CHAPTER 01 STD XII SCIENCE

ROTATIONAL DYNAMICS

Most Asked Board Qs 2022–26
solved line by line, with textbook Qs

MHT CET corner
in every topic

FOR HSC 2027 EXAM
Latest board paper pattern



01 Circular Motion
02 Banking of a Road
03 Vertical Circle
04 Moment of Inertia
05 Axes Theorems
06 Angular Momentum
07 Rolling Motion

CHAPTER 1 · CONTENTS AT A GLANCE

Rotational Dynamics

HSC BOARD	1 mark	2 marks	3 marks	4 marks
7 marks in every paper	13 MCQ / one line	10 short answer	5 short answer	2 derivation

TOPIC		PAGE	HSC Board marks	MHT CET share	JEE Main share
01	Circular Motion	6	2	23%	15%
02	Banking of a Road	18	15	6%	11%
03	Vertical Circle	41	5	6%	5%
04	Moment of Inertia	55	13	42%	22%
05	Axes Theorems	68	9		
06	Angular Momentum	79	12	16%	34%
07	Rolling Motion	94	0	8%	13%
BASED ON			8 board papers 2022–2026	301 PYQs 2019–2026	186 PYQs 2019–2026

MOST ASKED IN HSC BOARD · 2022–2026

QUESTION	Marks	Asked in	Times
Maximum speed on a level curved road	2	Feb 2024 · Feb 2026 · Jun 2026	3×
M.I. of a disc about its central axis	1–2	Mar 2022 · Jul 2022 · Feb 2024	3×
Law of conservation of angular momentum	1–2	Jul 2022 · Feb 2023 · Feb 2025	3×
Kinetic energy of a rotating body	3	Mar 2022 · Jul 2022	2×
Theorem of parallel / perpendicular axes	3–4	Jul 2023 · Jun 2026	2×
Angle of banking	1–3	Feb 2024 · Feb 2025	2×
Well of death: speed or period	1–2	Jul 2023 · Jun 2026	2×
Power of a ceiling fan (torque × ω)	1–2	Feb 2025 · Feb 2026	2×

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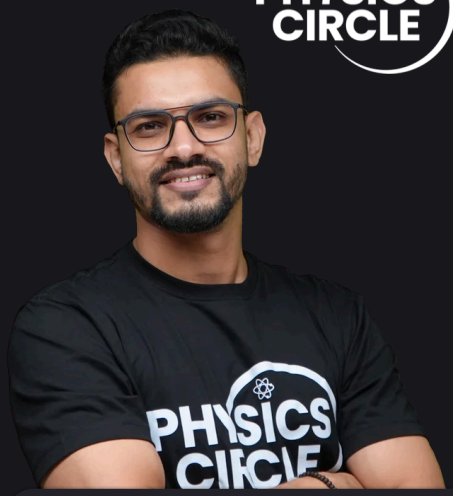

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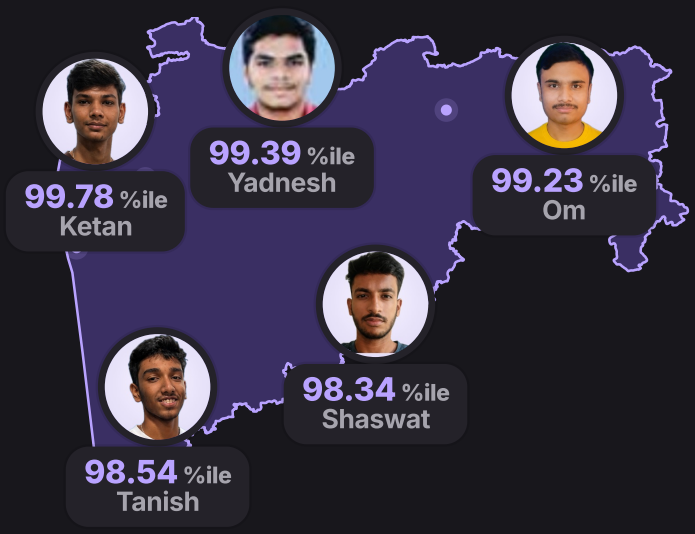

