This question paper contains 2 printed pages. *Your Roll No. .....*

C

Sl. No. of Ques. Paper : 8382

Unique Paper Code : 222103

Name of Paper : **PHHT-102 : Mechanics**

Name of Course : **B.Sc. (Hons.) Physics Part I**

Semester : I

Duration : 3 hours *Maximum Marks* : 75

Attempt five questions in all, including Question No. 1 which is compulsory.

1. Attempt any *five*: $5 \times 3 = 15$

(a) Show that the element of volume $\Delta x \Delta y \Delta z \Delta t$ in space time coordinates is invariant under Lorentz transformation.

(b) A disc and a ring of same mass M and radius R are rolling down an inclined plane, both starting from rest. Which one will have more K.E. ? Explain.

(c) Calculate momentum of a photon of energy $6{\cdot}2 \times 10^{-19}$ J.

(d) A pendulum of length l has a bob of mass m and is hung from the ceiling of a car. If the car accelerates at $g/\sqrt{2}$ m/s^2, calculate:

(i) angle made by the string with vertical.

(ii) tension in the string.

(e) A flywheel with 15 kg mass and radius of gyration 0·15 m is rotating at the rate 1800 rpm. Calculate torque necessary to stop it in 5 sec.

(f) Calculate the height at which the P.E. of a mass m will reduce to half of its P.E. on the surface of the earth.

(g) In the surface Poiseuille's experiment, if the radius of the capillary is reduced by 50%, how will the coefficient of viscosity be affected? Explain.

2. (a) Show how a two body problem involving central force can be reduced to a one body problem. What would be the corresponding expressions for angular momentum and energy? 10

(b) Plot and discuss the energy diagram for the planetary motion for all possible values of energy. 5

3. (a) Define viscosity of a fluid. Derive the Poiseuille's equation for the flow of viscous fluid through a capillary. State the assumptions involved. 8

(b) Establish the relation between the elastic constants of a material:

P. T. O.

$$\frac{9}{Y}=\frac{3}{\eta}+\frac{1}{K}.$$ 7

4. (a) Show that for a body undergoing translation and rotation, its angular momentum is given by:

$$L_z=I_0\omega+\left(\vec{R}\times M\vec{V}\right)_z,$$

and hence explain the meaning of the two terms on R.H.S. of the equation. 8

(b) Derive an expression for the moment of inertia of a rectangular lamina about an axis perpendicular to its plane and passing through one of its corners. 7

5. (a) Show that the expression for the force observed in rotating co-ordinate system is:

$$\overrightarrow{F_{rot}}=m\overrightarrow{a_{in}}-m\left[2\vec{\Omega}\times\overrightarrow{v_{rot}}+\vec{\Omega}\times(\vec{\Omega}\times\vec{r})\right].$$

Explain the different terms on the R.H.S. of the equation. 10

(b) What is an inertial frame of reference? Derive the expressions for Galilean Transformation equations for space-time coordinates. Show that acceleration is invariant under Galilean Transformation. 5

6. (a) Find the expression for the momentum and velocity of two particles colliding elastically with each other in C.M. system. Show that the speed of each particle is same before and after the collision in C.M. system. 6

(b) Find the limitations on laboratory scattering angle during elastic collision of two bodies. 4

(c) The stages of a two stage rocket separately weigh 100 kg and 10 kg and contain 800 kg and 90 kg of fuel respectively. Calculate the final velocity attained by the rocket with an exhaust velocity 2 km/s. Neglect the gravitational attraction. ($\ln 5 = 1\cdot609$, $\ln 10 = 2\cdot3$). 5

7. (a) State postulates of Einstein's theory of relativity. Derive Lorentz transformation equation for space-time coordinates. 7

(b) Explain the physical significance of null result of Michelson-Morley experiment. 3

(c) A spaceship coasting in space detects an alien space probe. As the probe approaches, the frequency received by the ship is 130 MHz and 60 MHz when it recedes into distance. What is the intrinsic frequency of the transmitter and what is the relative speed of the two ships? 5

This question paper contains 4 printed pages]

Roll No. | | | | | | | | | | |

S. No. of Question Paper : 907

Unique Paper Code : 222103 E

Name of the Paper : PHHT-102 Mechanics

Name of the Course : B.Sc. (Hons.) Physics

Semester : I

Duration : 3 Hours Maximum Marks : 75

(Write your Roll No. on the top immediately on receipt of this question paper.)

Attempt *Five* questions in all including

Q. No. 1 which is compulsory.

1. Attempt any *five* of the following :

(*a*) Is it necessary that the center of mass of a solid body lies within the body ? Explain with the help of an example.

(*b*) A particle of mass *m* moves along a curve given by $\vec{r} = 6t^2\hat{i} - 3t\hat{j} + 5\hat{k}$. Calculate its angular momentum.

(*c*) Prove that the angular momentum is conserved under the action of a central force.

P.T.O.

(*d*) Differentiate between elastic and inelastic collision of particles.

(*e*) A hollow cylinder and a solid sphere of the same mass and radius are allowed to roll down without slipping along an inclined plane. Determine the ratio of their accelerations.

(*f*) Explain the terms 'gravitational potential' and 'gravitational field'.

(*g*) Show that the theoretical limiting values of Poisson's ratio are –1 and 0.5.

(*h*) Calculate the momentum of a photon of energy 6.2×10^{-19} Joules. 5×3=15

2. (*a*) What are potential energy diagrams ? Discuss the concept of stable, unstable and neutral equilibrium. How does the total energy affect the motion of a particle in a given potential field ? 8

(*b*) Show that in the case of a conservative force, the work done around a closed path is zero. 4

(*c*) Show that the electrostatic force is a conservative force. 3

3. (*a*) Define moment of inertia of a body and discuss its physical significance. Derive an expression for the moment of inertia of a solid sphere about an axis tangent to its surface. 10

(*b*) The maximum and minimum distances of a comet from the sun are 2×10^{12} m and 8×10^{10} m respectively. If the speed of the comet at the nearest point is 60 km/sec, calculate its speed at the farthest point. 5

4. (*a*) Derive the expressions for gravitational field at a point inside, outside and on the surface of a thin uniform spherical shell. 9

(*b*) Show the variation of gravitational field of a point particle of mass *m* graphically and compare with electrostatic field of point charge. 6

5. (*a*) Derive a relation connecting the elastic constants Y, K and σ. 8

(*b*) Derive an expression for the rate of flow of a liquid through a capillary. 7

6. (*a*) What is an inertial frame of reference ? Can the earth be regarded as an inertial frame of reference ? 3

(*b*) What is meant by Galilean transformation and Galilean invariance ? Show that whereas length (or distance) and acceleration are invariant to Galilean transformation, velocity is not. 12

P.T.O.

7. (*a*) What is longitudinal and transverse Doppler Effect in light ? Obtain an expression for the apparent frequency of light pulse in a moving frame of reference. 10

(*b*) The rest mass of a particle is 10 gm. What is its mass when it is moving with a velocity of 3×10^9 cm/sec ? What will happen if this velocity is equal to the velocity of light ? 5

his question paper contains 4 printed pages]

Roll No. | | | | | | | | | | | |

No. of Question Paper : 1230

11 DEC 2014

nique Paper Code : 222161 E

ame of the Paper : PHPT-101 : Physics—I Mechanics

ame of the Course : B.Sc. Physical Science/Applied Physical Science Part I

emester : I

uration : 3 Hours Maximum Marks : 75

(Write your Roll No. on the top immediately on receipt of this question paper.)

Attempt *five* questions in all.

Question No. 1 is compulsory.

Attempt *four* questions from the rest of the paper.

1. Attempt any *five* of the following : 5×3=15

(*a*) Determine the constant *a* so that the following vector is solenoidal :

$$V = (-4x - 6y + 3z)\hat{i} + (-2x + y - 5z)\hat{j} + (5x + 6y + az)\hat{k}.$$

(*b*) The position of a moving particle at any instant is given by :

$$\vec{r} = A\cos\theta\hat{i} + A\sin\theta\hat{j}.$$

Show that the force acting on it is a conservative one.

P.T.O.

(c) A rod 1 m long is moving along its length with a velocity $0.6c$. Calculate its length it appears to an observer on the earth.

(d) Estimate the mass of the sun, assuming the orbit of the Earth round the sun to a circle. The distance between the Sun and the Earth is 1.49×10^{13} cm and $G = 6.66 \times 10^{-8}$ dyne cm^2/gm^2.

(e) State Kepler's Laws of Planetary motion.

(f) For a particle of mass m, position $\vec{r} = 12\hat{i} + 8\hat{j}$ and velocity $\vec{v} = 6\hat{i}$, calculate its angular momentum about the origin.

(g) Explain the physical significance of the negative results of the Michelson-Morley experiment.

