

# Research Instruments and Test Design

## 1 Introduction

This document describes the research instruments used in the study titled “*A Study of Alternative Conceptions in Science in Relation to the Achievement of Students at Elementary Level.*” The instruments were designed to identify students’ alternative conceptions in elementary astronomy and to measure conceptual change following instruction.

Two assessment tools were employed:

- A diagnostic pre-test
- An achievement post-test

Both instruments were aligned with the prescribed curriculum for the topic *Stars and the Solar System* and were developed to assess conceptual understanding rather than rote memorization.

## 2 Diagnostic Pre-Test

The diagnostic pre-test was administered prior to instruction to identify students’ existing conceptions and alternative conceptions related to elementary astronomy concepts. The test consisted of ten multiple-choice questions, each carrying one mark, for a maximum score of ten.

### 2.1 Conceptual Coverage

The pre-test covered the following conceptual areas:

- Seasons and tilt of planets
- Phases of the Moon
- Luminosity of stars
- Working of astronomers

- Asteroids in the solar system
- Planets of the solar system

Each item was designed to probe commonly reported misconceptions at the elementary level.

## 2.2 Blueprint of the Pre-Test

Table 1: Blueprint of the Diagnostic Pre-Test

S.No	Concept Area	Knowledge	Understanding	Application	Total Marks
1	Seasons and tilt of planets	1	1	–	2
2	Phases of the Moon	1	1	–	2
3	Luminosity of stars	1	1	–	2
4	Working of astronomers	1	1	–	2
5	Asteroids in the solar system	1	1	–	2
6	Planets of the solar system	2	1	2	5
<b>Total</b>		4	2	4	10

## 2.3 Difficulty-Level Distribution

Table 2: Difficulty-Level Distribution of the Pre-Test

Difficulty Level	Percentage Weightage
Difficult	30%
Average	50%
Easy	20%
Total	100%

The pre-test was used strictly as a diagnostic instrument. No negative marking was applied, and the scores did not contribute to academic grading.

### 3 Diagnostic Pre-Test Instrument

#### Pre-Test

**Topic:** Astronomy Quiz

**Maximum Marks:** 10

**Instructions:**

- All the questions are compulsory.
- All questions have four possible answers.
- Answer the following questions by selecting the correct option.
- There is no negative marking for wrong answers.

1. Why is winter colder than summer?

- a) The Earth's axis is tilted  $23.5^\circ$ . The Northern Hemisphere of the Earth experiences winter when it is angled away from the Sun's direct rays.
- b) The Earth's axis is tilted  $22.5^\circ$ . The Southern Hemisphere of the Earth experiences winter when it is angled away from the Sun's direct rays.
- c) The Earth's axis is tilted  $22.5^\circ$ . The Northern Hemisphere of the Earth experiences winter when it is angled towards the Sun's direct rays.
- d) None of the above.

2. Describe the phases of the Moon and how they are produced.

- a) As the Sun's light is scattered off the Earth and as the Moon revolves around the Earth, different amounts of the illuminated portion of the Moon face the Earth.
- b) As the Sun's light is scattered off the Moon and as the Moon revolves around the Earth, different amounts of the illuminated portion of the Moon face the Earth.
- c) The size of the Moon changes due to the fact that it comes closer to Earth and moves away every month.
- d) Due to rotation of the Moon as well as the Earth along with revolution around the Sun.

3. Choose the correct statement:

- a) All the stars are luminous in nature.
  - b) All the stars which are rotating on their axis are not luminous.
  - c) Some of the stars in the universe are luminous but not all.
  - d) All the stars which are rotating on their axis are not luminous.
4. What does an astronomer do?
- a) Astronomers help in planning various satellite launches.
  - b) Astronomers study the stars, planets, Sun, Moon, solar system, galaxies, universe, the forces that work on them, and their effects on Earth.
  - c) Astronomers write books, articles and teach students at postgraduate level.
  - d) All of the above.
5. What is common between all the planets of our solar system?
- a) All of them have atmosphere.
  - b) All of them revolve anticlockwise around the Sun.
  - c) All of them rotate on their axis from west to east.
  - d) All of them consist of features like craters, mountains and valleys.
6. Name the planet which has the highest mountain in our solar system.
- a) Mercury
  - b) Mars
  - c) Venus
  - d) Earth
7. Asteroids in our solar system exist:
- a) Only between Mars and Jupiter.
  - b) Only beyond Pluto.
  - c) Between Mars and Jupiter as well as beyond Pluto.
  - d) At several places in the solar system.
8. Which statement describes the atmosphere of the planet correctly?
- a) Venus is mostly carbon dioxide.
  - b) Mercury is mostly nitrogen.
  - c) Earth is mostly oxygen.

