Mechanics (BMETE11AP59) exam

1. Units, magnitudes, significant digits. Particle kinematics in one dimension: trajectory, derivative, velocity, acceleration, integration. Motion under constant acceleration, free fall.
2. Two-dimensional motion: vectors. Projectiles. Uniform circular motion. Tangential and radial acceleration. Relative velocity, relative acceleration. Inertial frames, Galilei's relativity principle, Galilei transformation.
3. Laws of motion, dynamics. Concept of force and mass, Newton's laws. Forces of friction.
4. Non-uniform circular motion. Motion in accelerated frames. Motion in the presence of resistive forces.
5. Work, kinetic energy, work theorem. Conservative and non-conservative forces. Potential energy, energy conservation for particles. Energy diagram and equilibrium of a system.
6. Conservation of energy. Isolated and non-isolated systems. Kinetic friction. Changes in mechanical energy for non-conservative systems. Power.
7. Linear momentum. Isolated and non-isolated systems. Collisions in one and two dimensions. Center of mass.
8. Systems of many particles, momentum, and energy conservation. Deformable systems. Rocket propulsion.
9. Rotation of a rigid object about a fixed axis. Angular position, velocity, and acceleration. Angular and translation quantities. Torque. Moment of inertia, Steiner theorem. Rotational kinetic energy. Rolling motion.
10. Angular momentum conservation, system of many particles. Kinematics of a rigid object. Torque on rigid object, equilibrium. Motion of gyroscopes and tops.
11. Change of vector in rotating frames. Inertial forces in rotating frames. Centrifugal and Coriolis forces on Earth.
12. Oscillatory motion. Object attached to spring. Simple harmonic motion, energy. Comparison to uniform circular motion. Pendulum: mathematical, physical, and torsional.
13. Complex formalism. Superposition of harmonic oscillations. Oscillations with the same direction and frequency. Beats. Combining perpendicular oscillations.
14. Damped oscillations, under and overdamping. Forced oscillations. Resonance, quality factor.
15. Molecular oscillations. Coupled oscillations. Matrix formalism, normal modes. Motion of two coupled pendulums.
16. Static equilibrium and elasticity. Elastic coefficients. Bending and twisting.
17. Newton's law of universal gravitation. Free fall. Kepler's laws and planetary motion. Gravitation potential energy. Equivalence of inertial and gravitational mass.
18. Static fluids and gases. Pascal's law. Hydrostatic pressure. Buoyant forces and Archimedes principle.
19. Surface tension, Laplace pressure, Young-Laplace equation. Contact angles, capillary phenomena.
20. Fluid dynamics. Continuity equation. Bernoulli's equation and its applications.
21. Viscous flow, Newton's law. Flow of viscous fluids in pipes, Hagen-Poiseuille equation. Turbulent flows. Resistive forces on bodies moving in fluids and gases.
22. Wave motion. Propagation of a disturbance, travelling wave. Harmonic waves in one dimension. Plane waves in three dimensions. Rate of energy transfer by wave on a string.
23. Linear wave equation, on a string and for sound. Transversal and longitudinal waves. Doppler effect. Polarisation.
24. Boundary effects: reflection and transmission. Interference for one-dimensional waves. Standing waves, strings, and pipes.
25. Interference with two point sources, coherence. Two-slit experiment. Huygens principle, reflection and refraction, Snell's law.