General Physics I. Mechanical Engineering - University of Pisa

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Course Content:

INTRODUCTION

MEASUREMENT AND VECTORS: Early developments in Physics; measurement units; conversion of units; system of units; estimation and approximation; coordinate systems: Cartesian, spherical, cylindrical; scalars and vectors; proprieties of vectors; elementary vector's algebra.

KINEMATICS

MOTION IN ONE DIMENSION: position, displacement, distance, velocity and speed, acceleration; constant acceleration motion; general motion; trajectory and time equations; integration of the equations of motion; separable differential equations; differential techniques.

MOTION IN TWO AND THREE DIMENSIONS: position, displacement, distance, velocity and acceleration vectors; projectile motion and projectile range; circular motion and centripetal acceleration; angular velocity.

DYNAMICS OF A POINT MASS

NEWTON'S LAWS OF DYNAMICS: Newton's first law; inertial reference systems; relative velocity and acceleration; mass; force; Newton's second law; Galilean relativity; gravity force and weight; contact forces; free-body diagram; Newton's third law; problems with two or more objects.

RELEVANT FORCES IN ELEMENTARY MECHANICS: static and dynamic friction; aerodynamic and hydrodynamic drag; cable tension; springs and Hooke's law; center of mass; motion of the center of mass; non-inertial reference system and fictitious forces.

WORK AND KINETIC ENERGY: work accomplished by a constant force; work for a variable force; work in a line or curved path; line integral; work-energy theorem; power; kinetic energy of a mechanical system; second Koenig's theorem; .

CONSERVATION OF ENERGY: work on different paths; potential energy; mechanical energy; conservation of mechanical energy; chemical, electric and thermal energy; conservation of energy.

SYSTEM DYNAMICS

MECHANICAL SYSTEMS: continuous systems and discrete systems; linear, superficial and volume density; calculating the center of mass of solid bodies.

LINEAR MOMENTUM: linear momentum; impulse of a force; impulse-momentum theorem; conservation of linear momentum; linear momentum of a mechanical system;

elastic and inelastic collisions; collisions in one or two dimensions.

ROTATORY MOTION: angular velocity and acceleration of a mechanical system; rotational kinetic energy; calculating the moment of inertia; Newton's second law for rotation; rotation and rolling.

ANGULAR MOMENTUM: vector treatment of rotatory motion; torque; angular momentum of a dynamic system; angular momentum of a solid body; torque as rate of change of angular momentum; angular impulse; angular impulse's theorem; conservation of angular momentum; first Koenig's theorem; collisions among rotating objects.

APPLICATION OF FUNDAMENTAL MECHANICS

GRAVITY: Kepler's laws; gravitational orbits; Newton's law of gravity; gravitational potential energy; escape velocity.

STATIC EQUILIBRIUM: conditions for equilibrium; the six equations of static; the center of gravity; static equilibrium, stable, unstable and indifferent; undetermined problems.

FLUIDS MECHANICS: density; pressure; Torricelli's law; Archimede's principle; stable floating; Bernoulli's law; ideal fluids; real fluids; fluid dynamics.

OSCILLATIONS: equilibrium and small oscillations; simple harmonic motion; differential equation of the harmonic motion and its solutions; frequency, period, amplitude; pulse width and phase of oscillations; damped oscillations; resonance.

WAVES: harmonic waves on a string; waves equations; d'Alembert solution; velocity of propagation; regressive and progressive waves; two dimensions waves; superposition of waves; standing waves; Doppler effect.

THERMODYNAMICS

TEMPERATURE AND KINETIC THEORY: thermal equilibrium and temperature; gas thermometers and absolute temperature; perfect gas state equation; kinetic theory of gases.

HEAT AND THE FIRST LAW OF THERMODYNAMICS: heat capacities; change of state; first law of thermodynamics; internal energy of a perfect gas; work an PV diagram for gases; isothermal, isobaric, isochoric transformations; heat capacity of gases; heat capacity of solids; equipartition theorem; quasi-static adiabatic transformations.

THE SECOND LAW OF THERMODYNAMICS: heath engines and the second law of thermodynamics; Clausius' and Kelvin's theorems; heat engines, efficiency; refrigerators, COP; heat pumps; Carnot cycles; entropy and lost work; entropy and microstates density.

THERMAL PROPRIETIES AND PROCESSES: thermal expansion; heat transmission; conduction; radiation; convection; Stefan-Boltzmann's law.