

## **Instructor's Manual**

*for*

# **Applied Statics and Strength of Materials**

**Sixth Edition**

**George F. Limbrunner  
Leonard Spiegel  
Craig D'Allaird**

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APPLIED STATICS AND STRENGTH OF MATERIALS  
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George F. Limbrunner, P.E.  
Craig T. D'Allaird, P.E.

NOTES:

1. The solutions presented herein are, in general, somewhat abbreviated to conserve space. Very little explanation is furnished. Sketches are kept to a minimum. Few checks are shown.
2. The solutions follow the procedures developed in the examples in the text.
3. The solutions are based on the limited tables furnished in the text and/or the appendices. The tables furnished are for the purposes of this text only and should not be used for design.
4. The solutions for the design problems are generally not the only solution nor are they necessarily the most economical solutions.
5. Please note that problem numbers in the solution manual are depicted with both dashes (-) and periods (.) between the chapter and problem numbers. These are interchangeable.
6. It should be noted that the previous editions of the text used lowercase *s* to denote stresses. This has changed in the 6<sup>th</sup> edition, but due to time constraints this solution manual has not been completely updated to reflect such.
7. If you find errors in this manual or in the text, please forward them to me at [c.dallaird@hvcc.edu](mailto:c.dallaird@hvcc.edu).

*Craig T. D'Allaird*  
*Troy, NY*  
*November 2014*

# Chapter 1

Prob. 1.1

$$(a) c = \sqrt{10^2 + 7^2} = 12.21 \text{ ft}$$

$$(b) b = \sqrt{20^2 - 16^2} = 12.00 \text{ m}$$


---

Prob. 1.2

$$(a) a = 25 \sin 48^\circ = 18.58 \text{ ft}$$

$$(b) b = \sqrt{25^2 - 18.58^2} = 16.73 \text{ ft}$$

$$(c) h = b \sin 48^\circ = 16.73 \sin 48^\circ = 12.43 \text{ ft}$$


---

Prob. 1.3

$$a = \sqrt{72^2 - 67.3^2} = 25.59 \text{ ft}$$

$$A = \cos^{-1}(67.3/72) = 20.8^\circ$$

$$B = \sin^{-1}(67.3/72) = 69.2^\circ$$


---

Prob. 1.4

$$AB = 28 \sin 70^\circ = 26.3 \text{ ft}$$


---

Prob. 1.5

$$c = \sqrt{10^2 + 6^2} = 11.6 \text{ ft}$$

$$\theta = \tan^{-1}(6/10) = 31.0^\circ$$


---

Prob. 1.6

$$AB = \sqrt{12^2 + 16^2} = 20 \text{ ft}$$

$$BC = \sqrt{12^2 + 32^2} = 34.2 \text{ ft}$$

$$A = \tan^{-1}(12/16) = 36.9^\circ$$

$$C = \tan^{-1}(12/32) = 20.6^\circ$$


---

Prob. 1.7

$$\theta = \sin^{-1}(5/6) = 56.4^\circ$$

$$x = \sqrt{12^2 + 10^2} = 6.63 \text{ ft}$$


---

Prob. 1.8

Assume all angles to be  $45^\circ$

$$R_x = +2 + 3 \cos 45^\circ + 0 - 6 \sin 45^\circ = 0.1213 \text{ mi}$$

$$R_y = 0 - 3 \sin 45^\circ + 6 - 6 \sin 45^\circ = -0.364 \text{ mi.}$$

$$R = \sqrt{(-0.1213)^2 + (-0.364)^2} = 0.384 \text{ mi.}$$

Prob. 1.9

(a)

$$c^2 = 11^2 + 13^2 - 2(11)(13)\cos 80^\circ$$

$$= 15.50 \text{ ft}$$

$$\frac{\sin 80^\circ}{15.50} = \frac{\sin A}{11} = \frac{\sin B}{13}$$

$$\rightarrow A = 44.3^\circ, B = 55.7^\circ$$

(b)

