PHYSICS 3 AND PHYSICAL EXPERIMENT

1. General Information

Course name: PHYSICS 3 AND PHYSICAL EXPERIMENT

Course ID: BAS 1227

The number of credits: 4

2. Objectives

- ***Knowledge:*** Physics 3 and Physical Experiments provides ICT students with fundamental knowledge about:

  - The wave- particle nature of light
  - Relativistic Mechanics
  - Quantum mechanics
  - Atomic physics
  - Solids and semiconductors

- ***Skills:*** Through this course, students can have these following skills:

  - Logical thinking
  - Applying the provided knowledge in order to study specialized issues
  - Through the experiments, students will be provided with a multitude of helpful skills such as carefulness and persistence, as well as a chance to be familiar with researching methods.

- ***Attitude and Diligence***

  - Students must prepare the lesson before attending the class, actively listen to the lectures and practice those given skills.
  - Completely finish all the exercises and exams.

- Detailed objectives for each content of the course

Objective / Content	Level 1	Level 2	Level 3
Chapter 1: Oscillation and wave	Understand the definitions of: - Mechanical oscillation -Electromagnetic oscillation - Mechanical waves - Electromagnetic waves	Know about: - Harmonic, damped and forced electromagnetic oscillation, resonance phenomenon. - Synthesis of two oscillations with the same frequency. - The properties of electromagnetic waves	- Be able to analyze phenomena related to oscillations and waves. - Be able to do exercises about oscillations and waves.

Chapter 2: Light interference	Understand the definition of light interference.	Understand: - The fundamentals of wave optics: Maxwell's electromagnetic theorem about light; Optical path; Light wave function; Principle of wave superposition; The Huygens-Fresnel principle - Study light interference through 2 slits and light interference caused by reflection.	- Be able to analyze light interference phenomena and the applications of light interference. - Be able to do exercises about light interference - Be able to do experiments on light interference in the laboratory.
Chapter 3: Light diffraction	Understand: - The definition of light diffraction - The Fresnel spherical segment method - The definition of diffraction grating.	- Understand the Fresnel spherical segment properties. - Use the Fresnel spherical segment method to study light diffraction of spherical waves through circular hole and a small circular plate. - Study light diffraction caused by plane waves through a narrow slit and diffraction grating.	- Be able to analyze and compare light diffraction through a slit and diffraction grating. - Be able to do exercises about light diffraction. - Understand the applications of diffraction grating.
Chapter 4: Light dispersion, absorption and scattering	Understand the definitions of: - Light dispersion. - Light absorption. - Light scattering.	Understand these following phenomena: - Light dispersion caused by a prism - Dispersion curve and dispersion - Light absorption - Light dispersion and absorption	- Understand the meaning of dispersion curve and dispersion. Be able to differentiate between normal dispersion and abnormal dispersion. - Understand the Bouger-Lambert and Lamber-Beer laws about light absorption and their meaning

Chapter 5: **Light polarization**	Understand: - The definition of natural and polarized light. - Malus's law of light polarization.	- Be able to prove Malus's law of light polarization. - Be able to analyze light polarization caused by reflection and refraction, Polarization caused by birefringence and types of polarizing filter - Understand linear, elliptical and circular polarization, artificial birefringence and optical rotation.	- Be able to analyze light polarization, as well as do exercises about light polarization. - Understand the applications of light polarization.
Chapter 6: **The special theory of relativity by Einstein**	- Be able to state the two Einstein's axioms. - Be able to state the Lorentz transformation and Einstein's relation.	- Be able to write the consequences of Lorentz transformation. - Be able to state the momentum, energy and mass expressions of an object when travelling near the speed of light.	- Be able to explain length contraction and time dilation. - Analyzes the relativity of the concurrency of events and the cause-effect relation. - Proves that Newton mechanics is a limited case of Einstein's theory of relativity when $v << c$ or c is infinite. - Be able to do exercises about relativistic mechanics.

