King Fahd University of Petroleum and Minerals
Physics Department
Phys 212: Modern Physics
First Exam
March 20,2002

Name :
ID#

You will have two hours (3.30-5.30). Please solve all the problems.

1. (20 points)

Lightning simultaneously strikes two trees on a golf course which are 100 m apart, according to a greenskeeper standing near the trees. A terrified golfer wearing typically appalling golf clothes is driving a golf cart at (4/5)c on a direct line between the two trees

   a. Does the golfer agree that the lightning struck the trees simultaneously? How far apart are the trees according to the golfer ?
   b. Suppose instead that one lightning occurred 3 μs later than the other, according to a greenskeeper. Now how far apart the lightning strikes according to the driver of the golf cart?

2. (20 points)

A rocket with a proper length of 1000 m moves in the +x direction at a speed of 0.80 c relative to an observer on earth. An astronaut standing at the rear of the rocket fires an electron (rest energy = 0.51 MeV) toward the front of the rocket (through a vacuum pipe) at a speed of 0.90 c relative to the rocket.

a. How long a time does the electron take to reach the front of the rocket, as measured in the rest frame of the rocket?

b. How long a time does the electron take to reach the front of the rocket, as measured in the rest frame of the earth observer?

c. How long a time does the electron take to reach the front of the rocket, as measured in the rest frame of the electron?

d. What is the kinetic energy of the electron, as measured in the rest frame of the rocket?

e. What is the kinetic energy of the electron, as measured in the rest frame of the earth observer?

3. (20 points)

A.

1. If the photoelectric effect is observed for one metal, can you conclude that the effect will also be observed for another metal under the same conditions? Why?
2. Suppose the photoelectric effect occurs in a gaseous target rather than a solid. (The atoms in a gas are far separated and can be considered as independent). Will the photoelectrons be produced at all frequencies of the incident photon? Explain.

B.

When cesium metal is illuminated with light of wavelength 300 nm, the photoelectrons emitted have a maximum kinetic energy of 2.23 eV. Find

1. the work function of cesium,
2. the stopping potential if the incident light has a wavelength of 400 nm.

4. (20 points)

In a Compton scattering event, the scattered photon has an energy of 120 keV and the recoiling electron has a kinetic energy of 40 keV. Find

a. the wavelength of the incident photon,
b. the angle at which the photon is scattered
c. the recoil angle of the electron,
d. what does the Compton experiments tell us about photons?

5. (20 points)

A. The following scientists have made major contributions for the advancement of the quantum theory. Write briefly about their contributions:

1. Planck
2. Einstein
3. Millikan
4. Rutherford
5. Bohr

B. A hydrogen atom initially in its ground state (n=1) absorbs a photon and ends up in the state for which n = 3.

a. What is the energy of the absorbed photon?
b. If the atom returns to the ground state, what photon energies could the atom emit?

CONSTANTS

Speed of light = 3×10^{8} meters per second

Avogadro's Number NA = 6×10^{23} particles/mole
(Remember, a mole is the molecular weight in grams, not kilograms)

Boltzmann's constant = 1.4×10^{-23} Joules/K

Planck's constant h = 6.6×10^{-34} Joule-sec

Electron mass = 9×10^{-31} kilograms

Electron charge = 1.6×10^{-19} coulombs

Rydberg constant = 1.097×10^{7} /m