$$a^2 = 78^2 + 85^2 - 2(78)(85)\cos 72^\circ$$

$$= 96.0 \text{ ft}$$

$$\frac{\sin 72^\circ}{96.0} = \frac{\sin C}{85} = \frac{\sin B}{78}$$

$$\rightarrow A = 57.4^\circ, B = 50.6^\circ$$

(c) Right Triangle Check

$$\text{Check } a^2 + b^2 = c^2$$

$$A = \tan^{-1}(7/24) = 16.26^\circ$$

$$B = \tan^{-1}(24/7) = 73.7^\circ$$


---

Prob. 1.10

$$C = 180^\circ - 55^\circ - 63^\circ = 62^\circ$$

$$\frac{a}{\sin 63^\circ} = \frac{100}{\sin 55^\circ} = \frac{c}{\sin 62^\circ}$$

$$\therefore a = \frac{\sin 63^\circ}{\sin 55^\circ} (100) = 108.8 \text{ ft}$$

$$\& c = \frac{\sin 62^\circ}{\sin 55^\circ} (100) = 107.8 \text{ ft}$$

$$\text{Perimeter} = a + b + c = 317 \text{ ft}$$


---

Prob. 1.11

S = wt of one shock

P = wt of one set of brake pads

$$\text{Eq1: } 8S + 10P = 101.6 \text{ lb}$$

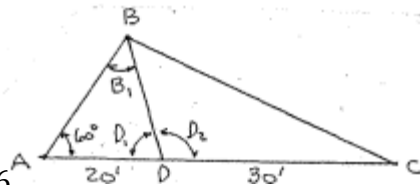
$$\text{Eq2: } 10S + 6P = 106.2 \text{ lb}$$

Multiply Eq2 by 8/10:

$$\text{Eq3: } 8S + 4.8P = 84.96 \text{ lb}$$

$$\begin{array}{r} 8S + 10P = 101.6 \text{ lb} \\ - 8S - 4.8P = -84.96 \text{ lb} \\ \hline 5.2P = 16.64 \text{ lb} \\ P = 3.20 \text{ lb} \\ \therefore S = 8.70 \text{ lb} \end{array}$$

Prob. 1.12



$$\frac{20}{\sin B_1} = \frac{26}{\sin 60^\circ} \rightarrow \therefore B_1 = 41.77^\circ$$

$$D_1 = 78.23^\circ \text{ and } D_2 = 101.77^\circ$$

$$\frac{AB}{\sin 78.23^\circ} = \frac{20}{\sin 41.77^\circ} \rightarrow \therefore AB = 29.39 \text{ ft}$$

$$BC = \sqrt{(AB)^2 + 50^2 - 2(AB)(50) \cos 60^\circ}$$

$$BC = 43.52 \text{ ft}$$

$$\frac{50}{\sin B} = \frac{43.5}{\sin 60^\circ} \rightarrow \therefore B = 84.25^\circ$$

$$C = 180^\circ - 60^\circ - 84.25^\circ = 35.75^\circ$$

Prob. 1.13

$$(a) 0.015 \text{ ton} \times 2000 \text{ lb/ton} = 30.0 \text{ lb}$$

$$(b) 30.0 \text{ lb} \times 16 \text{ oz./lb} = 480 \text{ oz.}$$

Prob. 1.14

$$(a) 5 \text{ mi} \times 5280 \text{ ft/mi} \times 1 \text{ yd}/3 \text{ ft} = 8800 \text{ yd}$$

$$(b) 5 \text{ mi} \times 5280 \text{ ft/mi} = 26,400 \text{ ft}$$

Prob. 1.15

$$60 \frac{\text{mi}}{\text{hr}} \times 5280 \frac{\text{ft}}{\text{mi}} \times \frac{1 \text{ hr}}{60 \text{ min}} \times \frac{1 \text{ min}}{60 \text{ sec}} = 88 \frac{\text{ft}}{\text{sec}}$$

Prob. 1.16

$$43,560 \frac{\text{ft}^2}{\text{acre}} \times \left(\frac{1 \text{ yd}}{3 \text{ ft}}\right)^2 \times \left(\frac{1 \text{ rod}}{5.5 \text{ yd}}\right)^2 = 160 \frac{\text{rod}^2}{\text{acre}}$$

