Date: 21 November, 2026

Question Paper Code

41

Aakash
Medical | IIT-JEE | Foundations

Corporate Office: AESL, 3rd Floor, Incuspaze Campus-2, Plot-13, Sector-18,
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Answers & Solutions

Time : 120 Minute

for

Max. Marks : 216

Indian Association of Physics Teachers
National Standard Examination in
ASTRONOMY (NSEA)-2026

INSTRUCTIONS TO CANDIDATES

(1) There are 60 questions in this paper. Attempt all the 60 Questions.

(2) Question paper has two parts. In **Part A-1** (Q. No. 1 to 48) each question has four alternatives, out of which **only one** is correct. Choose the correct alternative and fill the appropriate bubble, as shown.

Q. No. 22 (a) (●) (c) (d)

In **Part A-2** (Q. No. 49 to 60) each question has four alternatives, out of which **any number of alternative (s)** (1, 2, 3 or 4) may be correct. You have to choose ALL correct alternative(s) and fill the appropriate bubble(s), as shown.

Q. No. 54 (a) (●) (c) (●)

(3) For **Part A-1**, each correct answer carries **3 marks** whereas 1 mark will be deducted for each wrong answer. In **Part A-2**, you get **6 marks** if all the correct alternatives are marked. No negative marks in this part.

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Attempt All Sixty Questions

A - 1

ONLY ONE OUT OF FOUR OPTIONS IS CORRECT. BUBBLE THE CORRECT OPTION

1. A person claims to have followed this path: She was standing at location 'A' on the Earth. She walked towards the north direction for 100 km. Next, she turned towards east and walked for 100 km. Then she turned towards south and walked for 100 km and reached back the same location 'A'.
   (a) Her claim is not possible.
   (b) Location A can be only one particular place on the Earth.
   (c) Location A can be only at two distinct places on the Earth.
   (d) Location A can be anywhere on the Earth.

Answer (d)

Sol. Idea: The walk is north 100 km, east 100 km, south 100 km. The east leg stays on one latitude circle. The walk can close only if that eastward leg brings her back to exactly where the leg started.

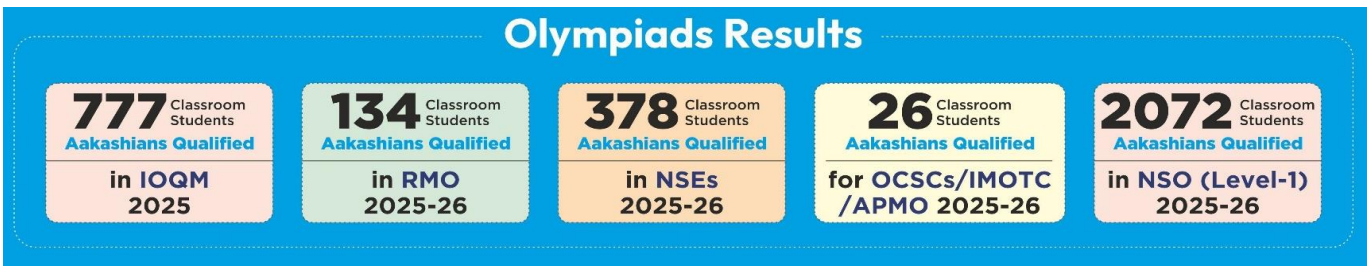
1. Call the point reached after walking north P. The eastward leg of 100 km must cover a whole number n of laps of P's latitude circle. So the circle's circumference must be **100/n km** (n = 1, 2, 3, …).
2. After the n laps she is back at P. Walking 100 km south along the same meridian returns her to A.
3. Circles of circumference 100/n km exist near the poles. Near the North Pole, the circle's radius is about $100/(2\pi n) \approx 15.9/n$ km.
4. Valid starting points A lie **100 km south of each such circle**, so on circles about 100 + 15.9/n km from the North Pole. There is one circle for each n, and every point on each circle works, so there are infinitely many valid points.
5. The **South Pole** also works. Walking north 100 km and then east 100 km does not complete a loop. But every meridian meets at the pole, so walking south 100 km brings her back to it.

2. For a binary star system with two identical mass stars,
   (a) the orbit is always circular.
   (b) the centre of mass of the system shows a periodic motion.
   (c) the elliptical orbit may appear to be circular to the observer due to certain inclination.
   (d) the stars can be always resolved using powerful telescopes.

Answer (c)

Sol. Two identical-mass stars orbit their common centre of mass, which lies midway between them.

(a) **False:** Identical masses do not force a circular orbit. The orbit can be an ellipse.
(b) **False:** With no external force, the centre of mass stays at rest or moves uniformly. It shows no periodic motion.
(c) **True:** An elliptical orbit seen at an inclination is a projection, and the projection of an ellipse can look like a circle.
(d) **False:** Resolving stars depends on their angular separation and the telescope's resolution. Very close or very distant binaries cannot always be resolved.



3. Two locations on the southern hemisphere of the earth have exactly the same length of day (and night) on any given day, but the times of sunrise and sunset both are offset by twelve hours each. A plane flying between the two locations trying to cover the shortest path will always fly

(a) first southwards and then northwards
(b) first northwards and then southwards
(c) exactly westwards.
(d) exactly eastwards.

Answer (a)

Sol. 1. **Same day length on the same date, both in the southern hemisphere.** Day length depends only on latitude and date, so both places are at the **same latitude**.

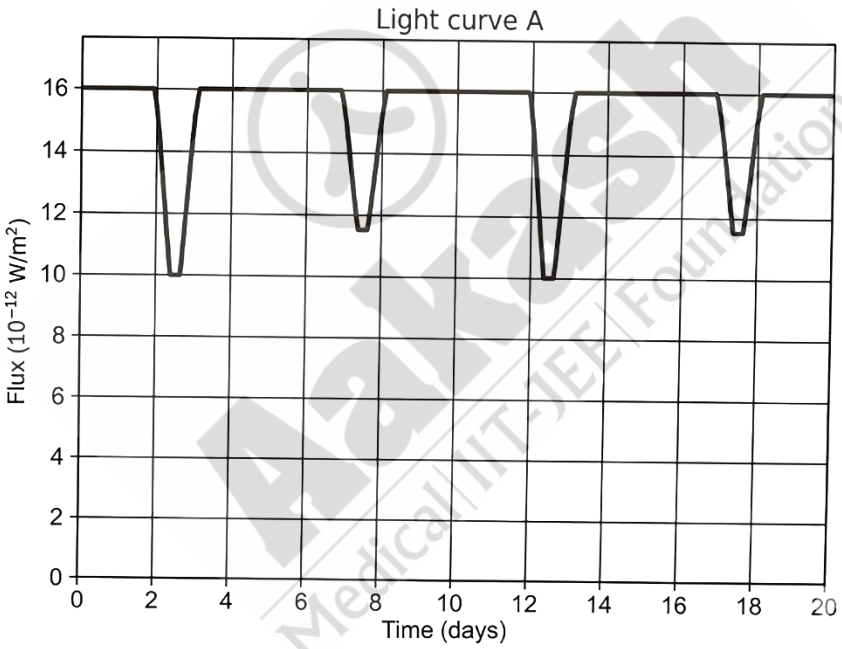
2. **Sunrise and sunset differ by 12 hours**. Local solar time changes by 1 hour per 15° of longitude, so the longitudes differ by **180°**.

3. Two points at the same latitude and 180° apart in longitude lie on a **common meridian circle through both poles**. The great circle joining them can go over the South Pole or over the North Pole.

4. For latitude φ (south), the path via the South Pole is $2(90° - |\varphi|)$ long. The path via the North Pole is $2(90° + |\varphi|)$ long. The south route is shorter.

The plane flies **first southwards (towards the South Pole), then northwards.**

4. The light curve shows a fictional edge-on eclipsing binary system containing star X and star Y. Which of the following is the correct option about the light curve?



(a) Two stars revolve around common centre of mass in necessarily circular orbit.
(b) Both stars are surely not of the same size.
(c) The two stars have their intensities in the ratio of 6 : 5.
(d) Larger dip is when cooler star comes in front of hotter star.

Answer (d)

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Sol. The depth is proportional to the area blocked and the intensity of the stars.

But area blocked is same

$\Rightarrow$ deeper dip is for hotter star

$\therefore$ (D) is correct.

(A) is incorrect because the orbit is not 'necessarily' circular

(B) can not be inferred

(C) $\frac{6}{5}$ ratio can not produce total

Intensity of 16 => incorrect

5. An astronomical telescope has objective with focal length of 750 mm. When eyepiece of 25 mm is used to observe a binary star, it is barely separated to a normal human eye. The aperture of telescope is 150 mm. The actual angular separation of the binary stars is approximately

(a) 1 arc sec (b) 2 arc sec

(c) 1 arc min (d) 2 arc min

Answer (b)

Sol. Magnification M = $\frac{f_o}{f_e} = \frac{750}{25} = 30$

For normal human eye minimum angular separation = 1 arcmin = 60″

$\Rightarrow$ Actual separation = $\frac{60''}{30} = 2'' = 2$ arc sec

$\Rightarrow$ (B) is correct.

6. An observer is located at latitude of 60° south and he can only see the sky above 10° horizon due to local geography. What percentage of sky will he never see from his location?