Chapter 7: Quantum optics	- Know the definitions of thermal radiation and balanced thermal radiation, the photoelectric phenomenon and Compton effect. - Be able to state absolute black-body radiation laws, Planck's quantum theory and Einstein's photon theory.	- State the expressions and meanings of characteristic quantities of balanced thermal radiation. - State the meaning of general function and draw the characteristic radiation spectrum line graph of the absolute blackbody - State the Planck formula and the successes of the theory about quantum energy. - Apply the photon theory to explain the three photoelectric laws - Explains the Compton effect.	- State the Rayleigh-Jeans formula and the limitations of it with thermal radiation phenomenon. - Explain that in the Compton effect, X-rays scatter on the bonding electron and the Compton effect is an empirical evidence that completely confirm the particle properties of light. - Be able to do exercises of quantum optics. - Be able to do experiments about photoelectric phenomena in the laboratories.
Chapter *8:* Quantum mechanics	- States the de Broglie hypothesis about wave-particle duality of elementary particles. - States the Heisenberg's uncertainty principle about position and momentum. - States and gives the definitions of uncertainty principle about energy and time.	- Establish the Heisenberg's uncertainty principle for position and momentum. - State the wave function explanation for elementary particles and the statisticle meaning of wave function. - State the Schrodinger's equation for free elementary particles and elementary particles moving in a force potential field. - Apply the Schrodinger's equation to find the expressions of wave function and the energy of elementary particles in an one-dimensional potential well with infinite depth.	- Explain why in quantum mechanics the definition of elementary particle orbit has no meanings and what definition will replace it. - Be able to do exercises in the quantum mechanics chapter.
Chapter 9: Atomic physics	- Know about the electron configuration of hydrogen and alkali	Understand: - The conclusions of quantum mechanics in	- State the difference between the energy of valence electrons in

	metal atoms. - Understand the definitions of angular and magnetic momentum and electron spin	the research into hydrogen atom. - The energy of valence electrons in alkali metal atoms - The emission spectrum of alkali metal atoms. - The existence of electron spin; the state and energy of electrons in atoms and the binary line structure of emission spectrum.	hydrogen and alkali metal atoms - State the selection rule for ℓ orbital quantums. Applies this rule to state the primary and secondary spectral lines of lithium (Li) atoms. - State the orbital angular momentum from of the electrons orbiting the nuclei and their projections on the z axis. - Be able to do exercises in the atomic physics chapter.
Chapter 10: Solid-state physics and semiconductors	Understand the definitions of: - The crystal lattice structure of solids - Band diagram - Band structure - Conductive electron and electron hole - Intrinsic and extrinsic semiconductors	Know about: - Principles of energy bands formation and energy band diagram of semiconductors - The definition of p-n junction	Know about: - The band theory and the formation of valence band, band gap and conductive band in crystal materials. - The definitions of conductive electron and electron hole - The definitions of intrinsic, n and p semiconductors.

3. Abstract

Physics 3 and physical experiments includes 10 chapters and 2 experiments. The first chapter is about oscillation and waves as a base for wave optics. Chapters 2 to 5 show the phenomena characteristic of the wave properties of light, namely interference, diffraction, absorption, dispersion and polarization of light. Chapter 6 is about the dependency on the motion of space, time and the mass of an object when travelling near the speed of light. Chapter 7 shows the particle properties of light with thermal radiation, photoelectric phenomenon and Compton effect. Chapter 8 provides knowledge on the motion of elementary particles, helping to solve many problems related to the physical properties of matter in a deeper level. The next chapter uses the consequences of quantum mechanics to research into spectrum and properties of atoms. And the last chapter researches into solids and semiconductors.

4. Teaching and learning methods

Lectures: *36 (hours)*

Project & practice: *4 (hours) & 8(hours)*

Individual reading: *12 (hours)*

5. Prerequisites

Previous subjects: Physics 1; Analytics 1,2 ; Algebra ; Probability statistics.

Course requirements: Theoretical classroom: Must have enough lighting, chalks, chalkboards, projector and a computer.

Physics laboratory: Must have enough lighting, fans, air conditioners, internet-enabled computers, projector, projector screen.

6. Learning Outcomes:

Students must have full component marks. If they either lack a component mark (attendance, mid-term exam or experiment) or do not attend over 20% of the course's total time, they cannot do the end-of-course exam.

7. Assessment Criteria

Types of exercises	Evaluation criteria
- Oscillation and waves exercises (electromagnetic oscillations, mechanical and electromagnetic waves)	- Fully understand oscillation and waves - Correctly answer questions and exercises
- Light's wave properties exercises (light interference, diffraction and polarization)	- Fully understand light interference, diffraction and polarization - Correctly answer questions and exercises
- Relativistic mechanics exercises (Lorentz transformations and its consequences. Relativistic dynamics)	- Fully understand relativistic mechanics - Correctly answer questions and exercises
- Quantum optics exercises (black-body thermal radiation, photoelectric phenomenon, Compton effect)	- Fully understand quantum optics - Correctly answer questions and exercises
- Quantum mechanics exercises (wave-particle duality of subatomic particles, Heisenburg's uncertainty principle, Schrodinger equation)	- Fully understand quantum mechanics - Correctly answer questions and exercises
- Atomic physics exercises (hydrogen and alkali metal atoms, angular and magnetic momentum in atoms)	- Fully understand atomic physics - Correctly answer questions and exercises
- Mid-term and end of term exams	- Understand the subject's knowledge - Correctly answer questions and exercises

