

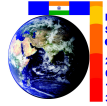
Theoretical Test
Astronomy

Time: 45 Minutes

Maximum Marks: 28.5

Instructions:

1. Please write your student code on the cover page as well as on the top right of every page of answer sheet / calculations sheets.
2. Please write your answers legibly. Illegible answers will be counted as incorrect.
3. Please write your final answers in appropriate boxes in the main answer sheet.
For numerical questions, show the calculations on blank calculation sheets provided.
4. For numerical questions, you may attempt part of the answer even if you don't know the final result. There will be stepwise marking.
5. You can get as many calculations sheets as you want. Just raise your hand to ask for extra sheets. The volunteers will bring extra sheets to your table.
6. Write question number clearly at the top of the calculations sheet.
7. Read the entire question group carefully before starting to answer. Each question has a point value assigned and indicated on the right hand side of the question.
8. Any inappropriate examination behaviour will result in your withdrawal from the IESO.



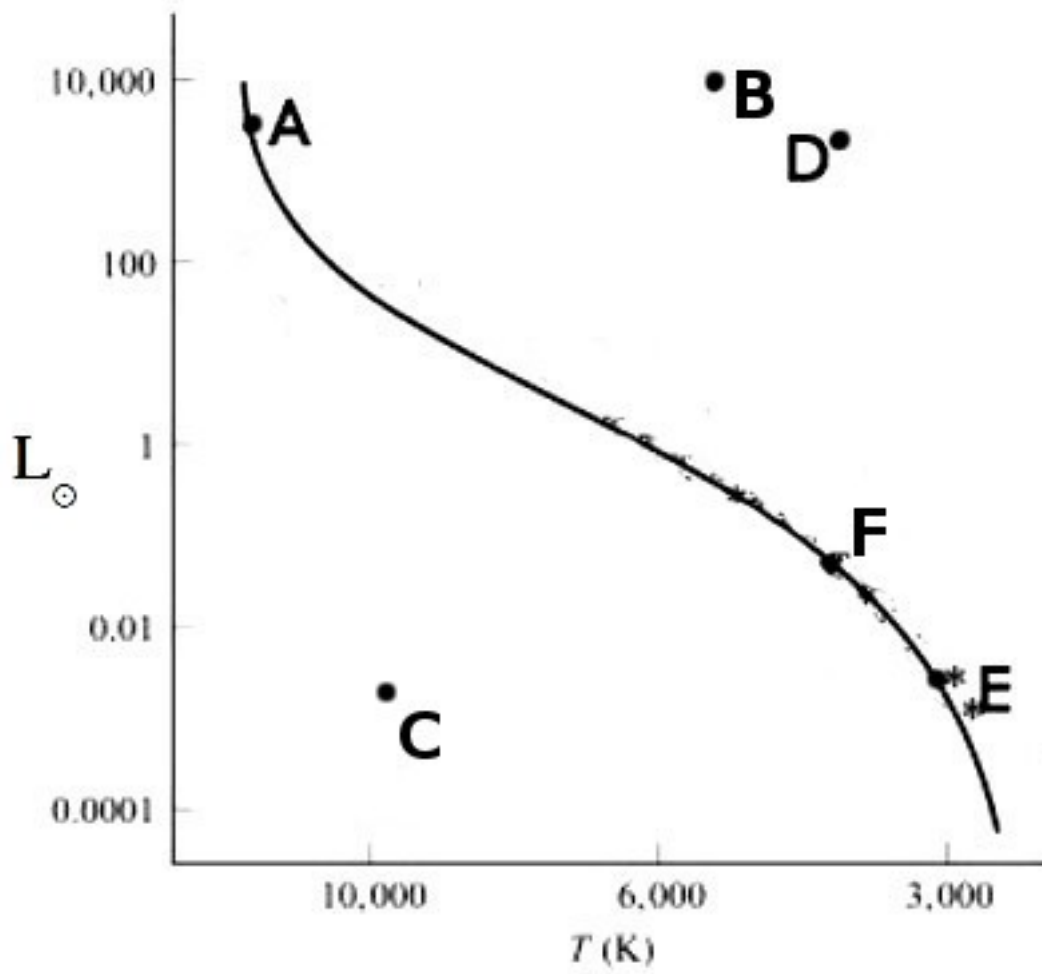
- A1. We list a few facts below about temperatures at the surface of Venus, Earth and Mars.
- The yearly mean temperatures of planets do not match with their expected black body temperature.
 - Absolute variation in the temperature during the course of one day differs significantly from one planet to another.
 - Absolute variation in the temperature during the course of one year at the equator of the planet differs significantly from one planet to another.
 - On some planets, there is a large latitudinal percentage variation in temperatures.
 - Mean temperature (averaged over a day) on Earth is different on different days.

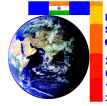
In the table given in your answer sheet, we list a number of physical properties related to a planet and its various motions, which may or may not be relevant in explaining the facts above. In the table, tick in appropriate rows those properties which are relevant for each of the facts above. Number of relevant parameters for each row can be none, one or more than one.

Total 10 points for correct tick-marks.

Warning: Every wrong tick mark has penalty of **-0.2 points**.

