MONMOUTH COUNTY VOCATIONAL SCHOOL DISTRICT
105 NEPTUNE BOULEVARD SUITE 315
NEPTUNE, NJ 07753

PHYSICS

School:	Allied Academy of Health & Science
Grade:	Eleventh
Credits:	5
Subject Area:	Physics
Prepared by:	George Sant
Date:	Summer 2004

MEDICAL PHYSICS

COURSE PHILOSOPHY

There is a strong connection between the basic science of physics and the medical career field. The very word "physics" comes from the Greek word for nature and forms the root word of a number of medical words such as physician, physical and physiology.

Since physics was once defined as "the purposeful interrogation of nature", this course should sharpen the students' skills as observers and experimenters. The student should develop the ability to analyze results and distinguish between the essential and the peripheral. Thus the laboratory is an integral and necessary part of the course. Students will also be able to see physics principles at work outside the classroom. The culminating experience for the section of the course dealing with concepts in mechanics will be a visit to the world's largest physics laboratory: Great Adventure.

The course gives preference to developing an understanding of the basic laws of physics over blindly memorizing formulas. It will purposefully integrate the concepts of physics with applications in the medical and health sciences. These include but are not limited to static equilibrium and its applications to traction and immobilization of injured limbs, electronic instrumentation used for diagnoses (such as MRI), the optics involved in sight and the correction of vision problems. One part of the course will highlight waves and sound with a special accent on ultrasound, music and hearing. Physics is extremely useful in understanding the function of the various organ systems of the body, such as the eyes, ears. lungs and the heart and circulatory systems.

Physics must also contribute its share to general intellectual development by providing a student with the opportunity to reason, to express thoughts clearly and to be able to follow the development of the ideas of others. As she moves through this vital, ever expanding subject, the student will have the chance to nourish that curiosity about the world which marks humans off so sharply from other animals, that wonderful feeling of wanting to know which can be a deep satisfaction throughout a whole lifetime.

Last but far from least, the course will help to enhance the student's aesthetic sense by developing an appreciation for the order and beauty of natural phenomena. Students will leave the physics class with a new way of looking at the world around them.

COURSE DESCRIPTION

_____This course is designed to present physics not as a mere body of facts but as a continuing process by which humankind seeks to understand the nature of the physical world and builds models to explain and predict natural phenomena.

What is nearsightedness and how can it be corrected? How does ultrasound work? How is electricity generated and how is it used in the body ? **Physics** enables the student to answer these questions. It gives her the power to predict and to design, to understand and to adventure into the unknown. From what the student will learn in physics, new applications are made. Physics lies behind the headlines, behind the gadgets that create new jobs, and behind the problems every citizen has to face.

The study of physics will begin with Mechanics, the description and explanation of objects in motion and the three great conservation laws. A look at the world of wave motion follows: what is a wave? how is sound transmitted? The course continues with a paradox: what is the nature of light? The student looks at the properties of light and tries to reconcile its wave and particle nature as they look at the medical applications of optics. The student then leaves the study of waves and delves into an exploration of the microscopic and submicroscopic domain through a look at Electricity and Magnetism. The course concludes with a look at the nucleus of the atom. Power from the nucleus of the atom has been with us since the earth was formed but its application in diagnostic instrumentation will be of particular interest.

Primary Text: **Hewitt, Paul G. Conceptual Physics. Menlo Park,CA: Addison-Wesley Publishing Company, 1997.**

Supplemental: Hewitt, Paul G. Conceptual Physics Lab Manual. Menlo Park,CA. Addison-Wesley Publishing Company, 1997.

Bond Hickman, Jennifer. Problem-Solving Exercises in Physics: Addison-Wesley Publishing Company, 1997.

Hewitt, Paul G. Conceptual Physics Practice Book. Menlo Park,CA. Addison-Wesley Publishing Company, 1997.

Eisenkraft, Arthur, editor, Active Physics: Sports Module, 1998.

Eisenkraft, Arthur, editor, Active Physics: Medicine, 1998.

Laboratory exercises developed by staff.

Major Computer Graphical Analysis, Vernier Software Version 2.0.

Software:

Microsoft Office.

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PROGRAM GOALS

The Medical Physics program developed for the Academy of Allied Health and Science has goals which have been divided into three major areas: concepts, attitudes and skills. This course is also designed to integrate applications of physics in the medical field with basic principles and concepts..

I. Concepts

The student, after completing this course, should understand the basic principles of Newtonian Mechanics, Waves and Sound, Optics, Electricity and Magnetism, and Nuclear Physics.

The student should understand the process behind the development of physical theories as well as how such theories are modified and updated when necessary.

II. Attitudes

The student, after completing this course, should appreciate the importance of physics concepts in his/her everyday life.

The student should appreciate the impact of physics concepts and applications of these concepts in the fields of health and medicine.

The student should develop an awareness of the rich variety of careers open to the person who has made a serious study of physics.

The student should understand and appreciate the nature of the scientific process and the need for verification of theories by experimental tests, a characteristic which differentiates science from other branches of study.

III. Skills

The student, after completing this course, should be able to use the computer confidently as a tool for collecting and analyzing data, solving problems, and constructing and interpreting graphs.

The student should have developed skills in the safe use of scientific equipment.

The student should have improved his/her organizational skills so that he/she may budget time effectively.

The student should have enhanced his/her problem solving and critical thinking skills.

The student should be able to use appropriate mathematical skills to describe and analyze physical situations and real world problems.

The student should have enhanced his/her skills at analyzing scientific data both graphically and mathematically.

The student should be able to write a lucid, cohesive lab report including conclusions based on data which he/she collected and analyzed.

