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**MHT-CET**

# Triumph Physics

**Based on Maharashtra Board Syllabus**

## STD. XII Sci.

### Salient Features

- Exhaustive subtopic wise coverage of MCQs.
- Notes, Shortcuts, Mindbenders, Formulae provided in each chapter.
- Hints included for relevant questions.
- Exhaustive coverage of various competitive exam questions.
- Includes solved MCQs from MHT CET, JEE (Main), NEET (UG) 2015, 2016, 2017.
- Evaluation test provided at the end of each chapter.
- Two Model Question Papers with answers at the end of the book.
- Additional inclusion: 'The physics of ….'.

*Solutions/hints to Evaluation Test available in downloadable PDF format at* ***www.targetpublications.org/tp12111***

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# *Preface*

**"Std. XII: Sci. Triumph Physics"** is a complete and thorough guide to prepare students for a competitive level examination. The book will not only assist students with MCQs of Std. XII but will also help them to prepare for MHT CET, NEET (UG), JEE and various other competitive examinations.

The content of this book is based on the Maharashtra State Board Syllabus. **Formulae** that form a vital part of MCQ solving are provided in each chapter. **Notes** provide important information about the topic. **Shortcuts** provide easy and less tedious solving methods. **Mindbenders** have been introduced to bridge the gap between a text book topic and the student's understanding of the same. A quick reference to the notes, shortcuts and mindbenders has been provided wherever possible.

MCQs in each chapter are divided into three sections:

**Classical Thinking**: consists of straight forward questions including knowledge based questions.

**Critical Thinking**: consists of questions that require a basic understanding of the concept.

**Competitive Thinking**: consists of questions from various competitive examinations like MHT CET, JEE, AIPMT/NEET-UG, AIIMS, AFMC, CPMT, Gujarat (GUJ CET), KCET, Assam CEE, BCECE, Telangana State (TS) EAMCET(Engineering, Medical) etc.

**Hints** have been provided to relevant MCQs which are broken down to the simplest form possible.

An **Evaluation Test** has been provided at the end of each chapter and two **Model Question Papers** (as per MHT CET pattern) to assess the level of preparation of the student on a competitive level.

An additional feature called **"The physics of ....."** has been included in the book to foster a keen interest in the subject of physics.

Informative Table of "**Various Physical Quantities and Conversion Factors"** has been provided at the end for a quick glance.

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

*Best of luck to all the aspirants!*

Yours faithfully
Authors

**Edition:** Second

# 01 Circular Motion

## *Subtopics*

1.0 Introduction

1.1 Angular displacement

1.2 Angular velocity and angular acceleration

1.3 Relation between linear velocity and angular velocity

1.4 Uniform circular motion

1.5 Acceleration in U.C.M (Radial acceleration)

1.6 Centripetal and centrifugal forces

1.7 Banking of roads

1.8 Conical pendulum

1.9 Vertical circular motion

1.10 Kinematical equation for circular motion in analogy with linear motion

*Riding on a vertical circular arc, this roller coaster fans experience a net force and acceleration that point towards the centre of the circle*

## Formulae

**1. Uniform Circular Motion (U.C.M.):**

i. Instantaneous angular velocity,

$$\omega = \lim_{\Delta t\to 0} = \frac{\Delta\theta}{\Delta t} = \frac{v}{r} = 2\pi n = \frac{2\pi}{T}$$

ii. Average angular velocity,

$$\omega_{av} = \frac{\theta_2 - \theta_1}{t_2 - t_1} = \frac{\Delta\theta}{\Delta t}$$

where,

$\theta_1$ = angular position of the body at time $t_1$

$\theta_2$ = angular position of the body at time $t_2$

iii. $\omega = \omega_{av}$ for U.C.M.

iv. If a particle makes n rotations in t second, then

$$\omega_{av} = \frac{2\pi n}{t}$$

v. Angular acceleration = $\alpha = 0$

vi. Instantaneous angular acceleration,

$$\alpha_{inst} = \lim_{\Delta t\to 0}\frac{\Delta\omega}{\Delta t} = \frac{d\omega}{dt} = \frac{d^2\theta}{dt^2}$$

vii. Average angular acceleration,

$$\alpha_{ave.} = \frac{\omega_2 - \omega_1}{t_2 - t_1} = \frac{\Delta\omega}{\Delta t}$$

where, $\omega_1$ = instantaneous angular speed at time $t_1$

$\omega_2$ = instantaneous angular speed at time $t_2$.

