

SAMPLE CONTENT

PRECISE



# SCIENCE AND TECHNOLOGY (PART - 1)

BASED ON TEXTBOOK AND BOARD PAPER PATTERN



#itna hi kaafi hain

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**STD. X**  
(Eng. Med.)

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# PRECISE

## Science and Technology (Part – 1)

### STD. X

#### Salient Features

- ☞ Written as per the latest textbook and Board Paper Pattern
- ☞ Marks provided to the Questions as per relevant weightage wherever deemed necessary
- ☞ Solved questions from Board Activity Sheets  
**March 2019 to July 2023**
- ☞ Each chapter contains:
  - ‘An Overview’ of the chapter to facilitate easy comprehension
  - A surfeit of ‘Objective Questions’ for ample practice
  - Various types of ‘Theoretical Questions’ to study concepts in depth
  - ‘Numerical Section’ to cover numerical aspect in detail
  - ‘Intext Questions’ section for intext questions of Textbook
- ☞ Includes Important Features for holistic learning:
  - **Reading Between the Lines** - **Illustrative Examples** - **HOTS**
  - **Hints to Objective Questions** - **Important words**
- ☞ Q.R. codes provide the Video/pdf links to boost understanding of a concept or activity
- ☞ Includes Board Activity Sheet of March 2024 (Solution is provided in pdf format through QR code.)

Printed at: **Print to Print**, Mumbai

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## PREFACE

‘**Precise Science and Technology Part-1, Std. X**’ has been prepared as per the latest syllabus which is more student-centric and focuses on active learning along-with making the process of education more enjoyable and interesting.

Each chapter consists of:

- **An Overview** section, facilitating a quick review of key points for students.
- **Objective Questions** categorized under specific headings such as:
  - *Choose the correct alternative* - *Name the following* - *True or False*
  - *Odd one out* - *Complete the analogy* - *Match the following*
- **Theoretical Questions** are diversified into categories like:
  - *Answer the following* - *Distinguish between* - *Give reasons*
  - *Questions based on diagram* - *Complete the given chart/table* - *Questions based on paragraph*
- For the students to grasp a better understanding of the concept lying behind the answer, **Reading between the lines** has been provided wherever necessary.
- Questions that entail students to apply higher order thinking skills are marked **HOTS**.
- **Important words** are underlined in long answers to enhance retention and recall.
- To enhance audio-visual learning, videos showing demonstration of activities / concept explanation are included wherever required.
- Solved questions from the **Board Activity Sheets** of March and July 2019, March and December 2020, March and July 2022, March and July 2023 have been included to keep students updated about the kind of questions asked in the previous examinations. Questions are allotted with marks in accordance with the latest marking scheme wherever possible. In examination, the question may be changed to reflect new marking scheme.

‘**Illustrative Examples**’ are clear, step-by-step demonstrations that help students understand and feel more confident in solving numerical problems. The solution to these examples is elaboration of the answer of the numerical and not the exact solution expected in examination. ‘**Practice Problems**’ are provided for further revision of numericals.

With absolute trust in our work, we hope our holistic efforts towards making this book an ideal knowledge hub for students pays off.

The journey to create a complete book is strewn with triumphs, failures and near misses. If you think we’ve nearly missed something or want to applaud us for our triumphs, we’d love to hear from you.

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*A book affects eternity; one can never tell where its influence stops.*

Publisher

**Edition:** Fourth

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## KEY FEATURES

**An Overview:** An Overview summarizes the key points in the chapter.

**Question Types:** Optimum coverage of different types of questions i.e., diagram based questions, paragraph based questions.

**Latest Board Questions:** Includes questions from Board Activity Sheets till July 2023.

**Reading between The lines:** 'Reading between the lines' helps students to grasp a better understanding of the concept lying behind the answer. *(Students are not expected to write this as a part of the answer.)*

**Weightage of Marks:** Wherever possible, questions are allotted with marks in accordance with latest marking scheme wherever possible..

**Important words:** Important words are underlined in long answers to enhance retention and recall among students.

**Numerical Section:** Solved numerical questions segregated type wise are provided wherever applicable. For revision, list of all important formulae is provided at the beginning of the section.

**Illustrative Examples:** A detailed thinking process involved while solving numerical problems is explained in step wise manner in 'Illustrative Examples'.

**QR Codes:** QR code provides:

- i. Access to a video/PDF in order to boost understanding of a concept or activity
- ii. Solution to Board Activity Sheet of March 2024

## PAPER PATTERN

- There will be separate question papers for Part 1 and Part 2 of 40 marks each.
- Duration of each paper will be 2 hours.

Question No.	Type of Questions	Total Marks
1.	(A) 5 Questions of 1 mark each (Multiple Choice Questions)	05
	(B) 5 Questions of 1 mark each (Objectives)	05
2.	(A) 3 Questions of 2 marks each (Scientific Reasoning) (Solve any 2)	04
	(B) 5 Questions of 2 marks each (Solve any 3)	06
3.	8 Questions of 3 marks each (Solve any 5)	15
4.	2 Questions of 5 marks each (Solve any 1)	05

### Distribution of marks according to question type and aims

Sr. No.	Question type	Marks	Marks with option	% Marks
1.	Objective	10	10	25
2.	Very short answer	10	16	25
3.	Short answer	15	24	37.5
4.	Long answer	5	10	12.5
	<b>Total</b>	<b>40</b>	<b>60</b>	<b>100</b>

Sr. No.	Aims	Marks	Marks with option	% Marks
1.	Knowledge	10	15	25
2.	Understanding	10	15	25
3.	Application	16	24	40
4.	Skill	4	6	10
	<b>Total</b>	<b>40</b>	<b>60</b>	<b>100</b>

[Maharashtra State Board of Secondary and Higher Secondary Education, Pune - 04]

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No.	Topic Name	Marks	Marks with option	Page No.
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3.	Chemical Reactions and Equations	04	06	37
4.	Effects of Electric Current	05	07	57
5.	Heat	03	05	76
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10.	Space Missions	03	05	169
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**Note: Textual exercise questions are represented by \* mark.**

**Textual solved examples are represented by + mark.**

**Modified textual questions are represented by ♣ mark.**

This book comprises of **QR Codes** at strategic touch points. You can simply scan these Codes through your Smartphone camera and get a plethora of subject knowledge at your disposal. The QR Codes included herein would take you to videos that shall provide you a better understanding of 'Activities', 'Experiments', 'Projects' and 'Try This' section of the book. We hope students would maximize the use of this book with the aid of these videos.

## Exam Pointers

Students are expected to write the answers in their Examination as illustrated below.

**Find out the correlation – Determine the correlation between two components and rewrite it.**

1. In Fleming's right hand rule-Thumb: Motion of conductor :: In Fleming's right hand rule-Index finger:

**Ans:** In Fleming's right hand rule-Thumb: Motion of conductor :: In Fleming's right hand rule-Index finger:  
**Magnetic field**

**MCQ – Write only the correct option while answering the MCQ.**

2. When \_\_\_\_\_ is passed through fresh lime water, it turns milky.

- (A)  $H_2$  (B)  $CO_2$   
(C)  $CO$  (D)  $SO_2$

**Ans:** 2. (B)

**Numericals - Write the valid final answer along with the correct unit.**

3. Calculate the escape velocity on the surface of the moon given the mass and radius of the moon to be  $7.34 \times 10^{22}$  kg and  $1.74 \times 10^6$  m respectively.

**Ans:**  $v_{esc} = 2.372$  km/s

## Reading between the lines

The explanation provided under 'Reading between the lines' is not expected to be a part of the answer. Its sole purpose is to provide a sound understanding of the concept behind the answer.

1. What is the expected trend in the variation of nonmetallic character of elements from left to right in a period?

**Ans:** The nonmetallic character increases from left to right in a period.

} **Answer**



### *Reading between the lines*

*While going from left to right within a period, electrons get added in the same shell. At the same time, protons get added in the nucleus increasing the nuclear charge. This increases the effective nuclear charge experienced by valence electrons. As a result, the tendency to gain electrons increases. Thus, the nonmetallic character increases from left to right in a period.*

} **Not part of the answer**



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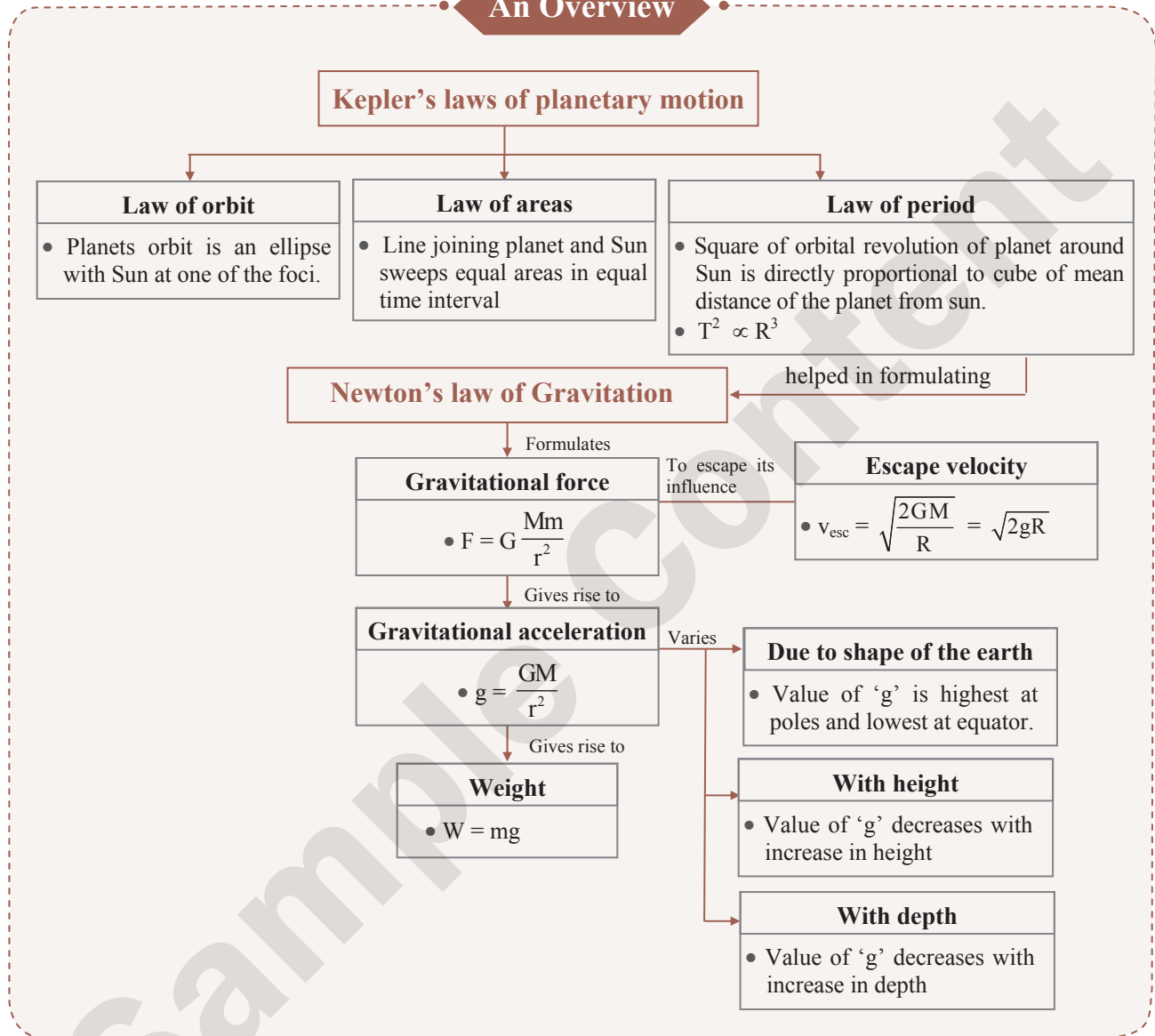


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book for Std. X and Learn about the types of questions that are asked in the X Board  
Examination.



