Engineering Mechanics Statics 9th edition Meriam Solutions Manual

SKU: 9781119392743-SOLUTIONS

©2018 by John Wiley & Sons. No part of this Instructor's Manual may be reproduced or distributed in any form or by any means without the written consent of the publisher. The publisher hereby limits distribution to instructors who have adopted the corresponding Meriam/Kraige/Bolton textbook. This material is written for instructors and is not intended for students.

2/1

$$\begin{cases} F_x = 600 \cos 40^\circ = 460 \text{ N} \\ F_y = -600 \sin 40^\circ = -386 \text{ N} \end{cases}$$

$$\underline{F} = 460\underline{i} - 386\underline{j} \text{ N}$$

WILEY

©2018 by John Wiley & Sons. No part of this Instructor's Manual may be reproduced or distributed in any form or by any means without the written consent of the publisher. The publisher hereby limits distribution to instructors who have adopted the corresponding Meriam/Kraige/Bolton textbook. This material is written for instructors and is not intended for students.

2/2

$$\underline{F} = 400(-\cos 30^\circ \underline{i} + \sin 30^\circ \underline{j})$$

$$= -346\underline{i} + 200\underline{j} \text{ lb}$$

Scalar components:

$$F_x = -346 \text{ lb}$$

$$F_y = 200 \text{ lb}$$

Vector components:

$$\underline{F}_x = -346\underline{i} \text{ lb}$$

$$\underline{F}_y = 200\underline{j} \text{ lb}$$

WILEY

©2018 by John Wiley & Sons. No part of this Instructor's Manual may be reproduced or distributed in any form or by any means without the written consent of the publisher. The publisher hereby limits distribution to instructors who have adopted the corresponding Meriam/Kraige/Bolton textbook. This material is written for instructors and is not intended for students.

2/3

$$\underline{F} = 6.5\left(-\frac{12}{13}\underline{i} - \frac{5}{13}\underline{j}\right)$$

$$= -6\underline{i} - 2.5\underline{j} \text{ kN}$$

(Note: Writing 6, rather than 6.00, indicates an exact result.)

WILEY

©2018 by John Wiley & Sons. No part of this Instructor's Manual may be reproduced or distributed in any form or by any means without the written consent of the publisher. The publisher hereby limits distribution to instructors who have adopted the corresponding Meriam/Kraige/Bolton textbook. This material is written for instructors and is not intended for students.

2/4

$$\underline{F} = F\underline{n}_{AB} = 3000\left[\frac{15\underline{i} + 8\underline{j}}{\sqrt{15^2 + 8^2}}\right]$$

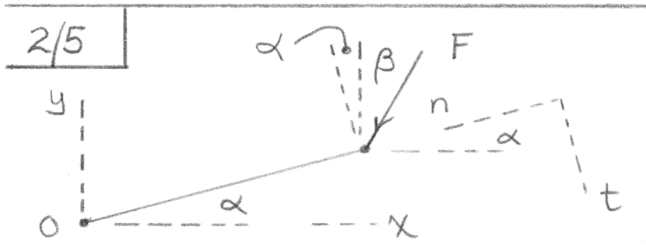
$$= 2650\underline{i} + 1412\underline{j} \text{ lb}$$

Scalar components: $\begin{cases} F_x = 2650 \text{ lb} \\ F_y = 1412 \text{ lb} \end{cases}$

WILEY

©2018 by John Wiley & Sons. No part of this Instructor's Manual may be reproduced or distributed in any form or by any means without the written consent of the publisher. The publisher hereby limits distribution to instructors who have adopted the corresponding Meriam/Kraige/Bolton textbook. This material is written for instructors and is not intended for students.

2/5



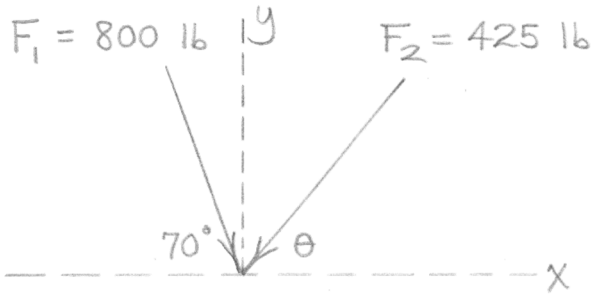
$$\begin{cases} F_x = -F\sin\beta \\ F_y = -F\cos\beta \end{cases}$$

$$\begin{cases} F_n = F\sin(\alpha+\beta) \\ F_t = F\cos(\alpha+\beta) \end{cases}$$

WILEY

©2018 by John Wiley & Sons. No part of this Instructor's Manual may be reproduced or distributed in any form or by any means without the written consent of the publisher. The publisher hereby limits distribution to instructors who have adopted the corresponding Meriam/Kraige/Bolton textbook. This material is written for instructors and is not intended for students.

2/6



$$R_x = \Sigma F_x = 800 \cos 70^\circ - 425 \cos\theta = 0$$

$$\theta = 49.9^\circ$$

$$R_y = \Sigma F_y = -800 \sin 70^\circ - 425 \sin 49.9^\circ$$

$$= -1077 \text{ lb}$$

So $R = 1077$ lb

WILEY

©2018 by John Wiley & Sons. No part of this Instructor's Manual may be reproduced or distributed in any form or by any means without the written consent of the publisher. The publisher hereby limits distribution to instructors who have adopted the corresponding Meriam/Kraige/Bolton textbook. This material is written for instructors and is not intended for students.

2/7

$$\underline{R} = (500 + 350\cos 60^\circ)\,\underline{i} + 350 \sin 60^\circ\,\underline{j}$$

$$\underline{R} = 675\,\underline{i} + 303\,\underline{j}\ \text{N}$$

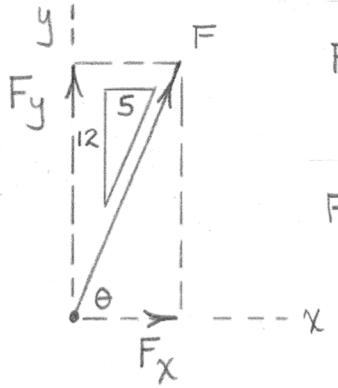
$$R = \sqrt{675^2 + 303^2} \longrightarrow R = 740\ \text{N}$$

$$\theta_x = \cos^{-1}\left(\frac{R_x}{R}\right) = \cos^{-1}\left(\frac{675}{740}\right) \longrightarrow \theta_x = 24.2^\circ \text{ ABOVE } +x \text{ AXIS}$$

WILEY

©2018 by John Wiley & Sons. No part of this Instructor's Manual may be reproduced or distributed in any form or by any means without the written consent of the publisher. The publisher hereby limits distribution to instructors who have adopted the corresponding Meriam/Kraige/Bolton textbook. This material is written for instructors and is not intended for students.

2/8



$\cos\theta = \frac{5}{13}$, $\sin\theta = \frac{12}{13}$

$F_y = F\sin\theta = F\frac{12}{13} = 70$

$F = 75.8$ lb

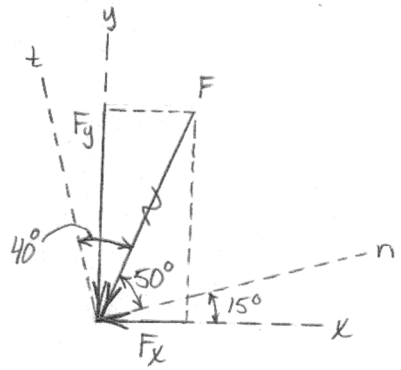
$F_x = F\cos\theta = 75.8\left(\frac{5}{13}\right)$

$= 29.2$ lb

WILEY

©2018 by John Wiley & Sons. No part of this Instructor's Manual may be reproduced or distributed in any form or by any means without the written consent of the publisher. The publisher hereby limits distribution to instructors who have adopted the corresponding Meriam/Kraige/Bolton textbook. This material is written for instructors and is not intended for students.

2/9

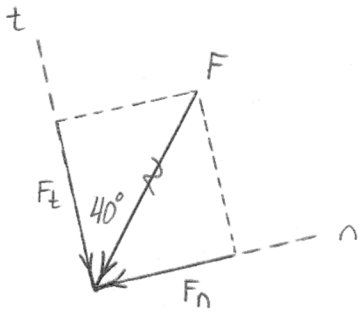


$$F_x = -F\cos 65^\circ = -13\cos 65^\circ$$

$$F_x = -5.49 \text{ kips}$$

$$F_y = -F\sin 65^\circ = -13\sin 65^\circ$$

$$F_y = -11.78 \text{ kips}$$



$$F_n = -F\sin 40^\circ = -13\sin 40^\circ$$

$$F_n = -8.36 \text{ kips}$$

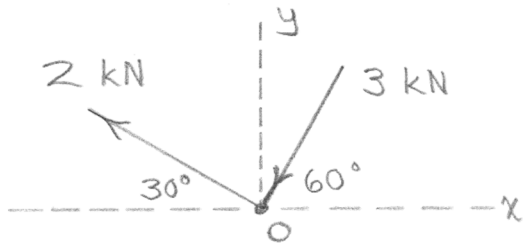
$$F_t = -F\cos 40^\circ = -13\cos 40^\circ$$

$$F_t = -9.96 \text{ kips}$$

WILEY

©2018 by John Wiley & Sons. No part of this Instructor's Manual may be reproduced or distributed in any form or by any means without the written consent of the publisher. The publisher hereby limits distribution to instructors who have adopted the corresponding Meriam/Kraige/Bolton textbook. This material is written for instructors and is not intended for students.

2/10



$$R_x = \Sigma F_x = -2\cos 30^\circ - 3\cos 60^\circ = -3.23 \text{ kN}$$

$$R_y = \Sigma F_y = 2\sin 30^\circ - 3\sin 60^\circ = -1.598 \text{ kN}$$

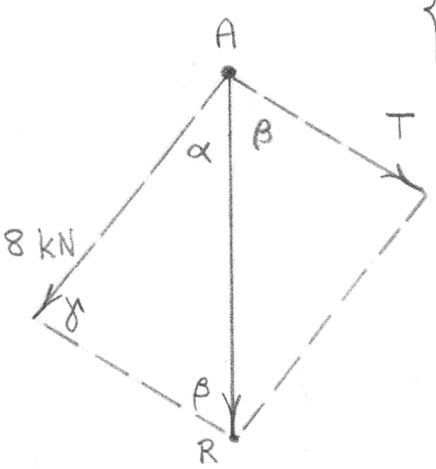
$$R = \sqrt{R_x^2 + R_y^2} = \underline{3.61 \text{ kN}}$$

$$\theta = \tan^{-1}\left(\frac{R_y}{R_x}\right) = \tan^{-1}\left(\frac{-1.598}{-3.23}\right) = \underline{206^\circ}$$

WILEY

©2018 by John Wiley & Sons. No part of this Instructor's Manual may be reproduced or distributed in any form or by any means without the written consent of the publisher. The publisher hereby limits distribution to instructors who have adopted the corresponding Meriam/Kraige/Bolton textbook. This material is written for instructors and is not intended for students.

2/11



$$\alpha = \tan^{-1}\frac{40}{50} = 38.7^\circ$$

$$\beta = \tan^{-1}\frac{50}{30} = 59.0^\circ$$

$$\gamma = 180^\circ - \alpha - \beta$$

$$= 82.3^\circ$$

$$\frac{\sin\beta}{8} = \frac{\sin\alpha}{T}$$

$$T = 5.83 \text{ kN}$$

$$\frac{\sin\beta}{8} = \frac{\sin\gamma}{R}, \qquad R = 9.25 \text{ kN}$$

WILEY

©2018 by John Wiley & Sons. No part of this Instructor's Manual may be reproduced or distributed in any form or by any means without the written consent of the publisher. The publisher hereby limits distribution to instructors who have adopted the corresponding Meriam/Kraige/Bolton textbook. This material is written for instructors and is not intended for students.

2/12

$$R_x = \Sigma F_x = 400 + 400 \cos 60^\circ = 600 \text{ N}$$

$$R_y = \Sigma F_y = 400 \sin 60^\circ = 346 \text{ N}$$

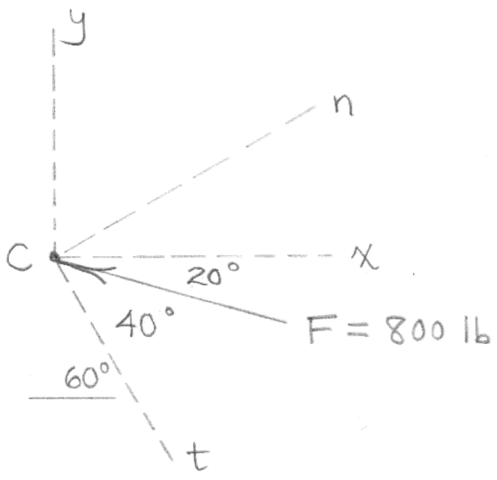
$$\Rightarrow \underline{R} = 600\underline{i} + 346\underline{j} \text{ N}$$

$$R = \sqrt{600^2 + 346^2} = \underline{693 \text{ N}}$$

WILEY

©2018 by John Wiley & Sons. No part of this Instructor's Manual may be reproduced or distributed in any form or by any means without the written consent of the publisher. The publisher hereby limits distribution to instructors who have adopted the corresponding Meriam/Kraige/Bolton textbook. This material is written for instructors and is not intended for students.

2/13



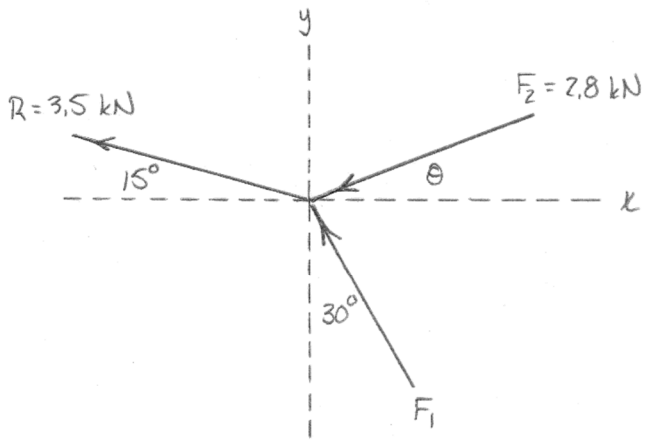
$$\begin{cases} F_x = -800 \cos 20^\circ = \underline{-752 \text{ lb}} \\ F_y = 800 \sin 20^\circ = \underline{274 \text{ lb}} \end{cases}$$

$$\begin{cases} F_n = -800 \sin 40^\circ = \underline{-514 \text{ lb}} \\ F_t = -800 \cos 40^\circ = \underline{-613 \text{ lb}} \end{cases}$$

WILEY

©2018 by John Wiley & Sons. No part of this Instructor's Manual may be reproduced or distributed in any form or by any means without the written consent of the publisher. The publisher hereby limits distribution to instructors who have adopted the corresponding Meriam/Kraige/Bolton textbook. This material is written for instructors and is not intended for students.

2/14



$$\begin{cases} R_x = \Sigma F_x: & -3.5\cos 15^\circ = -F_1 \sin 30^\circ - 2.8\cos\theta \quad (1) \\ R_y = \Sigma F_y: & 3.5\sin 15^\circ = F_1\cos 30^\circ - 2.8\sin\theta \quad (2) \end{cases}$$

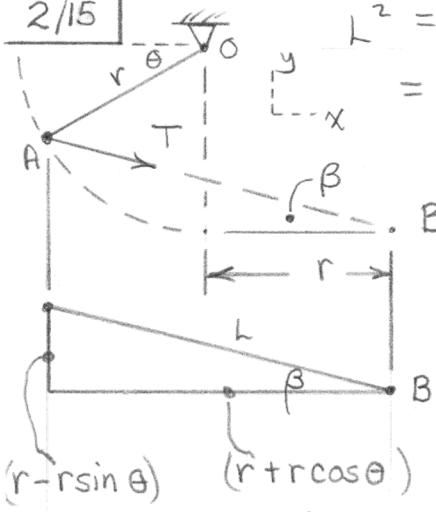
SOLVING (1) AND (2)...

$$\begin{cases} F_1 = 1.165 \text{ kN} \\ \theta = 2.11^\circ \end{cases} \quad \text{OR} \quad \begin{cases} F_1 = 3.78 \text{ kN} \\ \theta = 52.9^\circ \end{cases}$$

WILEY

©2018 by John Wiley & Sons. No part of this Instructor's Manual may be reproduced or distributed in any form or by any means without the written consent of the publisher. The publisher hereby limits distribution to instructors who have adopted the corresponding Meriam/Kraige/Bolton textbook. This material is written for instructors and is not intended for students.

2/15



$$L^2 = (r - r\sin\theta)^2 + (r + r\cos\theta)^2$$

$$= r^2 - 2r^2\sin\theta + r^2\sin^2\theta + r^2 + 2r^2\cos\theta + r^2\cos^2\theta$$

$$= r^2(3 + 2\cos\theta - 2\sin\theta)$$

So $\cos\beta = \dfrac{r(1+\cos\theta)}{r\sqrt{3+2\cos\theta-2\sin\theta}}$

$$= \frac{1+\cos\theta}{\sqrt{3+2\cos\theta-2\sin\theta}}$$

$$\sin\beta = \frac{1-\sin\theta}{\sqrt{3+2\cos\theta-2\sin\theta}}$$

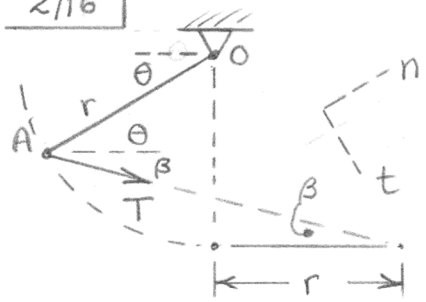
$$T_x = T\cos\beta = \frac{T(1+\cos\theta)}{\sqrt{3+2\cos\theta-2\sin\theta}}$$

$$T_y = -T\sin\beta = \frac{T(\sin\theta-1)}{\sqrt{3+2\cos\theta-2\sin\theta}}$$

WILEY

©2018 by John Wiley & Sons. No part of this Instructor's Manual may be reproduced or distributed in any form or by any means without the written consent of the publisher. The publisher hereby limits distribution to instructors who have adopted the corresponding Meriam/Kraige/Bolton textbook. This material is written for instructors and is not intended for students.

2/116



From solution to previous problem:

$$\beta = \tan^{-1}\left[\frac{1-\sin\theta}{1+\cos\theta}\right]$$

$$\begin{cases} T_n = T\cos(\theta+\beta) \\ T_t = T\sin(\theta+\beta) \end{cases}$$

For $T = 100$ N and $\theta = 35°$:

$\beta = 13.19°$

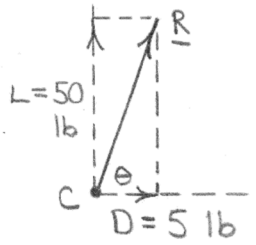
$$\begin{cases} T_n = 66.7 \text{ N} \\ T_t = 74.5 \text{ N} \end{cases}$$

WILEY

©2018 by John Wiley & Sons. No part of this Instructor's Manual may be reproduced or distributed in any form or by any means without the written consent of the publisher. The publisher hereby limits distribution to instructors who have adopted the corresponding Meriam/Kraige/Bolton textbook. This material is written for instructors and is not intended for students.

2/17

$$\frac{L}{D} = \frac{50}{D} = 10 \; ; \quad D = 5 \text{ lb}$$



$$R = \sqrt{L^2 + D^2} = \sqrt{50^2 + 5^2}$$

$$= \underline{50.2 \text{ lb}}$$

$$\theta = \tan^{-1}\left(\frac{L}{D}\right) = \tan^{-1}\left(\frac{50}{5}\right)$$

$$= \underline{84.3^\circ}$$

WILEY

©2018 by John Wiley & Sons. No part of this Instructor's Manual may be reproduced or distributed in any form or by any means without the written consent of the publisher. The publisher hereby limits distribution to instructors who have adopted the corresponding Meriam/Kraige/Bolton textbook. This material is written for instructors and is not intended for students.

2/18 Using the coordinates of the problem figure:

$$R_x = \Sigma F_x = 200 \cos 35^\circ - 150 \sin 30^\circ$$
$$= 88.8 \text{ N}$$

$$R_y = \Sigma F_y = 200 \sin 35^\circ + 150 \cos 30^\circ$$
$$= 245 \text{ N}$$

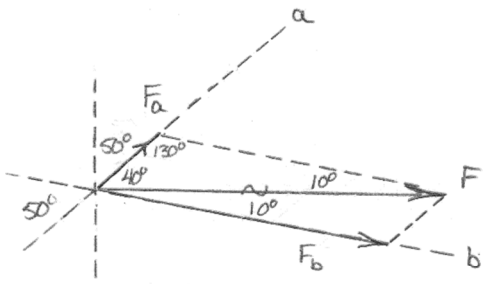
$$\therefore \underline{R} = 88.8\underline{i} + 245\underline{j} \text{ N}$$

WILEY

©2018 by John Wiley & Sons. No part of this Instructor's Manual may be reproduced or distributed in any form or by any means without the written consent of the publisher. The publisher hereby limits distribution to instructors who have adopted the corresponding Meriam/Kraige/Bolton textbook. This material is written for instructors and is not intended for students.

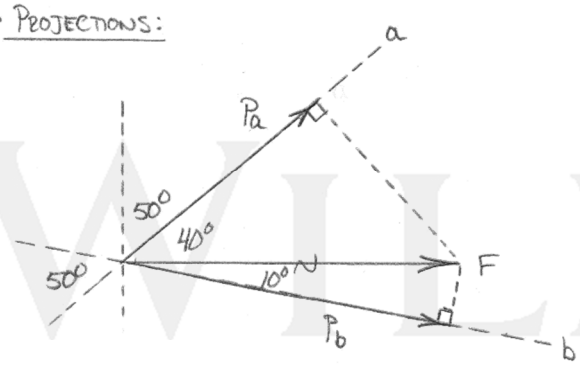
2/19 $F = 2.5$ kN

• COMPONENTS:



$$\frac{F}{\sin 130^\circ} = \frac{F_a}{\sin 10^\circ} = \frac{F_b}{\sin 40^\circ} \longrightarrow \begin{cases} F_a = 0.567 \text{ kN} \\ F_b = 2.10 \text{ kN} \end{cases}$$

• PROJECTIONS:

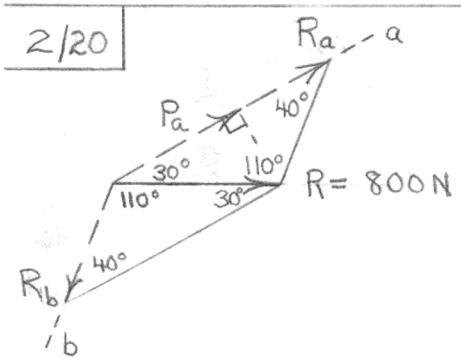


$$\begin{cases} P_a = F\cos 40^\circ = 2.5\cos 40^\circ \longrightarrow P_a = 1.915 \text{ kN} \\ P_b = F\cos 10^\circ = 2.5\cos 10^\circ \longrightarrow P_b = 2.46 \text{ kN} \end{cases}$$

Engineering Mechanics Statics 9th edition Meriam Solutions Manual

©2018 by John Wiley & Sons. No part of this Instructor's Manual may be reproduced or distributed in any form or by any means without the written consent of the publisher. The publisher hereby limits distribution to instructors who have adopted the corresponding Meriam/Kraige/Bolton textbook. This material is written for instructors and is not intended for students.

2/20



Law of sines:

$$\frac{800}{\sin 40^\circ} = \frac{R_a}{\sin 110^\circ} = \frac{R_b}{\sin 30^\circ}$$

$$R_a = 1170 \text{ N}$$

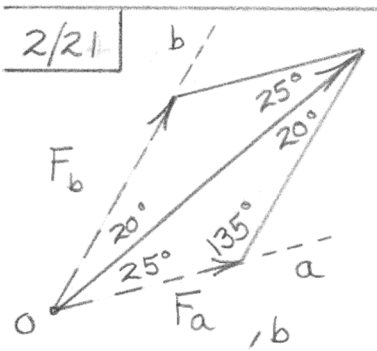
$$R_b = 622 \text{ N}$$

Projection $P_a = R\cos 30^\circ = 800 \cos 30^\circ = 693$ N

WILEY

©2018 by John Wiley & Sons. No part of this Instructor's Manual may be reproduced or distributed in any form or by any means without the written consent of the publisher. The publisher hereby limits distribution to instructors who have adopted the corresponding Meriam/Kraige/Bolton textbook. This material is written for instructors and is not intended for students.

2/21

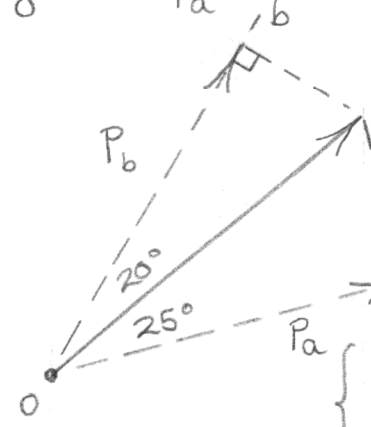


$F = 4$ kN

Components:

$$\frac{\sin 135^\circ}{4} = \frac{\sin 20^\circ}{F_a}, \quad F_a = 1.935 \text{ kN}$$

$$\frac{\sin 135^\circ}{4} = \frac{\sin 25^\circ}{F_b}, \quad F_b = 2.39 \text{ kN}$$



$F = 4$ kN

Projections:

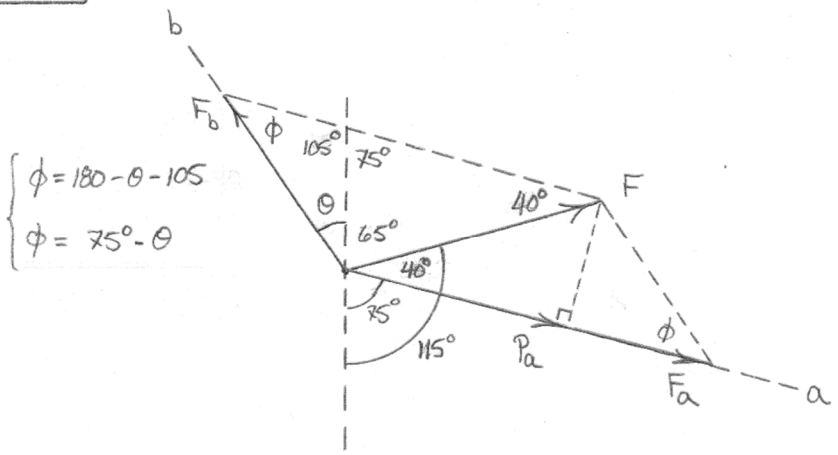
$$P_a = 4\cos 25^\circ = 3.63 \text{ kN}$$

$$P_b = 4\cos 20^\circ = 3.76 \text{ kN}$$

WILEY

©2018 by John Wiley & Sons. No part of this Instructor's Manual may be reproduced or distributed in any form or by any means without the written consent of the publisher. The publisher hereby limits distribution to instructors who have adopted the corresponding Meriam/Kraige/Bolton textbook. This material is written for instructors and is not intended for students.

2/22



$\phi = 180 - \theta - 105$

$\phi = 75° - \theta$

$P_a = F\cos 40° \rightarrow 325 = F\cos 40° \rightarrow \underline{F = 424\ \text{N}}$

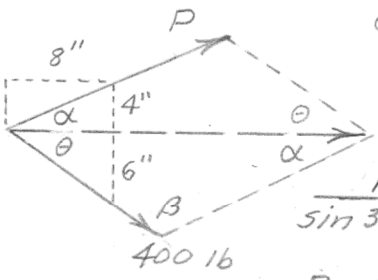
$$\frac{F}{\sin\phi} = \frac{F_b}{\sin 40°} \rightarrow \frac{424}{\sin(75°-\theta)} = \frac{325}{\sin 40°}$$

SOLVING THIS YIELDS ... $\underline{\theta = 17.95° \text{ OR } -48.0°}$

WILEY

©2018 by John Wiley & Sons. No part of this Instructor's Manual may be reproduced or distributed in any form or by any means without the written consent of the publisher. The publisher hereby limits distribution to instructors who have adopted the corresponding Meriam/Kraige/Bolton textbook. This material is written for instructors and is not intended for students.

2/23



$\alpha = \tan^{-1}\frac{4}{8} = 26.57°$

$\theta = \tan^{-1}\frac{16}{8} = 36.87°$

$\beta = 180 - (\alpha + \theta) = 116.57°$

$$\frac{P}{\sin 36.87°} = \frac{400}{\sin 26.57°}$$

$$P = 400\,\frac{0.6}{0.4472} = \underline{537 \text{ lb}}$$

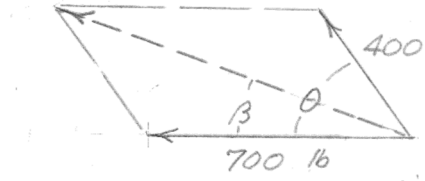
$$\frac{T}{\sin 116.56°} = \frac{400}{\sin 26.57°}, \quad T = 400\,\frac{0.8944}{0.4472} = \underline{800 \text{ lb}}$$

WILEY

©2018 by John Wiley & Sons. No part of this Instructor's Manual may be reproduced or distributed in any form or by any means without the written consent of the publisher. The publisher hereby limits distribution to instructors who have adopted the corresponding Meriam/Kraige/Bolton textbook. This material is written for instructors and is not intended for students.

2/24 Law of cosines: $\overline{1000}^2 = \overline{400}^2 + \overline{700}^2 + 2(400)(700)\cos\theta$

$\cos\theta = 0.6250, \quad \theta = 51.3°$



Law of sines:

$$\frac{1000}{\sin(180 - 51.3)°} = \frac{400}{\sin\beta}$$

$$\sin\beta = \frac{400}{1000}\,0.7806 = 0.312$$

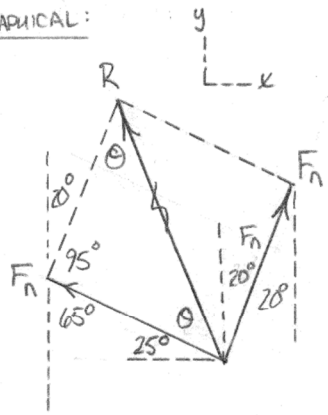
$$\beta = 18.19°$$

WILEY

©2018 by John Wiley & Sons. No part of this Instructor's Manual may be reproduced or distributed in any form or by any means without the written consent of the publisher. The publisher hereby limits distribution to instructors who have adopted the corresponding Meriam/Kraige/Bolton textbook. This material is written for instructors and is not intended for students.

2/25

• GRAPHICAL:



$$R = \sqrt{F_n^2 + F_n^2 - 2F_n^2 \cos 95^\circ}$$

$$R = \sqrt{2(5500)^2[1 - \cos 95^\circ]}$$

$$R = 8110 \text{ N}$$

$$\theta = \frac{180^\circ - 95^\circ}{2} \longrightarrow \theta = 42.5^\circ$$

$$R = 8110 \text{ N} \ @ \ 112.5^\circ \text{ CCW FROM } +x \text{ AXIS}$$

• VECTORS:

$$\underline{R} = (F_n \sin 20^\circ - F_n \sin 65^\circ)\underline{i} + (F_n \cos 20^\circ + F_n \cos 65^\circ)\underline{j}$$

$$\underline{R} = 5500[(\sin 20^\circ - \sin 65^\circ)\underline{i} + (\cos 20^\circ + \cos 65^\circ)\underline{j}]$$

$$\underline{R} = -3100\underline{i} + 7490\underline{j} \text{ N}$$

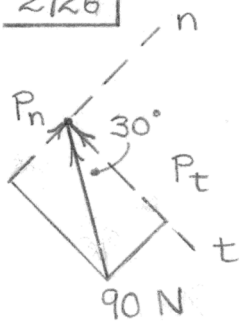
$$R = \sqrt{3100^2 + 7490^2} \longrightarrow R = 8110 \text{ N}$$

$$\theta_x = \cos^{-1}\left(\frac{R_x}{R}\right) = \cos^{-1}\left(\frac{-3100}{8110}\right) \longrightarrow \theta_x = 112.5^\circ \text{ CCW FROM } +x \text{ AXIS}$$

WILEY

©2018 by John Wiley & Sons. No part of this Instructor's Manual may be reproduced or distributed in any form or by any means without the written consent of the publisher. The publisher hereby limits distribution to instructors who have adopted the corresponding Meriam/Kraige/Bolton textbook. This material is written for instructors and is not intended for students.

