SAMPLE CONTENT

MHT-CET 2021

TRIUMPH

PHYSICS

MULTIPLE CHOICE QUESTIONS

4754 MCQS

BASED ON STD. XII SYLLABUS 2020-21

In butterflies like morpho butterfly, interference and diffraction of light produce varying colours on the wings instead of pigmentation.

Target Publications® Pvt. Ltd.

Written in accordance with the topics based on new syllabus XII Sci.
(Maharashtra State Board)

MHT-CET TRIUMPH PHYSICS MULTIPLE CHOICE QUESTIONS

Based on New Syllabus

Salient Features

- Includes chapters of Std. XII as per latest textbook of 2020.
- Exhaustive subtopic wise coverage of MCQs.
- 4754 MCQs including questions from various competitive exams.
- Notes, Shortcuts, Mindbenders, Formulae provided in each chapter.
- Includes MCQs from JEE (Main) (8th April, shift 1), NEET (UG), NEET (Odisha), MHT-CET (6th May, Afternoon) 2019 and JEE (Main) (7th January, shift 1) 2020.
- Includes MCQs from JEE (Main), NEET and MHT-CET upto 2018.
- Various competitive examination questions updated till the latest year.
- Evaluation test provided at the end of each chapter.
- Inclusion of 'The physics of ….' to engage students in scientific enquiry.

*Scan the adjacent QR code or visit **www.targetpublications.org/tp1628** to download Hints of relevant questions and Evaluation Test in PDF format.*

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PREFACE

"Don't follow your dreams; chase them!"- a quote by Richard Dumbrill is perhaps the most pertinent for one who is aiming to crack entrance examinations held after std. XII. We are aware of an aggressive competition a student appearing for such career defining examinations experiences and hence wanted to create books that develop the necessary knowledge, tools and skills required to excel in these examinations.

For the syllabus of MHT-CET 2020, 80% of the weightage is given to the syllabus for XIIth standard while only 20% is given to the syllabus for XIth standard (with inclusion of only selected chapters). Since there is no clarity on the syllabus for MHT-CET 2021 till the time when this book was going to be printed and taking the fact into consideration that the entire syllabus for std. XIIth Science has always been an integral part of MHT-CET syllabus, this book includes all the topics of std. XIIth Physics.

We believe that although the syllabus for Std. XII and MHT-CET is aligned, the outlook to study the subject should be altered based on the nature of the examination. To score in MHT-CET, a student has to be not just good with the concepts but also quick to complete the test successfully. Such ingenuity can be developed through sincere learning and dedicated practice.

Having thorough knowledge of theory, derivations and their applications is a prerequisite for beginning with MCQs on a given chapter in Physics. Students must know formulae, conversion factors, units and dimensions of physical quantities involved in the chapter. Physics is conveyed using mathematics, therefore, students should study essential mathematical concepts such as trigonometric functions, identities, derivatives and integration rigorously. They should befriend ideas of tangent, slope, area under the curve and nature of various plots and their equations to resolve graphical intricacy of Physics. It should be kept in mind that every single line of text has potential of generating several MCQs.

As a first step to MCQ solving, students should start with elementary questions. Once a momentum is gained, complex MCQs with higher level of difficulty should be practised. Questions from previous years as well as from other similar competitive exams should be solved to obtain an insight about plausible questions.

The competitive exams challenge understanding of students about subject by combining concepts from different chapters in a single question. To figure these questions out, cognitive understanding of subject is required. Therefore, students should put in extra effort to practise such questions.

Promptness being virtue in these exams, students should wear time saving short tricks and alternate methods upon their sleeves and should be able to apply them with accuracy and precision as required.

Such a holistic preparation is the key to succeed in the examination!
To quote Dr. A.P.J. Abdul Kalam, **"If you want to shine like a sun, first burn like a sun."**

Our **Triumph Physics** book has been designed to achieve the above objectives. Commencing from basic MCQs the book proceeds to develop competence to solve complex MCQs. It offers ample practice of recent questions from various competitive examination. While offering standard solutions in the form of concise hints, it also provides Shortcuts and Alternate Methods. Each chapter ends with an Evaluation test to allow self-assessment.

Features of the book presented on the next page will explicate more about the same!

We hope the book benefits the learner as we have envisioned.

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.

Best of luck to all the aspirants!

From,
Publisher

Edition: First

FEATURES

Formulae

1. Angular velocity:

i. $\omega = \frac{v}{r}$ ii. $\omega = \frac{\theta}{t}$

iii. $\omega = 2\pi n$ iv. $\omega = \frac{2\pi}{T}$

2. Angular displacement:

i. $\theta = \omega t$ ii. $\theta = \frac{2\pi t}{T}$

iii. $\theta = 2\pi nt$

Formulae

Formulae includes key formulae of the chapter.

This is our attempt to make pools of formulae accessible for the students while solving problems and revising at last minute at a glance.

Notes

Notes provides compilation of comprehensive points which elaborate textual concepts or cover missing fragments of concept essential for the complete understanding of the concept.

This is our attempt to offer gist of knowledge required from examination point of view.

Notes

2. Since specific heat = $\frac{\Delta Q}{m\Delta T}$

i. In isothermal expansion, ΔT being zero, specific heat is ∞.

ii. For adiabatic change, ΔQ being zero, specific heat is zero.

Mindbenders

1. Kirchhoff's laws are applicable for DC as well as AC circuits. They can be accurately used for DC circuits and low frequency AC circuits. In case of AC though, summation of current should be done in vector form or using instantaneous value for the AC components of the circuit.

Mindbenders

Mindbenders presents thought provoking snippets of concepts.

This is our attempt to enable the students perceive underlying depth and implications of concept.

Shortcuts

Shortcuts comprises important theoretical or formula based short tricks considering their utility in solving MCQ.

This is our attempt to highlight content that would come handy while solving questions.

Shortcuts

1. For a particle executing S.H.M:

i. From mean position in order to travel half of amplitude, time required is given by, $t = \frac{T}{12}$

ii. From extreme position, in order to travel half of amplitude, time required is given by, $t = \frac{T}{6}$ s

FEATURES

Classical Thinking

3.1 Introduction

1. A gas is not an ideal gas
   (A) in which there is impurity.
   (B) which does not obey Boyle's law and Charles' law.
   (C) whose molecules are not point masses.
   (D) whose molecules interact each other.

Classical Thinking

Classical Thinking section encompass straight forward questions including knowledge based questions.
This is our attempt to revise chapter in its basic form and warm up the students to deal with complex MCQs.

Critical Thinking

Critical Thinking section encompasses challenging questions which test understanding, rational thinking and application skills of the students.
This is our attempt to take the students from beginner to proficient level in smooth steps.

Critical Thinking

6.2 Progressive W ve

1. A travellin wav pass through a point of observation At thi point, the time interval etw n suc ssive cr sts is 0.2 s, then,
   (A) waveleng m.
   (B) frequ ncy is 5 Hz.
   (C) veloc of propagation is 5 m/s
   ( ) wav ength is 0.2 m.

Competitive Thinking

7.2 Nature of Light

1. According to corpus r theory of light which is NOT the property of lig MHT CET 2019]
   (A) The velo ligh ir is greater than in glass.
   (B) Lig trav s in straight lines.
   (C) T velocit f light does not change after refle ion.
   ( ) velo ty of light changes after reflection.