2. (a) State and prove Stokes' theorem for vector fields. 10

(b) Prove : 5

$$\vec{\nabla} \times \left(\vec{\nabla} \times \vec{A} \right) = -\nabla^2 A + \nabla(\nabla \cdot A).$$

3. (a) State and prove parallel axis theorem for moment of inertia of a rigid body. 4

(b) Define radius of gyration. Determine the moment of inertia of a solid sphere about its diameter. 11

4. (*a*) State and prove work-energy theorem. Is the theorem valid for all forces ? 5

(*b*) Show that for a central force, the angular momentum is conserved. 5

(*c*) During a baseball game, the pitcher throws the ball with a speed of 30 m/s. The mass of the ball is 0.15 kg. What is the kinetic energy of the ball when it leaves his hand ? How much work has been done by his hand on the ball during the throw ? 5

5. (*a*) State Hooke's law. Derive an expression for the couple required to twist one end of a cylindrical wire when its other end is fixed. 12

(*b*) Calculate the work done in twisting a steel wire of diameter 2 mm and length 0.5 m through 45°, the modulus of rigidity of steel wire being 2×10^{11} N/m^2. 3

6. (*a*) State Einstein's postulates of special theory of relativity. 5

(*b*) Write Lorentz transformation equations and use them to derive the expression for length contraction. 5

(*c*) The mass of a moving electron is 11 times its rest mass. Find its kinetic energy and momentum. 5

7. (*a*) What is curl of a vector field ? Derive its expression in Cartesian coordinates and explain the physical significance. 10

(*b*) Evaluate : 5

$$\oint (y - 2x)\, dx + (3x + 2y)\, dy$$

around the boundary of a circle of unit radius centered at origin.

8. (*a*) Obtain Einstein's formula for addition of velocities. 10

(*b*) The spectral line of $\lambda = 5000$ AU in the light coming from a distant star is observed at 5200 AU. Find the recessional velocity of the star. What is the distance of the galaxy ? 5

This question paper contains 3 printed pages]

Roll No. | | | | | | | | | | |

S. No. of Question Paper : 7877

Unique Paper Code : 2221102

F-1

Name of the Paper : **Mechanics (PHHT 102) (DC-1.2)**

Name of the Course : **B.Sc. (Hons.) Physics**

Semester : **I**

Duration : **3 Hours**

Maximum Marks : **75**

(Write your Roll No. on the top immediately on receipt of this question paper.)

Attempt *five* questions in all.

Question number **1** is compulsory.

1. Attempt any *five* of the following : 5×3=15

(*a*) What are the *two* postulates of special theory of relativity ?

(*b*) Differentiate inertial and non-inertial reference frames with examples.

(*c*) Define gravitational potential energy. How does it vary with distance represent graphically ?

(*d*) Differentiate among free, damped and forced harmonic oscillations.

(*e*) What are conservative and non-conservative forces ? Explain with examples.

P.T.O.

(*f*) Define radius of gyration. How does a compound pendulum prove a better choice for the computation of 'g' in comparison to normal string and bob set-up (i.e. simple pendulum) ?

(g) What was the main objective of the Michelson Morley experiment ?

2. (*a*) Derive Einstein mass-energy equivalence formula.

(*b*) How much mass a proton would gain when accelerated to a kinetic energy of 500 MeV ? 10,5

3. Write down the Lorentz transformation equations, using them derive formula for :

(*a*) Time dilation;

(*b*) Length contraction. 5,5,5

4. Compute gravitational potential due to a spherical shell at (*a*) an external point, (*b*) on the surface, and (*c*) at an internal point. Show graphical representation of the variation of potential with distance. 5,4,4,2

5. Write down the equation for the damped harmonic oscillations and solve it for over-damped, critically damped and damped oscillations. Also compute time period and logarithmic decrement for the damped oscillations. 5,5,3,2

6. Define moment of Inertia. Show that the moment of inertia of a solid cylinder about its own axis is $MR^2/2$, and about an axis passing through its centre of mass but perpendicular to its length is $M(R^2/4 + L^2/12)$, where M is the mass and L is the length of cylinder. 2,7,6

7. Explain laboratory and centre of mass frames of references. What is the advantage of studying a collision process in centre of mass system ? Prove that in centre of mass system the magnitude of velocities of the particles remain unaltered in elastic collision. 6,5,4

This question paper contains 3 printed pages]

Roll No. | | | | | | | | | | |

S. No. of Question Paper : 6202

Unique Paper Code : 222103 D

Name of the Paper : Mechanics (PHHT-102)

Name of the Course : B.Sc. (Hons.) Physics

Semester : I

Duration : 3 Hours Maximum Marks : 75

(Write your Roll No. on the top immediately on receipt of this question paper.)

Attempt *five* questions in all including Q. No. 1 which is compulsory.

1. Attempt any *five* of the following :

(*a*) What is meant by radius of gyration and centre of mass of a rigid body ?

(*b*) Check if the force $\vec{F} = 3xy\hat{i} - y\hat{j}$ is conservative or not.

(*c*) Show that the intensity of the field can be expressed in the form E = –grad V, where V is the potential.

(*d*) Show that in an elastic one-dimensional collision, the relative velocity with which the two particles approach each other before collision is equal to the relative velocity with which they recede from each other after collision.

(*e*) A solid spherical ball rolls on a horizontal table. What fraction of its total kinetic energy is rotational ?

P.T.O.

(*f*) What do you understand by inertial and gravitational mass ?

(*g*) What are the different types of energies a liquid in streamline flow may possess ?

(*h*) Draw a graph between mass of an object having rest mass m_0 moving with velocity v. 5×3=15

2. (*a*) Establish the relation for the velocity of a rocket taking into account the weight of the fuel. 10

(*b*) Find the impulse developed by a force $\vec{F} = 4t\hat{i} + \left(6t^2 - 2\right)\hat{j} + 12\hat{k}$ from time $t = 0$ to $t = 2$ sec. 5

3. (*a*) Obtain an expression for the acceleration of a body rolling down an inclined plane. 7

(*b*) A sphere and a cylinder are allowed to roll down simultaneously on an inclined plane from the same height without slipping. Explain which one reaches down first. 8

4. (*a*) Show that the gravitational potential at the centre of a solid sphere is one and a half times the potential at the surface. 8

(*b*) When a particle moves under a central force, prove that the angular momentum is conserved and the particle moves in a fixed plane. 7

5. (*a*) Derive an expression for the twisting couple per unit twist for a solid cylinder as well as a hollow one. 10

(*b*) Show that a hollow cylinder is stronger than a solid one of same material, mass and length. 5

6. (*a*) What is Coriolis force ? Show that the total Coriolis force acting on a body of mass m in a rotating frame is $-2m\vec{\omega} \times \vec{v}_r$, where $\vec{\omega}$ is the angular velocity of rotating frame and $\vec{v}_r$ is the velocity of the body in rotating frame. 7

(*b*) Explain the basic postulates of Einstein's special theory of relativity. Derive the Lorentz space-time transformation formulae. 8

7. (*a*) Describe the Michelson-Morley experiment and explain the physical significance of the negative results. 10

(*b*) What is length contraction ? Obtain the volume of a cube, the proper length of each edge of which is L_0, when it is moving with a velocity v along one of its edges. 5

[This question paper contains 4 printed pages.]

Sr. No. of Question Paper : 6623 **FC** **Your Roll No.....**

Unique Paper Code : 42221101

Name of the Paper : Physics – I : Mechanics

28 NOV 2015

Name of the Course : **B.Sc. (Prog.) Choice Based Credit System Exams.**

Semester : I

Duration : 3 Hours Maximum Marks : 75

Instructions for Candidates

1. Write your Roll No. on the top immediately on receipt of this question paper.
2. Attempt **five** questions in all.
3. Question No. **1** is compulsory.
4. Use of non-programmable scientific calculator is allowed.

1. Attempt any **five** of the following : (5×3=15)

   (a) Show that for a particle moving in a control force field, the red velocity is conduct.

   (b) Form a differential equation whose only solutions are a_1e^{2x} and a_2e^{3x}.

   (c) If a vector A has a constant magnitude then show that A is perpendicular to $\frac{dA}{dt}$.

   (d) A ball of mass m at rest breaks into three fragments each of equal mass. Out of three two fragments are moving with same speed v making an angle 90° with each other. Find the total K.E. of the three fragments after the explosion.

P.T.O.

(e) A particle of mass 5 kg is moving in anti-chronic direction with speed of 3 m/s in a circular path (in xy plane) of radius 10 cm. Find the angle moving of this particle. W.r.t. the centre of the path. (5)

(f) A particle is executing simple harmonic oscillation along a straight line. Its velocities at distance x_1 and x_2 are v_1 and v_2 respectively. Find the time period of oscillations.

(g) The maximum and minimum distances of a comet from the sun are 1.4×10^{12} m and 7×10^{10} m respectively. If the speed of the comet at the nearest point is 6×10^4 m/s, calculate the speed at the farthest point.

(h) A rod of proper length lm is moving with velocity 0.6c along its length as observed by an observer on earth. Find its length as observed from earth.

2. (a) Prove that $(\bar{A} \times \bar{B}) \times \bar{C} = \bar{B}(\bar{A} \cdot \bar{C}) - \bar{A}(\bar{B} \cdot \bar{C})$. (5)

(b) Find the general solution of $\frac{d^2y}{dx^2} - 6\frac{dy}{dx} + 9y = 0$. (5)

(c) Solve the following differential equation $(x^2 - y^2)dx - 2xydy = 0$. (5)

3. (a) State and prove Work-Energy theorem. (5)

(b) What are conservative forces ? If F = Ai, where A is a constant and i is the unit vector along increasing x, is it conservative or not ?