*Note: Textual exercise questions are represented by \* mark. Textual solved examples are represented by + mark.*

### An Overview



#### Choose the correct alternative [1 Mark each]

- A boy is rotating a stone tied to a string in a horizontal circular path. If he release the string, the stone
  - will move along a straight line towards the centre of the circular path.
  - will move along a straight line perpendicular to the circular path away from the boy.
  - will move along the tangent to the circular path.
  - will continue to move in circular path.
- Law of gravitation gives the gravitational force between \_\_\_\_\_.
  - the earth and a point mass only
  - the earth and Sun only
  - any two bodies having some mass
  - two charged bodies only
- The force of attraction between two unit point masses separated by a unit distance equals
  - gravitational potential.
  - acceleration due to gravity.
  - gravitational field.
  - universal gravitational constant.





4. According to Newton's law of gravitation, for two objects kept at a distance  $d$  from each other, if the distance between the objects is doubled, then the force between the two objects \_\_\_\_\_.  
 (A) increases 4 times (B) decreases 4 times  
 (C) decreases 2 times (D) increases 2 times
5. For bodies which are not spherical or having an irregular shape, the direction of the force is along the line joining their \_\_\_\_\_.  
 (A) centre of masses (B) centres  
 (C) nearest edges (D) both (A) and (B)
6. The tidal waves in the sea are primarily due to gravitational effect of  
 (A) earth on the sea. (B) Sun on the earth.  
 (C) earth on the moon. (D) moon on the earth.
7. The value of acceleration due to gravity  
 (A) is same at the equator and poles.  
 (B) is least at the poles.  
 (C) is least at the equator.  
 (D) is maximum at the centre of the earth.
8. For an object at infinite distance from the earth, the value of acceleration due to gravity ( $g$ ) is  
 (A) Infinite (B)  $9.8 \text{ m/s}^2$   
 (C)  $1.0 \text{ m/s}^2$  (D) zero
9. A spherical planet far out in space has a mass  $M_0$  and diameter  $D_0$ . A particle of mass  $m$  falling freely near the surface of this planet will experience acceleration due to gravity equal to  
 (A)  $GM_0/D_0^2$  (B)  $4mGM_0/D_0^2$   
 (C)  $4GM_0/D_0^2$  (D)  $GmM_0/D_0^2$
10. The value of  $g$  on moon is  $1/6^{\text{th}}$  of its value on the earth. If a person weighs  $14 \text{ N}$  on the moon's surface, then the weight of the person on earth's surface is  
 (A)  $96 \text{ N}$  (B)  $84 \text{ N}$  (C)  $62 \text{ N}$  (D)  $54 \text{ N}$
11. The minimum velocity of the spacecraft to escape from earth's gravitational force must be \_\_\_\_\_.  
 [Dec 2020]  
 (A)  $112 \text{ km/s}$  (B)  $11.2 \text{ km/s}$   
 (C)  $1.12 \text{ km/s}$  (D)  $0.112 \text{ km/s}$
12. The formula for escape velocity is [July 2023]  
 (A)  $\sqrt{\frac{2M}{R}}$  (B)  $\sqrt{\frac{2GM}{R}}$   
 (C)  $\sqrt{\frac{GM}{R^2}}$  (D)  $\sqrt{\frac{GMm}{R^2}}$

**Answers:**

1. (C)                      2. (C)                      3. (D)
4. (B)

**Hint:**  $F = \frac{Gm_1m_2}{r^2}$

$$F_1 = \frac{Gm_1m_2}{(2r)^2} = \frac{Gm_1m_2}{4r^2} = \frac{F}{4}$$

5. (A)                      6. (D)                      7. (C)
8. (D)
9. (A)

**Hint:**  $F = \frac{Gm_1m_2}{r^2} = \frac{GmM_0}{D_0^2} = ma$

$$\therefore a = \frac{GM_0}{D_0^2}$$

10. (B)

**Hint:**  $W_{\text{moon}} = mg_{\text{moon}}$

$$\therefore 14 = m \frac{1}{6} g_{\text{earth}}$$

$$\therefore W_{\text{earth}} = mg_{\text{earth}} = 14 \times 6 = 84 \text{ N}$$

11. (B)                      12. (B)

**Complete the paragraph [3 Marks]**

1. **Select the appropriate options and complete the following paragraph.**

(velocity, independent, initial velocity, dependent, gravity, friction, final velocity, direction)

The motion of any object under the influence of the force of \_\_\_\_\_ alone is called as free fall. During free fall, there will be no change in the \_\_\_\_\_ of motion of the object. But there will be a change in the magnitude of \_\_\_\_\_ of the object due to the gravitational pull of the earth. The acceleration that an object experiences during free fall is \_\_\_\_\_ of the mass of the object undergoing motion. When a body is dropped freely from a height, its \_\_\_\_\_ is zero. Whereas when a body is thrown vertically upwards, its \_\_\_\_\_ is zero.

**Answer:**

The motion of any object under the influence of the force of **gravity** alone is called as free fall. During free fall, there will be no change in the **direction** of motion of the object. But there will be a change in the magnitude of **velocity** of the object due to the gravitational pull of the earth. The acceleration that an object experiences during free fall is **independent** of the mass of the object undergoing motion. When a body is dropped freely from a height, its **initial velocity** is zero. Whereas when a body is thrown vertically upwards, its **final velocity** is zero.

**Name the following [1 Mark each]**

1. Force which is directed towards the centre of the circle (centre seeking)
2. Amount of matter present in an object
3. According to Newton's first law, mass of any object is the measure of this quantity
4. Force with which the earth attracts an object
5. Scientist who was appointed as the royal mathematician in place of Brahe
6. Observatory constructed by scientists to detect the gravitational waves emitted by astronomical sources

**Answers:**

- Centripetal force
- Mass
- Inertia
- Weight of the object.
- Johannes Kepler
- LIGO-Laser Interferometric Gravitational Wave Observatory

**True or False.****If false, write the correct sentence****[1 Mark each]**

- The orbit of a planet is an ellipse with the Sun at the centre.
- Two planets move around the Sun. The periodic times and the mean radii of the orbits are  $T_1$ ,  $T_2$  and  $r_1$ ,  $r_2$  respectively. Then the ratio  $T_1/T_2$  is equal to  $(r_1/r_2)^{2/3}$ .
- Gravitational forces have been called the waves on the fabric of space-time.
- The centre of a mass of any object having uniform density is at its centroid.
- According to Newton's third law of motion, a force acting on a body results in its acceleration.
- Due to its rotation, the earth is flatter at the equator and bulges at the poles.
- As we go above the earth's surface, the value of acceleration due to gravity increases.
- The acceleration due to gravity at a given point on the earth is the same for all the objects.
- The moon and the artificial satellites are all in free fall.
- True free fall is possible only in air.
- An object going vertically upwards will be free from the gravitational influence of the earth, if its initial velocity is equal to critical velocity of the earth.
- The escape velocity is same for different planets.

**Answers:**

- False  
The orbit of a planet is an ellipse with the Sun at one of the foci.
- False  
Two planets move around the Sun. The periodic times and the mean radii of the orbits are  $T_1$ ,  $T_2$  and  $r_1$ ,  $r_2$  respectively. Then the ratio  $T_1/T_2$  is equal to  $(r_1/r_2)^{3/2}$ .

**Hint:** Kepler's third law:

$$(T_1)^2 \propto (r_1)^3 \quad \text{and} \quad (T_2)^2 \propto (r_2)^3$$

$$\therefore \left(\frac{T_1}{T_2}\right)^2 = \left(\frac{r_1}{r_2}\right)^3$$

$$\therefore \frac{T_1}{T_2} = \left(\frac{r_1}{r_2}\right)^{3/2}$$

- True
- True
- False

According to Newton's second law of motion, a force acting on a body results in its acceleration.

- False  
Due to its rotation, the earth bulges at the equator and is flatter at the poles.
- False  
As we go above the earth's surface, the value of acceleration due to gravity decreases.
- True
- True
- False  
True free fall is possible only in vacuum.
- False  
An object going vertically upwards will be free from the gravitational influence of the earth, if its initial velocity is equal to escape velocity of the earth.
- False  
The escape velocity is different for different planets.

**Hint:** Escape velocity is given as,  $v_{\text{esc}} = \sqrt{\frac{2GM}{R}}$ , where

M is mass and R is radius of the planet which is not same for different planets.

**Odd one out****[1 Mark each]**

- Force, acceleration due to gravity, weight, mass.
- $v = gt$ ,  $h = \frac{1}{2}gt^2$ ,  $v = u + at$ ,  $v^2 = 2gh$
- The orbit of a planet is an ellipse, line joining the planet and the sun sweeps equal areas in equal intervals of time,  
 $F = \frac{Gm_1m_2}{r^2}$ ,  $T^2 \propto R^3$

**Answers:**

- Mass  
Mass is a scalar while other are vectors.
- $v = u + at$   
 $v = u + at$  is the fundamental kinematical equation of motion while others are kinematical equations for a freely falling body.
- $F = \frac{Gm_1m_2}{r^2}$   
 $F = \frac{Gm_1m_2}{r^2}$  is Newton's law of gravitation while others are Kepler's laws of planetary motion.

**Complete the analogy****[1 Mark each]**

- Gravitational constant: scalar quantity :: acceleration due to gravity : \_\_\_\_\_.
- Kinetic energy of a body of mass m on the surface of the earth:  $\frac{1}{2}mv_{\text{esc}}^2$  :: kinetic energy of a body of mass m at infinite distance from earth : \_\_\_\_\_.
- Kepler's first law: orbit of a planet is an ellipse :: \_\_\_\_\_ :  $T^2 \propto r^3$   
(T is orbital period of revolution of a planet and r is the mean distance of the planet from sun.)
- Increase in altitude: value of g decreases :: at the centre of the earth: \_\_\_\_\_.



