

MECHANICS QUESTION BANK FOR BSC STUDENTS

Short answer type (2 - 4 marks each)

- 1) What do you mean by escape velocity? Calculate the value of escape velocity for earth.
- 2) Explain Kepler's law of planetary motion.
- 3) Estimate the mass of sun, assuming the orbit of earth to be a circle. The distance between Sun & Earth is 1.4×10^{11} meters & $G = 6.67 \times 10^{-11} \text{Ns}^2\text{m} / \text{kg}^2$.
- 4) If g is acceleration due to gravity on the earth surface, Calculate the gain in potential energy of an object of mass m raised from surface of earth to a height R equal to radius of earth.
- 5) Compare the rms velocity of oxygen molecules at 27°C with escape velocity from earth surface ($K = 1.4 \times 10^{-23} \text{Joule} / \text{K}$)
- 6) If a body of mass m be projected vertically upward from earth surface (radius of earth = R) to reach a height of $10R$, how much kinetic energy is given to body?
- 7) What is potential energy of a mass of 1 kg at a distance of 10^6km from the center of earth?
- 8) Prove that the gravitational potential at the centre of solid sphere will be $3/2$ times the potential at its surface.
- 9) What are central forces? Give some examples of central forces.
- 10) Explain the terms 'gravitational field', 'gravitational attraction' & 'gravitational potential'.
- 11) Show that central force is conservative.
- 12) Show that for conservative forces the work done around the closed path is zero.
- 13) Show that conservative force can be expressed as $\mathbf{F} = -\text{grad } U$ where U is potential energy.
- 14) Prove that curl of conservative force is zero.
- 15) Show that following two forces are conservative:
a). $F = (y^2 - x^2) \mathbf{i} + 2xy \mathbf{j}$ and b). $F = (2xy + z^2) \mathbf{i} + x^2 \mathbf{j} + 2xz \mathbf{k}$
- 16) What do you mean by work energy theorem? Describe.
- 17) Show that force $F = (2xy + yz^2) \mathbf{i} + (x^2 + xz^2) \mathbf{j} + 2xyz \mathbf{k}$ is conservative. Calculate work done by this force in moving from $(0,1,2)$ to $(5,2,7)$.
- 18) What do you mean by linear restoring forces?
- 19) Explain law of conservation of total energy.
- 20) Explain gradient of electric potential.
- 21) Define unit vector & null vectors.
- 22) What is solenoidal vector point function?

- 23) What is conservative field?
- 24) Define del operator.
- 25) What is Laplacian Operator?
- 26) Show that vector $\hat{i} - 2\hat{j} - 4\hat{k}$, $-2\hat{i} + 3\hat{j} - 4\hat{k}$ & $-\hat{j} + 2\hat{k}$ are coplanar.
- 27) Prove the following cyclic relation in vector triple product: $\mathbf{A} \times (\mathbf{B} \times \mathbf{C}) + \mathbf{B} \times (\mathbf{C} \times \mathbf{A}) + \mathbf{C} \times (\mathbf{A} \times \mathbf{B}) = \mathbf{0}$
- 28) If any scalar quantity is given by $S = x^2y + 3y^2z^2 - 2x^3z^3$. Find $\Delta^2 S$ at point (1, 2, -1).
- 29) Prove that: $\text{grad}(u + v) = \text{grad } u + \text{grad } v$.
- 30) Derive an expression for curl of a vector field & give its physical significance.
- 31) A parallelepiped with one vertex at the origin has three adjacent vertices at (10, -5, 3), (3, -4, 7) and (-5, -6, -3) in Cartesian coordinates. Calculate its volume.
- 32) Show that gradient of scalar field is a vector.
- 33) Prove that the vectors $\mathbf{A} = 2\hat{i} + 4\hat{j} + 4\hat{k}$ and $\mathbf{B} = 4\hat{i} + 2\hat{j} - 4\hat{k}$ are perpendicular to each other.
- 34) Prove that $\text{curl}(\text{grad } r) = 0$.
- 35) Find area of parallelogram determined by vectors $(\hat{i} + 2\hat{j} + 3\hat{k})$ and $(3\hat{i} + 2\hat{j} + \hat{k})$.
- 36) Calculate curl & divergence of: $\mathbf{F} = 2x\hat{i} + (5y + 9z)\hat{j} + (-9y)\hat{k}$
- 37) If $f(x, y, z) = 3(x^2y - y^2x)$, Calculate $\text{grad } f$ at (1, -2, -1).
- 38) Show that $f = 2x\hat{i} + 2y\hat{j}$ is irrotational.
- 39) Show that $\hat{i} - 2\hat{j} + 3\hat{k}$, $-2\hat{i} + 3\hat{j} - 4\hat{k}$, $-\hat{j} + 2\hat{k}$ are coplanar.
- 40) Find the constant a , if $\mathbf{A} = (x + 3y)\hat{i} + (y - 2z)\hat{j} + (x + az)\hat{k}$ is solenoidal.
- 41) Show that for a rigid body the angular momentum about the axis of rotation is equal to product of moment of inertia & angular velocity about that axis.
- 42) Two bodies of different masses are moving with the same K.E of translation. Which one has greater momentum. Explain?
- 43) Show that conservation of Linear momentum is equal to Newton's third law.

Long answer type (5 - 10 marks each)

- 1) What are inertial & non inertial frames? Explain with example.
- 2) Under what conditions mechanical energy of a system is conserved What is energy function.
- 3) Explain conservation energy law. Also describe Energy function?
- 4) Find the gravitational attraction due to thin spherical shell at a point (i) external (ii) internal to the shell.
- 5) Describe expressions for the gravitational potential and attraction due to a thin uniform spherical shell at a general point outside as well as inside the shell. Give a graphical representation also.
- 6) Derive expressions for the gravitational potential and attraction due to a solid sphere of uniform density at an (i) external point. (ii) internal point
- 7) What is Kepler's law of planetary motion? Show how Newton's law of gravitation follows from them.
- 8) Deduce an expression for gravitational potential & field due to a thin circular coil at a point on its axis.
- 9) Derive Poisson's equation of gravitational self-energy.
- 10) Derive an expression for curl of vector field and give its physical significance.
- 11) State & prove Stokes theorem.
- 12) State & prove Green's theorem.
- 13) Verify Stokes theorem for $F = x(i + j + y)$ integrated, round the square in plane $z = 0$, whose sides are along the lines, $x=0, y=0, x=a, y=a$.
- 14) State & prove Gauss Divergence theorem.
- 15) Find the vectors whose magnitude is 12 & which is perpendicular to $(j - k)$ and lies in plane $3x + 3y + z = 5$.

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