COURSE PROFICIENCIES

Students enrolled in Medical Physics will demonstrate mastery of the following proficiency requirements:

1. An awareness of the career potentials related to the study of physics and its relation to the medical sciences, arts and humanities.

2. The ability to apply the metric systems of units to appropriate physics problems and laboratory measurements.

3. The ability to successfully complete appropriate lab experiments including: data collection, organization and analysis, and error analysis.

4. The ability to use computers in the laboratory as tools for data collection, measurements, and analyses.

5. The ability to analyze data through graphical and mathematical techniques, with and without the use of the computer.

6. Knowledge of and adherence to safety rules in the laboratory.

7. The ability to draw conclusions from their observations and write a well organized, articulate lab report.

8. The ability to solve physics problems using the appropriate mathematical techniques, including but not limited to vector composition and resolution, algebra, computer simulations , etc.

9. The ability to use the computer for concept development and to enhance problem solving skills.

10. An awareness of and appreciation for historical contributions and the international scope of physics.

11. The ability to work cooperatively with a group to design and produce open ended projects.

12. An understanding of displacement, velocity and acceleration in rectilinear and curvilinear kinematics.

13. A thorough understanding of Newton's Laws of Motion and their application to mechanical systems.

15. Knowledge of and ability to apply the Laws of the Conservation of Energy and Momentum.

16. An understanding of the gravitational attraction that exists between all particles having mass. and how that attraction changes with distance between the particles.

17. The ability to differentiate among the many types of mechanical and electromagnetic waves including but not limited to sound and visible light.

18. A familiarity with the properties exhibited by waves, such as reflection, refraction, interference, diffraction, total internal reflection.

19. An understanding of the Doppler Effect and the production of shock waves.

20. The ability to describe properties of light including its propagation, reflection and refraction.

21. An understanding of geometric optics in both mirrors and lenses.

22. A knowledge of both the particle model and the wave model of light and an appreciation of

the dual nature of matter and energy.

24. An ability to differentiate among the various forms of nuclear radiation.

25. The ability to distinguish nuclear fission and fusion.

26. The ability to describe the applications of atomic and nuclear physics principles in diagnostic and other electronic instrumentation used in the medical field.

23. An understanding of basic electrostatic principles, including fields, forces and conservation of charge.

24. Familiarity with electric potential energy and potential difference.

25. The ability to evaluate simple direct current circuits.

26. The ability to describe the motion of charged particles in electric and magnetic fields.

27. A familiarity with the process of electromagnetic induction.

28. A familiarity with the theory of special relativity and the equation $E = mc^2$

To measure mastery in accordance with the grading policy, attendance policy and other official policies of the Monmouth County Vocational School District Board of Education and the Academy of Allied Health and Science, the teacher will select appropriate evaluative methods which will include, but not necessarily be limited to those listed below:

Tests	Reports/ Readings
Quizzes	Performance in Lab
Homework	Projects
Lab Reports	Class work
Authentic Assessments	

METHODOLOGY OF INSTRUCTION

Medical Physics, in order to most resemble the methods of science in the real world, must be intrinsically an activity oriented, hands on course. Therefore, the instructor will use the lecture method sparingly, depending instead on class discussions, problem solving work by cooperative learning teams in class, and laboratory explorations and quantitative experiments. Students will also receive assignments to complete at home, according to the Academy of Allied Health and Science Homework Policy guidelines. They will write reports, do outside readings, perform computer simulations and individual and/or group projects. As much as possible, the work will involve the student actively, rather than passively.

Explorations will involve not only standard laboratory equipment but simple objects and devices that are familiar to the student (such as batteries and bulbs, balls of various sizes, etc) to develop concepts. The course will also employ many of the newer pedagogical technologies, both for instruction and for laboratory work. The video cassette recorder will be used to present supporting materials such as selections from "Conceptual Physics Video Lessons" and other enrichment materials, as well as experiments that are not easily performed in the high school setting due to safety or budgetary constraints. Videodiscs will also be used for laboratory and demonstration purposes.

Improving communication skills being a primary goal of all programs at Academy of Allied Health and Science, writing and vocabulary are emphasized in the physics class. Students are taught the etymology of terms such as rectilinear propagation, refraction, etc. Narrative lab reports are written with a word processing program. Lab reports and other written assignments are checked for appropriate grammar and spelling as well as physics content. Students are required to keep a course notebook in the adapted Cornell Method. This notebook is graded quarterly by the instructor and serves as an invaluable resource to the student whether they are doing homework or studying for a test.

Tests are designed not merely for recall of facts but to allow the student to articulate what they know and apply their knowledge to new situations. Therefore, multiple choice tests will be used very sparingly. Tests will be replaced when practical with authentic assessments. Mini quizzes, which are formative assessments used to check students' understanding before they receive a summative evaluation, will be given and evaluated frequently.

Since this course is designed specifically for students in the Academy of Allied Health and Science, it will integrate applications of basic physics concepts to the health science and medical fields as much as possible, including references to diagnostic and curative instrumentation. This includes such devices as x-ray and ultrasound machines and radiation therapy.

Sequence and Integration of Topics

INTRODUCTION: THE NATURE AND PROCESSES OF SCIENCE

Objectives: Upon completion of this unit the student will be able to

1. Explain why physics is the most basic of all sciences.
2. Describe how application of the scientific method distinguishes sciences from the humanities.
3. Use simple scientific techniques: observation, numerical data collection, graphical analysis tools.

