3490 MCQs

SAMPLE CONTENT

25 YEARS

PREVIOUS SOLVED PAPERS

1999 – 2023

MHT-CET

CHAPTER-WISE & TOPIC-WISE

PHYSICS

- Quick Review
- Important Formulae
- Smart Keys
- Statistical analysis of all the shifts of 2023

Target Publications® Pvt. Ltd.

25
YEARS
1999 - 2023

MHT-CET

PREVIOUS SOLVED PAPERS

PHYSICS

Chapter-wise & Topic-wise

Salient Features

- A compilation of 25 years of MHT-CET questions ***(1999-2023)*** that aligns with the most recent MHT-CET syllabus
- **'3490'** unique MCQs
- Chapter-wise and Topic-wise segregation of MCQs
- MCQs arranged in year-wise flow in each topic
- Quick Review provided for the revision of concepts
- Includes Important Study Techniques for holistic learning:
  - Thinking Hatke
  - Caution
  - Shortcuts
  - Mindbenders
- Solutions provided wherever required
- Trend analysis of all the shifts of MHT-CET 2023 examination in the form of:
  - Graphs of difficulty levels of each shift
  - Tables of Chapter-wise analysis of all shifts

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

P.O. No. 11004

TEID: 3304

PREFACE

Target's **'MHT-CET Physics: Previous Solved Papers (PSP)'** is a compilation of past 25 years' (1999-2023) questions asked in the MHT-CET examinations conducted by State Common Entrance Test Cell, Maharashtra State. This book is curated as per the **latest MHT-CET syllabus**.

The book consists of chapter-wise categorization of questions. Each chapter goes with a topic-wise flow. All the questions pertaining to a topic are arranged year-wise in a flow that concludes with the latest year. A special topic **Concept fusion** is drafted at the end of the MCQ section to cover multifarious questions. We have provided answers to all the questions and detailed solutions are given wherever required. The solutions will serve as valuable learning tools in understanding the concepts.

Selection of **unique MCQs** is prioritized while making this book to prevent the recurrence of identical questions. This will enable students to save time spent on repetitive questions.

We have infused several **Smart Keys** such as **Cautions, Thinking Hatke, Shortcuts and Mindbenders**. These Important Study Techniques are created to help students with key objectives such as time management, easy memorization, revision and non-conventional yet simple methods for MCQ solving. To ensure adequate revision, each chapter begins with a **Quick Review**, followed by all the key **Formulae** in the chapter.

A statistical analysis of the number of questions asked per chapter in each shift of MHT-CET 2023 examination is offered in tabular form. This analysis would help students understand the weighting allotted to each chapter. A graphical representation of analysis of all the papers (12 papers of PCM group & 12 papers of PCB group) is also included at the start of the book to elaborate on the breakdown of the difficulty level of questions asked in the examination. Studying these representations should undoubtedly aid students in planning their study strategy for the examination. *There is a possibility that the weightage to a chapter and the level of difficulty of the question paper in the future examination may vary.*

This book would provide students with confidence regarding their exam preparedness. We are confident that this book will comprehensively cater to the needs of students and effectively assist them to achieve their goal.

Publisher

Edition: First

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.

Please write to us on : mail@targetpublications.org

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

FEATURES

Quick Review

Quick Review includes tables/charts to summarize the key points of important concepts in the chapter.

Formulae

Formulae cover all of the key formulae in the chapter.

Shortcuts

Shortcuts incorporate important theoretical or formula based short tricks, beneficial in solving MCQs.

Mindbenders

Mindbenders present thought provoking snippets of concepts.

Topic-wise Segregation

MCQs are **segregated topic-wise** in each chapter. This is our attempt to cater to individualistic pace and preferences of studying a chapter in students and enable easy assimilation of questions based on the specific concept.

Concept Fusion

Concept Fusion section encompasses questions whose solutions require knowledge of concepts covered in different sub-topics of same chapter or from different chapters.

Thinking Hatke

Thinking Hatke reveals quick witted approach to crack the specific question.

Caution

Caution apprises students about mistakes often made while solving MCQs.

INDEX

MHT-CET PAPER PATTERN

- There will be three papers of Multiple Choice Questions (MCQs) in 'Mathematics', 'Physics and Chemistry' and 'Biology' of 100 marks each.
- Duration of each paper will be 90 minutes.
- Questions will be based on the syllabus prescribed by Maharashtra State Board of Secondary and Higher Secondary Education with approximately 20% weightage given to Std. XI and 80% weightage will be given to Std. XII curriculum.
- Difficulty level of questions will be at par with JEE (Main) for Mathematics, Physics, Chemistry and at par with NEET for Biology.
- There will be no negative marking.
- Questions will be mainly application based.
- Details of the papers are as given below:

Paper	Subject	Approximate No. of Multiple Choice Questions (MCQs) based on		Mark(s) Per Question	Total Marks
		Std. XI	Std. XII		
Paper I	Mathematics	10	40	2	100
Paper II	Physics	10	40	1	100
	Chemistry	10	40		
Paper III	Biology	20	80	1	100

- Questions will be set on
  i. the entire syllabus of Std. XII of Physics, Chemistry, Mathematics and Biology subjects prescribed by Maharashtra Bureau of Textbook Production and curriculum Research, Pune, and
  ii. chapters / units from Std. XI curriculum as mentioned below:

Sr. No.	Subject	Chapters / Units of Std. XI
1	Physics	Motion in a plane, Laws of motion, Gravitation, Thermal properties of matter, Sound, Optics, Electrostatics, Semiconductors
2	Chemistry	Some Basic Concepts of Chemistry, Structure of Atom, Chemical Bonding, Redox Reactions, Elements of Group 1 and Group 2, States of Matter: Gaseous and Liquid States, Basic Principles of Organic Chemistry, Adsorption and Colloids, Hydrocarbons
3	Mathematics	Trigonometry - II, Straight Line, Circle, Measures of Dispersion, Probability, Complex Numbers, Permutations and Combinations, Functions, Limits, Continuity
4	Biology	Biomolecules, Respiration and Energy Transfer, Human Nutrition, Excretion and osmoregulation

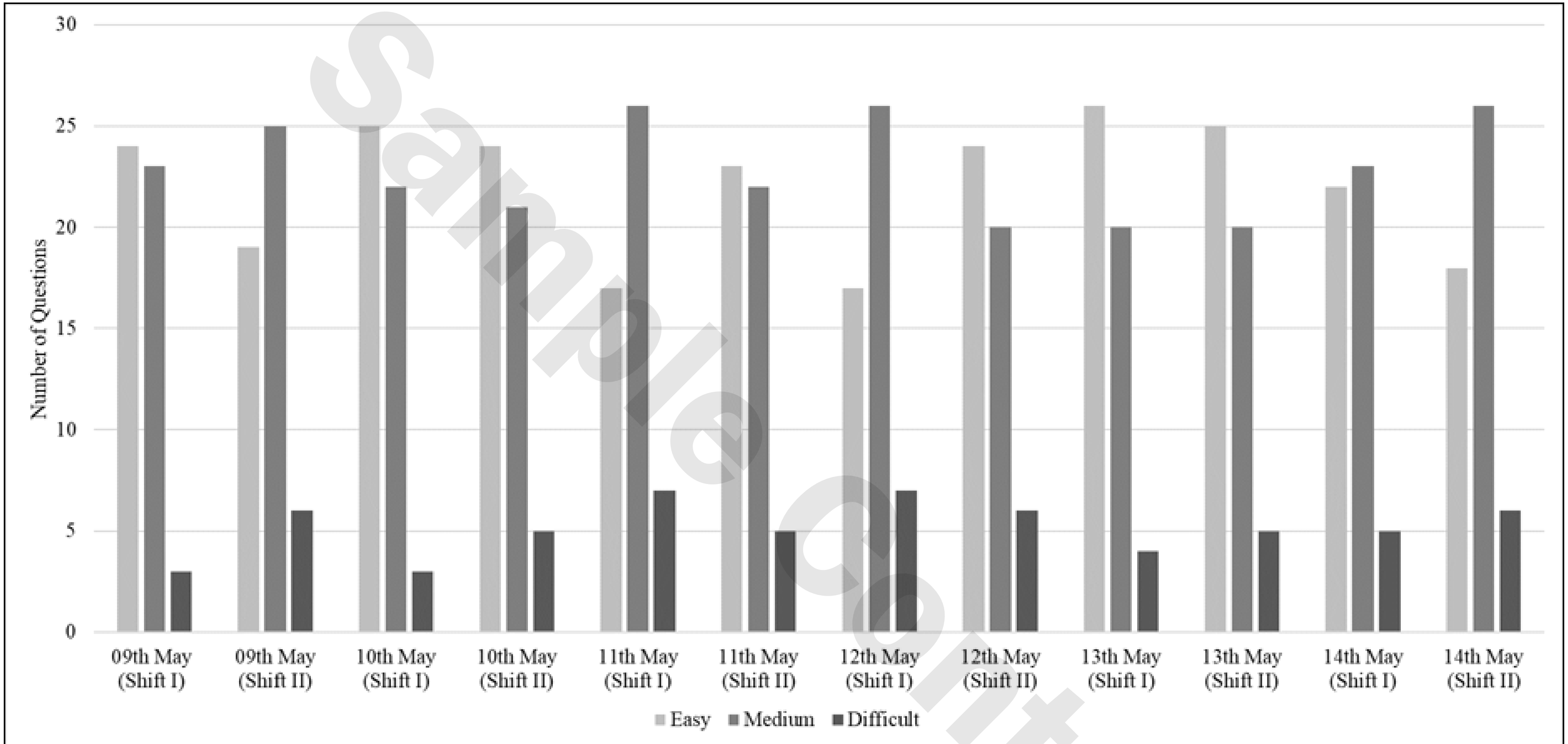
PHYSICS

Chapter-wise Analysis of MHT-CET 2023 Exam Papers (PCM Group)

