NAME:

AME 20231, Thermodynamics
Examination 1
Profs. T. Luo and J. M. Powers
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"The advantageous use of Steam-power is, unquestionably, a modern discovery.
And yet, as much as two thousand years ago the power of steam was not only observed,
but an ingenius toy was actually made and put in motion by it, at Alexandria in Egypt."

Abraham Lincoln, 6 April 1858
Bloomington, Illinois

Happy 204th Birthday!

1. (10) Ideal gases have compressibility of a) Zero, b) One, c) Some positive real number.
2. (10) Oxygen is an ideal gas. a) True, b) False, c) Maybe.
3. (10) Water at $T = 95°C$, $v = 0.01\ m^3/kg$ is a) Liquid, b) Vapor, c) Two-phase mixture.
4. (10) Water exists at $P = 1250\ kPa$, $T = 600°C$. Find v. Sketch the state in the $T - v$, $P - v$, and $P - T$ planes, taking care to orient the point relative to the vapor dome.
5. (25) An ideal gas of mass m and gas constant R at pressure P_1 and temperature T_1 is compressed in a polytropic process to pressure $P_2 = 2P_1$. The polytropic exponent is $n = 1/2$. The gas is isothermally expanded back to $P_3 = P_1$. The gas then undergoes an isobaric process to return to P_1 and T_1.
   (a) Find T_2 in terms of P_1, T_1, m, and R.
   (b) Find the work of each process in the cycle, ${}_1W_2$, ${}_2W_3$, and ${}_3W_1$ and W_{cycle} in terms of P_1, T_1, m, and R.
   (c) Sketch the cycle in the $P - v$ plane.
6. (35) 93.42929 kg of water is enclosed in a cylinder-piston arrangement (see figure). The initial volume is 1 m^3, and the cross-sectional area of the cylinder is 1 m^2. A linear spring is attached to the piston. The force from the spring is given as $F = k(y - y_1)$, with $k = 150\ kN/m$. The spring is initially relaxed, meaning it is neither stretched nor compressed. The water is then heated to expand to a final volume of 1.5 m^3.
   (a) What is the atmosphere pressure?
   (b) What is the initial phase and temperature of the water? If it is a two-phase mixture, what is the quality x_1?
   (c) What is the final pressure and temperature of the water?
   (d) How much work is done on the piston by the water during this expansion process?
   (e) Accurately sketch the process in the $P - v$ plane with respect to saturation curve.