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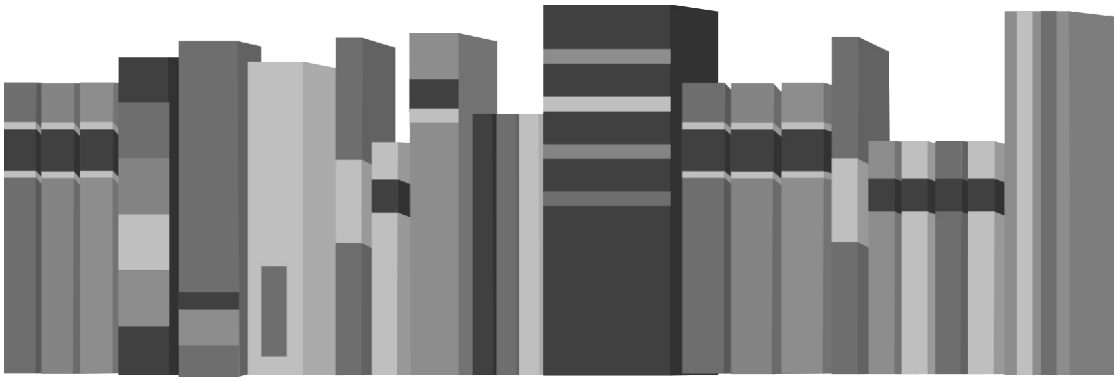

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Note : *Solutions of the Examination Paper are given within the book in their respective chapters / topics.*

PREFACE

Malcolm Forbes said ***"Education's purpose is to replace an empty mind with an open one"*** *and this is something which is always followed by* ***Maharashtra State Board of Secondary & Higher Education (MSBSHSE).*** *The aim of the Board is not just to let learners obtain basic knowledge but to make them life-long learners.*

The purpose of this book is to nurture individuality and thus enhance one's innate potentials which help in increasing the self-study mode for students. This book strengthens knowledge and attitude related to subject. This book is designed in such a way that students can set their own goals and can improve their problem solving and thinking skills.

This book is strictly as per the latest ***Maharashtra Board Curriculum for HSC Exams.*** *It contains variety of questions from latest textbooks. It contains all types of questions like VSA Questions (Very Short Answer), SA Questions (Short Answer), MCQs (Multiple Choice Questions) and LA Questions (Long Answer). A synopsis is given for every chapter which contains important points from that chapter. Each chapter has high quality figures wherever required for better, fast and clear understanding.*

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1. **Circular motion**

   Angular displacement, Angular velocity and angular acceleration, Relation between linear velocity and angular velocity, Uniform circular motion, Radial acceleration, Centripetal and centrifugal forces, Banking of roads, Vertical circular motion due to earth's gravitation, Equation for velocity and energy at different positions of vertical circular motion. Kinematical equations for circular motion in analogy with linear motion.

2. **Gravitation**

   Newton's law of gravitation, Projection of satellite, Periodic time, Statement of Kepler's laws of motion, Binding energy and escape velocity of a satellite, Weightlessness condition in orbit, Variation of 'g' due to altitude, lattitude, depth and motion, Communication satellite and its uses.

3. **Rotational motion**

   Definition of M.I., K.E. of rotating body, Rolling motion, Physical significance of M.I., Radius of gyration, Torque, Principle of parallel and perpendicular axes, M.I. of some regular shaped bodies about specific axes, Angular momentum and its conservation.

4. **Oscillations**

   Explanation of periodic motion, S.H.M., Differential equation of linear S.H.M. Projection of U.C.M. on any diameter, Phase of S.H.M., K.E. and P.E. in S.H.M., Composition of two S.H.M.'s having same period and along same line, Simple pendulum, Damped S.H.M.

5. **Elasticity**

   General explanation of elastic property, Plasticity, Deformation, Definition of stress and strain, Hooke's law, Poisson's ratio, Elastic energy, Elastic constants and their relation, Determination of 'Y', Behaviour of metal wire under increasing load, Applications of elastic behaviour of materials.