viii. Linear acceleration

$$= \text{centripetal acceleration} = \vec{\omega}\times\vec{v}$$

$$= a = v\omega = \frac{v^2}{r} = r\omega^2 = 4\pi^2 f^2 r = \frac{4\pi^2 r}{T^2}$$

ix. Time period $= T = \dfrac{1}{\text{frequency}(f)} = \dfrac{2\pi}{\omega}$

x. Relation between linear and angular velocity: $\vec{v} = \vec{\omega}\times\vec{r} = r\omega$ as $\theta = 90°$

**2. Non-uniform circular motion:**

i. Radial component of acceleration,

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

ii. Tangential component of acceleration,

$$a_t = \frac{dv}{dt}$$

iii. Net (linear) acceleration,

$$a = \sqrt{a_r^2 + a_t^2} \quad \text{....(Magnitude only)}$$

$$= \sqrt{\left(\frac{v^2}{r}\right) + \left(\frac{dv}{dt}\right)^2}$$

iv. Relation between tangential and angular acceleration,

$$\vec{a}_T = \vec{\alpha}\times\vec{r} = r\alpha$$

$\therefore$ $\theta = 0$

**3. Centripetal force:**

i. Centripetal force, $F_{cp} = \dfrac{mv^2}{r}$

$$= mr\omega^2 = mv\omega = mr\,(2\pi f)^2$$

$$= mr\left(\frac{2\pi}{T}\right)^2 = \frac{4\pi^2 mr}{T^2}$$

ii. Magnitude of Centrifugal force
= Magnitude of Centripetal force

i.e $F_{cf} = \dfrac{mv^2}{r}$ (in magnitude)

iii. When an electron moves round the nucleus of an atom along a circular path, we have

$$\frac{Ze^2}{4\pi\varepsilon_0 r^2} = \frac{mv^2}{r} = m\omega^2 r$$

$$= m\,4\pi^2 n^2 r = m\frac{4\pi^2 r}{T^2}$$

where, Z = atomic number of the nucleus.

**4. Motion of a vehicle on a curve road:**

The maximum velocity v, with which a vehicle can take a safe turn so that there is no skidding, is $v = \sqrt{\mu r g}$

where, $\mu$ = coefficient of limiting friction between the wheels and the road.

**5. Banking of roads:**

The proper velocity or optimum v on a road banked by an angle $\theta$ with the horizontal is given by,

$$v = \sqrt{rg\left(\frac{\mu_s + \tan\theta}{1 - \mu_s\tan\theta}\right)}$$

where r = radius of curvature of road

g = acceleration due to gravity

$\mu_s$ = coefficient of friction between road and tyres

when $\mu_s = 0$, $v = \sqrt{rg\tan\theta}$

**6. Vertical Circular Motion:**

i. Velocity at highest point $v_H \geq \sqrt{rg}$

ii. Velocity at the lowest point $v_L \geq \sqrt{5rg}$

iii. Velocity at a point along horizontal (midway position) $v_M \geq \sqrt{3rg}$

iv. Acceleration at the highest point $a_H = g$

v. Acceleration at the bottom point $a_L = 5g$

vi. Acceleration along horizontal $a_M = 3g$

vii. Tension at top most point,

$$T_H = \frac{mv_B^2}{r} - mg \geq 0$$

viii. Tension at the lowest point,

$$T_L = \frac{mv_A^2}{r} + mg \geq 6\ mg$$

ix. Tension at a point where the string makes an angle θ with the lower vertical line

$$T_\theta = \frac{mv^2}{r} + mg\cos\theta$$

x. Tension at midway position where θ = 90° (i.e. along horizontal)

$$T_M = \frac{mv^2}{r} \quad [\because \cos 90° = 0]$$

xi. Total energy at different points at the top, bottom and horizontal,

$$E_H = E_L = E_M = \frac{5}{2}mrg$$

xii. Total energy at any point,

$$E = \frac{1}{2}mv^2 + mgr(1-\cos\theta)$$

**7. Conical Pendulum:**

i. Angular velocity,

a. $\omega = \sqrt{\dfrac{g}{l\cos\theta}}$

b. $\omega = \sqrt{\dfrac{g\tan\theta}{r}}$

ii. Periodic time $= \dfrac{2\pi}{\omega} = 2\pi\sqrt{\dfrac{l\cos\theta}{g}}$

$$= \pi\sqrt{\frac{l\sin\theta}{g\tan\theta}}$$

iii. Radius of horizontal circle, $r = l \sin\theta$

**8. Kinematical equations in circular motion in analog with linear motion:**

i. $\omega = \omega_0 + \alpha t$

ii. $\theta = \omega_0 t + \frac{1}{2}\alpha t^2$

iii. $\omega^2 = \omega_0^2 + 2\,\alpha\theta$

**Notes**

1. *Radian measure must be used in equations that contain linear and angular quantities.*