Competitive Thinking

Competitive Thinking section encompasses questions from various competitive examinations like MHT CET, JEE, AIPMT/NEET-UG, etc.
This is our attempt to give the students practice of competitive questions and advance them to acquire knack essential to solve such questions.

S otopic wise segregation

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

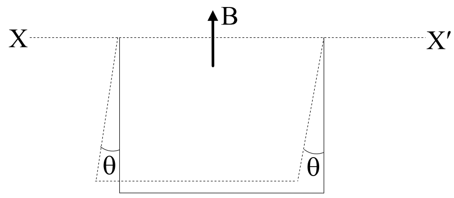
Subtopics

9.1 Introduction
9.2 Kirchhoff's Laws of Electrical Network
9.3 Wheatstone Bridge
9.4 Potentiometer
9.5 Galvanometer

FEATURES

Miscellaneous

93. A wire of cross-sectional area A forms 3 sides of a square and is free to turn about axis XX′. If the structure is deflected by θ from vertical when current I is passed through it, in a magnetic field B acting vertically upward and density of wire is ρ, the value of B is given by



(A) $\frac{2A\rho g}{I}\cot\theta$ (B) $\frac{2A\rho g}{I}\tan\theta$

(C) $\frac{A\rho g}{I}\sin\theta$ (D) $\frac{A\rho g}{2I}\cos\theta$

Miscellaneous

Every section, in general, ends with a sub-topic; miscellaneous.

Miscellaneous incorporates MCQs whose solutions require knowledge of concepts covered in different sub-topics of same chapter or from different chapters.

This is our attempt to develop cognitive thinking in the students essential to solve questions involving fusion of multiple key concepts.

Evaluation test

Evaluation Test covers questions from chapter for self-evaluation purpose.

This is our attempt to provide the students with a practice test and help them assess their range of preparation of the chapter.

Evaluation Test

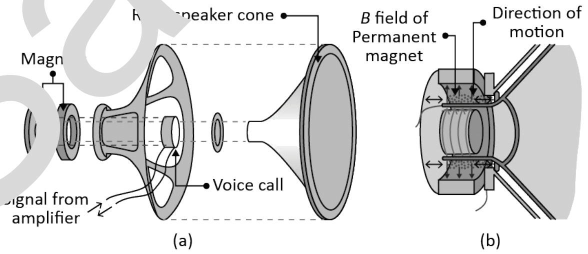
1. The ratio of areas within the electron orbits for the first excited state to the ground state for hydrogen atom is

(A) 16 : 1 (B) 18 : 1

(C) 4 : 1 (D) 2 : 1

The physics of …..

… how a loudspeaker produces sound….



Loud speakers help us to listen to wonderful music. What mechanism in them makes them produce the sound?

The answer is at the end of this chapter.

The physics of …..

The physics of ….. illustrates real life applications or examples related to the concept discussed.

This is our attempt to link learning to the life and make the students conscious of how Physics has touched entire spectrum of life.

CONTENTS

Textbook Chapter No.

01 Rotational Dynamics

Subtopics

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. Angular velocity:

i. $\omega = \frac{v}{r}$ ii. $\omega = \frac{\theta}{t}$

iii. $\omega = 2\pi n$ iv. $\omega = \frac{2\pi}{T}$

2. Angular displacement:

i. $\theta = \omega t$ ii. $\theta = \frac{2\pi t}{T}$

iii. $\theta = 2\pi nt$

3. Angular acceleration:

i. $\alpha = \frac{\omega_2 - \omega_1}{t}$ ii. $\alpha = \frac{2\pi}{t}(n_2 - n_1)$

4. Linear velocity:

i. $v = r\omega$ ii. $v = 2\pi nr$

5. Centripetal acceleration or radial acceleration: $a = \frac{v^2}{r} = \omega^2 r$

6. Tangential acceleration: $\vec{a}_T = \vec{\alpha} \times \vec{r}$

7. Centripetal force:

i. $F_{CP} = \frac{mv^2}{r}$ ii. $F_{CP} = mr\omega^2$

iii. $F_{CP} = mr4\pi^2 n^2$ iv. $F_{CP} = \frac{4\pi^2 mr}{T^2}$

8. Centrifugal force: $F_{CF} = -F_{CP}$

9. Inclination of banked road: $\theta = \tan^{-1}\left(\frac{v^2}{rg}\right)$

10. On unbanked road:

i. Maximum velocity of vehicle to avoid skidding on a curve unbanked road: $v_{max} = \sqrt{\mu rg}$

ii. Angle of leaning: $\theta = \tan^{-1}\left(\frac{v^2}{rg}\right)$

11. On banked road:

i. Upper speed limit: $v_{max} = \sqrt{rg\left[\frac{\mu_s + \tan\theta}{1 - \mu_s \tan\theta}\right]}$

ii. Lower speed limit: $v_{min} = \sqrt{rg\left[\frac{\tan\theta - \mu_s}{1 + \mu_s \tan\theta}\right]}$

iii. $v_{max} = \sqrt{rg \tan\theta}$ (in absence of friction)

12. Height of inclined road: $h = l \sin\theta$

13. Conical Pendulum:

i. Angular velocity of the bob of conical pendulum,

$\omega = \sqrt{\frac{g}{L \cos\theta}}$

ii. Period of conical pendulum

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

14. For mass tied to string:

i. Minimum velocity at lowest point to complete V.C.M: $v_L = \sqrt{5rg}$

ii. Minimum velocity at highest point to complete V.C.M: $v_H = \sqrt{rg}$

iii. Minimum velocity at midway point to complete in V.C.M: $v_M = \sqrt{3rg}$

iv. Tension at highest point in V.C.M:

$T_H = \frac{mv_H^2}{r} - mg$

v. Tension at midway point in V.C.M:

$T_M = \frac{mv_m^2}{r}$

vi. Tension at lowest point in V.C.M:

$T_L = \frac{mv_L^2}{r} + mg$

vii. Difference between tension at lowermost and uppermost point:

$T_L - T_H = 6\ mg$

15. Moment of Inertia: $I = \sum_{i=1}^{n} m_i r_i^2 = \int dmr^2$

16. Radius of gyration: $K = \sqrt{\frac{I}{M}}$

17. Kinetic energy:

i. $K.E_{rotational} = \frac{1}{2} I\omega^2 = \frac{1}{2} I (2\pi n)^2$

ii. $K.E_{translational} = \frac{1}{2} Mv^2$

iii. $K.E_{rolling} = \frac{1}{2}[Mv^2 + I\omega^2] = \frac{1}{2} Mv^2\left[1 + \frac{K^2}{R^2}\right]$

18. From principle of parallel axes: $I_o = I_c + Mh^2$

19. From principle of perpendicular axes:

$I_Z = I_X + I_Y$

20. Angular momentum of a body: $L = I\omega = I(2\pi n)$

21. From principle of conservation of angular momentum:

i. $I_1\omega_1 = I_2\omega_2$ ii. $I_1n_1 = I_2n_2$

22. Torque acting on a body:

i. $\tau = I\alpha = \frac{dL}{dt}$

ii. $\tau = I\frac{d\omega}{dt} = 2\pi I\left(\frac{n_2 - n_1}{t}\right)$

23. Velocity of rolling body: $v = \sqrt{\frac{2gh}{1 + \frac{K^2}{R^2}}}$

24. Acceleration of rolling body: $a = \frac{g \sin\theta}{1 + \frac{K^2}{R^2}}$

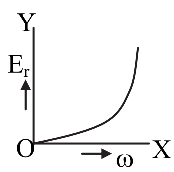
Table 1: Analogy of translational motion and rotational motion