(a) 17.1% (b) 25.0%

(c) 32.9% (d) 41.3%

Answer (c)

Sol. A star's maximum altitude

$h_{max} = 90° - |\phi - \delta|$

$\Rightarrow$ $h_{max} = 90° - |-60° - \delta|$

$= 90° - |\delta + 60°|$

The star can be seen only if $h_{max} > 10°$

$\Rightarrow$ $90° - |\delta + 60°| > 10°$

$\Rightarrow$ $\delta < +20°$

$\therefore$ The spherical cap out of vision is for $\delta > +20°$

$\therefore$ Fraction of celestial sphere in that cap = $\frac{(1-\sin 20°)}{2} = \frac{1-0.3420}{2} = 0.329$

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7. Brightness of stars is given in magnitude. If the flux of energy received from two stars is I_1 an I_2, their magnitudes (m_1 and m_2 respectively) are related as $m_2 - m_1 = -2.5 \log\left(\frac{I_2}{I_1}\right)$. A particular star X is seen with magnitude 3.0 from the earth and with magnitude 4.0 from an exoplanet around another star Y. From the Earth, stars X and Y are seen separated by 40° with each other. The distance of the star Y from the Earth is 30 ly. The distance of the star X from the exoplanet is

(a) 23.6 ly (b) 21.5 ly

(c) 13.5 ly (d) 9.4 ly

Answer (b)

Sol. $\frac{I_2}{I_1} = \left(\frac{d_1}{d_2}\right)^2$

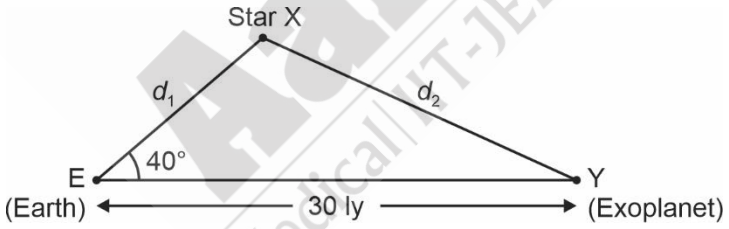
$$m_2 - m_1 = -2.5\log_{10}\left(\frac{I_2}{I_1}\right)$$

$$4 - 3 = -2.5\log_{10}\left[\left(\frac{d_1}{d_2}\right)^2\right]$$

$$\Rightarrow \quad 1 = -5\log\left(\frac{d_1}{d_2}\right)$$

$$\Rightarrow \quad \log\left(\frac{d_2}{d_1}\right) = \frac{1}{5} = 0.2$$

$$\therefore \quad \frac{d_2}{d_1} = 10^{0.2} \approx 1.585$$



$$\Rightarrow \quad d_2^2 = d_1^2 + 30^2 - 2 \times 30 \times d_1 \times \cos 40°$$

$$2.512d_1^2 = d_1^2 + 900 - 45.96d_1$$

$$1.512d_1^2 + 45.96d_1 - 900 = 0$$

$$\Rightarrow \quad d_2 \approx 21.5 \text{ ly}$$

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8. Which of the following constellations has smallest area?
   (a) Triangulum (b) Sagitta
   (c) Scutum (d) Crux

Answer (d)

Sol. Crux is the smallest of the 88 constellations covering only 68 square degrees.

9. A comet is orbiting around the sun with the closest distance as 3.00 AU. If its period of revolution around the Sun is 6.55 years, what is its farthest distance from the Sun?
   (a) 3.50 AU (b) 4.00 AU
   (c) 5.38 AU (d) 8.38 AU

Answer (b)

Sol. $T^2 = a^3$

$\Rightarrow 6.55^2 = a^3$

$\Rightarrow a \approx 3.5$ AU

$\therefore$ Farthest distance (Aphelion) = $2a - 3$ AU = 4 AU

10. Consider two statements A and R.
   Statement A : The ion tail of a comet is always seen on the opposite side of the sun.
   Statement R : Ion tail has very low density and hence it lags behind the comet approaching the Sun.
   Choose the most appropriate option that best describe the above two statements.
   (a) Both statements are correct and statement R is correct reason for statement A
   (b) Both statements are correct, but statement R is not correct reason for statement A
   (c) Statement A is correct, but statement R is wrong.
   (d) Statement A is wrong, but statement R is correct.

Answer (c)

Sol. A : Correct

The ion tail points away from the Sun.

R : Incorrect

The dust tail lags behind. The ion tail is pushed back by the solar wind.

11. It is observed that large number of stars follow $L \propto M^4$ relation between luminosity L and mass M. Similarly large number of stars have $R \propto M^{0.8}$. The surface temperature of stars will have relation $T \propto M^x$. The value of x is
   (a) 3.2 (b) 1.7
   (c) 0.8 (d) 0.6

Answer (d)

Sol. $\because \quad L \propto R^2T^4 \quad \ldots(i)$

$L \propto M^4$

& $R \propto M^{0.8} \Rightarrow R^2 \propto M^{1.6}$

$\therefore \quad M^4 \propto M^{1.6}T^4$

$\therefore \quad T^4 \propto M^{2.4}$

or $T \propto M^{0.6}$

$x = 0.6$

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12. Cosmological redshift

(a) is due to actual motion of galaxies away from the Milky Way.

(b) can be measured due to transverse motion of the sources as seen by the observer.

(c) is due to the cumulative expansion of space along the photon's path from the source to the observer.

(d) is due to slowing down of time near heavy stars and galaxies.

Answer (c)

Sol. The cosmological red shift comes from the expansion of space, which stretches the photon's wavelength.

13. Planetary scientists are interested in the study of asteroids because asteroids are

(a) numerous and can easily be found anywhere and hence help to study stability of orbits.

(b) chemically undifferentiated due to their smaller mass and hence chemical composition of solar system can be determined.

(c) chemically volatile and reflect lot of light, hence can tell us more about their orbits.

(d) less massive and hence have very stable orbits.

Answer (b)

Sol. Asteroids are small so their chemical composition doesn't change.

So they preserve the early Solar-system composition.

$\Rightarrow$ They can help determine the composition of Solar System

$\Rightarrow$ (b) is correct.

14. In a true scale model of the Solar system, the Earth's size is represented by a one-rupee coin (diameter approximately 2.2 cm). At what average distance can the Jupiter be placed from this one-rupee coin?

(a) 12.2 km (b) 1.22 km

(c) 122 m (d) 12.2 m

Answer (b)

Sol. Diameter of Earth $\left(D_E\right) = 12742$ km

$\Rightarrow$ Model diameter of Earth $d_E = 2.2$ cm

$\therefore$ Scale factor $= \dfrac{2.2\times10^{-5}\text{ km}}{12742\text{ km}}$

Jupiter's distance from Sun, $R_J = 5.2$ AU

$\Rightarrow R_J \approx 7.78\times10^{8}$ km

$\therefore r_J = 7.78\times10^{8}\times\dfrac{2.2\times10^{-5}}{12742}$

$r_J \approx 1.22$ km

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15. Period of satellite Io around the planet Jupiter is 42.5 hours. It is tidally locked to Jupiter. Period of Jupiter around the Sun is 11.86 years while period of its rotation is 9 h 56 m. An observer located on the Equatorial region of Io, is seeing Jupiter almost overhead while the Sun on the Eastern horizon. In how much minimum time will she see the Sun on her Western horizon?

(a) 4.96 hours (b) 21.25 hours

(c) 5.93 years (d) Sun will not change position in the sky

Answer (b)

Sol. $T_{Io} = 42.5$ hrs

$T_J = 11.86$ years $= 103965$ hrs

$\therefore$ Synodic Period of I_o.

$$\frac{1}{T_s} = \frac{1}{T_{Io}} - \frac{1}{T_J}$$

$$\therefore \frac{1}{T_s} = \frac{1}{42.5} - \frac{1}{103965}$$

$$\Rightarrow T_s \approx 42.5 \text{ hrs}$$

$$\therefore T_{req} = \frac{T_s}{2} = 21.25 \text{ hrs}$$

16. Brightness of celestial object is given in magnitude. If the flux of energy received from two objects are I_1 and I_2, then their magnitudes (m_1 and m_2 respectively) are related to fluxes as $m_2 - m_1 = -2.5\log\left(\frac{I_2}{I_1}\right)$. A space probe from a distance of 50 pc is observing transit of Jupiter in front of the Sun. How much will be the change in magnitude when Jupiter's disc is fully in front of the Sun? Assume Sun's disc is uniformly bright. Sun's diameter is 109 times diameter of the Earth and Jupiter's diameter is 11 times that of the Earth.

