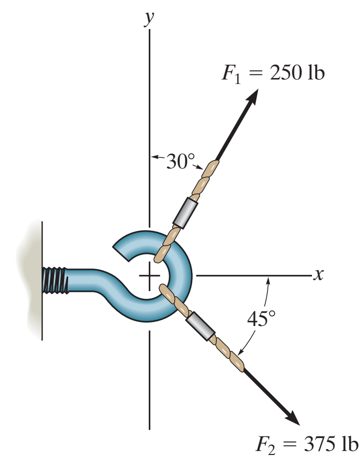
2–1.

Determine the magnitude of the resultant force $\mathbf{F}_R = \mathbf{F}_1 + \mathbf{F}_2$ and its direction, measured counterclockwise from the positive x axis.



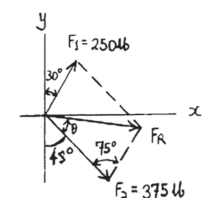
SOLUTION

$$F_R = \sqrt{(250)^2 + (375)^2 - 2(250)(375)\cos 75^\circ} = 393.2 = 393 \text{ lb} \qquad \textbf{Ans.}$$

$$\frac{393.2}{\sin 75^\circ} = \frac{250}{\sin\theta}$$

$$\theta = 37.89^\circ$$

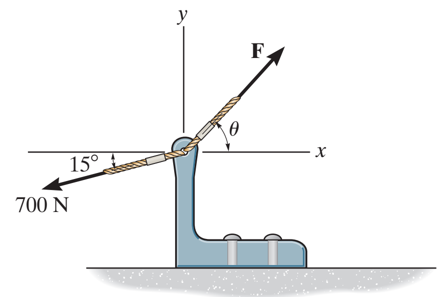
$$\phi = 360^\circ - 45^\circ + 37.89^\circ = 353^\circ \qquad \textbf{Ans.}$$



This work is protected by United States copyright laws and is provided solely for the use of instructors in teaching their courses and assessing student learning. Dissemination or sale of any part of this work (including on the World Wide Web) will destroy the integrity of the work and is not permitted.

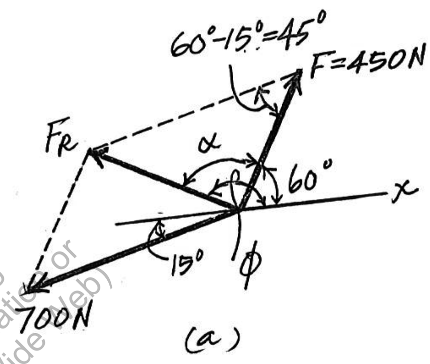
© 2013 Pearson Education, Inc., Upper Saddle River, NJ. All rights reserved. This publication is protected by Copyright and written permission should be obtained from the publisher prior to any prohibited reproduction, storage in a retrieval system, or transmission in any form or by any means, electronic, mechanical, photocopying, recording, or likewise. For information regarding permission(s), write to: Rights and Permissions Department, Pearson Education, Inc., Upper Saddle River, NJ 07458.

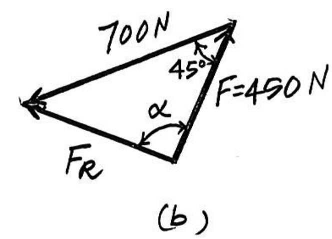
2–2.
If $\theta = 60^\circ$ and $F = 450$ N, determine the magnitude of the resultant force and its direction, measured counterclockwise from the positive x axis.



SOLUTION

The parallelogram law of addition and the triangular rule are shown in Figs. *a* and *b*, respectively.





Applying the law of consines to Fig. *b*,

$$F_R = \sqrt{700^2 + 450^2 - 2(700)(450)\cos 45^\circ}$$

$$= 497.01 \text{ N} = 497 \text{ N} \qquad \textbf{Ans.}$$

This yields

$$\frac{\sin \alpha}{700} = \frac{\sin 45^\circ}{497.01} \qquad \alpha = 95.19^\circ$$

Thus, the direction of angle ϕ of $\mathbf{F}_R$ measured counterclockwise from the positive x axis, is

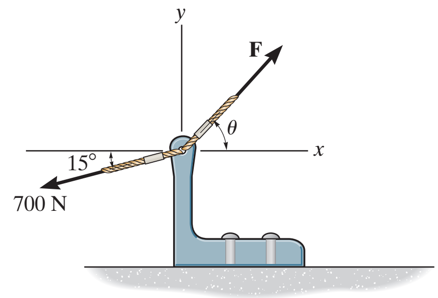
$$\phi = \alpha + 60^\circ = 95.19^\circ + 60^\circ = 155^\circ \qquad \textbf{Ans.}$$

This work is protected by United States copyright laws and is provided solely for the use of instructors in teaching their courses and assessing student learning. Dissemination or sale of any part of this work (including on the World Wide Web) will destroy the integrity of the work and is not permitted.

© 2013 Pearson Education, Inc., Upper Saddle River, NJ. All rights reserved. This publication is protected by Copyright and written permission should be obtained from the publisher prior to any prohibited reproduction, storage in a retrieval system, or transmission in any form or by any means, electronic, mechanical, photocopying, recording, or likewise. For information regarding permission(s), write to: Rights and Permissions Department, Pearson Education, Inc., Upper Saddle River, NJ 07458.

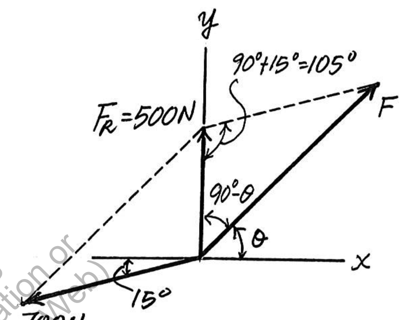
2–3.

If the magnitude of the resultant force is to be 500 N, directed along the positive y axis, determine the magnitude of force **F** and its direction θ.

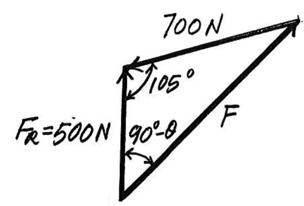


SOLUTION

The parallelogram law of addition and the triangular rule are shown in Figs. *a* and *b*, respectively.



(a)



(b)

Applying the law of cosines to Fig. *b*,

$$F = \sqrt{500^2 + 700^2 - 2(500)(700)\cos 105^\circ}$$

$$= 959.78 \text{ N} = 960 \text{ N} \qquad \textbf{Ans.}$$

Applying the law of sines to Fig. *b*, and using this result, yields

$$\frac{\sin(90^\circ + \theta)}{700} = \frac{\sin 105^\circ}{959.78}$$

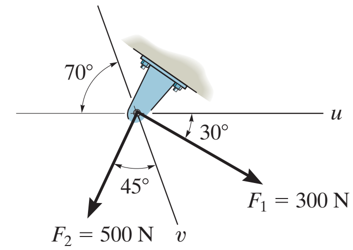
$$\theta = 45.2^\circ \qquad \textbf{Ans.}$$

This work is protected by United States copyright laws and is provided solely for the use of instructors in teaching their courses and assessing student learning. Dissemination or sale of any part of this work (including on the World Wide Web) will destroy the integrity of the work and is not permitted.

© 2013 Pearson Education, Inc., Upper Saddle River, NJ. All rights reserved. This publication is protected by Copyright and written permission should be obtained from the publisher prior to any prohibited reproduction, storage in a retrieval system, or transmission in any form or by any means, electronic, mechanical, photocopying, recording, or likewise. For information regarding permission(s), write to: Rights and Permissions Department, Pearson Education, Inc., Upper Saddle River, NJ 07458.

***2–4.**

Determine the magnitude of the resultant force $\mathbf{F}_R = \mathbf{F}_1 + \mathbf{F}_2$ and its direction, measured clockwise from the positive u axis.



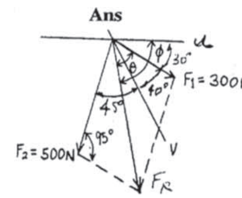
SOLUTION

$$F_R = \sqrt{(300)^2 + (500)^2 - 2(300)(500)\cos 95^\circ} = 605.1 = 605\text{ N}$$ **Ans.**

$$\frac{605.1}{\sin 95^\circ} = \frac{500}{\sin \theta}$$

$$\theta = 55.40^\circ$$

$$\phi = 55.40^\circ + 30^\circ = 85.4^\circ$$ **Ans.**

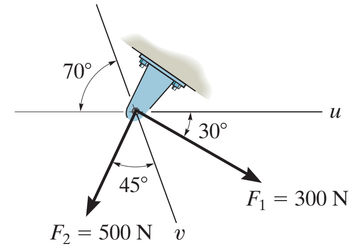


This work is protected by United States copyright laws and is provided solely for the use of instructors in teaching their courses and assessing student learning. Dissemination or sale of any part of this work (including on the World Wide Web) will destroy the integrity of the work and is not permitted.

© 2013 Pearson Education, Inc., Upper Saddle River, NJ. All rights reserved. This publication is protected by Copyright and written permission should be obtained from the publisher prior to any prohibited reproduction, storage in a retrieval system, or transmission in any form or by any means, electronic, mechanical, photocopying, recording, or likewise. For information regarding permission(s), write to: Rights and Permissions Department, Pearson Education, Inc., Upper Saddle River, NJ 07458.

2–5.

Resolve the force $\mathbf{F}_1$ into components acting along the u and v axes and determine the magnitudes of the components.



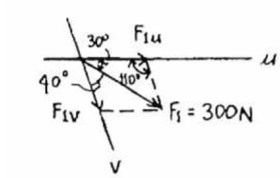
SOLUTION

$$\frac{F_{1u}}{\sin 40^\circ} = \frac{300}{\sin 110^\circ}$$

$$F_{1u} = 205 \text{ N}$$ **Ans.**

$$\frac{F_{1v}}{\sin 30^\circ} = \frac{300}{\sin 110^\circ}$$

$$F_{1v} = 160 \text{ N}$$ **Ans.**

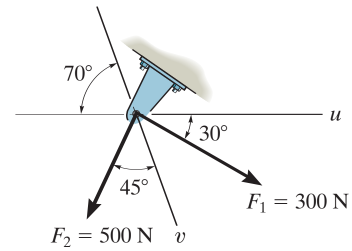


This work is protected by United States copyright laws and is provided solely for the use of instructors in teaching their courses and assessing student learning. Dissemination or sale of any part of this work (including on the World Wide Web) will destroy the integrity of the work and is not permitted.

© 2013 Pearson Education, Inc., Upper Saddle River, NJ. All rights reserved. This publication is protected by Copyright and written permission should be obtained from the publisher prior to any prohibited reproduction, storage in a retrieval system, or transmission in any form or by any means, electronic, mechanical, photocopying, recording, or likewise. For information regarding permission(s), write to: Rights and Permissions Department, Pearson Education, Inc., Upper Saddle River, NJ 07458.

2–6.

Resolve the force $\mathbf{F}_2$ into components acting along the u and v axes and determine the magnitudes of the components.



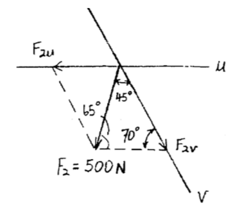
SOLUTION

$$\frac{F_{2u}}{\sin 45^\circ} = \frac{500}{\sin 70^\circ}$$

$$F_{2u} = 376 \text{ N} \qquad \textbf{Ans.}$$

$$\frac{F_{2v}}{\sin 65^\circ} = \frac{500}{\sin 70^\circ}$$

$$F_{2v} = 482 \text{ N} \qquad \textbf{Ans.}$$

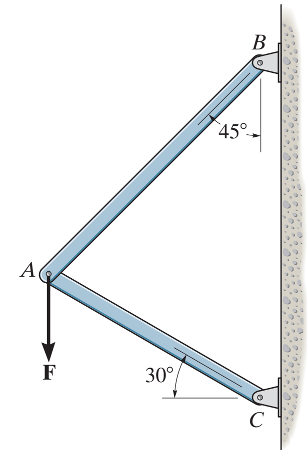


This work is protected by United States copyright laws and is provided solely for the use of instructors in teaching their courses and assessing student learning. Dissemination or sale of any part of this work (including on the World Wide Web) will destroy the integrity of the work and is not permitted.

© 2013 Pearson Education, Inc., Upper Saddle River, NJ. All rights reserved. This publication is protected by Copyright and written permission should be obtained from the publisher prior to any prohibited reproduction, storage in a retrieval system, or transmission in any form or by any means, electronic, mechanical, photocopying, recording, or likewise. For information regarding permission(s), write to: Rights and Permissions Department, Pearson Education, Inc., Upper Saddle River, NJ 07458.

2–7.

The vertical force **F** acts downward at A on the two-membered frame. Determine the magnitudes of the two components of **F** directed along the axes of AB and AC. Set $F = 500$ N.



SOLUTION

Parallelogram Law: The parallelogram law of addition is shown in Fig. *a*.

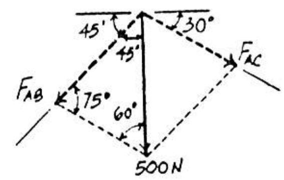
Trigonometry: Using the law of sines (Fig. *b*), we have

$$\frac{F_{AB}}{\sin 60^\circ} = \frac{500}{\sin 75^\circ}$$

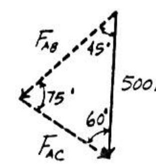
$$F_{AB} = 448 \text{ N}$$ **Ans.**

$$\frac{F_{AC}}{\sin 45^\circ} = \frac{500}{\sin 75^\circ}$$

$$F_{AC} = 366 \text{ N}$$ **Ans.**



(a)



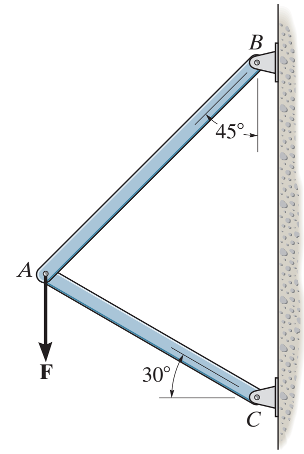
(b)

This work is protected by United States copyright laws and is provided solely for the use of instructors in teaching their courses and assessing student learning. Dissemination or sale of any part of this work (including on the World Wide Web) will destroy the integrity of the work and is not permitted.

© 2013 Pearson Education, Inc., Upper Saddle River, NJ. All rights reserved. This publication is protected by Copyright and written permission should be obtained from the publisher prior to any prohibited reproduction, storage in a retrieval system, or transmission in any form or by any means, electronic, mechanical, photocopying, recording, or likewise. For information regarding permission(s), write to: Rights and Permissions Department, Pearson Education, Inc., Upper Saddle River, NJ 07458.

***2–8.**

Solve Prob. 2-7 with $F = 350$ lb.



SOLUTION

Parallelogram Law: The parallelogram law of addition is shown in Fig. *a*.

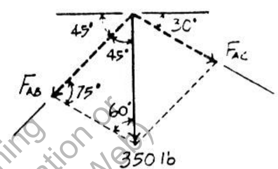
Trigonometry: Using the law of sines (Fig. *b*), we have

$$\frac{F_{AB}}{\sin 60^\circ} = \frac{350}{\sin 75^\circ}$$

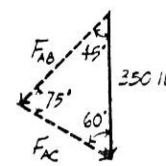
$$F_{AB} = 314 \text{ lb} \qquad \textbf{Ans.}$$

$$\frac{F_{AC}}{\sin 45^\circ} = \frac{350}{\sin 75^\circ}$$

$$F_{AC} = 256 \text{ lb} \qquad \textbf{Ans.}$$



(a)



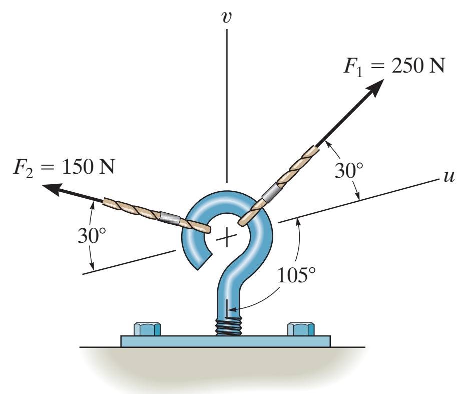
(b)

This work is protected by United States copyright laws and is provided solely for the use of instructors in teaching their courses and assessing student learning. Dissemination or sale of any part of this work (including on the World Wide Web) will destroy the integrity of the work and is not permitted.

© 2013 Pearson Education, Inc., Upper Saddle River, NJ. All rights reserved. This publication is protected by Copyright and written permission should be obtained from the publisher prior to any prohibited reproduction, storage in a retrieval system, or transmission in any form or by any means, electronic, mechanical, photocopying, recording, or likewise. For information regarding permission(s), write to: Rights and Permissions Department, Pearson Education, Inc., Upper Saddle River, NJ 07458.

2–9.

Resolve $\mathbf{F}_1$ into components along the u and v axes and determine the magnitudes of these components.

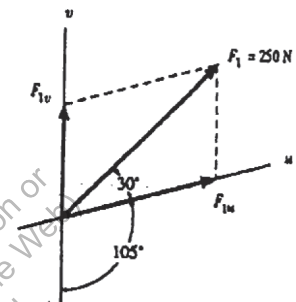


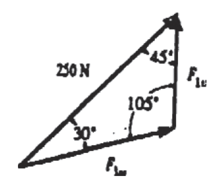
SOLUTION

Sine law:

$$\frac{F_{1v}}{\sin 30°} = \frac{250}{\sin 105°} \qquad F_{1v} = 129 \text{ N} \qquad \textbf{Ans.}$$

$$\frac{F_{1u}}{\sin 45°} = \frac{250}{\sin 105°} \qquad F_{1u} = 183 \text{ N} \qquad \textbf{Ans.}$$



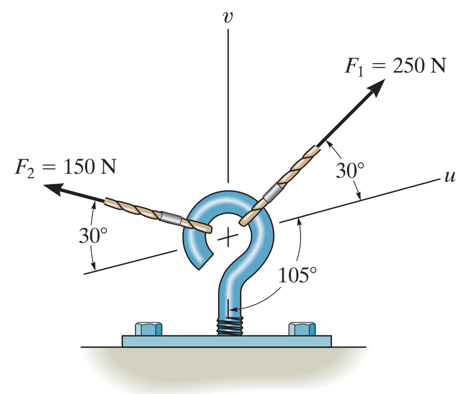


This work is protected by United States copyright laws and is provided solely for the use of instructors in teaching their courses and assessing student learning. Dissemination or sale of any part of this work (including on the World Wide Web) will destroy the integrity of the work and is not permitted.

© 2013 Pearson Education, Inc., Upper Saddle River, NJ. All rights reserved. This publication is protected by Copyright and written permission should be obtained from the publisher prior to any prohibited reproduction, storage in a retrieval system, or transmission in any form or by any means, electronic, mechanical, photocopying, recording, or likewise. For information regarding permission(s), write to: Rights and Permissions Department, Pearson Education, Inc., Upper Saddle River, NJ 07458.

2–10.

Resolve $\mathbf{F}_2$ into components along the u and v axes and determine the magnitudes of these components.

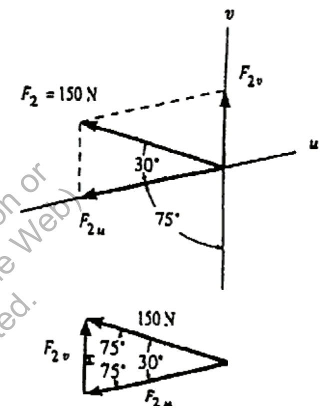


SOLUTION

Sine law:

$$\frac{F_{2v}}{\sin 30^\circ} = \frac{150}{\sin 75^\circ} \qquad F_{2v} = 77.6 \text{ N} \qquad \textbf{Ans.}$$

$$\frac{F_{2u}}{\sin 75^\circ} = \frac{150}{\sin 75^\circ} \qquad F_{2u} = 150 \text{ N} \qquad \textbf{Ans.}$$

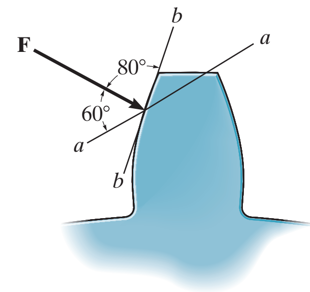


This work is protected by United States copyright laws and is provided solely for the use of instructors in teaching their courses and assessing student learning. Dissemination or sale of any part of this work (including on the World Wide Web) will destroy the integrity of the work and is not permitted.

© 2013 Pearson Education, Inc., Upper Saddle River, NJ. All rights reserved. This publication is protected by Copyright and written permission should be obtained from the publisher prior to any prohibited reproduction, storage in a retrieval system, or transmission in any form or by any means, electronic, mechanical, photocopying, recording, or likewise. For information regarding permission(s), write to: Rights and Permissions Department, Pearson Education, Inc., Upper Saddle River, NJ 07458.

2–11.

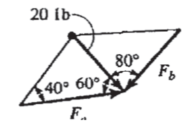
The force acting on the gear tooth is $F = 20$ lb. Resolve this force into two components acting along the lines *aa* and *bb*.



SOLUTION

$$\frac{20}{\sin 40°} = \frac{F_a}{\sin 80°}; \qquad F_a = 30.6 \text{ lb} \qquad \textbf{Ans.}$$

$$\frac{20}{\sin 40°} = \frac{F_b}{\sin 60°}; \qquad F_b = 26.9 \text{ lb} \qquad \textbf{Ans.}$$

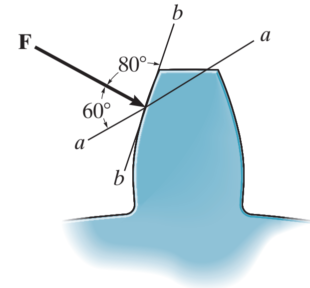


This work is protected by United States copyright laws and is provided solely for the use of instructors in teaching their courses and assessing student learning. Dissemination or sale of any part of this work (including on the World Wide Web) will destroy the integrity of the work and is not permitted.

© 2013 Pearson Education, Inc., Upper Saddle River, NJ. All rights reserved. This publication is protected by Copyright and written permission should be obtained from the publisher prior to any prohibited reproduction, storage in a retrieval system, or transmission in any form or by any means, electronic, mechanical, photocopying, recording, or likewise. For information regarding permission(s), write to: Rights and Permissions Department, Pearson Education, Inc., Upper Saddle River, NJ 07458.

***2–12.**

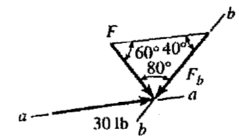
The component of force **F** acting along line *aa* is required to be 30 lb. Determine the magnitude of **F** and its component along line *bb*.



SOLUTION

$$\frac{30}{\sin 80^\circ} = \frac{F}{\sin 40^\circ}; \qquad F = 19.6 \text{ lb} \qquad \textbf{Ans.}$$

$$\frac{30}{\sin 80^\circ} = \frac{F_b}{\sin 60^\circ}; \qquad F_b = 26.4 \text{ lb} \qquad \textbf{Ans.}$$

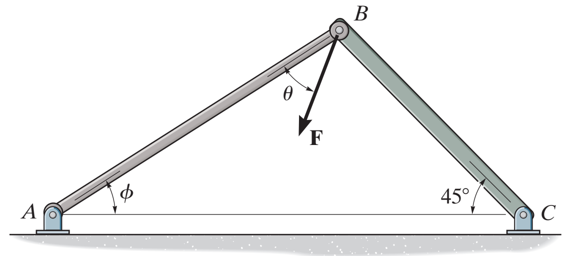


This work is protected by United States copyright laws and is provided solely for the use of instructors in teaching their courses and assessing student learning. Dissemination or sale of any part of this work (including on the World Wide Web) will destroy the integrity of the work and is not permitted.

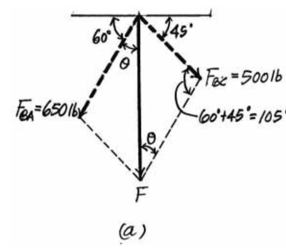
© 2013 Pearson Education, Inc., Upper Saddle River, NJ. All rights reserved. This publication is protected by Copyright and written permission should be obtained from the publisher prior to any prohibited reproduction, storage in a retrieval system, or transmission in any form or by any means, electronic, mechanical, photocopying, recording, or likewise. For information regarding permission(s), write to: Rights and Permissions Department, Pearson Education, Inc., Upper Saddle River, NJ 07458.

2–13.

Force **F** acts on the frame such that its component acting along member AB is 650 lb, directed from B towards A, and the component acting along member BC is 500 lb, directed from B towards C. Determine the magnitude of **F** and its direction θ. Set $\phi = 60°$.



SOLUTION



The parallelogram law of addition and triangular rule are shown in Figs. a and b, respectively.

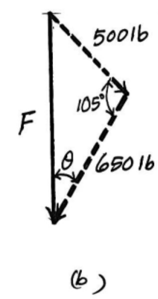
Applying the law of cosines to Fig. b,

$$F = \sqrt{500^2 + 650^2 - 2(500)(650)\cos 105°}$$

$$= 916.91 \text{ lb} = 917 \text{ lb} \qquad \textbf{Ans.}$$

Using this result and applying the law of sines to Fig. b, yields

$$\frac{\sin\theta}{500} = \frac{\sin 105°}{916.91} \qquad \theta = 31.8° \qquad \textbf{Ans.}$$

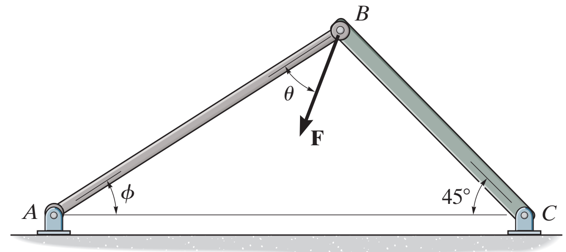


This work is protected by United States copyright laws and is provided solely for the use of instructors in teaching their courses and assessing student learning. Dissemination or sale of any part of this work (including on the World Wide Web) will destroy the integrity of the work and is not permitted.

© 2013 Pearson Education, Inc., Upper Saddle River, NJ. All rights reserved. This publication is protected by Copyright and written permission should be obtained from the publisher prior to any prohibited reproduction, storage in a retrieval system, or transmission in any form or by any means, electronic, mechanical, photocopying, recording, or likewise. For information regarding permission(s), write to: Rights and Permissions Department, Pearson Education, Inc., Upper Saddle River, NJ 07458.

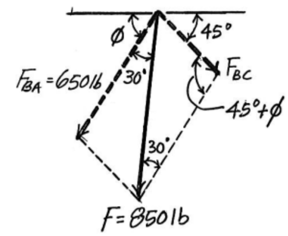
2–14.

Force **F** acts on the frame such that its component acting along member AB is 650 lb, directed from B towards A. Determine the required angle ϕ $(0^\circ \le \phi \le 90^\circ)$ and the component acting along member BC. Set $F = 850$ lb and $\theta = 30^\circ$.



SOLUTION

The parallelogram law of addition and the triangular rule are shown in Figs. *a* and *b*, respectively.



(a)

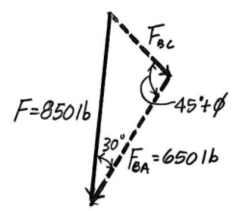
Applying the law of cosines to Fig. *b*,

$$F_{BC} = \sqrt{850^2 + 650^2 - 2(850)(650)\cos 30^\circ}$$

$$= 433.64 \text{ lb} = 434 \text{ lb} \qquad \textbf{Ans.}$$

Using this result and applying the sine law to Fig. *b*, yields

$$\frac{\sin(45^\circ + \phi)}{850} = \frac{\sin 30^\circ}{433.64} \qquad \phi = 56.5^\circ \qquad \textbf{Ans.}$$



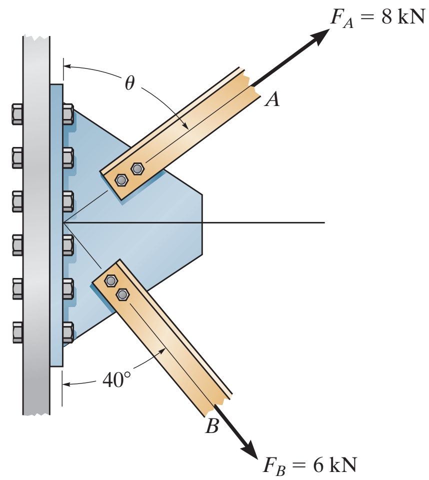
(b)

This work is protected by United States copyright laws and is provided solely for the use of instructors in teaching their courses and assessing student learning. Dissemination or sale of any part of this work (including on the World Wide Web) will destroy the integrity of the work and is not permitted.

© 2013 Pearson Education, Inc., Upper Saddle River, NJ. All rights reserved. This publication is protected by Copyright and written permission should be obtained from the publisher prior to any prohibited reproduction, storage in a retrieval system, or transmission in any form or by any means, electronic, mechanical, photocopying, recording, or likewise. For information regarding permission(s), write to: Rights and Permissions Department, Pearson Education, Inc., Upper Saddle River, NJ 07458.

2–15.

The plate is subjected to the two forces at A and B as shown. If $\theta = 60°$, determine the magnitude of the resultant of these two forces and its direction measured clockwise from the horizontal.



SOLUTION

Parallelogram Law: The parallelogram law of addition is shown in Fig. *a*.

Trigonometry: Using law of cosines (Fig. *b*), we have

$$F_R = \sqrt{8^2 + 6^2 - 2(8)(6)\cos 100°}$$

$$= 10.80 \text{ kN} = 10.8 \text{ kN} \qquad \textbf{Ans.}$$

The angle θ can be determined using law of sines (Fig. *b*).

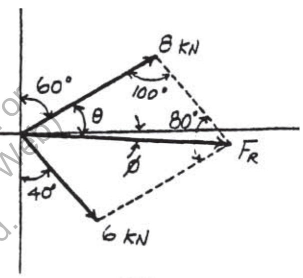
$$\frac{\sin \theta}{6} = \frac{\sin 100°}{10.80}$$

$$\sin \theta = 0.5470$$

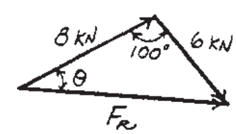
$$\theta = 33.16°$$

Thus, the direction ϕ of $\mathbf{F}_R$ measured from the x axis is

$$\phi = 33.16° - 30° = 3.16° \qquad \textbf{Ans.}$$



(a)



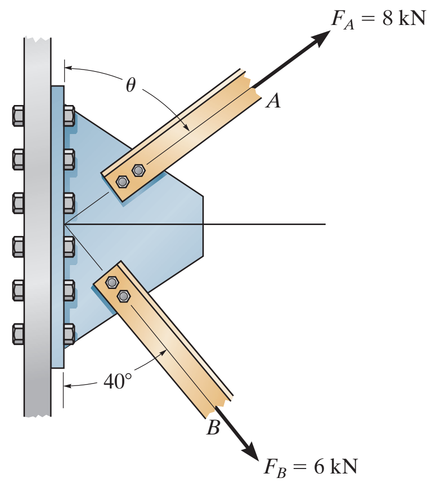
(b)

This work is protected by United States copyright laws and is provided solely for the use of instructors in teaching their courses and assessing student learning. Dissemination or sale of any part of this work (including on the World Wide Web) will destroy the integrity of the work and is not permitted.

© 2013 Pearson Education, Inc., Upper Saddle River, NJ. All rights reserved. This publication is protected by Copyright and written permission should be obtained from the publisher prior to any prohibited reproduction, storage in a retrieval system, or transmission in any form or by any means, electronic, mechanical, photocopying, recording, or likewise. For information regarding permission(s), write to: Rights and Permissions Department, Pearson Education, Inc., Upper Saddle River, NJ 07458.

***2–16.**

Determine the angle of θ for connecting member A to the plate so that the resultant force of $\mathbf{F}_A$ and $\mathbf{F}_B$ is directed horizontally to the right. Also, what is the magnitude of the resultant force?



SOLUTION

Parallelogram Law: The parallelogram law of addition is shown in Fig. *a*.

Trigonometry: Using law of sines (Fig .*b*), we have

$$\frac{\sin(90^\circ - \theta)}{6} = \frac{\sin 50^\circ}{8}$$

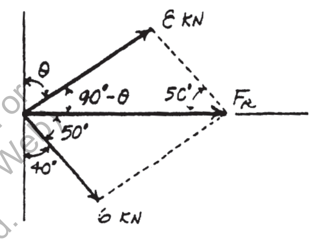
$$\sin(90^\circ - \theta) = 0.5745$$

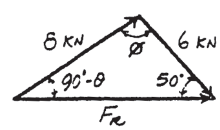
$$\theta = 54.93^\circ = 54.9^\circ \qquad \textbf{Ans.}$$

From the triangle, $\phi = 180^\circ - (90^\circ - 54.93^\circ) - 50^\circ = 94.93^\circ$. Thus, using law of cosines, the magnitude of $\mathbf{F}_R$ is

$$F_R = \sqrt{8^2 + 6^2 - 2(8)(6)\cos 94.93^\circ}$$

$$= 10.4 \text{ kN} \qquad \textbf{Ans.}$$





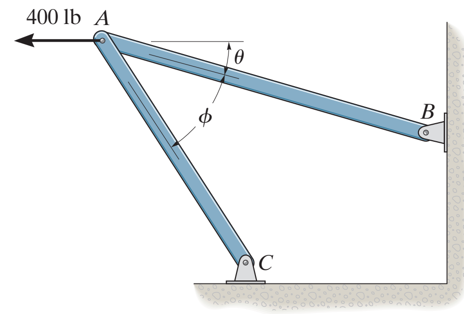
(b)

This work is protected by United States copyright laws and is provided solely for the use of instructors in teaching their courses and assessing student learning. Dissemination or sale of any part of this work (including on the World Wide Web) will destroy the integrity of the work and is not permitted.

© 2013 Pearson Education, Inc., Upper Saddle River, NJ. All rights reserved. This publication is protected by Copyright and written permission should be obtained from the publisher prior to any prohibited reproduction, storage in a retrieval system, or transmission in any form or by any means, electronic, mechanical, photocopying, recording, or likewise. For information regarding permission(s), write to: Rights and Permissions Department, Pearson Education, Inc., Upper Saddle River, NJ 07458.

2–17.

Determine the design angle θ ($0° \le \theta \le 90°$) for strut AB so that the 400-lb horizontal force has a component of 500 lb directed from A towards C. What is the component of force acting along member AB? Take $\phi = 40°$.



SOLUTION

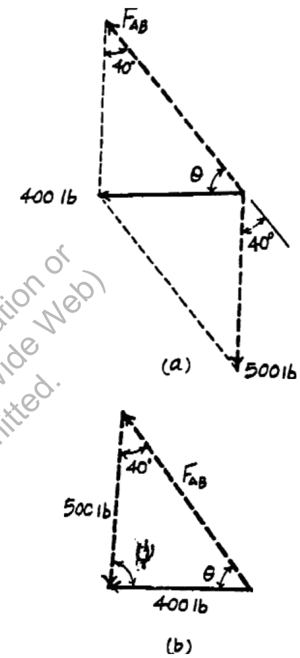
Parallelogram Law: The parallelogram law of addition is shown in Fig. *a*.

Trigonometry: Using law of sines (Fig. *b*), we have

$$\frac{\sin\theta}{500} = \frac{\sin 40°}{400}$$

$$\sin\theta = 0.8035$$

$$\theta = 53.46° = 53.5° \quad \textbf{Ans.}$$



Thus,

$$\psi = 180° - 40° - 53.46° = 86.54°$$

Using law of sines (Fig. *b*)

$$\frac{F_{AB}}{\sin 86.54°} = \frac{400}{\sin 40°}$$

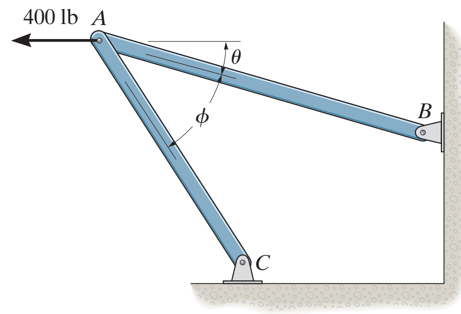
$$F_{AB} = 621 \text{ lb} \quad \textbf{Ans.}$$

This work is protected by United States copyright laws and is provided solely for the use of instructors in teaching their courses and assessing student learning. Dissemination or sale of any part of this work (including on the World Wide Web) will destroy the integrity of the work and is not permitted.

© 2013 Pearson Education, Inc., Upper Saddle River, NJ. All rights reserved. This publication is protected by Copyright and written permission should be obtained from the publisher prior to any prohibited reproduction, storage in a retrieval system, or transmission in any form or by any means, electronic, mechanical, photocopying, recording, or likewise. For information regarding permission(s), write to: Rights and Permissions Department, Pearson Education, Inc., Upper Saddle River, NJ 07458.

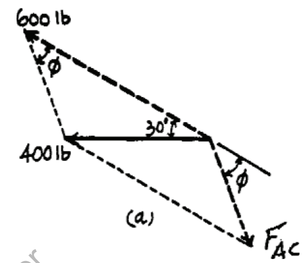
2–18.

Determine the design angle $\phi\,(0° \le \phi \le 90°)$ between struts AB and AC so that the 400-lb horizontal force has a component of 600 lb which acts up to the left, in the same direction as from B towards A. Take $\theta = 30°$.



SOLUTION

Parallelogram Law: The parallelogram law of addition is shown in Fig. a.



Trigonometry: Using law of cosines (Fig. b), we have

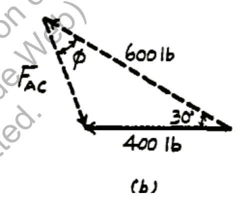
$$F_{AC} = \sqrt{400^2 + 600^2 - 2(400)(600)\cos 30°} = 322.97 \text{ lb}$$

The angle ϕ can be determined using law of sines (Fig. b).

$$\frac{\sin\phi}{400} = \frac{\sin 30°}{322.97}$$

$$\sin\phi = 0.6193$$

$$\phi = 38.3° \qquad \textbf{Ans.}$$

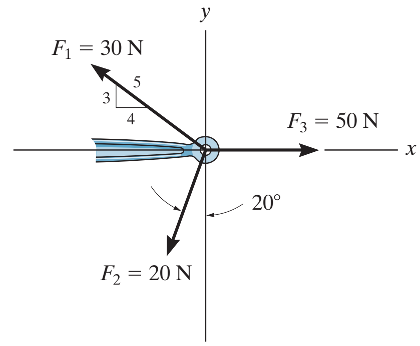


This work is protected by United States copyright laws and is provided solely for the use of instructors in teaching their courses and assessing student learning. Dissemination or sale of any part of this work (including on the World Wide Web) will destroy the integrity of the work and is not permitted.

© 2013 Pearson Education, Inc., Upper Saddle River, NJ. All rights reserved. This publication is protected by Copyright and written permission should be obtained from the publisher prior to any prohibited reproduction, storage in a retrieval system, or transmission in any form or by any means, electronic, mechanical, photocopying, recording, or likewise. For information regarding permission(s), write to: Rights and Permissions Department, Pearson Education, Inc., Upper Saddle River, NJ 07458.

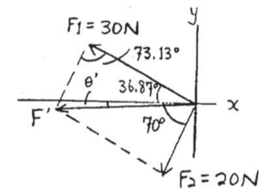
2–19.

Determine the magnitude and direction of the resultant $\mathbf{F}_R = \mathbf{F}_1 + \mathbf{F}_2 + \mathbf{F}_3$ of the three forces by first finding the resultant $\mathbf{F}' = \mathbf{F}_1 + \mathbf{F}_2$ and then forming $\mathbf{F}_R = \mathbf{F}' + \mathbf{F}_3$.



SOLUTION

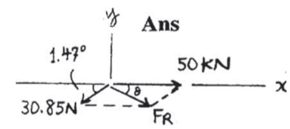
$$F' = \sqrt{(20)^2 + (30)^2 - 2(20)(30)\cos 73.13^\circ} = 30.85\text{ N}$$



$$\frac{30.85}{\sin 73.13^\circ} = \frac{30}{\sin(70^\circ - \theta')}; \qquad \theta' = 1.47^\circ$$

$$F_R = \sqrt{(30.85)^2 + (50)^2 - 2(30.85)(50)\cos 1.47^\circ} = 19.18 = 19.2\text{ N}$$ **Ans.**

$$\frac{19.18}{\sin 1.47^\circ} = \frac{30.85}{\sin\theta}; \qquad \theta = 2.37^\circ \measuredangle$$ **Ans.**

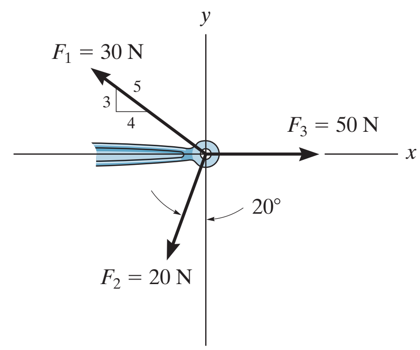


This work is protected by United States copyright laws and is provided solely for the use of instructors in teaching their courses and assessing student learning. Dissemination or sale of any part of this work (including on the World Wide Web) will destroy the integrity of the work and is not permitted.

