Modern Physics

Review Quiz-1
PHY-201: Modern Physics
LUMS School of Science and Engineering

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1 Special Relativity

1.1 Basic Consequences of SR

The period of a pendulum is measured to be 3.00s in the reference frame of the pendulum. What is the period when measured by an observer moving at a speed of 0.96c relative to the pendulum?

1.2 Lorentz Transformation

Suppose a runner moving at 0.75c carries a horizontal pole 15 m long toward a barn that is 10 m long. The barn has front and rear doors that are initially open. An observer on the ground can instantly and simultaneously close and open the two doors by remote control. When the runner and the pole are inside the barn, the ground observer closes and then opens both doors so that the runner and pole are momentarily captured inside the barn and then proceed to exit the barn from the back doorway. Do both the runner and the ground observer agree that the runner makes it safely through the barn?

1.3 Energy-Momentum Relations

A pion travelling at speed v decays into a muon and a neutrino (neutrino has zero mass). If the neutrino emerges at 90° to the original pion direction, at what angle does the muon comes off?

2 Photo-Electric Effect

2.1 Determination of the Work Function

Two light sources are used in a photoelectric experiments to determine the work function for a particular metal surface. When green light from a mercury lamp ($\lambda = 546.1nm$) is used, a stopping potential of 0.376V reduces the photocurrent to zero.

a) What is the work function of this metal?

b) What stopping potential will be observed when using yellow light from a helium discharge tube ($\lambda = 587.5nm$)?

2.2 Qualitative reasoning of photo-electric effect

a) How the photo-electric current depends on the intensity of the incident light? Explain.

b) The existence of a cutoff frequency in the photo-electric effect is often regarded as the most potent objection to a wave theory. Explain?

c) What is the emperical evidence to say that the interaction between incident photon and the electrons on the surface is one-to-one.

2.3 Experimental Evidence of the Doppler Effect!!!

A light source emitting radiation at frequency 7.00 x 10^{14} Hz is incapable of ejecting photoelectrons from a certain metal. In an attempt to use this source to eject photoelectrons from the metal, the source is given a veloity toward the metal.

a) Explain how this procedure can produce photoelectrons.

b) When the speed of the light source is equal to 0.280c, photoelectrons just begin to be ejected from the metal. What is the work function of the metal?

c) When the speed of the light source is increased to 0.900c, determine the maximum kinetic energy of the photoelectrons.

3 De-Broglie Wavelength

3.1 Wavelength of the Proton

Calculate the de Broglie wavelength for a proton moving with a speed of 1.00 x 10^6 m/s. Repeat the calculations for a proton with a speed of 1.00 x 10^8m/s.

3.2 Frequncy-Wavelength Relationship for a Relativistic Particle

Show that the frequency f and wavelength λ of a freely moving quantum particle with mass m are related by the expression:

$$(\frac{f}{c})^2 = \frac{1}{\lambda^2} + \frac{1}{\lambda_c^2}$$

where $\lambda_c = \frac{h}{mc}$.