Ch. No.	Std.	Chapter Name	09th May Shift I	09th May Shift II	10th May Shift I	10th May Shift II	11th May Shift I	11th May Shift II	12th May Shift I	12th May Shift II	13th May Shift I	13th May Shift II	14th May Shift I	14th May Shift II	Total
3	11th	Motion in a Plane	1	2	1	2	1	2	0	3	2	2	1	1	18
4	11th	Laws of Motion	1	2	1	1	1	1	1	0	1	1	1	1	12
5	11th	Gravitation	2	2	2	1	2	2	2	4	2	2	2	2	25
7	11th	Thermal Properties of Matter	1	1	1	1	1	2	1	2	1	2	0	1	14
8	11th	Sound	0	0	1	1	1	1	1	1	3	0	0	1	10
9	11th	Optics	2	2	2	2	2	2	2	2	2	0	2	2	22
10	11th	Electrostatics	0	0	1	0	1	0	1	0	1	2	3	2	11
14	11th	Semiconductors	0	1	2	2	1	1	1	1	1	1	1	1	13
1	12th	Rotational Dynamics	3	1	3	4	3	2	4	2	2	2	3	3	32
2	12th	Mechanical Properties of Fluids	3	3	3	2	3	4	3	3	3	2	3	3	35
3	12th	Kinetic Theory of Gases and Radiation	4	2	3	4	3	4	4	3	3	3	4	3	40
4	12th	Thermodynamics	2	3	2	2	2	0	1	1	2	2	2	2	21
5	12th	Oscillations	5	5	3	4	2	1	3	4	3	5	4	3	42
6	12th	Superposition of Waves	3	3	3	2	3	4	3	2	2	3	3	3	34
7	12th	Wave Optics	3	3	3	3	3	3	3	3	2	3	3	3	35
8	12th	Electrostatics	2	3	3	3	4	3	3	3	3	4	1	2	34
9	12th	Current Electricity	2	2	2	2	2	2	2	2	2	1	2	2	23
10	12th	Magnetic Fields due to Electric Current	3	2	2	2	2	4	4	3	2	2	3	2	31
11	12th	Magnetic Materials	1	1	1	1	1	1	0	0	1	1	0	1	9
12	12th	Electromagnetic Induction	3	3	3	3	4	3	2	3	3	3	3	3	36
13	12th	AC Circuits	2	3	3	3	2	3	3	3	3	3	3	4	35
14	12th	Dual Nature of Radiation and Matter	4	2	2	2	2	2	2	2	2	2	1	1	24
15	12th	Structure of Atoms and Nuclei	1	2	2	1	2	1	2	1	2	2	3	2	21
16	12th	Semiconductor Devices	2	2	1	2	2	2	2	2	2	2	2	2	23
		Total	50	50	50	50	50	50	50	50	50	50	50	50	600

PHYSICS

Difficulty level-wise Analysis of MHT-CET 2023 Exam Papers (PCM Group)



E – Easy: Questions whose answers can be directly and easily answered by the information given in Std. XI and XII Textbooks.
M – Medium: These questions require students to identify and apply the appropriate concepts which they studied from Std. XI and XII Textbooks.
D – Difficult: The most Challenging Questions that require application of various concepts and encourage students to think beyond the information given in the textbooks.

Analysis

- **Analysis of questions by difficulty level:** Although the proportion of easy, medium, and difficult questions varies amongst the twelve papers, the number of easy and medium questions is almost equal, with a few difficult questions.
  This indicates that the entrance exam emphasizes on thorough reading and grasping of textual content as well as understanding and application of concepts. Students are advised to study the chapters minutely and focus on the application of formulae and concepts while preparing for the entrance exam.

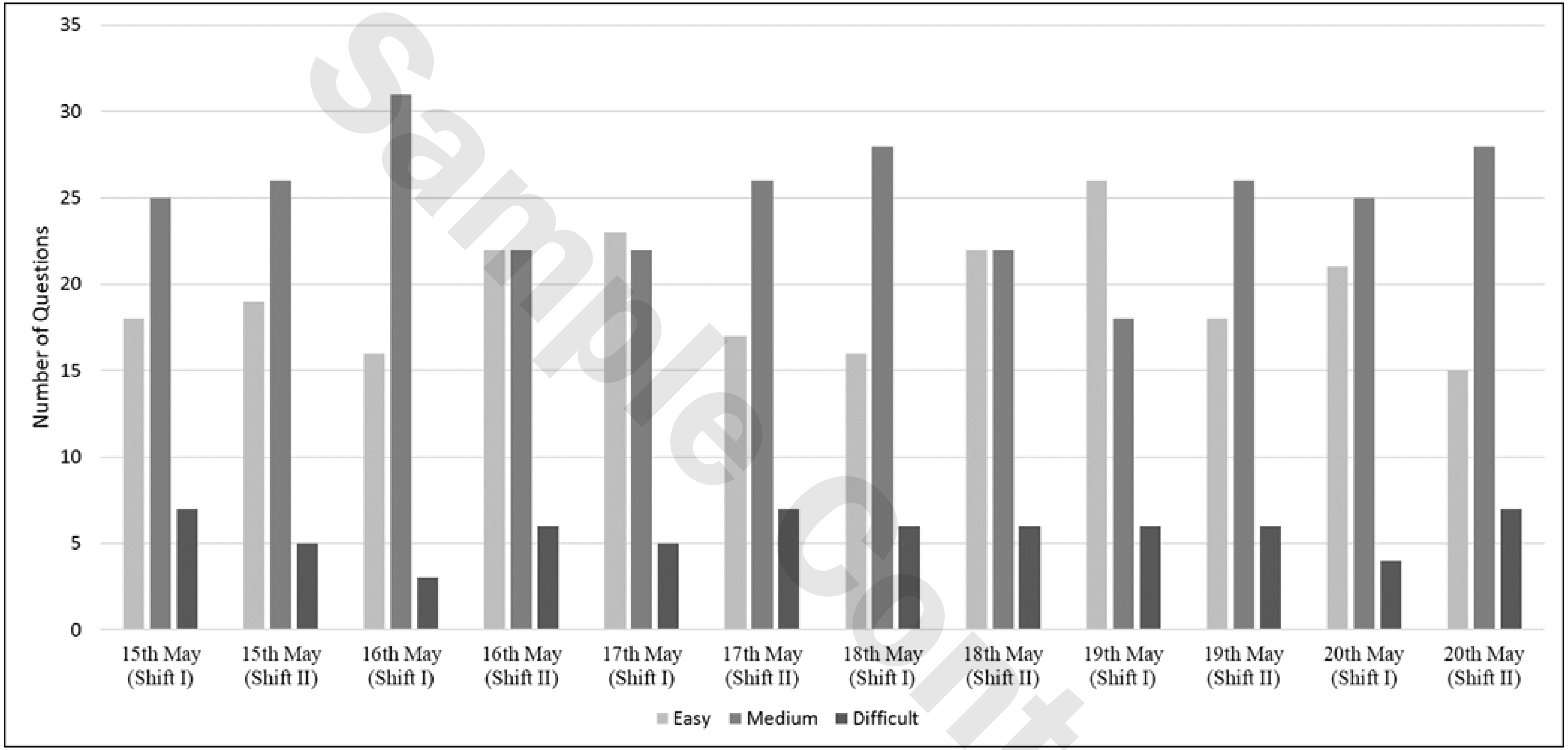
PHYSICS

Chapter-wise Analysis of MHT-CET 2023 Exam Papers (PCB Group)

Ch. No.	Std.	Chapter Name	15th May Shift I	15th May Shift II	16th May Shift I	16th May Shift II	17th May Shift I	17th May Shift II	18th May Shift I	18th May Shift II	19th May Shift I	19th May Shift II	20th May Shift I	20th May Shift II	Total
3	11th	Motion in a Plane	1	1	2	1	2	2	1	1	1	1	1	1	**15**
4	11th	Laws of Motion	1	1	1	1	1	1	1	1	3	2	1	1	**15**
5	11th	Gravitation	2	2	2	2	2	2	2	2	2	1	2	2	**23**
7	11th	Thermal Properties of Matter	1	1	1	1	1	1	1	1	3	1	1	1	**14**
8	11th	Sound	1	1	1	0	1	1	0	0	0	0	2	1	**8**
9	11th	Optics	2	3	2	2	3	1	2	2	2	2	2	2	**25**
10	11th	Electrostatics	0	0	1	2	1	0	1	2	2	2	1	2	**14**
14	11th	Semiconductors	1	0	1	1	0	1	1	1	1	1	0	1	**9**
1	12th	Rotational Dynamics	3	3	2	3	2	3	3	3	2	2	3	3	**32**
2	12th	Mechanical Properties of Fluids	3	4	3	3	3	3	3	3	3	4	3	2	**37**
3	12th	Kinetic Theory of Gases and Radiation	3	4	3	3	2	3	5	3	1	2	3	3	**35**
4	12th	Thermodynamics	2	1	2	2	3	2	0	2	2	2	2	3	**23**
5	12th	Oscillations	3	3	3	3	3	3	3	3	4	3	3	3	**37**
6	12th	Superposition of Waves	3	2	3	3	3	2	4	3	4	4	3	3	**37**
7	12th	Wave Optics	3	3	3	3	2	4	3	3	1	3	2	3	**33**
8	12th	Electrostatics	3	3	3	3	3	4	3	3	2	2	3	2	**34**
9	12th	Current Electricity	2	2	2	2	2	2	2	2	2	2	2	2	**24**
10	12th	Magnetic Fields due to Electric Current	3	3	2	2	2	2	2	2	2	2	2	2	**26**
11	12th	Magnetic Materials	1	1	1	1	1	1	1	1	1	2	1	1	**13**
12	12th	Electromagnetic Induction	3	3	3	3	3	3	3	3	3	3	4	2	**36**
13	12th	AC Circuits	3	3	3	3	3	3	3	3	3	3	2	4	**36**
14	12th	Dual Nature of Radiation and Matter	2	2	2	2	2	2	2	2	2	2	2	2	**24**
15	12th	Structure of Atoms and Nuclei	2	2	2	2	2	2	2	2	2	2	2	2	**24**
16	12th	Semiconductor Devices	2	2	2	2	3	2	2	2	2	2	3	2	**26**
		Total	**50**	**50**	**50**	**50**	**50**	**50**	**50**	**50**	**50**	**50**	**50**	**50**	**600**

PHYSICS

Difficulty level-wise Analysis of MHT-CET 2023 Exam Papers (PCB Group)



E – Easy: Questions whose answers can be directly and easily answered by the information given in Std. XI and XII Textbooks.
M – Medium: These questions require students to identify and apply the appropriate concepts which they studied from Std. XI and XII Textbooks.
D – Difficult: The most Challenging Questions that require application of various concepts and encourage students to think beyond the information given in the textbooks.

