Chapter 1: Introduction to the Engineering Profession

1.20 Estimate the amount of copy or printing paper that you use every year. A 500-sheet ream of copy paper has an approximate mass of 5 pounds (2.27 kg). How much of this consumption is truly necessary, and how much of your own paper consumption could be avoided? State your assumptions.

SOLUTION

For example, on average, I use 15 pages per day; then on a yearly basis, I use 5475 pages (15 x 365).

$$\left(\frac{5475 \text{ pages}}{\text{year}}\right)\left(\frac{5 \text{ pounds}}{500 \text{ pages}}\right) = 54.75 \ \frac{\text{pounds of paper}}{\text{year}}$$

- Print only when necessary; convert online articles, emails; online receipts, etc. to PDF and save them electronically. Submit reports electronically when appropriate.
- Print on both sides of the paper.

Chapter 4: Engineering Communication

4.14 Plot the following data. Use two different y-axes. Use a scale of zero to 100°F for temperature, and zero to 12 mph for wind speed. Present your work using the ideas discussed in this chapter and engineering papers.

Time (p.m.)	Temperature (°F)	Wind Speed (mph)
1	75	4
2	80	5
3	82	8
4	82	5
5	78	5
6	75	4
7	70	3
8	68	3

SOLUTION

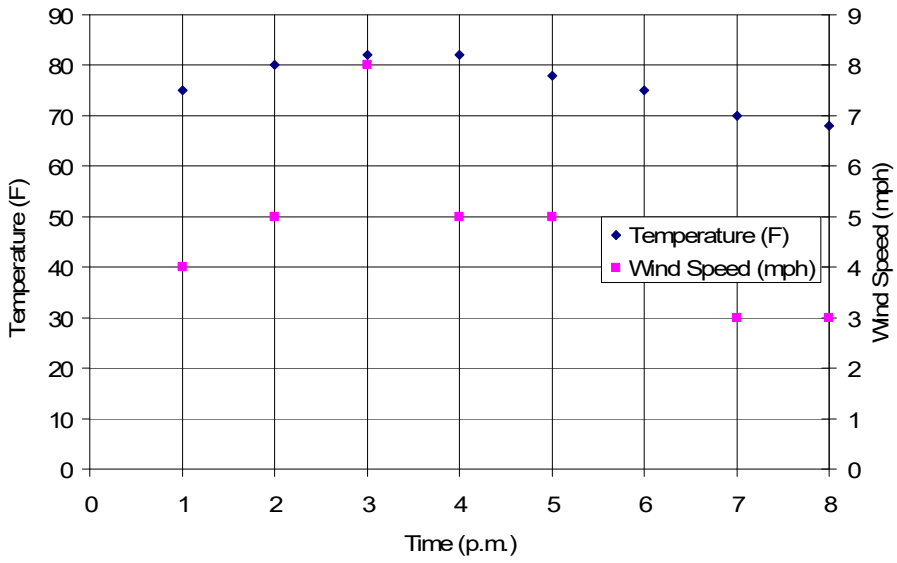


Figure 4-14 Plot of temperature and wind speed as a function of time

4. 15 Create a table that shows the relationship between the units of temperature in degree Celsius and Fahrenheit in the range of -50° to 50°C. Use Increments of 10°C. Present your work using the ideas discussed in this chapter and engineering paper.

SOLUTION

The relationship between the units of temperature in degrees Celsius and Fahrenheit

Temperature (°C)	Temperature (°F)
-50	-58
-45	-49
-40	-40
-35	-31
-30	-22
-25	-13
-20	-4
-15	5
-10	14
-5	23
0	32
5	41
10	50
15	59
20	68
25	77
30	86
35	95
40	104
45	113
50	122

4.16 Create a table that shows the relationship between the units of mass in kilogram and pound mass in the range of 50 kg to 120 kg. Use increments of 10 kg. Present your work using the ideas discussed in this chapter and engineering paper.

