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PREVIOUS YEAR PAPER · 2022

OLYMPIAD · STAGE I

NSEA

National Standard Examination in Astronomy

2022

Question paper, answer key and Zigyan solutions

60	216	120 min	41
Questions	Maximum marks	Time	Paper code

Question paper and official answer key: Indian Association of Physics Teachers (IAPT), NSEA 2022, paper code 41.
Solutions and notes: Zigyan. This booklet is not an IAPT publication.

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AIR 168	AIR 811
	99.95 percentile



Sulokya Bibhuty

3 YEARS CLASSROOM

JEE ADVANCED 2026	JEE MAIN 2026
AIR 1,315	AIR 1,095
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OLYMPIAD RESULTS

Above the Minimum Admissible Score - the national band for the subject

CHEMISTRY

- Sulokya Bibhuty — 3 Years Classroom
- Anay Gupta — 3 Years Classroom
- Akshat Khator — 3 Years Classroom
- Harshit Goyal — 4 Years Classroom
- Hardik Sharma — 3 Years Classroom
- Aarush Kumar — 1 Year Classroom

PHYSICS

- Sulokya Bibhuty — 3 Years Classroom
- Saksham Bishnoi — 4 Years Classroom

ASTRONOMY

- Sulokya Bibhuty — 3 Years Classroom

MATHEMATICS (IOQM)

- Priyanshi — 4 Years Classroom

Saksham Bishnoi qualified the Chemistry Olympiad twice and was selected for the Orientation-cum-Selection Camp at HBCSE, Mumbai.

16 selections	16 of 35	AIR 168
in JEE Advanced 2026	students of the batch selected	best JEE Advanced rank

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Given in the question paper

Constants you may need….

Magnitude of charge on electron $e = 1.60 \times 10^{-19}$ C	Avogadro's constant $A = 6.023 \times 10^{23}$ mol^{-1}
Mass of electron $m_e = 9.10 \times 10^{-31}$ kg	Speed of light in free space $c = 3 \times 10^{8}$ m/s
Mass of proton $m_p = 1.67 \times 10^{-27}$ kg	Permittivity of free space $\varepsilon_0 = 8.85 \times 10^{-12}$ C^2 / N. m^2
Acceleration due to gravity $g = 9.81$ m. s^{-2}	Permeability of free space $\mu_0 = 4\pi \times 10^{-7}$ H / m
Universal constant of gravitation $G = 6.67 \times 10^{-11}$ Nm^2 / kg^2	Planck's constant $h = 6.63 \times 10^{-34}$ J.s
Universal gas constant $R = 8.31$ J / mol. K	Faraday constant $= 96500$ C / mol
Boltzmann constant $k = 1.38 \times 10^{-23}$ J/K	Rydberg constant $R = 1.097 \times 10^{7}$ m^{-1}
Stefan's constant $\sigma = 5.67 \times 10^{-8}$ W / m^2 K^4	Solar mass $= 1.99 \times 10^{30}$ kg
Wien's constant $b = 2.90 \times 10^{-3}$ m K	Average Earth - Sun distance (=1 AU) $= 1.5 \times 10^{11}$ m

PART A-1 · ONE CORRECT OPTION

Q. 1 – 48 · +3 for a correct answer, –1 for a wrong one

1. If the perigee and the apogee of the Moon's orbit are 362600 km and 405400 km respectively, then the largest diameter of the moon apparent from the earth is larger than the apparent smallest diameter by

(A) 25% (B) 12% (C) 5% (D) None of these

Solution · Q1 **Answer: (B)**

The apparent diameter of the Moon is inversely proportional to its distance.

$$\frac{\theta_{max}}{\theta_{min}} = \frac{r_{apogee}}{r_{perigee}}$$

$$\Rightarrow \frac{\theta_{max}}{\theta_{min}} = \frac{405400}{362600} \approx 1.118$$

∴ The largest apparent diameter is larger than the smallest by about 11.8%, nearly 12%.

IAPT answer: (B) | **Zigyan answer:** (B)

2. A cylindrical bar magnet (of 6.0 cm length and 1.0 cm diameter) has magnetic moment 2.3×10^{-2} A. m^2. When suspended in a uniform, horizontal magnetic field of strength $B = 12 \times 10^{-4}$ T, with the axis of the bar magnet parallel to the direction of the field and set into small oscillations in the horizontal plane, the magnet oscillates with a period of 3.2 s. The density of the material of the magnet is

(A) 8.9 g/cc (B) 7.8 g/cc (C) 5.1 g/cc (D) 2.7 g/cc

Solution · Q2 **Answer: (C)**

For small oscillations of the magnet,

$$T = 2\pi\sqrt{\frac{I}{\mu B}}$$

$$\Rightarrow I = \frac{T^2 \mu B}{4\pi^2}$$

$$I = \frac{(3.2)^2 \times 2.3 \times 10^{-2} \times 12 \times 10^{-4}}{4\pi^2}\ \text{kg m}^2$$

$$\Rightarrow I \approx 7.16 \times 10^{-6}\ \text{kg m}^2$$

Taking the magnet as a thin rod of length L,

$$I = \frac{ML^2}{12}$$

$$\Rightarrow M \approx 23.9\ \text{g}$$

Volume of the cylinder:

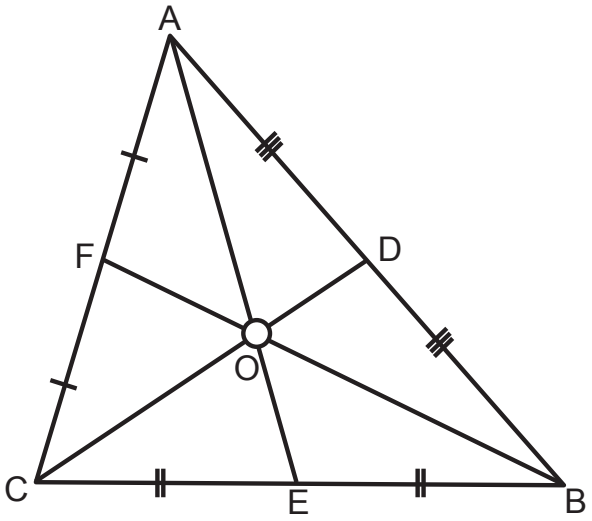
$$V = \pi \times (0.50)^2 \times 6.0 \approx 4.71\ \text{cm}^3$$

$$\Rightarrow \rho = \frac{23.9}{4.71} \approx 5.1\ \text{g/cm}^3$$

Keeping the radius term in I gives about 5.0 g/cm^3; the nearest option is unchanged.

IAPT answer: (C) | **Zigyan answer:** (C)

3. AE, BF, CD are medians of the triangle ABC. If the area of the triangle is 36 (in some arbitrary units) then the area of the quadrilateral AFOD is ...



(A) 12 (B) 6 (C) 18 (D) 36

Solution · Q3 **Answer: (A)**

The three medians divide the triangle into six triangles of equal area.

Area of each part:

$$36/6 = 6$$

The quadrilateral AFOD is made of the triangles AFO and AOD.

$$\therefore [AFOD] = 2 \times 6 = 12$$

IAPT answer: (A) | **Zigyan answer:** (A)

4. If the moon takes 29.53 days to go from one New Moon to the next (i.e. go round in the sky once relative to the Sun), then it will go round once relative to the Vernal Equinox and the stars in a time

(A) less than 29.53 days
(B) 29.53 days
(C) more than 29.53 days by about 1 day
(D) more than 29.53 days by about 2 days

Solution · Q4 **Answer: (A)**

The Earth also moves round the Sun, in the same sense as the Moon moves round the Earth.

For the period T relative to the equinox or the stars,

$$\frac{1}{T} = \frac{1}{29.53} + \frac{1}{365.25}$$

$$\Rightarrow T \approx 27.3 \text{ d}$$

$\therefore$ This time is less than 29.53 days.

IAPT answer: (A) | **Zigyan answer:** (A)

5. Define f(x) for real values of x as $\frac{|x|}{1+|x|}$. The correct statement regarding f is

(A) f(x) is an injective function on the real line.
(B) f(x) is an unbounded function on the real line.
(C) f(x) is a monotonically increasing function for real x > 0.
(D) f(x) is differentiable every where on the real line.

Solution · Q5 **Answer: (C)**

$$f(-x) = f(x)$$

So f is even and cannot be injective. Its values always stay below 1, so it is bounded.

For positive x,

$$f(x) = 1 - \frac{1}{1+x}$$

This increases steadily with x.

At the origin the left and right derivatives are −1 and +1, so f is not differentiable there.

