CBE20255
HW1

Problem 1

1 L = 0.264 gal
1 km = 0.621 mile

1. Total cost = Vehicle cost + fuel cost

Fuel cost = Distance driven/fuel economy (mpg) × fuel unit price

or Distance driven × fuel economy (L/km) × fuel unit price

If total cost for domestic and import vehicles are the same, we have equation:

$$\$28500 + y/(28\,mile/gal) \cdot x = \$35700 + y \cdot 5.3\,L/100km \cdot \frac{0.264\,gal}{L} \cdot \frac{km}{0.621\,mile} \cdot x$$

$$\rightarrow y = \frac{5.5 \times 10^5}{x}\ \$ \cdot mile/gal$$

2.

x ($/gal)	y (mile)
2	2.7×10^5
3	1.8×10^5
4	1.4×10^5
5	1.1×10^5

3. Mass balance for fuel burning:

$$C_{10}H_{17} + 14.25\ O_2 \longrightarrow 10\ CO_2 + 8.5\ H_2O$$

Molar mass: $C_{10}H_{17}$: 137 g/mol $\downarrow$ 137 g/mol; $10\ CO_2$: 48 g/mol $\downarrow$ 480 g/mol

Mass per gallon of fuel: 6 lbm/gal; CO_2: X

$$\frac{137\ g/mol}{480\ g/mol} = \frac{6\ lbm/gal}{X} \longrightarrow X = 21\ lbm/gal$$

Mass of CO_2 produced per gallon of fuel = 21 lbm/gal

Total mass of CO_2 produced = Mass of CO_2 per gallon of fuel · Fuel consumption

Domestic vehicle:

$$\text{Mass of } CO_2 \text{ produced} = 100\ km \cdot \frac{0.621\ mile}{km} \Big/ (28\ mile/gal) \cdot 21\ lbm/gal \cdot \frac{0.456\ kg}{lbm}$$

$$= \boxed{20\ kg}$$

Import vehicle:

$$\text{Mass of } CO_2 \text{ produced} = 100\ km \cdot 5.3\ L/100\ km \cdot \frac{0.264\ gal}{L} \cdot 21\ lbm/gal \cdot \frac{0.456\ kg}{lbm}$$

$$= \boxed{10\ kg}$$

Import vehicle produces around half amount of CO_2.

Problem 2

1. $1 \text{ poundal} = \dfrac{1 lb \cdot ft}{s^2}$

$$\left.\begin{array}{l} 1 \text{ slug} = \dfrac{1 lbF \cdot s^2}{ft} \\ 1 lbF = 1 lbm \times g_{earth} \end{array}\right\} \quad 1 \text{ slug} = \frac{1 lbm \cdot g_{earth} \cdot s^2}{ft}$$

(i) On earth,

$g_{earth} = 9.807 m/s^2$

$$\text{Weight of professor} = 170 lbF = 170 lbm \cdot g_{earth}$$
$$= 170 lbm \cdot 9.807 m/s^2 \cdot \frac{3.28 ft}{m}$$
$$= 5470 \frac{lbm \cdot ft}{s^2} = \boxed{5500 \text{ poundal}}$$

2 sig. fig.

$$\text{Mass of the professor} = \frac{\text{Weight}}{g_{earth}} = \frac{170 lbF}{g_{earth}}$$
$$= \frac{170 lbm \cdot g_{earth}}{g_{earth}} = 170 lbm$$

$$\text{Number of slug} = \frac{170 lbm \cdot ft}{lbm \cdot g_{earth} \cdot s^2}$$
$$= \frac{170 ft}{9.807 m/s^2 \cdot s^2} = \frac{170 ft}{9.807 m} \cdot \frac{m}{3.28 ft}$$
$$= 5.3$$
$$\longrightarrow \boxed{5.3 \text{ slug}} \quad \text{2 sig. fig.}$$

(ii) On moon,

$g_{moon} = 1.622 m/s^2$

$$\text{Mass of professor} = \frac{\text{Weight}}{g_{earth}} = \frac{170\,lbF}{g_{earth}} = \frac{170\,lbm \cdot g_{earth}}{g_{earth}}$$

$$= 170\,lbm$$

$$= \boxed{5.3\ slug} \quad 2 \text{ sig. fig.}$$

Mass does not change due to gravity and slug is always referenced to gravity on earth

$$\text{Weight of professor} = \text{Mass} \cdot g_{moon}$$

$$= 170\,lbm \cdot 1.622\,m/s^2 \cdot \frac{3.28\,ft}{m}$$

$$= \boxed{9.0 \times 10^2\ \text{poundal}} \quad 2 \text{ sig. fig.}$$

2. $F = ma = 170\,lbm \cdot 2\,m \cdot s^{-2} = 340\,lbm\,ms^{-2}$

$$= 340\,lbm \cdot \frac{0.454\,kg}{lbm}\,ms^{-2}$$

$$= 154\,kg\,ms^{-2} = \boxed{200\,N} \quad 1 \text{ sig. fig}$$

$$\frac{340\,lbm \cdot ms^{-2}}{1\,lb_F} = \frac{340\,lbm \cdot ms^{-2}}{lbm \cdot 9.807\,ms^{-2}} = 30 \rightarrow \boxed{30\,lbF} \quad 1 \text{ sig. fig}$$

$$\frac{340\,lbm \cdot ms^{-2}}{1\ \text{poundal}} = \frac{340\,lbm \cdot ms^{-2}}{lbm\,ft \cdot s^{-2}} = \frac{340\,lbm \cdot m^{-2}\ \frac{3.28\,ft}{m}}{lbm\,ft\,s^{-2}}$$

$$= 1000$$

$$\rightarrow \boxed{1000\ \text{poundal}} \quad 1 \text{ sig. fig.}$$

Problem 3

$$C_w = 1/(a+bt)$$

$$\rightarrow \frac{1}{C_w} = a + bt$$

So $\frac{1}{C_w}$ should be linear with respect to t

Question 1.