- A2. The maximum altitude of the Sun as seen from Mysore on summer solstice day and winter solstice day are $78^\circ 51'$ and $54^\circ 17'$ respectively. Using this information, obtain the inclination of the Earth's axis (ϵ) and find the latitude of Mysore (ϕ). **(6 points)**
- A3. The mass ratio of Pluto and Charon is 8:1. The period of revolution of Charon around Pluto is about 6.387 days. You are given that
 $M_{\text{Pluto}} = 1.31 \times 10^{22} \text{ kg}$, $R_{\text{Pluto}} = 1195 \text{ km}$, $G = 6.672 \times 10^{-11} \text{ N m}^2 \text{ kg}^{-2}$
 the Minimum and maximum distance of Pluto from Earth are $4284.7 \times 10^6 \text{ km}$ and $7528 \times 10^6 \text{ km}$ respectively.
- Find the length of the semi-major axis of Charon's orbit of revolution about Pluto. **(3 points)**
 - Find the ratio $a:R_{\text{Pluto}}$, where 'a' is the distance of the Centre of Mass of the Pluto-Charon system from the center of Pluto. **(2 points)**
 - Theoretically, what is the minimum diameter of the optical telescope which can resolve the system from Earth? Ignore effects of Earth's atmosphere. **(2 points)**
- A4. The diagram on the next page shows the Hertzsprung-Russell diagram (H-R diagram) with six positions (A – F) indicated. The y-axis is given in terms of Solar Luminosity (L_{\odot}) and x-axis gives effective surface temperature (T) of stars in Kelvin.
- Which letters indicate the position of stars that have the largest and the smallest diameters respectively? **(2 points)**
 - Which letters indicate the stars with the same spectral class but with different luminosities? **(1 points)**
 - Which letters indicate the stars that are primarily burning Hydrogen? **(1.5 points)**
 - Which letter would indicate position of a white dwarf in this diagram? **(1 point)**





Theoretical Test
Astronomy Answer Sheet

A1. Please see next page

A2. Inclination of the Earth's axis is

Latitude of Mysore is

A3. Pluto and Charon:

(a) Semi-major axis =

(b) $a:R_{\text{Pluto}} =$

(c) Diameter =

A4. H-R diagram

(a) Star of Largest Diameter

Star of Smallest Diameter

(b) Give letters of stars

(c) Give letters of stars

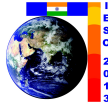
(d) White Dwarf letter

7th International Earth Science Olympiad



Student Code:

Sheet for numerical calculations (write question number clearly)



Statement	Mass of Planet	Radius of Planet	Inclination of Rotation Axis with respect to its Orbital Plane	Rotation Period	Length of Semi-major axis of the orbit	Eccentricity of Orbit	Total Mass of Satellites	Density of Atmosphere	Water Vapour Percentage	Green House Effect	Magnetic Field Strength	Geothermal Activity
The yearly mean temperatures of planets do not match with their expected black body temperature.												
Absolute variation in the temperature during the course of one day differs significantly from one planet to another.												
Absolute variation in the temperature during the course of one year at the equator of the planet differs significantly from one planet to another.												
On some planets, there is a large latitudinal percentage variation in temperatures.												
Mean temperature (averaged over a day) on Earth is different on different days.												



Theoretical Test
Astronomy Model Answers

A1. Atmosphere of Planets

See table: + **0.5** points for each correct marking, **-0.2** for each wrong marking.

- A2. For winter solstice, $a_w = 90 - \phi - \epsilon$
 For summer solstice (in northern tropical region), $a_s = 180 - (90 - \phi + \epsilon)$
 $= 90 + \phi - \epsilon$
 Using these, Inclination of the Earth's axis, $\epsilon = 23^\circ 26'$
 Latitude of Mysore, $\phi = 12^\circ 17'$
(1.5 points for each of the four steps)

A3. Pluto and charon:

- (a) By Kepler's Third Law, $a_0^3 = \frac{G(M_{pl} + M_{ch})T^2}{4\pi^2} = \frac{9GM_{pl}T^2}{32\pi^2}$ **(1.5 points)**

Hence $a_0 = 1.96 \times 10^7 m$ **(1.5 points)**

- (b) The distance of barycentre from Pluto will be $a_0/9$. **(1 point)**

By comparing, $a:b = \frac{a}{b} = \frac{1.965 \times 10^7}{9 \times 1.195 \times 10^6} = 1.83$ **(1 points)**

- (c) One should try to resolve the Pluto-charon system, when the Pluto is closest to the Earth as that when the angular separation will be highest. **(0.5 point)**

Let us say we are using optical wavelengths around 550nm (a slightly better approximation will be to use blue end of visible light around 400 nm)

$$D = \frac{1.22\lambda}{\theta} = \frac{1.22\lambda d_{pl}}{a_0} \approx 15 \text{ cm} \quad \textbf{(1.5 points)}$$

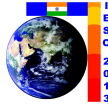
A4. H-R diagram

- (a) Star of Largest Diameter **B** Star of Smallest Diameter **C** **(2 points)**

- (b) **D** and **F** **(1 point)**

- (c) **A, E** and **F** **(1.5 points)**

- (d) **C** **(1 point)**



Statement	Planetof Mass	PlanetRadius of	with respect to Inclination of its Orbital PlaneRotation Axis	Rotation Period	Length of Semi-major axis of the orbit	Eccentricity of Orbit	Total Mass of Satellites	Density of Atmosphere	Water Vapour Percentage	Green House Effect	Magnetic Field Strength	Geothermal Activity
The yearly mean temperatures of planets do not match with their expected black body temperature.				X					X	X		X
Absolute variation in the temperature during the course of one day differs significantly from one planet to another.				X	X			X	X	X		
Absolute variation in the temperature during the course of one year at the equator of the planet differs significantly from one planet to another.			X	X	X	X		X	X	X		
On some planets, there is a large latitudinal percentage variation in temperatures.			X							X		
Mean temperature (averaged over a day) on Earth is different on different days.						X			X			