IAPT answer: (C) | **Zigyan answer:** (C)

6. Consider a rocky planet with atmospheric pressure 5.0 MPa at the surface, radius 5000 km and surface gravity 7.5 m/s^2. The carbon dioxide content (by mass) of the atmosphere is 97% and the rest is mostly nitrogen. An estimate for the total mass of carbon dioxide in the planet's atmosphere is

(A) 2.0×10^{20} kg (B) 6.8×10^{13} kg (C) 2.0×10^{10} kg (D) 4.7×10^{8} kg

Solution · Q6 **Answer: (A)**

The weight of the atmosphere produces the surface pressure.

$$P \times 4\pi R^2 = Mg$$

$$\Rightarrow M = \frac{4\pi R^2 P}{g}$$

$$M = \frac{4\pi\left(5.0\times10^6\right)^2\left(5.0\times10^6\right)}{7.5} \text{ kg}$$

$$\Rightarrow M \approx 2.09 \times 10^{20}\ \text{kg}$$

Mass of carbon dioxide:

$$0.97\ M \approx 2.0 \times 10^{20}\ \text{kg}$$

IAPT answer: (A) | **Zigyan answer:** (A)

7. Pluto is not considered as a planet of our solar system because

(A) It does not orbit the Sun

(B) It has not 'cleared' the neighborhood around its orbit

(C) It does not have sufficient mass to achieve hydrostatic equilibrium under its own gravity

(D) Its orbital plane makes an angle of 17° with the Earth's orbital plane

Solution · Q7 **Answer: (B)**

By the IAU definition of 2006, a planet orbits the Sun, has enough mass to become nearly round (hydrostatic equilibrium) and has cleared the neighbourhood around its orbit.

Pluto satisfies the first two conditions but not the third, so it is classed as a dwarf planet.

IAPT answer: (B) | **Zigyan answer:** (B)

8. The Gomateshwara statue (18 m tall) is focused on a screen using a 50 mm focal length convex lens from a distance u = 50 m. To shrink the image to $1/5^{th}$ size when image is taken from the same distance by another lens, the focal length of the second lens should be

(A) 10 mm (B) 22 mm (C) 112 mm (D) 250 mm

Solution · Q8 **Answer: (A)**

The magnification for a real image is

$$m = \frac{f}{u - f}$$

As u is much larger than f,

$$m \approx \frac{f}{u}$$

So, from the same distance, the image size is proportional to f.

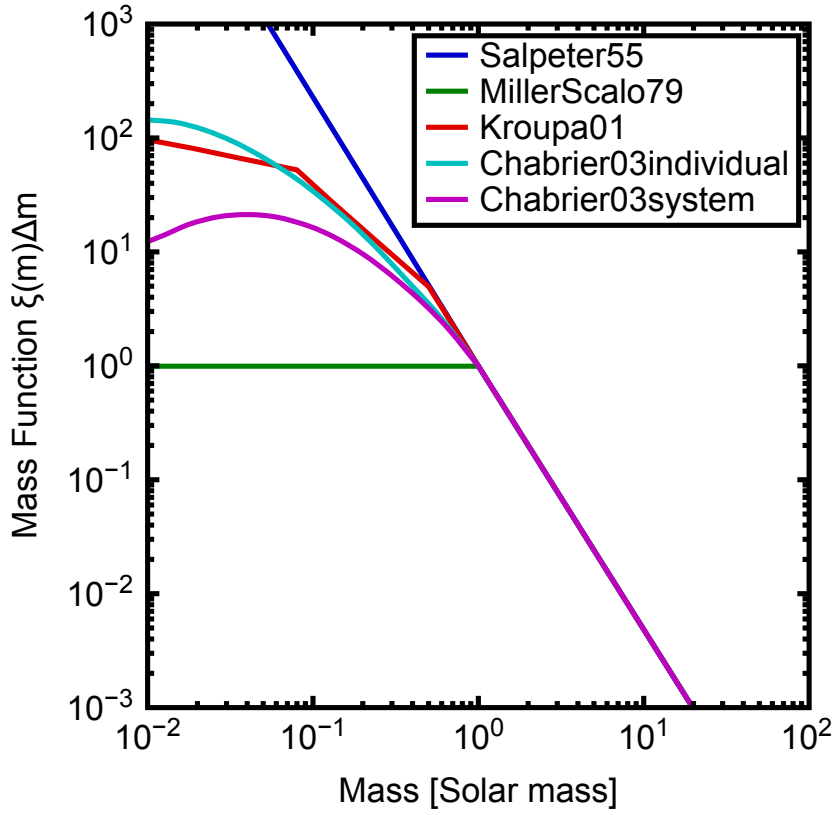
$$f_2 = \frac{50}{5}\ \text{mm}$$

$$\Rightarrow f_2 = 10\ \text{mm}$$

IAPT answer: (A) | **Zigyan answer:** (A)

9. Figure shows various approximations to what is called the Initial Mass Function (IMF) of stars which gives the number of stars in various mass ranges as a function of the logarithm of the mass log m = x as say y = f (x). One of the shapes is approximately an inverted parabola continuing as a straight line. Let the parabola portion be fitted by $y = y_0 + A\,(x - x_0)^2$ and the straight line portion be fitted by $y = -2.35\,x + C$. If the parabolic and linear portions join smoothly at the point (x_1, y_1) the unknown parameters A and C are given by

Picture credit: Johannes Buchner CC, BY-SA 4.0, https://commons.wikimedia.org/w/index.php?curid=44779435



(A) $\dfrac{2.35}{2(x_1 - x_0)}, y_0 + \dfrac{2.35(x_1 + x_0)}{2}$

(B) $\dfrac{-2.35}{2(x_1 - x_0)}, y_0 + \dfrac{2.35(x_1 + x_0)}{2}$

(C) $\dfrac{-2.35}{2(x_1 - x_0)}, y_0 + \dfrac{-2.35(x_1 + x_0)}{2}$

(D) $\dfrac{2.35}{2(x_1 - x_0)}, y_0 + \dfrac{-2.35(x_1 + x_0)}{2}$

Solution · Q9 **Answer: (B)**

At the joining point, both curves have the same slope and the same value.

Equal slopes:

$$2A(x_1 - x_0) = -2.35$$

$$\Rightarrow A = \frac{-2.35}{2(x_1 - x_0)}$$

Equal values:

$$y_0 + A(x_1 - x_0)^2 = -2.35x_1 + C$$

$$\Rightarrow C = y_0 - \frac{2.35(x_1 - x_0)}{2} + 2.35x_1$$

$$\Rightarrow C = y_0 + \frac{2.35(x_1 + x_0)}{2}$$

IAPT answer: (B) | **Zigyan answer:** (B)

10. Astronomers discover an exoplanet (a planet orbiting a star other than the Sun), that has an orbital period of 4.50 Earth years in a circular orbit around its star. The star has a measured mass of 3.70×10^{30} kg. The radius r of the exoplanet's orbit is approximately.

Constants you may need....

Universal constant of gravitation $G = 6.67 \times 10^{-11}\ Nm^2 / kg^2$

(A) 2.7×10^{11} m (B) 2.7×10^{12} m (C) 5.0×10^{13} m (D) 5.0×10^{11} m

Solution · Q10 **Answer: (D)**

For a circular orbit,

$$r^3 = \frac{GMT^2}{4\pi^2}$$

Period in seconds:

$$T = 4.50 \times 3.156 \times 10^7\ s$$

$$\Rightarrow T \approx 1.42 \times 10^8\ s$$

$$r^3 = \frac{6.67 \times 10^{-11} \times 3.70 \times 10^{30} \times \left(1.42 \times 10^8\right)^2}{4\pi^2}\ m^3$$

$$\Rightarrow r^3 \approx 1.26 \times 10^{35}\ m^3$$

$$\Rightarrow r \approx 5.0 \times 10^{11}\ m$$

IAPT answer: (D) | **Zigyan answer:** (D)

11. The complex matrix $U = \begin{pmatrix} a + ib & c + id \\ e + if & g + ih \end{pmatrix}$ is unitary (*i.e.* its complex conjugate transpose is its inverse and |det U| = 1). Which of the following holds regarding a, b, c, d, e, f, g, h

(A) only three of them are independent (B) only four of them are independent

(C) only five of them are independent (D) none of them are independent

Solution · Q11 **As per Zigyan: (B)**

For a unitary matrix,

$$U^\dagger U = I$$

Each column has unit length:

$$a^2 + b^2 + e^2 + f^2 = 1$$

$$c^2 + d^2 + g^2 + h^2 = 1$$

Orthogonal columns give two real conditions:

$$(a - ib)(c + id) + (e - if)(g + ih) = 0$$

Also, unitarity gives

$$|\det U|^2 = \det(U^\dagger U)$$

$$\Rightarrow |\det U| = 1$$

So there is no further restriction. Number of independent quantities:

$$8 - 4 = 4$$

Why Zigyan differs from IAPT: three needs the determinant itself to be 1. Only its modulus is fixed, so its phase is the fourth parameter, as in the unitary diagonal matrix with entries 1 and $e^{i\Phi}$.

Reference: University of Alberta, MA PH 464 Group Theory in Physics, lecture notes by V. Bouchard, Section 4.1 'Lie groups', Example 4.1.10: an n × n unitary matrix has n^2 independent real parameters and its determinant always has modulus one; demanding determinant one removes one parameter.