Analysis

- **Analysis of questions by difficulty level:** Although the proportion of easy, medium, and difficult questions varies amongst the twelve papers, the number of medium questions is slightly higher than easy questions, with a few difficult questions.
  This indicates that the entrance exam emphasises a lot on understanding and application of concepts. Students are advised to focus on the application of formulae, concepts along with thorough revision while preparing for the entrance exam.

Chapter

3 Motion in a Plane

Quick Review

Motion

Displacement

Difference between the position vectors of the object in that time interval.

$\Delta \vec{x} = \vec{x}_2 - \vec{x}_1$

Path length

Actual distance travelled by the particle during its motion.

Average velocity

Displacement $\Delta \vec{x}$ of the object during the time interval Δt over which average velocity is being calculate, divided by that time interval.

Instantaneous velocity

The limiting value of the average velocity of the object over a small time interval 'Δt' around t when the value of time interval goes to zero.

Average speed

The total path length (distance) travelled by the object during the time interval over which average speed is being calculated, divided by that time interval.

Instantaneous speed

The limiting value of the average speed of the object over a small time interval 'Δt' around t when the value of time interval goes to zero.

Average acceleration

The change in velocity divided by the total time required for the change.

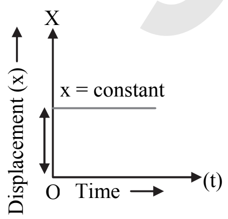
Instantaneous acceleration

The limiting value of the average acceleration of the object over a small time interval 'Δt' around t when the value of time interval goes to zero.

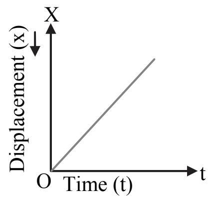
- **Position-time and velocity-time graph:**

Motion

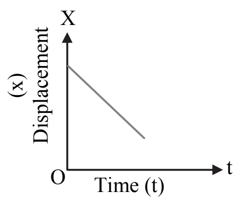
Position-time graph



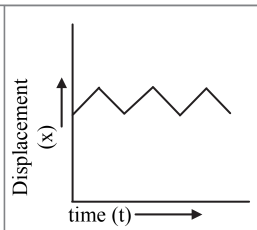
Object at rest



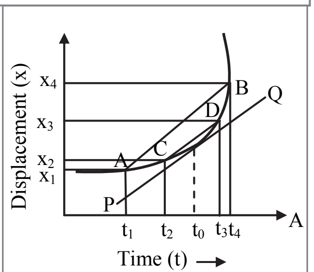
Object moving with uniform velocity along positive x-axis



Object moving with uniform velocity along negative x- axis



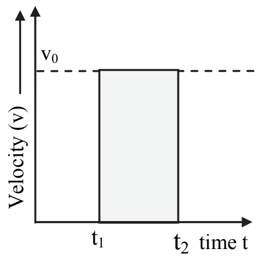
Object performing oscillatory motion with constant speed



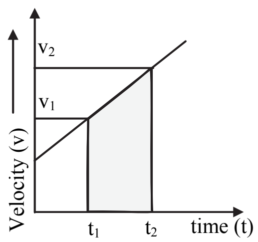
Particle moving with non-uniform velocity

Motion

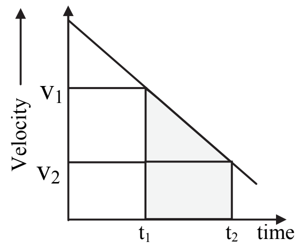
Velocity-time graph



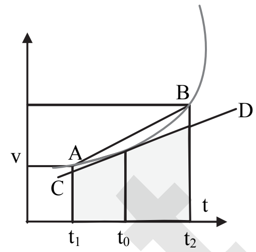
Object is moving with zero acceleration



Object is moving with constant positive acceleration



Object is moving with constant negative acceleration



Object is moving with non-uniform acceleration

Relative velocity

Relative velocity is defined as the time rate of change of relative position of one object with respect to another.

Relative velocity of A w.r.t. B is given by, $\vec{v}_{AB} = \vec{v}_A - \vec{v}_B$

Relative velocity of B w.r.t. A is given by, $\vec{v}_{BA} = \vec{v}_B - \vec{v}_A$

Projectile Motion

An object in flight after being thrown with some velocity is called a projectile and its motion is called projectile motion.

Equation: $\left[y = (\tan\theta)x - \frac{1}{2}\left(\frac{g}{u^2 \cos^2 x}\right)x^2\right]$

Horizontal Range (R)

- The maximum horizontal distance travelled by the projectile.
- It is maximum when angle of projection (θ) is 45°.

Maximum height (H)

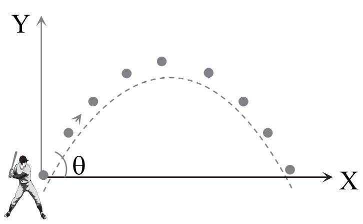
The maximum height H reached by the projectile is the distance travelled along the vertical (y) direction in time t_A.

Time of Flight (t)

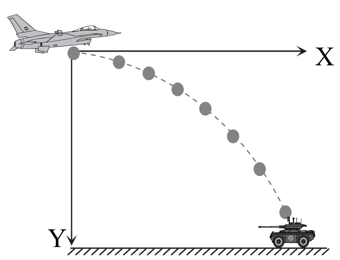
- It is the total time taken by the projectile to go up and come down to the same level from which it was projected.
- The time taken to reach the maximum height is called time of ascent (t_A).
- The time taken by projectile to travel to the ground from the maximum height, is called time of descent (t_D).

➢ **A projectile motion can be classified into three categories as follows:**

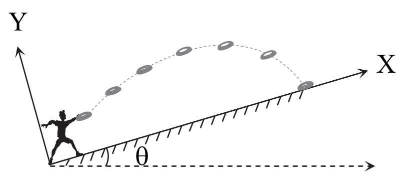
i. Oblique projectile motion:



ii. Horizontal projectile motion:



iii. Projectile motion on an inclined plane:



Uniform Circular Motion (UCM)

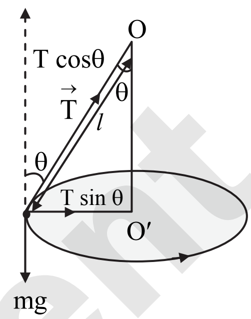
- **Time Period:** The time taken by a particle performing uniform circular motion to complete one revolution.
- **Centripetal Force:** A force in the case of circular motion which is directed towards the centre along the radius is called centripetal (radial) force.

Conical Pendulum

- A simple pendulum, which is given such a motion that the bob describes a horizontal circle and the string making a constant angle with the vertical describes a cone.
- Time period of a conical pendulum depends on the following factors:

i. Length of pendulum (l)
ii. Acceleration due to gravity (g)
iii. Angle of inclination (θ)

i.e., $T = 2\pi\sqrt{\dfrac{l\cos\theta}{g}}$



Formulae

1. Basic kinematical formulae:

i. Average speed $= \dfrac{\text{Total path length}}{\text{Total time interval}}$

$= \dfrac{\text{Total distance}}{\text{Total time}} = \dfrac{x}{t}$

ii. Instantaneous speed: $\vec{v} = \lim\limits_{\Delta t \to 0} \dfrac{\Delta \vec{x}}{\Delta t} = \dfrac{d\vec{x}}{dt}$

iii. Average velocity:

$\vec{v}_{avg} = \dfrac{\text{Displacement}}{\text{Time interval}} = \dfrac{x_2 - x_1}{t_2 - t_1} = \dfrac{\Delta \vec{x}}{\Delta t}$

iv. Acceleration:

$a = \dfrac{\text{Change in velocity}}{\text{Time}} = \dfrac{d\vec{v}}{dt}$

v. Average acceleration: $\vec{a}_{av} = \dfrac{\vec{v}_2 - \vec{v}_1}{t_2 - t_1} = \dfrac{\Delta \vec{v}}{\Delta t}$

vi. Instantaneous acceleration: $\vec{a}_{inst} = \lim\limits_{\Delta t \to 0} \dfrac{\Delta \vec{v}}{\Delta t} = \dfrac{d\vec{v}}{dt}$

2. Kinematic Equations of linear motion:

i. $\vec{v} = \vec{u} + \vec{a}\,t$
ii. $\vec{s} = \vec{u}\,t + \dfrac{1}{2}\vec{a}\,t^2$
iii. $v^2 = u^2 + 2\,\vec{a}\,.\,\vec{s}$
iv. $\vec{s} = \dfrac{(\vec{v} + \vec{u})}{2}t$

3. Relative velocity of a body A with respect to B:

i. $\vec{v}_{AB} = \vec{v}_A - \vec{v}_B$;
ii. $v = \sqrt{v_x^2 + v_y^2}$ (in magnitude)

4. Velocity of projectile:

i. $u_x = u \cos\theta$ (along horizontal)
ii. $u_y = u \sin\theta$ (along vertical)

5. Horizontal distance covered by projectile:
$x = (u \cos\theta)\, t$

6. Vertical distance of projectile:
$y = (u \sin\theta)\, t - \dfrac{1}{2}gt^2$

7. Equation of trajectory:
$y = x(\tan\theta) - \dfrac{gx^2}{2u^2\cos^2\theta}$

8. Maximum height: $H = \dfrac{u^2\sin^2\theta}{2g}$

9. Time of flight: $T = \dfrac{2u\sin\theta}{g}$

10. Time of ascent = Time of descent $= \dfrac{u\sin\theta}{g}$

11. Horizontal range: $R = \dfrac{u^2\sin 2\theta}{g}$

12. Maximum horizontal range: $R_{max} = \dfrac{u^2}{g}$

13. Time period in uniform circular motion:
$T = \dfrac{2\pi r}{v}$

14. Angular speed in uniform circular motion:

$$\omega = \frac{v}{r}$$

15. Centripetal acceleration:

i. $\vec{a} = -\omega^2 \vec{r}$

ii. $a = \omega^2 r$ (in magnitude)