6. **Surface tension**

   Surface tension on the basis of molecular theory, Surface energy, Surface tension, Angle of contact, Capillarity and capillary action, Effect of impurity and temperature on surface tension.

7. **Wave motion**

   Simple harmonic progressive waves, Reflection of transverse and longitudinal waves, Change of phase, Superposition of waves, Formation of beats, Doppler effect in sound.

8. **Stationary waves**

   Study of vibrations in a finite medium, Formation of stationary waves on string, Study of vibrations of air columns, Free and Forced vibrations, Resonance.

9. **Kinetic theory of gases and Radiation**

   Concept of an ideal gas, Assumptions of kinetic theory, Mean free path, Derivation for pressure of a gas, Degrees of freedom, Derivation of Boyle's law, Thermodynamics- Thermal equilibrium and definition of temperature, 1st law of thermodynamics, 2nd law of thermodynamics, Heat engines and refrigerators, Qualitative idea of black body radiation,Wein's displacement law, Green house effect, Stefan's law, Maxwell distribution, Law of equipartition of energy and application to Specific heat capacities of gases.

10. **Wave theory of light**

    Wave theory of light, Huygens' Principle, Construction of plane and spherical wave front, Wave front and wave normal, Reflection at plane surface, Refraction at plane surface, Polarisation, Polaroids, Plane polarised light, Brewster's law, Doppler effect in light.

11. **Interference and diffraction**

    Interference of light, Conditions for producing steady interference pattern, Young's experiment, Analytical treatment of interference bands, Measurement of wavelength by biprism experiment, Diffraction due to single slit, Rayleigh's criterion, Resolving power of a microscope and telescope, Difference between interference and diffraction.

12. Electrostatics

Gauss' theorem proof and applications, Mechanical force on unit area of a charged conductor, Energy density of a medium, Dielectrics and electric polarisation, Concept of condenser, Capacity of parallel plate condenser, Effect of dielectric on capacity, Energy of charged condenser, Condensers in series and parallel, van-de- Graaff generator.

13. Current electricity

Kirchhoff's law, Wheatstone's bridge, Meter bridge, Potentiometer.

14. Magnetic effects of electric current

Ampere's law and its applications, Moving coil galvanometer, Ammeter, Voltmeter, Sensitivity of moving coil galvanometer, Cyclotron.

15. Magnetism

Circular current loop as a magnetic dipole, Magnetic dipole moment of revolving electron, Magnetisation and magnetic intensity, Diamagnetism, Paramagnetism, Ferromagnetism on the basis of domain theory, Curie temperature.

16. Electromagnetic inductions

Laws of electromagnetic induction, proof of, Eddy currents, Self induction and mutual induction,

Need for displacement current, Transformer, Coil rotating in uniform magnetic induction, Alternating currents, Reactance and impedance, LC oscillations (qualitative treatment only) Power in a.c circuit with resistance, inductance and capacitance, Resonant circuit, Wattless current, AC generator.

17. Electrons and photons

Photoelectric effect, Hertz and Lenard's observations, Einstein's equation, Particle nature of light.

18. Atoms, Molecules and Nuclei

Alpha particle scattering experiment, Rutherford's model of atom. Bohr's model, Hydrogen spectrum, Composition and size of nucleus, Radioactivity, Decay law, massenergy relation, mass defect, B.E. per nucleon and its variation with mass number, Nuclear fission and fusion, de Broglie hypothesis, Matter waves – wave nature of particles, Wavelength of an electron, Davisson and Germer experiment, Continuous and characteristics X-rays.

19. Semiconductors

Energy bands in solids, Intrinsic and extrinsic semiconductors, P-type and Ntype semiconductor, P-N junction diode, I-V characteristics in forward and reverse bias, Rectifiers, Zener diode as a voltage regulator, Photodiode, Solar cell, I-V characteristics of LED, Transistor action and its characteristics, Transistor as an amplifier (CE mode), Transistor as a switch, Oscillators and Logic gates (OR, AND, NOT, NAND, NOR)

20. Communication systems

Elements of communication system, bandwidth of signals, bandwidth of transmission medium, Need for modulation, Production and detection of an amplitude modulated wave, space communication, Propagation of electromagnetic waves in atmosphere.