IAPT answer: (A) | **Zigyan answer:** (B)

12. A monoatomic ideal gas is at temperature T. Let v_x, v_y, v_z denote the components of velocity of the molecules. The mean value of $(v_x + v_y)^2$ is

(A) $\frac{kT}{m}$ (B) $\frac{8kT}{m}$

(C) $\frac{kT}{2m}$ (D) $\frac{2kT}{m}$

Solution · Q12 **Answer: (D)**

v_x and v_y are independent, and each has zero mean.

$$\langle (v_x + v_y)^2 \rangle = \langle v_x^2 \rangle + \langle v_y^2 \rangle + 2\langle v_x v_y \rangle$$

$$\langle v_x v_y \rangle = 0$$

By equipartition of energy,

$$\left\langle v_x^2 \right\rangle = \left\langle v_y^2 \right\rangle = \frac{kT}{m}$$

$$\therefore \left\langle \left(v_x + v_y\right)^2 \right\rangle = \frac{2kT}{m}$$

IAPT answer: (D) | **Zigyan answer:** (D)

13. The orbit of Halley's comet about the Sun is such that it arrives at perihelion every 75.3 years. If the perihelion distance is 0.586 AU, the aphelion distance is approximately

(A) 70 AU (B) 80 AU (C) 35 AU (D) 40 AU

Solution · Q13 **Answer: (C)**

By Kepler's third law, taking the semi-major axis a in AU and the period T in years,

$$a^3 = T^2$$

$$\Rightarrow a = (75.3)^{2/3} \approx 17.83 \text{ AU}$$

For an elliptical orbit,

$$r_{perihelion} + r_{aphelion} = 2a$$

$$\Rightarrow r_{aphelion} = 2 \times 17.83 - 0.586$$

$$\therefore r_{aphelion} \approx 35 \text{ AU}$$

IAPT answer: (C) | **Zigyan answer:** (C)

14. Earth has about 100 V/m potential gradient in clear weather. Potential increases in upward direction. If the conductivity of air is 2.0×10^{-14} SI unit. The total current given out by Earth (assuming clear weather everywhere) is

(A) 1.6×10^{-4} A (B) 1.0×10^{-3} A (C) 1.0×10^{3} A (D) 2.2×10^{9} A

Solution · Q14 **Answer: (C)**

Current density in the air near the ground:

$$J = \sigma E = 2.0 \times 10^{-14} \times 100$$

$$\Rightarrow J = 2.0 \times 10^{-12} \text{ A m}^{-2}$$

This current crosses the whole surface of the Earth, of radius

$$R = 6.4 \times 10^{6} \text{ m}$$

$$\Rightarrow I = J \times 4\pi R^2$$

$$\Rightarrow I = 2.0 \times 10^{-12} \times 4\pi \times (6.4 \times 10^{6})^2$$

$$\therefore I \approx 1.0 \times 10^{3} \text{ A}$$

IAPT answer: (C) | **Zigyan answer:** (C)

15. Solve the given equation for x : $\log_6 (4x + 8) = 2$

(A) 7 (B) 6 (C) 3 (D) None of these

Solution · Q15 **Answer: (A)**

$$\log_6 (4x + 8) = 2$$

$$\Rightarrow 4x + 8 = 6^2 = 36$$

$$\therefore x = 7$$

IAPT answer: (A) | **Zigyan answer:** (A)

16. If gcd (a, b) = 1 where a and b are integers, then gcd (a + b, a − b) can be

(A) 2 or 3 (B) 1 or 2 (C) 1 or 3 (D) 2 or 4

Solution · Q16 **Answer: (B)**

A common divisor d of a + b and a − b also divides their sum 2a and their difference 2b.

The greatest common divisor of 2a and 2b is

$$2 \text{ gcd } (a, b) = 2$$

Hence d divides 2, so it can only be 1 or 2.

The pairs (2, 1) and (3, 1) show that both values occur:

$$\text{gcd } (3, 1) = 1$$

$$\text{gcd } (4, 2) = 2$$

IAPT answer: (B) | **Zigyan answer:** (B)

17. The probability that a student will pass in both English and Mathematics is 0.5. The probability for passing in English is 0.75 and the probability for failing in both English and Mathematics is 0.1. What is the probability for passing in Mathematics?

(A) 0.35 (B) 0.65 (C) 0.6 (D) 0.4

Solution · Q17 **Answer: (B)**

Let E and M denote passing in English and in Mathematics.

$$P(E \cup M) = 1 - 0.1 = 0.9$$

By the addition theorem,

$$P(E \cup M) = P(E) + P(M) - P(E \cap M)$$

$$\Rightarrow 0.9 = 0.75 + P(M) - 0.5$$

$$\therefore P(M) = 0.65$$

IAPT answer: (B) | **Zigyan answer:** (B)

18. A wire mesh in a paraboloid shape can be used as collector of radio waves for a radio telescope. Such radio dishes are used to detect radio signals from distant galaxies. What will be the angular radius of the image of a point source emitting 21cm radio radiation, due to diffraction effects, if the dish is 250 m in diameter?

(A) 0.0010 arc minute (B) 0.058 arc minute
(C) 3.5 arc minute (D) 211 arc minute

Solution · Q18 **Answer: (C)**

For a circular aperture, the angular radius of the central diffraction disc is

$$\theta = \frac{1.22\lambda}{D}$$

$$\Rightarrow \theta = \frac{1.22 \times 0.21}{250} \approx 1.025 \times 10^{-3} \text{ rad}$$

In arc minutes,

$$\theta = 1.025 \times 10^{-3} \times \frac{180}{\pi} \times 60$$

$$\therefore \theta \approx 3.5 \text{ arcmin}$$

IAPT answer: (C) | **Zigyan answer:** (C)

19. Which one of the following equations has no integer solutions?

(A) $2x^2 + 4y^3 = 23$ (B) $5x^3 - 2y^2 = 8$
(C) $15x^2 - 7y^2 = 107$ (D) $3x - 2y = 5$

Solution · Q19 **Answer: (A)**

(A) For all integers x and y,

$$2x^2 + 4y^3 = 2(x^2 + 2y^3)$$

The left side is even but 23 is odd, so there is no integer solution.

Each of the other equations has an integer solution:

(B) x = 2, y = 4

(C) $x = 3, y = 2$

(D) $x = 1, y = -1$

IAPT answer: (A) | **Zigyan answer:** (A)

20. LIGO gravitational wave observatory detected the merger of two black holes of masses 30 and 35 solar masses to form a single black hole of mass 62 solar masses. The total energy radiated away in the form of gravitational waves in the merger is

Constants you may need....

Speed of light in free space $c = 3 \times 10^8$ m/s

Solar mass = 1.99×10^{30} kg

(A) 2.3×10^{44} joule

(B) 4.0×10^{26} watt

(C) 3.6×10^{49} watt

(D) 5.4×10^{47} joule

Solution · Q20 **Answer: (D)**

With M_s as the solar mass, the mass converted into energy is

$$\Delta m = (30 + 35 - 62)M_s = 3M_s$$

By mass–energy equivalence,

$$E = \Delta mc^2$$

$$\Rightarrow E = 3 \times 1.99 \times 10^{30} \times (3 \times 10^8)^2$$

$$\therefore E \approx 5.4 \times 10^{47} \text{ J}$$

IAPT answer: (D) | **Zigyan answer:** (D)

21. Let $x^3 + y^3 = xy + 1$ be a function implicitly defined for y. Find y' (1) at the point (1,1).

(A) 1 (B) 2 (C) − 1 (D) 4

Solution · Q21 **Answer: (C)**

Differentiating with respect to x,

$$3x^2 + 3y^2y' = y + xy'$$

At the point (1, 1),

$$3 + 3y' = 1 + y'$$

$$\therefore y' = -1$$

IAPT answer: (C) | **Zigyan answer:** (C)

22. Two stars A and B, have masses M_A and M_B and radii R_A and R_B respectively. It is given that $R_A = R_B = R$, but $M_A \neq M_B$. Star A has a constant density ρ_0, and the density profile of star B is $\rho = \rho_0\left(1 - \frac{r}{R}\right)$. In the region $0 < r < R$, the gravitational accelerations g_A and g_B of these two stars are related as

(A) $g_B = g_A\left(1 - \frac{3r}{4R}\right)$ (B) $g_B = g_A\left(1 - \frac{r}{12R}\right)$

(C) $g_B = g_A\left(1 - \frac{3r}{R}\right)$ (D) $g_B = g_A\left(1 - \frac{12r}{R}\right)$

Solution · Q22 **Answer: (A)**

Only the mass inside radius r contributes to g.