Determine whether the force $\bar{F} = Ai$ is conservative or not. How A is a +ve units ? (5)

(c) A body of mass m is moving horizontally with speed v and sticks to a bob of a simple pendulum of equal mass, which is initially at equilibrium. If the length of the pendulum is l, find the maximum deflection of the pendulum with the vertical ? (5)

4. (a) Two particles of mass 34 & 54 move under the influence of a force field so that their pv^5 are given resp. by $\bar{r}_x = (t+1)i + 3tj - 4k$ & $\bar{r}_x = t^2i - tj + (2t-1)k$, where t is the time. Find the folding of the system unit origin. (5)

(b) Setup the differential equation of motion for a damped Harmonic Oscillator. Solve this equation for the case of under damped motion and hence derive the expression for the time period of this motion. (10)

5. (a) Prove that if a particle moves in a central force field, then its path must be a plane curve.

(b) Both Venus and Earth have approximately circular orbits around the sun. The period of the orbital motion of Venus is 0.615 years and period of the earth is one year. By what factor do the sizes of the two orbit differ ? (5)

(c) An earth's satellite makes a circle around earth in 120 minutes. Calculate the height of the satellite above the surface of earth.

(Given radius of earth is 6400 Km and $g = 9.8\ m/s^2$) (5)

6. (a) Derive the relation between K, Y and σ. (7)

(b) Describe with necessary theory the Searle's method for determination of the modulus of rigidity. (8)

7. (a) State the postulates of the Special Theory of Relativity. Deduce the mathemetical expression for the law of addⁿ of relativity velocities. (10)

(b) Two electrons leave a radioactive sample in opposite directions, each having a speed 0.8c with respect to the sample. What is their relative speed according to Einstein's velocity addition theorem. (5)

This question paper contains 4 printed pages]

Roll No. | | | | | | | | | | |

S. No. of Question Paper : 6552

Unique Paper Code : 32221102 28 NOV 2015 FC

Name of the Paper : Mechanics

Name of the Course : B.Sc. (Hons.) Physics : Choice Based Credit System

Semester : I

Duration : 3 Hours Maximum Marks : 75

(Write your Roll No. on the top immediately on receipt of this question paper.)

Attempt *Five* questions in all.

Question No. 1 is compulsory.

Use of non-programmable scientific calculator is allowed.

1. Attempt any *five* of the following questions :

   (*i*) What is the speed of a particle whose relativistic mass is twice its rest mass ?

   (*ii*) Two bodies of different masses are moving with the same kinetic energy of translation. Which has greater momentum ?

   (*iii*) What is potential energy curve of a particle ? What significant information does it give about the motion of the particle ?

   (*iv*) Calculate the period of revolution of an artificial satellite at a height h from the surface of the earth, assuming that the satellite takes a circular orbit around earth.

P.T.O.

(*v*) Find the centre of mass of a thin uniform wire bent in the form of a semi-circle of radius R.

(*vi*) Find the impulse developed by a force $\mathbf{F} = 4t\boldsymbol{i} + (6t^2 - 2)\boldsymbol{j} + 12\boldsymbol{k}$ from time $t = 0$ to $t = 4$ s.

(*vii*) A person normally weighing 60 kg stands on a platform which is oscillating up and down harmonically with a time period of 1.0 s and amplitude of 10 cm. If a weighing machine on the platform gives the person's weight against time, what will be the maximum and minimum readings shown by it ?

(*viii*) A solid sphere of mass 0.1 kg and radius 2.5 cm rolls without slipping with uniform velocity of 0.1 ms^{-1} along a straight line on a horizontal table. Calculate its total energy. 5×3

2. (*i*) Establish the equation of motion of a damped harmonic oscillator subjected to a resistive force that is proportional to the first power of its velocity. If the damping is less than critical, show that the motion of the system is oscillatory with its amplitude decaying exponentially with time.

(*ii*) What do you understand by 'logarithmic decrement', 'relaxation time' and 'equality factor' of a weakly damped harmonic oscillator ? 12,3

3. A particle of mass m_1 moves with velocity v_1 in the Laboratory frame of reference and collides elastically with a particle of mass m_2 at rest in the Laboratory frame. If, after the collision, the direction of the first particle makes angles θ and φ with respect to its initial direction in the Laboratory and Centre of mass frames respectively :

(*i*) Verify that :

$$\tan\theta = \sin\varphi/\{\cos\varphi + (1/A)\}, \text{ where } = m_2/m_1.$$

(*ii*) If $m_1 = m_2$, then verify that $\theta = \varphi/2$. What is then the maximum value of θ ?

(*iii*) Show that the maximum value of θ for arbitrary A when $A < 1$ is given by $\tan \theta = A/(1 - A^2)^{1/2}$. 7,4,4

4. (*i*) A reference frame S' rotates with respect to another reference frame S with uniform angular velocity ω. Obtain a relation between the acceleration experienced by a particle in the two frames of reference. Highlight the physical significance of each term in the above relation.

(*ii*) Calculate the values of the Centrifugal and the Coriolis forces on a mass of 20 g placed at a distance of 10 cm from the axis of rotating frame of reference, if the angular speed of rotation of the frame be 10 $rads^{-1}$. 9,6

5. (*i*) On the basis of Lorentz transformations derive an expression for length contraction and time dilation.

(*ii*) With what velocity should a rocket move so that every year spent on it corresponds to 4 years on earth.

(*iii*) Two electrons move towards each other, the speed of each being 0.8 c in a Galilean frame of reference. What is their speed relative to each other ? 8,3,4

6. (*i*) Show that the total angular momentum of a system of particles about a fixed point is given by the relation $\mathbf{J} = \mathbf{R} \times \mathbf{P} + \mathbf{J}_{c.m.}$, where $(\mathbf{R} \times \mathbf{P})$ is the angular momentum of the centre of mass about that point and $\mathbf{J}_{c.m.}$, the angular momentum of the system about the centre of mass. What do the two terms in the above relation represent physically ?

P.T.O.

(*ii*) Show that the angular momentum of a particle under the influence of a central force always remains constant.

(*iii*) Prove that a projectile launched on level ground reaches its maximum height midway along its trajectory. 6,4,5

7. (*i*) A rocket ascends from rest in a uniform gravitational field by ejecting exhaust gases with a constant speed u relative to the rocket. Assuming that the rate at which mass is expelled is given by $\frac{dM}{dt} = -\gamma M$, where M is the instantaneous mass of the rocket and γ is a constant, find the velocity of the rocket as a function of time. 8

(*ii*) A particle moves along the x-axis under the influence of a force $F = ax^2 - b$, where a and b are positive constants.

(*a*) Find its potential energy as a function of position, taking $U = 0$ at $x = 0$.

(*b*) Determine the positions of equilibrium of the particle and predict the nature of equilibrium at these points.

(*c*) Find the value/s of equilibrium potential energy of the particle. 2,3,2

8. (*i*) Derive expressions for gravitational potential at a point inside and outside a uniform solid sphere of radius R and mass M. Also, represent your results graphically.

(*ii*) (*a*) Find the moment of inertia of a solid sphere of radius R and mass M about its diameter and tangent.

(*b*) Calculate the radius of gyration of a solid sphere of radius 5 cm rotating about its diameter. 7,6,2

[This question paper contains 4 printed pages.]

Sr. No. of Question Paper : 5757 **F** **Your Roll No.....**

Unique Paper Code : 222103

Name of the Paper : Mechanics (PHHT-102)

04 DEC 2015

Name of the Course : **B.Sc. (Hons.) Physics**

Semester : I

Duration : 3 Hours Maximum Marks : 75

Instructions for Candidates

1. Write your Roll No. on the top immediately on receipt of this question paper.
2. Attempt any **five** questions in all.
3. Q. No. **1** is compulsory.

1. Attempt any **five** of the following:

   (a) It is essential to burn the fuel as quickly as possible during take-off of a spacecraft.

   (b) A small object of uniform density rolls up a curved surface with an initial velocity v, it reaches upto a maximum height $3v^2 14g$, with respect to initial position. Show that the object is a disc.

   (c) How would you distinguish between a solid sphere and a hollow sphere of same mass and same radius?

   (d) Show that in a central force field, the angular momentum of a particle remains conserved.

   (e) State Einstein's postulate of special theory of relativity.

   (f) Differentiate between inertial frame and non-inertial frame of reference?

   (g) The rest mass of an electron is 9×10^{-21} kg. What will be its mass if it were moving with 4/5th the speed of light? (5×3)

P.T.O.