**Answers:**

1. vector quantity  
Gravitational constant is a scalar quantity and acceleration due to gravity is a vector quantity.
2. zero  
Kinetic energy of a body of mass  $m$  on the surface of the earth is  $\frac{1}{2}mv_{esc}^2$  while kinetic energy of a body of mass  $m$  at infinite distance from earth is zero.
3. Kepler's third law  
Orbit of a planet is an ellipse is Kepler's first law while  $T^2 \propto r^3$  is Kepler's third law.
4. value of  $g$  is zero.  
Value of  $g$  increases with increase in altitude while the value of  $g$  becomes zero at the centre of the earth.

**Match the following**

- \*1. Study the entries in the following table and rewrite them putting the connected items in a single row.

I	II	III
Mass	$m/s^2$	Zero at the centre
Weight	kg	Measure of inertia
Acceleration due to gravity	$Nm^2/kg^2$	Same in the entire universe
Gravitational constant	N	Depends on height

Ans:

I	II	III
Mass	kg	Measure of inertia
Weight	N	Zero at the centre
Acceleration due to gravity	$m/s^2$	Depends on height
Gravitational constant	$Nm^2/kg^2$	Same in the entire universe.

2. Match the laws/physical quantities in column I with their corresponding formula/relation in column II.

	Column I		Column II
i.	Kepler's third law	a.	$\frac{GMm}{R+h}$
ii.	Law of gravitation	b.	$T^2 \propto r^3$
iii.	Gravitational Potential energy	c.	$F \propto \frac{m_1 m_2}{r^2}$
iv.	Escape velocity	d.	$\sqrt{\frac{2GM}{R}}$
		e.	$\frac{GM}{R^2}$

Ans: (i – b), (ii – c), (iii – a), (iv – d)

**Answer the following**

- \*1. What are (i) free fall (ii) acceleration due to gravity (iii) escape velocity (iv) centripetal force? [1 Mark each]

Ans:

- i. **Free fall:**  
Whenever an object moves under the influence of the force of gravity alone, then the object is said to be under free fall.
- ii. **Acceleration due to gravity:**  
The acceleration produced in a body under the influence of the force of gravity alone is called acceleration due to gravity.
- iii. **Escape velocity:**  
When a body is thrown vertically upwards, at a particular value of initial velocity, the body will be able to overcome the downward pull by the earth and can escape the earth forever and will not fall back on the earth. This velocity is called escape velocity.
- iv. **Centripetal force:**  
The force acting on any object moving in a circle and directed towards the centre of the circle is called as centripetal force.

- \*2. Write the three laws given by Kepler. How did they help Newton to arrive at the inverse square law of gravity? [5 Marks]

Ans: The three laws given by Kepler are:

- i. **Kepler's first law:** The orbit of a planet is an ellipse with the sun at one of the foci.
- ii. **Kepler's second law:** The line joining the planet and the sun sweeps equal areas in equal intervals of time.
- iii. **Kepler's third law:** The square of orbital period of revolution of a planet around the Sun is directly proportional to the cube of the mean distance of the planet from the Sun.
- iv. **Derivation of inverse square law of gravity with the help of Kepler's law:**

- a. The centripetal force acting on a planet of mass  $m$  and velocity  $v$ , revolving at a distance of  $r$  from the Sun, is given as,

$$F = \frac{mv^2}{r} \dots(1)$$

- b. Let  $T$  be the period of revolution of the planet and  $2\pi r$  be the distance travelled by the planet in one revolution. Then the speed of the planet is given as,

$$\text{speed } (v) = \frac{\text{distance travelled}}{\text{time taken}} = \frac{2\pi r}{T} \dots(2)$$

- c. Substituting equation (2) in (1), we get,

$$F = \frac{m \left( \frac{2\pi r}{T} \right)^2}{r} = \frac{4m\pi^2 r}{T^2}$$



d. Multiplying and dividing by  $r^2$ , we get,

$$F = \frac{4m\pi^2 r^3}{r^2 T^2}$$

$$= \frac{4m\pi^2}{r^2} \left( \frac{r^3}{T^2} \right) \quad \dots(3)$$

e. But, According to Kepler's third law,  
 $T^2 \propto r^3$

$$\therefore \frac{T^2}{r^3} = \text{constant (K)} \quad \dots(4)$$

Substituting equation (4) in (3), we get,

$$F = \frac{4m\pi^2}{r^2 K}$$

But,  $\frac{4m\pi^2}{K} = \text{constant}$

$$\therefore F \propto \frac{1}{r^2}$$

Thus, with the help of Kepler's third law, Newton concluded that the centripetal force which is the force acting on the planet and is responsible for its circular motion, must be inversely proportional to the square of the distance between the planet and the Sun. Newton identified this force with the force of gravity and hence postulated the inverse square law of gravitation.

**\*3. Let the period of revolution of a planet at a distance R from a star be T. Prove that if it was at a distance of 2R from the star, its period of revolution will be  $\sqrt{8}T$ . [2 Marks]**

**Ans:**

i. According to Kepler's third law, the square of orbital period of revolution T of a planet around a star is directly proportional to the cube of the mean distance R of the planet from the star.

$$T^2 \propto R^3$$

$$\therefore T^2 = k(R)^3 \quad \dots(1)$$

Where, k is constant of proportionality.

ii. When the planet is at a distance of 2R from the star, then its period of revolution T' will be,

$$T'^2 \propto (2R)^3$$

$$\therefore T'^2 = k(2R)^3 \quad \dots(2)$$

iii. Dividing equations (1) and (2), we get,

$$\frac{T^2}{T'^2} = \frac{(R)^3}{(2R)^3}$$

$$\therefore \frac{T^2}{T'^2} = \frac{1}{8}$$

$$\therefore T' = \sqrt{8}T$$

Thus, for a planet at a distance of 2R from the star, its period of revolution will be  $\sqrt{8}T$ .

**4. What is acceleration due to gravity? Derive an expression for acceleration due to gravity on the earth's surface. [3 Marks]**

**Ans: Acceleration due to gravity:**

The acceleration produced in a body under the influence of the force of gravity alone is called acceleration due to gravity. It is denoted by 'g'.

**Expression for acceleration due to gravity:**

- Suppose an object of mass 'm' is situated at a distance 'R' from the centre of the earth.
- Let 'M' be the mass of the earth, then the gravitational force of attraction F between the object and the earth is given by,

$$F = G \frac{Mm}{R^2}$$

Where, G = constant of gravitation

$$\therefore \frac{F}{m} = G \frac{M}{R^2} \quad \dots(1)$$

iii. But acceleration is given by acceleration due to gravity.

$$g = \frac{\text{force}}{\text{mass}} = \frac{F}{m} \quad \dots(2)$$

iv. From equations (1) and (2), we have, acceleration due to gravity on the earth's surface,

$$g = \frac{GM}{R^2}$$

v. From the above relation, acceleration due to gravity on earth's surface depends upon the mass of the earth (M) and distance (R) of the object from the centre of the earth i.e., the radius of the earth.

**5. Explain the factors affecting the value of gravitational acceleration of the earth 'g'. [3 Marks]**

[3 Marks]

**Ans: The following factors affect the value of gravitational acceleration of the earth 'g':**

**i. Shape of the earth:**

- The shape of the earth is not perfectly spherical. It is slightly flattened at the poles and bulged at the equator.
- As a result, the radius of the earth at the poles is less than that at the equator.
- Hence, the value of 'g' is the highest at the poles (9.832 m/s<sup>2</sup>) and decreases slowly with decreasing latitude. It is the lowest at the equator (9.78 m/s<sup>2</sup>).

**ii. Height:**

- As the height of an object from the surface of the earth increases, the distance between the object and the centre of the earth (r) increases.
- As a result, the value of 'g' decreases with increase in height. However, the decrease is rather small for heights which are small in comparison to the earth's radius.

**iii. Depth:**

- The value of g is maximum on the surface of the earth.
- As depth of an object increases, the distance between the object and the centre of the earth (r) decreases.
- Along with the distance, the part of the earth which contributes towards the gravitational force felt by the object (M) also decreases.



d. As a combined result of change in  $r$  and  $M$ , the value of  $g$  decreases as we go deep inside the earth.

e. At the centre of the earth, the value of ' $g$ ' becomes zero.

**6. On what factors does acceleration due to gravity ( $g$ ) on earth's surface depend on?**

[1 Mark]

**Ans:** On earth's surface, acceleration due to gravity ( $g$ ) depends on mass and radius of the Earth.

**\*7. Will the mass and weight of an object on the earth be same as their values on Mars? Why?**

[2 Marks]

**Ans:**

i. Mass is a fundamental quantity whose value remains same everywhere. Hence, the mass of an object on earth will be same as its value on Mars.

ii. Weight of an object is product of mass and gravitational acceleration, i.e.,  $W = F = mg$

iii. As the weight depends on the value of acceleration due to gravity ( $g$ ) which changes from place-to-place and it is different for earth and Mars. Hence, the weight of the object on earth and Mars will not be the same.

**\*8. A stone thrown vertically upwards with initial velocity  $u$  reaches a height ' $h$ ' before coming down. Show that the time taken to go up is same as the time taken to come down.**

[3 Marks]

**Ans:**

i. We know,  
 $v = u + at$  .....(1)

$\therefore u = v - at$  .....(2)

We know,  
 $s = ut + \frac{1}{2}at^2$  .....(3)

From equation (2) and (3),

$$s = (v - at)t + \frac{1}{2}at^2$$

$\therefore s = vt - at^2 + \frac{1}{2}at^2$  .....(4)

ii. For upward motion of the stone,  
 $s = h$  (height)

$a = -g$  (negative sign indicates the direction of force is opposite to that of velocity.)

$v = 0$  ( $\because$  at the highest point velocity becomes zero).

$$t = t_1$$

Substituting these in equation (4),

$$\therefore h = (0)t - (-g)t_1^2 + \frac{1}{2}(-g)t_1^2$$

$$\therefore h = gt_1^2 - \frac{1}{2}gt_1^2$$

$$\therefore h = \frac{1}{2}gt_1^2 \quad \dots(5)$$

iii. For downward motion of the stone,  $a = g$   
 $u = 0$

( $\because$  at maximum height, initial velocity is zero.)

$$s = h$$

$$t = t_2$$

Substituting these in equation (3),

$$h = 0 + \frac{1}{2}gt_2^2$$

$$\therefore h = \frac{1}{2}gt_2^2 \quad \dots(6)$$

From equations (5) in (6),

$$\frac{1}{2}gt_1^2 = \frac{1}{2}gt_2^2$$

$$\therefore t_1^2 = t_2^2$$

$$\therefore t_1 = t_2$$

Hence, we can conclude that the time taken by the stone to go up is same as the time taken to come down.

