

Indian National Astronomy Olympiad – 2009

Junior Category
Question PaperRoll 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	☐	☒	☐	☐	OR	35	☒	☒	☐	☐

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	$1 \text{ A. U.} \approx 1.5 \times 10^{11} \text{ m}$
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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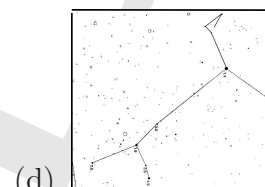
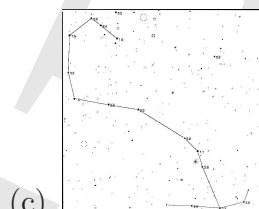
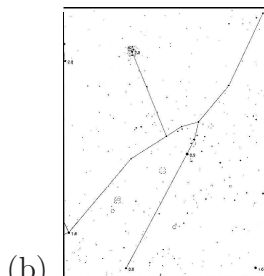
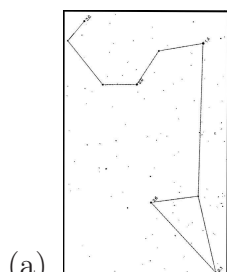
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Section A: (10 questions $\times$ 3 marks each)

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.



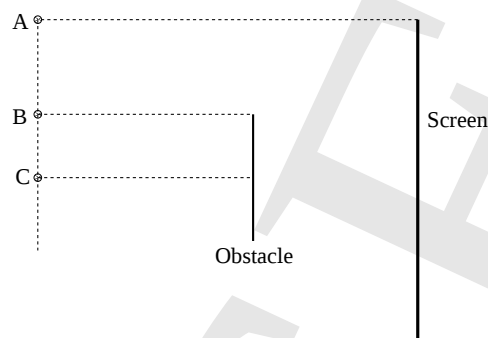
3. Gravitational force between two identical solid uniform gold sphere of radius r each in contact is proportional to

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

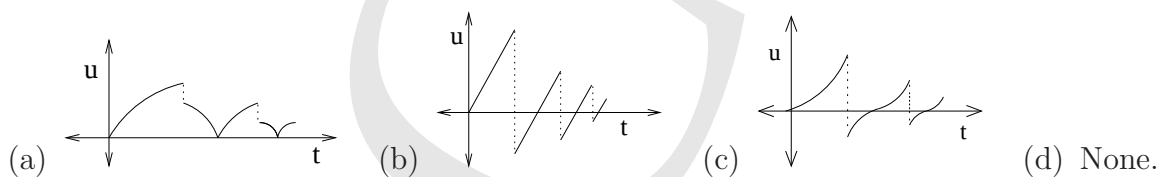
4. A copper cube and a wooden cube of same size are initially at room temperature. Then they are kept in an enclosure at 50°C . What can we conclude about the temperatures attained by both cubes after 5 hours?

- (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. A repairman on the T. V. tower finds his water bottle leaking at the rate of 5ml per second. He drops the bottle and it reaches the ground straight. If he was at a height of 125m at that time and there was 200ml of water left in the bottle, the amount of water left in the bottle (neglecting air resistance) just before it hit the ground was
- (a) 175ml (b) 50ml (c) 100ml (d) 200ml
7. In which of the following cities, your shadow will be the shortest, on the 15th of June?
- (a) Delhi (b) Bhopal (c) Bangalore (d) Thiruvananthapuram

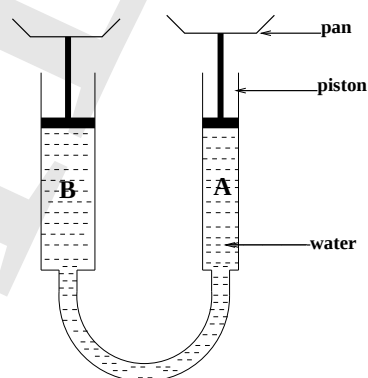
8. In the following figure, A, B, C are three light source positions with respect to the obstacle and the screen. Which of these light source positions will result in the longest shadow of the obstacle on the screen?



- (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. Which of the following represents the correct speed-time graph, for a ball bouncing frequently from a fixed surface?



10. Two glass tubes filled with water are held vertical and connected by a plastic tube as shown in the figure. Pans are mounted on top of each piston such that $(\text{weight of the piston} + \text{pan})_A = (\text{weight of the piston} + \text{pan})_B$ radius of the piston A = 1.0cm and radius of piston B = 1.5cm. A 30.0gm of mass is added in pan B, what is the mass required in pan A to balance 30.0gm in pan B?



- (a) 67.5gm (b) 30.0gm (c) 13.3gm (d) 24.0gm

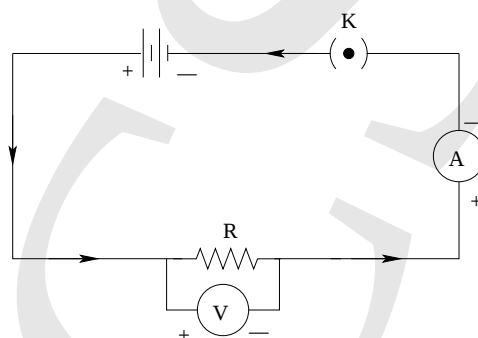
Section B: (4 questions $\times$ 5 marks each)

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. In one of the truly revolutionary finds of the 20th century, Howard Carter discovered discovered tomb of Egyptian Pharaoh (emperor) Tutankhamun in 1922. Along with the mummy following items were also removed from the tomb. Which of these items could have been carbon dated to fix the period of the Pharaoh?
- (a) Fragments of glass
 - (b) Bronze Razor
 - (c) Dried Fruits
 - (d) Leather Shoe
13. There is a regular bus service between Pune and Mumbai (180km apart) at every hour from both the ends, from 4am to 11pm. These busses run at average speed of 45km/hr. Taxies also run on the same route at 60km/hr with regular interval of 30min from 5am to 10pm. Following statements are based upon the number of taxies or busses crossed (not overtaken) only during travelling i.e. excluding instances of arrival and departure. Select the correct statement(s).
- (a) First ST bus crosses 6 taxies.
 - (b) Last taxi crosses 5 buses.
 - (c) Bus left at 8pm crosses 10 taxies.
 - (d) Taxi left at 12 noon crosses 6 buses.
14. Which of the following statement(s) 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.
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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.

- 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 $7'$. Was she able to witness a total solar eclipse? If yes, then find duration of the eclipse. If no, then 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 . Mehul performed an experiment to verify Ohm's law. He connected following circuit to measure voltage and current.



Here, **R** is the unknown resistance, V the voltmeter, A the ammeter and K is the key. He obtained following readings :

V (v)	1	2	3	4	5	6
I (mA)	1.40	2.83	4.26	5.68	7.11	8.54

- (a) (9 marks) Plot appropriate graph to represent the data.
- (b) (2 marks) Find the value of **R**.
- (c) (1 mark) From the graph, what will be the voltage across the resistance when **I** = 8mA?
- ϵ . (10 marks) If the entire surface of the earth is covered using A4 size (size of this question paper) sheets of paper, what will be the total weight of paper used?