



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 : 11 July 2024

Time : 0900 hrs to 1200 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.
 - i. Define the following with suitable sketches;
 - a) Great Circle
 - b) Parallels of Declination
 - c) Celestial Meridians
 - d) Ecliptic

(12 marks)
 - ii. A vessel leaves position $45^{\circ} 12' N$. $161^{\circ} 12' W$. and steams $213^{\circ} (T)$. for 406 nautical miles. Find the position arrived at.

(08 marks)

2.
 - i. List the planets that are useful for navigation.

(5 marks)
 - ii. Describes the earth's elliptical orbit and states approximate perihelion and aphelion distances and dates.

(10 marks)

3. 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 following
- i) $LHA^* = GHA_{\gamma} + SHA^* + Long (E)$
- ii) $LHA^* = GHA_{\gamma} + SHA^* - Long (W)$ (5 marks)
- c) Calculate the LHA of a star whose RA is 75° , for an observer in longitude $50^{\circ}E$, when GHA_{γ} is 200° . (10 marks)
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4. a) Why is the Moon's Synodic Period longer than its Sidereal Period? (06 marks)
- b) With the aid of a sketch describe the lunar eclipse. (06 marks)
- c) Describe with a diagram the phases of the moon. (08 marks)
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5. a) Explain Kepler's three laws of planetary motion. (10 marks)
- b) Describe the difference between Inferior and Superior conjunctions. (5 marks)
- c) With the aid of a diagram explain the Apparent motion of the planet "Jupiter". (5 marks)
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6. a) Explain the following;
- i) Standard Time
- ii) Zone Time (08 marks)
- b) What is Local Mean Time? (04 marks)
- c) Describe the International Date Line and how the date on ships are altered on crossing the International date line. (08 marks)

Answers

Answers sheets;

1. i. Define the following with suitable sketches; (03 marks each)

a) Great Circle

A great circle is a circle on a sphere, the plane of which passes through the centre of the sphere.

b) Paralleles of Declination

Parallels of declination are the small circles on the celestial sphere, plane of which are parallel to the plane of the equinoctial.

c) Celestial Poles

The celestial poles are the two points on the celestial sphere where the axis of earth produced would meet celestial sphere.

d) Celestial Meridians

Celestial Meridians are semi-great circles on the celestial sphere joining two celestial poles. Celestial meridians cross the equinoctial at right angles.

e) Ecliptic

Ecliptic is a great circle on the celestial sphere in the same plane as the plane of the Earth's orbit around the sun. Thus the sun's apparent annual path on the celestial sphere is the Ecliptic. Though the earth's orbit is an ellipse, the ecliptic as drawn on the celestial sphere is a great circle, in the same plane as the orbit.

ii. A vessel leaves position $45^{\circ} 12' N$. $161^{\circ} 12' W$. and steams $213^{\circ} (T)$. for 406 miles. Find the position arrived at.

(10 marks)

$$\begin{aligned}\text{True course} &= 213^{\circ} (T) \\ &= S 33^{\circ} W\end{aligned}$$

Figure;

$$\begin{aligned}\text{dep} &= \text{dist} \times \sin \text{co.} \\ &= 406' \times \sin 33^{\circ} \\ &= 221.1' W\end{aligned}$$

$$d'lat = \text{dist} \times \cos \text{co.}$$

$$\begin{aligned}
&= 406' \times \cos 33^\circ \\
&= 340.5' \text{ S} \\
&= 05^\circ 40.5' \text{ S}
\end{aligned}$$

$$\begin{aligned}
\text{Initial lat.} &= 45^\circ 12.0' \text{ N} \\
d'lat &= \underline{05^\circ 40.5' \text{ S}} \\
\text{Final lat.} &= \underline{\underline{39^\circ 31.5' \text{ N}}}
\end{aligned}$$

$$\begin{aligned}
M'lat &= \frac{\text{Initial lat.} + / - \text{Final lat.}}{2} \\
&= 42^\circ 21.75'
\end{aligned}$$