(a) 0.01 (b) 0.02

(c) 0.04 (d) 0.5

Answer (a)

Sol. $$\frac{A_{\text{Jupiter}}}{A_{\text{sun}}} = \left(\frac{D_{\text{Jupiter}}}{D_{\text{sun}}}\right)^2 = \left(\frac{11}{109}\right)^2 \approx 0.01018$$

$$\therefore \frac{I_2}{I_1} = 1 - 0.01018 = 0.98982$$

$$\therefore \Delta m = m_2 - m_1 = -2.5\log_{10}\left(\frac{I_2}{I_1}\right)$$

$$\therefore \Delta m = -2.5 \times (-0.00444)$$

$$\approx 0.0111$$

$$\therefore \Delta m \approx 0.01$$

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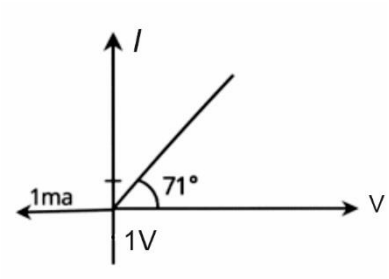
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17. A student applies various voltages (V) across a resistor and measures corresponding currents (I). She then plots the graph of I (1cm as 1 mA on Y axis) and V (1 cm as 1 V on X axis). The best fit line makes an angle of $71° \pm 1°$ with voltage axis. The value of resistor can be determined as

(a) 344 ± 5 Ω
(b) 344 ± 20 Ω
(c) 2.90 ± 0.04 kΩ
(d) 2.90 ± 0.16 kΩ

Answer (b)

Sol.



$$\frac{I}{V} = \tan 71°$$

$$\frac{V}{I} = \frac{1}{\tan 71°}$$

$$\frac{V}{I} = \frac{10^3}{2.904}$$

$$= 344.35\ \Omega$$

$$R = 1000\cot\theta$$

$$\frac{dR}{d\theta} = -1000\,\text{cosec}^2\theta$$

$$dR = \frac{1000}{(0.9455)^2} \times \frac{\pi}{180}$$

$$= 19.52$$

$$= 344 \pm 20\ \Omega$$

18. Weight of a cubical block is measured to be 360 gram force with a spring balance having least count of 20 gram force. Side length of the block, measured with least count of 1 mm, is equal to 13.6 cm. Calculation of pressure developed by the block on a table would have the uncertainty of

(a) 3 %
(b) 5 %
(c) 7 %
(d) will depend on size of the table

Answer (c)

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Sol. $P = \frac{F}{A}$

$$\frac{\Delta P}{P} = \frac{\Delta F}{F} + \frac{2\Delta l}{l}$$

$$= \left(\frac{20}{360} + \frac{2\times 1}{136}\right)\times 100$$

$$= 5.55 + 1.47$$

$$= 7.02\%$$

19. A truck of length 17 m is running on a straight highway with uniform speed of 60.0 km/hr. A car of length 3 m is running with zero acceleration on a track parallel to that of the truck. The car takes 3.6 seconds to completely overtake the truck. The speed of the car must be

(a) 20 km/hr (b) 71 km/hr

(c) 80 km/hr (d) 82 km/hr

Answer (c)

Sol. Let the speed of car is v_c, so

$$v_{rel} = (v_c - 60)\times\frac{5}{18}\ \text{m/s}$$

$$S_{rel} = 20\ \text{m}.$$

So

$$t = \frac{S_{rel}}{v_{rel}}$$

$$3.6 = \frac{20}{(v_c - 60)\times\frac{5}{18}}$$

$$v_c - 60 = \frac{20}{3.6}\times\frac{18}{5}$$

$$v_c = 80\ \text{km/hr}$$

20. A circular loop of radius R has N closely wound turns of a wire carrying current I. It is suspended vertically in a region of horizontal magnetic field of strength B in such a way that its area vector makes an angle of 30° with the magnetic field. Keeping the perimeter of the loop same if it is made into square shape,

(a) If the angle between area vector and B is increased to 60° without changing N, I and B the amount of torque will decrease.

(b) With the same N and I, to get the same amount of torque, angle between area vector and B should be increased without changing the magnitude of B.

(c) With the same N, I and orientation of the loop, torque developed will increase if magnitude of B is decreased.

(d) With the same N and orientation of the loop, to get the same torque developed, current I and magnitude of B should be decreased.

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Answer (b)

Sol. Let side of square is a

$2\pi R = 4a$

$a = \dfrac{\pi R}{2}$

Area of circle $A_1 = \pi R^2$

Area of square $A_2 = a^2 = \dfrac{\pi}{4} \cdot \pi R^2$

$A_1 > A_2$

$\tau = NIAB\sin\theta$

If N, I, B are same, then $\sin\theta\,(\text{for square}) > \sin\theta\,(\text{for circle})$

21. Consider following statements:

Statement I: During heavy winters ponds freeze from top.

Statement II: Volume of water increases on heating as well as cooling starting at 4°C.

Which of the following is correct conclusion.

(a) Both the statements are correct and statement II is the correct reason for statement I.

(b) Both the statements are correct but statement II is not the correct reason for statement I.

(c) Only statement I is correct.

(d) Only statement II is correct.

Answer (a)

Sol. Water has maximum density at 4°C, so Statement II is correct. Below 4°C water becomes lighter and goes up, so it freezes first and pond starts to freeze from top. Statement II explains Statement I.

22. A moving coil galvanometer with a coil having resistance R_G, is being used as a current meter, connecting a shunt resistance R_S << R_G parallel to the coil. The galvanometer now works with current sensitivity of 1 rad/microampere. Magnetic field of the MCG is now doubled and a resistance of 100 kΩ >> R_G is connected in series with its coil so that it can be used as a voltmeter. Voltage sensitivity of this voltmeter would be,

(a) 20 rad/mV (b) 2.0 rad/mV

(c) 0.20 rad/mV (d) 0.020 rad/mV

Answer (d)

Sol. $\phi_i = \dfrac{NAB_1}{k}$

$\phi_v = \dfrac{NAB_2}{kR}$

$\Rightarrow \dfrac{\phi_v}{\phi_i} = \dfrac{NAB_2/kR}{NAB_1/k} = \dfrac{2}{R}$

$\phi_v = \dfrac{2\phi_i}{R} = \dfrac{2\times10^6}{100\times10^3}$ = 20 rad/V

= 0.02 rad/mV

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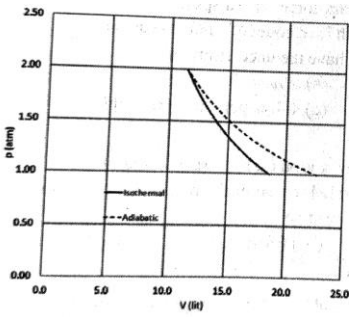
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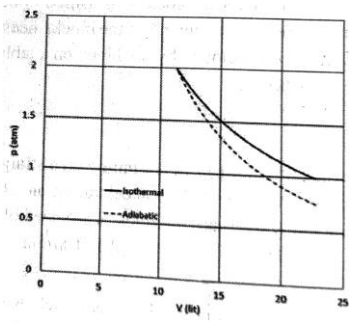
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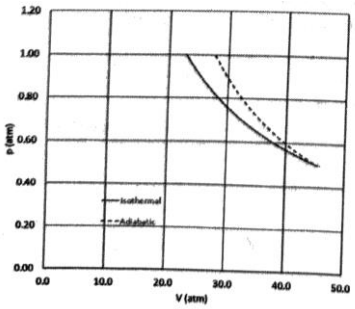
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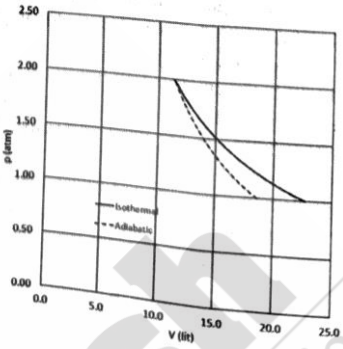
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23. A reversible process is an infinitesimally slow process that can be reversed without leaving any change in the system. One mole of air at STP is compressed isothermally and reversibly to one-half of the original volume. It is then expanded adiabatically and reversibly to its original pressure. Which of the following graphs correctly shows these processes?

(a) 

(b) 

(c) 

(d) 

Answer (d)

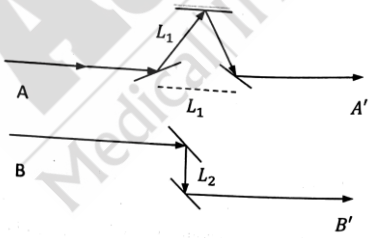
Sol. (a) Adiabatic has higher slope ⇒ incorrect

(b) Final pressure is different ⇒ incorrect

(c) Volume is increased ⇒ incorrect

(d) Slope is higher & volume is halved ⇒ correct

24. Two rays **A** & **B** are light waves of equal wavelength λ and they are in phase. Ray **A** gets reflected at three mirrors and ray **B** at two mirrors as shown in the figure. Distance between consecutive reflecting faces for A is L_1 and that for B is L_2 such that $L_2 = L_1/3$. The smallest value of L_1 giving A′ and B′ in phase is



(a) $\frac{3\lambda}{4}$

(b) $\frac{3\lambda}{5}$

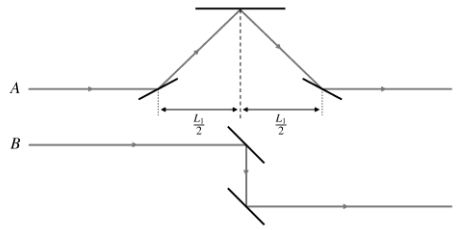
(c) $\frac{3\lambda}{10}$

(d) $\frac{3\lambda}{15}$

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Answer (a)

Sol.



$$\Delta x = 2L_1 + \frac{3\lambda}{2} - \left(L_1 + \frac{\lambda}{2} + L_2\right) = n\lambda$$

$$L_1 - L_2 + \frac{\lambda}{2} = n\lambda$$

$$L_1 - \frac{L_1}{3} + \frac{\lambda}{2} = n\lambda$$

$$\frac{2L_1}{3} + \frac{\lambda}{2} = \lambda$$

$$L_1 = \frac{3\lambda}{4}$$

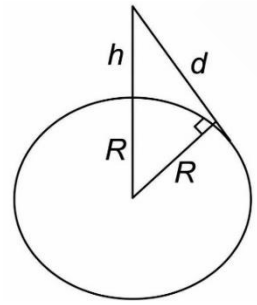
25. When a person of average height stands on a smooth surface with clear horizons, the approximate distance to the horizon from the person is

(a) 500 km (b) 50 km

(c) 15 km (d) 5 km

Answer (d)

Sol.