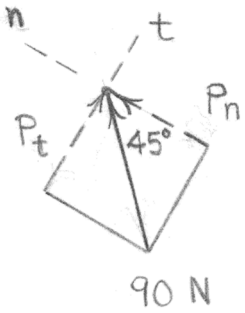
2/26



BC

$P_t = -90 \cos 30° = -77.9$ N

$P_n = 90 \sin 30° = 45.0$ N



AB

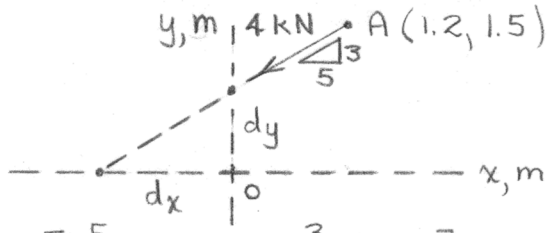
$P_t = 90 \sin 45° = 63.6$ N

$P_n = 90 \cos 45° = 63.6$ N

WILEY

©2018 by John Wiley & Sons. No part of this Instructor's Manual may be reproduced or distributed in any form or by any means without the written consent of the publisher. The publisher hereby limits distribution to instructors who have adopted the corresponding Meriam/Kraige/Bolton textbook. This material is written for instructors and is not intended for students.

2/27



$\curvearrowleft + \quad M_O = 4\left[\frac{5}{\sqrt{34}}(1.5) - \frac{3}{\sqrt{34}}(1.2)\right] = \underline{2.68 \text{ kN·m}}$

As a vector, $\underline{\mathbf{M}_O = 2.68\mathbf{k} \text{ kN·m}}$

$\frac{1.5}{d_x + 1.2} = \frac{3}{5}, \quad d_x = 1.3 \text{ m}$

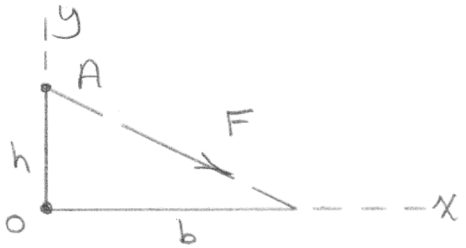
$\frac{d_y}{1.3} = \frac{3}{5}, \quad d_y = 0.78 \text{ m}$

Coordinates of intercepts (in m): $\underline{(-1.3, 0), (0, 0.78)}$

WILEY

©2018 by John Wiley & Sons. No part of this Instructor's Manual may be reproduced or distributed in any form or by any means without the written consent of the publisher. The publisher hereby limits distribution to instructors who have adopted the corresponding Meriam/Kraige/Bolton textbook. This material is written for instructors and is not intended for students.

2/28



$$\underline{F} = F\left[\frac{b\underline{i} - h\underline{j}}{\sqrt{b^2+h^2}}\right]$$

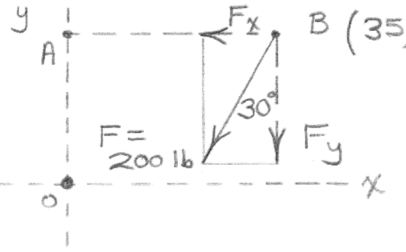
Acting at A:

$$+\circlearrowright M_O = \frac{Fb}{\sqrt{h^2+b^2}}(h) = \frac{Fbh}{\sqrt{h^2+b^2}} \quad \text{CW}$$

WILEY

©2018 by John Wiley & Sons. No part of this Instructor's Manual may be reproduced or distributed in any form or by any means without the written consent of the publisher. The publisher hereby limits distribution to instructors who have adopted the corresponding Meriam/Kraige/Bolton textbook. This material is written for instructors and is not intended for students.

2/29



$|F_x| = 200 \sin 30°$
$= 100$ lb

$|F_y| = 200 \cos 30°$
$= 173.2$ lb

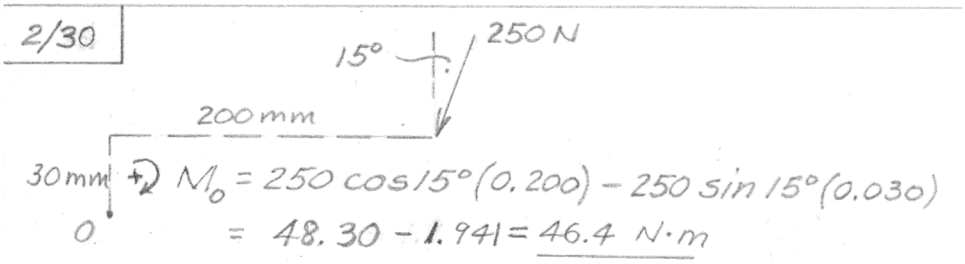
$+\circlearrowright M_A = 173.2(35) = 6060$ lb-in. $(505$ lb-ft$)$ CW

$+\circlearrowright M_O = 173.2(35) - 100(25)$
$= 3560$ lb-in. $(297$ lb-ft$)$ CW

WILEY

©2018 by John Wiley & Sons. No part of this Instructor's Manual may be reproduced or distributed in any form or by any means without the written consent of the publisher. The publisher hereby limits distribution to instructors who have adopted the corresponding Meriam/Kraige/Bolton textbook. This material is written for instructors and is not intended for students.

2/30



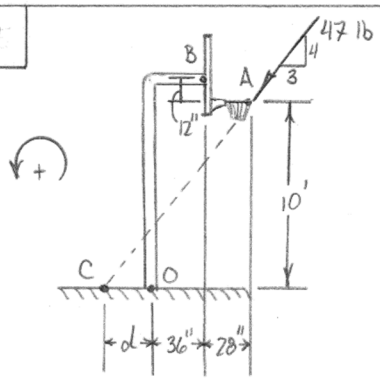
$$\curvearrowleft + M_O = 250\cos 15°(0.200) - 250\sin 15°(0.030)$$

$$= 48.30 - 1.941 = \underline{46.4\ \text{N·m}}$$

WILEY

©2018 by John Wiley & Sons. No part of this Instructor's Manual may be reproduced or distributed in any form or by any means without the written consent of the publisher. The publisher hereby limits distribution to instructors who have adopted the corresponding Meriam/Kraige/Bolton textbook. This material is written for instructors and is not intended for students.

2/31



a) $M_O = 10\left(\frac{3}{5}47\right) - \left(\frac{36+28}{12}\right)\left(\frac{4}{5}47\right) = \underline{81.5} \longrightarrow \underline{M_O = 81.5 \text{ lb-ft CCW}}$

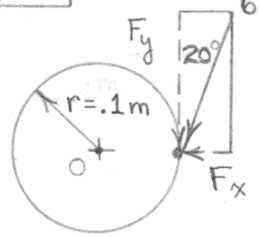
b) $M_B = -\frac{12}{12}\left(\frac{3}{5}47\right) - \frac{28}{12}\left(\frac{4}{5}47\right) = \underline{-115.9} \longrightarrow \underline{M_B = 115.9 \text{ lb-ft CW}}$

c) $M_C = 0 = 10\left(\frac{3}{5}47\right) - \left(\frac{36+28+d}{12}\right)\left(\frac{4}{5}47\right) \longrightarrow \underline{d = 26 \text{ in. LEFT OF O}}$

WILEY

©2018 by John Wiley & Sons. No part of this Instructor's Manual may be reproduced or distributed in any form or by any means without the written consent of the publisher. The publisher hereby limits distribution to instructors who have adopted the corresponding Meriam/Kraige/Bolton textbook. This material is written for instructors and is not intended for students.

2/32

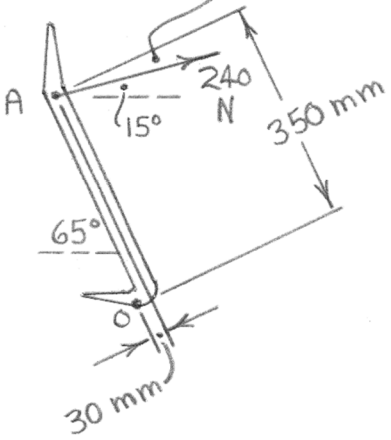


$$60\ \text{N} + \circlearrowleft M_O = r F_y$$
$$= (0.1)(60 \cos 20°)$$
$$= 5.64\ \text{N·m}$$

WILEY

©2018 by John Wiley & Sons. No part of this Instructor's Manual may be reproduced or distributed in any form or by any means without the written consent of the publisher. The publisher hereby limits distribution to instructors who have adopted the corresponding Meriam/Kraige/Bolton textbook. This material is written for instructors and is not intended for students.

2/33



$25° - 15° = 10°$

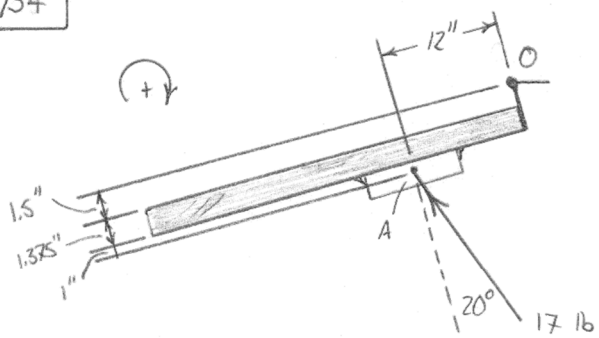
$+\circlearrowleft M_O = (240 \cos 10°)(0.350) + (240 \sin 10°)(0.030)$

$M_O = 84.0 \text{ N·m CW}$

WILEY

©2018 by John Wiley & Sons. No part of this Instructor's Manual may be reproduced or distributed in any form or by any means without the written consent of the publisher. The publisher hereby limits distribution to instructors who have adopted the corresponding Meriam/Kraige/Bolton textbook. This material is written for instructors and is not intended for students.

2/34



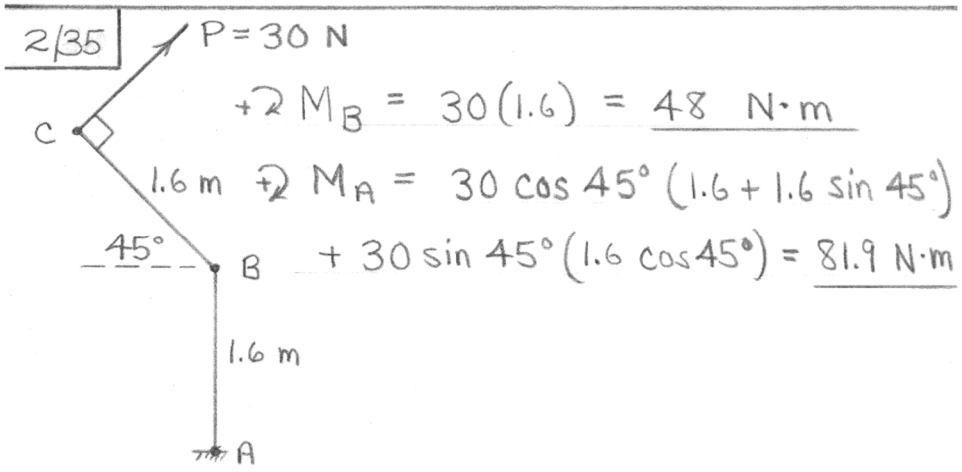
$$M_O = 12(17\cos 20^\circ) + (1 + 1.375 + 1.5)(17\sin 20^\circ)$$

$$M_O = 214 \text{ lb-in. CW}$$

WILEY

©2018 by John Wiley & Sons. No part of this Instructor's Manual may be reproduced or distributed in any form or by any means without the written consent of the publisher. The publisher hereby limits distribution to instructors who have adopted the corresponding Meriam/Kraige/Bolton textbook. This material is written for instructors and is not intended for students.

2/35



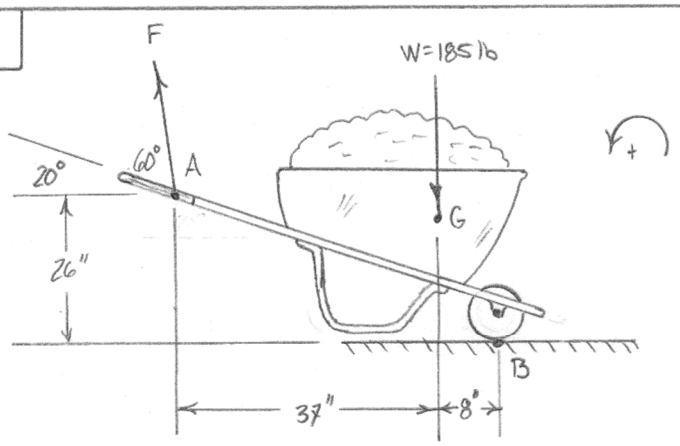
$+\circlearrowright M_B = 30(1.6) = 48 \text{ N·m}$

$+\circlearrowright M_A = 30\cos 45^\circ (1.6 + 1.6\sin 45^\circ) + 30\sin 45^\circ (1.6\cos 45^\circ) = 81.9 \text{ N·m}$

WILEY

©2018 by John Wiley & Sons. No part of this Instructor's Manual may be reproduced or distributed in any form or by any means without the written consent of the publisher. The publisher hereby limits distribution to instructors who have adopted the corresponding Meriam/Kraige/Bolton textbook. This material is written for instructors and is not intended for students.

2/36



$\Sigma M_B = 0$: $185(8) - F\sin(20°+60°)(37+8) + F\cos(20°+60°)(26) = 0$

$\therefore \quad F = 37.2 \text{ lb}$

WILEY

©2018 by John Wiley & Sons. No part of this Instructor's Manual may be reproduced or distributed in any form or by any means without the written consent of the publisher. The publisher hereby limits distribution to instructors who have adopted the corresponding Meriam/Kraige/Bolton textbook. This material is written for instructors and is not intended for students.

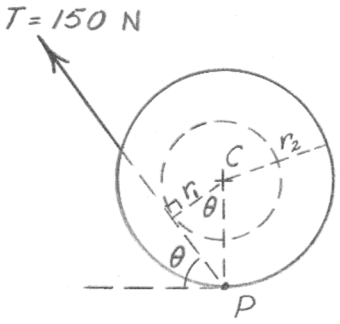
2/37

$\circlearrowleft M_C = Tr_1 = 150(0.125)$

$= \underline{18.75 \text{ N·m CW}}$

$\cos\theta = \frac{r_1}{r_2} = \frac{125}{200}$

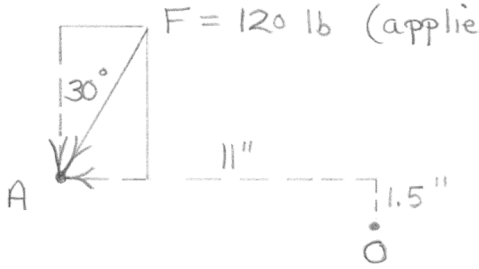
$\underline{\theta = 51.3^\circ}$



WILEY

©2018 by John Wiley & Sons. No part of this Instructor's Manual may be reproduced or distributed in any form or by any means without the written consent of the publisher. The publisher hereby limits distribution to instructors who have adopted the corresponding Meriam/Kraige/Bolton textbook. This material is written for instructors and is not intended for students.

2/38



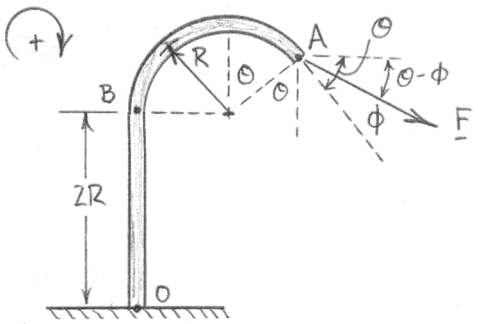
$$+\circlearrowleft M_O = 120\cos 30^\circ (11) + 120\sin 30^\circ (1.5)$$

$$= \underline{1233 \text{ lb-in.}} \text{ or } \underline{102.8 \text{ lb-ft CCW}}$$

WILEY

©2018 by John Wiley & Sons. No part of this Instructor's Manual may be reproduced or distributed in any form or by any means without the written consent of the publisher. The publisher hereby limits distribution to instructors who have adopted the corresponding Meriam/Kraige/Bolton textbook. This material is written for instructors and is not intended for students.

2/39



$$M_B = F\sin(\theta-\phi)(R+R\sin\theta) + F\cos(\theta-\phi)(R\cos\theta)$$

$$M_B = FR[\cos\phi + \sin(\theta-\phi)]$$

$$M_O = F\sin(\theta-\phi)(R+R\sin\theta) + F\cos(\theta-\phi)(2R+R\cos\theta)$$

$$M_O = FR[2\cos(\theta-\phi) + \cos\phi + \sin(\theta-\phi)]$$

IF $F = 750$ N, $R = 2.4$ m, $\theta = 30°$, AND $\phi = 15°$ ...

$$M_B = 2200 \text{ N·m CW}$$

$$M_O = 5680 \text{ N·m CW}$$

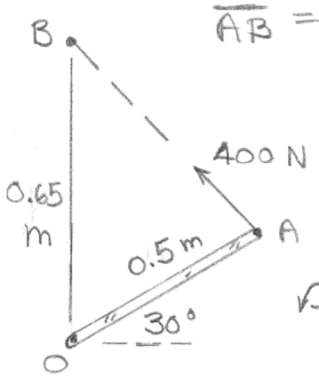
WILEY

©2018 by John Wiley & Sons. No part of this Instructor's Manual may be reproduced or distributed in any form or by any means without the written consent of the publisher. The publisher hereby limits distribution to instructors who have adopted the corresponding Meriam/Kraige/Bolton textbook. This material is written for instructors and is not intended for students.

2/40

$\overline{AB}^2 = 0.65^2 + 0.5^2 - 2(0.65)(0.5)\cos 60°$

$\overline{AB} = 0.589$ m



$\frac{\sin 60°}{\overline{AB}} = \frac{\sin \measuredangle OAB}{0.65}$

$\measuredangle OAB = 72.7°$

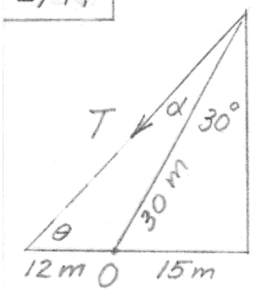
$+\circlearrowleft M_O = 0.5(400 \sin 72.7°)$

$= 191.0$ N·m CCW

WILEY

©2018 by John Wiley & Sons. No part of this Instructor's Manual may be reproduced or distributed in any form or by any means without the written consent of the publisher. The publisher hereby limits distribution to instructors who have adopted the corresponding Meriam/Kraige/Bolton textbook. This material is written for instructors and is not intended for students.

2/41



$$\theta = \tan^{-1}\frac{30(0.866)}{12+15} = 43.90^\circ$$

$$\alpha = 90^\circ - (30^\circ + 43.90^\circ) = 16.10^\circ$$

$$M_O = 72 \text{ kN·m}$$

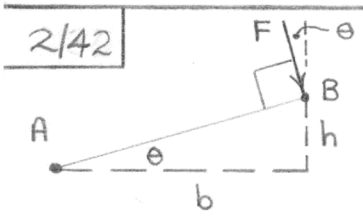
$$= T \sin 16.10^\circ (30) = 8.32T$$

$$T = \frac{72}{8.32} = \underline{8.65 \text{ kN}}$$

WILEY

©2018 by John Wiley & Sons. No part of this Instructor's Manual may be reproduced or distributed in any form or by any means without the written consent of the publisher. The publisher hereby limits distribution to instructors who have adopted the corresponding Meriam/Kraige/Bolton textbook. This material is written for instructors and is not intended for students.

2/42



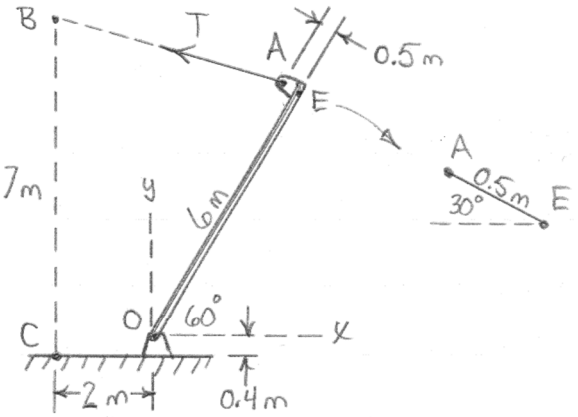
M_A is maximum when F is perpendicular to AB.

Thus $\theta = \tan^{-1}(h/b)$

WILEY

©2018 by John Wiley & Sons. No part of this Instructor's Manual may be reproduced or distributed in any form or by any means without the written consent of the publisher. The publisher hereby limits distribution to instructors who have adopted the corresponding Meriam/Kraige/Bolton textbook. This material is written for instructors and is not intended for students.

2/43 $T = 6.75$ kN



$$\underline{r}_{OA} = (6\cos 60^\circ - 0.5\cos 30^\circ)\underline{i} + (6\sin 60^\circ + 0.5\sin 30^\circ)\underline{j}$$

$$= 2.57\underline{i} + 5.45\underline{j} \text{ m}$$

$$\underline{r}_{OB} = -2\underline{i} + (7 - 0.4)\underline{j} = -2\underline{i} + 6.6\underline{j} \text{ m}$$

$$\underline{n}_{AB} = \frac{\underline{r}_{OB} - \underline{r}_{OA}}{|\underline{r}_{OB} - \underline{r}_{OA}|} \longrightarrow \underline{n}_{AB} = -0.970\underline{i} + 0.245\underline{j}$$

$$\underline{T} = T\underline{n}_{AB} = 6.75(-0.970\underline{i} + 0.245\underline{j}) = -6.54\underline{i} + 1.653\underline{j} \text{ kN}$$

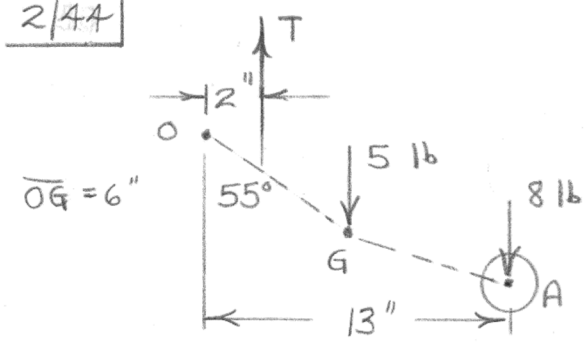
$$\underline{M}_O = \underline{r}_{OA} \times \underline{T} = (2.57\underline{i} + 5.45\underline{j}) \times (-6.54\underline{i} + 1.653\underline{j})$$

$$\underline{M}_O = 39.9\underline{k} \text{ kN·m}$$

WILEY

©2018 by John Wiley & Sons. No part of this Instructor's Manual may be reproduced or distributed in any form or by any means without the written consent of the publisher. The publisher hereby limits distribution to instructors who have adopted the corresponding Meriam/Kraige/Bolton textbook. This material is written for instructors and is not intended for students.

2/44



The combined moment about O of the 5-lb and 8-lb weights is

$$+\circlearrowright M_O = 5(6 \sin 55°) + 8(13) = 128.6 \text{ lb-in.} \quad (CW)$$

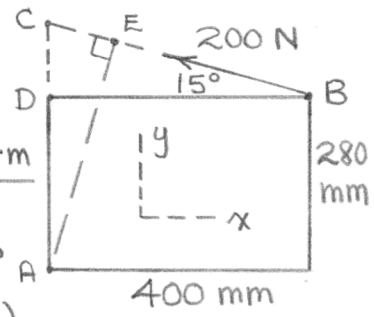
$$+\circlearrowright \Sigma M_O = 0: \quad -T(2) + 128.6 = 0$$

$$T = 64.3 \text{ lb}$$

WILEY

©2018 by John Wiley & Sons. No part of this Instructor's Manual may be reproduced or distributed in any form or by any means without the written consent of the publisher. The publisher hereby limits distribution to instructors who have adopted the corresponding Meriam/Kraige/Bolton textbook. This material is written for instructors and is not intended for students.

2/45



(1) $M_A = 200 \cos 15° (0.280) + 200 \sin 15° (0.400) = \underline{74.8 \text{ N·m}}$

(2) $AE = 0.280 \cos 15° + 0.400 \sin 15° = 0.374 \text{ m}$; $M_A = 200(0.374) = \underline{74.8 \text{ N·m}}$

(3) Apply force at C

$CD = 0.400 \tan 15° = 0.1072 \text{ m}$

$CA = 0.280 + 0.1072 = 0.387 \text{ m}$

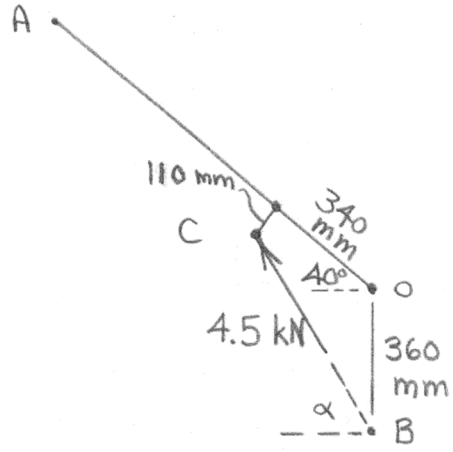
$M_A = (200 \cos 15°)(0.387) = \underline{74.8 \text{ N·m}}$

(4) $\underline{M}_A = \underline{r} \times \underline{F} = (0.400\underline{i} + 0.280\underline{j}) \times 200(-\cos 15°\underline{i} + \sin 15°\underline{j}) = \underline{74.8\underline{k} \text{ N·m}}$

WILEY

©2018 by John Wiley & Sons. No part of this Instructor's Manual may be reproduced or distributed in any form or by any means without the written consent of the publisher. The publisher hereby limits distribution to instructors who have adopted the corresponding Meriam/Kraige/Bolton textbook. This material is written for instructors and is not intended for students.

2/46



$$\alpha = \tan^{-1}\left[\frac{360 + 340\sin 40^\circ - 110\sin 50^\circ}{340\cos 40^\circ + 110\cos 50^\circ}\right]$$

$$= 56.2^\circ$$

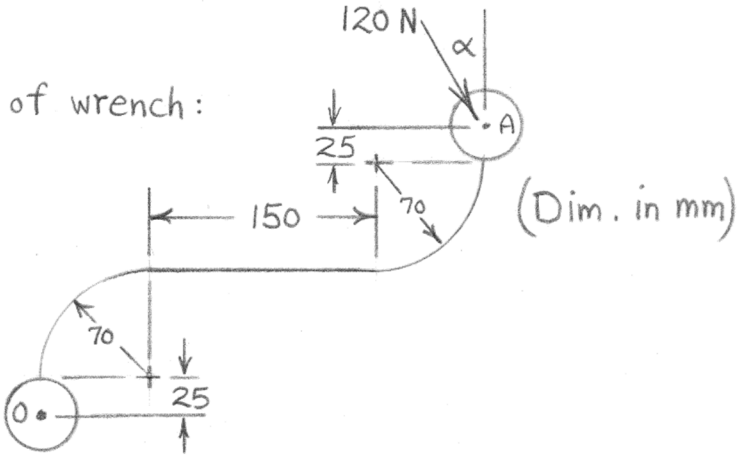
$$+\circlearrowright M_O = 4.5\,(0.360\cos 56.2^\circ) = \underline{0.902\ \text{kN}\cdot\text{m CW}}$$

WILEY

©2018 by John Wiley & Sons. No part of this Instructor's Manual may be reproduced or distributed in any form or by any means without the written consent of the publisher. The publisher hereby limits distribution to instructors who have adopted the corresponding Meriam/Kraige/Bolton textbook. This material is written for instructors and is not intended for students.

2/47

Elements of wrench:



$\alpha = 30°$:

$$+\circlearrowleft M_O = 120\cos 30°[70+150+70] + 120\sin 30°[25+70+70+25] = 41\,500 \text{ N·mm}$$

or $M_O = 41.5 \text{ N·m CW}$

For maximum M_O:

$$\alpha = \tan^{-1}\left[\frac{25+70+25+70}{70+150+70}\right] = 33.2°$$

$$(M_O)_{max} = 120\sqrt{(25+70+25+70)^2 + (70+150+70)^2}$$

$$= 41\,600 \text{ N·mm} \quad \text{or} \quad 41.6 \text{ N·m CW}$$

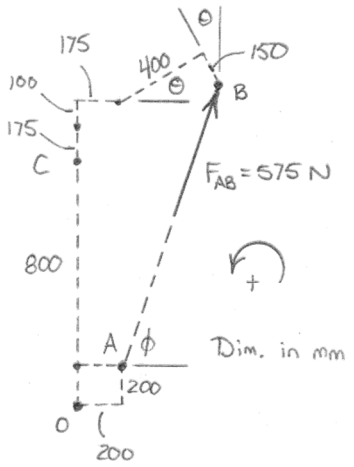
Engineering Mechanics Statics 9th edition Meriam Solutions Manual

©2018 by John Wiley & Sons. No part of this Instructor's Manual may be reproduced or distributed in any form or by any means without the written consent of the publisher. The publisher hereby limits distribution to instructors who have adopted the corresponding Meriam/Kraige/Bolton textbook. This material is written for instructors and is not intended for students.

2/48

$\theta = 30^\circ$

$$\phi = \text{TAN}^{-1}\left(\frac{800 + 175 + 100 + 400\sin\theta - 150\cos\theta}{175 + 400\cos\theta + 150\sin\theta - 200}\right) = 70.9^\circ$$



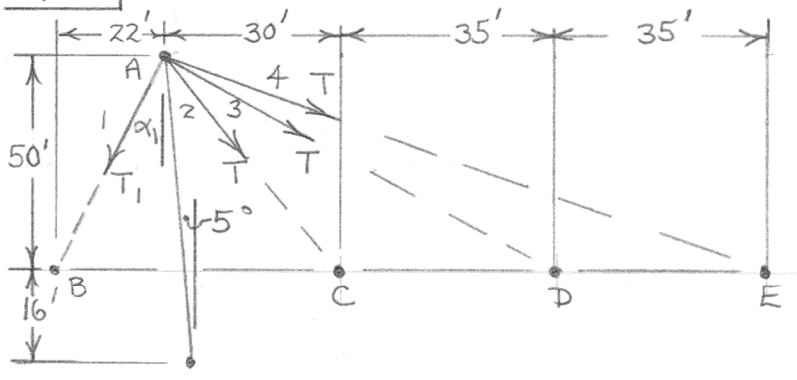
$$M_O = 575\sin\phi\,(0.200) - 575\cos\phi\,(0.200) \longrightarrow M_O = 71.1 \text{ N·m CCW}$$

$$M_C = 575\sin\phi\,(0.200) + 575\cos\phi\,(0.800) \longrightarrow M_C = 259 \text{ N·m CCW}$$

WILEY

©2018 by John Wiley & Sons. No part of this Instructor's Manual may be reproduced or distributed in any form or by any means without the written consent of the publisher. The publisher hereby limits distribution to instructors who have adopted the corresponding Meriam/Kraige/Bolton textbook. This material is written for instructors and is not intended for students.