2. (a) State and prove work -energy theorem. (6)

(b) Show that the force field given by the equation $\vec{F} = (y^2 - x^2)\hat{i} + 2xy\hat{j}$ is conservative in nature. (4)

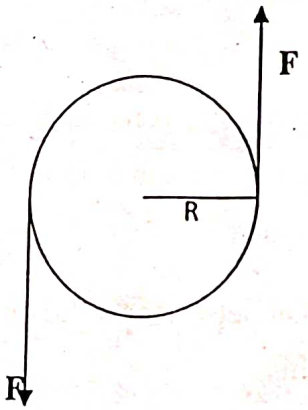
(c) Consider a particle of mass m moving in one dimension under a force with potential energy $U(x) = k(2x^3 - 5x^2 + 4x)$, where constant k>0. Show that the point $x = 1$ corresponds to a stable equilibrium position of the particle. (5)

3. (a) Show that kinetic energy of a rolling body is sum total of its kinetic energy of pure rotation and kinetic energy of pure translation. (5)

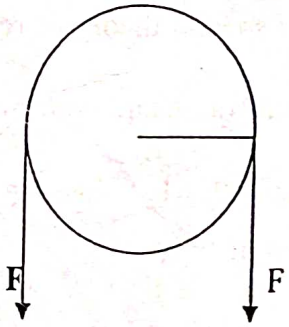
(b) State and prove perpendicular axis theorem of moment of inertia. (5)

(c) Evaluate net force and the torque about the center of each disc in following sketches:

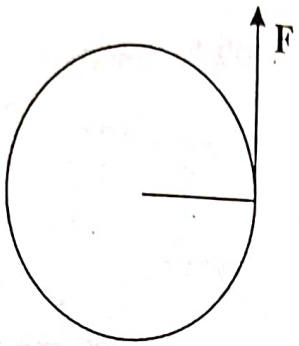
(i)



(ii)



(iii)



What do you conclude about relationship between force and torque? (5)

4. (a) State and prove Kepler's Laws of planetary motion. Show that the orbit traced by a planet moving under gravitational force is an ellipse. (12)

(b) Obtain the value of escape velocity for a particle 1000 km above the surface of the earth. Given mass of earth=5.98×10^{24} kg, radius of earth = 6.37×10^{3} km, G = 6.67×10^{-11} Nm^2/ kg^2. (3)

5. (a) Define coefficient of viscosity of a liquid. Derive Poiseulle's formula for rate of flow of aliquid through a capillary. (10)

(b) Show that the velocity of escape of a body from the surface of earth is $\sqrt{2}$ times its orbital velocity near the surface of earth. (5)

6. (a) Describe the Michelson- Morley experiment and discuss how Einstein explained negative result obtained. (12)

(b) Obtain the volume of a cube, the proper length of each edge of which is L_0 when it is moving with a velocity v along one of its edges. (3)

7. (a) State the fundamental postulates of the special theory of relativity and deduce from them the Lorentz space time transformation equations. (8)

(b) Deduce Einstein's mass-energy relation $E = m\,c^2$ and discuss it. Name some phenomena which verify this relation. (7)

[This question paper contains 3 printed pages.]

Sr. No. of Question Paper : 5048 F Your Roll No.....

Unique Paper Code : 222161

Name of the Paper : Physics-I: Mechanics (PHPT-101)

Name of the Course : **B.Sc. Physical Sciences/Applied Physical Sciences**

Semester : I

Duration : 3 Hours Maximum Marks : 75

Instructions for Candidates

1. Write your Roll No. on the top immediately on receipt of this question paper.
2. Attempt **five** questions in all.
3. Question no. **1** is compulsory.
4. Attempt **four** questions from the rest of the paper.

Attempt any **5** of the following :

1. (a) Find the equation for the tangent plane to the surface $z = x^2 + y^2$ at the point (2, -1, 5)

   (b) A satellite revolves around a planet in an elliptical orbit. Its maximum and minimum distances from the planet are 1.5×10^7 m and 0.5×10^7 m respectively. If the speed of the satellite at the farther point is 5×10^3 m/s, calculate its speed at the nearest point.

   (c) Why cannot a material particle attain a velocity equal to the velocity of light?

   (d) Show that a conservative force can be written as the negative gradient of potential energy.

   (e) Calculate the momentum of a photon.

(f) A cube of aluminium of side 10 cm is subjected to a shearing force of 100 N. If the top surface of the cube is displaced by 0.01 cm with respect to the bottom, calculate the shearing stress and shearing strain.

(g) Evaluate $\vec{\nabla} \cdot \left(r^3 \vec{r}\right)$ (5×3=15)

2. (a) State Keplers Laws of Planetary motion.

(b) Calculate the moment of inertia of a spherical shell about its diameter.

(c) Calculate the acceleration of a solid sphere rolling without slipping down an inclined plane having an angle of inclination φ. (3,6,6)

3. (a) Define Poisson ratio. What are its limiting values?

(b) Obtain an expression for the couple required to twist one end of a cylindrical wire having circular cross-section.

(c) What couple must be applied to a wire one metre long, 1 mm in diameter in order to twist one end of it, through 90° , the other end remaining fixed. Rigidity of material of the wire is 2.8×10^{10} N/m²? (4,8,3)

4. (a) Describe the Michelson-Morley experiment and discuss the importance of its negative result.

(b) The edge of a cube as measured by an observer in a stationary frame S is L. What the volume of the cube is as observed in a frame S', moving with uniform velocity v with respect to S along one of the sides of the cube? (12,3)

5. (a) Obtain the expression for relativistic Doppler's effect in light. Explain the result.

(b) A motorist goes through a red light and claims that the colour he actually saw was green ($\lambda=5.4^{*}10^{-7}$m) and not red ($\lambda=6.2^{*}10^{-7}$m) because of the Doppler Effect. What should have been his speed for his claim to be true? (10,5)

6. (a) Verify Green's theorem in the plane for

$$\oint_c \left(3x^2 - 8y^2\right) dx + \left(4y - 6xy\right) dy$$

where C is boundary of the region defined by x = 0, y = 0, x + y = 1.

(b) Prove that

$$\vec{F} = (4xy - 3x^2z^2)\hat{i} + 2x^2\hat{j} - 2x^3\, z\hat{k}$$

is irrotational. (10,5)

7. (a) State and prove Gauss divergence theorem.

(b) Prove

$$\vec{\nabla}.\left(\vec{A} \times \vec{B}\right) = \vec{B}.\left(\vec{\nabla} \times \vec{A}\right) - \vec{A}.\left(\vec{\nabla} \times \vec{B}\right)$$ (10,5)

This question paper contains 4 printed pages]

Roll No. | | | | | | | | | | | |

S. No. of Question Paper : 6904

Unique Paper Code : 32225201 FC-2

Name of the Paper : Mechanics

Name of the Course : Generic Elective—Physics

Semester : II

Duration : 3 Hours Maximum Marks : 75

(Write your Roll No. on the top immediately on receipt of this question paper.)

Attempt *five* questions in all. Question No. **1** is compulsory.

Attempt *four* questions from the rest of the paper.

1. Attempt any *five* of the following :

(*a*) If $\vec{A} = 4\hat{i} + 6\hat{j} - 3\hat{k}$ and $\vec{B} = -2\hat{i} - 5\hat{j} + 7\hat{k}$, find cosine of the angle between $\vec{A}$ and $\vec{B}$.

(*b*) Solve the differential equation :

$$\frac{d^2y}{dx^2} - 6\frac{dy}{dx} + 9y = 0.$$

(*c*) Show that in any type of strain, work done per unit volume is equal to $\frac{1}{2}$ (stress × strain).

(*d*) State Kepler's laws of planetary motion.

(*e*) Define damped oscillations. Write differential equation for the damped oscillator.

P.T.O.

(*f*) A rod 1 m long is moving along its length with velocity 0.6 *c*. Calculate its length as it appears to an observer on the earth.

(g) Locate the centre of mass of three particles of 2 kg. 3 kg and 4 kg placed at the three corners of an equilateral triangle of 1 m side. 5×3=15

2. (*a*) Find the equation of a rocket. Deduce an expression for the instantaneous velocity of the rocket under uniform gravitational field.

(*b*) A particle moves from position :

$$3\hat{i} + 2\hat{j} - 6\hat{k} \text{ to } 14\hat{i} + 13\hat{j} + 9\hat{k},$$

while a uniform force $4\hat{i} + \hat{j} + 3\hat{k}$ acts on it. Calculate the work done by the force. 10.5

3. (*a*) What is simple harmonic motion ? Give *two* examples. Deduce the differential equation of simple harmonic motion and find its solution.

(*b*) A particle executes simple harmonic motion of amplitude 0.06 m and time period 31.4 sec. Calculate its maximum velocity and maximum acceleration. 10.5

4. (*a*) Obtain all the four relationships between the elastic constants.

(*b*) What couple must be applied to a wire of diameter 2 mm and length 1.0 m to twist one of its end through angle 45°, when other end remains fixed ? The modulus of rigidity of wire is 5×10^{10} Nm^{-2}. 10.5

5. (*a*) Discuss relativity of length and time in detail.

(*b*) Rocket A and B are observed from earth to be travelling with velocities $0.8c$ and $0.7c$ in same direction. What is velocity of A as seen by an observer in B ?

10.5

6. (*a*) Prove that angular momentum is conserved under the action of a central force.

(*b*) The maximum and minimum distance of a comet from the sun are 2×10^{12} m and 8×10^{10} m respectively. If the speed of the comet at the nearest point is 60 km/sec, calculate its speed at the farthest point.

(*c*) What is satellite ? Obtain the expression for the time period of a satellite orbiting around earth. Give *two* applications of artificial satellite.

4,3,8

7. (*a*) Solve the differential equations :

(*i*) $\frac{dy}{dx} + \frac{1}{x} y = x^3 - 3$

(*ii*) $xydx + (1 + x^2)\, dy = 0$

(*b*) Show that for a harmonic oscillator, the average potential energy is equal to the average kinetic energy and each is equal to half the total energy.

(*c*) A load of 5 kg produces an extension of 2 cm in a wire 5 m in length and 1 mm in diameter. Calculate Young's Modulus of wire.

6,6,3

8. (*a*) Find a unit vector perpendicular to the plane of $\vec{A}$ and $\vec{B}$ if :

$$\vec{A} = 2\hat{i} + 3\hat{j} \text{ and } \vec{B} = \hat{i} - \hat{j} + 2\hat{k} .$$

(*b*) Derive the relation between Torque and Angular Momentum. Give *two* examples when angular momentum of particle is conserved.