© 2013 Pearson Education, Inc., Upper Saddle River, NJ. All rights reserved. This publication is protected by Copyright and written permission should be obtained from the publisher prior to any prohibited reproduction, storage in a retrieval system, or transmission in any form or by any means, electronic, mechanical, photocopying, recording, or likewise. For information regarding permission(s), write to: Rights and Permissions Department, Pearson Education, Inc., Upper Saddle River, NJ 07458.

***2–20.**

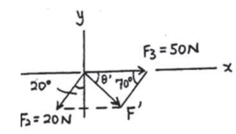
Determine the magnitude and direction of the resultant $\mathbf{F}_R = \mathbf{F}_1 + \mathbf{F}_2 + \mathbf{F}_3$ of the three forces by first finding the resultant $\mathbf{F}' = \mathbf{F}_2 + \mathbf{F}_3$ and then forming $\mathbf{F}_R = \mathbf{F}' + \mathbf{F}_1$.



SOLUTION

$$F' = \sqrt{(20)^2 + (50)^2 - 2(20)(50)\cos 70^\circ} = 47.07 \text{ N}$$

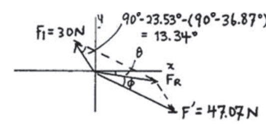
$$\frac{20}{\sin\theta'} = \frac{47.07}{\sin 70^\circ}; \qquad \theta' = 23.53^\circ$$



$$F_R = \sqrt{(47.07)^2 + (30)^2 - 2(47.07)(30)\cos 13.34^\circ} = 19.18 = 19.2 \text{ N} \qquad \textbf{Ans.}$$

$$\frac{19.18}{\sin 13.34^\circ} = \frac{30}{\sin\phi}; \qquad \phi = 21.15^\circ$$

$$\theta = 23.53^\circ - 21.15^\circ = 2.37^\circ \qquad \textbf{Ans.}$$

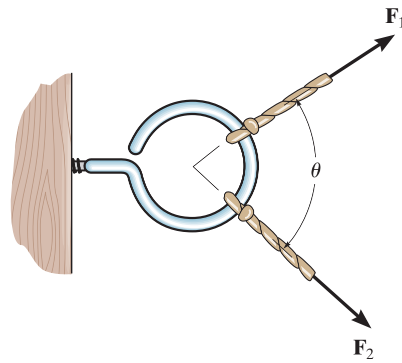


This work is protected by United States copyright laws and is provided solely for the use of instructors in teaching their courses and assessing student learning. Dissemination or sale of any part of this work (including on the World Wide Web) will destroy the integrity of the work and is not permitted.

© 2013 Pearson Education, Inc., Upper Saddle River, NJ. All rights reserved. This publication is protected by Copyright and written permission should be obtained from the publisher prior to any prohibited reproduction, storage in a retrieval system, or transmission in any form or by any means, electronic, mechanical, photocopying, recording, or likewise. For information regarding permission(s), write to: Rights and Permissions Department, Pearson Education, Inc., Upper Saddle River, NJ 07458.

2–21.

Two forces act on the screw eye. If $F_1 = 400\text{ N}$ and $F_2 = 600\text{ N}$, determine the angle $\theta(0° \leq \theta \leq 180°)$ between them, so that the resultant force has a magnitude of $F_R = 800\text{ N}$.



SOLUTION

The parallelogram law of addition and triangular rule are shown in Figs. *a* and *b*, respectively. Applying law of cosines to Fig. *b*,

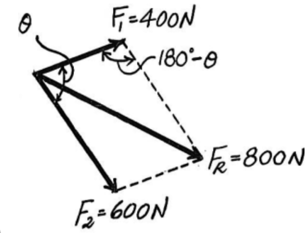
$$800 = \sqrt{400^2 + 600^2 - 2(400)(600)\cos(180° - \theta°)}$$

$$800^2 = 400^2 + 600^2 - 480000\cos(180° - \theta)$$

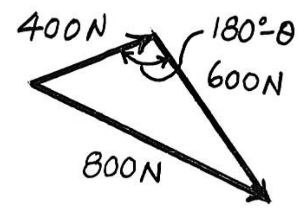
$$\cos(180° - \theta) = -0.25$$

$$180° - \theta = 104.48$$

$$\theta = 75.52° = 75.5° \qquad \textbf{Ans.}$$



(a)



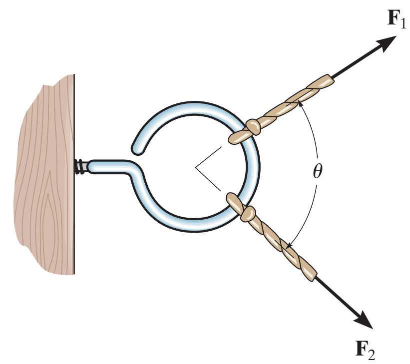
(b)

This work is protected by United States copyright laws and is provided solely for the use of instructors in teaching their courses and assessing student learning. Dissemination or sale of any part of this work (including on the World Wide Web) will destroy the integrity of the work and is not permitted.

© 2013 Pearson Education, Inc., Upper Saddle River, NJ. All rights reserved. This publication is protected by Copyright and written permission should be obtained from the publisher prior to any prohibited reproduction, storage in a retrieval system, or transmission in any form or by any means, electronic, mechanical, photocopying, recording, or likewise. For information regarding permission(s), write to: Rights and Permissions Department, Pearson Education, Inc., Upper Saddle River, NJ 07458.

2–22.

Two forces $\mathbf{F}_1$ and $\mathbf{F}_2$ act on the screw eye. If their lines of action are at an angle θ apart and the magnitude of each force is $F_1 = F_2 = F$, determine the magnitude of the resultant force $\mathbf{F}_R$ and the angle between $\mathbf{F}_R$ and $\mathbf{F}_1$.



SOLUTION

$$\frac{F}{\sin \phi} = \frac{F}{\sin (\theta - \phi)}$$

$$\sin (\theta - \phi) = \sin \phi$$

$$\theta - \phi = \phi$$

$$\phi = \frac{\theta}{2} \qquad \textbf{Ans.}$$

$$F_R = \sqrt{(F)^2 + (F)^2 - 2(F)(F)\cos(180^\circ - \theta)}$$

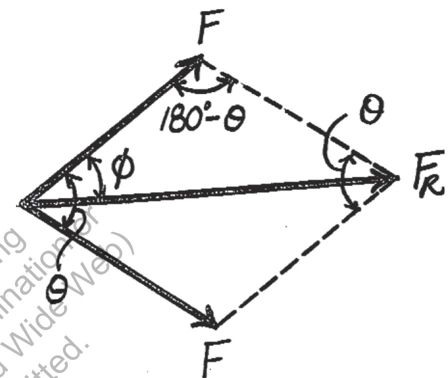
Since $\cos(180^\circ - \theta) = -\cos\theta$

$$F_R = F\left(\sqrt{2}\right)\sqrt{1 + \cos\theta}$$

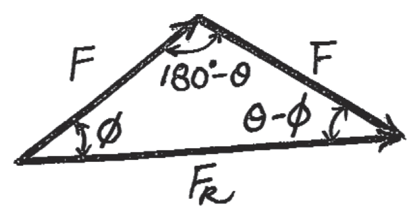
Since $\cos\left(\dfrac{\theta}{2}\right) = \sqrt{\dfrac{1 + \cos\theta}{2}}$

Then

$$F_R = 2F\cos\left(\frac{\theta}{2}\right) \qquad \textbf{Ans.}$$



(a)



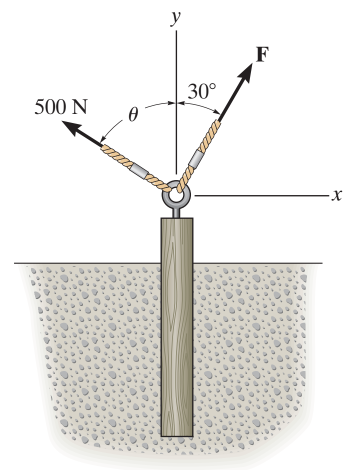
(b)

This work is protected by United States copyright laws and is provided solely for the use of instructors in teaching their courses and assessing student learning. Dissemination or sale of any part of this work (including on the World Wide Web) will destroy the integrity of the work and is not permitted.

© 2013 Pearson Education, Inc., Upper Saddle River, NJ. All rights reserved. This publication is protected by Copyright and written permission should be obtained from the publisher prior to any prohibited reproduction, storage in a retrieval system, or transmission in any form or by any means, electronic, mechanical, photocopying, recording, or likewise. For information regarding permission(s), write to: Rights and Permissions Department, Pearson Education, Inc., Upper Saddle River, NJ 07458.

2–23.

Two forces act on the screw eye. If $F = 600$ N, determine the magnitude of the resultant force and the angle θ if the resultant force is directed vertically upward.



SOLUTION

The parallelogram law of addition and triangular rule are shown in Figs. *a* and *b* respectively. Applying law of sines to Fig. *b*,

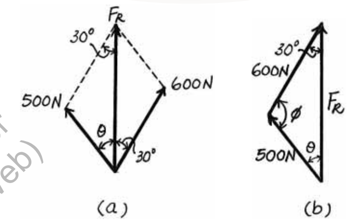
$$\frac{\sin\theta}{600} = \frac{\sin 30^\circ}{500}; \quad \sin\theta = 0.6 \quad \theta = 36.87^\circ = 36.9^\circ \qquad \textbf{Ans.}$$

Using the result of θ,

$$\phi = 180^\circ - 30^\circ - 36.87^\circ = 113.13^\circ$$

Again, applying law of sines using the result of ϕ,

$$\frac{F_R}{\sin 113.13^\circ} = \frac{500}{\sin 30^\circ}; \quad F_R = 919.61 \text{ N} = 920 \text{ N} \qquad \textbf{Ans.}$$

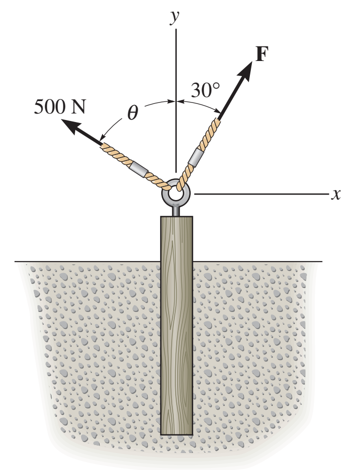


This work is protected by United States copyright laws and is provided solely for the use of instructors in teaching their courses and assessing student learning. Dissemination or sale of any part of this work (including on the World Wide Web) will destroy the integrity of the work and is not permitted.

© 2013 Pearson Education, Inc., Upper Saddle River, NJ. All rights reserved. This publication is protected by Copyright and written permission should be obtained from the publisher prior to any prohibited reproduction, storage in a retrieval system, or transmission in any form or by any means, electronic, mechanical, photocopying, recording, or likewise. For information regarding permission(s), write to: Rights and Permissions Department, Pearson Education, Inc., Upper Saddle River, NJ 07458.

***2–24.**

Two forces are applied at the end of a screw eye in order to remove the post. Determine the angle θ $(0° \le \theta \le 90°)$ and the magnitude of force **F** so that the resultant force acting on the post is directed vertically upward and has a magnitude of 750 N.



SOLUTION

Parallelogram Law: The parallelogram law of addition is shown in Fig. *a*.

Trigonometry: Using law of sines (Fig. *b*), we have

$$\frac{\sin \phi}{750} = \frac{\sin 30°}{500}$$

$$\sin \phi = 0.750$$

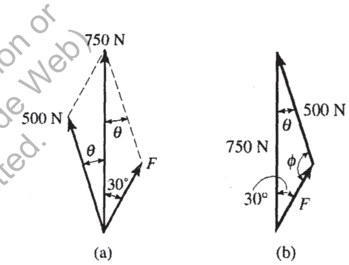
$$\phi = 131.41° \text{ (By observation, } \phi > 90°\text{)}$$

Thus,

$$\theta = 180° - 30° - 131.41° = 18.59° = 18.6°$$ **Ans.**

$$\frac{F}{\sin 18.59°} = \frac{500}{\sin 30°}$$

$$F = 319 \text{ N}$$ **Ans.**

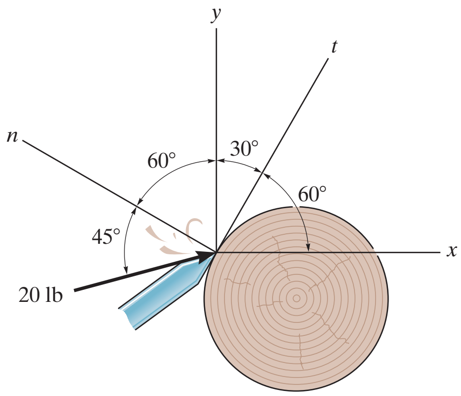


This work is protected by United States copyright laws and is provided solely for the use of instructors in teaching their courses and assessing student learning. Dissemination or sale of any part of this work (including on the World Wide Web) will destroy the integrity of the work and is not permitted.

© 2013 Pearson Education, Inc., Upper Saddle River, NJ. All rights reserved. This publication is protected by Copyright and written permission should be obtained from the publisher prior to any prohibited reproduction, storage in a retrieval system, or transmission in any form or by any means, electronic, mechanical, photocopying, recording, or likewise. For information regarding permission(s), write to: Rights and Permissions Department, Pearson Education, Inc., Upper Saddle River, NJ 07458.

2–25.

The chisel exerts a force of 20 lb on the wood dowel rod which is turning in a lathe. Resolve this force into components acting (a) along the *n* and *t* axes and (b) along the *x* and *y* axes.



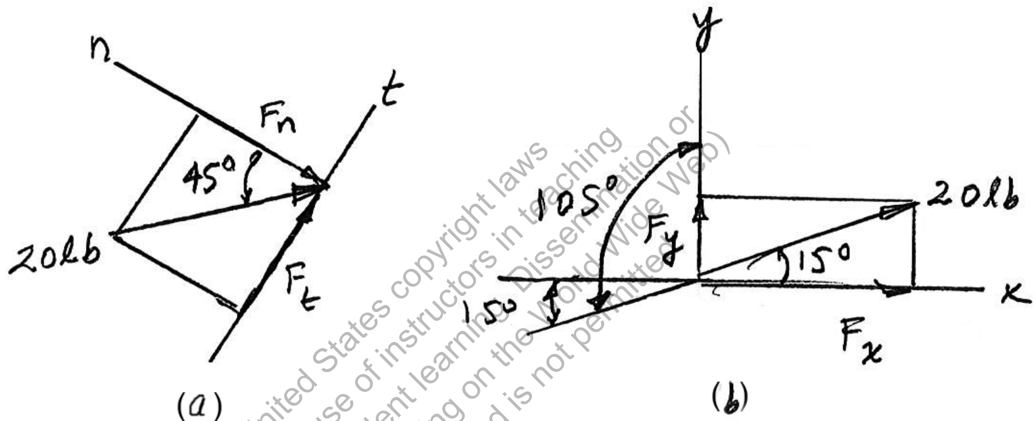
SOLUTION

a) $F_n = -20\cos 45^\circ = -14.1\text{ lb}$ **Ans.**

$F_t = 20\sin 45^\circ = 14.1\text{ lb}$ **Ans.**

b) $F_x = 20\cos 15^\circ = 19.3\text{ lb}$ **Ans.**

$F_y = 20\sin 15^\circ = 5.18\text{ lb}$ **Ans.**

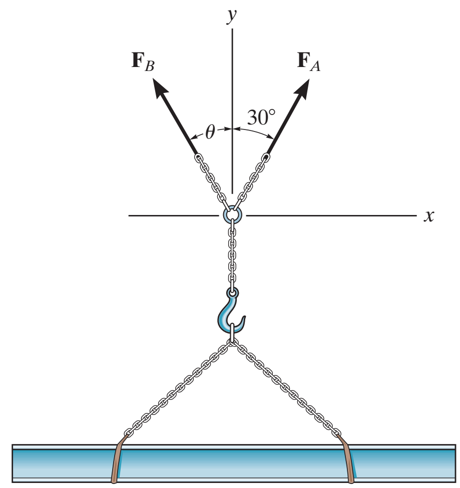


This work is protected by United States copyright laws and is provided solely for the use of instructors in teaching their courses and assessing student learning. Dissemination or sale of any part of this work (including on the World Wide Web) will destroy the integrity of the work and is not permitted.

© 2013 Pearson Education, Inc., Upper Saddle River, NJ. All rights reserved. This publication is protected by Copyright and written permission should be obtained from the publisher prior to any prohibited reproduction, storage in a retrieval system, or transmission in any form or by any means, electronic, mechanical, photocopying, recording, or likewise. For information regarding permission(s), write to: Rights and Permissions Department, Pearson Education, Inc., Upper Saddle River, NJ 07458.

2–26.

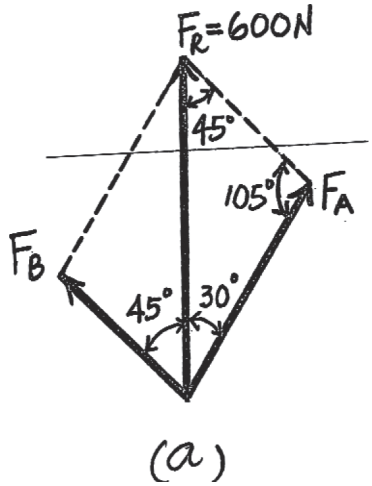
The beam is to be hoisted using two chains. Determine the magnitudes of forces $\mathbf{F}_A$ and $\mathbf{F}_B$ acting on each chain in order to develop a resultant force of 600 N directed along the positive y axis. Set $\theta = 45°$.

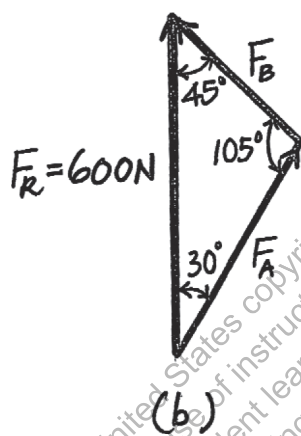


SOLUTION

$$\frac{F_A}{\sin 45°} = \frac{600}{\sin 105°}; \qquad F_A = 439 \text{ N} \qquad \textbf{Ans.}$$

$$\frac{F_B}{\sin 30°} = \frac{600}{\sin 105°}; \qquad F_B = 311 \text{ N} \qquad \textbf{Ans.}$$



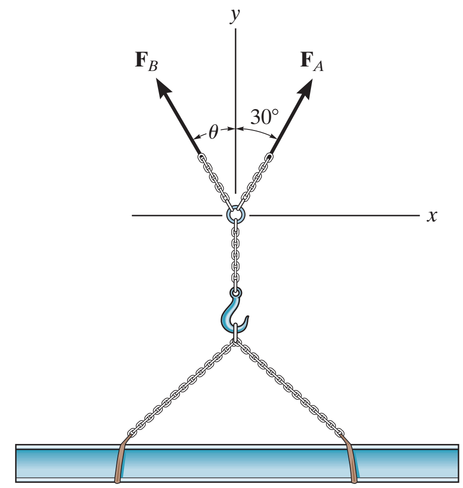


This work is protected by United States copyright laws and is provided solely for the use of instructors in teaching their courses and assessing student learning. Dissemination or sale of any part of this work (including on the World Wide Web) will destroy the integrity of the work and is not permitted.

© 2013 Pearson Education, Inc., Upper Saddle River, NJ. All rights reserved. This publication is protected by Copyright and written permission should be obtained from the publisher prior to any prohibited reproduction, storage in a retrieval system, or transmission in any form or by any means, electronic, mechanical, photocopying, recording, or likewise. For information regarding permission(s), write to: Rights and Permissions Department, Pearson Education, Inc., Upper Saddle River, NJ 07458.

2–27.

The beam is to be hoisted using two chains. If the resultant force is to be 600 N directed along the positive y axis, determine the magnitudes of forces $\mathbf{F}_A$ and $\mathbf{F}_B$ acting on each chain and the angle θ of $\mathbf{F}_B$ so that the magnitude of $\mathbf{F}_B$ is a *minimum*. $\mathbf{F}_A$ acts at 30° from the y axis, as shown.



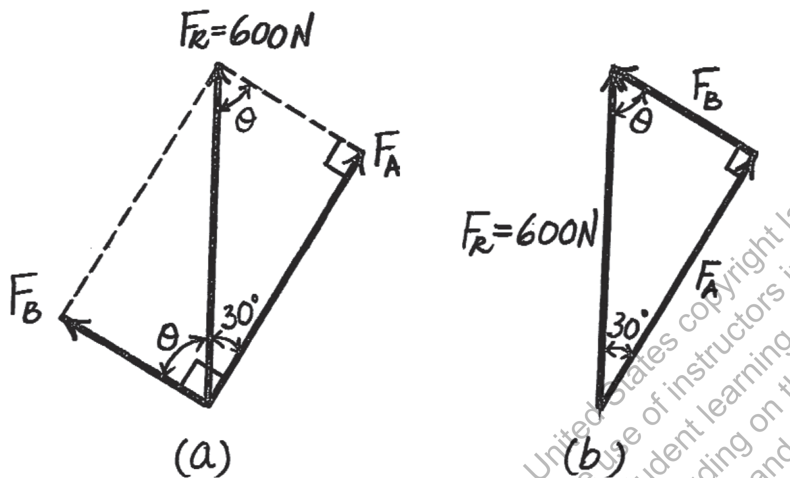
SOLUTION

For minimum F_B, require

$$\theta = 60^\circ \qquad \textbf{Ans.}$$

$$F_A = 600 \cos 30^\circ = 520 \text{ N} \qquad \textbf{Ans.}$$

$$F_B = 600 \sin 30^\circ = 300 \text{ N} \qquad \textbf{Ans.}$$

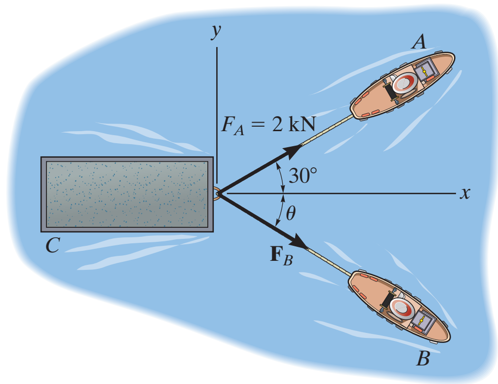


This work is protected by United States copyright laws and is provided solely for the use of instructors in teaching their courses and assessing student learning. Dissemination or sale of any part of this work (including on the World Wide Web) will destroy the integrity of the work and is not permitted.

© 2013 Pearson Education, Inc., Upper Saddle River, NJ. All rights reserved. This publication is protected by Copyright and written permission should be obtained from the publisher prior to any prohibited reproduction, storage in a retrieval system, or transmission in any form or by any means, electronic, mechanical, photocopying, recording, or likewise. For information regarding permission(s), write to: Rights and Permissions Department, Pearson Education, Inc., Upper Saddle River, NJ 07458.

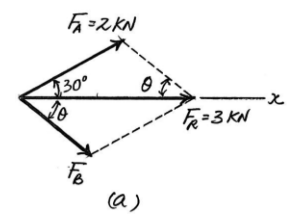
***2–28.**

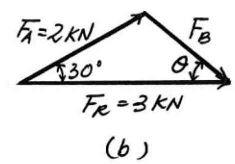
If the resultant force of the two tugboats is 3 kN, directed along the positive x axis, determine the required magnitude of force $\mathbf{F}_B$ and its direction θ.



SOLUTION

The parallelogram law of addition and the triangular rule are shown in Figs. *a* and *b*, respectively.





Applying the law of cosines to Fig. *b*,

$$F_B = \sqrt{2^2 + 3^2 - 2(2)(3)\cos 30^\circ}$$

$$= 1.615\text{kN} = 1.61 \text{ kN} \qquad \textbf{Ans.}$$

Using this result and applying the law of sines to Fig. *b*, yields

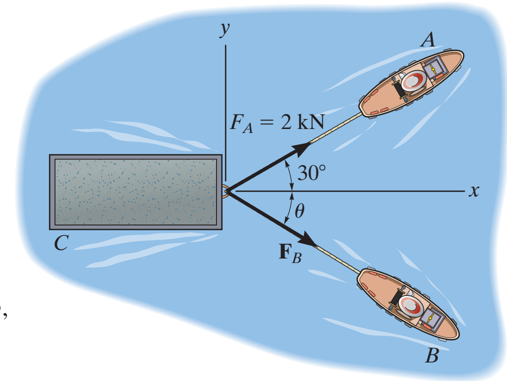
$$\frac{\sin\theta}{2} = \frac{\sin 30^\circ}{1.615} \qquad \theta = 38.3^\circ \qquad \textbf{Ans.}$$

This work is protected by United States copyright laws and is provided solely for the use of instructors in teaching their courses and assessing student learning. Dissemination or sale of any part of this work (including on the World Wide Web) will destroy the integrity of the work and is not permitted.

© 2013 Pearson Education, Inc., Upper Saddle River, NJ. All rights reserved. This publication is protected by Copyright and written permission should be obtained from the publisher prior to any prohibited reproduction, storage in a retrieval system, or transmission in any form or by any means, electronic, mechanical, photocopying, recording, or likewise. For information regarding permission(s), write to: Rights and Permissions Department, Pearson Education, Inc., Upper Saddle River, NJ 07458.

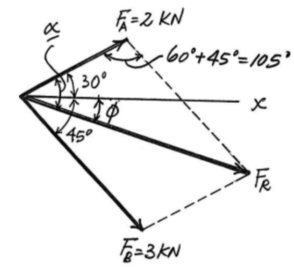
2–29.

If $F_B = 3$ kN and $\theta = 45°$, determine the magnitude of the resultant force of the two tugboats and its direction measured clockwise from the positive x axis.



SOLUTION

The parallelogram law of addition and the triangular rule are shown in Figs. *a* and *b*, respectively.



(a)

Applying the law of cosines to Fig. *b*,

$$F_R = \sqrt{2^2 + 3^2 - 2(2)(3)\cos 105°}$$

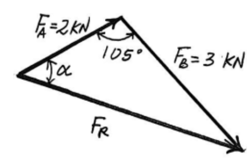
$$= 4.013 \text{ kN} = 4.01 \text{ kN} \qquad \textbf{Ans.}$$

Using this result and applying the law of sines to Fig. *b*, yields

$$\frac{\sin\alpha}{3} = \frac{\sin 105°}{4.013} \qquad \alpha = 46.22°$$

Thus, the direction angle ϕ of $\mathbf{F}_R$, measured clockwise from the positive x axis, is

$$\phi = \alpha - 30° = 46.22° - 30° = 16.2° \qquad \textbf{Ans.}$$



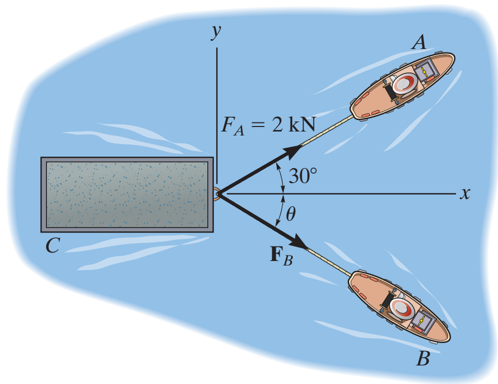
(b)

This work is protected by United States copyright laws and is provided solely for the use of instructors in teaching their courses and assessing student learning. Dissemination or sale of any part of this work (including on the World Wide Web) will destroy the integrity of the work and is not permitted.

© 2013 Pearson Education, Inc., Upper Saddle River, NJ. All rights reserved. This publication is protected by Copyright and written permission should be obtained from the publisher prior to any prohibited reproduction, storage in a retrieval system, or transmission in any form or by any means, electronic, mechanical, photocopying, recording, or likewise. For information regarding permission(s), write to: Rights and Permissions Department, Pearson Education, Inc., Upper Saddle River, NJ 07458.

2–30.

If the resultant force of the two tugboats is required to be directed towards the positive x axis, and F_B is to be a minimum, determine the magnitude of $\mathbf{F}_R$ and $\mathbf{F}_B$ and the angle θ.



SOLUTION

For $\mathbf{F}_B$ to be minimum, it has to be directed perpendicular to $\mathbf{F}_R$. Thus,

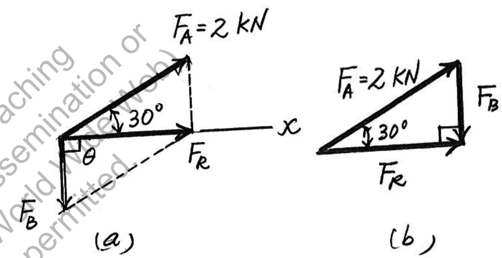
$$\theta = 90^\circ \qquad \textbf{Ans.}$$

The parallelogram law of addition and triangular rule are shown in Figs. a and b, respectively.

By applying simple trigonometry to Fig. b,

$$F_B = 2 \sin 30^\circ = 1 \text{ kN} \qquad \textbf{Ans.}$$

$$F_R = 2 \cos 30^\circ = 1.73 \text{ kN} \qquad \textbf{Ans.}$$

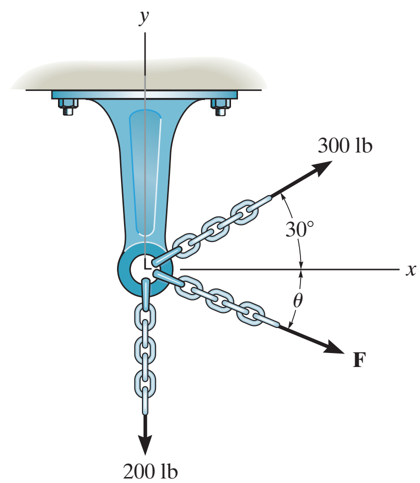


This work is protected by United States copyright laws and is provided solely for the use of instructors in teaching their courses and assessing student learning. Dissemination or sale of any part of this work (including on the World Wide Web) will destroy the integrity of the work and is not permitted.

© 2013 Pearson Education, Inc., Upper Saddle River, NJ. All rights reserved. This publication is protected by Copyright and written permission should be obtained from the publisher prior to any prohibited reproduction, storage in a retrieval system, or transmission in any form or by any means, electronic, mechanical, photocopying, recording, or likewise. For information regarding permission(s), write to: Rights and Permissions Department, Pearson Education, Inc., Upper Saddle River, NJ 07458.

2–31.

Three chains act on the bracket such that they create a resultant force having a magnitude of 500 lb. If two of the chains are subjected to known forces, as shown, determine the angle θ of the third chain measured clockwise from the positive x axis, so that the magnitude of force $\mathbf{F}$ in this chain is a *minimum*. All forces lie in the x–y plane. What is the magnitude of $\mathbf{F}$? *Hint*: First find the resultant of the two known forces. Force $\mathbf{F}$ acts in this direction.



SOLUTION

Cosine law:

$$F_{R1} = \sqrt{300^2 + 200^2 - 2(300)(200)\cos 60^\circ} = 264.6 \text{ lb}$$

Sine law:

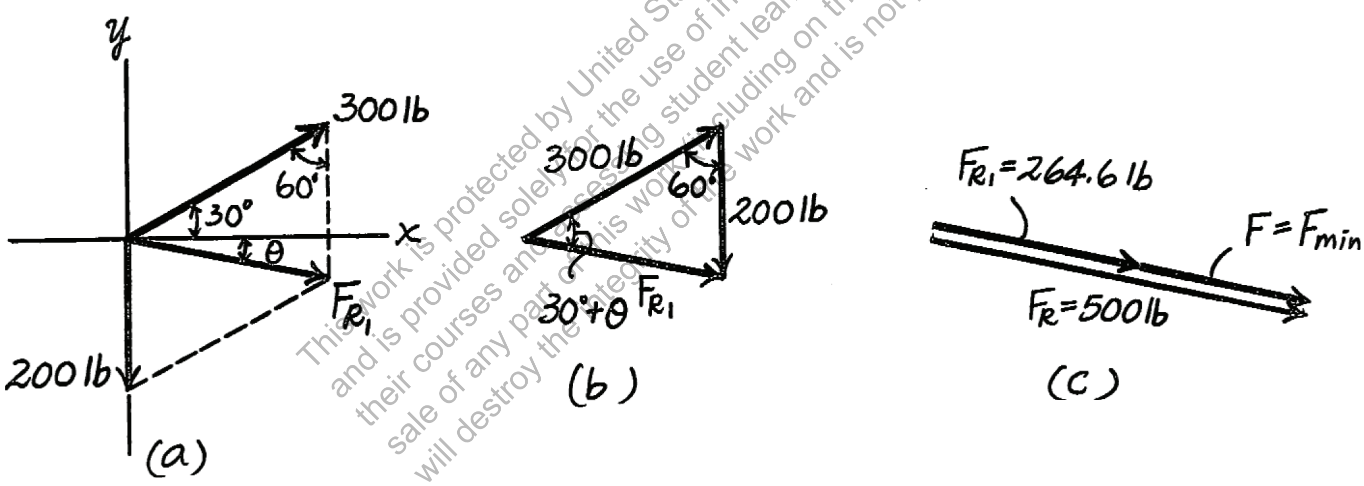
$$\frac{\sin(30^\circ + \theta)}{200} = \frac{\sin 60^\circ}{264.6} \qquad \theta = 10.9^\circ \qquad \textbf{Ans.}$$

When $\mathbf{F}$ is directed along $\mathbf{F}_{R1}$, F will be minimum to create the resultant force.

$$F_R = F_{R1} + F$$

$$500 = 264.6 + F_{min}$$

$$F_{min} = 235 \text{ lb} \qquad \textbf{Ans.}$$

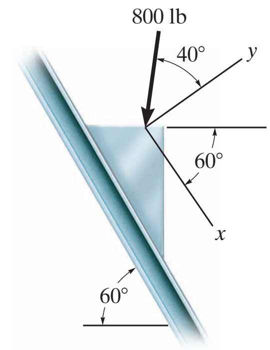


This work is protected by United States copyright laws and is provided solely for the use of instructors in teaching their courses and assessing student learning. Dissemination or sale of any part of this work (including on the World Wide Web) will destroy the integrity of the work and is not permitted.

© 2013 Pearson Education, Inc., Upper Saddle River, NJ. All rights reserved. This publication is protected by Copyright and written permission should be obtained from the publisher prior to any prohibited reproduction, storage in a retrieval system, or transmission in any form or by any means, electronic, mechanical, photocopying, recording, or likewise. For information regarding permission(s), write to: Rights and Permissions Department, Pearson Education, Inc., Upper Saddle River, NJ 07458.

***2–32.**

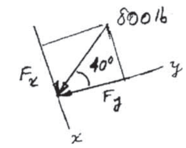
Determine the x and y components of the 800-lb force.



SOLUTION

$$F_x = 800 \sin 40° = 514 \text{ lb}$$ **Ans.**

$$F_y = -800 \cos 40° = -613 \text{ lb}$$ **Ans.**

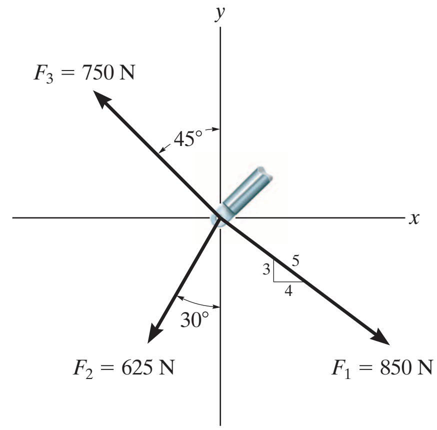


This work is protected by United States copyright laws and is provided solely for the use of instructors in teaching their courses and assessing student learning. Dissemination or sale of any part of this work (including on the World Wide Web) will destroy the integrity of the work and is not permitted.

© 2013 Pearson Education, Inc., Upper Saddle River, NJ. All rights reserved. This publication is protected by Copyright and written permission should be obtained from the publisher prior to any prohibited reproduction, storage in a retrieval system, or transmission in any form or by any means, electronic, mechanical, photocopying, recording, or likewise. For information regarding permission(s), write to: Rights and Permissions Department, Pearson Education, Inc., Upper Saddle River, NJ 07458.

2–33.

Determine the magnitude of the resultant force and its direction, measured counterclockwise from the positive x axis.



SOLUTION

$\xrightarrow{+} F_{R_x} = \Sigma F_x;$ $\quad F_{R_x} = \frac{4}{5}(850) - 625 \sin 30° - 750 \sin 45° = -162.8 \text{ N}$

$+\uparrow F_{R_y} = \Sigma F_y;$ $\quad F_{Ry} = -\frac{3}{5}(850) - 625 \cos 30° + 750 \cos 45° = -520.9 \text{ N}$

$$F_R = \sqrt{(-162.8)^2 + (-520.9)^2} = 546 \text{ N}$$ **Ans.**

$$\phi = \tan^{-1}\left[\frac{-520.9}{-162.8}\right] = 72.64°$$

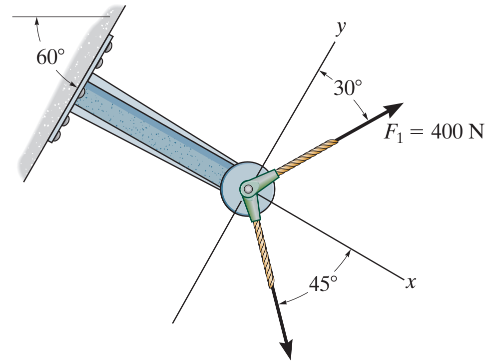
$$\theta = 180° + 72.64° = 253°$$ **Ans.**

This work is protected by United States copyright laws and is provided solely for the use of instructors in teaching their courses and assessing student learning. Dissemination or sale of any part of this work (including on the World Wide Web) will destroy the integrity of the work and is not permitted.

© 2013 Pearson Education, Inc., Upper Saddle River, NJ. All rights reserved. This publication is protected by Copyright and written permission should be obtained from the publisher prior to any prohibited reproduction, storage in a retrieval system, or transmission in any form or by any means, electronic, mechanical, photocopying, recording, or likewise. For information regarding permission(s), write to: Rights and Permissions Department, Pearson Education, Inc., Upper Saddle River, NJ 07458.

2–34.

Resolve $\mathbf{F}_1$ and $\mathbf{F}_2$ into their x and y components.



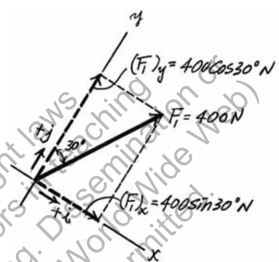
SOLUTION

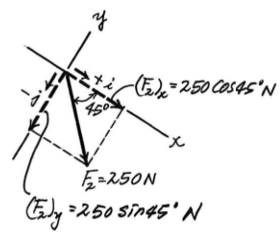
$$\mathbf{F}_1 = \{400 \sin 30°(+\mathbf{i}) + 400 \cos 30°(+\mathbf{j})\} \text{ N}$$

$$= \{200\mathbf{i} + 346\mathbf{j}\} \text{ N} \qquad \textbf{Ans.}$$

$$\mathbf{F}_2 = \{250 \cos 45°(+\mathbf{i}) + 250 \sin 45°(-\mathbf{j})\} \text{ N}$$

$$= \{177\mathbf{i} + 177\mathbf{j}\} \text{ N} \qquad \textbf{Ans.}$$



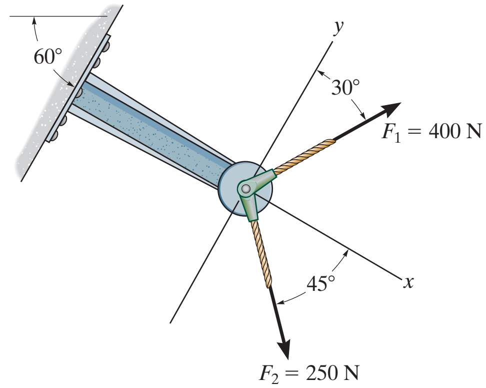


This work is protected by United States copyright laws and is provided solely for the use of instructors in teaching their courses and assessing student learning. Dissemination or sale of any part of this work (including on the World Wide Web) will destroy the integrity of the work and is not permitted.

© 2013 Pearson Education, Inc., Upper Saddle River, NJ. All rights reserved. This publication is protected by
Copyright and written permission should be obtained from the publisher prior to any prohibited reproduction, storage in a retrieval system,
or transmission in any form or by any means, electronic, mechanical,
photocopying, recording, or likewise. For information regarding permission(s), write to:
Rights and Permissions Department, Pearson Education, Inc., Upper Saddle River, NJ 07458.

2–35.

Determine the magnitude of the resultant force and its direction measured counterclockwise from the positive x axis.