SOLUTION

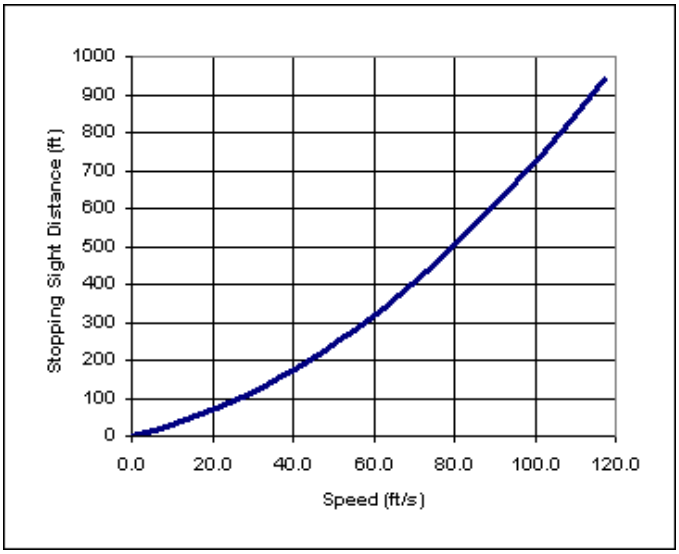
The relationship between the units of mass in kilograms and pound mass

mass (kg)	mass (lb_m)
50	110.2
60	132.3
70	154.3
80	176.4
90	198.4
100	220.5
110	242.5
120	264.6

4.17 The given data show the result of a model known as *stopping sight distance,* used by civil engineers to design roadways. This simple model estimates the distance a driver needs in order to stop his car traveling at a certain speed after detecting a hazard. Present your work using the ideas discussed in this chapter and engineering papers.

SOLUTION

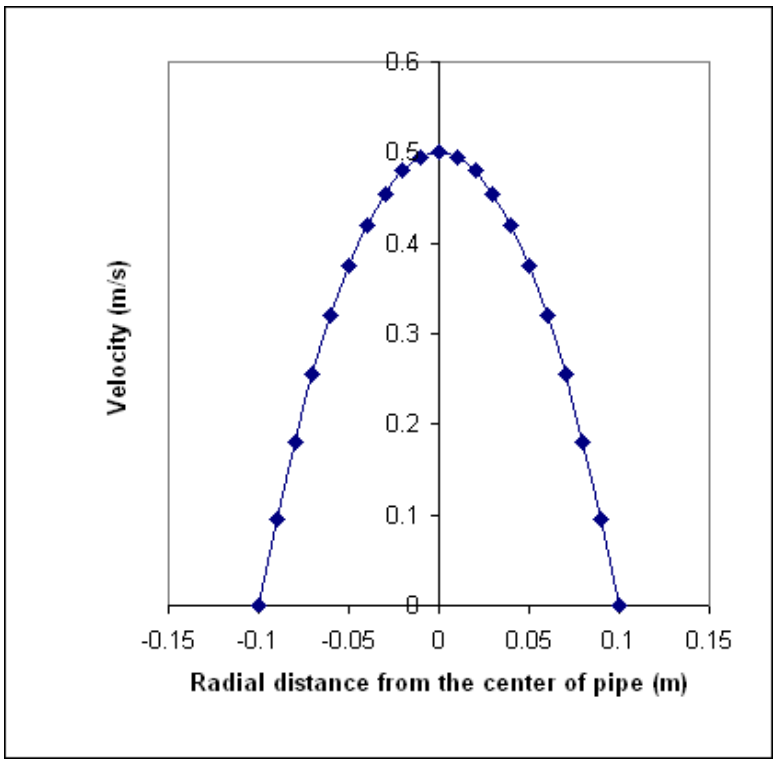
Speed (mph)	Speed (ft/s)	Stopping Sight Distance (ft)
0	0.0	0
5	7.3	21
10	14.7	47
15	22.0	78
20	29.3	114
25	36.7	155
30	44.0	201
35	51.3	252
40	58.7	309
45	66.0	370
50	73.3	436
55	80.7	508
60	88.0	584
65	95.3	666
70	102.7	753
75	110.0	844
80	117.3	941



4.18 The given data represent the velocity distribution for a flow of a fluid inside a circular pipe with a radius of 0.1 m. Plot the data using engineering paper and incorporating the ideas discussed in this chapter.