Topic Outline:

1. How is science different from other areas of study?
2. What are some of the ways in which science is "done"?
3. Review of scientific terminology: laws, theories, hypotheses, facts, observations.
4. The Role of measurement in science: statistical analyses
5. Error analysis: Why it is important to know the scope of our information

Activities:

1. The "Two Word" Game: Looking for Patterns
2. Review of "Surely You're Joking Mr. Feynman" (story of Richard Feynman) showing him describing the quirks of a Nobel Prize winning physicist.
3. Cooperative learning group discussion about what makes science different from other activities.Students will write their answers on kraft paper. Each group will share this with the class.A master list will then be constructed.
4. Have students bring in a photograph that shows a physics principle in action. (Any photograph will work: physics is everywhere!) Students use textbook to find their principle and write a short paragraph about the photo. Photos are mounted and made into a display for the classroom.
5. After studying the table of contents of their textbook, students will cut a picture from a magazine or newspaper which illustrates one of the major topic headings. These will be pasted on construction paper and displayed around the classroom
6. Students will learn how to use the Graphical Analysis program on the computer by analyzing and making graphs for their Lab on the Statistical Analysis of Weight.

7. Students will discuss their experiment and the importance of error analysis, including descriptions of precision, accuracy, percent error and percent deviation.

Laboratory Experiments:

1. A Statistical Analysis of Student Weight

PART I. NEWTONIAN MECHANICS

A. Straight Line Kinematics

Objectives: Upon completion of this unit the student will be able to

1. Recognize graphs of motion as representing uniform or variable motion.
2. Analyze graphs of displacement as a function of time, velocity as a function of time and acceleration as a function of time.
3. Distinguish between instantaneous and average velocity.
4. Derive information from one type of motion graph and use it to draw another graph representing the same motion.
5. Construct motion graphs from experimental data.
6. Apply equations to problems involving moving objects.

Topic Outline:____________

1. Position and Displacement
2. Motion at constant Velocity
3. Instantaneous vs Average Velocity
4. Graphical Analysis of Motion
   a. Displacement vs Time
   b. Velocity vs Time
   c. Acceleration vs Time
5. Equations to use when acceleration is constant

Activities:

1. Active Physics Sports Module: Challenge One: The Track and Field Challenge Activity One:Running the Race
2. Active Physics Sports Module: Challenge One: The Track and Field Challenge Activity Two: Analysis of Trends (Graphing methods)
3. Writing stories about real objects from graphical representations.
4. Reinforcing computer graphing skills.
5. Problem Solving Exercises in Physics: Chapter 1: Motion
6. Concept Development Exercises
7. Worksheet: Trucking Right Along Part I and Part II
9. Graph charades.

9. Active Physics Sports Module: Challenge One: The Track and Field Challenge Activity Four: Understanding the Sprint
10. Active Physics Sports Module: Challenge One: The Track and Field Challenge Activity Five: Acceleration
11 Active Physics Sports Module: Challenge One: The Track and Field Challenge Activity Six:Running a Smart Race
12. Active Physics Sports Module: Challenge One: The Track and Field Challenge Activity Seven: Increasing Top Speed

Laboratory Experiments:

1. The Physics 500
2. Active Physics Sports Module: Challenge One: The Track and Field Challenge Activity Three: Who Wins the Race
3. Kinematics of a Student
4. Lab. 4: Merrily We Roll Along
5. Graphical Analysis of an Object in Free Fall
6. Movin' Out
7. Using an Accelerometer to Classify Motion

B. <u>Straight Line Dynamics</u>

Objectives: Upon completion of this unit the student will be able to

1. Describe the motion of an object when the sum of the forces on it is zero.
2. Recognize the effects of a constant force on an object.
3. Interpret graphs involving forces as well as kinematics quantities.
4. Analyze ticker tape records of an object's motion.
5. Analyze the motion of an object to determine whether a net force is acting on it.
6. Apply Newton's Second Law to problem solving situations.
7. Integrate Newton's Second Law with kinematics problems.

Topic Outline:

1. Law of Inertia: Motion without Force
2. Mass versus Weight
3. Force causes acceleration
4. Mass resists acceleration
5. Friction
6. Pressure
7. Falling and Air Resistance
8. Applications of Newton's Laws to Problem Solving

Activities:

1. Problem worksheets and problem solving work in class.
2. Graphing motion when forces are present.

3. Graphical analysis worksheets.
4. Physics Fun: "Parachutes and Terminal Velocity".
5. Inertia Demonstrations
6. Conceptual Physics Video Lesson: Newton's First Law
7. Conceptual Physics Video Lesson: Newton's Second Law
8. Concept Development Exercises
9. Problem Solving Exercises in Physics: Chapter 3: Forces.
10. Interactive Physics Computer Simulations: Lesson 4.
11. Active Physics Sports Module: Challenge Two: Physics in Action
    Activity One: A Running Start
12. Active Physics Sports Module: Challenge Two: Physics in Action
    Activity Two: Push or Pull

Laboratory Experiments:

1. Changes in Velocity with a Constant Force
2. Dependence of Acceleration on Force and Mass
3. Activity 7: Going Nuts
4. Activity 8: Buckle Up
5. Activity 9: Getting Pushy
6. Lab: Rolling Along
7. Active Physics Sports Module: Challenge Two: Physics in Action
   Activity Six: The Mu of the Shoe

C. Motion in Three Dimensions: Vector Analysis

Objectives: Upon completion of this unit the student will be able to

1. Identify vector and scalar quantities.
2. Perform arithmetic processes on vector quantities.
3. Describe the motion of projectiles and objects in uniform circular motion verbally, graphically, and mathematically.
4. Solve problems involving the addition and/or subtraction of vector quantities.
5. Recognize that all motion is relative to a particular frame of reference.