**9. Using the law of conservation of energy, derive an expression for the escape velocity of an object from the surface of the earth.**

[3 Marks]

**Ans: Expression for escape velocity:**

i. Consider an object of mass  $m$  moving with initial velocity equal to escape velocity  $v_{esc}$  on the surface of the earth.

The kinetic energy of the object is given as, K.E  
 $= \frac{1}{2}mv_{esc}^2$

The potential energy of the object is given as,

$$\text{Potential energy} = -\frac{GMm}{R}$$

$\therefore$  Total energy =  $E_1 = \text{K.E} + \text{P.E}$

$$= \frac{1}{2}mv_{esc}^2 - \frac{GMm}{R} \quad \dots(1)$$

ii. The object escapes the gravitational force of the earth and comes to rest at infinite distance from the earth.

The kinetic energy of the object is given as,  $\text{K.E} = 0$

The potential energy of the object is given as,

$$\text{Potential energy} = -\frac{GMm}{\infty} = 0$$

$\therefore$  Total energy =  $E_2 = \text{K.E} + \text{P.E} = 0$  .....(2)

iii. From the principle of conservation of energy,  $E_1 = E_2$

$$\frac{1}{2}mv_{esc}^2 - \frac{GMm}{R} = 0$$

$$\therefore v_{esc}^2 = \frac{2GM}{R}$$

$$\therefore v_{esc} = \sqrt{\frac{2GM}{R}} \quad \dots(3)$$





iv. Also, we know, acceleration due to gravity is given as,  $g = \frac{GM}{R^2}$

$$\therefore GM = gR^2 \quad \dots(4)$$

v. Substituting equation (4) in (3), we get,

$$v_{\text{esc}} = \sqrt{\frac{2gR^2}{R}}$$

$$v_{\text{esc}} = \sqrt{2gR} \quad \dots(5)$$

Equations (3) and (5) represent the equations for escape velocity from the surface of the earth.

**10. What is the cause of weightlessness of space travellers in a spacecraft? [1 Mark]**

**Ans:** Space travellers being in a state of free fall is the cause of their weightlessness in a spacecraft.

**Give reasons [2 Marks each]**

**\*1. Explain why the value of  $g$  is zero at the centre of the earth.**

**Ans:**

i. The acceleration due to gravity ( $g$ ) on earth's surface is given as,  $g = \frac{GM}{R^2}$

The value of  $g$  depends on the mass  $M$  of the earth and the radius  $R$  of the earth.

ii. As we go inside the earth, the value of  $R$  decreases.

iii. The part of the earth which contributes towards the gravitational force felt by the object also decreases. It means that the value of  $M$  decreases.

iv. As a combined result of change in  $R$  and  $M$ , the value of  $g$  decreases as we go deep inside the earth.

v. At the centre of the earth, the value of  $R$  would be zero. Hence, the value of  $g$  would be zero too.

**2. Explain why value of  $g$  changes if we go inside the earth. [July 2019]**

**Ans:** Refer Give reasons Q.1 (ii to iv)

**\*3. If the value of  $g$  suddenly becomes twice its value, it will become two times more difficult to pull a heavy object along the floor. Why?**

**Ans:**

i. In order to pull an object along the floor, it is necessary to do work against the force of friction.

ii. The force of friction is directly proportional to the weight ( $mg$ ).

iii. If the value of  $g$  doubles, the weight of an object doubles and therefore, the force of friction also doubles.

iv. Thus, it will become two times more difficult to pull a heavy object along the floor.

**4. A body weighs more at poles and less at equator.**

**Ans:**

i. The weight of an object ( $W = mg$ ) is directly proportional to its mass and acceleration due to gravity.

ii. The value of  $g$  is the highest ( $9.832 \text{ m/s}^2$ ) at the poles and decreases slowly with decreasing latitude. It is the lowest ( $9.78 \text{ m/s}^2$ ) at the equator.

Hence, a body weighs more at the poles and less at equator.

**5. The weight of an object changes from place to place though its mass is constant.**

[Mar 2020] [2 Marks]

**Ans:** Refer Answer the following Q.7

**Distinguish between [2 Marks each]**

**\*1. What is the difference between mass and weight of an object?**

OR

**Distinguish between Mass and Weight.**

[Mar 2023]

**Ans:**

	Mass	Weight
i.	Mass is the amount of matter present in the object.	Weight is the force with which the earth attracts the object.
ii.	Mass remains same everywhere.	Weight of an object keeps on changing from place to place.
iii.	Mass is measured in kilogram (kg).	Weight is measured in newton (N).
iv.	Mass is a scalar quantity.	Weight is a vector quantity.

**Questions based on diagram**

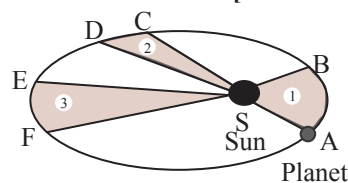
**1. State the laws related to the given diagram:**

[Mar 2022]

OR

**Observe the given figure showing the orbit of a planet moving around the Sun and write the three laws related to it:**

[Mar 2020] [3 Marks]



**The orbit of a planet moving around the Sun**

**Ans:**

i. **Kepler's first law:** The orbit of a planet is an ellipse with the sun at one of the foci.

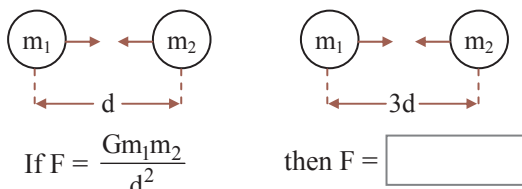
ii. **Kepler's second law:** The line joining the planet and the sun sweeps equal areas in equal intervals of time.





iii. **Kepler's third law:** The square of orbital period of revolution of a planet around the Sun is directly proportional to the cube of the mean distance of the planet from the Sun.

2. Write proper answer in the box:



[Mar 2019] [1 Mark]

Ans:  $\frac{Gm_1m_2}{9d^2}$



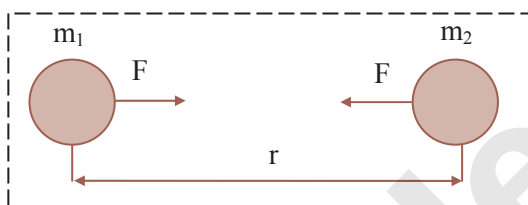
**Reading between the lines**

As,  $F = \frac{Gm_1m_2}{d^2}$ ,  $F \propto \frac{1}{d^2}$

∴ for  $d = 3d$ ,

$F = \frac{Gm_1m_2}{(3d)^2} = \frac{Gm_1m_2}{9d^2}$

3. Observe the following diagram and answer the questions. [5 Marks]



- Which law do we understand from the above diagram? State the law.
- State the mathematical equation for the law.
- In case the two bodies are not spherical, then in which direction is the force directed?
- How will the value of force F change if the mass  $m_2$  is increased to  $4m_2$ ?
- How will the value of force F change if the distance r is doubled? [HOTS]

Ans:

i. From the given diagram, we understand Newton's law of gravitation.

**Statement:** Gravitational force between two bodies in the universe is directly proportional to the product of their masses and inversely proportional to the square of the distance between them.

ii. The mathematical equation for the law is given as,  $F = G \frac{m_1m_2}{r^2}$

iii. If the two bodies are not spherical, then the direction of force is along the line joining their centres of mass.

iv. Gravitational force between the two bodies is given by,

$F = \frac{Gm_1m_2}{r^2}$

The mass  $m_2$  is increased to  $4m_2$ , then the force  $F'$  will be,

$F' = \frac{Gm_1(4m_2)}{(r)^2} = 4 \frac{Gm_1m_2}{r^2} = 4F$

∴ Force becomes **four times** the initial force.

v. Gravitational force between the two bodies is given by,

$F = \frac{Gm_1m_2}{r^2}$

When distance between the objects is doubled, the force  $F'$  will be,

$F' = \frac{Gm_1m_2}{(2r)^2} = \frac{Gm_1m_2}{4r^2} = \frac{1}{4}F$

∴ Force becomes **one fourth** the initial force.



**Numerical Section**

**Formulae**

1. **Kepler's third law:**

i.  $T^2 \propto r^3$

Where,

$T$  = the period of revolution of a body,

$r$  = the radius of orbit in which the body is revolving.

ii.  $\left(\frac{T_1}{T_2}\right)^2 = \left(\frac{r_1}{r_2}\right)^3$

Where  $T_1, T_2$  and  $r_1, r_2$  are periodic times and mean radii of the orbits of two planets around the Sun respectively.

2. **Gravitational force between two bodies:**

$F = \frac{Gm_1m_2}{r^2}$

Where,  $m_1$  and  $m_2$  = masses of two bodies,

$r$  = distance of separation between them,

$G$  = universal gravitational constant

3. **Universal gravitational constant:**  $G = \frac{Fr^2}{m_1m_2}$

4. **Acceleration due to gravity:**

On the earth surface,  $g = \frac{GM}{R^2}$

Where,  $M$  = mass of the earth,

$R$  = radius of the earth.

5. **Kinematical equations of motion:**

i.  $v = u + at$       ii.  $s = ut + \frac{1}{2}at^2$

iii.  $v^2 = u^2 + 2as$

**For a freely falling body:**

i.  $v = gt$       ii.  $h = \frac{1}{2}gt^2$       iii.  $v^2 = 2gh$

**For a body thrown upwards:**

- $u = -gt$   
(negative sign indicates velocity is decreasing)
- $h = ut - \frac{1}{2}gt^2$
- $u^2 = 2gh$

Where,  $u$  = initial velocity,  
 $v$  = final velocity,  
 $g$  = acceleration due to gravity,  
 $h$  = distance of the body from the surface of the earth

**6. Potential energy of a body:**

- On the earth's surface, P.E. =  $\frac{-GMm}{R}$
- At a height  $h$  from surface of earth,  
P.E. =  $\frac{-GMm}{R+h}$   
where,  $m$  = mass of the body.

