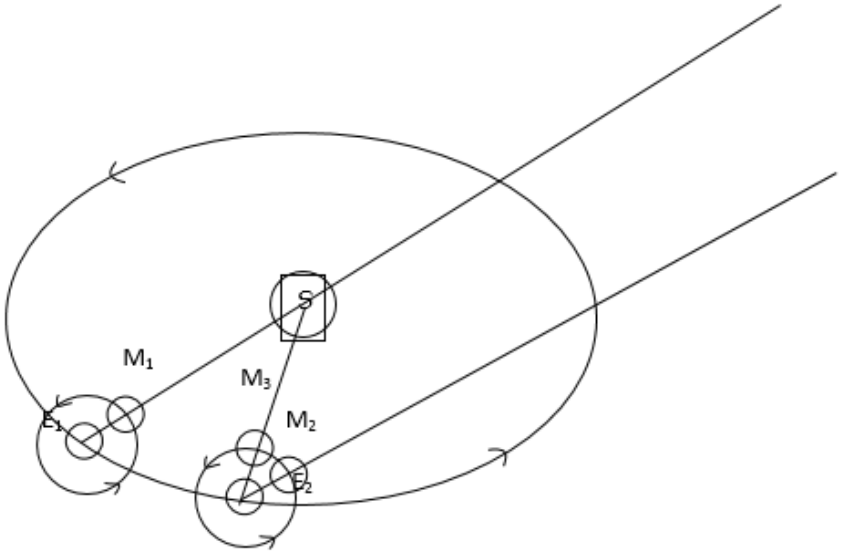
(ii)

c). LHA* = GHAγ + SHA* + Long (E)

= 200 + 285 + 50

=535 -360 = 174◦

2).



a).

As the Moon revolves about the Earth, the Earth is also moving in its orbit around the Sun.
When the Earth is at position E1, in its orbit, and the Moon at position M_1, the Moon is in conjunction with the Sun and we have New Moon.
Let us assume that as viewed from the Earth, the Sun and Moon are now in the direction of a star. This direction to the star is constant, irrespective of the Earth's motion in its orbit, as the star is at an infinite distance from the Earth.
By the time Moon completes one revolution of 360^0 around the Earth, (it comes back in the direction of the same star) the Earth has moved in its orbit to position E_2.
Now one sidereal period has been completed but not a synodic period.
To complete a synodic period, the Moon has to move further in its orbit till it is again in conjunction with the Sun (at position M_3).
Thus, to complete a synodic period, the Moon has to revolve 360^0 + the angular motion of the Earth around the Sun, during that period.
The synodic period of the Moon is therefore of longer duration than its sidereal period.

b).

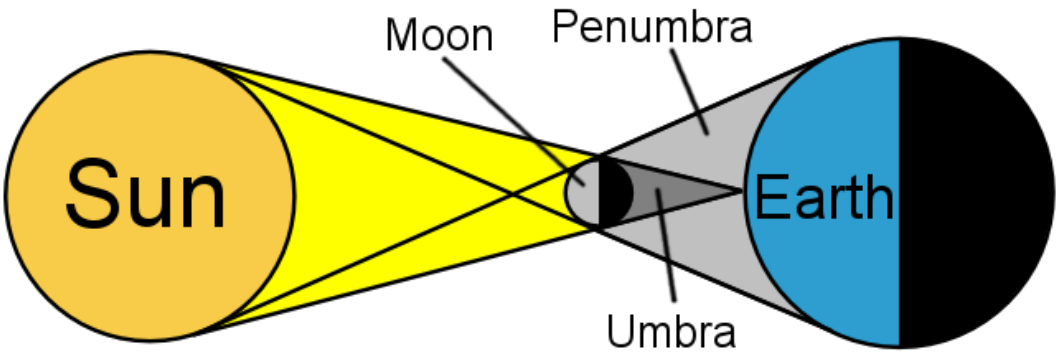
The Moon is not self luminous and we see it only because it reflects sun-light. A lunar eclipse therefore takes place when the Moon passes through the Earth's shadow. This can happen only when the Moon is in opposition with the Sun.