2/49



$\alpha_1 = \tan^{-1}\frac{22}{50} = 23.7°$; Similarly, $\alpha_2 = 31.0°$, $\alpha_3 = 52.4°$, $\alpha_4 = 63.4°$ (all relative to vertical)

$$\circlearrowleft \Sigma M_O = 0: \left[T_1 \sin(\alpha_1 + 5°) - T\sin(\alpha_2 - 5°) - T\sin(\alpha_3 - 5°) - T\sin(\alpha_4 - 5°)\right]\frac{50+16}{\cos 5°} = 0$$

$$T_1 = 4.21T$$

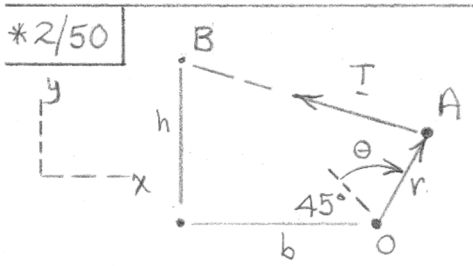
$$+\downarrow \Sigma F = P = T_1\cos(\alpha_1 + 5°) + T\left[\cos(\alpha_2 - 5°) + \cos(\alpha_3 - 5°) + \cos(\alpha_4 - 5°)\right]$$

$$\text{or } P = 5.79T \quad \text{(with } T_1 = 4.21T\text{)}$$

WILEY

©2018 by John Wiley & Sons. No part of this Instructor's Manual may be reproduced or distributed in any form or by any means without the written consent of the publisher. The publisher hereby limits distribution to instructors who have adopted the corresponding Meriam/Kraige/Bolton textbook. This material is written for instructors and is not intended for students.

***2/50**



$$\underline{M}_O = \underline{r}_{OA} \times \underline{T}$$

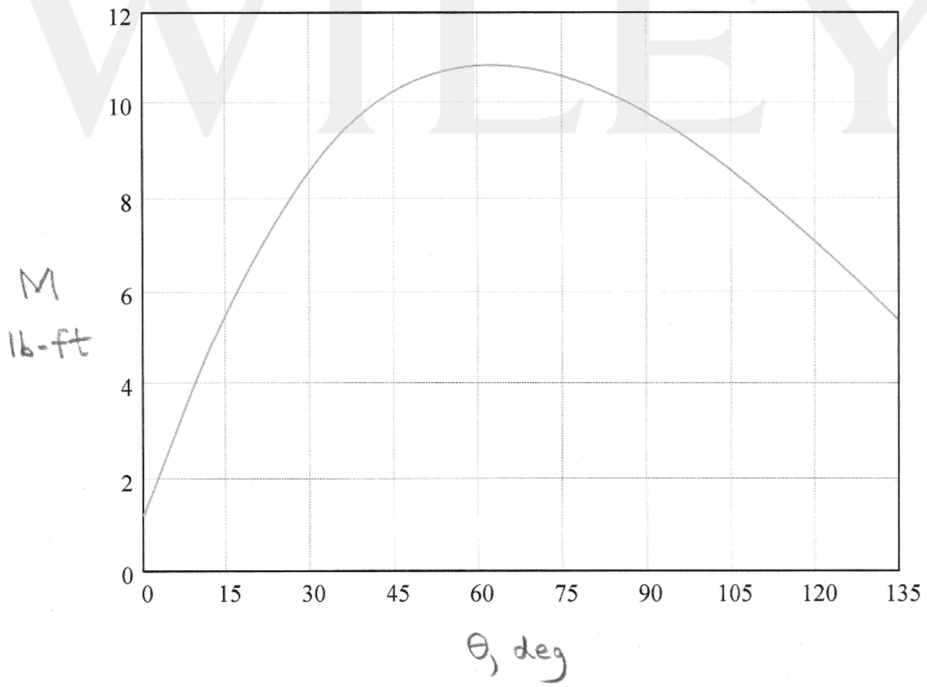
$$\underline{r}_{OA} = r\left[-\cos(\theta+45^\circ)\,\underline{i} + \sin(\theta+45^\circ)\,\underline{j}\right]$$

$\underline{T} = T\underline{n}_{AB}$, where

$$\underline{n}_{AB} = \frac{[-b + r\cos(\theta+45^\circ)]\,\underline{i} + [h - r\sin(\theta+45^\circ)]\,\underline{j}}{\{[-b + r\cos(\theta+45^\circ)]^2 + [h - \sin(\theta+45^\circ)]^2\}^{1/2}}$$

With $r = \frac{13}{12}$ ft, $h = \frac{21}{12}$ ft, $b = \frac{24}{12}$ ft, and $T = 10$ lb, vary θ and take the z-comp. of $\underline{M}_O$ to obtain the following plot.

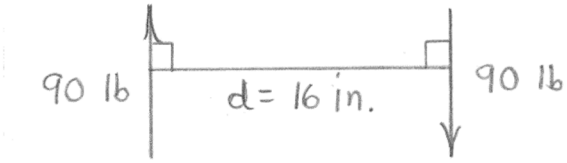
Note that $M_{max} = 10.83$ lb-ft at $\theta = 62.1^\circ$



Engineering Mechanics Statics 9th edition Meriam Solutions Manual

©2018 by John Wiley & Sons. No part of this Instructor's Manual may be reproduced or distributed in any form or by any means without the written consent of the publisher. The publisher hereby limits distribution to instructors who have adopted the corresponding Meriam/Kraige/Bolton textbook. This material is written for instructors and is not intended for students.

2/51 $\circlearrowright + \quad M = M_O = M_A = Fd = 90(16) = 1440$ lb-in. CW



WILEY

©2018 by John Wiley & Sons. No part of this Instructor's Manual may be reproduced or distributed in any form or by any means without the written consent of the publisher. The publisher hereby limits distribution to instructors who have adopted the corresponding Meriam/Kraige/Bolton textbook. This material is written for instructors and is not intended for students.

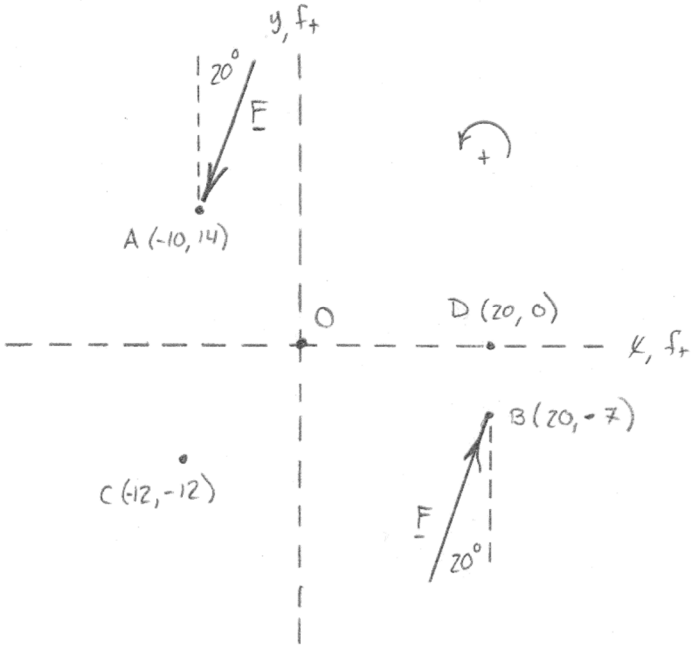
2/52 $+\circlearrowright M = Fd = 80(1.4) = 112$ lb-in. CW

(or 9.33 lb-ft CW)

WILEY

©2018 by John Wiley & Sons. No part of this Instructor's Manual may be reproduced or distributed in any form or by any means without the written consent of the publisher. The publisher hereby limits distribution to instructors who have adopted the corresponding Meriam/Kraige/Bolton textbook. This material is written for instructors and is not intended for students.

2/53 $F = 65$ lb



a) $M_O = 65 \cos 20^\circ (20 + 10) + 65 \sin 20^\circ (14 + 7)$

$M_O = 2300$ lb-ft CCW

b) By inspection... $M_C = 2300$ lb-ft CCW

c) By inspection... $M_D = 2300$ lb-ft CCW

WILEY

©2018 by John Wiley & Sons. No part of this Instructor's Manual may be reproduced or distributed in any form or by any means without the written consent of the publisher. The publisher hereby limits distribution to instructors who have adopted the corresponding Meriam/Kraige/Bolton textbook. This material is written for instructors and is not intended for students.

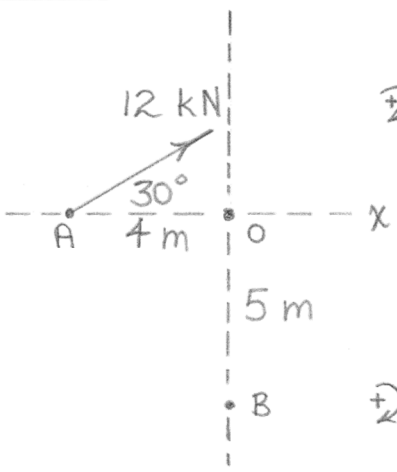
2/54 $\underline{R} = 6\underline{j}$ kN @ $x = \frac{400}{6000} = 0.0667$ m

or $x = 66.7$ mm

WILEY

©2018 by John Wiley & Sons. No part of this Instructor's Manual may be reproduced or distributed in any form or by any means without the written consent of the publisher. The publisher hereby limits distribution to instructors who have adopted the corresponding Meriam/Kraige/Bolton textbook. This material is written for instructors and is not intended for students.

2/55



At O:

$F = 12\ \text{kN}\ \angle 30°$

$\circlearrowleft + \sum M_O = (12 \sin 30°)(4)$

$= 24\ \text{kN·m CW}$

At B:

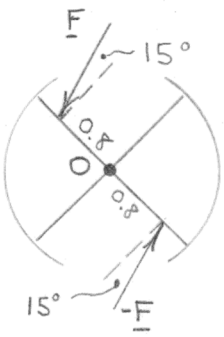
$F = 12\ \text{kN}\ \angle 30°$

$\circlearrowleft + \sum M_B = (12 \sin 30°)(4) + (12 \cos 30°)(5) = 76.0\ \text{kN·m CW}$

WILEY

©2018 by John Wiley & Sons. No part of this Instructor's Manual may be reproduced or distributed in any form or by any means without the written consent of the publisher. The publisher hereby limits distribution to instructors who have adopted the corresponding Meriam/Kraige/Bolton textbook. This material is written for instructors and is not intended for students.

2/56



$$\curvearrowleft + M_O = \Sigma Fd$$

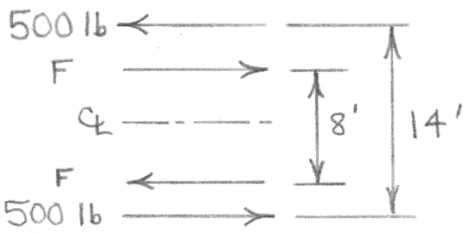
$$25 = 2F(\cos 15^\circ)(0.8)$$

$$F = \underline{16.18 \text{ N}}$$

WILEY

©2018 by John Wiley & Sons. No part of this Instructor's Manual may be reproduced or distributed in any form or by any means without the written consent of the publisher. The publisher hereby limits distribution to instructors who have adopted the corresponding Meriam/Kraige/Bolton textbook. This material is written for instructors and is not intended for students.

2/57



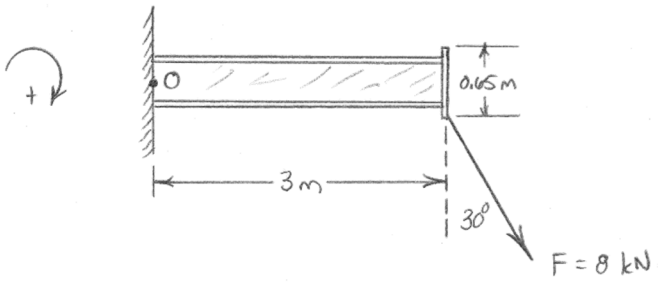
$\circlearrowleft + \sum M = 500(14) - F(8) = 0$

$F = 875 \text{ lb}$

WILEY

©2018 by John Wiley & Sons. No part of this Instructor's Manual may be reproduced or distributed in any form or by any means without the written consent of the publisher. The publisher hereby limits distribution to instructors who have adopted the corresponding Meriam/Kraige/Bolton textbook. This material is written for instructors and is not intended for students.

2/58



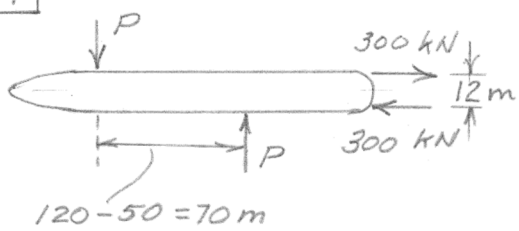
$F = 8$ kN @ 60° CW BELOW HORIZONTAL

$M_O = 8\cos 30^\circ (3) - 8 \sin 30^\circ \left(\frac{0.165}{2}\right) \longrightarrow M_O = 19.48$ kN·m CW

WILEY

©2018 by John Wiley & Sons. No part of this Instructor's Manual may be reproduced or distributed in any form or by any means without the written consent of the publisher. The publisher hereby limits distribution to instructors who have adopted the corresponding Meriam/Kraige/Bolton textbook. This material is written for instructors and is not intended for students.

2/59



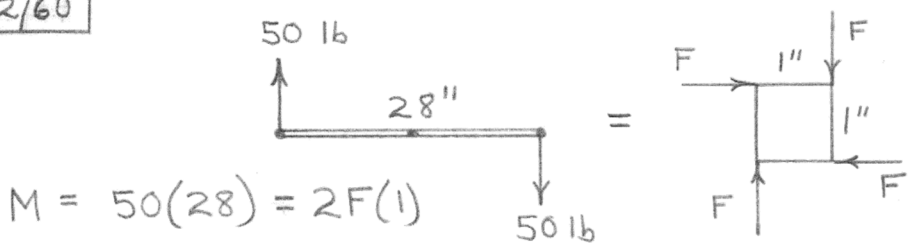
$70P = 300(12)$

$P = 51.4 \text{ kN}$

WILEY

©2018 by John Wiley & Sons. No part of this Instructor's Manual may be reproduced or distributed in any form or by any means without the written consent of the publisher. The publisher hereby limits distribution to instructors who have adopted the corresponding Meriam/Kraige/Bolton textbook. This material is written for instructors and is not intended for students.

2/60



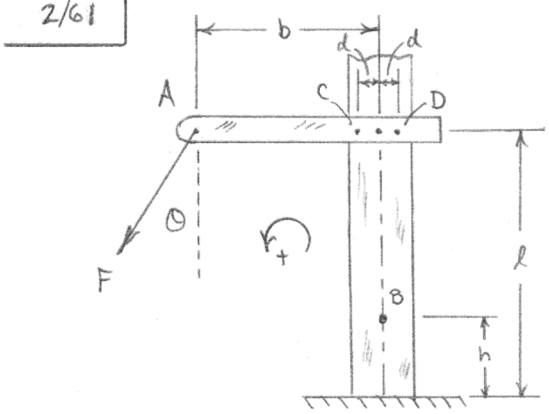
$M = 50(28) = 2F(1)$

$F = 700$ lb

WILEY

©2018 by John Wiley & Sons. No part of this Instructor's Manual may be reproduced or distributed in any form or by any means without the written consent of the publisher. The publisher hereby limits distribution to instructors who have adopted the corresponding Meriam/Kraige/Bolton textbook. This material is written for instructors and is not intended for students.

2/61



$F = 425\ N$
$\theta = 30°$
$b = 1.9\ m$
$d = 0.2\ m$
$h = 0.8\ m$
$l = 2.75\ m$

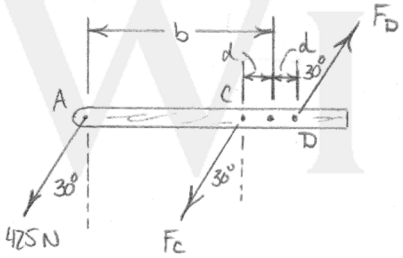
a) FORCE-COUPLE AT B:

$F = 425\ N$ @ $120°$ CW BELOW HORIZONTAL

$$M_B = F\cos\theta\, b + F\sin\theta\,(l-h) = 425\cos 30°(1.9) + 425\sin 30°(2.75-0.8)$$

$$\therefore M_B = 1114\ N\cdot m\ CCW$$

b) FORCES AT C AND D:



$$\Sigma F_{+\swarrow}: \quad F_C - F_D = 425$$

$$\Sigma M_A = 0: \quad F_d\cos 30°(b+d) - F_C\cos 30°(b-d) = 0$$

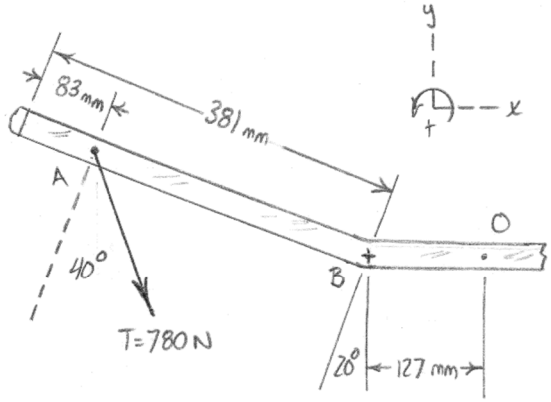
SOLVING...

$F_C = 2230\ N$ @ $120°$ CW BELOW HORIZONTAL

$F_D = 1806\ N$ @ $60°$ CCW ABOVE HORIZONTAL

©2018 by John Wiley & Sons. No part of this Instructor's Manual may be reproduced or distributed in any form or by any means without the written consent of the publisher. The publisher hereby limits distribution to instructors who have adopted the corresponding Meriam/Kraige/Bolton textbook. This material is written for instructors and is not intended for students.

2/62



$$\underline{T} = 780 \sin 20^\circ \underline{i} - 780 \cos 20^\circ \underline{j} \longrightarrow \underline{T} = 267 \underline{i} - 733 \underline{j} \text{ N}$$

$$\underline{M}_B = 780 \cos 40^\circ \left(\frac{381 - 83}{1000}\right) \underline{k} \longrightarrow \underline{M}_B = 178.1 \underline{k} \text{ N·m}$$

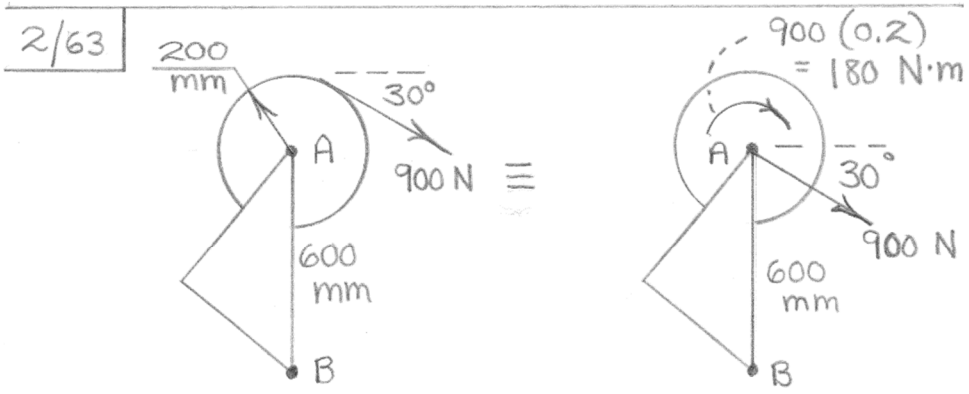
$$\underline{M}_O = \underline{M}_B + T \cos 20^\circ (\overline{OB}) = \left(178.1 + 780 \cos 20^\circ \left(\frac{127}{1000}\right)\right) \underline{k}$$

$$\therefore \underline{M}_O = 271 \hat{k} \text{ N·m}$$

WILEY

©2018 by John Wiley & Sons. No part of this Instructor's Manual may be reproduced or distributed in any form or by any means without the written consent of the publisher. The publisher hereby limits distribution to instructors who have adopted the corresponding Meriam/Kraige/Bolton textbook. This material is written for instructors and is not intended for students.

2/63

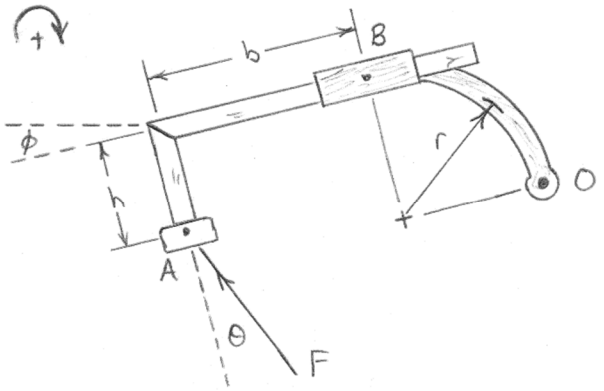


$$+\circlearrowleft M_B = 180 + 900 \cos 30^\circ (0.6) = \underline{648 \text{ N·m CW}}$$

WILEY

©2018 by John Wiley & Sons. No part of this Instructor's Manual may be reproduced or distributed in any form or by any means without the written consent of the publisher. The publisher hereby limits distribution to instructors who have adopted the corresponding Meriam/Kraige/Bolton textbook. This material is written for instructors and is not intended for students.

2/64 $b = 450\text{ mm}$, $h = 215\text{ mm}$, $r = 325\text{ mm}$, $F = 520\text{ N}$, $\theta = 15^\circ$, $\phi = 10^\circ$



$F = 520\text{ N}$ @ 115° CCW ABOVE HORIZONTAL

$$M_O = F\cos\theta(b+r) - F\sin\theta(r-h)$$

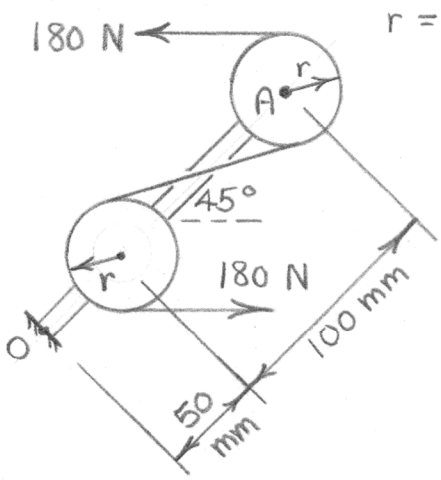
$$= 520\cos 15^\circ\left(\frac{450+325}{1000}\right) - 520\sin 15^\circ\left(\frac{325-215}{1000}\right)$$

$$\therefore M_O = 374\text{ N}\cdot\text{m CW}$$

WILEY

©2018 by John Wiley & Sons. No part of this Instructor's Manual may be reproduced or distributed in any form or by any means without the written consent of the publisher. The publisher hereby limits distribution to instructors who have adopted the corresponding Meriam/Kraige/Bolton textbook. This material is written for instructors and is not intended for students.

2/65



The system at O is a couple.

$$\curvearrowleft M = Fd = 180(100 \sin 45^\circ + 25 + 25)$$

$$= 21\,700 \text{ N·mm or } \underline{21.7 \text{ N·m CCW}}$$

WILEY

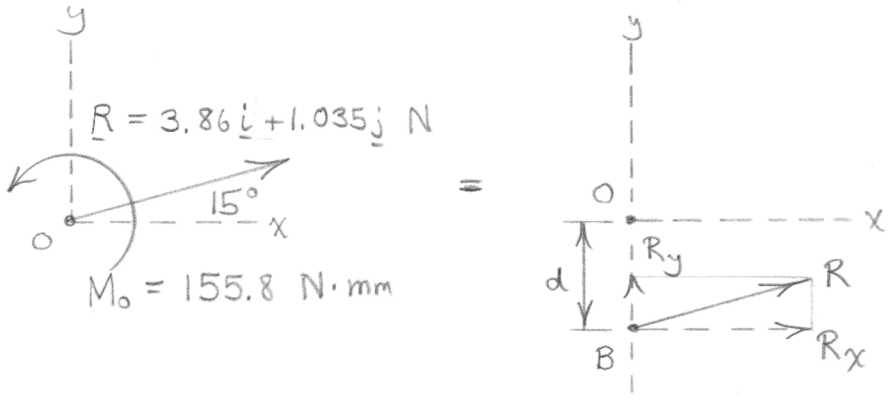
©2018 by John Wiley & Sons. No part of this Instructor's Manual may be reproduced or distributed in any form or by any means without the written consent of the publisher. The publisher hereby limits distribution to instructors who have adopted the corresponding Meriam/Kraige/Bolton textbook. This material is written for instructors and is not intended for students.

2/66 At O:

$$\underline{R} = 4(\cos 15^\circ \underline{i} + \sin 15^\circ \underline{j}) = 3.86\underline{i} + 1.035\underline{j} \text{ N}$$

$$\curvearrowleft + M_O = 300 - 4\cos 15^\circ (40) + 4\sin 15^\circ (10)$$

$$= 155.8 \text{ N·mm} \quad \text{CCW}$$



Condition: $R_x d = M_O$

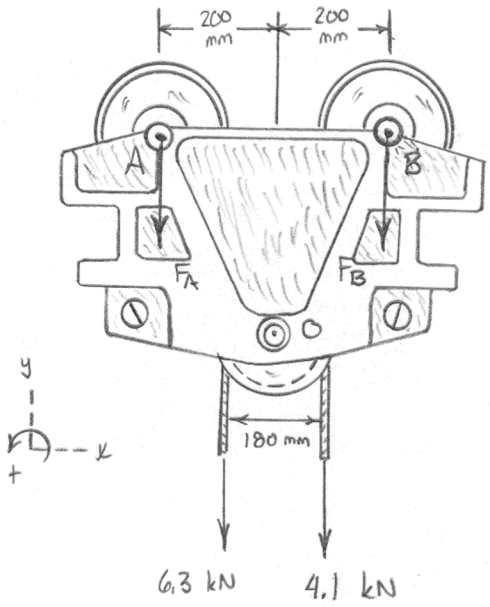
$$3.86\, d = 155.8, \quad d = 40.3 \text{ mm}$$

So $\underline{y = -40.3 \text{ mm}}$

WILEY

©2018 by John Wiley & Sons. No part of this Instructor's Manual may be reproduced or distributed in any form or by any means without the written consent of the publisher. The publisher hereby limits distribution to instructors who have adopted the corresponding Meriam/Kraige/Bolton textbook. This material is written for instructors and is not intended for students.

2/67



F_A & F_B ARE DOWN AT A & B.

$$\begin{cases} \Sigma F_y: & F_A + F_B = 6.3 + 4.1 \\ \Sigma M_O: & 200\,F_A - 200\,F_B = 90(6.3) - 90(4.1) \end{cases}$$

SOLVING...

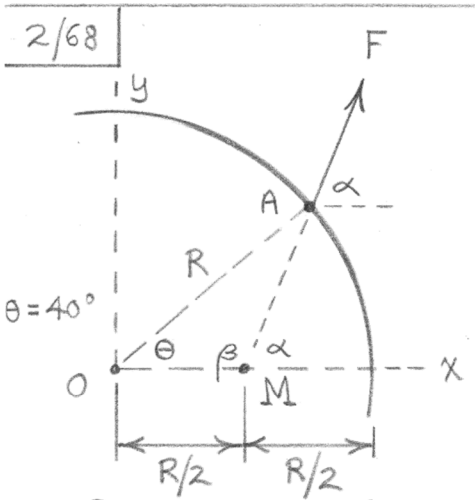
$$\begin{cases} F_A = 5.70 \text{ kN} \\ F_B = 4.70 \text{ kN} \end{cases}$$

(BOTH DOWN AS SHOWN)

WILEY

©2018 by John Wiley & Sons. No part of this Instructor's Manual may be reproduced or distributed in any form or by any means without the written consent of the publisher. The publisher hereby limits distribution to instructors who have adopted the corresponding Meriam/Kraige/Bolton textbook. This material is written for instructors and is not intended for students.

2/68



$$\overline{AM}^2 = R^2 + (R/2)^2 - 2(R)\left(\frac{R}{2}\right)\cos 40^\circ$$

$$= 0.484R^2, \quad \overline{AM} = 0.696R$$

$$\frac{\sin\beta}{R} = \frac{\sin 40^\circ}{0.696R}, \quad \beta = 112.5^\circ$$

$$\alpha = 180^\circ - \beta = 180^\circ - 112.5^\circ = 67.5^\circ$$

$$\curvearrowleft M_O = (F\sin\alpha)\frac{R}{2} = (F\sin 67.5^\circ)\frac{R}{2}$$

$$= 0.462FR$$

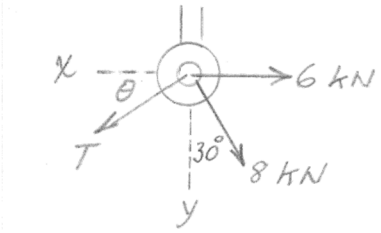
So the force-couple system for $\theta = 40^\circ$ is

$$\begin{cases} F \ \angle 67.5^\circ \\ M_O = 0.462FR \quad \text{CCW} \end{cases}$$

WILEY

©2018 by John Wiley & Sons. No part of this Instructor's Manual may be reproduced or distributed in any form or by any means without the written consent of the publisher. The publisher hereby limits distribution to instructors who have adopted the corresponding Meriam/Kraige/Bolton textbook. This material is written for instructors and is not intended for students.

2/69



$R = R_y = 15 = T\sin\theta + 8\cos 30°$

$R_x = 0 = T\cos\theta - 6 - 8\sin 30°$

So $T\sin\theta = 8.07$

$T\cos\theta = 10$

Divide & get $\theta = \tan\frac{8.07}{10}$

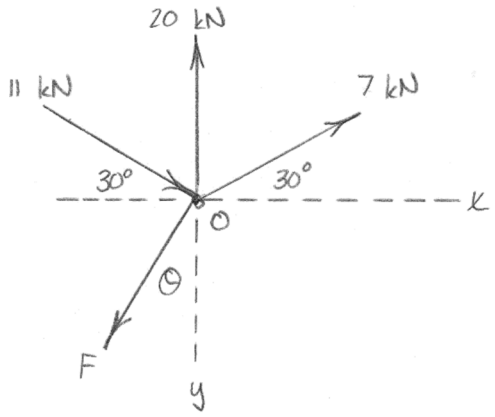
$\theta = 38.9°$

$T = \frac{10}{\cos 38.9°} = 12.85 \text{ kN}$

WILEY

©2018 by John Wiley & Sons. No part of this Instructor's Manual may be reproduced or distributed in any form or by any means without the written consent of the publisher. The publisher hereby limits distribution to instructors who have adopted the corresponding Meriam/Kraige/Bolton textbook. This material is written for instructors and is not intended for students.

2/70 $R = 9$ kN, RIGHTWARD



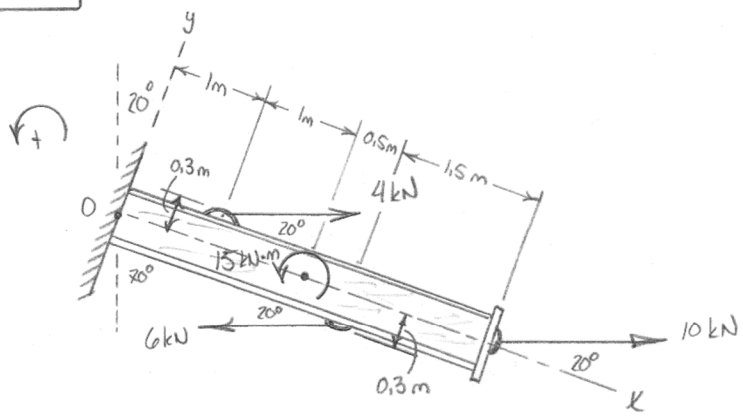
$$\begin{cases} R_x = 9 = 11\cos 30^\circ + 7\cos 30^\circ - F\sin\theta \\ R_y = 0 = 11\sin 30^\circ - 7\sin 30^\circ + F\cos\theta - 20 \end{cases}$$

SOLVING... $F = 19.17$ kN AND $\theta = 20.1^\circ$

WILEY

©2018 by John Wiley & Sons. No part of this Instructor's Manual may be reproduced or distributed in any form or by any means without the written consent of the publisher. The publisher hereby limits distribution to instructors who have adopted the corresponding Meriam/Kraige/Bolton textbook. This material is written for instructors and is not intended for students.