SOLUTION

Rectangular Components: By referring to Fig. a, the x and y components of $\mathbf{F}_1$ and $\mathbf{F}_2$ can be written as

$$(F_1)_x = 400 \sin 30° = 200 \text{ N} \qquad (F_1)_y = 400 \cos 30° = 346.41 \text{ N}$$

$$(F_2)_x = 250 \cos 45° = 176.78 \text{ N} \qquad (F_2)_y = 250 \sin 45° = 176.78 \text{ N}$$

Resultant Force: Summing the force components algebraically along the x and y axes, we have

$$\overset{+}{\rightarrow} \Sigma(F_R)_x = \Sigma F_x; \qquad (F_R)_x = 200 + 176.78 = 376.78 \text{ N} \qquad \textbf{Ans.}$$

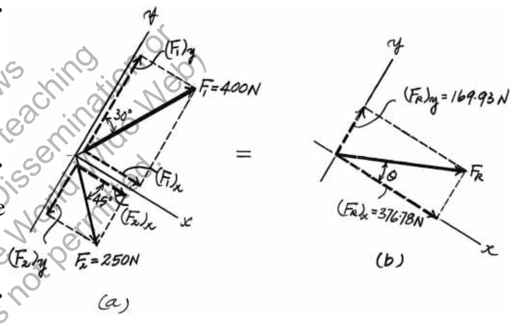
$$+\uparrow \Sigma(F_R)_y = \Sigma F_y; \qquad (F_R)_y = 346.41 - 176.78 = 169.63 \text{ N} \uparrow$$

The magnitude of the resultant force $\mathbf{F}_R$ is

$$F_R = \sqrt{(F_R)_x^{\,2} + (F_R)_y^{\,2}} = \sqrt{376.78^2 + 169.63^2} = 413 \text{ N} \qquad \textbf{Ans.}$$

The direction angle θ of $\mathbf{F}_R$, Fig. b, measured counterclockwise from the positive axis, is

$$\theta = \tan^{-1}\left[\frac{(F_R)_y}{(F_R)_x}\right] = \tan^{-1}\left(\frac{169.63}{376.78}\right) = 24.2° \qquad \textbf{Ans.}$$

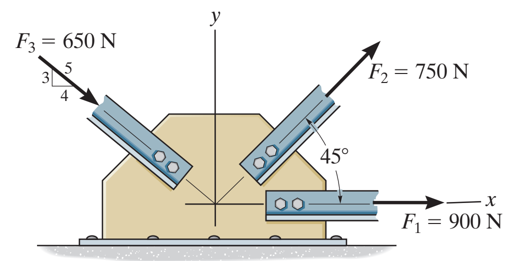


This work is protected by United States copyright laws and is provided solely for the use of instructors in teaching their courses and assessing student learning. Dissemination or sale of any part of this work (including on the World Wide Web) will destroy the integrity of the work and is not permitted.

© 2013 Pearson Education, Inc., Upper Saddle River, NJ. All rights reserved. This publication is protected by Copyright and written permission should be obtained from the publisher prior to any prohibited reproduction, storage in a retrieval system, or transmission in any form or by any means, electronic, mechanical, photocopying, recording, or likewise. For information regarding permission(s), write to: Rights and Permissions Department, Pearson Education, Inc., Upper Saddle River, NJ 07458.

***2–36.**

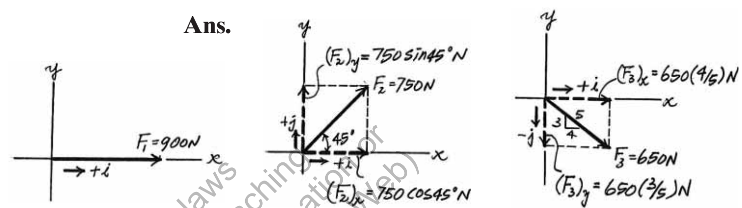
Resolve each force acting on the gusset plate into its x and y components, and express each force as a Cartesian vector.



$$\mathbf{F}_1 = \{900(+\mathbf{i})\} = \{900\mathbf{i}\}\ \text{N}$$ **Ans.**

$$\mathbf{F}_2 = \{750\cos 45°(+\mathbf{i}) + 750\sin 45°(+\mathbf{j})\}\ \text{N}$$
$$= \{530\mathbf{i} + 530\mathbf{j}\}\ \text{N}$$ **Ans.**

$$\mathbf{F}_3 = \left\{650\left(\frac{4}{5}\right)(+\mathbf{i}) + 650\left(\frac{3}{5}\right)(-\mathbf{j})\right\}\ \text{N}$$
$$= \{520\ \mathbf{i} - 390\mathbf{j})\}\ \text{N}$$ **Ans.**

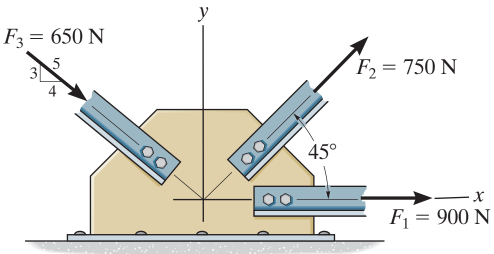


This work is protected by United States copyright laws and is provided solely for the use of instructors in teaching their courses and assessing student learning. Dissemination or sale of any part of this work (including on the World Wide Web) will destroy the integrity of the work and is not permitted.

© 2013 Pearson Education, Inc., Upper Saddle River, NJ. All rights reserved. This publication is protected by
Copyright and written permission should be obtained from the publisher prior to any prohibited reproduction, storage in a retrieval system,
or transmission in any form or by any means, electronic, mechanical,
photocopying, recording, or likewise. For information regarding permission(s), write to:
Rights and Permissions Department, Pearson Education, Inc., Upper Saddle River, NJ 07458.

2–37.

Determine the magnitude of the resultant force acting on the plate and its direction, measured counterclockwise from the positive x axis.



SOLUTION

Rectangular Components: By referring to Fig. a, the x and y components of $\mathbf{F}_1$, $\mathbf{F}_2$, and $\mathbf{F}_3$ can be written as

$$(F_1)_x = 900 \text{ N} \qquad (F_1)_y = 0$$

$$(F_2)_x = 750 \cos 45° = 530.33 \text{ N} \qquad (F_2)_y = 750 \sin 45° = 530.33 \text{ N}$$

$$(F_3)_x = 650\left(\frac{4}{5}\right) = 520 \text{ N} \qquad (F_3)_y = 650\left(\frac{3}{5}\right) = 390 \text{ N}$$

Resultant Force: Summing the force components algebraically along the x and y axes, we have

$$\overset{+}{\rightarrow} \Sigma(F_R)_x = \Sigma F_x; \qquad (F_R)_x = 900 + 530.33 + 520 = 1950.33 \text{ N} \rightarrow$$

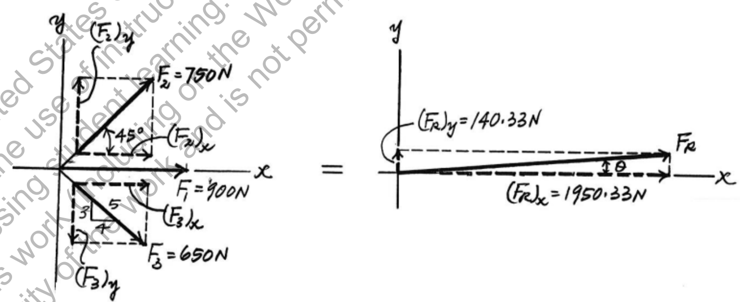
$$+\uparrow \Sigma(F_R)_y = \Sigma F_y; \qquad (F_R)_y = 530.33 - 390 = 140.33 \text{ N} \uparrow$$

The magnitude of the resultant force $\mathbf{F}_R$ is

$$F_R = \sqrt{(F_R)_x^{\,2} + (F_R)_y^{\,2}} = \sqrt{1950.33^2 + 140.33^2} = 1955 \text{ N} = 1.96 \text{ kN} \quad \textbf{Ans.}$$

The direction angle θ of $\mathbf{F}_R$, measured clockwise from the positive x axis, is

$$\theta = \tan^{-1}\left[\frac{(F_R)_y}{(F_R)_x}\right] = \tan^{-1}\left(\frac{140.33}{1950.33}\right) = 4.12° \quad \textbf{Ans.}$$



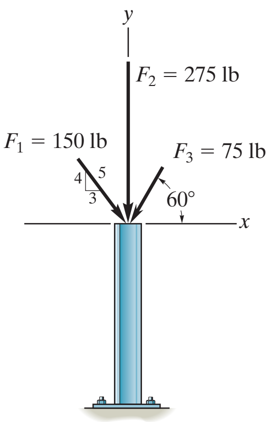
(a)

This work is protected by United States copyright laws and is provided solely for the use of instructors in teaching their courses and assessing student learning. Dissemination or sale of any part of this work (including on the World Wide Web) will destroy the integrity of the work and is not permitted.

© 2013 Pearson Education, Inc., Upper Saddle River, NJ. All rights reserved. This publication is protected by Copyright and written permission should be obtained from the publisher prior to any prohibited reproduction, storage in a retrieval system, or transmission in any form or by any means, electronic, mechanical, photocopying, recording, or likewise. For information regarding permission(s), write to: Rights and Permissions Department, Pearson Education, Inc., Upper Saddle River, NJ 07458.

2–38.

Express each of the three forces acting on the column in Cartesian vector form and compute the magnitude of the resultant force.



SOLUTION

$$\mathbf{F}_1 = 150\left(\frac{3}{5}\right)\mathbf{i} - 150\left(\frac{4}{5}\right)\mathbf{j}$$

$$\mathbf{F}_1 = \{90\mathbf{i} - 120\mathbf{j}\}\ \text{lb}$$ **Ans.**

$$\mathbf{F}_2 = \{-275\mathbf{j}\}\ \text{lb}$$ **Ans.**

$$\mathbf{F}_3 = -75\cos 60°\mathbf{i} - 75\sin 60°\mathbf{j}$$

$$\mathbf{F}_3 = \{-37.5\mathbf{i} - 65.0\mathbf{j}\}\ \text{lb}$$ **Ans.**

$$\mathbf{F}_R = \Sigma\mathbf{F} = \{52.5\mathbf{i} - 460\mathbf{j}\}\ \text{lb}$$

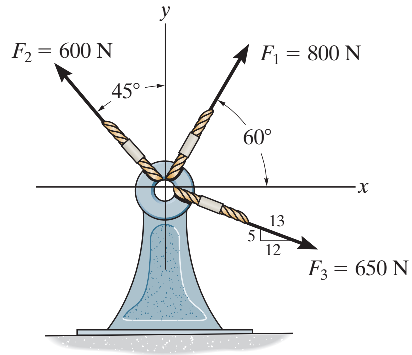
$$\mathbf{F}_R = \sqrt{(52.5)^2 + (-460)^2} = 463\ \text{lb}$$ **Ans.**

This work is protected by United States copyright laws and is provided solely for the use of instructors in teaching their courses and assessing student learning. Dissemination or sale of any part of this work (including on the World Wide Web) will destroy the integrity of the work and is not permitted.

© 2013 Pearson Education, Inc., Upper Saddle River, NJ. All rights reserved. This publication is protected by Copyright and written permission should be obtained from the publisher prior to any prohibited reproduction, storage in a retrieval system, or transmission in any form or by any means, electronic, mechanical, photocopying, recording, or likewise. For information regarding permission(s), write to: Rights and Permissions Department, Pearson Education, Inc., Upper Saddle River, NJ 07458.

2–39.

Resolve each force acting on the support into its x and y components, and express each force as a Cartesian vector.

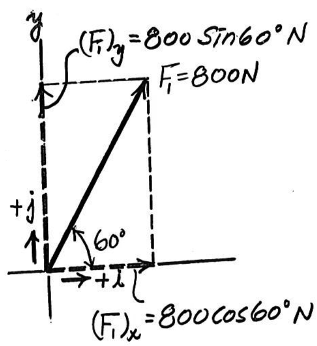


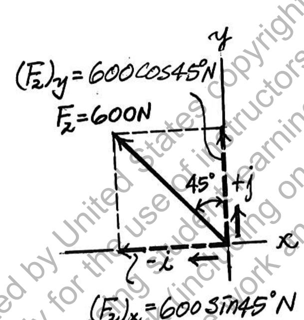
SOLUTION

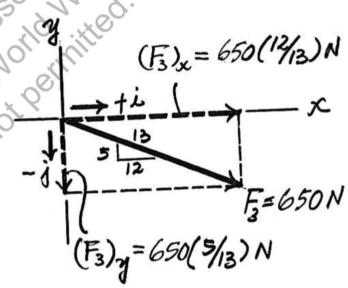
$$\mathbf{F}_1 = \{800\cos 60°(+\mathbf{i}) + 800\sin 60°(+\mathbf{j})\}\ \text{N}$$
$$= \{400\mathbf{i} + 693\mathbf{j}\}\ \text{N} \qquad \textbf{Ans.}$$

$$\mathbf{F}_2 = \{600\sin 45°(-\mathbf{i}) + 600\cos 45°(+\mathbf{j})\}\ \text{N} \qquad \textbf{Ans.}$$
$$= \{-424\mathbf{i} + 424\mathbf{j}\}\ \text{N}$$

$$\mathbf{F}_3 = \left\{650\left(\frac{12}{13}\right)(+\mathbf{i}) + 650\left(\frac{5}{13}\right)(-\mathbf{j})\right\}\ \text{N} \qquad \textbf{Ans.}$$
$$= \{600\mathbf{i} - 250\mathbf{j}\}\ \text{N}$$





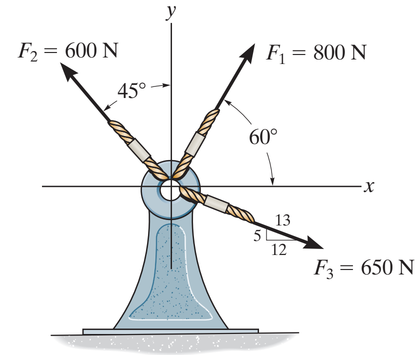


This work is protected by United States copyright laws and is provided solely for the use of instructors in teaching their courses and assessing student learning. Dissemination or sale of any part of this work (including on the World Wide Web) will destroy the integrity of the work and is not permitted.

© 2013 Pearson Education, Inc., Upper Saddle River, NJ. All rights reserved. This publication is protected by Copyright and written permission should be obtained from the publisher prior to any prohibited reproduction, storage in a retrieval system, or transmission in any form or by any means, electronic, mechanical, photocopying, recording, or likewise. For information regarding permission(s), write to: Rights and Permissions Department, Pearson Education, Inc., Upper Saddle River, NJ 07458.

***2–40.**

Determine the magnitude of the resultant force and its direction θ, measured counterclockwise from the positive x axis.



SOLUTION

Rectangular Components: By referring to Fig. *a*, the x and y components of $\mathbf{F}_1$, $\mathbf{F}_2$, and $\mathbf{F}_3$ can be written as

$$(F_1)_x = 800 \cos 60° = 400 \text{ N} \qquad (F_1)_y = 800 \sin 60° = 692.82 \text{ N}$$

$$(F_2)_x = 600 \sin 45° = 424.26 \text{ N} \qquad (F_2)_y = 600 \cos 45° = 424.26 \text{ N}$$

$$(F_3)_x = 650\left(\frac{12}{13}\right) = 600 \text{ N} \qquad (F_3)_y = 650\left(\frac{5}{13}\right) = 250 \text{ N}$$

Resultant Force: Summing the force components algebraically along the x and y axes, we have

$$\overset{+}{\rightarrow} \Sigma(F_R)_x = \Sigma F_x; \qquad (F_R)_x = 400 - 424.26 + 600 = 575.74 \text{ N} \rightarrow$$

$$+\uparrow \Sigma(F_R)_y = \Sigma F_y; \qquad (F_R)_y = \; -692.82 + 424.26 - 250 = 867.08 \text{ N} \uparrow$$

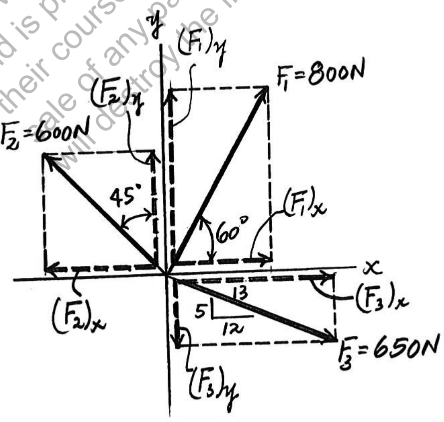
The magnitude of the resultant force $\mathbf{F}_R$ is

$$F_R = \sqrt{(F_R)_x{}^2 + (F_R)_y{}^2} = \sqrt{575.74^2 + 867.08^2} = 1041 \text{ N} = 1.04 \text{ kN} \quad \textbf{Ans.}$$

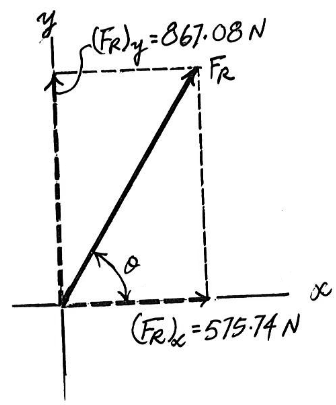
The direction angle θ of $\mathbf{F}_R$, Fig. *b*, measured counterclockwise from the positive x axis, is

$$\theta = \tan^{-1}\left[\frac{(F_R)_y}{(F_R)_x}\right] = \tan^{-1}\left(\frac{867.08}{575.74}\right) = 56.4° \quad \textbf{Ans.}$$

This work is protected by United States copyright laws and is provided solely for the use of instructors in teaching their courses and assessing student learning. Dissemination or sale of any part of this work (including on the World Wide Web) will destroy the integrity of the work and is not permitted.



(a)

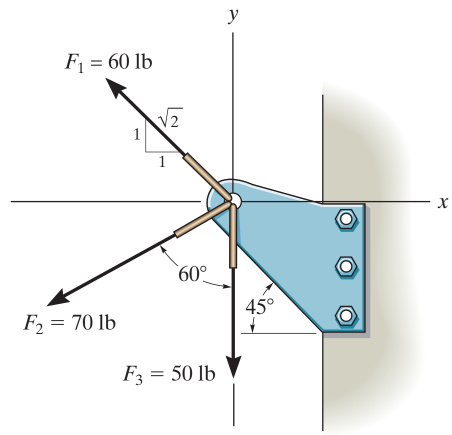


(b)

© 2013 Pearson Education, Inc., Upper Saddle River, NJ. All rights reserved. This publication is protected by Copyright and written permission should be obtained from the publisher prior to any prohibited reproduction, storage in a retrieval system, or transmission in any form or by any means, electronic, mechanical, photocopying, recording, or likewise. For information regarding permission(s), write to: Rights and Permissions Department, Pearson Education, Inc., Upper Saddle River, NJ 07458.

2–41.

Determine the magnitude of the resultant force and its direction measured counterclockwise from the positive x axis.



SOLUTION

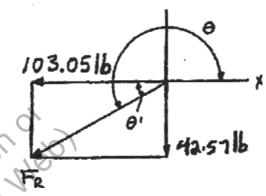
$$\mathbf{F}_1 = -60\left(\frac{1}{\sqrt{2}}\right)\mathbf{i} + 60\left(\frac{1}{\sqrt{2}}\right)\mathbf{j} = \{-42.43\mathbf{i} + 42.43\mathbf{j}\}\ \text{lb}$$

$$\mathbf{F}_2 = -70\sin 60°\mathbf{i} - 70\cos 60°\mathbf{j} = \{-60.62\mathbf{i} - 35\mathbf{j}\}\ \text{lb}$$

$$\mathbf{F}_3 = \{-50\,\mathbf{j}\}\ \text{lb}$$

$$\mathbf{F}_R = \Sigma\mathbf{F} = \{-103.05\,\mathbf{i} - 42.57\,\mathbf{j}\}\ \text{lb}$$

$$F_R = \sqrt{(-103.05)^2 + (-42.57)^2} = 111\ \text{lb}$$ **Ans.**



$$\theta' = \tan^{-1}\left(\frac{42.57}{103.05}\right) = 22.4°$$

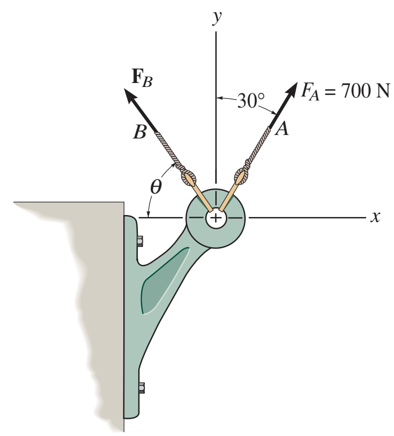
$$\theta = 180° + 22.4° = 202°$$ **Ans.**

This work is protected by United States copyright laws and is provided solely for the use of instructors in teaching their courses and assessing student learning. Dissemination or sale of any part of this work (including on the World Wide Web) will destroy the integrity of the work and is not permitted.

© 2013 Pearson Education, Inc., Upper Saddle River, NJ. All rights reserved. This publication is protected by Copyright and written permission should be obtained from the publisher prior to any prohibited reproduction, storage in a retrieval system, or transmission in any form or by any means, electronic, mechanical, photocopying, recording, or likewise. For information regarding permission(s), write to: Rights and Permissions Department, Pearson Education, Inc., Upper Saddle River, NJ 07458.

2–42.

Determine the magnitude and orientation θ of $\mathbf{F}_B$ so that the resultant force is directed along the positive y axis and has a magnitude of 1500 N.



SOLUTION

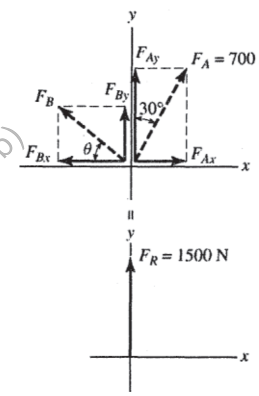
Scalar Notation: Summing the force components algebraically, we have

$\overset{+}{\rightarrow} F_{R_x} = \Sigma F_x; \qquad 0 = 700 \sin 30° - F_B \cos\theta$

$$F_B \cos\theta = 350 \qquad \textbf{(1)}$$

$+\uparrow F_{R_y} = \Sigma F_y; \qquad 1500 = 700 \cos 30° + F_B \sin\theta$

$$F_B \sin\theta = 893.8 \qquad \textbf{(2)}$$



Solving Eq. (1) and (2) yields

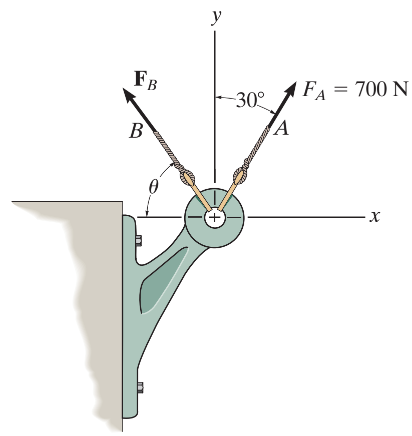
$$\theta = 68.6° \quad F_B = 960 \text{ N} \qquad \textbf{Ans.}$$

This work is protected by United States copyright laws and is provided solely for the use of instructors in teaching their courses and assessing student learning. Dissemination or sale of any part of this work (including on the World Wide Web) will destroy the integrity of the work and is not permitted.

© 2013 Pearson Education, Inc., Upper Saddle River, NJ. All rights reserved. This publication is protected by Copyright and written permission should be obtained from the publisher prior to any prohibited reproduction, storage in a retrieval system, or transmission in any form or by any means, electronic, mechanical, photocopying, recording, or likewise. For information regarding permission(s), write to: Rights and Permissions Department, Pearson Education, Inc., Upper Saddle River, NJ 07458.

2–43.

Determine the magnitude and orientation, measured counterclockwise from the positive y axis, of the resultant force acting on the bracket, if $F_B = 600$ N and $\theta = 20°$.



SOLUTION

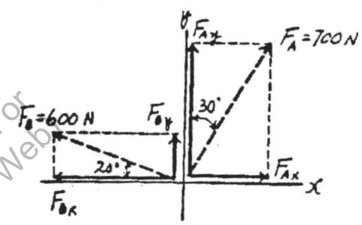
Scalar Notation: Summing the force components algebraically, we have

$$\overset{+}{\rightarrow} F_{R_x} = \Sigma F_x; \qquad F_{R_x} = 700 \sin 30° - 600 \cos 20°$$

$$= -213.8 \text{ N} = 213.8 \text{ N} \leftarrow$$

$$+\uparrow F_{R_y} = \Sigma F_y; \qquad F_{R_y} = 700 \cos 30° + 600 \sin 20°$$

$$= 811.4 \text{ N} \uparrow$$

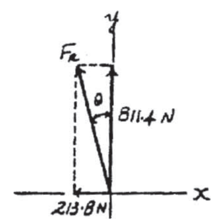


The magnitude of the resultant force $\mathbf{F}_R$ is

$$F_R = \sqrt{F_{R_x}^2 + F_{R_y}^2} = \sqrt{213.8^2 + 811.4^2} = 839 \text{ N}$$ **Ans.**

The direction angle θ measured counterclockwise from the positive y axis is

$$\theta = \tan^{-1}\frac{F_{R_x}}{F_{R_y}} = \tan^{-1}\left(\frac{213.8}{811.4}\right) = 14.8°$$ **Ans.**

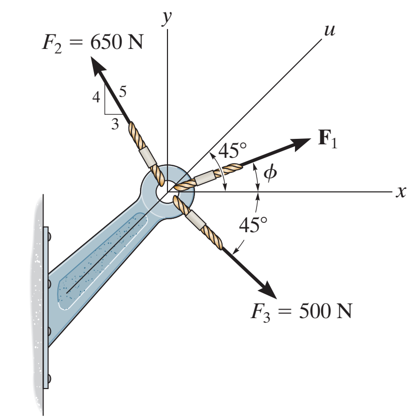


This work is protected by United States copyright laws and is provided solely for the use of instructors in teaching their courses and assessing student learning. Dissemination or sale of any part of this work (including on the World Wide Web) will destroy the integrity of the work and is not permitted.

© 2013 Pearson Education, Inc., Upper Saddle River, NJ. All rights reserved. This publication is protected by Copyright and written permission should be obtained from the publisher prior to any prohibited reproduction, storage in a retrieval system, or transmission in any form or by any means, electronic, mechanical, photocopying, recording, or likewise. For information regarding permission(s), write to: Rights and Permissions Department, Pearson Education, Inc., Upper Saddle River, NJ 07458.

***2–44.**

The magnitude of the resultant force acting on the bracket is to be 400 N. Determine the magnitude of $\mathbf{F}_1$ if $\phi = 30°$.



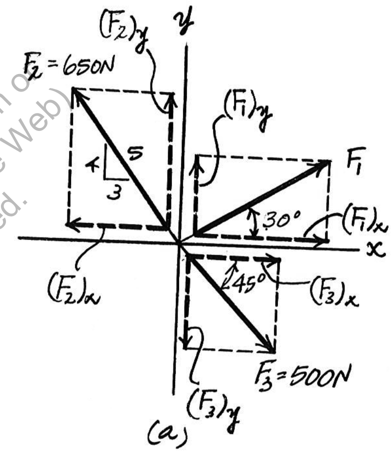
SOLUTION

Rectangular Components: By referring to Fig. *a*, the *x* and *y* components of $\mathbf{F}_1$, $\mathbf{F}_2$, and $\mathbf{F}_3$ can be written as

$$(F_1)_x = F_1 \cos 30° = 0.8660F_1 \qquad (F_1)_y = F_1 \sin 30° = 0.5F_1$$

$$(F_2)_x = 650\left(\frac{3}{5}\right) = 390 \text{ N} \qquad (F_2)_y = 650\left(\frac{4}{5}\right) = 520 \text{ N}$$

$$(F_3)_x = 500 \cos 45° = 353.55 \text{ N} \qquad (F_3)_y = 500 \sin 45° = 353.55 \text{ N}$$



Resultant Force: Summing the force components algebraically along the *x* and *y* axes, we have

$$\xrightarrow{+} \Sigma(F_R)_x = \Sigma F_x; \qquad (F_R)_x = 0.8660F_1 - 390 + 353.55$$
$$= 0.8660F_1 - 36.45$$

$$+\uparrow \Sigma(F_R)_y = \Sigma F_y; \qquad (F_R)_y = 0.5F_1 + 520 - 353.55$$
$$= 0.5F_1 + 166.45$$

Since the magnitude of the resultant force is $\mathbf{F}_R = 400$ N, we can write

$$F_R = \sqrt{(F_R)_x^{\,2} + (F_R)_y^{\,2}}$$

$$400 = \sqrt{(0.8660F_1 - 36.45)^2 + (0.5F_1 + 166.45)^2}$$

$$F_1^{\,2} + 103.32F_1 - 130967.17 = 0 \qquad \textbf{Ans.}$$

Solving,

$$F_1 = 314 \text{ N} \qquad \text{or} \qquad F_1 = -417 \text{ N} \qquad \textbf{Ans.}$$

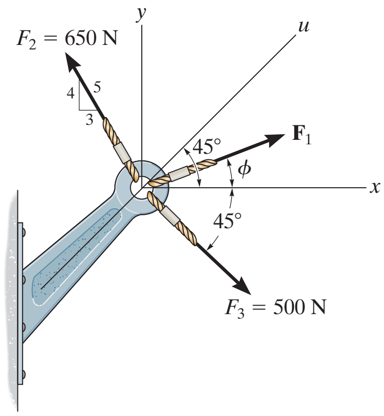
The negative sign indicates that $\mathbf{F}_1 = 417$ N must act in the opposite sense to that shown in the figure.

This work is protected by United States copyright laws and is provided solely for the use of instructors in teaching their courses and assessing student learning. Dissemination or sale of any part of this work (including on the World Wide Web) will destroy the integrity of the work and is not permitted.

© 2013 Pearson Education, Inc., Upper Saddle River, NJ. All rights reserved. This publication is protected by Copyright and written permission should be obtained from the publisher prior to any prohibited reproduction, storage in a retrieval system, or transmission in any form or by any means, electronic, mechanical, photocopying, recording, or likewise. For information regarding permission(s), write to: Rights and Permissions Department, Pearson Education, Inc., Upper Saddle River, NJ 07458.

2–45.

If the resultant force acting on the bracket is to be directed along the positive u axis, and the magnitude of $\mathbf{F}_1$ is required to be *minimum*, determine the magnitudes of the resultant force and $\mathbf{F}_1$.



SOLUTION

Rectangular Components: By referring to Figs. a and b, the x and y components of $\mathbf{F}_1$, $\mathbf{F}_2$, $\mathbf{F}_3$, and $\mathbf{F}_R$ can be written as

$$(F_1)_x = F_1 \cos\phi \qquad (F_1)_y = F_1 \sin\phi$$

$$(F_2)_x = 650\left(\frac{3}{5}\right) = 390\text{ N} \qquad (F_2)_y = 650\left(\frac{4}{5}\right) = 520\text{ N}$$

$$(F_3)_x = 500\cos 45° = 353.55\text{ N} \qquad (F_3)_y = 500\sin 45° = 353.55\text{ N}$$

$$(F_R)_x = F_R\cos 45° = 0.7071F_R \qquad (F_R)_y = F_R\sin 45° = 0.7071F_R$$

Resultant Force: Summing the force components algebraically along the x and y axes, we have

$$\overset{+}{\rightarrow}\Sigma(F_R)_x = \Sigma F_x; \qquad 0.7071F_R = F_1\cos\phi - 390 + 353.55 \qquad (1)$$

$$+\uparrow\Sigma(F_R)_y = \Sigma F_y; \qquad 0.7071F_R = F_1\sin\phi + 520 - 353.55 \qquad (2)$$

Eliminating F_R from Eqs. (1) and (2), yields

$$F_1 = \frac{202.89}{\cos\phi - \sin\phi} \qquad (3)$$

The first derivative of Eq. (3) is

$$\frac{dF_1}{d\phi} = \frac{\sin\phi + \cos\phi}{(\cos\phi - \sin\phi)^2} \qquad (4)$$

The second derivative of Eq. (3) is

$$\frac{d^2F_1}{d\phi^2} = \frac{2(\sin\phi + \cos\phi)^2}{(\cos\phi - \sin\phi)^3} + \frac{1}{\cos\phi - \sin\phi} \qquad (5)$$

For $\mathbf{F}_1$ to be minimum, $\frac{dF_1}{d\phi} = 0$. Thus, from Eq. (4)

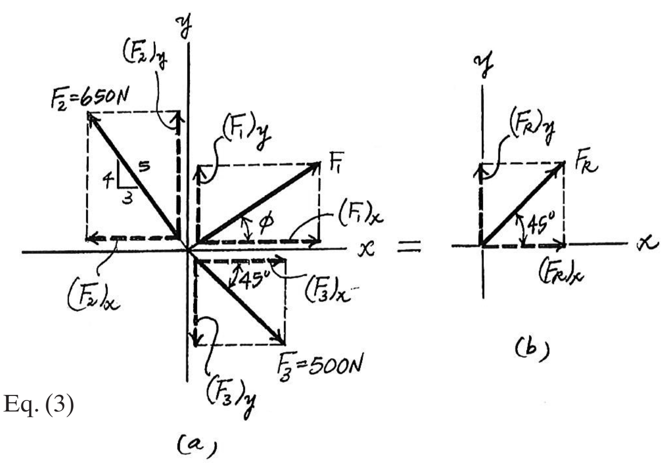
$$\sin\phi + \cos\phi = 0$$

$$\tan\phi = -1$$

$$\phi = -45°$$

Substituting $\phi = -45°$ into Eq. (5), yields

$$\frac{d^2F_1}{d\phi^2} = 0.7071 > 0$$



This shows that $\phi = -45°$ indeed produces minimum F_1. Thus, from Eq. (3)

$$F_1 = \frac{202.89}{\cos(-45°) - \sin(-45°)} = 143.47\text{ N} = 143\text{ N} \qquad \textbf{Ans.}$$

Substituting $\phi = -45°$ and $F_1 = 143.47$ N into either Eq. (1) or Eq. (2), yields

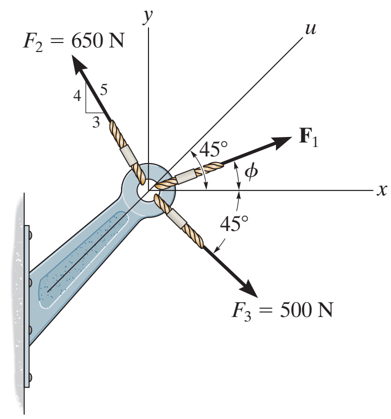
$$F_R = 919\text{ N} \qquad \textbf{Ans.}$$

This work is protected by United States copyright laws and is provided solely for the use of instructors in teaching their courses and assessing student learning. Dissemination or sale of any part of this work (including on the World Wide Web) will destroy the integrity of the work and is not permitted.

© 2013 Pearson Education, Inc., Upper Saddle River, NJ. All rights reserved. This publication is protected by Copyright and written permission should be obtained from the publisher prior to any prohibited reproduction, storage in a retrieval system, or transmission in any form or by any means, electronic, mechanical, photocopying, recording, or likewise. For information regarding permission(s), write to: Rights and Permissions Department, Pearson Education, Inc., Upper Saddle River, NJ 07458.

2–46.

If the magnitude of the resultant force acting on the bracket is 600 N, directed along the positive u axis, determine the magnitude of **F** and its direction ϕ.



SOLUTION

Rectangular Components: By referring to Figs. *a* and *b*, the x and y components of $\mathbf{F}_1, \mathbf{F}_2, \mathbf{F}_3$, and $\mathbf{F}_R$ can be written as

$(F_1)_x = F_1 \cos\phi \qquad (F_1)_y = F_1 \sin\phi$

$(F_2)_x = 650\left(\frac{3}{5}\right) = 390 \text{ N} \qquad (F_2)_y = 650\left(\frac{4}{5}\right) = 520 \text{ N}$

$(F_3)_x = 500 \cos 45° = 353.55 \text{ N} \qquad (F_3)_y = 500 \cos 45° = 353.55 \text{ N}$

$(F_R)_x = 600 \cos 45° = 424.26 \text{ N} \qquad (F_R)_y = 600 \sin 45° = 424.26 \text{ N}$

Resultant Force: Summing the force components algebraically along the x and y axes, we have

$\overset{+}{\rightarrow} \Sigma(F_R)_x = \Sigma F_x; \qquad 424.26 = F_1 \cos\phi - 390 + 353.55$

$F_1 \cos\phi = 460.71 \qquad$ **(1)**

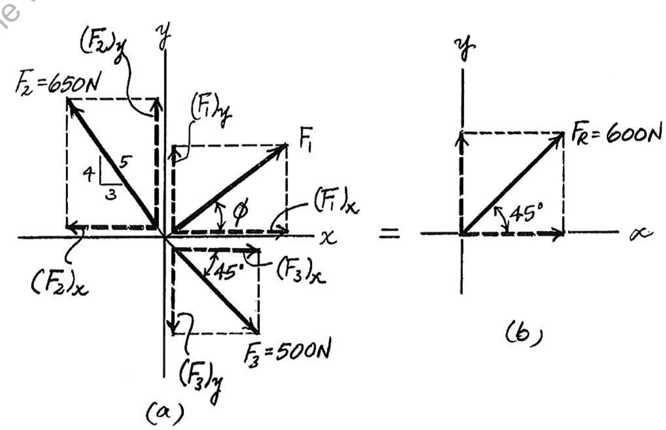
$+\uparrow \Sigma(F_R)_y = \Sigma F_y; \qquad 424.26 = F_1 \sin\phi + 520 - 353.55$

$F_1 \sin\phi = 257.82 \qquad$ **(2)**

Solving Eqs. (1) and (2), yields

$\phi = 29.2° \qquad F_1 = 528 \text{ N} \qquad$ **Ans.**

This work is protected by United States copyright laws and is provided solely for the use of instructors in teaching their courses and assessing student learning. Dissemination or sale of any part of this work (including on the World Wide Web) will destroy the integrity of the work and is not permitted.

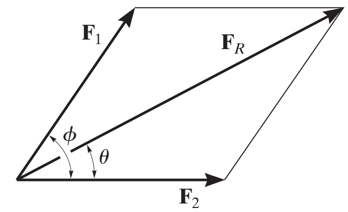


© 2013 Pearson Education, Inc., Upper Saddle River, NJ. All rights reserved. This publication is protected by Copyright and written permission should be obtained from the publisher prior to any prohibited reproduction, storage in a retrieval system, or transmission in any form or by any means, electronic, mechanical, photocopying, recording, or likewise. For information regarding permission(s), write to: Rights and Permissions Department, Pearson Education, Inc., Upper Saddle River, NJ 07458.

2–47.

Determine the magnitude and direction θ of the resultant force $\mathbf{F}_R$. Express the result in terms of the magnitudes of the components $\mathbf{F}_1$ and $\mathbf{F}_2$ and the angle ϕ.

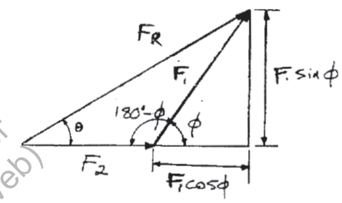
SOLUTION



$$F_R^2 = F_1^2 + F_2^2 - 2F_1F_2\cos(180^\circ - \phi)$$

Since $\cos(180^\circ - \phi) = -\cos\phi$,

$$F_R = \sqrt{F_1^2 + F_2^2 + 2F_1F_2\cos\phi}$$ **Ans.**



From the figure,

$$\tan\theta = \frac{F_1\sin\phi}{F_2 + F_1\cos\phi}$$

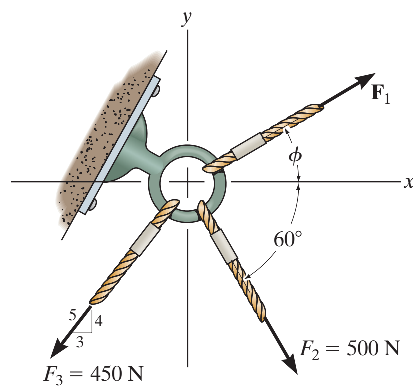
$$\theta = \tan^{-1}\left(\frac{F_1\sin\phi}{F_2 + F_1\cos\phi}\right)$$ **Ans.**

This work is protected by United States copyright laws and is provided solely for the use of instructors in teaching their courses and assessing student learning. Dissemination or sale of any part of this work (including on the World Wide Web) will destroy the integrity of the work and is not permitted.

© 2013 Pearson Education, Inc., Upper Saddle River, NJ. All rights reserved. This publication is protected by Copyright and written permission should be obtained from the publisher prior to any prohibited reproduction, storage in a retrieval system, or transmission in any form or by any means, electronic, mechanical, photocopying, recording, or likewise. For information regarding permission(s), write to: Rights and Permissions Department, Pearson Education, Inc., Upper Saddle River, NJ 07458.

***2–48.**

If $F_1 = 600$ N and $\phi = 30°$, determine the magnitude of the resultant force acting on the eyebolt and its direction measured clockwise from the positive x axis.