For star A:

$$g_A = \frac{G}{r^2} \times \frac{4}{3}\pi r^3 \rho_0 = \frac{4\pi G \rho_0 r}{3}$$

Mass of star B inside radius r:

$$M_B = \int_0^r 4\pi x^2 \rho_0\left(1 - \frac{x}{R}\right)dx$$

$$\Rightarrow M_B = 4\pi\rho_0\left(\frac{r^3}{3} - \frac{r^4}{4R}\right)$$

$$\Rightarrow g_B = \frac{GM_B}{r^2} = \frac{4\pi G\rho_0 r}{3}\left(1 - \frac{3r}{4R}\right)$$

$$\therefore g_B = g_A\left(1 - \frac{3r}{4R}\right)$$

IAPT answer: (A) | **Zigyan answer:** (A)

23. If $\alpha = \sin^{-1}\frac{\sqrt{12}}{4}$ then the value of cot α is

(A) $\frac{1}{\sqrt{3}}$ (B) $\frac{2}{\sqrt{3}}$

(C) $\frac{\sqrt{12}}{4}$ (D) $\frac{4}{\sqrt{12}}$

Solution · Q23 **Answer: (A)**

$$\sin\alpha = \frac{\sqrt{12}}{4} = \frac{\sqrt{3}}{2}$$

$$\Rightarrow \alpha = 60°$$

$$\therefore \cot\alpha = \frac{1}{\sqrt{3}}$$

IAPT answer: (A) | **Zigyan answer:** (A)

24. Imagine a large asteroid of circular disc shape with diameter D = 50 km and thickness 2 km. The magnitude of gravitational acceleration at distances h = 100 m and h = 200 m above the surface can be approximated to have the same value (neglecting corrections of the order of h/D)

(A) anywhere above the disc.

(B) anywhere above the disc but not near the edges.

(C) only along the axis.

(D) nowhere above the disc.

Solution · Q24 **Answer: (B)**

As h is much smaller than D, away from the edges the disc acts like an infinite flat slab of thickness t.

$$g \approx 2\pi G\rho t$$

This is independent of h, apart from corrections of order h/D.

Near an edge, the field also has a large sideways component, and its magnitude changes with h by much more than this.

∴ the values are equal above the disc, but not near the edges.

IAPT answer: (B) | **Zigyan answer:** (B)

25. A cylindrical vessel of height h and radius r, filled with water, is falling down freely. All along the downward fall the vessel remains vertical. If ρ is the density of water and g the acceleration due to gravity, then the pressure of water at the bottom of the cylindrical vessel is

(A) ρgh (B) 2ρgh (C) ρgh/2 (D) None of these

Solution · Q25 **Answer: (D)**

In free fall, the effective gravity inside the vessel is

$$g_{eff} = g - g = 0$$

Pressure difference between the bottom and the top of the water:

$$\Delta P = \rho g_{eff} h = 0$$

∴ The water adds no pressure at the bottom. The pressure there is the same as at the free surface (zero gauge pressure).

IAPT answer: (D) | **Zigyan answer:** (D)

26. A neutron, a proton and an alpha particle are projected together simultaneously along a uniform magnetic field, with equal energy. The separation between them will go on increasing as: (magnetic moments of both the particles may be neglected)

(A) $\propto t^{1/2}$ (B) $\propto t$ (C) $\propto t^{3/2}$ (D) $\propto t^2$

Solution · Q26 **Answer: (B)**

The particles move along the field, so there is no magnetic force on them.

$$F = qvB \sin 0° = 0$$

Neglecting the forces between the particles, each moves with a constant speed.

$$v = \sqrt{\frac{2E}{m}}$$

The neutron and the proton have nearly equal masses. The alpha particle is about four times as heavy, so its speed is

$$v_\alpha \approx v/2$$

Separation of any two of them at time t:

$$d = |v_1 - v_2|\, t$$

$$\therefore d \propto t$$

IAPT answer: (B) | **Zigyan answer:** (B)

27. Which of the following is a convergent series?

(A) $\sum_2^\infty \frac{1}{n^2 \log n}$ (B) $\sum_2^\infty \frac{1}{n \log n}$

(C) $\sum_2^\infty \frac{1}{\log n}$ (D) None of these.

Solution · Q27 **Answer: (A)**

For all large n, with natural logarithms,

$$\log n > 1$$

$$\frac{1}{n^2 \log n} < \frac{1}{n^2}$$

The p-series with power 2 converges, so (A) converges by comparison.

For (B), by the integral test:

$$\int_2^\infty \frac{dx}{x \log x} = \left[\log(\log x)\right]_2^\infty \to \infty$$

So (B) diverges.

For (C):

$$\frac{1}{\log n} > \frac{1}{n}$$

The harmonic series diverges, so (C) also diverges.

IAPT answer: (A) | **Zigyan answer:** (A)

28. If the surface temperature of a star is 6000K, in which colour would it appear in a colour photograph?

Constants you may need....

Wien's constant $b = 2.90 \times 10^{-3}$ m K

(A) Red (B) Violet (C) Yellow (D) Blue

Solution · Q28 **As per Zigyan: (C)**

By Wien's law, the wavelength of maximum emission is

$$\lambda_{max} = \frac{b}{T} = \frac{2.90 \times 10^{-3}}{6000}\ \text{m}$$

$$\Rightarrow \lambda_{max} \approx 483\ \text{nm}$$

This is only the peak of a broad spectrum. A star at this temperature sends out strong light over the whole visible range.

A colour photograph records this mixture, not just the colour at the peak. Stars near 6000 K, like the Sun, are the yellow stars.

Why Zigyan differs from IAPT: a peak at 483 nm does not make a star blue, since all the visible colours arrive together. Blue stars are far hotter, near 25,000 K.

Reference: OpenStax Astronomy 2e, section 17.2 'Colors of Stars', Table 17.1: it gives about 25,000 K for a blue star and about 6000 K for a yellow star, with the Sun as the example.

IAPT answer: (D) | **Zigyan answer:** (C)

29. The value of the constant c such that the curve $y = x^2 + c$ is tangent to the line $y = 2x$ is

(A) $c = -1$ (B) $c = 1$ (C) $c = 2$ (D) $c = 3$

Solution · Q29 **Answer: (B)**

At the common points of the curve and the line,

$$x^2 + c = 2x$$

$$\Rightarrow x^2 - 2x + c = 0$$

For tangency, the two roots are equal.

$$(-2)^2 - 4c = 0$$

$$\Rightarrow c = 1$$

IAPT answer: (B) | **Zigyan answer:** (B)

30. A circular disc of radius 'a' is placed at a distance 'a' in front of a spherical convex mirror of focal length '4a', with its axis along the principal axis of the mirror. Determine the solid angle (in steradians) subtended by the image at the centre of the disc.

(A) 1.58 (B) 0.83 (C) 0.54 (D) 0.44

Solution · Q30 **Answer: (C)**

For the convex mirror,

$$u = -a,\ f = +4a$$

$$\frac{1}{v} = \frac{1}{f} - \frac{1}{u} = \frac{1}{4a} + \frac{1}{a}$$

$$\Rightarrow v = 4a/5$$

The image is behind the mirror.

$$m = -\frac{v}{u} = \frac{4}{5}$$

Radius of the image, and its distance from the centre of the disc:

$$r = 4a/5$$

$$d = a + 4a/5 = 9a/5$$

For a disc seen along its axis, with semi-vertical angle θ,

$$\cos\theta = \frac{d}{\sqrt{d^2 + r^2}} = \frac{9}{\sqrt{97}}$$

$$\Omega = 2\pi(1 - \cos\theta) = 2\pi\left(1 - \frac{9}{\sqrt{97}}\right)$$

$$\Rightarrow \Omega \approx 0.54 \text{ sr}$$

IAPT answer: (C) | **Zigyan answer:** (C)

31. The average flux of solar radiation on Earth is $F = 1.36 \times 10^3$ W m^{-2} and the average Earth-Sun distance is 1.5×10^{11} m. The power radiated by the Sun is

(A) 3.8×10^{26} W (B) 3.8×10^{33} W (C) 4.0×10^{28} W (D) None of these

Solution · Q31 **Answer: (A)**

The Sun's power spreads over a sphere whose radius d is the Earth-Sun distance.

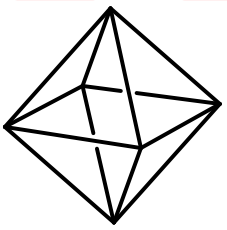
$$P = 4\pi d^2 F$$

$$P = 4\pi \times (1.5 \times 10^{11})^2 \times 1.36 \times 10^3 \text{ W}$$

$$\Rightarrow P \approx 3.8 \times 10^{26} \text{ W}$$

IAPT answer: (A) | **Zigyan answer:** (A)

32. Twelve identical resistors each of resistance R, are connected in the configuration of a regular octahedron (a solid made of eight equilateral triangles four of which meet at each vertex). Find the equivalent resistor between any two opposite vertices.



(A) $\frac{R}{6}$ (B) $\frac{R}{2}$

(C) $\frac{2R}{3}$ (D) $\frac{6R}{5}$

Solution · Q32 **Answer: (B)**

Let the current enter at one vertex and leave at the opposite vertex.

By symmetry, the other four vertices are at the same potential. So the four resistors joining them carry no current.

This leaves four parallel paths, each with two resistors in series.