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11th Foundation Week for MHT-CET

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23 – 30 Nov · **11 AM live on YouTube** · free for everyone

DAILY LIVE · 11 AM

Mon 23 Nov	**Basic Maths 1** Trigonometry, log, binomial approximation, graphs
Tue 24 Nov	**Basic Maths 2** Differentiation + integration for Physics
Wed 25 Nov	**Vectors** Dot + cross product, right-hand rule · 46 CET PYQs
Thu 26 Nov	**Units, Dimensions + Measurement** Dimensional analysis, errors · 51 CET PYQs
Fri 27 Nov	**Motion in 1D + Projectile** Graphs with calculus · 63 CET PYQs
Sat 28 Nov	**Laws of Motion + Work, Energy, Power** Friction, connected bodies · 68 CET PYQs
Sun 29 Nov	**Free mock test** on the app 30 MHT-CET PYQs from this week
Mon 30 Nov	**Test discussion + 2027 roadmap** Vajra 2.0 Pro walkthrough · last day of ₹799

Why this week?

These 11th basics are about **5% of MHT-CET Physics** (our PYQ bank, 2019–26), and the maths is used in **every 12th chapter**. Start strong before 1 Dec.

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Schedule & Timetable

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DECEMBER · 12TH CHAPTERS

1–6 Dec	Current Electricity
7–13 Dec	Magnetic Fields due to Electric Current · Magnetic Materials
14–20 Dec	Electromagnetic Induction
21–27 Dec	AC Circuits · Dual Nature
28 Dec–3 Jan	Atoms and Nuclei · Semiconductors

JANUARY · 12TH CHAPTERS

4–10 Jan	Rotational Dynamics · Fluids
11–17 Jan	Kinetic Theory · Thermodynamics
18–24 Jan	Oscillations · Superposition of Waves
25–31 Jan	Wave Optics · Electrostatics ✓ Full 12th Physics done

FEBRUARY ONWARDS · BOARDS, THEN CET

1–11 Feb	**Board revision** Droppers: 11th CET chapters
12–23 Feb	**HSC Board exams** Physics paper on 12 Feb
From 22 Feb	**CET Crash Course** Revision, PYQs, MHT-CET mock tests
Apr–May	**MHT-CET** PCB 8–13 Apr · PCM 16–26 Apr · Attempt 2 in May (tentative)

CET Crash Course

Only revision after the Boards?

22 Feb to 31 May · included in Vajra 2.0

₹399

1–21 Feb
₹499 after

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TOPIC 01

Circular Motion

IN THIS TOPIC

- Characteristics of circular motion
- Kinematics
- Centripetal and centrifugal force

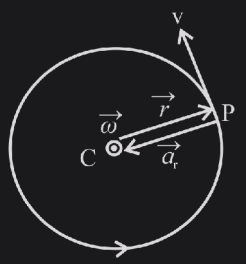

Fig. 1.2 · HSC Textbook · Directions of linear velocity and acceleration

1 Concept in brief

- Circular motion is an **accelerated motion**: the direction of velocity changes at every instant. It is also a **periodic** motion.
- Angular displacement θ, angular velocity $\omega = \frac{d\theta}{dt}$ and angular acceleration $\alpha = \frac{d\omega}{dt}$ are analogous to s, v and a.
- Tangential velocity $v = \omega r$. The direction of ω is along the axis of rotation, given by the **right-hand thumb rule**.
- **Uniform circular motion (UCM):** speed is constant; only the direction of velocity changes. The **centripetal acceleration** $a_r = \omega^2 r = \frac{v^2}{r}$ is directed towards the centre.
- **Non-uniform circular motion:** the speed also changes, so there is a **tangential acceleration** a_T as well.
- **Centripetal force** is the resultant of all real forces, directed towards the centre. **Centrifugal force** is a **pseudo force** $m\omega^2 r$, directed away from the centre, felt in a rotating frame.