List of Practicals

1. To determine Young's modulus of elasticity of the material of a given wire.
2. To find the force constant and effective mass of helical spring by plotting T^2--m graph using method of oscillations.
3. To determine the surface tension of water by capillary rise method.
4. To study the relationship between the temperature of a hot body and time by plotting a cooling curve.
5. To study the relation between frequency and length of a given wire under constant tension using sonometer.
6. To study the relation between the length of a given wire and tension for constant frequency using sonometer.

7. To find the speed of sound in air at room temperature using a resonance tube.
8. To find resistance of given wire using metre bridge and hence determine the specific resistance of its material.
9. To verify the laws of combination (series/ parallel) of resistances using a metre bridge.
10. To compare the emf of two given cells using potentiometer.
11. To determine the internal resistance of given cell using potentiometer.
12. To determine resistance of galvanometer using metre bridge.
13. To draw the I-V characteristic curves of a p-n junction diode in forward bias and reverse bias.
14. To study the characteristics of a commonemitter npn or pnp transistor and to find out the values of current and voltage gains.
15. To draw the characteristic curve of a zener diode and to determine its reverse break down voltage.

List of Activities

1. To study dissipation of energy of a simple pendulum by plotting a graph between square of amplitude and time.
2. To study the effect of detergent on surface tension by observing capillary rise.
3. To study the factors affecting the rate of loss of heat of a liquid.
4. To study the effect of load on depression of a suitably clamped meter scale loaded
   (i) at its end (ii) in the middle.
5. To measure the resistance and impedance of an inductor with or without iron core.
6. To study the variation in potential drop with length of a wire for a steady current.
7. To draw the diagram of a given open circuit comprising at least a battery, resistor/ rheostat, key, ammeter and voltmeter. Mark the components that are not connected in proper order and correct the circuit and also the circuit diagram.
8. To study effect of intensity of light (by varying distance of the source) on an L.D.R.
9. To identify a diode, an LED, a transistor, and 1C, a resistor and a capacitor from mixed collection of such items.
10. Use of multimeter to
    (i) identify base of transistor
    (ii) distinguish between npn and pnp type transistors,
    (iii) see the unidirectional flow of current in case of a diode and an LED
    (iv) check whether a given electronic component (e.g. diode, transistor or IC) is in working order.
11. To observe polarization of light using two polaroids.
12. To assemble a household circuit comprising three bulbs, three (on/off) switches, a fuse and a power source.

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Solved Paper	Maharashtra HSC Exam March 2017 Set No. J - 531	Physics

Time : 3 Hours **Max. Marks : 70**

Note :

(i) All questions are compulsory.
(ii) Neat diagrams must be drawn wherever necessary.
(iii) Figures to the right indicate full marks.
(iv) Use of only logarithmic tables is allowed.
(v) All symbols have their usual meaning unless otherwise stated.
(vi) Answers to both sections must be written in the same answer book.
(vii) Answer to every questions must be written on a new page.

SECTION-I

1. Select and write the most appropriate answer from the given alternatives for each sub-questions : [7]

(i) If the pressure of an ideal gas decreases by 10 % isothermally, then its volume will ..... .
(a) decrease by 9% (b) increase by 7%
(c) increase by 10% (d) increase by 11.4%

(ii) Stretching of a rubber band results in ..... .
(a) no change in potential energy (b) zero value of potential energy
(c) increase in potential energy (d) decrease in potential energy.