8. Outlines

Chapter 1: OSCILLATIONS AND WAVES

1.1 Oscillations

1.1.1 Mechanical oscillations

1.1.2. Electromagnetic Oscillations

1.1.3. Synthesis of Oscillations

1.2. Waves

1.2.1. Mechanical waves, Sound waves and Doppler effect

1.2.2. Electromagnetic waves

Chapter 2: LIGHT INTERFERENCE

2. 1. The fundamentals of wave optics
2. 1. 1. Maxwell's electromagnetic theorem about light
2. 1. 2. Optical path
2. 1. 3. Malus's theorem about Optical path
2. 1. 4. Light wave function
2. 1. 5. Luminous intensity
2. 1. 6. Principle of superposition
2. 1. 7. The Huygens-Fresnel principle
2. 2. The phenomenon of light interference
2. 2. 1. The definition of light interference
2. 2. 2. Study the phenomenon of light interference
2. 3 Interference caused by thin plates
2. 3. 1. Lloyd's experiment
2. 3. 2. Interference caused by thin plates
2. 4. Applications of interference phenomenon
2. 4. 1. Checking plano-convex lenses
2. 4. 2. Reducing reflection on lenses
2. 4. 3. Rayleigh interferometers
2. 4. 4. Michelson interferometers
Chapter 3 : LIGHT DIFFRACTION
3. 1. The phenomenon of light diffraction
3. 2. Light diffraction of spherical waves
3. 2. 1. The Fresnel spherical segment method
3. 2. 2. Diffraction through circular hole
3. 2. 3. Diffraction through circular plate
3. 3. Diffraction caused by plane waves- Diffration grating
3. 3. 1. Diffraction of plane waves through narrow slit
3. 3. 2. Diffraction of plane waves through multiple slits – Diffraction grating
3. 3. 3. Diffration on crystals
Chapter 4: LIGHT DISPERSION, ABSORPTION AND SCATTERING
4. 1. Light dispersion
4. 1. 1. The phenomenon of light dispersion caused by prism
4. 1. 2. Dispersion curve and dispersion
4. 2. Light absorption
4. 3. Theory of light dispersion and absorption
4. 4. Light Scattering

4. 4. 1. The phenomenon of light scattering
4. 4. 2. Tyndall scattering
4. 4. 3. Molecular scattering
4. 4. 4 . Raman Scattering
4. 4. 5. Mandelstam – Brillouin Scattering
4. 5. Rainbow
Chapter 5: LIGHT POLARIZATION
5.1. Light polarization
5. 1. 1. Natural light
5. 1. 2. Polarized light
5. 1. 3. Malus's law of light polarization
5. 1. 4. Light polarization caused by reflection and refraction
5. 2. Birefringent polarization
5. 2. 1. Birefringence of crystals
5. 2. 2. Wavefront in single axis crystal environment
5. 2. 3. Polarizing filter types
5. 3. Elliptically polarized light and circular polarization
5. 3. 1. Quarter-wave plate
5. 3. 2. Half-wave plate
5. 3. 3. Single-wave plate
5. 4. Artificial birefringence
5. 4. 1. Birefringence caused by mechanical deformations
5. 4. 2. Birefringence caused by electric field
5. 5. Optical rotation
Chapter 6: THE SPECIAL THEORY OF RELATIVITY BY EINSTEIN
6. 1. The two Einstein's axioms
6. 1. 1. Absolute space and aether
6. 1. 2. Michelson – Morley experiment
6. 1. 3. Time and length measurement
6. 1. 4. Einstein's axioms
6. 2. Lorentz transformation and its consequences
6. 2. 1. Contradiction of Galileo transformation with Einstein's theory of relativity
6. 2. 2. Lorentz transformation
6. 2. 3. The consequences of Lorentz transformation
6. 3. Relativistic dynamics – Einstein's relation
6.3.1.. Fundamental equation of material point's motion