Topic Outline:

1. Vector and Scalar Quantities
2. Components of Vectors
3. Addition of Vectors and Scalars
4. Projectile Motion
5. Satellites
6. Frames of Reference
7. Vector Nature of Newton's Law

Activities:

1. Film: Frames of Reference
2. Drawing vector diagrams.
3. Graphical solutions to vector addition and subtraction.
4. Problems from text(s) and worksheets.
5. Interactive Physics computer simulations: Lessons 5 and 6.
6. Physics Fun: "Why You Can't Hit a Home run with a Whiffle Ball"
7. Outdoor demonstrations.
8. Concept Development Exercises
9. Videotape student being pulled in wagon while throwing ball up into air. Trace path of ball on TV screen to see effect of different frames of reference on perception of motion.
10. Problem Solving Exercises in Physics: Chapter 2: Vectors
11. Active Physics Sports Module: Challenge One: The Track and Field Challenge Activity Eight: Projectile Motion
12. Active Physics Sports Module: Challenge One: The Track and Field Challenge Activity Nine: The Shot Put

Laboratory Experiments:

1. Riding with the Wind
2. Forces Acting at An Angle
3. Resolution of Forces
4. Slip- Stick: Friction
5. Frictional Forces
6. Projectile Motion

D. Newton's Third Law

Objectives: Upon completion of this unit the student will be able to

1. Define forces in terms of interactions
2. Use the law of conservation of momentum in problem solving.
3. Predict whether a large or small force was acting given the results of a particular impulse.
4. Describe the reasons for the use of such devices as car air bags, guard rails, break-away light poles, etc.
5. Explain how a rocket works
6. Given an action force, identify the reaction force.
7. Explain why the acceleration caused by an action and reaction force do not have to be the same.

Topic Outline:

1. Forces and Interactions
2. Newton's Third Law

3. Impulse Changes Momentum
4. Momentum
5. Center of Mass
6. Conservation of Momentum
   a. Action-Reaction
   b. Applications, especially to rocketry and automobile safety

Activities:

1. Investigate jet and rocket propulsion systems.
2. Use water rockets as examples of third law.
3. Demonstrations: drop object into student's hand to check reaction to impulse.
4. Solve problems using conservation of linear momentum.
5. Demonstration: the egg and the sheet.
6. Analyze different physical situations for sets of action-reaction forces.
7. Discuss Paul Hewitt's "Cart and the Horse" cartoon.
8. Conceptual Physics Video Lesson: Newton's Third Law.
9. Egg drop: construct a container that will enable you to drop an egg from a second story window without the egg breaking.
10. Interactive Physics Computer Simulations Lessons 10 Part I and Part II
11. Active Physics Sports Module: Challenge Two: Physics in Action
    Activity Five: Run and Jump
12. Active Physics Sports Module: Challenge Two: Physics in Action
    Activity Seven: Concentrating on Collisions
13. Active Physics Sports Module: Challenge Two: Physics in Action
    Activity Eight: Conservation of Momentum
14. Problem Solving Exercises in Physics: Chapter 4: Momentum.

Laboratory Experiments:

1. Conservation of Momentum with Dynamics carts
2. Activity 16: Balloon Rockets
3. Experiment 17: Tension
4. Experiment 18: Tug- Of- War
5. Experiment 19: Go Cart
6. Experiment 20: Tailgated by a Dart

E. <u>Laws of Gravitation</u>

Objectives: Upon completion of this unit the student will be able to

1. Differentiate between weight and mass
2. Relate the historical development of the model of the solar system devised by Kepler
3. Describe the Three Laws of Planetary Motion
4. Explain the inverse square law ("Butter Gun Rule")

Topic Outline:

1. The Falling Apple and the Falling Moon
2. Kepler's Laws of Planetary Motion
   a. Elliptical Law
   b. Law of Equal Areas
   c. Period as a function of Orbital Radius
3. Newton's Law of Universal Gravitation

Activities:

1. PSSC film: Universal Gravitation
2. Determine weights on other planets.
3. Calculate gravitational force of attraction between two students in class.
4. Visit Franklin Institute and use scales showing weights on various planets in the solar system.
5. Demonstration on the inverse square law.
6. Problem Solving Exercises in Physics: Chapter 7: Law of Universal Gravitation
7. Essay on history of heliocentric model of the solar system.

F. Mechanical Energy

Objectives: Upon completion of this unit the student will be able to

1. Describe the energy transformations in various physical processes, such as lighting a bulb.
2. Identify the different forms of energy.
3. Define energy in terms of work.
4. Describe how the kinetic energy of an object depends on its velocity.
5. Differentiate between conservative and dissipative forces
6. State the Law of Conservation of Energy.
7. Explain why no machine can have an efficiency of 100%
8. Apply the conservation laws to the design of amusement park rides.

Topic Outline:

1. Work
2. Kinetic Energy
   a. Transfer of Energy
   b. Elastic Collisions
   c. Conservation of Kinetic Energy
   d. Friction and its Effect on Kinetic Energy
3. Potential Energy
   a. Potential Energy stored in Magnetic Fields
   b. Elastic Potential Energy
   c. Simple Harmonic Motion

d. Gravitational Potential
e. Conservation of Energy
4. Energy Conversions and Entropy
5. Power: rate at which work is performed

Activities:

1. Produce a videotape showing one of the types of simple machines and describe its application in more complicated systems.
2. Write a story about a person packing a suitcase and taking a trip. Determine when work is done on the suitcase.
3. Identify energy transformations in a swinging pendulum or with a child on a swing.
4. Rub your hands together and describe the energy transformations.
5. Use a hand crank generator to demonstrate mechanical to electrical energy transformations.
6. Perform weight lifting exercises and determine which ones result in the greatest amount of work and power.
7. Attend Physics Day at Great Adventure and complete a workbook on qualitative and quantitative aspects of the rides.
8. Concept Development Exercises
9. Active Physics Sports Module: Challenge One: The Track and Field Challenge Activity Ten: Energy in the Pole Vault
10. Interactive Physics Computer Simulations
11. Active Physics Sports Module: Challenge Two: Physics in Action Activity Four: Defy Gravity