Three types of Lunar eclipses;

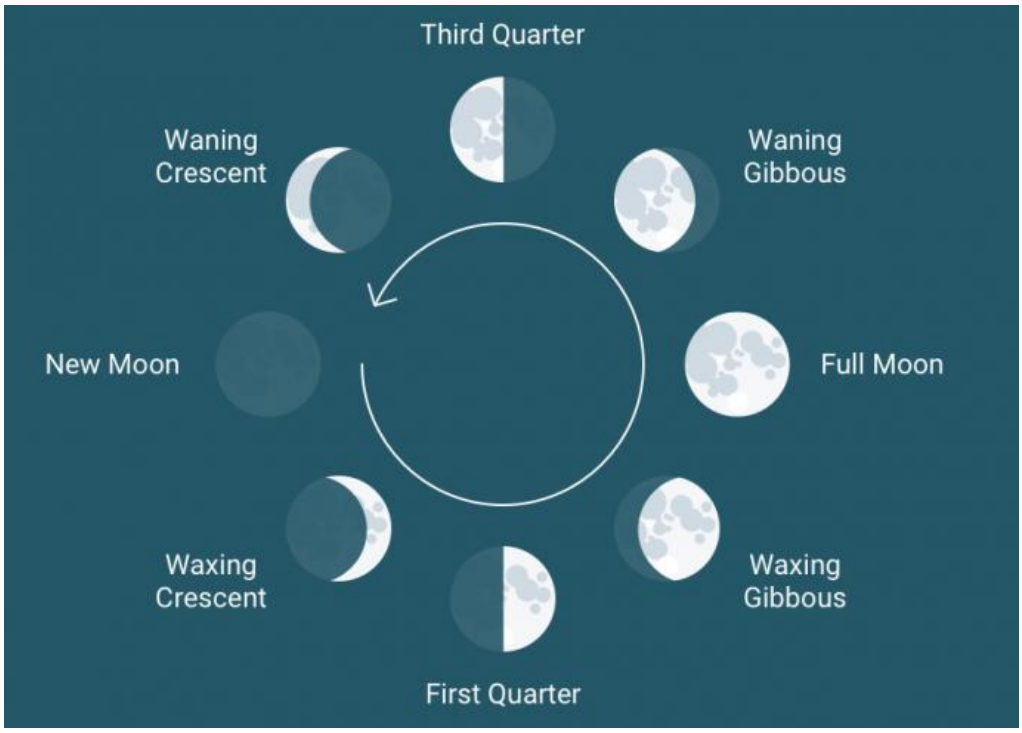
i. 'Total',

ii. 'Penumbral'

iii. 'Partial'.



c).



Candidate should demonstrate phases of the moon with clear diagram.

3). a)

1st law : Kepler's first Law states that all planets revolve about the sun in elliptical orbits with the sun situated at one of the foci of the ellipse.

2nd law : Kepler's second Law states that the radius vector of a planet sweeps out equal areas in equal time periods.

3rd law : Kepler's third gives the relationship between the distance of a planet from the sun and the time it takes to complete one revolution around the sun.
According to the third law planets which are closer to the Sun have a greater angular orbital velocity than the planets which are further away.

According to the third law:

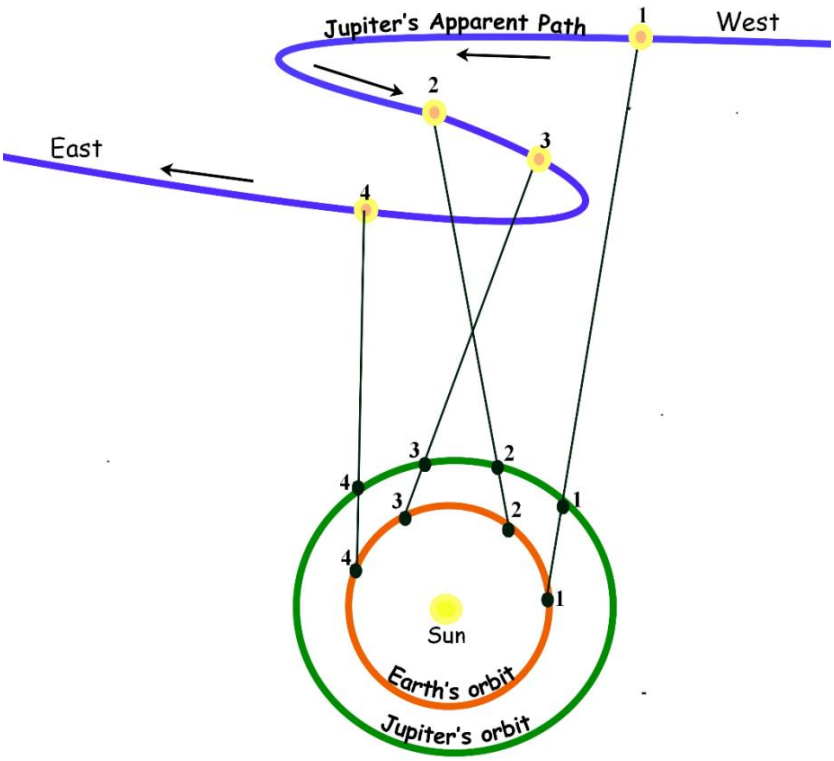
$\frac{T^2}{d^3}$ for all planets is a constant.