SOLUTION

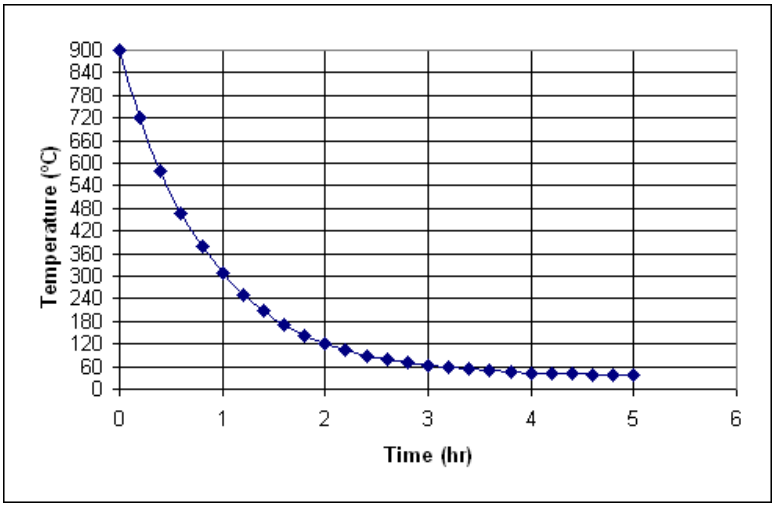
r	u(r)
-0.1	0
-0.09	0.095
-0.08	0.18
-0.07	0.255
-0.06	0.32
-0.05	0.375
-0.04	0.42
-0.03	0.455
-0.02	0.48
-0.01	0.495
0	0.5
0.01	0.495
0.02	0.48
0.03	0.455
0.04	0.42
0.05	0.375
0.06	0.32
0.07	0.255
0.08	0.18
0.09	0.095
0.1	0



4.19 In an annealing process—a process wherein materials such as glass and metal are heated to high temperatures and then cooled slowly to toughen them — thin steel plates are heated to temperatures of 900°C and then cooled in an environment with temperature of 35°C. The results of an annealing process for a thin plate are shown below. Plot the data

SOLUTION

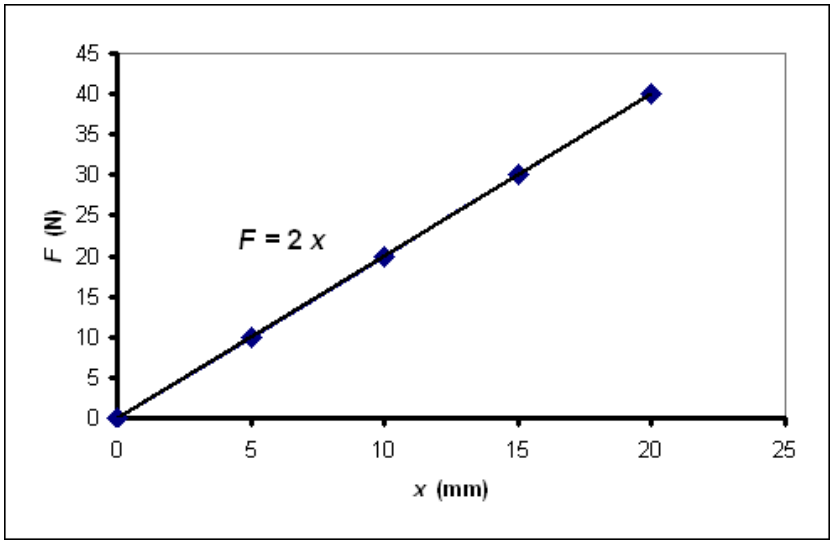
Time (hr)	Temperature (°C)
0	900
0.2	722
0.4	580
0.6	468
0.8	379
1	308
1.2	252
1.4	207
1.6	172
1.8	143
2	121
2.2	103
2.4	89
2.6	78
2.8	69
3	62
3.2	57
3.4	52
3.6	49
3.8	46
4	44
4.2	42
4.4	40
4.6	39
4.8	38
5	38



4.20 The relationship between a spring force and its deflection is given in the accompanying table. Plot the results using engineering paper and incorporating the ideas discussed in this chapter.

SOLUTION

X (mm)	*F* (N)
0	0
5	10
10	20
15	30
20	40



Chapter 5: Engineering Ethics

5.1 The following is a series of questions pertaining to the NSPE Code of Ethics. Please indicate whether the statements are true or false. These questions are provided by the NSPE.