SOLUTION

Rectangular Components: By referring to Fig. *a*, the x and y components of each force can be written as

$$(F_1)_x = 600\cos 30° = 519.62\text{ N} \quad (F_1)_y = 600\sin 30° = 300\text{ N}$$

$$(F_2)_x = 500\cos 60° = 250\text{ N} \quad (F_2)_y = 500\sin 60° = 433.01\text{ N}$$

$$(F_3)_x = 450\left(\frac{3}{5}\right) = 270\text{ N} \quad (F_3)_y = 450\left(\frac{4}{5}\right) = 360\text{ N}$$

Resultant Force: Summing the force components algebraically along the x and y axes,

$$\overset{+}{\rightarrow}\Sigma(F_R)_x = \Sigma F_x; \quad (F_R)_x = 519.62 + 250 - 270 = 499.62\text{ N} \rightarrow$$

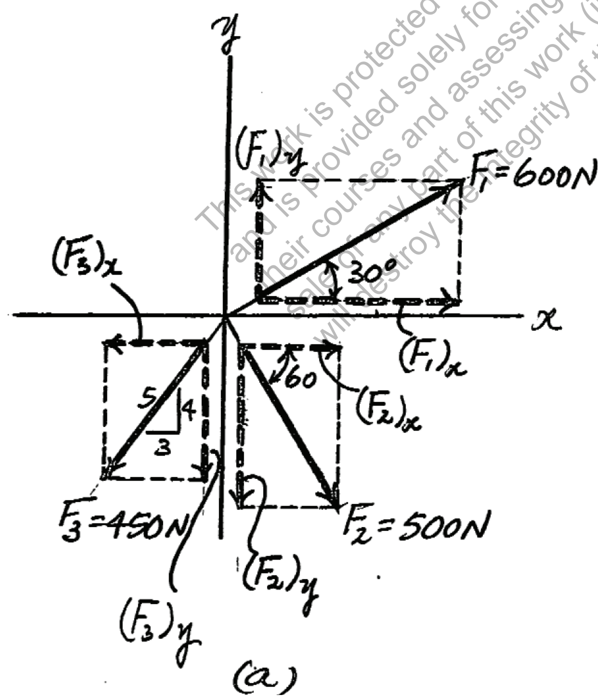
$$+\uparrow\Sigma(F_R)_y = \Sigma F_y; \quad (F_R)_y = 300 - 433.01 - 360 = -493.01\text{ N} = 493.01\text{ N} \downarrow$$

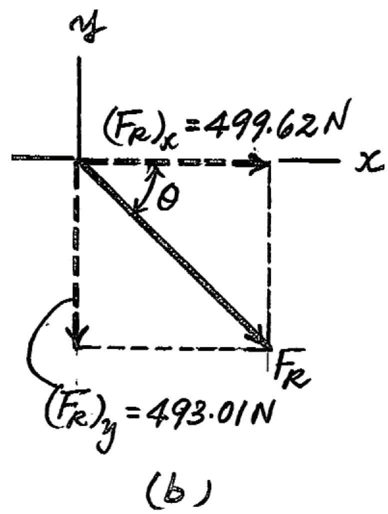
The magnitude of the resultant force $\mathbf{F}_R$ is

$$F_R = \sqrt{(F_R)_x^2 + (F_R)_y^2} = \sqrt{499.62^2 + 493.01^2} = 701.91\text{ N} = 702\text{ N} \qquad \textbf{Ans.}$$

The direction angle θ of $\mathbf{F}_R$, Fig. *b*, measured clockwise from the x axis, is

$$\theta = \tan^{-1}\left[\frac{(F_R)_y}{(F_R)_x}\right] = \tan^{-1}\left(\frac{493.01}{499.62}\right) = 44.6° \qquad \textbf{Ans.}$$



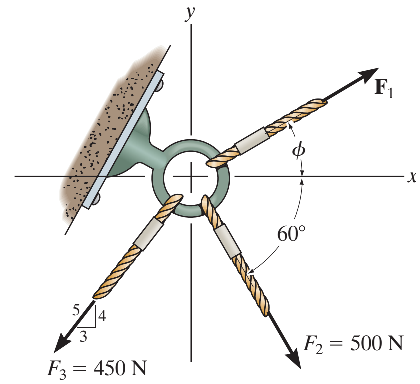


This work is protected by United States copyright laws and is provided solely for the use of instructors in teaching their courses and assessing student learning. Dissemination or sale of any part of this work (including on the World Wide Web) will destroy the integrity of the work and is not permitted.

© 2013 Pearson Education, Inc., Upper Saddle River, NJ. All rights reserved. This publication is protected by Copyright and written permission should be obtained from the publisher prior to any prohibited reproduction, storage in a retrieval system, or transmission in any form or by any means, electronic, mechanical, photocopying, recording, or likewise. For information regarding permission(s), write to: Rights and Permissions Department, Pearson Education, Inc., Upper Saddle River, NJ 07458.

2–49.

If the magnitude of the resultant force acting on the eyebolt is 600 N and its direction measured clockwise from the positive x axis is $\theta = 30°$, determine the magnitude of $\mathbf{F}_1$ and the angle ϕ.



SOLUTION

Rectangular Components: By referring to Figs. a and b, the x and y components of $\mathbf{F}_1$, $\mathbf{F}_2$, $\mathbf{F}_3$, and $\mathbf{F}_R$ can be written as

$$(F_1)_x = F_1 \cos\phi \qquad (F_1)_y = F_1 \sin\phi$$

$$(F_2)_x = 500 \cos 60° = 250 \text{ N} \qquad (F_2)_y = 500 \sin 60° = 433.01 \text{ N}$$

$$(F_3)_x = 450\left(\frac{3}{5}\right) = 270 \text{ N} \qquad (F_3)_y = 450\left(\frac{4}{5}\right) = 360 \text{ N}$$

$$(F_R)_x = 600 \cos 30° = 519.62 \text{ N} \qquad (F_R)_y = 600 \sin 30° = 300 \text{ N}$$

Resultant Force: Summing the force components algebraically along the x and y axes,

$$\overset{+}{\rightarrow} \Sigma(F_R)_x = \Sigma F_x; \qquad 519.62 = F_1 \cos\phi + 250 - 270$$

$$F_1 \cos\phi = 539.62 \qquad \textbf{(1)}$$

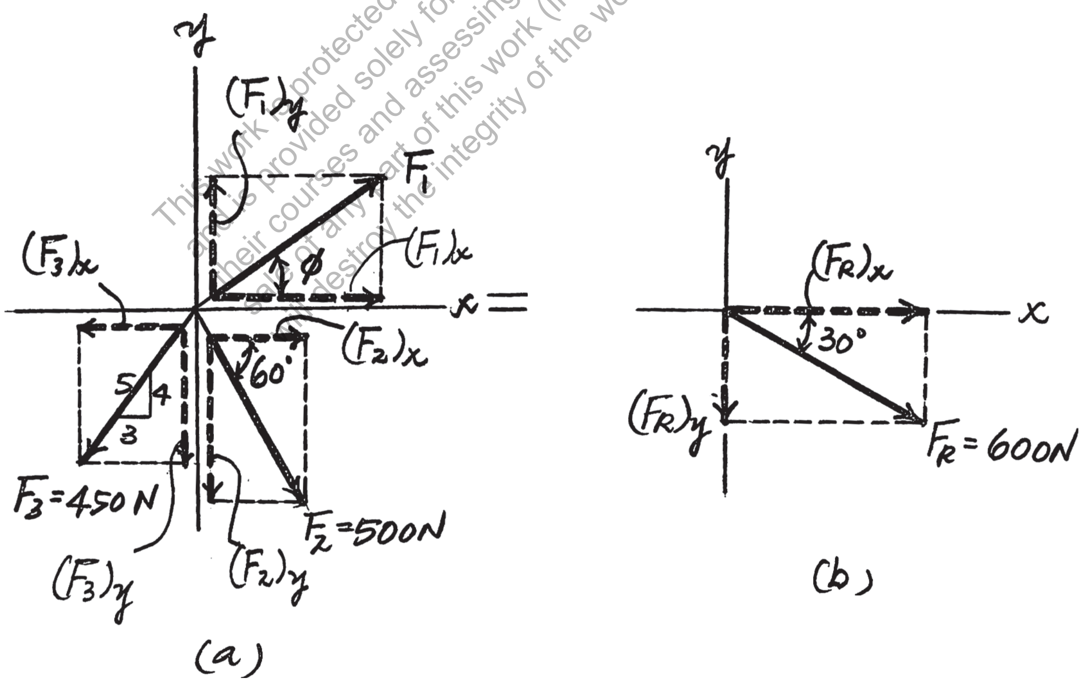
$$+\uparrow \Sigma(F_R)_y = \Sigma F_y; \quad -300 = F_1 \sin\phi - 433.01 - 360$$

$$F_1 \sin\phi = 493.01 \qquad \textbf{(2)}$$

Solving Eqs. (1) and (2), yields

$$\phi = 42.4° \qquad F_1 = 731 \text{ N} \qquad \textbf{Ans.}$$

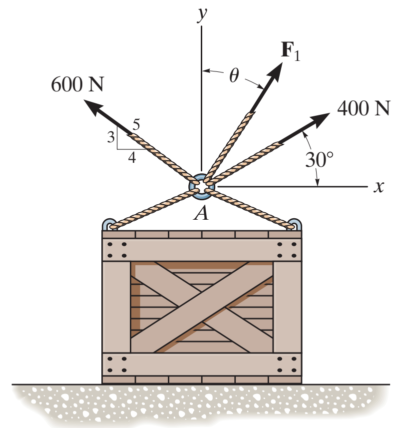
This work is protected by United States copyright laws and is provided solely for the use of instructors in teaching their courses and assessing student learning. Dissemination or sale of any part of this work (including on the World Wide Web) will destroy the integrity of the work and is not permitted.



© 2013 Pearson Education, Inc., Upper Saddle River, NJ. All rights reserved. This publication is protected by Copyright and written permission should be obtained from the publisher prior to any prohibited reproduction, storage in a retrieval system, or transmission in any form or by any means, electronic, mechanical, photocopying, recording, or likewise. For information regarding permission(s), write to: Rights and Permissions Department, Pearson Education, Inc., Upper Saddle River, NJ 07458.

2–50.

Determine the magnitude of $\mathbf{F}_1$ and its direction θ so that the resultant force is directed vertically upward and has a magnitude of 800 N.



SOLUTION

Scalar Notation: Summing the force components algebraically, we have

$$\xrightarrow{+} F_{R_x} = \Sigma F_x; \qquad F_{R_x} = 0 = F_1 \sin\theta + 400\cos 30^\circ - 600\left(\frac{4}{5}\right)$$

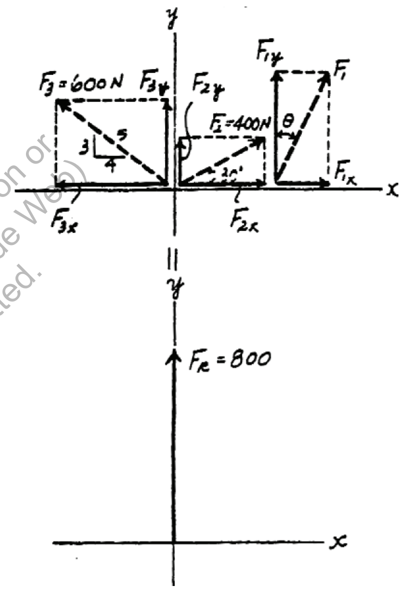
$$F_1 \sin\theta = 133.6 \qquad \textbf{(1)}$$

$$+\uparrow F_{R_y} = \Sigma F_y; \qquad F_{R_y} = 800 = F_1 \cos\theta + 400\sin 30^\circ + 600\left(\frac{3}{5}\right)$$

$$F_1 \cos\theta = 240 \qquad \textbf{(2)}$$

Solving Eqs. (1) and (2) yields

$$\theta = 29.1^\circ \qquad F_1 = 275 \text{ N} \qquad \textbf{Ans.}$$

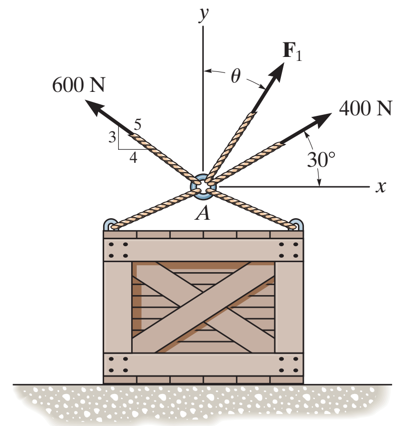


This work is protected by United States copyright laws and is provided solely for the use of instructors in teaching their courses and assessing student learning. Dissemination or sale of any part of this work (including on the World Wide Web) will destroy the integrity of the work and is not permitted.

© 2013 Pearson Education, Inc., Upper Saddle River, NJ. All rights reserved. This publication is protected by Copyright and written permission should be obtained from the publisher prior to any prohibited reproduction, storage in a retrieval system, or transmission in any form or by any means, electronic, mechanical, photocopying, recording, or likewise. For information regarding permission(s), write to: Rights and Permissions Department, Pearson Education, Inc., Upper Saddle River, NJ 07458.

2–51.

Determine the magnitude and direction measured counterclockwise from the positive x axis of the resultant force of the three forces acting on the ring A. Take $F_1 = 500$ N and $\theta = 20°$.



SOLUTION

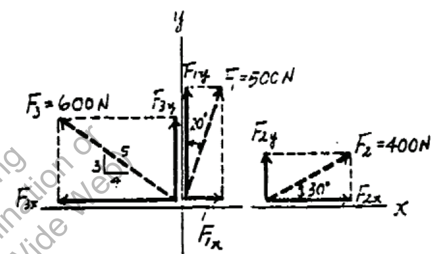
Scalar Notation: Summing the force components algebraically, we have

$$\overset{+}{\rightarrow} F_{R_x} = \Sigma F_x; \qquad F_{R_x} = 500 \sin 20° + 400 \cos 30° - 600\left(\frac{4}{5}\right)$$

$$= 37.42 \text{ N} \rightarrow$$

$$+\uparrow F_{R_y} = \Sigma F_y; \qquad F_{R_y} = 500 \cos 20° + 400 \sin 30° + 600\left(\frac{3}{5}\right)$$

$$= 1029.8 \text{ N} \uparrow$$

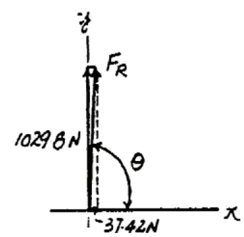


The magnitude of the resultant force $\mathbf{F}_R$ is

$$F_R = \sqrt{F_{R_x}^2 + F_{R_y}^2} = \sqrt{37.42^2 + 1029.8^2} = 1030.5 \text{ N} = 1.03 \text{ kN} \qquad \textbf{Ans.}$$

The direction angle θ measured counterclockwise from positive x axis is

$$\theta = \tan^{-1}\frac{F_{R_y}}{F_{R_x}} = \tan^{-1}\left(\frac{1029.8}{37.42}\right) = 87.9° \qquad \textbf{Ans.}$$

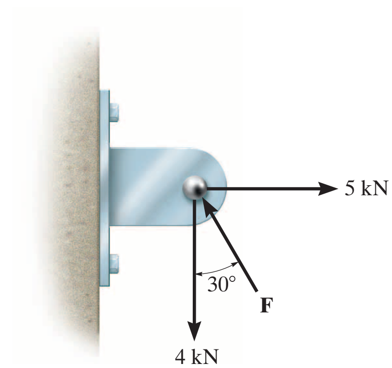


This work is protected by United States copyright laws and is provided solely for the use of instructors in teaching their courses and assessing student learning. Dissemination or sale of any part of this work (including on the World Wide Web) will destroy the integrity of the work and is not permitted.

© 2013 Pearson Education, Inc., Upper Saddle River, NJ. All rights reserved. This publication is protected by Copyright and written permission should be obtained from the publisher prior to any prohibited reproduction, storage in a retrieval system, or transmission in any form or by any means, electronic, mechanical, photocopying, recording, or likewise. For information regarding permission(s), write to: Rights and Permissions Department, Pearson Education, Inc., Upper Saddle River, NJ 07458.

***2–52.**

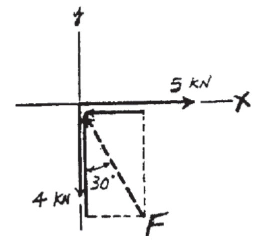
Determine the magnitude of force **F** so that the resultant $\mathbf{F}_R$ of the three forces is as small as possible. What is the minimum magnitude of $\mathbf{F}_R$?



SOLUTION

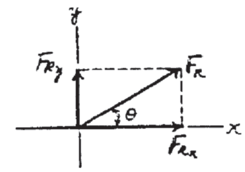
Scalar Notation: Summing the force components algebraically, we have

$$\xrightarrow{+} F_{R_x} = \Sigma F_x; \qquad F_{R_x} = 5 - F \sin 30^\circ$$
$$= 5 - 0.50F \rightarrow$$
$$+\uparrow F_{R_y} = \Sigma F_y; \qquad F_{R_y} = F \cos 30^\circ - 4$$
$$= 0.8660F - 4 \uparrow$$



The magnitude of the resultant force $\mathbf{F}_R$ is

$$F_R = \sqrt{F_{R_x}^2 + F_{R_y}^2}$$
$$= \sqrt{(5 - 0.50F)^2 + (0.8660F - 4)^2}$$
$$= \sqrt{F^2 - 11.93F + 41} \qquad \textbf{(1)}$$
$$F_R^2 = F^2 - 11.93F + 41$$
$$2F_R \frac{dF_R}{dF} = 2F - 11.93 \qquad \textbf{(2)}$$
$$\left(F_R \frac{d^2F_R}{dF^2} + \frac{dF_R}{dF} \times \frac{dF_R}{dF}\right) = 1 \qquad \textbf{(3)}$$



In order to obtain the *minimum* resultant force $\mathbf{F}_R$, $\frac{dF_R}{dF} = 0$. From Eq. (2)

$$2F_R \frac{dF_R}{dF} = 2F - 11.93 = 0$$
$$F = 5.964 \text{ kN} = 5.96 \text{ kN} \qquad \textbf{Ans.}$$

Substituting $F = 5.964$ kN into Eq. (1), we have

$$F_R = \sqrt{5.964^2 - 11.93(5.964) + 41}$$
$$= 2.330 \text{ kN} = 2.33 \text{ kN} \qquad \textbf{Ans.}$$

Substituting $F_R = 2.330$ kN with $\frac{dF_R}{dF} = 0$ into Eq. (3), we have

$$\left[(2.330)\frac{d^2F_R}{dF^2} + 0\right] = 1$$
$$\frac{d^2F_R}{dF^2} = 0.429 > 0$$

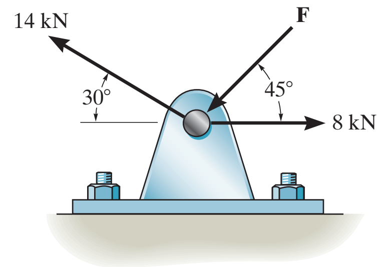
Hence, $F = 5.96$ kN is indeed producing a minimum resultant force.

This work is protected by United States copyright laws and is provided solely for the use of instructors in teaching their courses and assessing student learning. Dissemination or sale of any part of this work (including on the World Wide Web) will destroy the integrity of the work and is not permitted.

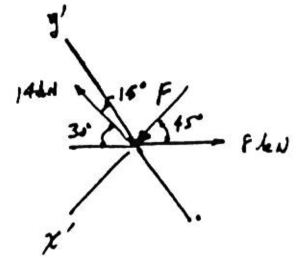
© 2013 Pearson Education, Inc., Upper Saddle River, NJ. All rights reserved. This publication is protected by Copyright and written permission should be obtained from the publisher prior to any prohibited reproduction, storage in a retrieval system, or transmission in any form or by any means, electronic, mechanical, photocopying, recording, or likewise. For information regarding permission(s), write to: Rights and Permissions Department, Pearson Education, Inc., Upper Saddle River, NJ 07458.

2–53.

Determine the magnitude of force **F** so that the resultant force of the three forces is as small as possible. What is the magnitude of the resultant force?



SOLUTION



$\overset{+}{\rightarrow} F_{Rx} = \Sigma F_x;$ $\quad F_{Rz} = 8 - F\cos 45° - 14\cos 30°$

$$= -4.1244 - F\cos 45°$$

$+\uparrow F_{Ry} = \Sigma F_y;$ $\quad F_{Ry} = -F\sin 45° + 14\sin 30°$

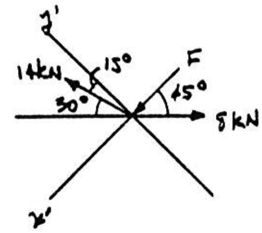
$$= 7 - F\sin 45°$$

$$F_R^2 = (-4.1244 - F\cos 45°)^2 + (7 - F\sin 45°)^2 \qquad \textbf{(1)}$$

$$2F_R\frac{dF_R}{dF} = 2(-4.1244 - F\cos 45°)(-\cos 45°) + 2(7 - F\sin 45°)(-\sin 45°) = 0$$

$F = 2.03\text{ kN}$ **Ans.**

From Eq. (1); $\quad F_R = 7.87\text{ kN}$ **Ans.**



Also, from the figure require

$(F_R)_{x'} = 0 = \Sigma F_{x'};$ $\quad F + 14\sin 15° - 8\cos 45° = 0$

$F = 2.03\text{ kN}$ **Ans.**

$(F_R)_{y'} = \Sigma F_{y'};$ $\quad F_R = 14\cos 15° - 8\sin 45°$

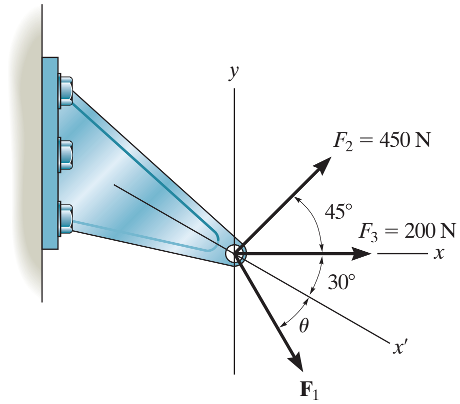
$F_R = 7.87\text{ kN}$ **Ans.**

This work is protected by United States copyright laws and is provided solely for the use of instructors in teaching their courses and assessing student learning. Dissemination or sale of any part of this work (including on the World Wide Web) will destroy the integrity of the work and is not permitted.

© 2013 Pearson Education, Inc., Upper Saddle River, NJ. All rights reserved. This publication is protected by Copyright and written permission should be obtained from the publisher prior to any prohibited reproduction, storage in a retrieval system, or transmission in any form or by any means, electronic, mechanical, photocopying, recording, or likewise. For information regarding permission(s), write to: Rights and Permissions Department, Pearson Education, Inc., Upper Saddle River, NJ 07458.

2–54.

Three forces act on the bracket. Determine the magnitude and direction θ of $\mathbf{F}_1$ so that the resultant force is directed along the positive x' axis and has a magnitude of 1 kN.



SOLUTION

$\overset{+}{\rightarrow} F_{Rx} = \Sigma F_x; \qquad 1000 \cos 30° = 200 + 450 \cos 45° + F_1 \cos(\theta + 30°)$

$+\uparrow F_{Ry} = \Sigma F_y; \qquad -1000 \sin 30° = 450 \sin 45° - F_1 \sin(\theta + 30°)$

$F_1 \sin(\theta + 30°) = 818.198$

$F_1 \cos(\theta + 30°) = 347.827$

$\theta + 30° = 66.97°, \quad \theta = 37.0°$ **Ans.**

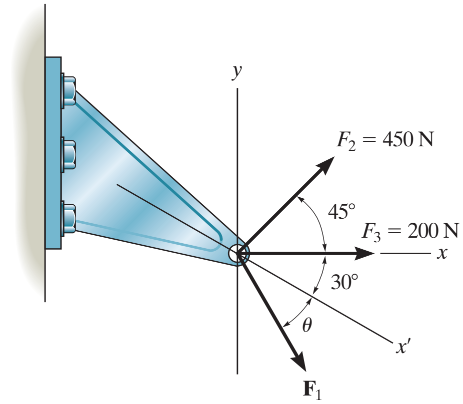
$F_1 = 889 \text{ N}$ **Ans.**

This work is protected by United States copyright laws and is provided solely for the use of instructors in teaching their courses and assessing student learning. Dissemination or sale of any part of this work (including on the World Wide Web) will destroy the integrity of the work and is not permitted.

© 2013 Pearson Education, Inc., Upper Saddle River, NJ. All rights reserved. This publication is protected by Copyright and written permission should be obtained from the publisher prior to any prohibited reproduction, storage in a retrieval system, or transmission in any form or by any means, electronic, mechanical, photocopying, recording, or likewise. For information regarding permission(s), write to: Rights and Permissions Department, Pearson Education, Inc., Upper Saddle River, NJ 07458.

2–55.

If $F_1 = 300$ N and $\theta = 20°$, determine the magnitude and direction, measured counterclockwise from the x' axis, of the resultant force of the three forces acting on the bracket.



SOLUTION

$\xrightarrow{+} F_{Rx} = \Sigma F_x; \qquad F_{Rx} = 300 \cos 50° + 200 + 450 \cos 45° = 711.03 \text{ N}$

$+\uparrow F_{Ry} = \Sigma F_y; \qquad F_{Ry} = -300 \sin 50° + 450 \sin 45° = 88.38 \text{ N}$

$$F_R = \sqrt{(711.03)^2 + (88.38)^2} = 717 \text{ N} \qquad \textbf{Ans.}$$

$$\phi' \text{ (angle from } x \text{ axis)} = \tan^{-1}\left[\frac{88.38}{711.03}\right]$$

$\phi' = 7.10°$

ϕ (angle from x' axis) $= 30° + 7.10°$

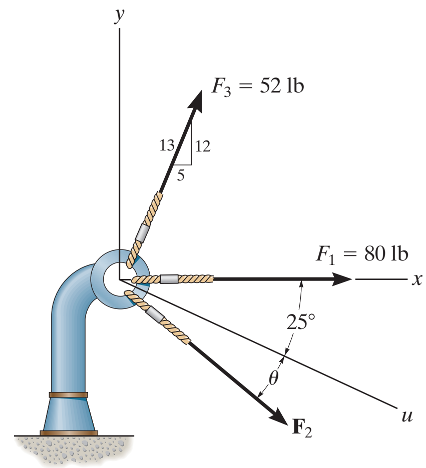
$\phi = 37.1°$ **Ans.**

This work is protected by United States copyright laws and is provided solely for the use of instructors in teaching their courses and assessing student learning. Dissemination or sale of any part of this work (including on the World Wide Web) will destroy the integrity of the work and is not permitted.

© 2013 Pearson Education, Inc., Upper Saddle River, NJ. All rights reserved. This publication is protected by Copyright and written permission should be obtained from the publisher prior to any prohibited reproduction, storage in a retrieval system, or transmission in any form or by any means, electronic, mechanical, photocopying, recording, or likewise. For information regarding permission(s), write to: Rights and Permissions Department, Pearson Education, Inc., Upper Saddle River, NJ 07458.

***2–56.**

Three forces act on the bracket. Determine the magnitude and direction θ of $\mathbf{F}_2$ so that the resultant force is directed along the positive u axis and has a magnitude of 50 lb.



SOLUTION

Scalar Notation: Summing the force components algebraically, we have

$$\overset{+}{\rightarrow} F_{R_x} = \Sigma F_x; \qquad 50 \cos 25° = 80 + 52\left(\frac{5}{13}\right) + F_2 \cos (25° + \theta)$$

$$F_2 \cos (25° + \theta) = -54.684 \qquad \textbf{(1)}$$

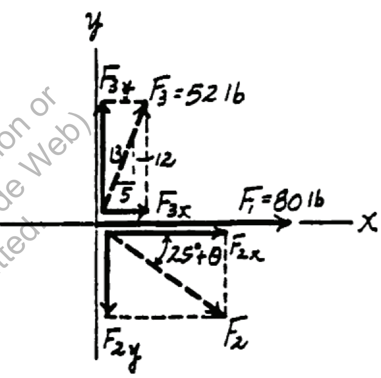
$$+\uparrow F_{R_y} = \Sigma F_y; \qquad -50 \sin 25° = 52\left(\frac{12}{13}\right) - F_2 \sin (25° + \theta)$$

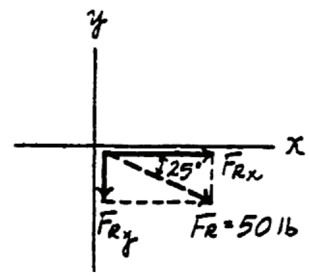
$$F_2 \sin (25° + \theta) = 69.131 \qquad \textbf{(2)}$$

Solving Eqs. (1) and (2) yields

$$25° + \theta = 128.35° \qquad \theta = 103° \qquad \textbf{Ans.}$$

$$F_2 = 88.1 \text{ lb} \qquad \textbf{Ans.}$$



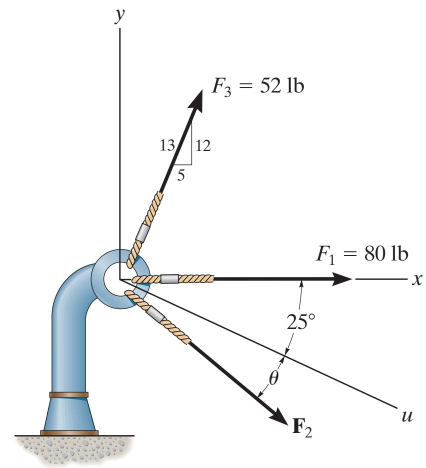


This work is protected by United States copyright laws and is provided solely for the use of instructors in teaching their courses and assessing student learning. Dissemination or sale of any part of this work (including on the World Wide Web) will destroy the integrity of the work and is not permitted.

© 2013 Pearson Education, Inc., Upper Saddle River, NJ. All rights reserved. This publication is protected by Copyright and written permission should be obtained from the publisher prior to any prohibited reproduction, storage in a retrieval system, or transmission in any form or by any means, electronic, mechanical, photocopying, recording, or likewise. For information regarding permission(s), write to: Rights and Permissions Department, Pearson Education, Inc., Upper Saddle River, NJ 07458.

2–57.

If $F_2 = 150$ lb and $\theta = 55°$, determine the magnitude and direction, measured clockwise from the positive x axis, of the resultant force of the three forces acting on the bracket.



SOLUTION

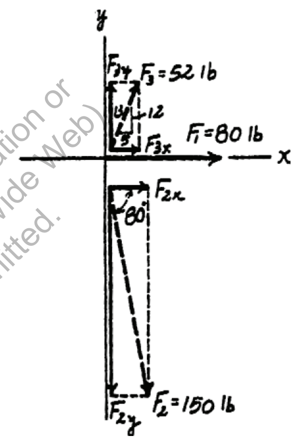
Scalar Notation: Summing the force components algebraically, we have

$$\overset{+}{\rightarrow} F_{R_x} = \Sigma F_x; \qquad F_{R_x} = 80 + 52\left(\frac{5}{13}\right) + 150 \cos 80°$$

$$= 126.05 \text{ lb} \rightarrow$$

$$+\uparrow F_{R_y} = \Sigma F_y; \qquad F_{R_y} = 52\left(\frac{12}{13}\right) - 150 \sin 80°$$

$$= -99.72 \text{ lb} = 99.72 \text{ lb} \downarrow$$

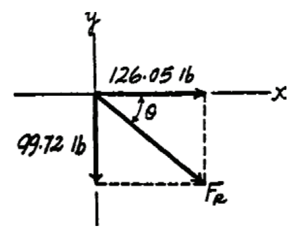


The magnitude of the resultant force $\mathbf{F}_R$ is

$$F_R = \sqrt{F_{R_x}^2 + F_{R_y}^2} = \sqrt{126.05^2 + 99.72^2} = 161 \text{ lb} \qquad \textbf{Ans.}$$

The direction angle θ measured clockwise from positive x axis is

$$\theta = \tan^{-1}\frac{F_{R_y}}{F_{R_x}} = \tan^{-1}\left(\frac{99.72}{126.05}\right) = 38.3° \qquad \textbf{Ans.}$$

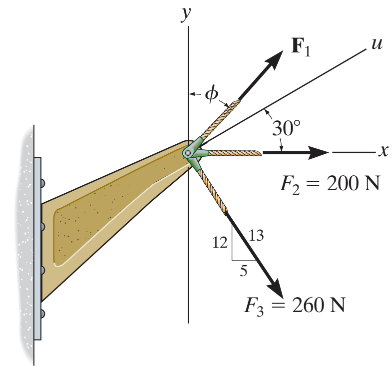


This work is protected by United States copyright laws and is provided solely for the use of instructors in teaching their courses and assessing student learning. Dissemination or sale of any part of this work (including on the World Wide Web) will destroy the integrity of the work and is not permitted.

© 2013 Pearson Education, Inc., Upper Saddle River, NJ. All rights reserved. This publication is protected by Copyright and written permission should be obtained from the publisher prior to any prohibited reproduction, storage in a retrieval system, or transmission in any form or by any means, electronic, mechanical, photocopying, recording, or likewise. For information regarding permission(s), write to: Rights and Permissions Department, Pearson Education, Inc., Upper Saddle River, NJ 07458.

2–58.

If the magnitude of the resultant force acting on the bracket is to be 450 N directed along the positive u axis, determine the magnitude of $\mathbf{F}_1$ and its direction ϕ.



SOLUTION

Rectangular Components: By referring to Fig. *a*, the x and y components of $\mathbf{F}_1$, $\mathbf{F}_2$, $\mathbf{F}_3$, and $\mathbf{F}_R$ can be written as

$$(F_1)_x = F_1 \sin\phi \qquad (F_1)_y = F_1 \cos\phi$$

$$(F_2)_x = 200 \text{ N} \qquad (F_2)_y = 0$$

$$(F_3)_x = 260\left(\frac{5}{13}\right) = 100 \text{ N} \qquad (F_3)_y = 260\left(\frac{12}{13}\right) = 240 \text{ N}$$

$$(F_R)_x = 450\cos 30^\circ = 389.71 \text{ N} \qquad (F_R)_y = 450\sin 30^\circ = 225 \text{ N}$$

Resultant Force: Summing the force components algebraically along the x and y axes,

$$\overset{+}{\rightarrow}\Sigma(F_R)_x = \Sigma F_x; \quad 389.71 = F_1 \sin\phi + 200 + 100$$

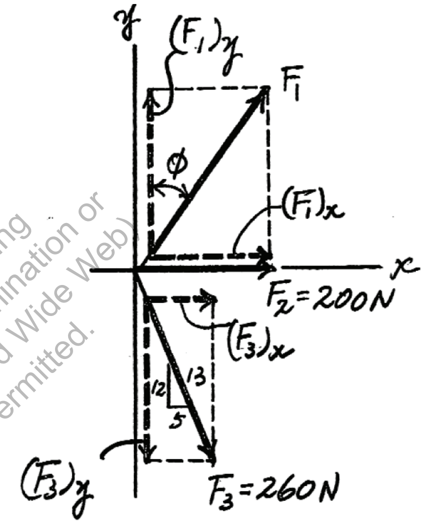
$$F_1 \sin\phi = 89.71 \qquad \textbf{(1)}$$

$$+\uparrow\Sigma(F_R)_y = \Sigma F_y; \quad 225 = F_1\cos\phi - 240$$

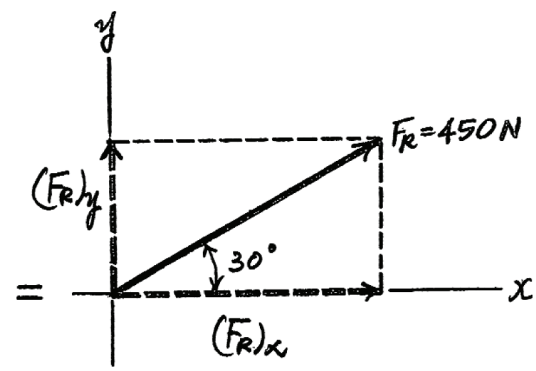
$$F_1\cos\phi = 465 \qquad \textbf{(2)}$$

Solving Eqs. (1) and (2), yields

$$\phi = 10.9^\circ \qquad F_1 = 474 \text{ N} \qquad \textbf{Ans.}$$



(a)



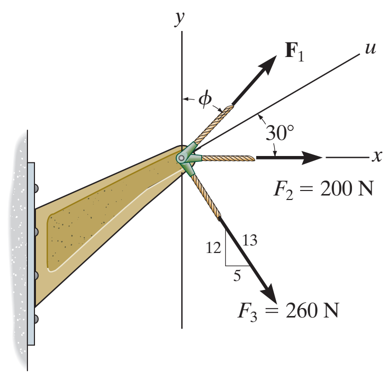
(b)

This work is protected by United States copyright laws and is provided solely for the use of instructors in teaching their courses and assessing student learning. Dissemination or sale of any part of this work (including on the World Wide Web) will destroy the integrity of the work and is not permitted.

© 2013 Pearson Education, Inc., Upper Saddle River, NJ. All rights reserved. This publication is protected by Copyright and written permission should be obtained from the publisher prior to any prohibited reproduction, storage in a retrieval system, or transmission in any form or by any means, electronic, mechanical, photocopying, recording, or likewise. For information regarding permission(s), write to: Rights and Permissions Department, Pearson Education, Inc., Upper Saddle River, NJ 07458.

2–59.

If the resultant force acting on the bracket is required to be a minimum, determine the magnitudes of $\mathbf{F}_1$ and the resultant force. Set $\phi = 30°$.



SOLUTION

Rectangular Components: By referring to Fig. *a*, the *x* and *y* components of $\mathbf{F}_1$, $\mathbf{F}_2$, and $\mathbf{F}_3$ can be written as

$$(F_1)_x = F_1 \sin 30° = 0.5F_1 \qquad (F_1)_y = F_1 \cos 30° = 0.8660F_1$$

$$(F_2)_x = 200\text{ N} \qquad (F_2)_y = 0$$

$$(F_3)_x = 260\left(\frac{5}{13}\right) = 100\text{ N} \qquad (F_3)_y = 260\left(\frac{12}{13}\right) = 240\text{ N}$$

Resultant Force: Summing the force components algebraically along the *x* and *y* axes,

$$\overset{+}{\rightarrow} \Sigma(F_R)_x = \Sigma F_x; \quad (F_R)_x = 0.5F_1 + 200 + 100 = 0.5F_1 + 300$$

$$+\uparrow \Sigma(F_R)_y = \Sigma F_y; \quad (F_R)_y = 0.8660F_1 - 240$$

The magnitude of the resultant force $\mathbf{F}_R$ is

$$F_R = \sqrt{(F_R)_x^2 + (F_R)_y^2}$$

$$= \sqrt{(0.5F_1 + 300)^2 + (0.8660F_1 - 240)^2}$$

$$= \sqrt{F_1^2 - 115.69F_1 + 147\,600} \qquad \textbf{(1)}$$

Thus,

$$F_R^2 = F_1^2 - 115.69F_1 + 147\,600 \qquad \textbf{(2)}$$

The first derivative of Eq. (2) is

$$2F_R\frac{dF_R}{dF_1} = 2F_1 - 115.69 \qquad \textbf{(3)}$$

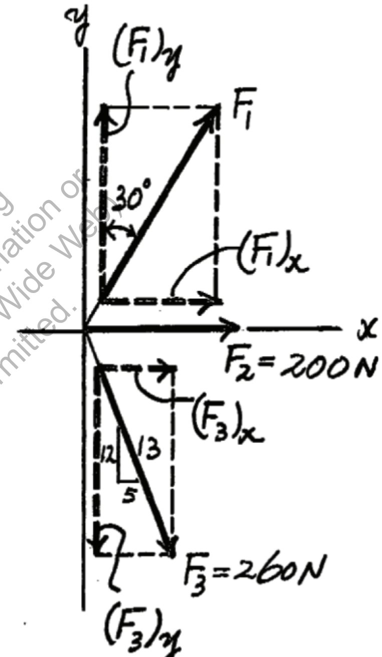
For $\mathbf{F}_R$ to be minimum, $\dfrac{dF_R}{dF_1} = 0$. Thus, from Eq. (3)

$$2F_R\frac{dF_R}{dF_1} = 2F_1 - 115.69 = 0$$

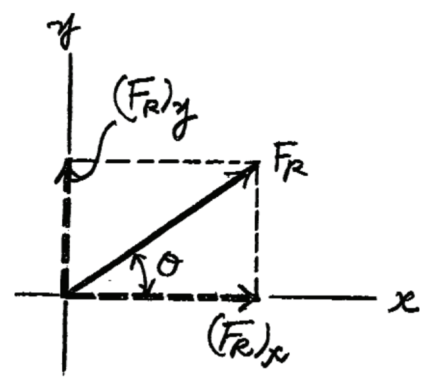
$$F_1 = 57.846\text{ N} = 57.8\text{ N} \qquad \textbf{Ans.}$$

from Eq. (1),

$$F_R = \sqrt{(57.846)^2 - 115.69(57.846) + 147\,600} = 380\text{ N} \qquad \textbf{Ans.}$$



(a)



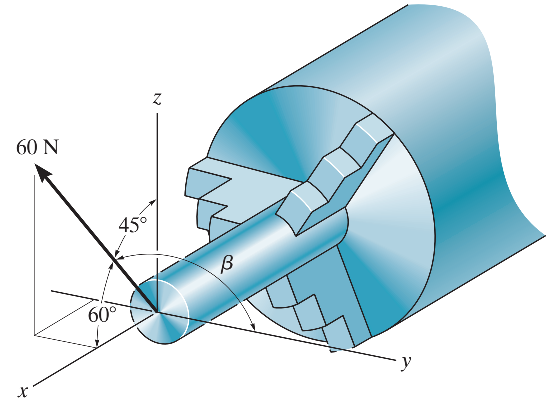
(b)

This work is protected by United States copyright laws and is provided solely for the use of instructors in teaching their courses and assessing student learning. Dissemination or sale of any part of this work (including on the World Wide Web) will destroy the integrity of the work and is not permitted.