(*c*) A mass m moves along a curve given by :

$$\vec{r} = 6t^2\hat{i} - 3t\,\hat{j} + 5\hat{k} .$$

Calculate its angular momentum.

his question paper contains 3 printed pages]

Roll No. | | | | | | | | | | |

No. of Question Paper : 66

nique Paper Code : 222161 G

ame of the Paper : **Physics-I : Mechanics (PHPT-101)**

ame of the Course : **B.Sc. Physical Sciences/Applied Physical Sciences**

emester : I

uration : **3 Hours** Maximum Marks : **75**

(Write your Roll No. on the top immediately on receipt of this question paper.)

Attempt *five* questions in all.

Question No. **1** is compulsory.

Attempt any *four* questions from the rest of the paper.

Attempt any *five* of the following : 5×3=15

(*a*) If $\vec{A}$ and $\vec{B}$ are irrotational, prove that $\vec{A} \times \vec{B}$ is solenoidal.

(*b*) A flywheel in the form of a solid disc of 500 kg and 1 m radius is rotating making 120 rotations per minute. Compute its kinetic energy.

(*c*) What are conservative forces ? Show that central force field is conservative in nature.

(*d*) Calculate the energy equivalent of 1 amu.

(*e*) What is recessional red shift ?

(*f*) Calculate the velocity of a solid sphere rolling down an inclined plane when it reaches its bottom.

P.T.O.

(g) Prove :

$$\vec{\nabla} \cdot (\vec{\nabla} \times \vec{A}) = 0$$

2. (a) Define angular momentum and torque. Show that angular momentum of a body moving under the effect of a central force is a constant.

(b) State and prove work energy theorem.

(c) If the centre of mass of three particles of masses 2, 4, 6 gm be at (1, 1, 1) then where should the fourth particle of mass 8 gm be placed so that the position of the centre of mass of the new system is at (3, 3, 3). 5,5,5

3. (a) Explain the terms stress and strain. Define Young's modulus (Y), Bulk modulus (K), modulus of rigidity (η) and Poisson's ratio (σ).

(b) Show that the bulk modulus (K), Young's modulus (Y) and the Poisson's ratio (σ) are connected by the relation $K = Y/[3(1 - 2\sigma)]$, 8,7

4. (a) State the postulates of the special theory of relativity. On its basis obtain the Lorentz transformation equations. Show that for low velocities Lorentz transformations reduce to Galilean transformations.

(b) What is the kinetic energy of a proton of rest mass 1.67×10^{-27} kg moving with velocity 2.7×10^8 m/s ? 10,5

5. (a) Deduce the relativistic transformation equations for velocities of a body along X, Y and Z axes.

(b) Calculate the length and orientation of a rod of length 5 m in a frame of reference which is moving with a velocity 0.6 c in a direction making an angle of 30° with the rod. 9,6

(*a*) State and prove Green's theorem in the plane.

(*b*) Find the directional derivative of : 10.5

$$\phi = x^2 yz + 4xz^2$$

at (1, – 2, – 1) in the direction :

$$2\hat{i} - \hat{j} - 2\hat{k}$$

(*a*) State and prove Stokes theorem. 10.5

(*b*) Evaluate :

$$\iint_S (\vec{\nabla} \times \vec{A}) \cdot \hat{n}\, dS$$

$\vec{A} = (2x - y)\ \hat{i} - yz^2\ \hat{j} - y^2\ z\hat{k}$

and S is the upper half surface of the sphere :

$$x^2 + y^2 + z^2 = 16$$

[This question paper contains 4 printed pages.]

Sr. No. of Question Paper : 1793 **GC-3** **Your Roll No.....**

Unique Paper Code : 32221102

Name of the Paper : Mechanics

Name of the Course : **B.Sc. (Hons.) Physics : Choice Based Credit System**

Semester : I

Duration : 3 Hours Maximum Marks : 75

Instructions for Candidates

1. Write your Roll No. on the top immediately on receipt of this question paper.
2. Attempt any **Five** questions.
3. Question No. **1** is compulsory.
4. Use of Non-programmable scientific calculator is allowed.

1. Attempt **any five** of the following questions :

(i) A galaxy moves away from the earth at 0.2c. What is the natural wavelength of a spectral line whose wavelength measured in a laboratory is 600 nm ?

(ii) Calculate the minimum velocity with which a body may be projected so that it may become a satellite of the earth assuming it takes a circular orbit around earth.

(iii) A particle executing a S.H.M. has a maximum displacement of 4 cm and its acceleration at a distance of 1cm from its mean position is 3 cm/s^2. What will its velocity be when it is at a distance of 2 cm from its mean position ?

P.T.O.

(iv) Two objects, one initially at rest, undergo a one dimensional elastic collision. If half the kinetic energy of the initially moving object is transferred to the other object, what is the ratio of their masses ?

(v) Show that the force field $F = (y^2z^3 - 6xz^2)i + 2xyz^3j + (3xy^2z^2 - 6x^2z)\,k$ is a conservative force field. Hence, find the work done in moving a particle from the point A (–2, 1, 3) to (1, –2, –1) in the given force field.

(vi) Find the centre of mass of a homogeneous semi-circular plate of radius R.

(vii) Distinguish between inertial and gravitational mass of a body.

(viii) A hoop of radius 100cm and mass 19 Kg is rolling along a horizontal surface, so that its centre of mass has a velocity of 20 cms^{-1}. How much work will have to be done to stop it ?

(5×3)

2. (i) Setup the differential equation of motion of a damped harmonic oscillator subjected to a sinusoidal force, $F = F_0 Sin\omega t$. Discuss its steady state solution and obtain an expression for its maximum amplitude.

(ii) What is sharpness of resonance ? Explain the effect of damping on sharpness of resonance.

(12,3)

3. (i) What is reduced mass ? Reduce two body problem to one body problem and obtain equation of motion for equivalent one body problem for two masses.

(ii) A uniform sphere of mass M and radius R and a uniform cylinder of mass M and radius R are released simultaneously from rest at the top of an inclined plane. Which body reaches the bottom first if both roll without slipping ? Find the velocity of both at the bottom. (9,6)

(i) What are Inertial and Non-Inertial frames ? Explain giving an example of each.

(ii) How does the rotation of Earth about its axis affect the acceleration due to gravity experienced by a body at rest at a point on the surface of earth ? Support your answe with a suitable derivation and diagram. (6,9)

(i) Deduce the mathematical expression for the law of addition of relativistic velocities. Hence, show that in no case the resultant velocity of a material particle can be greater than c and that the Lorentz velocity transformation equations reduce to Galilean ones for values of $v << e$.

(iii) A spaceship moving away from the earth with velocity 0.6c fires a rocket (whose velocity relative to the spaceship is 0.7c),

(a) away from the earth

(b) towards the earth.

What will be the velocity of the rocket, as observed from the earth in the two cases. (10,5)

(i) A projectile launched at an angle θ to the horizontal reaches a maximum height h. Show that its horizontal range is $4h/\tan\theta$.

(ii) Prove that in the Centre of mass frame of reference, magnitude of velocities of the two particles remain unaltered in an elastic collision between them.

(iii) A head-on elastic collision between two particles with equal initial speeds v leaves the more massive particle at rest. Find the ratio of the particle masses. (6,4,5)

7. (i) Obtain expressions for gravitational potential at a point inside and outside a thin uniform spherical shell of radius R and mass M. Also depict your results graphically.

(ii) (a) Find the moment of inertia of a solid cylinder of length L, radius R and mass M about an axis passing through its centre and perpendicular to its geometrical axis.

(b) Calculate the radius of gyration of the solid cylinder of min 34, length 24 cm and radius 8 cm about an axis through its centre and perpendicular to its geometrical axis. (7,6,2)

[This question paper contains 2 printed pages.]

Sr. No. of Question Paper : 1873 **GC-3** **Your Roll No.....**

Unique Paper Code : 42221101

Name of the Paper : Physics – I (Mechanics)

Name of the Course : **B.Sc. Physical Science (CBCS)**

Semester : I

Duration : 3 Hours

Maximum Marks : 75

Instructions for Candidates

1. Write your Roll No. on the top immediately on the receipt of this question paper.
2. Attempt any **five** questions in all.
3. Use of nonprogrammable calculator is allowed.

1. (a) What is a position vector ? Find modulus of position vector $2\hat{i} + 2\hat{j} - 3\hat{k}$. (2,2)

   (b) What are polar and axial vectors ? Give one example of each. (2,1)

   (c) Solve following differential equations :

   (i) $(x^2 - 2y)dx = (5x - y^2)dy$

   (ii) $x^2dy + y(x + y)dx = 0$ (4,4)

2. (a) What are conservative forces ? Give two examples of conservative forces. (2,2)

   (b) State and prove work energy theorem. (2,5)

   (c) Two particles of masses 20 g and 40 g are moving opposite to each other with speed 2 m/s and 5 m/s respectively, on a straight line. They collide elastically. Find the change in momentum of each particle. (4)

P.T.O.