(iii) When the angular acceleration of a rotating body is zero, which physical quantity will be equal to zero ?
(a) Angular momentum (b) Moment of inertia
(c) Torque (d) Radius of gyration

(iv) In a damped harmonic oscillator, periodic oscillations have ..... amplitude.
(a) gradually increasing (b) suddenly increasing
(c) suddenly decreasing (d) gradually decreasing

(v) A sine wave of wavelength 'λ' is travelling in a medium. What is the minimum distance between two particles of the medium which always have the same speed ?
(a) λ (b) $\frac{\lambda}{2}$
(c) $\frac{\lambda}{3}$ (d) $\frac{\lambda}{4}$

(vi) Velocity of a transverse wave along a stretched string is proportional to ..... . (T = tension in the string)
(a) $\sqrt{T}$ (b) T
(c) $\frac{1}{\sqrt{T}}$ (d) $\frac{1}{T}$

(vii) Find the wavelength at which a black body radiates maximum energy, if its temperature is 427° C.
(Wein's constant $b = 2.898 \times 10^{-3}$ mK)
(a) 0.0414×10^{-6} m (b) 4.14×10^{-6} m
(c) 41.4×10^{-6} m (d) 414×10^{-6} m

2. Attempt Any SIX :

(i) Explain the concept of centripetal force.
(ii) Prove that root mean square velocity of gas molecule is directly proportional to the square root of its absolute temperature.
(iii) Obtain the differential equation of linear simple harmonic motion.

(iv) Draw a neat, labelled diagram for a liquid surface in contact with a solid, when the angle of contact is acute.

(v) A hole is drilled half way to the centre of the Earth. A body is dropped into the hole. How much will it weigh at the bottom of the hole if the weight of the body on the Earth's surface is 350 N ?

(vi) A solid sphere of mass 1 kg rolls on a table with linear speed 2 m/s, find its total kinetic energy.

(vii) A transverse wave is produced on a stretched string 0.9 m long and fixed at its ends. FInd the speed of the transverse wave, when the string vibrates while emitting second overtone of frequency 324 Hz.

(viii) A body cools at the rate of 0.5 °C/minute when it is 25°C above the surroundings. Calculate the rate of cooling when it is 15° C above the same surroundings.

3. Attempt any THREE :

(i) Show that period of a satellite revolving around the Earth depends upon mass of the Earth.

(ii) Obtain an expression for torque acting on a rotating body with constant angular acceleration. Hence state the dimensions and SI unit of torque.

(iii) The total energy of free surface of a liquid drop is 2π times the surface tension of the liquid. What is the diameter of the drop ?

[Assume all terms in SI unit]

(iv) A vehicle is moving on a circular track whose surface is inclined towards the horizon at an angle of 10°. The maximum velocity with which it can move safely is 36 km/hr. Calculate the length of the circular track. [π = 3.142]

4. Prove the law of conservation of energy for a particle performing simple harmonic motion. Hence graphically show the variation of kinetic energy and potential energy w.r.t. instantaneous displacement.

Two sound notes have wavelengths $\frac{83}{170}$ m and $\frac{83}{172}$ m in the air. These notes when sounded together produce 8 beats per second. Calculate the velocity of sound in the air and frequencies of the two notes.

OR

Explain the formation of stationary waves by analytical method. Show the formation of stationary wave diagramatically.

A mass of 1 kg is hung from a steel wire of radius 0.5 mm and length 4 m. Calculate the extension produced. What should be the area of cross-section of the wire so that elastic limit is not exceeded ? Change in radius in negligible. (Given : g = 9.8 m/s^2; Elastic limit of steel 2.4 × 10^8 N/m^2; Y for steel (Y_{steel}) = 20 × 10^{10} N/m^2; π = 3.142)

SECTION-II

5. Select and write the most appropriate answer from the given alternatives for each sub-questions : [7]

(i) If A.C. voltage is applied to a pure capacitor, then voltage across the capacitor .....

(a) leads the current by phase angle $\left(\frac{\pi}{2}\right)$ rad.

(b) leads the current by phase angle (π) rad.

(c) lags behind the current by phase angle $\left(\frac{\pi}{2}\right)$ rad.

(d) lags behind the current by phase angle (π) rad.

(ii) In Doppler effect of light, the term ''red shift'' is used for ..... .

(a) frequency increase (b) frequency decrease

(c) wavelength decrease (d) frequency and wavelength increase.

