Waves, Optics and Modern Physics

Objectives:	00UT	**Discipline:**	Physics
Ponderation:	3-2-3	**Course Code:**	203-NYC-05

Objectives and Standards for Waves, Optics and Modern Physics

In the following chart, italicized items marked with (*) are optional enrichment items which will not be evaluated in the final exam (these are not the only possible enrichment items — they are the most commonly used ones).

OBJECTIVE	STANDARD	LEARNING OBJECTIVES
Course objective	**Achievement Context**	
To analyze various situations or phenomena associated with waves, optics and modern physics using basic principles	1. In theoretical situations, working individually to solve problems taken from a standard college-level Physics textbook 2. In experimental settings, in the lab, working individually or in a group, with the aid of a laboratory write-up, or of scientific documentation, to write lab reports	
	General Performance Criteria	
	1. Appropriate use of concepts, laws and principles 2. Adequate use of diagrams to represent physical situations 3. Appropriate use of terminology and units 4. Accurate graphical representations of situations 5. Proper justification of the steps taken in analyzing a situation 6. Rigorous application of the principles in the models used to represent phenomena 7. Critical judgment of results 8. Proper interpretation of the limits of models 9. Meticulous experimentation 10. Adequate observation of College standards for scientific essays and laboratory reports	

Elements of Competency	Specific Performance Criteria

Elements of Competency	Specific Performance Criteria	Intermediate Learning Objectives
	concerning one dimensional waves such as a wave travelling on a string	1.7.3.

Elements of Competency	Specific Performance Criteria	Intermediate Learning Objectives
		2.1.4. State the conditions for total internal reflection. 2.1.5. Define the index of refraction of a medium in terms of the speed of light in it. 2.1.6. Explain what is meant by dispersion, or a dispersive medium. 2.1.7. Describe how a prism spreads light into a spectrum.
	2.2. Rigorous application of the laws of reflection and refraction to solve mathematical problems and answer qualitative questions	2.2.1. Calculate the angles of reflection and refraction of light rays at the interface between two media or given information about angle of refraction, calculate index of refraction. 2.2.2. Using Snell's Law, calculate the path of a light ray through a parallel-sided glass block and through a prism. 2.2.3. Explain how light is transmitted along fibre optics cables. Discuss examples of the application of fibre optics to medicine and telecommunications. **[00UU]** 2.2.4. Using the formula derived from Snell's Law and appropriate sign conventions, calculate the characteristics of an image formed by a single plane refracting surface; *a single spherical refracting surface (small angle approximation) ** 2.2.5. Describe the image formed by a plane mirror and explain it using the laws of reflection.
	2.3. Rigorous application of the equations for image formation by spherical mirrors and thin lenses to solve a variety of 4o74rf 42cvmetspheribre opions	2.2.1. Describe 2.2.2. Defioherihinge path o by spherical mition analculatticsibe rae mspeed offibon of cal miri 2.2.3. Defing thherihinge path oand thin rism. 2.2.4. Calculate thherihinge path oand thin n it usingthin nmakdisnelld of 2.2.5.

7.2.4. 2.3. Rigorous application of the equatiion for image t i o n

Elements of Competency	Specific Performance Criteria	Intermediate Learning Objectives
		a lens in diopters. **[00UU]** 2.4.2. Explain the operation of a compound microscope. **[00UU]** 2.4.3. Explain the operation of a camera. **[00UU]**
3. To apply the characteristics of waves to light phenomena (physical optics)	3.1. Proper characterization of light as a wave	3.1.1. List the parts of the electromagnetic spectrum in order of wavelength. 3.1.2. State the range of wavelengths in the visible spectrum.
	3.2. Rigorous application of the concepts of waves and superposition and the technique of phasors to solving problems and answering qualitative questions involving interference of light	3.2.1. State the necessary conditions for the observation of interference in light waves. 3.2.2. Describe Young's double slit experiment and derive an expression for the locations of minima and maxima in the interference pattern. 3.2.3. Derive an expression for the intensity distribution of the interference pattern in a double slit experiment. Plot the function. 3.2.4. Define phasor. Use phasors to calculate intensity in interference patterns. 3.2.5. Explain how interference occurs in thin films. Work out the conditions for constructive and destructive interference.
	3.3. Rigorous application of the concepts of waves and superposition and the technique of phasors to solving problems and answering qualitative questions involving diffraction of light	3.3.1. Define diffraction. 3.3.2. Derive an expression for the positions of destructive interference in a single slit Fraunhofer diffraction pattern. 3.3.3. Derive an expression for the intensity of light in a single slit diffraction pattern as a function of slit width, angle, and wavelength. 3.3.4. Define resolution. State Rayleigh's criterion. for a rectangular slit and for a circular aperture. 3.3.5. Describe a diffraction grating. 3.3.6. Use the formula for the angle at which maxima occur in each order of the diffraction pattern as a function of the wavelength of the light and the slit spacing of the grating.
	3.4. Rigorous application of the concept of polarization and certain laws to solve mathematical problems and answer qualitative questions concerning phenomena involving polarization and polarized light	3.4.1. Define linearly (or plane) polarized light and circularly polarized light. 3.4.2. Describe how light becomes polarized by selective absorption. 3.4.3. State Malus's Law and use it to calculate transmitted intensity when