2 Formulas

ANGULAR VELOCITY

$$\omega = \frac{2\pi}{T} = 2\pi n$$

LINEAR SPEED

$$v = \omega r$$

CENTRIPETAL ACCELERATION

$$a_r = \frac{v^2}{r} = \omega^2 r$$

CENTRIPETAL FORCE

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

3 Key words

WORD	MEANING
uniform	constant, not changing
angular velocity	angle turned per second
periodic	repeats after equal intervals
tangential	along the tangent to the circle

WORD	MEANING
centripetal	towards the centre
centrifugal	away from the centre
pseudo force	force seen only in a non-inertial frame
rpm / rps	revolutions per minute / second

4 Board questions

Q1. A body performing uniform circular motion has constant _____.

1 mark · HSC Jul 2023

(a) velocity

(b) kinetic energy

(c) displacement

(d) acceleration

SOLUTION

→ UCM: speed constant, direction of velocity and acceleration changes.

→ KE = $\frac{1}{2}mv^2$ depends only on speed

⇒ constant.

→ **Answer:** (b) kinetic energy

Q2. A stone tied to one end of a string is whirled in a horizontal plane with progressively increasing speed. It breaks at some speed because _____.

1 mark · SCERT Question Bank · MCQ 3

(a) gravitational force of the earth is greater than the tension in the string

(b) the required centripetal force is greater than the tension sustained by the string

(c) the required centripetal force is less than the tension in the string

(d) the centripetal force is greater than the weight of the stone

SOLUTION

→ Tension supplies the centripetal force mv^2/r, which increases with speed.

→ String breaks when the required force exceeds the tension it can bear.

→ **Answer:** (b)

Q3. **A 500 kg car takes a round turn of radius 50 m with a velocity of 36 km/hr. The centripetal force is _____.**

1 mark · SCERT Question Bank · MCQ 5

(a) 250 N

(b) 750 N

(c) 1000 N

(d) 1200 N

SOLUTION

→ v = 36 km/h = 10 m/s

$$F = \frac{mv^2}{r} = \frac{500 \times 10^2}{50}$$

$$= 1000 \text{ N}$$

→ **Answer:** (c) 1000 N

Q4. When seen from below, the blades of a ceiling fan are seen to be revolving anticlockwise and their speed is decreasing. Select the correct statement about the directions of its angular velocity and angular acceleration.

1 mark · HSC Textbook Ex. 1(i)

(a) ω upwards, α downwards

(b) ω downwards, α upwards

(c) both ω and α upwards

(d) both ω and α downwards

SOLUTION

→ Anticlockwise as seen by the observer

⇒ ω points towards the observer = **downwards** (right-hand thumb rule).

→ Speed decreasing

⇒ α opposite to ω = **upwards**.

→ **Answer:** (b)

Q5. Define centripetal force.

1 mark · HSC Feb 2024

SOLUTION

→ The force acting on a body in circular motion, directed along the radius **towards the centre** of the circle, is called centripetal force.

→ **Formula:** $F = \frac{mv^2}{r} = m\omega^2 r$.

Q6. Is centrifugal force a real force? Justify in one line.

1 mark · Expected question · based on HSC Textbook 1.2.2

SOLUTION

→ No. It is a **pseudo** force (non-real but not imaginary), felt only in a rotating frame, directed away from the centre: magnitude $m\omega^2 r$.

Q7. Distinguish between centripetal force and centrifugal force.

2 marks · Expected question · based on HSC Textbook 1.2.2

SOLUTION

→ **Nature:** centripetal – real force (resultant of real forces); centrifugal – pseudo force.

→ **Direction:** centripetal – towards the centre; centrifugal – away from the centre.

→ **Frame:** centripetal – inertial frame; centrifugal – rotating (non-inertial) frame.

→ **Example:** tension in a whirled string; outward push felt on a merry-go-round.

Q8. What is uniform circular motion? Why is it called an accelerated motion?

2 marks · Expected question · based on HSC Textbook 1.2.1

SOLUTION

→ Circular motion with constant speed is uniform circular motion (UCM).

→ Velocity is always tangential, so its **direction changes** at every instant.

→ Change in velocity

⇒ acceleration $a_r = \frac{v^2}{r} = \omega^2 r$ towards the centre; hence UCM is accelerated.

Q9. A fan is rotating at 90 rpm. It is then switched OFF. It stops after 21 rotations. Calculate the time taken by it to stop assuming that the frictional torque is constant.