Resistance of each path:

$$R + R = 2R$$

$$R_{eq} = \frac{2R}{4} = \frac{R}{2}$$

IAPT answer: (B) | **Zigyan answer:** (B)

33. Find all values of positive even numbers n so that n. $2^n - 1$ is divisible by 3

(A) $6k + 2, k \in \mathbb{N}$ (B) $6k + 4, k \in \mathbb{N}$ (C) $6k + 6, k \in \mathbb{N}$ (D) $6k + 8, k \in \mathbb{N}$

Solution · Q33 **Answer: (B)**

As n is even,

$$2^n = 4^{n/2}$$

A power of 4 leaves remainder 1 on division by 3. So, for an integer p,

$$2^n = 3p + 1$$

$$\Rightarrow n \cdot 2^n - 1 = 3np + (n - 1)$$

So 3 must divide n − 1. For an integer q,

$$n = 3q + 1$$

Since n is even, q must be odd.

$$q = 2k + 1$$

$$\Rightarrow n = 6k + 4$$

These are 4, 10, 16 and so on. Here k starts from 0, so that 4 is included.

IAPT answer: (B) | **Zigyan answer:** (B)

34. The photospheric radius of the Sun is 0.696 million km. Rotation period of the Sun at the solar equator is approximately 24 days. The end regions of the solar equator on the solar disc, are simultaneously and separately observed using an H alpha filter with mid wavelength 6563 Angstroms. The difference in measured wavelength between the observations at the two edges is

Constants you may need....

Speed of light in free space $c = 3 \times 10^8$ m/s

(A) 0.0459 Angstrom (B) 0.0229 Angstrom (C) 0.1836 Angstrom (D) 0.0918 Angstrom

Solution · Q34 **Answer: (D)**

Speed of a point on the solar equator:

$$v = \frac{2\pi R}{T} = \frac{2\pi \times 6.96 \times 10^8}{24 \times 86400} \text{ m/s}$$

$$\Rightarrow v \approx 2.11 \times 10^3 \text{ m/s}$$

One edge moves towards the observer and the other moves away. By the Doppler effect, the wavelength from each edge shifts by

$$\Delta\lambda = \frac{\lambda v}{c}$$

Difference between the two edges:

$$2\Delta\lambda = \frac{2 \times 6563 \times 2.11 \times 10^3}{3 \times 10^8} \text{ Å}$$

$$\Rightarrow 2\Delta\lambda \approx 0.092 \text{ Å}$$

The nearest option is 0.0918 Å.

IAPT answer: (D) | **Zigyan answer:** (D)

35. The radii of the circumcircle and the in-circle of a triangle are 2.5 cm and 1.0 cm respectively. If the perimeter of the triangle is 12 cm, then the area of the triangle is

(A) 15 cm^2 (B) 12 cm^2 (C) 9 cm^2 (D) 6 cm^2

Solution · Q35 **Answer: (D)**

Semi-perimeter of the triangle:

$$s = 12/2 = 6 \text{ cm}$$

The area is the inradius multiplied by the semi-perimeter.

$$\Delta = rs$$

$$\Delta = 1.0 \times 6 = 6 \text{ cm}^2$$

IAPT answer: (D) | **Zigyan answer:** (D)

36. The electron, muon and the tauon are particles of the lepton family. All have charge − e and spin $\frac{\hbar}{2}$. The mass of the muon is approximately 207 times the mass of the electron. The mass of a tauon is 3478 times the mass of an electron and 1.894 times the mass of a proton. The mass of a proton is 1836 times that of the electron. Consider a 'heavy' atom with a tauon and a proton in orbit around each other. Assuming the Bohr model of the atom to be applicable, estimate the ground state energy of this atom. (The ground state energy of the hydrogen atom is −13.6 eV).

(A) −8.9 eV (B) −16.34 keV (C) −13.6 eV (D) −25.7 keV

Solution · Q36 **Answer: (B)**

The two particles move about their common centre of mass, so the reduced mass is used.

$$\mu = \frac{m_\tau m_p}{m_\tau + m_p}$$

$$\mu = \frac{3478 \times 1836}{3478 + 1836} m_e$$

$$\Rightarrow \mu \approx 1201.7\ m_e$$

In the Bohr model, the energy is proportional to the reduced mass. For hydrogen, this mass is very nearly the electron mass.

$$E = -13.6 \times 1201.7 \text{ eV}$$

$$\Rightarrow E \approx -16.34 \text{ keV}$$

IAPT answer: (B) | **Zigyan answer:** (B)

37. A planet of mass m is in a circular orbit of radius r around a star of mass M and radius R (radius of the star). By some physical process the star instantaneously shrinks to a black hole of the same mass M. The final orbit of the planet will be

(A) circular with radius 2r.

(B) a spiral going in towards the black hole.

(C) circular with radius r.

(D) a hyperbola as the planet escapes with speed greater than the escape speed.

Solution · Q37 **Answer: (C)**

Outside a spherical mass M, its gravity is that of a point mass M at the centre.

So the force on the planet is unchanged when the star shrinks. It still provides the centripetal force:

$$\frac{GMm}{r^2} = \frac{mv^2}{r}$$

The planet stays in the same circular orbit of radius r.

IAPT answer: (C) | **Zigyan answer:** (C)

38. Consider the two statements:

Statement A: Objects are closer than they appear when seen in a convex mirror.

Statement B: The image distance is always greater than the object distance for convex mirrors.

(A) Both statements are correct and statement B is the correct explanation of statement A.

(B) Both statements are correct but statement B is not the correct explanation of statement A.

(C) Statement A is correct but statement B is not correct.

(D) Statement B is correct but statement A is not correct.

Solution · Q38 **Answer: (C)**

For a convex mirror, using magnitudes of the distances,

$$v = \frac{uf}{u+f}$$
$$\Rightarrow v < u$$

So the image distance is smaller than the object distance: statement B is false.

The image is also diminished, so the object seems farther than it really is: statement A is true.

IAPT answer: (C) | **Zigyan answer:** (C)

39. Three sisters inherit n gold pieces, each weighing 1, 2, 3.... n (arbitry unit). For what n can the gold pieces be split into three heaps of equal weight?

(A) n is divisible by 5

(B) n is divisible by 3

(C) n + 1 is divisible by 5

(D) None of these

Solution · Q39 **Answer: (D)**

Each heap must have a whole-number weight, not less than the heaviest piece n:

$$W = \frac{n(n+1)}{6}$$

Testing option (A):

$$n = 10$$

$$\Rightarrow W = \frac{55}{3}$$

W is not a whole number.

Testing option (B):

$$n = 3$$

$$\Rightarrow W = 2$$

The piece of weight 3 cannot be placed.

Testing option (C):

$$n = 4$$

$$\Rightarrow W = \frac{10}{3}$$

W is not a whole number.

A split is possible only for the following n:

$$n = 3k \text{ or } 3k + 2$$

$$n \geq 5$$

IAPT answer: (D) | **Zigyan answer:** (D)

40. According to Wien's displacement law the wavelength of peak emission from a body is inversely proportional to the temperature of the body in kelvin. Two stars A and B with surface temperatures 3000 kelvin and 6000 kelvin respectively, are at the same distance from the Earth. They are of equal radius. The correct statement about the radiations emitted by the two stars is

(A) Both A and B will look equally bright in visible.

(B) A will look brighter than B in infrared.

(C) B will look brighter than A in infrared.

(D) A will emit more in the visible range than in the infrared.

Solution · Q40 **Answer: (C)**

By Planck's law, at every wavelength a hotter black body emits more per unit area.

The black-body curve of B (6000 K) therefore lies above that of A (3000 K) everywhere.

With equal radius and equal distance, B looks brighter than A in infrared too.

IAPT answer: (C) | **Zigyan answer:** (C)

41. Given the radius of the Earth as R and the height of the mast of a ship above sea level as h, when observed from a beach, the minimum distance along the sea surface d of the ship when the ship's mast goes below the horizon is (ignore the density variation of the atmosphere with height)

(A) $R\text{Cos}^{-1}\left(\frac{R}{R+h}\right)$

(B) $R\text{Tan}^{-1}\left(\frac{h}{R}\right)$

(C) $R\text{Sin}^{-1}\left(\frac{h}{R}\right)$

(D) $\frac{Rh}{R+h}$

Solution · Q41 **Answer: (A)**

With the eye at sea level, the mast top just disappears when it lies on the tangent to the sea at the observer.

If the arc d subtends angle θ at the centre of the Earth,

$$\cos\theta = \frac{R}{R+h}$$

$$d = R\theta$$

$$\therefore d = R\cos^{-1}\left(\frac{R}{R+h}\right)$$

IAPT answer: (A) | **Zigyan answer:** (A)

42. The sum ${}^{3}C_3 + {}^{4}C_3 + \ldots\ldots\ldots\ldots + {}^{n}C_3$ is equal to

(A) n! (B) ${}^{n}C_4$ (C) ${}^{n+1}C_4$ (D) ${}^{n}C_3$

Solution · Q42 **Answer: (C)**

By Pascal's rule,

$${}^{r}C_3 = {}^{r+1}C_4 - {}^{r}C_4$$

Adding from r equal to 3 up to n, the middle terms cancel. For the given sum S,

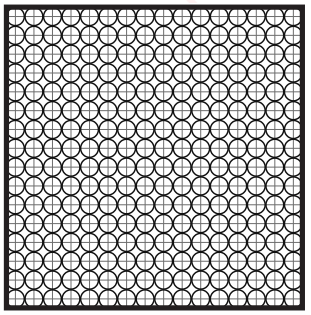
$$S = {}^{n+1}C_4 - {}^{3}C_4$$

The last term is zero.

$$\therefore S = {}^{n+1}C_4$$

IAPT answer: (C) | **Zigyan answer:** (C)

43. A cubical box is filled with a million identical spherical glass marbles all of radius 1.00 cm (the diagram shows representation of the positions of the marbles and not their actual number or size). The layers are placed exactly one above the other. If another set of smaller identical spherical marbles is introduced so that they just fit in the gaps between the first kind of marbles, then how much volume of water can fill the box fully?