(iii) If a watch-glass containing a small quantity of water is placed on two dissimilar magnetic poles, then water ..... .

(a) shows a depression in the middle. (b) shows an elevation in the middle.

(c) surface remains horizontal. (d) evaporates immediately.

(iv) Any device that converts one form of energy into another is termed as ..... .

(a) amplifier (b) transducer

(c) receiver (d) demodulator

(v) When a *p-n-p* transistor is operated in saturation region, then its .....

(a) base-emitter junction is forward biased and base-collector junction is reverse biased.

(b) both base-emitter and base-collector junctions are reverse biased.

(c) both base-emitter and base-collector junctions are forward biased.

(d) base-emitter junction is reverse biased and base-collector junction is forward biased.

(vi) In a photon-electron collision .....

(a) only total energy is conserved.

(b) only total momentum is conserved.
(c) both total energy and total momentum are conserved.
(d) both total momentum and total energy are not conserved.

(vii) If the charge on the condenser of 10 μF is doubled, then the energy stored in it becomes ..... .
(a) zero (b) twice that of initial energy
(c) half the initial energy (d) four times the initial energy

6. Attempt any SIX : [12]

(i) Distinguish between the phenomenon of interference and diffraction of light.
(ii) Explain how moving coil galvanometer is converted into a voltmeter. Derive the necessary formula.
(iii) State the advantages of potentiometer over voltmeter.
(iv) Draw a neat, labelled block diagram of a receiver for the detection of amplitude modulated wave.
(v) A rectangular coil of a moving coil galvanometer contains 100 turns, each having area 15 cm^2. It is suspended in the radial magnetic field 0.03 T. The twist constant of suspension fibre is 15×10^{-10} N-m/degree. Calculate the sensitivity of the moving coil galvanometer.
(vi) The magnetic flux through a loop is a varying according to a relation $\phi = 6t^2 + 7t + 1$ where ϕ is in milliweber and t is in second. What is the e.m.f. induced in the loop at $t = 2$ second ?
(vii) An unknown resistance is placed in the left gap and resistance of 50 ohm is placed in the right gap of a meter bridge. The null point is obtained at 40 cm from the left end. Determine the unknown resistance.
(viii) Find the frequency of revolution of an electron in Bohr's 2nd orbit; if the radius and speed of electron in that orbit is 2.14×10^{-10} m and 1.09×10^6 m/s respectively. [$\pi = 3.142$]

7. Attempt any THREE : [9]

(i) Explain with a neat diagram, how a *p-n* junction diode is used as a half wave rectifier.
(ii) Explain self induction and mutual induction.
(iii) A cube of marble having each side 1 cm is kept in an electric field of intensity 300 V/m. Determine the energy contained in the cube of dielectric constant 8.
[Given : $\epsilon_0 = 8.85 \times 10^{-12}$ C^2/Nm^2]
(iv) An electron in an atom revolves around the nucleus in an orbit of radius 0.53 Å. If the frequency of revolution of an electron is 9×10^9 MHz, calculate the orbital angular momentum.
[Given : Charge on an electron = 1.6×10^{-19} C; Gyromagnetic ratio = 8.8×10^{10} C/Kg; $\pi = 3.142$]

8. Describe the biprism experiment to find the wavelength of the monochromatic light. Draw the necessary ray diagram. **[7]**

The width of plane incident wavefront is found to be doubled on refraction in denser medium. If it makes an angle of 65° with the normal, calculate the refractive index for the denser medium.

OR

Draw a neat, labelled energy level diagram for H atom showing the transitions.

Explain the series of spectral lines for H atom, whose fixed inner orbit numbers are 3 and 4 respectively.

The work functions for potassium and caesium are 2.25 eV and 2.14 eV respectively. Is the photoelectric effect possible for either of them if the incident wavelength is 5180 Å ?