$(R + h)^2 = R^2 + d^2$

$R^2 + h^2 + 2Rh = R^2 + d^2$

$d \simeq \sqrt{2Rh}$

$d \simeq \sqrt{2 \times 6.4 \times 10^6 \times 1.5}$

$\simeq 5$ km

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26. Imagine a new scale for measuring sound energy is designed. In this scale, 1 μJ energy incident per unit second per square meter, is denoted as 0 sonus. Every increase of 4 sonus increases the sound energy by 100 times. Two identical sound sources of rating 3.2 sonus are played simultaneously. It was observed that one of them has its frequency slightly shifted, so they create beats. What will be the highest level of beats?

(a) 3.2 sonus
(b) 3.8 sonus
(c) 4.4 sonus
(d) 6.4 sonus

Answer (c)

Sol. Scale must be exponential

$$I(\text{SI value}) = 10^{\left(\frac{\text{sonus value}}{2}\right)}$$

$$\Rightarrow I_0 = 10^{n/2}$$

Here n is sonus numbers

In question $I_0 = 10^{3.2/2} = 10^{1.6}$

In beats, maximum intensity is $4I_0$

$$\Rightarrow I(\text{SI}) = 4 \times 10^{1.6} = 10^{n'/2}$$

$$\Rightarrow \frac{n'}{2} = 10^{0.6} \times 10^{1.6}$$

$$n' = 4.4$$

27. A radioactive sample of Na-24 used for irradiation of a patient is prepared exactly 6.0 hrs before it is to be used for a patient. It has half-life of 14.96 hrs. If it is expected to have activity of 40 kBq at the start of the treatment, what should be its mass when it is prepared?

(a) 5.90×10^{-4} μg
(b) 2.46×10^{-5} μg
(c) 3.94×10^{-6} μg
(d) 1.64×10^{-7} μg

Answer (d)

Sol. $A = A_0 e^{-\lambda t}$

$$A_0 = Ae^{\lambda t}$$

$$\lambda N_0 = Ae^{\lambda t}$$

$$N_0 = \frac{A}{\ln 2 / T_{1/2}} e^{\left(\frac{\ln 2}{T_{1/2}}\right)t}$$

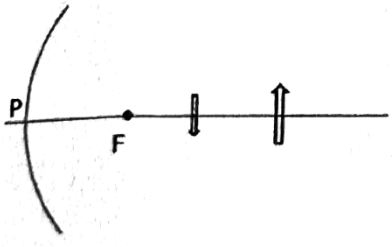
Mass = $N_0 \times 24 \times 1.6 \times 10^{-27}$

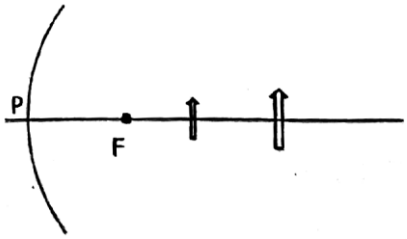
$$\text{Mass} = \frac{40 \times 10^3}{\ln 2} \times 14.96 \times 3600 \times e^{\frac{\ln 2}{14.96} \times 6} \times 24 \times 1.6 \times 10^{-27}$$

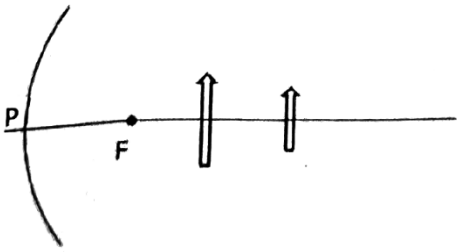
Mass = 1.64×10^{-7} μg

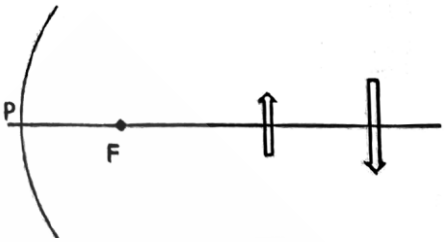
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28. A caterpillar is in front of a concave mirror of focal length *f* as shown in the diagram. It is located at a distance of 2.5 *f* from the pole of the mirror and its height, perpendicular to the axis is 1.2 cm. Select the correct image of caterpillar for this situation. Caterpillar is shown with an upright arrow at the same location in all images. The other arrow is the image.

(a) 

(b) 

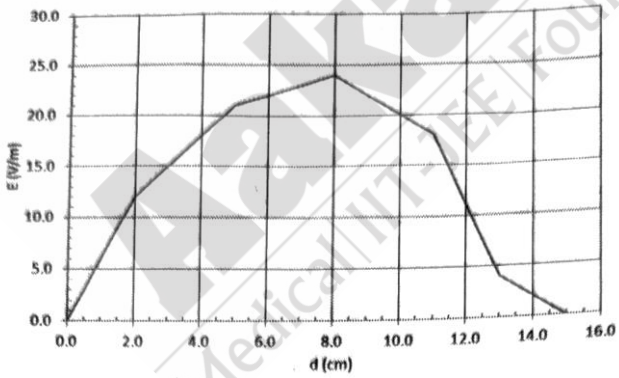
(c) 

(d) 

Answer (a)

Sol. The object is placed between R & ∞ so the nature of image is "real", "inverted" and "smaller than the object" and the image will be between f & r. Only matching option is (a)

29. A proton moves in variable electric field as shown in the graph. If original speed of proton is 2.00 km/s, what is its final speed?



(a) 22.4 km/s

(b) 20.5 km/s

(c) 205 km/s

(d) 880 km/s

Answer (b)

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Sol. Total Area $= \left[\begin{array}{l} \frac{1}{2}\times 2\times 12+\frac{1}{2}\times(12+18)\times 2+\frac{1}{2}\times(18+21)\times 1 \\ +\frac{1}{2}\times(21+24)\times 3+\frac{1}{2}\times(24+20)\times 2 \\ +\frac{1}{2}\times(20+18)\times 1+\frac{1}{2}\times(18+4.5)\times 2 \\ +\frac{1}{2}\times(4.5+0.5)\times 2 \end{array}\right]\times 10^{-2}$

$= 2.2$ volt

Potential difference $(\Delta V) = 2.2$ volt

ΔK.E. $= W$

$$\frac{mv^2}{2}-\frac{mu^2}{2}=e\Delta V$$

$$v^2 = u^2+\frac{2eV}{m}$$

$$v^2 = \left(2\times 10^3\right)^2+\frac{2\times 1.6\times 10^{-19}\times 2.2}{1.67\times 10^{-27}}$$

$$v^2 = 4.25\times 10^8$$

$v = 20.5$ km / sec

30. A compressor designed to compress air is used to compress Helium instead of air near room temperature. Select correct statement regarding the functioning of this compressor with Helium. When the compressor is used for the same gauge reading, it will

(a) be overheated
(b) develop less pressure than that for air
(c) be cooled
(d) compress the gas to smaller volume

Answer (a)

Sol. $\gamma_{He} = 1.66$

$\gamma_{air} = 1.4$

Same gauge reading, so pressure is same

$$T \propto P^{\frac{\gamma-1}{\gamma}}$$

for He, $\frac{1.66-1}{1.66} = 0.39$

for air, $\frac{1.4-1}{1.4} = 0.28$

$T_{He} > T_{air}$

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31. An athlete weighing 60 kg has participated in hammer throw. Weight of the hammer is 4.0 kg. It is connected to a non-stretchable wire. The distance between grip and the hammer head is 1.16 m. At the time of releasing the hammer, athlete stretches her hands such that the grip of the hammer is at 32 cm from the axis of rotation. To achieve the linear velocity of 27 m/s, the centrifugal force on the hammer and the time it should complete each rotation is,

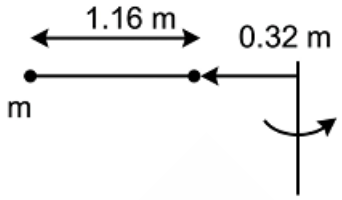
(a) 36496 N, 0.36 s
(b) 30512 N, 0.27 s
(c) 1970 N, 0.34 s
(d) 1906 N, 0.27 s

Answer (c)

Sol. $F = \frac{mv^2}{R}$

$= \frac{4 \times 27 \times 27}{1.48} = 1970\ \text{N}$

$t = \frac{2\pi r}{v} = \frac{2\pi \times 1.48}{27} = 0.34$



32. An astronomical telescope with a primary mirror of 600 mm focal length is focussed for distant object using an eyepiece of focal length 15 mm. When a concave lens of 30 mm focal length is introduced between the primary and eyepiece to triple magnification of the system by what distance eyepiece needs to be shifted when focussed for distant object?

(a) 15 mm
(b) 30 mm
(c) 40 mm
(d) 45 mm

Answer (c)

Sol. $\frac{1}{v} - \frac{1}{u} = \frac{1}{f}$

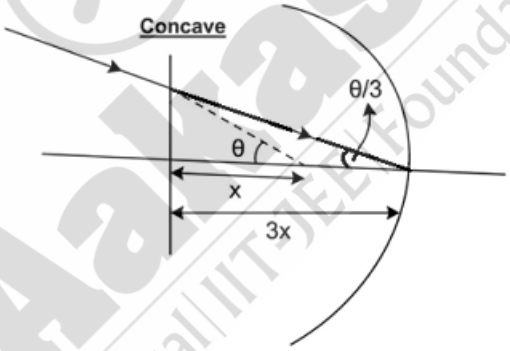
$f = -30$ mm

$\frac{1}{3x} - \frac{1}{x} = -\frac{1}{30}$

$-\frac{2}{3x} = -\frac{1}{30}$

$x = 20$

Shift = 2x = 40 mm



33. If $\alpha, \beta, \gamma \in \left(0, \frac{\pi}{2}\right)$ such that $\tan\alpha + \tan\beta + \tan\gamma = \tan\alpha\tan\beta\tan\gamma$, then the value of $\cos^2\alpha + \cos^2\beta + \cos^2\gamma + 2\cos\alpha\cos\beta\cos\gamma$ is

(a) 0
(b) 1
(c) 2
(d) –1

Answer (b)

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Sol. Given: $\tan\alpha+\tan\beta+\tan\gamma=\tan\alpha\tan\beta\tan\gamma$.