(A) 1.11 m^3 (B) 2.08 m^3 (C) 2.22 m^3 (D) 2.56 m^3

Solution · Q43 **Answer: (C)**

The marbles form a 100 × 100 × 100 stack, so the box has side 2 m and volume 8 m^3.

Volume of the large marbles:

$$V_1 = 10^6 \times \frac{4}{3}\pi(1\text{ cm})^3 \approx 4.19\text{ m}^3$$

Each small marble sits at the centre of a cube formed by 8 large ones. Its radius is

$$r = \left(\sqrt{3} - 1\right)\text{ cm} \approx 0.732\text{ cm}$$

Number of such gaps:

$$N = 99^3 = 970299$$

Volume of the small marbles:

$$V_2 = N \times \frac{4}{3}\pi r^3 \approx 1.59\ m^3$$

Volume of water:

$$V = 8 - 4.19 - 1.59$$

$$\Rightarrow V \approx 2.22\ m^3$$

IAPT answer: (C) | **Zigyan answer:** (C)

44. A rubber band is being stretched slowly and uniformly. Hooke's law holds good. Observed from any given point on the rubber band every other point

(A) will move away with a constant speed

(B) will move with speed inversely proportional to the distance to the point

(C) will appear stationary

(D) will move with a speed proportional to the distance to the point

Solution · Q44 **Answer: (D)**

In uniform stretching, every length on the band grows in the same ratio. For two points separated by x along the band, with k fixed for the pair and L the length of the band,

$$x = kL$$

$$\Rightarrow \frac{dx}{dt} = k\frac{dL}{dt}$$

$$\Rightarrow \frac{dx}{dt} = \frac{x}{L}\frac{dL}{dt}$$

So at any instant the relative speed is proportional to the separation.

IAPT answer: (D) | **Zigyan answer:** (D)

45. A projectile is launched horizontally with speed $v_0 << v_{escape}$ from a height h above Earth's surface. Considering the Earth's curvature and non-uniformity of its gravity, viewed from space, the approximate shape of the trajectory of the projectile would be the arc of

(A) a parabola (B) a hyperbola (C) an ellipse (D) a circle

Solution · Q45 **Answer: (C)**

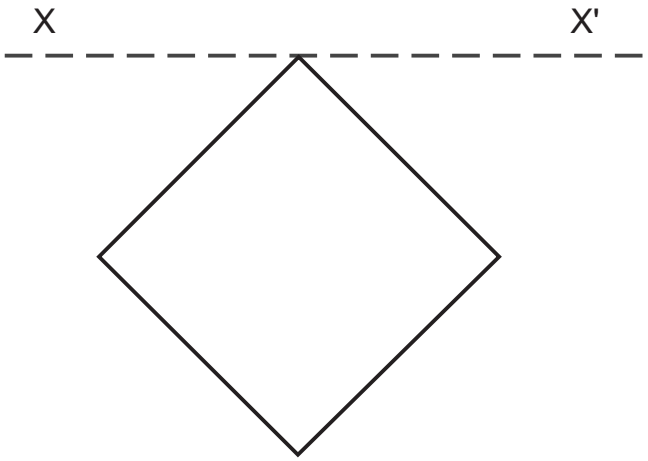
Gravity is an inverse-square force towards the centre of the Earth. As the launch speed is far below the escape speed, the total energy is negative:

$$E = \frac{1}{2}mv_0^2 - \frac{GMm}{R+h} < 0$$

The path is therefore bound: an ellipse with one focus at the centre of the Earth.

IAPT answer: (C) | **Zigyan answer:** (C)

46. A thin wire of uniform cross section is bent to form a square. Mass of the square is M and length of one side is L. The moment of inertia of the loop about the axis XX' is



(A) $\frac{2}{3}ML^2$ (B) $\frac{4}{3}ML^2$

(C) $\frac{13}{6}ML^2$ (D) $\frac{16}{3}ML^2$

Solution · Q46 **Answer: (A)**

Each side has a quarter of the mass. About the perpendicular axis through the centre,

$$I_z = 4\left[\frac{M}{4}\frac{L^2}{12} + \frac{M}{4}\left(\frac{L}{2}\right)^2\right] = \frac{ML^2}{3}$$

By the perpendicular axis theorem, for the central axis in the plane parallel to XX',

$$I_C = \frac{I_z}{2} = \frac{ML^2}{6}$$

XX' is half a diagonal away from it. By the parallel axis theorem,

$$I = I_C + M\left(\frac{L}{\sqrt{2}}\right)^2$$

$$\Rightarrow I = \frac{2}{3}ML^2$$

IAPT answer: (A) | **Zigyan answer:** (A)

47. Let $F(x) = \begin{vmatrix} x & x^2 & x^3 \\ 1 & 1 & 1 \\ 2 & 4 & 8 \end{vmatrix}$

Then find $c \in (1, 2)$ such that F' (c) = 0

(A) $1 + \frac{1}{\sqrt{3}}$ (B) $\sqrt{3}$

(C) $\frac{1}{\sqrt{3}}$ (D) $1 - \sqrt{3}$

Solution · Q47 **Answer: (A)**

Expanding along the first row,

$$F(x) = x(8 - 4) - x^2(8 - 2) + x^3(4 - 2)$$

$$\Rightarrow F(x) = 2x^3 - 6x^2 + 4x$$

$$\Rightarrow F'(x) = 6x^2 - 12x + 4$$

The derivative vanishes at c, so

$$3c^2 - 6c + 2 = 0$$

$$\Rightarrow c = 1 \pm \frac{1}{\sqrt{3}}$$

Taking the root lying in (1, 2),

$$\therefore c = 1 + \frac{1}{\sqrt{3}}$$

IAPT answer: (A) | **Zigyan answer:** (A)

48. The distance to a latitude circle from the pole (= R θ where θ is the colatitude and R is the radius of the Earth assumed spherical) is equal in all directions along the surface of the sphere. For latitude circles, the ratio of circumference to the diameter along the surface of the sphere is

(A) $\pi\frac{\text{Cos}\theta}{\theta}$ (B) $\pi\frac{\text{Sin}\theta}{\theta}$

(C) $\pi\frac{\theta}{\text{Sin}\theta}$ (D) $\pi\frac{\theta}{\text{Cos}\theta}$

Solution · Q48 **Answer: (B)**

The latitude circle has radius R sin θ about the polar axis, so its circumference is

$$C = 2\pi R \sin\theta$$

Its diameter measured along the sphere passes through the pole:

$$D = 2R\theta$$

$$\therefore \frac{C}{D} = \pi\frac{\sin\theta}{\theta}$$

IAPT answer: (B) | **Zigyan answer:** (B)

PART A-2 · ONE OR MORE CORRECT OPTIONS

Q. 49 – 60 · 6 marks only if all correct options are marked · no negative marking

49. In a two body system, Lagrange points are

(A) total six in number

(B) total five in number

(C) locations where net force (gravitational + centrifugal)) is zero.

(D) locations where the effective potential (gravitational + centrifugal) is zero

Solution · Q49 **Answer: (B), (C)**

A two body system has five Lagrange points, L_1 to L_5.

∴ (A) is false and (B) is true.

A body at rest there in the rotating frame stays at rest, so gravitational and centrifugal forces cancel. ∴ (C) is true.

This only makes the effective potential stationary:

$$\nabla U_{\text{eff}} = 0$$

The effective potential itself is negative there, not zero. ∴ (D) is false.

IAPT answer: (B), (C) | **Zigyan answer:** (B), (C)

50. Which of the following problems are same as that of the problem of selecting r objects with repetition from n different objects?

(A) The problem of distributing r identical objects with repetition into n different boxes.

(B) The number of non-negative integer solutions to the equation: $x_1 + x_2 + ... + x_n = r$.

(C) Permutations of r objects taken n at a time.

(D) Combinations of r objects taken n at a time

Solution · Q50 **Answer: (A), (B)**

Let object i be chosen x_i times.

$$x_1 + x_2 + ... + x_n = r,\ x_i \geq 0$$

Number of solutions:

${}^{n+r-1}C_r$

This is the problem in (B). ∴ same.

In (A), x_i is the number of identical objects in box i, giving the same equation. ∴ same.

(C) and (D) take n at a time from r objects, without repetition:

${}^{r}P_n$, ${}^{r}C_n$

These are different counts. ∴ not the same.

IAPT answer: (A), (B) | **Zigyan answer:** (A), (B)

51. A and B are two van-der-Waals gases. Critical temperature of gas B is double that of gas A. Which of the following statement/s is/are valid?

