

1-1. Represent each of the following quantities with combinations of units in the correct SI form, using an appropriate prefix: (a) $\text{GN} \cdot \text{mm}$, (b) kg / mm , (c) N / ks^2 , (d) kN / ms .

SOLUTION

a) $\text{GN} \cdot \text{mm} = (10^9)\text{N}(10^{-6})\text{m} = 10^3 \text{N} \cdot \text{m} = \text{kN} \cdot \text{m}$

Ans.

b) $\text{kg} / \text{mm} = (10^3)\text{g} / (10^{-6})\text{m} = 10^9 \text{g} / \text{m} = \text{Gg} / \text{m}$

Ans.

c) $\text{N} / \text{ks}^2 = \text{N} / (10^3 \text{s})^2 = 10^{-6} \text{N} / \text{s}^2 = \text{mN} / \text{s}^2$

Ans.

d) $\text{kN} / \text{ms} = (10^3)\text{N} / (10^{-6})\text{s} = 10^9 \text{N} / \text{s} = \text{GN} / \text{s}$

Ans.

Ans:

a) $\text{kN} \cdot \text{m}$

b) Gg / m

c) pN / s^2

d) GN / s

Solution Manual for Fluid Mechanics 1st Edition by Russell C. Hibbeler

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1–2. Evaluate each of the following to three significant figures, and express each answer in SI units using an appropriate prefix: (a) $(425 \text{ mN})^2$, (b) $(67\,300 \text{ ms})^2$, (c) $[723(10^6)]^{1/2} \text{ mm}$.

SOLUTION

a) $(425 \text{ mN})^2 = [425(10^{-3}) \text{ N}]^2 = 0.181 \text{ N}^2$

Ans.

b) $(67\,300 \text{ ms})^2 = [67.3(10^3)(10^{-3}) \text{ s}]^2 = 4.53(10^3) \text{ s}^2$

Ans.

c) $[723(10^6)]^{1/2} \text{ mm} = [723(10^6)]^{1/2}(10^{-3}) \text{ m} = 26.9 \text{ m}$

Ans.

Ans:

a) 0.181 N^2

b) $4.53(10^3) \text{ s}^2$

c) 26.9 m

1–3. Evaluate each of the following to three significant figures, and express each answer in SI units using an appropriate prefix: (a) $749 \mu\text{m}/63 \text{ ms}$, (b) $(34 \text{ mm})(0.0763 \text{ Ms})/263 \text{ mg}$, (c) $(4.78 \text{ mm})(263 \text{ Mg})$.

SOLUTION

$$\begin{aligned} \text{a) } 749 \mu\text{m}/63 \text{ ms} &= 749(10^{-6}) \text{ m}/63(10^{-3}) \text{ s} = 11.88(10^{-3}) \text{ m/s} \\ &= 11.9 \text{ mm/s} \end{aligned} \quad \text{Ans.}$$

$$\begin{aligned} \text{b) } (34 \text{ mm})(0.0763 \text{ Ms})/263 \text{ mg} &= [34(10^{-3}) \text{ m}][0.0763(10^6) \text{ s}]/[263(10^{-6})(10^3) \text{ g}] \\ &= 9.86(10^6) \text{ m} \cdot \text{s}/\text{kg} = 9.86 \text{ Mm} \cdot \text{s}/\text{kg} \end{aligned} \quad \text{Ans.}$$

$$\begin{aligned} \text{c) } (4.78 \text{ mm})(263 \text{ Mg}) &= [4.78(10^{-3}) \text{ m}][263(10^6) \text{ g}] \\ &= 1.257(10^6) \text{ g} \cdot \text{m} = 1.26 \text{ Mg} \cdot \text{m} \end{aligned} \quad \text{Ans.}$$

Ans:
a) 11.9 mm/s
b) 9.86 Mm · s/kg
c) 1.26 Mg · m

*1-4. Convert the following temperatures: (a) 20°C to degrees Fahrenheit, (b) 500 K to degrees Celsius, (c) 125°F to degrees Rankine, (d) 215°F to degrees Celsius.

