Time: 9:00 AM to 10:00 AM
Question Paper Code: 41

Student's Roll No:														

Write the question paper code mentioned above on YOUR OMR Answer Sheet (in the space provided), otherwise your Answer Sheet will NOT be evaluated. Note that the same Question Paper Code appears on each page of the question paper.

Instructions to Candidates:

1. Use of mobile phone, smart watch and iPad during examination is STRICTLY PROHIBITED.
2. In addition to this question paper, you are given OMR Answer Sheet along with candidate's copy.
3. On the OMR sheet, make all the entries carefully in the space provided **ONLY** in **BLOCK CAPITALS** as well as by properly darkening the appropriate bubbles.

   Incomplete/ incorrect/ carelessly filled information may disqualify your candidature.
4. On the OMR Answer Sheet, use only **BLUE** or **BLACK BALL POINT PEN** for making entries and filling the bubbles.
5. Your **fourteen-digit roll number and date of birth** entered on the OMR Answer Sheet shall remain your login credentials means login id and password respectively for accessing your performance / result in Indian Olympiad Qualifier in Astronomy 2020-21 (Part I).
6. Question paper has two parts. In part A1 (Q. No.1 to 24) 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. 12 (a) ● (c) (d)

   In part A2 (Q. No. 25 to 32) 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. 30 (a) ● (c) ●
7. For **Part A1**, each correct answer carries 3 marks whereas 1 mark will be deducted for each wrong answer. In **Part A2**, you get 6 marks if all the correct alternatives are marked and no incorrect. No negative marks in this part.
8. Rough work should be done only in the space provided. There are **07** printed pages in this paper.
9. Use of **non- programmable scientific** calculator is allowed.
10. No candidate should leave the examination hall before the completion of the examination.
11. After submitting answer paper, take away the question paper and candidate's copy of OMR for your reference.

Please DO NOT make any mark other than filling the appropriate bubbles properly in the space provided on the OMR answer sheet.

OMR answer sheets are evaluated using machine, hence CHANGE OF ENTRY IS NOT ALLOWED. Scratching or overwriting may result in a wrong score.

DO NOT WRITE ON THE BACK SIDE OF THE OMR ANSWER SHEET.

Instructions to Candidates (Continued) :

You may read the following instructions after submitting the answer sheet.

12. **Comments/Inquiries/Grievances regarding this question paper, if any, can be shared on the Inquiry/Grievance column on www.iaptexam.in on the specified format till February 12, 2021.**
13. **The answers/solutions to this question paper will be available on the website: www.iapt.org.in by February 13, 2021.**
14. **CERTIFICATES and AWARDS:**

    Following certificates are awarded by IAPT to students, successful in the Indian Olympiad Qualifier in Astronomy 2020-21 (Part I)

    (i) "CENTRE TOP 10 %"

    (ii) "STATE TOP 1 %"

    (iii) "NATIONAL TOP 1 %"

    (iv) "GOLD MEDAL & MERIT CERTIFICATE" to all students who attend OCSC-2021 at HBCSE Mumbai
15. All these certificates (except gold medal) will be downloadable from IAPT website : www.iapt.org.in after March 15, 2020-21.
16. List of students (with centre number and roll number only) having score above MAS will be displayed on the website: www.iapt.org.in by **February 25, 2021. See the Minimum Admissible score Clause** on the Student's brochure on the web.
17. List of Students eligible for evaluation of IOQA 2020-21 (Part II) shall be displayed on www.iapt.org.in by March 1, 2021.

Physical constants you may need….

CONSTANT	MAGNITUDE	UNIT
Charge of electron	1.60×10^{-19}	C
Mass of electron	9.10×10^{-31}	kg
Mass pf proton	1.67×10^{-27}	kg
Universal Gravitational Constant	6.67×10^{-11}	$Nm^{-2} kg^{-2}$
Boltzmann constant	1.38×10^{-23}	JK^{-1}
Stefan's constant	5.67×10^{-8}	$Wm^{-2} K^{-4}$
Avogadro's Constant	6.02×10^{23}	mol^{-1}
Speed of light in vacuum	3.00×10^{8}	ms^{-1}
Rydberg's constant	1.10×10^{7}	m^{-1}
Density of water	1.00×10^{3}	kgm^{-3}
Plank's constant	6.63×10^{-34}	Js
Faraday's constant	9.65×10^{4}	$Cmol^{-1}$
permeability of free space	8.85×10^{-12}	$C^{-} N^{-1} m^{-2}$
Light year	9.46×10^{15}	m
Earth - Sun Distance	1.50×10^{11}	m
Diameter of the Sun	1.39×10^{9}	m
Permeability of free space	$4\pi\times10^{-7}$	Hm^{-1}
Universal Gas Constant	8.31	$J mol^{-1} K^{-1}$
Acceleration due to gravity	9.81	ms^{-2}
Parsec	3.26	light year