Linear or Translational motion		S.I. Unit	Rotational motion		S.I. Unit
Displacement	s	m	Angular Displacement	θ	rad
Speed	v	ms^{-1}	Angular Speed	ω	rad s^{-1}
Velocity	$v = \frac{ds}{dt}$	ms^{-1}	Angular velocity	$\omega = \frac{d\theta}{dt}$	rad s^{-1}
Acceleration	$a = \frac{dv}{dt}$	ms^{-2}	Angular acceleration	$\alpha = \frac{d\omega}{dt}$	rad s^{-2}
Mass	m	kg	M.I.	$I = mr^2$	kg m^2
Force	$F = \frac{dP}{dt} = ma$	N	Torque or couple	$\tau = I\alpha = \frac{dL}{dt}$	Nm
Momentum	$P = mv$	$kgms^{-1}$	Angular momentum	$L = I\omega$	kg m^2 s^{-1}
Work	$W = Fs$	J	Work	$W = \tau\theta$	J
Kinetic energy	$E_k = \frac{1}{2}mv^2$	J	Rotational Energy	$E_{Rot} = \frac{1}{2}I\omega^2 = \frac{1}{2}LI$	J
Power	$P = Fv$ or $\vec{F}.\vec{v}$	W	Power	$P = \tau\omega$ or $\vec{\tau}.\vec{\omega}$	W

Table 2: Moment of inertia of different bodies

No.	Shape of regular body	Axis of rotation	Moment of Inertia
i.	Rod of mass M and length L (thin rod)	Centre of rod and perpendicular to length.	$\frac{ML^2}{12}$
		One end and perpendicular to length.	$\frac{ML^2}{3}$
ii.	Circular ring of mass M and radius R	Line passing through its centre and perpendicular to its plane.	MR^2
		Any diameter.	$\frac{1}{2}MR^2$
		Any tangent in the plane of the ring.	$\frac{3}{2}MR^2$
		Any tangent perpendicular to the plane of the ring.	$2MR^2$
iii.	Circular disc of mass M and radius R	Through centre, perpendicular to plane of disc.	$\frac{1}{2}MR^2$
		Any diameter.	$\frac{1}{4}MR^2$
		Tangent in the plane of the disc.	$\frac{5}{4}MR^2$
		Tangent perpendicular to plane of disc.	$\frac{3}{2}MR^2$
iv.	Solid sphere of mass M and radius R	Any diameter.	$\frac{2}{5}MR^2$
		Any tangent.	$\frac{7}{5}MR^2$
v.	Hollow sphere of mass M and radius R	Any diameter	$\frac{2}{3}MR^2$
vi.	Solid cylinder of mass M, radius R and length L	Axis passing through its centre and parallel to its length	$\frac{1}{2}MR^2$
		Through centre perpendicular to length.	$M\left(\frac{R^2}{4}+\frac{L^2}{12}\right)$
vii.	Hollow cylinder of mass M, radius R	Axis passing through its centre and parallel to its length	MR^2
viii.	Annular ring or thick walled hollow cylinder	Axis passing through its centre and perpendicular to its plane	$I = \frac{1}{2}M\left(r_2^2 + r_1^2\right)$
ix.	Uniform symmetric spherical shell	Any diameter	$I = \frac{2}{5}M\frac{\left(r_2^5 - r_1^5\right)}{\left(r_2^3 - r_1^3\right)}$
x.	Uniform plate or rectangular parallelepiped	Axis passing through its centre of the side and perpendicular to its plane	$I = \frac{1}{12}M(L^2 + b^2)$

Table 3: Table representing the graphs of different parameters of rotational motion

Sr. No.	Graph of	Formula	Graph
1.	K.E.$_{rotational}$ v/s ω where, ω = angular velocity	$K.E._{rot} = \frac{1}{2}I\omega^2$ i.e. $K.E._{rot} \propto \omega^2$ if I is constant	

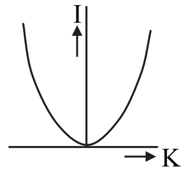
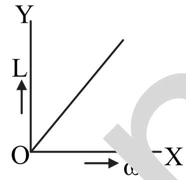
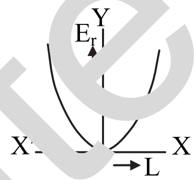
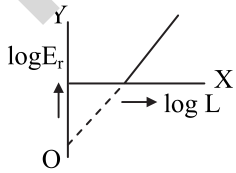
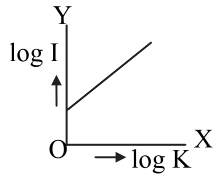
2.	I v/s K where, K = radius of gyration	$I = MK^2$ i.e. $I \propto K^2$	
3.	L v/s ω where, L = angular momentum	$L = I\omega$ i.e. $L \propto \omega$	
4.	$K.E._{rotational}$ v/s L	$K.E._{rot} = \frac{L^2}{2I}$ i.e. $K.E._{rot} \propto L^2$ if I is constant	
5.	log ($K.E._{rot}$) v/s log (L)	$K.E._{rot} = \frac{L^2}{2I}$ i.e. $\log(K.E._{rot}) = 2\log(L) - \log(2I)$	
6.	log (I) v/s log (K)	$I = MK^2$ i.e. $\log(I) = \log(M) + 2\log(K)$	

Table 4: Kinetic energy distribution table for different rolling bodies

Body	$\frac{K^2}{R^2}$	Translational $(K_T) = \frac{1}{2}mv^2$	Rotational $(K_R) = \frac{1}{2}mv^2\frac{K^2}{R^2}$	Rolling $(K_{Roll}) = \frac{1}{2}mv^2\left(1+\frac{K^2}{R^2}\right)$
Ring and Cylindrical shell	1	$\frac{1}{2}mv^2$	$\frac{1}{2}mv^2$	mv^2
Disc and solid cylinder	$\frac{1}{2}$	$\frac{1}{2}mv^2$	$\frac{1}{4}mv^2$	$\frac{3}{4}mv^2$
Solid sphere	$\frac{2}{5}$	$\frac{1}{2}mv^2$	$\frac{1}{5}mv^2$	$\frac{7}{10}mv^2$
Hollow sphere	$\frac{2}{3}$	$\frac{1}{2}mv^2$	$\frac{1}{3}mv^2$	$\frac{5}{6}mv^2$

Table 5: Velocity, Acceleration and Time of descent for Different Bodies

Body	Velocity $v = \sqrt{\frac{2gh}{1+\frac{K^2}{R^2}}}$	Acceleration $a = \frac{g\sin\theta}{\left(1+\frac{K^2}{R^2}\right)}$	Time of descent $t = \frac{1}{\sin\theta}\sqrt{\frac{2h}{g}\left(1+\frac{K^2}{R^2}\right)}$
Ring or Hollow cylinder	$\sqrt{gh}$	$\frac{1}{2}g\sin\theta$	$\frac{1}{\sin\theta}\sqrt{\frac{4h}{g}}$
Disc or solid cylinder	$\sqrt{\frac{4gh}{3}}$	$\frac{2}{3}g\sin\theta$	$\frac{1}{\sin\theta}\sqrt{\frac{3h}{g}}$

