



National University of Engineering (UNI)
School of Computer Science
Syllabus 2027-I

1. COURSE

BFI101. Physics I (Mandatory)

2. GENERAL INFORMATION

2.1 Course	: BFI101. Physics I
2.2 Semester	: 2 nd Semester.
2.3 Credits	: 5
2.4 Hours	: 4 HT; 4 HP;
2.5 Duration of the period	: 16 weeks
2.6 Type of course	: Mandatory
2.7 Learning modality	: Face to face
2.8 Prerequisites	: None

3. PROFESSORS

Meetings after coordination with the professor

4. INTRODUCTION TO THE COURSE

Physics I introduces the foundations of classical mechanics as a mathematical and experimental discipline. Through the study of kinematics, Newtonian dynamics, conservation principles, rotational motion, elasticity, fluid mechanics, vibrations and waves, and an introduction to transport phenomena, students acquire the analytical tools needed to model and solve problems of the physical world. This course provides the indispensable foundation for the study of oscillatory, wave, and electromagnetic phenomena addressed in subsequent courses.

5. GOALS

- Describe the motion of particles in different coordinate systems and formulate the equations of motion from Newton's laws.
- Apply the principles of work, potential energy, and conservation of mechanical energy to systems with conservative and non-conservative forces.
- Solve particle-system dynamics problems using conservation of linear momentum and collision analysis.
- Analyze rotational motion and angular momentum dynamics in systems of particles and extended bodies.
- Apply elastic moduli and Hooke's law to relate stress and strain in solids.
- Apply the principles of hydrostatics and hydrodynamics, including the continuity and Bernoulli equations, to fluid flow problems.
- Analyze simple harmonic motion and mechanical wave propagation, including superposition and resonance phenomena.
- Apply Fourier's and Fick's laws to describe basic heat conduction and mass diffusion processes.

6. COMPETENCES

AG-C07) Computing Knowledge: Applies knowledge of mathematics, science, and computing. (Familiarity)

7. TOPICS

Unit 1: Kinematics and Dynamics of Particles (22 hours)	
Competences Expected: AG-C07	
Topics	Learning Outcomes
• Vector description of position, velocity, and acceleration; Newton's three laws and inertial reference frames • Formulation and analytical solution of equations of motion for constant and variable forces • Phase space diagrams (position vs. velocity) for visualizing mechanical state, stability, and periodicity • Numerical integration of equations of motion using Euler, Verlet, and Runge-Kutta methods • Constrained motion and holonomic constraints relevant to robotic linkages and articulated bodies	• Identify all forces acting on a particle in a given mechanical scenario and draw a correct free-body diagram [Familiarity] • Implement a numerical integration algorithm such as the Runge-Kutta method to compute the trajectory of a particle under variable forces [Usage] • Construct and interpret phase space diagrams to characterize the stability and periodicity of a simulated mechanical system [Assessment]
Readings : [Serway2018], [Young2015]	

Unit 2: Work, Energy, and Conservation Laws (12 hours)	
Competences Expected: AG-C07	
Topics	Learning Outcomes
• Work-energy theorem relating net work done to change in kinetic energy • Potential energy functions and the force-gradient relation for conservative force fields • Conservation of total mechanical energy and conditions for its applicability • Energy diagrams for identifying equilibrium points, turning points, and stability • Elastic and inelastic collision models: momentum and energy exchange in physics engine implementations	• Explain the distinction between conservative and non-conservative forces and the conditions under which mechanical energy is conserved [Familiarity] • Apply energy conservation methods to compute speeds and positions in one-dimensional motion problems common in physics engine implementations [Usage] • Analyze elastic and inelastic collision events, computing post-collision velocities and quantifying energy dissipation [Assessment]
Readings : [Serway2018], [Tipler2010]	

