Indian National Astronomy Olympiad – 2010

Junior Category Roll Number: ☐
Question Paper

INAO – 2010 Date: 30th January 2010
Duration: **Three Hours** 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 computational aides like calculators, log tables, slide rule etc. are allowed.
- **The answer-sheet must be returned to the invigilator**. You can take this question booklet back with you.

Useful Physical Constants

Mass of the Earth	M_E	$\approx$	5.97×10^{24} kg
Radius of the Earth	R_E	$\approx$	6.4×10^{6} m
Mass of the Sun	$M_\odot$	$\approx$	1.99×10^{30} kg
Radius of the Sun	$R_\odot$	$\approx$	7×10^{8} m
Radius of the Moon	R_m	$\approx$	1.7×10^{6} m
Speed of Light	c	$\approx$	3×10^{8} m/s
Astronomical Unit	1 A. U.	$\approx$	1.5×10^{11} m
Gravitational Constant	G	$\approx$	6.67×10^{-11} $m^3/(Kg\ s^2)$
Speed of Sound in Air	c_s	$\approx$	330 m/s
Inclination of the Earth's Axis	ϵ	$\approx$	23.5°

Space for Rough Work

Section 1:Multiple Choice Questions

Part A: (10 Q × 3 marks each)

1. As seen from the Earth, the stars appear to twinkle, while the planets do not because,
   (a) Light coming from the stars gets absorbed by interstellar dust.
   (b) the stars are self luminous while the planets merely reflect the light.
   (c) Angular sizes of the stars are much smaller than the planets.
   (d) All the above.

A wooden cube of length 5 units is painted on all faces and then cut in 85 smaller cubes of varying sizes. The sides of each of the smaller cubes are some integer number of units. All bigger cubes are carved out of the corners of the original cube. Answer the following three questions:

2. How many cubes have no side painted?
   (a) 15 (b) 17 (c) 20 (d) 27

3. How many cubes have exactly 2 sides painted?
   (a) 24 (b) 27 (c) 30 (d) 36

4. If one was to cut the original cube (of size 5 units each side) with a condition that all corners would be occupied by the cubes bigger than 1 unit size, what will be the smallest total of cube pieces possible?
   (a) 69 (b) 64 (c) 62 (d) 50

5. In a given watch, the minute and the hour hand come together successively exactly after 65 minutes. Does the watch gain or lose time and how much per hour?
   (a) Gains about 27 seconds.
   (b) Loses about 27 seconds.
   (c) Neither gains nor loses.
   (d) Information insufficient.

6. Two parallel wires carrying current in opposite direction will
   (a) exert a force twisting the wires.
   (b) attract each other.
   (c) repel each other.
   (d) not exert any force on each other.

7. If you hold a magnifying glass of focal length 10 cm in the sunlight and place a piece of paper at its focus, you can burn a hole in the paper. What could be the size of this hole?

   (a) 10 mm (b) 5 mm (c) 0.5 mm (d) 0.1 mm

8. During an earthquake, an earthquake monitering cntre observed that transverse waves travelling with speed 4.5 km/s arrived at the centre 3 minutes after the longitudinal waves travelling at 8.2 km/s. Deduce the approximate distance to the epicenter.

   (a) 60 km (b) 220 km (c) 660 km (d) 1800 km

9. A certain person nicknamed "Enthu", encountered an automatic staircase (i.e. escalator) at a shopping complex, which was moving upward at a constant rate. Just for the fun of it he decided to walk up this escalator at the rate of one step a second. Twenty steps brings him to the top. Next day he goes up at two steps a second and reaching the top in 32 steps. How many steps are there in the escalator?

   (a) 40 (b) 60 (c) 64 (d) 80

10. Two stars of masses M and $3M$ respectively are going around each other, in near circular orbits, with period T. The separation between them is given by $D = \sqrt[3]{\frac{kGMT^2}{\pi^2}}$. The value of k is,

    (a) 0.5 (b) 1 (c) 1.5 (d) 3

Section B: (4 questions × 5 marks each)

11. If we throw a ball in a shallow water tank, prapogation velocity of ripples on surface of the water will depend on

    (a) surface tension of the water

    (b) depth of the water tank

    (c) density of the water

    (d) height from which the ball was dropped

12. Amit decided to experiment with cannon ball by making it hollow and filling water inside it. He then punched few holes in it. After the ball was fired horizontally, he was expecting to see water jets coming out from some of the holes. Which of the following locations of holes will allow water jet to come out?