Laboratory Experiments:

1. Throwing a Baseball (Kinetic Energy)
2. Elastic and Inelastic Collisions
3. Changes in Potential Energy
4. Activity 21 (Exploration) Making the Grade
5. Activity 22 (Exploration): Muscle Up
6. Activity 23 (Exploration): Releasing your Potential
7. Experiment 24 (Concept Development): Conserving Your Energy
8. Experiment 27 (Concept Development): On a Roll

G. <u>Circular Motion</u>

Objectives: Upon completion of this unit the student will be able to

1. Distinguish between rotation and revolution
2. Distinguish between and define linear and angular velocity
3. Give examples of a centripetal force
4. Explain why centrifugal force is considered fictitious
5. Describe the motion of an object when it is released from circular motion

Topic Outline:

1. Rotation and Revolution
2. Rotational speed
3. Centripetal Force
4. Centripetal and Centrifugal Forces
5. Centrifugal Force in a Rotating Frame of Reference

Activities:

1. Demonstrations with pails and water
2. Discussion of tapered wheels of a railroad car
3. Interactive Physics Computer Simulations Lessons
4. Concept Development Exercises
5. Problem Solving Exercises in Physics: Chapter 6: Circular Motion
6. Videodisk segments from the Physics Video Classics collection on relative motion in moving in a circle
7. Active Physics Sports Module: Challenge Two: Physics in Action
   Activity Nine: Circular Motion

Laboratory Experiments:

1. Going in Circles
2. Centripetal Force

PART II: WAVES AND SOUND

A. Introduction: Vibrations and Waves

Objectives: Upon completion of this unit the student will be able to

1. Describe the factors affecting the period of a pendulum.
2. Describe the relationship between the frequency and the period of any vibrating object.
3. Classify waves as electromagnetic or mechanical, transverse or longitudinal.
4 Explain the basic properties of waves using water waves as a model.
5. Predict what will happen when two waves interact.
6. Describe the Doppler Effect for sound and relate it to the blue and red shifts for light.
7. Relate a drawing of a sine curve to the crests, troughs, amplitude and wavelength of a wave.
8. Describe the factors influencing the speed of a wave.
9. Given two of the three factors: speed, wavelength or frequency, calculate the third for any longitudinal or transverse wave.

Topic Outline:

1. Examples and Definition
2. Pendulum Motion
3. Simple Harmonic Motion
4. Properties of Mechanical Waves
    a. Rectilinear Propagation
    b. Reflection
    c. Refraction
    d. Diffraction
5. Superposition Principal and Standing Waves
6. Doppler Effect

Activities:

1. View wave motion at the beach. Identify wave properties like rectilinear propagation, refraction, etc.
2. Perform "people waves" to describe wave properties for mechanical waves.
3. Home Activity: Dip your finger into a pan of water and demonstrate periodic waves, wave pulses, etc.
4. Demonstrate formation of sine waves with a slinky.
5. Draw diagrams of longitudinal and transverse waves, label their parts.
6. Problem Solving Worksheets: Counting Waves and Periodic Motion.
7. Worksheet: Waves in a Bathtub
8. Identify practical devices such as directional microphones, etc. that use wave properties.
9. Concept Development Exercises
10. "Thinking Physics" and "Next Time Questions" as springboards for class discussions.
11. Use computer graphing program to investigate relationships among frequency, speed, and wavelength of a standing wave.
12. Conceptual Physics Video: Vibrations and Sound I

Laboratory Experiments:

1. Activity 64 (Exploration):Tick Tock
2. Activity 66 (Exploration) Wave Addition
3. Experiment 65: Grandfather's Clock
4. Activity 67: Ripple While You Work
5. Pulses on a Coil Spring
6. Periodic Waves
7. Standing Waves

B. **<u>Sound</u>**

Objectives: Upon completion of this unit the student will be able to

1. Describe what happens to a medium when sound moves through it.

2. Compare the transmission of sound through air with transmission through solids, liquids, and a vacuum.
3. Explain the factors that influence the speed of sound.
4. Differentiate between
   a. Loudness and intensity
   b. Frequency and pitch
5 Describe the conditions for resonance
6. Describe the conditions for beats.
7. Describe the criteria for distinguishing between music and noise.
8. Explain what ultrasound is
9. Explain how ultrasound can be produced
10. Describe how ultrasound is used in medical diagnostics

Topic Outline:

1. Nature of Sound
2. Speed of sound
3. Frequency and Pitch
4. Intensity and Loudness
5. Resonance
6. Beats
7. Music Vs. Noise
8. Ultrasound and its Uses

Activities

1. Make a refrigerator grill sounding board.
2. Make instruments out of paper and tape
3. Make a list of different examples of resonance.
4. Examine what happens to the pitch of a glass which you are tapping when the water level is changed.
5. Look at different musical instruments to see how they produce sounds of different pitch, loudness, etc.
6. Show a tuning fork is vibrating by dipping it into a glass of water and holding it up in front of a computer monitor.
7. Demonstrate different types of resonance phenomena.
8. Videodisc: Tacoma Narrows Bridge Collapse
9. Optional: Active Physics Medicine Module Hearing Challenge/ Ultrasound Challenge.

