

Chapter 37, 38, 39, 40 Tutorial

Modern Physics

Chapter 37 : Relativity

Chapter 38: Photons: Light Waves Behaving as Particles

Chapter 39: Particles Behaving as Waves

Chapter 40: Quantum Mechanics

Question 1:

The positive muon (μ^+), an unstable particle, lives on average 2.20×10^{-6} s, which is measured in its own frame of reference before decaying.

- (a) If such a particle is moving, with respect to the laboratory, with a speed of $0.900c$, what average lifetime is measured in the laboratory?
- (b) What average distance, measured in the laboratory, does the particle move before decaying?

Question 2:

An airplane flies from San Francisco to New York (about 4800 km, or 4.80×10^6 m) at a steady speed of 300 m/s. How much time does the trip take, as measured by an observer on the ground? By an observer in the plane?

Question 3:

A proton (rest mass 1.67×10^{-27} kg) has total energy that is 4.00 times its rest energy.

- (a) What is the kinetic energy of the proton?
- (b) The magnitude of the momentum of the proton?
- (c) The speed of the proton?

Question 4:

- (a) What is the minimum potential difference between the filament and the target of an x-ray tube if the tube is to produce x rays with a wavelength of 0.150 nm?
- (b) What is the shortest wavelength produced in an x-ray tube operated at 30.0 kV?

Question 5:

A photon of green light has a wavelength of 520 nm. Find

- (a) the photon's frequency.
- (b) Magnitude of momentum.
- (c) Energy of photon.

Question 6:

A laser pointer with a power output of 5.00 mW emits red light having wavelength 650 nm.

- (a) What is the magnitude of the momentum of each photon?
- (b) How many photons does the laser pointer emit each second?

Question 7:

An atom in a metastable state has a lifetime of 5.2 ms. What is the uncertainty in energy of the metastable state?

Question 8:

- (a) An atom initially in an energy level with $E = -6.52$ eV absorbs a photon that has wavelength 860 nm. What is the internal energy of the atom after it absorbs the photon?
- (b) An atom initially in an energy level with $E = -2.68$ eV emits a photon that has wavelength 420 nm. What is the internal energy of the atom after it emits the photon?

Question 9:

A hydrogen atom initially in the ground level absorbs a photon, which excites it to the level $n = 4$. Determine the wavelength and frequency of the photon.

Question 10:

The wave function $\psi(x, t) = Ae^{i(k_1x - \omega_1t)} + Ae^{i(k_2x - \omega_2t)}$ is a superposition of two free-particle wave functions. Both k_1 and k_2 are positive.

- (a) Show that this wave function satisfies the Schrödinger equation for a free particle of mass m .
- (b) Find the probability distribution function for $\psi(x, t)$.

Question 11:

Compute $|\psi|^2$ for $\psi = \psi \sin \omega t$, where ψ is time independent and ω is real constant. Is this a wave function for a stationary state? Why or why not?