Prob. 1.17

$$(a) \frac{125,000,000,000 \text{ gal}}{7.481 \frac{\text{gal}}{\text{ft}^3} \times 43,560 \frac{\text{ft}^2}{\text{acre}}} = 384 \times 10^3 \text{ acre} - \text{ft}$$

$$(b) \frac{125,000,000,000 \text{ gal} \times 62.4 \frac{\text{lb}}{\text{ft}^3}}{7.481 \frac{\text{gal}}{\text{ft}^3} \times 2000 \frac{\text{lb}}{\text{ton}}} = 521 \times 10^6 \text{ tons}$$

Prob. 1.18

$$(a) 27' - 7 \frac{3}{4}'' \rightarrow \frac{7.75 \text{ in.}}{12 \frac{\text{in.}}{\text{ft}}} = 0.646 \text{ ft} \rightarrow 27.65 \text{ ft}$$

(b) 1.815 ft  $\rightarrow$  in.

$$0.815 \text{ ft} \times 12 \frac{\text{in.}}{\text{ft}} = 9.78 \text{ in.}$$

$$0.815 \text{ ft} \times 12 \frac{\text{in.}}{\text{ft}} = 9.78 \text{ in.}$$

$$0.78 \text{ in.} \times 32 = 24.96$$

$$\therefore 1.815 \text{ ft} = 1' - 9 \frac{25}{32}''$$

Prob. 1.19

Volume = Area  $\times$  length

$$= \frac{\pi(2 \text{ in.})^2}{4} (0.25 \text{ mi}) \left(5280 \frac{\text{ft}}{\text{mi}}\right) \left(12 \frac{\text{in.}}{\text{ft}}\right)$$

$$= 1728 \frac{\text{in.}^3}{\text{ft}^3}$$

$$= 28.80 \text{ ft}^3$$

$$\text{Flushing Water} = 2(28.8 \text{ ft}^3)(7.481 \text{ gal/ft}^3) = 431 \text{ gal}$$

Prob. 1.20

$$2 \frac{\text{tons}}{\text{ft}^2} \times 2000 \frac{\text{lb}}{\text{ton}} = 4000 \frac{\text{lb}}{\text{ft}^2}$$

$$2 \frac{\text{tons}}{\text{ft}^2} \times 2000 \frac{\text{lb}}{\text{ton}} \times \frac{1 \text{ ft}^2}{144 \text{ in.}^2} = 27.8 \frac{\text{lb}}{\text{in.}^2}$$

Prob. 1.22

$$60.5 \text{ ft} \times 0.3048 \text{ m/ft} = 18.44 \text{ m}$$

$$90.0 \text{ ft} \times 0.3048 \text{ m/ft} = 27.4 \text{ m}$$

$$413.0 \text{ ft} \times 0.3048 \text{ m/ft} = 125.9 \text{ m}$$

Prob. 1.23

$$(a) 2212 \text{ lb} \times 0.4536 \text{ kg/lb} = 1003 \text{ kg}$$

$$(b) 87 \text{ ft}^2 \times 0.0929 \text{ m}^2/\text{ft}^2 = 8.08 \text{ m}^2$$

$$8.08 \text{ m}^2 \times 10^6 \text{ mm}^2/\text{m}^2 = 8.08 \times 10^6 \text{ mm}^2$$

(c)

$$18,460 \frac{\text{lb}}{\text{in.}^2} \times 0.006895 \frac{\text{MPa}}{\text{lb/in.}^2} = 127.3 \text{ MPa}$$