Unit 3: Systems of Particles and Linear Momentum (8 hours)	
Competences Expected: AG-C07	
Topics	Learning Outcomes
• Definition of center of mass: $\vec{R}_{CM} = \frac{1}{M} \sum m_i \vec{r}_i$ • Linear momentum of a particle and system: $\vec{p} = m\vec{v}$ and $\vec{P} = M\vec{V}_{CM}$ • Newton's second law for systems: $\vec{F}_{ext} = \frac{d\vec{P}}{dt}$ • Conservation of linear momentum for isolated systems • Distinction between internal and external forces in a system • Two-body collisions including elastic, inelastic, and completely inelastic cases • Coefficient of restitution and its physical meaning in collisions • Systems with variable mass such as the rocket equation: $M \frac{dV}{dt} = v_{ex} \frac{dM}{dt}$ • Many-particle systems and their center of mass dynamics • Continuous mass distributions and their center of mass calculation using integration	• Locate the center of mass for a discrete set of particles in One, Two, and Three dimensions [Usage] • Determine the total linear momentum of a system from the motion of its center of mass [Usage] • Apply conservation of linear momentum to solve collision problems in One and Two dimensions [Usage] • Classify collisions as elastic, inelastic, or completely inelastic based on kinetic energy conservation [Familiarity] • Calculate the coefficient of restitution from pre-collision and post-collision velocities [Usage] • Solve the rocket equation to determine velocity as a function of ejected mass [Usage] • Analyze how internal forces affect individual particles but not the total momentum of a system [Assessment] • Integrate to find the center of mass of symmetric continuous bodies such as rods, disks, and spheres [Usage]
Readings : [Young2015], [Tipler2010]	

Unit 4: Rotational Motion and Angular Momentum (12 hours)	
Competences Expected: AG-C07	
Topics	Learning Outcomes
• Rotational kinematics including angular displacement, velocity, and acceleration (θ, ω, α) • Torque definition: $\vec{\tau} = \vec{r} \times \vec{F}$ and its magnitude calculation • Angular momentum of a particle: $\vec{L} = \vec{r} \times \vec{p}$ • Rotational form of Newton's second law: $\vec{\tau}_{net} = \frac{d\vec{L}}{dt}$ • Moment of inertia $I = \sum m_i r_i^2$ and the parallel axis theorem • Rotational kinetic energy: $K_{rot} = \frac{1}{2} I \omega^2$ • Conservation of angular momentum for isolated systems • Gyroscopic motion and the phenomenon of precession • Rolling without slipping dynamics: $v_{CM} = R\omega$ • Coriolis effect as a manifestation of rotational dynamics in non-inertial frames	• Relate linear and angular kinematic quantities for circular motion [Usage] • Calculate torque about a given axis for a force applied at a specific point [Usage] • Determine the moment of inertia for simple geometries such as a rod, hoop, disk, or sphere [Usage] • Apply conservation of angular momentum to analyze changes in rotational speed when the moment of inertia changes [Assessment] • Compute rotational kinetic energy for a rotating rigid body [Usage] • Analyze the motion of objects rolling without slipping down an incline [Assessment] • Predict the direction of precession for a spinning top or gyroscope [Assessment] • Explain the Coriolis effect in terms of rotating reference frames and its effect on projectiles [Familiarity]
Readings : [Serway2018], [Kleppner2013]	

Unit 5: Elasticity (2 hours)	
Competences Expected: AG-C07	
Topics	Learning Outcomes
• Definition of stress (force/area) and strain ($\Delta L/L$) • Young's modulus and Hooke's law for longitudinal strain: $\sigma = E\epsilon$ • Shear modulus (rigidity) and shear strain • Bulk modulus (compressibility) and volumetric strain • Elastic limit, plastic region, and fracture point on the stress-strain diagram • Elastic energy stored in a deformed material	• Apply the scalar Hooke's law to calculate the deformation of a rod under axial load [Usage] • Calculate Young's, shear, or bulk modulus from experimental stress-strain data [Usage] • Identify the elastic region, elastic limit, and fracture point on a stress-strain curve [Familiarity] • Calculate the elastic potential energy stored in a deformed spring or rod [Usage]
Readings : [Serway2018], [Young2015]	