Laboratory Experiments:

1. The Echo Speed Calculator
2. Gravity and the Speed of Sound
3. Resonance and the Speed of Sound in Air
4. Activity 68 (Exploration) : Chalk Talk

5. Experiment 69 (Concept Development): Sound Barrier
6. Optional: Active Physics Medicine Module Hearing Challenge/ Ultrasound Challenge.

PART III: LIGHT: ITS BEHAVIOR AND NATURE

A. Nature of Light

Objectives: Upon completion of this unit the student will be able to

1. Differentiate between luminous and illuminated sources of light
2. Describe how light is transmitted by different materials.
3. Diagram the formation of shadows when objects are at various positions in front of a light source.
4. Explain why it is much more difficult to measure the speed of light than the speed of sound.
5. Describe the conditions for a solar and a lunar eclipse.

6. Describe the dependence of intensity on distance from the source.
7. Describe the relation among the parts of the electromagnetic spectrum.
8. State the evidence for the dual nature of light.

Topic Outline:

1. Sources of Light: All We can See is Light
2. Speed of Light
3. Beams, Pencils, and Rays of Light
4. Transparent, Opaque, Translucent Materials
5. Polarization
6. Shadow Formation and Eclipses
7. Polarized Light and 3-D Viewing
8. Light: A particle or wave?

Activities:

1. Demonstration: different types of light sources
2. Draw ray diagrams for shadow formation
3. Use spray paint to investigate the inverse square law.
4. Show TV Ontario videos: Dual Nature of Light
5. Demonstration: a mechanical analog for polarization
6. Project: polarization through cellophane on a microscope slide
7. Concept Development Exercises
8. Lab report for Light Potpourri: essay in which individual students use word processor to write portions of lab, then merge them on the computer for a single narrative report.

Laboratory Experiments:

1. A Potpourri of Light Properties
2. Light Intensity Vs. Distance
3. Activity 70 (Exploration) Shady Business
4. Activity 72: Shades

B. <u>Color</u>

Objectives: Upon completion of this unit the student will be able to

1. Explain how white and black are formed
2. Describe why the interaction of light with atoms or molecules of a material differs for different frequencies.
3. Describe the relationship between color and wavelength.
4. Describe what factors determine whether a material will reflect or transmit light of particular colors.
5. Define complementary colors and give examples of pairs of complementary colors.

6. Distinguish between color mixing by subtraction and color mixing by addition.
7. Explain why the sky appears blue and water is greenish blue.
9. Explain what the lines in an atomic spectrum represent
10. Describe how the colors of a blue jays feathers and a soap bubble are formed.

Topic Outline:

1. The color spectrum
3. Color by reflection
4. Color by transmission
5. Mixing colored lights
6. Formation of a rainbow and the color of the sky
7. Production of Colors by thin film interference
8. Mixing colored pigments
9. Why water is bluish green and sunsets are red: scattering

Activities:

1. Spectrum Day: Students assume role of a color of the spectrum, investigate properties of light as this color.
2. Demonstration: Primary Colors of Light and Pigments
3. Separate light into colors with diffraction gratings, prisms, thin films, etc.
4. Colored Shadows
5. Physics Fun: "Our Red, White and Blue Sky"
6. Guest Speaker: Art teacher to discuss differences between additive and subtractive color mixing.
7. Physics Fun: "Rainbows, Halos and Other Lights in the Sky"
8. Activity: Bubble-ology

Laboratory Experiments:

1. Color

C. Reflection and Refraction

Objectives: Upon completion of this unit the student will be able to

1. Differentiate between specular and diffuse reflectors.
2. State the laws of reflection and refraction.
3. Predict angles of refraction from angles of incidence using Snell's Law.
4 Describe the characteristics of the images formed by curved mirrors and lenses for different locations of the object
5. Differentiate between concave and convex lenses and the effects on incident light.
6. Understand the reason why refraction occurs.
7. Describe total internal reflection.
8. Given a particular angle of incidence, predict whether light will be refracted or totally

internally reflected.

9. Given the location of an object, locate the image formed by curved mirrors and lenses.

Topic Outline:

1. Reflection: Specular and Diffuse
2. Laws of Reflection
3. Reflection from Curved Surfaces
4, Reflection of Sound
4. Using ray diagrams to locate images
5. Refraction of Sound and Light
6. Snell's Law
7. Indices of Refraction
8. Total Internal Reflection
9. Dispersion
19. Converging and Diverging Lenses

Activities:

1. Locate images in mirrors with ray diagrams.
2. Demonstration: The Magically Lit Candle
3. Computer simulations of ray tracing.
4. Skit: Students "become" the parts of a curved mirror, objects and images of various types.
5. Students predict what the mirror looked like by viewing photos of images in fun house mirrors.
7. "Oral Borealis": Producing light by the piezoelectric effect
8. Problem solving using Snell's Law.
9. Index of Refraction worksheet.
10. Make an analogy between refraction of light waves and wheeled object turning onto muddy field.
11. Demonstration: Fiber Optic flashlights and lamps
12. Guest Speaker: physicist from Lucent to speak on uses of fiber optics and laser.