$$= 127,300 \text{ kPa}$$

Prob. 1.24

$$(a) 18.6 \text{ ft} \times 0.3048 \text{ m/ft} = 5.67 \text{ m}$$

$$5.67 \text{ m} \times 1000 \text{ mm/m} = 5670 \text{ mm}$$

$$(b) 8 \text{ ft} - 10 \text{ in.} = 106 \text{ in.}$$

$$106 \text{ in.} \times 25.4 \text{ mm/in.} = 2690 \text{ mm}$$

$$2690 \text{ mm} \times 1 \text{ m}/1000 \text{ mm} = 2.69 \text{ m}$$

$$(c) 27.5 \text{ in.} \times 25.4 \text{ mm/in.} = 699 \text{ mm}$$

$$699 \text{ mm} \times 1 \text{ m}/1000 \text{ mm} = 0.699 \text{ m}$$

Prob. 1.25

- (a)  $248 \text{ lb} \times 4.448 \text{ N/lb} = 1103 \text{ N}$   
 $= 1.103 \text{ kN}$
- (b)  $3.65 \text{ k} \times 1000 \text{ lb/k} \times 4.448 \text{ N/lb}$   
 $= 16\,240 \text{ N} = 16.24 \text{ kN}$
- (c)  $8.7 \text{ tons} \times 2000 \text{ lb/ton} \times 4.448 \text{ N/lb}$   
 $= 77\,400 \text{ N} = 77.4 \text{ kN}$

Prob. 1.26

- (a)  $627 \text{ in.}^2 \times 645.2 \text{ mm}^2/\text{in.}^2$   
 $= 404\,500 \text{ mm}^2 = 0.4045 \text{ m}^2$
- (b)  $14 \text{ yd}^2 \times 0.8361 \text{ m}^2/\text{yd}^2$   
 $= 11.71 \text{ m}^2 = 11.71 \times 10^6 \text{ mm}^2$
- (c)  $3.5 \frac{\text{k}}{\text{ft}} \times 14\,594 \frac{\text{N/m}}{\text{k/ft}} \times \frac{1 \text{ kN}}{1000 \text{ N}} = 51.1 \frac{\text{kN}}{\text{m}}$
- (d)  $8470 \frac{\text{lb}}{\text{in.}^2} \times 0.006895 \frac{\text{MPa}}{\text{lb/in.}^2} = 58.4 \text{ MPa}$   
 $= 58\,400 \text{ kPa}$
- (e)  $1740 \frac{\text{lb}}{\text{ft}^2} \times 47.88 \frac{\text{Pa}}{\text{lb/ft}^2} = 83\,300 \text{ Pa}$   
 $= 83.3 \text{ kPa}$
- (f)  $2.8 \text{ k/ft}^2 \times 47.88 \frac{\text{kPa}}{\text{k/ft}^2} = 134 \text{ kPa}$
- (g)
- $$247 \frac{\text{lb}}{\text{ft}^3} \times 4.448 \frac{\text{N}}{\text{lb}} \times \frac{1 \text{ ft}^3}{0.02832 \text{ m}^3} \times \frac{1 \text{ kN}}{1000 \text{ N}} = 38.8 \text{ kN/m}^3$$

Prob. 1.27

$$V = \frac{\pi (50 \text{ mm})^2}{4} \left( \frac{1 \text{ m}^2}{10^3 \text{ mm}^2} \right) (400 \text{ m})$$

$$= 0.7854 \text{ m}^3$$

Flushing water

$$= 2(0.7854 \text{ m}^3)(1000 \text{ liters/m}^3)$$

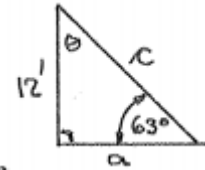
$$= 1571 \text{ liters}$$

Prob. 1.28

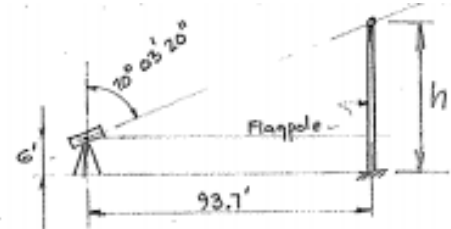
- (a)  $V = \frac{4}{3} \pi (27 \text{ in.})^3 = 82,400 \text{ in.}^3$
- (b)  $82,400 \text{ in.}^3 \times 16,387 \text{ mm}^3/\text{in.}^3$   
 $= 1.350 \times 10^9 \text{ mm}^3$
- (c)  $1.350 \times 10^9 \text{ mm}^3 = 1.350 \text{ m}^3$
- (d)  $1.350 \text{ m}^3 \times 1000 \text{ liters/m}^3 = 1351 \text{ liters}$

Prob. 1.29

- (a)  $c = \frac{12}{\sin 63^\circ} = 13.47 \text{ ft}$
- (b)  $a = \frac{12}{\tan 63^\circ} = 6.11 \text{ ft}$
- (c)  $\theta = 90 - 63 = 27^\circ$