- d) Saturn is mostly helium.
9. Which of the following are the terrestrial planets?
- a) Jupiter, Saturn, Neptune and Uranus.
  - b) Earth, Jupiter and Pluto.
  - c) Mercury, Venus, Earth and Mars.
  - d) Pluto, comets, asteroids and meteors.
10. Planet X is a small planet that has one moon, liquid water, and a thin atmosphere. What is planet X?
- a) Mercury
  - b) Jupiter
  - c) Mars
  - d) Earth

# Pre-Test Answer Key

Topic: Astronomy Quiz

Max. Marks: 10

Q.No	Correct Option	Correct Answer
1	A	The Earth's axis is tilted $23.5^\circ$ . The Northern Hemisphere of the Earth experiences winter when it is angled away from the Sun's direct rays.
2	B	As the Sun's light is scattered off the Moon and as the Moon revolves around the Earth, different amounts of the illuminated portion of the Moon face the Earth.
3	C	Some of the stars in the universe are luminous but not all.
4	B	Astronomers study the stars, planets, Sun, Moon, solar system, galaxies, universe, the forces that work on them, and their effects on Earth.
5	B	All of them revolve anticlockwise around the Sun.
6	C	Mars.
7	C	Between Mars and Jupiter as well as beyond Pluto.
8	A	Venus is mostly carbon dioxide.
9	C	Mercury, Venus, Earth and Mars.
10	D	Earth.

## 4 Achievement Post-Test

The achievement post-test was administered after instruction to assess conceptual understanding and to evaluate changes in previously identified alternative conceptions. The post-test carried a maximum of ten marks.

### 4.1 Test Structure

The post-test included:

- Very short answer questions (1 mark)
- Short answer questions (2–3 marks)
- A diagram-based question on the phases of the Moon

The post-test assessed the same conceptual domains as the pre-test but required higher levels of reasoning, explanation, and application.

## 4.2 Blueprint of the Post-Test

Table 3: Blueprint of the Achievement Post-Test

S.No	Concept Area	VSA (1M)	SA (2–3M)	Total Marks
1	Seasons and tilt of planets	1	–	1
2	Phases of the Moon	–	3	3
3	Luminosity of stars	–	2	2
4	Working of astronomers	1	–	1
5	Asteroids in the solar system	1	–	1
6	Planets of the solar system	–	2	2
<b>Total</b>		3	7	10

## 4.3 Difficulty-Level Distribution

Table 4: Difficulty-Level Distribution of the Post-Test

Difficulty Level	Percentage Weightage
Difficult	50%
Average	30%
Easy	20%
Total	100%

A detailed marking scheme was prepared in advance to ensure consistency and objectivity in scoring.

# Achievement Test

Topic: Astronomy

Max. Marks: 10

## Instructions:

- All questions are compulsory.
- Draw neat and labelled diagrams wherever required.
- Marks for each question are indicated in brackets.

1. Name the force due to which the Sun attracts all other members of the solar system towards itself. (1)

2. What do you understand by the term *Jovian planets*? (2)

3. (a) Suppose a planet is discovered between Saturn and Jupiter. Its time period would be: (1)

☐ Greater than Saturn      ☐ Less than Saturn

(b) Give any one reason for your choice. (1)

4. Differentiate between the following: (2)

STAR	Planet
A.	A.
B.	B.



5. Draw a neat and labelled diagram showing the phases of the Moon on the reverse side of the sheet. (3)

# Achievement Test Answer Key

Topic: Astronomy Quiz

Max. Marks: 10

Q.No	Correct Answer	Distribution of Marks
1	Gravitational force.	1
2	Jovian planets are the outer planets of our solar system which are gaseous in nature. The four Jovian planets are: Jupiter, Saturn, Uranus, and Neptune.	$1 + 1 = 2$
3	i) Less than Saturn. ii) The orbit of the new planet will be smaller than Saturn, so it will take lesser time to orbit around the Sun.	$1 + 1 = 2$
4	i) Some stars are luminous in nature and all planets are non-luminous in nature. ii) Stars are gaseous by nature and planets could be solid or gaseous by nature. <i>OR any other correct difference.</i>	$\frac{1}{2} \times 2 = 1$ $\frac{1}{2} \times 2 = 1$
5	<b>Distribution of marks in diagram:</b> <ul style="list-style-type: none"><li>• Correct position of Sun with respect to positions of various phases.</li><li>• Correct new moon.</li><li>• Correct full moon.</li><li>• Correct gibbous moon.</li><li>• Correct crescent moon.</li><li>• Labelling.</li></ul>	$\frac{1}{2} \times 6 = 3$

## **5 Alignment and Validity**

Both the pre-test and post-test were aligned with instructional objectives and curriculum expectations. Content validity was established through systematic mapping of test items to conceptual domains and instructional outcomes. The diagnostic pre-test identified alternative conceptions, while the post-test evaluated conceptual change and learning gains following instruction.

## **6 Ethical Considerations**

Student participation was part of regular classroom assessment practices. All data used for analysis were anonymized prior to processing, and no personally identifiable information was retained.