16. Centripetal force:

$$F = m\omega^2 r = \frac{mv^2}{r} = m\omega v$$

17. Time period of a conical pendulum:

$$T = 2\pi\sqrt{\frac{l\cos\theta}{g}} = 2\pi\sqrt{\frac{h}{g}}$$

Shortcuts

1. If a particle is accelerated for time t_1 with acceleration a_1 and for time t_2 with acceleration a_2 then average acceleration is $\vec{a}_{av} = \frac{\vec{a}_1 t_1 + \vec{a}_2 t_2}{t_1 + t_2}$

2. If a particle moves in two equal intervals of time at different speed v_1 and v_2 respectively, then $v_{av} = \frac{v_1 + v_2}{2}$

3. When a body starts from rest and moves with uniform acceleration, distance covered by the body in n^{th} second is directly proportional to $(2n - 1)$ i.e., ratio of the distances covered in 1^{st} s, 2^{nd} s and 3^{rd} s is $[2(1) - 1] : [2(2) - 1] : [2(3) - 1] = 1:3:5$.

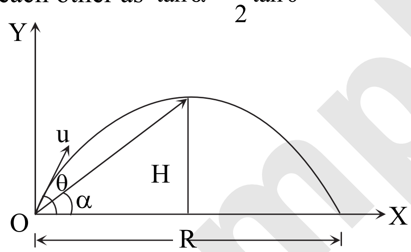
4. Horizontal range of projectile is same when angles of projection are (Complimentary)

i. θ and $90° - \theta$ or

ii. $(45° + \theta)$ and $(45° - \theta)$

5. A ball is dropped from a building of height h and it reaches after t seconds on earth. From the same building if two balls are thrown (one upwards and other downwards) with the same velocity u and they reach the earth surface after t_1 and t_2 seconds respectively then $t = \sqrt{t_1 t_2}$

6. The angle of elevation α of the highest point of the projectile and the angle of projection θ are related to each other as $\tan\alpha = \frac{1}{2}\tan\theta$



7. When a projectile is projected at an angle 45°, the range is maximum and the height attained by the projectile is $H = \frac{u^2}{4g} = \frac{R_{max}}{4}$

8. The height attained by a projectile is maximum, when $\theta = 90°$.

$$H_{max} = \frac{u^2}{4g}$$

9. When the range of the projectile is maximum, the time of flight is $T = 2t = \frac{\sqrt{2}u}{g}$

10. The time of flight of the projectile is also largest for $\theta = 90°$.

$$T_{max} = \frac{2u}{g}$$

11. In U.C.M., if central angle or angular displacement is given, then simply apply $dv = 2v \sin\frac{\theta}{2}$ to determine change in velocity.

Mindbenders

1. If the two bodies are moving with unequal uniform velocities, then their position-time graphs must intersect each other.
2. The kinematic equations of motion cannot be applied to circular motion or simple harmonic motion.
3. A body may have zero velocity but can still accelerate.
   e.g.: When an object is thrown straight up, at the highest point, its velocity is zero and acceleration is 9.8 m/s^2 downward.
4. A projectile fired at an angle with horizontal returns to ground at the same angle and with the same velocity with which it is projected.
5. In practical situation, where the friction of air comes into the play, an object thrown upward has higher time of descent than time of ascent. i.e., $t_D > t_A$.

Multiple Choice Questions

3.2 Rectilinear Motion

1. A body at rest starts sliding from top of a smooth inclined plane and requires 4 second to reach bottom. How much time does it take, starting from rest at top, to cover one-fourth of a distance ? **[2014]**

(A) 1 second (B) 2 second
(C) 3 second (D) 4 second

2. A particle at rest is moved along a straight line by a machine giving constant power. The distance moved by the particle in time 't' is proportional to **[2014]**

(A) $t^{1/2}$ (B) $t^{2/3}$
(C) t (D) $t^{3/2}$

3. A moving body is covering distances which are proportional to square of the time. Then the acceleration of the body is **[2020]**

(A) constant but not zero
(B) increasing
(C) zero
(D) decreasing

4. A driver applies the brakes on seeing the red traffic signal 400 m ahead. At the time of applying the brakes, the vehicle was moving with 15 m/s and retarding at 0.3 m/s^2. The distance covered by the vehicle from the traffic light 1 minute after the application of brakes is **[2021]**

(A) 25 m (B) 360 m
(C) 40 m (D) 375 m

5. The engine of an aeroplane during take-off exerts a force of 150 × 10^3 N. Mass of aeroplane is 25 × 10^3 kg. if the take-off speed is 60 m/s, the length of the runway required is **[2021]**

(A) 300 m (B) 100 m
(C) 200 m (D) 400 m

6. A body starts falling from height 'h' and travels a distance h/2 during last second of its motion then time of flight in second is **[2021]**

(A) $\left(2+\sqrt{3}\right)$ (B) $\left(\sqrt{2}-1\right)$
(C) $\left(2+\sqrt{2}\right)$ (D) $\left(\sqrt{2}+\sqrt{3}\right)$

7. A car travelling at a speed 'U' m/s, stops within a distance 'S', when the brakes are applied. If the car is travelling at '2U' m/s then the stopping distance is **[2021]**

(A) more than 'S'
(B) less than 'S'
(C) equal to 'S'
(D) zero

8. A student is throwing balls vertically upwards such that he throws the 2nd ball when the 1st ball reaches maximum height. If he throws balls at an interval of 3 second, the maximum height of the balls is $\left(g=10\frac{m}{s^2}\right)$ **[2021]**

(A) 45 m (B) 35 m
(C) 25 m (D) 30 m

9. A bomb is dropped by an aeroplane flying horizontally with a velocity 200 km/hr and at a height of 980 m. At the time of dropping a bomb, the distance of the aeroplane from the target on the ground to hit directly is ($g = 9.8\ m/s^2$) **[2021]**

(A) $\frac{\sqrt{2}\times10^4}{9}$m (B) $\frac{10^4}{9}$m

(C) $\frac{10^4}{9\sqrt{2}}$m (D) $\frac{10^4}{18}$m

10. A body at rest falls through a height 'h' with velocity 'V'. If it has to fall down further for its velocity to become three times, the distance travelled in that interval is **[2021]**

(A) 8h (B) 6h (C) 4h (D) l2h

11. A body covers half of its distance with speed 'u' and the other half with a speed 'v' the average speed of the body is **[2022]**

(A) $\frac{2uv}{u+v}$ (B) $\frac{u+v}{2uv}$

(C) $\frac{u+v}{2}$ (D) $\frac{u-v}{2}$

12. Two bodies A and B move in same straight line starting from the same position. Body A moves with constant velocity 'u' and B moves with constant acceleration 'a'. when their velocities become equal, the distance between them is **[2022]**

(A) $2au^2$ (B) $\frac{u^2}{2a}$ (C) $\frac{u^2}{3a}$ (D) $\frac{2u^2}{a}$

13. A ball is dropped from the tower of height 'h'. The total distance covered by it in last second of its motion is equal to the distance covered by it in first 3 seconds. The value of 'h' is ($g = 10\ ms^{-2}$) **[2022]**

(A) 200 m (B) 125 m
(C) 100 m (D) 80 m

14. A vehicle moving with 15 km/hr comes to rest by covering 5 m distance after applying brakes. If the same vehicle moves at 45 km/hr then by applying brakes it will come to rest by covering a distance **[2022, 2020]**

(A) 30 m (B) 15 m
(C) 60 m (D) 45 m

15. A vehicle without passengers moving on a frictionless horizontal road with velocity 'u' can be stopped in a distance 'd'. Now 40% of its weight is added. If the retardation remains same the stopping distance at velocity 'u' is **[2022]**

(A) d (B) (1.2)d
(C) (1.4)d (D) (1.6)d

16. A body is released from the top of a tower 'H' metre high. It takes t second to reach the ground. The height of the body $\frac{t}{2}$ second after release is **[2023]**

(A) $\frac{H}{2}$ metre from ground

(B) $\frac{H}{4}$ metre from ground

(C) $3\frac{H}{4}$ metre from ground

(D) $\frac{H}{6}$ metre from ground

17. A bullet is fired on a target with velocity 'V'. Its velocity decreases from 'V' to 'V/2' when it penetrates 30 cm in a target. Through what thickness it will penetrate further in the target before coming to rest? **[2023]**

(A) 5 cm (B) 8 cm
(C) 10 cm (D) 20 cm

18. Two cars A and B start from a point at the same time in a straight line and their positions are represented by $R_A(t) = at + bt^2$ and $R_B(t) = xt - t^2$. At what time do the cars have same velocity? **[2023]**

(A) $\frac{x-a}{2(b+1)}$ (B) $\frac{x+a}{2(b-1)}$

(C) $\frac{x-a}{(b+1)}$ (D) $\frac{x+a}{(b-1)}$

19. A ball is projected vertically upwards from ground. It reaches a height 'h' in time t_1, continues its motion and then takes a time t_2 to reach ground. The height h in terms of g, t_1 and t_2 is (g = acceleration due to gravity) **[2023]**

(A) $\frac{1}{2}\frac{gt_1}{t_2}$ (B) $\frac{1}{2}g\,t_1\,t_2$

(C) $g\,t_1\,t_2$ (D) $2\,g\,t_1\,t_2$

20. Which one of the following statements is wrong? **[2023]**

(A) A body can have zero velocity and still be accelerated.
(B) A body can have a constant velocity and still have a varying speed.
(C) A body can have a constant speed and still have a varying velocity.
(D) The direction of the velocity of a body can change when its acceleration is constant.