Elements of Competency	Specific Performance Criteria	Intermediate Learning Objectives
ment of quantum mechanics		ultraviolet catastrophe. **[00UU]** 4.1.3. State Planck's two assumptions which allowed him to correctly derive the spectral shape of black body radiation and which led to the realization of the "quantization" of energy. **[00UU]** 4.1.4. State Stefan's Law and Wein's Law.
	4.2. Coherent explanation of Einstein's theory of the photoelectric effect and brief description of the historical significance of this work	4.2.1. Define the photoelectric effect. **[00UU]** 4.2.2. List the major observations in this experiment that could not be explained by classical theory. **[00UU]** 4.2.3. State Einstein's theory of the photoelectric effect and show how it can account for each of the previously unexplained observations. 4.2.4. Solve problems involving the wavelength of photons, the work function, maximum kinetic energy of photoelectrons, and cut-off wavelength.
	4.3. Coherent explanation of the Bohr theory of the atom and brief description of its historical significance	4.3.1. Describe atomic emission and absorption spectra. **[00UU]** 4.3.2. Calculate the wavelengths in atomic spectra from the energy level diagrams of hydrogen and other atoms. **[00UU]** 4.3.3. State the basic assumptions of the Bohr theory as it applies to the hydrogen atom. **[00UU]** 4.3.4. *(*) Using these assumptions and concepts from classical physics , derive expressions for the energies of the allowed levels in the hydrogen atom, the ionization energy of the hydrogen atom, and the equation for the wavelengths of the lines in the hydrogen spectrum.* **[00UU]**
	4.4. Correct interpretation of the concept of wave-particle duality	4.4.1. State de Broglie's postulate and describe its historical significance. **[00UU]** 4.4.2. Calculate the wavelength associated with a particle of momentum p or energy E. 4.4.3. Describe the two slit interference pattern for electrons and discuss its interpretation in terms of the interference of two matter waves. 4.4.4. Explain the advantages of an electron microscope over a light microscope. **[00UU]** 4.4.5. State the Heisenberg Uncertainty Principle in terms of position and momentum and in terms of time and energy. **[00UU]**
	4.5. Rigorous application of the concepts, theories and mathematical laws from sections 4.1 through 4.4 to solve mathematical problems and to answer qualitative questions	
	4.6. Basic understanding of the major developments of modern physics presented in the course.	4.6.1. List the major developments of modern physics presented in this course in historical order.

Elements of Competency	Specific Performance Criteria	Intermediate Learning Objectives
		4.6.2. Compare and contrast the quantum viewpoint of the twentieth century with the classical view of continuously variable quantities. **[00UU]** 4.6.3. Discuss the impact of the uncertainty principle on classical determinism. **[00UU]**
5. To analyze a number of situations using concepts from modern physics: the physics of the nucleus and radioactivity	5.1. Precise use of terms and correct notation for the description of the nucleus, of radioactivity and of nuclear reactions	5.1.1. Define mass number, atomic number and neutron number for a nucleus, isotope, unified mass unit, binding energy, nuclear fusion and nuclear fission. 5.1.2. Use standard notation in the style ${}_{Z}^{A}X$ to describe nuclei. **[00UU]**
	5.2. Precise description of certain properties of nuclei	5.2.1. Represent a nucleus whose mass number and atomic number are given in standard notation and calculate the number of neutrons in it. 5.2.2. Given the standard notation for a nucleus, determine the number of protons and neutrons in it. 5.2.3. Describe the structure of an atom. 5.2.4. *Describe the phenomenon of nuclear magnetic resonance and its use in medicine* *. **[00UU]**
	5.3. Precise description of the three nuclear decay processes	5.3.1. Define half-life, alpha particle, beta particle, gamma ray, alpha decay, beta decay and gamma decay. 5.3.2. Write an equation describing the alpha, beta or gamma decay of a nucleus using the standard ${}_{Z}^{A}X$ notation. 5.3.3. Write an equation describing the beta plus or beta minus decay of a nucleus using the standard ${}_{Z}^{A}X$ notation. 5.3.4. Explain why the existence of neutrinos and anti-neutrinos was originally hypothesized and list their properties. 5.3.5. Explain the application of beta decay of carbon-14 to date historical artifacts. **[00UU]** 5.3.6. Explain the use of radio-isotopes in medicine. **[00UU]**
	5.4. Rigorous application of the concepts, theories and mathematical laws from sections 5.1 through 5.3 to solve mathematical problems and to answer qualitative questions	
6. To verify experimentally some of the laws and principles associated with oscillatory motion, waves, optics and modern physics	6.1. Careful performance of the laboratory procedures provided	6.1.1. Work cooperatively in a small group to obtain data. 6.1.2. Employ safe procedures and show concern for one's own safety and the safety of others in the lab. 6.1.3. Exercise care in carrying out measurements to obtain the best results possible.
	6.2. Logical analysis of and appropriate mathematical treatment of data	6.2.1. Choose and apply appropriate mathematical, graphical and logical tools.

Elements of Competency	Specific Performance Criteria	Intermediate Learning Objectives
	6.3. Coherent and justifiable conclusions	6.3.1. Understand and apply the principles involved in each experiment. 6.3.2. State clearly the conclusions to be drawn from your analysis and justify them.
	6.4. Proper adherence to course norms for submitting laboratory reports	
	6.5. Competent use of computers	6.5.1. Use computers in the laboratory to gather and analyze data. 6.5.2. Use a computer spreadsheet to perform: • curve-fitting and regression analysis; • modelling and changing parameters; • graphical representation of physical phenomena; and • numerical solutions to Physics problems.

Methodology

1. Lecture presentation and participation in class discussions and activities.
2. Presentation of demonstrations, films.
3. Laboratory experiments
4. Assigned practice problems
5. Use of computer spreadsheets.