

Indian National Astronomy Olympiad – 2009

Senior Category
Question Paper

Roll Number:

INAO – 2009

Duration: **Three Hours**

Date: 31st January 2009

Maximum Marks: 100

Please Note:

- Please write your roll number on top of this page in the space provided.
- Before starting, please ensure that you have received a copy of the question paper containing total 3 pages (6 sides).
- In Section A, there are 10 multiple choice questions with 4 alternatives out of which only 1 is correct. You get 3 marks for each correct answer and **-1 mark for each wrong answer**.
- In Section B, there are 4 multiple choice questions with 4 alternatives each, out of which any number of alternatives may be correct. You get 5 marks for each correct answer. No marks are deducted for any wrong answers. **You will get credit for the question if and only if you mark all correct choices and no wrong choices**. There is no partial credit.
- For both these sections, you have to indicate the answers on the page 2 of the answersheet by putting a × in the appropriate box against the relevant question number, like this:

Q.NO.	(a)	(b)	(c)	(d)	Q.NO.	(a)	(b)	(c)	(d)	
22	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	OR	35	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

Marking a cross (×) means affirmative response (selecting the particular choice). Do not use ticks or any other signs to mark the correct answers.

- In Section C, there are 5 analytical questions totalling 50 marks.
- Blank spaces are provided in the question paper for the rough work. No rough work should be done on the answer-sheet.
- No calculators are allowed.
- **The answer-sheet must be returned to the invigilator**. You can take this question booklet back with you.

HOMI BHABHA CENTRE FOR SCIENCE EDUCATION

Tata Institute of Fundamental Research

V. N. Purav Marg, Mankhurd, Mumbai, 400 088

Useful Physical Constants

Mass of the Earth	$M_E \approx 5.97 \times 10^{24} \text{ kg}$
Radius of the Earth	$R_E \approx 6.4 \times 10^6 \text{ m}$
Mass of the Sun	$M_\odot \approx 1.99 \times 10^{30} \text{ kg}$
Radius of the Sun	$R_\odot \approx 7 \times 10^8 \text{ m}$
Radius of the Moon	$R_m \approx 1.7 \times 10^6 \text{ m}$
Speed of Light	$c \approx 3 \times 10^8 \text{ m/s}$
Astronomical Unit	1 A. U. $\approx 1.5 \times 10^{11} \text{ m}$
Gravitational Constant	$G \approx 6.67 \times 10^{-11} \text{ m}^3/(\text{Kg s}^2)$
Gravitational Acceleration on the Earth	$g \approx 9.8 \text{ m/s}^2$
Gravitational Acceleration on the Moon	$g_m \approx 1.6 \text{ m/s}^2$

Space for Rough Work

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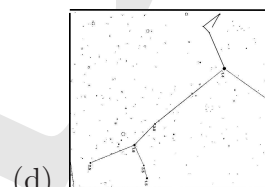
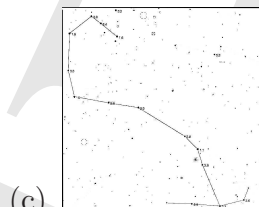
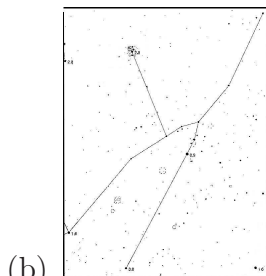
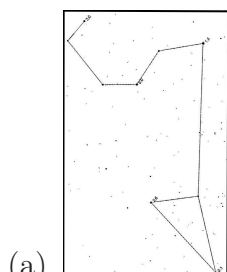
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Part A: (10 Q × 3 marks each)

1. If $a^x = b^y = c^z$ and $b^2 = ac$, then $y = ?$

- (a) $\frac{2xz}{x+z}$ (b) $\frac{xz}{x+z}$ (c) $\sqrt{2xz}$ (d) \sqrt{xz}

2. Each of the figures below depict a constellation. Find the odd one out.



3. Gravitational force between two identical uniform solid gold spheres of radius r each in contact is proportional to

- (a) r^4 (b) r^2 (c) $\frac{1}{r^2}$ (d) $\frac{1}{r^3}$

4. A copper cube and a wooden cube of volume 10^{-3} m^3 each are initially at room temperature. They are then moved to an enclosure of ambient temperature 50°C . What can we conclude about the temperatures attained by both cubes after 5 hours?

