Overview for the Models of Light

The teacher's notes for each model contains a detailed story line. The models of light fit together as follows:

Particle Model of Light

- Sources and seeing
- Shadows
- Pinholes
- Reflection
  - Plane & (optional) Curved mirrors
- Refraction
  - (optional) Lenses

Wave Model of Light

- Problems with the particle model
- One dimensional mechanical waves
- Two dimensional mechanical waves
- Interpreting light behavior in terms of waves
  - Reflection
  - Refraction
  - Diffraction
  - Interference
  - Color

Photon Model of Light

- Photoelectric effect
- Problems with the wave model
- Emission spectra
- Bohr model of the atom
- Wave-particle duality

Overview Elaboration

The modern model of light is complex and involves aspects of both particles and waves. Presenting a single unified model without background in the particle nature and the wave nature of light would challenge any concept flow. A particle model of light is presented and found to be useful but lacking in simplicity. A wave model is next considered, but also found lacking. A photon model is then considered and the student lead to appreciate the dual particle wave nature of light.

The particle model is presented first because students are more familiar with the concepts involved because of their work in mechanics. In addition, this unit provides an opportunity to introduce the students to many of the different behaviors of light. The particle model is very successful in the treatment of straight-line travel, reflection, and energy transfer, but is less successful for refraction and diffraction.

These difficulties are not insurmountable, but leave us with a particle model, which is far more complex than a simple sphere traveling through space. Our choice then is to accept and "fit" this complex particle model, or to seek a simpler model. That simpler model might be the wave.

One of the difficulties with the wave model concerns the student's familiarity with waves. While all students are familiar with particles, having tossed objects or played pool, but are far less knowledgeable about wave behavior. The wave model will involve more experience with the nature of waves as well as its appropriateness as a model for light. Reflection, energy transfer, refraction, diffraction, interference, and straight-line travel are well modeled by a wave. In addition, color can be understood in wave terms. While this model seems to overcome all our difficulties with the particle model, waves predict that light energy should be a function primarily of amplitude. The photoelectric effect demonstrates a connection between the frequency of light and energy, and requires us to re-examine our rejection of the particle model.

The photon model is now explored and students are introduced to concepts of atomic structure, spectra, and the quantization of light. The student is now in a position to view light as a model with wave like behaviors and particle like behaviors. The wave nature of light is more obvious for long wavelength "light" such as radio or microwaves where the energy of single photons are difficult or impossible to detect and group behavior becomes more observable. The particle nature of light is more observable for short wavelength "light" such as x-rays and gamma rays, where the energy of each particle is so high, that paths of individual particles can be easily detected.

The student should not be forced into a concept of a photon as a particle that waves. Light is neither a particle nor a wave: light is light. In some applications light exhibits wave properties. In other applications light exhibits particle properties. In some instances light seems to behave as a wave and a particle. Both these models are useful and the model used will depend to a large degree on the particular application considered.