6. 3. 2. Momentum and Energy
6. 3. 3. The consequences
Chapter 7: QUANTUM OPTICS
7. 1. Thermal radiation
7. 1. 1. Balanced thermal radiation
7. 1. 2. The characteristic quantities of balanced thermal radiation
7. 1. 3. Kirchhoff's law of thermal radiation
7. 2. Black-body radiation laws
7. 2. 1. Stefan-Boltzmann law
7. 2. 2. Wien's displacement law
7. 2. 3. Ultraviolet crisis
7. 3. Planck's quantum theory and Einstein's photon theory
7. 3. 1. Planck's theory on quantum energy
7. 3. 2. The success of the theory about quantum theory
7. 3. 3 Einstein's photon theory
7. 3. 4. Photon dynamics
7. 4. Photoelectric phenomenon
7. 4. 1. The definition of Photoelectric phenomenon
7. 4. 2. The laws of photoelectric and explanations
7. 5. Compton effect
7. 5. 1. Compton experiment
7. 5. 2. Explanation
Chapter 8: QUANTUM MECHANICS
8. 1. Wave-particle duality of elementary particles
8. 1. 1. Wave-particle duality of light
8. 1. 2. De - Broglie hypothesis
8. 1. 3. Experiment to verify the wave properties of subatomic particles
8. 2. Heisenberg's uncertainty principle
8. 3. Wave function
8. 3. 1. Wave function expression
8. 3. 2. Statistical meaning of wave function
8. 3. 3. Wave function conditions
8. 4. Schrodinger equation
8. 5. Applications of Schrodinger equation
8. 5. 1. Particles in potential well
8. 5. 2. Quantum tunnelling

8. 5. 3. Quantum harmonic oscillator

Chapter 9: ATOMIC PHYSICS

9. 1. Hydrogen atoms

9. 1. 1. The motion of electrons in hydrogen atoms

9. 1. 2. Conclusions

9. 2. Alkali metal atoms

9. 2. 1. The energy of valence electrons in alkali metal atoms

9. 2. 2. Spectrum of alkali metal atoms

9. 3. Angular and magnetic momentum of electrons

9. 3. 1. Orbital angular momentum

9. 3. 2. Magnetic momentum

9. 3. 3. Zeeman effect

9. 4. Electron spin

9. 4. 1. The existence of spin in electrons

9. 4. 2. State and energy of electrons in atoms

9. 4. 3. The binary line structure of emission spectrum.

9. 5. Mendeleev's periodic system

9. 6. Homogeneous particle system and Statistical quantum

9. 6. 1. Homogeneous particle system

9. 6. 2. Statistical quantum

Chapter 10: SOLID STATE PHYSICS AND SEMICONDUCTORS

10. 1. Solid-state Physics

10. 1. 1. Crystal lattice structure of solids

10. 1. 2. Band theory

10. 2. Semiconductor physics

10. 2. 1. Band diagram

10. 2. 2. Definition of conductive electron and electron hole

10. 2. 3. Fermi – Dirac distribution function

10. 2. 4. Intrinsic semiconductor

10. 2. 5. Extrinsic semiconductor

10. 2. 6. p-n junction. Diodes

10. 2. 7. Semiconductor laser diode

EXPERIMENTS

Experiment 1: Study the light interference

Experiment 2: Prove the photoelectric laws, determine the Planck constant

9. Required Textbooks

[1] Vo Thi Thanh Ha, Nguyen Thi Thuy Lieu, Physics 3 and Physical Experiment Lecture, Post and Telecommunication Institute of Techonology, 2011.

[2] Physics Experiments, Post and Telecommunication Institute of Techonology, 2011.

10. Suggested Textbooks

[1] General physics, part I, II, III ; Luong Duyen Binh, Vietnam Education Publishing House,1995.

[2] General physics exercises, part I, II, III ; Luong Duyen Binh, Vietnam Education Publishing House, 1995.

[3] General physics, part III ; Nguyen Xuan Chi, Dang Quang Khang ; Hanoi University of Science and Technology, 2001.

[4] Fundamentals of Physics, part VI ; Halliday, Resnick, Walker ; Vietnam Education Publishing House, 1998.

[5] Optics; Nguyen The Binh, Vietnam National University Publishing House, 2007.

[6] Solid-state Physics, Nguyen Ngoc Long, Vietnam National University Publishing House, 2007.

11. Grading Policy

Attendance: fully attending the class and actively discussing	10 %
Average of mini mid term tests (ind)	10 %
Project (group): Experiment	20 %
Final exam (practice room)	60 %

Lecturer **Head of Department of Physic**

Dr. Nguyen Thi Thuy Lieu **Dr. Lê Minh Thanh**