Solid sphere	$\sqrt{\frac{10}{7}gh}$	$\frac{5}{7}g\sin\theta$	$\frac{1}{\sin\theta}\sqrt{\frac{14}{5}\frac{h}{g}}$
Hollow sphere	$\sqrt{\frac{6}{5}gh}$	$\frac{3}{5}g\sin\theta$	$\frac{1}{\sin\theta}\sqrt{\frac{10}{3}\frac{h}{g}}$

Table 6: Rolling, Sliding and Falling bodies

Motion	Velocity	Acceleration	Time
Rolling	$\sqrt{\frac{2gh}{1+\frac{K^2}{R^2}}}$	$\frac{g\sin\theta}{\left(1+\frac{K^2}{R^2}\right)}$	$\frac{1}{\sin\theta}\sqrt{\frac{2h}{g}\left(1+\frac{K^2}{R^2}\right)}$
Sliding	$\sqrt{2gh}$	g sin θ	$\frac{1}{\sin\theta}\sqrt{\frac{2h}{g}}$
Falling	$\sqrt{2gh}$	g	$\sqrt{\frac{2h}{g}}$

Notes

1. *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.*
2. *The value of ω of earth about its axis is* 7×10^{-5} *rad/s or 360° per day.*
3. *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.*
4. *An observer on the moving particle experiences only the centrifugal force, but an observer stationary with respect to the centre can experience or measure only the centripetal force.*
5. *Whenever a particle is in a U.C.M. or non U.C.M., centripetal and centrifugal forces act simultaneously. They are both equal and opposite but do not cancel each other.*
6. *Centripetal force and Centrifugal force are not action-reaction forces as action-reaction forces act on different bodies.*
7. *Since the centripetal force acting on a particle in circular motion acts perpendicular to its displacement (and also its velocity), the work done by it is always zero.*
8. *The radius of the curved path is the distance from the centre of curved path to the centre of gravity of the body. It is to be considered when the centre of gravity of body is at a height from the surface of road or surface of spherical body.*
9. *Whenever a car is taking a horizontal turn, the normal reaction is at the inner wheel.*
10. *While taking a turn, when car overturns, its inner wheels leave the ground first.*
11. *For a vehicle negotiating a turn along a circular path, if its speed is very high, then the vehicle starts skidding outwards. This causes the radius of the circle to increase resulting in the decrease in the centripetal force.*

    $[\because F_{cp} \propto \frac{1}{r}]$
12. *If a body moves in a cylindrical well (well of death) the velocity required will be minimum safest velocity and in this case the weight of the body will be balanced by component of normal reaction and the minimum safest velocity is given by the formula* $\sqrt{\mu rg}$.
13. *If a body is kept at rest at the highest point of convex road and pushed along the surface to perform circular motion, the body will fall after travelling a vertical distance of* $\frac{r}{3}$ *from the highest point where r is the radius of the circular path.*
14. *Since the centripetal force is not zero for a particle in circular motion, the torque acting is zero i.e.,* $\vec{\tau} = 0$ *(as the force is central) Hence the angular momentum is constant i.e.* $\vec{L}$ *= constant.*

15. *If a particle performing circular motion comes to rest momentarily, i.e. $\vec{v} = 0$, then it will move along the radius towards the centre and if its radial acceleration is zero, i.e. $a_r = 0$, then the body will move along the tangent drawn at that point.*

16. *For non uniform circular motion*
$\vec{a} = \vec{\alpha} \times \vec{r} + \vec{\omega} \times \vec{v}$

17. *When a bucket full of water is rotated in a vertical circle, water will not spill only if velocity of bucket at the highest point is $\geq \sqrt{gr}$.*

18. *If velocity imparted to body at the lowest position is equal to $\sqrt{2rg}$, then it will oscillate in a semicircle.*

19. *If bodies of same shape but different masses and radii are allowed to roll down an inclined plane, then they will reach the bottom with the same speed and at the same time.*

20. *If ice on poles starts melting, then both moment of inertia and length of the day (T) will increase, because $I\omega = I \times \frac{2\pi}{T}$ = constant.*

21. *Moment of inertia of the body will be minimum along the axis passing through its centre of mass.*

22. *M.I. of cube is minimum about its diagonal.*

23. *For same mass and dimensions, moment of inertia of a hollow body is more than moment of inertia of solid body.*

24. *For a given L, lesser the moment of inertia, more is the rotational kinetic energy.*

25. *Angular velocity of fan is constant due to applied torque. It is balanced by some frictional torque. When the applied torque is removed, fan comes to rest because of frictional torque.*

26. *Angular momentum has same direction as that of angular velocity.*

Mindbenders

1. A flywheel is a rotating mechanical device that is used to store rotational energy. Flywheels, on account of a significant moment of inertia, resist changes in rotational speed. The amount of energy stored in a flywheel is proportional to the square of its rotational speed. Energy is transferred to a flywheel by applying torque to it, thereby increasing its rotational speed and hence its stored energy. Conversely, a flywheel releases stored energy by applying torque to a mechanical load, thereby decreasing its rotational speed.

2. In a reciprocating engine, the dead centre is the position of a piston in which it is farthest from, or nearest to, the crankshaft.
In general, the dead centre is any position of a crank where the applied force is straight along its axis, meaning no turning force can be applied. A few examples of crank driven machines are bicycles, tricycles, various types of machine presses, gasoline engines, diesel engines, steam locomotives and other steam engines. Crank-driven machines rely on the energy stored in a flywheel to overcome the dead centre. A steam locomotive is an example in which the connecting rods are arranged such that the dead centre for each cylinder occurs out of phase with the other one (or two) cylinders.

3. If the Earth suddenly stops rotating, then duration of day decreases. According to law of conservation of angular momentum,
$I\omega$ = constant or $I \times \frac{2\pi}{T}$ = constant
$\therefore$ T ∝ I. Here T represents the length of the day. When the earth contracts, the distribution of mass comes near to the axis of rotation. So I decreases. Consequently, T decreases i.e. the duration of the day will be decreased.

4. A swimmer executing a somersault takes the help of principle of conservation of angular momentum to increase his spin motion.
According to principle of conservation of angular momentum, $I\omega$ = constant or $\omega \propto \frac{1}{I}$.
Thus, angular velocity increases when moment of inertia decreases. To decrease the moment of inertia, he folds her arms and brings the stretched leg close to the other leg. Thus, angular velocity increases and hence the spin becomes faster

Shortcuts

1. 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.

2. There are two types of acceleration; a_r (radial) and a_t (tangential) acceleration.
Formula for $a_r = \omega^2 r$ and $a_t = \frac{dv}{dt}$ or $r\alpha$

3. To find out number of revolutions, always apply the formula,
Number of revolutions $= \frac{\theta}{2\pi} = \frac{\omega t}{2\pi} = \frac{2\pi nt}{2\pi} = nt$

4. The minimum safe velocity for not overturning is $v = \sqrt{\frac{gdr}{2h}}$

5. While rounding a curve on a level road, centripetal force required by the vehicle is provided by force of friction between the tyres and the road.

$$\frac{mv^2}{r} = F = \mu R = \mu mg$$

6. The maximum velocity with which a vehicle can go without toppling, is given by

$$v = \sqrt{rg\frac{d}{2h}} = \sqrt{rg\tan\theta}$$

where, $\tan\theta = \frac{d}{2h}$

d = distance between the wheels

h = height of centre of gravity from the road

g = acceleration due to gravity

7. Skidding of an object placed on a rotating platform:
The maximum angular velocity of rotation of the platform so that object will not skid on it is

$$\omega_{max} = \sqrt{(\mu g / r)}$$

8. If earth suddenly contracts to $\left(\frac{1}{n}\right)^{th}$ of its present size without changes in its mass, then duration of new day = $\frac{24}{n^2}$ hours.

