ENSC 388 Week #2, Tutorial #1– Dimensions and Units

Problem 1: Water flows through a pipe with diameter =2 *in*. If the average velocity of water is *1 m/s*, find mass flow rate of water in (*lbm/s*) and (*kg/s*). Consider density of water 62.1 *lbm/ft*^{3} and use $\dot{m} = \rho\pi \frac{d^2}{4}\bar{V}$.

Solution

Step 1: Write out what you are required to solve for (this is so you don't forget to answer everything the question is asking for)

Find:

$\dot{m}$ – Mass flow rate of water in (*lbm/s*) and (*kg/s*)

Step 2: Prepare a data table

Data	Value	Unit
d	2	$[in]$
ρ	62.1	$\left[\frac{lbm}{ft^3}\right]$
$\bar{V}$	1	$\left[\frac{m}{s}\right]$

Step 3: Calculations

Part a) English Unit

$$\dot{m} = \frac{\pi}{4}(62.1)\left[\frac{lbm}{ft^3}\right]\times(2)^2[in]^2\times\left[\frac{1\,ft}{12\,in}\right]^2\times(1)\left[\frac{m}{s}\right]\times\left[\frac{1\,ft}{0.3048\,m}\right] = 4.44\left[\frac{lbm}{s}\right] \quad \text{(Eq1)}$$

Part b) SI Unit

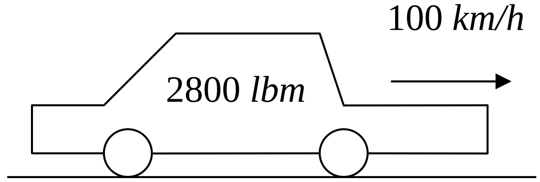
Using conversion factors the mass flow rate can be written in SI units.

$$\dot{m} = 4.44\left[\frac{lbm}{s}\right]\times\left[\frac{0.4536\,kg}{lbm}\right] = 2.0140\left[\frac{kg}{s}\right] \qquad \text{(Eq2)}$$

Step 4: Concluding Statement

The mass flow rate was found to be $4.44\left[\frac{lbm}{s}\right]$ or $2.0140\left[\frac{kg}{s}\right]$.

Problem 2: A car goes with average velocity of 100 *km/h*. Find kinetic energy of the car in [*Btu*] and [*J*].



<u>Solution</u>

Step 1: Write out what you are required to solve for (this is so you don't forget to answer everything the question is asking for)

Find:

KE: kinetic energy of the car in [*Btu*] and [*J*]

Step 2: Prepare a data table

Data	Value	Unit
m	2800	$[lbm]$
$\bar{V}$	100	$\left[\frac{km}{h}\right]$

Step 3: Calculations

$$KE = \frac{1}{2} m \bar{V}^2 \qquad \text{(Eq1)}$$

Part a) English Unit

$$KE = \frac{1}{2}(2800)[lbm] \times (100)^2 \left[\frac{km}{h}\right]^2 \times \left[\frac{1000\,m}{1km}\right]^2 \times \left[\frac{1\,ft}{0.3048\;m}\right]^2 \times \qquad \text{(Eq2)}$$

$$\left[\frac{1h}{3600\,s}\right]^2 \times \left[\frac{1\,slug}{32.174\,lbm}\right] = 361400\;\left[\frac{slug.\,ft^2}{s^2}\right] = 361400\;\left[lbf\,.\,ft\right]$$

Note: $1[lbf\,] = 1[slug\,] \times 1\left[\frac{ft}{s^2}\right]$

$$KE = 361400\,[lbf\,.\,ft] \times \left[\frac{1\,Btu}{778\;lbf\,.\,ft}\right] = 465\,[Btu] \qquad \text{(Eq3)}$$

Part b) SI Unit

Using conversion factors the kinetic energy can be written in SI units.

$$KE = 465[Btu] \times \left[\frac{1054\,J}{1Btu}\right] = 490 \times 10^3\;[J] \qquad \text{(Eq4)}$$

Step 4: Concluding Statement

The kinetic energy was found to be $465\,[Btu]$ or $490 \times 10^3\;[J]$.

Problem 3: Calculate power required to lift a 1*ton* mass to 30 yards above the ground in 10 minutes. Express your result in [*hp*] and [*kW*].

<u>Solution</u>

Step 1: Write out what you are required to solve for (this is so you don't forget to answer everything the question is asking for)

Find:

$\dot{W}$: power required to lift a 1 *ton* mass to 30 yards elevation in [*hp*] and [*kW*]

Step 2: Prepare a data table

Data	Value	Unit
m	1	$[ton]$
Δz	30	$[yards]$
t	10	$[\min]$

Step 3: Calculations

$$\dot{W} = \frac{mg\Delta z}{t} \qquad \text{(Eq1)}$$

Part a) English Unit

$$\dot{W} = 1[ton] \times (9.8)^2 \left[\frac{m}{s^2}\right] \times 30[yards] \times \frac{1}{10[\min]} \times \left[\frac{2000\, lbm}{1 ton}\right] \times \left[\frac{1\, slug}{32.174\, lbm}\right] \times \left[\frac{1\, ft}{0.3048\, m}\right] \times \left[\frac{3\, ft}{1\, yard}\right] = 17988 \left[\frac{lbf\,.\,ft}{\min}\right] \qquad \text{(Eq2)}$$

$$\dot{W} = 17988 \left[\frac{lbf\,.\,ft}{\min}\right] \times \left[\frac{1 hp}{550\ \ lbf\,.\,ft/s}\right] \times \left[\frac{1 \min}{60\, s}\right] = 0.545\,[hp] \qquad \text{(Eq3)}$$

Part b) SI Unit

Using conversion factors the power can be written in SI units.

$$\dot{W} = 0.545[hp] \times \left[\frac{0.746\, kW}{1 hp}\right] = 0.407\,[kW] \qquad \text{(Eq4)}$$

Step 4: Concluding Statement

The power was found to be $0.545\,[hp]$ or $0.407\,[kW]$.