Note: This ethics test is intended solely to test individual knowledge of the specific language contained in the NSPE Code of Ethics and is not intended to measure individual knowledge of engineering ethics or the ethics of individual engineers or engineering students.

1. Engineers in the fulfillment of their professional duties must carefully consider the safety, health and welfare of the public. *False*

2. Engineers may perform services outside of their areas of competence as long as they inform their employer or client of this fact. *False*

3. Engineers may issue subjective and partial statements if such statements are in writing and consistent with the best interests of their employer, client or the public. *False*

4. Engineers shall act for each employer or client as faithful agents or trustees. *True*

5. Engineers shall not be required to engage truthful acts when required to protect the public health, safety, and welfare. *False*

6. Engineers may not be required to follow the provisions of state or federal law when such actions could endanger or compromise their employer or their client's interests. *False*

7. If engineers' judgment is overruled under circumstances that endanger life or property, they shall notify their employer or client and such other authority as may be appropriate. *True*

8. Engineers may review but shall not approve those engineering documents that are in conformity with applicable standards. *False*

9. Engineers shall not reveal facts, data or information without the prior consent of the client or employer except as authorized or required by law or this Code. *True*

10. Engineers shall not permit the use of their name or their associate's name in business ventures with any person or firm that they believe is engaged in fraudulent or dishonest enterprise, unless such enterprise or activity is deemed consistent with applicable state or federal law. *False*

11. Engineers having knowledge of any alleged violation of this Code, following a period of thirty days during which the violation is not corrected, shall report thereon to appropriate professional bodies and, when relevant, also to public authorities, and cooperate with the proper authorities in furnishing such information or assistance as may be required. *False*

12. Engineers shall undertake assignments only when qualified by education or experience in the specific technical fields involved. *True*

13. Engineers shall not affix their signatures to plans or documents dealing with subject matter in which they lack competence, but may affix their signatures to plans or documents not prepared under their direction and control where the engineer has a good faith belief that such plans or documents were competently prepared by another designated party. *False*

14. Engineers may accept assignments and assume responsibility for coordination of an entire project and shall sign and seal the engineering documents for the entire project, including each technical segment of the plans and documents. *False*

15. Engineers shall strive to be objective and truthful in professional reports, statements or testimony, with primary consideration for the best interests of the engineer's client or employer. The engineer's reports shall include all relevant and pertinent information in such reports, statements or testimony, which shall bear the date on which the engineer was retained by the client to prepare the reports. *False*

16. Engineers may express publicly technical opinions that are founded upon knowledge of the facts and competence in the subject matter. *True*

17. Engineers shall issue no statements, criticisms, or arguments on technical matters that are inspired or paid for by interested parties, unless they have prefaced their comments by explicitly identifying the interested parties on whose behalf they are speaking, and by revealing the existence of any interest the engineers may have in the matters. *True*

18. Engineers may not participate in any matter involving a conflict of interest if it could influence or appear to influence their judgment or the quality of their services. *False*

19. Engineers shall not accept compensation, financial or otherwise, from more than one party for services on the same project, or for services pertaining to the same project, unless the circumstances are fully disclosed and agreed to by all interested parties. *True*

20. Engineers shall not solicit but may accept financial or other valuable consideration, directly or indirectly, from outside agents in connection with the work for which they are responsible, if such compensation is fully disclosed. *False*

21. Engineers in public service as members, advisors or employees of a governmental or quasi-governmental body or department may participate in decisions with respect to services solicited or provided by them or their organizations in private or public engineering practice as long as such decisions do not involve technical engineering matters for which they do not posses professional competence. *False*

22. Engineers shall not solicit or accept a contract from a governmental body on which a principal or officer of their organization serves as a member. *True*

23. Engineers shall not intentionally falsify their qualifications or actively permit written misrepresentation of their or their associate's qualifications. Engineers may accept credit for previous work performed where the work was performed during the period the engineer was employed by the previous employer. Brochures or other presentations incident to the solicitation of employment shall specifically indicate the work performed and the dates the engineer was employed by the firm. *False*

24. Engineers shall not offer, give, solicit, or receive, either directly or indirectly, any contribution to influence the award of a contract by a public authority, or which may be reasonably construed by the public as having the effect or intent of influencing the award of a contract unless such contribution is made in accordance with applicable federal or state election campaign finance laws and regulations. *False*

25. Engineers shall acknowledge their errors after consulting with their employer or client. *False*

Chapter 6: Fundamental Dimensions and Systems of Units

6.1 Convert the information given in the accompanying table from SI units to U.S. Customary units. Refer to conversion tables on the front and back end sheets of this book. Show all steps of your solutions. See Examples 6.3 and 6.4.