Using the tangent addition formula:

$$\tan(\alpha+\beta+\gamma)=\frac{\tan\alpha+\tan\beta+\tan\gamma-\tan\alpha\tan\beta\tan\gamma}{1-(\tan\alpha\tan\beta+\tan\beta\tan\gamma+\tan\gamma\tan\alpha)}=0$$

Since $\alpha,\beta,\gamma\in(0,\pi/2)$, we have $\alpha+\beta+\gamma=\pi$. Thus, $\gamma=\pi-(\alpha+\beta)\Rightarrow\cos\gamma=-\cos(\alpha+\beta)$.

Substitute this into the given expression:

$$E=\cos^2\alpha+\cos^2\beta+\cos^2(\alpha+\beta)-2\cos\alpha\cos\beta\cos(\alpha+\beta)$$

Expand $\cos(\alpha+\beta)=\cos\alpha\cos\beta-\sin\alpha\sin\beta$:

$$E=\cos^2\alpha+\cos^2\beta+(\cos\alpha\cos\beta-\sin\alpha\sin\beta)^2-2\cos\alpha\cos\beta(\cos\alpha\cos\beta-\sin\alpha\sin\beta)$$

$$E=\cos^2\alpha+\cos^2\beta+\cos^2\alpha\cos^2\beta-2\cos\alpha\cos\beta\sin\alpha\sin\beta+\sin^2\alpha\sin^2\beta-2\cos^2\alpha\cos^2\beta+2\cos\alpha\cos\beta\sin\alpha\sin\beta$$

Cancel the middle terms:

$$E=\cos^2\alpha+\cos^2\beta-\cos^2\alpha\cos^2\beta+\sin^2\alpha\sin^2\beta$$

Substitute $\sin^2\alpha\sin^2\beta=(1-\cos^2\alpha)(1-\cos^2\beta)=1-\cos^2\alpha-\cos^2\beta+\cos^2\alpha\cos^2\beta$:

$$E=\cos^2\alpha+\cos^2\beta-\cos^2\alpha\cos^2\beta+1-\cos^2\alpha-\cos^2\beta+\cos^2\alpha\cos^2\beta=1$$

34. If $\begin{vmatrix}1+x & 1 & 1\\ 1 & 1+y & 1\\ 1 & 1 & 1+z\end{vmatrix}=0$, and $xyz\neq0$; then

(a) $\frac{1}{x}+\frac{1}{y}+\frac{1}{z}=1$ (b) $\frac{1}{x}+\frac{1}{y}+\frac{1}{z}=0$

(c) $\frac{1}{x}+\frac{1}{y}+\frac{1}{z}=-1$ (d) $\frac{1}{x}+\frac{1}{y}+\frac{1}{z}=-2$

Answer (c)

Sol. Expand the determinant along the first row:

$$(1+x)[(1+y)(1+z)-1]-1[(1+z)-1]+1[1-(1+y)]=0$$

Simplify the terms inside the brackets:

$$(1+x)(y+z+yz)-z-y=0$$

$$y+z+yz+xy+xz+xyz-z-y=0$$

$$xy+yz+zx+xyz=0$$

Divide by xyz (since $xyz\neq0$):

$$\frac{1}{z}+\frac{1}{x}+\frac{1}{y}+1=0\quad\frac{1}{x}+\frac{1}{y}+\frac{1}{z}=-1$$

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35. $\sum_{k=1}^{n} \frac{1}{k(k+1)(k+2)} =$

(a) $\frac{1}{4}+\frac{1}{2(n+1)(n+2)}$ (b) $\frac{1}{4}-\frac{1}{2(n+1)(n+2)}$

(c) $\frac{1}{2}-\frac{1}{(n+1)(n+2)}$ (d) $\frac{1}{2(n+1)}$

Answer (b)

Sol. Use partial fractions:

$$\frac{1}{k(k+1)(k+2)} = \frac{1}{2}\left(\frac{1}{k(k+1)} - \frac{1}{(k+1)(k+2)}\right)$$

Sum from $k = 1$ to n (telescoping series):

$$S_n = \frac{1}{2}\left[\left(\frac{1}{1\cdot 2} - \frac{1}{2\cdot 3}\right) + \left(\frac{1}{2\cdot 3} - \frac{1}{3\cdot 4}\right) + \cdots + \left(\frac{1}{n(n+1)} - \frac{1}{(n+1)(n+2)}\right)\right]$$

Cancel intermediate terms:

$$S_n = \frac{1}{2}\left[\frac{1}{2} - \frac{1}{(n+1)(n+2)}\right]$$

$$S_n = \frac{1}{4} - \frac{1}{2(n+1)(n+2)}$$

36. The area (in appropriate units) enclosed by $y = x^3 - 4x + 3$ and $y = 3 - x$ is

(a) $\frac{3}{2}$ (b) $\frac{9}{2}$

(c) 6 (d) 9

Answer (b)

Sol. Find intersection points by equating the curves

$x^3 - 4x + 3 = 3 - x \Rightarrow 3 - 3x = 0 \Rightarrow x(x^2 - 3) = 0$

The intersection points are $x = 0, \pm\sqrt{3}$. The area is given by

$$A = \int_{-\sqrt{3}}^{\sqrt{3}} |(x^3 - 4x + 3) - (3 - x)|\, dx = \int_{-\sqrt{3}}^{\sqrt{3}} |x^3 - 3x|\, dx$$

Since $f(x) = x^3 - 3x$ is an odd function, the area is symmetric. In the interval $[0, \sqrt{3}]$, $x^3 - 3x \le 0$

$$A = \int_{0}^{\sqrt{3}} -(x^3 - 3x)\, dx = 2\int_{0}^{\sqrt{3}} (3x - x^3)\, dx$$

$$A = 2\left[\frac{3x^2}{2} - \frac{x^4}{4}\right]_0^{\sqrt{3}} = 2\left(\frac{9}{2} - \frac{9}{4}\right) = 2\left(\frac{9}{4}\right) = \frac{9}{2}$$

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37. If $a_n = \frac{1}{\sqrt{n}+\sqrt{n+1}}$, then $\sum_{n=1}^{99} a_n = ?$

(a) 9 (b) 10

(c) $\sqrt{99}-1$ (d) 11

Answer (a)

Sol. Given $a_n = \frac{1}{\sqrt{n}+\sqrt{n+1}}$.

Rationalize the denominator

$$a_n = \frac{\sqrt{n+1}-\sqrt{n}}{(\sqrt{n+1}+\sqrt{n})(\sqrt{n+1}-\sqrt{n})} = \sqrt{n+1}-\sqrt{n}$$

Now, find the sum from n = 1 to 99 (telescoping series)

$$\sum_{n=1}^{99} a_n = \sum_{n=1}^{99}(\sqrt{n+1}-\sqrt{n})$$

$$= (\sqrt{2}-\sqrt{1})+(\sqrt{3}-\sqrt{2})+\ldots+(\sqrt{100}-\sqrt{99})$$

All intermediate terms cancel out

$$= \sqrt{100}-\sqrt{1} = 10-1 = 9$$

38. If $f(x) = x^x$, then $f'(1) = ?$

(a) 0 (b) 1

(c) 2 (d) e

Answer (b)

Sol. Given $f(x) = x^x$.

To differentiate, take the natural logarithm of both sides,

$\ln(f(x)) = \ln(x^x) = x\ln x$

Differentiate both sides with respect to x,

$$\frac{1}{f(x)}\cdot f'(x) = 1\cdot \ln x + x\cdot\frac{1}{x}$$

$f'(x) = f(x)(\ln x + 1) = x^x(\ln x + 1)$

Evaluate at x = 1,

$f'(1) = 1^1(\ln 1 + 1) = 1(0 + 1) = 1$

39. The number of 5 digit numbers formed using 1, 2, 3, 4, 5 without repetition and divisible by 6 is

(a) 24 (b) 36

(c) 40 (d) 48

Answer (d)

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Sol. For a number to be divisible by 6, it must be divisible by both and 3. The sum of digits is 1 + 2 + 3 + 4 + 5 = 15, which is divisible by 3. Thus, any permutation is divisible by 3. For divisibility by 2, the last digit must be even. The available even digits are 2 and 4.

- Case 1 : Last digit is 2. The remaining 4 digits can be arranged in 4! = 24 ways.
- Case 2 : Last digit is 4. The remaining 4 digits can be arranged in 4! = 24 ways.

Total number of ways = 24 + 24 = 48

40. A number is chosen randomly from 1, 2, 3, …, 100. The probability that it is divisible by neither 2 nor 5 is

(a) $\frac{2}{5}$ (b) $\frac{1}{2}$

(c) $\frac{3}{5}$ (d) $\frac{5}{2}$

Answer (a)

Sol. Total numbers in the sample space = 100. Let A be the set of numbers divisible by 2 : $n(A)=\frac{100}{2}=50$. Let be the set of numbers divisible by 5 : $n(B)=\frac{100}{5}=20$. Intersection $A \cap B$ (divisible by both 2 and 5, *i.e.*, by 10) : $n(A\cap B)=\frac{100}{10}=10$. Using the principle of inclusion-exclusion, the number of outcomes divisible by 2 or 5 is

$n(A \cup B) = n(A) + n(B) - n(A \cap B) = 50 + 20 - 10 = 60$

Numbers divisible by neither 2 nor 5 = 100 – 60 = 40.