3. (a) Give the statement of law of conservation of angular momentum. Give two examples of its application where the law of conservation of angular momentum helps us to understand rotational motion. (3,3)

(b) A solid sphere of mass 100 g and radius 5 cm is rotating about its own axis. It completes 5 revolutions in 2 minute, calculate its

(i) Moment of inertia

(ii) Angular momentum

(iii) Rotational kinetic energy (2,2,2)

(c) State the importance of Newton's first law of motions. (3)

4. (a) Define damped oscillations. Give one example. (2,2)

(b) Write the differential equation for a damped harmonic oscillator. Solve the differential equation for its displacement for under-damped condition only. (3,8)

5. (a) What is Poisson's ratio ? Can it be more than 0.5 ? Give reason for your answer using appropriate equation. (2,1,2)

(b) Obtain the relation between Poisson's ratio (a), bulk modulus (K) and Young's modulus (Y) for an isotropic material. (10)

6. (a) Describe the Michelson-Morley experiment and explain the physical significance of its negative result. (6,4)

(b) Find the velocity of a rod moving in the direction of its length so that its length appears to be 60% of its original length. (5)

7. Write short notes on any two of the following :

(a) Geo-stationary satellite

(b) Searle's method of determining Young's modulus

(c) Time dilation in special theory of relativity. (7½,7½)

This question paper contains 4+2 printed pages]

Roll No. | | | | | | | | | | | |

S. No. of Question Paper : 6672

Unique Paper Code : 32221102 HC

Name of the Paper : Mechanics

Name of the Course : B.Sc. (Hons.) Physics

Semester : I

Duration : 3 Hours Maximum Marks : 75

(Write your Roll No. on the top immediately on receipt of this question paper.)

Attempt *five* questions in all.

Question No. 1 is compulsory.

All questions carry equal marks.

Use of non-programmable scientific calculator is allowed.

1. Attempt any *five* of the following questions :

(*i*) Locate the centre of mass of a system of three particles masses 1 kg, 2 kg and 3 kg placed at the corners of an equilateral triangle of side 1 m.

P.T.O.

(*ii*) When a particle moves under a central force, prove that the particle moves in a fixed plane.

(*iii*) Show that damping has little or no effect on the frequency of a harmonic oscillator if its quality factor is large.

(*iv*) State Kepler's laws of planetary motion.

(*v*) Show that a conservative force can be expressed as $\vec{F} = -\nabla V$, where V is the potential energy.

(*vi*) What is potential energy curve ? Identify stable, unstable and neutral equilibrium from the curve.

(*vii*) Calculate the recessional velocity of a galaxy at a distance of 3×10^9 light years. Is this velocity relativistic ?

(*viii*) Explain the physical significance of negative results obtained from Michelson-Morley experiment. 3×5=15

2. (*a*) Find the centre of mass of a homogeneous semi-circular plate of radius R. 3

(*b*) An object falling in the earth's gravitational field gains mass from surrounding stationary material :

(*i*) Show that :

$$M\frac{dv}{dt} + v\frac{dM}{dt} = Mg,$$

where v is the instantaneous downward velocity of the object when its mass is M. 2

(*ii*) If :

$$\frac{dM}{dt} = kM,$$

where k is a constant, show that the object acquires a terminal velocity and determine this velocity. 4

(*c*) A particle is projected with a velocity of 40 m/s at an elevation of 30°. Calculate (*i*) the greatest height attained (*ii*) the horizontal range and (*iii*) the velocity and direction at a height of 12 m. 2,2,2

3. (*a*) Show that in the case of an elastic and glancing collision between two particles of masses m_1 and m_2 respectively, the maximum value of scattering angle θ_1 in the

laboratory frame corresponds to the scattering angle θ in the centre mass reference frame, where $\theta = \cos^{-1}(-m_2/m_1)$.

Also show that this maximum value of the scattering angle $\theta_1 = \tan^{-1}\left(\frac{m_1^2}{m_2^2} - 1\right)^{1/2}$. 5

(*b*) Show that if a heavy particle is incident on a light particle initially at rest, the heavy particle will not bounce backward as a result of collision. 3

(*c*) Prove that in centre of mass system, the magnitude of the velocities of the particles remains unaltered in elastic collision. 5

4. (*a*) Find the moment of inertia of a uniform solid cylinder of radius R, height H and mass M about an axis passing through its centre of mass and perpendicular to its axis of symmetry. 8

(*b*) Show that the ratio of rotational to translational kinetic energy for a solid cylinder rolling down a plane without slipping is 1 : 2. 3

(c) Moment of inertia of a bigger solid sphere about its diameter is I. 64 smaller, equal spheres are made out of bigger sphere. What will be the moment of inertia of such smaller sphere about its diameter ? 4

5. (a) Derive the expressions for gravitational field and potential at a point inside and outside a uniform solid sphere of radius R and mass M. 5,5

(b) Represent the variations of field and potential graphically with respect to distance from the centre of the shell. 5

6. (a) Derive differential equation for a forced harmonic oscillator and find its steady state solution. Obtain the amplitude and phase of the steady state solution. 2,6,2,2

(b) What is the displacement of a particle executing SHM from its mean position when its KE is half of its PE ? 3

7. (a) What is longitudinal and transverse Doppler effect in light. Obtain an expression for the apparent frequency of light pulse in case of longitudinal Doppler effect in a moving frame of reference. 2,9

P.T.O.

(*b*) How does mass of a material particle change with velocity ? Show that c is the ultimate speed of the particle in free space. 2,2

8. (*a*) Derive the relativistic law of variation of mass with velocity. For a relativistic particle, show that : 7,3

$$E^2 = p^2c^2 + m_0^2c^4.$$

(*b*) Find the velocity that an electron must be given so that its momentum is 10 times its rest mass times the speed of light. What is the energy at this speed ?

(Rest mass of electron = 9×10^{-31} kg). 3,2

[This question paper contains 4 printed pages.]

Your Roll No.....

Sr. No. of Question Paper : 6871 **HC**

Unique Paper Code : 42221101

Name of the Paper : Physics - I (Mechanics)

Name of the Course : **B.Sc. (Prog.)** Science

Semester : I

Duration : 3 Hours Maximum Marks : 75

Instructions for Candidates

1. Write your Roll No. on the top immediately on receipt of this question paper.
2. Attempt any **five** questions in all, including **Q. No. 1** which is compulsory.
3. Use of nonprogrammable calculator is allowed.

1. Attempt any **five** of the following: (5×3=15)

   (a) What are the two postulates of special theory of relativity?

   (b) Differentiate b/w inertial and non-inertial reference frames with one example.

P.T.O.

(c) What do you understand by inertial mass a gravitational mass?

(d) Show that addition of vectors is associati

i.e. $\vec{A}+(\vec{B}+\vec{C})=(\vec{A}+\vec{B})+\vec{C}$

(e) If $\vec{r}$ = (t^3+2+) **i**-$3e^{-2t}$ **j**+2 sin5t **k**, find d^2r/dt^2 at t =

(f) Solve differential equation $\frac{d^2y}{dx^2}-6\frac{dy}{dx}+9y=0$

(g) A spring of spring constant 'k' is loaded by mass 'm' If this spring is cut half in length and same mass loaded on it, what will be new time period?

(h) What is Hook's law in elasticity? What do you mean elastic limit and breaking stress?

2. (a) What are polar and axial vectors? Give one example each.

(b) Solve differential equation $\frac{d^2y}{dx^2}+4\frac{dy}{dx}+5y=$

where, y = 2 and $\frac{dy}{dx}=\frac{d^2y}{dx^2}$, when $x = 0$

(c) Prove that $\vec{A}\times(\vec{B}\times\vec{C})=\vec{B}(\vec{A}.\vec{C})-\vec{C}(\vec{A}.\vec{B})$

3. (a) Find the centre of mass of a uniform solid hemisphere of radius 'R'. (5)

(b) A bomb of mass **'4M'** in flight explodes into two fragments when its velocity is $(10\hat{i}+2\hat{j})$ *m/sec.* If the smaller mass *'M'* files with velocity $(20\hat{i}+50\hat{j})$ *m/sec*, deduce the velocity of the larger mass **'3M'**. (5)

(c) State and prove the 'work-energy' theorem. (5)

4. (a) Describe the principle of a rocket? Why multistage rocket is necessary? Establish the following relation for a rocket, $V = V_0 + v \log_e (M_0/M)$, where v is the exhaust Velocity of gases relative to rocket, M_0, V_0 are initial mass and velocity of rocket respectively, M and V are mass and velocity of rocket at any time 't'.

(3,3,4)

(b) For a particle of mass m = 10 gm, position $\vec{r}=(10\hat{i}+6\hat{J})$ cm and velocity $\vec{v}=5\hat{i}$ cm/s, calculate the angular momentum about the z-axis through origin. (5)

(a) Show that the ratio of rotational to translational kinetic energy for a solid cylinder rolling down a plane without slipping is 1:2. (5)

P.T.O.

(b) Define the central forces. Show that the path or c of the particle under the central force must be a p curve and its areal velocity is constant. (2,

6. (a) What do you understand by a damping or a dissipa force? Deduce the differential equation of dam harmonic oscillator and discuss in detail the case critical and under-damped cases. (

(b) A smooth straight tunnel is board through the centr the earth. A particle of mass 'm' is dropped into tun Prove that the motion is simple harmonic and calcu its time period.

