

8. STUDENT LEARNING OUTCOMES

By means of written responses, drawing diagrams, and solving problems involving calculation, the student will demonstrate the ability to

describe electric charge in terms of charge quantization and transfer of electrons;

calculate electric forces on point charges using Coulomb's law;

describe and calculate the electric fields of point charges, and the force on a charge in an electric field; analyze the motion of a charged particle in a uniform electric field;

use Gauss' law to calculate symmetric electric fields, and relate electric flux through a closed surface to the enclosed charge;

describe electric current and resistance, and use Ohm's law, conductivity, resistivity, and current density in calculations; describe the operation of a battery; add resistances in series and parallel, and analyze circuits using Kirchhoff's laws;

calculate the electric potential of a system of point charges and the potential energy of the system; relate uniform electric fields and differences in electric potential; describe equipotential surfaces and their relation to conductors in electrostatics;

describe sources of magnetic fields, and use the Biot-Savart law and Ampere's law to calculate magnetic fields;

calculate magnetic forces on and resulting motion of point charges; calculate magnetic forces on current-carrying wires; describe the operation of electric motors;

describe electromagnetic induction, and deduce directions of induced currents due to changes in magnetic flux; use Faraday's law to calculate induced currents; describe the operation of electric generators; relate transformer input and output currents and voltages;

calculate the fields of electric and magnetic dipoles, torque and potential energy of a dipole in an external field;

analyze time dependent electric circuits including resistance, capacitance, and/or inductance; analyze alternating current circuits;

describe transverse and longitudinal traveling waves; make use of the mathematical description of harmonic traveling waves and wave pulses, and the quantitative relations between wavelength, frequency and speed of traveling waves;

relate the power of a sound source and the intensity of sound; calculate frequency changes in sound waves due to the Doppler effect;

deduce the possible wavelengths and frequencies of standing waves in a given medium; calculate phase differences between waves from two sources and the resulting interference effects;

relate induced magnetic fields to changing electric flux; make use of the mathematical

description of electromagnetic waves, including the relation between electric and magnetic field magnitudes, the relation between wavelength, frequency and wave speed; relate wavelength and frequency to the mathematical description of harmonic waves;

describe polarization of electromagnetic waves, and relate polarization direction to intensity transmitted through polarizers;

analyze interference patterns of light transmitted through two slits, and through diffraction gratings;

use ray tracing techniques to locate the images produced by plane and curved mirrors, and by thin lenses; use ray tracing techniques to show how images are produced by telescopes and microscopes.

describe cavity radiation in terms of standing waves; use the laws of Kirchhoff, Wien and Stefan-Boltzmann to relate temperature of a cavity, energy density, intensity and wavelength of emitted electromagnetic waves;

draw and interpret a rough graph of Planck's curve for cavity radiation; relate photon energy and wavelength using Planck's constant; relate photon energy to the minimum x-ray wavelength emitted by a metal bombarded with electrons;

state the principle of relativity; use calculations of length contraction, time dilation and relativity of simultaneity according to the theory of special relativity; use the Lorentz transformations to relate event coordinates in different frames of reference;

use the relativistic formula for addition of velocities, and for the Doppler effect on light; analyze collisions of subatomic particles using relativistic principles of conservation of energy and momentum;

analyze scattering of x-rays according to the Compton effect, using the photon concept; analyze examples of the photoelectric effect using the photon concept;

use the concept of matter waves and the relation between particle momentum and wavelength to analyze propagation and reflection from crystals of electrons and other particles;

analyze descriptions of measurements using the limitations imposed by the Heisenberg uncertainty principle;

relate energy levels, conservation of energy and the photon concept to the emission and absorption of light by hydrogen atoms, and in less detail by other atoms and molecules;

interpret the solutions the Schrodinger equation in terms of probability density; use the hydrogen atom wave functions to calculate probabilities of finding electrons in specified regions;

describe the filling of positions in the periodic table using the concepts of quantum numbers for energy and angular momentum, including electron spin, and the Pauli exclusion principle;

describe the strong nuclear force that binds nuclei, the effect of proton-proton repulsion, and the role neutrons play in stabilizing nuclei; relate binding energy to nuclear stability and mass defect;

describe the principle types of radioactive decay, including emitted particles and changes in the emitting nuclei; relate nuclear half life to decay rates and to initial and final numbers of radioactive nuclei; describe radioactive decay series;

describe nuclear fission, and the types of nuclei likely to fission; describe how nuclear fission is used in nuclear power plants to generate energy; describe nuclear fusion and the types of nuclei that are likely to fuse; describe the release of energy by nuclear fusion in the sun, and the reason high temperatures are required;

describe the three classes of subatomic particles: baryons, mesons, and leptons; distinguish fermions and bosons in terms of the Pauli exclusion principle;

describe the quark model of subatomic particles, including the quark composition of protons and neutrons; distinguish baryons and mesons in terms of the quark model; describe the role of color charge and gluons in the quark model; describe the three families of subatomic particles based on the quark model; describe the various conservation laws that limit the types of subatomic particles that can be produced in particle colliders.

Students will be required to demonstrate laboratory skills in a series of experiments by doing the following:

measuring quantities carefully and correctly, including units and uncertainties;
Making calculations from data correctly, including uncertainties in results where required;
recording data and calculations in a clear and organized way, with notes that make their meanings clear;
carefully and correctly plotting required graphs, and obtaining quantitative results from them;
organizing data, calculations, graphs, results and additional written work to clarify them into a clear and literate report on the experiment.

