

Problems:

3.10, 3.12, 3.15, 3.16, 3.20, 3.22, 3.25, 3.28, 3.36 (1)

Dynamics

1. Relativistically the following equation remains valid

$$\frac{d\mathbf{p}}{dt} = \mathbf{F}$$

where the momentum is the relativistic form

$$\mathbf{p} = \gamma m \mathbf{v} \quad \gamma = \frac{1}{\sqrt{1 - (v/c)^2}}$$

2. For a particle moving around in a circle of radius R , the change in momentum per unit time is pointed toward the center of the circle and has magnitude

$$\frac{dp}{dt} = \frac{pv}{R} = \frac{\gamma m v^2}{R}$$

Usually the equation the particle is held in circular orbit by a magnetic field and we have

$$\frac{\gamma m v^2}{R} = qvB \implies \gamma v = \frac{q}{m} BR$$

Quantum Nature of Light

1. Light comes in discrete units called photons. The energy and momentum of the photon is related to the frequency.

$$E = hf \quad cp = E$$

2. h is planck's constant and is

$$hc = 1240 \text{ eV nm}$$

3. The intensity of the light is the energy moving across a screen per area per time

$$I = \left\langle \frac{E}{A\Delta t} \right\rangle \quad (2)$$

4. For monochromatic light this is

$$I = hf \left\langle \frac{N}{A\Delta t} \right\rangle \quad (3)$$

$N/A\Delta t$ is the number of photons per area per time.

5. If for a detector of area A and time resolution Δt the number of photons N crossing the detector is very large (compared to one) then classical electromagnetism is a good approximation and we have

$$I = \left\langle \frac{\mathcal{E} \times \mathcal{B}}{\mu_0} \right\rangle \quad (4)$$

$$= \sqrt{\frac{\epsilon_0}{\mu_0}} \langle \mathcal{E}^2 \rangle \quad (5)$$

where \mathcal{E} and \mathcal{B} are the electric and magnetic fields respectively.

Photoelectric Effect and Compton Scattering

1. The photo-electric effect is when photons tear away an electron from a metal. The energy of the electron after it is ripped away is

$$E_e = hf - \phi \quad (6)$$

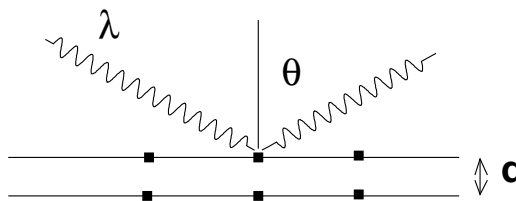
where ϕ is the work function of the metal given in Table 3.1 on page 84 of the book. By applying a retarding voltage V_s we can stop the flow of electrons from the metal. When the voltage is

$$|e|V_s = E_e \quad (7)$$

the electrons will not have enough energy to make it to the collector and current will stop.

2. X rays are produced by accelerating electrons into a metal foil
3. The wavelength of an X-ray may be determined with Bragg's crystal. The condition for constructive interference is

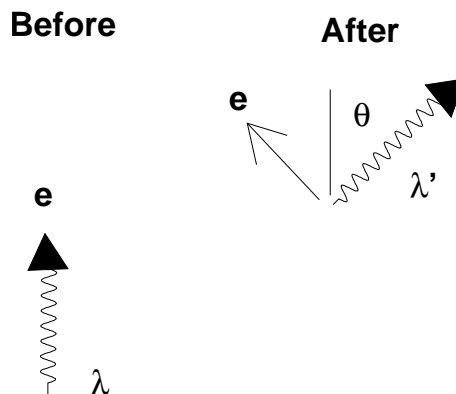
$$2d \sin(\theta) = n\lambda \quad n = 1, 2, 3, \dots \quad (8)$$



4. The Compton process is the scattering of light (X-rays) on electrons nearly at rest. The following formula results (after algebra) from energy and momentum conservation and $E = hf$

$$\lambda' - \lambda = \frac{h}{m_e c} (1 - \cos \theta) \quad (9)$$

To determine the electron momentum and direction one would write down relativistic energy and momentum conservation and use the above formula. energy and momentum conservation and use the above formula to determine



5. The Compton wavelength is a measure of the size of the "fuzziness" of the electron

$$\lambda_C = \frac{h}{m_e c} = 0.0024 \text{ nm} \quad (10)$$