Probability = $\frac{40}{100}=\frac{2}{5}$

41. If $z+\frac{1}{z}=2, z\neq 0$ and $z\in\mathbb{C}$, then $z^{2026}+\frac{1}{z^{2026}}=$

(a) 0 (b) 1

(c) 2 (d) 2026

Answer (c)

Sol. Given: $z+\frac{1}{z}=2$. Multiply by z (since $z\neq 0$):

$z^2+1=2z \Rightarrow z^2-2z+1=0 \Rightarrow (z-1)^2=0$

Thus, $z=1$. Substitute $z=1$ into the required expression:

$z^{2026}+\frac{1}{z^{2026}}=1^{2026}+\frac{1}{1^{2026}}=1+1=2$

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42. The number of solutions of $\sin x + \sin 2x + \sin 3x = 0$ in $[0, 2\pi]$ is

(a) 4 (b) 5

(c) 6 (d) 7

Answer (c)

Sol. Given equation: $\sin x + \sin 2x + \sin 3x = 0$. Group the terms to use sum-to-product formula $\left(\sin A + \sin B = 2\sin\frac{A+B}{2}\cos\frac{A-B}{2}\right)$:

$(\sin x + \sin 3x) + \sin 2x = 0$

$2\sin(2x)\cos(x) + \sin 2x = 0$

Factor out $\sin 2x$:

$\sin 2x(2\cos x + 1) = 0$

This gives two cases: 1. $\sin 2x = 0 \Rightarrow 2x = k\pi \Rightarrow x = \frac{k\pi}{2}$. For $x \in [0, 2\pi)$, $x = 0, \frac{\pi}{2}, \pi, \frac{3\pi}{2}$ (4 solutions). 2. $2\cos x + 1 = 0 \Rightarrow \cos x = -\frac{1}{2}$. For $x \in [0, 2\pi)$, $x = \frac{2\pi}{3}, \frac{4\pi}{3}$ (2 solutions). Total number of solutions $= 4 + 2 = 6$.

43. If an integer n leaves reminder 1, when divided by 2 and 3, then $n^2 - 1$ is always divisible by

(a) 6 (b) 13

(c) 24 (d) 36

Answer (a and c Both are correct)

Sol. Given n leaves a remainder of 1 when divided by 2 and 3. This implies:

$n - 1$ is divisible by 2 and 3

Since $\gcd(2,3) = 1$, $n - 1$ is divisible by their LCM, which is 6. So, $n = 6k + 1$ for some integer k. We need to check divisibility of $n^2 - 1$:

$n^2 - 1 = (6k+1)^2 - 1 = 36k^2 + 12k + 1 - 1 = 12k(3k+1)$

If k is even, $k = 2m$, then $12k(3k+1) = 24m(3k+1)$, which is divisible by 24. If k is odd, $3k + 1$ is even $(\text{odd} \times 3 + 1 = \text{even})$. Let $3k + 1 = 2m$, then $12k(3k+1) = 24km$, which is divisible by 24. Therefore, $n^2 - 1$ is always divisible by 24.

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44. Consider $f(x)=\sin^{-1}(\sin x)+\cos^{-1}(\cos x)$ for $x\in[-\pi,2\pi]$. Which of the following correctly describes f ?

(a) $f(x)=2x$ for all $x\in[-\pi,2\pi]$.

(b) f is piecewise linear and takes the value π on the interval $\left[\frac{\pi}{2},\pi\right]$.

(c) $f(x)=0$ for all $x\in[0,\pi]$.

(d) The range of f on $[-\pi,2\pi]$ is $[0,2\pi]$.

Answer (b)

Sol. Consider $f(x)=\sin^{-1}(\sin x)+\cos^{-1}(\cos x)$ for $x\in[-\pi,2\pi]$. Let's analyze the functions on different intervals:

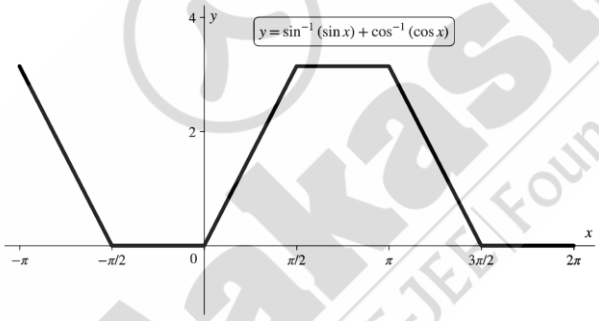
For $x\in[-\pi,-\pi/2]$: $\sin^{-1}(\sin x)=-\pi-x$ and $\cos^{-1}(\cos x)=-x$. So, $f(x)=-\pi-2x$.

For $x\in[-\pi/2,0]$: $\sin^{-1}(\sin x)=x$ and $\cos^{-1}(\cos x)=-x$. So, $f(x)=0$.

For $x\in[0,\pi/2]$: $\sin^{-1}(\sin x)=x$ and $\cos^{-1}(\cos x)=x$. So, $f(x)=2x$.

For $x\in[\pi/2,\pi]$: $\sin^{-1}(\sin x)=\pi-x$ and $\cos^{-1}(\cos x)=x$. So, $f(x)=(\pi-x)+x=\pi$.

For $x\in[\pi,2\pi]$: The function continues piecewise linearly.



Graph of $f(x)=\sin^{-1}(\sin x)+\cos^{-1}(\cos x)$ on $[-\pi,2\pi]$

Looking at the options, $f(x)$ is indeed piecewise linear and takes the constant value π on the interval $\left[\frac{\pi}{2},\pi\right]$.

45. Bag X contains 3 red and 4 black balls; Bag Y contains 5 red and 3 black balls. One ball is transferred at random from X to Y, and then one ball is drawn at random from Y. The probability that the drawn ball is red equals:

(a) $\frac{38}{63}$ (b) $\frac{5}{9}$

(c) $\frac{37}{63}$ (d) $\frac{17}{28}$

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Answer (a)

Sol. Use the Law of Total Probability. Let R be the event of drawing a red ball.

Probability of transferring a red ball from X to Y: $P(R_X) = \frac{3}{7}$.

Probability of transferring a black ball from X to Y: $P(B_X) = \frac{4}{7}$.

After transfer, Bag Y will have a total of 9 balls.

If a red ball is transferred, Y has 6 red, 3 black. $P(R \mid R_X) = \frac{6}{9} = \frac{2}{3}$.

If a black ball is transferred, Y has 5 red, 4 black. $P(R \mid B_X) = \frac{5}{9}$.

$$P(R) = P(R_X) \cdot P(R \mid R_X) + P(B_X) \cdot P(R \mid B_X)$$

$$P(R) = \left(\frac{3}{7} \cdot \frac{6}{9}\right) + \left(\frac{4}{7} \cdot \frac{5}{9}\right) = \frac{18}{63} + \frac{20}{63} = \frac{38}{63}$$

46. The maximum area of a quadrilateral with sides 1.0 cm, 4.0 cm, 7.0 cm, 8.0 cm is

(a) $\sqrt{799}$ cm²
(b) 3.5 cm²
(c) 18.0 cm²
(d) 11.06 cm²

Answer (c)

Sol. The area of a quadrilateral with given side lengths is maximized when it is a cyclic quadrilateral (inscribed in a circle). By Brahmagupta's formula, the maximum area A is given by:

$$A = \sqrt{(s-a)(s-b)(s-c)(s-d)}$$

where a, b, c, d are the side lengths and s is the semi-perimeter.

$$s = \frac{a+b+c+d}{2} = \frac{1.0+4.0+7.0+8.0}{2} = \frac{20}{2} = 10$$

$$A = \sqrt{(10-1)(10-4)(10-7)(10-8)}$$

$$A = \sqrt{9 \cdot 6 \cdot 3 \cdot 2} = \sqrt{9 \cdot 36} = 3 \cdot 6 = 18.0 \text{ cm}^2$$

47. A sequence is defined by $a_1 = 1$, $a_{n+1} = a_n + \frac{1}{a_n^2}$. Choose the correct option from the following.

(a) $\lim_{n\to\infty} a_n = 0$
(b) $\lim_{n\to\infty} a_n$ is a finite number
(c) $a_{3000} > 30$
(d) $a_{3000} < 30$

Answer (d)

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Sol. Given $a_1 = 1$ and $a_{n+1} = a_n + \frac{1}{a_n^2}$. Since $a_1 > 0$ and $1/a_n^2 > 0$, the sequence is strictly increasing $(a_{n+1} > a_n)$, so it cannot converge to 0. Thus, (a) is false. Also, $a_{n+1} - a_n = \frac{1}{a_n^2} > 0$. As $n \to \infty$, the sequence is increasing and bounded below by 1, but since the difference doesn't go to 0 fast enough (it's at least $1/a_n^2 \geq 1/n^2$ if $a_n \leq n$, but actually a_n grows slower than n), let's formalize the growth. Consider a_{n+1}^3:

$$a_{n+1}^3 = \left(a_n + \frac{1}{a_n^2}\right)^3 = a_n^3 + 3a_n^2\left(\frac{1}{a_n^2}\right) + 3a_n\left(\frac{1}{a_n^4}\right) + \frac{1}{a_n^6} = a_n^3 + 3 + \frac{3}{a_n^3} + \frac{1}{a_n^6}$$

Since $a_n \geq 1$ for all n, $\frac{3}{a_n^3} \leq 3$ and $\frac{1}{a_n^6} \leq 1$. Therefore:

$$a_{n+1}^3 - a_n^3 \leq 3 + 3 + 1 = 7$$

Summing from $k = 1$ to $n-1$:

$$a_n^3 - a_1^3 = \sum_{k=1}^{n-1}\left(a_{k+1}^3 - a_k^3\right) \leq \sum_{k=1}^{n-1} 7 = 7(n-1)$$

$$a_n^3 \leq 1 + 7(n-1)$$

For $n = 3000$:

$$a_{3000}^3 \leq 1 + 7(2999) = 20994$$

Since $30^3 = 27000$ and $20994 < 27000$, we have $a_{3000}^3 < 30^3$, which implies $a_{3000} < 30$.