2 marks · HSC Textbook Example 1.1

SOLUTION

→ **Given:** $\omega_o = 90$ rpm $= 1.5$ rps

$\omega = 0$

$\theta = 21$ rev.

→ **Formula:** $\theta = \left(\frac{\omega_o + \omega}{2}\right) t$

→ **Substitution:** $21 = \left(\frac{1.5 + 0}{2}\right) t$

$\Rightarrow t = \frac{21 \times 2}{1.5}$

→ **Answer:** $t = 28$ s

Q10. Somehow, an ant is stuck to the rim of a bicycle wheel of diameter 1 m. While the bicycle is on a central stand, the wheel is set into rotation and it attains the frequency of 2 rev/s in 10 seconds, with uniform angular acceleration. Calculate (i) number of revolutions completed by the ant in these 10 seconds (ii) time taken by it for first complete revolution and the last complete revolution.

3 marks · HSC Textbook Ex. 12

SOLUTION

→ **Given:** $n_o = 0$

$n = 2$ rev/s

$t = 10$ s

$\Rightarrow \alpha = \frac{2 - 0}{10} = 0.2$ rev/s².

→ **(i)** $\theta = \frac{1}{2}\alpha t^2 = \frac{1}{2} \times 0.2 \times 10^2$

$= \mathbf{10}$ **rev**.

→ **(ii) First revolution:** $1 = \frac{1}{2}(0.2)t_1^2$

$\Rightarrow t_1 = \sqrt{10} = \mathbf{3.16}$ **s**.

→ **Last revolution:** 9 rev take $t = \sqrt{\frac{9}{0.1}} = 9.487$ s

$\Rightarrow t_{last} = 10 - 9.487 = \mathbf{0.513}$ **s**.

→ **Answer:** 10 rev; √10 s; 0.513 s

Q11. Coefficient of static friction between a coin and a gramophone disc is 0.5. Radius of the disc is 8 cm. Initially the centre of the coin is 2 cm away from the centre of the disc. At what minimum frequency will it start slipping from there? By what factor will the answer change if the coin is almost at the rim? (use g = π² m/s²)

3 marks · HSC Textbook Ex. 13

SOLUTION

→ **Concept:**

friction gives the centripetal force; slipping starts when $\mu mg = m\omega^2 r$.

→ **Formula:** $\omega = \sqrt{\frac{\mu g}{r}}$

$n = \frac{\omega}{2\pi}$

→ **Substitution:** $\omega = \sqrt{\frac{0.5 \times \pi^2}{0.02}} = 5\pi$ rad/s

$\Rightarrow n = \frac{5\pi}{2\pi} = \mathbf{2.5}$ **rev/s**.

→ **At the rim:** $n \propto \frac{1}{\sqrt{r}}$; r becomes 4 times

⇒ n becomes **half**: $n_2 = \frac{1}{2}n_1 = 1.25$ rev/s.

→ **Answer:** 2.5 rev/s; $n_2 = \frac{1}{2}\, n_1$

5 MHT CET corner

C1. A body moves along a circular path of diameter 30 cm. It starts from one end of a diameter and reaches the other end of the diameter in 3 s. Its angular speed in rad/s is

MHT CET 2026

(a) $\frac{\pi}{5}$ (b) $\frac{\pi}{4}$

(c) $\frac{\pi}{3}$ (d) $\frac{\pi}{2}$

SOLUTION

→ Half a circle = π rad in 3 s

⇒ $\omega = \frac{\pi}{3}$ rad/s

→ **Answer:** (c) $\frac{\pi}{3}$

C2. **The angular velocity of the hour hand of a watch is (in rad/s)**

MHT CET 2026

(a) $\frac{\pi}{43200}$

(b) $\frac{\pi}{30}$

(c) $\frac{\pi}{21600}$

(d) $\frac{\pi}{1800}$

SOLUTION

→ Hour hand: T = 12 h = 43200 s

$\Rightarrow \omega = \frac{2\pi}{43200} = \frac{\pi}{21600}$ rad/s

→ **Answer:** (c) $\frac{\pi}{21600}$

C3. **For a particle moving in a circle with constant angular speed, which statement is false?**

MHT CET 2025

(a) The velocity vector is tangent to the circle.

