

# ME 201

## Thermodynamics

### Homework #3, Solutions

1. Convert the following temperatures to °F, °C, K, R (each temperature ¼ pt)

a. 98.6 °F

$$T(^{\circ}\text{F})=98.6\text{ }^{\circ}\text{F}, T(^{\circ}\text{C})=(98.6-32)/1.8=37^{\circ}\text{C}, T(\text{K})=(98.6+460)/1.8=310.3\text{ K},$$

$$T(\text{R})=98.6+460=558.6\text{ R}$$

b. 298 K

$$T(^{\circ}\text{F})=(298)1.8-460=76.4^{\circ}\text{F}, T(^{\circ}\text{C})=298-273=25^{\circ}\text{C}, T(\text{K})=298\text{ K},$$

$$T(\text{R})=(298)1.8=536.4\text{ R}$$

c. 5715 °F

$$T(^{\circ}\text{F})=5715^{\circ}\text{F}, T(^{\circ}\text{C})=(5715-32)/1.8=3157.6^{\circ}\text{C}, T(\text{K})=(5715+460)/1.8=3430.6\text{ K},$$

$$T(\text{R})=5715+460=6175\text{ R}$$

d. 460 R

$$T(^{\circ}\text{F})=460-460=0^{\circ}\text{F}, T(^{\circ}\text{C})=(460)/1.8-273= -17.4^{\circ}\text{C}, T(\text{K})=460/1.8=255.6\text{ K},$$

$$T(\text{R})=460\text{R}$$

e. 100 °C

$$T(^{\circ}\text{F})=(100)1.8+32=212^{\circ}\text{F}, T(^{\circ}\text{C})=100^{\circ}\text{C}, T(\text{K})=100+273=373\text{ K},$$

$$T(\text{R})=(100+273)1.8=671.4\text{ R}$$

2. Convert the following pressures to psia and kPa. (each pressure ½ pt)

a. 760 mm of Hg

$$P(\text{psia}) = 760\text{ (mm of Hg)} \times 0.019\text{ (psia/mm of Hg)} = 14.4\text{ psia}$$

$$P(\text{kPa}) = 760\text{ (mm of Hg)} \times 0.133\text{ (kPa/mm of Hg)} = 101.1\text{ kPa}$$

b. 101 bar

$$P(\text{psia}) = 101\text{ (bar)} \times 14.50\text{ (psia/bar)} = 1464.5\text{ psia}$$

$$P(\text{kPa}) = 101\text{ (bar)} \times 100\text{ (kPa/bar)} = 10,100\text{ kPa}$$

c.  $15.3 \times 10^6 \text{ N/m}^2$

$$P(\text{psia}) = 15.3 \times 10^6\text{ (N/m}^2) \times 1.45 \times 10^{-4}\text{ (psia/N/m}^2) = 2218.5\text{ psia}$$

$$P(\text{kPa}) = 15.3 \times 10^6\text{ (N/m}^2) \times 10^{-3}\text{ (kPa/N/m}^2) = 15,300\text{ kPa}$$

3. What is the potential energy (in kJ) of an egg of 0.003 slugs at 50 inches above sea level?(3 pts)

$$\text{PE} = \text{Mass} \times \text{Acceleration Due to Gravity} \times \text{Elevation}$$

Convert to SI

$$\text{Mass} = 0.003\text{ (slugs)} \times 14.59\text{ (kg/slug)} = 0.044\text{ kg}$$

$$\text{Elevation} = 50 \text{ (inches)} \times 0.0254 \text{ (m/inch)} = 1.27 \text{ m}$$

$$\text{PE} = (0.044)(9.8)(1.27) = 0.548 \text{ (J)} / 1000 \text{ (J/kJ)} = 5.48 \times 10^{-4} \text{ kJ}$$

4. What is the kinetic energy (in Btu) associated with a 300 gm hockey puck flying at 120 mph?(3 pts)

$$\text{KE} = 0.5 \times \text{Mass} \times \text{Velocity Squared}$$

Convert to SI

$$\text{Mass} = 300 \text{ (gm)} \times 0.001 \text{ (kg/gm)} = 0.3 \text{ kg}$$

$$\text{Velocity} = 120 \text{ (mph)} \times 0.447 \text{ (m/s/mph)} = 53.6 \text{ m/s}$$

$$\text{KE} = (0.5)(0.3)(53.6)^2 = 430.9 \text{ (J)} / 1055 \text{ (J/Btu)} = 0.41 \text{ Btu}$$

5. What is the density ( $\text{kg/m}^3$ ) of a material of mass 2  $\text{lb}_m$  occupying a volume of dimensions 20 cm by 45 in by 2 feet?(3 pts)

$$\text{Density} = \text{Mass} / \text{Volume}$$

$$\text{Volume} = \text{Height} \times \text{Width} \times \text{Length}$$

Convert to SI

$$\text{Mass} = 2 \text{ (lb}_m\text{)} \times 0.45 \text{ (kg/lb}_m\text{)} = 0.9 \text{ kg}$$

$$\text{Height} = 20 \text{ (cm)} \times 0.01 \text{ (m/cm)} = 0.200 \text{ m}$$

$$\text{Width} = 45 \text{ (in)} \times 0.0254 \text{ (m/in)} = 1.143 \text{ m}$$

$$\text{Length} = 2 \text{ (ft)} \times 0.305 \text{ (m/ft)} = 0.610 \text{ m}$$

$$\text{Volume} = 0.200 \times 1.143 \times 0.610 = 0.139 \text{ m}^3$$

$$\text{Density} = 0.9/0.139 = 6.475 \text{ kg/m}^3$$

6. Determine the pressure (in psia) when a 100 N force is exerted over 5  $\text{in}^2$ .(3 pts)

$$\text{Pressure} = \text{Force} / \text{Area}$$

Convert to SI Units

$$\text{Force} = 100 \text{ N}$$

$$\text{Area} = 5 \text{ in}^2 \times (0.0254)^2 \text{ (m/in)}^2 = 3.226 \times 10^{-3} \text{ m}^2$$

$$\text{Pressure} = 100/(3.226 \times 10^{-3}) = 31,000 \text{ Pa} = 31 \text{ kPa}$$

Covert to psia

$$\text{Pressure} = 31 \text{ (kPa)} / 6.895 \text{ (kPa/psia)} = 4.496 \text{ psia}$$