(A) If the volume of molecules of B is same as that of the molecules of A, then the critical pressure of gas B is double that of gas A.

(B) If the critical pressure of gas B is four times that of gas A, then the critical volume of gas B is double that of gas A.

(C) If the critical volume of gas B is four times that of gas A, then the critical pressure of gas B must be double that of gas A.

(D) If the critical volume of gas B is double that of gas A, then their critical pressures must be equal.

Solution · Q51 **Answer: (A), (D)**

For a van der Waals gas,

$$T_c = \frac{8a}{27Rb}$$

$$P_c = \frac{a}{27b^2}$$

$$V_c = 3b$$

$$\Rightarrow P_c = \frac{RT_c}{8b}$$

$$\Rightarrow P_c = \frac{3RT_c}{8V_c}$$

Given:

$$T_{cB} = 2T_{cA}$$

(A) Equal molecular volumes mean equal b.

$$\Rightarrow P_{cB} = 2P_{cA}$$

$\therefore$ valid.

(B) If B has four times the critical pressure of A,

$$\Rightarrow V_{cB} = V_{cA}/2$$

$\therefore$ not valid.

(C) If B has four times the critical volume of A,

$$\Rightarrow P_{cB} = P_{cA}/2$$

$\therefore$ not valid.

(D) If B has twice the critical volume of A,

$$\Rightarrow P_{cB} = P_{cA}$$

$\therefore$ valid.

IAPT answer: (A), (D) | **Zigyan answer:** (A), (D)

52. The tidal force (due to Sun/Moon) at the surface of the Earth

(A) by Moon's gravity is stronger than that due to Sun's gravity

(B) by Sun's gravity is stronger than that due to Moon's gravity

(C) is proportional to $1/R^2$, if R is the distance between the centres of mass

(D) is proportional to $1/R^3$, if R is the distance between the centres of mass

Solution · Q52 **Answer: (A), (D)**

Tidal force is the change in pull between the Earth's centre and its surface. For the Sun or Moon, of mass M, with Earth's radius r much smaller than R,

$$\frac{F_{tidal}}{m} \approx \frac{2GMr}{R^3}$$

$$\Rightarrow F_{tidal} \propto M/R^3$$

$\therefore$ (C) is false and (D) is true.

The Sun is far heavier but much farther. The Moon's value of M/R^3 is about 2.2 times the Sun's.

$\therefore$ (A) is true and (B) is false.

IAPT answer: (A), (D) | **Zigyan answer:** (A), (D)

53. Which of the following statements is correct about the electrostatic field?

(A) Field inside a uniform positively charged circular ring in the plane of the ring would be zero if the electrostatic force were proportional to 1/r.

(B) Field inside a uniform positively charged spherical shell would be directed towards the centre if the electrostatic force were proportional to $1/r^3$.

(C) Field in the plane of a uniform positively charged disc would be proportional to the distance from the centre if the force were proportional to 1/r.

(D) Field above/below a uniform positively charged large plane would be inversely proportional to the distance from the plane if the force were proportional to $1/r^3$.

Solution · Q53 **As per Zigyan: (A), (B), (D)**

(A) For a 1/r force, Gauss's law holds within a plane. On a circle of radius r,

$$E(2\pi r) \propto q_{enclosed}$$

Inside the ring, no charge is enclosed.

$$\Rightarrow E = 0$$

$\therefore$ correct.

(B) For a $1/r^3$ force, the nearer part of the shell dominates and pushes a positive charge towards the centre. $\therefore$ correct.

(C) On the disc, the enclosed charge grows as r^2:

$$E \propto r$$

Beyond the rim, the enclosed charge is fixed:

$$E \propto 1/r$$

So the field in the plane is not proportional to the distance. $\therefore$ not correct.

(D) For force kqQ/r^3 and surface charge density σ, at height z,

$$E = 2\pi k\sigma z \int_0^\infty \frac{\rho d\rho}{(\rho^2 + z^2)^2}$$

$$\Rightarrow E = \frac{\pi k\sigma}{z}$$

$\therefore$ correct.

Check: direct numerical integration of the 1/r force over a disc, without Gauss's law, gives E/r constant on the disc and E × r constant beyond the rim.

IAPT answer: (A), (B), (D) | **Zigyan answer:** (A), (B), (D)

54. Identify the correct identities.

(A) ${}^nC_0 + {}^nC_2 + {}^nC_4 + ... = 2^{n-1}$

(B) ${}^nC_0 + {}^nC_1 + {}^nC_2 + ... + {}^nC_n = 2^n$

(C) $1\,{}^nC_1 + 2\,{}^nC_2 + 3\,{}^nC_3 + ... + n\,{}^nC_n = n2^{n-1}$

(D) ${}^nC_1 + {}^nC_3 + {}^nC_5 + ... = 2^{n-1}$

Solution · Q54 **Answer: (A), (B), (C), (D)**

For a positive integer n,

$$(1 + x)^n = {}^nC_0 + {}^nC_1x + ... + {}^nC_nx^n$$

Putting 1 for x,

$$\Rightarrow {}^nC_0 + {}^nC_1 + ... + {}^nC_n = 2^n$$

$\therefore$ (B) is correct.

Putting −1 for x,

$$\Rightarrow {}^nC_0 - {}^nC_1 + {}^nC_2 - .... = 0$$

Adding and subtracting the last two results,

$$\Rightarrow {}^nC_0 + {}^nC_2 + ... = 2^{n-1}$$

$$\Rightarrow {}^nC_1 + {}^nC_3 + ... = 2^{n-1}$$

$\therefore$ (A) and (D) are correct.

Differentiating the expansion, then putting 1 for x,

$$\Rightarrow 1\,{}^nC_1 + 2\,{}^nC_2 + ... + n\,{}^nC_n = n2^{n-1}$$

$\therefore$ (C) is correct.

IAPT answer: (A), (B), (C), (D) | **Zigyan answer:** (A), (B), (C), (D)

55. A geosychronous orbit is one

(A) which is synchronized with the rotation of the Earth

(B) which is synchronized with half the rotation period of the Earth

(C) which can have any inclination

(D) which can only be above the equator

Solution · Q55 **Answer: (A), (C)**

A geosynchronous orbit has a period equal to the Earth's rotation period, about 23 h 56 min. $\therefore$ (A) is true and (B) is false.

The period is fixed by the size of the orbit, not by its tilt. $\therefore$ (C) is true.

Only a geostationary orbit, circular with zero inclination, has to lie above the equator. $\therefore$ (D) is false.

IAPT answer: (A), (C) | **Zigyan answer:** (A), (C)

56. Identify the correct statements about vectors A, B and C.

(A) (A × B) × C has a nonzero component along the vector A

(B) (A × B) × C is orthogonal to C

(C) (A × B) × C has zero component along B.

(D) (A × B) × C is orthogonal to A.

Solution · Q56 **Answer: (B)**

(A × B) × C is a cross product with C, so it is perpendicular to C. ∴ (B) is correct.

With unit vectors along the axes, first take

$$A = \hat{i}, B = \hat{j}, C = \hat{i}$$

$$\Rightarrow (A \times B) \times C = \hat{j}$$

It has no component along A, but it has one along B. ∴ (A) and (C) need not hold.

Next take

$$A = \hat{i}, B = \hat{j}, C = \hat{j}$$

$$\Rightarrow (A \times B) \times C = -\hat{i}$$

This is opposite to A, not orthogonal to it. ∴ (D) need not hold.

IAPT answer: (B) | **Zigyan answer:** (B)

57. Ohm's law can be written as $I = \frac{V}{R}$. Resistance of any electronic component is defined as $R = \frac{V}{I}$

Which of the following statements are valid:

(A) Diode does not obey Ohm's law, hence its resistance cannot be found out.

(B) Ohm's law is equivalent to definition of resistance of electronic component.

(C) Ohm's law is valid only for naturally occurring materials and not for artificially created electronic materials.

(D) If resistance of a component varies with current then it does not obey Ohm's law.

Solution · Q57 **Answer: (D)**

The ratio

$$R = \frac{V}{I}$$

defines resistance for any component at any operating point. Ohm's law says more: under fixed physical conditions this ratio stays constant.

(A) A diode's resistance can still be found at each point. ∴ not valid.

(B) A definition is not the same as a law. ∴ not valid.

(C) The law does not depend on whether a material is natural or artificial. ∴ not valid.

(D) If resistance changes with current, voltage is not proportional to current. ∴ valid.

IAPT answer: (D) | **Zigyan answer:** (D)

58. Retrograde motion of planets

(A) is due to epicyclic motion

(B) arises from the projection of the planet's motion on the sky plane

(C) is exhibited only by the inner planets

(D) shows that the planets are not all moving with the same angular speed

Solution · Q58 **Answer: (B), (D)**

Retrograde motion is the apparent backward drift of a planet against the background stars.

It appears when the Earth and a planet pass each other: the motion relative to the moving Earth is seen projected on the sky. ∴ (B) is true.

With coplanar circular orbits and equal angular speeds, the line from Earth to planet would turn steadily one way and never reverse. ∴ (D) is true.