(b) The acceleration vector is tangent to the circle.

(c) The velocity and acceleration vectors are perpendicular.

(d) The acceleration vector points to the centre.

SOLUTION

→ In UCM the acceleration is centripetal (towards the centre), not tangential

→ **Answer:** (b) The acceleration vector is tangent to the circle.

C4. **Two bodies of mass 10 kg and 5 kg move in concentric circles of radii R and r with the same period. The ratio of their centripetal accelerations is**

MHT CET 2025

(a) R/r

(b) r/R

(c) R^2/r^2

(d) r^2/R^2

SOLUTION

→ Same period

⇒ same ω; $a = \omega^2 r \propto r$

⇒ $\frac{a_1}{a_2} = \frac{R}{r}$

→ Mass does not matter

→ **Answer:** (a) R/r

FREE SAMPLE ENDS HERE

You just read Topic 1. The full Dark Horse guide is in Vajra 2.0 Pro.

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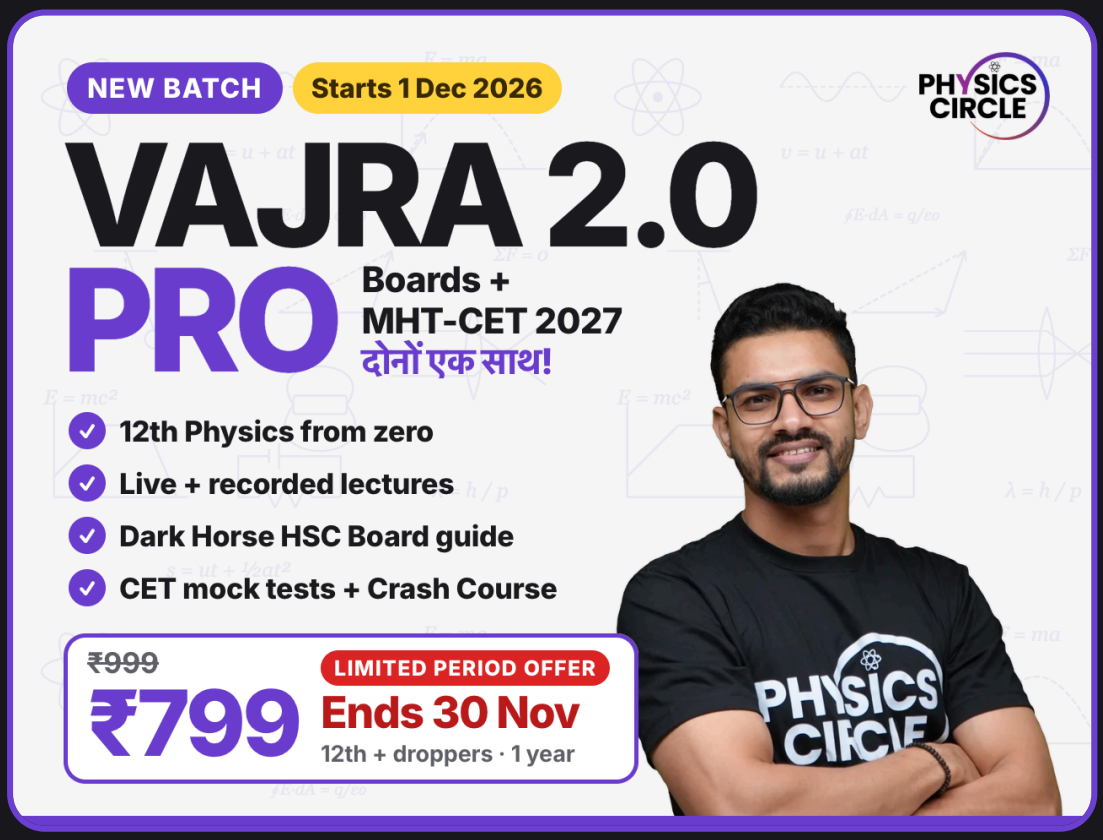

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