**7. Escape velocity of a body (On the surface of the earth):**

$$v_{\text{esc}} = \sqrt{\frac{2GM}{R}} = \sqrt{2gR}$$

**Values to remember**

- Gravitational constant ( $G$ ) =  $6.7 \times 10^{-11} \text{ Nm}^2/\text{kg}^2$
- Acceleration due to gravity ( $g$ ) =  $9.8 \text{ m/s}^2$
- Mass of the earth =  $6 \times 10^{24} \text{ kg}$
- Radius of the earth =  $6.4 \times 10^6 \text{ m}$

**Solve the following problems****Type I Gravitational force between two bodies****Formulae:**

$$\text{i. } F = \frac{Gm_1m_2}{r^2} \quad \text{ii. } G = \frac{Fr^2}{m_1m_2}$$

- +1. Mahendra and Virat are sitting at a distance of 1 metre from each other. Their masses are 75 kg and 80 kg respectively. What is the gravitational force between them?**

(Textbook page no. 06) [2 Marks]

**Solution:**

**Given:** Distance ( $r$ ) = 1 m, mass ( $m_1$ ) = 75 kg, mass ( $m_2$ ) = 80 kg, gravitational constant ( $G$ ) =  $6.67 \times 10^{-11} \text{ Nm}^2/\text{kg}^2$

**To find:** Gravitational force ( $F$ )

**Formula:**  $F = \frac{Gm_1m_2}{r^2}$

**Calculation:** From formula,  

$$F = \frac{6.67 \times 10^{-11} \times 75 \times 80}{1^2}$$

$$\therefore F = 4.002 \times 10^{-7} \text{ N}$$

**Ans:** The gravitational force between Mahendra and Virat is  $4.002 \times 10^{-7} \text{ N}$ .

- +2. Calculate the gravitational force due to the earth on Mahendra who has mass of 75 kg. [Mass of the earth =  $6 \times 10^{24} \text{ kg}$ , Radius of the earth =  $6.4 \times 10^6 \text{ m}$ , Gravitational constant ( $G$ ) =  $6.67 \times 10^{-11} \text{ Nm}^2/\text{kg}^2$ ]**

(Textbook page no. 07) [2 Marks]

**Solution:**

**Given:** Mass of the earth ( $m_1$ ) =  $6 \times 10^{24} \text{ kg}$ ,  
Radius of the earth ( $R$ ) =  $6.4 \times 10^6 \text{ m}$ ,  
Mahendra's mass ( $m_2$ ) = 75 kg,  
Gravitational constant ( $G$ ) =  $6.67 \times 10^{-11} \text{ Nm}^2/\text{kg}^2$

**To find:** Gravitational force ( $F$ )

**Formula:**  $F = \frac{Gm_1m_2}{R^2}$

**Calculation:** From formula,  

$$F = \frac{6.67 \times 10^{-11} \times 75 \times 6 \times 10^{24}}{(6.4 \times 10^6)^2}$$

$$= \frac{6.67 \times 75 \times 6}{6.4 \times 6.4} \times 10 = 733 \text{ N}$$

**Ans:** The gravitational force due to the earth on Mahendra is 733 N.

- \*3. The masses of the earth and moon are  $6 \times 10^{24} \text{ kg}$  and  $7.4 \times 10^{22} \text{ kg}$ , respectively. The distance between them is  $3.84 \times 10^5 \text{ km}$ . Calculate the gravitational force of attraction between the two.**

Use  $G = 6.7 \times 10^{-11} \text{ Nm}^2 \text{ kg}^{-2}$  [2 Marks]

**Solution:**

**Given:** Mass of the earth ( $M_e$ ) =  $6 \times 10^{24} \text{ kg}$ ,  
Mass of the moon ( $M_m$ ) =  $7.4 \times 10^{22} \text{ kg}$ ,  
Distance ( $r$ ) =  $3.84 \times 10^5 \text{ km}$   
=  $3.84 \times 10^8 \text{ m}$ ,  
Gravitational constant ( $G$ ) =  $6.7 \times 10^{-11} \text{ Nm}^2/\text{kg}^2$

**To find:** Gravitational force ( $F$ )

**Formula:**  $F = \frac{Gm_1m_2}{r^2}$

**Calculation:** From formula,  

$$F = \frac{(6.7 \times 10^{-11}) \times (6 \times 10^{24}) \times (7.4 \times 10^{22})}{(3.84 \times 10^8)^2}$$

$$= \frac{6.7 \times 6 \times 7.4}{3.84 \times 3.84} \times 10^{19} = 2 \times 10^{20} \text{ N}$$

**Ans:** The gravitational force between the earth and the moon is  $2 \times 10^{20} \text{ N}$ .

- \*4. The mass of the earth is  $6 \times 10^{24} \text{ kg}$ . The distance between the earth and the Sun is  $1.5 \times 10^{11} \text{ m}$ . If the gravitational force between the two is  $3.5 \times 10^{22} \text{ N}$ , what is the mass of the Sun? Use  $G = 6.7 \times 10^{-11} \text{ Nm}^2 \text{ kg}^{-2}$ . [2 Marks]**



**Solution:**

**Given:** Mass of the earth ( $M_e$ ) =  $6 \times 10^{24}$  kg,  
Gravitational force ( $F$ ) =  $3.5 \times 10^{22}$  N,  
Distance ( $r$ ) =  $1.5 \times 10^{11}$  m,  
Gravitational constant ( $G$ ) =  $6.7 \times 10^{-11}$  Nm<sup>2</sup>/kg<sup>2</sup>

**To find:** Mass of Sun ( $M_s$ )

**Formula:**  $F = \frac{Gm_1m_2}{r^2}$

**Calculation:** From formula,

$$M_s = \frac{Fr^2}{GM_e}$$

$$\therefore M_s = \frac{(3.5 \times 10^{22}) \times (1.5 \times 10^{11})^2}{6.7 \times 10^{-11} \times 6 \times 10^{24}}$$

$$= \frac{7.88 \times 10^{44}}{40.2 \times 10^{13}} = 1.96 \times 10^{30} \text{ kg}$$

**Ans:** The mass of the Sun is  $1.96 \times 10^{30}$  kg.

5. A spaceship is  $10^{14}$  km away from a massive star. The gravitational force between them is 70 N. Calculate the distance between them, if the force between them is increased to  $7 \times 10^5$  N. [2 Marks]

**Solution:**

**Given:** Force ( $F_1$ ) = 70 N,  
distance ( $r_1$ ) =  $10^{14}$  km =  $10^{17}$  m,

**To find:** force ( $F_2$ ) =  $7 \times 10^5$  N  
Distance ( $r_2$ )

**Formula:**  $F = \frac{Gm_1m_2}{r^2}$

**Calculation:** From formula,

For  $r_1 = 10^{17}$  m:  $F_1 = \frac{Gm_1m_2}{(r_1)^2}$

$70 = \frac{Gm_1m_2}{(10^{17})^2} \dots(1)$

For  $r_2$ :  $F_2 = \frac{Gm_1m_2}{(r_2)^2}$

$7 \times 10^5 = \frac{Gm_1m_2}{r_2^2} \dots(2)$

Dividing equation (1) by (2), we have,

$$\frac{70}{7 \times 10^5} = \frac{r_2^2}{(10^{17})^2}$$

$\therefore r_2^2 = \frac{70}{7 \times 10^5} \times 10^{34} = 10^{30}$

$\therefore r_2 = 10^{15} \text{ m} = 10^{12} \text{ km}$

**Ans:** The distance between the spaceship and the star is  $10^{12}$  km.

**Type II Kinematical equations of motion**

**Formulae:**

**i. Kinematical equations of motion:**

1.  $v = u + at$                       2.  $s = ut + \frac{1}{2}at^2$                       3.  $v^2 = u^2 + 2as$

**ii. For a freely falling body:**

1.  $v = gt$                       2.  $h = \frac{1}{2}gt^2$                       3.  $v^2 = 2gh$

**iii. For a body thrown upwards:**

1.  $u = -gt$  (negative sign indicates velocity is decreasing)    2.  $h = ut - \frac{1}{2}gt^2$                       3.  $u^2 = 2gh$

**Illustrative Example:**

+ An iron ball of mass 3 kg is released from a height of 125 m and falls freely to the ground. Assuming that the value of  $g$  is  $10 \text{ m/s}^2$ , calculate

- i. time taken by the ball to reach the ground
- ii. velocity of the ball on reaching the ground
- iii. the height of the ball at half the time it takes to reach the ground.

**Analyse**

**Step 1:** Read the problem and make a list of what is given or can be inferred from the problem.  
From the information given, we come to know that the iron ball is in a state of free fall.  
Mass ( $m$ ) of the ball = 3 kg, distance travelled by the ball ( $s$ ) = 125 m,  
The iron ball is released from a height means initial velocity of the ball ( $u$ ) = 0,  
During free fall, acceleration  $a = g = 10 \text{ m/s}^2$ .

**Step 2:** Make a note of all the quantities which are required to be found.

- i. Time taken ( $t$ )
- ii. Final velocity ( $v$ )
- iii. Height ( $h$ )

**Solve**

**Step 3:** Based on the information provided and the quantity to be found, identify which kinematical equation of motion best fits the situation.

To find the time taken by the ball to reach the ground.

An equation that includes distance (s), initial velocity (u), acceleration (a) and time (t) i.e.,

$$s = ut + \frac{1}{2}at^2 \text{ fits the given situation.}$$

**Step 4:** Substitute known values into the equation and use appropriate algebraic steps to solve for the unknown quantity.

$$125 = 0t + 12 \times 10 \times t^2 = 5t^2$$

$$\therefore t^2 = \frac{125}{5} = 25$$

$$\therefore t = 5 \text{ s}$$

**Step 5:** Check the final answer in terms of its magnitude, sign and unit.

To find the velocity of the ball on reaching the ground.

Repeat step (3) for above case.

An equation that includes final velocity (v), initial velocity (u), acceleration (a) and time (t) i.e.,  $v = u + at$  fits the given situation.

Repeat step (4).

$$v = 0 + 10 \times 5$$

$$\therefore v = 50 \text{ m/s}$$

Repeat step (5).

To find the height of the ball at half the time it takes to reach the ground.

Repeat step (3) for above case.

An equation that includes distance (s), initial velocity (u), acceleration (a) and time (t). i.e.,  $s = ut + \frac{1}{2}at^2$  fits the given situation.

We consider the ball's distance from top as 's'

**Take note of any conditions given in the problem, in this case the height to be found is at half the time.**

$$\text{Half time} = t' = \frac{5}{2} = 2.5 \text{ s}$$

Repeat step (4).

$$s = ut' + \frac{1}{2}at'^2$$

$$\therefore s = 0 + \frac{1}{2} \times 10 \times (2.5)^2 = 31.25 \text{ m.}$$

Thus, the distance of the ball from the top is 31.25 m.

To get the height of the ball at half time,

$$h = 125 - 31.25 = 93.75 \text{ m}$$

Repeat step (5).

6. An iron ball of mass 3 kg is released from a height of 125 m and falls freely to the ground. Assuming that the value of 'g' is  $10 \text{ m/s}^2$ , calculate:

- Time taken by the ball to reach the ground.
- Velocity of the ball on reaching the ground.

[Dec 2020] [3 Marks]

Ans: Refer Illustrative example (i, ii.)

