Key Physics Concepts

Section Summaries	Physics Principles
Section 1 Static Electricity and Coulomb's Law: Opposites Attract Using transparent cellophane tape, students investigate the static electricity of charged objects. Electric forces are explored and the students read about conservation of charge and Coulomb's law to prepare them to understand the forces holding an atom together.	**Electric fields** **Charge** **Conservation of charge** **Coulomb's law** **Grounding, Induction**
Section 2 The Nature of Charge: Tiny and Indivisible In a simulation of Millikan's oil-drop experiment, students use inquiry to find the number of coins enclosed in a film canister. They then learn how related techniques were used to determine that electric charge is quantized. The process of inference to obtain information about systems that cannot be directly measured is used.	**Quantization of charge** **Charge on the electron** **Millikan experiment**
Section 3 The Size of a Nucleus: How Big Is Small? Using statistical measurements, students estimate the size of a penny. They then compare their statistical approach with direct measurement. Finally, they compare their experiment with Rutherford's experiment to determine the size of a nucleus in relation to an atom and the evidence we have to verify that knowledge.	**Atomic models** **Atomic nucleus** **Atomic forces** **Atom as mostly empty space**
Section 4 Hydrogen Spectra and Bohr's Model of the Hydrogen Atom Students investigate spectral lines by using a spectrometer to measure the wavelengths of light emitted by three gases. The unique spectra of atoms are discussed and the students then learn about the Bohr model of the atom. Using this model, they calculate the wavelengths of light emitted as electrons jump from one quantized orbit to another. The discovery of helium from its spectrum is discussed. In the Active Physics Plus, the formula for the energy of a photon is also discussed.	**Bohr model** **Quantized electron orbits** **Atomic spectra** **Electron energy levels** **Balmer series**
Section 5 Wave-Particle Model of Light: Two Models Are Better Than One! The wave and particle nature of light is explored by investigating two-slit interference and the photoelectric effect. By drawing an analogy to standing waves on a string, a new interpretation of the Bohr orbit as standing waves of electrons is introduced, with a nonmathematical introduction of the Schrödinger wave equation. The dual wave and particle nature of electrons is also discussed.	**Interference of waves** **Photoelectric effect** **Work function** **Photon energy** **Photon model of light** **Schrödinger wave equation** **DeBroglie waves**
Section 6 The Strong Force: Inside the Nucleus The proton-neutron model of the nucleus is introduced and explored. With a huge Coulomb repulsion pushing protons apart, the need for a strong attractive force in the nucleus is investigated. Students are then introduced to Feynman diagrams as a means of understanding how forces are transmitted.	**Proton-neutron model** **Strong force** **Feynman diagram** **Action at a distance** **Virtual particles**
Section 7 Radioactive Decay and the Nucleus Students investigate the statistical properties of randomly tossing marked cubes. They then relate these results to the statistics of radioactive decay. The concept of half-life is introduced as a clock for measuring radioactive decay. Students are then introduced to complete nuclear equations for alpha, beta, and gamma decays.	**Radioactive decay** **Half-life** **Atomic mass** **Atomic number** **Nuclear transmutation**

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Section Summaries	Physics Principles
Section 8 Energy Stored within the Nucleus Students are introduced to Einstein's famous equation E = mc2 and use it to calculate the energy liberated by the conversion of mass to energy. After calculating the mass defect of the nucleus, the equation is used to calculate nuclear binding energies.	**Atomic mass unit** **Conservation of mass energy** **Nuclear mass defect** **Nuclear binding energy** **Particle-antiparticle annihilation**
Section 9 Nuclear Fission and Fusion: Breaking Up Is Hard to Do Students start by calculating the nuclear binding energy of various elements and then graph the binding energy per nucleon versus the element's atomic number. Students explore nuclear fission and fusion reactions. How a fission chain reaction works is also studied.	**Binding energy per nucleon** **Nuclear fission** **Nuclear fusion**

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