7. (a) If Y, η and K represent Young modulus, coefficient rigidity and bulk modulus, respectively, then prove th

$$\frac{9}{y}=\frac{3}{\eta}+\frac{1}{K}$$

(b) Write down the Lorentz space-time transformati equations. Discuss the time dilation in special theory relativity. (

(c) Two objects are moving in the opposite direction, ea with a speed of 0.9c. Find the relative speed of the t objects. (*c=velocity of light in free space*)

This question paper contains 4+1 printed pages]

Roll No. | | | | | | | | | | | |

S. No. of Question Paper : **2451**

Unique Paper Code : **32225201** **GC-4**

Name of the Paper : **Mechanics**

Name of the Course : **GE : Physics for Honours**

Semester : **II**

Duration : **3 Hours** Maximum Marks : **75**

(Write your Roll No. on the top immediately on receipt of this question paper.)

Attempt *five* questions in all.

Question No. **1** is compulsory.

Attempt *four* questions from the rest of the paper.

1. Attempt any *five* of the following :

(*a*) A unit vector is $0.4\hat{i} + 0.8\hat{j} + c\hat{k}$. Calculate the value of c and also the cosine of the angle which the vector makes with x-axis.

(*b*) Solve the following differential equation :

$$e^{y}\frac{dy}{dx} = e^{x} + x^{2}.$$

(*c*) Does the centre of mass of solid body necessarily lie within the body ? Give examples.

P.T.O.

(*d*) For a particle of mass m, position $\vec{r} = 12\hat{i} + 8\hat{j}$ a
$\vec{v} = 6\hat{i}$, calculate its angular momentum about the orig

(*e*) What is Hooke's law ? Sketch labelled stress-stra
diagram.

(*f*) The length of a rod is 10 meters in reference fram
A. What is its length as seen by an observer
reference frame B, when reference frame B has a veloc
of $0.8c\,\hat{i}$ relative to reference frame A.

(*g*) The maximum and minimum distances of a comet fro
the sun are 8×10^{12} metre and 1.6×10^{12} met
respectively. If its velocity when nearest to the sun
60 metres/sec, what is the velocity when farthest ? 5×

2. (*a*) If the vectors $(\hat{i} + 2\hat{j} + 4\hat{k})$ and $(5\hat{i})$ represent the tw
sides of a triangle, find a vector perpendicular to th
plane of the triangle.

(*b*) Obtain expressions for the velocity and acceleration
a particle moving at constant speed in circular orbit
constant radius r.

(*c*) Discuss physical significance of the following differential equation, $\frac{d^2x}{dt^2}+\omega^2 x=0$. Also find its general solution. 3,6,6

3. (*a*) Define linear momentum of a moving particle. Derive an expression for the total momentum of a system of particles. Show that if the total linear momentum of system of particles is conserved the centre of mass is either moving with a constant velocity or is at rest.

(*b*) State and prove Work Energy theorem.

(*c*) Force acting on a particle is given by $\vec{F}=(2xy+2z)\hat{i}+x^2\hat{j}+2xz\hat{k}$. Calculate the work done on a particle in moving it from position (0, 1, 2) to (5, 6, 8). 6,6,3

4. (*a*) A bomb of mass 4M explodes in flight at a time when its velocity is $5\hat{i}+4\hat{j}$ m/sec. It splits into two fragments of masses M and 3M and the smaller mass M is observed to fly with a velocity $10\hat{i}+100\hat{j}$ m/sec after the explosion. Calculate the velocity of larger fragment of mass 3M just after the explosion.

(*b*) Deduce equation of motion of rocket and neglecting gravity, find the instantaneous velocity of the rocket.

(*c*) Given that $\vec{r} = x\hat{i} + y\hat{j} + z\hat{k}$ and $\vec{F} = F_x\hat{i} + F_y\hat{j} + F_z\hat{k}$. Find the torque $\vec{\tau}$. Show that if $\vec{r}$ and $\vec{F}$ lie in the given plane $\vec{\tau}$ has no component in that plane. 4,7,4

5. (*a*) State Kepler's laws of planetary motion. Derive expressions for the velocity and time period of a satellite in circular orbits.

(*b*) What are central forces ? Give *two* examples. Show that in central force field :

(*i*) the angular momentum is conserved;

(*ii*) areal velocity is constant. 7,8

6. (*a*) What is simple harmonic motion ? Explain the following physical quantities associated with simple harmonic motion :

(*i*) Time Period

(*ii*) Frequency

(*iii*) Amplitude

(*iv*) Phase.

(*b*) Show that for a harmonic oscillator, mechanical energy remains constant and it is proportional to the square of the amplitude.

(*c*) In Simple Harmonic Motion when the displacement is one half of the amplitude, what fractions of the total energy are kinetic and potential ? 6,5,4

7. (*a*) Find the work done in stretching the wire.

(*b*) Define modulus of rigidity and Poisson's ratio. Deduce an expression for couple in twisting a cylinder by an angle θ. 5,10

8. (*a*) Obtain formula for relativistic addition of velocities.

(*b*) We observe two galaxies A and B moving in opposite directions with speeds 0.5c and 0.4c respectively. What is the velocity of B as seen from galaxy A.

(*c*) Explain the concept of time dilation in relativity. What is proper interval of time ? Deduce an expression for time dilation. 6,3,6

[This question paper contains 4 printed pages]

Your Roll No. : .....

Sl. No. of Q. Paper : **7598** **HC**

Unique Paper Code : 32225201

Name of the Course : **Generic Elective : Physics**

Name of the Paper : Mechanics

Semester : II

Time : 3 Hours ***Maximum Marks : 75***

Instructions for Candidates :

(a) Write your Roll No. on the top immediately on receipt of this question paper.

(b) Attempt any **FIVE** questions. **All** questions carry equal marks.

1. (a) Prove that the four points $4i+5j+k$, $-(j+k)$, $3i+9j+4k$ and $4(-i+j+k)$ are coplanar. 5

(b Solve the following differential equations. 5,5

(i) $d^2y/dx^2 - 8(dy/dx)+15y = 0$

(ii) $e^y dx + (1+xe^y)dy = 0$

P.T.O.

2. (a) State the Work-Energy theorem and calculate the work done by a force $F = kx^2$ acting on a particle at an angle of 60° with x-axis to displace it from x_1 to x_2 along the x-axis. 2+6

(b) Define torque acting on a particle and its angular momentum L. Show that the time rate of change of angular momentum of a particle is equal to the torque acting on it

2+5

3. (a) Define the centre of mass of a rigid body. Does the Centre of Mass of a body necessarily lie within the body? Give example. 8

(b) Consider two spaceships A and B moving in the vertical direction with speed 2×10^8 m/s and 2.5×10^8 m/s. Find the relative speed of B with respect to A. 7

4. (a) When a particle moves under a central force, verify that (i) the angular momentum is conserved (ii) the particles moves in a fixed plane (iii) the areal velocity of the radius vector remains constant.

3+3+3

(b) Derive expressions for the velocity and time period of a satellite moving in a circular orbit around the Earth. 6

5. (a) Deduce relations between the elastic constants Y, K and σ. 10

(b) What Couple must be applied to a wire 1 meter long and 2 mm in diameter to twist one of its end through 45^0 when the other end remains fixed. (Given $\eta = 5x10^{10}$ N/m^2) 5

6. (a) Deduce Lorentz transformation equations. Show that for values of v<<c, Lorentz transformation reduces to Galilean one. 10

(b) A man on the moon observes two spaceships coming towards him from opposite directions at speed of 0.8c and 0.9c respectively. What is the relative speed of the two space ships as measured by an observer on either one ? 5

7. (a) Define damped oscillations. Obtain and solve the differential equation for a damped harmonic oscillator. 2+8

P.T.O.

(b) 1.6 kg-wt extends a spring 8 cm from its unstretched position. The mass is replaced by a body of 50 gm. The mass is pulled and then released. Find the period of oscillations. 5

This question paper contains 4 printed pages]

Roll No. | | | | | | | | | | |

S. No. of Question Paper : 103

Unique Paper Code : 32221102 I

Name of the Paper : Mechanics

Name of the Course : B.Sc. (Hons.) Physics (CBCS)

Semester : I

Duration : 3 Hours Maximum Marks : 75

(Write your Roll No. on the top immediately on receipt of this question paper.)

Attempt any *five* questions in all.

Q. No. 1 is compulsory.

Use of non-programmable scientific calculator is allowed.

1. Attempt any *five* of the following : 5×3=15

(*a*) Prove that the radius vector sweeps out equal areas in equal intervals of time for any elliptical orbit under central force motion.

(*b*) Explain the theory of expanding universe using Doppler effect in light.

(*c*) What are the effects of Coriolis force due to Earth's rotation.

P.T.O.

(*d*) Show that the ratio of rotational to translational kinetic energy for a solid cylinder rolling down a plane without slipping is 1 : 2.

(*e*) Compare gravitational mass with inertial mass of the body.

(*f*) Show that $E^2 - c^2p^2$ is invariant to Lorentz transformations.

(*g*) Show that damping has little or no effect on the frequency of a harmonic oscillator if its quality factor is large.

(*h*) Explain how a hollow cylinder is stronger than a solid cylinder having same material, mass and length.