2/71



$$\begin{cases} R = 10 + 4 - 6 \longrightarrow R = 8\ \text{kN} \\ \underline{R} = 8\cos 20^\circ \underline{i} + 8\sin 20^\circ \underline{j} \longrightarrow \underline{R} = 7.52\,\underline{i} + 2.74\,\underline{j}\ \text{kN} \end{cases}$$

$$M_O = 15 + 4\sin 20^\circ(1) - 6\sin 20^\circ(2) + 10\sin 20^\circ(4) - 4\cos 20^\circ(0.3) - 6\cos 20^\circ(0.3)$$

$$\therefore \underline{M_O = 22.1\ \text{kN·m CCW}}$$

• LINE-OF-ACTION:

$$\underline{r} \times \underline{R} = \underline{M}_O \longrightarrow (x\,\underline{i} + y\,\underline{j}) \times (7.52\,\underline{i} + 2.74\,\underline{j}) = 22.1\,\underline{k}$$

$$\underline{k}: \quad 2.74x - 7.52y = 22.1$$

$$\therefore \quad \underline{y = 0.364x - 2.94\ (\text{m})}$$

WILEY

©2018 by John Wiley & Sons. No part of this Instructor's Manual may be reproduced or distributed in any form or by any means without the written consent of the publisher. The publisher hereby limits distribution to instructors who have adopted the corresponding Meriam/Kraige/Bolton textbook. This material is written for instructors and is not intended for students.

2/72 (a) $\underline{R} = -2F\underline{j}$, $\underline{M}_O = \underline{0}$

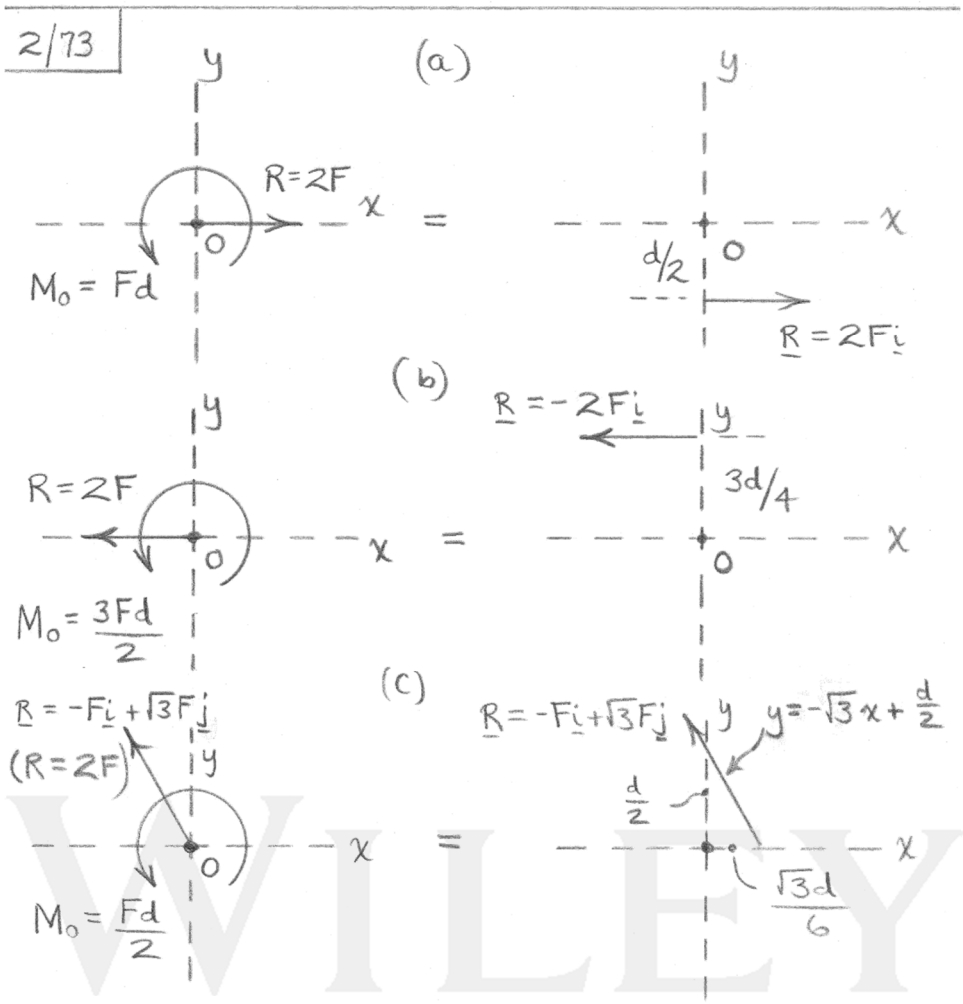
(b) $\underline{R} = \underline{0}$, $\underline{M}_O = Fd\underline{k}$ $(+\underline{k}$ is out$)$

(c) $\underline{R} = -F\underline{i} + F\underline{j}$, $\underline{M}_O = \underline{0}$

WILEY

©2018 by John Wiley & Sons. No part of this Instructor's Manual may be reproduced or distributed in any form or by any means without the written consent of the publisher. The publisher hereby limits distribution to instructors who have adopted the corresponding Meriam/Kraige/Bolton textbook. This material is written for instructors and is not intended for students.

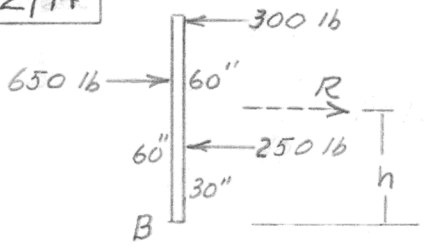
2/73



WILEY

©2018 by John Wiley & Sons. No part of this Instructor's Manual may be reproduced or distributed in any form or by any means without the written consent of the publisher. The publisher hereby limits distribution to instructors who have adopted the corresponding Meriam/Kraige/Bolton textbook. This material is written for instructors and is not intended for students.

2/174



$R = \Sigma F = 650 - 250 - 300$

$= 100 \text{ lb}$

$Rh = \Sigma M_B;$

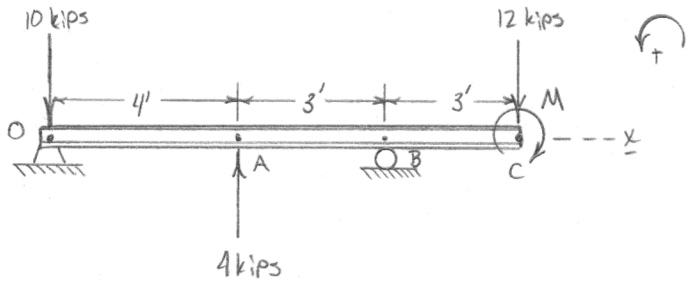
$100h = 650(60) - 300(90) - 250(30)$

$h = 45 \text{ in.}$

WILEY

©2018 by John Wiley & Sons. No part of this Instructor's Manual may be reproduced or distributed in any form or by any means without the written consent of the publisher. The publisher hereby limits distribution to instructors who have adopted the corresponding Meriam/Kraige/Bolton textbook. This material is written for instructors and is not intended for students.

2/75



$R = 18$ kips DOWN

$\Sigma M_B = 0: \quad 7(10) - 4(3) - 12(3) - M = 0 \longrightarrow M = 22$ kip-ft CW

$M_O = 4(4) - 12(10) - 22 = -126$ so... $M_O = 126$ kip-ft CW

WILEY

©2018 by John Wiley & Sons. No part of this Instructor's Manual may be reproduced or distributed in any form or by any means without the written consent of the publisher. The publisher hereby limits distribution to instructors who have adopted the corresponding Meriam/Kraige/Bolton textbook. This material is written for instructors and is not intended for students.

2/76 $M_O = 0$, so

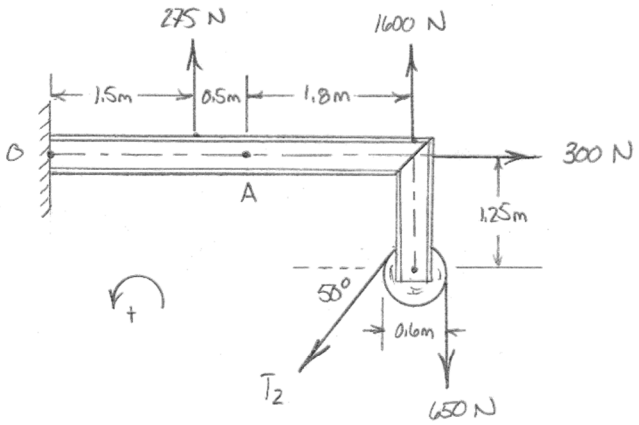
$$\circlearrowleft_+ M - 400(0.150\cos 30^\circ) - 320(0.300) = 0$$

$$M = 148.0 \text{ N·m}$$

WILEY

©2018 by John Wiley & Sons. No part of this Instructor's Manual may be reproduced or distributed in any form or by any means without the written consent of the publisher. The publisher hereby limits distribution to instructors who have adopted the corresponding Meriam/Kraige/Bolton textbook. This material is written for instructors and is not intended for students.

2/77



$\Sigma M_A = 0$: $-275(0.5) + 1.8(1600) - 650(1.8+0.3) + T_2(0.3) - T_2 \sin 50^\circ (1.8) \ldots$
$- T_2 \cos 50^\circ (1.25)$

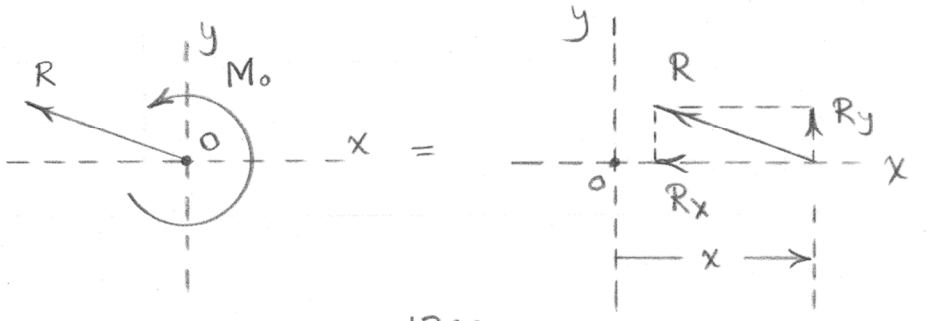
$T_2 = 732$ N

WILEY

©2018 by John Wiley & Sons. No part of this Instructor's Manual may be reproduced or distributed in any form or by any means without the written consent of the publisher. The publisher hereby limits distribution to instructors who have adopted the corresponding Meriam/Kraige/Bolton textbook. This material is written for instructors and is not intended for students.

2/78 $\underline{R} = -50\underline{i} + 20\underline{j}$ lb

$\curvearrowleft + M_O = -40(10) + 60(20) + 50(10) = 1300$ lb-in.

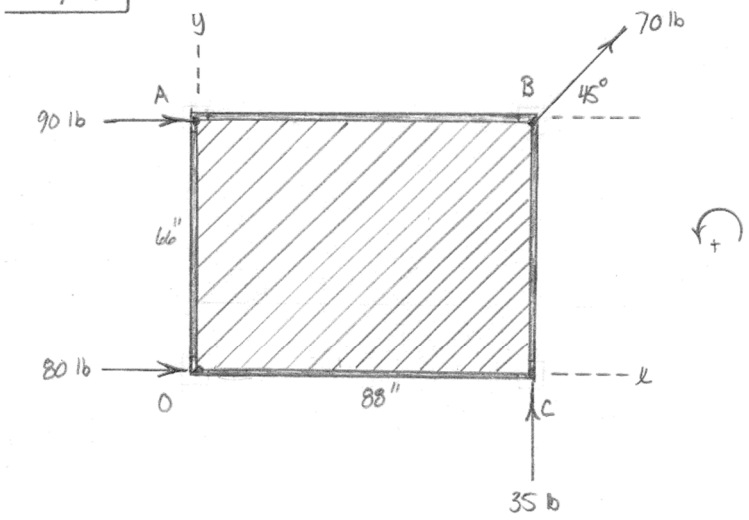


$R_y x = M_O$, $x = \frac{1300}{20} = \underline{65 \text{ in. (off pipe)}}$

WILEY

©2018 by John Wiley & Sons. No part of this Instructor's Manual may be reproduced or distributed in any form or by any means without the written consent of the publisher. The publisher hereby limits distribution to instructors who have adopted the corresponding Meriam/Kraige/Bolton textbook. This material is written for instructors and is not intended for students.

2/79



$$\underline{R} = (90 + 80 + 70\cos 45^\circ)\,\underline{i} + (35 + 70\sin 45^\circ)\,\underline{j}$$

$$\underline{R} = 219\,\underline{i} + 84.5\,\underline{j}\ \text{lb}$$

$$M_O = -90(66) + 35(88) + 70\sin 45^\circ(88) - 70\cos 45^\circ(66) = -1771$$

$$M_O = 1771\ \text{lb-in. CW}$$

To produce a CW moment about O with R_x positive, R_x is placed above O.

$$R_x y = M_O \rightarrow 219y = 1771 \rightarrow y = 8.07\ \text{in. above O}$$

To produce a CW moment about O with R_y positive, R_y is placed left of O.

$$R_y x = M_O \rightarrow 84.5x = 1771 \rightarrow x = 21.0\ \text{in. left of O}$$

Engineering Mechanics Statics 9th edition Meriam Solutions Manual

©2018 by John Wiley & Sons. No part of this Instructor's Manual may be reproduced or distributed in any form or by any means without the written consent of the publisher. The publisher hereby limits distribution to instructors who have adopted the corresponding Meriam/Kraige/Bolton textbook. This material is written for instructors and is not intended for students.

2/80 $\Sigma M_O = 0$ since $\underline{R}$ passes through O.

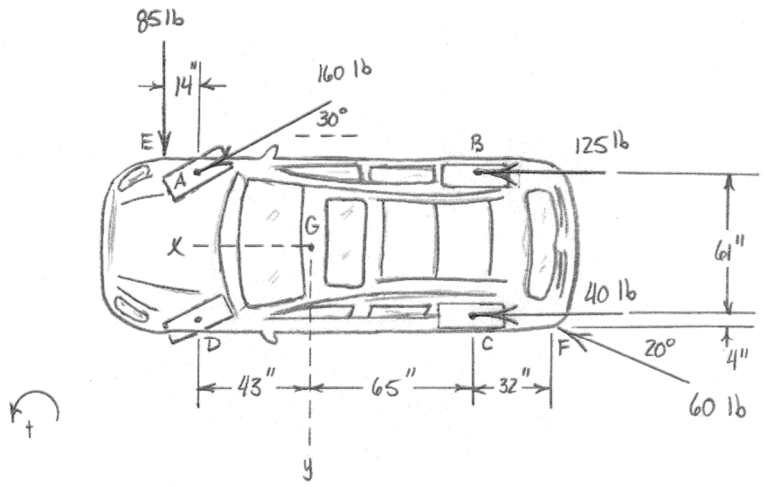
$40(8) + 60(4) - 5P\cos 20^\circ = 0, \quad P = 119.2 \text{ lb}$

Moment of 40-lb & 60-lb forces unaffected by θ so result for P is not dependent on θ.

WILEY

©2018 by John Wiley & Sons. No part of this Instructor's Manual may be reproduced or distributed in any form or by any means without the written consent of the publisher. The publisher hereby limits distribution to instructors who have adopted the corresponding Meriam/Kraige/Bolton textbook. This material is written for instructors and is not intended for students.

2/81



$$\underline{R} = \Sigma \underline{F} = (160\cos 30^\circ + 40 + 125 + 60\cos 20^\circ)\underline{i} + (85 + 160\sin 30^\circ - 60\sin 20^\circ)\underline{j}$$

$$\therefore \quad \underline{R} = 360\,\underline{i} + 144.5\,\underline{j}\ \text{lb}$$

$$\Sigma M_G = 85(14+43) + 160\cos 30^\circ\left(\tfrac{61}{2}\right) + 160\sin 30^\circ(43) + 125\left(\tfrac{61}{2}\right) - 40\left(\tfrac{61}{2}\right) + 60\sin 20^\circ(65+32) - 60\cos 20^\circ\left(4+\tfrac{61}{2}\right)$$

$$\Sigma M_G = 15{,}150\ \text{lb-in. or } 1262\ \text{lb-ft CCW}$$

For CCW M_G with positive R_x, R is placed above G, in negative y.

$M_G = R_x|y| \longrightarrow 15{,}150 = 360|y| \longrightarrow |y| = 42.1$ in. so $(0, -42.1)$ in.

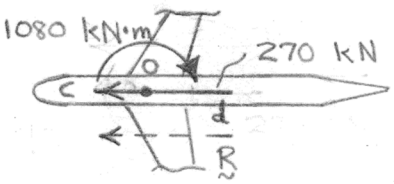
For CCW M_G with positive R_y, R is placed left of G, in positive x.

$M_G = R_y x \longrightarrow 15{,}150 = 144.5\,x \longrightarrow x = 104.9$ in. so $(104.9, 0)$ in.

©2018 by John Wiley & Sons. No part of this Instructor's Manual may be reproduced or distributed in any form or by any means without the written consent of the publisher. The publisher hereby limits distribution to instructors who have adopted the corresponding Meriam/Kraige/Bolton textbook. This material is written for instructors and is not intended for students.

2/82 Force – Couple system at point O:

$$\begin{cases} R = 3(90) = 270\ \text{kN}\ (\leftarrow) \\ +\circlearrowleft M_O = 12(90) = 1080\ \text{kN}\cdot\text{m} \end{cases}$$



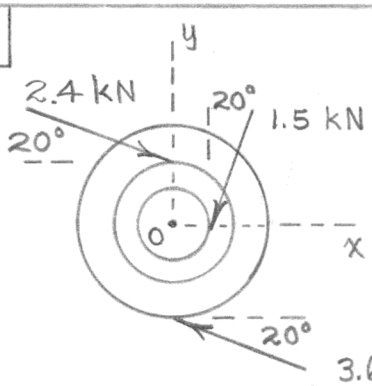
$$d = \frac{M_O}{R} = \frac{1080}{270}$$

$$= 4\ \text{m}$$

WILEY

©2018 by John Wiley & Sons. No part of this Instructor's Manual may be reproduced or distributed in any form or by any means without the written consent of the publisher. The publisher hereby limits distribution to instructors who have adopted the corresponding Meriam/Kraige/Bolton textbook. This material is written for instructors and is not intended for students.

2/83



$r_1 = 0.120$ m
$r_2 = 0.200$ m
$r_3 = 0.300$ m

$$\underline{R} = \Sigma \underline{F} = 2.4(c20°\underline{i} - s20°\underline{j}) + 1.5(-s20°\underline{i} - c20°\underline{j}) + 3.6(-c20°\underline{i} + s20°\underline{j}) = -1.641\underline{i} - 0.999\underline{j} \text{ kN}$$

$$\circlearrowleft M_O = (2.4(0.2) + 1.5(0.12) + 3.6(0.3))\cos 20° = 1.635 \text{ kN·m}$$

$$\underline{r} \times \underline{R} = \underline{M}_O: \quad (x\underline{i} + y\underline{j}) \times (-1.641\underline{i} - 0.999\underline{j}) = -1.635$$

$$\Rightarrow -0.999x + 1.641y = -1.635$$

Axis intercepts: $x = 1.637$ m, $y = -0.997$ m

WILEY

©2018 by John Wiley & Sons. No part of this Instructor's Manual may be reproduced or distributed in any form or by any means without the written consent of the publisher. The publisher hereby limits distribution to instructors who have adopted the corresponding Meriam/Kraige/Bolton textbook. This material is written for instructors and is not intended for students.

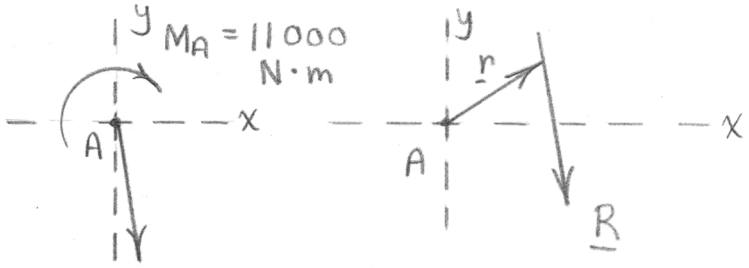
2/84 Equivalent force-couple system at A:

$$\underline{R} = \Sigma \underline{F} = [-2(250) - 3(500)]\underline{j} + 400[\cos 30^\circ \underline{i} - \sin 30^\circ \underline{j}]$$

$$= \underline{346\underline{i} - 2200\underline{j}\ \text{N}}$$

$$+\circlearrowright M_A = 500[2.5 + 5 + 7.5] + 250[10] + 400(2.5)$$

$$= \underline{11\,000\ \text{N}\cdot\text{m}\ \ \text{CW}}$$



$\underline{R} = 346\underline{i} - 2200\underline{j}$ N

Condition: $\underline{M}_A = \underline{r} \times \underline{R}$

$$-11\,000\underline{k} = (x\underline{i} + y\underline{j}) \times (346\underline{i} - 2200\underline{j})$$

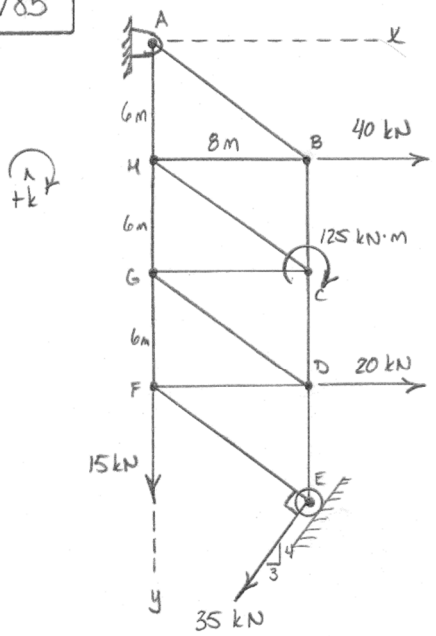
$$= (-2200x - 346y)\underline{k}$$

Set $y = 0$ & obtain $\underline{x = 5\ \text{m}}$ (!)

WILEY

©2018 by John Wiley & Sons. No part of this Instructor's Manual may be reproduced or distributed in any form or by any means without the written consent of the publisher. The publisher hereby limits distribution to instructors who have adopted the corresponding Meriam/Kraige/Bolton textbook. This material is written for instructors and is not intended for students.

2/85



$$\underline{R} = \left(40 + 20 - \tfrac{3}{5}35\right)\underline{i} + \left(15 + \tfrac{4}{5}35\right)\underline{j}$$

$$\underline{R} = 39\underline{i} + 43\underline{j}\ \text{kN}$$

$$\underline{M}_A = \left[-40(6) - 20(18) + 125 + 35(10) + \tfrac{3}{5}35(18)\right]\underline{k} \longrightarrow \underline{M}_A = 253\,\underline{k}\ \text{kN·m}$$

$$\underline{r} \times \underline{R} = \underline{M}_A \longrightarrow (x\underline{i} + y\underline{j}) \times (39\underline{i} - 43\underline{j}) = 253\underline{k}$$

$$\underline{k}: \quad 43x - 39y = 253 \longrightarrow y = 1.103x - 6.49\ \text{(m)}$$

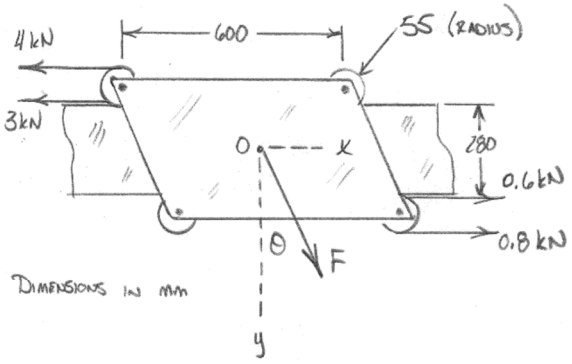
$$x\text{-Axis:} \quad y = 0 = 1.103x - 6.49 \longrightarrow x = 5.88\ \text{m} \quad \text{so} \quad (5.88, 0)\ \text{m}$$

$$y\text{-Axis:} \quad x = 0 \longrightarrow y = -6.49\ \text{m} \quad \text{so} \quad (0, -6.49)\ \text{m}$$

Engineering Mechanics Statics 9th edition Meriam Solutions Manual

©2018 by John Wiley & Sons. No part of this Instructor's Manual may be reproduced or distributed in any form or by any means without the written consent of the publisher. The publisher hereby limits distribution to instructors who have adopted the corresponding Meriam/Kraige/Bolton textbook. This material is written for instructors and is not intended for students.

2/86 $F = 5$ kN, $\Theta = 30^\circ$



$$\underline{R} = (0.8 + 0.6 + 5\sin 30^\circ - 4 - 3)\,\underline{i} + 5\cos 30^\circ\,\underline{j} \longrightarrow \underline{R} = -3.10\,\underline{i} + 4.33\,\underline{j} \text{ kN}$$

$$\Sigma M_O = 0.6\left(\frac{140}{1000}\right) + 0.8\left(\frac{140+110}{1000}\right) + 3\left(\frac{140}{1000}\right) + 4\left(\frac{140+110}{1000}\right) =$$

$$\therefore \Sigma M_O = 1.704 \text{ kN·m CCW}$$

FOR A CCW M_O WITH NEGATIVE R_x, R IS PLACED ABOVE O IN MINUS y.

$$R_x y = M_O \longrightarrow 3.10|y| = 1.704 \longrightarrow |y| = 0.550$$

$$\therefore |y| = 550 \text{ mm ABOVE O OR } (0, -550) \text{ (mm)}$$

WILEY

©2018 by John Wiley & Sons. No part of this Instructor's Manual may be reproduced or distributed in any form or by any means without the written consent of the publisher. The publisher hereby limits distribution to instructors who have adopted the corresponding Meriam/Kraige/Bolton textbook. This material is written for instructors and is not intended for students.

2/87

$$\underline{R} = \Sigma \underline{F} = 400(\cos 45^\circ \underline{i} - \sin 45^\circ \underline{j}) + 500(\sin 15^\circ \underline{i} - \cos 15^\circ \underline{j})$$

$$= 412\underline{i} - 766\underline{j} \text{ N}$$

$$+\circlearrowleft M_O = (500 - 400)(0.060) = 6 \text{ N} \cdot \text{m}$$

For the line of action of the standalone force:

$$\underline{r} \times \underline{R} = \underline{M}_O$$

$$(x\underline{i} + y\underline{j}) \times (412\underline{i} - 766\underline{j}) = -6\underline{k}$$

$$-766x - 412y = -6$$

For $x = 0$: $y = 0.01455$ m or $y = 14.55$ mm

For $y = 0$: $x = 0.00783$ m or $x = 7.83$ mm

WILEY

©2018 by John Wiley & Sons. No part of this Instructor's Manual may be reproduced or distributed in any form or by any means without the written consent of the publisher. The publisher hereby limits distribution to instructors who have adopted the corresponding Meriam/Kraige/Bolton textbook. This material is written for instructors and is not intended for students.

2/88 For a zero force-couple system at point O:

$$\underline{R} = \Sigma \underline{F} = (-F_C \sin 30^\circ + F_D \sin 30^\circ)\,\underline{i} + (50 - 10 - 100 - 50 + F_B + F_C \cos 30^\circ + F_D \cos 30^\circ)\,\underline{j} = \underline{0}$$

$$\Rightarrow F_C = F_D = F$$

$$\circlearrowleft M_O = -10(0.5) + 50(0.7) - 100(1.35) + F_B(2) - 50(2.5) + 2F \cos 30^\circ (2.9) = 0$$

$$F = F_C = F_D = 6.42 \text{ N}, \quad F_B = 98.9 \text{ N}$$

WILEY

©2018 by John Wiley & Sons. No part of this Instructor's Manual may be reproduced or distributed in any form or by any means without the written consent of the publisher. The publisher hereby limits distribution to instructors who have adopted the corresponding Meriam/Kraige/Bolton textbook. This material is written for instructors and is not intended for students.

2/89

$$\underline{F} = F\underline{n}$$

$$= 60\left[\frac{40\underline{i} - 50\underline{j} + 110\underline{k}}{\sqrt{40^2 + 50^2 + 110^2}}\right]$$

$$= \underline{18.86\underline{i} - 23.6\underline{j} + 51.9\underline{k}\ \text{N}}$$

$$\cos\theta_y = \frac{F_y}{F} = \frac{-23.6}{60}, \quad \underline{\theta_y = 113.1^\circ}$$

WILEY

©2018 by John Wiley & Sons. No part of this Instructor's Manual may be reproduced or distributed in any form or by any means without the written consent of the publisher. The publisher hereby limits distribution to instructors who have adopted the corresponding Meriam/Kraige/Bolton textbook. This material is written for instructors and is not intended for students.

2/90

$$\underline{T} = T\underline{n}_{BA}$$

$$\underline{T} = 12\left[\frac{-35\underline{i} + 25\underline{j} + 60\underline{k}}{\sqrt{35^2 + 25^2 + 60^2}}\right]$$

$$= -5.69\underline{i} + 4.06\underline{j} + 9.75\underline{k} \quad \text{kN}$$

WILEY

©2018 by John Wiley & Sons. No part of this Instructor's Manual may be reproduced or distributed in any form or by any means without the written consent of the publisher. The publisher hereby limits distribution to instructors who have adopted the corresponding Meriam/Kraige/Bolton textbook. This material is written for instructors and is not intended for students.

2/91 $F_z = 5 \cos 40^\circ = 3.83 \text{ kN}$

$F_h = 5 \sin 40^\circ = 3.21 \text{ kN}$

$F_x = -3.21 \sin 35^\circ = -1.843 \text{ kN}$

$F_y = 3.21 \cos 35^\circ = 2.63 \text{ kN}$

So $\underline{F} = -1.843\underline{i} + 2.63\underline{j} + 3.83\underline{k} \text{ kN}$

$F_{OA} = \underline{F} \cdot \underline{n}_{OA}$

$= (-1.843\underline{i} + 2.63\underline{j} + 3.83\underline{k}) \cdot (\cos 30^\circ \underline{i} + \sin 30^\circ \underline{j})$

$= -0.280 \text{ kN}$ (as a scalar)

$\underline{F}_{OA} = F_{OA}\underline{n}_{OA}$

$= -0.280(\cos 30^\circ \underline{i} + \sin 30^\circ \underline{j})$

$= -0.243\underline{i} - 0.1401\underline{j} \text{ kN}$

WILEY

©2018 by John Wiley & Sons. No part of this Instructor's Manual may be reproduced or distributed in any form or by any means without the written consent of the publisher. The publisher hereby limits distribution to instructors who have adopted the corresponding Meriam/Kraige/Bolton textbook. This material is written for instructors and is not intended for students.

2/92

$$\underline{F} = F\underline{n} = 300\left[\frac{4\underline{i} - 8\underline{j} - 8\underline{k}}{\sqrt{4^2 + 8^2 + 8^2}}\right]$$

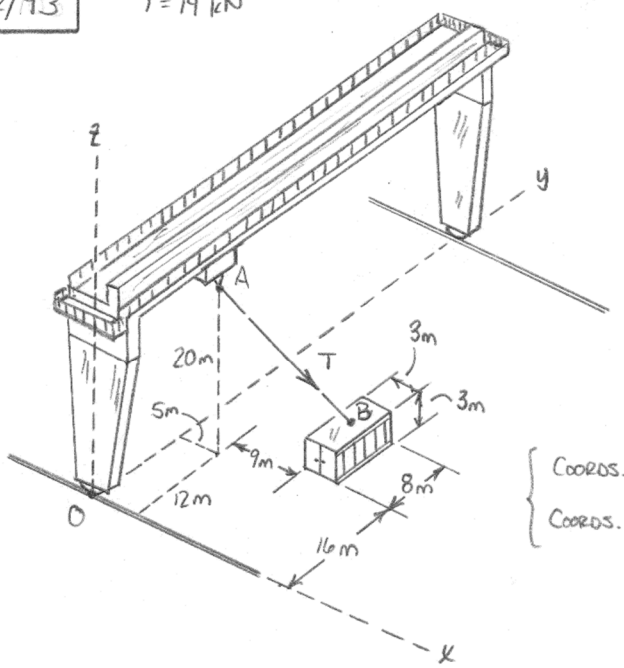
$$= 300\left[\frac{1}{3}\underline{i} - \frac{2}{3}\underline{j} - \frac{2}{3}\underline{k}\right] \text{ lb}$$

$F_x = 100$ lb, $F_y = -200$ lb, $F_z = -200$ lb

WILEY

©2018 by John Wiley & Sons. No part of this Instructor's Manual may be reproduced or distributed in any form or by any means without the written consent of the publisher. The publisher hereby limits distribution to instructors who have adopted the corresponding Meriam/Kraige/Bolton textbook. This material is written for instructors and is not intended for students.