© 2013 Pearson Education, Inc., Upper Saddle River, NJ. All rights reserved. This publication is protected by Copyright and written permission should be obtained from the publisher prior to any prohibited reproduction, storage in a retrieval system, or transmission in any form or by any means, electronic, mechanical, photocopying, recording, or likewise. For information regarding permission(s), write to: Rights and Permissions Department, Pearson Education, Inc., Upper Saddle River, NJ 07458.

***2–60.**

The stock mounted on the lathe is subjected to a force of 60 N. Determine the coordinate direction angle β and express the force as a Cartesian vector.



SOLUTION

$$1 = \sqrt{\cos^2\alpha + \cos^2\beta + \cos^2\gamma}$$

$$1 = \cos^2 60^\circ + \cos^2\beta + \cos^2 45^\circ$$

$$\cos\beta = \pm 0.5$$

$$\beta = 60^\circ, 120^\circ$$

Use

$$\beta = 120^\circ$$ **Ans.**

$$F = 60\text{ N}(\cos 60^\circ\mathbf{i} + \cos 120^\circ\mathbf{j} + \cos 45^\circ\mathbf{k})$$

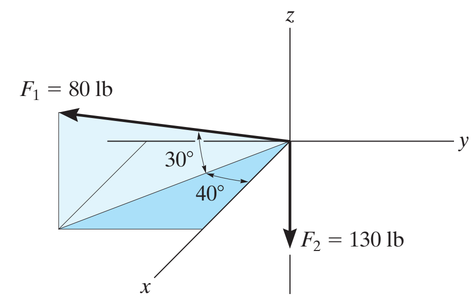
$$= \{30\mathbf{i} - 30\mathbf{j} + 42.4\mathbf{k}\}\text{ N}$$ **Ans.**

This work is protected by United States copyright laws and is provided solely for the use of instructors in teaching their courses and assessing student learning. Dissemination or sale of any part of this work (including on the World Wide Web) will destroy the integrity of the work and is not permitted.

© 2013 Pearson Education, Inc., Upper Saddle River, NJ. All rights reserved. This publication is protected by Copyright and written permission should be obtained from the publisher prior to any prohibited reproduction, storage in a retrieval system, or transmission in any form or by any means, electronic, mechanical, photocopying, recording, or likewise. For information regarding permission(s), write to: Rights and Permissions Department, Pearson Education, Inc., Upper Saddle River, NJ 07458.

2–61.

Determine the magnitude and coordinate direction angles of the resultant force and sketch this vector on the coordinate system.



SOLUTION

$$\mathbf{F}_1 = \{80 \cos 30° \cos 40° \mathbf{i} - 80 \cos 30° \sin 40° \mathbf{j} + 80 \sin 30° \mathbf{k}\} \text{ lb}$$

$$\mathbf{F}_1 = \{53.1\mathbf{i} - 44.5\mathbf{j} + 40\mathbf{k}\} \text{ lb}$$

$$\mathbf{F}_2 = \{-130\mathbf{k}\} \text{ lb}$$

$$\mathbf{F}_R = \mathbf{F}_1 + \mathbf{F}_2$$

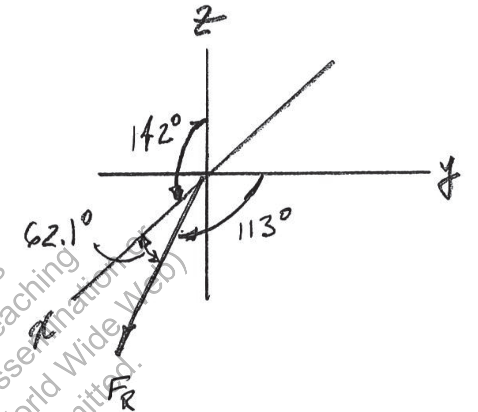
$$\mathbf{F}_R = \{53.1\mathbf{i} - 44.5\mathbf{j} - 90.0\mathbf{k}\} \text{ lb}$$

$$F_R = \sqrt{(53.1)^2 + (-44.5)^2 + (-90.0)^2} = 114 \text{ lb}$$ **Ans.**

$$\alpha = \cos^{-1}\left(\frac{53.1}{113.6}\right) = 62.1°$$ **Ans.**

$$\beta = \cos^{-1}\left(\frac{-44.5}{113.6}\right) = 113°$$ **Ans.**

$$\gamma = \cos^{-1}\left(\frac{-90.0}{113.6}\right) = 142°$$ **Ans.**

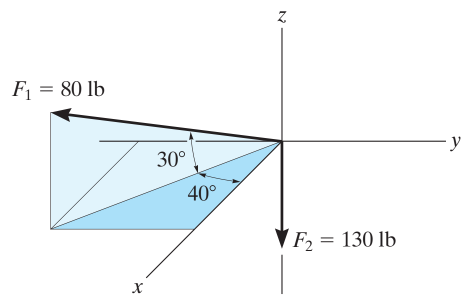


This work is protected by United States copyright laws and is provided solely for the use of instructors in teaching their courses and assessing student learning. Dissemination or sale of any part of this work (including on the World Wide Web) will destroy the integrity of the work and is not permitted.

© 2013 Pearson Education, Inc., Upper Saddle River, NJ. All rights reserved. This publication is protected by Copyright and written permission should be obtained from the publisher prior to any prohibited reproduction, storage in a retrieval system, or transmission in any form or by any means, electronic, mechanical, photocopying, recording, or likewise. For information regarding permission(s), write to: Rights and Permissions Department, Pearson Education, Inc., Upper Saddle River, NJ 07458.

2–62.

Specify the coordinate direction angles of $\mathbf{F}_1$ and $\mathbf{F}_2$ and express each force as a Cartesian vector.



SOLUTION

$\mathbf{F}_1 = \{80 \cos 30° \cos 40° \mathbf{i} - 80 \cos 30° \sin 40° \mathbf{j} + 80 \sin 30° \mathbf{k}\}$ lb

$\mathbf{F}_1 = \{53.1\mathbf{i} - 44.5\mathbf{j} + 40\mathbf{k}\}$ lb **Ans.**

$\alpha_1 = \cos^{-1}\left(\frac{53.1}{80}\right) = 48.4°$ **Ans.**

$\beta_1 = \cos^{-1}\left(\frac{-44.5}{80}\right) = 124°$ **Ans.**

$\gamma_1 = \cos^{-1}\left(\frac{40}{80}\right) = 60°$ **Ans.**

$\mathbf{F}_2 = \{-130\mathbf{k}\}$ lb **Ans.**

$\alpha_2 = \cos^{-1}\left(\frac{0}{130}\right) = 90°$ **Ans.**

$\beta_2 = \cos^{-1}\left(\frac{0}{130}\right) = 90°$ **Ans.**

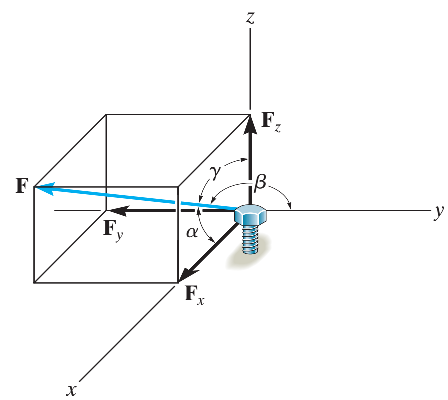
$\gamma_2 = \cos^{-1}\left(\frac{-130}{130}\right) = 180°$ **Ans.**

This work is protected by United States copyright laws and is provided solely for the use of instructors in teaching their courses and assessing student learning. Dissemination or sale of any part of this work (including on the World Wide Web) will destroy the integrity of the work and is not permitted.

© 2013 Pearson Education, Inc., Upper Saddle River, NJ. All rights reserved. This publication is protected by Copyright and written permission should be obtained from the publisher prior to any prohibited reproduction, storage in a retrieval system, or transmission in any form or by any means, electronic, mechanical, photocopying, recording, or likewise. For information regarding permission(s), write to: Rights and Permissions Department, Pearson Education, Inc., Upper Saddle River, NJ 07458.

2–63.

The bolt is subjected to the force **F**, which has components acting along the x, y, z axes as shown. If the magnitude of **F** is 80 N, and $\alpha = 60°$ and $\gamma = 45°$, determine the magnitudes of its components.



SOLUTION

$$\cos\beta = \sqrt{1 - \cos^2\alpha - \cos^2\gamma}$$

$$= \sqrt{1 - \cos^2 60° - \cos^2 45°}$$

$$\beta = 120°$$

$$F_x = |80 \cos 60°| = 40 \text{ N}$$ **Ans.**

$$F_y = |80 \cos 120°| = 40 \text{ N}$$ **Ans.**

$$F_z = |80 \cos 45°| = 56.6 \text{ N}$$ **Ans.**

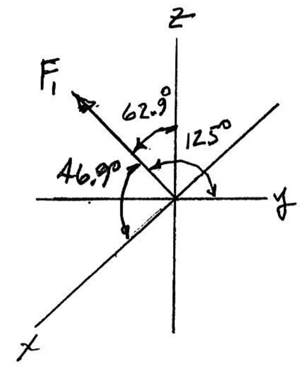
This work is protected by United States copyright laws and is provided solely for the use of instructors in teaching their courses and assessing student learning. Dissemination or sale of any part of this work (including on the World Wide Web) will destroy the integrity of the work and is not permitted.

© 2013 Pearson Education, Inc., Upper Saddle River, NJ. All rights reserved. This publication is protected by Copyright and written permission should be obtained from the publisher prior to any prohibited reproduction, storage in a retrieval system, or transmission in any form or by any means, electronic, mechanical, photocopying, recording, or likewise. For information regarding permission(s), write to: Rights and Permissions Department, Pearson Education, Inc., Upper Saddle River, NJ 07458.

***2–64.**

Determine the magnitude and coordinate direction angles of $\mathbf{F}_1 = \{60\mathbf{i} - 50\mathbf{j} + 40\mathbf{k}\}$ N and $\mathbf{F}_2 = \{-40\mathbf{i} - 85\mathbf{j} + 30\mathbf{k}\}$ N. Sketch each force on an x, y, z reference frame.

SOLUTION



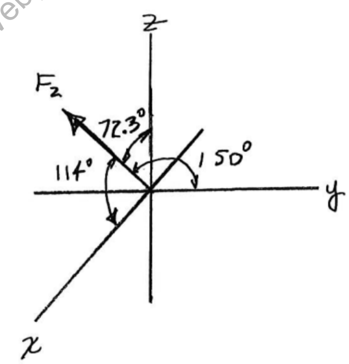
$\mathbf{F}_1 = 60\,\mathbf{i} - 50\,\mathbf{j} + 40\,\mathbf{k}$

$F_1 = \sqrt{(60)^2 + (-50)^2 + (40)^2} = 87.7496 = 87.7\text{ N}$ **Ans.**

$\alpha_1 = \cos^{-1}\left(\frac{60}{87.7496}\right) = 46.9°$ **Ans.**

$\beta_1 = \cos^{-1}\left(\frac{-50}{87.7496}\right) = 125°$ **Ans.**

$\gamma_1 = \cos^{-1}\left(\frac{40}{87.7496}\right) = 62.9°$ **Ans.**



$\mathbf{F}_2 = -40\,\mathbf{i} - 85\,\mathbf{j} + 30\,\mathbf{k}$

$F_2 = \sqrt{(-40)^2 + (-85)^2 + (30)^2} = 98.615 = 98.6\text{ N}$ **Ans.**

$\alpha_2 = \cos^{-1}\left(\frac{-40}{98.615}\right) = 114°$ **Ans.**

$\beta_2 = \cos^{-1}\left(\frac{-85}{98.615}\right) = 150°$ **Ans.**

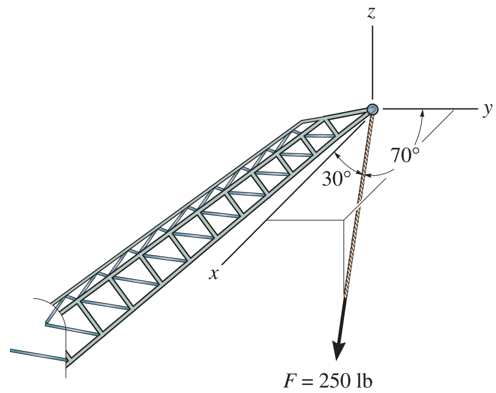
$\gamma_2 = \cos^{-1}\left(\frac{30}{98.615}\right) = 72.3°$ **Ans.**

This work is protected by United States copyright laws and is provided solely for the use of instructors in teaching their courses and assessing student learning. Dissemination or sale of any part of this work (including on the World Wide Web) will destroy the integrity of the work and is not permitted.

© 2013 Pearson Education, Inc., Upper Saddle River, NJ. All rights reserved. This publication is protected by Copyright and written permission should be obtained from the publisher prior to any prohibited reproduction, storage in a retrieval system, or transmission in any form or by any means, electronic, mechanical, photocopying, recording, or likewise. For information regarding permission(s), write to: Rights and Permissions Department, Pearson Education, Inc., Upper Saddle River, NJ 07458.

2–65.

The cable at the end of the crane boom exerts a force of 250 lb on the boom as shown. Express **F** as a Cartesian vector.



SOLUTION

Cartesian Vector Notation: With $\alpha = 30^\circ$ and $\beta = 70^\circ$, the third coordinate direction angle γ can be determined using Eq. 2–8.

$$\cos^2 \alpha + \cos^2 \beta + \cos^2 \gamma = 1$$

$$\cos^2 30^\circ + \cos^2 70^\circ + \cos^2 \gamma = 1$$

$$\cos \gamma = \pm 0.3647$$

$$\gamma = 68.61^\circ \text{ or } 111.39^\circ$$

By inspection, $\gamma = 111.39^\circ$ since the force **F** is directed in negative octant.

$$\mathbf{F} = 250\{\cos 30^\circ \mathbf{i} + \cos 70^\circ \mathbf{j} + \cos 111.39^\circ\} \text{ lb}$$

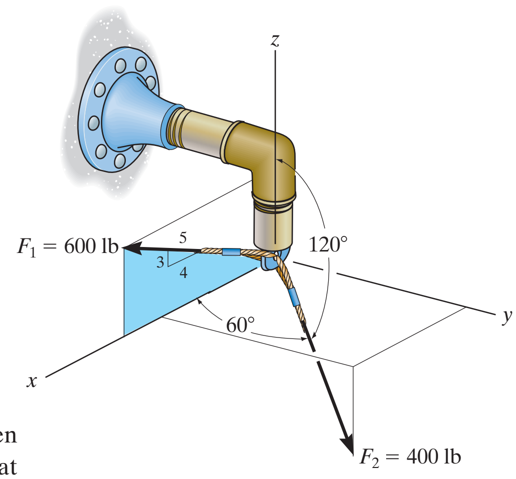
$$= \{217\mathbf{i} + 85.5\mathbf{j} - 91.2\mathbf{k}\} \text{ lb} \qquad \textbf{Ans.}$$

This work is protected by United States copyright laws and is provided solely for the use of instructors in teaching their courses and assessing student learning. Dissemination or sale of any part of this work (including on the World Wide Web) will destroy the integrity of the work and is not permitted.

© 2013 Pearson Education, Inc., Upper Saddle River, NJ. All rights reserved. This publication is protected by Copyright and written permission should be obtained from the publisher prior to any prohibited reproduction, storage in a retrieval system, or transmission in any form or by any means, electronic, mechanical, photocopying, recording, or likewise. For information regarding permission(s), write to: Rights and Permissions Department, Pearson Education, Inc., Upper Saddle River, NJ 07458.

2–66.

Express each force acting on the pipe assembly in Cartesian vector form.



SOLUTION

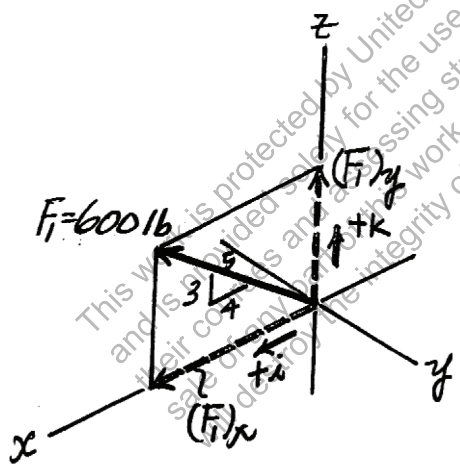
Rectangular Components: Since $\cos^2\alpha_2 + \cos^2\beta_2 + \cos^2\gamma_2 = 1$, then $\cos\beta_2 = \pm\sqrt{1 - \cos^2 60° - \cos^2 120°} = \pm 0.7071$. However, it is required that $\beta_2 < 90°$, thus, $\beta_2 = \cos^{-1}(0.7071) = 45°$. By resolving $\mathbf{F}_1$ and $\mathbf{F}_2$ into their x, y, and z components, as shown in Figs. a and b, respectively, $\mathbf{F}_1$ and $\mathbf{F}_2$ can be expressed in Cartesian vector form, as

$$\mathbf{F}_1 = 600\left(\frac{4}{5}\right)(+\mathbf{i}) + 0\mathbf{j} + 600\left(\frac{3}{5}\right)(+\mathbf{k})$$

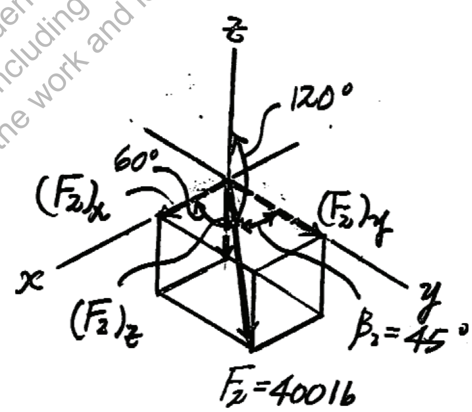
$$= [480\mathbf{i} + 360\mathbf{k}]\text{ lb}$$ **Ans.**

$$\mathbf{F}_2 = 400\cos 60°\mathbf{i} + 400\cos 45°\mathbf{j} + 400\cos 120°\mathbf{k}$$

$$= [200\mathbf{i} + 283\mathbf{j} - 200\mathbf{k}]\text{ lb}$$ **Ans.**



(a)



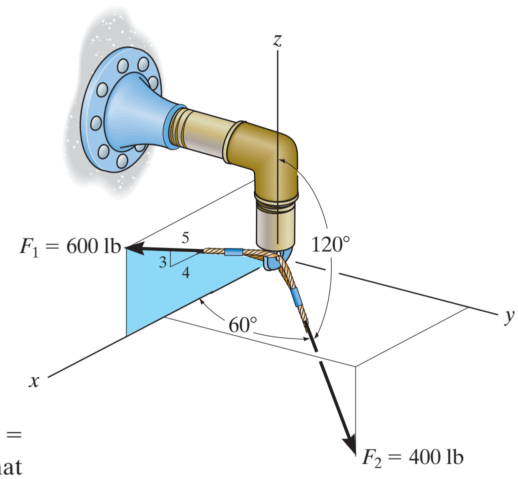
(b)

This work is protected by United States copyright laws and is provided solely for the use of instructors in teaching their courses and assessing student learning. Dissemination or sale of any part of this work (including on the World Wide Web) will destroy the integrity of the work and is not permitted.

© 2013 Pearson Education, Inc., Upper Saddle River, NJ. All rights reserved. This publication is protected by Copyright and written permission should be obtained from the publisher prior to any prohibited reproduction, storage in a retrieval system, or transmission in any form or by any means, electronic, mechanical, photocopying, recording, or likewise. For information regarding permission(s), write to: Rights and Permissions Department, Pearson Education, Inc., Upper Saddle River, NJ 07458.

2–67.

Determine the magnitude and direction of the resultant force acting on the pipe assembly.



SOLUTION

Force Vectors: Since $\cos^2\alpha_2 + \cos^2\beta_2 + \cos^2\gamma_2 = 1$, then $\cos\gamma_2 = \pm\sqrt{1 - \cos^2 60° - \cos^2 120°} = \pm\ 0.7071$. However, it is required that $\beta_2 < 90°$, thus, $\beta_2 = \cos^{-1}(0.7071) = 45°$. By resolving $\mathbf{F}_1$ and $\mathbf{F}_2$ into their x, y, and z components, as shown in Figs. a and b, respectively, $\mathbf{F}_1$ and $\mathbf{F}_2$ can be expressed in Cartesian vector form, as

$$\mathbf{F}_1 = 600\left(\frac{4}{5}\right)(+\mathbf{i}) + 0\mathbf{j} + 600\left(\frac{3}{5}\right)(+\mathbf{k})$$

$$= \{480\mathbf{i} + 360\mathbf{k}\}\ \text{lb}$$

$$\mathbf{F}_2 = 400\cos 60°\mathbf{i} + 400\cos 45°\mathbf{j} + 400\cos 120°\mathbf{k}$$

$$= \{200\mathbf{i} + 282.84\mathbf{j} - 200\mathbf{k}\}\ \text{lb}$$

Resultant Force: By adding $\mathbf{F}_1$ and $\mathbf{F}_2$ vectorally, we obtain $\mathbf{F}_R$.

$$\mathbf{F}_R = \mathbf{F}_1 + \mathbf{F}_2$$

$$= (480\mathbf{i} + 360\mathbf{k}) + (200\mathbf{i} + 282.84\mathbf{j} - 200\mathbf{k})$$

$$= \{680\mathbf{i} + 282.84\mathbf{j} + 160\mathbf{k}\}\ \text{lb}$$

The magnitude of $\mathbf{F}_R$ is

$$F_R = \sqrt{(F_R)_x^2 + (F_R)_y^2 + (F_R)_z^2}$$

$$= \sqrt{680^2 + 282.84^2 + 160^2} = 753.66\ \text{lb} = 754\ \text{lb} \qquad \textbf{Ans.}$$

The coordinate direction angles of $\mathbf{F}_R$ are

$$\alpha = \cos^{-1}\left[\frac{(F_R)_x}{F_R}\right] = \cos^{-1}\left(\frac{680}{753.66}\right) = 25.5° \qquad \textbf{Ans.}$$

$$\beta = \cos^{-1}\left[\frac{(F_R)_y}{F_R}\right] = \cos^{-1}\left(\frac{282.84}{753.66}\right) = 68.0° \qquad \textbf{Ans.}$$

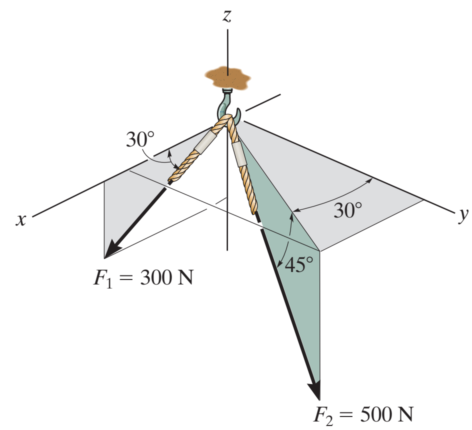
$$\gamma = \cos^{-1}\left[\frac{(F_R)_z}{F_R}\right] = \cos^{-1}\left(\frac{160}{753.66}\right) = 77.7° \qquad \textbf{Ans.}$$

This work is protected by United States copyright laws and is provided solely for the use of instructors in teaching their courses and assessing student learning. Dissemination or sale of any part of this work (including on the World Wide Web) will destroy the integrity of the work and is not permitted.

© 2013 Pearson Education, Inc., Upper Saddle River, NJ. All rights reserved. This publication is protected by Copyright and written permission should be obtained from the publisher prior to any prohibited reproduction, storage in a retrieval system, or transmission in any form or by any means, electronic, mechanical, photocopying, recording, or likewise. For information regarding permission(s), write to: Rights and Permissions Department, Pearson Education, Inc., Upper Saddle River, NJ 07458.

***2–68.**

Express each force as a Cartesian vector.



SOLUTION

Rectangular Components: By referring to Figs. *a* and *b*, the *x*, *y*, and *z* components of $\mathbf{F}_1$ and $\mathbf{F}_2$ can be written as

$$(F_1)_x = 300\cos 30^\circ = 259.8\text{ N} \qquad (F_2)_x = 500\cos 45^\circ \sin 30^\circ = 176.78\text{ N}$$

$$(F_1)_y = 0 \qquad (F_2)_y = 500\cos 45^\circ \cos 30^\circ = 306.19\text{ N}$$

$$(F_1)_t = 300\sin 30^\circ = 150\text{ N} \qquad (F_2)_z = 500\sin 45^\circ = 353.55\text{ N}$$

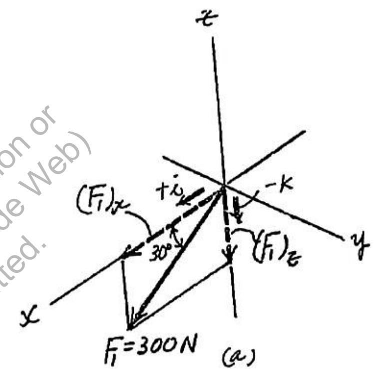
Thus, $\mathbf{F}_1$ and $\mathbf{F}_2$ can be written in Cartesian vector form as

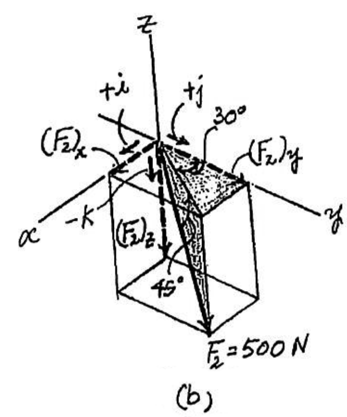
$$\mathbf{F}_1 = 259.81(+\mathbf{i}) + 0\mathbf{j} + 150(-\mathbf{k})$$

$$= \{260\mathbf{i} - 150\mathbf{k}\}\text{ N} \qquad \textbf{Ans.}$$

$$\mathbf{F}_2 = 176.78(+\mathbf{i}) + 306.19(+\mathbf{j}) + 353.55(-\mathbf{k})$$

$$= 2\{177\mathbf{i} + 306\mathbf{j} - 354\mathbf{k}\}\text{ N} \qquad \textbf{Ans.}$$



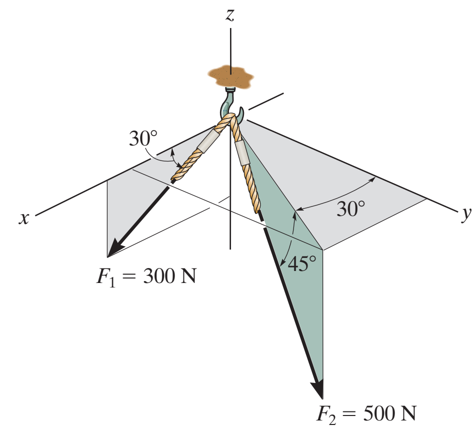


This work is protected by United States copyright laws and is provided solely for the use of instructors in teaching their courses and assessing student learning. Dissemination or sale of any part of this work (including on the World Wide Web) will destroy the integrity of the work and is not permitted.

© 2013 Pearson Education, Inc., Upper Saddle River, NJ. All rights reserved. This publication is protected by Copyright and written permission should be obtained from the publisher prior to any prohibited reproduction, storage in a retrieval system, or transmission in any form or by any means, electronic, mechanical, photocopying, recording, or likewise. For information regarding permission(s), write to: Rights and Permissions Department, Pearson Education, Inc., Upper Saddle River, NJ 07458.

2–69.

Determine the magnitude and coordinate direction angles of the resultant force acting on the hook.

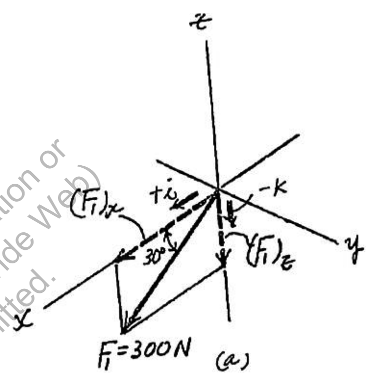


SOLUTION

Force Vectors: By resolving $\mathbf{F}_1$ and $\mathbf{F}_2$ into their x, y, and z components, as shown in Figs. a and b, respectively, $\mathbf{F}_1$ and $\mathbf{F}_2$ can be expessed in Cartesian vector form as

$$\begin{aligned}\mathbf{F}_1 &= 300\cos 30°(+\mathbf{i}) + 0\mathbf{j} + 300\sin 30°(-\mathbf{k})\\ &= \{259.81\mathbf{i} - 150\mathbf{k}\}\text{ N}\end{aligned}$$

$$\begin{aligned}\mathbf{F}_2 &= 500\cos 45°\sin 30°(+\mathbf{i}) + 500\cos 45°\cos 30°(+\mathbf{j}) + 500\sin 45°(-\mathbf{k})\\ &= \{176.78\mathbf{i} - 306.19\mathbf{j} - 353.55\mathbf{k}\}\text{ N}\end{aligned}$$



Resultant Force: The resultant force acting on the hook can be obtained by vectorally adding $\mathbf{F}_1$ and $\mathbf{F}_2$. Thus,

$$\begin{aligned}\mathbf{F}_R &= \mathbf{F}_1 + \mathbf{F}_2\\ &= (259.81\mathbf{i} - 150\mathbf{k}) + (176.78\mathbf{i} + 306.19\mathbf{j} - 353.55\mathbf{k})\\ &= \{436.58\mathbf{i}) + 306.19\mathbf{j} - 503.55\mathbf{k}\}\text{ N}\end{aligned}$$

The magnitude of $\mathbf{F}_R$ is

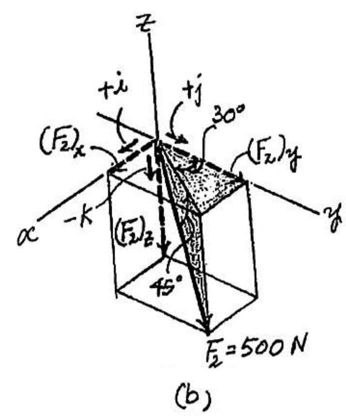
$$\begin{aligned}F_R &= \sqrt{(F_R)_x{}^2 + (F_R)_y{}^2(F_R)_z{}^2}\\ &= \sqrt{(436.58)^2 + (306.19)^2 + (-503.55)^2} = 733.43\text{ N} = 733\text{ N} \qquad \textbf{Ans.}\end{aligned}$$

The coordinate direction angles of $\mathbf{F}_R$ are

$$\theta_x = \cos^{-1}\left[\frac{(F_R)_x}{F_R}\right] = \cos^{-1}\left(\frac{436.58}{733.43}\right) = 53.5° \qquad \textbf{Ans.}$$

$$\theta_y = \cos^{-1}\left[\frac{(F_R)_y}{F_R}\right] = \cos^{-1}\left(\frac{306.19}{733.43}\right) = 65.3° \qquad \textbf{Ans.}$$

$$\theta_z = \cos^{-1}\left[\frac{(F_R)_z}{F_R}\right] = \cos^{-1}\left(\frac{-503.55}{733.43}\right) = 133° \qquad \textbf{Ans.}$$

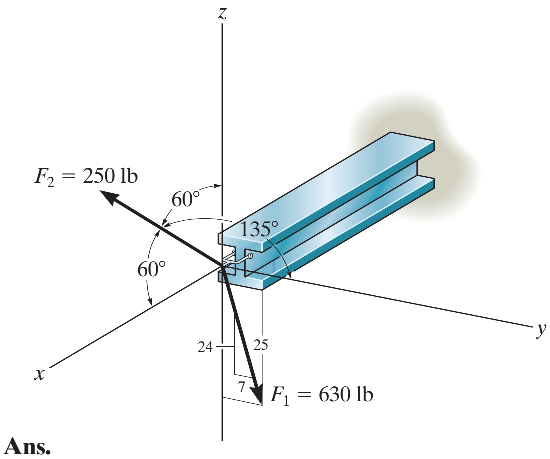


This work is protected by United States copyright laws and is provided solely for the use of instructors in teaching their courses and assessing student learning. Dissemination or sale of any part of this work (including on the World Wide Web) will destroy the integrity of the work and is not permitted.

© 2013 Pearson Education, Inc., Upper Saddle River, NJ. All rights reserved. This publication is protected by Copyright and written permission should be obtained from the publisher prior to any prohibited reproduction, storage in a retrieval system, or transmission in any form or by any means, electronic, mechanical, photocopying, recording, or likewise. For information regarding permission(s), write to: Rights and Permissions Department, Pearson Education, Inc., Upper Saddle River, NJ 07458.

2–70.

The beam is subjected to the two forces shown. Express each force in Cartesian vector form and determine the magnitude and coordinate direction angles of the resultant force.



SOLUTION

$$\mathbf{F}_1 = 630\left(\frac{7}{25}\right)\mathbf{j} - 630\left(\frac{24}{25}\right)\mathbf{k}$$

$$\mathbf{F}_1 = (176.4\,\mathbf{j} - 604.8\mathbf{k})$$

$$\mathbf{F}_1 = \{176\mathbf{j} - 605\mathbf{k}\}\text{ lb}$$ **Ans.**

$$\mathbf{F}_2 = 250\cos 60°\mathbf{i} + 250\cos 135°\mathbf{j} + 250\cos 60°\mathbf{k}$$

$$\mathbf{F}_2 = (125\mathbf{i} - 176.777\mathbf{j} + 125\mathbf{k})$$

$$\mathbf{F}_2 = \{125\mathbf{i} - 177\mathbf{j} + 125\mathbf{k}\}\text{ lb}$$ **Ans.**

$$\mathbf{F}_R = \mathbf{F}_1 + \mathbf{F}_2$$

$$\mathbf{F}_R = 125\mathbf{i} - 0.3767\mathbf{j} - 479.8\mathbf{k}$$

$$\mathbf{F}_R = \{125\mathbf{i} - 0.377\mathbf{j} - 480\mathbf{k}\}\text{ lb}$$

$$F_R = \sqrt{(125)^2 + (-0.3767)^2 + (-479.8)^2} = 495.82$$

$$= 496\text{ lb}$$ **Ans.**

$$\alpha = \cos^{-1}\left(\frac{125}{495.82}\right) = 75.4°$$ **Ans.**

$$\beta = \cos^{-1}\left(\frac{-0.3767}{495.82}\right) = 90.0°$$ **Ans.**

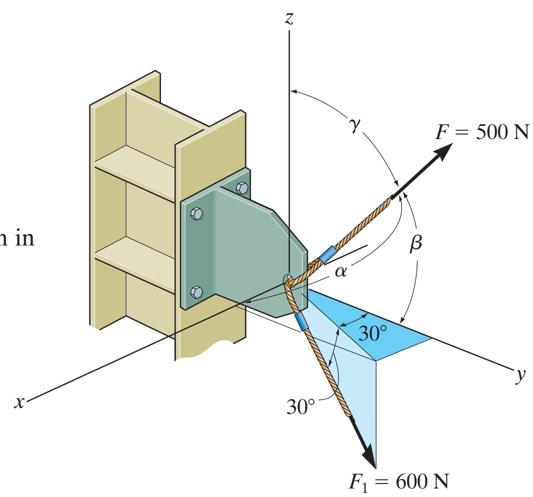
$$\gamma = \cos^{-1}\left(\frac{-479.8}{495.82}\right) = 165°$$ **Ans.**

This work is protected by United States copyright laws and is provided solely for the use of instructors in teaching their courses and assessing student learning. Dissemination or sale of any part of this work (including on the World Wide Web) will destroy the integrity of the work and is not permitted.

© 2013 Pearson Education, Inc., Upper Saddle River, NJ. All rights reserved. This publication is protected by Copyright and written permission should be obtained from the publisher prior to any prohibited reproduction, storage in a retrieval system, or transmission in any form or by any means, electronic, mechanical, photocopying, recording, or likewise. For information regarding permission(s), write to: Rights and Permissions Department, Pearson Education, Inc., Upper Saddle River, NJ 07458.

2–71.

If the resultant force acting on the bracket is directed along the positive y axis, determine the magnitude of the resultant force and the coordinate direction angles of $\mathbf{F}$ so that $\beta < 90°$.



SOLUTION

Force Vectors: By resolving $\mathbf{F}_1$ and $\mathbf{F}$ into their x, y, and z components, as shown in Figs. a and b, respectively, $\mathbf{F}_1$ and $\mathbf{F}$ can be expressed in Cartesian vector form as

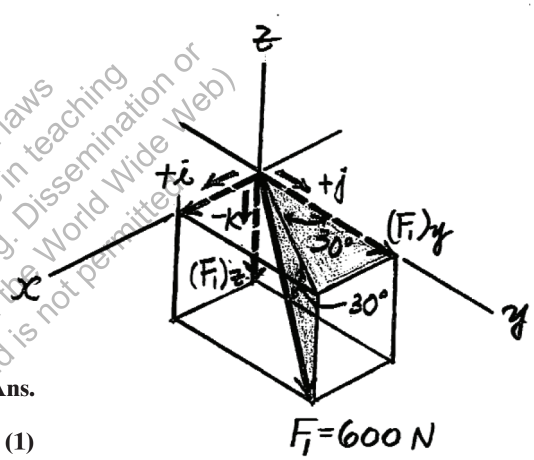
$$\mathbf{F}_1 = 600 \cos 30° \sin 30°(+\mathbf{i}) + 600 \cos 30° \cos 30°(+\mathbf{j}) + 600 \sin 30°(-\mathbf{k})$$

$$= \{259.81\mathbf{i} + 450\mathbf{j} - 300\mathbf{k}\} \text{ N}$$

$$\mathbf{F} = 500 \cos \alpha\mathbf{i} + 500 \cos \beta\mathbf{j} + 500 \cos \gamma\mathbf{k}$$

Since the resultant force $\mathbf{F}_R$ is directed towards the positive y axis, then

$$\mathbf{F}_R = F_R\,\mathbf{j}$$



(a)

Resultant Force:

$$\mathbf{F}_R = \mathbf{F}_1 + \mathbf{F}$$

$$F_R\,\mathbf{j} = (259.81\mathbf{i} + 450\mathbf{j} - 300\mathbf{k}) + (500 \cos \alpha\mathbf{i} + 500 \cos \beta\mathbf{j} + 500 \cos \gamma\mathbf{k})$$

$$F_R\,\mathbf{j} = (259.81 + 500 \cos \alpha)\mathbf{i} + (450 + 500 \cos \beta)\mathbf{j} + (500 \cos \gamma - 300)\mathbf{k}$$

Equating the **i**, **j**, and **k** components,

$$0 = 259.81 + 500 \cos \alpha$$

$$\alpha = 121.31° = 121° \qquad \textbf{Ans.}$$

$$F_R = 450 + 500 \cos \beta \qquad \textbf{(1)}$$

$$0 = 500 \cos \gamma - 300$$

$$\gamma = 53.13° = 53.1° \qquad \textbf{Ans.}$$

However, since $\cos^2 \alpha + \cos^2 \beta + \cos^2 \gamma = 1$, $\alpha = 121.31°$, and $\gamma = 53.13°$,

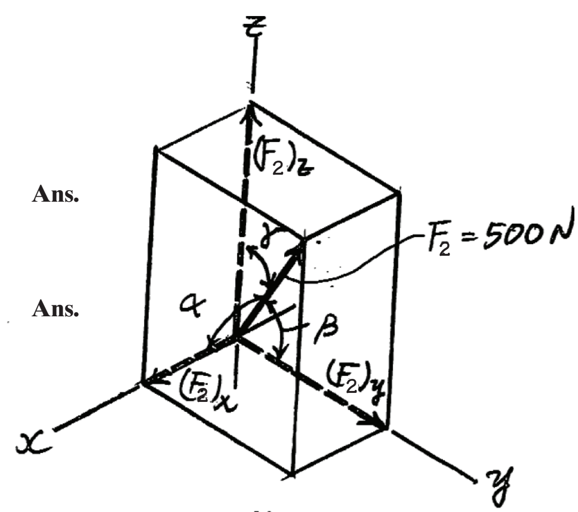
$$\cos \beta = \pm\sqrt{1 - \cos^2 121.31° - \cos^2 53.13°} = \pm 0.6083$$

If we substitute $\cos \beta = 0.6083$ into Eq. (1),

$$F_R = 450 + 500(0.6083) = 754 \text{ N} \qquad \textbf{Ans.}$$

and

$$\beta = \cos^{-1}(0.6083) = 52.5° \qquad \textbf{Ans.}$$



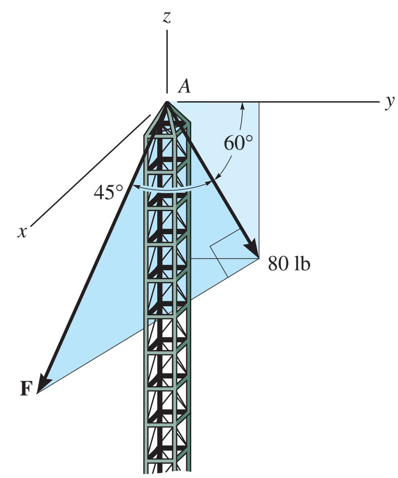
(b)

This work is protected by United States copyright laws and is provided solely for the use of instructors in teaching their courses and assessing student learning. Dissemination or sale of any part of this work (including on the World Wide Web) will destroy the integrity of the work and is not permitted.