48. Consider the following functional equation for a real valued function on real numbers

$$f(x+y) + f(x-y) = 2f(x)f(y)$$

and f is not identically zero function.

Choose the correct option from the following:

(a) f is an odd function

(b) f is always differentiable on the set of real numbers

(c) f is always a periodic function

(d) $f(0) = 1$

Answer (d)

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Sol. Given the functional equation $f(x+y)+f(x-y)=2f(x)f(y)$ and f is not identically zero. Let $x=y=0$:

$f(0)+f(0)=2f(0)f(0)\ 2f(0)=2(f(0))^2\ f(0)(f(0)-1)=0$

So, $f(0)=0$ or $f(0)=1$. If $f(0)=0$, setting $y=0$ in the original equation gives:

$f(x)+f(x)=2f(x)f(0)\ 2f(x)=0\ f(x)=0$ for all x.

This contradicts the condition that f is not identically zero. Therefore, $f(0)\neq 0$, which means $f(0)=1$.

A – 2

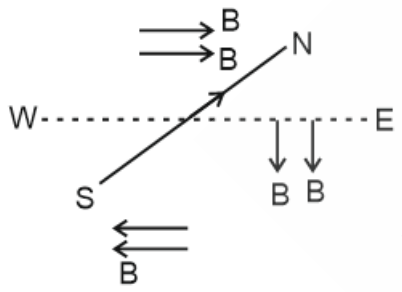
ANY NUMBER OF OPTIONS (4, 3, 2 or 1) MAY BE CORRECT

MARKS WILL BE AWARDED ONLY IF ALL THE CORRECT OPTIONS ARE BUBBLED AND NO INCORRECT

49. A current carrying conductor is kept horizontal along North – South. It carries current from South to North. A small magnetic needle, free to rotate about vertical axis can be held in the neighbourhood of the conductor. If the needle is held
    (a) above the conductor, its North pole deflects towards East.
    (b) below the conductor, its South pole deflects towards East.
    (c) East of the conductor in the same horizontal plane, North pole deflects towards East.
    (d) West of the conductor in the same horizontal plane, South pole deflects towards East.

Answer (a, b)

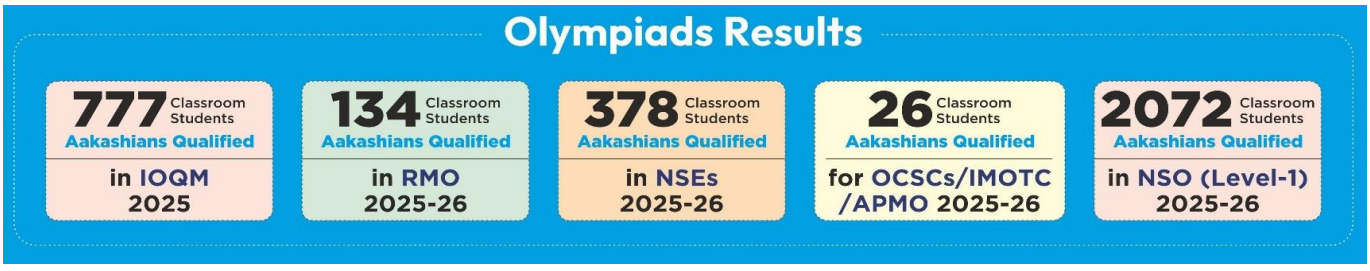
Sol.



North pole deflects in the direction of magnetic field and south in the opposite direction of field.

50. A charge given to a solid copper sphere, kept on insulator stand, distributes uniformly on its surface only. Which of the following principles is/are involved in this fact?
    (a) Like charges repel each other.
    (b) Copper is a good conductor.
    (c) Shape of the conductor is sphere.
    (d) Every system tries to minimize its potential energy.

Answer (a, b, c, d)



Sol. (a) Like charges repel each other apart as far as they can go.

(b) Copper is a good conductor, that's why charges are able to move freely and can go to the surface.

(c) Every point on sphere is symmetrical, so charge distribution is uniform.

(d) Charges always try to settle in a way such that potential energy of system is minimized.

51. Assume Earth as a sphere with density radially increasing from surface (3 g/cc) to the core (>15 g/cc). Which of the following statements is/are correct statements?

(a) Gravitational field at height h above the surface will never be greater than field on the surface.

(b) Gravitational field at some depth d below the surface can be greater than field on the surface.

(c) Gravitational potential will always decrease as one moves towards the centre from surface.

(d) Gravitational potential near the centre of the Earth can be taken zero for calculations.

Answer (a, b, c, d)

Sol. (a) $E_{surface} = \frac{GM_{total}}{R^2}$

$$E(r > R) = \frac{GM}{(R+h)^2}$$

(b) Let $\rho = -\frac{12r}{R} + 15$

$$m(r) = \int_0^r \rho 4\pi r^2 \, dr$$

$$= 4\pi\left[5r^3 - \frac{3r^4}{R}\right]$$

$$g = \frac{Gm}{r^2} = 4\pi G\left[5r - \frac{3r^2}{R}\right]$$

$$\frac{dg}{dr} = 0$$

$$r = \frac{5R}{6}$$

(c) Potential decreases in the direction of field.

(d) Reference can be taken anywhere.

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52. If the Planck's constant increases by 1 order of magnitude and speed of light reduces by one order of magnitude, without changing any other constants, which of the following will hold true?

(a) Energy of hydrogen atoms will reduce by 2 orders of magnitude

(b) Wavelength of hydrogen spectral lines will increase by 2 orders of magnitude

(c) Electron's rest mass energy will reduce by 2 orders of magnitude

(d) Moment of inertia of diatomic molecules will increase by 2 orders of magnitude.

Answer (a, b, c)

Sol. (a) $E = \frac{me^4}{8 \in h^2 n^2}$ $\quad h \to h + 1$

$c \to c - 1$

$E \propto \frac{1}{h^2} \quad \Rightarrow$ (a) is correct

(b) $E_p = \frac{hc}{\lambda} = \Delta E \propto \frac{1}{h^2}$

$\lambda \propto h^3 c \quad \propto 10^3 \times 10^{-1}$ (b) is correct

(c) $E = mc^2 \to \frac{mc^2}{100}$ (c) is correct

(d) $r = \frac{\in_0 h^2 n^2}{\pi m_e e^2} \Rightarrow r \to 100$

$I = mr^2 \quad I \to 100 \times 100$

(d) is incorrect

53. Let $a_n = x^n + \frac{1}{x^n}$, where $x + \frac{1}{x} = 3$. Which of the following are correct?

(a) $a_n = 3a_{n-1} - a_{n-2}$ (b) $a_2 = 7$

(c) $a_4 = 49$ (d) $a_6 = 322$

Answer (a, b, d)

Sol. $a_n = x^n + \frac{1}{x^n}$ and $x + \frac{1}{x} = 3.$

$\because \left(x^{n-1} + \frac{1}{x^{n-1}}\right)\left(x + \frac{1}{x}\right) = x^n + x^{n-2} + \frac{1}{x^{n-2}} + \frac{1}{x^n}$

$\therefore 3a_{n-1} = a_n + a_{n-2}$

$\therefore a_n = 3a_{n-1} - a_{n-2}, \ \forall n \geq 3.$

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and $a_2 = x^2 + \frac{1}{x^2} = \left(x + \frac{1}{x}\right)^2 - 2 = 9 - 2 = 7$

$a_3 = 3a_2 - a_1 = 3 \cdot 7 - 3 = 18$

$a_4 = 3a_3 - a_2 = 54 - 7 = 47$

$a_5 = 3 \cdot 47 - 18 = 123$

$a_6 = 3 \cdot 123 - 47 = 322$

54. Let $\Delta = \begin{vmatrix} a+b & c & c \\ c+a & b & a \\ b+c & a & b \end{vmatrix}$. Which of the following are correct?

(a) $\Delta = 0$

(b) $a + b + c = 0 \Rightarrow \Delta = 0$

(c) Δ changes sign, if a and b are interchanged

(d) Δ is divisible by $(a - b)$

Answer (b, c, d)

Sol. $\Delta = \begin{vmatrix} a+b & c & c \\ c+a & b & a \\ b+c & a & b \end{vmatrix}$

$= (a+b+c)\begin{vmatrix} 1 & c & c \\ 1 & b & a \\ 1 & a & b \end{vmatrix}, \; C_1 \to C_1 + C_2$

$= (a+b+c)\begin{vmatrix} 1 & c & c \\ 0 & b-c & a-c \\ 0 & a-b & b-a \end{vmatrix} \begin{matrix} R_2 \to R_2 - R_1 \\ R_3 \to R_3 - R_2 \end{matrix}$

$= (a+b+c)(a-b)\begin{vmatrix} 1 & c & c \\ 0 & b-c & a-c \\ 0 & 1 & -1 \end{vmatrix}$

$= (a + b + c)(a - b)(2c - a - b)$

55. Let $\vec{a}$, $\vec{b}$ and $\vec{c}$ be the three non-coplanar vectors to define other three vectors $\vec{p}$, $\vec{q}$ and $\vec{r}$ such that

$\vec{p} = \frac{\vec{b} \times \vec{c}}{\left[\vec{a}\,\vec{b}\,\vec{c}\right]}$, $\vec{q} = \frac{\vec{c} \times \vec{a}}{\left[\vec{a}\,\vec{b}\,\vec{c}\right]}$ and $\vec{r} = \frac{\vec{a} \times \vec{b}}{\left[\vec{a}\,\vec{b}\,\vec{c}\right]}$.