2/93 $T = 14$ kN



Coords. of A are $(5, 12, 20)$ m

Coords. of B are $(15.5, 20, 3)$ m

$$\underline{\Omega}_{AB} = \frac{(15.5-5)\underline{i} + (20-12)\underline{j} + (3-20)\underline{k}}{\left[(15.5-5)^2 + (20-12)^2 + (3-20)^2\right]^{1/2}} \rightarrow \underline{n}_{AB} = 0.488\underline{i} + 0.372\underline{j} - 0.790\underline{k}$$

$T_x = T n_x = 14(0.488) \rightarrow T_x = 6.83$ kN

$T_y = T n_y = 14(0.372) \rightarrow T_y = 5.20$ kN

$T_z = T n_z = 14(-0.790) \rightarrow T_z = -11.06$ kN

WILEY

©2018 by John Wiley & Sons. No part of this Instructor's Manual may be reproduced or distributed in any form or by any means without the written consent of the publisher. The publisher hereby limits distribution to instructors who have adopted the corresponding Meriam/Kraige/Bolton textbook. This material is written for instructors and is not intended for students.

2/94 $\underline{T} = T\underline{n}_{AB} = 2.4\left(\frac{2\underline{i} + \underline{j} - 5\underline{k}}{\sqrt{2^2 + 1^2 + 5^2}}\right)$

$= 0.876\,\underline{i} + 0.438\,\underline{j} - 2.19\,\underline{k}$ kN

Projection $T_{AC} = \underline{T} \cdot \underline{n}_{AC}$

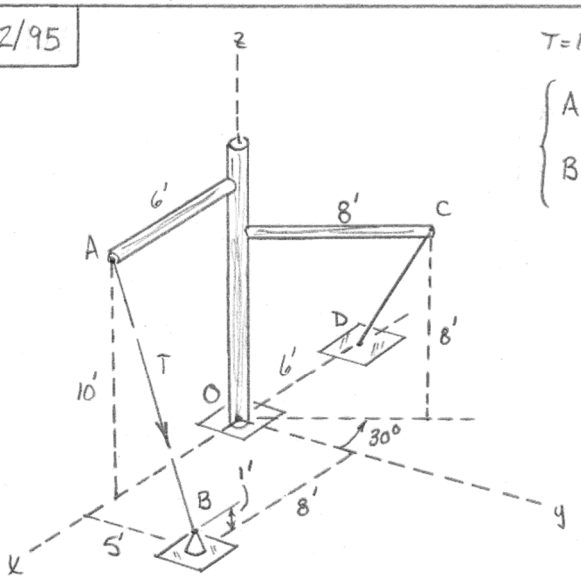
$= (0.876\,\underline{i} + 0.438\,\underline{j} - 2.19\,\underline{k}) \cdot \left(\frac{2\underline{i} - 2\underline{j} - 5\underline{k}}{\sqrt{2^2 + 2^2 + 5^2}}\right)$

$= 2.06$ kN

WILEY

©2018 by John Wiley & Sons. No part of this Instructor's Manual may be reproduced or distributed in any form or by any means without the written consent of the publisher. The publisher hereby limits distribution to instructors who have adopted the corresponding Meriam/Kraige/Bolton textbook. This material is written for instructors and is not intended for students.

2/95



$T = 1750\ \text{lb}$

$A(6, 0, 10)$ ft

$B(8, 5, 1)$ ft

$$\underline{\Omega}_{AB} = \frac{(8-6)\underline{i} + (5-0)\underline{j} + (1-10)\underline{k}}{[(8-6)^2 + 5^2 + (1-10)^2]^{1/2}} \rightarrow \underline{\Omega}_{AB} = 0.1907\underline{i} + 0.477\underline{j} - 0.858\underline{k}$$

$$\theta_x = \cos^{-1}(n_x) = \cos^{-1}(0.1907) \rightarrow \theta_x = 79.0°$$

$$\theta_y = \cos^{-1}(n_y) = \cos^{-1}(0.477) \rightarrow \theta_y = 61.5°$$

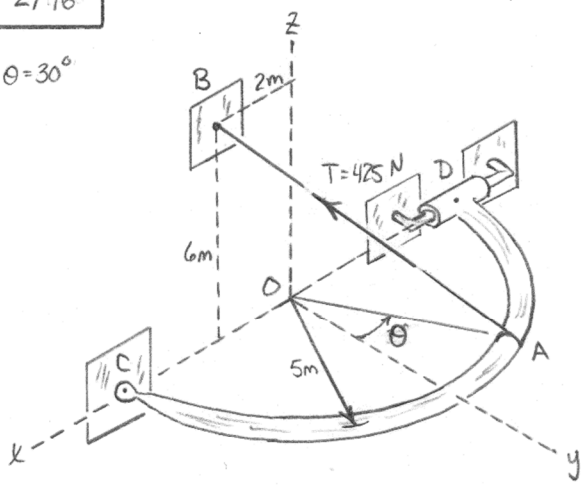
$$\theta_z = \cos^{-1}(n_z) = \cos^{-1}(-0.858) \rightarrow \theta_z = 149.1°$$

WILEY

©2018 by John Wiley & Sons. No part of this Instructor's Manual may be reproduced or distributed in any form or by any means without the written consent of the publisher. The publisher hereby limits distribution to instructors who have adopted the corresponding Meriam/Kraige/Bolton textbook. This material is written for instructors and is not intended for students.

2/96

$\theta = 30^\circ$



$\begin{cases} A(-5\sin 30,\ 5\cos 30,\ 0)\ m \\ B(2, 0, 6)\ m \end{cases}$

$$\Omega_{AB} = \frac{(2+5\sin 30)\underline{i} + (0-5\cos 30)\underline{j} + (6-0)\underline{k}}{[(2+5\sin 30)^2 + (5\cos 30)^2 + 6^2]^{1/2}}$$

$$\therefore \quad \Omega_{AB} = 0.520\underline{i} - 0.5\underline{j} + 0.693\underline{k}$$

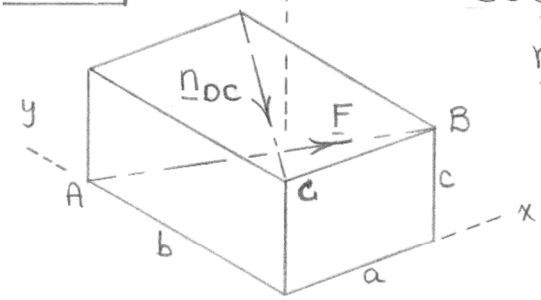
$$\underline{T}_A = T\Omega_{AB} = 425(0.520\hat{i} - 0.5\hat{j} + 0.693\hat{k}) \longrightarrow \underline{T}_A = 221\underline{i} - 212\underline{j} + 294\underline{k}\ \text{N}$$

$$\underline{T}_B = -\underline{T}_A \longrightarrow \underline{T}_B = -221\underline{i} + 212\underline{j} - 294\underline{k}\ \text{N}$$

WILEY

©2018 by John Wiley & Sons. No part of this Instructor's Manual may be reproduced or distributed in any form or by any means without the written consent of the publisher. The publisher hereby limits distribution to instructors who have adopted the corresponding Meriam/Kraige/Bolton textbook. This material is written for instructors and is not intended for students.

2/97



Set up x-y-z axes shown

$$\underline{n}_{DC} = \frac{\underline{DC}}{\overline{DC}} = \frac{-a\underline{i} - b\underline{j}}{\sqrt{a^2+b^2}}$$

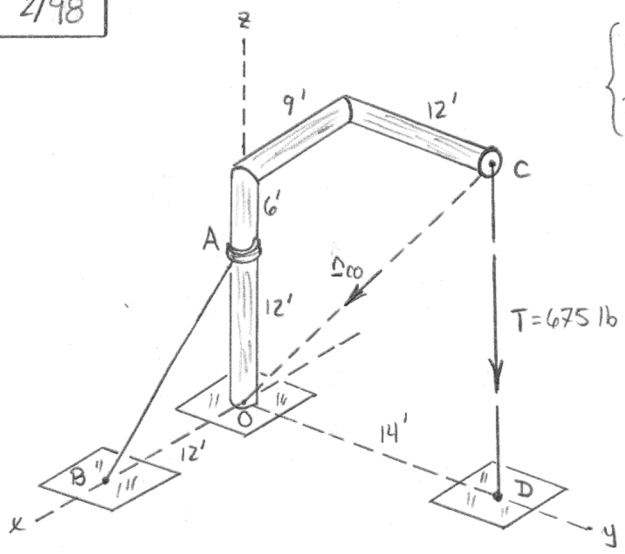
$$\underline{F} = F\underline{n}_{AB} = F\frac{\underline{AB}}{\overline{AB}} = F\frac{a\underline{i} - b\underline{j} + c\underline{k}}{\sqrt{a^2+b^2+c^2}}$$

$$F_{DC} = \underline{F}\cdot\underline{n}_{DC} = \frac{(b^2-a^2)F}{\sqrt{(a^2+b^2)}\sqrt{(a^2+b^2+c^2)}}$$

WILEY

©2018 by John Wiley & Sons. No part of this Instructor's Manual may be reproduced or distributed in any form or by any means without the written consent of the publisher. The publisher hereby limits distribution to instructors who have adopted the corresponding Meriam/Kraige/Bolton textbook. This material is written for instructors and is not intended for students.

2/98



C (-9, 12, 18)

D (0, 14, 0)

$$\underline{n}_{CD} = \frac{(0+9)\underline{i} + (14-12)\underline{j} + (0-18)\underline{k}}{[9^2 + (14-12)^2 + (-18)^2]^{1/2}} \rightarrow \hat{n}_{CD} = 0.445\underline{i} + 0.0989\underline{j} - 0.890\underline{k}$$

$$\underline{T} = T\underline{n}_{CD} = 675(0.445\underline{i} + 0.0989\underline{j} - 0.890\underline{k}) \rightarrow \underline{T} = 300\underline{i} + 66.8\underline{j} - 601\underline{k} \text{ lb}$$

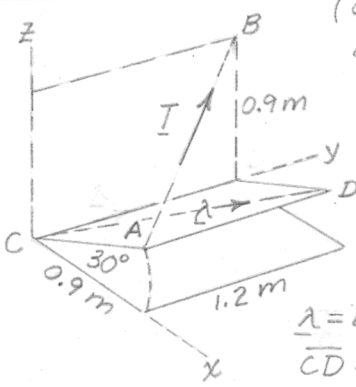
$$\underline{n}_{CO} = \frac{9\underline{i} - 12\underline{j} - 18\underline{k}}{\sqrt{9^2 + 12^2 + 18^2}} \rightarrow \underline{n}_{CO} = \frac{3}{\sqrt{61}}\underline{i} - \frac{4}{\sqrt{61}}\underline{j} - \frac{6}{\sqrt{61}}\underline{k}$$

$$T_{CO} = \underline{T} \cdot \underline{n}_{CO} = (300\underline{i} + 66.8\underline{j} - 601\underline{k}) \cdot \left(\frac{3}{\sqrt{61}}\underline{i} - \frac{4}{\sqrt{61}}\underline{j} - \frac{6}{\sqrt{61}}\underline{k}\right) \rightarrow T_{CO} = 543 \text{ lb}$$

Engineering Mechanics Statics 9th edition Meriam Solutions Manual

©2018 by John Wiley & Sons. No part of this Instructor's Manual may be reproduced or distributed in any form or by any means without the written consent of the publisher. The publisher hereby limits distribution to instructors who have adopted the corresponding Meriam/Kraige/Bolton textbook. This material is written for instructors and is not intended for students.

2/99 $T = 150$ N



Coordinates of A are
$(0.9\cos 30°,\ 0,\ 0.9\sin 30°)$
or $(0.779, 0, 0.45)$ m

$\overline{AB} = \sqrt{0.779^2 + 1.2^2 + (0.9-0.45)^2}$

$= 1.50$ m

$l = -0.779/1.5,\ m = 1.2/1.5,\ n = \frac{0.45}{1.5}$

$\underline{T} = \frac{100}{1.5}(-0.779\underline{i} + 1.2\underline{j} + 0.45\underline{k})$ N

$\underline{\lambda}$ = unit vector along CD

$\overline{CD} = \sqrt{0.9^2 + 1.2^2} = 1.5$ m

$l = 0.779/1.5,\ m = 1.2/1.5,\ n = 0.45/1.5$

$\underline{\lambda} = \frac{1}{1.5}(0.779\underline{i} + 1.2\underline{j} + 0.45\underline{k})$

$$\underline{T}_{CD} = \underline{T}\cdot\underline{\lambda} = \frac{100}{1.5}(-0.779\underline{i} + 1.2\underline{j} + 0.45\underline{k})\cdot\frac{1}{1.5}(0.779\underline{i} + 1.2\underline{j} + 0.45\underline{k})$$

$$= \frac{100}{2.25}(-0.779^2 + 1.2^2 + 0.45^2) = \frac{100}{2.25}(-0.6075 + 1.44 + 0.2025)$$

$$= \frac{400}{9}(1.035) = \underline{46.0\ \text{N}}$$

WILEY

©2018 by John Wiley & Sons. No part of this Instructor's Manual may be reproduced or distributed in any form or by any means without the written consent of the publisher. The publisher hereby limits distribution to instructors who have adopted the corresponding Meriam/Kraige/Bolton textbook. This material is written for instructors and is not intended for students.

2/100

$$\underline{F} = F\underline{n}_{AB} = 200\left[\frac{-12\underline{i} + 24\underline{j} + 8\underline{k}}{\sqrt{12^2 + 24^2 + 8^2}}\right]$$

$$= -85.7\underline{i} + 171.4\underline{j} + 57.1\underline{k} \quad \text{lb}$$

$$\underline{OC} = 12\underline{i} + 24\underline{j} \quad \text{in.}$$

The angle θ between $\underline{F}$ and $\underline{OC}$ is

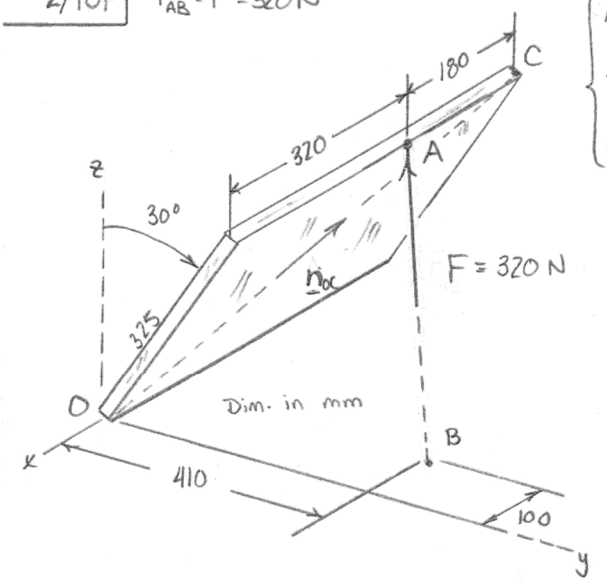
$$\theta = \cos^{-1}\frac{\underline{F}\cdot\underline{OC}}{F(\overline{OC})} = \cos^{-1}\left[\frac{-85.7(12) + 171.4(24)}{200\left(\sqrt{12^2+24^2}\right)}\right]$$

$$= \underline{54.9^\circ}$$

WILEY

©2018 by John Wiley & Sons. No part of this Instructor's Manual may be reproduced or distributed in any form or by any means without the written consent of the publisher. The publisher hereby limits distribution to instructors who have adopted the corresponding Meriam/Kraige/Bolton textbook. This material is written for instructors and is not intended for students.

2/101 $F_{AB} = F = 320\ N$



$A\,(-320,\ 325\sin30^\circ,\ 325\cos30^\circ)$

$B\,(-100,\ 410,\ 0)$

$C\,(-500,\ 325\sin30^\circ,\ 325\cos30^\circ)$

$$\underline{n}_{BA} = \frac{(-320+100)\underline{i} + (325\sin30^\circ - 410)\underline{j} + 325\cos30^\circ\,\underline{k}}{\left[(-320+100)^2 + (325\sin30^\circ - 410)^2 + (325\cos30^\circ)^2\right]^{1/2}}$$

$$\therefore \quad \underline{n}_{BA} = -0.506\underline{i} - 0.569\underline{j} + 0.648\underline{k}$$

$$\underline{F} = F\underline{n}_{BA} = 320(-0.506\underline{i} - 0.569\underline{j} + 0.648\underline{k}) \longrightarrow \underline{F} = -162.0\underline{i} - 182.2\underline{j} + 207\underline{k}\ N$$

$$\underline{n}_{OC} = \frac{-500\underline{i} + 325\sin30^\circ\underline{j} + 325\cos30^\circ\underline{k}}{\sqrt{500^2 + 325^2}} \longrightarrow \underline{n}_{OC} = -0.838\underline{i} + 0.272\underline{j} + 0.472\underline{k}$$

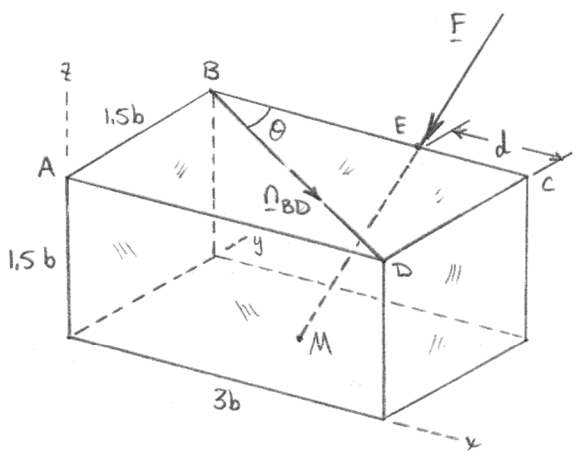
$$F_{OC} = \underline{F}\cdot\underline{n}_{OC} = (-162.0\underline{i} - 182.2\underline{j} + 207\underline{k})\cdot(-0.838\underline{i} + 0.272\underline{j} + 0.472\underline{k})$$

$$\therefore \quad F_{OC} = 184.0\ N$$

Engineering Mechanics Statics 9th edition Meriam Solutions Manual

©2018 by John Wiley & Sons. No part of this Instructor's Manual may be reproduced or distributed in any form or by any means without the written consent of the publisher. The publisher hereby limits distribution to instructors who have adopted the corresponding Meriam/Kraige/Bolton textbook. This material is written for instructors and is not intended for students.

2/102



$B\ (0, 1.5b, 1.5b)$

$D\ (3b, 0, 1.5b)$

$E\ (3b-d, 1.5b, 1.5b)$

$M\left(\frac{3b}{2}, \frac{3b}{4}, 0\right)$

$\theta = \tan^{-1}\left(\frac{1.5b}{3b}\right) = 26.6°$

$$\underline{n}_{BD} = \cos\theta\,\underline{i} - \sin\theta\,\underline{j} \longrightarrow \underline{n}_{BD} = 0.894\,\underline{i} - 0.447\,\underline{j}$$

$$\underline{n}_{EM} = \frac{\left(\frac{3b}{2} - 3b + d\right)\underline{i} + \left(\frac{3b}{4} - 1.5b\right)\underline{j} + (0 - 1.5b)\underline{k}}{\left[\left(\frac{3b}{2} - 3b + d\right)^2 + \left(\frac{3b}{4} - 1.5b\right)^2 + (-1.5b)^2\right]^{1/2}}$$

$$\therefore \underline{n}_{EM} = \frac{(4d - 6b)\underline{i} - 3b\,\underline{j} - 6b\,\underline{k}}{\sqrt{81b^2 - 48bd + 16d^2}} \quad \text{AND} \quad \underline{F} = F\,\underline{n}_{EM}$$

$$F_{BD} = \underline{F} \cdot \underline{n}_{BD} = F\left(\frac{(4d - 6b)\underline{i} - 3b\,\underline{j} - 6b\,\underline{k}}{\sqrt{81b^2 - 48bd + 16d^2}}\right) \cdot \left(0.894\,\underline{i} - 0.447\,\underline{j}\right)$$

$$\therefore F_{BD} = \frac{(8d - 9b)F}{\sqrt{5}\sqrt{81b^2 - 48bd + 16d^2}}$$

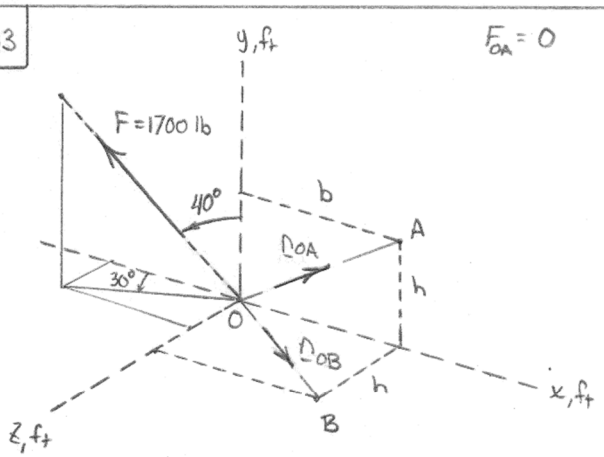
IF $d = \frac{b}{2}$ ... $F_{BD} = -0.286\,F$

IF $d = \frac{5b}{2}$ ... $F_{BD} = 0.630\,F$

WILEY

©2018 by John Wiley & Sons. No part of this Instructor's Manual may be reproduced or distributed in any form or by any means without the written consent of the publisher. The publisher hereby limits distribution to instructors who have adopted the corresponding Meriam/Kraige/Bolton textbook. This material is written for instructors and is not intended for students.

2/103 $F_{OA} = 0$ AND $b = 6$ ft.



$$\begin{cases} F_x = -1700 \sin 40^\circ \cos 30^\circ = -946 \text{ lb} \\ F_y = 1700 \cos 40^\circ = 1302 \text{ lb} \\ F_z = 1700 \sin 40^\circ \sin 30^\circ = 546 \text{ lb} \end{cases} \qquad \underline{F} = -946\underline{i} + 1302\underline{j} + 546\underline{k} \text{ lb}$$

$$\underline{n}_{OA} = \frac{b\underline{i} + h\underline{j}}{\sqrt{b^2 + h^2}} \quad \text{so...} \quad \underline{F} \cdot \underline{n}_{OA} = (-946\underline{i} + 1302\underline{j} + 546\underline{k}) \cdot \frac{6\underline{i} + h\underline{j}}{\sqrt{6^2 + h^2}}$$

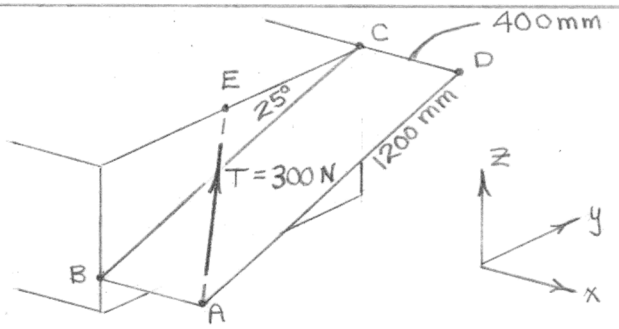
$$F_{OA} = \underline{F} \cdot \underline{n}_{OA} = 0 = \frac{1302\,(h - 4.36)}{\sqrt{36 + h^2}} \quad \text{so...} \quad h = 4.36 \text{ ft}$$

$$\underline{n}_{OB} = \frac{b\underline{i} + h\underline{k}}{\sqrt{b^2 + h^2}} = 0.809\underline{i} + 0.588\underline{k}$$

$$F_{OB} = \underline{F} \cdot \underline{n}_{OB} = (-946\underline{i} + 1302\underline{j} + 546\underline{k}) \cdot (0.809\underline{i} + 0.588\underline{k}) \longrightarrow \underline{F_{OB} = -444 \text{ lb}}$$

©2018 by John Wiley & Sons. No part of this Instructor's Manual may be reproduced or distributed in any form or by any means without the written consent of the publisher. The publisher hereby limits distribution to instructors who have adopted the corresponding Meriam/Kraige/Bolton textbook. This material is written for instructors and is not intended for students.

2/104



$$\underline{T} = T\underline{n}_{AE} = 300\left[\frac{-400\underline{i} + 544\underline{j} + 507\underline{k}}{\sqrt{400^2 + 544^2 + 507^2}}\right]$$

$$= 300\left[-0.474\underline{i} + 0.644\underline{j} + 0.601\underline{k}\right] \text{ N}$$

$$\underline{n}_{BC} = \cos 25^\circ \underline{j} + \sin 25^\circ \underline{k}$$

Carry out $T_{BC} = \underline{T} \cdot \underline{n}_{BC}$ to obtain

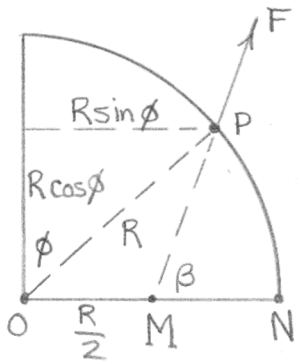
$$T_{BC} = 251 \text{ N}$$

WILEY

©2018 by John Wiley & Sons. No part of this Instructor's Manual may be reproduced or distributed in any form or by any means without the written consent of the publisher. The publisher hereby limits distribution to instructors who have adopted the corresponding Meriam/Kraige/Bolton textbook. This material is written for instructors and is not intended for students.

▶2/105 $F_x = F_{xy}\cos\theta$, $F_y = F_{xy}\sin\theta$

$F_z = F\sin\beta$, $F_{xy} = F\cos\beta$



$$\tan\beta = \frac{R\cos\phi}{R\sin\phi - \frac{R}{2}} = \frac{2\cos\phi}{2\sin\phi - 1}$$

$$\text{So } \sin\beta = \frac{2\cos\phi}{\sqrt{(2\sin\phi-1)^2 + (2\cos\phi)^2}}$$

$$\cos\beta = \frac{2\sin\phi - 1}{\sqrt{(2\sin\phi-1)^2 + (2\cos\phi)^2}}$$

Note that $\sqrt{(2\sin\phi-1)^2 + (2\cos\phi)^2} = \sqrt{5-4\sin\phi}$

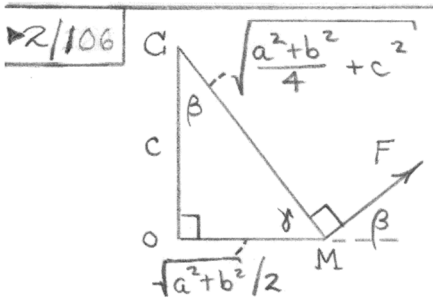
$$\text{So } \underline{F} = F\left[\cos\theta\cos\beta\,\underline{i} + \sin\theta\cos\beta\,\underline{j} + \sin\beta\,\underline{k}\right]$$

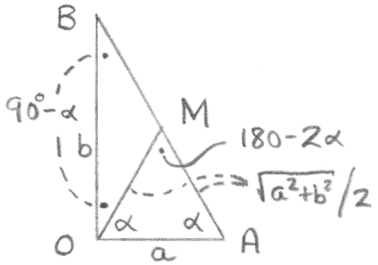
$$= \frac{F}{\sqrt{5-4\sin\phi}}\left[(2\sin\phi-1)(\cos\theta\,\underline{i} + \sin\theta\,\underline{j}) + 2\cos\phi\,\underline{k}\right]$$

WILEY

©2018 by John Wiley & Sons. No part of this Instructor's Manual may be reproduced or distributed in any form or by any means without the written consent of the publisher. The publisher hereby limits distribution to instructors who have adopted the corresponding Meriam/Kraige/Bolton textbook. This material is written for instructors and is not intended for students.

2/106





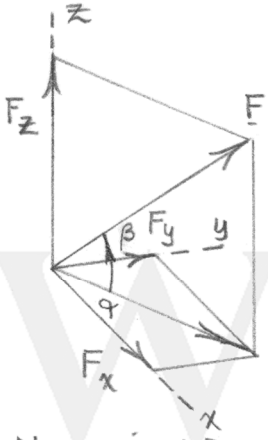
$$\tan\gamma = \frac{c}{\sqrt{a^2+b^2}/2} = \frac{2c}{\sqrt{a^2+b^2}}$$

$$\gamma + 90^\circ + \beta = 180^\circ$$

$$\beta = 90^\circ - \gamma = 90^\circ - \tan^{-1}\frac{2c}{\sqrt{a^2+b^2}}$$

$$\tan\alpha = \frac{b}{a}$$

$$\begin{cases} \cos\alpha = \dfrac{a}{\sqrt{a^2+b^2}} \\ \sin\alpha = \dfrac{b}{\sqrt{a^2+b^2}} \end{cases}$$



$$\begin{cases} F_z = F\sin\beta \\ F_h = F\cos\beta \\ F_x = F_h\cos\alpha = F\cos\beta\cos\alpha \\ F_y = F_h\sin\alpha = F\cos\beta\sin\alpha \end{cases}$$

Now simplify $\sin\beta$ & $\cos\beta$ expressions:

$$\sin\beta = \sin\left[90^\circ - \tan^{-1}\frac{2c}{\sqrt{a^2+b^2}}\right]$$

$$= \sin 90^\circ\cos\left[\tan^{-1}\frac{2c}{\sqrt{a^2+b^2}}\right] - \cos 90^\circ\sin\left[\tan^{-1}\frac{2c}{\sqrt{a^2+b^2}}\right]$$

$$= \frac{\sqrt{a^2+b^2}}{\sqrt{a^2+b^2+4c^2}}$$ (Also see that $\sin\beta = \cos\gamma$!)

$$\cos\beta = \sin\gamma = \frac{c}{\sqrt{\frac{a^2+b^2}{4}+c^2}} = \frac{2c}{\sqrt{a^2+b^2+4c^2}}$$

Finally,

$$F_x = F\frac{2c}{\sqrt{a^2+b^2+4c^2}}\frac{a}{\sqrt{a^2+b^2}} = \frac{2acF}{\sqrt{a^2+b^2}\sqrt{a^2+b^2+4c^2}}$$

$$F_y = F\frac{2c}{\sqrt{a^2+b^2+4c^2}}\frac{b}{\sqrt{a^2+b^2}} = \frac{2bcF}{\sqrt{a^2+b^2}\sqrt{a^2+b^2+4c^2}}$$

$$F_z = F\sqrt{\frac{a^2+b^2}{a^2+b^2+4c^2}}$$

©2018 by John Wiley & Sons. No part of this Instructor's Manual may be reproduced or distributed in any form or by any means without the written consent of the publisher. The publisher hereby limits distribution to instructors who have adopted the corresponding Meriam/Kraige/Bolton textbook. This material is written for instructors and is not intended for students.

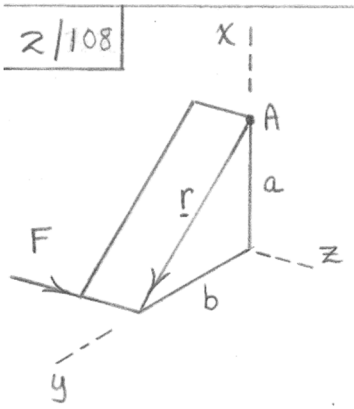
2/107

$$\begin{cases} \underline{M}_1 = -cF_1\underline{j} \\ \underline{M}_2 = cF_2\underline{j} - bF_2\underline{k} = F_2(c\underline{j} - b\underline{k}) \\ \underline{M}_3 = -bF_3\underline{k} \end{cases}$$

WILEY

©2018 by John Wiley & Sons. No part of this Instructor's Manual may be reproduced or distributed in any form or by any means without the written consent of the publisher. The publisher hereby limits distribution to instructors who have adopted the corresponding Meriam/Kraige/Bolton textbook. This material is written for instructors and is not intended for students.

2/108



$$\underline{M}_A = \underline{r} \times \underline{F}$$

$$= (-a\underline{i} + b\underline{j}) \times F\underline{k}$$

$$= \underline{F(b\underline{i} + a\underline{j})}$$

WILEY

©2018 by John Wiley & Sons. No part of this Instructor's Manual may be reproduced or distributed in any form or by any means without the written consent of the publisher. The publisher hereby limits distribution to instructors who have adopted the corresponding Meriam/Kraige/Bolton textbook. This material is written for instructors and is not intended for students.

