1. A projectile of mass $m = 200g$ strikes a stationary block of mass $M = 1.3kg$ from below with speed $u = 30m/s$ (see Fig.1). The projectile embeds (埋入) in the block. (a) To what height does the block rise? (b) What is the loss in kinetic energy due to the collision? (15分)

2. A block of mass m is attached to a vertical spring via a string that hangs over a pulley $\left(I = \frac{1}{2}MR^2\right)$ of mass M and radius R, as shown in Fig.2. The string does not slip. Show that the angular frequency of oscillations is given by $\omega^2 = 2k/(M + 2m)$, where k is the spring constant. (20分)

3. Three moles of a monatomic ideal gas $(\gamma = 5/3)$ expand adiabatically from an initial pressure of 200 kPa $(1Pa = 1N/m^2)$ at a temperature of $10°C$ to a final pressure of 50 kPa. Find: (a) the initial and final volume; (b) the final temperature; (c) the work done by the gas. ($R = 8.314 J/K \cdot mol$) (20分)

4. Assume the proton is a uniformly charged sphere of radius 10^{-11} m. Find the potential at the following points: (a) its surface; (b) the position of the electron in a hydrogen atom; that is, 5.3×10^{-11} m. (c) How would these results change if the proton were a spherical shell instead. ($\varepsilon_0 = 8.854 \times 10^{-12} C^2/N \cdot m^2$, $e = 1.602 \times 10^{-19}C$) (15分)

5. A straight wire lies along a body diagonal of an imaginary cube of side $a = 20cm$, and carries a current of 5A (see Fig.5). Find the force on it due to a uniform field $\vec{B} = 0.6\hat{j}$ T. (15分)

6. Calculate the de Broglie wavelengths of a proton moving at (a)$10^3 \, m/s$, and (b)$10^6 \, m/s$. ($m_p = 1.672 \times 10^{-27} kg$, $h = 6.626 \times 10^{-34} J \cdot s$) (15分)
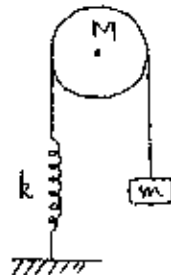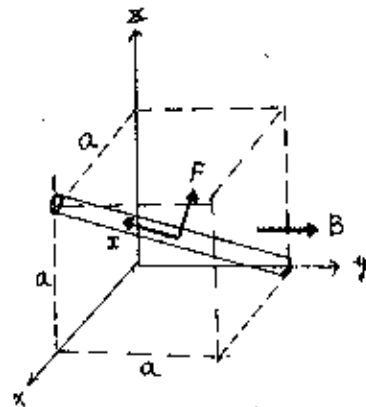

Fig.1

Fig.2

Fig.5