9. TOPICAL COURSE OUTLINE:

Periodic Motion & Waves

1. Periodic Motion

The Simple Pendulum, Simple Harmonic Motion, Damped and Forced Oscillatory Motion, Vibrating Bodies as the Source of Waves, Transverse and Longitudinal Waves, The Mathematical Description of Wave Motion, The Superposition Principle and Phase, Standing Waves on a String and Forced Vibrations of a String.

2. Sound

The Nature of Sound Waves, The Speed of Sound Waves, Standing Sound Waves; Resonance, Interference of Sound Waves of Different Frequencies: Beats The Detection of Sound, Intensity and Loudness Quality of Sound and Pitch The Doppler Effect in Sound, Supersonic Speeds and Ultrasonic Waves

Electricity & Magnetism

3. *Charge and Electric Fields*

Elementary Electric Charges and their Interaction, Conductors and Insulators Electroscopes and Coulomb's Law, Electrostatic Problems with Point Charges, The Electric Field and Gauss' Law

4. *Electric Potential, Energy, and Capacitance*

Electric Potential Energy and Electric Potential, Potential Difference and Voltage Electric Potential and the Electric Field, The Electric Potential in the Vicinity of a Point Charge, The Storage of Electric Charge, Capacitors and Capacitance, Dielectrics Capacitors in Series and in Parallel, The Energy Stored in a Capacitor

5. *Direct Current Electricity*

EMF and Direct Current ,Electric Currents in Electrolytes Electric Currents in Metals Resistance and Resistivity, Ohm's Law and Kirchhoff's Rule, Some Application, of Kirchhoff's Rule, Energy and Power in DC Circuits, Joule Heating

6. *Magnetism*

Magnets and the Magnetic Field, Force on a Charged Particle in a Magnetic Field The Force on a Current Carrying Conductor in a Magnetic Field Determination of e/m for the Electron, Magnetic Field of a Straight, Current-Carrying Wire, Ampere's Circuital Law, The Magnetic Field of Coils and Solenoids Magnetic Properties of Materials, The Earth's Magnetic Field, Galvanometers and Meters

7. *Electromagnetic Induction*

Motional EMF, Faraday's Law of Induction, Lenz's Law Self and Mutual Induction, Inductance, Energy Stored in an Inductor Circuit with Inductance and Resistance: The RL Circuit, Circuit with Capacitance and Resistance: The RC Circuit, Electric Generators & Electric Motors

8. *Alternating Current Circuits*

AC Circuit Containing only Resistance, AC Circuit Containing only inductance, AC circuit Containing only Capacitance, The LC Circuit RLC Series Circuit Resonance, Transformers, Practical Aspects of Electric Power

9. *Electromagnetic Waves*

Maxwell's Equations, Displacement Current, The Nature of Electromagnetic Waves The Predicted Speed of Electromagnetic Waves, Energy in Electromagnetic Waves; Intensity, Measurement of the Speed of Electromagnetic Waves, The Complete Electromagnetic Spectrum, The Generation of Radio Waves, The Detection and Modulation of Radio Wave. Practical Radio and Television

Optics

10. *Geometrical Optics*

Ray (Geometrical) Optics, Reflection and Refraction of Rays, Huygens' Principle Dispersion, Plane & Spherical Mirrors, Converging & Diverging Thin Lenses, Combinations of Lenses, Lens Aberrations

11. *Physical Optics*

Interference: Young's Double-Slit Experiment Multi-slit interference: The Diffraction Grating, Interference in Thin Films Applications of interference, The Polarization of Light

Some Modern Physics

12. *Relativity*

Galilean Relativity, The Aether and the Speed of Light, The Michelson-Morley Experiment, Einstein's Special Theory of Relativity, The Lorentz Transformation Equations, Experimental Tests of the Special Theory of Relativity, The General Theory of Relativity

13. *Quantum Mechanics and Atomic Physics*

Particle Properties of Light; the Photon, Blackbody Radiation The Photoelectric Effect, X-Rays & The Compton Effect Wave Properties of Matter: De Broglie Waves, The Wave-Particle Duality The Heisenberg Uncertainty Principle The Spectrum of the Hydrogen Atom Bohr's Theory of the Hydrogen Atom, Quantum Numbers

14. *Nuclear Physics*

The Structure of the Atomic Nucleus, Nuclear Forces and Binding Energies, Natural Radioactivity, Nuclear Fission and Nuclear Fusion Biological Effects of Radiation, Use of Radioactive Isotopes in Medicine and Technology

10. TEXTS AND MATERIALS USED: List of books and/or materials suggested for this course.

Physics, 3rd Edition, James S. Walker, Pearson/Prentiss Hall, 2007.

Chapters 14 and 19-32.

Laboratory material provided by instructor.

11. AMOUNT OF WRITING REQUIRED:

Laboratory reports, short answer essay questions and explanations of problem situations.

12. METHODS OF EVALUATION: (Direct and indirect)

Tests, lab reports, quizzes.

13. AUTHORIZED SIGNATURE AND FILE DATE:

DEPARTMENT AND CAMPUS

**Physical Science Department
Harold Washington College**

5/06