2/109

$$\underline{M}_O = F(-c\underline{i} + a\underline{k})$$

$$\underline{M}_A = Fa\underline{k}$$

$$\underline{M}_{OB} = (\underline{M}_O \cdot \underline{n}_{OB})\underline{n}_{OB}$$

$$= \left[F(-c\underline{i} + a\underline{k}) \cdot \frac{a\underline{i} + b\underline{j}}{\sqrt{a^2+b^2}}\right] \frac{a\underline{i} + b\underline{j}}{\sqrt{a^2+b^2}}$$

$$= -\frac{Fac}{a^2+b^2}(a\underline{i} + b\underline{j})$$

WILEY

©2018 by John Wiley & Sons. No part of this Instructor's Manual may be reproduced or distributed in any form or by any means without the written consent of the publisher. The publisher hereby limits distribution to instructors who have adopted the corresponding Meriam/Kraige/Bolton textbook. This material is written for instructors and is not intended for students.

2/110

$$\underline{M}_O = \underline{r}_{OA} \times \underline{F}$$

$$= (1.5\underline{j} + 0.75\underline{k}) \times 4(-\cos 30^\circ \underline{i} + \sin 30^\circ \underline{j})$$

$$= \underline{-1.5\underline{i} - 2.60\underline{j} + 5.20\underline{k} \text{ lb-in.}}$$

WILEY

©2018 by John Wiley & Sons. No part of this Instructor's Manual may be reproduced or distributed in any form or by any means without the written consent of the publisher. The publisher hereby limits distribution to instructors who have adopted the corresponding Meriam/Kraige/Bolton textbook. This material is written for instructors and is not intended for students.

2/111

$$R = \Sigma F = 250 \text{ kips}$$

$$\underline{M} = -150(3)\underline{i} + (150-100)6\underline{j}$$

$$= -450\underline{i} + 300\underline{j} \text{ kip-in.}$$

or $$\underline{M} = (-0.450\underline{i} + 0.300\underline{j})10^6 \text{ lb-in.}$$

WILEY

©2018 by John Wiley & Sons. No part of this Instructor's Manual may be reproduced or distributed in any form or by any means without the written consent of the publisher. The publisher hereby limits distribution to instructors who have adopted the corresponding Meriam/Kraige/Bolton textbook. This material is written for instructors and is not intended for students.

2/112 $\underline{M} = \underline{r} \times \underline{F}$

$= -0.5\underline{i} \times 400\left(\cos 15^\circ \underline{j} + \sin 15^\circ \underline{k}\right)$

$= \underline{51.8\underline{j} - 193.2\underline{k}}$ N·m

WILEY

©2018 by John Wiley & Sons. No part of this Instructor's Manual may be reproduced or distributed in any form or by any means without the written consent of the publisher. The publisher hereby limits distribution to instructors who have adopted the corresponding Meriam/Kraige/Bolton textbook. This material is written for instructors and is not intended for students.

2/113 $\overline{AB} = \sqrt{0.8^2 + 1.5^2 + 2^2} = 2.62$ m

$\underline{T} = \frac{1.2}{2.62}(0.8\underline{i} + 1.5\underline{j} - 2\underline{k})$ kN

Take $\underline{r} = \overrightarrow{OA} = 1.6\underline{i} + 2\underline{k}$ m

$$\underline{M}_O = \underline{r} \times \underline{T} = \begin{vmatrix} \underline{i} & \underline{j} & \underline{k} \\ 1.6 & 0 & 2 \\ 0.8 & 1.5 & -2 \end{vmatrix} \frac{1.2}{2.62}$$

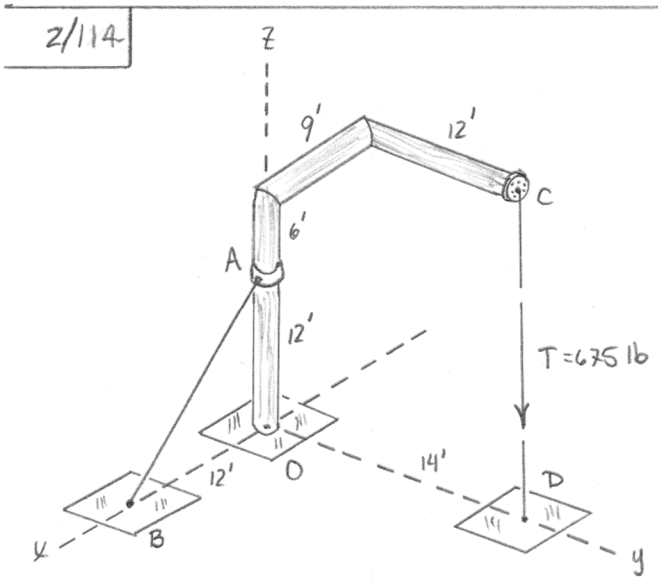
$$\underline{M}_O = 0.457(-3\underline{i} + 4.8\underline{j} + 2.40\underline{k}) \text{ kN·m}$$

$$M_O = |\underline{M}_O| = 0.457\sqrt{3^2 + 4.8^2 + 2.40^2} = \underline{2.81 \text{ kN·m}}$$

WILEY

©2018 by John Wiley & Sons. No part of this Instructor's Manual may be reproduced or distributed in any form or by any means without the written consent of the publisher. The publisher hereby limits distribution to instructors who have adopted the corresponding Meriam/Kraige/Bolton textbook. This material is written for instructors and is not intended for students.

2/114



FROM 2/98... $\underline{T} = 300\underline{i} + 66.8\underline{j} - 601\underline{k}$ lb

$$\underline{M}_O = \underline{r}_{OD} \times \underline{T} = 14\underline{j} \times (300\underline{i} + 66.8\underline{j} - 601\underline{k})$$

$$\underline{M}_O = -8410\underline{i} - 4210\underline{k} \text{ lb-ft}$$

WILEY

©2018 by John Wiley & Sons. No part of this Instructor's Manual may be reproduced or distributed in any form or by any means without the written consent of the publisher. The publisher hereby limits distribution to instructors who have adopted the corresponding Meriam/Kraige/Bolton textbook. This material is written for instructors and is not intended for students.

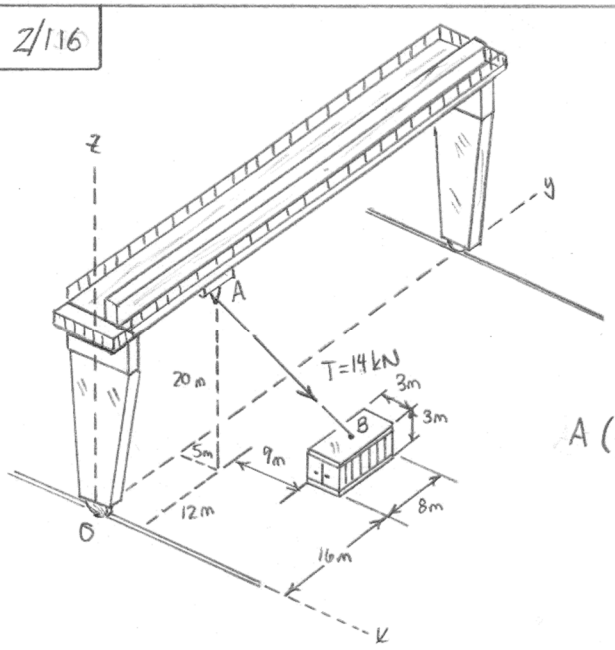
2/115 $\underline{M} = -150(0.250+0.250)\underline{i} + 150(0.150)\underline{j}$

$= -75\underline{i} + 22.5\underline{j}$ N·m

WILEY

©2018 by John Wiley & Sons. No part of this Instructor's Manual may be reproduced or distributed in any form or by any means without the written consent of the publisher. The publisher hereby limits distribution to instructors who have adopted the corresponding Meriam/Kraige/Bolton textbook. This material is written for instructors and is not intended for students.

2/116



A (5, 12, 20) m

From 2/93 ... $\underline{T} = \underline{R} = 6.83\,\underline{i} + 5.20\,\underline{j} - 11.06\,\underline{k}$ kN

$$\underline{M}_O = \underline{r}_{OA} \times \underline{T} = (5\underline{i} + 12\underline{j} + 20\underline{k}) \times (6.83\,\underline{i} + 5.20\,\underline{j} - 11.06\,\underline{k})$$

$$\underline{M}_O = -237\,\underline{i} + 191.9\,\underline{j} - 55.9\,\underline{k} \text{ kN·m}$$

WILEY

©2018 by John Wiley & Sons. No part of this Instructor's Manual may be reproduced or distributed in any form or by any means without the written consent of the publisher. The publisher hereby limits distribution to instructors who have adopted the corresponding Meriam/Kraige/Bolton textbook. This material is written for instructors and is not intended for students.

2/117

$$M_O = (250 \sin 60^\circ)12 + (250 \cos 60^\circ) \sin 40^\circ (8 - 4.2)$$

$$= 2900 \text{ lb-in.} \quad \curvearrowleft$$

WILEY

©2018 by John Wiley & Sons. No part of this Instructor's Manual may be reproduced or distributed in any form or by any means without the written consent of the publisher. The publisher hereby limits distribution to instructors who have adopted the corresponding Meriam/Kraige/Bolton textbook. This material is written for instructors and is not intended for students.

2/118 $\underline{M}_O = \underline{r} \times \underline{F}$

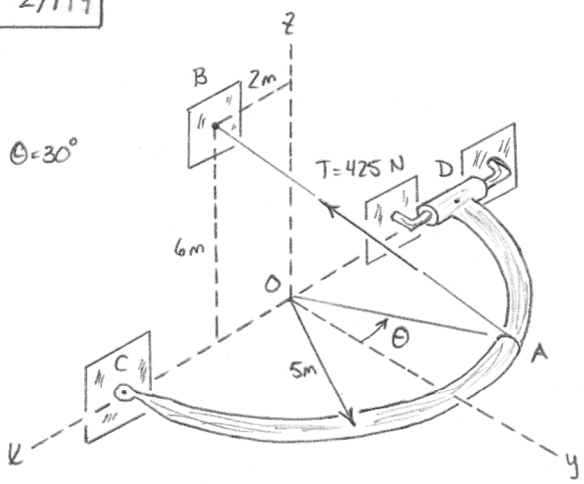
$= (-6\underline{i} + 0.8\underline{j} + 1.2\underline{k}) \times (-400\underline{j})$

$= \underline{480\underline{i} + 2400\underline{k}} \ \text{N} \cdot \text{m}$

WILEY

©2018 by John Wiley & Sons. No part of this Instructor's Manual may be reproduced or distributed in any form or by any means without the written consent of the publisher. The publisher hereby limits distribution to instructors who have adopted the corresponding Meriam/Kraige/Bolton textbook. This material is written for instructors and is not intended for students.

2/119



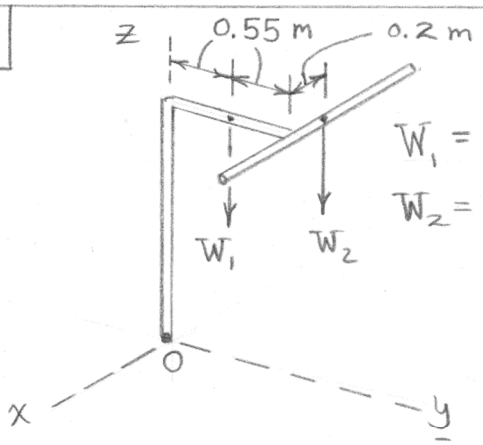
From 2/108 ... $\underline{T} = 221\underline{i} - 212\underline{j} + 294\underline{k}$ N

$M_{O_x} = r\cos\theta\, T_z = 5\cos 30^\circ (294) \longrightarrow \underline{M_{O_x} = 1275 \text{ N·m}}$

WILEY

©2018 by John Wiley & Sons. No part of this Instructor's Manual may be reproduced or distributed in any form or by any means without the written consent of the publisher. The publisher hereby limits distribution to instructors who have adopted the corresponding Meriam/Kraige/Bolton textbook. This material is written for instructors and is not intended for students.

2/120



$W_1 = 1.1(7)(9.81) = 75.5$ N

$W_2 = 2(7)(9.81) = 137.3$ N

$$\begin{cases} M_{O_x} = -75.5(0.55) - 137.3(1.1) = -192.6 \text{ N·m} \\ M_{O_y} = -137.3(0.2) = -27.5 \text{ N·m} \\ M_{O_z} = 0 \end{cases}$$

$\therefore \underline{M}_O = -192.6\,\underline{i} - 27.5\,\underline{j}$ N·m

$M_O = 194.6$ N·m

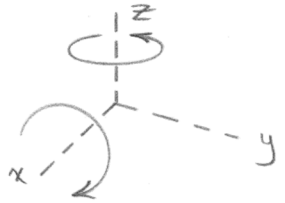
WILEY

©2018 by John Wiley & Sons. No part of this Instructor's Manual may be reproduced or distributed in any form or by any means without the written consent of the publisher. The publisher hereby limits distribution to instructors who have adopted the corresponding Meriam/Kraige/Bolton textbook. This material is written for instructors and is not intended for students.

2/121 $\underline{M} = 1.2(40)\underline{k} - 1.2(50)\underline{i}$

$= -60\underline{i} + 48\underline{k}$ lb-in.

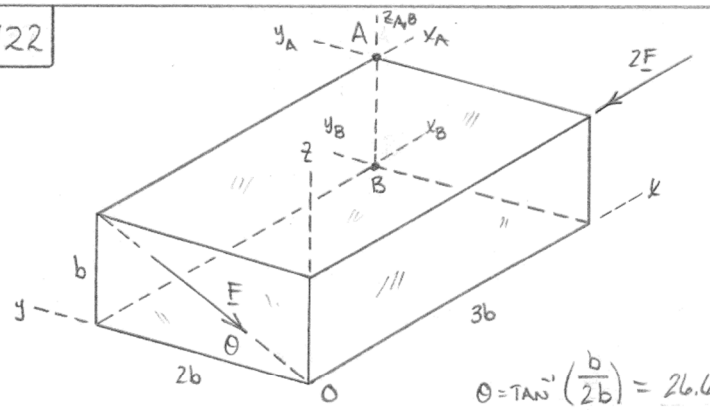
The spacecraft will begin to rotate about its x- and z axes.



WILEY

©2018 by John Wiley & Sons. No part of this Instructor's Manual may be reproduced or distributed in any form or by any means without the written consent of the publisher. The publisher hereby limits distribution to instructors who have adopted the corresponding Meriam/Kraige/Bolton textbook. This material is written for instructors and is not intended for students.

2/122



$\theta = \tan^{-1}\left(\frac{b}{2b}\right) = 26.6°$

· Force $\underline{F}$

$$\underline{M}_A = F\cos\theta(3b)\underline{k} - F\sin\theta(3b)\underline{j} \longrightarrow \underline{M}_A = \frac{Fb}{\sqrt{5}}(-3\underline{j} + 6\underline{k})$$

$$\underline{M}_B = F\cos\theta(3b)\underline{k} - F\sin\theta(3b)\underline{j} + F\sin\theta(2b)\underline{i}$$

$$\therefore \underline{M}_B = \frac{Fb}{\sqrt{5}}(2\underline{i} - 3\underline{j} + 6\underline{k})$$

· Force $2\underline{F}$

$$\underline{M}_A = -2F(2b)\underline{k} \longrightarrow \underline{M}_A = -4Fb\,\underline{k}$$

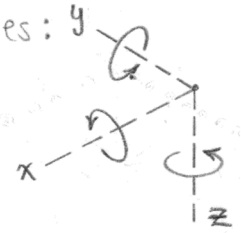
$$\underline{M}_B = -2F(2b)\underline{k} - 2F(b)\underline{j} \longrightarrow \underline{M}_B = -2Fb(\underline{j} + 2\underline{k})$$

©2018 by John Wiley & Sons. No part of this Instructor's Manual may be reproduced or distributed in any form or by any means without the written consent of the publisher. The publisher hereby limits distribution to instructors who have adopted the corresponding Meriam/Kraige/Bolton textbook. This material is written for instructors and is not intended for students.

2/123 $\underline{M} = (1700)(2)\underline{i} - (1700)(30)\underline{j} - (1700)(30)\underline{k}$

$= \underline{3400\,\underline{i} - 51\,000\,\underline{j} - 51\,000\,\underline{k}\ \text{N·m}}$

The orbiter would acquire rotational motion about all three axes:



WILEY

©2018 by John Wiley & Sons. No part of this Instructor's Manual may be reproduced or distributed in any form or by any means without the written consent of the publisher. The publisher hereby limits distribution to instructors who have adopted the corresponding Meriam/Kraige/Bolton textbook. This material is written for instructors and is not intended for students.

2/124

$$\underline{M}_O = 0\underline{i} - (200)(0.2 + 0.125\sin 20^\circ)\underline{j}$$
$$-200\,(0.125\cos 20^\circ - 0.070)\underline{k}$$
$$= -48.6\underline{j} - 9.49\underline{k} \ \text{N·m}$$

There would be no z-component of $\underline{M}_O$ if

$$d\cos 20^\circ - 70 = 0, \quad d = 74.5 \ \text{mm}$$

WILEY

©2018 by John Wiley & Sons. No part of this Instructor's Manual may be reproduced or distributed in any form or by any means without the written consent of the publisher. The publisher hereby limits distribution to instructors who have adopted the corresponding Meriam/Kraige/Bolton textbook. This material is written for instructors and is not intended for students.

2/125

$$\underline{T} = T\left[\frac{-0.35\underline{i} - 0.45\cos 20^\circ \underline{j} + (0.4 + 0.45\sin 20^\circ)\underline{k}}{\sqrt{(0.35)^2 + (0.45\cos 20^\circ)^2 + (0.4 + 0.45\sin 20^\circ)^2}}\right]$$

$$= 143.4\left[-0.449\underline{i} - 0.542\underline{j} + 0.710\underline{k}\right] \text{ N}$$

Moment of this force about the x-axis is

$$M_{O_x} = (0.710)(143.4)(0.45\cos 20^\circ) - 0.542(143.4)(0.45\sin 20^\circ) = \underline{31.1 \text{ N·m}}$$

The moment of the weight W of the 15-kg plate about the x-axis is

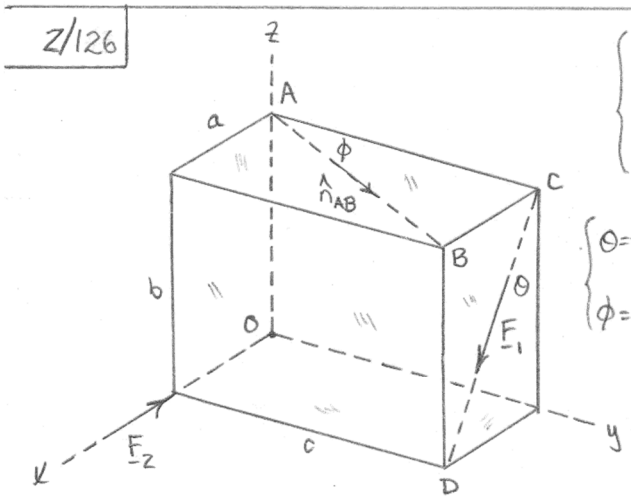
$$(M_{O_x})_W = -15(9.81)\frac{0.45\cos 20^\circ}{2} = \underline{-31.1 \text{ N·m}}$$

The moment of $\underline{T}$ about the line OB is zero, because $\underline{T}$ intersects OB.

WILEY

©2018 by John Wiley & Sons. No part of this Instructor's Manual may be reproduced or distributed in any form or by any means without the written consent of the publisher. The publisher hereby limits distribution to instructors who have adopted the corresponding Meriam/Kraige/Bolton textbook. This material is written for instructors and is not intended for students.

2/126



$a = 200\ mm$ $\quad F_1 = 450\ N$

$b = 400\ mm$ $\quad M_{AB} = 30\ N\cdot m$

$c = 500\ mm$

$\theta = \tan^{-1}\left(\frac{a}{b}\right) = \tan^{-1}\left(\frac{200}{400}\right) = 26.6°$

$\phi = \tan^{-1}\left(\frac{a}{c}\right) = \tan^{-1}\left(\frac{200}{500}\right) = 21.8°$

$\underline{F}_1 = 450(\sin\theta\,\underline{i} - \cos\theta\,\underline{k}) \longrightarrow \underline{F}_1 = 201\,\underline{i} - 402\,\underline{k}\ N$

$\underline{n}_{AB} = \sin\phi\,\underline{i} + \cos\phi\,\underline{j} \longrightarrow \underline{n}_{AB} = 0.371\,\underline{i} + 0.928\,\underline{j}$

$\underline{M}_A = bF_z\,\underline{j} - cF_{1_z}\,\underline{i} - cF_{1_x}\,\underline{k} = 0.4F_z\,\underline{j} - 0.5(402)\,\underline{i} - 0.5(201)\,\underline{k}$

$\underline{M}_A = -201\,\underline{i} + 0.4F_z\,\underline{j} - 100.6\,\underline{k}\ N\cdot m$

$M_{AB} = \underline{M}_A \cdot \underline{n}_{AB} \longrightarrow 30 = (-201\,\underline{i} + 0.4F_z\,\underline{j} - 100.6\,\underline{k}) \cdot (0.371\,\underline{i} + 0.928\,\underline{j})$

$30 = 0.371F_z - 74.7 \longrightarrow \underline{F_z = 282\ N}$

WILEY

©2018 by John Wiley & Sons. No part of this Instructor's Manual may be reproduced or distributed in any form or by any means without the written consent of the publisher. The publisher hereby limits distribution to instructors who have adopted the corresponding Meriam/Kraige/Bolton textbook. This material is written for instructors and is not intended for students.

2/127 Using the coordinates of the figure:

$$\underline{M}_A = \underline{r} \times \underline{F}, \qquad \underline{F} = -1.8\,\underline{k} \text{ lb}$$

$$\underline{r} = [(2+1)\cos 30^\circ]\,\underline{i} + 3\,\underline{j} + [(2+1)\sin 30^\circ]\,\underline{k} \text{ in.}$$

$$\therefore \quad \underline{M}_A = -5.40\,\underline{i} + 4.68\,\underline{j} \text{ lb-in.}$$

$$\underline{M}_{AB} = (\underline{M}_A \cdot \underline{n}_{AB})\,\underline{n}_{AB}, \qquad \underline{n}_{AB} = \cos 30^\circ\,\underline{i} + \sin 30^\circ\,\underline{k}$$

$$\therefore \quad \underline{M}_{AB} = -4.05\,\underline{i} - 2.34\,\underline{k} \text{ lb-in.}$$

WILEY

©2018 by John Wiley & Sons. No part of this Instructor's Manual may be reproduced or distributed in any form or by any means without the written consent of the publisher. The publisher hereby limits distribution to instructors who have adopted the corresponding Meriam/Kraige/Bolton textbook. This material is written for instructors and is not intended for students.

2/128 Moment of couple is $240(\underline{j}\cos 30° - \underline{k}\sin 30°)$

$= 207.8\underline{j} - 120\underline{k}$ N·m

Moment of force is

$1200\cos 30°(-0.250\underline{i} + 0.200\underline{k}) + 1200\sin 30°(0.200\underline{j})$

$= -259.8\underline{i} + 120\underline{j} + 207.8\underline{k}$ N·m

Thus total moment is

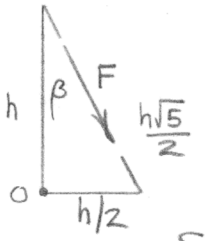
$\underline{M}_O = -259.8\underline{i} + 327.8\underline{j} + 87.8\underline{k}$ N·m

or $\underline{M}_O = -260\underline{i} + 328\underline{j} + 88\underline{k}$ N·m

WILEY

©2018 by John Wiley & Sons. No part of this Instructor's Manual may be reproduced or distributed in any form or by any means without the written consent of the publisher. The publisher hereby limits distribution to instructors who have adopted the corresponding Meriam/Kraige/Bolton textbook. This material is written for instructors and is not intended for students.

2/129



$$F_z = -F\cos\beta = -F\frac{1}{\sqrt{5}/2} = -\frac{2F}{\sqrt{5}}$$

$$F_{hor} = F\sin\beta = F/\sqrt{5}$$

$$F_x = F_{hor}\cos\theta = \frac{F}{\sqrt{5}}\cos\theta$$

$$F_y = F_{hor}\sin\theta = \frac{F}{\sqrt{5}}\sin\theta$$

So $\underline{F} = \frac{F}{\sqrt{5}}\left[\cos\theta\,\underline{i} + \sin\theta\,\underline{j} - 2\underline{k}\right]$

$$\underline{M}_O = \underline{r}\times\underline{F} = h\underline{k}\times\frac{F}{\sqrt{5}}\left[\cos\theta\,\underline{i} + \sin\theta\,\underline{j} - 2\underline{k}\right]$$

$$= \frac{Fh}{\sqrt{5}}\left(\cos\theta\,\underline{j} - \sin\theta\,\underline{i}\right)$$

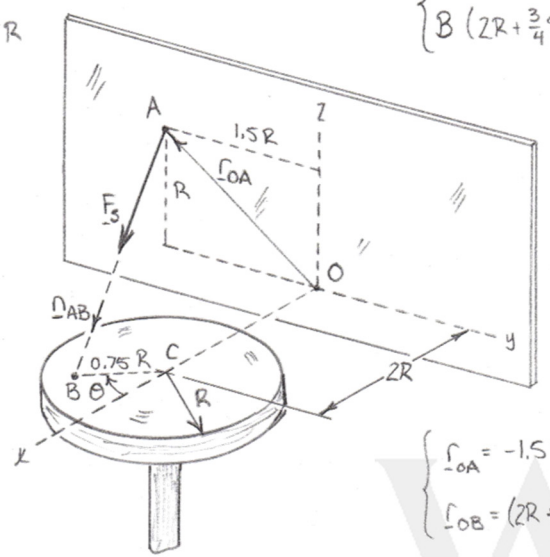
WILEY

©2018 by John Wiley & Sons. No part of this Instructor's Manual may be reproduced or distributed in any form or by any means without the written consent of the publisher. The publisher hereby limits distribution to instructors who have adopted the corresponding Meriam/Kraige/Bolton textbook. This material is written for instructors and is not intended for students.

***2/130**

$L_0 = 1.5R$

$\begin{cases} A\ (0, -1.5R, R) \\ B\ (2R + \frac{3}{4}R\cos\theta, -\frac{3}{4}R\sin\theta, 0) \end{cases}$



$\begin{cases} F_s = k\delta \\ \text{AND} \quad \delta = d - L_0 \end{cases}$

$\begin{cases} \underline{r}_{OA} = -1.5R\underline{j} + R\underline{k} \\ \underline{r}_{OB} = (2R + \frac{3}{4}R\cos\theta)\underline{i} - \frac{3}{4}R\sin\theta\,\underline{j} \end{cases}$

$$\underline{\Omega}_{AB} = \frac{(8 + 3\cos\theta)\,\underline{i} + (6 - 3\sin\theta)\,\underline{j} - 4\,\underline{k}}{\sqrt{125 + 48\cos\theta - 36\sin\theta}}$$

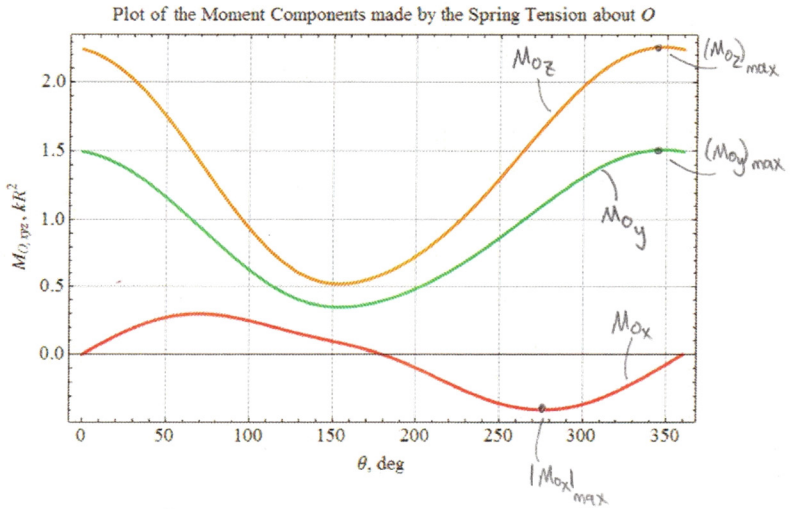
$$d = |\underline{r}_{OB} - \underline{r}_{OA}| = \frac{R}{4}\sqrt{125 + 48\cos\theta - 36\sin\theta}$$

$$\delta = d - L_0 = \frac{R}{4}\left(\sqrt{125 + 48\cos\theta - 36\sin\theta} - 6\right)$$

$$\underline{F}_s = k\delta\,\underline{\Omega}_{AB}$$

$$\underline{M}_O = \underline{r}_{OA} \times \underline{F}_s \quad \text{AND} \quad \underline{r}_{OA} = -1.5R\,\hat{j} + R\,\hat{k}$$

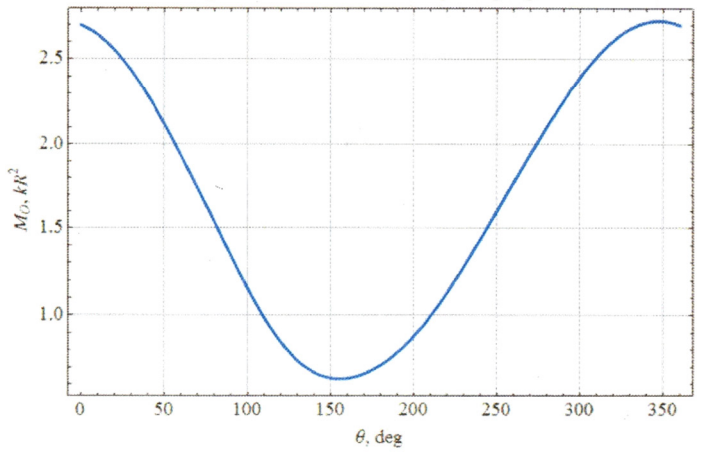
CARRY OUT THE CROSS PRODUCT AND PLOT THE MOMENT COMPONENTS.



$$|M_{Ox}|_{max} = 0.398\ kR^2 \quad \text{AT} \quad \theta = 277^\circ$$

$$|M_{Oy}|_{max} = 1.509\ kR^2 \quad \text{AT} \quad \theta = 348^\circ$$

$$|M_{Oz}|_{max} = 2.26\ kR^2 \quad \text{AT} \quad \theta = 348^\circ$$



$$|M_O|_{max} = 2.72\ kR^2 \quad \text{AT} \quad \theta = 347^\circ$$

©2018 by John Wiley & Sons. No part of this Instructor's Manual may be reproduced or distributed in any form or by any means without the written consent of the publisher. The publisher hereby limits distribution to instructors who have adopted the corresponding Meriam/Kraige/Bolton textbook. This material is written for instructors and is not intended for students.

2/131

$$\begin{cases} R_x = \Sigma F_x = -7 \text{ kN} \\ R_y = \Sigma F_y = 4 - F_3 \cos\theta = -5 \text{ kN} \quad (1) \\ R_z = \Sigma F_z = F_3 \sin\theta = 6 \text{ kN} \quad (2) \end{cases}$$

(1): $F_3 \cos\theta = 9$

(2): $F_3 \sin\theta = 6$

Divide Eq. (2) by Eq. 1: $\tan\theta = \frac{2}{3}$

$$\theta = 33.7^\circ$$

Then $F_3 = 10.82 \text{ kN}$

$$R = \sqrt{7^2 + 5^2 + 6^2} = 10.49 \text{ kN}$$

WILEY

©2018 by John Wiley & Sons. No part of this Instructor's Manual may be reproduced or distributed in any form or by any means without the written consent of the publisher. The publisher hereby limits distribution to instructors who have adopted the corresponding Meriam/Kraige/Bolton textbook. This material is written for instructors and is not intended for students.

