Homework 1

Sunday, January 31, 2021 7:43 PM

"I pledge my honor I have abided by the Stevens Honor system."

\- Alex Dadskins

1. In the US, several different systems of units and dimensions are commonly used. Convert the following quantities to SI units (*hint: check the conversion tables at the start of the textbook, some units are given to help guide you*): [18]

QUANTITY	SYMBOL	GIVEN VALUE	SI VALUE	SI UNITS
Density	ρ	120 lb_m/ft^3	1922.2	kg/m^3
Thermal Conductivity	k	170 Btu/(hr.ft.F)	294.03	W/mK
Convective heat transfer coefficient	h_{conv}	211 Btu/(hr.ft^2.F)	1198.11	W/m^2K
Specific heat	c_p	175 Btu/(lb_m.F)	732690	$J/kg\cdot{}^\circ K$
Viscosity	μ	20 centipoise	.02	Pa·s
Viscosity	μ	77 $lb_f.s/ft^2$	3686.78	Pa·s
Kinematic Viscosity	v	3 ft^2/s	.28	m^2/s
Stefan-Boltzmann Constant	σ	0.1713 x 10-8 Btu/(ft^2.hr.R^4)	5.67×10^{-8}	W/m^2K^4
Acceleration	a	12 ft/s^2	3.66	m/s^2

$$\rho = 120\ lb/ft^3 \left(\frac{16.0185\ kg/m^3}{1\ lb/ft^3}\right) = 1922.2\ kg/m^3$$

$$k = 170\ Btu/(hr.ft.{}^\circ F)\left(\frac{1.73\ W/mK}{1\ Btu/(hr.ft.{}^\circ F)}\right) = 294.03\ W/mK$$

$$h_{conv} = 211\ Btu/(hr.ft^2\ {}^\circ F)\left(\frac{5.68\ W/m^2K}{1\ Btu/(hr.ft^2\ {}^\circ F)}\right) = 1198.11\ W/m^2K$$

$$c_p = 175\ Btu/(lb.{}^\circ F)\left(\frac{4186.8\ J/kg.{}^\circ K}{1\ Btu/(lb.{}^\circ F)}\right) = 732690\ J/kg.{}^\circ K$$

$$\mu = 20\ centipoise\left(\frac{.001\ Pa\cdot s}{1\ centipoise}\right) = .02\ Pa\cdot s$$

$$\mu = 77\ lbf.s/ft^2\left(\frac{47.88\ Pa\cdot s}{1\ lbf.s/ft^2}\right) = 3686.78\ Pa\cdot s$$

$$v = 3\ ft^2/s\left(\frac{.093\ m^2/s}{1\ ft^2/s}\right) = .28\ m^2/s$$

$$\sigma = .1713\times10^{-8}\ Btu/(ft^2.hr.R^4)\left(\frac{33.08\ W/m^2K^4}{1\ Btu/(ft^2.hr.R^4)}\right) = 5.67\times10^{-8}\ W/m^2K^4$$

$$a = 12\ ft/s^2\left(\frac{.3048\ m/s^2}{1\ ft/s^2}\right) = 3.66\ m/s^2$$

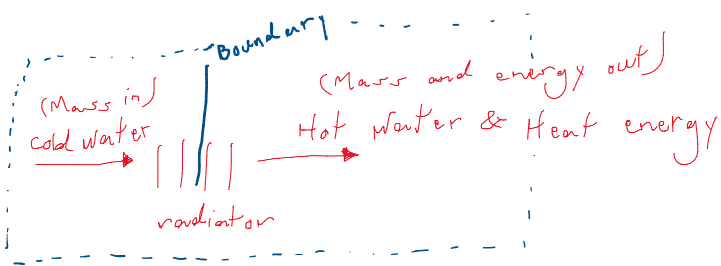
2. If a man weighs 210 lb_f on the Earth ($g = 32.10\ ft/s^2$), what is his mass? What would his weight be on the moon ($g = 5.47\ ft/s^2$). Answer in both English and SI units. [10]

$$210\ (5.47) = 1148.7\ lb\ ft/s^2$$

$$\frac{1148.7}{32.1\ ft/s^2} = \boxed{35.8\ lbf}$$

3. Consider a hot water radiator like some of those that we have on campus. Would you consider this radiator to be an open or closed system? Why is this? Draw a system boundary around a diagram of a radiator and show what crosses this boundary. [10]

It is an open system, as it involves mass (cold water) going into the radiator and leaving as hot water steam and heat energy.



4. What is the state postulate? Why is it important? [4]

Any two known properties are enough to solve for other unknowns. (Except P and T)

This is important when it comes to solving for important unknown values when little data is given.

5. Complete the table by indicating whether these variables are intensive or extensive properties: [20]

VARIABLE	INTENSIVE	EXTENSIVE
Pressure	✓	
Dynamic Viscosity	✓	
Mass		✓
Length		✓
Volume		✓
Specific Volume		✓
Temperature	✓	
Bulk Modulus		✓
Melting Point	✓	
Momentum		✓

6. Convert the following temperatures to Kelvin: [5]

Given Temperature	Temperature (Kelvin)
27°C	300.15
0 °F	255.372
488 R	271.11
-12 °F	248.706
-273.15 °C	0

7. What is a temperature **change** of 10°F when expressed in Celsius, Kelvin and Rankine[1]? [3]

Celsius:

$32°F = 0°C$
$22°F = -5.56°C$

Kelvin:

Kelvin = Celsius + 273.15

$\Delta T = 5.56$ (°C and K)

Rankine:

$32°F = 491.67°R$
$22°F = 481.67°R$

$\Delta T = 10°R$

8. A diver is 57.5 ft under the surface of a lake (ρ_{H2O}=1000 kg/m³). What are the absolute and gage pressures at that depth? Answer in both English and SI units. [15]

57.5 ft. = 17.526 m.

Absolute Pressure:

$P_{atm} = 101\,325$ Pa

Gage Pressure:

$P_G = \rho g h$
$P_G = (1000)(9.8)(17.526)$

$P_A = P_G + P_{atm}$

$P_A = 171754.8 + 101325$

$\boxed{P_A = 273079.8 \text{ Pa} \quad \text{or} \quad 39.61 \text{ psi}}$

$\boxed{P_G = 171754.8 \text{ Pa} \quad \text{or} \quad 24.91 \text{ psi}}$

9. The water level in a sealed tank above ground is 26m above the ground level. There is an air space at the top of the tank in which the air pressure is 0.25 MPa gage. The average density of the water is 1000 kg/m³. What is the absolute pressure in the water at the ground level? [15]

$P = 250000 + (1000)(9.8)(26)$

$\boxed{P = 504800 \text{ Pa}}$