- (a) $T_{\text{copper}} > T_{\text{wood}}$ as thermal conductivity of copper is greater than that of wood.
(b) $T_{\text{wood}} > T_{\text{copper}}$ as specific heat capacity of wood is greater than that of copper.
(c) The temperatures will depend on the interplay between specific heat capacity and thermal conductivity of the materials.
(d) Both temperatures will be practically the same, as they are in the enclosure for 5 hours.

5. If the product of all the numbers from 1 to 100 is divisible by 2^n , then what is the maximum possible value for n ?

- (a) 128 (b) 97 (c) 64 (d) 87

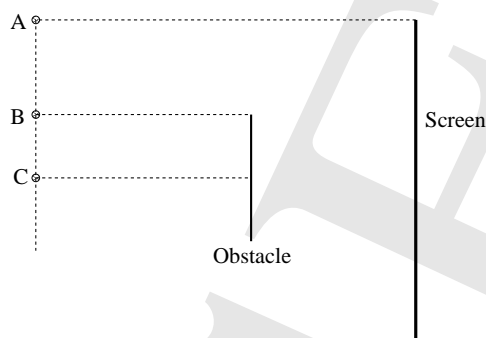
6. Two vectors \vec{P} and \vec{Q} are acting at a point such that their resultant is perpendicular to \vec{Q} . If θ is the angle between \vec{P} and \vec{Q} then $\frac{|P|}{|Q|}$ is given by,

- (a) $\cos \theta$ (b) $\sec \theta$ (c) $-\cos \theta$ (d) $-\sec \theta$

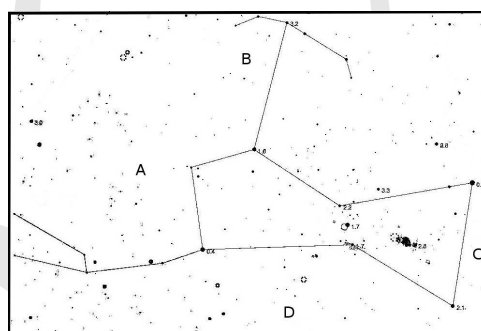
7. What will be the approximate period of Chandrayaan moving in an orbit 100 km above the moon's surface?

- (a) 57 min (b) 30 min (c) 118 min (d) 79 min

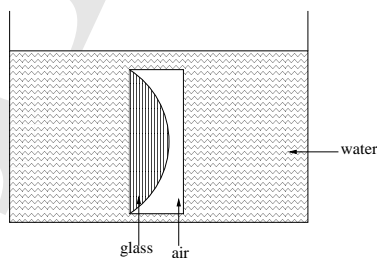
8. In the following figure, A, B, C are three light source positions with respect to the obstacle and the screen. Which of these light source positions will result in the longest shadow of the obstacle on the screen?



- (a) A
 (b) C
 (c) A and C form shadows of same length, while B forms a smaller shadow.
 (d) All the three light sources will form shadows of same length.
9. The following figure shows skeleton chart of the Orion constellation. Approximate “North” is indicated by the letter



- (a) A (b) B (c) C (d) D
10. Find the resultant focal length for following system where the radius of curvature is 15cm.