2/132 $R = \Sigma F = 160 + 200 + 80 + 160 = 600\ \text{N} \downarrow$

$$\underline{M}_O = (-200-160)(0.6)\underline{i} + (80+160)(0.9)\underline{j}$$

$$= -216\underline{i} + 216\underline{j}\ \text{N}\cdot\text{m}$$

$$\underline{R}\cdot\underline{M}_O = -600\underline{k}\cdot(-216\underline{i} + 216\underline{j}) = 0, \quad \underline{R} \perp \underline{M}_O$$

WILEY

©2018 by John Wiley & Sons. No part of this Instructor's Manual may be reproduced or distributed in any form or by any means without the written consent of the publisher. The publisher hereby limits distribution to instructors who have adopted the corresponding Meriam/Kraige/Bolton textbook. This material is written for instructors and is not intended for students.

2/133

$$\underline{R} = -2F\underline{k} + F\underline{k} + F(\cos 30^\circ \underline{k} + \sin 30^\circ \underline{j})$$

$$= \frac{F}{2}\underline{j} + F\left(\frac{\sqrt{3}}{2} - 1\right)\underline{k} = \underline{F\left(\frac{1}{2}\underline{j} + \left(\frac{\sqrt{3}}{2} - 1\right)\underline{k}\right)}$$

$$\underline{M}_o = 2Fb\underline{j} + Fb\underline{i} + \frac{F}{2}(2b)\underline{k} + \frac{\sqrt{3}}{2}Fb\underline{i} - \frac{\sqrt{3}}{2}F(2b)\underline{j}$$

$$= \underline{Fb\left[\left(1 + \frac{\sqrt{3}}{2}\right)\underline{i} + (2 - \sqrt{3})\underline{j} + \underline{k}\right]}$$

$$\underline{R} \cdot \underline{M}_o = \left[\frac{1}{2}(2 - \sqrt{3}) + \left(\frac{\sqrt{3}}{2} - 1\right)(1)\right]F^2 b = 0, \text{ so}$$

$\underline{R} \perp \underline{M}_o$.

WILEY

©2018 by John Wiley & Sons. No part of this Instructor's Manual may be reproduced or distributed in any form or by any means without the written consent of the publisher. The publisher hereby limits distribution to instructors who have adopted the corresponding Meriam/Kraige/Bolton textbook. This material is written for instructors and is not intended for students.

2/134 $\underline{R} = \Sigma \underline{F} = -8\underline{i}$ kN

$\underline{M}_G = 50(10)\underline{k} + 8(6)\underline{j} + 8(40)\underline{k}$

$= 48\underline{j} + 820\underline{k}$ kN·m

WILEY

©2018 by John Wiley & Sons. No part of this Instructor's Manual may be reproduced or distributed in any form or by any means without the written consent of the publisher. The publisher hereby limits distribution to instructors who have adopted the corresponding Meriam/Kraige/Bolton textbook. This material is written for instructors and is not intended for students.

2/135 $R = \Sigma F_z = 70 + 30 - 80 - 60 - 50 = -90 \text{ lb}$

$-|R|y = \Sigma M_x$: $-90y = 30(12) + 70(12) - 60(6) - 50(12)$

$$y = -2.67 \text{ in.}$$

$|R|x = \Sigma M_y$: $90x = 80(10) - 30(10) - 50(8)$

$$x = 1.111 \text{ in.}$$

WILEY

©2018 by John Wiley & Sons. No part of this Instructor's Manual may be reproduced or distributed in any form or by any means without the written consent of the publisher. The publisher hereby limits distribution to instructors who have adopted the corresponding Meriam/Kraige/Bolton textbook. This material is written for instructors and is not intended for students.

2/136 The two 160-N forces constitute a couple $160(0.250)\underline{j} = 40\underline{j}$ N·m

$\underline{R} = \Sigma \underline{F} = 120\underline{i} - 180\underline{j} - 100\underline{k}$ N

$\underline{M} = \Sigma \underline{M}_A = [120(0.25) + 100(0.3) + 40]\underline{j} + 50\underline{k}$ N·m

$= 100\underline{j} + 50\underline{k}$ N·m

WILEY

©2018 by John Wiley & Sons. No part of this Instructor's Manual may be reproduced or distributed in any form or by any means without the written consent of the publisher. The publisher hereby limits distribution to instructors who have adopted the corresponding Meriam/Kraige/Bolton textbook. This material is written for instructors and is not intended for students.

2/137

$$\underline{R} = \Sigma \underline{F} = 600(\sin 30^\circ \underline{j} + \cos 30^\circ \underline{k}) + 800(-\sin 45^\circ \underline{j} + \cos 45^\circ \underline{k})$$

$$= \underline{-266\underline{j} + 1085\underline{k}} \ \text{N}$$

$$\underline{M}_O = -0.080\underline{i} \times 600(\sin 30^\circ \underline{j} + \cos 30^\circ \underline{k}) + 0.160\underline{i} \times 800(-\sin 45^\circ \underline{j} + \cos 45^\circ \underline{k})$$

$$= \underline{-48.9\underline{j} - 114.5\underline{k}} \ \text{N·m}$$

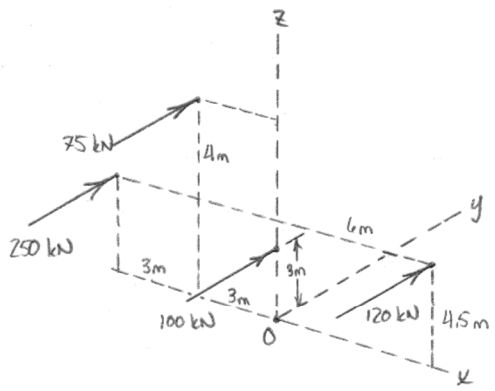
$\underline{R}$ is not perpendicular to $\underline{M}_O$, because

$\underline{R} \cdot \underline{M}_O \neq 0$.

WILEY

©2018 by John Wiley & Sons. No part of this Instructor's Manual may be reproduced or distributed in any form or by any means without the written consent of the publisher. The publisher hereby limits distribution to instructors who have adopted the corresponding Meriam/Kraige/Bolton textbook. This material is written for instructors and is not intended for students.

2/138



$\underline{r} = x\underline{i} + z\underline{k}$

$\underline{R} = (75 + 250 + 100 + 120)\underline{j} \longrightarrow \underline{R} = 545\,\underline{j}$ kN

$\underline{M}_O = -[120(4.5) + 100(3) + 250(4.5) + 75(8.5)]\,\underline{i} + [120(6) - 75(3) - 250(6)]\,\underline{k}$

$\underline{M}_O = -2600\,\underline{i} - 1010\,\underline{k}$ kN·m

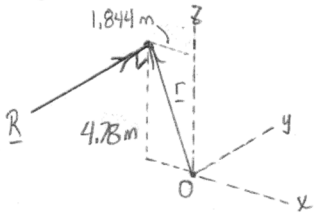
$\underline{r} \times \underline{R} = \underline{M}_O \longrightarrow (x\underline{i} + z\underline{k}) \times 545\,\underline{j} = -2600\,\underline{i} - 1010\,\underline{k}$

$\underline{i}$: $-545z = -2600$

$\underline{k}$: $545x = -1010$

Solving... $x = -1.844$ m $\quad z = 4.78$ m

$P = (-1.844, 0, 4.78)$ m



Engineering Mechanics Statics 9th edition Meriam Solutions Manual

©2018 by John Wiley & Sons. No part of this Instructor's Manual may be reproduced or distributed in any form or by any means without the written consent of the publisher. The publisher hereby limits distribution to instructors who have adopted the corresponding Meriam/Kraige/Bolton textbook. This material is written for instructors and is not intended for students.

2/139

$$\underline{R} = (200 + 800)\underline{i} + 1200(\cos 10^\circ \underline{j} - \sin 10^\circ \underline{i})$$

$$= \underline{792\,\underline{i} + 1182\,\underline{j}\ \text{N}}$$

$$\underline{M}_O = [(200-800)(0.1) + (1200\cos 10^\circ)(0.075)]\underline{k}$$

$$+ [-(200+800)(0.220+0.330) + 1200\sin 10^\circ (0.220)]\underline{j}$$

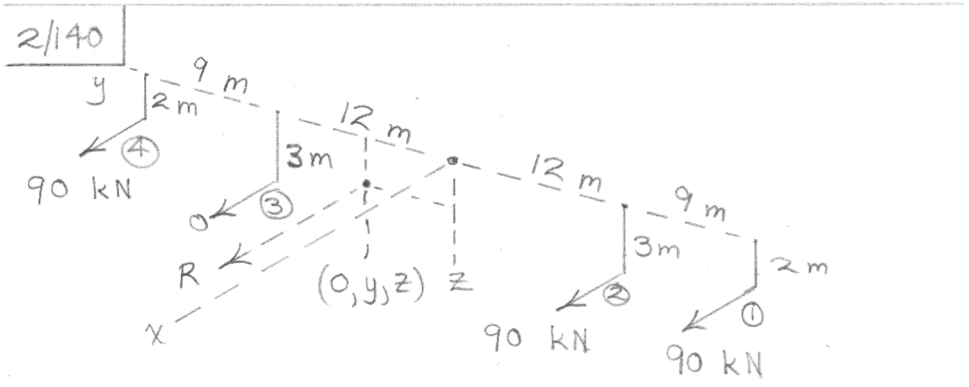
$$+ [1200\cos 10^\circ (0.220)]\underline{i}$$

$$= \underline{260\,\underline{i} - 504\,\underline{j} + 28.6\,\underline{k}\ \text{N}\cdot\text{m}}$$

WILEY

©2018 by John Wiley & Sons. No part of this Instructor's Manual may be reproduced or distributed in any form or by any means without the written consent of the publisher. The publisher hereby limits distribution to instructors who have adopted the corresponding Meriam/Kraige/Bolton textbook. This material is written for instructors and is not intended for students.

2/140



$$R = \Sigma F = 3(90) = 270 \text{ kN}$$

$$\Sigma M_z = -Ry : 90(21) + 90(12) - 90(21) = -270y$$

$$y = -4 \text{ m}$$

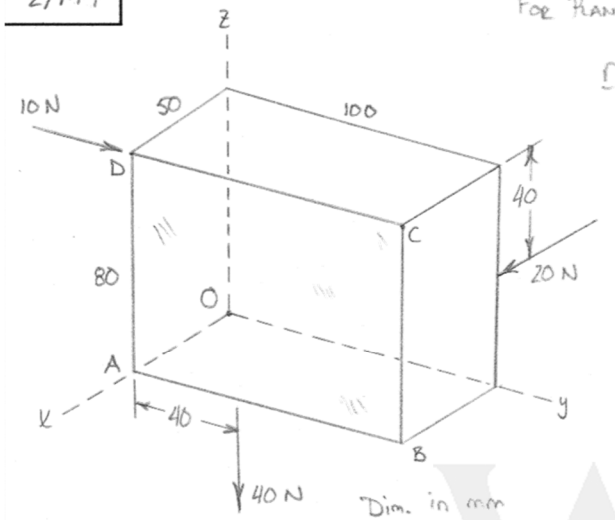
$$\Sigma M_y = Rz : 2(90)(2) + 90(3) = 270z$$

$$z = 2.33 \text{ m}$$

WILEY

©2018 by John Wiley & Sons. No part of this Instructor's Manual may be reproduced or distributed in any form or by any means without the written consent of the publisher. The publisher hereby limits distribution to instructors who have adopted the corresponding Meriam/Kraige/Bolton textbook. This material is written for instructors and is not intended for students.

2/141



For plane ABCD

$\underline{r} = 50\,\underline{i} + y\,\underline{j} + z\,\underline{k}$ mm

$\underline{R} = 20\,\underline{i} + 10\,\underline{j} - 40\,\underline{k}$

$\underline{n} = \dfrac{\underline{R}}{R} = \dfrac{1}{\sqrt{21}}(2\,\underline{i} + \underline{j} - 4\,\underline{k})$

$\underline{M}_O = [-10(0.08) - 40(0.04)]\,\underline{i} + [20(0.04) + 40(0.05)]\,\underline{j} + [10(0.05) - 20(0.1)]\,\underline{k}$

$\underline{M}_O = -2.4\,\underline{i} + 2.8\,\underline{j} - 1.5\,\underline{k}$ N·m

$M = \underline{M}_O \cdot \underline{n} = (-2.4\,\underline{i} + 2.8\,\underline{j} - 1.5\,\underline{k}) \cdot \left[\dfrac{1}{\sqrt{21}}(2\,\underline{i} + \underline{j} - 4\,\underline{k})\right] \rightarrow M = 0.873$ N·m (+)

$\underline{M} = M\,\underline{n} = 0.873\left(\dfrac{2}{\sqrt{21}}\,\underline{i} + \dfrac{1}{\sqrt{21}}\,\underline{j} - \dfrac{4}{\sqrt{21}}\,\underline{k}\right) \rightarrow \underline{M} = 0.381\,\underline{i} + 0.1905\,\underline{j} - 0.762\,\underline{k}$ N·m

$\underline{r} \times \underline{R} + \underline{M} = \underline{M}_O \rightarrow \left(\dfrac{50}{1000}\,\underline{i} + \dfrac{y}{1000}\,\underline{j} + \dfrac{z}{1000}\,\underline{k}\right) \times (20\,\underline{i} + 10\,\underline{j} - 40\,\underline{k}) + 0.381\,\underline{i} + 0.1905\,\underline{j} -$

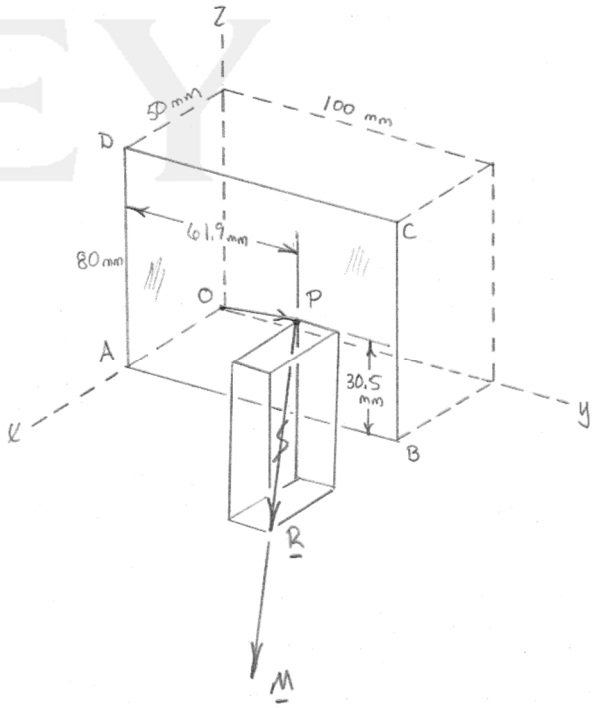
$\ldots\ 0.762\,\underline{k} = -2.4\,\underline{i} + 2.8\,\underline{j} - 1.5\,\underline{k}$

$$\begin{cases} \underline{i}: & -0.04\,y - 0.01\,z + 0.381 = -2.4 \\ \underline{j}: & 0.02\,z + 2.19 = 2.8 \\ \underline{k}: & -0.02\,y - 0.262 = -1.5 \end{cases}$$

Solving...

$$\begin{cases} y = 61.9 \text{ mm} \\ z = 30.5 \text{ mm} \end{cases}$$

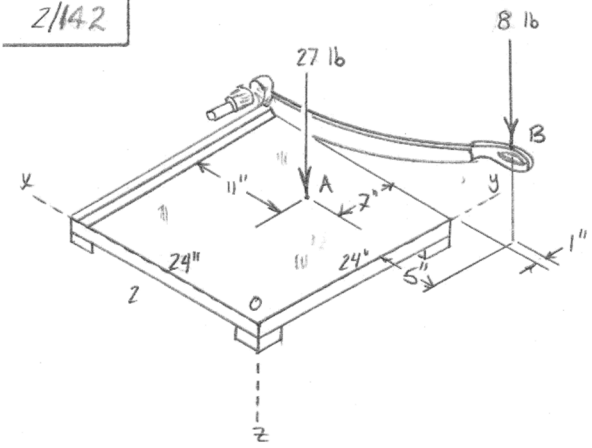
$P = (50, 61.9, 30.5)$ mm



WILEY

©2018 by John Wiley & Sons. No part of this Instructor's Manual may be reproduced or distributed in any form or by any means without the written consent of the publisher. The publisher hereby limits distribution to instructors who have adopted the corresponding Meriam/Kraige/Bolton textbook. This material is written for instructors and is not intended for students.

2/142



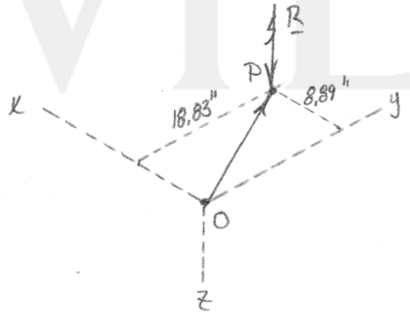
$\underline{R} = 35\underline{k}$ lb

$\underline{r} = x\underline{i} + y\underline{j}$

$\underline{M}_O = [27(24-7) + 8(24+1)]\underline{i} + [8(5) - 27(24-11)]\underline{j} \rightarrow \underline{M}_O = 659\underline{i} - 311\underline{j}$ lb-in.

$\underline{r} \times \underline{R} = \underline{M}_O \rightarrow (x\underline{i} + y\underline{j}) \times 35\underline{k} = 659\underline{i} - 311\underline{j}$

$\begin{cases} \underline{i}: & 35y = 659 \\ \underline{j}: & -35x = -311 \end{cases} \rightarrow$ $x = 8.89$ in. & $y = 18.83$ in.

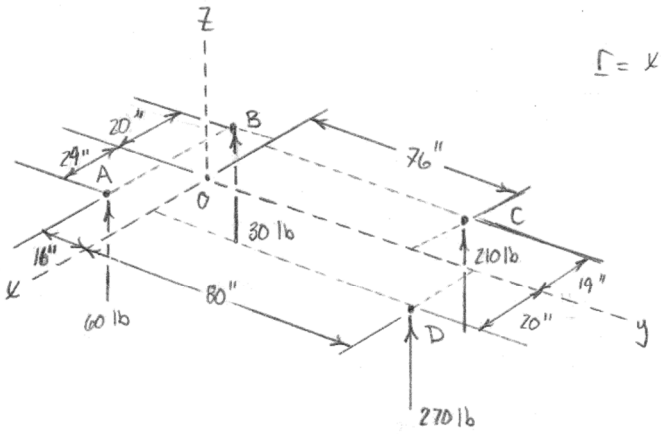


WILEY

©2018 by John Wiley & Sons. No part of this Instructor's Manual may be reproduced or distributed in any form or by any means without the written consent of the publisher. The publisher hereby limits distribution to instructors who have adopted the corresponding Meriam/Kraige/Bolton textbook. This material is written for instructors and is not intended for students.

2/143

$$\underline{R} = (60 + 30 + 210 + 270)\underline{k} \longrightarrow \underline{R} = 570\underline{k}\ \text{lb}$$



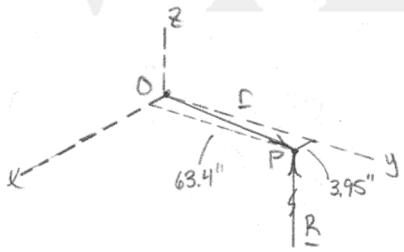
$$\underline{r} = x\underline{i} + y\underline{j}$$

$$\underline{M}_O = [270(80) + 210(76) - 60(16) - 30(16)]\underline{i} + [210(19) + 30(20) - 270(20) - 60(24)]\underline{j}$$

$$\underline{M}_O = 36{,}120\underline{i} - 2250\underline{j}\ \text{lb-in.}$$

$$\underline{r} \times \underline{R} = \underline{M}_O \longrightarrow (x\underline{i} + y\underline{j}) \times 570\underline{k} = 36{,}120\underline{i} - 2250\underline{j}$$

$$\begin{cases} \underline{i}: & 570y = 36{,}120 \\ \underline{j}: & -570x = -2250 \end{cases} \longrightarrow \underline{x = 3.95\ \text{in.}} \quad \& \quad \underline{y = 63.4\ \text{in.}}$$



WILEY

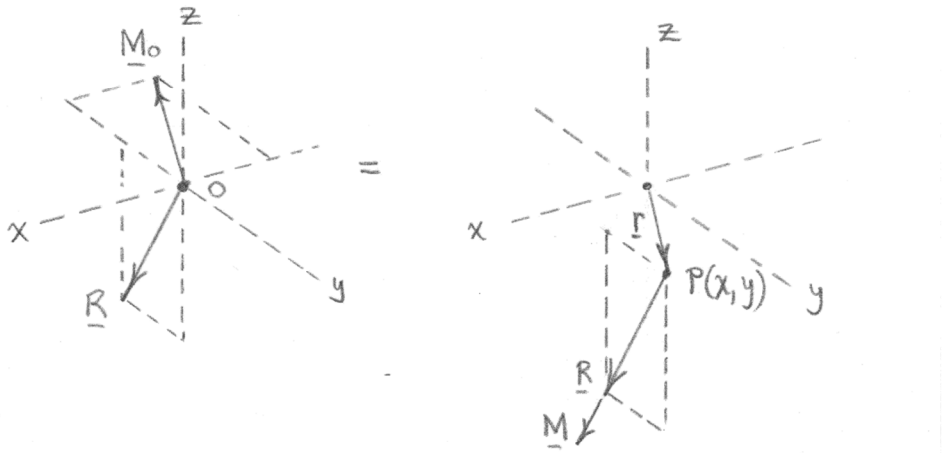
©2018 by John Wiley & Sons. No part of this Instructor's Manual may be reproduced or distributed in any form or by any means without the written consent of the publisher. The publisher hereby limits distribution to instructors who have adopted the corresponding Meriam/Kraige/Bolton textbook. This material is written for instructors and is not intended for students.

2/144

$$\underline{R} = -20\underline{j} - 40\underline{k} \text{ lb} \quad (= 44.7(-0.447\underline{j} - 0.894\underline{k}))$$

$$\underline{M}_O = -40(1.4)\underline{i} - 40(8)\underline{j}$$

$$= -56\underline{i} - 320\underline{j} \text{ lb-in.}$$



$$\underline{M}_O: -56\underline{i} - 320\underline{j} = \underline{r} \times \underline{R} + \underline{M} = (x\underline{i} + y\underline{j}) \times (-20\underline{j} - 40\underline{k}) + M(-0.447\underline{j} - 0.894\underline{k})$$

Equate coefficients:

$$\begin{cases} \underline{i}: & -56 = -40y \\ \underline{j}: & -320 = 40x - 0.447M \\ \underline{k}: & 0 = -20x - 0.894M \end{cases}$$

Solution:

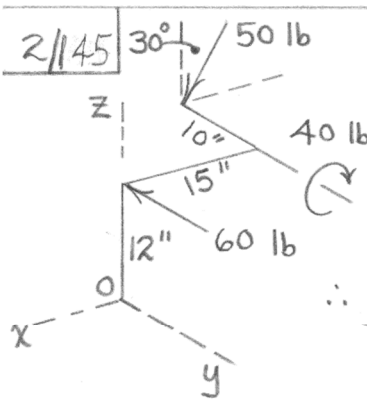
$x = -6.4$ in.

$y = 1.4$ in.

WILEY

©2018 by John Wiley & Sons. No part of this Instructor's Manual may be reproduced or distributed in any form or by any means without the written consent of the publisher. The publisher hereby limits distribution to instructors who have adopted the corresponding Meriam/Kraige/Bolton textbook. This material is written for instructors and is not intended for students.

2/145



$R_x = \Sigma F_x = 50 \sin 30^\circ = 25$ lb

$R_y = \Sigma F_y = -60$ lb

$R_z = \Sigma F_z = -50 \cos 30^\circ = -43.3$ lb

$\therefore \underline{R} = 25\underline{i} - 60\underline{j} - 43.3\underline{k}$ lb

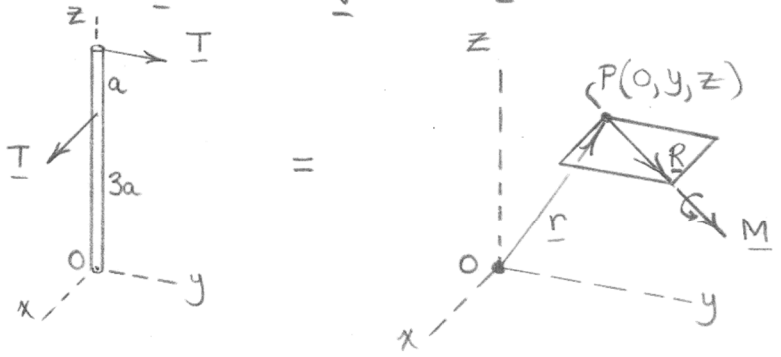
$$\underline{M}_O = 12(60)\underline{i} + 50 \sin 30^\circ (12)\underline{j} + 50 \sin 30^\circ (10)\underline{k}$$
$$+ 50 \cos 30^\circ (10)\underline{i} - 50 \cos 30^\circ (15)\underline{j} - 40(12)\underline{j}$$
$$= 1153\underline{i} - 830\underline{j} + 250\underline{k} \text{ lb-in.}$$

WILEY

©2018 by John Wiley & Sons. No part of this Instructor's Manual may be reproduced or distributed in any form or by any means without the written consent of the publisher. The publisher hereby limits distribution to instructors who have adopted the corresponding Meriam/Kraige/Bolton textbook. This material is written for instructors and is not intended for students.

2/146 $\underline{R} = \Sigma \underline{F} = T\underline{i} + T\underline{j} = \sqrt{2}T\left[\frac{1}{\sqrt{2}}\underline{i} + \frac{1}{\sqrt{2}}\underline{j}\right]$

$\Sigma \underline{M}_O = 3aT\underline{j} - 4aT\underline{i}$



$\Sigma \underline{M}_O = \underline{r} \times \underline{R} + \underline{M}$

$3aT\underline{j} - 4aT\underline{i} = (y\underline{j} + z\underline{k}) \times (T\underline{i} + T\underline{j}) + M\left(\frac{1}{\sqrt{2}}\underline{i} + \frac{1}{\sqrt{2}}\underline{j}\right)$

$$\Rightarrow \begin{cases} -4aT = -zT + \frac{M}{\sqrt{2}} \\ 3aT = zT + \frac{M}{\sqrt{2}} \\ 0 = -yT \end{cases} \quad \text{So} \quad \begin{cases} y = 0 \\ z = \frac{7}{2}a \\ M = -\frac{\sqrt{2}}{2}aT \end{cases}$$

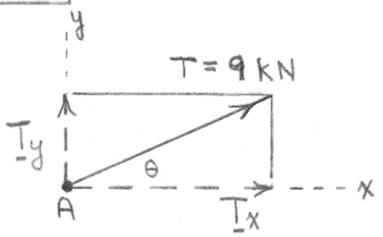
So $\underline{M} = -\frac{\sqrt{2}}{2}aT\left(\frac{1}{\sqrt{2}}\underline{i} + \frac{1}{\sqrt{2}}\underline{j}\right)$

$= \underline{\frac{-aT}{2}(\underline{i} + \underline{j})}$ (a negative wrench)

WILEY

©2018 by John Wiley & Sons. No part of this Instructor's Manual may be reproduced or distributed in any form or by any means without the written consent of the publisher. The publisher hereby limits distribution to instructors who have adopted the corresponding Meriam/Kraige/Bolton textbook. This material is written for instructors and is not intended for students.

2|147



$\theta = \tan^{-1}\frac{6}{10} = 31.0°$

$T_x = T\cos\theta = 9\cos 31.0°$

$= 7.72$ kN

$T_y = T\sin\theta = 9\sin 31.0°$

$= 4.63$ kN

$\underline{T} = 7.72\,\underline{i} + 4.63\,\underline{j}$ kN

WILEY

©2018 by John Wiley & Sons. No part of this Instructor's Manual may be reproduced or distributed in any form or by any means without the written consent of the publisher. The publisher hereby limits distribution to instructors who have adopted the corresponding Meriam/Kraige/Bolton textbook. This material is written for instructors and is not intended for students.

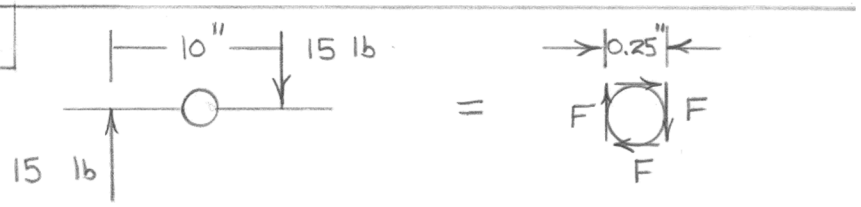
2/148

$$\begin{cases} \underline{M}_1 = -cF_1\underline{i} \\ \underline{M}_2 = cF_2\underline{i} - aF_2\underline{k} = F_2(c\underline{i} - a\underline{k}) \\ \underline{M}_3 = -aF_3\underline{k} \end{cases}$$

WILEY

©2018 by John Wiley & Sons. No part of this Instructor's Manual may be reproduced or distributed in any form or by any means without the written consent of the publisher. The publisher hereby limits distribution to instructors who have adopted the corresponding Meriam/Kraige/Bolton textbook. This material is written for instructors and is not intended for students.

2/149

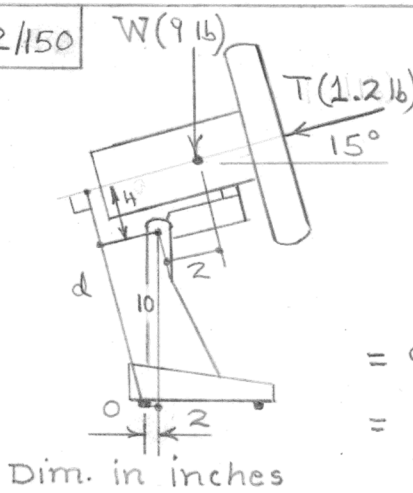


$M = Fd = 15(10) = 2F(0.25)$, $F = 300$ lb

WILEY

©2018 by John Wiley & Sons. No part of this Instructor's Manual may be reproduced or distributed in any form or by any means without the written consent of the publisher. The publisher hereby limits distribution to instructors who have adopted the corresponding Meriam/Kraige/Bolton textbook. This material is written for instructors and is not intended for students.

2/150



$$M_O = Fd$$
$$= 1.2(4 + 10\cos 15^\circ - 2\sin 15^\circ)$$
$$= 15.77 \text{ lb-in.} \quad (\curvearrowleft)$$

$$M_{O_W} = W d_W$$
$$= 9(2 + 2\cos 15^\circ - 4\sin 15^\circ)$$
$$= 26.1 \text{ lb-in.} \quad (\curvearrowright)$$

WILEY

©2018 by John Wiley & Sons. No part of this Instructor's Manual may be reproduced or distributed in any form or by any means without the written consent of the publisher. The publisher hereby limits distribution to instructors who have adopted the corresponding Meriam/Kraige/Bolton textbook. This material is written for instructors and is not intended for students.

2/151 $\underline{P} = P\left(\frac{4}{5}\underline{i} + \frac{3}{5}\underline{j}\right)$; $\underline{r}_{AB} = b\left(-\underline{i} + \underline{j} + \underline{k}\right)$

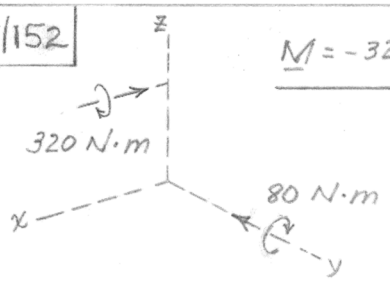
Carry out $\underline{M}_A = \underline{r}_{AB} \times \underline{P}$ to obtain

$$\underline{M}_A = \frac{Pb}{5}\left(-3\underline{i} + 4\underline{j} - 7\underline{k}\right)$$

WILEY

©2018 by John Wiley & Sons. No part of this Instructor's Manual may be reproduced or distributed in any form or by any means without the written consent of the publisher. The publisher hereby limits distribution to instructors who have adopted the corresponding Meriam/Kraige/Bolton textbook. This material is written for instructors and is not intended for students.