9. If an inclined plane ends into circular loop of radius r, then height from which a body must start from rest to complete the loop is given by $h = \frac{5}{2}r$

Hence h is independent of mass of the body.

10. When a small body of mass m slides down from the top of a smooth hemispherical surface of radius R, then height at which the body loses the contact with surface, $h = \frac{2R}{3}$

11. The angle of banking (θ) is given by,

$$\tan\theta = \frac{v^2}{rg} = \frac{h}{\sqrt{l^2 - h^2}}$$

where h is height of the outer edge above the inner edge and l is length of the road.

12. On the same basis, a cyclist has to bend through an angle θ from his vertical position while rounding a curve of radius r with velocity v such that $\tan\theta = \frac{v^2}{rg}$

If θ is very very small, then

$$\tan\theta = \sin\theta = \frac{v^2}{rg}$$

$$\frac{v^2}{rg} = \frac{h}{l}$$

where h is height of the outer edge from the inner edge and l is the distance between the tracks or width of the road.

13. Always remember the formulae for velocity of the body at the top, bottom and at the middle of a circle with two distinct cases:

i. path is convex

ii. path is concave

Remember in both the cases, formula will be different.

i. $\frac{mv^2}{r} = mg - N$ where N is normal reaction.

ii. $\frac{mv^2}{r} = N - mg$

Remember if in the question, it is given that body falls from a certain point then at that point N = 0.

14. In horizontal circle, tension will be equal to centripetal force i.e. $T = \frac{mv^2}{r}$

i. The minimum velocity of projection at the lowest point of vertical circle so that the string slacken at the highest point, is given by $v_L = \sqrt{5gr}$

ii. velocity at the highest point is $v_H = \sqrt{gr}$

15. When

i. $v_L = \sqrt{2gr}$, the body moves in a vertical semicircle about the lowest point L,

ii. $v_L < \sqrt{2gr}$, then the body oscillates in a circular arc smaller than the semicircle.

iii. For a motor cyclist to loop a vertical loop, $v_L > \sqrt{5gr}$ and $v_H > \sqrt{gr}$

16. The distance travelled by the particle performing uniform circular motion in t seconds is given by the formula, $d = \frac{2\pi r}{T}t$.

17. If a rod falls, apply the formula,

$\frac{1}{2}I\omega^2 = mg \times \left(\frac{L}{2}\right)$ where L is the length of the rod because when the rod falls, centre of mass travels a vertical distance of $\frac{L}{2}$ and I will be equal to $\frac{mL^2}{3}$.

18. If there is a change in mass or distribution of mass for example, for a piece of wax falling on rotating rod, apply the formula, $I_1\omega_1 = I_2\omega_2$.

19. Whenever the body falls from an inclined plane, apply $mgh = \frac{1}{2}I\omega^2 + \frac{1}{2}mv^2$ and always remember, acceleration of a rolling body is given by $\frac{g\sin\theta}{\left(1+\frac{K^2}{R^2}\right)}$. Therefore, body for which $\left(\frac{K^2}{R^2}\right)$ is smallest, will fall first.

20. The condition for a body to roll down the inclined plane without slipping:

$$\mu \geq \left[\frac{K^2}{K^2+R^2}\right]\tan\theta$$

where μ = coefficient of limiting friction (μ)

21. A body cannot roll down an inclined plane when the friction is absent.

For this situation, the relative values of μ for rolling without slipping down the inclined plane are:

$\mu_{ring} > \mu_{shell} > \mu_{disc} > \mu_{solid\ sphere}$

22. The ratio of moments of inertia of two discs of the same mass and same thickness but of different densities is given by $\frac{I_1}{I_2} = \frac{R_1^2}{R_2^2} = \frac{d_2}{d_1}$

23. To find ratios of different K.E., use

i. $$\frac{\text{Rotational K.E.}}{\text{Total K.E.}} = \frac{\frac{K^2}{R^2}}{\left(1+\frac{K^2}{R^2}\right)}$$

ii. $$\frac{\text{Linear K.E.}}{\text{Total K.E.}} = \frac{1}{\left(1+\frac{K^2}{R^2}\right)}$$

Classical Thinking

1.2 Characteristics of Circular Motion

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

2. 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.

3. 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) $\vec{v} = \vec{r} - \vec{\omega}$

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

5. 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

6. 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

7. 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

8. 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

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/π Hz
(C) 20/2π Hz (D) 40 Hz

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

11. Calculate the angular acceleration of a centrifuge which is accelerated from rest to 350 r.p.s. in 220 s.
(A) 10 rad s^{-2} (B) 20 rad s^{-2}
(C) 25 rad s^{-2} (D) 30 rad s^{-2}

12. 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

13. 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

14. 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.

15. A particle performing uniform circular motion has
(A) radial velocity and radial acceleration.
(B) radial velocity and transverse acceleration.
(C) transverse velocity and radial acceleration.
(D) transverse velocity and transverse acceleration.

16. **Assertion:** In circular motion, the centripetal and centrifugal forces acting in opposite direction balance each other.
Reason: Centripetal and centrifugal forces don't act at the same time.
(A) Assertion is True, Reason is True; Reason is a correct explanation for Assertion
(B) Assertion is True, Reason is True; Reason is not a correct explanation for Assertion
(C) Assertion is True, Reason is False
(D) Assertion is False but Reason is True.

17. When a body moves with a constant speed along a circle,
(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.

18. In uniform circular motion,
(A) both the angular velocity and the angular momentum vary.
(B) the angular velocity varies but the angular momentum remains constant.
(C) both the angular velocity and the angular momentum remains constant.
(D) the angular momentum varies but the angular velocity remains constant.

19. **Assertion:** If a body moving in a circular path has constant speed, then there is no force acting on it.
Reason: The direction of the velocity vector of a body moving in a circular path is changing.
(A) Assertion is True, Reason is True; Reason is a correct explanation for Assertion
(B) Assertion is True, Reason is True; Reason is not a correct explanation for Assertion
(C) Assertion is True, Reason is False
(D) Assertion is False but Reason is True.

20. A particle is moving on a circular path with constant speed, then its acceleration will be
(A) zero.
(B) external radial acceleration.
(C) internal radial acceleration.
(D) constant acceleration.

21. 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.

22. 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.

23. 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.

24. 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

25. 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.

26. 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.

27. If the angle between tangential acceleration and resultant acceleration in non U.C.M. is α, then direction of the resultant acceleration will be
(A) $\tan^{-1}\left(\frac{a_t}{a_r}\right)$ (B) $\tan^{-1}\left(\frac{a_r}{a_t}\right)$
(C) $\tan^{-1}\left(\frac{a_r}{a_\alpha}\right)$ (D) $\tan^{-1}\left(\frac{a_t}{a_\alpha}\right)$

28. The force required to keep a body in uniform circular motion is
(A) centripetal force.
(B) centrifugal force.
(C) frictional force.
(D) breaking force.

29. Select the WRONG statement.
(A) Centrifugal force has same magnitude as that of centripetal force.
(B) Centrifugal force is along the radius, away from the centre.
(C) Centrifugal force exists in inertial frame of reference.
(D) Centrifugal force is called pseudo force, as its origin cannot be explained.