$$\begin{aligned}
\text{Dep} &= d'long \times \cos m'lat \\
d'long &= \frac{\text{dep}}{\cos m'lat} \\
&= \frac{221.1'}{\cos 42^\circ 21.75'} \\
&= 299.2' \text{ W} \\
d'long &= 04^\circ 59.2' \text{ W}
\end{aligned}$$

$$\begin{aligned}
\text{Initial long} &= 161^\circ 12.0' \text{ W} \\
d'long &= \underline{04^\circ 59.2' \text{ W}} \\
\text{Final long} &= \underline{\underline{166^\circ 11.2' \text{ W}}}
\end{aligned}$$

$$\text{Final Position} = \underline{\underline{39^\circ 31.5' \text{ N} 166^\circ 11.2' \text{ W}}}$$

Answer 2

- i. **State the planets useful for navigation.**
Venus, Mars, Saturn and Jupiter
- ii. **Describes the earth's elliptical orbit and states approximate perihelion and aphelion distances and dates.**

A planet is said to be in Aphelion, when in its orbit, it is farthest from sun. It is said to be in Perihelion, when in its orbit, it is nearest to the sun.

When the Earth is at Aphelion, the Sun is about 94.45 million miles away and which occurs around 1st of July each year. When the Earth is at Perihelion, the Sun is about 91.35 millions miles away and this occurs about 1st of January each year. The line Aphelion to

Perihelion, if definitely produced on each side is called the Line of Apsides.

Answer 3

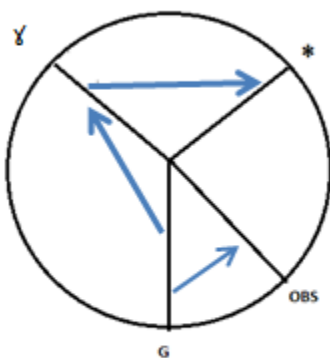
a) i) .GHA of a celestial body is the arc of the Equinoctial or the angle at the celestial poles contained between the celestial meridian of Greenwich and the celestial meridian of the body, measured westward from Greenwich.

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

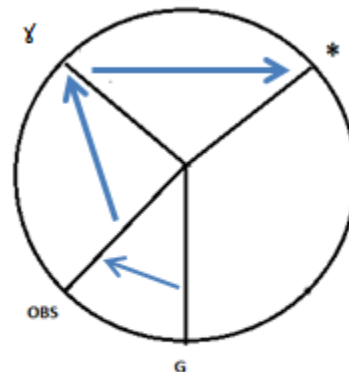
iii). Declination of a celestial body is the arc of a celestial meridian or the angle at the center of the Earth contained between the Equinoctial and the parallel of declination through that body. Declinations are measured from 0° to 90° N or S of the Equinoctial.

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**. Magnitude with minus bodies are more suitable for observation.

b). Candidate should describe with diagram.



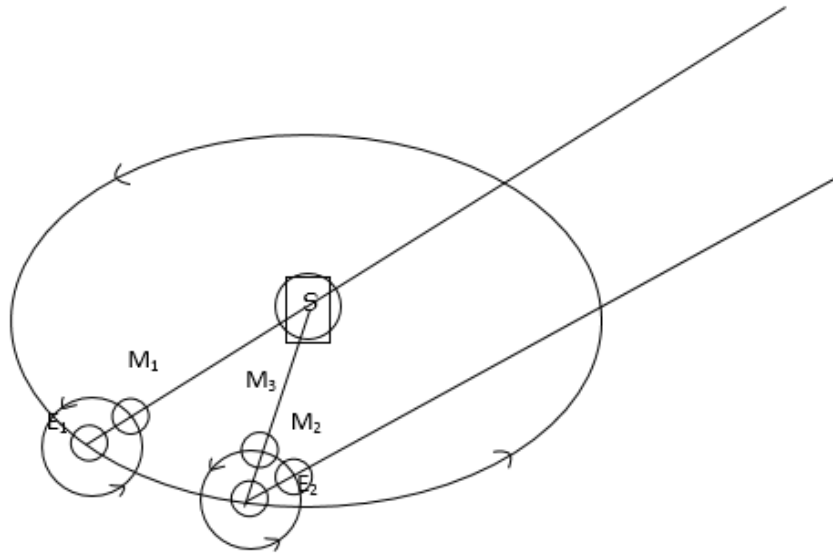
(i)