SOLUTION

a) $T_C = \frac{5}{9}(T_F - 32)$

$$20^\circ\text{C} = \frac{5}{9}(T_F - 32)$$

$$T_F = 68.0^\circ\text{F}$$

Ans.

b) $T_K = T_C + 273$

$$500\text{ K} = T_C + 273$$

$$T_C = 227^\circ\text{C}$$

Ans.

c) $T_R = T_F + 460$

$$T_R = 125^\circ\text{F} + 460 = 585^\circ\text{R}$$

Ans.

d) $T_C = \frac{5}{9}(T_F - 32)$

$$T_C = \frac{5}{9}(215^\circ\text{F} - 32) = 102^\circ\text{C}$$

Ans.

1-5. Mercury has a specific weight of 133 kN/m^3 when the temperature is 20°C . Determine its density and specific gravity at this temperature.

SOLUTION

$$\gamma = \rho g$$

$$133(10^3) \text{ N/m}^3 = \rho_{\text{Hg}}(9.81 \text{ m/s}^2)$$

$$\rho_{\text{Hg}} = 13\,558 \text{ kg/m}^3 = 13.6 \text{ Mg/m}^3$$

Ans.

$$S_{\text{Hg}} = \frac{\rho_{\text{Hg}}}{\rho_w} = \frac{13\,558 \text{ kg/m}^3}{1000 \text{ kg/m}^3} = 13.6$$

Ans.

Ans:
 $\rho_{\text{Hg}} = 13.6 \text{ Mg/m}^3$
 $S_{\text{Hg}} = 13.6$

1-6. The fuel for a jet engine has a density of 1.32 slug/ft^3 . If the total volume of fuel tanks A is 50 ft^3 , determine the weight of the fuel when the tanks are completely full.



SOLUTION

The specific weight of the fuel is

$$\gamma = \rho g = (1.32 \text{ slug/ft}^3)(32.2 \text{ ft/s}^2) = 42.504 \text{ lb/ft}^3$$

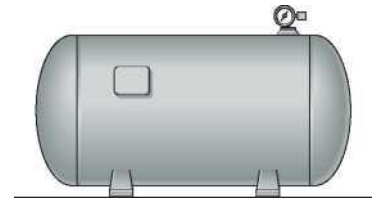
Then, the weight of the fuel is

$$W = \gamma V = (42.504 \text{ lb/ft}^3)(50 \text{ ft}^3) = 2.13(10^3) \text{ lb} = 2.13 \text{ kip}$$

Ans.

Ans:
 $\gamma = 42.5 \text{ lb/ft}^3$
 $W = 2.13 \text{ kip}$

1-7. If air within the tank is at an absolute pressure of 680 kPa and a temperature of 70°C, determine the weight of the air inside the tank. The tank has an interior volume of 1.35 m³.



SOLUTION

From the table in Appendix A, the gas constant for air is $R = 286.9 \text{ J/kg} \cdot \text{K}$.

$$\begin{aligned} p &= \rho RT \\ 680(10^3) \text{ N/m}^2 &= \rho(286.9 \text{ J/kg} \cdot \text{K})(70^\circ + 273) \text{ K} \\ \rho &= 6.910 \text{ kg/m}^3 \end{aligned}$$

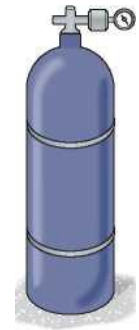
The weight of the air in the tank is

$$\begin{aligned} W &= \rho g V = (6.910 \text{ kg/m}^3)(9.81 \text{ m/s}^2)(1.35 \text{ m}^3) \\ &= 91.5 \text{ N} \end{aligned}$$

Ans.

Ans:
91.5 N

*1-8. The bottle tank has a volume of 1.12 m^3 and contains oxygen at an absolute pressure of 12 MPa and a temperature of 30°C . Determine the mass of oxygen in the tank.



SOLUTION

From the table in Appendix A, the gas constant for oxygen is $R = 259.8 \text{ J/kg} \cdot \text{K}$.