2. *Finite angular displacement is a scalar quantity because it does not obey the laws of vector addition.*

3. *In U.C.M., angular velocity $\left(\vec{\omega}\right)$ is only constant vector but angular acceleration $\left(\vec{\alpha}\right)$ and angular displacement $\left(\vec{\theta}\right)$ are variable vectors.*

4. *All the points on a rotating body in U.C.M. have same ω except centre as it is not rotating.*

5. *Instantaneous angular displacement is a vector quantity.*

6. *Angular speed is a scalar quantity but angular velocity is a vector quantity but both have same units i.e rad/s.*

7. *The direction of $\vec{\theta}$, $\vec{\omega}$, $\vec{\alpha}$ is given by the right hand thumb rule.*

8. *The value of ω of earth about its axis is $7 \times 10^{-5}$ rad/s or 360° per day.*

9. *When a particle moves in a circle with constant speed, its velocity is variable because of changing direction.*

10. *Circular motion is a two-dimensional motion in which the linear velocity and linear acceleration vectors lie in the plane of the circle but the angular velocity and angular acceleration vectors are perpendicular to the plane of the circle.*

11. *Centrifugal force is a fictitious force and holds good in a rotating frame of reference.*

## Classical Thinking

### 1.1 Angular displacement

1. The angular displacement in circular motion is
   (A) dimensional quantity.
   (B) dimensionless quantity.
   (C) unitless and dimensionless quantity.
   (D) unitless quantity.

2. Angular displacement is measured in
   (A) metre. (B) time.
   (C) radian. (D) steradian.

3. A flywheel rotates at a constant speed of 3000 r.p.m. The angle described by the shaft in one second is
   (A) $3\pi$ rad (B) $30\pi$ rad
   (C) $100\pi$ rad (D) $3000\pi$ rad

### 1.2 Angular velocity and angular acceleration

4. Direction of $\vec{\alpha} \times \vec{r}$ is
   (A) tangent to path.
   (B) perpendicular to path.
   (C) parallel to the path.
   (D) along the path.

5. What is the angular speed of the seconds hand of a watch?
   (A) 60 rad/s (B) $\pi$ rad/s
   (C) $\pi/30$ rad/s (D) 2 rad/s

6. The angular velocity of a particle rotating in a circular orbit 100 times per minute is
   (A) 1.66 rad/s (B) 10.47 rad/s
   (C) 10.47 deg/s (D) 60 deg/s

7. A body of mass 100 g is revolving in a horizontal circle. If its frequency of rotation is 3.5 r.p.s. and radius of circular path is 0.5 m, the angular speed of the body is
   (A) 18 rad/s (B) 20 rad/s
   (C) 22 rad/s (D) 24 rad/s

8. What is the angular velocity of the earth?
   (A) $\frac{2\pi}{86400}$ rad/s (B) $\frac{2\pi}{3600}$ rad/s
   (C) $\frac{2\pi}{24}$ rad/s (D) $\frac{2\pi}{6400}$ rad/s

9. An electric motor of 12 horse-power generates an angular velocity of 125 rad/s. What will be the frequency of rotation?
   (A) 20 Hz (B) $20/\pi$ Hz
   (C) $20/2\pi$ Hz (D) 40 Hz

10. The ratio of angular speeds of minute hand and hour hand of a watch is
    (A) 1 : 12 (B) 60 : 1
    (C) 1 : 60 (D) 12 : 1

11. A body moves with constant angular velocity on a circle. Magnitude of angular acceleration is
    (A) $r\omega^2$ (B) constant
    (C) zero (D) $r\omega$

12. A wheel having a diameter of 3 m starts from rest and accelerates uniformly to an angular velocity of 210 r.p.m. in 5 seconds. Angular acceleration of the wheel is
    (A) 4.4 rad $s^{-2}$ (B) 3.3 rad $s^{-2}$
    (C) 2.2 rad $s^{-2}$ (D) 1.1 rad $s^{-2}$