    (a) Front, bottom and sides (b) Back, top and sides (c) back and bottom
    (d) None of the holes

13. In the progress of Astronomy over the ages, we find several instances of startling new observations changing our ideas about the Universe and lead to new thoeries. Listed below are some milestones in the history of Astronomy and observations which necessited them. Pick the <u>correct</u> statement(s).

    (a) Ptolemy was aware of retrograde motion of planets when he gave his model of the solar system.

    (b) Newton was aware of Kepler's Laws when he gave his Law of Gravitation.

(c) Einstein felt need to modify Newton's theory of Gravitation to explain the expansion of the Universe.

(d) Existence of Cosmic Microwave Background Radiation (CMBR) led to the creation of the Big Bang Theory.

14. Two simple pendula are hung close to each other on a thin, rigid support and are allowed to oscillate independently in planes parallel to each other. They have periods 3 seconds and 7 seconds respectively with same amplitudes and are initially released from the opposite extreme positions of each other. At which of the following times the threads of the two pendula will be coplaner again?

(a) 1.05 seconds (b) 7.88 seconds (c) 10.50 seconds (d) 23.10 seconds

Section C: Analytical Questions

α. An alien civilisation on a star far far away came to know about the Astronomy Olympiad Examination and wanted to test smartness of the students. They sent following two coded secret messages. Decode them.

(a) (5 marks) First is a pictorial message in black and white colour. They sent it on radio waves in the form of ones and zeros. Find out what the picture says.
00000 00000 00000 00000 00000 00000 11111 01100 00100 00100 00011 10000 01000 10100 01000 10100 01101 10000 10001 00100 10001 11000 10001 00001 00010 00101 00100 01001 10110 01111 10100 00110 10000 01001 11000 00000 00000 00000 00000 00000 000

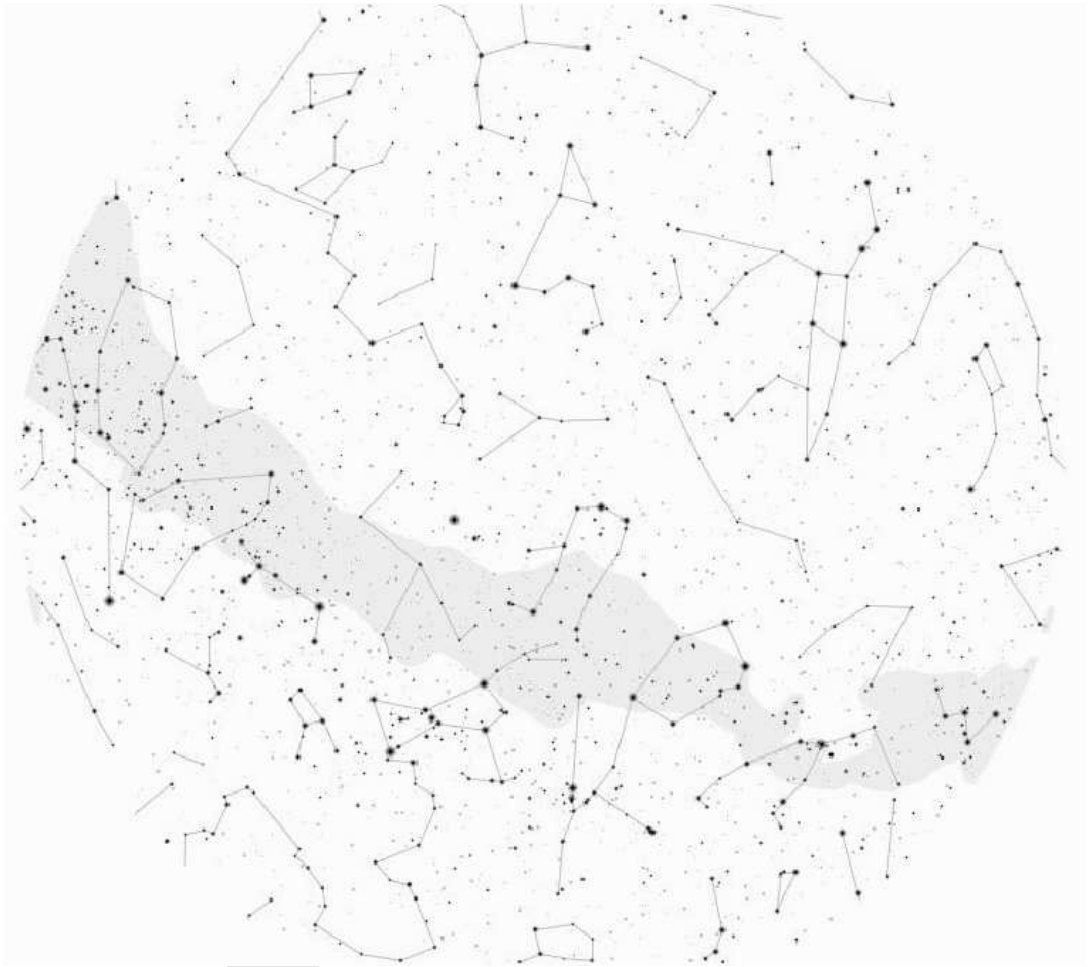
(b) (5 marks) Surprisingly, the aliens are also proficient in English and the following coded message is actually a sentence in English language. In the answersheet, write down the coded sentence and also the true meaning of each alphabet in the code.