21. The position 'x' of a particle varies with a time as x = at2 – bt3 where 'a' and 'b' are constants. The acceleration of the particle will be zero at **[2023]**

(A) $\frac{2a}{3b}$ (B) $\frac{a}{b}$ (C) $\frac{a}{3b}$ (D) zero

22. A person throws balls into air after every second. The next ball is thrown when the velocity of the first ball is zero. How high do the balls rise above his hand? (acceleration due to gravity = 10 ms^{-2}) b **[2023]**

(A) 2 m (B) 5 m
(C) 8 m (D) 10 m

23. A ball is dropped from the top of a tower of height 'h'. It takes time 'T' to reach the ground. The position of the ball after time $\frac{T}{3}$ is (from the ground) **[2023]**

(A) $\frac{2h}{9}$ (B) $\frac{4h}{9}$ (C) $\frac{6h}{9}$ (D) $\frac{8h}{9}$

24. Two bodies 'A' an 'B' start from the same point at the same instant and move along a straight line. Body 'A' moves with uniform acceleration 'a' and body 'B' moves with uniform velocity 'V'. They meet after time 't'. The value of 't' is **[2023, 2021]**

(A) $\frac{2V}{a}$ (B) $\frac{a}{2V}$ (C) $\frac{V}{2a}$ (D) $\sqrt{\frac{V}{a}}$

3.3 Motion in Two Dimensions – Motion in a plane

1. A projectile is thrown with an initial velocity $(a\hat{i} + b\hat{j})$ m/s, where $\hat{i}$ and $\hat{j}$ are unit vectors along horizontal and vertical directions respectively. If the range of the projectile is twice the maximum height reached by it, then **[2021]**

(A) b = 2a (B) b = 4a
(C) $b = \frac{a}{2}$ (D) b = a

2. Two bodies A and B are projected with same velocity. If bodies A and B are projected at an angle of 30° and 60° with the horizontal respectively, the ratio of maximum height reached by the body A to that of body B is $(\sin 30° = \cos 60° = \frac{1}{2}, \sin 60° = \cos 30° = \frac{\sqrt{3}}{2})$ **[2021]**

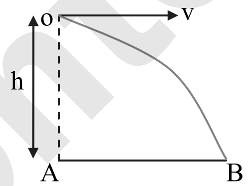
(A) 1 : 2 (B) 2 : 1
(C) 3 : 1 (D) 1 : 3

3. A projectile thrown from the ground has initial speed 'u' and its direction makes an angle 'θ' with the horizontal. If at maximum height from ground, the speed of projectile is half its initial speed of projection, then the maximum height reached by the projectile is

[g = acceleration due to gravity, sin 30° = cos 60° = 0.5, cos 30° = sin 60° = $\sqrt{3}/2$] **[2022]**

(A) $\frac{2u^2}{g}$ (B) $\frac{u^4}{4g}$ (C) $\frac{3u^2}{8g}$ (D) $\frac{u^2}{g}$

4. The aeroplane is flying in a horizontal direction with a velocity of 540 km/hr at a height of 1960 m. when it is vertically above the point A on the ground, a body is dropped from it. The body strikes the ground at point B. The distance AB is equal to (g = 9.8 m/s^2) **[2022]**



(A) 3600 m (B) 3000 m
(C) 4000 m (D) 2000 m

5. The equation of the trajectory of a ball projected at an angle 'θ' with the horizontal, is given as $y = \sqrt{3}x - \frac{gx^2}{2}$. The initial velocity of the ball is

(sin 30° = 0.5 = cos 60°, cos 30° = $\sqrt{3}/2$ = sin 60°, g = acceleration due to gravity) **[2022]**

(A) 3 m/s (B) 2 m/s
(C) 1 m/s (D) 5 m/s

6. A shell fired at an angle of 30° to the horizontal with velocity 196 m/s. The time of flight is

[sin 30° = $\frac{1}{2}$ = cos 60°] **[2022]**

(A) 10 s (B) 20 s
(C) 6.5 s (D) 16.5 s

7. Two bodies are thrown up at angles of 45° and 60° with the horizontal respectively. If same vertical height is attained by both the bodies, then the ratio of velocities with which they are thrown is

$(\sin 45° = \cos 45° = \frac{1}{\sqrt{2}}, \sin 60° = \cos 30° = \frac{\sqrt{3}}{2}, \sin 30° = \cos 60° = \frac{1}{2})$ **[2022]**

(A) $\sqrt{\frac{2}{3}}$ (B) $\sqrt{\frac{3}{2}}$ (C) $\frac{2}{\sqrt{3}}$ (D) $\frac{\sqrt{3}}{2}$

8. Two projectiles A and B are projected with velocities $\sqrt{2}$V and V respectively. They have the same range. If A is thrown at angle of 15° with the horizontal, the angle of projection of B with horizontal will be (sin30° = cos 60° = $\frac{1}{2}$, sin90° = cos 0° = 1) **[2022]**

(A) 90° (B) 60°
(C) 30° (D) 45°

9. Two trains, each 30 m long are travelling in opposite directions with velocities 5 m/s and 10 m/s. They will cross after **[2023]**

(A) 4 s (B) 3 s (C) 2 s (D) 1 s

10. A large number of bullets are fired in all directions with same speed 'U'. The maximum area on the ground on which the bullets will spread is **[2023]**

(A) $\frac{\pi u^2}{g}$ (B) $\frac{\pi u^4}{g^2}$
(C) $\frac{\pi^2 u^4}{g^2}$ (D) $\frac{\pi^2 u^2}{g^2}$

11. A particle covers 50 m distance when projected with some initial speed in horizontal direction. When this particle is projected with double the initial speed then the horizontal distance covered is (keep angle of projection constant) **[2023]**

(A) 100 m (B) 200 m
(C) 150 m (D) 50 m

12. A ball of mass 'm' shot from a spring gun whose spring has a force constant 'K'. The spring is compressed by 'x'. The greatest possible range of the ball for this compression is **[2023]**

(A) $\frac{Kx}{mg}$ (B) $\frac{mg}{Kx^2}$
(C) $\frac{Kx^2}{mg}$ (D) $\frac{1}{2}Kx^2$

13. A body is projected with certain velocity at two different angles of projection with respect to horizontal so that the horizontal range (R) is same. If 't_1' and 't_2' are the times taken for the two paths, the product ($t_1 . t_2$) is (g = acceleration due to gravity) **[2023]**

(A) $\frac{R}{2g}$ (B) $\frac{R}{g}$
(C) $\frac{2R}{g}$ (D) $\frac{4R}{g}$

14. A particle P is projected with velocity 10 m/s from the ground at an angle of 60° with horizontal. Another particle Q is projected horizontally with velocity 5 m/s, so that they will collide on ground at point R. If both are projected simultaneously, from what height particle Q should be projected? (g = 10 m/s^2) (sin 60° = $\frac{\sqrt{3}}{2}$) **[2023]**

(A) 5 m (B) 10 m (C) 15 m (D) 20 m

15. For a particle the ratio of maximum height reached to the square of time of flight is (Given acceleration due to gravity g = 10 m/s^2) **[2023]**

(A) 5 : 4 (B) 5 : 2
(C) 5 : 1 (D) 10 : 1

16. A stone is projected vertically upwards with speed 'v'. Another stone of same mass is projected at an angle of 60º with the vertical with the same speed 'v'. The ratio of their potential energies at the highest points of their journey is [sin30º = cos60º = 0.5, cos30º = sin60º = $\frac{\sqrt{3}}{2}$] **[2023, 2021]**

(A) 4 : 1 (B) 3 : 2
(C) 2 : 1 (D) 1 : 1

3.4 Uniform Circular Motion

1. If a cycle wheel of radius 0.4 m completes one revolution in one second, then acceleration of the cycle is **[1999]**

(A) 0.4 π m/s^2 (B) 0.8 π m/s^2
(C) 0.4 π^2 m/s^2 (D) 1.6 π^2 m/s^2

2. When a body moves with a constant speed along a circle, **[2003]**

(A) its linear velocity remains constant.
(B) no force acts on it.
(C) no work is done on it.
(D) no acceleration is produced in it.

3. Angular velocity of hour hand of a watch is **[2005]**

(A) $\frac{\pi}{43200}$ rad s^{-1} (B) $\frac{\pi}{30}$ rad s^{-1}
(C) $\frac{\pi}{21600}$ rad s^{-1} (D) $\frac{\pi}{1800}$ rad s^{-1}

4. An electric fan has blades of length of 30 cm as measured from the axis of rotation. If the fan is rotating at 1200 rpm, the acceleration of a point on the tip of the blade is about. **[2006]**

(A) 1600 ms^{-2} (B) 4750 ms^{-2}
(C) 2370 ms^{-2} (D) 5055 ms^{-2}

5. The relation between linear speed v, angular speed ω and angular acceleration α in circular motion is **[2010]**

(A) $\alpha = \frac{a\omega}{v}$ (B) $\alpha = \frac{av}{\omega}$

(C) $\alpha = \frac{v\omega}{a}$ (D) $\alpha = \frac{\omega}{av}$

6. If K.E. of the particle of mass m performing U.C.M. in a circle of radius r is E. The acceleration of the particle is **[2010]**

(A) $\frac{2E}{mr}$ (B) $\left(\frac{2E}{mr}\right)^2$

(C) 2Emr (D) $\frac{4E}{mr}$

7. A coin is placed on a rotating turn table rotated with angular speed ω. The coin just slips if it is placed at 4 cm from the center of the table. If angular velocity is doubled, at what distance will coin starts to slip. **[2010]**

(A) 1 cm (B) 4 cm
(C) 9 cm (D) 16 cm

8. If the body is moving in a circle of radius r with a constant speed v. Its angular velocity is **[2011]**

(A) v^2/r (B) vr (C) v/r (D) r/v

9. The relative velocity of geostationary satellite with respect to the spinning motion of the earth is _______. **[2013]**