### 1.3 Relation between linear velocity and angular velocity

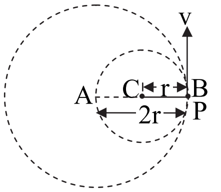
13. The vector relation between linear velocity $\vec{v}$, angular velocity $\vec{\omega}$ and radius vector $\vec{r}$ is given by
    (A) $\vec{v} = \vec{\omega} \times \vec{r}$ (B) $\vec{v} = \vec{r} + \vec{\omega}$
    (C) $\vec{v} = \vec{\omega} \cdot \vec{r}$ (D) $\vec{v} = \vec{r} - \vec{\omega}$

14. A wheel has circumference C. If it makes f r.p.s., the linear speed of a point on the circumference is
    (A) $2\pi fC$ (B) fC
    (C) $fC/2\pi$ (D) fC/60

15. A body is whirled in a horizontal circle of radius 20 cm. It has angular velocity of 10 rad/s. What is its linear velocity at any point on circular path?
    (A) 10 m/s (B) 2 m/s
    (C) 20 m/s (D) $\sqrt{2}$ m/s

16. A particle moves in a circular path, 0.4 m in radius, with constant speed. If particle makes 5 revolutions in each second of its motion, the speed of the particle is
    (A) 10.6 m/s (B) 11.2 m/s
    (C) 12.6 m/s (D) 13.6 m/s

17. A particle P is moving in a circle of radius 'r' with a uniform speed v. C is the centre of the circle and AB is a diameter. When passing through B, the angular velocity of P about A and C are in the ratio
(A) 1 : 1
(B) 1 : 2
(C) 2 : 1
(D) 4 : 1




## 1.4 Uniform Circular Motion (U.C.M.)

18. In uniform circular motion,
(A) both velocity and acceleration are constant.
(B) velocity changes and acceleration is constant.
(C) velocity is constant and acceleration changes.
(D) both velocity and acceleration change.

19. A particle moves along a circular orbit with constant angular velocity. This necessarily means,
(A) its motion is confined to a single plane.
(B) its motion is not confined to a single plane.
(C) nothing can be said regarding the plane of motion.
(D) its motion is one-dimensional.

20. Select the WRONG statement.
(A) In U.C.M. linear speed is constant.
(B) In U.C.M. linear velocity is constant.
(C) In U.C.M. magnitude of angular momentum is constant.
(D) In U.C.M. angular velocity is constant.

21. If a particle moves in a circle describing equal angles in equal intervals of time, the velocity vector
(A) remains constant.
(B) changes in magnitude only.
(C) changes in direction only.
(D) changes both in magnitude and direction.

22. A particle moves along a circle with a uniform speed v. After the position vector has made an angle of 30° with the reference position, its speed will be
(A) $v\sqrt{2}$ (B) $\frac{v}{\sqrt{2}}$
(C) $\frac{v}{\sqrt{3}}$ (D) v

23. A car travels due north with a uniform velocity. As the car moves over muddy area, mud sticks to the tyre. The particles of the mud as it leaves the ground are thrown
(A) vertically upwards.
(B) vertically inwards.
(C) towards north.
(D) towards south.

## 1.5 Acceleration in U.C.M. (Radial acceleration)

24. A particle in U.C.M. possesses linear acceleration since
(A) its linear speed changes continuously.
(B) both magnitude and direction of linear velocity change continuously.
(C) direction of linear velocity changes continuously.
(D) its linear speed does not change continuously.

25. The acceleration of a particle in U.C.M. directed towards centre and along the radius is called
(A) centripetal acceleration.
(B) centrifugal acceleration.
(C) gravitational acceleration.
(D) tangential acceleration.

26. In an inertial frame of reference, a body performing uniform circular motion in clockwise direction has
(A) constant velocity.
(B) zero angular acceleration.
(C) centripetal acceleration.
(D) tangential acceleration.

27. An electric fan has blades of length 30 cm as measured from the axis of rotation. If the fan is rotating at 1200 r.p.m., the acceleration of a point on the tip of the blade is about
(A) 1600 $cm/s^2$ (B) 4740 $cm/s^2$
(C) 2370 $cm/s^2$ (D) 5055 $cm/s^2$

28. The diameter of a flywheel is 1.2 m and it makes 900 revolutions per minute. Calculate the acceleration at a point on its rim.
(A) 540 $\pi^2$ $m/s^2$ (B) 270 $m/s^2$
(C) 360 $\pi^2$ $m/s^2$ (D) 540 $m/s^2$

29. The angular speed (in rev/min) needed for a centrifuge to produce an acceleration of 1000 g at a radius arm of 10 cm is
(Take g = 10 $m/s^2$)
(A) 1500 rev/min (B) 4000 rev/min
(C) 2000 rev/min (D) 3000 rev/min