© 2013 Pearson Education, Inc., Upper Saddle River, NJ. All rights reserved. This publication is protected by Copyright and written permission should be obtained from the publisher prior to any prohibited reproduction, storage in a retrieval system, or transmission in any form or by any means, electronic, mechanical, photocopying, recording, or likewise. For information regarding permission(s), write to: Rights and Permissions Department, Pearson Education, Inc., Upper Saddle River, NJ 07458.

***2–72.**

A force **F** is applied at the top of the tower at A. If it acts in the direction shown such that one of its components lying in the shaded y-z plane has a magnitude of 80 lb, determine its magnitude F and coordinate direction angles α, β, γ.



SOLUTION

Cartesian Vector Notation: The magnitude of force **F** is

$$F\cos 45^\circ = 80 \qquad F = 113.14\text{ lb} = 113\text{ lb}$$ **Ans.**

Thus,

$$\mathbf{F} = \{113.14\sin 45^\circ\mathbf{i} + 80\cos 60^\circ\mathbf{j} - 80\sin 60^\circ\mathbf{k}\}\text{ lb}$$

$$= \{80.0\mathbf{i} + 40.0\mathbf{j} - 69.28\mathbf{k}\}\text{ lb}$$

The coordinate direction angles are

$$\cos\alpha = \frac{F_x}{F} = \frac{80.0}{113.14} \qquad \alpha = 45.0^\circ$$ **Ans.**

$$\cos\beta = \frac{F_y}{F} = \frac{40.0}{113.14} \qquad \beta = 69.3^\circ$$ **Ans.**

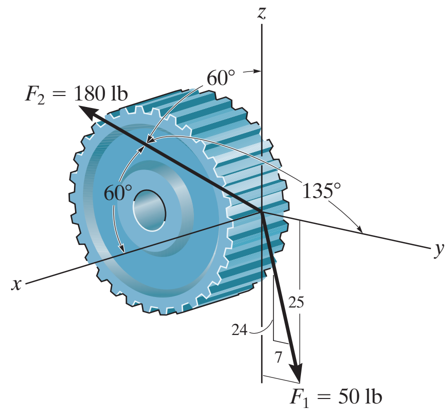
$$\cos\gamma = \frac{F_z}{F} = \frac{-69.28}{113.14} \qquad \gamma = 128^\circ$$ **Ans.**

This work is protected by United States copyright laws and is provided solely for the use of instructors in teaching their courses and assessing student learning. Dissemination or sale of any part of this work (including on the World Wide Web) will destroy the integrity of the work and is not permitted.

© 2013 Pearson Education, Inc., Upper Saddle River, NJ. All rights reserved. This publication is protected by Copyright and written permission should be obtained from the publisher prior to any prohibited reproduction, storage in a retrieval system, or transmission in any form or by any means, electronic, mechanical, photocopying, recording, or likewise. For information regarding permission(s), write to: Rights and Permissions Department, Pearson Education, Inc., Upper Saddle River, NJ 07458.

2–73.

The spur gear is subjected to the two forces caused by contact with other gears. Express each force as a Cartesian vector.



SOLUTION

$$\mathbf{F}_1 = \frac{7}{25}(50)\mathbf{j} - \frac{24}{25}(50)\mathbf{k} = \{14.0\mathbf{j} - 48.0\mathbf{k}\}\text{ lb} \qquad \textbf{Ans.}$$

$$\mathbf{F}_2 = 180\cos 60°\mathbf{i} + 180\cos 135°\mathbf{j} + 180\cos 60°\mathbf{k}$$

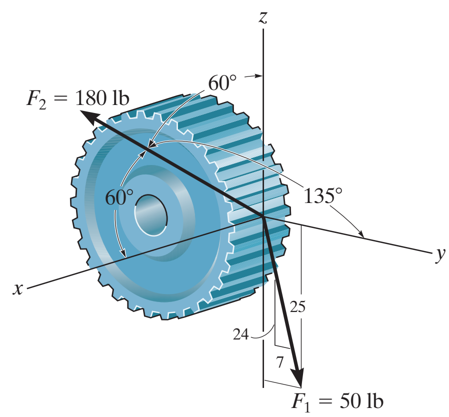
$$= \{90\mathbf{i} - 127\mathbf{j} + 90\mathbf{k}\}\text{ lb} \qquad \textbf{Ans.}$$

This work is protected by United States copyright laws and is provided solely for the use of instructors in teaching their courses and assessing student learning. Dissemination or sale of any part of this work (including on the World Wide Web) will destroy the integrity of the work and is not permitted.

© 2013 Pearson Education, Inc., Upper Saddle River, NJ. All rights reserved. This publication is protected by Copyright and written permission should be obtained from the publisher prior to any prohibited reproduction, storage in a retrieval system, or transmission in any form or by any means, electronic, mechanical, photocopying, recording, or likewise. For information regarding permission(s), write to: Rights and Permissions Department, Pearson Education, Inc., Upper Saddle River, NJ 07458.

2–74.

The spur gear is subjected to the two forces caused by contact with other gears. Determine the resultant of the two forces and express the result as a Cartesian vector.



SOLUTION

$$F_{Rx} = 180 \cos 60° = 90$$

$$F_{Ry} = \frac{7}{25}(50) + 180 \cos 135° = -113$$

$$F_{Rz} = -\frac{24}{25}(50) + 180 \cos 60° = 42$$

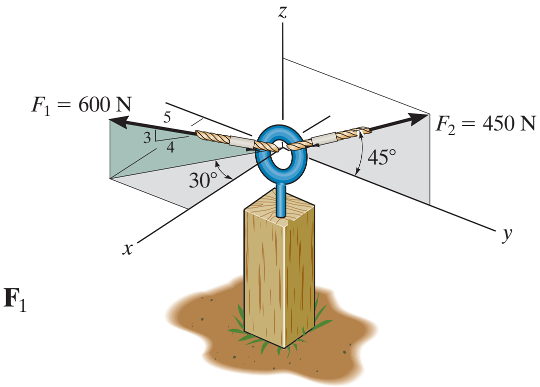
$$\mathbf{F}_R = \{90\mathbf{i} - 113\mathbf{j} + 42\mathbf{k}\} \text{ lb}$$ **Ans.**

This work is protected by United States copyright laws and is provided solely for the use of instructors in teaching their courses and assessing student learning. Dissemination or sale of any part of this work (including on the World Wide Web) will destroy the integrity of the work and is not permitted.

© 2013 Pearson Education, Inc., Upper Saddle River, NJ. All rights reserved. This publication is protected by Copyright and written permission should be obtained from the publisher prior to any prohibited reproduction, storage in a retrieval system, or transmission in any form or by any means, electronic, mechanical, photocopying, recording, or likewise. For information regarding permission(s), write to: Rights and Permissions Department, Pearson Education, Inc., Upper Saddle River, NJ 07458.

2–75.

Determine the coordinate direction angles of force $\mathbf{F}_1$.



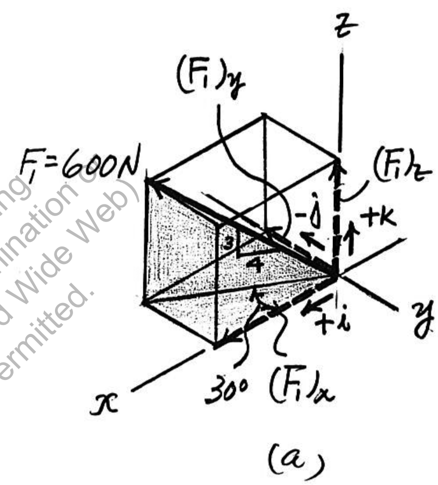
SOLUTION

Rectangular Components: By referring to Figs. *a*, the *x*, *y*, and *z* components of $\mathbf{F}_1$ can be written as

$$(F_1)_x = 600\left(\frac{4}{5}\right)\cos 30°\text{ N} \qquad (F_1)_y = 600\left(\frac{4}{5}\right)\sin 30°\text{ N} \qquad (F_1)_z = 600\left(\frac{3}{5}\right)\text{N}$$

Thus, $\mathbf{F}_1$ expressed in Cartesian vector form can be written as

$$\mathbf{F}_1 = 600\left\{\frac{4}{5}\cos 30°(+\mathbf{i}) + \frac{4}{5}\sin 30°(-\mathbf{j}) + \frac{3}{5}(+\mathbf{k})\right\}\text{N}$$
$$= 600[0.6928\mathbf{i} - 0.4\mathbf{j} + 0.6\mathbf{k}]\text{ N}$$



Therefore, the unit vector for $\mathbf{F}_1$ is given by

$$\mathbf{u}_{F_1} = \frac{\mathbf{F}_1}{F_1} = \frac{600(0.6928\mathbf{i} - 0.4\mathbf{j} + 0.6\mathbf{k})}{600} = 0.6928\mathbf{i} - 0.4\mathbf{j} + 0.6\mathbf{k}$$

The coordinate direction angles of $\mathbf{F}_1$ are

$$\alpha = \cos^{-1}(u_{F_1})_x = \cos^{-1}(0.6928) = 46.1° \qquad \textbf{Ans.}$$

$$\beta = \cos^{-1}(u_{F_1})_y = \cos^{-1}(-0.4) = 114° \qquad \textbf{Ans.}$$

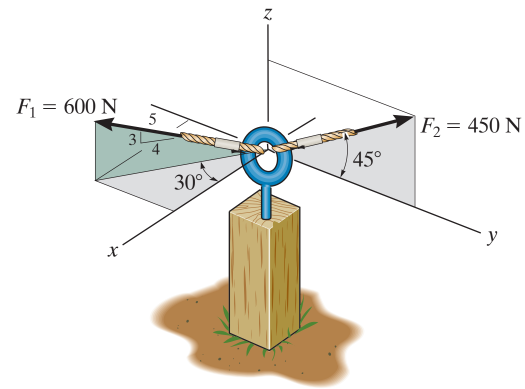
$$\gamma = \cos^{-1}(u_{F_1})_z = \cos^{-1}(0.6) = 53.1° \qquad \textbf{Ans.}$$

This work is protected by United States copyright laws and is provided solely for the use of instructors in teaching their courses and assessing student learning. Dissemination or sale of any part of this work (including on the World Wide Web) will destroy the integrity of the work and is not permitted.

© 2013 Pearson Education, Inc., Upper Saddle River, NJ. All rights reserved. This publication is protected by Copyright and written permission should be obtained from the publisher prior to any prohibited reproduction, storage in a retrieval system, or transmission in any form or by any means, electronic, mechanical, photocopying, recording, or likewise. For information regarding permission(s), write to: Rights and Permissions Department, Pearson Education, Inc., Upper Saddle River, NJ 07458.

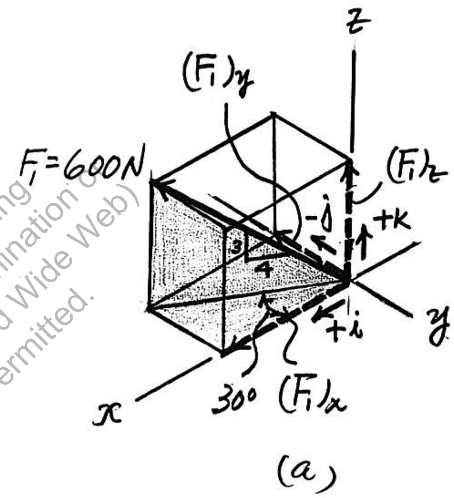
***2–76.**

Determine the magnitude and coordinate direction angles of the resultant force acting on the eyebolt.



SOLUTION

Force Vectors: By resolving $\mathbf{F}_1$ and $\mathbf{F}_2$ into their x, y, and z components, as shown in Figs. *a* and *b*, respectively, they are expressed in Cartesian vector form as



$$\mathbf{F}_1 = 600\left(\frac{4}{5}\right)\cos 30°(+\mathbf{i}) + 600\left(\frac{4}{5}\right)\sin 30°(-\mathbf{j}) + 600\left(\frac{3}{5}\right)(+\mathbf{k})$$

$$= \{415.69\mathbf{i} - 240\mathbf{j} + 360\mathbf{k}\} \text{ N}$$

$$\mathbf{F}_2 = 0\mathbf{i} + 450\cos 45°(+\mathbf{j}) + 450\sin 45°(+\mathbf{k})$$

$$= \{318.20\mathbf{j} + 318.20\mathbf{k}\} \text{ N}$$

Resultant Force: The resultant force acting on the eyebolt can be obtained by vectorally adding $\mathbf{F}_1$ and $\mathbf{F}_2$. Thus,

$$\mathbf{F}_R = \mathbf{F}_1 + \mathbf{F}_2$$

$$= (415.69\mathbf{i} - 240\mathbf{j} + 360\mathbf{k}) + (318.20\mathbf{j} + 318.20\mathbf{k})$$

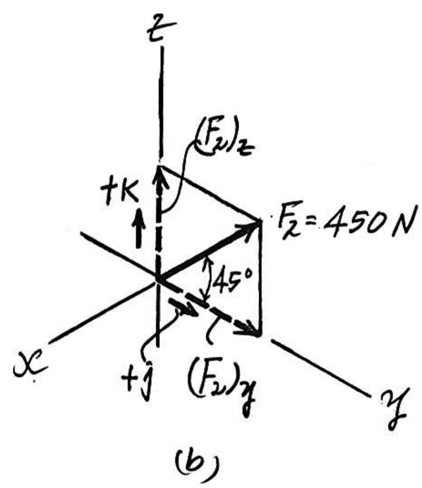
$$= \{415.69\mathbf{i} + 78.20\mathbf{j} + 678.20\mathbf{k}\} \text{ N}$$

The magnitude of $\mathbf{F}_R$ is given by

$$F_R = \sqrt{(F_R)_x{}^2 + (F_R)_y{}^2 + (F_R)_z{}^2}$$

$$= \sqrt{(415.69)^2 + (78.20)^2 + (678.20)^2} = 799.29 \text{ N} = 799 \text{ N} \qquad \textbf{Ans.}$$

The coordinate direction angles of $\mathbf{F}_R$ are



$$\alpha = \cos^{-1}\left[\frac{(F_R)_x}{F_R}\right] = \cos^{-1}\left(\frac{415.69}{799.29}\right) = 58.7° \qquad \textbf{Ans.}$$

$$\beta = \cos^{-1}\left[\frac{(F_R)_y}{F_R}\right] = \cos^{-1}\left(\frac{78.20}{799.29}\right) = 84.4° \qquad \textbf{Ans.}$$

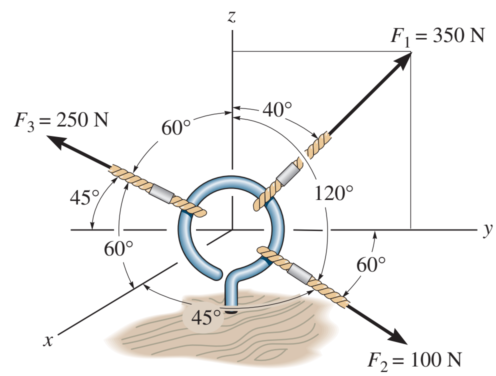
$$\gamma = \cos^{-1}\left[\frac{(F_R)_z}{F_R}\right] = \cos^{-1}\left(\frac{678.20}{799.29}\right) = 32.0° \qquad \textbf{Ans.}$$

This work is protected by United States copyright laws and is provided solely for the use of instructors in teaching their courses and assessing student learning. Dissemination or sale of any part of this work (including on the World Wide Web) will destroy the integrity of the work and is not permitted.

© 2013 Pearson Education, Inc., Upper Saddle River, NJ. All rights reserved. This publication is protected by Copyright and written permission should be obtained from the publisher prior to any prohibited reproduction, storage in a retrieval system, or transmission in any form or by any means, electronic, mechanical, photocopying, recording, or likewise. For information regarding permission(s), write to: Rights and Permissions Department, Pearson Education, Inc., Upper Saddle River, NJ 07458.

2–77.

The cables attached to the screw eye are subjected to the three forces shown. Express each force in Cartesian vector form and determine the magnitude and coordinate direction angles of the resultant force.



SOLUTION

Cartesian Vector Notation:

$$\mathbf{F}_1 = 350\{\sin 40°\mathbf{j} + \cos 40°\mathbf{k}\}\text{ N}$$

$$= \{224.98\mathbf{j} + 268.12\mathbf{k}\}\text{ N}$$

$$= \{225\mathbf{j} + 268\mathbf{k}\}\text{ N}$$ **Ans.**

$$\mathbf{F}_2 = 100\{\cos 45°\mathbf{i} + \cos 60°\mathbf{j} + \cos 120°\mathbf{k}\}\text{ N}$$

$$= \{70.71\mathbf{i} + 50.0\mathbf{j} - 50.0\mathbf{k}\}\text{ N}$$

$$= \{70.7\mathbf{i} + 50.0\mathbf{j} - 50.0\mathbf{k}\}\text{ N}$$ **Ans.**

$$\mathbf{F}_3 = 250\{\cos 60°\mathbf{i} + \cos 135°\mathbf{j} + \cos 60°\mathbf{k}\}\text{ N}$$

$$= \{125.0\mathbf{i} - 176.78\mathbf{j} + 125.0\mathbf{k}\}\text{ N}$$

$$= \{125\mathbf{i} - 177\mathbf{j} + 125\mathbf{k}\}\text{ N}$$ **Ans.**

Resultant Force:

$$\mathbf{F}_R = \mathbf{F}_1 + \mathbf{F}_2 + \mathbf{F}_3$$

$$= \{(70.71 + 125.0)\mathbf{i} + (224.98 + 50.0 - 176.78)\mathbf{j} + (268.12 - 50.0 + 125.0)\mathbf{k}\}\text{ N}$$

$$= \{195.71\mathbf{i} + 98.20\mathbf{j} + 343.12\mathbf{k}\}\text{ N}$$

The magnitude of the resultant force is

$$F_R = \sqrt{F_{R_x}^2 + F_{R_y}^2 + F_{R_z}^2}$$

$$= \sqrt{195.71^2 + 98.20^2 + 343.12^2}$$

$$= 407.03\text{ N} = 407\text{ N}$$ **Ans.**

The coordinate direction angles are

$$\cos\alpha = \frac{F_{R_x}}{F_R} = \frac{195.71}{407.03} \qquad \alpha = 61.3°$$ **Ans.**

$$\cos\beta = \frac{F_{R_y}}{F_R} = \frac{98.20}{407.03} \qquad \beta = 76.0°$$ **Ans.**

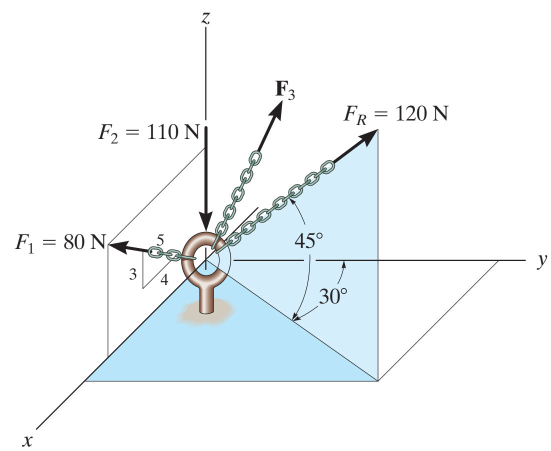
$$\cos\gamma = \frac{F_{R_z}}{F_R} = \frac{343.12}{407.03} \qquad \gamma = 32.5°$$ **Ans.**

This work is protected by United States copyright laws and is provided solely for the use of instructors in teaching their courses and assessing student learning. Dissemination or sale of any part of this work (including on the World Wide Web) will destroy the integrity of the work and is not permitted.

© 2013 Pearson Education, Inc., Upper Saddle River, NJ. All rights reserved. This publication is protected by Copyright and written permission should be obtained from the publisher prior to any prohibited reproduction, storage in a retrieval system, or transmission in any form or by any means, electronic, mechanical, photocopying, recording, or likewise. For information regarding permission(s), write to: Rights and Permissions Department, Pearson Education, Inc., Upper Saddle River, NJ 07458.

2–78.

Three forces act on the ring. If the resultant force $\mathbf{F}_R$ has a magnitude and direction as shown, determine the magnitude and the coordinate direction angles of force $\mathbf{F}_3$.



SOLUTION

Cartesian Vector Notation:

$$\mathbf{F}_R = 120\{\cos 45°\sin 30°\mathbf{i} + \cos 45°\cos 30°\mathbf{j} + \sin 45°\mathbf{k}\}\text{ N}$$

$$= \{42.43\mathbf{i} + 73.48\mathbf{j} + 84.85\mathbf{k}\}\text{ N}$$

$$\mathbf{F}_1 = 80\left\{\frac{4}{5}\mathbf{i} + \frac{3}{5}\mathbf{k}\right\}\text{ N} = \{64.0\mathbf{i} + 48.0\mathbf{k}\}\text{ N}$$

$$\mathbf{F}_2 = \{-110\mathbf{k}\}\text{ N}$$

$$\mathbf{F}_3 = \{F_{3_x}\mathbf{i} + F_{3_y}\mathbf{j} + F_{3_z}\mathbf{k}\}\text{ N}$$

Resultant Force:

$$\mathbf{F}_R = \mathbf{F}_1 + \mathbf{F}_2 + \mathbf{F}_3$$

$$\{42.43\mathbf{i} + 73.48\mathbf{j} + 84.85\mathbf{k}\} = \left\{\left(64.0 + F_{3_x}\right)\mathbf{i} + F_{3_y}\mathbf{j} + \left(48.0 - 110 + F_{3_z}\right)\mathbf{k}\right\}$$

Equating **i**, **j** and **k** components, we have

$$64.0 + F_{3_x} = 42.43 \qquad F_{3_x} = -21.57\text{ N}$$

$$F_{3_y} = 73.48\text{ N}$$

$$48.0 - 110 + F_{3_z} = 84.85 \qquad F_{3_z} = 146.85\text{ N}$$

The magnitude of force $\mathbf{F}_3$ is

$$F_3 = \sqrt{F_{3_x}^2 + F_{3_y}^2 + F_{3_z}^2}$$

$$= \sqrt{(-21.57)^2 + 73.48^2 + 146.85^2}$$

$$= 165.62\text{ N} = 166\text{ N} \qquad \textbf{Ans.}$$

The coordinate direction angles for $\mathbf{F}_3$ are

$$\cos\alpha = \frac{F_{3_x}}{F_3} = \frac{-21.57}{165.62} \qquad \alpha = 97.5° \qquad \textbf{Ans.}$$

$$\cos\beta = \frac{F_{3_y}}{F_3} = \frac{73.48}{165.62} \qquad \beta = 63.7° \qquad \textbf{Ans.}$$

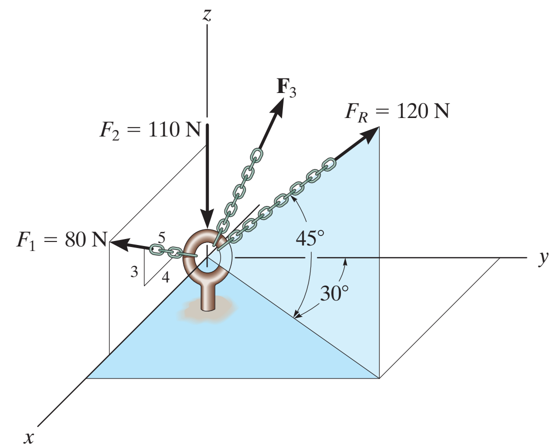
$$\cos\gamma = = \frac{F_{3_z}}{F_3} = \frac{146.85}{165.62} \qquad \gamma = 27.5° \qquad \textbf{Ans.}$$

This work is protected by United States copyright laws and is provided solely for the use of instructors in teaching their courses and assessing student learning. Dissemination or sale of any part of this work (including on the World Wide Web) will destroy the integrity of the work and is not permitted.

© 2013 Pearson Education, Inc., Upper Saddle River, NJ. All rights reserved. This publication is protected by Copyright and written permission should be obtained from the publisher prior to any prohibited reproduction, storage in a retrieval system, or transmission in any form or by any means, electronic, mechanical, photocopying, recording, or likewise. For information regarding permission(s), write to: Rights and Permissions Department, Pearson Education, Inc., Upper Saddle River, NJ 07458.

2–79.

Determine the coordinate direction angles of $\mathbf{F}_1$ and $\mathbf{F}_R$.



SOLUTION

***Unit Vector of* $\mathbf{F}_1$ *and* $\mathbf{F}_R$:**

$$\mathbf{u}_{F_1} = \frac{4}{5}\mathbf{i} + \frac{3}{5}\mathbf{k} = 0.8\mathbf{i} + 0.6\mathbf{k}$$

$$\mathbf{u}_R = \cos 45^\circ \sin 30^\circ \mathbf{i} + \cos 45^\circ \cos 30^\circ \mathbf{j} + \sin 45^\circ \mathbf{k}$$

$$= 0.3536\mathbf{i} + 0.6124\mathbf{j} + 0.7071\mathbf{k}$$

Thus, the coordinate direction angles $\mathbf{F}_1$ and $\mathbf{F}_R$ are

$\cos \alpha_{F_1} = 0.8 \qquad \alpha_{F_1} = 36.9^\circ$ **Ans.**

$\cos \beta_{F_1} = 0 \qquad \beta_{F_1} = 90.0^\circ$ **Ans.**

$\cos \gamma_{F_1} = 0.6 \qquad \gamma_{F_1} = 53.1^\circ$ **Ans.**

$\cos \alpha_R = 0.3536 \qquad \alpha_R = 69.3^\circ$ **Ans.**

$\cos \beta_R = 0.6124 \qquad \beta_R = 52.2^\circ$ **Ans.**

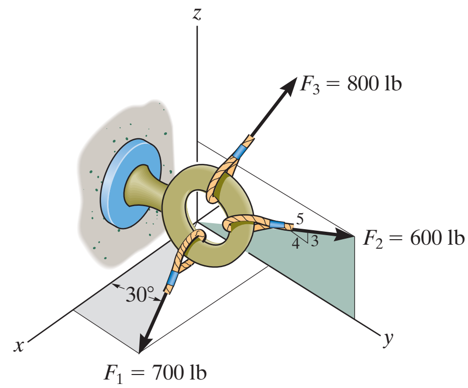
$\cos \gamma_R = 0.7071 \qquad \gamma_R = 45.0^\circ$ **Ans.**

This work is protected by United States copyright laws and is provided solely for the use of instructors in teaching their courses and assessing student learning. Dissemination or sale of any part of this work (including on the World Wide Web) will destroy the integrity of the work and is not permitted.

© 2013 Pearson Education, Inc., Upper Saddle River, NJ. All rights reserved. This publication is protected by Copyright and written permission should be obtained from the publisher prior to any prohibited reproduction, storage in a retrieval system, or transmission in any form or by any means, electronic, mechanical, photocopying, recording, or likewise. For information regarding permission(s), write to: Rights and Permissions Department, Pearson Education, Inc., Upper Saddle River, NJ 07458.

***2–80.**

If the coordinate direction angles for $\mathbf{F}_3$ are $\alpha_3 = 120°$, $\beta_3 = 45°$ and $\gamma_3 = 60°$, determine the magnitude and coordinate direction angles of the resultant force acting on the eyebolt.



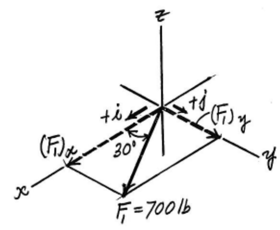
SOLUTION

Force Vectors: By resolving $\mathbf{F}_1$, $\mathbf{F}_2$ and $\mathbf{F}_3$ into their x, y, and z components, as shown in Figs. a, b, and c, respectively, $\mathbf{F}_1$, $\mathbf{F}_2$ and $\mathbf{F}_3$ can be expressed in Cartesian vector form as

$$\mathbf{F}_1 = 700\cos 30°(+\mathbf{i}) + 700\sin 30°(+\mathbf{j}) = \{606.22\mathbf{i} + 350\mathbf{j}\}\text{ lb}$$

$$\mathbf{F}_2 = 0\mathbf{i} + 600\left(\frac{4}{5}\right)(+\mathbf{j}) + 600\left(\frac{3}{5}\right)(+\mathbf{k}) = \{480\mathbf{j} + 360\mathbf{k}\}\text{ lb}$$

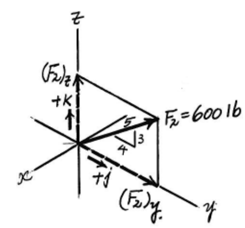
$$\mathbf{F}_3 = 800\cos 120°\mathbf{i} + 800\cos 45°\mathbf{j} + 800\cos 60°\mathbf{k} = [-400\mathbf{i} + 565.69\mathbf{j} + 400\mathbf{k}]\text{ lb}$$



(a)

Resultant Force: By adding $\mathbf{F}_1$, $\mathbf{F}_2$ and $\mathbf{F}_3$ vectorally, we obtain $\mathbf{F}_R$. Thus,

$$\begin{aligned}\mathbf{F}_R &= \mathbf{F}_1 + \mathbf{F}_2 + \mathbf{F}_3\\ &= (606.22\mathbf{i} + 350\mathbf{j}) + (480\mathbf{j} + 360\mathbf{k}) + (-400\mathbf{i} + 565.69\mathbf{j} + 400\mathbf{k})\\ &= [206.22\mathbf{i} + 1395.69\mathbf{j} + 760\mathbf{k}]\text{ lb}\end{aligned}$$



(b)

The magnitude of $\mathbf{F}_R$ is

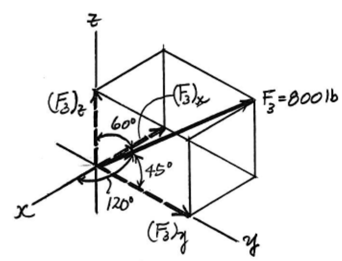
$$\begin{aligned}F_R &= \sqrt{(F_R)_x{}^2 + (F_R)_y{}^2 + (F_R)_z{}^2}\\ &= \sqrt{(206.22)^2 + (1395.69)^2 + (760)^2} = 1602.52\text{ lb} = 1.60\text{ kip}\end{aligned} \qquad \textbf{Ans.}$$

The coordinate direction angles of $\mathbf{F}_R$ are

$$\alpha = \cos^{-1}\left[\frac{(F_R)_x}{F_R}\right] = \cos^{-1}\left(\frac{206.22}{1602.52}\right) = 82.6° \qquad \textbf{Ans.}$$

$$\beta = \cos^{-1}\left[\frac{(F_R)_y}{F_R}\right] = \cos^{-1}\left(\frac{1395.69}{1602.52}\right) = 29.4° \qquad \textbf{Ans.}$$

$$\gamma = \cos^{-1}\left[\frac{(F_R)_z}{F_R}\right] = \cos^{-1}\left(\frac{760}{1602.52}\right) = 61.7° \qquad \textbf{Ans.}$$



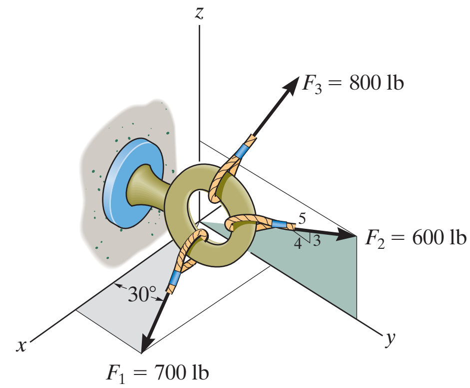
(c)

This work is protected by United States copyright laws and is provided solely for the use of instructors in teaching their courses and assessing student learning. Dissemination or sale of any part of this work (including on the World Wide Web) will destroy the integrity of the work and is not permitted.

© 2013 Pearson Education, Inc., Upper Saddle River, NJ. All rights reserved. This publication is protected by Copyright and written permission should be obtained from the publisher prior to any prohibited reproduction, storage in a retrieval system, or transmission in any form or by any means, electronic, mechanical, photocopying, recording, or likewise. For information regarding permission(s), write to: Rights and Permissions Department, Pearson Education, Inc., Upper Saddle River, NJ 07458.

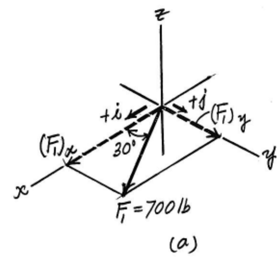
2–81.

If the coordinate direction angles for $\mathbf{F}_3$ are $\alpha_3 = 120^\circ$, $\beta_3 = 45^\circ$ and $\gamma_3 = 60^\circ$, determine the magnitude and coordinate direction angles of the resultant force acting on the eyebolt.



SOLUTION

Force Vectors: By resolving $\mathbf{F}_1$, $\mathbf{F}_2$ and $\mathbf{F}_3$ into their x, y, and z components, as shown in Figs. a, b, and c, respectively, $\mathbf{F}_1$, $\mathbf{F}_2$, and $\mathbf{F}_3$ can be expressed in Cartesian vector form as



$$\mathbf{F}_1 = 700\cos 30^\circ(+\mathbf{i}) + 700\sin 30^\circ(+\mathbf{j}) = \{606.22\mathbf{i} + 350\mathbf{j}\}\text{ lb}$$

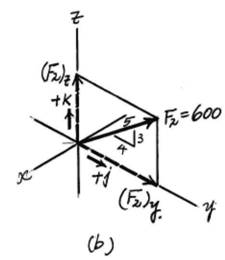
$$\mathbf{F}_2 = 0\mathbf{i} + 600\left(\frac{4}{5}\right)(+\mathbf{j}) + 600\left(\frac{3}{5}\right)(+\mathbf{k}) = \{480\mathbf{j} + 360\mathbf{k}\}\text{ lb}$$

$$\mathbf{F}_3 = 800\cos 120^\circ\mathbf{i} + 800\cos 45^\circ\mathbf{j} + 800\cos 60^\circ\mathbf{k} = \{-400\mathbf{i} + 565.69\mathbf{j} + 400\mathbf{k}\}\text{ lb}$$

$$\mathbf{F}_R = \mathbf{F}_1 + \mathbf{F}_2 + \mathbf{F}_3$$

$$= 606.22\mathbf{i} + 350\mathbf{j} + 480\mathbf{j} + 360\mathbf{k} - 400\mathbf{i} + 565.69\mathbf{j} + 400\mathbf{k}$$

$$= \{206.22\mathbf{i} + 1395.69\mathbf{j} + 760\mathbf{k}\}\text{ lb}$$



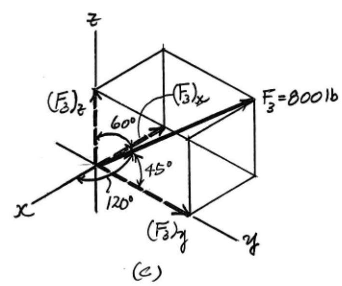
$$F_R = \sqrt{(206.22)^2 + (1395.69)^2 + (760)^2}$$

$$= 1602.52\text{ lb} = 1.60\text{ kip}$$ **Ans.**

$$\alpha = \cos^{-1}\left(\frac{206.22}{1602.52}\right) = 82.6^\circ$$ **Ans.**

$$\beta = \cos^{-1}\left(\frac{1395.69}{1602.52}\right) = 29.4^\circ$$ **Ans.**

$$\gamma = \cos^{-1}\left(\frac{760}{1602.52}\right) = 61.7^\circ$$ **Ans.**

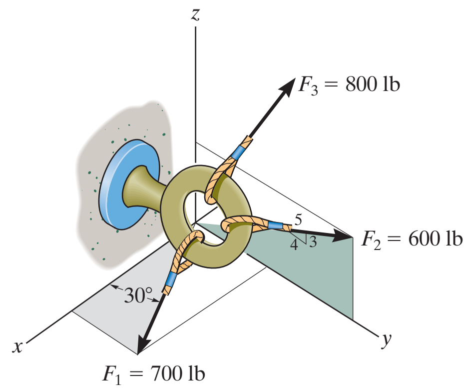


This work is protected by United States copyright laws and is provided solely for the use of instructors in teaching their courses and assessing student learning. Dissemination or sale of any part of this work (including on the World Wide Web) will destroy the integrity of the work and is not permitted.

© 2013 Pearson Education, Inc., Upper Saddle River, NJ. All rights reserved. This publication is protected by Copyright and written permission should be obtained from the publisher prior to any prohibited reproduction, storage in a retrieval system, or transmission in any form or by any means, electronic, mechanical, photocopying, recording, or likewise. For information regarding permission(s), write to: Rights and Permissions Department, Pearson Education, Inc., Upper Saddle River, NJ 07458.

2–82.

If the direction of the resultant force acting on the eyebolt is defined by the unit vector $\mathbf{u}_{F_R} = \cos 30°\mathbf{j} + \sin 30°\mathbf{k}$, determine the coordinate direction angles of $\mathbf{F}_3$ and the magnitude of $\mathbf{F}_R$.



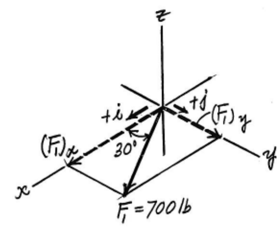
SOLUTION

Force Vectors: By resolving $\mathbf{F}_1$, $\mathbf{F}_2$ and $\mathbf{F}_3$ into their x, y, and z components, as shown in Figs. *a*, *b*, and *c*, respectively, $\mathbf{F}_1$, $\mathbf{F}_2$, and $\mathbf{F}_3$ can be expressed in Cartesian vector form as

$$\mathbf{F}_1 = 700\cos 30°(+\mathbf{i}) + 700\sin 30°(+\mathbf{j}) = \{606.22\mathbf{i} + 350\mathbf{j}\}\text{ lb}$$

$$\mathbf{F}_2 = 0\mathbf{i} + 600\left(\frac{4}{5}\right)(+\mathbf{j}) + 600\left(\frac{3}{5}\right)(+\mathbf{k}) = \{480\mathbf{j} + 360\mathbf{k}\}\text{ lb}$$

$$\mathbf{F}_3 = 800\cos\alpha_3\mathbf{i} + 800\cos\beta_3\mathbf{j} + 800\cos\gamma_3\mathbf{k}$$



(a)

Since the direction of $\mathbf{F}_R$ is defined by $\mathbf{u}_{F_R} = \cos 30°\mathbf{j} + \sin 30°\mathbf{k}$, it can be written in Cartesian vector form as

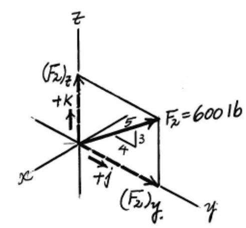
$$\mathbf{F}_R = F_R\mathbf{u}_{F_R} = F_R(\cos 30°\mathbf{j} + \sin 30°\mathbf{k}) = 0.8660F_R\mathbf{j} + 0.5F_R\mathbf{k}$$

Resultant Force: By adding $\mathbf{F}_1$, $\mathbf{F}_2$, and $\mathbf{F}_3$ vectorally, we obtain $\mathbf{F}_R$. Thus,

$$\mathbf{F}_R = \mathbf{F}_1 + \mathbf{F}_2 + \mathbf{F}_3$$

$$0.8660F_R\mathbf{j} + 0.5F_R\mathbf{k} = (606.22\mathbf{i} + 350\mathbf{j}) + (480\mathbf{j} + 360\mathbf{k}) + (800\cos\alpha_3\mathbf{i} + 800\cos\beta_3\mathbf{j} + 800\cos\gamma_3\mathbf{k})$$

$$0.8660F_R\mathbf{j} + 0.5F_R\mathbf{k} = (606.22 + 800\cos\alpha_3)\mathbf{i} + (350 + 480 + 800\cos\beta_3)\mathbf{j} + (360 + 800\cos\gamma_3)\mathbf{k}$$



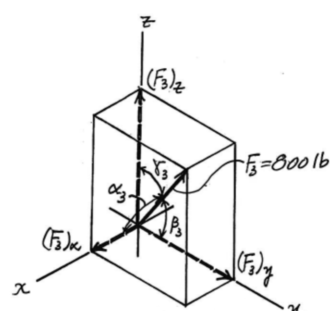
(b)

Equating the **i**, **j**, and **k** components, we have

$$0 = 606.22 + 800\cos\alpha_3$$
$$800\cos\alpha_3 = -606.22 \qquad \textbf{(1)}$$

$$0.8660F_R = 350 + 480 + 800\cos\beta_3$$
$$800\cos\beta_3 = 0.8660F_R - 830 \qquad \textbf{(2)}$$

$$0.5F_R = 360 + 800\cos\gamma_3$$
$$800\cos\gamma_3 = 0.5F_R - 360 \qquad \textbf{(3)}$$



(c)

Squaring and then adding Eqs. (1), (2), and (3), yields

$$800^2\left[\cos^2\alpha_3 + \cos^2\beta_3 + \cos^2\gamma_3\right] = F_R^{\,2} - 1797.60F_R + 1{,}186{,}000 \qquad \textbf{(4)}$$

However, $\cos^2\alpha_3 + \cos^2\beta_3 + \cos^2\gamma_3 = 1$. Thus, from Eq. (4)

$$F_R^{\,2} - 1797.60F_R + 546{,}000 = 0$$

Solving the above quadratic equation, we have two positive roots

$F_R = 387.09\text{ N} = 387\text{ N}$ **Ans.**

$F_R = 1410.51\text{ N} = 1.41\text{ kN}$ **Ans.**

From Eq. (1),

$\alpha_3 = 139°$ **Ans.**

Substituting $F_R = 387.09$ N into Eqs. (2), and (3), yields

$\beta_3 = 128°$ $\qquad \gamma_3 = 102°$ **Ans.**

Substituting $F_R = 1410.51$ N into Eqs. (2), and (3), yields

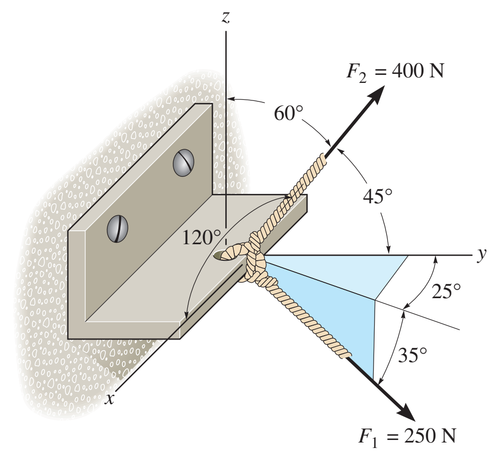
$\beta_3 = 60.7°$ $\qquad \gamma_3 = 64.4°$ **Ans.**

This work is protected by United States copyright laws and is provided solely for the use of instructors in teaching their courses and assessing student learning. Dissemination or sale of any part of this work (including on the World Wide Web) will destroy the integrity of the work and is not permitted.