Convert from SI units	To U.S. Customary units
120 km/h	miles/h and ft/s
1000 W	Btu/hr and horsepower
100 m^3	ft^3
80 kg	lbm
1000 kg/m^3	lbm/ft^3
900 N	lbf
100 kPa	lbf/in^2
9.81 m/s^2	ft/s^2

SOLUTION

$$120\left(\frac{\text{km}}{\text{h}}\right)\left(\frac{1000\text{ m}}{1\text{ km}}\right)\left(\frac{3.28\text{ ft}}{1\text{ m}}\right)\left(\frac{1\text{ mile}}{5280\text{ ft}}\right)=74.5\text{ miles/h}$$

$$120\left(\frac{\text{km}}{\text{h}}\right)\left(\frac{1000\text{ m}}{1\text{ km}}\right)\left(\frac{3.28\text{ ft}}{1\text{ m}}\right)\left(\frac{1\text{ h}}{3600\text{ s}}\right)=109.3\text{ ft/s}$$

$$1\,(\text{kW})\left(\frac{3412\text{ Btu/h}}{1\text{ kW}}\right)=3412\text{ Btu/h}$$

$$1\,(\text{kW})\left(\frac{1.341\text{ hp}}{1\text{ kW}}\right)=1.341\text{ hp}$$

$$100\,(\text{m}^3)\left(\frac{3.28\text{ ft}}{1\text{ m}}\right)^3=3529\text{ ft}^3$$

$$80\ (\text{kg})\left(\frac{2.2046\text{ lbm}}{1\text{ kg}}\right)=176.4\text{ lbm}$$

$$1000\left(\frac{\text{kg}}{\text{m}^3}\right)\left(\frac{1\text{ m}}{3.28\text{ ft}}\right)^3\left(\frac{2.2046\text{ lbm}}{1\text{ kg}}\right)=62.5\ \frac{\text{lbm}}{\text{ft}^3}$$

$$900\ (\text{N})\left(\frac{224.809\times10^{-3}\ \text{lbf}}{1\ \text{N}}\right)=202.3\ \text{lbf}$$

$$100\times10^{3}\ (\text{Pa})\left(\frac{145.0377\times10^{-6}\ \frac{\text{lb}}{\text{in}^2}}{1\ \text{Pa}}\right)=14.5\ \frac{\text{lb}}{\text{in}^2}$$

$$9.81\left(\frac{\text{m}}{\text{s}^2}\right)\left(\frac{3.28\ \text{ft}}{1\ \text{m}}\right)=32.2\ \frac{\text{ft}}{\text{s}^2}$$

6.2 Convert the information given in the accompanying table from U.S. Customary units to SI units. Refer to conversion tables on the inside and back covers of this book. Show all steps of your solutions. See Examples 6.3 and 6.4.

Convert from U.S. Customary Units	To SI Units
65 miles/h	km/h and m/s
60,000 Btu/h	W
120 lbm/ft^3	kg/m^3
30 lb/in^2	kPa
200 lbm	kg
200 lbf	N

SOLUTION

$$65\left(\frac{\text{miles}}{\text{h}}\right)\left(\frac{5280\ \text{ft}}{1\ \text{mile}}\right)\left(\frac{1\ \text{km}}{1\,000\ \text{m}}\right)\left(\frac{1\ \text{m}}{3.28\ \text{ft}}\right)=104.6\ \text{km/h}$$

$$104.6\left(\frac{\text{km}}{\text{h}}\right)\left(\frac{1000\ \text{m}}{1\ \text{km}}\right)\left(\frac{1\ \text{h}}{3600\ \text{s}}\right)=29\ \text{m/s}$$