Prob. 1.30



$$h = 6 + \frac{93.7}{\tan 70^\circ 03' 20''} = 40.0 \text{ ft}$$

Prob. 1.31

$$AB = 32(\tan 55^\circ) = 45.7 \text{ m}$$

Prob. 1.32

$$W = 30/(\tan 17^\circ)$$

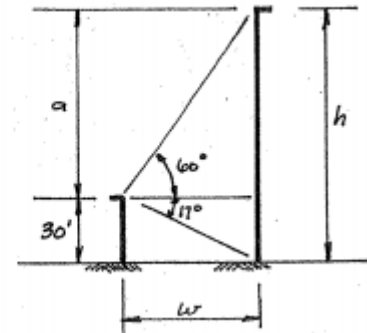
$$= 98.13 \text{ ft}$$

$$a = 98.13(\tan 60^\circ)$$

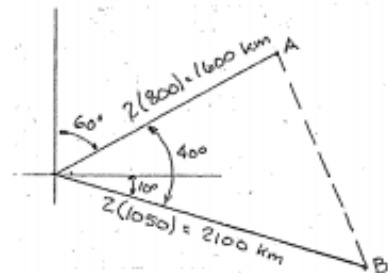
$$= 169.97 \text{ ft}$$

$$h = 30 + 169.97$$

$$= 200 \text{ ft}$$



Prob. 1.33



$$(AB)^2 = 1600^2 + 2100^2$$

$$- 2(1600)(2100)\cos 40^\circ$$

$$= 1350 \text{ km}$$



Prob. 1.34

$$\theta = \tan^{-1}(1/5)$$

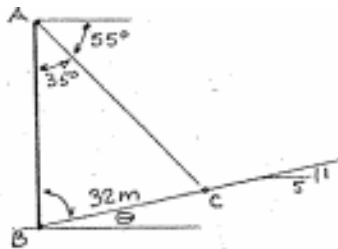
$$= 11.31^\circ$$

$$\angle CBA = 90 - 11.31$$

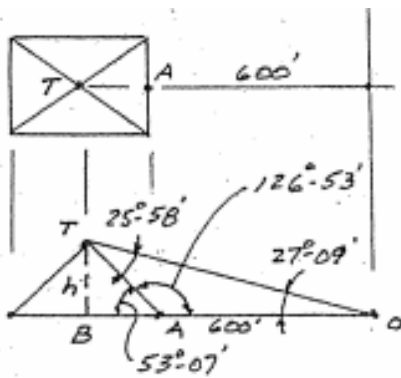
$$= 78.69^\circ$$

$$\angle C = 180 - 78.69 - 35 = 66.31^\circ$$

$$\frac{AB}{\sin 66.31^\circ} = \frac{32}{\sin 35^\circ} \rightarrow AB = 51.1 \text{ m}$$



Prob. 1.35



$$\frac{TO}{\sin 126^\circ 53'} = \frac{600}{\sin 25^\circ 58'} \rightarrow TO = 1096 \text{ ft}$$

$$h = (TO) \sin 27^\circ 09' = 500 \text{ ft}$$

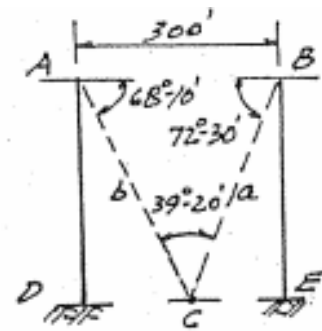
$$OB = \sqrt{1096^2 - 500^2} = 975 \text{ ft}$$

$$BA = 975 - 600 = 375 \text{ ft}$$

$$\therefore \text{Base width} = 2 \times BA = 750 \text{ ft}$$

$$TA = \sqrt{500^2 + 375^2} = 625 \text{ ft}$$

Prob. 1.36



$$\angle C = 180^\circ - 68^\circ 10' - 72^\circ 30' = 39^\circ 20'$$

$$\frac{300}{\sin 39^\circ 20'} = \frac{a}{\sin 68^\circ 10'} = \frac{b}{\sin 72^\circ 30'}$$

