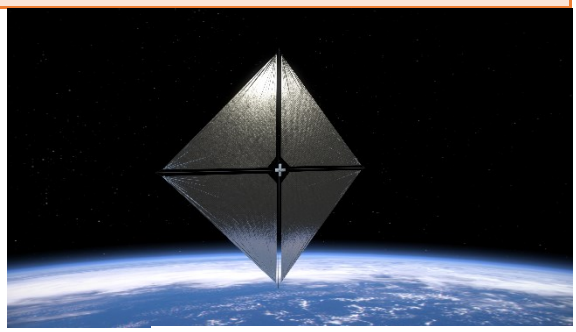
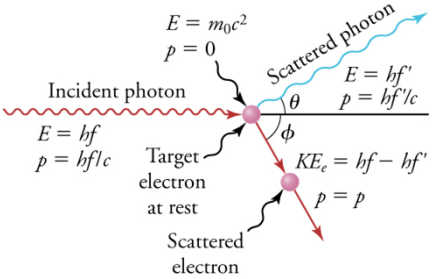
Physics 12-06 The Dual Nature of Light **Name:** _____

- Light behaves as a wave
  - _____
  - _____
  - _____
- Light behaves as a particle
  - _____energy – Blackbody radiation
  - _____effect
  - _____



Momentum of light

- Light from the sun pushes a _____tail away
- NASA is developing a _____spaceship that is pushed away from the sun using a sail that is hit by the _____
- When _____ are shot through atoms, then they _____from hitting electrons
  - The scattered photons have _____energy than before because they gave some energy to the electron like a _____collision



$$p = \frac{h}{\lambda} = \frac{hf}{c}$$

Calculate the momentum of a visible photon that has a wavelength of red light 680 nm.

Find the velocity of an electron with the same momentum.

What is the energy of the electron, and how does it compare with the energy of the photon?

Particle-Wave Duality

- Light waves can act as _____
- Particles can act as _____
  - Electrons can _____with each other
  - Electron currents can _____out
- _____matter is both _____and _____

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Practice Work

1. Why don't we feel the momentum of sunlight when we are on the beach? (HSP 21.8)
2. Describe one type of evidence for the wave nature of matter. (OpenStax C29.23)
3. Describe one type of evidence for the particle nature of EM radiation. (OpenStax C29.24)
4. In what region of the electromagnetic spectrum will photons be most effective in accelerating a solar sail? (HSP 21.19)
5. Terms like frequency, amplitude, and period are tied to what component of wave-particle duality? (HSP 21.44)
6. Upon collision, what happens to the frequency of a photon? (HSP 21.59)
7. How does the momentum of a photon compare to the momentum of an electron of identical energy? (HSP 21.60)
8. Large objects can move with great momentum. Why then is it difficult to see their wave-like nature? (HSP 21.66)
9. What is the momentum of a 0.0100-nm-wavelength photon that could detect details of an atom? (HSP 21.26)
   $\mathbf{6.63 \times 10^{-23}\ kg\ m/s}$
10. What is the momentum of a 500-nm photon? (HSP 21.42) $\mathbf{1.33 \times 10^{-27}\ kg\ m/s}$
11. A 500-nm photon strikes an electron and loses 20 percent of its energy. What is the new momentum of the photon? (HSP 21.61) $\mathbf{1.06 \times 10^{-27}\ kg\ m/s}$
12. A 500-nm photon strikes an electron and loses 20 percent of its energy. What is the speed of the recoiling electron? (HSP 21.62) $\mathbf{4.18 \times 10^{5}\ m/s}$
13. The wavelength of a particle is called the de Broglie wavelength, and it can be found with the equation, $p = \frac{h}{\lambda}$.
    Can the wavelength of an electron match that of a proton? Explain. (HSP 21.65) **Yes**