$$60000\left(\frac{\text{Btu}}{\text{h}}\right)\left(\frac{1\ \text{kW}}{3412\ \text{Btu/h}}\right)=17.6\ \text{kW}$$

$$120\left(\frac{1\text{bm}}{\text{ft}^3}\right)\left(\frac{1\ \text{kg/m}^3}{0.06248\ \text{lbm/ft}^3}\right)=1920\ \text{kg/m}^3$$

$$30\left(\frac{\text{lb}}{\text{in}^2}\right)\left(\frac{1\text{ Pa}}{145.0377\times10^{-6}\text{ lb/in}^2}\right)=206.8\text{ kPa}$$

$$200\ (\text{lbm})\left(\frac{1\text{ kg}}{2.2046\text{ lbm}}\right)=90.7\text{ kg}$$

$$200\ (\text{lbf})\left(\frac{1\text{ N}}{224.809\times10^{-3}\text{ lbf}}\right)=890\text{ N}$$

6.3 The angle of twist for a shaft subjected to twisting torque can be expressed by the following equation

$$\phi=\frac{\boldsymbol{TL}}{\boldsymbol{JG}}$$

where

ϕ = the angle of twist in radians
T = applied torque (N· m)
L = length of the shaft in meter (m)
J = shaft's polar moment of inertia (measure of resistance to twisting)
G = shear modulus of the material in N/m^2

What is the appropriate unit for J, if the preceding equation is to be homogenous in units?

SOLUTION

$$\boldsymbol{J}=\frac{\boldsymbol{TL}}{\boldsymbol{\phi G}}=\frac{(\text{N.m})(\text{m})}{\left(\frac{\text{N}}{\text{m}^2}\right)}=\text{m}^4$$

Note ϕ is dimensionless and the appropriate SI unit for $\boldsymbol{J}$ is m^4.

6.4 Which one of the following equations is dimensionally homogenous? Show your proof.

a. $\boldsymbol{F = ma}$

b. $\boldsymbol{F = m\frac{V^2}{R}}$

c. $\boldsymbol{F(t_2 - t_1) = m(V_2 - V_1)}$

d. $\boldsymbol{F = mV}$

e. $\boldsymbol{F = m\frac{(V_2 - V_1)}{(t_2 - t_1)}}$

where

F = force (N)
m = mass (kg)
a = acceleration (m/s^2)
V = velocity (m/s)
R = radius (m)
t = time (s)

SOLUTION

a. $\boldsymbol{F = ma}$

N = (kg)(m/s^2)

This relationship is dimensionally homogenous, since Newton's Second law is used to define one newton.

b. $\boldsymbol{F = m\frac{V^2}{R}}$

N = (kg)(m/s)^2/m = (kg)(m/s^2)

Dimensionally homogenous.

c. $\boldsymbol{F(t_2 - t_1) = m(V_2 - V_1)}$

(N)(s) = (kg)(m/s) → N = (kg)(m/s^2)

Dimensionally homogenous.

d. $F = mV$

N = (kg)(m/s)

Not dimensionally homogenous.

e. $F = m\dfrac{(V_2 - V_1)}{(t_2 - t_1)}$

N = (kg)(m/s)/(s) = (kg)(m/s^2)

Dimensionally homogenous.

6.5 Determine the number of significant digits for the following numbers:

	Number of Significant Digits
286.5	
2.2 x 10^2	
2200	
0.0286	

SOLUTION

	Number of Significant Digits
286.5	Four
2.2 x 10^2	Two
2200	Unknown, if we meant to write 2.2 x 10^3 then two significant digits; If we meant to write 2200.0 then four significant digits
0.0286	Three

6.6 Present the results of the following operations using the proper number of significant digits.

	Your Calculator Displays	Should be recorded as
1.2856 + 10.1 =		
155 – 0.521 =		
155 – 0.52 =		
1558 x 12 =		
3.585 / 12 =		

SOLUTION

	Your Calculator Displays	Should be recorded as
1.2856 + 10.1	11.3856	11.3
155 – 0.521 =	154.479	154
155 – 0.52 =	154.48	154
1558 x 12 =	18696	1.86×10^4
3.585 / 12 =	0.29875	0.29

6.11 How many gallons of gasoline would be saved if someone drives a car with 35 miles per gallon versus a car with 20 miles per gallon? Assume the car is driven 12,000 miles per year for the next 10 years.