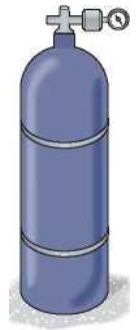
$$\begin{aligned} p &= \rho RT \\ 12(10^6) \text{ N/m}^2 &= \rho(259.8 \text{ J/kg} \cdot \text{K})(30^\circ + 273) \text{ K} \\ \rho &= 152.44 \text{ kg/m}^3 \end{aligned}$$

The mass of oxygen in the tank is

$$\begin{aligned} m &= \rho V = (152.44 \text{ kg/m}^3)(0.12 \text{ m}^3) \\ &= 18.3 \text{ kg} \end{aligned}$$

Ans.

1-9. The bottle tank has a volume of 0.12 m^3 and contains oxygen at an absolute pressure of 8 MPa and temperature of 20°C . Plot the variation of the temperature in the tank (horizontal axis) versus the pressure for $20^\circ\text{C} \leq T \leq 80^\circ\text{C}$. Report values in increments of $\Delta T = 10^\circ\text{C}$.



SOLUTION

$T_C(^{\circ}\text{C})$	20	30	40	50	60	70	80
$p(\text{MPa})$	8.00	8.27	8.55	8.82	9.09	9.37	9.64

From the table in Appendix A, the gas constant for oxygen is $R = 259.8 \text{ J}/(\text{kg} \cdot \text{K})$.
For $T = (20^\circ\text{C} + 273) \text{ K} = 293 \text{ K}$,

$$p = \rho RT$$

$$8(10^6) \text{ N/m}^2 = \rho [259.8 \text{ J}/(\text{kg} \cdot \text{K})](293 \text{ K})$$

$$\rho = 105.10 \text{ kg/m}^3$$

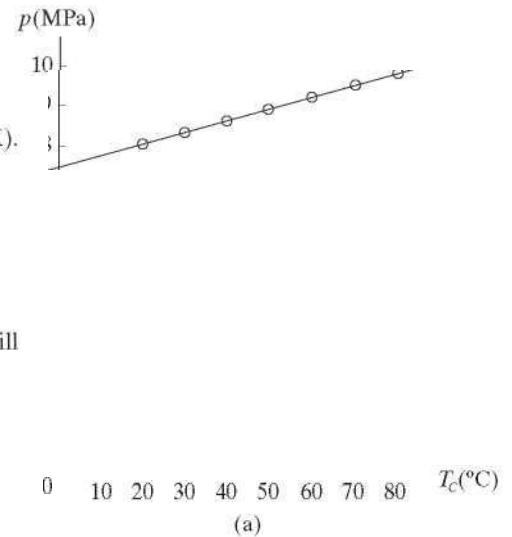
Since the mass and volume of the oxygen in the tank remain constant, its density will also be constant.

$$p = \rho RT$$

$$p = (105.10 \text{ kg/m}^3)[259.8 \text{ J}/(\text{kg} \cdot \text{K})](T_C + 273)$$

$$p = (0.02730 T_C + 7.4539)(10^6) \text{ Pa}$$

$$p = (0.02730 T_C + 7.4539) \text{ MPa where } T_C \text{ is in } ^{\circ}\text{C}.$$



The plot of p vs T_C is shown in Fig. *a*.

Ans:

$$p = (0.0273 T_C + 7.45) \text{ MPa, where } T_C \text{ is in } ^{\circ}\text{C}$$

1-10. Determine the specific weight of carbon dioxide when the temperature is 100°C and the absolute pressure is 400 kPa.

SOLUTION

From the table in Appendix A, the gas constant for carbon dioxide is $R = 188.9 \text{ J / kg} \cdot \text{K}$.

$$p = \rho R T$$
$$400(10^3) \text{ N/m}^2 = \rho(188.9 \text{ J/kg} \cdot \text{K})(100^\circ + 273) \text{ K}$$
$$\rho = 5.677 \text{ kg / m}^3$$

The specific weight of carbon dioxide is

$$g = \rho g = (5.677 \text{ kg / m}^3)(9.81 \text{ m / s}^2)$$
$$= 55.7 \text{ N/m}^3$$

Ans.

Ans:
55.7 N / m³

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