Question Paper Code: 41

Time: 60 Minute **Max. Marks: 120**

Attempt All The Thirty Two Questions

A - 1

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

1. The value of $\tan^{-1}\left[\frac{\cos x}{1-\sin x}\right]$ is equal to

(a) $\frac{x}{2}$ (b) $\frac{x}{2}-\frac{\pi}{2}$ (c) $\frac{x}{2}-\frac{\pi}{4}$ (d) $\frac{x}{2}+\frac{\pi}{4}$

2. The determinant $\begin{vmatrix} 1 & 1 & -1 \\ -1 & 1 & 1 \\ 1 & 1 & x \end{vmatrix} = 0$ The value of x is

(a) $x = 0$ or 1 (b) $x = \pm 1$ (c) $x = -1$ (d) $x = 1$

3. The value of the given integral

$$\int_{\pi/3}^{\pi/4} \frac{dx}{\sin^2 x \cdot \cos^2 x}$$

is

(a) $\frac{\pi}{4}-\frac{\pi}{3}$ (b) 0 (c) $\frac{1}{\sqrt{3}}$ (d) $-\frac{2}{\sqrt{3}}$

4. Consider the four points A, B, C, D forming a regular tetrahedron with sides each of length L. The coordinates (x, y, z) of A, B and C are A (0,0,0), B (L,O,O) & C $\left(\frac{L}{2},\frac{L\sqrt{3}}{2},0\right)$ The possible coordinates of D are

(a) $\left(\frac{L}{2},\frac{L}{2},\pm\frac{L}{\sqrt{2}}\right)$ (b) $\left(\frac{L}{2},\frac{L}{2\sqrt{3}},\pm\frac{L\sqrt{2}}{\sqrt{3}}\right)$

(c) $\left(\frac{L}{\sqrt{2}},\frac{L}{\sqrt{3}},\pm\frac{L}{\sqrt{3}}\right)$ (d) $\left(\frac{L}{\sqrt{2}},\frac{L}{\sqrt{3}},\pm\frac{L\sqrt{5}}{\sqrt{12}}\right)$

5. The argument of the complex number $z = \frac{1+i}{1-i\sqrt{3}}$ is

(a) π (b) $\frac{7\pi}{12}$ (c) $-\frac{5\pi}{12}$ (d) $+\frac{5\pi}{12}$

6. Consider the two curves $y_1 = \frac{4x^2}{\pi^2}$ and $y_2 = \sin x$ in the region $0 < x < \pi$. The angle made by the curves at the point of intersection is

(a) $\tan^{-1}(\frac{1}{\pi})$ (b) $\tan^{-1}(\frac{4}{\pi})$ (c) $\tan^{-1}\infty$ (d) $\tan^{-1} 0$

7. The three points (2, 3, - 4), (1, -2, 3) and (3, 8, r) are collinear. The value of r is

(a) 0 (b) -10 (c) -11 (d) 10

8. The time period of a simple pendulum is theoretically π seconds. In an experiment to measure this time period, a stop clock having least count of one-hundredth of a second is used and the time taken for 'n' oscillations is measured. The percentage error in the calculation of the time period will be

(a) $(n\pi)^{-1}\%$ (b) $\pi\%$ (c) 2% (d) $2(n\pi)^{-1}\%$

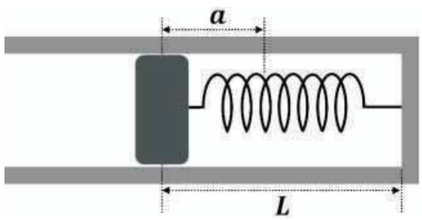
9. A large sphere A of 20 kg being accelerated at 5.0 ms^{-2} strikes another sphere B of mass 8.0 kg. At the moment of impact, the acceleration of B is 12 ms^{-2}. The force on B at the moment of impact is

(a) 40N (b) 96N (c) 240N (d) 100N

10. Consider that in space with no air resistance and negligible gravity, a ball of mass 250 g, initially at rest, is projected with a force of 30N giving it a speed of 20 ms^{-1}. The ball travels a distance of 1000 m before it strikes a space ship. The original energy, E (in Joule) with which the ball was projected is

(a) 30,000 (b) 50 (c) $50 < E < 30,000$ (d) none of these

11. The diagram shows a mass m free to slide inside a long frictionless tube along the x axis. It is attached to a spring of spring constant k whose unscratched length is L. Initially the mass is pushed to a position x = a (< L) and released from rest. Let there be a certain position $x = x_m$ at which the maximum power, P_{max}, is generated due to kinetic energy. The values x_m and P_{max} are respectively