Laboratory Experiments:

1. Activity 75: Images
2. Activity 76: Pepper's Ghost
3. Activity 77: The Kaleidoscope
4. Experiment 78: Funland
5. Activity 81: The Lensless Lens
6. Experiment 82: Bifocals
7. Activity 83: Where's the Point

D. <u>Physics of the Eye and Vision</u>

Objectives: Upon completion of this unit the student will be able to

1. Describe the structure and function of the various parts of the human eye
2. Explain how rectilinear propagation helps to form images on the retina
3. Create images with the use of pinhole viewers, mirrors and lenses
4. Describe the common vision problems of nearsightedness and farsightedness
5. Use ray diagrams to trace the formation of images
6. Explain how corrective lenses work
7. Describe the function or rod and cone cells
8. Describe peripheral vision and visual acuity

Topic Outline:

1. Focusing Elements of the Eye
2. Other Elements of the Eye
3. The Retina: The Light Detector of the Eye
4. How Little Light Can You See
5. Diffraction Effects on the Eye
6. How Sharp Are Your Eyes?
7. Optical Illusions and Related Phenomena
8. Defective Vision and Its Correction
9. Color Vision and Chromatic Aberration
10. Instruments Used in Ophthalmology

Activities:

1. Monitor the size of your pupil as you look through a pinhole in cardboard.
2. Test which eye you use more
3. Check color fatigue by staring at a colored object for 30 sec. then staring at a blank screen.

Experiments:

1. Active Physics Medicine Module: Vision Challenge: Activity Three: Refraction
2. Active Physics Medicine Module: Vision Challenge: Activity Four: How Images are Made- Converging Lenses
3. Active Physics Medicine Module: Vision Challenge: Activity Six: How Images are Meade- Diverging Lenses

<u>PART IV: RADIOACTIVITY</u>

<u>A. The Atomic Nucleus and Radioactivity</u>

Objectives: Upon completion of this unit the student will be able to

1. Distinguish between atomic and nuclear physics

2. Describe alpha particles and list their properties
3. Detail JJ Balmer's contributions to the structure of the atom
4. Explain the Bohr model of the atom
5. Show the relationship between the wave and particle model for the electron
6. Differentiate between xrays and visible light
7. Construct a comparison chart for alpha, beta and gamma radiation properties
8. Define atomic and nuclear terminology
9. Explain what is meant by half life
10. Construct a transmutation flow chart

Topic Outline:

1. Xrays and Radioactivity
2. Alpha, Beta and Gamma Rays
3. The Nucleus
4. Isotopes
5. Why Atoms are Radioactive
6. Radiation Detectors
7. Transmutation of Elements
8. Radioactive Isotopes
9. Carbon and Uranium dating
10. Effects of Radiation on Humans
11. Diagnostic Effects of Radiation
12. Medical Uses of Radiation

Activities:

1. Construct a timeline showing the history of nuclear and atomic physics in the last 100 years.
2. Write a chapter from a science fiction book using the information about atoms and nuclei that you learned in the chapter.
3. Examine a luminous faced watch in a very dark room with a magnifying glass
4. Make a list of where you might encounter nuclear and atomic effects in your daily activities.
5. Have a guest speaker from a teaching hospital explain the diagnostic and treatment uses of radioactive materials.
6. Use a radioactive analog (dice, cards, etc.) to explain half life

Laboratory Experiments:

1. Nuclear Marbles
2. Half Life

B. <u>Nuclear Fission and Fusion</u>

Objectives: Upon completion of this unit the student will be able to

1. Differentiate between the processes of nuclear fission and fusion
2. Explain which process could produce a chain reaction and why
3. Describe the nuclear fission reactor
4. Name three isotopes that undergo spontaneous nuclear fission
5. Tell how a breeder reactor produces energy and fuel
6. State the principle of mass-energy equivalence in both word and equation form.
7. Specify how a star produces its energy

Topic Outline:

1. Nuclear Fission
2. Nuclear Fission Reactors
3. Plutonium
4. Breeder Reactors
5. Mass-Energy Equivalence
6. Nuclear Fusion- Producing and Controlling It

Activities:

1. Demonstrate chain reactions in an enclosed area with corks as the breeder material
2. Make a chart showing the properties and problems associated with conventional and nuclear power plants (include both a fission plant and a proposed fusion plant).
3. Beta test some of the new Physics of Diagnostic Instruments book activities.

Laboratory Experiment:

1. Chain Reaction

<u>PART V:ELECTRICITY AND MAGNETISM</u>

A. <u>Electrostatic Forces, Fields and Potential</u>

Objectives: Upon completion of this unit the student will be able to

1. Explain why "likes repel, and everything else attracts."
2. Determine experimentally whether an object is carrying a net charge.
3. Describe the relation among the electrical forces between two charged objects, their charge, and the distance between the objects (Coulomb's Law).
4. Mathematically solve simple Coulomb's Law problems by application of the inverse square law, etc.
5. Explain from the point of view of electron transfer, how an object becomes charged.
6. Differentiate between the effects of charging by conduction or induction.
7. Distinguish between an insulator and a conductor.
8. Describe the characteristics of an object which can hold a net charge.
9. Sketch the electric field around one or more charged objects and indicate the direction of the field.

10. Describe the conditions under which an object can be completely shielded from an electric field.
11. Distinguish between electric potential energy and electric potential (energy difference).
12. Describe the contributions made by Benjamin Franklin to scientific progress in the 18th century.

Topic Outline:

1. Basic Law of Electrostatics
2. Electrostatic Conduction
3. Electrostatic Induction
4. Coulomb's Law
5. The Elementary Charge
6. Lightning Rod
7. Electric Fields and Potential
8. The Faraday Cage
9. Charge Polarization
10. Conservation of Charge

Activities:

1. Demonstration: the Van de Graaff Generator
2. Charge two balloons and use them as electroscope to show basic electrostatics laws.
3. Physics Fun: "Why does a balloon stick to the Wall?"
4. Construct apparatus with everyday materials and perform simple experiments.
5. Sketch field diagrams.
6. Physics Fun: "Lightning and Lightning Rods"
7. Computer graphing of force as a function of distance, using Graphical Analysis program.