(A) 0 m/s (B) 6 m/s
(C) 12 m/s (D) 14 m/s

10. The difference between angular speed of minute hand and second hand of a clock is **[2015]**

(A) $\frac{59\pi}{900}$ rad / s (B) $\frac{59\pi}{1800}$ rad / s

(C) $\frac{59\pi}{2400}$ rad / s (D) $\frac{59\pi}{3600}$ rad / s

11. A toy cart is tied to the end of an unstretched string of length '*l*'. When revolved, the toy cart moves in horizontal circle with radius '2*l*' and time period T. If it is speeded until it moves in horizontal circle of radius '3*l*' with period T_1, relation between T and T_1 is (Hooke's law is obeyed) **[2015]**

(A) $T_1 = \frac{2}{\sqrt{3}}T$ (B) $T_1 = \sqrt{\frac{3}{2}}T$

(C) $T_1 = \sqrt{\frac{2}{3}}T$ (D) $T_1 = \frac{\sqrt{3}}{2}T$

12. Angular speed of hour hand of a clock in degree per second is **[2016]**

(A) $\frac{1}{30}$ (B) $\frac{1}{60}$ (C) $\frac{1}{120}$ (D) $\frac{1}{720}$

13. The angular separation between the minute hand and the hour hand of a clock at 12:20 pm is **[2019]**

(A) 120° (B) 90°
(C) 110° (D) 100°

14. In U.C.M. when time interval $\delta t \to 0$, the angle between change in velocity $\left(\delta \vec{v}\right)$ and linear velocity $\left(\vec{v}\right)$ will be **[2019]**

(A) 0° (B) 45° (C) 90° (D) 180°

15. A particle is performing U.C.M. along the circumference of a circle of diameter 50 cm with frequency 2 Hz. The acceleration of the particle in m/s^2 is **[2019]**

(A) $2\pi^2$ (B) $4\pi^2$ (C) $8\pi^2$ (D) π^2

16. A body of mass 'm' is performing a U.C.M. in a circle of radius 'r' with speed 'v'. The work done by the centripetal force in moving it through $\left(\frac{2}{3}\right)^{rd}$ of the circular path is **[2019]**

(A) $mv^2\pi r$ (B) $\frac{2\pi mv^2 r}{3}$

(C) zero (D) $\frac{2mv^2\pi}{3}$

17. The ratio of the angular speed of the hour hand of a clock to that of its minute hand is **[2019]**

(A) 3600 : 1 (B) 1 : 24
(C) 1 : 12 (D) 12 : 1

18. A wheel completes 2000 revolutions to cover the distance of 9.42 km. The diameter of this wheel is (π = 3.14) **[2019]**

(A) 1 cm (B) 1 m
(C) 1.5 cm (D) 1.5 m

19. A particle is performing a uniform circular motion along the circumference of a circle of radius 'R' and 'T' is the periodic time. In the time 'T/4' its displacement and distance covered are respectively **[2019]**

(A) $\sqrt{2}R, \frac{\pi R}{4}$ (B) $\frac{\pi R}{4}, \sqrt{2}R$

(C) $\sqrt{2}R, \pi R$ (D) $\sqrt{2}R, \frac{\pi R}{2}$

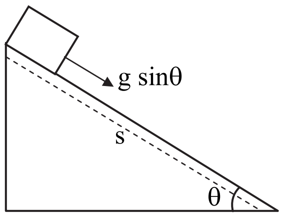
Page no. **10** to 1**2** are purposely left blank.

To see complete chapter buy **Target Notes** or **Target E-Notes**

Answers and Solutions to MCQs

3.2 Rectilinear Motion

1. (B)



$s = \frac{1}{2}at^2$

For t = 4 s

$s = \frac{1}{2}\ g\sin\theta \times (4)^2$

Now $\frac{s}{4} = \frac{1}{2} g \sin\theta \times (t')^2$

$\Rightarrow t' = 2$ s

2. (D)

$P = Fv = (ma) \times (at)$

$P = ma^2t$

$\Rightarrow a = \sqrt{P/mt}$

$s = ut + \frac{1}{2}\ at^2 = \frac{1}{2}\ at^2$ ....($\because$ u = 0)

Substituting for a

$s = \frac{1}{2}\left(\sqrt{\frac{P}{mt}}\right)\ t^2$

$\Rightarrow s \propto t^{3/2}$

3. (A)

Given that, $s \propto t^2$

$\therefore$ $s = kt^2 \Rightarrow \frac{ds}{dt} = 2kt$

$\therefore$ $\frac{d^2s}{dt^2} = 2k$

This indicates that, the acceleration has a non-zero constant value.

4. (C)

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

$= 15 \times 60 + \frac{1}{2} \times (-0.3) \times (60)^2$

....($\because$ a is the retardation in vehicle)

s = 900 – 540 = 360 m

Distance from traffic light = 400 – 360 = 40 m

5. (A)

Acceleration, $a = \frac{F}{M} = \frac{150 \times 10^3}{25 \times 10^3} = 6\ m/s^2$

Initial velocity, u = 0

$\therefore$ $v^2 = u^2 + 2as = 2as$

$\therefore$ $s = \frac{v^2}{2a} = \frac{60 \times 60}{2 \times 6} = 300$ m

6. (C)

Let t be the time of flight. Then

$h = \frac{1}{2}\ gt^2$ ....(i)

and $\frac{h}{2} = \frac{1}{2}g(t-1)^2$ ....(ii)

Dividing equation (i) by equation (ii),

$2 = \frac{t^2}{(t-1)^2}$

$\therefore$ $2(t-1)^2 = t^2$

$\therefore$ $2t^2 - 4t + 2 = t^2$

$\therefore$ $t^2 - 4t + 2 = 0$

Roots of this quadratic equation are

$t = \frac{4 + \sqrt{16 - 4 \times (2)}}{2} = 2 \pm \sqrt{2}$

According to given condition, t cannot be less than 1,

$\therefore$ $t = 2 + \sqrt{2}$ s

7. (A)

$S = \frac{U^2}{2a}$

$\therefore$ $S' = \frac{(2U)^2}{2a} = \frac{4U^2}{2a} = 4S$

$\therefore$ S′ is more than S.

8. (A)

As the ball attains maximum height in 3 s, t = 3 s.

Now, at the highest point v = 0

$\therefore$ 0 = u – gt

$\therefore$ u = gt = 10 × 3 = 30 m/s

Also, $0 = u^2 - 2gh$

$\therefore$ $h = \frac{u^2}{2g} = \frac{(30)^2}{2 \times 10} = 45$ m

9. (C)

The plane is flying horizontally. Hence initial vertical component of the velocity is zero.

If it reaches the ground in time t, then

$h = \frac{1}{2}gt^2$

$\therefore$ $t^2 = \frac{2h}{g} = \frac{2\times980}{9.8} = 200$

$\therefore$ $t = 10\sqrt{2}$ s

The horizontal component of the velocity is,

$V = 200$ km/hr $= 200 \times \frac{5}{18} = \frac{1000}{18}$ m/s

The horizontal distance to be covered is,

$d = Vt = \frac{1000}{18}\times10\sqrt{2} = \frac{10^4}{9\sqrt{2}}$ m

10. (A)

Let V be the velocity acquired by the body when it falls through height h, starting from rest.

$\therefore$ $V^2 = 2gh \Rightarrow h = \frac{V^2}{2g}$

If it falls further and attains velocity 3V and if the total height through which it falls is h′, then

$(3V^2) = 2gh'$

$\therefore$ $9V^2 = 2gh'$

$\therefore$ $h' = \frac{9V^2}{2g} = 9h$

$\therefore$ The distance travelled in that interval is,

$h' - h = 9h - h = 8h$

11. (C)

Refer ***Shortcut 2***

12. (B)

For body B moving with acceleration a, initial velocity is zero and final velocity is u.

$\therefore$ $u^2 = 2as \Rightarrow s = \frac{u^2}{2a}$

If the time taken to attain this velocity is t, then

$u = at \Rightarrow t = \frac{u}{a}$

For body A, distance travelled is given by,

$s' = ut = u \times \frac{u}{a} = \frac{u^2}{a}$

Hence distance between A and B is

$s' - s = \frac{u^2}{a} - \frac{u^2}{2a} = \frac{u^2}{2a}$

13. (B)

Distance covered in first 3 seconds is given by

$s_3 = \frac{1}{2}gt^2 = \frac{1}{2}\times10\times(3)^2 = 45$ m

Distance covered in n^{th} second is given by

$s_{n^{th}} = g\left(n - \frac{1}{2}\right)$

$\therefore$ $45 = 10\left(n - \frac{1}{2}\right) \Rightarrow 4.5 = n - \frac{1}{2}$

$\Rightarrow n = 5$

$\therefore$ Total time = 5 sec

$\therefore$ $h = \frac{1}{2}gt^2 = \frac{1}{2}\times10\times(5)^2 = 5\times25 = 125$ m

14. (D)

Case I:

$u = 15$ km/hr $= \frac{15\times1000}{60\times60} = \frac{25}{6}$ m/s

As the vehicle comes to rest, v = 0

$v^2 = u^2 - 2as$

$\therefore$ $a = \frac{u^2}{2s} = \left(\frac{25}{6}\right)^2 \times \frac{1}{10} = \frac{25\times25}{6\times6\times2\times5}$ m/s^2

Case II:

$u = 45$ km/hr $= \frac{25}{2}$ m/s

$\therefore$ $s = \frac{u^2}{2a} = \left(\frac{25}{2}\right)^2 \times \left(\frac{6}{25}\right)^2 \times \frac{10}{2} = 9\times5 = 45$ m

15. (C)

If u is the initial velocity and d is the distance, then $u^2 = 2ad$ …..(i)

Where a is the retardation.

Now, 40% weight is added, i.e., m′ = 1.4 m

If the retarding force remains same, then the retardation becomes,

$a' = \frac{a}{1.4}$

$\therefore$ $u^2 = \frac{2ad'}{1.4}$ …. (ii)

From equations (i) and (ii), $2ad = \frac{2ad'}{1.4}$

$\therefore$ $d' = 1.4d$

16. (C)

Let the body be at x from the top after $\frac{t}{2}$ s.