[**Given :** Planck's constant = 6.63×10^{-34} J.s.; Velocity of light = 3×10^8 m/s; 1 eV = 1.6×10^{-19} J]

■■

Solutions

SECTION-I

1. (i) (d) increase by 11.4.%

(ii) (c) increase in potential energy

(iii) (c) Torque

(iv) (d) gradually decreasing.

(v) (b) $\frac{\lambda}{2}$

(vi) (a) $\sqrt{T}$

(vii) (b) 4.14×10^{-6} m

2. (i) Centripetal force is that force which is required to move a body uniformly in a circle. This force acts along the radius and towards the centre of the circle. If m is the mass of the particle, the magnitude of the centripetal force is :

$$\frac{mv^2}{r} \text{ or } m\omega^2 r$$

Examples : (1) Turning of car on road

(2) Conical Pendulum.

(ii)
$$P = \frac{1}{3}\frac{mn}{V} \times \bar{v}^2$$

$\Rightarrow$
$$PV = \frac{1}{3} mn \times \bar{v}^2$$

But PV = RT and mn = M

$\therefore$
$$\bar{v}^2 = \frac{3RT}{M}$$

As
$$V_{rms} = \sqrt{\bar{v}^2}$$

$\Rightarrow$
$$V_{rms} = \sqrt{\frac{3RT}{M}}$$

$\therefore$
$$V_{rms} \propto \sqrt{T} \qquad \left[\frac{R}{M} = \text{constant}\right]$$

Here P = Pressure, V = volume, n = no. of moles.

m = mass of gas moleucles

R = universal gas constant.

T = Temperature.

(iii) Differential equation of linear simple harmonic motion : Consider a particle performs linear SHM. The force on the particle is always directed towards the mean position. If force acting on the particle is $\vec{F}$ at displacement $\vec{x}$ from mean position,

$$\vec{F} = -K\vec{x} \qquad ...(i)$$

K = force constant

(–) ve sign indicates the force and displacement are in opposite direction.

Therefore, Velocity of particle $= \frac{d\vec{x}}{dt}$

Acceleration $= \frac{d^2\vec{x}}{dt^2}$

such that, $$\text{Force} = \text{mass} \times \text{acceleration}$$

$$\vec{F} = m \times \frac{d^2\vec{x}}{dt^2}$$

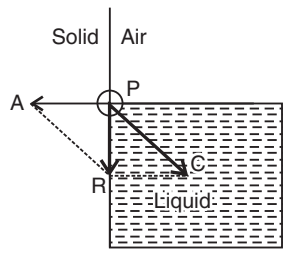
From eqn. (i)

$$m \times \frac{d^2\vec{x}}{dt^2} = -K\vec{x}$$

$$\Rightarrow \quad \frac{d^2\vec{x}}{dt^2} + \frac{K}{m}\vec{x} = 0$$

This is required expression.

(iv) **Diagram**



Let a molecule P in liquid surface is in contact with solid. The forces on molecule P –

(a) Solid-liquid adhesive force $\vec{PA}$ (at right angles to solid surface)

(b) Liquid-air cohesive force $\vec{PC}$ (at 45° with horizontal)

(c) Negligible liquid-air adhesive force.

(d) Negligible weight of molecule acting vertically downward.

(v) $d = 3200$ km, R = 6400 km, $g = 9.8$ m/s^2,

$$W = 350 \text{ N}$$

$$\text{Weight at bottom of hole } W_d = W\left(\frac{R-d}{R}\right)$$

$$= 350\left(\frac{6400-3200}{6400}\right)$$

$$= 350 \times \frac{3200}{6400}$$

$$= 350 \times \frac{1}{2}$$

$$= 175 \text{ N}$$

(vi) M = 1 kg, V = 2 m/s.

$$\text{Total Kinetic Energy} = E_{\text{translational}} + E_{\text{rotational}}$$