"Up tpmwf uif qsfwjpvt tvcrvftujpo uijol pg uif nfttbhf tfou cz uif bsfdjcp ufmftdpqf up bmjfot."

β. (8 marks) In the following table, the first column gives various optical phenomena / instruments and the top row gives various optical effects which may help in explaining them. In the answers sheet, tick the correct effect(s) involved in each phenomena in appropriate rows.

	Appreciable Dispersion	**Internal Reflection**	**Reflection**	**Refraction**	**Scattering**
Blue Sky					
Mirage					
Rainbow					
Smooth Convex Mirror					
Thick Concave Lens					

γ. Study the following image of the night sky (bigger version is printed in your answer-sheet) for mid-night on a certain day at a certain place and answer the questions below it. All answers must be marked / written on the answer-sheet.



(a) (2 marks) Mark all the four directions on the map.

(b) (1 mark) Is this place in northern part of India or the southern part?

(c) (3 marks) Mark and name 2 constellations each from the following two lists:

- **0.5 marks each; any 2:** Orion, Ursa Major, Taurus, Leo, Cygnus, Scorpio
- **1 mark each; any 2:** Hydra, Corvus, Aquarius, Cancer, Canis Major, Aries

(d) (2 marks) Sketch rough band of ecliptic i.e. apparent path of the Sun, the Moon and all the planets in the sky.

(e) (2 marks) In which month the sky will appear like this at this time? Give reason in one line.

δ. Mayank visited a place located at latitude ϕ and longitude $82.5°E$ on 21st June. He observed that at local noon, shadow of a one meter stick standing vertically on the ground was 26.8 cm long due south.

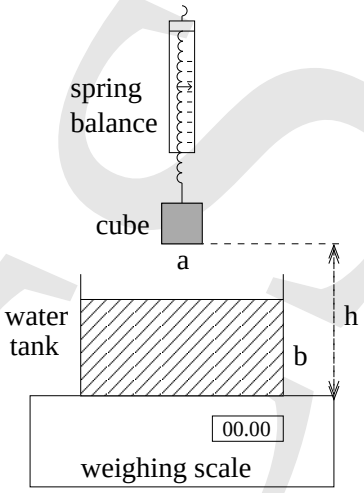
(a) (5 marks) Find latitude of the place.

(b) (5 marks) Find the day on which the shadow of this stick at the local noon will be longest and find length and direction of that shadow.

Note: $\sin^{-1}(0.268) = 15.5°$, $\cos^{-1}(0.268) = 74.5°$, $\tan^{-1}(0.268) = 15.0°$, $\tan(2°) \approx \frac{1}{30}$ and $\sqrt{3} = 1.73$

ϵ. Sketch approximate graphs for the following situations:

(a) (4 marks) See the figure below. A tank of water (height of water column b) is kept on a electronic weighing scale. A metal cube (side a and density ρ) is hung from a spring balance and the spring balance is slowly lowered into the tank till the cube reaches the bottom of the tank. The distance of separation between the bottom of the tank and bottom of the cube is denoted by h with initial value h_0.



Sketch the graph of reading on the spring balance as a function of h.

(b) (3 marks) For the situation above, sketch the graph of reading on the electronic scale as a function of h.

(c) (2 marks) For the situation above, sketch the graph of sum of the reading on the electronic scale and the reading on the spring balance as a function of h.

(d) (3 marks) For a typical primary mirror used in Newtonian telescope, sketch a graph of object distance, u versus image distance, v. All physically measurable lengths should be taken as positive.

In all cases, mark the significant points on the graph and give their coordinates.

Space for Rough Work