Epicycles belong to the old geocentric model; planets do not really move on them. ∴ (A) is false.

Outer planets such as Mars show it too. ∴ (C) is false.

IAPT answer: (B), (D) | **Zigyan answer:** (B), (D)

59. Which of the following elements present in hemoglobin molecules were produced by stars

(A) Oxygen (B) Nitrogen (C) Hydrogen (D) Iron

Solution · Q59 **Answer: (A), (B), (D)**

Hydrogen was formed soon after the Big Bang, before any star existed.

Oxygen is made by helium burning in stars.

Nitrogen is made mainly through the CNO cycle in stars.

Iron is made in the last burning stages of massive stars and in supernova explosions.

∴ Oxygen, nitrogen and iron came from stars; hydrogen did not.

IAPT answer: (A), (B), (D) | **Zigyan answer:** (A), (B), (D)

60. Let S = {A, B, C ..} denote either the set of real numbers or the set of N × N real square matrices and let ∘ denote either of the two operations addition or multiplication. Then which of the following statements hold/s always.

(A) There exists $E \in S$ such that $A \circ E = E \circ A = A$ for all $A \in S$

(B) $A \circ B = C$

(C) For every A there exists a B such that $A \circ B = E$

(D) $A \circ (B \circ C) = (A \circ B) \circ C$

Solution · Q60 **Answer: (A), (B), (D)**

(A) An identity exists: zero or the zero matrix for addition, one or the identity matrix for multiplication. ∴ holds.

(B) Closure: adding or multiplying any two elements A and B of S gives an element C of S. ∴ holds.

(C) Under multiplication, the number zero and singular matrices have no inverse. ∴ does not always hold.

(D) Addition and multiplication of real numbers or square matrices are associative. ∴ holds.

IAPT answer: (A), (B), (D) | **Zigyan answer:** (A), (B), (D)

ANSWER KEY

NSEA 2022 · PAPER CODE 41

60
QUESTIONS · 216 MARKS

IAPT final answer key for paper code 41. ★ marks an answer given as per Zigyan.

1	(B)	2	(C)	3	(A)	4	(A)	5	(C)
6	(A)	7	(B)	8	(A)	9	(B)	10	(D)
11	(B)★	12	(D)	13	(C)	14	(C)	15	(A)
16	(B)	17	(B)	18	(C)	19	(A)	20	(D)
21	(C)	22	(A)	23	(A)	24	(B)	25	(D)
26	(B)	27	(A)	28	(C)★	29	(B)	30	(C)
31	(A)	32	(B)	33	(B)	34	(D)	35	(D)
36	(B)	37	(C)	38	(C)	39	(D)	40	(C)
41	(A)	42	(C)	43	(C)	44	(D)	45	(C)
46	(A)	47	(A)	48	(B)	49	(B), (C)	50	(A), (B)
51	(A), (D)	52	(A), (D)	53	(A), (B), (D)★	54	(A), (B), (C), (D)	55	(A), (C)
56	(B)	57	(D)	58	(B), (D)	59	(A), (B), (D)	60	(A), (B), (D)

★ Answers as per Zigyan

- **Q11** — As per Zigyan: (B); IAPT key (A).
- **Q28** — As per Zigyan: (C); IAPT key (D).
- **Q53** — As per Zigyan: (A), (B), (D); IAPT key (A), (B), (D).

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OLYMPIADS · 2026

Olympiad results



TOP ACHIEVEMENT · CHEMISTRY

Qualified the Chemistry Olympiad twice, and selected for the HBCSE camp.

Saksham Bishnoi reached the national stage of the Chemistry Olympiad in two consecutive years and was selected for the Orientation-cum-Selection Camp at HBCSE, Mumbai. 4 Years Classroom - the same student who took AIR 168 in JEE Advanced 2026.

Qualified twice | HBCSE selection camp | Only student from Faridabad

Above MAS means above the **Minimum Admissible Score**: clearing it puts a student in the national band for their subject. It is a real threshold, not a participation marker.

CHEMISTRY · ABOVE MAS



Sulokya Bibhuty
Class XII
3 Years Classroom
Above MAS



Anay Gupta
Class XI
3 Years Classroom
Above MAS



Akshat Khator
Class XI
3 Years Classroom
Above MAS



Harshit Goyal
Class XII
4 Years Classroom
Above MAS



Hardik Sharma
Class XI
3 Years Classroom
Above MAS



Aarush Kumar
Class XII
1 Year Classroom
Above MAS

PHYSICS · ASTRONOMY · MATHEMATICS

PHYSICS



Sulokya Bibhuty
Class XII
3 Years Classroom
Above MAS

PHYSICS



Saksham Bishnoi
Class XII
4 Years Classroom
Above MAS

ASTRONOMY



Sulokya Bibhuty
Class XI
3 Years Classroom
Above MAS

MATHEMATICS · IOQM



Priyanshi
Class XI
4 Years Classroom
IOQM Qualifier

OLYMPIADS WE PREPARE STUDENTS FOR

NSEP	NSEC	NSEB	NSEA	IOQM	NSEJS
Physics	Chemistry	Biology	Astronomy	Mathematics	Class X and below

The olympiad pathway starts in Class 8.

NSEJS is open to Class 10 and below - the habit of staying with one hard problem is the one JEE Advanced rewards.

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RESULTS · 2021 – 2026

Our toppers, year by year

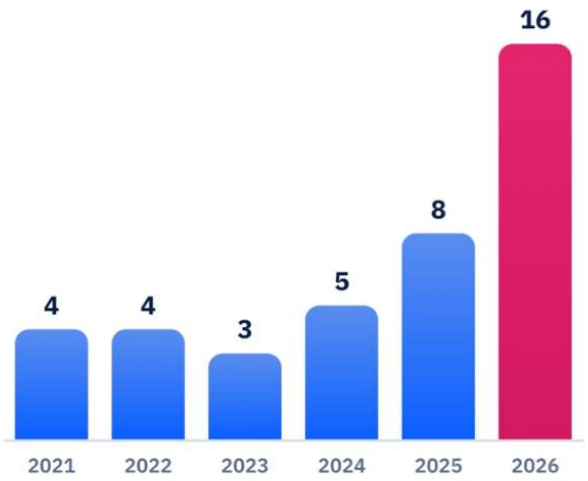
40
JEE Advanced selections in 6 years

AIR 168
best rank — Saksham Bishnoi, 2026

16 of 35
students selected, JEE Advanced 2026

14 of 35
above 98 percentile, JEE Main 2026

JEE ADVANCED SELECTIONS PER YEAR



BEST RANK EACH YEAR

YEAR	JEE ADVANCED	JEE MAIN
2026	**Saksham Bishnoi** AIR 168 · 4 Years Classroom	**Saksham Bishnoi** AIR 811 · 99.95 %ile
2025	**Chakshu** AIR 4,233 · 2 Years Classroom	**Chakshu** AIR 8,538 · 99.44 %ile
2024	**Harshit** AIR 777 · 2 Years Classroom	**Harshit** AIR 1,473 · 99.91 %ile
2023	**Aditya Jain** AIR 2,373 · 2 Years Classroom	**Aditya Jain** AIR 2,503 · 99.79 %ile
2022	**Rachit Sharma** AIR 698 · 1 Year Classroom	**Rachit Sharma** AIR 1,016 · 99.90 %ile
2021	**Sparsh Mittal** AIR 2,237 · 1 Year Classroom	**Sparsh Mittal** AIR 1,562

JEE ADVANCED 2026 — THIRTEEN NAMED SELECTIONS



Saksham Bishnoi
AIR 168
4 Years Classroom



Sulokya Bibhuty
AIR 1,315
3 Years Classroom



Aarush
AIR 2,699
1 Year Classroom



Manishka
AIR 2,869
4 Years Classroom



Oojit Kumar
AIR 5,765
4 Years Classroom



Harshit Goyal
AIR 6,407
4 Years Classroom



Pranab Sharma
AIR 6,750
3 Years Classroom



Aditya Dhar
AIR 15,183
3 Years Classroom



Arpit Anshuman
AIR 19,308
4 Years Classroom



Lokesh
AIR 22,857
3 Years Classroom



Arjun
AIR 24,674
3 Years Classroom



Sanyam Gulyani
AIR 25,123
1 Year Classroom



Saket
AIR 27,628
3 Years Classroom

Sixteen students of the 2026 batch were selected in JEE Advanced; the thirteen above are named with their All India Rank.

JEE MAIN 2026 — TOP SIX, WITH PERCENTILE



Saksham Bishnoi
AIR 811
99.95 %ile
4 Years Classroom



Sulokya Bibhuty
AIR 1,095
99.94 %ile
3 Years Classroom



Harshit Goyal
AIR 2,662
99.83 %ile
4 Years Classroom



Manishka
AIR 4,817
99.70 %ile
4 Years Classroom



Oojit Kumar
AIR 5,040
99.69 %ile
4 Years Classroom



Aarush
AIR 5,276
99.67 %ile
1 Year Classroom

14 of the 35 students in the 2026 batch scored above the 98th percentile in JEE Main.

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