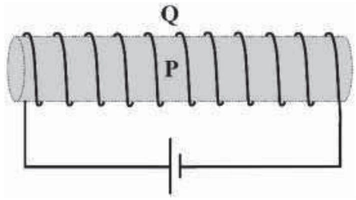
(a) $\frac{a}{2}$ & $\left(\frac{3ka^2}{2}\sqrt{\frac{k}{m}}\right)$ (b) 0 & $\left(ka^2\sqrt{\frac{k}{m}}\right)$

(c) $\frac{a}{\sqrt{2}}$ & $\left(\frac{ka^2}{2}\sqrt{\frac{k}{m}}\right)$ (d) $\frac{3a}{4}$ & $\left(2ka^2\sqrt{\frac{k}{m}}\right)$

12. Consider a cube with one of its 6 faces open. A charge q is placed at the center of the open face. The total electric flux through the rest of the 5 faces will be nearly equal to

(a) zero (b) $\frac{q}{\varepsilon_0}$ (c) $\frac{q}{2\varepsilon_0}$ (d) $\frac{5q}{6\varepsilon_0}$

13. In the diagram of solenoid shown, point P is inside the solenoid and point Q is just outside the solenoid. Which of the following is true for Magnetic Fields $\vec{B}_p$ and $\vec{B}_Q$ at point P and Q respectively?



(a) $\vec{B}_p \neq 0$ & $\vec{B}_Q \approx 0$ (b) $\vec{B}_p \approx 0$ & $\vec{B}_Q \neq 0$ (c) $\vec{B}_p \neq 0$ & $\vec{B}_Q = \vec{B}_p$ (d) $\vec{B}_p = 0$ & $\vec{B}_Q \neq 0$

14. A 156 Ω non-inductive resistor is connected to an AC source which generates an emf which is given by $e = 312 \sin(100\pi t + \pi\sqrt{2})$V. The value of current flowing through the resistor as measured by a millimeter (in A) will be

(a) $2\sqrt{2}$ (b) 2 (c) $\sqrt{2}$ (d) 1

15. Consider an atom of mass m in an excited state, moving with a speed v, (v << c) along the x axis. It makes a transition to the ground state by emitting a photon along the y axis. If ΔE is the energy difference between the excited state and the ground state, the frequency of the emitted photon is

(a) $\frac{\Delta E}{h}$ (b) $\frac{\Delta E}{h}\left[1-\frac{\Delta E}{mc^2}\right]$

(c) $\frac{mc^2}{h}\left[\left(\sqrt{1+2\frac{\Delta E}{mc^2}}\right)-1\right]$ (d) not determinable

16. Messier Object M1 is
(a) Andromeda Nebula (b) Crab Nebula
(c) Orion Nebula (d) Horsehead Nebula

17. The right ascension of winter solstice is
(a) 18 hours (b) 12 hours
(c) 6 hours (d) depends on the time of the year

18. The latitude and longitude of the two cities A and B are at (13.0^{0}N, 77.6^{0}E) and (28.7^{0}N, 77.6^{0}E) respectively. On 15th December 2021,
(a) The Sun will rise earlier and set later in A compared to B.
(b) The Sun will rise earlier and set earlier in A compared to B.
(c) The Sun will rise later and set earlier in A compared to B.
(d) The Sun will rise later and set later in A compared to B.

19. In the Period - Luminosity relationship of Cepheid variables, type I Cepheid has 4 times the luminosity than that of type II Cepheid for the same period. The distance to Andromeda Galaxy was determined by assuming a Cepheid located in it as type I. If it had been assumed to be a type II Cepheid, the distance would

(a) increase by a factor of 4 (b) increase by a factor of 2
(c) decrease by a factor of 4 (d) decrease by a factor of 2

20. The energy emitted by the Sun is due to fusion reaction $4\,{}_1H^1 \rightarrow {}_2He^4 + 2\,{}_1\beta^0 + 2v_e$ (v_e are neutrinos) with a release of 27 MeV. Assume the solar constant i.e, the energy received per second per meter^2 on the surface of Earth is 1.4 k Wm^{-2} The neutrino flux on the Earth (in $m^{-2}\,s^{-1}$) is approximately (assume that the neutrinos do not interact with anything on their way to the Earth)

(a) 6.5×10^{14} (b) 6.5×10^{10} (c) 6.5×10^{18} (d) 6.5×10^{22}

21. A large cluster of radius R has N stars each having a mass M. The stars are moving in the cluster such that the average kinetic energy of a star equals the magnitude of the average gravitational potential energy between two neighbouring stars. Assume the average gravitational potential energy of a star due to a neighbouring star is proportional to $\left(-\frac{GM^2}{r}\right)$, where r is the average distance between two stars. Then the average speed of the star is proportional to