30. The centripetal acceleration is given by
(A) v^2/r (B) vr (C) vr^2 (D) v/r

31. An important consequence of centrifugal force is that the earth is,
(A) bulged at poles and flat at the equator.
(B) flat at poles and bulged at the equator.
(C) high tides and low tides.
(D) rising and setting of sun.

32. When a car is going round a circular track, the resultant of all the forces on the car in an inertial frame is
(A) acting away from the centre.
(B) acting towards the centre.
(C) zero.
(D) acting tangential to the track.

33. Place a coin on gramophone disc near its centre and set the disc into rotation. As the speed of rotation increases, the coin will slide away from the centre of the disc. The motion of coin is due to
(A) radial force towards centre.
(B) non-conservative force.
(C) centrifugal force.
(D) centripetal force.

34. If p is the magnitude of linear momentum of a particle executing a uniform circular motion, then the ratio of centripetal force acting on the particle to its linear momentum is given by
(A) $\frac{r}{v}$ (B) $\frac{v^2}{pr}$ (C) $\frac{v}{r}$ (D) vr

35. Two particles of equal masses are revolving in circular paths of radii r_1 and r_2 respectively with the same speed. The ratio of their centripetal forces is
(A) $\frac{r_2}{r_1}$ (B) $\sqrt{\frac{r_2}{r_1}}$
(C) $\left(\frac{r_1}{r_2}\right)^2$ (D) $\left(\frac{r_2}{r_1}\right)^2$

36. A 10 kg object attached to a nylon cord outside a space vehicle is rotating at a speed of 5 m/s. If the force acting on the cord is 125 N, its radius of path is
(A) 2 m (B) 4 m (C) 6 m (D) 1 m

37. The breaking tension of a string is 50 N. A body of mass 1 kg is tied to one end of a 1 m long string and whirled in a horizontal circle. The maximum speed of the body should be
(A) $5\sqrt{2}$ m/s (B) 10 m/s
(C) 7.5 m/s (D) 5 m/s

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

1.3 Applications of Uniform Circular Motion

39. The safety speed of a vehicle on a curve horizontal road is
(A) μrg (B) $\sqrt{\mu rg}$
(C) $\mu r^2 g$ (D) $\mu/(rg)^2$

40. The safe speed of a vehicle on a horizontal curve road is independent of
(A) mass of vehicle.
(B) coefficient of friction between road surface and tyre of vehicle.
(C) radius of curve.
(D) acceleration due to gravity.

Page no. **11** to 47 are purposely left blank.

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

Answer Key

Classical Thinking

1.	(B)	2.	(A)	3.	(A)	4.	(C)	5.	(A)	6.	(D)	7.	(B)	8.	(C)	9.	(A)	10.	[illegible]
11.	(A)	12.	(B)	13.	(B)	14.	(D)	15.	(C)	16.	(D)	17.	(C)	18.	(C)	19.	(D)	20.	(C)
21.	(A)	22.	(B)	23.	(C)	24.	(D)	25.	(D)	26.	(A)	27.	(B)	28.	(A)	29.	(C)	30.	[illegible]
31.	(B)	32.	(B)	33.	(C)	34.	(C)	35.	(A)	36.	(A)	37.	(A)	38.	(C)	39.	(B)	40.	(A)
41.	(C)	42.	(C)	43.	(B)	44.	(A)	45.	(D)	46.	(C)	47.	(A)	48.	(B)	49.	(B)	50.	(C)
51.	(B)	52.	(C)	53.	(C)	54.	(C)	55.	(A)	56.	(C)	57.	(A)	58.	(B)	59.	(B)	60.	(D)
61.	(C)	62.	(C)	63.	(B)	64.	(C)	65.	(D)	66.	(B)	67.	(A)	68.	(C)	69.	[illegible]	70.	(A)
71.	(B)	72.	(D)	73.	(A)	74.	(C)	75.	(A)	76.	(A)	77.	(A)	78.	[illegible]	79.	(B)	80.	(C)
81.	(A)	82.	(B)	83.	(B)	84.	(B)	85.	(D)	86.	(D)	87.	(C)	88.	(C)	89.	[illegible]	90.	(B)
91.	(D)	92.	(C)	93.	(C)	94.	(A)	95.	(C)	96.	(B)	97.	(C)	98.	(D)	99.	(C)	100.	(D)
101.	(B)	102.	(B)	103.	(B)	104.	(C)	105.	(A)	106.	(A)	107.	(D)	108.	(B)	109.	(D)	110.	(A)
111.	(D)	112.	(A)	113.	(B)	114.	(C)	115.	(C)	116.	(A)	117.	(A)	118.	(D)	119.	(A)	120.	(B)
121.	(D)																		

Critical Thinking

1.	(D)	2.	(C)	3.	(A)	4.	(A)	5.	(B)	6.	(D)	7.	(C)	8.	(B)	9.	(A)	10.	(B)
11.	(A)	12.	(C)	13.	(A)	14.	(C)	15.	(C)	16.	(D)	17.	(B)	18.	(B)	19.	(B)	20.	(C)
21.	(C)	22.	(C)	23.	(D)	24.	(D)	25.	(C)	26.	[illegible]	27.	(B)	28.	(D)	29.	(D)	30.	(D)
31.	(A)	32.	(C)	33.	(C)	34.	(B)	35.	(C)	36.	(C)	37.	(B)	38.	(B)	39.	(C)	40.	(B)
41.	(D)	42.	(A)	43.	(A)	44.	(B)	45.	[illegible]	46.	(B)	47.	(D)	48.	(D)	49.	(D)	50.	(B)
51.	(B)	52.	(D)	53.	(B)	54.	(A)	55.	(D)	56.	(B)	57.	(B)	58.	(B)	59.	(C)	60.	(B)
61.	(C)	62.	(A)	63.	(B)	64.	(D)	65.	(B)	66.	(A)	67.	(A)	68.	(D)	69.	(D)	70.	(D)
71.	(A)	72.	(D)	73.	(B)	74.	[illegible]	75.	(B)	76.	(D)	77.	(A)	78.	(A)	79.	(A)	80.	(A)
81.	(C)	82.	(C)	83.	(B)	84.	(D)	85.	(B)	86.	(B)	87.	(A)	88.	(C)	89.	(C)	90.	(D)
91.	(B)	92.	(A)	93.	[illegible]	94.	[illegible]	95.	(C)	96.	(B)	97.	(A)	98.	(D)	99.	(A)	100.	(C)
101.	(D)	102.	(A)	103.	(C)	104.	[illegible]	105.	(D)	106.	(A)	107.	(A)	108.	(B)	109.	(B)	110.	(B)
111.	(B)	112.	(C)	113.	[illegible]	114.	(B)	115.	(B)	116.	(B)	117.	(A)	118.	(D)	119.	(B)	120.	(D)
121.	(B)	122.	(A)	123.	(C)	124.	(A)	125.	(B)	126.	(A)	127.	(B)	128.	(A)	129.	(A)	130.	(A)
131.	(C)	132.	(D)	133.	(A)	134.	(C)	135.	(D)	136.	(C)	137.	(B)	138.	(A)	139.	(A)	140.	(A)
141.	(C)	142.	[illegible]	143.	(C)	144.	(C)	145.	(B)	146.	(C)	147.	(D)	148.	(A)	149.	(C)	150.	(B)
151.	(D)	152.	(D)	153.	(A)	154.	(C)	155.	(B)	156.	(B)	157.	(A)	158.	(B)	159.	(B)	160.	(B)
161.	[illegible]	162.	(A)	163.	(B)	164.	(C)	165.	(A)	166.	(C)	167.	(A)	168.	(D)	169.	(C)	170.	(B)
171.	(A)	172.	(A)	173.	(A)	174.	(B)	175.	(B)	176.	(A)	177.	(A)	178.	(D)	179.	(D)	180.	(A)
181.	(C)	182.	(A)	183.	(A)	184.	(D)	185.	(C)	186.	(B)	187.	(B)	188.	(B)	189.	(C)	190.	(D)
191.	[illegible]	192.	(B)	193.	(B)	194.	(C)	195.	(B)	196.	(D)	197.	(C)	198.	(C)	199.	(C)	200.	(A)
201.	(B)	202.	(A)	203.	(B)	204.	(C)	205.	(C)	206.	(A)	207.	(A)	208.	(A)	209.	(C)	210.	(D)
211.	(A)	212.	(B)	213.	(D)	214.	(C)	215.	(A)	216.	(C)	217.	(A)	218.	(D)	219.	(D)	220.	(C)
221.	(A)	222.	(C)	223.	(C)	224.	(C)	225.	(D)	226.	(A)	227.	(B)	228.	(C)	229.	(C)	230.	(B)
231.	(B)	232.	(C)	233.	(C)	234.	(A)	235.	(A)	236.	(C)	237.	(D)	238.	(B)	239.	(C)	240.	(C)
241.	(A)	242.	(D)	243.	(B)	244.	(B)	245.	(C)	246.	(A)	247.	(C)	248.	(B)	249.	(D)	250.	(A)
251.	(A)	252.	(B)	253.	(A)	254.	(D)	255.	(A)	256.	(A)	257.	(A)	258.	(B)	259.	(C)	260.	(D)
261.	(B)	262.	(A)	263.	(B)	264.	(B)	265.	(B)	266.	(D)	267.	(A)	268.	(A)	269.	(C)	270.	(A)
271.	(A)	272.	(A)	273.	(B)	274.	(A)	275.	(C)	276.	(C)	277.	(A)						