(ii)

c). $LHA^* = GHA_{\gamma} + SHA^* + Long (E)$
 $= 200 + 285 + 50$
 $= 535 - 360 = \underline{175^{\circ}}$

Answer 4



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 M1, 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° around the Earth, (it comes back in the direction of the same star) the Earth has moved in its orbit to position E2.

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 M3).

Thus, to complete a synodic period, the Moon has to revolve $360^\circ +$ the angular motion of the Earth around the Sun, during that period.

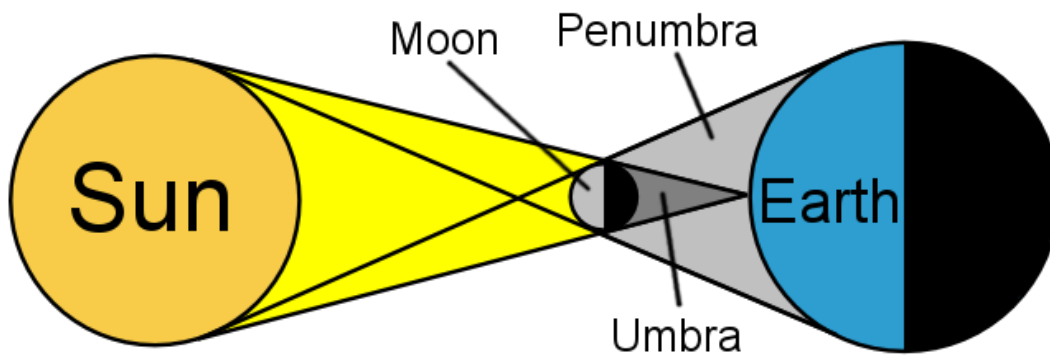
The synodic period of the Moon is therefore of longer duration than its sidereal period.

b).

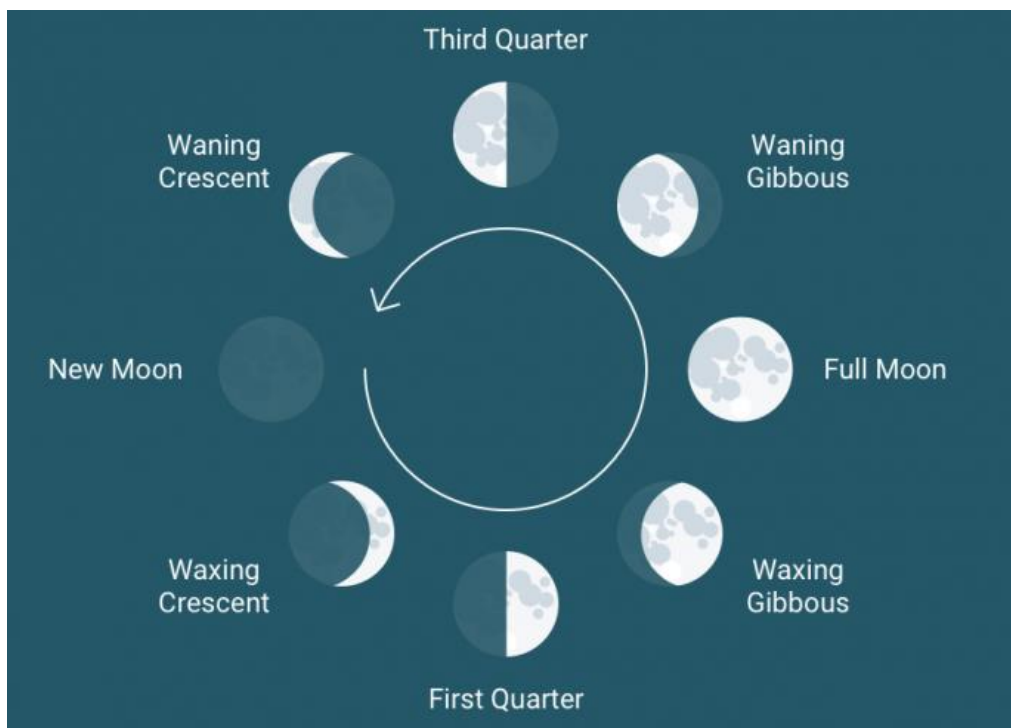
The Moon is not self luminous and we see it only because it reflects sun-light. A lunar eclipse therefore takes place when the Moon passes through the Earth's shadow. This can happen only when the Moon is in opposition with the Sun.