$\therefore$ $x = \frac{1}{2}g\frac{t^2}{4} = \frac{gt^2}{8}$ ….(i)

$H = \frac{1}{2}gt^2$ ….(ii)

Solving equations (i) and (ii), we get

$\frac{8x}{g} = \frac{2H}{g} \Rightarrow x = \frac{H}{4}$

$\therefore$ Height of the body from the ground

$= H - \frac{H}{4} = \frac{3H}{4}$ metre

17. (C)

When the velocity of the bullet changes from V to $\frac{V}{2}$ the distance travelled by the bullet is 30 cm.

Using 3rd equation of motion,

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

$\left(\frac{V}{2}\right)^2 = V^2 + 2a(30)$

$\frac{V^2}{4} = V^2 + 60a$

$\frac{-3V^2}{4} = 60a$

$a = \frac{-V^2}{80}$

Further, when a bullet penetrates it comes to rest. So, the final velocity of the bullet becomes zero.

Using the relation,

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

$0 = \left(\frac{V}{2}\right)^2 + 2\left(-\frac{V^2}{80}\right)s$

$\frac{V^2}{4} = \left(\frac{V^2}{40}\right)s$

$s = \frac{40}{4}$

s = 10 cm

18. (A)

Velocity of car A and B:

$V_A = \frac{d(R_A)}{dt} = a + 2bt$ ….(i)

$V_B = \frac{d(R_B)}{dt} = x - 2t$ ….(ii)

∴ Time at which cars have same velocity can be calculated using (i) and (ii).

$V_A = V_B$

∴ $a + 2bt = x - 2t$

∴ $t = \frac{x-a}{2(b+1)}$

19. (B)

We know,

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

The total time required for the ball to go up and reach the ground is $t = t_1 + t_2$, and the total displacement is zero.

∴ $0 = u(t_1 + t_2) + \frac{1}{2}g(t_1 + t_2)^2$

∴ $u = \frac{1}{2}g(t_1 + t_2)$

The displacement in time t_1 is

$h = \frac{1}{2}g(t_1 + t_2)t_1 - \frac{1}{2}gt_1^2$

$h = \frac{1}{2}gt_1(t_1 + t_2 - t_1)$

∴ $h = \frac{1}{2}gt_1t_2$

20. (B)

21. (C)

$x = at^2 - bt^3$

Differentiating the displacement, we get velocity

$v = 2at - 3bt^2$

Differentiating, we get acceleration

$A = 2a - 6bt$

Substituting A = 0

$0 = 2a - 6bt \Rightarrow 6bt = 2a$

∴ $t = \frac{2a}{6b} = \frac{a}{3b}$

22. (B)

The time between the two balls getting thrown = 1 s

As the velocity of the ball becomes zero at the maximum height, the first ball will be at its highest point when the second ball is about to be thrown.

Using equation of motion for a body in free fall,

$s = \frac{1}{2}gt^2$

Given: s = h at t = 1 s

∴ $h = \frac{g}{2} = \frac{10}{2} = 5$ m

23. (D)

The position of body after time T/3 is,

$h' = \frac{1}{2}gt^2 = \frac{g}{2}\left(\frac{T}{3}\right)^2 = \frac{g}{2}\times\frac{T^2}{9}$ ….(i)

But $h = \frac{gT^2}{2}$ …. (ii)

Comparing (i) and (ii),

$h' = \frac{h}{9}$

∴ Height from ground, $h - h' = \frac{8h}{9}$

24. (A)

At point A, $s_A = ut + \frac{1}{2}at^2$

$s_A = \frac{1}{2}at^2$

At point B, $s_B = vt$

∴ At the point where they meet,

$s_A = s_B$

$\frac{1}{2}at^2 = vt$

$t = \frac{2v}{a}$

3.3 Motion in Two Dimensions – Motion in a plane

1. (A)

$u_x = a$ = horizontal component of the velocity
$u_y = b$ = Vertical component of the velocity

Maximum height $H = \frac{u_y^2}{2g} = \frac{b^2}{2g}$

Range $R = \frac{2u_y u_x}{g} = \frac{2ba}{g}$

Given that,
$R = 2H$

$\therefore \quad \frac{2ba}{g} = \frac{2b^2}{2g}$

$\therefore \quad b = 2a$

2. (D)

Maximum height $h = \frac{u^2 \sin^2\theta}{2g}$

$\therefore \quad \frac{h_A}{h_B} = \frac{\sin^2 30°}{\sin^2 60°} = \frac{1}{4} \times \frac{4}{3} = \frac{1}{3}$

3. (C)

At the highest point of projection, velocity has only the horizontal component (ucosθ)

$\therefore \quad u\cos\theta = \frac{u}{2}$ ….(Given)

$\therefore \quad \cos\theta = \frac{1}{2}$

$\therefore \quad \theta = 60°$

The maximum height is given by

$H = \frac{u^2 \sin^2\theta}{2g} = \frac{u^2 \sin^2(60°)}{2g}$

$= \frac{3u^2}{8g}$ ….$\left(\because \sin 60° = \frac{\sqrt{3}}{2}\right)$

4. (B)

The aeroplane is moving in horizontal direction

$\therefore \quad u_x = 540$ km/hr $= 540 \times \frac{5}{18}$ m/s $= 150$ m/s

h = 1960 m,
Initial velocity in vertical direction is zero.

$\therefore$ For vertical motion, $h = \frac{1}{2}gt^2$

Where t is the time taken to reach the ground

$\therefore \quad t = \sqrt{\frac{2h}{g}} = \sqrt{\frac{2\times1960}{9.8}} = \sqrt{400} = 20$ s

The horizontal distance covered during this time is
$x = u_x t = 150 \times 20 = 3000$ m

5. (B)

Comparing the given equation, $y = \sqrt{3}x - \frac{gx^2}{2}$ with the standard equation of trajectory,

$y = (\tan\theta)x - \frac{1}{2}\left(\frac{g}{u^2 \cos^2\theta}\right)$

We get
$\tan\theta = \sqrt{3}$

$\therefore \quad \theta = 60°$

Also, $\frac{g}{2} = \frac{g}{2u^2 \cos^2\theta}$

$\therefore \quad u^2 \cos^2\theta = 1$

$\therefore \quad u^2 \cos^2 60° = 1$ or $u^2 \times \frac{1}{4} = 1$

$\therefore \quad u^2 = 4$

$\therefore \quad u = 2$ m/s

6. (B)

u = 196 m/s, θ = 30°

time of flight $T = \frac{2u\sin\theta}{g} = \frac{2\times196\times0.5}{9.8} = 20$ s

7. (B)

Maximum height $H = \frac{u_1^2 \sin^2\theta_1}{2g} = \frac{u_2^2 \sin^2\theta_2}{2g}$

$\therefore \quad u_1 \sin\theta_1 = u_2 \sin\theta_2$

$\therefore \quad \frac{u_1}{u_2} = \frac{\sin\theta_2}{\sin\theta_1} = \frac{\sin 60°}{\sin 45°} = \frac{\sqrt{3}}{2} \times \frac{\sqrt{2}}{1} = \sqrt{\frac{3}{2}}$

8. (D)

Horizontal range is given by

$R = \frac{u^2 \sin 2\theta}{g}$

$\therefore \quad u_1^2 \sin 2\theta_1 = u_2^2 \sin 2\theta_2$

$\therefore \quad 2V^2 \times \frac{1}{2} = V^2 \sin 2\theta_2$

$\therefore \quad \sin 2\theta_2 = 1$

$\therefore \quad 2\theta_2 = 90°$

$\therefore \quad \theta_2 = 45°$

Thinking Hatke - Q.8

Referring to ***Shortcut 4***,

The range of projectiles is same for complementary angles.

$\therefore \quad \theta_2 = 90 - \theta_1 = 90 - 15 = 45°$

9. (A)

Relative velocity of one train w. r. t other = 5 + 10 = 15 m/s

Total length to cross (L) = 30 + 30 = 60 m

$\therefore \quad t = \frac{L}{V} = \frac{60}{15} = 4$ s

10. **(B)**

Area in which bullet will spread = πr^2

For maximum area, $r = R_{max} = \frac{u^2}{g}$ [when $\theta = 45°$]

Maximum area $\pi R_{max}^2 = \pi\left(\frac{u^2}{g}\right)^2 = \frac{\pi u^4}{g^2}$

11. **(B)**

$R = \frac{u^2 \sin^2\theta}{g}$

$\therefore$ $R \propto u^2$

$\therefore$ $\frac{R_1}{R_2} = \frac{u^2}{4u^2}$

$\therefore$ $\frac{50}{R_2} = \frac{1}{4}$

$\therefore$ $R_2 = 200\,m$

12. **(C)**

Horizontal range = $\frac{u^2 \sin 2\theta}{g}$

For maximum range, $\theta = 45°$

$R_{max} = \frac{u^2}{g}$ ….(i)

The stored P.E of the spring, P.E = $\frac{1}{2}Kx^2$

This P.E is converted into the K.E of the ball

$\therefore$ The K.E of the ball, K.E = $\frac{1}{2}mv^2$

As P.E = K.E,

$\frac{1}{2}Kx^2 = \frac{1}{2}mv^2$

$\therefore$ $v^2 = \frac{Kx^2}{m}$ ….(ii)

Substituting equation (ii) into equation (i) we get,

$R = \frac{Kx^2}{gm}$ ….($\because$ v = u)

13. **(C)**

Given the horizontal range is the same.

