1. A person gets in a spaceship and makes a roundtrip journey to the star Sirius A, located 8.6 light years away. According to the person, the total time elapsed during the entire voyage is 4 years.

   (a) How fast was the spaceship traveling? Assume constant velocity for the entire journey. Hint: Analyze the problem using length contractions from the point of view of the spaceship. (13 points)

   (b) How much time has elapsed on earth during the time the spaceship was away? (10 points)

   (c) If the spaceship is 1000 m long in its rest frame, how long is the spaceship during the voyage as measured from earth? (10 points)
2. A neutral ‘K’ particle (rest mass $m_K$) at rest spontaneously decays into a ‘W’ particle (rest mass $m_W$) and a γ-ray photon (mass = 0) as shown in the figure. After the decay, the W particle and the travel in opposite directions.

Before: $m_K$

After: $m_W$, γ

(a) What are the total energy and momentum of the ‘K’ particle before it decays? (8 points)

(b) What is the total momentum of the W particle $m_K, m_W$ and $c$? (12 points)

(c) What is the total momentum of the γ-ray photon $m_K, m_W$ and $c$? (8 points)

(d) Which particle has the heavier rest mass, the K or the W particle? (5 points)

3. (a) The work function of silver (Ag) is 4.73 eV. Compute the threshold wavelength (in nm) for the photoelectric effect. If 5 W of light at that wavelength impinges on the surface of silver, how many electrons are emitted per second? (17 points)

(b) Assuming the earth is an ideal blackbody, compute the equilibrium surface temperature of the earth (in K) if the solar energy reaching the earth is $1.36 \times 10^3$ W/m². Does your answer make sense? (16 points)

4. Sulfur has an atomic number of $Z = 16$. It is possible to create $S^{15+}$, i.e., a sulfur ion that has one bound electron. Using the Bohr model, answer the following questions:

(a) Compute the ground state energy of $S^{15+}$. (12 points)

(b) Write down the angular momentum of the n=1,2,3 states of $S^{15+}$. (8 points)

(c) Compute the frequency of the orbit of the n=29 state. (13 points)