Unit 6: Fluids: Hydrostatics, Hydrodynamics, and Viscosity (10 hours)	
Competences Expected: AG-C07	
Topics	Learning Outcomes
• Density, pressure, and its variation with depth in a fluid at rest: $p = p_0 + \rho gh$ • Pascal's principle and its applications (hydraulic press) • Archimedes' principle, buoyant force, and flotation • Pressure measurement with manometers and barometers • Continuity equation for incompressible flow: $A_1 v_1 = A_2 v_2$ • Bernoulli's equation and energy conservation in ideal flow • Applications: Venturi tube, Torricelli's theorem, Pitot tube • Viscosity and Poiseuille's law for laminar flow in pipes • Reynolds number and the transition to turbulent flow • Stokes' law for the drag force on a sphere in a viscous fluid	• Calculate the pressure at a point in a fluid at rest given depth and density [Usage] • Apply Archimedes' principle to determine whether an object floats, sinks, or remains in equilibrium [Usage] • Apply the continuity and Bernoulli equations to solve flow problems in pipes of varying cross-section [Usage] • Interpret manometer and barometer readings to determine absolute and gauge pressures [Assessment] • Apply Poiseuille's law to calculate the flow rate of a viscous fluid in a cylindrical tube [Usage] • Estimate the Reynolds number of a flow and predict whether it is laminar or turbulent [Assessment]
Readings : [Serway2018], [Young2015]	

Unit 7: Vibrations and Waves (14 hours)	
Competences Expected: AG-C07	
Topics	Learning Outcomes
• Simple harmonic motion (SHM): equation of motion, position, velocity, and acceleration • Oscillating systems: spring-mass and simple/physical pendulum • Energy in simple harmonic motion • Damped and forced oscillations; introduction to resonance • Transverse and longitudinal waves; propagation speed • Wave equation and speed of a wave on a taut string: $v = \sqrt{T/\mu}$ • Superposition principle and standing waves • Sound waves, intensity, and sound intensity level (decibels) • Doppler effect for sound waves • Beats and interference of waves of nearby frequencies	• Derive the equation of motion and the period of a spring-mass system and a simple pendulum [Usage] • Calculate the kinetic, potential, and total energy of a simple harmonic oscillator at any instant [Usage] • Analyze the amplitude response of a forced oscillator near the resonance frequency [Assessment] • Calculate the propagation speed of a wave on a string from the tension and linear density [Usage] • Determine the frequencies and wavelengths of the normal modes of a standing wave on a fixed string [Usage] • Calculate the sound intensity level in decibels from the intensity of a sound wave [Usage] • Apply the Doppler effect formula for a moving source and/or observer [Usage]
Readings : [Serway2018], [Young2015]	

Unit 8: Transport Phenomena (4 hours)	
Competences Expected: AG-C07	
Topics	Learning Outcomes
• Heat conduction and Fourier's law: $\vec{q} = -k\nabla T$ • Thermal conductivity of materials and thermal resistance in composite walls • Molecular diffusion and Fick's first law: $\vec{J} = -D\nabla C$ • Analogy between heat, mass, and momentum transport (Prandtl and Schmidt numbers)	• Apply Fourier's law to calculate the heat flux through a plane or composite wall [Usage] • Apply Fick's first law to calculate the diffusive flux of a species in a concentration gradient [Usage] • Identify mathematical analogies between heat, mass, and momentum transport processes [Familiarity]
Readings : [Serway2018], [Tipler2010]	

8. WORKPLAN

8.1 Methodology

Individual and team participation is encouraged to present their ideas, motivating them with additional points in the different stages of the course evaluation.

8.2 Theory Sessions

The theory sessions are held in master classes with activities including active learning and roleplay to allow students to internalize the concepts.

8.3 Practical Sessions

The practical sessions are held in class where a series of exercises and/or practical concepts are developed through problem solving, problem solving, specific exercises and/or in application contexts.

9. EVALUATION SYSTEM

Theory Sessions:

The theory sessions are held in master classes with activities including active learning and roleplay to allow students to internalize the concepts.

Lab Sessions:

In order to verify their competences, several activities including active learning and roleplay will be developed during lab sessions.

Oral Presentations:

Individual and team participation is encouraged to present their ideas, motivating them with additional points in the different stages of the course evaluation.

Reading:

Throughout the course different readings are provided, which are evaluated. The average of the notes in the readings is considered as the mark of a qualified practice. The use of our virtual campus allows each student to access the course information, and interact outside the classroom with the teacher and with the other students.

The final grade NF depends on the following grades:

- PE : Partial Exam.
- FE : Final Exam.
- P : Permanent Evaluation (Average of practical work and graded assignments).

The final grade NF is calculated as follows:

$$NF = \frac{PE + FE + P}{3}$$

10. BASIC BIBLIOGRAPHY