Where 'T' is the sidereal period of the planet (i.e. time taken by the planet to go round the sun, exactly through 360º) and'd' is the mean distance from the sun to the planet.

b). Inferior Conjunction : An inferior conjunction occurs when the two planets lie in a line on the same side of the Sun.

Superior conjunction : A superior conjunction occurs when a body or a planet lies along a straight line joining the Earth and the Sun, but is on the opposite side of the Sun from the Earth.

c).



Candidate should describe apparent motion of Jupiter with diagram.

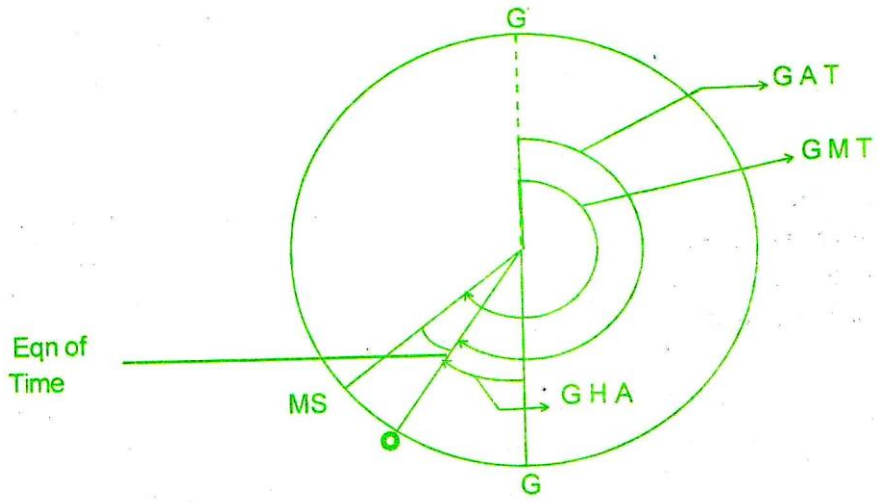
4)

a). Equation of time is the difference between the Mean time and the Apparent time, measured from the same meridian, at any instant. It is expressed in minutes and seconds of time.

Navigators generally express Equation of time as Mean time minus Apparent time. In the nautical text books, equation of time will be expressed as Mean time minus Apparent time. Therefore, if Mean time is greater than Apparent time, equation of time is +ve and if Apparent time is greater than Mean time, equation of time is -ve.

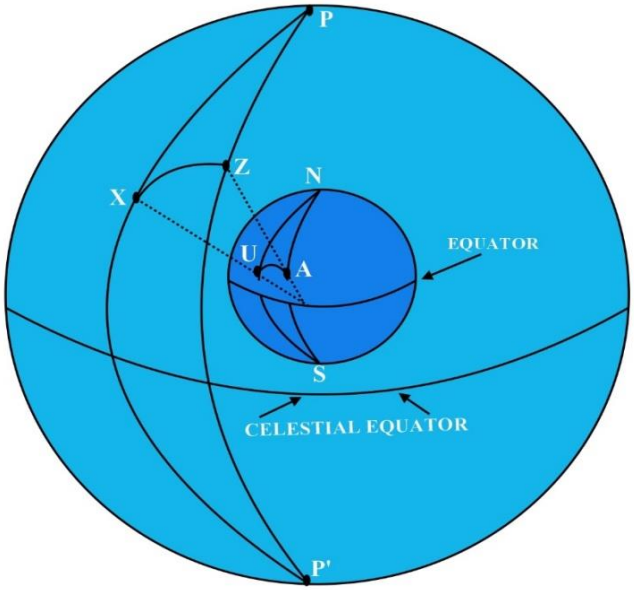
_Component E_1, produced due to the eccentricity of the Earth's orbit, and
_Component E_2, produced due to the obliquity of the Ecliptic.

b)



c). Equation of Time values is tabulated in the daily pages of the nautical almanac, for 00 hours and 12hours GMT on each day. The value for any intermediate time may be obtained by interpolation. The values tabulated in the almanac are the absolute values i.e. signs are omitted. Whether it is positive or negative may however be determined by inspecting the meridian passage time of the Sun in the adjacent column of the almanac. If the tabulated meridian passage time is in excess of 12 hours, say 12 04, it indicates that at 12 04 Mean time, the True Sun is on the meridian i.e. the Apparent time is 1200. Equation of Time is then obviously +ve.
Meridian passage time - 12 hours. = Equation of time (correct to the nearest minute).