(a) $\sqrt{\left[\frac{GMN^{\frac{1}{3}}}{R}\right]}$ (b) $\sqrt{\left[\frac{GMN^{\frac{2}{3}}}{R}\right]}$ (c) $\sqrt{\left[\frac{GMN}{R}\right]}$ (d) $\sqrt{\left[\frac{GMN^{\frac{4}{3}}}{R}\right]}$

22. The distance to Venus from Earth at a particular time is 9.00×10^{10} m. Assume the orbits of Venus and Earth around the Sun to be circular with radii 1.10×10^{11} m and 1.50×10^{11} m respectively. The angle between Sun and Venus as viewed from the Earth is approximately

(a) 20^0 (b) 47^0 (c) 60^0 (d) 80^0

23. As viewed from a place on the Earth, a star makes an angle of 10^0 with the north pole and is just circumpolar. The latitude of the place is

(a) 10^0N (b) 80^0N (c) 10^0S (d) 80^0S

24. The Moon makes hour angle of 40^0 at 6 pm on a particular day when the Sun is about to set. The hour angle of the Moon at the same time next day is approximately

(a) 70^0 (b) 40^0 (c) -40^0 (d) 27^0

A - 2

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

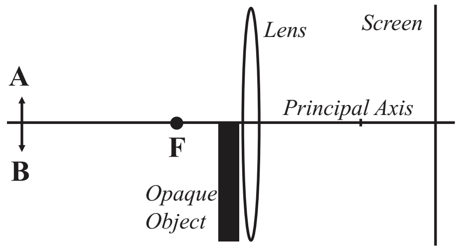
MARKS WILL BE AWARDED ONLY IF ALL CORRECT OPTIONS ARE BUBBLED AND NO WRONG OPTION

25. If a and b are real numbers, the equation $a(x+3)^2 + b(y+4)^2 = 1$ represents
    (a) An ellipse or a circle if $a > 0$ and $b > 0$
    (b) An ellipse or a circle if $a < 0$ and $b < 0$
    (c) A hyperbola if $a > 0$ and $b < 0$ or $a < 0$ and $b > 0$
    (d) A parabola if $a > 0$ and $b = 0$

26. If $\tan\theta = \cot\left(\frac{\pi}{3}\right)$ then θ can be
    (a) $\frac{\pi}{6}$
    (b) $\frac{7\pi}{6}$
    (c) $\frac{13\pi}{6}$
    (d) $\frac{5\pi}{6}$

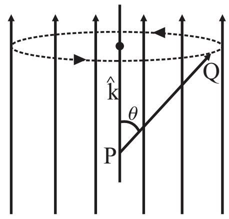
27. The critical velocity of a flowing liquid depends on
    (a) Coefficient of viscosity
    (b) Reynold number
    (c) Density of the liquid
    (d) Diameter of the tube

28. Consider the situation as shown in the diagram where a symmetric biconvex lens is half covered with an opaque object. Given that the object shown AB is symmetric about the principal axis, which of the following is true about the image seen on the screen?



    (a) Full image of AB is formed
    (b) Intensity of the image is reduced
    (c) Full image of AB is formed and the intensity is reduced.
    (d) Only half of AB is visible

29. A uniform magnetic field $\vec{B} = B_0\hat{k}$ exists over a certain region of space as shown in figure. A metal rod PQ of length L is fixed at P and PQ makes a constant angle of θ with $\hat{k}$ as it rotates about $\hat{k}$ with a constant angular velocity ω.



    (a) The velocity of point Q is $\vec{v} = \vec{\omega} \times \vec{L}$
    (b) The magnitude of induced electric field along the rod at a distance r from P is $E = r\omega B_0 \sin^2\theta$
    (c) The magnitude of emf developed between P and Q is $= 0.5\, L^2 \omega B_0 \sin 2\theta$
    (d) The magnitude of emf developed between P and Q is $= 0.5\, L^2 \omega B_0 \sin^2\theta$

30. Spectroscopic analysis of light from stars gives us information about
    (a) The abundance of elements in the stars
    (b) Parallax of stars
    (c) The radial velocity of stars
    (d) Proper motion of stars

31. Which of the following terms refer to a variable star?
    (a) White dwarf
    (b) RR Lyrae
    (c) Black hole
    (d) Eclipsing binary

32. Which of the statement(s) about Globular cluster(s) is / are true?
    (a) They are in the outer regions of the Milky Way
    (b) They comprise of variable stars
    (c) They comprise of young stars
    (d) They are receding from us at very high speed

Rough Work

ROUGH WORK

ROUGH WORK

ROUGH WORK

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