7. A metal ball of mass 5 kg falls from a height of 490 m. How much time it will take to reach the ground? ( $g = 9.8 \text{ m/s}^2$ )

[Mar 2019] [2 Marks]

**Solution:**

Given: Mass (M) = 5 kg, height (s) = 490 m, gravitational acceleration ( $g$ ) =  $9.8 \text{ m/s}^2$

To find: Time taken (t)

Formula:  $s = ut + \frac{1}{2}gt^2$



*Calculation:* From formula,

$$490 = (0 \times t) + \left(\frac{1}{2} \times 9.8 \times t^2\right)$$

$$\therefore 490 = 4.9 t^2$$

$$\therefore t^2 = \frac{490}{4.9} = 100$$

$$\therefore t = 10 \text{ s}$$

**Ans:** The metal ball will take **10 s** to reach the ground.

- \*8. An object takes 5 s to reach the ground from a height of 5 m on a planet. What is the value of g on the planet?**

[Mar 2022; Dec 2020] [2 Marks]

**Solution:**

*Given:* Time (t) = 5 s, height (s) = 5 m

*To find:* Gravitational acceleration (g)

*Formula:*  $s = ut + \frac{1}{2}gt^2$

*Calculation:* From formula,

$$5 = 0 \times t + \frac{1}{2}g(5)^2$$

$$\therefore 5 = \frac{1}{2}g \times 25$$

$$\therefore g = \frac{2}{5} = 0.4 \text{ m/s}^2$$

**Ans:** The gravitational acceleration of the planet is **0.4 m/s<sup>2</sup>**.

- 9. Use your brain power! (Textbook page no. 06) How long will Mahendra take to move 1 cm towards Virat, if a constant acceleration of  $5.34 \times 10^{-9} \text{ m/s}^2$  is produced in Mahendra?**

[2 Marks]

**Solution:**

*Given:* Height (s) = 1 cm = 0.01 m,  
initial velocity (u) = 0 m/s,  
acceleration (a) =  $5.34 \times 10^{-9} \text{ m/s}^2$

*To find:* Time taken (t)

*Formula:*  $s = ut + \frac{1}{2}at^2$

*Calculation:* From formula,

$$0.01 = \frac{1}{2} \times 5.34 \times 10^{-9} \times t^2$$

$$\therefore 0.01 = 2.67 \times 10^{-9} \times t^2$$

$$\therefore t^2 = \frac{0.01}{2.67 \times 10^{-9}} = 3.75 \times 10^6$$

$$\therefore t = 1936 \text{ s}$$

**Ans:** With constant acceleration, Mahendra takes **1936 s** to move 1 cm towards Virat.

- 10. A stone is released from the top of a tower of height 19.6 m. Calculate its final velocity just before touching the ground. [2 Marks]**

**Solution:**

*Given:* Height (h) = 19.6 m,  
Initial velocity (u) = 0 m/s,

*To find:* Final velocity (v)

*Formula:*  $v^2 = u^2 + 2as$

*Calculation:* For downward motion,

$$a = g, s = h, u = 0$$

From formula,

$$v^2 = 2 \times 9.8 \times 19.6$$

$$\therefore v^2 = 384.16$$

$$\therefore v = 19.6 \text{ m/s}$$

**Ans:** Final velocity of the stone just before touching the ground is **19.6 m/s**.

- +11. A gravitational force of  $4.002 \times 10^{-7} \text{ N}$  is acting between Mahendra (75 kg) and Virat (80 kg). Assuming that the bench on which Mahendra is sitting is frictionless, starting with zero velocity, what will be Mahendra's velocity of motion towards Virat after 1 s? Will this velocity change with time and how?**

(Textbook page no. 06) [3 Marks]

**Solution:**

*Given:* Force on Mahendra (F) =  $4.002 \times 10^{-7} \text{ N}$ ,  
Mahendra's mass (m) = 75 kg

*To find:* Velocity (v)

*Formulae:* i.  $F = ma$  ii.  $v = u + at$

*Calculation:* From formula (i),

$$a = \frac{F}{m} = \frac{4.002 \times 10^{-7}}{75} = 5.34 \times 10^{-9} \text{ m/s}^2$$

As Mahendra is sitting on the bench, his initial velocity is zero (u = 0)

Assuming the bench to be frictionless,

From formula (ii),

$$v = 0 + 5.34 \times 10^{-9} \times 1$$

$$\therefore v = 5.34 \times 10^{-9} \text{ m/s}$$

As Mahendra is moving towards Virat, the distance between them decreases causing an increase in gravitational force.

For a given mass, gravitational force being directly proportional to acceleration, acceleration increases.

$$a = \frac{F}{m}$$

As acceleration increases, the velocity **increases**.

**Ans:** Mahendra's velocity after 1 s towards Virat will be  **$5.34 \times 10^{-9} \text{ m/s}$**  and will **increase** with time.

- +12. The gravitational force of 733 N acts on Mahendra who has mass of 75 kg. Starting from rest, what will be Mahendra's velocity after one second if he is falling down due to the gravitational force of the earth?**

(Textbook page no. 07) [2 Marks]

**Solution:**

*Given:* Initial velocity (u) = 0, force (F) = 733 N,  
Mahendra's mass (m) = 75 kg,  
time (t) = 1 s



*To find:* Velocity ( $v$ )  
*Formulae:* i.  $F = ma$                       ii.  $v = u + at$

*Calculation:* Mahendra's acceleration  
 From formula (i),

$$a = \frac{F}{m} = \frac{733}{75} = 9.77 \text{ m/s}^2$$

Mahendra's velocity after 1 second,

From formula (ii),

$$v = 0 + 9.77 \times 1 = \mathbf{9.77 \text{ m/s}}$$

**Ans:** Mahendra's velocity after one second, if he is falling down due to the gravitational force of the earth is **9.77 m/s**.

- \*13. A ball falls off a table and reaches the ground in 1 s. Assuming  $g = 10 \text{ m/s}^2$ , calculate its speed on reaching the ground and the height of the table. [2 Marks]**

**Solution:**

*Given:* Initial velocity ( $u$ ) = 0,  
 acceleration due to gravity ( $g$ ) =  $10 \text{ m/s}^2$ ,  
 time ( $t$ ) = 1 s

*To find:* Height ( $s$ ), velocity ( $v$ )

*Formulae:* i.  $s = ut + \frac{1}{2}gt^2$

ii.  $v^2 = u^2 + 2gs$

*Calculation:* From formula (i),

$$s = 0 \times t + \frac{1}{2} \times 10 \times 1^2 = \mathbf{5 \text{ m}}$$

From formula (ii),

$$v^2 = 0 + 2 \times 10 \times 5$$

$$\therefore v^2 = 100$$

$$\therefore v = \mathbf{10 \text{ m/s}}$$

**Ans:** i. The velocity of the ball when it reaches the ground is **10 m/s**.

ii. The height of the table is **5 m**.

- \*14. An object thrown vertically upwards reaches a height of 500 m. What was its initial velocity? How long will the object take to come back to the earth? Assume  $g = 10 \text{ m/s}^2$ . [July 2019] [3 Marks]**

**Solution:**

*Given:* Height ( $s$ ) = 500 m, acceleration due to gravity ( $g$ ) =  $10 \text{ m/s}^2$

*To find:* i. Initial velocity ( $u$ ),  
 ii. Total time taken

*Formulae:* i.  $v^2 = u^2 + 2as$

ii.  $s = ut + \frac{1}{2}at^2$

*Calculation:* For upward motion of the ball, ( $v$ ) = 0.

$$a = -g = -10 \text{ m/s}^2$$

From formula (i),

$$0 = u^2 + 2(-10) \times 500$$

$$\therefore u^2 = 10000$$

$$\therefore u = \mathbf{100 \text{ m/s}}$$

For downward motion of the ball,  
 ( $u$ ) = 0.

$$a = g = 10 \text{ m/s}^2$$

From formula (ii),

$$500 = 0 + \frac{1}{2} \times 10 t^2$$

$$\therefore t^2 = \frac{500}{5} = 100$$

$$\therefore t = 10 \text{ s}$$

Time for upward journey of the ball will be the same as time for downward journey i.e., 10 s.

$$\therefore \text{Total time taken} = 2 \times t = 2 \times 10 = \mathbf{20 \text{ s}}$$

**Ans:** i. The initial velocity of the object is **100 m/s**.

ii. The total time taken by the object to reach the height and come down is **20 s**.

- +15. A tennis ball is thrown up and reaches a height of 4.05 m before coming down. What was its initial velocity? How much total time will it take to come down? Assume  $g = 10 \text{ m/s}^2$ . (Textbook page no. 12) [3 Marks]**

**Solution:**

*Given:* Distance travelled by the ball ( $s$ ) = 4.05 m, acceleration  $a = g = 10 \text{ m/s}^2$

*To find:* i. Initial velocity ( $u$ )

ii. Time taken ( $t$ )

*Formulae:* i.  $v^2 = u^2 + 2as$

ii.  $s = ut + \frac{1}{2}at^2$

*Calculation:* For upward motion of the ball, ( $v$ ) = 0.

$$a = -g = -10 \text{ m/s}^2$$

From formula (i),

$$0 = u^2 + 2(-10) \times 4.05$$

$$\therefore u^2 = 81$$

$$\therefore u = \mathbf{9 \text{ m/s}}$$

For downward motion of the ball, ( $u$ ) = 0.

$$a = g = 10 \text{ m/s}^2$$

From formula (ii),

$$4.05 = 0 + \frac{1}{2} \times 10 t^2$$

$$\therefore t^2 = \frac{4.05}{5} = 0.81$$

$$\therefore t = 0.9 \text{ s}$$

Time for upward journey of the ball will be the same as time for downward journey i.e., 0.9 s.

$$\therefore \text{Total time taken} = 2 \times 0.9 = \mathbf{1.8 \text{ s}}$$

**Ans:** i. The initial velocity of the ball is **9 m/s**.

ii. The total time taken by the ball to reach the ground is **1.8 s**.