$\therefore$ $\theta_1 = \theta$ and $\theta_2 = 90 - \theta$

Time taken by the body in the first case,

$t_1 = \frac{2u \sin\theta_1}{g}$

$t_1 = \frac{2u\sin\theta}{g}$ ….(i)

Time taken by the body in the second case,

$t_2 = \frac{2u\sin\theta_2}{g} = \frac{2u\sin(90-\theta)}{g}$

$= \frac{2u\cos\theta}{g}$ ….(ii)

Multiplying equations (i) and (ii), we get

$t_1 \cdot t_2 = \frac{2u\sin\theta}{g}\cdot\frac{2u\cos\theta}{g}$

$= \frac{4u^2\sin\theta\cos\theta}{g^2}$ ….(iii)

But $\sin2\theta = 2\sin\theta\cos\theta$ and $R = \frac{u^2\sin2\theta}{g}$

$\therefore$ $t_1 \cdot t_2 = \frac{2u\sin2\theta}{g^2} = \frac{2}{g}R$

14. **(C)**

For P,

Time of flight, $t = \frac{2u\sin\theta}{g} = \frac{2\times10\times\sin60^\circ}{10}$

$= \sqrt{3}$ s

Q is projected horizontally,

$\therefore$ Distance it covers in $\sqrt{3}$ s,

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

$= 0 + \frac{1}{2}\times 10 \times (\sqrt{3})^2 = 15$ m.

$\therefore$ Q should be dropped from height of 15 m.

15. **(A)**

$\frac{h_{max}}{T^2} = \frac{\frac{u^2\sin^2\theta}{2g}}{\left(\frac{2u\sin\theta}{g}\right)^2}$

$\frac{h_{max}}{T^2} = \frac{u^2\sin^2\theta}{2g}\times\frac{g^2}{4u^2\sin^2\theta} = \frac{g}{8} = \frac{10}{8}$

$\therefore$ $\frac{h_{max}}{T^2} = \frac{5}{4}$

16. **(A)**

P.E. of the stone projected vertically is,

P.E. = mgh

But $h = \frac{v^2}{2g}$

$\therefore$ $P.E_1 = mg\left(\frac{v^2}{2g}\right)$

$= \frac{mv^2}{2}$ ….(i)

For the second stone thrown at an angle θ to the horizontal,

$h = \frac{v^2\sin^2\theta}{2g} = \frac{v^2\sin^2 30°}{2g} = \frac{v^2}{8g}$

$\therefore$ $P.E._2 = mg\left(\frac{v^2}{8g}\right) = \frac{mv^2}{8}$ ….(ii)

Dividing equation (i) by equation (ii)

$$\frac{P.E_1}{P.E_2} = \frac{\left(\frac{mv^2}{2}\right)}{\left(\frac{mv^2}{8}\right)} = 4 : 1$$

Caution - Q.16

The angle given in the question is with respect to the vertical. Whereas, angle of projection θ is always considered with the horizontal.

3.4 Uniform Circular Motion

1. **(D)**
   Acceleration $a = r\omega^2 = r \times (2\pi f)^2$
   Given that, f = 1 rev/s
   ∴ $a = 0.4 \times (2\pi)^2 = 0.4 \times 4 \times \pi^2 = 1.6\ \pi^2\ m/s^2$

2. **(C)**

3. **(C)**
   Angular velocity $= \frac{\text{Angle traced}}{\text{Time taken}}$
   Time period of hour hand is 12 h
   So, $\omega = \frac{2\pi}{12}\,\text{rad h}^{-1}$
   $= \frac{2\pi}{12\times60\times60}\,\text{rad s}^{-1} = \frac{\pi}{21600}\,\text{rad s}^{-1}$

4. **(B)**
   $n = 1200\text{ r.p.m.} = \frac{1200}{60}\text{ r.p.s.} = 20\text{ r.p.s.}$
   $a = \omega^2 r = (4\pi^2 n^2)\, r$
   $= 4 \times (3.142)^2 \times (20)^2 \times 0.3$
   $\approx 4740\ m/s^2$
   Hence, the nearest correct answer is (B)

5. **(A)**

6. **(A)**
   $E = \frac{1}{2}mv^2 \Rightarrow v^2 = \frac{2E}{m}$
   $a = \frac{v^2}{r} = \frac{2E}{mr}$

7. **(A)**
   $r_1 = 4$ cm, $\omega_2 = 2\omega_1$
   $r\omega^2$ = constant
   ∴ $r_1\omega_1^2 = r_2\omega_2^2$
   ∴ $r_1\omega_1^2 = r_1(2\omega_1)^2 = r_1 = 4\,r_2$
   ∴ $r_2 = \frac{r_1}{4} = \frac{4}{4} = 1$ cm

8. **(C)**
   Linear velocity $v = r\omega \Rightarrow \omega = \frac{v}{r}$

9. **(A)**
   A geostationary satellite has same sense of rotation as that of the earth and has same period of rotation. Hence when observed from the surface of the earth, it appears stationary.

10. **(B)**
   Angular speed of minute hand $\omega_m = \frac{2\pi}{60\times60}$
   Angular speed of second hand $\omega_s = \frac{2\pi}{60}$
   ∴ $\omega_s - \omega_m = \frac{2\pi}{60} - \frac{2\pi}{3600} = \frac{59\pi}{1800}\text{ rad / s}$

11. **(D)**
   $F = m\omega^2 r$
   Substituting for $r = 2l$, $\omega = \frac{2\pi}{T}$
   $kl = m(2l)\left(\frac{2\pi}{T}\right)^2$ ....(i)
   ....(∵ F = kx and x = l here)
   Upon speeding, $F_1 = m\omega_1^2 r_1$
   Substituting for $r_1 = 3l$, $\omega_1 = \frac{2\pi}{T_1}$
   $k(2l) = m(3l)\left(\frac{2\pi}{T_1}\right)^2$ ....(ii)
   ....(∵ x = $2l$ here)
   Dividing equation (i) by equation (ii),
   $\frac{kl}{k(2l)} = \frac{m(2l)(2\pi/T)^2}{m(3l)(2\pi/T_1)^2}$
   ∴ $\left(\frac{T_1}{T}\right)^2 = \frac{3}{4}$
   $\Rightarrow T_1 = \frac{\sqrt{3}}{2}T$

12. **(C)**
   $\omega_{hour} = \frac{2\pi}{T_{hour}}$
   $= \frac{2\pi}{12\times60\times60} \times \frac{180}{\pi}$ ...$\left(\because 1^c = \frac{180°}{\pi}\right)$
   $\omega_{hour} = \frac{1}{120}$ degree / s

13. **(C)**
   Degree moved by hour hand,
   for 1 revolution = 360°
   for 1 hour $= \frac{360°}{12} = 30°$
   for 1 min $= \frac{30}{60} = 0.5°$
   ∴ for 20 mins = 20 × 0.5° = 10°
   Hence, at 12.20 pm
   Angular separation = 120° – 10° = 110°

14. (C)

As, $\delta \vec{v}$ is along the radius and $\vec{v}$ is along the tangent, both are perpendicular to each other.

15. (B)

d = 50 cm $\Rightarrow r = 25 \times 10^{-2}$ m, f = 2 Hz

Now, $a = \frac{V^2}{r} = \frac{r^2\omega^2}{r} = r\omega^2 = 4\pi^2 f^2 r$

$= 4\pi^2 \times 4 \times 25 \times 10^{-2} = 4\pi^2$

16. (C)

The direction of force and velocity is perpendicular to each other. Hence, work done is zero.

17. (C)

$\omega_h = \frac{2\pi}{12 \times 60}$, $\omega_m = \frac{2\pi}{60}$

$\therefore$ $\omega_h : \omega_m = 1 : 12$

18. (D)

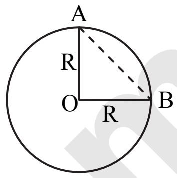
The distance covered by the wheel will be equal to 2000 times its circumference.

$\therefore$ $(2\pi r).(2000) = 9.42 \times 1000$

$\therefore$ $2r = \frac{9.42 \times 1000}{3.14 \times 2000} = 1.5$ m

19. (D)

In time $\frac{T}{4}$, the particle covers quarter circle as shown in figure.



Displacement = $l(AB) = \sqrt{R^2 + R^2} = \sqrt{2}R$

Distance = arc (AB) = $\frac{2\pi R}{4} = \frac{\pi R}{2}$

20. (A)

$F = \frac{mv^2}{r} = mr\omega^2$

$\therefore$ $\sqrt{F} = \sqrt{mr}\omega = \sqrt{mr}\frac{2\pi}{T}$

21. (D)

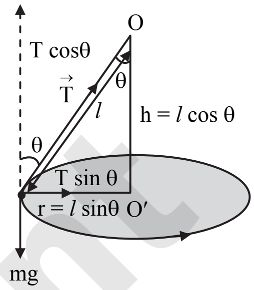
Since the two particles and the centre of the circle lie on straight line during the motion, they are describing the same angle in same time. Hence their angular velocities are same.

22. (C)

Given that, $f = \frac{1}{\pi}$ rps,

$\therefore$ $\omega = 2\pi f = 2\pi \times \frac{1}{\pi} = 2$ rad/s

In a conical pendulum, the centripetal force is provided by the horizontal component of the tension i.e., (Tsinθ).



$\therefore$ $T\sin\theta = mr\omega^2$

But $r = l\sin\theta$ and

$\omega^2 = 4$

$\therefore$ $T \sin\theta = m \times (l\sin\theta) \times 4$

$\therefore$ $T = 4ml$

23. (D)

Tension $T = mr\omega^2$

$\therefore$ $T \propto \omega^2$

$\therefore$ $\omega \propto \sqrt{T}$

$\therefore$ $\frac{\omega_2}{\omega_1} = \sqrt{\frac{T_2}{T_1}} = \sqrt{4} = 2$

$\therefore$ $\omega_2 = 2\omega_1 = 2 \times 10$ cycles / min

= 20 cycles / min

$= \frac{20}{60}$ cycle/s

$= \frac{1}{3}$ cycle/s

24. (C)

25. (B)

For conical pendulum, $\tan\theta = \frac{v^2}{rg}$

$\therefore$ $\frac{v^2}{r} = g\tan\theta = 10 \times \tan 45° = 10 \times 1 = 10$ m/s^2

Centripetal force $F = \frac{mv^2}{r} = 3 \times 10 = 30$ N

26. (A)

Centripetal force $F = \frac{mv^2}{r}$

$F_1 = \frac{mv_1^2}{r_1}$ and $F_2 = \frac{mv_2^2}{r_2}$

$\therefore$ $\frac{F_2}{F_1} = \frac{v_2^2}{v_1^2} \times \frac{r_1}{r_2}$