© 2013 Pearson Education, Inc., Upper Saddle River, NJ. All rights reserved. This publication is protected by Copyright and written permission should be obtained from the publisher prior to any prohibited reproduction, storage in a retrieval system, or transmission in any form or by any means, electronic, mechanical, photocopying, recording, or likewise. For information regarding permission(s), write to: Rights and Permissions Department, Pearson Education, Inc., Upper Saddle River, NJ 07458.

2–83.

The bracket is subjected to the two forces shown. Express each force in Cartesian vector form and then determine the resultant force $\mathbf{F}_R$. Find the magnitude and coordinate direction angles of the resultant force.



SOLUTION

Cartesian Vector Notation:

$$\mathbf{F}_1 = 250\{\cos 35^\circ \sin 25^\circ \mathbf{i} + \cos 35^\circ \cos 25^\circ \mathbf{j} - \sin 35^\circ \mathbf{k}\}\ \text{N}$$

$$= \{86.55\mathbf{i} + 185.60\mathbf{j} - 143.39\mathbf{k}\}\ \text{N}$$

$$= \{86.5\mathbf{i} + 186\mathbf{j} - 143\mathbf{k}\}\ \text{N}$$ **Ans.**

$$\mathbf{F}_2 = 400\{\cos 120^\circ \mathbf{i} + \cos 45^\circ \mathbf{j} + \cos 60^\circ \mathbf{k}\}\ \text{N}$$

$$= \{-200.0\mathbf{i} + 282.84\mathbf{j} + 200.0\mathbf{k}\}\ \text{N}$$

$$= \{-200\mathbf{i} + 283\mathbf{j} + 200\mathbf{k}\}\ \text{N}$$ **Ans.**

Resultant Force:

$$\mathbf{F}_R = \mathbf{F}_1 + \mathbf{F}_2$$

$$= \{(86.55 - 200.0)\mathbf{i} + (185.60 + 282.84)\mathbf{j} + (-143.39 + 200.0)\mathbf{k}\}$$

$$= \{-113.45\mathbf{i} + 468.44\mathbf{j} + 56.61\mathbf{k}\}\ \text{N}$$

$$= \{-113\mathbf{i} + 468\mathbf{j} + 56.6\mathbf{k}\}\ \text{N}$$ **Ans.**

The magnitude of the resultant force is

$$F_R = \sqrt{F_{R_x}^2 + F_{R_y}^2 + F_{R_z}^2}$$

$$= \sqrt{(-113.45)^2 + 468.44^2 + 56.61^2}$$

$$= 485.30\ \text{N} = 485\ \text{N}$$ **Ans.**

The coordinate direction angles are

$$\cos\alpha = \frac{F_{R_x}}{F_R} = \frac{-113.45}{485.30} \qquad \alpha = 104^\circ$$ **Ans.**

$$\cos\beta = \frac{F_{R_y}}{F_R} = \frac{468.44}{485.30} \qquad \beta = 15.1^\circ$$ **Ans.**

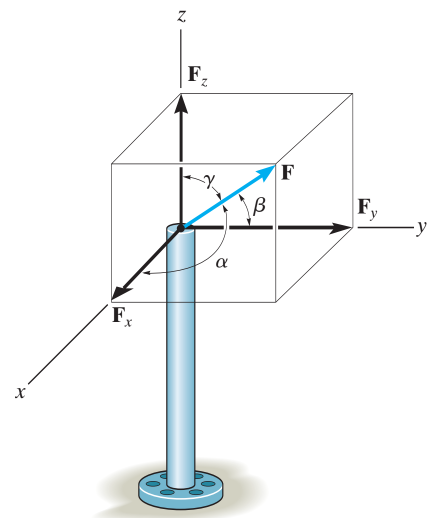
$$\cos\gamma = \frac{F_{R_z}}{F_R} = \frac{56.61}{485.30} \qquad \gamma = 83.3^\circ$$ **Ans.**

This work is protected by United States copyright laws and is provided solely for the use of instructors in teaching their courses and assessing student learning. Dissemination or sale of any part of this work (including on the World Wide Web) will destroy the integrity of the work and is not permitted.

© 2013 Pearson Education, Inc., Upper Saddle River, NJ. All rights reserved. This publication is protected by Copyright and written permission should be obtained from the publisher prior to any prohibited reproduction, storage in a retrieval system, or transmission in any form or by any means, electronic, mechanical, photocopying, recording, or likewise. For information regarding permission(s), write to: Rights and Permissions Department, Pearson Education, Inc., Upper Saddle River, NJ 07458.

***2–84.**

The pole is subjected to the force **F**, which has components acting along the x, y, z axes as shown. If the magnitude of **F** is 3 kN, $\beta = 30°$, and $\gamma = 75°$, determine the magnitudes of its three components.



SOLUTION

$$\cos^2 \alpha + \cos^2 \beta + \cos^2 \gamma = 1$$

$$\cos^2 \alpha + \cos^2 30° + \cos^2 75° = 1$$

$$\alpha = 64.67°$$

$$F_x = 3 \cos 64.67° = 1.28 \text{ kN}$$ **Ans.**

$$F_y = 3 \cos 30° = 2.60 \text{ kN}$$ **Ans.**

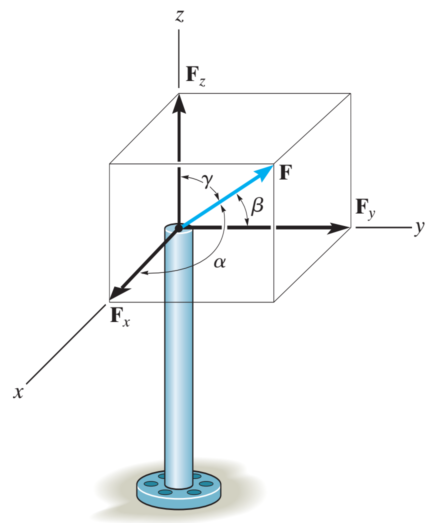
$$F_z = 3 \cos 75° = 0.776 \text{ kN}$$ **Ans.**

This work is protected by United States copyright laws and is provided solely for the use of instructors in teaching their courses and assessing student learning. Dissemination or sale of any part of this work (including on the World Wide Web) will destroy the integrity of the work and is not permitted.

© 2013 Pearson Education, Inc., Upper Saddle River, NJ. All rights reserved. This publication is protected by Copyright and written permission should be obtained from the publisher prior to any prohibited reproduction, storage in a retrieval system, or transmission in any form or by any means, electronic, mechanical, photocopying, recording, or likewise. For information regarding permission(s), write to: Rights and Permissions Department, Pearson Education, Inc., Upper Saddle River, NJ 07458.

2–85.

The pole is subjected to the force **F** which has components $F_x = 1.5$ kN and $F_z = 1.25$ kN. If $\beta = 75°$, determine the magnitudes of **F** and $\mathbf{F}_y$.



SOLUTION

$$\cos^2 \alpha + \cos^2 \beta + \cos^2 \gamma = 1$$

$$\left(\frac{1.5}{F}\right)^2 + \cos^2 75° + \left(\frac{1.25}{F}\right)^2 = 1$$

$$F = 2.02 \text{ kN}$$ **Ans.**

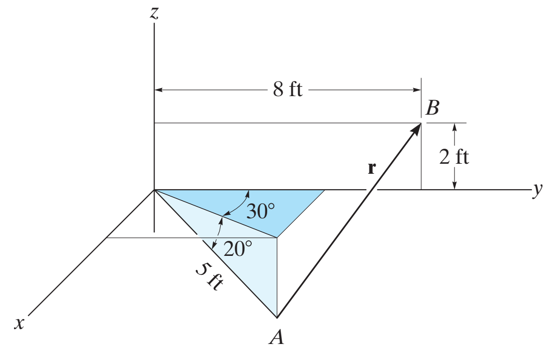
$$F_y = 2.02 \cos 75° = 0.523 \text{ kN}$$ **Ans.**

This work is protected by United States copyright laws and is provided solely for the use of instructors in teaching their courses and assessing student learning. Dissemination or sale of any part of this work (including on the World Wide Web) will destroy the integrity of the work and is not permitted.

© 2013 Pearson Education, Inc., Upper Saddle River, NJ. All rights reserved. This publication is protected by Copyright and written permission should be obtained from the publisher prior to any prohibited reproduction, storage in a retrieval system, or transmission in any form or by any means, electronic, mechanical, photocopying, recording, or likewise. For information regarding permission(s), write to: Rights and Permissions Department, Pearson Education, Inc., Upper Saddle River, NJ 07458.

2–86.

Express the position vector **r** in Cartesian vector form; then determine its magnitude and coordinate direction angles.



SOLUTION

$$\mathbf{r} = (-5\cos 20^\circ \sin 30^\circ)\mathbf{i} + (8 - 5\cos 20^\circ \cos 30^\circ)\mathbf{j} + (2 + 5\sin 20^\circ)\mathbf{k}$$

$$\mathbf{r} = \{-2.35\mathbf{i} + 3.93\mathbf{j} + 3.71\mathbf{k}\}\text{ ft}$$ **Ans.**

$$r = \sqrt{(-2.35)^2 + (3.93)^2 + (3.71)^2} = 5.89\text{ ft}$$ **Ans.**

$$\alpha = \cos^{-1}\left(\frac{-2.35}{5.89}\right) = 113^\circ$$ **Ans.**

$$\beta = \cos^{-1}\left(\frac{3.93}{5.89}\right) = 48.2^\circ$$ **Ans.**

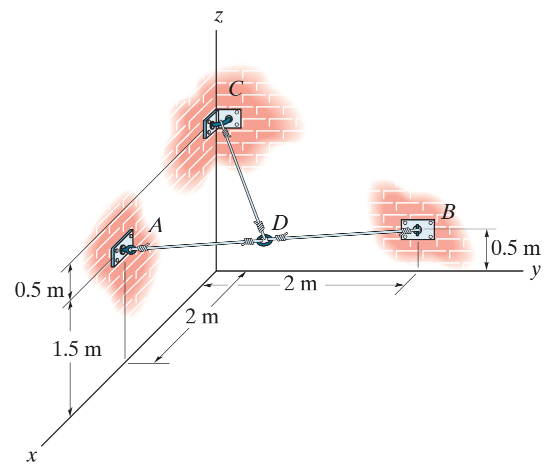
$$\gamma = \cos^{-1}\left(\frac{3.71}{5.89}\right) = 51.0^\circ$$ **Ans.**

This work is protected by United States copyright laws and is provided solely for the use of instructors in teaching their courses and assessing student learning. Dissemination or sale of any part of this work (including on the World Wide Web) will destroy the integrity of the work and is not permitted.

© 2013 Pearson Education, Inc., Upper Saddle River, NJ. All rights reserved. This publication is protected by Copyright and written permission should be obtained from the publisher prior to any prohibited reproduction, storage in a retrieval system, or transmission in any form or by any means, electronic, mechanical, photocopying, recording, or likewise. For information regarding permission(s), write to: Rights and Permissions Department, Pearson Education, Inc., Upper Saddle River, NJ 07458.

2–87.

Determine the lengths of wires *AD*, *BD*, and *CD*. The ring at *D* is midway between *A* and *B*.



SOLUTION

$$D\left(\frac{2+0}{2}, \frac{0+2}{2}, \frac{1.5+0.5}{2}\right)\text{m} = D(1, 1, 1)\text{ m}$$

$$\mathbf{r}_{AD} = (1-2)\mathbf{i} + (1-0)\mathbf{j} + (1-1.5)\mathbf{k}$$

$$= -1\mathbf{i} + 1\mathbf{j} - 0.5\mathbf{k}$$

$$\mathbf{r}_{BD} = (1-0)\mathbf{i} + (1-2)\mathbf{j} + (1-0.5)\mathbf{k}$$

$$= 1\mathbf{i} - 1\mathbf{j} + 0.5\mathbf{k}$$

$$\mathbf{r}_{CD} = (1-0)\mathbf{i} + (1-0)\mathbf{j} + (1-2)\mathbf{k}$$

$$= 1\mathbf{i} + 1\mathbf{j} - 1\mathbf{k}$$

$r_{AD} = \sqrt{(-1)^2 + 1^2 + (-0.5)^2} = 1.50\text{ m}$ **Ans.**

$r_{BD} = \sqrt{1^2 + (-1)^2 + 0.5^2} = 1.50\text{ m}$ **Ans.**

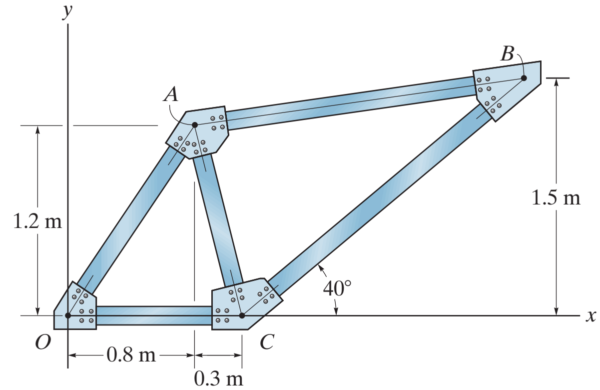
$r_{CD} = \sqrt{1^2 + 1^2 + (-1)^2} = 1.73\text{ m}$ **Ans.**

This work is protected by United States copyright laws and is provided solely for the use of instructors in teaching their courses and assessing student learning. Dissemination or sale of any part of this work (including on the World Wide Web) will destroy the integrity of the work and is not permitted.

© 2013 Pearson Education, Inc., Upper Saddle River, NJ. All rights reserved. This publication is protected by Copyright and written permission should be obtained from the publisher prior to any prohibited reproduction, storage in a retrieval system, or transmission in any form or by any means, electronic, mechanical, photocopying, recording, or likewise. For information regarding permission(s), write to: Rights and Permissions Department, Pearson Education, Inc., Upper Saddle River, NJ 07458.

***2–88.**

Determine the length of member AB of the truss by first establishing a Cartesian position vector from A to B and then determining its magnitude.



SOLUTION

$$\mathbf{r}_{AB} = (1.1) = \frac{1.5}{\tan 40^\circ} - 0.80)\mathbf{i} + (1.5 - 1.2)\mathbf{j}$$

$$\mathbf{r}_{AB} = \{2.09\mathbf{i} + 0.3\mathbf{j}\}\text{ m}$$

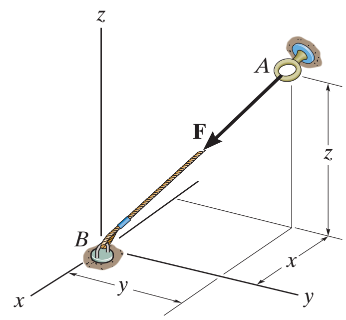
$$\mathbf{r}_{AB} = \sqrt{(2.09)^2 + (0.3)^2} = 2.11\text{ m}$$ **Ans.**

This work is protected by United States copyright laws and is provided solely for the use of instructors in teaching their courses and assessing student learning. Dissemination or sale of any part of this work (including on the World Wide Web) will destroy the integrity of the work and is not permitted.

© 2013 Pearson Education, Inc., Upper Saddle River, NJ. All rights reserved. This publication is protected by Copyright and written permission should be obtained from the publisher prior to any prohibited reproduction, storage in a retrieval system, or transmission in any form or by any means, electronic, mechanical, photocopying, recording, or likewise. For information regarding permission(s), write to: Rights and Permissions Department, Pearson Education, Inc., Upper Saddle River, NJ 07458.

2–89.

If $\mathbf{F} = \{350\mathbf{i} - 250\mathbf{j} - 450\mathbf{k}\}$ N and cable AB is 9 m long, determine the x, y, z coordinates of point A.



SOLUTION

Position Vector: The position vector $\mathbf{r}_{AB}$, directed from point A to point B, is given by

$$\mathbf{r}_{AB} = [0 - (-x)]\mathbf{i} + (0 - y)\mathbf{j} + (0 - z)\mathbf{k}$$

$$= x\mathbf{i} - y\mathbf{j} - z\mathbf{k}$$

Unit Vector: Knowing the magnitude of $\mathbf{r}_{AB}$ is 9 m, the unit vector for $\mathbf{r}_{AB}$ is given by

$$\mathbf{u}_{AB} = \frac{\mathbf{r}_{AB}}{r_{AB}} = \frac{x\mathbf{i} - y\mathbf{j} - z\mathbf{k}}{9}$$

The unit vector for force $\mathbf{F}$ is

$$\mathbf{u}_F = \frac{\mathbf{F}}{F} = \frac{350\mathbf{i} - 250\mathbf{j} - 450\mathbf{k}}{\sqrt{350^2 + (-250)^2 + (-450)^2}} = 0.5623\mathbf{i} - 0.4016\mathbf{j} - 0.7229\mathbf{k}$$

Since force $\mathbf{F}$ is also directed from point A to point B, then

$$\mathbf{u}_{AB} = \mathbf{u}_F$$

$$\frac{x\mathbf{i} - y\mathbf{j} - z\mathbf{k}}{9} = 0.5623\mathbf{i} - 0.4016\mathbf{j} - 0.7229\mathbf{k}$$

Equating the $\mathbf{i}$, $\mathbf{j}$, and $\mathbf{k}$ components,

$\frac{x}{9} = 0.5623$ $\qquad x = 5.06$ m **Ans.**

$\frac{-y}{9} = -0.4016$ $\qquad y = 3.61$ m **Ans.**

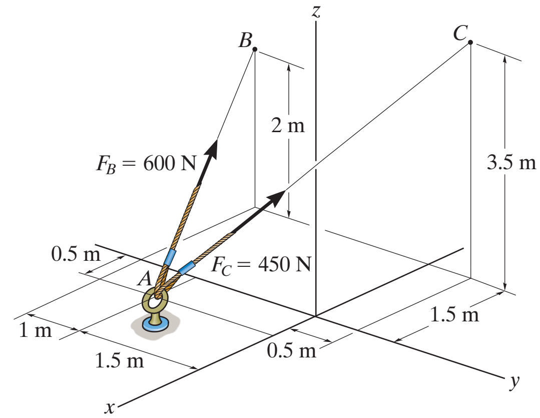
$\frac{-z}{9} = 0.7229$ $\qquad z = 6.51$ m **Ans.**

This work is protected by United States copyright laws and is provided solely for the use of instructors in teaching their courses and assessing student learning. Dissemination or sale of any part of this work (including on the World Wide Web) will destroy the integrity of the work and is not permitted.

© 2013 Pearson Education, Inc., Upper Saddle River, NJ. All rights reserved. This publication is protected by Copyright and written permission should be obtained from the publisher prior to any prohibited reproduction, storage in a retrieval system, or transmission in any form or by any means, electronic, mechanical, photocopying, recording, or likewise. For information regarding permission(s), write to: Rights and Permissions Department, Pearson Education, Inc., Upper Saddle River, NJ 07458.

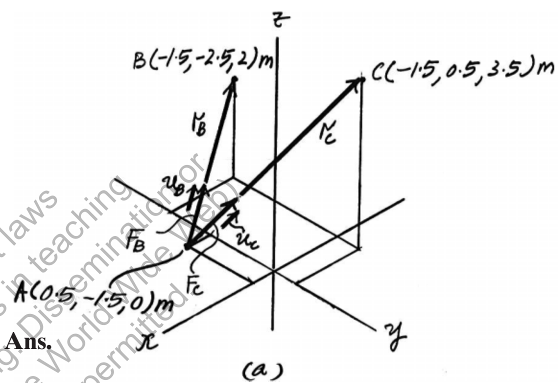
2–90.

Express $\mathbf{F}_B$ and $\mathbf{F}_C$ in Cartesian vector form.



SOLUTION

Force Vectors: The unit vectors $\mathbf{u}_B$ and $\mathbf{u}_C$ of $\mathbf{F}_B$ and $\mathbf{F}_C$ must be determined first. From Fig. *a*



$$\mathbf{u}_B = \frac{\mathbf{r}_B}{r_B} = \frac{(-1.5 - 0.5)\mathbf{i} + [-2.5 - (-1.5)]\mathbf{j} + (2 - 0)\mathbf{k}}{\sqrt{(-1.5 - 0.5)^2 + [-2.5 - (-1.5)]^2 + (2 - 0)^2}}$$

$$= -\frac{2}{3}\mathbf{i} - \frac{1}{3}\mathbf{j} + \frac{2}{3}\mathbf{k}$$

$$\mathbf{u}_C = \frac{\mathbf{r}_C}{r_C} = \frac{(-1.5 - 0.5)\mathbf{i} + [0.5 - (-1.5)]\mathbf{j} + (3.5 - 0)\mathbf{k}}{\sqrt{(-1.5 - 0.5)^2 + [0.5 - (-1.5)]^2 + (3.5 - 0)^2}}$$

$$= -\frac{4}{9}\mathbf{i} + \frac{4}{9}\mathbf{j} + \frac{7}{9}\mathbf{k}$$

Thus, the force vectors $\mathbf{F}_B$ and $\mathbf{F}_C$ are given by

$$\mathbf{F}_B = F_B\mathbf{u}_B = 600\left(-\frac{2}{3}\mathbf{i} - \frac{1}{3}\mathbf{j} + \frac{2}{3}\mathbf{k}\right) = \{-400\mathbf{i} - 200\mathbf{j} + 400\mathbf{k}\}\text{ N}$$ **Ans.**

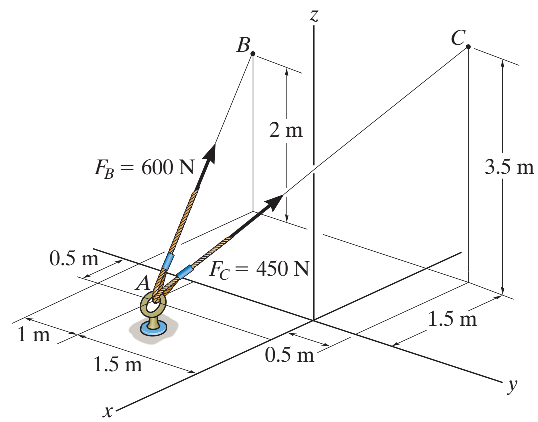
$$\mathbf{F}_C = F_C\mathbf{u}_C = 450\left(-\frac{4}{9}\mathbf{i} + \frac{4}{9}\mathbf{j} + \frac{7}{9}\mathbf{k}\right) = \{-200\mathbf{i} + 200\mathbf{j} + 350\mathbf{k}\}\text{ N}$$ **Ans.**

This work is protected by United States copyright laws and is provided solely for the use of instructors in teaching their courses and assessing student learning. Dissemination or sale of any part of this work (including on the World Wide Web) will destroy the integrity of the work and is not permitted.

© 2013 Pearson Education, Inc., Upper Saddle River, NJ. All rights reserved. This publication is protected by Copyright and written permission should be obtained from the publisher prior to any prohibited reproduction, storage in a retrieval system, or transmission in any form or by any means, electronic, mechanical, photocopying, recording, or likewise. For information regarding permission(s), write to: Rights and Permissions Department, Pearson Education, Inc., Upper Saddle River, NJ 07458.

2–91.

Determine the magnitude and coordinate direction angles of the resultant force acting at A.



SOLUTION

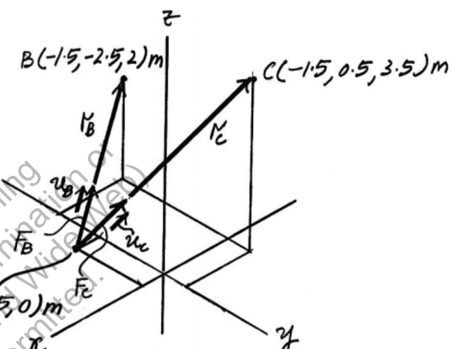
Force Vectors: The unit vectors $\mathbf{u}_B$ and $\mathbf{u}_C$ of $\mathbf{F}_B$ and $\mathbf{F}_C$ must be determined first. From Fig. *a*

$$\mathbf{u}_B = \frac{\mathbf{r}_B}{r_B} = \frac{(-1.5 - 0.5)\mathbf{i} + [-2.5 - (-1.5)]\mathbf{j} + (2 - 0)\mathbf{k}}{\sqrt{(-1.5 - 0.5)^2 + [-2.5 - (-1.5)]^2 + (2 - 0)^2}}$$

$$= -\frac{2}{3}\mathbf{i} - \frac{1}{3}\mathbf{j} + \frac{2}{3}\mathbf{k}$$

$$\mathbf{u}_C = \frac{\mathbf{r}_C}{r_C} = \frac{(-1.5 - 0.5)\mathbf{i} + [0.5 - (-1.5)]\mathbf{j} + (3.5 - 0)\mathbf{k}}{\sqrt{(-1.5 - 0.5)^2 + [0.5 - (-1.5)]^2 + (3.5 - 0)^2}}$$

$$= -\frac{4}{9}\mathbf{i} + \frac{4}{9}\mathbf{j} + \frac{7}{9}\mathbf{k}$$



(a)

Thus, the force vectors $\mathbf{F}_B$ and $\mathbf{F}_C$ are given by

$$\mathbf{F}_B = F_B\mathbf{u}_B = 600\left(-\frac{2}{3}\mathbf{i} - \frac{1}{3}\mathbf{j} + \frac{2}{3}\mathbf{k}\right) = \{-400\mathbf{i} - 200\mathbf{j} + 400\mathbf{k}\}\text{ N}$$

$$\mathbf{F}_C = F_C\mathbf{u}_C = 450\left(-\frac{4}{9}\mathbf{i} + \frac{4}{9}\mathbf{j} + \frac{7}{9}\mathbf{k}\right) = \{-200\mathbf{i} + 200\mathbf{j} + 350\mathbf{k}\}\text{ N}$$

Resultant Force:

$$\mathbf{F}_R = \mathbf{F}_B + \mathbf{F}_C = (-400\mathbf{i} - 200\mathbf{j} + 400\mathbf{k}) + (-200\mathbf{i} + 200\mathbf{j} + 350\mathbf{k})$$

$$= \{-600\mathbf{i} + 750\mathbf{k}\}\text{ N}$$

The magnitude of $\mathbf{F}_R$ is

$$F_R = \sqrt{(F_R)_x{}^2 + (F_R)_y{}^2 + (F_R)_z{}^2}$$

$$= \sqrt{(-600)^2 + 0^2 + 750^2} = 960.47\text{ N} = 960\text{ N}$$

The coordinate direction angles of $\mathbf{F}_R$ are

$$\alpha = \cos^{-1}\left[\frac{(F_R)_x}{F_R}\right] = \cos^{-1}\left(\frac{-600}{960.47}\right) = 129^\circ$$ **Ans.**

$$\beta = \cos^{-1}\left[\frac{(F_R)_y}{F_R}\right] = \cos^{-1}\left(\frac{0}{960.47}\right) = 90^\circ$$ **Ans.**

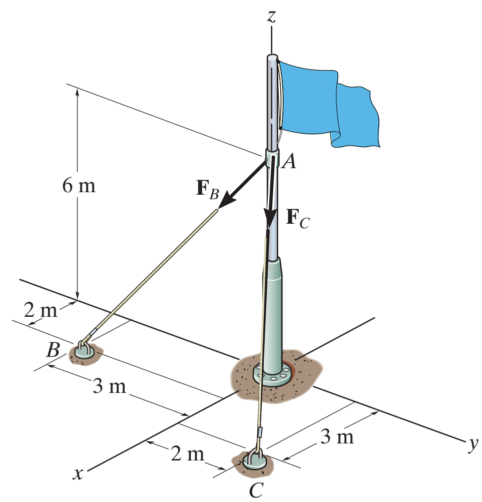
$$\gamma = \cos^{-1}\left[\frac{(F_R)_z}{F_R}\right] = \cos^{-1}\left(\frac{760}{960.47}\right) = 38.7^\circ$$ **Ans.**

This work is protected by United States copyright laws and is provided solely for the use of instructors in teaching their courses and assessing student learning. Dissemination or sale of any part of this work (including on the World Wide Web) will destroy the integrity of the work and is not permitted.

© 2013 Pearson Education, Inc., Upper Saddle River, NJ. All rights reserved. This publication is protected by Copyright and written permission should be obtained from the publisher prior to any prohibited reproduction, storage in a retrieval system, or transmission in any form or by any means, electronic, mechanical, photocopying, recording, or likewise. For information regarding permission(s), write to: Rights and Permissions Department, Pearson Education, Inc., Upper Saddle River, NJ 07458.

***2–92.**

If $F_B = 560$ N and $F_C = 700$ N, determine the magnitude and coordinate direction angles of the resultant force acting on the flag pole.



SOLUTION

Force Vectors: The unit vectors $\mathbf{u}_B$ and $\mathbf{u}_C$ of $\mathbf{F}_B$ and $\mathbf{F}_C$ must be determined first. From Fig. *a*

$$\mathbf{u}_B = \frac{\mathbf{r}_B}{r_B} = \frac{(2-0)\mathbf{i} + (-3-0)\mathbf{j} + (0-6)\mathbf{k}}{\sqrt{(2-0)^2 + (-3-0)^2 + (0-6)^2}} = \frac{2}{7}\mathbf{i} - \frac{3}{7}\mathbf{j} - \frac{6}{7}\mathbf{k}$$

$$\mathbf{u}_C = \frac{\mathbf{r}_C}{r_C} = \frac{(3-0)\mathbf{i} + (2-0)\mathbf{j} + (0-6)\mathbf{k}}{\sqrt{(3-0)^2 + (2-0)^2 + (0-6)^2}} = \frac{3}{7}\mathbf{i} + \frac{2}{7}\mathbf{j} - \frac{6}{7}\mathbf{k}$$

Thus, the force vectors $\mathbf{F}_B$ and $\mathbf{F}_C$ are given by

$$\mathbf{F}_B = F_B\mathbf{u}_B = 560\left(\frac{2}{7}\mathbf{i} - \frac{3}{7}\mathbf{j} - \frac{6}{7}\mathbf{k}\right) = \{160\mathbf{i} - 240\mathbf{j} - 480\mathbf{k}\}\ \text{N}$$

$$\mathbf{F}_C = F_C\mathbf{u}_C = 700\left(\frac{3}{7}\mathbf{i} + \frac{2}{7}\mathbf{j} - \frac{6}{7}\mathbf{k}\right) = \{300\mathbf{i} + 200\mathbf{j} - 600\mathbf{k}\}\ \text{N}$$

Resultant Force:

$$\mathbf{F}_R = \mathbf{F}_B + \mathbf{F}_C = (160\mathbf{i} - 240\mathbf{j} - 480\mathbf{k}) + (300\mathbf{i} + 200\mathbf{j} - 600\mathbf{k})$$

$$= \{460\mathbf{i} - 40\mathbf{j} + 1080\mathbf{k}\}\ \text{N}$$

The magnitude of $\mathbf{F}_R$ is

$$F_R = \sqrt{(F_R)_x{}^2 + (F_R)_y{}^2 + (F_R)_z{}^2}$$

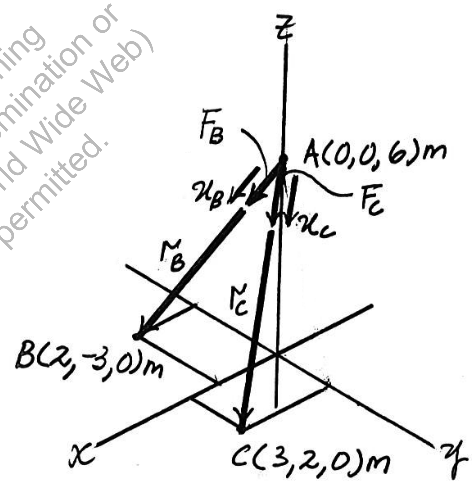
$$= \sqrt{(460)^2 + (-40)^2 + (-1080)^2} = 1174.56\ \text{N} = 1.17\ \text{kN} \qquad \textbf{Ans.}$$

The coordinate direction angles of $\mathbf{F}_R$ are

$$\alpha = \cos^{-1}\left[\frac{(F_R)_x}{F_R}\right] = \cos^{-1}\left(\frac{460}{1174.56}\right) = 66.9° \qquad \textbf{Ans.}$$

$$\beta = \cos^{-1}\left[\frac{(F_R)_y}{F_R}\right] = \cos^{-1}\left(\frac{-40}{1174.56}\right) = 92.0° \qquad \textbf{Ans.}$$

$$\gamma = \cos^{-1}\left[\frac{(F_R)_z}{F_R}\right] = \cos^{-1}\left(\frac{-1080}{1174.56}\right) = 157° \qquad \textbf{Ans.}$$



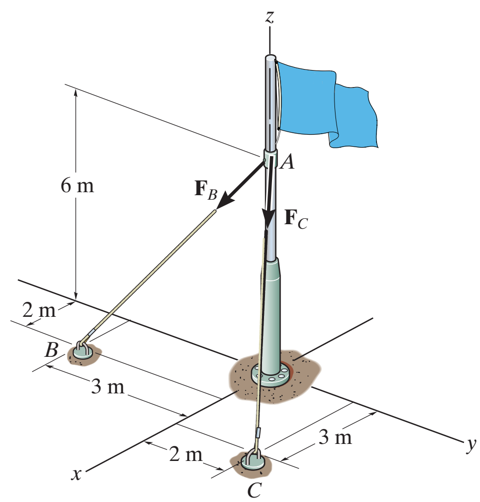
(a)

This work is protected by United States copyright laws and is provided solely for the use of instructors in teaching their courses and assessing student learning. Dissemination or sale of any part of this work (including on the World Wide Web) will destroy the integrity of the work and is not permitted.

© 2013 Pearson Education, Inc., Upper Saddle River, NJ. All rights reserved. This publication is protected by Copyright and written permission should be obtained from the publisher prior to any prohibited reproduction, storage in a retrieval system, or transmission in any form or by any means, electronic, mechanical, photocopying, recording, or likewise. For information regarding permission(s), write to: Rights and Permissions Department, Pearson Education, Inc., Upper Saddle River, NJ 07458.

2–93.

If $F_B = 700$ N, and $F_C = 560$ N, determine the magnitude and coordinate direction angles of the resultant force acting on the flag pole.



SOLUTION

Force Vectors: The unit vectors $\mathbf{u}_B$ and $\mathbf{u}_C$ of $\mathbf{F}_B$ and $\mathbf{F}_C$ must be determined first. From Fig. *a*

$$\mathbf{u}_B = \frac{\mathbf{r}_B}{r_B} = \frac{(2-0)\mathbf{i} + (-3-0)\mathbf{j} + (0-6)\mathbf{k}}{\sqrt{(2-0)^2 + (-3-0)^2 + (0-6)^2}} = \frac{2}{7}\mathbf{i} - \frac{3}{7}\mathbf{j} - \frac{6}{7}\mathbf{k}$$

$$\mathbf{u}_C = \frac{\mathbf{r}_C}{r_C} = \frac{(3-0)\mathbf{i} + (2-0)\mathbf{j} + (0-6)\mathbf{k}}{\sqrt{(3-0)^2 + (2-0)^2 + (0-6)^2}} = \frac{3}{7}\mathbf{i} + \frac{2}{7}\mathbf{j} - \frac{6}{7}\mathbf{k}$$

Thus, the force vectors $\mathbf{F}_B$ and $\mathbf{F}_C$ are given by

$$\mathbf{F}_B = F_B\mathbf{u}_B = 700\left(\frac{2}{7}\mathbf{i} - \frac{3}{7}\mathbf{j} - \frac{6}{7}\mathbf{k}\right) = \{200\mathbf{i} - 300\mathbf{j} - 600\mathbf{k}\}\text{ N}$$

$$\mathbf{F}_C = F_C\mathbf{u}_C = 560\left(\frac{3}{7}\mathbf{i} + \frac{2}{7}\mathbf{j} - \frac{6}{7}\mathbf{k}\right) = \{240\mathbf{i} + 160\mathbf{j} - 480\mathbf{k}\}\text{ N}$$

Resultant Force:

$$\mathbf{F}_R = \mathbf{F}_B + \mathbf{F}_C = (200\mathbf{i} - 300\mathbf{j} - 600\mathbf{k}) + (240\mathbf{i} + 160\mathbf{j} - 480\mathbf{k})$$

$$= \{440\mathbf{i} - 140\mathbf{j} - 1080\mathbf{k}\}\text{ N}$$

The magnitude of $\mathbf{F}_R$ is

$$F_R = \sqrt{(F_R)_x{}^2 + (F_R)_y{}^2 + (F_R)_z{}^2}$$

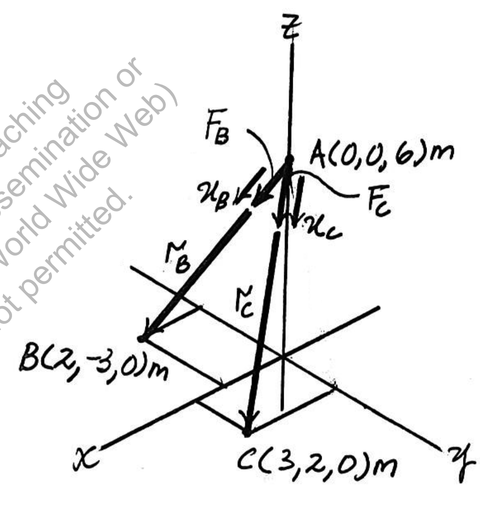
$$= \sqrt{(440)^2 + (-140)^2 + (-1080)^2} = 1174.56\text{ N} = 1.17\text{ kN} \qquad \textbf{Ans.}$$

The coordinate direction angles of $\mathbf{F}_R$ are

$$\alpha = \cos^{-1}\left[\frac{(F_R)_x}{F_R}\right] = \cos^{-1}\left(\frac{440}{1174.56}\right) = 68.0° \qquad \textbf{Ans.}$$

$$\beta = \cos^{-1}\left[\frac{(F_R)_y}{F_R}\right] = \cos^{-1}\left(\frac{-140}{1174.56}\right) = 96.8° \qquad \textbf{Ans.}$$

$$\gamma = \cos^{-1}\left[\frac{(F_R)_z}{F_R}\right] = \cos^{-1}\left(\frac{-1080}{1174.56}\right) = 157° \qquad \textbf{Ans.}$$



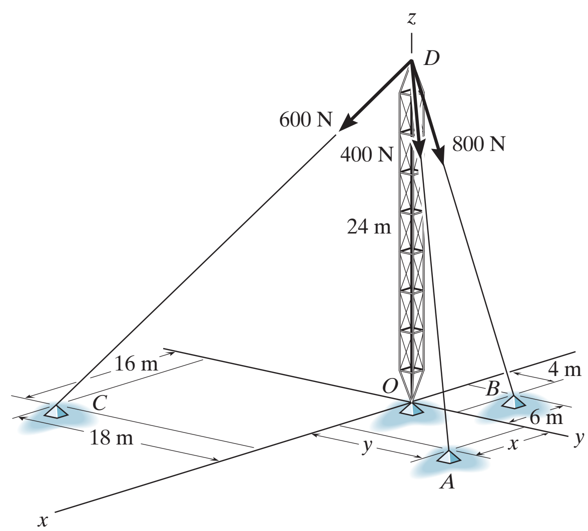
(a)

This work is protected by United States copyright laws and is provided solely for the use of instructors in teaching their courses and assessing student learning. Dissemination or sale of any part of this work (including on the World Wide Web) will destroy the integrity of the work and is not permitted.