SOLUTION

$$\left(\frac{12{,}000 \text{ miles}}{\frac{20 \text{ miles}}{1 \text{ gallon}}} - \frac{12{,}000 \text{ miles}}{\frac{35 \text{ miles}}{1 \text{ gallon}}} \right) (10 \text{ years}) = 2{,}571 \text{ gallons}$$

6.13 Which one of the following equation is dimensionally homogenous? Show your proof.

a. $$F(x_2 - x_1) = \frac{1}{2} m V_2^2 - \frac{1}{2} m V_1^2$$

b. $$F = \frac{1}{2} m V_2^2 - \frac{1}{2} m V_1^2$$

c. $F(V_2 - V_1) = \frac{1}{2}mx_2^2 - \frac{1}{2}mx_1^2$

d. $F(t_2 - t_1) = mV_2 - mV_1$

where

F = Force (N)
x = distance (m)
m = mass (kg)
V = velocity (m/s)
t = time (s)

SOLUTION

a. $(\text{N})(\text{m})\,? = (\text{kg})(\text{m/s})^2 = (\text{kg})(\text{m/s}^2).\text{m} = \text{N.m.}$ dimensionally homogenous

b. $(\text{N})\,? = (\text{kg})(\text{m/s})^2 = (\text{kg})(\text{m/s}^2).\text{m}$ not dimensionally homogenous

c. $(\text{N})(\text{m/s})\,? = (\text{kg})(\text{m})^2$ not dimensionally homogenous

d. $(\text{N})(\text{s})\,? = (\text{kg})(\text{m/s}) = (\text{kg})(\frac{\text{m}}{\text{s}})(\frac{\text{s}}{\text{s}}) = \text{N.s.}$ dimensionally homogenous

6.14 A car has a mass of 1500 kg. Express the mass and the weight of the car using B.G. and U.S. Customary units. Show the conversion steps.

SOLUTION

mass:

$$1500\,(\text{kg})\left(\frac{1\,\text{slug}}{14.593\,\text{kg}}\right) = 102.8\,\text{slugs}$$

$$1500\,(\text{kg})\left(\frac{1\,\text{lb}_\text{m}}{0.4536\,\text{kg}}\right) = 3307\,\text{lb}_\text{m}$$

weight:

$$1500\,(\text{kg})\left(9.81\,\text{m/s}^2\right) = 14715\,\text{N}$$

$$14715\,(\text{N})\left(\frac{1\,\text{lb}}{4.448\,\text{N}}\right) = 3308\,\text{lb}$$

6.15 Express the kinetic energy $\frac{1}{2}(\text{mass})(\text{speed})^2$ of a car with a mass of 1200 kg and moving at a speed of 100 km/h using SI, BG, and U.S. Customary units. Show the conversion steps.

SOLUTION

$$\text{speed} = (100)\left(\frac{\text{km}}{\text{h}}\right)\left(\frac{1\,\text{h}}{3600\,\text{s}}\right)\left(\frac{1\,000\,\text{m}}{1\,\text{km}}\right) = 27.7\ \text{m/s}$$

$$\text{K.E.} = (\tfrac{1}{2})(1200\ \text{kg})\left(27.7\ \text{m/s}\ \right)^2 = 4.6\times10^5\ \text{kg.m/s}^2\text{.m} = 4.6\times10^5\,\text{N.m} = 4.6\times10^5\ \text{J}$$

$$\text{K.E.} = \left(4.6\times10^5\ \text{J}\right)\left(\frac{1\,\text{ft.lb}}{1.3558\ \text{J}}\right) = 3.4\times10^5\,\text{ft.lb}$$

6.16 A machine shop has a rectangular floor shape with dimensions of 30 ft by 50 ft. Express the area of the floor in ft^2, m^2, in^2, and cm^2. Show the conversion steps.

SOLUTION

$$A = (30\ \text{ft})(50\ \text{ft}) = 1500\ \text{ft}^2$$

$$A = (1500\ \text{ft}^2)\left(\frac{1\,\text{m}}{3.28\,\text{ft}}\right)^2 = 139.4\ \text{m}^2$$