2. (*a*) State and prove Work-Energy theorem. 7

(*b*) Show that in an elastic collision of two particles in centre of mass frame of reference, the magnitude of the velocity remains unchanged before and after the collision. 8

3. (*a*) Find the centre of mass of a uniform solid hemisphere of mass M and radius R w.r.t. its geometrical centre. 7

(*b*) Determine the moment of inertia of a uniform hollow sphere of mass M, and radius R about its diameter and tangent. 8

4. (*a*) Derive the expression for the gravitational potential due to a solid sphere of radius R and mass M at a point outside the shell and also at a point inside the shell. 10

(*b*) Show graphically the variation of both gravitational potential and gravitational field as a function of radial distance from the centre of the sphere. 5

5. (*a*) State and prove theorem of perpendicular axes of moment of inertia for a three-dimensional rigid body. 7

(*b*) Establish the relation between Y, K and *n* where Y is the Young's modulus, K is the bulk modulus and *n* is the modulus of rigidity of the material. 8

6. (*a*) Deduce the differential equation of a damped harmonic oscillator and discuss in detail the cases of overdamped, critical and underdamped oscillators. 12

(*b*) A condenser of capacity I microF, an inductance of 0.2 Henry and a resistance of 800 ohm are connected in series. Is the circuit oscillatory ? If yes, calculate the frequency and quality factor of the circuit. What do you understand by Quality factor of an oscillator ? 3

7. (*a*) What is Coriolis force ? Show that the total Coriolis force acting on a body of mass m in a rotating frame is $-2m\ \vec{\omega} \times \vec{v}_{rot}$, where $\vec{\omega}$ is the angular velocity of rotating frame and $\vec{v}_{rot}$ is the velocity of the body in rotating frame. 9

(*b*) Calculate the values of the centrifugal and Coriolis forces on a mass of 20 g placed at a distance of 10 cm from the axis of a rotating frame of reference, if the angular speed of rotation of the frame be 10 radians per second. 4

(*c*) Calculate the effective weight of an astronaut ordinarily weighing 60 kg when his rocket moves vertically upward with 5 g acceleration. 2

8. (*a*) Describe Michelson-Morley experiment and explain the significance of the null result. State the postulates of special theory of relativity. 6,2,2

(*b*) The proper mean life time of pi meson is 2.5×10^{-8} sec. Calculate :

(i) the mean life time of pi meson travelling with velocity 2.4×10^{10}cm/sec.

(*ii*) distance travelled by it before disintegrating. 3,2

[This question paper contains 4 printed pages]

Your Roll No. : .....

Sl. No. of Q. Paper : **203** **I**

Unique Paper Code : 42221101

Name of the Course : **B.Sc.(Prog.)**

Name of the Paper : Mechanics

Semester : I

Time : 3 Hours ***Maximum Marks : 75***

Instructions for Candidates :

(a) Write your Roll No. on the top immediately on receipt of this question paper.

(b) Attempt any **five** questions. Use of non programmable calculator is allowed.

1. (a) If $A = 2i - 3j - k$ and $B = i + 4j - 2k$. Find $(A+B) \times (A-B)$. 5

(b) If $\vec{R} = e^{-t}\hat{i} + \ln(t^2+1)\hat{j} + \tan(t)\hat{k}$. 5

Find $\left|\frac{d\vec{R}}{dt}\right|$ and $\left|\frac{d^2\vec{R}}{dt^2}\right|$ at $t = 0$.

P.T.O.

(c) Solve the differential equation : 5

$$\frac{dy}{dx} = \frac{2y^4 + x^4}{xy^3}$$

2. (a) What is centre of mass ? Show that in the absence of an external force the velocity of centre of mass remains constant. 5

(b) A vessel at rest explodes breaking into three pieces. Two pieces having equal masses, fly off perpendicular to each other with the same speed of 30 m/sec. The third piece has three times the mass of each piece. What is the direction and magnitude of its velocity immediately after explosion. 5

(c) Show that the force $\vec{F} = yz\hat{i} + zx\hat{j} + xy\hat{k}$ is a conservative force. 5

3. (a) Define angular momentum $\vec{j}$ and torque $\vec{\tau}$.

Show that $\vec{\tau} = \frac{d\vec{j}}{dt}$. 5

(b) A 500 gm mass is whirled round in a circle at the end of a string 40 cm long. The other end of the string is held in hand. If the mass makes 5 rev/sec, what is its angular momentum. If the number of revolutions reduce to 1 rev/sec in 20 seconds, find the torque acting on the mass. 5

(c) Prove law of conservation of mechanical energy for conservative forces. 5

4. (a) State Kepler's laws of planetary motion. 6

(b) Show that the areal for a particle moving under the influence of a central force velocity is constant. 4

(c) What are geostationary satellites ? Find the height of a geostationary satellite above the surface of earth. Given, Radius of earth = 6400 km. 5

5. (a) What is simple harmonic motion ? Explain with the help of an example. Write down the differential equation of simple harmonic motion and find its solution. 10

(b) Show that for a particle executing simple harmonic motion the average potential energy is equal to half the total energy. 5

6. (a) Derive the relation $K = \frac{Y}{3(1-2\sigma)}$ where K = Bulk's Modulus, Y = Young's Modulus and σ = Poisson's ratio. 10

(b) A steel bar 2 m long, 40 mm wide and 20 mm thick is subjected to an axial pull of 160 kN along its length. Find changes in its length, width and thickness. Take Young's Modulus = 2×10^5 N/mm^2 and Poisson's ratio = 0.3 5

7. (a) Write down Lorentz transformation equations and derive the expression for length contraction. 10

(b) How fast would a rocket have to go relative to an observer on earth for its length to be contracted to 50% of its length when at rest ? 5

This question paper contains 4 printed pages]

Roll No. | | | | | | | | | | |

S. No. of Question Paper : 2985

Unique Paper Code : 32225201 IC

Name of the Paper : Mechanics

Name of the Course : Physics : Generic Elective for Honours

Semester : II

Duration : 3 Hours Maximum Marks : 75

(Write your Roll No. on the top immediately on receipt of this question paper.)

Attempt *five* questions in all.

Question No. 1 is Compulsory.

Attempt *four* questions from rest of the paper.

1. Attempt any *five* of the following :

(*a*) Find the angle between $\vec{A} = 2\hat{i} + 2\hat{j} - \hat{k}$ and $\vec{B} = 6\hat{i} - 3\hat{j} + 2\hat{k}$.

(*b*) Solve the differential equation :

$$\frac{d^2y}{dx^2} - 5y = 0.$$

P.T.O.

(c) Does the centre of mass of solid body necessarily lie within the body ? Give examples.

(d) State Kepler's laws of planetary motion.

(e) Define simple harmonic motion. Write differential equation for simple harmonic motion.

(f) What is Poisson's ratio ? Can it be more than 0.5 ?

(g) What are the *two* postulates of special theory of relativity ? 5×3=15

2. (a) If $\vec{A} = 5t^2\,\hat{i} + t\,\hat{j} - t^3\,\hat{k}$ and $\vec{B} = \sin t\,\hat{i} - \cos t\,\hat{j}$, find $\frac{d}{dt}(\vec{A} \cdot \vec{B})$. 5

(b) Solve : 5

$$\frac{dy}{dx} = \frac{2x^3 + y^3}{3xy^2}.$$

(c) Solve : 5

$$\frac{d^2x}{dt^2} + 4\frac{dx}{dt} + 4x = 0.$$

3. (a) State and prove work energy theorem. 1,5

(*b*) Find the total work done in moving a particle in a force field given by $\vec{F} = 3xy\hat{i} - 5z\hat{j} + 10x\hat{k}$ along the curve $x = t^2 + 1$, $y = 2t^2$, $z = t^3$, from $t = 1$ to $t = 2$. 3

(*c*) Define centre of mass. Show that in the absence of the external forces, the velocity of centre of mass remains constant. 1,5

4. (*a*) Explain the principle of a rocket. Establish the following relation for a rocket :

$$V = V_0 + v \log e \frac{M_0}{M},$$

where v is the exhaust velocity of the gases relative to rocket, M_0, V_0 are initial mass and velocity of rocket respectively. M and V are mass and velocity of the rocket at any time 't'. 3,7

(*b*) A particle of mass m, is moving in x-y plane and the components of its velocity along x and y directions are v_x and v_y. Show that its angular momentum has only a z component. 5

5. (*a*) What are central forces ? Give *two* examples. Show that in a central force field :

(*i*) the angular momentum is conserved.

(*ii*) the particle moves in a fixed plane. 1,1,3,3

(*b*) What is satellite ? Derive expressions for the velocity and time period of a satellite orbiting around earth. 2,2½,2½

6. (*a*) What is simple harmonic motion ? Give *two* examples. Deduce the differential equation of simple harmonic motion and find its solution. 1,1,3,4

(*b*) Show that for a harmonic oscillator, mechanical energy remains constant and it is proportional to the square of the amplitude. 6

7. (*a*) Find the work done in stretching the wire. 5

(*b*) Define Young's modulus (Y), bulk modulus (K) and modulus of rigidity (η). Prove the relation :

$$Y = \frac{9K\eta}{3K + \eta}.$$ 1,1,1,7

8. (*a*) Write down the Lorentz space-time transformation equations. Discuss the time dilation in special theory of relativity. 2,4

(*b*) Obtain the formula for relativistic addition of velocities. 6

(*c*) A spacecraft is moving relative to earth. An observer on the earth finds that, according to her clock, 3601 s elapse between 1 p.m. and 2 p.m. on the spacecraft's clock. What is the spacecraft's speed relative to the earth ? 3