Competitive Thinking

1.	(C)	2.	(B)	3.	(B)	4.	(C)	5.	(A)	6.	(B)	7.	(D)	8.	(C)	9.	(C)	10.	(C)
11.	(D)	12.	(D)	13.	(B)	14.	(A)	15.	(D)	16.	(D)	17.	(B)	18.	(A)	19.	(B)	20.	(D)
21.	(A)	22.	(D)	23.	(B)	24.	(A)	25.	(A)	26.	(A)	27.	(B)	28.	(B)	29.	(D)	30.	(A)
31.	(A)	32.	(B)	33.	(A)	34.	(B)	35.	(D)	36.	(C)	37.	(A)	38.	(B)	39.	(B)	40.	[illegible]
41.	(C)	42.	(B)	43.	(D)	44.	(B)	45.	(B)	46.	(B)	47.	(D)	48.	(B)	49.	(C)	50.	(C)
51.	(B)	52.	(C)	53.	(A)	54.	(B)	55.	(D)	56.	(A)	57.	(C)	58.	(D)	59.	(A)	60.	(B)
61.	(C)	62.	(C)	63.	(B)	64.	(D)	65.	(C)	66.	(D)	67.	(D)	68.	(B)	69.	(A)	70.	(A)
71.	(D)	72.	(B)	73.	(A)	74.	(D)	75.	(B)	76.	(A)	77.	(B)	78.	(D)	79.	(C)	[illegible]	(A)
81.	(D)	82.	(C)	83.	(A)	84.	(B)	85.	(B)	86.	(B)	87.	(B)	88.	(A)	89.	[illegible]	90.	(C)
91.	(D)	92.	(C)	93.	(A)	94.	(A)	95.	(A)	96.	(D)	97.	(A)	98.	(A)	99.	(A)	100.	[illegible]
101.	(B)	102.	(D)	103.	(C)	104.	(A)	105.	(C)	106.	(C)	107.	(A)	108.	(D)	[illegible]	[illegible]	[illegible]	(B)
111.	(D)	112.	(B)	113.	(B)	114.	(B)	115.	(C)	116.	(A)	117.	(C)	118.	[illegible]				

Evaluation Test

1. Angular velocity of hour arm of a clock, in rad/s, is

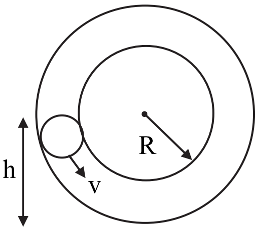
(A) $\frac{\pi}{43200}$ (B) $\frac{\pi}{21600}$

(C) $\frac{\pi}{30}$ (D) $\frac{\pi}{1800}$

2. 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

3. With what minimum speed v must a small ball be pushed inside a smooth vertical tube from a height h so that it may reach the top of the tube?



(A) $\sqrt{2g(h+2R)}$

(B) [illegible]

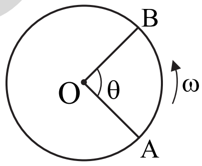
(C) $\sqrt{g(5R-2h)}$

(D) $\sqrt{2g(2R-h)}$

4. A wheel rotates with constant acceleration of 2.0 rad/s^2. If the wheel has an initial angular velocity of 4 rad/s, then the number of revolutions it makes in the first ten seconds will be approximately,

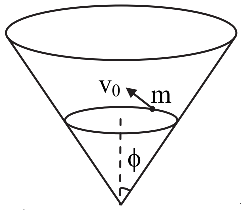
(A) 16 (B) 22
(C) 24 (D) 20

5. A circular disc of radius R is rotating about its axis through O with uniform angular velocity ω rad/s as shown. The magnitude of velocity of A relative to B is



(A) zero (B) Rω sin (θ/2)
(C) 2Rω sin (θ/2) (D) $\sqrt{3}$ Rω sin (θ/2)

6. Consider an object of mass m that moves in a circular orbit with constant velocity v_0 along the inside of a cone. Assume the wall of the cone to be frictionless. Find radius of the orbit.



(A) $\frac{v_0^2}{g}\tan^2\phi$ (B) $\frac{v_0^2}{g}\cos^2\phi$

(C) $\frac{v_0^2}{g}\tan\phi$ (D) $\frac{v_0^2}{g}$

7. A bullet is moving horizontally with certain velocity. It pierces two paper discs rotating co-axially with angular speed ω separated by a distance l. If the hole made by bullet on second disc is shifted by an angle θ with respect to the first, find velocity of bullet.

(A) ωl (B) $\frac{l\theta}{\omega}$

(C) $\omega\frac{l}{\theta}$ (D) $\omega l(\theta)^2$

8. If a particle moves with uniform speed then its tangential acceleration will be

(A) $\frac{v^2}{r}$ (B) zero

(C) $r\omega^2$ (D) infinite

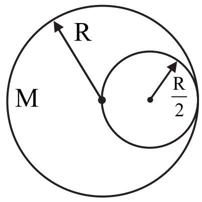
9. 

Figure shows a sphere from which a small sphere is excavated. Find the MI of this system about the centre of bigger circle.