2/152



$$\underline{M} = -320\underline{i} - 80\underline{j} \quad \text{N·m}$$

$$\cos\theta_x = \frac{M_x}{|\underline{M}|} = \frac{-320}{\sqrt{320^2 + 80^2}} = \underline{-0.970}$$

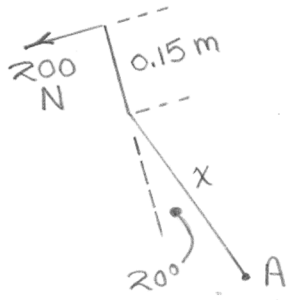
WILEY

©2018 by John Wiley & Sons. No part of this Instructor's Manual may be reproduced or distributed in any form or by any means without the written consent of the publisher. The publisher hereby limits distribution to instructors who have adopted the corresponding Meriam/Kraige/Bolton textbook. This material is written for instructors and is not intended for students.

2/153

$M_A = Fd$: $80 = 200(0.15 + x\cos 20°)$

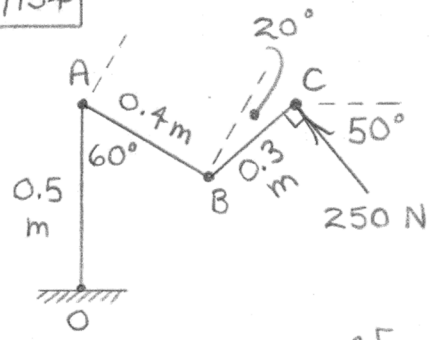
$x = 0.266\text{ m}$ or $\underline{266\text{ mm}}$



WILEY

©2018 by John Wiley & Sons. No part of this Instructor's Manual may be reproduced or distributed in any form or by any means without the written consent of the publisher. The publisher hereby limits distribution to instructors who have adopted the corresponding Meriam/Kraige/Bolton textbook. This material is written for instructors and is not intended for students.

2/154



$$\curvearrowleft M_O = 250\cos 50^\circ\left[0.5 - 0.4\cos 60^\circ + 0.3\sin 40^\circ\right]$$
$$+ 250\sin 50^\circ\left[0.4\sin 60^\circ + 0.3\cos 40^\circ\right]$$
$$= \underline{189.6 \text{ N·m CCW}}$$

WILEY

©2018 by John Wiley & Sons. No part of this Instructor's Manual may be reproduced or distributed in any form or by any means without the written consent of the publisher. The publisher hereby limits distribution to instructors who have adopted the corresponding Meriam/Kraige/Bolton textbook. This material is written for instructors and is not intended for students.

2/155

$$\underline{R} = 800\left[-\sin 30^\circ \cos 20^\circ \underline{i} + \sin 30^\circ \sin 20^\circ \underline{j} + \cos 30^\circ \underline{k}\right]$$

$$= \underline{-376\underline{i} + 136.8\underline{j} + 693\underline{k}} \quad \text{N}$$

$$\underline{M}_O = \underline{r}_{OB} \times \underline{F}$$

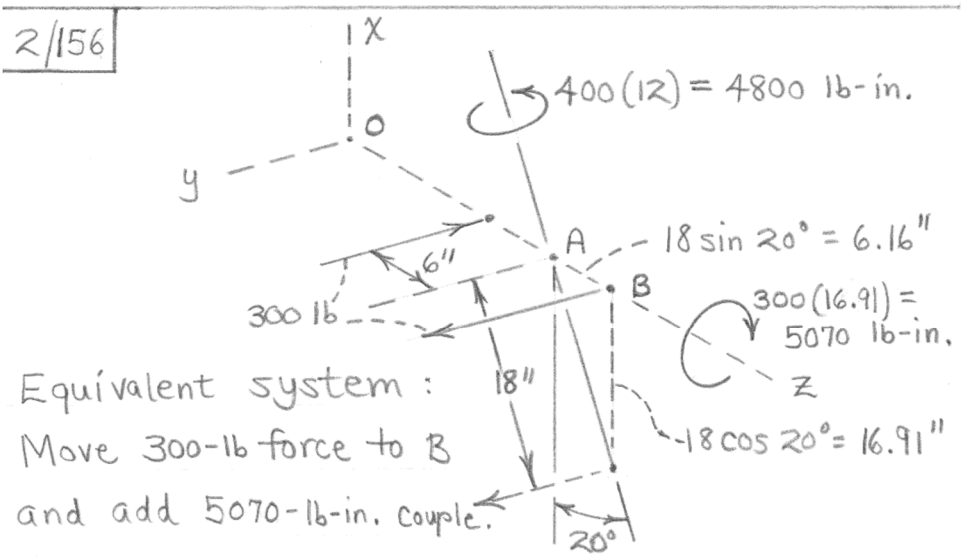
$$\underline{r}_{OB} = \left[300 \sin 20^\circ \underline{i} + 300 \cos 20^\circ \underline{j} + 250\underline{k}\right] \text{mm}$$

$$\underline{M}_O = 161.1\underline{i} - 165.1\underline{j} + 120\underline{k} \quad \text{N·m}$$

WILEY

©2018 by John Wiley & Sons. No part of this Instructor's Manual may be reproduced or distributed in any form or by any means without the written consent of the publisher. The publisher hereby limits distribution to instructors who have adopted the corresponding Meriam/Kraige/Bolton textbook. This material is written for instructors and is not intended for students.

2/156



Equivalent system:
Move 300-lb force to B
and add 5070-lb-in. couple.

The components of the resultant couple are

$M_X = -300(6+6.16) + 4800 \cos 20° = 864$ lb-in.

$M_Y = 0$

$M_Z = -4800 \sin 20° - 5070 = -6720$ lb-in.

$\underline{M} = 864\underline{i} - 6720\underline{k}$ lb-in.

$M = \sqrt{864^2 + 6720^2} = 6770$ lb-in.

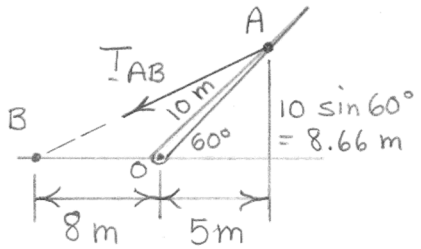
WILEY

©2018 by John Wiley & Sons. No part of this Instructor's Manual may be reproduced or distributed in any form or by any means without the written consent of the publisher. The publisher hereby limits distribution to instructors who have adopted the corresponding Meriam/Kraige/Bolton textbook. This material is written for instructors and is not intended for students.

2/157

$\overline{AB}^2 = 8^2 + 10^2 - 2(8)(10)\cos 120°$

$\overline{AB} = 15.62$ m



(a) $\underline{T}_{AB} = 3\left[-\frac{13}{15.62}\cos 35°\,\underline{i} - \frac{13}{15.62}\sin 35°\,\underline{j} - \frac{8.66}{15.62}\underline{k}\right]$

$= -2.05\underline{i} - 1.432\underline{j} - 1.663\underline{k}$ kN

(b) Carry out $\underline{r}_{OB} \times \underline{T}_{AB}$, where $\underline{r}_{OB} = 8(-\cos 35°\,\underline{i} - \sin 35°\,\underline{j})$ m to obtain

$\underline{M}_O = 7.63\underline{i} - 10.90\underline{j}$ kN·m

$\therefore M_{Ox} = 7.63$ kN·m, $M_{Oy} = -10.90$ kN·m, $M_{Oz} = 0$

(c) $T_{AO} = \underline{T}_{AB} \cdot \underline{n}_{AO}$

With $\underline{n}_{AO} = -\cos 60°\cos 35°\,\underline{i} - \cos 60°\sin 35°\,\underline{j} - \sin 60°\,\underline{k}$,

we obtain $T_{AO} = 2.69$ kN

WILEY

©2018 by John Wiley & Sons. No part of this Instructor's Manual may be reproduced or distributed in any form or by any means without the written consent of the publisher. The publisher hereby limits distribution to instructors who have adopted the corresponding Meriam/Kraige/Bolton textbook. This material is written for instructors and is not intended for students.

2/158

$$\underline{R} = \Sigma \underline{F} = 500 \cos 45^\circ (\underline{i}) + 400 \underline{j} - (600 + 500 \sin 45^\circ) \underline{k}$$

$$= 354 \underline{i} + 400 \underline{j} - 954 \underline{k} \text{ lb}$$

$$R = \sqrt{354^2 + 400^2 + 954^2} = 1093 \text{ lb}$$

$$\underline{M} = [500 \cos 45^\circ (3) - 600 (3) - 400 (10)] \underline{i}$$
$$+ [500 \cos 45^\circ (6) + 500 \sin 45^\circ (7) + 600 (6)] \underline{j}$$
$$+ [500 \sin 45^\circ (3) + 400 (3)] \underline{k}$$

$$= -4739 \underline{i} + 8196 \underline{j} + 2261 \underline{k} \text{ lb-ft}$$

$$M = \sqrt{4739^2 + 8196^2 + 2261^2} = 9730 \text{ lb-ft}$$

WILEY

©2018 by John Wiley & Sons. No part of this Instructor's Manual may be reproduced or distributed in any form or by any means without the written consent of the publisher. The publisher hereby limits distribution to instructors who have adopted the corresponding Meriam/Kraige/Bolton textbook. This material is written for instructors and is not intended for students.

***2/159**

$\Sigma F_x = 0: -360 - 240\sin\theta + T\sin 30^\circ + 400\cos 30^\circ = 0$ (1)

$\Sigma F_y = 600: 240\cos\theta + T\cos 30^\circ + 400\sin 30^\circ = 600$ (2)

Numerical solution of Eqs. (1) & (2):

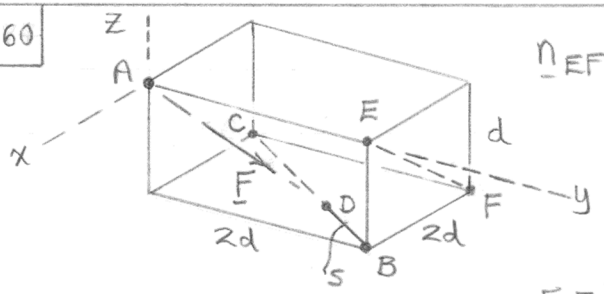
$$\theta = 21.7^\circ, \quad T = 204 \text{ lb}$$

(We could eliminate T between Eqs. (1) & (2), but the resulting equation is still transcendental.)

WILEY

©2018 by John Wiley & Sons. No part of this Instructor's Manual may be reproduced or distributed in any form or by any means without the written consent of the publisher. The publisher hereby limits distribution to instructors who have adopted the corresponding Meriam/Kraige/Bolton textbook. This material is written for instructors and is not intended for students.

***2/160**



$$\underline{n}_{EF} = \frac{-2d\underline{i} - d\underline{k}}{\sqrt{5}\,d} = \frac{-2\underline{i} - \underline{k}}{\sqrt{5}}$$

$$\underline{AD} = \underline{AB} + \underline{BD} = 2d\underline{j} - d\underline{k} + s\left[\frac{-2d\underline{i} - 2d\underline{j}}{\sqrt{8}\,d}\right]$$

$$= -\frac{s}{\sqrt{2}}\underline{i} + \left(2d - \frac{s}{\sqrt{2}}\right)\underline{j} - d\underline{k}$$

$$|\underline{AD}| = \sqrt{\frac{s^2}{2} + \left(2d - \frac{s}{\sqrt{2}}\right)^2 + d^2} = \sqrt{s^2 + 5d^2 - 2\sqrt{2}\,ds}$$

$$\underline{F} = F\frac{\underline{AD}}{|\underline{AD}|} = F\,\frac{-\frac{s}{\sqrt{2}}\underline{i} + \left(2d - \frac{s}{\sqrt{2}}\right)\underline{j} - d\underline{k}}{\sqrt{s^2 + 5d^2 - 2\sqrt{2}\,ds}}$$

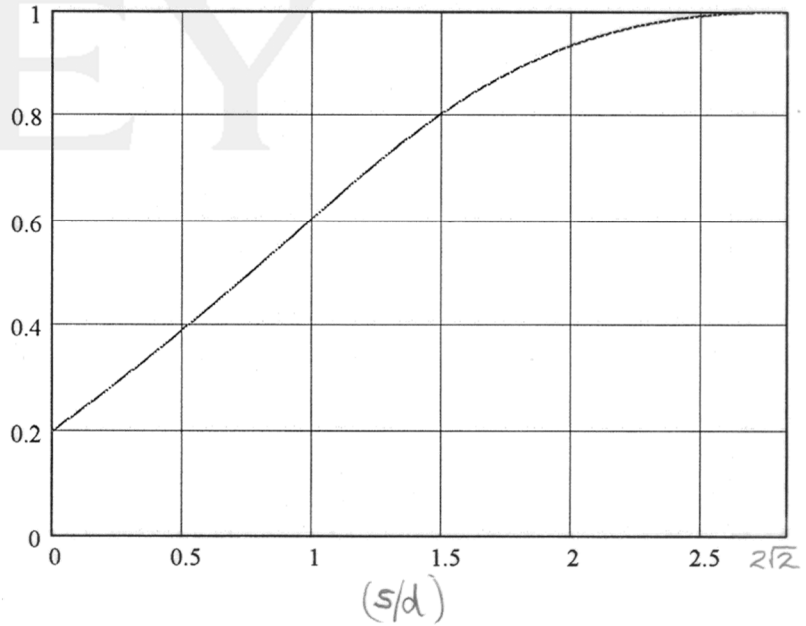
Carry out $\underline{F}\cdot\underline{n}_{EF}$ to obtain the projection

$$\underline{F}\cdot\underline{n}_{EF} = \frac{F(s\sqrt{2} + d)}{\sqrt{5}\sqrt{s^2 + 5d^2 - 2\sqrt{2}\,ds}}$$

The nondimensionalized fraction n of the magnitude F projected is then

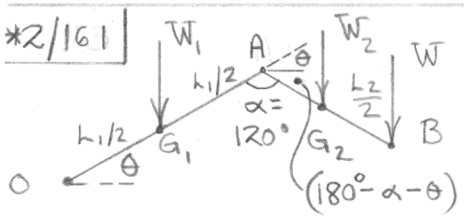
$$n = \frac{\underline{F}\cdot\underline{n}_{EF}}{F} = \frac{\sqrt{2}\,\frac{s}{d} + 1}{\sqrt{5}\sqrt{\left(\frac{s}{d}\right)^2 + 5 - 2\sqrt{2}\,\frac{s}{d}}}$$

We let $\frac{s}{d}$ vary from 0 to $2\sqrt{2}$ as D moves from B to C. Resulting plot:



©2018 by John Wiley & Sons. No part of this Instructor's Manual may be reproduced or distributed in any form or by any means without the written consent of the publisher. The publisher hereby limits distribution to instructors who have adopted the corresponding Meriam/Kraige/Bolton textbook. This material is written for instructors and is not intended for students.

***2/161**



$$\begin{cases} W_1 = 120 \text{ lb} & h_1 = 3 \text{ ft} \\ W_2 = 50 \text{ lb} & h_2 = 2 \text{ ft} \\ W = 300 \text{ lb} & \alpha = 120^\circ \end{cases}$$

$$+\circlearrowleft M_O = W_1 \frac{h_1}{2}\cos\theta + W_2\left(h_1\cos\theta + \frac{L_2}{2}\cos(180^\circ - \alpha - \theta)\right) + W\left(h_1\cos\theta + h_2\cos(180^\circ - \alpha - \theta)\right)$$

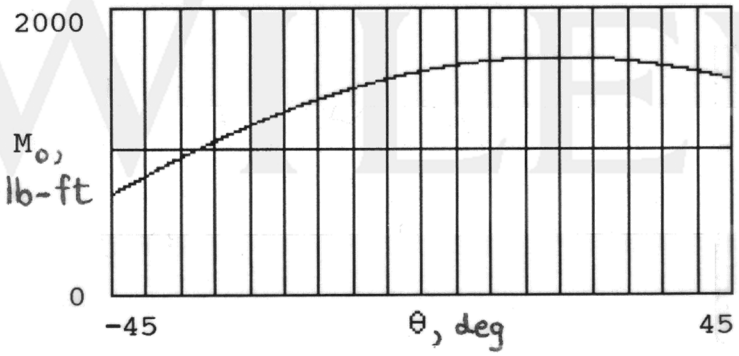
With the above numbers:

$$M_O = 1230\cos\theta + 650\cos(60^\circ - \theta) \quad \text{(in lb-ft)}$$

(see plot below)

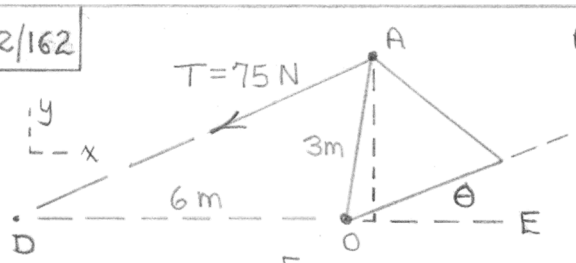
For $(M_O)_{max}$: $\frac{dM_O}{d\theta} = -1230\sin\theta + 650\sin(60^\circ - \theta) = 0$

Numerical solution: $\theta = 19.90^\circ$, $(M_O)_{max} = 1654$ lb-ft



©2018 by John Wiley & Sons. No part of this Instructor's Manual may be reproduced or distributed in any form or by any means without the written consent of the publisher. The publisher hereby limits distribution to instructors who have adopted the corresponding Meriam/Kraige/Bolton textbook. This material is written for instructors and is not intended for students.

***2/162**



Angle $AOE = \theta + 60^\circ$

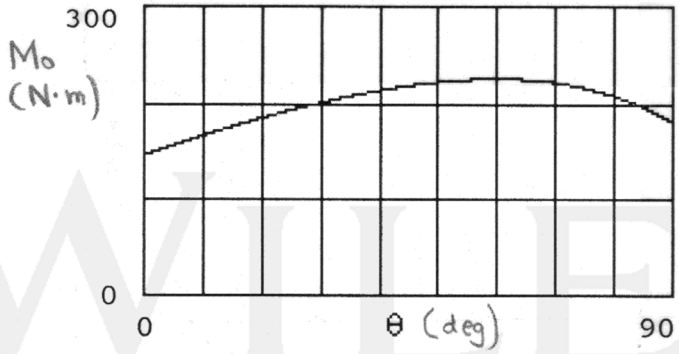
Use $\underline{M}_O = \underline{r}_{OD} \times \underline{T}$

$\underline{r}_{OD} = -6\underline{i}$ m

$$\underline{T} = T\underline{n}_{AD} = 75\left[\frac{-(6+3\cos(\theta+60^\circ))\underline{i} - 3\sin(\theta+60^\circ)\underline{j}}{\sqrt{[6+3\cos(\theta+60^\circ)]^2+[3\sin(\theta+60^\circ)]^2}}\right] \text{N}$$

$$\underline{M}_O = \underline{r}_{OD} \times \underline{T} = \frac{1350\sin(\theta+60^\circ)\,\underline{k}}{\sqrt{45+36\cos(\theta+60^\circ)}} \text{ N·m}$$

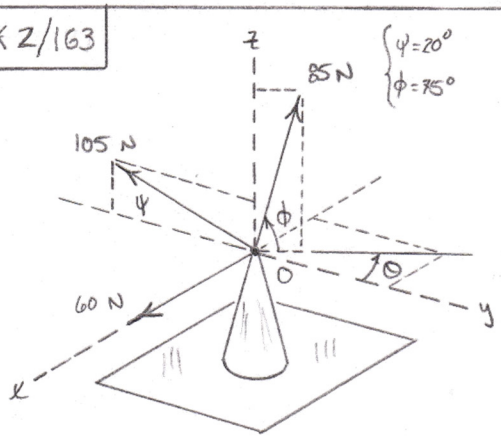
M_O is a max @ $\theta = 60^\circ$: $M_O = 225$ N·m



WILEY

©2018 by John Wiley & Sons. No part of this Instructor's Manual may be reproduced or distributed in any form or by any means without the written consent of the publisher. The publisher hereby limits distribution to instructors who have adopted the corresponding Meriam/Kraige/Bolton textbook. This material is written for instructors and is not intended for students.

*2/163



$\psi = 20°$

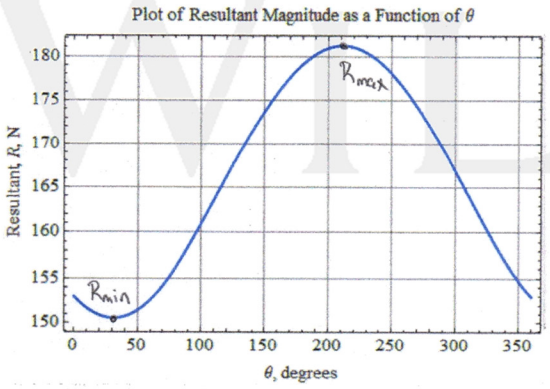
$\phi = 75°$

$$\underline{R} = (60 - 85\cos 75°\sin\theta)\hat{i} + (85\cos 75°\cos\theta - 105\cos 20°)\hat{j} + (85\sin 75° + 105\sin 20°)\hat{k}$$

$$\underline{R} = (60 - 22.0\sin\theta)\underline{i} + (22.0\cos\theta - 98.7)\underline{j} + 118.0\underline{k} \text{ N}$$

$$R = \sqrt{\underline{R}\cdot\underline{R}} \longrightarrow R = \left[(60 - 22.0\sin\theta)^2 + (22.0\cos\theta - 98.7)^2 + 118.0^2\right]^{1/2}$$

Plotting R... For θ_{max}, set $\frac{dR}{d\theta} = 0$



$R_{min} = 150.6$ N

$\theta_{min} = 31.3°$

$R_{max} = 181.2$ N

$\theta_{max} = 211°$

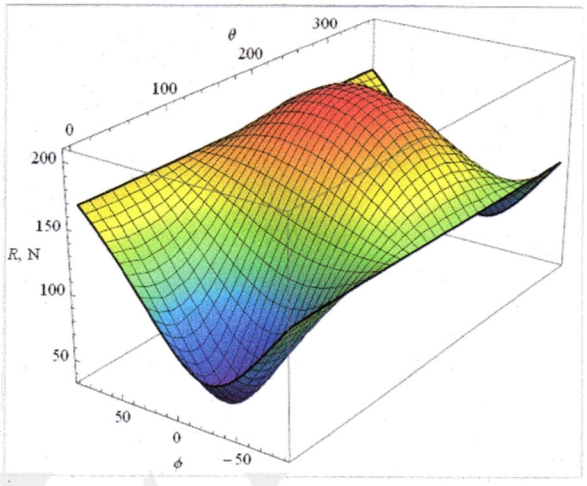
©2018 by John Wiley & Sons. No part of this Instructor's Manual may be reproduced or distributed in any form or by any means without the written consent of the publisher. The publisher hereby limits distribution to instructors who have adopted the corresponding Meriam/Kraige/Bolton textbook. This material is written for instructors and is not intended for students.

* 2/164

FROM 2/163...

$$\underline{R} = (60 - 85\cos\phi\sin\theta)\underline{i} + (85\cos\phi\cos\theta - 105\cos 20)\underline{j} + (85\sin\phi + 105\sin 20)\underline{k}$$

$R = \sqrt{\underline{R}\cdot\underline{R}}$ AND WE PLOT FOR $0 \le \theta \le 360°$ AND $-90° \le \phi \le 90°$



$R_{min} = 35.9$ N

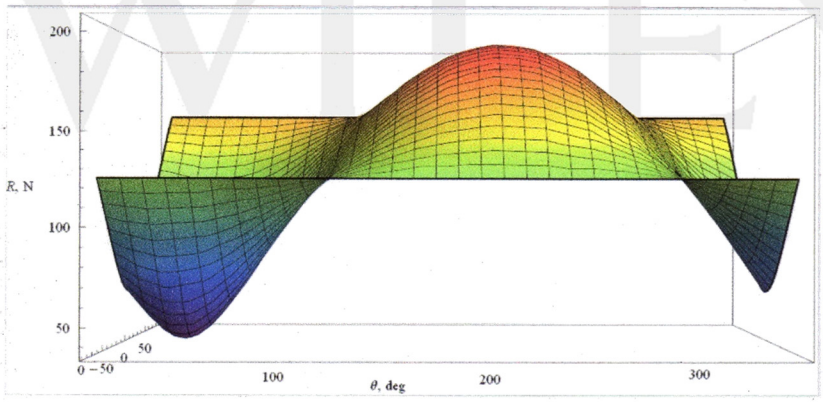
$\theta_{min} = 31.3°$

$\phi_{min} = -17.27°$

$R_{max} = 206$ N

$\theta_{max} = 211°$

$\phi_{max} = 17.27°$



Engineering Mechanics Statics 9th edition Meriam Solutions Manual

©2018 by John Wiley & Sons. No part of this Instructor's Manual may be reproduced or distributed in any form or by any means without the written consent of the publisher. The publisher hereby limits distribution to instructors who have adopted the corresponding Meriam/Kraige/Bolton textbook. This material is written for instructors and is not intended for students.

***2/165** $\underline{T} = T\underline{n}_{AB}$



$$\underline{T} = T\left[\frac{(d+40\cos\beta)\underline{i} + 40(1-\sin\beta)\underline{j}}{\sqrt{(d+40\cos\beta)^2 + 40^2(1-\sin\beta)^2}}\right] \qquad \left(\beta = \theta + \frac{\pi}{4}\right)$$

$$\underline{r}_{OB} = (d\underline{i} + 40\underline{j})$$

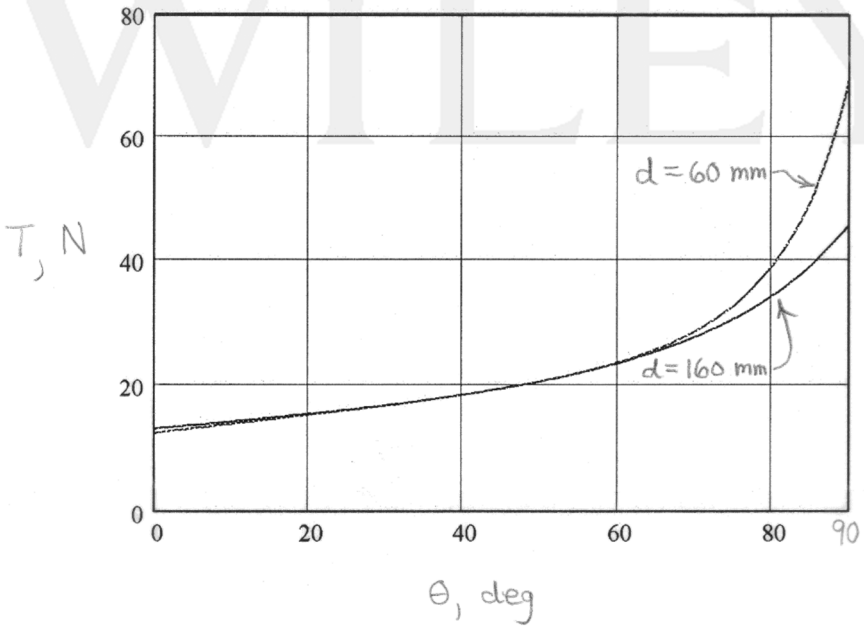
$$\Sigma \underline{M}_O = \underline{0}: \quad \underline{r}_{OB} \times \underline{T} + K\beta\underline{k} = \underline{0}$$

Carry out the cross product, consider the z-component, and solve for T to obtain

$$T = \frac{12.5\left(\theta+\frac{\pi}{4}\right)\sqrt{d^2 + 80d\cos\left(\theta+\frac{\pi}{4}\right) - 3200\sin\left(\theta+\frac{\pi}{4}\right) + 3200}}{\left[d\sin\left(\theta+\frac{\pi}{4}\right) + 40\cos\left(\theta+\frac{\pi}{4}\right)\right]}$$

(T in N, θ in radians)

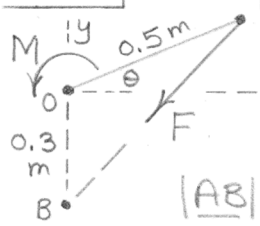
Plot of T versus θ for $d = 60$ mm and for $d = 160$ mm:



Engineering Mechanics Statics 9th edition Meriam Solutions Manual

©2018 by John Wiley & Sons. No part of this Instructor's Manual may be reproduced or distributed in any form or by any means without the written consent of the publisher. The publisher hereby limits distribution to instructors who have adopted the corresponding Meriam/Kraige/Bolton textbook. This material is written for instructors and is not intended for students.

***2/166**



$$\underline{F} = F\underline{n}_{AB} = F\frac{\underline{AB}}{|\underline{AB}|}$$

$$\underline{AB} = -0.5\cos\theta\,\underline{i} - (0.5\sin\theta + 0.3)\underline{j}\ \text{m}$$

$$|\underline{AB}| = \sqrt{(0.5\cos\theta)^2 + (0.5\sin\theta + 0.3)^2}$$

$$= \sqrt{0.34 + 0.3\sin\theta}\ \text{m}$$

$$F = k\delta = 600\left[\sqrt{0.34 + 0.3\sin\theta} - 0.65\right]\ \text{N}$$

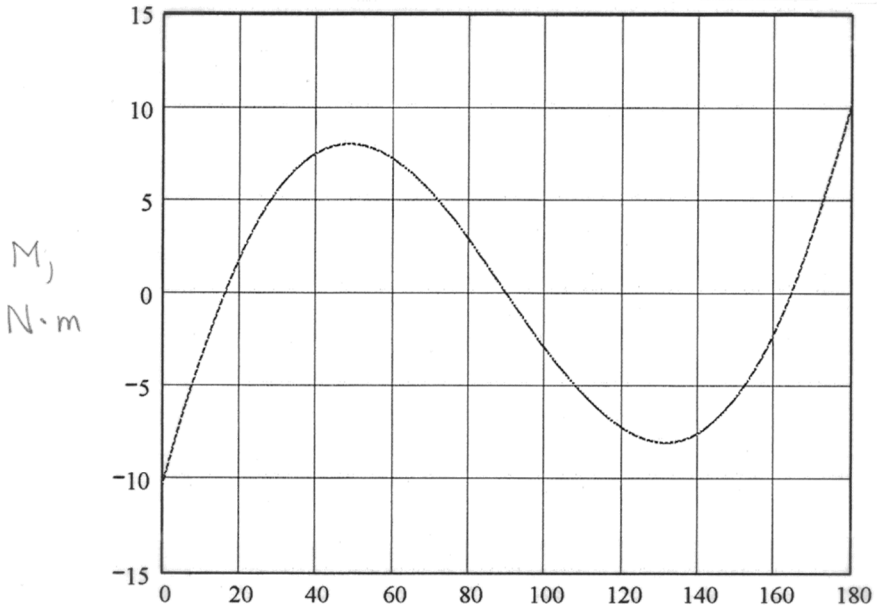
So

$$\underline{F} = \frac{600\left[\sqrt{0.34 + 0.3\sin\theta} - 0.65\right]}{\sqrt{0.34 + 0.3\sin\theta}}\left[-0.5\cos\theta\,\underline{i} - (0.5\sin\theta + 0.3)\underline{j}\right]$$

Now form $\underline{r}_{OB} \times \underline{F}$, where $\underline{r}_{OB} = -0.3\underline{j}$ m, to obtain $-\dfrac{90\cos\theta\left(\sqrt{0.34 + 0.3\sin\theta} - 0.65\right)}{\sqrt{0.34 + 0.3\sin\theta}}\underline{k}$

With the above moment plus $M\underline{k}$ summing to zero, we obtain the scalar

$$M = \frac{90\cos\theta\left[\sqrt{0.34 + 0.3\sin\theta} - 0.65\right]}{\sqrt{0.34 + 0.3\sin\theta}}\ (\text{N}\cdot\text{m})$$



(Note: $M(0) = -10.33$ N·m
$M(180°) = 10.33$ N·m)

Engineering Mechanics Statics 9th edition Meriam Solutions Manual