But, $\omega = 0 \Rightarrow E_{rot} = 0$

$$\therefore \quad \text{Total K.E.} = \frac{1}{2}mv^2$$

$$= \frac{1}{2} \times 1 \times 2 \times 2$$

$$= 2 \text{ Joule.}$$

(vii)

$$\text{Length of wire} = 0.9 \text{ m}$$

$$\text{Frequency, } n = 324 \text{ Hz}$$

$$\text{Speed of transverse waves } v = n\lambda$$

$$= n(2l)$$

$$= 324 \times 2 \times 0.9$$

$$= 648 \times 0.9$$
$$= 583.2 \text{ m/s}$$

(viii) Given,

$$\left(\frac{d\theta}{dt}\right) = 0.5°\text{C/min}$$
$$\theta_1 - \theta_0 = 25°\text{C}, \theta_2 - \theta_0 = 15°\text{C}$$

By Newton law of cooling

$$\left(\frac{d\theta}{dt}\right) = K(\theta - \theta_0)$$

$$\therefore \quad \frac{(d\theta/dt)_1}{(d\theta/dt)_2} = \left(\frac{\theta_1 - \theta_0}{\theta_2 - \theta_0}\right)$$

$$\frac{(d\theta/dt)_1}{(d\theta/dt)_2} = \frac{25°}{15°}$$

$$\left(\frac{d\theta}{dt}\right)_2 = \frac{15°}{25°} \times \left(\frac{d\theta}{dt}\right)_1$$

$$\left(\frac{d\theta}{dt}\right)_2 = \frac{15}{25} \times 0.5$$

$$= \frac{7.5}{25}$$

$$\left(\frac{d\theta}{dt}\right)_2 = 0.3°\text{C/min}$$

3. (i) Critical speed for circular orbit :

$$V_c = \sqrt{\frac{GM}{r}}$$

Here G = gravitational constant
M = mass of Earth
$r = R^{th}$ = radius of circular orbit
R = Radius of Earth
h = altitude of an orbit
In time period T, satellite travels :

$$\text{Distance} = \text{circumference of its circular orbit}$$

$$\therefore \quad T = \frac{\text{Circumference}}{\text{Critical speed}}$$

$$= \frac{2\pi r}{V_c}$$

$$\Rightarrow \quad T = \frac{2\pi r}{\sqrt{\frac{GM}{r}}} = 2\pi\sqrt{\frac{r^3}{GM}}$$

$$T = 2\pi\sqrt{\frac{(R+h)^3}{GM}}$$

This is required expression for period of revolution of a satellite which clearly shows that T depends on the mass of planet.

(ii) Let a torque $\vec{\tau}_1$ on the rigid body produces uniform angular acceleration $\vec{\alpha}$ along axis of rotation.

Consider the rigid body having N particles with masses m_1, m_2, m_3 ..... m_n at distances r_1, r_2, r_3 ..... r_n from axis of rotation and also respective external forces is same for all particles.

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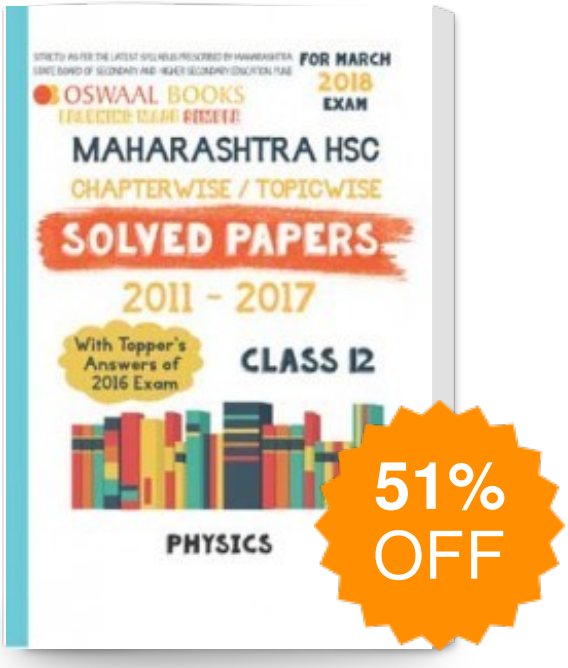

Publisher : Oswaal Books ISBN : 9788184819410 Author : Panel Of Experts