General Physics I. Mechanical Engineering - University of Pisa

Teacher: Prof. Giuseppe TRIGGIANI

Course's program:

INTRODUCTION

MEASUREMENT AND VECTORS: History of early Physics; 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: displacement, distance, velocity and acceleration; constant acceleration motion; general motion; trajectory and time equations; integration of the equations of motion; separable variables differential equations; differential techniques.

MOTION IN TWO AND THREE DIMENSIONS: 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; 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; theorem of work and kinetic energy; power.

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 system and discrete system; linear, superficial and volume density; center of mass and how to calculate it.

LINEAR MOMENTUM: linear momentum; impulse of a force; motion of the center of mass; first cardinal equation for dynamic systems; impulse's theorem; conservation of linear momentum; linear momentum and energy of a mechanical system; Koenig's theorem; 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; mechanical momentum; angular momentum of a dynamic system; angular momentum of a body; second cardinal equation for mechanical systems; angular impulse; angular impulse’s theorem; conservation of angular momentum; Noether's theorem; collisions with rotations.

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 equations; 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; gases' heat capacities; solids' heat capacities; 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 refrigerators; heat pumps; Carnot cycles; entropy and lost work; entropy and probability.

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