Laboratory Experiments:

1. Electrified Objects: Mini Labs Adapted from Operation Physics
2. Electrostatic Induction
3. The Force Between Two Charged Spheres**.**

B. Direct Current Electricity

Objectives: Upon completion of this unit the student will be able to

1. Describe the conditions for the production of a continuous flow of electric charge.
2. Describe the variety of methods that may be used to produce continuous current: chemical, solar, electromagnetic, etc.
3. Describe the factors that determine the resistance of a wire.
4. Relate the amount of current in a circuit to the voltage impressed across the circuit and the resistance of the circuit (Ohm's Law).

5. Relate the electric power used by a device to the current and the voltage.
6. Determine whether current will flow through a bulb, given a diagram showing the bulb and a battery connection.
7. Predict what will happen to the current flow if there is a break in a series circuit or in a parallel circuit.
8. Interpret a simple schematic diagram of a circuit.
9 Solve problems involving series circuits and parallel circuits
10. Determine the equivalent single resistance for a given circuit with two or more devices connected in series, parallel or series/parallel.
11. Follow energy transformations from power source through loads in electrical circuits.

Topic Outline:

1. Potential Difference
2. The Relation between Charge and Current
3. Work and Power in Electric Circuits
4. Ohm's Law
5. Conservation of Energy in Electric Circuits
6. Conservation of Charge in Electric Circuits
7. Solving Circuit Problems
   a. Resistors in Series
   b. Resistors in Parallel
   c. Series/ Parallel Circuits
8. Home Lighting Circuits

Activities:

1. Learn to use oscilloscope and multimeter.
2. Work with analog circuits trainer to demonstrate Ohm's Law and simple circuits.
3. Series and Parallel Circuits Worksheets.
4. Board work on circuit problems.
5. Physics Fun: " Wiring Christmas Tree Lights"
6. Physics Fun: " Power Lost in the Transport of Power."
7. Demonstration: The Series/ Parallel Hot Dog Cooker

Laboratory Experiments:

1. "Fruits and Veggies" Lab: what combinations of electrolytes and electrodes will produce working voltaic cells?
3. Electrical Work and Changes in Internal Energy
4. Sparky the Electrician
5. Ohm Sweet Ohm
6. Getting Wired
7. 3 Way Switch
8. Cranking Up

C. <u>Magnetism</u>

Objectives: Upon completion of this unit the student will be able to

1. Describe the differences and similarities between magnetic poles and electric charges
2. Describe the Domain Theory of magnetization.
3. Explain why magnets lose their magnetism under certain conditions.
4. Describe what happens to the magnetic domains of iron in presence of a strong magnet.
5. Sketch the fields around permanent magnets.
6. Sketch the fields around current carrying conductors and use Ampere's Law to determine their polarity.
7. Describe the conditions for a magnetic field exerting a force on a charged particle or stream of particles in the field.
8. Describe the shape and origin of the earth's magnetic field as well as the effects of solar wind on that field.

Topic Outline:

1. Magnetic poles and their interactions
2. The Earth's Magnetic field
3. Fields around permanent magnets
4. Magnetization of ferromagnetic materials
5. Magnetic domains
6. Making a magnet with Electricity
7. Fields around Current Carrying Conductors
8. Forces on Charges in Magnetic Fields
   a. Force on Charged Particles
   b. Forces on Conductors
   c. Forces between Parallel Conductors
   d. The Mass Spectrometer

Activities:

1. Test materials for reaction to a magnet.
2. Using sets of magnets, test actions of poles.
3. Demonstration: Torsion pendulum with copper coils and strong magnet to show diamagnetism.
4. Draw diagram of earth's magnetic field, show poles, effects of solar wind.
5. Use compass and dip needle to determine directions of local magnetic field.
6. Use a compass to investigate fields around coils and conductors.
7. Use road and private pilots' maps to find angles of declination and inclination.
8. Demonstration: Show how a magnet disrupts the picture on a black and white TV set.
9. Show how a wire jumps out of a magnet when a current is passing through the wire
10. Have students demonstrate direction of fields around current carrying wires, using cardboard arrows and signs to designate positive and negative connections.

Laboratory Experiments:

1. Properties of Magnets
2. Magnetic field of a Current
3. 3-D Magnetic Field
4. You're Repulsive
5. The Magnetic Field of the Earth

D. <u>Electromagnetic Induction</u>

Objectives: Upon completion of this unit the student will be able to

1. Describe how changing magnetic fields cause the flow of charge in a conductor.
2. Identify the factors affecting the amount of induced current produced.
3. Describe a generator and how it works.
4. Use Lenz's Law to determine the direction of the current produced in a wire or coil moving in a magnetic field.
5. Describe a transformer and how it works.
6. Solve problems involving step up and step down transformers.
7. Compare and contrast how a generator works to how a motor works.
8. Explain why transformers are used in the transmission of electric power.

Topic Outline:

1. Inducing A Current with a Magnetic Field
2. Induced EMF
3. Lenz's Law
4. Faraday's Law and Factors affecting Induced EMF
5. Electric Fields around Changing Magnetic Fluxes
6. Power Transmission
7. Electromagnetic Waves

Activities:

1. Class discussion of conditions needed to produce induced EMF.
2. Demonstration : Students predict what will happen when magnet and coil of wire are moved in various ways.
3. Worksheets applying Lenz's Law.
4. Qualitative problems; narrative responses.
5. Students describe conservation of energy in relation to electromagnetic fields.
6. Demonstration: Mechanical Generator.
7. "Skits": Kinesthetic experiences with arrows representing currents and fields to reinforce concepts.

Laboratory Experiments:

1. The Jump Rope Generator
2. Electromagnetism
3. Electromagnetic Induction
4. Investigation and Verification of Lenz's Law