1. (20 分) Draw the schematic diagrams of (a) a simple steam power cycle and (b) a simple refrigeration cycle. Then express the conditions of the working fluid at each stage of each cycle, respectively.

2. (15 分) A 5-kg piston in a cylinder with diameter of 100 mm is loaded with a linear spring and the outside atmospheric pressure of 100 kPa as shown in Fig. P2. The spring exerts no force on the piston when it is at the bottom of the cylinder, and for the state shown, the pressure is 400 kPa with volume 0.4 L. The valve is opened to let some air in, causing the piston to rise 2 cm. Find the new pressure.

3. (25 分) An air pistol contains compressed air in a small cylinder, as shown in Fig. P3. Assume that the volume is 1 cm³, the pressure is 1 MPa, and the temperature is 27°C when armed. A bullet, with m=15g, acts as a piston initially held by a pin (trigger); when released, the air expands in an isothermal process (T=constant). If the air pressure is 0.1 MPa in the cylinder as the bullet leaves the gun, find
   a. the final volume and the mass of air,
   b. the work done by the air and work done on the atmosphere, and
   c. the work done to the bullet and the bullet exit velocity.
   (Hint: For air \( R = 0.287 \text{kJ/kg·K} \), \( C_v = 0.717 \text{kJ/kg·K} \), and \( C_p = 1.004 \text{kJ/kg·K} \))

4. (25 分) A cylinder/piston setup contains air at ambient conditions, 100 kPa and 20°C, with a volume of 0.3 m³. The air is compressed to 800 kPa in a reversible polytropic process with exponent \( n = 1.2 \), after which it is expanded back to 100 kPa in a reversible adiabatic process.
   a. Show the two processes in \( P-v \) and \( T-s \) diagrams.
   b. Determine the final temperature and the net work.

5. (15 分) A heat exchanger increases the availability of 3 kg/s water by 1650 kJ/kg using 10 kg/s air coming in at 1400 K and leaving with 600 kJ/kg less availability. What are the irreversibility and the second-law efficiency?