**Type III Acceleration due to gravity (g)**

**Formula:** On the earth surface,  $g = \frac{GM}{R^2}$

- \*16. The mass and weight of an object on earth are 5 kg and 49 N respectively. What will be their values on the moon? Assume that the acceleration due to gravity on the moon is  $1/6^{\text{th}}$  of that on the earth. [2 Marks]

**Solution:**

**Given:** Mass on earth ( $m_e$ ) = 5 kg, weight on earth ( $W_e$ ) = 49 N, acceleration due to gravity on moon ( $g_m$ ) =  $9.8/6 = 1.63 \text{ m/s}^2$

**To find:** Mass ( $m_m$ ), weight ( $W_m$ ) on moon

**Formula:**  $W_m = m_m g_m$

**Calculation:** The mass of the object is independent of gravity and remains unchanged i.e., 5 kg.

From formula,

$W_m = 5 \times 1.63$

$\therefore W_m = 8.15 \text{ N}$

**Ans:** On moon, the mass of the object is 5 kg and weight is 8.15 N.

17. Can you tell? (Textbook page no. 08) What would be the value of g on the surface of the earth if its mass was twice as large and its radius half of what it is now? [Mar 2019] [3 Marks]

**Solution:**

**Given:** Mass of the earth  $M' = 2M$ , radius of the earth  $R' = \frac{R}{2}$

**To find:** gravitational acceleration ( $g'$ )

**Formula:**  $g = \frac{GM}{R^2}$

**Calculation:** From formula,

$g' = \frac{G \times M'}{(R')^2}$

$= \frac{G \times 2M}{\left(\frac{R}{2}\right)^2}$

$g' = \frac{G \times 2M \times 4}{R^2}$

$\therefore g' = 8g = 8 \times 9.8$

$\therefore g = 78.4 \text{ m/s}^2$  i.e., 8 times the original value of g.

**Ans:** The value of g would be  $78.4 \text{ m/s}^2$  on the surface of the earth if its mass was twice as large and its radius half of the present value.

- \*18. The radius of planet A is half the radius of planet B. If the mass of A is  $M_A$ , what must be the mass of B so that the value of g on B is half that of its value on A? [2 Marks]

**Solution:**

**Given:** For planet A: mass =  $M_A$ ,

radius  $R_A = \frac{R_B}{2}$ ,

acceleration due to gravity =  $g_A$

For planet B: radius =  $R_B$ ,

acceleration due to gravity  $g_B = \frac{g_A}{2}$

**To find:** Mass of planet B ( $M_B$ )

**Formula:**  $g = \frac{GM}{R^2}$

**Calculation:** From formula,

$\frac{M_A}{M_B} = \frac{g_A R_A^2}{G} \times \frac{G}{g_B R_B^2} = \frac{g_A R_B^2}{4} \times \frac{2}{g_A R_B^2}$

...[Substituting for  $R_A$  and  $g_B$ ]

$\therefore \frac{M_A}{M_B} = \frac{1}{2}$

$\therefore M_B = 2M_A$

**Ans:** The mass of planet B is  $2M_A$ .

- +19. If a person weighs 750 N on earth, how much would be his weight on the moon given that moon's mass is  $\frac{1}{81}$  of that of the earth and its radius is  $\frac{1}{3.7}$  of that of the earth? (Textbook page no. 10) [2 Marks]

**Solution:**

**Given:** Weight on earth = 750 N, Ratio of mass of the earth ( $M_E$ ) to mass of the moon

$(M_M) = \frac{M_E}{M_M} = 81$

Ratio of radius of the earth ( $R_E$ ) to

radius of moon ( $R_M$ ) =  $\frac{R_E}{R_M} = 3.7$

**To find:** Weight ( $W$ )

**Formula:** weight =  $mg = \frac{mGM}{R^2}$

**Calculation:** Weight on the earth,

$mg = 750 = \frac{mGM_E}{R_E^2}$

$\therefore m = \frac{750 R_E^2}{(G M_E)} \dots(i)$

Weight on Moon

$W_{\text{moon}} = \frac{mGM_M}{R_M^2} \dots(ii)$

Substituting equation (i) in equation (ii),

$W_{\text{moon}} = \frac{750 R_E^2}{(G M_E)} \times \frac{G M_M}{R_M^2}$

$= 750 \frac{R_E^2}{R_M^2} \times \frac{M_M}{M_E}$

$\therefore W_{\text{moon}} = 750 \times (3.7)^2 \times \frac{1}{81} = 126.8 \text{ N}$

**Ans:** The weight of the person on moon will be 126.8 N.



20. Use your brain power! (Textbook page no. 10)  
Suppose you are standing on a tall ladder. If your distance from the centre of the earth is  $2R$ , what will be your weight?

OR

A person is standing on a tall ladder. If his distance from the centre of the earth is  $2R$ , what will be his weight? [2 Marks]

**Solution:**

Given:  $h = R$  ( $\because$  distance from centre of the earth is  $2R$ )

To find: Weight ( $W$ )

Formulae: i. On earth's surface,

$$W = mg = \frac{GMm}{R^2}$$

ii. At a height ( $h$ ) above earth's surface,

$$W = \frac{GMm}{(R+h)^2}$$

Calculation: On earth's surface,  
From formula (i),

$$W = \frac{GMm}{R^2} \quad \dots(1)$$

At a distance of  $2R$  from centre of the earth,

From formula (ii),

$$W' = \frac{GMm}{(R+R)^2} = \frac{GMm}{4R^2} \quad \dots(2)$$

Dividing equation (2) by (1), we have,

$$\frac{W'}{W} = \frac{R^2}{4R^2}$$

$$\therefore W' = \frac{1}{4} W$$

**Ans:** The person's weight at a distance of  $2R$  from the centre of the earth, would reduce to  $\frac{1}{4}$  the weight on the surface of the earth.

#### Type IV Escape velocity

$$\text{Formula: } v_{\text{esc}} = \sqrt{\frac{2GM}{R}} = \sqrt{2gR}$$

- +21. Calculate the escape velocity on the surface of the moon given the mass and radius of the moon to be  $7.34 \times 10^{22}$  kg and  $1.74 \times 10^6$  m respectively.

(Given:  $G = 6.67 \times 10^{-11}$  Nm<sup>2</sup>/kg<sup>2</sup>)

(Textbook page no. 14)[Mar 2023] [3 Marks]

**Solution:**

Given: Gravitational constant ( $G$ ) =  $6.67 \times 10^{-11}$  Nm<sup>2</sup>/kg<sup>2</sup>, Mass of the moon ( $M$ ) =  $7.34 \times 10^{22}$  kg, radius of the moon ( $R$ ) =  $1.74 \times 10^6$  m.

To find: Escape velocity ( $v_{\text{esc}}$ )

$$\text{Formula: } v_{\text{esc}} = \sqrt{\frac{2GM}{R}}$$

Calculation: From formula,

$$v_{\text{esc}} = \sqrt{\frac{2 \times 6.67 \times 10^{-11} \times 7.34 \times 10^{22}}{1.74 \times 10^6}}$$

$$= \sqrt{\frac{97.9 \times 10^5}{1.74}}$$

$$\therefore v_{\text{esc}} = 2372 \text{ m/s} = 2.372 \text{ km/s}$$

**Ans:** Escape velocity on the moon is **2.372 km/s**.

22. The escape velocity of a body from the earth's surface is **11.2 km/s**. The mass of the Moon is  $(1/81)$ <sup>th</sup> of that of earth. The radius of the moon is  $(1/3.7)$ <sup>th</sup> that of earth. Find the escape velocity from Moon's surface. [2 Marks]

**Solution:**

Given: Escape velocity on earth's surface ( $v_{\text{esc}}$ ) = 11.2 km/s,  
ratio of moon and earth's mass ( $M_m/M_e$ ) =  $1/81$ ,  
ratio of moon and earth's radius ( $R_m/R_e$ ) =  $1/3.7$ .

To find: Escape velocity ( $v_e$ )<sub>m</sub>

$$\text{Formulae: i. } v_{\text{esc}} = \sqrt{\frac{2GM_e}{R_e}}$$

$$\text{ii. } (v_{\text{esc}})_m = \sqrt{\frac{2GM_m}{R_m}}$$

Calculation: From formula (i) and (ii),

$$\frac{(v_{\text{esc}})_m}{v_{\text{esc}}} = \sqrt{\frac{M_m \times R_e}{M_e \times R_m}}$$

$$= \sqrt{\frac{1}{81} \times 3.7}$$

$$= 0.214$$

$$\therefore (v_{\text{esc}})_m = v_{\text{esc}} \times 0.214 = 11.2 \times 0.214 = 2.39 \text{ km/s}$$

**Ans:** The escape velocity from Moon's surface is **2.39 km/s**.

#### Practice Problems

1. The masses of earth and Jupiter are  $6 \times 10^{24}$  kg and  $1.9 \times 10^{27}$  kg, respectively. The distance between them is  $6.2 \times 10^{11}$  m. Calculate the gravitational force of attraction between the two.

Use  $G = 6.7 \times 10^{-11}$  Nm<sup>2</sup> kg<sup>-2</sup> [2 Marks]

**Ans:**  $1.98 \times 10^{18}$  N

2. The mass of a planet is 6 times the mass of earth and its radius is 3 times that of the earth. Considering acceleration due to gravity on earth to be  $9.8 \text{ m/s}^2$ , calculate the value of 'g' on the other planet. [2 Marks]

**Ans:**  $6.53 \text{ m/s}^2$



3. An object takes 15 s to reach the ground from a height of 40 m on a planet. What is the value of  $g$  on the planet? [2 Marks]

Ans:  $0.35 \text{ m/s}^2$

4. A ball falls off a table and reaches the ground in 10 s. Assuming  $g = 10 \text{ m/s}^2$ , calculate its speed on reaching the ground and the height of the table. [2 Marks]

Ans: 100 m/s, 500m

5. An object thrown vertically upwards reaches a height of 320 m. What was its initial velocity? How long will the object take to come back to the earth? Assume  $g = 10 \text{ m/s}^2$ . [3 Marks]

Ans: 80 m/s, 16 s

6. An object is thrown vertically upwards and rises to a height of 10 m. Calculate

- the velocity with which the object was thrown upwards and
- the time taken by the object to reach the highest point. ( $g = 9.8 \text{ m/s}^2$ ) [3 Marks]

Ans: i.  $14 \text{ ms}^{-1}$   
ii. 1.43 s

7. Calculate the maximum height attained by the body thrown vertically upward with a velocity of  $9.8 \text{ m/s}$ . ( $g = 9.8 \text{ m/s}^2$ ) [2 Marks]

Ans: 4.9 m

8. An apple of mass  $0.15 \text{ kg}$  falls from a tree. What is the acceleration of the apple towards the earth? Also calculate the acceleration of the earth towards the apple. [Given: Mass of earth =  $6 \times 10^{24} \text{ kg}$ , Radius of earth =  $6.4 \times 10^6 \text{ m}$ ,  $G = 6.67 \times 10^{-11} \text{ Nm}^2 \text{ kg}^{-2}$ .] [3 Marks]

Ans:  $9.8 \text{ m/s}^2$ ,  $2.44 \times 10^{-25} \text{ m/s}^2$

9. A body weighs  $400 \text{ N}$  on the surface of earth. How much will it weigh on the surface of a planet whose mass is  $\frac{1}{6}$  and radius  $\frac{1}{2}$  that of the earth? [2 Marks]

Ans: 266.67 N

10. Find the escape speed of a body from the surface of Mars. [Radius of Mars =  $3392 \text{ km}$ ,  $g_{\text{Mars}} = 3.724 \text{ m/s}^2$ ] [2 Marks]

Ans: 5 km/s



### Intext Questions

1. **Intext Question. (Textbook page no. 01)**  
Why all apples fall vertically downward and not at an angle to the vertical. Why do they not fly off in a horizontal direction? [2 Marks]

Ans: The centre of mass of the earth is situated at its centre, so the gravitational force on any object due to the earth is always directed towards the centre of the earth. Because of this force, an object falls vertically downwards on the earth.