- (a) 40 cm (b) 60 cm (c) 120 cm (d) ∞

Section B: (4 Q × 5 marks each)

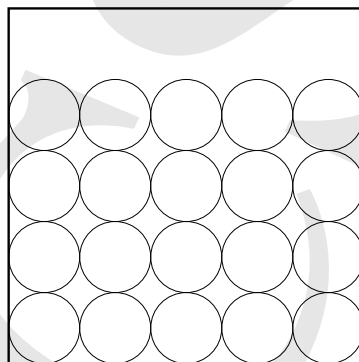
11. Which of the following observations support the statement that “Every system tends to adjust by itself to have minimum Potential Energy”.
- (a) Andromeda galaxy and Milky Way are approaching each other.
 - (b) Two unlike, free charges move towards each other.
 - (c) External work is required to compress a spring.
 - (d) A powerful magnet can deflect a compass needle from equilibrium position.
12. Consider a sealed cylinder with frictionless, free-moving piston of fixed mass attached on the top, kept in an environment of constant atmospheric pressure. The ideal gas in the cylinder is slowly heated and it expands. Which of the following is / are true?
- (a) The density of the gas will increase.
 - (b) The pressure of the gas will decrease.
 - (c) The internal energy of the system will remain the same.
 - (d) In this process work is done by the gas.
13. In one of the truly revolutionary finds of the 20th century, Howard Carter discovered the tomb of the Egyptian Pharaoh (emperor) Tutankhamen in 1922. Following items were removed from the tomb, along with the mummy of the Pharaoh. Which of these items could have been carbon dated to fix the period of the Pharaoh?
- (a) Fragments of glass
 - (b) Golden Bracelets
 - (c) Dried Fruits
 - (d) Leather Shoe
14. Which of the following phenomena is / are useful, in estimating distances in the Universe?
- (a) Some time Venus can be seen transiting over the solar disc.
 - (b) Stars with no proper motion appear to change their position in the sky when viewed six months apart.
 - (c) Stars exhibit Doppler shift.
 - (d) All supernovae of Type Ia have same absolute brightness.

Section C: Analytical Questions

- α . (8 marks) What will be area of the largest cyclic quadrilateral that can be inscribed in a given circle? Justify your answer qualitatively (formal proof not necessary).
- β . (12 marks) Jayshree claimed that she saw a solar eclipse when the size of the solar disk was $26'$ and that of the lunar disk was $30'$. She also claimed that at the time of the maximum eclipse, distance between the centres of the two disks was $7'$. Qualitatively show that she could not have observed a total eclipse. Find the percentage of the solar disk covered at the time of the maximum eclipse. (Given: $\cos^{-1}(\frac{1}{26}) \approx 0.49\pi$ rad).

- γ . (8 marks) The famous Indian astronomer, Aryabhata, expressed the value of π in what we now know as continuing fractions i.e. $\pi = 3.1416 = a + \frac{1}{b + \frac{1}{c + \frac{1}{d}}}$ where a, b, c, d are positive integers. Find a, b, c, d.

- δ . (10 marks) Kedar sent a container of marbles by road from Mumbai to Parag in Pune. The container was $2m \times 2m \times 2.5m$ in size, with height being the larger dimension. Marbles of 2 cm diameter were arranged to fill the entire base and then additional layers of marbles were arranged with each upper marble exactly on top of corresponding marble in the previous layer (see figure). The marbles were thus placed upto 2m height to complete the cubical structure. However, on reaching Pune, when Parag opened the container, he found the height of structure was not 2m as promised by Kedar, but something else. Kedar defended saying that marbles may have readjusted due to jiggling. Can you find new height of this marble pile?



- ϵ . Chiraag performed an experiment using a simple pendulum to find value of g . He measured time taken for 30 oscillations of the pendulum for various values of length (repeated thrice for each value of length), following readings were obtained.

L	Readings		
cm	t_1 (Sec)	t_2 (Sec)	t_3 (Sec)
20.0	26.9	26.9	27.0
25.0	30.1	30.1	30.1
30.0	32.9	32.8	32.7
35.0	35.6	35.8	35.7
40.0	38.0	38.1	38.1
45.0	40.4	40.4	40.5

Mass of the bob of the pendulum was known to be 50 gm.

- (a) (9 marks) Plot appropriate graph to represent the data.
 (b) (2 marks) Find the value of g .
 (c) (1 mark) Using the graph, find out required length of the pendulum to get a time period of 1.24 sec.