1. (10 points) A steam turbine is designed to have a power output of 9 MW for a mass flow rate of 17 kg/s. The inlet state is 3 MPa, 450°C, and 200 m/s, and the outlet state is 0.5 MPa, saturated vapor, and 80 m/s. Calculate the heat transfer to the surroundings for this turbine and show the process on a p-v diagram.

2. (30 points) An insulated 10-ft³ cylinder is used to displace a load through the motion of a piston, as shown in the diagram. The piston has negligible volume and is initially at the bottom of the cylinder. The valve to a steam line (200 psia and 700°F) is opened to raise the load, and it is closed when the piston reaches the top of the cylinder. The total work done is 50 Btu. What is the final pressure in the cylinder if the final mass is 0.5 lbm?

3. (30 points) Two components of a steam engine are shown below. The turbine is adiabatic. Determine the heat transferred in the boiler (kJ/kg) and the power output of the turbine (kW).
4. (30 points) Determine the exit temperature $T_3$ of the vortex-tube refrigeration device shown. The device is insulated, and the medium is air.