2. **Intext Question. (Textbook page no. 01)**

- i. If the force of gravitation acts on apples on the tree at different heights from the surface of the earth, can it also act on objects at even greater heights, much farther away from the earth, like for example, the moon?

Ans: Yes, the gravitational force acts on objects at greater heights and farther away from the earth like the moon.

- ii. Can it act on even farther objects like the other planets and the Sun?

Ans: Yes, the gravitational force acts on other planets and Sun.

3. **Try this. (Textbook page no. 02)**

Tie a stone to one end of a string. Take the other end in your hand and rotate the string so that the stone moves along a circle as shown in the figure 1.2 (a) of your textbook.

- Are you applying any force on the stone?
- In which direction is this force acting?
- How will you stop this force from acting?
- What will be the effect on the stone?

Ans:

- Yes, I am applying a force on the stone.
- The force is acting in the direction towards the centre of the circle along which the stone is rotated.
- The force can be stopped from acting by releasing the string.
- The stone will fly off along a straight line tangential to the circle at the position of the stone, when the string is released.

[Note: Students are expected to refer the accompanying Q. R. code in *Quill – The Padhai App* for demonstration of the activity.]



4. **Intext Question. (Textbook page no. 02)**

- Do you think some force is constantly acting on the moon?
- What must be the direction of this force?
- How would its motion have been if no such force acted on it?
- Do the other planets in the solar system revolve around the Sun in a similar fashion?
- Is similar force acting on them? What must be its direction? [HOTS]

Ans:

- There is a force constantly acting on the moon known as centripetal force.
- The force is directed towards the centre of the earth.
- If there was no force acting on the moon, it would have moved along a straight line which is the tangent to the circle.

- iv. Yes, other planets revolve around the Sun in the similar fashion.
- v. The other planets revolve around the Sun in the similar fashion due to the centripetal force exerted on them by the Sun. The direction of the force is towards the centre of the Sun.



### Reading between the lines

'Centripetal' means centre seeking, i.e. the object tries to go towards the centre of the circle because of this force. Thus, the gravitational force that earth exerts on moon in this situation is termed as centripetal force.

5. Use your brain power! (Textbook page no. 04)  
If the area ESF given in figure 1.4 of your textbook is equal to area ASB, what will you infer about EF?

**Ans:** According to Kepler's second law, if area of ESF = area of ASB, then AB and EF are distances covered by planet in the same time.



### Reading between the lines

The distance AB is much larger than the distance EF. This means, the planet has to move faster between A and B than it does between E and F. As a result, the planet moves faster in its orbit near the Sun (A to B) and comparatively slower when it is further away from the Sun (E to F). The distance from A to B contains the point at which the planet is closest to the Sun. This point is known as perihelion. The distance from E to F contains the point at which the planet is furthest from the sun. This point is known as aphelion.

6. Use your brain power! (Textbook page no. 04)  
Show that in SI units, the unit of G is newton  $\text{m}^2 \text{kg}^{-2}$ .

**Ans:**

- i. According to Newton's law of gravitation,
- $$F = \frac{Gm_1m_2}{r^2}$$
- $$\therefore G = \frac{Fr^2}{m_1m_2} \quad \dots(1)$$
- ii. In SI system, force is measured in newton (N), distance is measured in metre (m) and mass is measured in kilogram (kg).
- iii. Substituting in equation (1), we get, unit of G as,
- $$\frac{\text{newton} \times (\text{metre})^2}{\text{kg} \times \text{kg}}$$
- iv. Thus, in SI system,
- $$\text{Unit of } G = \frac{\text{Nm}^2}{\text{kg}^2} \text{ or newton } \text{m}^2 \text{kg}^{-2}$$

7. Intext Question. (Textbook page no. 05)

**Why did Newton assume inverse square dependence on distance in his law of gravitation?**

**Ans:** Newton assumed inverse square dependence on distance in his law of gravitation by considering Kepler's third law. It states that, 'The square of orbital period of revolution of a planet around the sun is directly proportional to the cube of the mean distance of the planet from the sun' i.e.,  $T^2 \propto r^3$ .

8. Use your brain power! (Textbook page no. 05)

**Is there a gravitational force between two objects kept on a table or between you and your friend sitting next to you? If yes, why don't the two move towards each other?**

**Ans:**

- i. Yes, there exists a gravitational force between two different objects kept on the table or between me and my friend sitting beside each other.
- ii. The gravitational force between two objects on earth is too small as compared to the gravitational force of the earth. Hence, two different objects kept on the table or me and my friend don't move towards each other.



### Reading between the lines

The gravitational force between any two objects is given by,  $F = \frac{Gm_1m_2}{r^2}$

Where,

$F$  = force between any two objects in newtons

$G$  = universal gravitational constant taken as  $6.67 \times 10^{-11} \text{ N-m}^2/\text{kg}^2$

$m_1$  and  $m_2$  = mass of the two objects in kg

$r$  = distance between the two objects in metres (m)

9. Intext Question. (Textbook page no. 07)

**Will the velocity of a stone thrown vertically upwards remain constant or will it change with time? How will it change? Why doesn't the stone move up all the time? Why does it fall down after reaching a certain height? What does its maximum height depend on?**

**Ans:**

- i. The velocity of a stone thrown vertically upwards decreases with time till it becomes zero.
- ii. The gravitational force of the earth tries to pull stone down and reduces its velocity. The velocity becomes zero after reaching a certain height.
- iii. The maximum height of the stone depends on the initial velocity with which the stone is thrown vertically upwards.





**10. Use your brain power! (Textbook page no. 07)**

According to Newton's law of gravitation, every object attracts every other object. Thus, if the earth attracts an apple towards itself, the apple also attracts the earth towards itself with the same force. Why then does the apple fall towards the earth, but the earth does not move towards the apple? [2 Marks]

**Ans:** As the mass of the earth is very large as compared to that of the apple, the magnitude of acceleration of the earth is too small that it cannot be noticed. Hence, the apple falls towards the earth while the earth does not move towards the apple.

**11. Intext Question. (Textbook page no. 07)**

The moon and the artificial satellites orbit the earth. The earth attracts them towards itself but unlike a falling apple, they do not fall on the earth, why?

**Ans:** The moon and the artificial satellites are attracted towards the earth. However, the velocity of the moon and the satellites along their orbits is such that it prevents them from falling on the earth.

**12. Think about it. (Textbook page no. 08)**

**i. What would happen if there were no gravity?**

**Ans:** If gravitational force ceased to exist on earth, then:

- All the objects will no longer be drawn towards each other and the earth. Objects not being attracted to the earth along-with humans would float off into space away from the surface of the earth.
- The important constituents of the earth including the atmosphere and the water from the ocean, seas etc would also float into space.
- The moon would stop orbiting the earth and would drift in space.

**ii. What would happen if the value of  $G$  was twice as large?**

**Ans:** If the value of  $G$  were to be doubled, then:

- The value of acceleration due to gravity ( $g$ ) would become double.
- Weight of all the objects on the earth will become double making simple tasks like picking an object difficult.
- The atmospheric air pressure would increase leading to various climatic changes. To counter this change in air pressure, the blood pressure of human body will increase making it hard to survive on earth.
- The earth's orbit around the Sun will be affected which will result in catastrophic climatic changes.

**13. Intext Question. (Textbook page no. 08)**

Will the value of  $g$  be the same everywhere on the surface of the earth? [1 Mark]

**Ans:** No, the value of  $g$  will not be same everywhere on the surface of earth.

**14. Think about it. (Textbook page no. 09)**

**i. Will the direction of the gravitational force change as we go inside the earth? [1 Mark]**

**Ans:** There will be no change in the direction of the gravitational force. Gravitational force always acts downwards, towards the centre of the earth.

**ii. What will be the value of  $g$  at the centre of the earth? [1 Mark]**

**Ans:** The value of  $g$  at the centre of the earth is zero.

**15. Use your brain power! (Textbook page no. 10)**

**i. Will your weight remain constant as you go above the surface of the earth?**

**Ans:** No, our weight decreases as we move away from the surface of the earth.

[Note: Refer table 1.7 of your textbook to observe variation in value of  $g$  with respect to height from surface of the earth.]

**16. Try This. (Textbook page no. 11)**

Take a small stone. Hold it in your hand. Which forces are acting on the stone? Now release the stone. What do you observe? What are the forces acting on the stone after you release it?

**Ans:**

- When a stone is held in our hands, it experiences the gravitational force exerted on it by the earth pulling it downward and the force of the hand pushing it upwards.
- When the stone is released, it falls down.
- Once the stone is released, the forces acting on the stone are gravitational force and an upward force opposing the gravitational force.
- If the medium in which the stone is released is air, frictional force due to air also acts on the stone opposing its motion.

[Note: Students are expected to refer the accompanying Q. R. code in *Quill – The Padhai App* for understanding of the concept.]



**17. Use your brain power! (Textbook page no. 12)**

According to Newton's law of gravitation, earth's gravitational force is higher on an object of larger mass. Why doesn't that object fall down with higher velocity as compared to an object with lower mass?



**Ans:**

- i. The acceleration produced in a body under the influence of the force of gravity alone is called acceleration due to gravity. It is given by,

$$g = \frac{GM}{R^2}$$

- ii. This acceleration depends only on the mass  $M$  and radius  $R$  of the earth and so the acceleration due to gravity at a given point on the earth is the same for all objects. It does not depend on the properties of the object.

Hence, all objects of different masses will fall down with the same velocity.

- 18. Intext Question. (Textbook page no. 14)**  
**Space travellers as well as objects in the spacecraft appear to be floating.**

**OR**

**Space travellers as well as objects in the spacecraft appear to be floating. Why does this happen?**

**Ans:**

- i. Though the spacecraft is at a height from the surface of the earth, the value of  $g$  there is not zero.
- ii. In the space station the value of  $g$  is only 11% less than its value on the surface of the earth. Thus, the height of a spacecraft is not the reason for their weightlessness.
- iii. Their weightlessness is caused by their being in the state of free fall. Though the spacecraft is not falling on the earth because of its velocity along the orbit, the only force acting on it is the gravitational force of the earth and therefore, it is in a free fall.
- iv. As the velocity of free fall does not depend on the properties of an object, the velocity of free fall is the same for the spacecraft, the travelers and the objects in the craft.

Hence, space travellers as well as objects in the spacecraft appear to be floating.

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