Which of the following is/are necessarily true?

(a) $\vec{a} \cdot \vec{p} + \vec{b} \cdot \vec{q} + \vec{c} \cdot \vec{r} = 3$

(b) $\vec{a} \cdot \vec{q} = 0$

(c) $\left[\vec{p}\,\vec{q}\,\vec{r}\right] = \frac{1}{\left[\vec{a}\,\vec{b}\,\vec{c}\right]}$

(d) $\vec{p}, \vec{q}, \vec{r}$ are coplanar

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Answer (a, b, c)

Sol. $\vec{p}=\frac{\vec{b}\times\vec{c}}{\left[\vec{a}\,\vec{b}\,\vec{c}\right]}, \vec{q}=\frac{\vec{c}\times\vec{a}}{\left[\vec{a}\,\vec{b}\,\vec{c}\right]}$

$\vec{r}=\frac{\vec{a}\times\vec{b}}{\left[\vec{a}\,\vec{b}\,\vec{c}\right]}$

$\therefore \vec{a}\cdot\vec{p}+\vec{b}\cdot\vec{q}+\vec{c}\cdot\vec{r}=\frac{3\left[\vec{a}\,\vec{b}\,\vec{c}\right]}{\left[\vec{a}\,\vec{b}\,\vec{c}\right]}=3$

Option (a) correct

and $\vec{a}\cdot\vec{q}=\frac{\vec{a}\cdot\left(\vec{c}\times\vec{a}\right)}{\left[\vec{a}\,\vec{b}\,\vec{c}\right]}=\frac{0}{\left[\vec{a}\,\vec{b}\,\vec{c}\right]}=0$

Option (b) correct

Now $\vec{q}\times\vec{r}=\frac{\left(\vec{c}\times\vec{a}\right)\times\left(\vec{a}\times\vec{b}\right)}{\left[\vec{a}\,\vec{b}\,\vec{c}\right]^2}=\frac{\left[\vec{c}\,\vec{a}\,\vec{b}\right]\vec{a}-\left[\vec{c}\,\vec{a}\,\vec{a}\right]\vec{b}}{\left[\vec{a}\,\vec{b}\,\vec{c}\right]^2}$

$=\frac{\left[\vec{a}\,\vec{b}\,\vec{c}\right]\vec{a}}{\left[\vec{a}\,\vec{b}\,\vec{c}\right]^2}$

$\therefore \left[\vec{p}\,\vec{q}\,\vec{r}\right]=\frac{\left(\vec{b}\times\vec{c}\right)\cdot\vec{a}}{\left[\vec{a}\,\vec{b}\,\vec{c}\right]^2}=\frac{1}{\left[\vec{a}\,\vec{b}\,\vec{c}\right]}$

$\therefore$ Option (c) is correct.

and Option (d) is incorrect.

56. An ellipse has foci at F_1 (1, 0) and F_2 (–1, 0) and passes through the point $P\left(1,\frac{1}{\sqrt{2}}\right)$. Which of the following are correct?

(a) $a^2 = 2, b^2 = 1$

(b) The eccentricity is $e=\frac{1}{\sqrt{2}}$

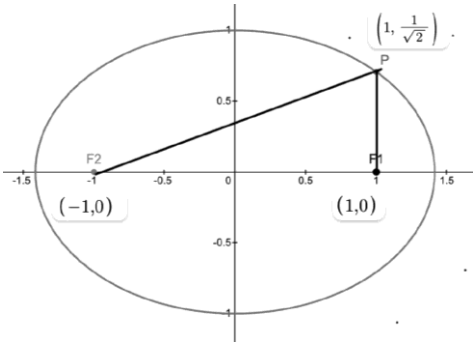
(c) The length of the minor axis is 2

(d) The directrices of the ellipse are $x = \pm 2$

Answer (a, b, c, d)

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Sol.



$\therefore 2ae = 2 \Rightarrow ae = 1 \quad \cdots(1)$

$PF_1 + PF_2 = \frac{1}{\sqrt{2}} + \frac{3}{\sqrt{2}} = 2\sqrt{2} = 2a$

$\therefore a = \sqrt{2} \quad \cdots(2)$

$\therefore e = \frac{1}{\sqrt{2}}$

$\therefore b^2 = a^2\left(1 - e^2\right) = 2\left(1 - \frac{1}{2}\right) = 1$

$\therefore a^2 = 2, b^2 = 1$ Option (a) correct

$e = \frac{1}{\sqrt{2}}$ Option (b) correct

$2b = 2$ Option (c) correct

Eq. of directrices: $x = \pm\frac{a}{e} = \pm\frac{\sqrt{2}}{1/\sqrt{2}} = \pm 2$ Option (d) correct

57. Inside the core of star,

(a) the p-p chain of nuclear fusion creates He from H in a solar mass or a less massive star

(b) the CNO cycle creates the nuclei of elements N and O

(c) all heavy nuclei till Fe are created if star is massive and evolved

(d) the triple alpha process creates the nuclei of C

Answer (a, b, c, d)

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Sol. (a) True :

In stars with M ≤ 1.3 Ms the p-p chain is dominant, converting H into He

(b) False :

The CNO cycle uses carbon, nitrogen and oxygen isotopes as catalysts to produce He from H.

(c) True :

Massive stars (M ≥ 8Ms), have high enough. temperatures & pressures to sustain higher stages of nuclear reaction (carbon, neon, oxygen, silicon burning) synthesizing synthesizing upto Fe.

(d) True :

The triple alpha process produces carbon

58 For an observer located at the equator of the Earth, moving in an elliptical orbit around the Sun,

(a) duration between two sunrises is always the same

(b) the sun passes over zenith every 24 hours

(c) a star can rise twice on a particular date

(d) if two stars rise together, they also set together

Answer (c, d)

Sol. (a) False :

Length of the solar day various throughout the year

(b) False :

Sun is at zenith only at equinoxes

(c) Sidereal day = 23 h 56 m

So a star rising just after 00 : 00 hrs can rise again around 23 : 56 hrs.

(d) At equator, the half sideral day is nearly 12 hrs

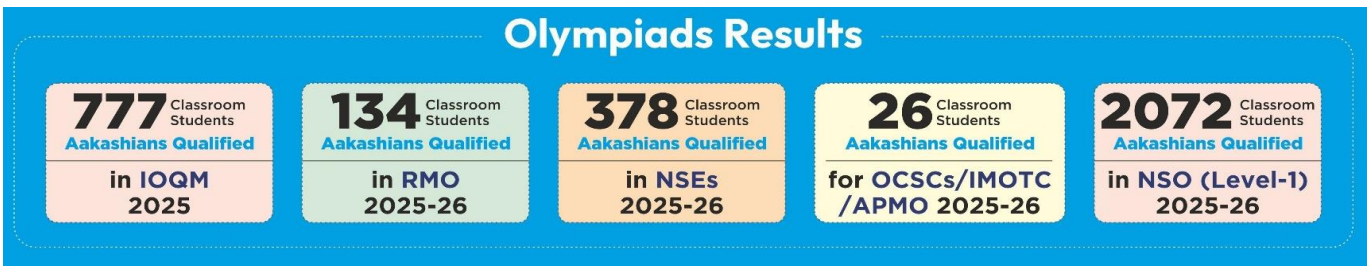
59. Two planets, A and B, move around the same star with exactly the same time period. Planet A and planet B will

(a) always be exactly on opposite sides of the star

(b) sweep out exactly equal areas in equal intervals of time

(c) always have the same distance of closest approach to the star

(d) have the same distance of farthest approach from the star



Answer (b)

Sol. Both planets will have same major axis length but can have different eccentricity.

60. A hypothetical planet-star system, behaves exactly like the Earth-Sun system (rotation and revolution period of the planet are the same as that of Earth), with only one difference – the axis of the rotation of the planet is in the orbital plane.

(a) The star will appear always on the zenith to the observer at north pole

(b) When the star sets (or rises) for the observer at the poles, the star will be at the zenith at mid-day for the observer at the equator

(c) The star will always appear at the horizon to the observer at the equator

(d) An observer on either of the poles of the planet will see the sun rise once and set once in one year cycle

Answer (b, d)

Sol. (a) False :

$\because$ The axis lies in the orbital plane, so the star's declination is between +90 and –90°

So the star is at pole's zenith only at certain times.

(b) True :

When the star is at horizon for poles ($\delta = 0$) it will be at equation's zenith

(c) False :

It will be at equator's horizon all day only when $\delta = \pm 90°$

(d) True :

At each pole the star is up for half year, so it rises once and sets once.

❑ ❑ ❑

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378 Classroom Students Aakashians Qualified in NSEs 2025-26

26 Classroom Students Aakashians Qualified for OCSCs/IMOTC /APMO 2025-26

2072 Classroom Students Aakashians Qualified in NSO (Level-1) 2025-26