(1) Make plot of relativistic kinetic energy versus speed of a particle. (10%)

(2) An electron of rest mass m_e has a kinetic energy $10m_ec^2$. What is the wavelength of this electron in units of nm ? (20%)
(Hints : $m_e = 0.511 MeV/c^2$, $hc = 1240 eV \cdot nm$)

(3) The radial wave function of a hydrogen atom is

$$R(r) = 2a_0^{-3/2} e^{-r/a_0}$$

where a_0= Bohr's radius. What is the probability of finding the electron between $r=0$ and $r=a_0$? (20%)

(4) Consider a particle in an infinite one-dimensional well with width l.
(a) Find the normalized wavefunctions of the ground state Ψ_1 and the first excited state Ψ_2. (10%)
(b) If the particle is in a state

$$\Psi = \frac{1}{2}\Psi_1 + \frac{\sqrt{3}}{2}\Psi_2 .$$

Find the mean value of the position, momentum, and energy of the particle. (15%)

(5) Consider a two-electrons of atom with quantum numbers

$$n_1 = 2, l_1 = 1, s_1 = 1/2$$
$$n_2 = 3, l_2 = 1, s_2 = 1/2,$$

where n_i, l_i, and s_i are the principal, orbital angular momentum, and spin quantum numbers of electrons, respectively.
(a) What are the good quantum numbers for j-j coupling ? (5%)
(b) What are the good quantum numbers for L-S coupling ? (5%)
(c) In a weak magnetic field, how many possible states are there ? (5%)

(6) Try to answer the following questions:
(a) Why does the electrical conductivity of a metal decrese as the temperature is increased ? (5%)
(b) How would you expect the conductivity of a semiconductor to change with temperature ? (5%)