(A) $\frac{51}{140}MR^2$ (B) $\frac{37}{140}MR^2$

(C) $\frac{27}{70}MR^2$ (D) $\frac{3}{14}MR^2$

10. A particle comes round a circle of radius 1 m once. The time taken by it is 10 s. The average velocity of motion is

(A) 0.2π m/s (B) 2π m/s

(C) 2 m/s (D) zero

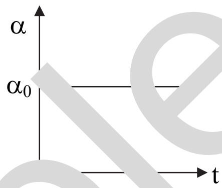
11. Given is the α-t graph for a car wheel, where brakes produce an acceleration α. Which of the following can be the form of θ – t graph?

(A) Straight line

(B) Parabola

(C) Circle

(D) Hyperbola

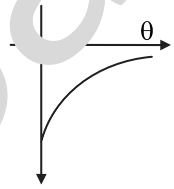


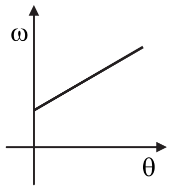
12. The diameter of a fly wheel is [illegible] m and it makes 900 revolutions per minute. Calculate the acceleration at a point on its rim.

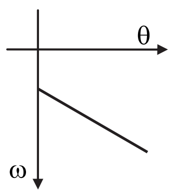
(A) $540\ \pi^2\ m/s^2$ (B) [illegible]70 m/s^2

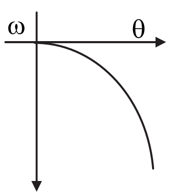
(C) $360\ \pi^2\ m/s^2$ (D) 54[illegible] m/s^2

13. The graphs below show angular velocity as a function of θ. In which one of these is the magnitude of angular velocity constantly decreasing with time?

(A) 

(B) 

(C) 

(D) 

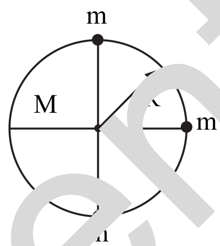
14. A solid cylinder of mass M and radius R is pivoted at its centre and three particles of mass m are fixed at the perimeter of the cylinder. Find the angular velocity of the cylinder after the system has moved through 90°.

(A) $\sqrt{\frac{Mg}{R(M+6m)}}$

(B) $\sqrt{\frac{4mg}{R(M+6m)}}$

(C) $\sqrt{\frac{2Mg}{R(M+6m)}}$

(D) $\sqrt{\frac{3mg}{R(M+6m)}}$



15. If a tension in a string is [illegible] N. A load at the lower end of a string is 0.1 kg, the length of string is 6 m then find its angular velocity ($g = 10\ m/s^2$)

(A) [illegible] rad/s (B) 4 rad/s

(C) 2 rad/s (D) 1 rad/s

16. The maximum speed of a car on a road–turn of radius 30 m, if the coefficient of friction between the tyres and the road is 0.4, will be

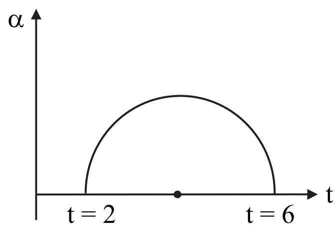
(A) 10.84 m/s

(B) 9.84 m/s

(C) 8.84 m/s

(D) 6.84 m/s

17. For the given situation as shown in the graph, the initial angular velocity of the particle is 2π rad/s. What will be the final angular velocity if the particle follows the given α – t graph?



(A) 3π rad/s (B) 4π rad/s

(C) 5π rad/s (D) 6π rad/s

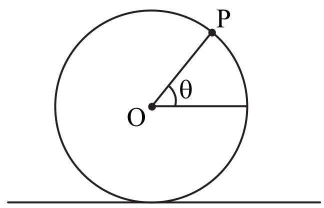
18. A disc is in pure rolling motion with a velocity v on a rough horizontal surface. The resultant velocity of a point P at an angle θ with the horizontal would be

(A) $2\ v\cos\left(\frac{\theta}{2}\right)$

(B) $2\ v\sin\left(\frac{\theta}{2}\right)$

(C) v

(D) 2 v



19. A thin rod is placed co-axially within a thin hollow tube which lies on a smooth horizontal table. The rod having the same mass 'M' and length 'L' as that of tube is free to move within the tube. The system is given an angular velocity 'ω' about a vertical axis from one of its ends. Considering negligible friction between surfaces, find the angular velocity of the rod as it just slips out of the tube.

(A) $\frac{\omega}{2}$ (B) $\frac{\omega}{4}$

(C) $\frac{\omega}{3}$ (D) ω

20. A sphere rolls on the surface with velocity v. It encounters a smooth frictionless incline of height h which it needs to climb. What will be the minimum velocity for which it will climb the incline?

(A) $\sqrt{\frac{10}{7}gh}$ (B) $\sqrt{gh}$

(C) $\sqrt{\frac{5}{2}gh}$ (D) $\sqrt{2gh}$

Answers to Evaluation Test

1.	(B)	2.	(C)	3.	(D)	4.	(B)
5.	(C)	6.	(C)	7.	(C)	8.	[illegible]
9.	(A)	10.	(D)	11.	(B)	12.	(A)
13.	(A)	14.	(B)	15.	(A)	16.	[illegible]
17.	(B)	18	(B)	19.	(B)	20.	(D)

The Answers to Physics of...

1. *A trapeze act in circus*

When the man and his partner are stationary, the man's arms must support his partner's weight. When the two are swinging, however, the man's arms must do an additional job. Then the partner is moving on a circular arc and has a centripetal acceleration. The man's arms must exert an additional pull so that there will be sufficient centripetal force to produce this acceleration. Because of the additional pull, it is harder for the man to hold his partner while swinging than while stationary.

2. *Riding the bicycle in a loop the loop*

A key idea in analyzing the stunt is to assume that rider and his bicycle travel through the top of the loop as a single particle in uniform circular motion. Thus, at the top, the acceleration $\vec{a}$ of this particle must have the magnitude $a = v^2/R$ and be directed downwards, toward the centre of the circular loop.

The gravitational force $\vec{F}_g$ is directed downward along a y-axis. The normal force $\vec{N}$ on the particle from the loop is also directed downward. Thus, Newton's second law for y-axis components ($F_{net,y} = ma_y$) gives us

$$-N - F_g = m(-a)$$

$$\therefore \quad -N - mg = m\left(\frac{v^2}{R}\right) \quad \ldots(1)$$

Another Key idea is that if the particle has the least speed v needed to remain in contact, then it is on the verge of losing contact with the loop (falling away from the loop), which means that N = 0. Substituting this value for N into Equation (1) gives $v = \sqrt{gR}$

The rider has to make certain that his speed at the top of the loop is greater than $\sqrt{gR}$ so that he does not lose contact with the loop and fall away from it. Note that this speed requirement is independent of mass rider and his bicycle.

3. *Spinning ice skater*

Choosing the skater as the system, we can apply the conservation principle provided that the net external torque produced by air resistance and by friction between the skates and the ice is negligibly small. We assume it is to be negligible. Then the skater in first half of figure would spin forever at the same angular velocity, since her angular momentum is conserved in the absence of a net external torque. In the second half of figure, the inward movement of her arms and leg involves internal and not external torques and therefore, does not change her angular momentum. But angular momentum is the product of the moment of inertia I and angular velocity ω. By moving the mass of her arms and leg inward, the skater decreases the distance r of the mass from the axis of rotation and consequently, decreases her moment of inertia I ($I = \sum mr^2$). If the product of I and ω is to remain constant, then ω must increase. Thus, by pulling her arms and leg inward, she spins with a larger angular velocity.