5).
a).



The PZX Triangle

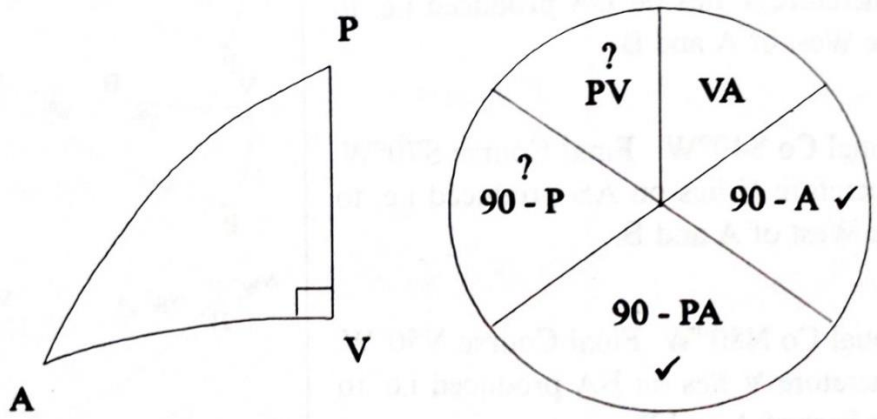
In the diagram above,

PX = 90^o – Dec.
PZ = 90^o – Lat.
ZX = 90^o – Alt.
Alt = 90^o – ZX
<PZX = Azimuth.
<ZPX = Hour angle.

b).
Napier's rule. : either of two rules in spherical trigonometry: the sine of any part is equal to the product of the tangents of the adjacent parts and the sine of any part is equal to the product of the cosines of the opposite parts.

Sin mid part = Cos opp.x Cos opp.

Sin mid part = Tan adj.x Tan adj.

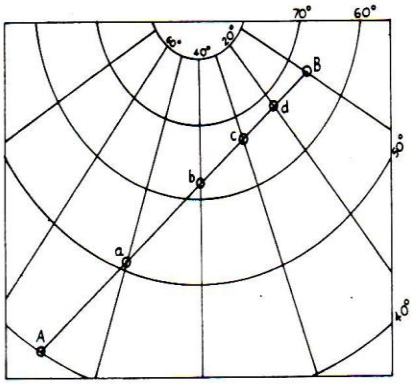


c). 1. Index Error
2. Dip/ Height of Eye
3. *Refraction*
4. Semi-Diameter
5. Augmentation of the Moon's SD
6. *Parallax in Altitude*

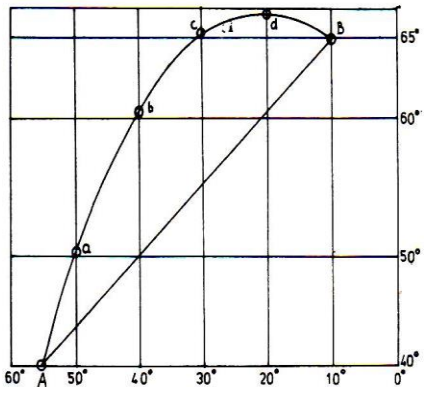
6)

a). 1. Mercator projection
2.Gnomonic projection
3.Transverse Mercator charts

b).



Gnomonic chart



Mercator chart

Candidate should describe plotting GC track on Gnomonic charts and transferring to WPs to Mercator chart

c).

I. Rhumb line courses are easily laid off as straight lines.
II. Distances are easily measured as scale of distance = scale of latitude.
III. Shapes of land masses in the neighborhood of a point are correctly shown.
IV. Angles between rhumb lines are unaltered between the Earth and the chart.
V. Directions remain correct though distortions of areas occur.
VI. Directions and position lines can be transferred correctly from one part of the chart to another as parallel lines. This facility which is often used by a navigator for obtaining running fixes is not available in most other projections.