Physics 25
Midterm Exam: May 9, 2007

The exam will run for 50 minutes. The exam is open book, and you are also permitted the use of a calculator. The exam consists of **two** problems, and you should answer both of them to obtain full marks. Each problem counts for an equal number of points. To obtain full credit, remember to show your work and draw a box around your answer to each question.

The exam counts for 25% of the total marks in the course.

Some Possibly Useful Information

Speed of light $c = 3.00 \times 10^8$ ms^{-1}.

Magnitude of charge of electron $e = 1.60 \times 10^{-19}$ C.

Mass of proton $m_p = 1.67 \times 10^{-27}$ kg.

Mass of electron $m_e = 9.11 \times 10^{-31}$ kg.

Permittivity of free space $\epsilon_0 = 8.85 \times 10^{-12}$ C^2 N^{-1} m^{-2}.

$k = 1/(4\pi\epsilon_0) = 8.99 \times 10^9$ Nm^{2}C^{-2}.

Permeability of free space $\mu_0 = 4\pi \times 10^{-7}$Ns^{2}C^{-2}.

Gravitational constant $G = 6.67 \times 10^{-11}$ Nm^{2}kg^{-2}.

Acceleration due to gravity near the earth's surface $g = 9.81$ ms^{-2}.

Boltzmann constant $k = 1.38 \times 10^{-23}$ JK^{-1}.

Planck's constant $h = 6.63 \times 10^{-34}$ Js.

Stefan-Boltzmann constant $\sigma = 5.67 \times 10^{-8}$ Wm^{-2}K^{-4}.

1. The Υ particle has a rest mass of 9460 MeV/c^2. It is unstable, and one of the ways it decays is to produce two charged tau particles:

$$\Upsilon \rightarrow \tau^+ + \tau^-.$$

The tau particles each have rest mass 1784 MeV/c^2. They are also unstable, with a mean lifetime of 3.05×10^{-13} s in their own rest frame. Suppose the Υ is at rest in our frame and then decays according to the above reaction. How fast will each of the tau particles be moving in our frame? How far will they typically travel in our frame? (Reminder: 1 MeV= 10^6 eV. You may ignore the electrostatic attraction between the two tau particles, i.e. assume that they move at constant speed.)

2.(a) A spherical blackbody has radius 1.50 cm and a temperature of 2.00×10^4 K. What is the total power radiated by this blackbody? (You should find it to be very bright!!) At what wavelength does the spectrum peak? Assuming this is a typical wavelength of photons that are emitted by this blackbody, what is the typical energy of these photons?

(b) The blackbody of part (a) is used to illuminate a metal surface. Electrons are observed to be emitted by the surface, but if a stopping potential of 6.70 V is applied to the metal, then the number of electrons emitted is greatly reduced. Estimate the work function of the metal.

(c) What would the stopping potential have to be to ensure that absolutely no electrons are emitted from the metal surface? Why?