$$a = 439.36 \text{ ft}$$

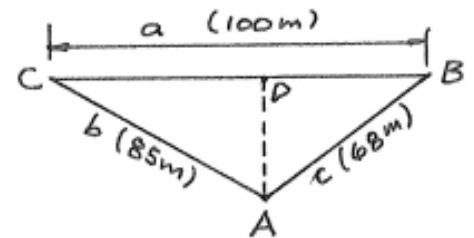
$$b = 451.41 \text{ ft}$$

$$DC = 451.41 \sin(90^\circ - 68^\circ 10') = 167.88 \text{ ft}$$

$$EC = 439.36 \sin(90^\circ - 72^\circ 30') = 132.12 \text{ ft}$$

$$\text{Tower ht} = \sqrt{439.36^2 - 132.12^2} = 419 \text{ ft}$$

Prob. 1.37



$$A = \cos^{-1} \left[ \frac{100^2 - 85^2 - 68^2}{-2(85)(68)} \right] = 80.8^\circ$$

$$\frac{\sin B}{85} = \frac{\sin 80.0^\circ}{100} \rightarrow B = 57.0^\circ$$

$$AD = 68 \sin B = 57.0 \text{ m}$$

Prob. 1.38

$$\frac{1 \text{ mi}}{4 \text{ min}} \times \frac{60 \text{ min}}{\text{hr}} = 15 \text{ mph}$$

$$\frac{26 \text{ mi}}{2 \text{ hr} - 47 \text{ min}} = \frac{26 \text{ mi}}{2.78 \text{ hr}} = 9.35 \text{ mph}$$

Prob. 1.39

$$(a) \quad 5000 \frac{\text{ft}^3}{\text{sec}} \times 7.481 \frac{\text{gal}}{\text{ft}^3} \times 60 \frac{\text{sec}}{\text{min}} = 2,240,000 \frac{\text{gal}}{\text{min}}$$

$$(b) \quad 5000 \frac{\text{ft}^3}{\text{sec}} \times \frac{1 \text{ mi}^3}{(5280 \text{ ft})^3} \times 60 \frac{\text{sec}}{\text{min}} \times 60 \frac{\text{min}}{\text{hr}} \\ \times 24 \frac{\text{hr}}{\text{day}} \times 365 \frac{\text{days}}{\text{yr}} = 1.071 \frac{\text{mi}^3}{\text{yr}}$$

Prob. 1.40

$$\text{Wt of sand: } 816 - 38 = 778 \text{ lb}$$

$$\frac{778 \text{ lb}}{55 \text{ gal}} \times 7.481 \frac{\text{gal}}{\text{ft}^3} = 105.8 \text{ pcf}$$

Prob. 1.41

 $x = \text{Building area}$  $y = \text{Parking lot area}$ 

$$\text{I. } x + y = 90,000$$

$$\text{II } y = 43,560/2 + 3x$$

$$\text{Solve I for } y: y = 90,000 - x$$

Substitute into II:

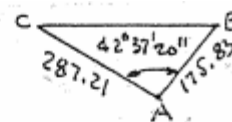
$$90,000 - x = 21,780 + 3x$$

$$x = 17,060 \text{ ft}^2 \text{ (Building)}$$

$$Y = 72,900 \text{ ft}^2 \text{ (Parking lot)}$$

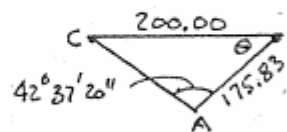
Prob. 1.42

(a)



$$(CB)^2 = 175.83^2 + 287.21^2 \\ - 2(175.83)(287.21)\cos 42^\circ 37' 20'' \\ CB = 197.7 \text{ m}$$

(b)



$$\frac{\sin C}{175.83} = \frac{\sin 42^\circ 37' 20''}{200} \rightarrow C = 36.5359^\circ \\ \theta = 180^\circ - 42^\circ 37' 20'' - C = 100.8419^\circ$$

$$\frac{AC}{\sin \theta} = \frac{200}{\sin 42^\circ 37' 20''} \rightarrow AC = 290.08 \text{ m}$$