AS1300: Thermodynamics for Aerospace Engineers

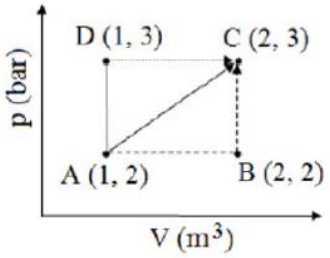
Tutorial 1 (22/01/2020)

1. Classify the following entities as system, control volume or neither:
a) Contents of a closed flask, b) air inside a tyre being inflated, c) sand in a sand clock, d) Air conditioner, e) A spring in a machine, f) filling of a gas cylinder, g) water flowing through a shower head, h) lungs of a living human, i) combustion inside a closed vessel

2. Classify the following quantities as extensive or intensive:
a) P, b) T, c) V, d) E + PV, e) PT / V, f) P / T, g) PV/T^2

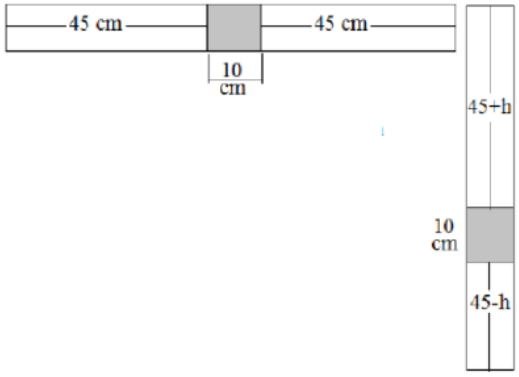
3. Discuss the path independence of the following quantities, for the paths A-B-C, A-D-C and A-C.

i) $\int_1^3 \boldsymbol{pdV}$,
ii) $\int_1^3 \boldsymbol{Vdp}$,
iii) $\int_1^3 \boldsymbol{pdV + Vdp}$,
iv) $\int_1^3 \boldsymbol{pdV - Vdp}$



4. If $\delta\Phi = f(T)dT + \frac{RT}{V}dV$, is Φ a property?

5. Consider a thin horizontal tube 1 m long sealed at both ends. The middle 10 cm of the tube contains mercury and the rest of the tube contains air at atmospheric pressure (= 76 cm of mercury). The tube is now brought to a vertical position. How far will the mercury fall? Assume the changes in the pressure and velocity of the air are related by pV = constant.



TEMPERATURE

6. The relation between the resistance R and the temperature T of a resistance thermometer is given as $R = R_0[1 + \boldsymbol{\alpha}(T - T_0)]$ where R_0 is the resistance measured in ohms at temperature T_0 (in $^\circ C$) and α is a material constant. The thermometer reads temperatures of $0^\circ C$ and $91^\circ C$ corresponding to resistance values of 51.39 and 51.72 ohms respectively. What would be the resistance corresponding to the temperature of $50\ ^\circ C$ in this thermometer?

7. The readings T_A and T_B are in$^\circ C$, of 2 thermometers A and B agree well at ice and steam points. At other points, their temperatures are related as $T_A = p + qT_B + r(T_B)^2$, where p, q,and r are constants. When A reads $51\ ^\circ C$, B reads $50\ ^\circ C$. Determine what A reads when B reads $30\ ^\circ C$?

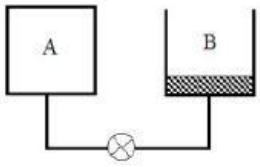
8. A thermometer is constructed by arranging an aluminum rod so that its length can be measured by using a scale made of a different material. The thermometer is calibrated at $0\ ^\circ C$ and $100\ ^\circ C$ and the distance between these points is divided uniformly into 100 degrees of equal length on the scale. What is the true

temperature when this thermometer reads 40 ° C ? The coefficient of linear expansion of aluminum in this temperature range is $0.2221 \times 10^{-4} \frac{cm}{cm.K}$ while that of the material of the scale is $10^{-5} \frac{cm}{cm.K}$.

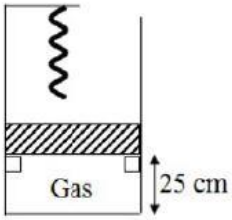
WORK

9. Tank A shown in the figure has a volume of 0.4 m^3 and contains argon gas at 250 Pa. Cylinder B contains a frictionless piston of mass such that a pressure of 150 kPa is required to lift it. The connecting tube is opened allowing the argon gas to flow into the cylinder. Eventually the argon gas reaches a uniform state. Determine:

(a) The final pressure
(b) The work interaction for the argon gas, piston and the atmosphere.
Take the atmospheric pressure to be 100 kPa. Any change in the state of the argon gas is related through PV = constant.



10. A gas is contained in a piston cylinder mechanism at an initial pressure of 1 bar. The piston diameter is 15 cm and it rests on stops initially as shown in the figure below. The piston weight is such that it requires a pressure of 1.2 bar to be lifted from the stops. The gas is now heated which causes the piston to rise slowly. After a rise of 10 cm, the piston touches a linear spring with a stiffness value of 10 N/mm. The heating of the gas is finally stopped when the spring is compressed by 1 cm. Determine the work interaction for the gas, piston, spring and the atmosphere. Also sketch the process undergone by the gas on a PV diagram and show the four work interactions mentioned above by hatching the appropriate areas.



11. A DC electrical motor is used to operate the hoist mechanism in a crane. The motor is supplied with 150 V and 10 A from a DC source for a period of 2 minutes. The torque provided by the motor to the hoist shaft is 230 Nm at 60 rpm. The hoist mechanism lifts a mass of 3000 kg through a height of 5 m. Calculate the work interaction for the DC source, motor, hoist and the mass.