Three types of Lunar eclipses;

- i. 'Total',
- ii. 'Penumbral'
- iii. 'Partial'.



c).



Candidate should demonstrate phases of the moon with clear diagram.

Answer 5

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:

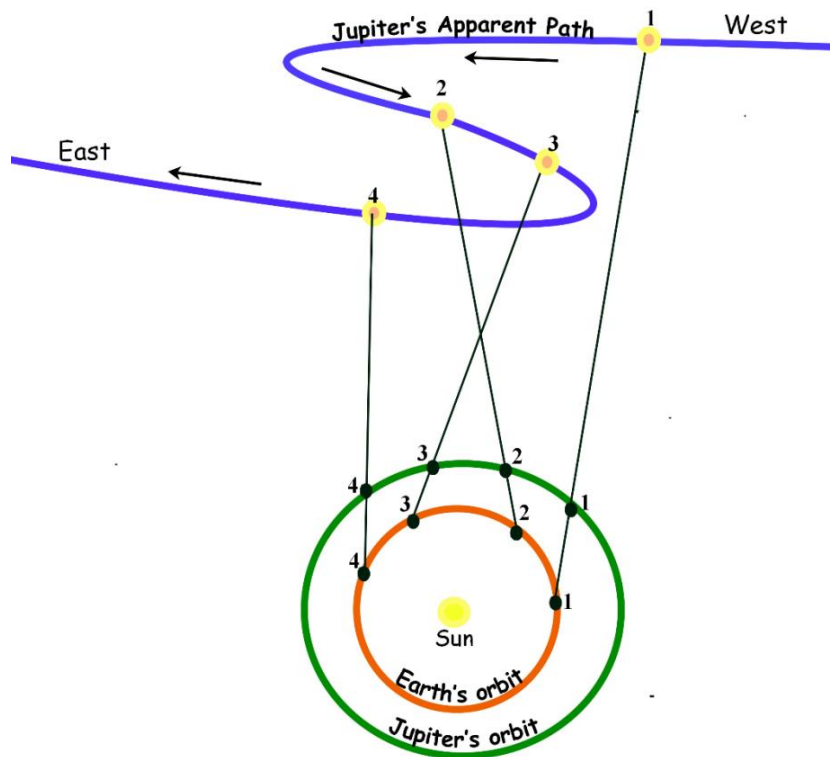
$$\frac{T^2}{d^3} \text{ for all planets is a constant.}$$

Where 'T' is the sidereal period of the planet (i.e. time taken by the planet to go round the sun, exactly through 360°) 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.

Answer 6

a) Standard Time – the meridians on which the standard times of the various time zones are based are chosen so that the times based on them would differ from GMT by a convenient number of hours. For instance, Sri Lanka standard time used through out Sri Lanka. Candidate should further discuss about the allocation of standard times and about the tables in ALRS Volume 2 and advantages.

Zone time – The earth is divided in to 24 time zones. 15 degree longitude each zone The time kept in the time zone is based on the central meridian time zone.

Candidate should further discuss the topic and highlight the areas with some examples.

b) Is the westerly hour angle of the Mean Sun measured from the observer's inferior meridian.

c) International date line, imaginary line on the earth's surface, generally following the 180° meridian of longitude where, by international agreement, travelers change dates.

Ship crossing IDL in westerly course Advance the date by one day.

Ship crossing IDL in easterly course Retard the date by one day.