所別：太空科學研究所碩士班　　　　　科目：近代物理　共__1__頁 第__1__頁

1. Assume that Earth travels, relative to an inertial frame of reference attached the center of the sun, with the velocity $\vec{v}$.
   (a) Find the average speed of a light pulse $< v_{\parallel} >$, relative to Earth, traveling forth and back along a line parallel to $\vec{v}$, in the sense that the time required for a round trip between two points a distance d apart on Earth is $2d / < v_{\parallel} >$. (5%)
   (b) Find the average speed of a light pulse, relative to the Earth, traveling a round trip along a line perpendicular to $\vec{v}$. (5%)

2. (a) At what value of the speed does the total energy of a particle exceed its rest energy by 20%? (5%)
   (b) Find its momentum in terms of its rest energy. (5%)

3. (a) Compute the force exerted on the palm of your hand by the beam from a 1000W flashlight if the light reflects from your hand. (5%)
   (b) What would be the mass of a particle that exerts the same force if you hold it at Earth's surface? (5%)

4. (a) Why the Planck's law for the energy density distribution function $u(f)$ of the radiation in the cavity $u(f) = \dfrac{8\pi h f^3 / c^3}{e^{hf/kT} - 1}$ can be used for a blackbody? (5%)
   where f is the frequency of the radiation.
   (b) Find the temperature of a blackbody if its spectrum has its peak at wavelength $\lambda_m = 0.3cm$. (5%)
   [$h = 6.626 \times 10^{-34} J.s$, $k = 1.38 \times 10^{-23} J/K = 8.617 \times 10^{-5} eV/K$]

5. (a) What is the Compton effect? (5%)
   (b) What is the energy of a photon whose wavelength is equal to the Compton wavelength of the proton? (5%)

6. Find Planck's constant and the work function of the surface by using the following information. A metal surface illuminated by $5 \times 10^{14} Hz$ light emits electrons whose maximum kinetic energy is $0.5eV$. The same surface illuminated by $8.6 \times 10^{14} Hz$ light emits electrons whose maximum kinetic energy is $2eV$. (5%)

7. A free particle of mass m moves back and forth between rigid walls separated by a distance l.
   (a) Show that the allowed values of the de Broglie wavelength are given by $\lambda = 2l/n$ where n is a positive integer. (5%)
   (b) Derive a general expression for the allowed kinetic energy of the particle. (5%)
   (c) Find the uncertainty in momentum for the particle in the ground state and first excited state. (10%)

8. From the quantum theory of the hydrogen atom, what are the angles between its orbital angular momentum vector $\vec{L}$ and the z-axis for energy quantum number (a) $n = 2$. (5%) and (b) $n = 3$? (5%)

9. The total energy of the system $E = 11\varepsilon$ of a gas of 4 particles, each particle can occupy a state of energy $E_n = n\varepsilon$, where n is an integer $(1,2...)$.
   List all possible macrostates and determine the number of microstates associated with each macrostate, for
   (a) a gas of classical atoms. (5%)
   (b) a gas of bosons. (5%)
   (c) a gas of fermions. (5%)