© 2013 Pearson Education, Inc., Upper Saddle River, NJ. All rights reserved. This publication is protected by Copyright and written permission should be obtained from the publisher prior to any prohibited reproduction, storage in a retrieval system, or transmission in any form or by any means, electronic, mechanical, photocopying, recording, or likewise. For information regarding permission(s), write to: Rights and Permissions Department, Pearson Education, Inc., Upper Saddle River, NJ 07458.

2–94.

The tower is held in place by three cables. If the force of each cable acting on the tower is shown, determine the magnitude and coordinate direction angles α, β, γ of the resultant force. Take $x = 20$ m, $y = 15$ m.



SOLUTION

$$\mathbf{F}_{DA} = 400\left(\frac{20}{34.66}\mathbf{i} + \frac{15}{34.66}\mathbf{j} - \frac{24}{34.66}\mathbf{k}\right) \text{N}$$

$$\mathbf{F}_{DB} = 800\left(\frac{-6}{25.06}\mathbf{i} + \frac{4}{25.06}\mathbf{j} - \frac{24}{25.06}\mathbf{k}\right) \text{N}$$

$$\mathbf{F}_{DC} = 600\left(\frac{16}{34}\mathbf{i} - \frac{18}{34}\mathbf{j} - \frac{24}{34}\mathbf{k}\right) \text{N}$$

$$\mathbf{F}_R = \mathbf{F}_{DA} + \mathbf{F}_{DB} + \mathbf{F}_{DC}$$

$$= \{321.66\mathbf{i} - 16.82\mathbf{j} - 1466.71\mathbf{k}\} \text{ N}$$

$$F_R = \sqrt{(321.66)^2 + (-16.82)^2 + (-1466.71)^2}$$

$$= 1501.66 \text{ N} = 1.50 \text{ kN}$$ **Ans.**

$$\alpha = \cos^{-1}\left(\frac{321.66}{1501.66}\right) = 77.6^\circ$$ **Ans.**

$$\beta = \cos^{-1}\left(\frac{-16.82}{1501.66}\right) = 90.6^\circ$$ **Ans.**

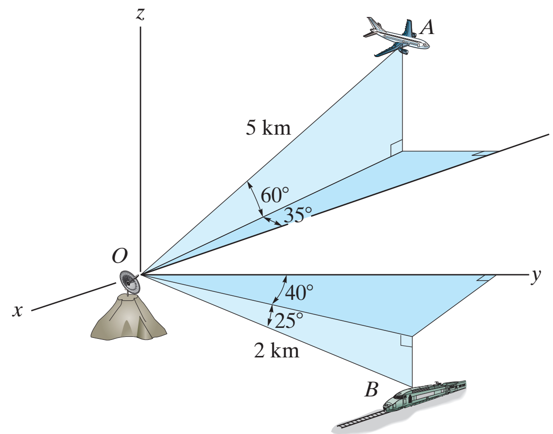
$$\gamma = \cos^{-1}\left(\frac{-1466.71}{1501.66}\right) = 168^\circ$$ **Ans.**

This work is protected by United States copyright laws and is provided solely for the use of instructors in teaching their courses and assessing student learning. Dissemination or sale of any part of this work (including on the World Wide Web) will destroy the integrity of the work and is not permitted.

© 2013 Pearson Education, Inc., Upper Saddle River, NJ. All rights reserved. This publication is protected by Copyright and written permission should be obtained from the publisher prior to any prohibited reproduction, storage in a retrieval system, or transmission in any form or by any means, electronic, mechanical, photocopying, recording, or likewise. For information regarding permission(s), write to: Rights and Permissions Department, Pearson Education, Inc., Upper Saddle River, NJ 07458.

2–95.

At a given instant, the position of a plane at A and a train at B are measured relative to a radar antenna at O. Determine the distance d between A and B at this instant. To solve the problem, formulate a position vector, directed from A to B, and then determine its magnitude.



SOLUTION

Position Vector: The coordinates of points A and B are

$$A(-5\cos 60^\circ \cos 35^\circ, -5\cos 60^\circ \sin 35^\circ, 5\sin 60^\circ)\text{ km}$$

$$= A(-2.048, -1.434, 4.330)\text{ km}$$

$$B(2\cos 25^\circ \sin 40^\circ, 2\cos 25^\circ \cos 40^\circ, -2\sin 25^\circ)\text{ km}$$

$$= B(1.165, 1.389, -0.845)\text{ km}$$

The position vector $\mathbf{r}_{AB}$ can be established from the coordinates of points A and B.

$$\mathbf{r}_{AB} = \{[1.165 - (-2.048)]\mathbf{i} + [1.389 - (-1.434)]\mathbf{j} + (-0.845 - 4.330)\mathbf{k}\}\text{ km}$$

$$= \{3.213\mathbf{i} + 2.822\mathbf{j} - 5.175)\mathbf{k}\}\text{ km}$$

The distance between points A and B is

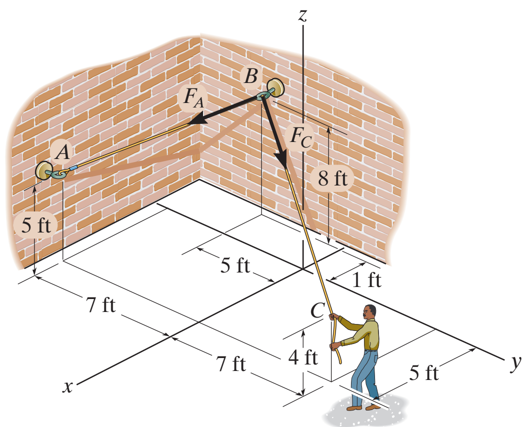
$$d = r_{AB} = \sqrt{3.213^2 + 2.822^2 + (-5.175)^2} = 6.71\text{ km}$$ **Ans.**

This work is protected by United States copyright laws and is provided solely for the use of instructors in teaching their courses and assessing student learning. Dissemination or sale of any part of this work (including on the World Wide Web) will destroy the integrity of the work and is not permitted.

© 2013 Pearson Education, Inc., Upper Saddle River, NJ. All rights reserved. This publication is protected by Copyright and written permission should be obtained from the publisher prior to any prohibited reproduction, storage in a retrieval system, or transmission in any form or by any means, electronic, mechanical, photocopying, recording, or likewise. For information regarding permission(s), write to: Rights and Permissions Department, Pearson Education, Inc., Upper Saddle River, NJ 07458.

***2–96.**

The man pulls on the rope at C with a force of 70 lb which causes the forces $\mathbf{F}_A$ and $\mathbf{F}_C$ at B to have this same magnitude. Express each of these two forces as Cartesian vectors.



SOLUTION

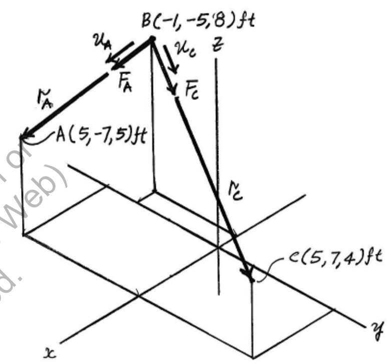
Unit Vectors: The coordinate points A, B, and C are shown in Fig. a. Thus,

$$\mathbf{u}_A = \frac{\mathbf{r}_A}{r_A} = \frac{[5-(-1)]\mathbf{i} + [-7-(-5)]\mathbf{j} + (5-8)\mathbf{k}}{\sqrt{[5-(-1)]^2 + [-7-(-5)]^2 + (5-8)^2}}$$

$$= \frac{6}{7}\mathbf{i} + \frac{2}{7}\mathbf{j} + \frac{3}{7}\mathbf{k}$$

$$\mathbf{u}_C = \frac{\mathbf{r}_C}{r_C} = \frac{[5-(-1)]\mathbf{i} + [-7(-5)]\mathbf{j} + (4-8)\mathbf{k}}{\sqrt{[5-(-1)]^2 + [-7(-5)]^2 + (4-8)^2}}$$

$$= \frac{3}{7}\mathbf{i} + \frac{6}{7}\mathbf{j} + \frac{2}{7}\mathbf{k}$$



(a)

Force Vectors: Multiplying the magnitude of the force with its unit vector,

$$\mathbf{F}_A = F_A\mathbf{u}_A = 70\left(\frac{6}{7}\mathbf{i} - \frac{2}{7}\mathbf{j} + \frac{3}{7}\mathbf{k}\right)$$

$$= \{60\mathbf{i} - 20\mathbf{j} + 30\mathbf{k}\}\ \text{lb}$$ **Ans.**

$$\mathbf{F}_C = F_C\mathbf{u}_C = 70\left(\frac{3}{7}\mathbf{i} + \frac{6}{7}\mathbf{j} + \frac{2}{7}\mathbf{k}\right)$$

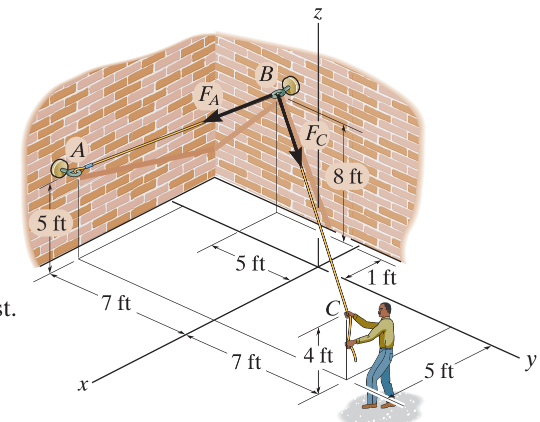
$$= \{30\mathbf{i} + 60\mathbf{j} + 20\mathbf{k}\}\ \text{lb}$$ **Ans.**

This work is protected by United States copyright laws and is provided solely for the use of instructors in teaching their courses and assessing student learning. Dissemination or sale of any part of this work (including on the World Wide Web) will destroy the integrity of the work and is not permitted.

© 2013 Pearson Education, Inc., Upper Saddle River, NJ. All rights reserved. This publication is protected by Copyright and written permission should be obtained from the publisher prior to any prohibited reproduction, storage in a retrieval system, or transmission in any form or by any means, electronic, mechanical, photocopying, recording, or likewise. For information regarding permission(s), write to: Rights and Permissions Department, Pearson Education, Inc., Upper Saddle River, NJ 07458.

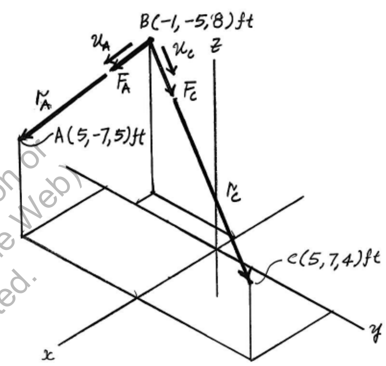
2–97.

The man pulls on the rope at C with a force of 70 lb which causes the forces $\mathbf{F}_A$ and $\mathbf{F}_C$ at B to have this same magnitude. Determine the magnitude and coordinate direction angles of the resultant force acting at B.



SOLUTION

Force Vectors: The unit vectors $\mathbf{u}_B$ and $\mathbf{u}_C$ of $\mathbf{F}_B$ and $\mathbf{F}_C$ must be determined first. From Fig. *a*



(a)

$$\mathbf{u}_A = \frac{\mathbf{r}_A}{r_A} = \frac{[5-(-1)]\mathbf{i} + [-7(-5)]\mathbf{j} + (5-8)\mathbf{k}}{\sqrt{[5-(-1)]^2 + [-7(-5)]^2 + (5-8)^2}}$$

$$= \frac{6}{7}\mathbf{i} + \frac{2}{7}\mathbf{j} + \frac{3}{7}\mathbf{k}$$

$$\mathbf{u}_C = \frac{\mathbf{r}_C}{r_C} = \frac{[5-(-1)]\mathbf{i} + [-7(-5)]\mathbf{j} + (4-8)\mathbf{k}}{\sqrt{[5-(-1)]^2 + [-7(-5)]^2 + (4-8)^2}}$$

$$= \frac{3}{7}\mathbf{i} + \frac{6}{7}\mathbf{j} + \frac{2}{7}\mathbf{k}$$

Thus, the force vectors $\mathbf{F}_B$ and $\mathbf{F}_C$ are given by

$$\mathbf{F}_A = F_A\mathbf{u}_A = 70\left(\frac{6}{7}\mathbf{i} - \frac{2}{7}\mathbf{j} + \frac{3}{7}\mathbf{k}\right) = \{60\mathbf{i} - 20\mathbf{j} + 30\mathbf{k}\}\text{ lb}$$

$$\mathbf{F}_C = F_C\mathbf{u}_C = 70\left(\frac{3}{7}\mathbf{i} + \frac{6}{7}\mathbf{j} + \frac{2}{7}\mathbf{k}\right) = \{30\mathbf{i} + 60\mathbf{j} + 20\mathbf{k}\}\text{ lb}$$

Resultant Force:

$$\mathbf{F}_R = \mathbf{F}_A + \mathbf{F}_C = (60\mathbf{i} - 20\mathbf{j} - 30\mathbf{k}) + (30\mathbf{i} + 60\mathbf{j} - 20\mathbf{k})$$

$$= \{90\mathbf{i} + 40\mathbf{j} - 50\mathbf{k}\}\text{ lb}$$

The magnitude of $\mathbf{F}_R$ is

$$F_R = \sqrt{(F_R)_x{}^2 + (F_R)_y{}^2 + (F_R)_z{}^2}$$

$$= \sqrt{(90)^2 + (40)^2 + (-50)^2} = 110.45\text{ lb} = 110\text{ lb}$$ **Ans.**

The coordinate direction angles of $\mathbf{F}_R$ are

$$\alpha = \cos^{-1}\left[\frac{(F_R)_x}{F_R}\right] = \cos^{-1}\left(\frac{90}{110.45}\right) = 35.4°$$ **Ans.**

$$\beta = \cos^{-1}\left[\frac{(F_R)_y}{F_R}\right] = \cos^{-1}\left(\frac{40}{110.45}\right) = 68.8°$$ **Ans.**

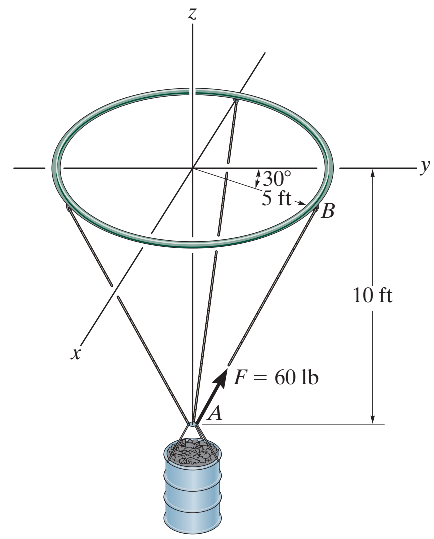
$$\gamma = \cos^{-1}\left[\frac{(F_R)_z}{F_R}\right] = \cos^{-1}\left(\frac{-50}{110.45}\right) = 117°$$ **Ans.**

This work is protected by United States copyright laws and is provided solely for the use of instructors in teaching their courses and assessing student learning. Dissemination or sale of any part of this work (including on the World Wide Web) will destroy the integrity of the work and is not permitted.

© 2013 Pearson Education, Inc., Upper Saddle River, NJ. All rights reserved. This publication is protected by Copyright and written permission should be obtained from the publisher prior to any prohibited reproduction, storage in a retrieval system, or transmission in any form or by any means, electronic, mechanical, photocopying, recording, or likewise. For information regarding permission(s), write to: Rights and Permissions Department, Pearson Education, Inc., Upper Saddle River, NJ 07458.

2–98.

The load at A creates a force of 60 lb in wire AB. Express this force as a Cartesian vector acting on A and directed toward B as shown.



SOLUTION

Unit Vector: First determine the position vector $\mathbf{r}_{AB}$. The coordinates of point B are

$B\,(5 \sin 30°, 5 \cos 30°, 0)\text{ ft} = B\,(2.50, 4.330, 0)\text{ ft}$

Then

$$\mathbf{r}_{AB} = \{(2.50 - 0)\mathbf{i} + (4.330 - 0)\mathbf{j} + [0 - (-10)]\mathbf{k}\}\text{ ft}$$

$$= \{2.50\mathbf{i} + 4.330\mathbf{j} + 10\mathbf{k}\}\text{ ft}$$

$$r_{AB} = \sqrt{2.50^2 + 4.330^2 + 10.0^2} = 11.180\text{ ft}$$

$$\mathbf{u}_{AB} = \frac{\mathbf{r}_{AB}}{r_{AB}} = \frac{2.50\mathbf{i} + 4.330\mathbf{j} + 10\mathbf{k}}{11.180}$$

$$= 0.2236\mathbf{i} + 0.3873\mathbf{j} + 0.8944\mathbf{k}$$

Force Vector:

$$\mathbf{F} = F\mathbf{u}_{AB} = 60\,\{0.2236\mathbf{i} + 0.3873\mathbf{j} + 0.8944\mathbf{k}\}\text{ lb}$$

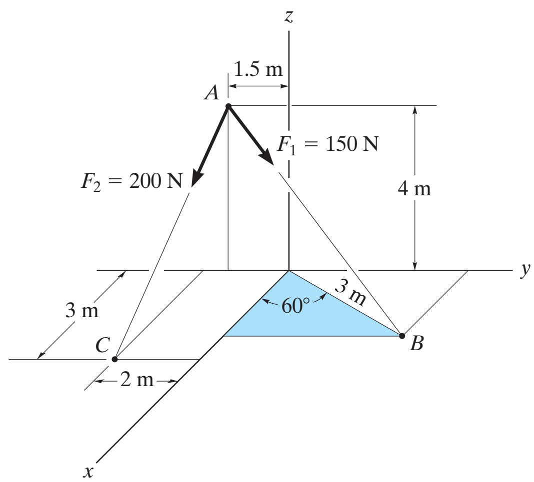
$$= \{13.4\mathbf{i} + 23.2\mathbf{j} + 53.7\mathbf{k}\}\text{ lb}$$ **Ans.**

This work is protected by United States copyright laws and is provided solely for the use of instructors in teaching their courses and assessing student learning. Dissemination or sale of any part of this work (including on the World Wide Web) will destroy the integrity of the work and is not permitted.

© 2013 Pearson Education, Inc., Upper Saddle River, NJ. All rights reserved. This publication is protected by Copyright and written permission should be obtained from the publisher prior to any prohibited reproduction, storage in a retrieval system, or transmission in any form or by any means, electronic, mechanical, photocopying, recording, or likewise. For information regarding permission(s), write to: Rights and Permissions Department, Pearson Education, Inc., Upper Saddle River, NJ 07458.

2–99.

Determine the magnitude and coordinate direction angles of the resultant force acting at point A.



SOLUTION

$$\mathbf{r}_{AC} = \{3\mathbf{i} - 0.5\mathbf{j} - 4\mathbf{k}\}\text{ m}$$

$$|\mathbf{r}_{AC}| = \sqrt{3^2 + (-0.5)^2 + (-4)^2} = \sqrt{25.25} = 5.02494$$

$$\mathbf{F}_2 = 200\left(\frac{3\mathbf{i} - 0.5\mathbf{j} - 4\mathbf{k}}{5.02494}\right) = (119.4044\mathbf{i} - 19.9007\mathbf{j} - 159.2059\mathbf{k})$$

$$\mathbf{r}_{AB} = (3\cos 60°\mathbf{i} + (1.5 + 3\sin 60°)\mathbf{j} - 4\mathbf{k})$$

$$\mathbf{r}_{AB} = (1.5\mathbf{i} + 4.0981\mathbf{j} + 4\mathbf{k})$$

$$|\mathbf{r}_{AB}| = \sqrt{(1.5)^2 + (4.0981)^2 + (-4)^2} = 5.9198$$

$$\mathbf{F}_1 = 150\left(\frac{1.5\mathbf{i} + 4.0981\mathbf{j} - 4\mathbf{k}}{5.9198}\right) = (38.0079\mathbf{i} + 103.8396\mathbf{j} - 101.3545\mathbf{k})$$

$$\mathbf{F}_R = \mathbf{F}_1 + \mathbf{F}_2 = (157.4124\mathbf{i} + 83.9389\mathbf{j} - 260.5607\mathbf{k})$$

$$F_R = \sqrt{(157.4124)^2 + (83.9389)^2 + (-260.5604)^2} = 315.7786 = 316\text{ N}$$ **Ans.**

$$\alpha = \cos^{-1}\left(\frac{157.4124}{315.7786}\right) = 60.100° = 60.1°$$ **Ans.**

$$\beta = \cos^{-1}\left(\frac{83.9389}{315.7786}\right) = 74.585° = 74.6°$$ **Ans.**

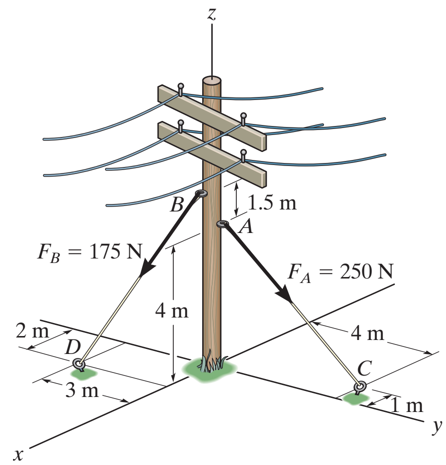
$$\gamma = \cos^{-1}\left(\frac{-260.5607}{315.7786}\right) = 145.60° = 146°$$ **Ans.**

This work is protected by United States copyright laws and is provided solely for the use of instructors in teaching their courses and assessing student learning. Dissemination or sale of any part of this work (including on the World Wide Web) will destroy the integrity of the work and is not permitted.

© 2013 Pearson Education, Inc., Upper Saddle River, NJ. All rights reserved. This publication is protected by Copyright and written permission should be obtained from the publisher prior to any prohibited reproduction, storage in a retrieval system, or transmission in any form or by any means, electronic, mechanical, photocopying, recording, or likewise. For information regarding permission(s), write to: Rights and Permissions Department, Pearson Education, Inc., Upper Saddle River, NJ 07458.

***2–100.**

The guy wires are used to support the telephone pole. Represent the force in each wire in Cartesian vector form. Neglect the diameter of the pole.



SOLUTION

Unit Vector:

$$\mathbf{r}_{AC} = \{(-1-0)\mathbf{i} + (4-0)\mathbf{j} + (0-4)\mathbf{k}\}\ \text{m} = \{-1\mathbf{i} + 4\mathbf{j} - 4\mathbf{k}\}\ \text{m}$$

$$r_{AC} = \sqrt{(-1)^2 + 4^2 + (-4)^2} = 5.745\ \text{m}$$

$$\mathbf{u}_{AC} = \frac{\mathbf{r}_{AC}}{r_{AC}} = \frac{-1\mathbf{i} + 4\mathbf{j} - 4\mathbf{k}}{5.745} = -0.1741\mathbf{i} + 0.6963\mathbf{j} - 0.6963\mathbf{k}$$

$$\mathbf{r}_{BD} = \{(2-0)\ \mathbf{i} + (-3-0)\mathbf{j} + (0-5.5)\mathbf{k}\}\ \text{m} = \{2\mathbf{i} - 3\mathbf{j} - 5.5\mathbf{k}\}\ \text{m}$$

$$r_{BD} = \sqrt{2^2 + (-3)^2 + (-5.5)^2} = 6.576\ \text{m}$$

$$\mathbf{u}_{BD} = \frac{\mathbf{r}_{BD}}{r_{BD}} = \frac{2\mathbf{i} - 3\mathbf{j} - 5.5\mathbf{k}}{6.576} = 0.3041\mathbf{i} - 0.4562\mathbf{j} - 0.8363\mathbf{k}$$

Force Vector:

$$\mathbf{F}_A = F_A\,\mathbf{u}_{AC} = 250\{-0.1741\mathbf{i} + 0.6963\mathbf{j} - 0.6963\mathbf{k}\}\ \text{N}$$

$$= \{-43.52\mathbf{i} + 174.08\mathbf{j} - 174.08\mathbf{k}\}\ \text{N}$$

$$= \{-43.5\mathbf{i} + 174\mathbf{j} - 174\mathbf{k}\}\ \text{N}$$ **Ans.**

$$\mathbf{F}_B = F_B\mathbf{u}_{BD} = 175\{0.3041\mathbf{i} + 0.4562\mathbf{j} - 0.8363\mathbf{k}\}\ \text{N}$$

$$= \{53.22\mathbf{i} - 79.83\mathbf{j} - 146.36\mathbf{k}\}\ \text{N}$$

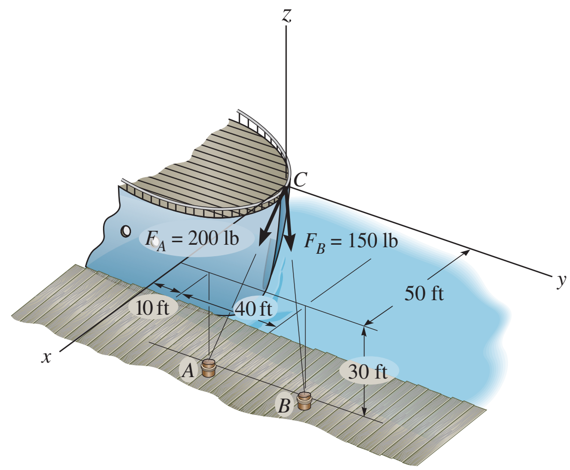
$$= \{53.2\mathbf{i} - 79.8\mathbf{j} - 146\mathbf{k}\}\ \text{N}$$ **Ans.**

This work is protected by United States copyright laws and is provided solely for the use of instructors in teaching their courses and assessing student learning. Dissemination or sale of any part of this work (including on the World Wide Web) will destroy the integrity of the work and is not permitted.

© 2013 Pearson Education, Inc., Upper Saddle River, NJ. All rights reserved. This publication is protected by Copyright and written permission should be obtained from the publisher prior to any prohibited reproduction, storage in a retrieval system, or transmission in any form or by any means, electronic, mechanical, photocopying, recording, or likewise. For information regarding permission(s), write to: Rights and Permissions Department, Pearson Education, Inc., Upper Saddle River, NJ 07458.

2–101.

The two mooring cables exert forces on the stern of a ship as shown. Represent each force as a Cartesian vector and determine the magnitude and coordinate direction angles of the resultant.



SOLUTION

Unit Vector:

$$\mathbf{r}_{CA} = \{(50 - 0)\mathbf{i} + (10 - 0)\mathbf{j} + (-30 - 0)\mathbf{k}\}\text{ ft} = \{50\mathbf{i} + 10\mathbf{j} - 30\mathbf{k}\}\text{ ft}$$

$$r_{CA} = \sqrt{50^2 + 10^2 + (-30)^2} = 59.16\text{ ft}$$

$$\mathbf{u}_{CA} = \frac{\mathbf{r}_{CA}}{r_{CA}} = \frac{50\mathbf{i} + 10\mathbf{j} - 30\mathbf{k}}{59.16} = 0.8452\mathbf{i} + 0.1690\mathbf{j} - 0.5071\mathbf{k}$$

$$\mathbf{r}_{CB} = \{(50 - 0)\mathbf{i} + (50 - 0)\mathbf{j} + (-30 - 0)\mathbf{k}\}\text{ ft} = \{50\mathbf{i} + 50\mathbf{j} - 30\mathbf{k}\}\text{ ft}$$

$$r_{CB} = \sqrt{50^2 + 50^2 + (-30)^2} = 76.81\text{ ft}$$

$$\mathbf{u}_{CB} = \frac{\mathbf{r}_{CA}}{r_{CA}} = \frac{50\mathbf{i} + 50\mathbf{j} - 30\mathbf{k}}{76.81} = 0.6509\mathbf{i} + 0.6509\mathbf{j} - 0.3906\mathbf{k}$$

Force Vector:

$$\mathbf{F}_A = F_A\mathbf{u}_{CA} = 200\{0.8452\mathbf{i} + 0.1690\mathbf{j} - 0.5071\mathbf{k}\}\text{ lb}$$

$$= \{169.03\mathbf{i} + 33.81\mathbf{j} - 101.42\mathbf{k}\}\text{ lb}$$

$$= \{169\mathbf{i} + 33.8\mathbf{j} - 101\mathbf{k}\}\text{ lb} \qquad \textbf{Ans.}$$

$$\mathbf{F}_B = F_B\mathbf{u}_{CB} = 150\{0.6509\mathbf{i} + 0.6509\mathbf{j} - 0.3906\mathbf{k}\}\text{ lb}$$

$$= \{97.64\mathbf{i} + 97.64\mathbf{j} - 58.59\mathbf{k}\}\text{ lb}$$

$$= \{97.6\mathbf{i} + 97.6\mathbf{j} - 58.6\mathbf{k}\}\text{ lb} \qquad \textbf{Ans.}$$

Resultant Force:

$$\mathbf{F}_R = \mathbf{F}_A + \mathbf{F}_B$$

$$= \{(169.03 + 97.64)\mathbf{i} + (33.81 + 97.64)\mathbf{j} + (-101.42 - 58.59)\mathbf{k}\}\text{ lb}$$

$$= \{266.67\mathbf{i} + 131.45\mathbf{j} - 160.00\mathbf{k}\}\text{ lb}$$

The magnitude of $\mathbf{F}_R$ is

$$F_R = \sqrt{266.67^2 + 131.45^2 + (-160.00)^2}$$

$$= 337.63\text{ lb} = 338\text{ lb} \qquad \textbf{Ans.}$$

The coordinate direction angles of $\mathbf{F}_R$ are

$$\cos\alpha = \frac{266.67}{337.63} \qquad \alpha = 37.8° \qquad \textbf{Ans.}$$

$$\cos\beta = \frac{131.45}{337.63} \qquad \beta = 67.1° \qquad \textbf{Ans.}$$

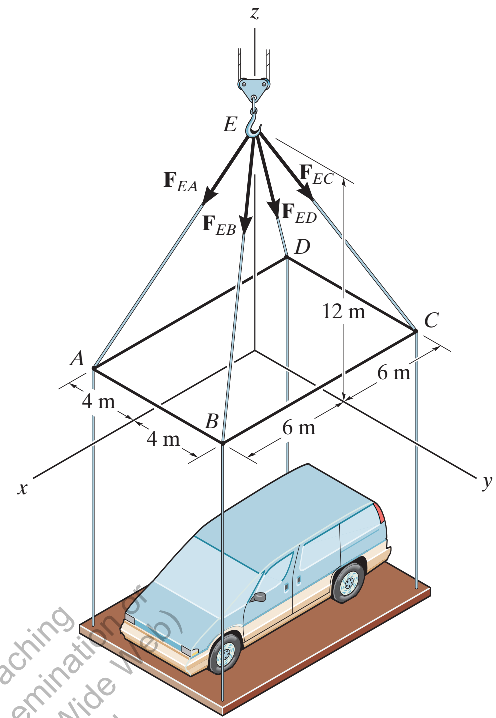
$$\cos\gamma = -\frac{160.00}{337.63} \qquad \gamma = 118° \qquad \textbf{Ans.}$$

This work is protected by United States copyright laws and is provided solely for the use of instructors in teaching their courses and assessing student learning. Dissemination or sale of any part of this work (including on the World Wide Web) will destroy the integrity of the work and is not permitted.

© 2013 Pearson Education, Inc., Upper Saddle River, NJ. All rights reserved. This publication is protected by Copyright and written permission should be obtained from the publisher prior to any prohibited reproduction, storage in a retrieval system, or transmission in any form or by any means, electronic, mechanical, photocopying, recording, or likewise. For information regarding permission(s), write to: Rights and Permissions Department, Pearson Education, Inc., Upper Saddle River, NJ 07458.

2–102.

Each of the four forces acting at E has a magnitude of 28 kN. Express each force as a Cartesian vector and determine the resultant force.



SOLUTION

$$\mathbf{F}_{EA} = 28\left(\frac{6}{14}\mathbf{i} - \frac{4}{14}\mathbf{j} - \frac{12}{14}\mathbf{k}\right)$$

$$\mathbf{F}_{EA} = \{12\mathbf{i} - 8\mathbf{j} - 24\mathbf{k}\}\text{ kN}$$ **Ans.**

$$\mathbf{F}_{EB} = 28\left(\frac{6}{14}\mathbf{i} + \frac{4}{14}\mathbf{j} - \frac{12}{14}\mathbf{k}\right)$$

$$\mathbf{F}_{EB} = \{12\mathbf{i} + 8\mathbf{j} - 24\mathbf{k}\}\text{ kN}$$ **Ans.**

$$\mathbf{F}_{EC} = 28\left(\frac{-6}{14}\mathbf{i} + \frac{4}{14}\mathbf{j} - \frac{12}{14}\mathbf{k}\right)$$

$$\mathbf{F}_{EC} = \{-12\mathbf{i} + 8\mathbf{j} - 24\mathbf{k}\}\text{ kN}$$ **Ans.**

$$\mathbf{F}_{ED} = 28\left(\frac{-6}{14}\mathbf{i} - \frac{4}{14}\mathbf{j} - \frac{12}{14}\mathbf{k}\right)$$

$$\mathbf{F}_{ED} = \{-12\mathbf{i} - 8\mathbf{j} - 24\mathbf{k}\}\text{ kN}$$ **Ans.**

$$\mathbf{F}_R = \mathbf{F}_{EA} + \mathbf{F}_{EB} + \mathbf{F}_{EC} + \mathbf{F}_{ED}$$

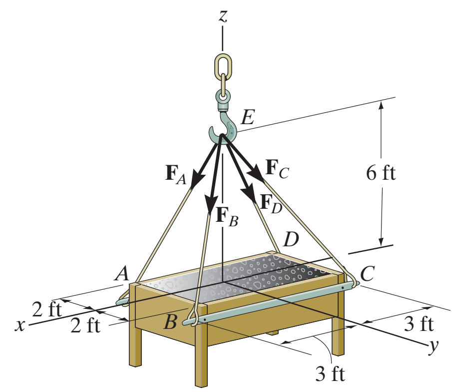
$$= \{-96\mathbf{k}\}\text{ kN}$$ **Ans.**

This work is protected by United States copyright laws and is provided solely for the use of instructors in teaching their courses and assessing student learning. Dissemination or sale of any part of this work (including on the World Wide Web) will destroy the integrity of the work and is not permitted.

© 2013 Pearson Education, Inc., Upper Saddle River, NJ. All rights reserved. This publication is protected by Copyright and written permission should be obtained from the publisher prior to any prohibited reproduction, storage in a retrieval system, or transmission in any form or by any means, electronic, mechanical, photocopying, recording, or likewise. For information regarding permission(s), write to: Rights and Permissions Department, Pearson Education, Inc., Upper Saddle River, NJ 07458.

2–103.

If the force in each cable tied to the bin is 70 lb, determine the magnitude and coordinate direction angles of the resultant force.



SOLUTION

Force Vectors: The unit vectors $\mathbf{u}_A$, $\mathbf{u}_B$, $\mathbf{u}_C$, and $\mathbf{u}_D$ of $\mathbf{F}_A$, $\mathbf{F}_B$, $\mathbf{F}_C$, and $\mathbf{F}_D$ must be determined first. From Fig. *a*,

$$\mathbf{u}_A = \frac{\mathbf{r}_A}{r_A} = \frac{(3-0)\mathbf{i} + (-2-0)\mathbf{j} + (0-6)\mathbf{k}}{\sqrt{(3-0)^2 + (-2-0)^2 + (0-6)^2}} = \frac{3}{7}\mathbf{i} - \frac{2}{7}\mathbf{j} - \frac{6}{7}\mathbf{k}$$

$$\mathbf{u}_B = \frac{\mathbf{r}_B}{r_B} = \frac{(3-0)\mathbf{i} + (2-0)\mathbf{j} + (0-6)\mathbf{k}}{\sqrt{(3-0)^2 + (2-0)^2 + (0-6)^2}} = \frac{3}{7}\mathbf{i} + \frac{2}{7}\mathbf{j} - \frac{6}{7}\mathbf{k}$$

$$\mathbf{u}_C = \frac{\mathbf{r}_C}{r_C} = \frac{(-3-0)\mathbf{i} + (2-0)\mathbf{j} + (0-6)\mathbf{k}}{\sqrt{(-3-0)^2 + (2-0)^2 + (0-6)^2}} = -\frac{3}{7}\mathbf{i} + \frac{2}{7}\mathbf{j} - \frac{6}{7}\mathbf{k}$$

$$\mathbf{u}_D = \frac{\mathbf{r}_D}{r_D} = \frac{(-3-0)\mathbf{i} + (-2-0)\mathbf{j} + (0-6)\mathbf{k}}{\sqrt{(-3-0)^2 + (-2-0)^2 + (0-6)^2}} = -\frac{3}{7}\mathbf{i} - \frac{2}{7}\mathbf{j} - \frac{6}{7}\mathbf{k}$$

Thus, the force vectors $\mathbf{F}_A$, $\mathbf{F}_B$, $\mathbf{F}_C$, and $\mathbf{F}_D$ are given by

$$\mathbf{F}_A = F_A\mathbf{u}_A = 70\left(\frac{3}{7}\mathbf{i} - \frac{2}{7}\mathbf{j} - \frac{6}{7}\mathbf{k}\right) = [30\mathbf{i} - 20\mathbf{j} - 60\mathbf{k}]\text{ lb}$$

$$\mathbf{F}_B = F_B\mathbf{u}_B = 70\left(\frac{3}{7}\mathbf{i} + \frac{2}{7}\mathbf{j} - \frac{6}{7}\mathbf{k}\right) = [30\mathbf{i} + 20\mathbf{j} - 60\mathbf{k}]\text{ lb}$$

$$\mathbf{F}_C = F_C\mathbf{u}_C = 70\left(-\frac{3}{7}\mathbf{i} + \frac{2}{7}\mathbf{j} - \frac{6}{7}\mathbf{k}\right) = [-30\mathbf{i} + 20\mathbf{j} - 60\mathbf{k}]\text{ lb}$$

$$\mathbf{F}_D = F_D\mathbf{u}_D = 70\left(-\frac{3}{7}\mathbf{i} - \frac{2}{7}\mathbf{j} - \frac{6}{7}\mathbf{k}\right) = [-30\mathbf{i} - 20\mathbf{j} - 60\mathbf{k}]\text{ lb}$$

Resultant Force:

$$\mathbf{F}_R = \mathbf{F}_A + \mathbf{F}_B + \mathbf{F}_C + \mathbf{F}_D = (30\mathbf{i} - 20\mathbf{j} - 60\mathbf{k}) + (30\mathbf{i} + 20\mathbf{j} - 60\mathbf{k}) + (-30\mathbf{i} + 20\mathbf{j} - 60\mathbf{k}) + (-30\mathbf{i} - 20\mathbf{j} - 60\mathbf{k})$$
$$= \{-240\mathbf{k}\}\text{ N}$$

The magnitude of $\mathbf{F}_R$ is

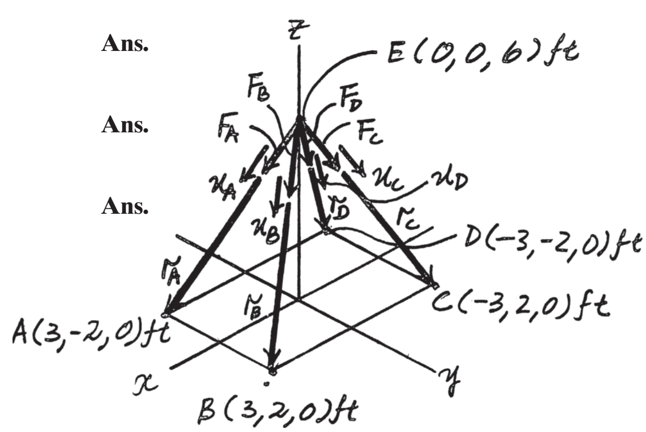
$$F_R = \sqrt{(F_R)_x^2 + (F_R)_y^2 + (F_R)_z^2}$$
$$= \sqrt{0 + 0 + (-240)^2} = 240\text{ lb}$$ **Ans.**

The coordinate direction angles of $\mathbf{F}_R$ are

$$\alpha = \cos^{-1}\left[\frac{(F_R)_x}{F_R}\right] = \cos^{-1}\left(\frac{0}{240}\right) = 90°$$ **Ans.**

$$\beta = \cos^{-1}\left[\frac{(F_R)_y}{F_R}\right] = \cos^{-1}\left(\frac{0}{240}\right) = 90°$$ **Ans.**

$$\gamma = \cos^{-1}\left[\frac{(F_R)_z}{F_R}\right] = \cos^{-1}\left(\frac{-240}{240}\right) = 180°$$ **Ans.**

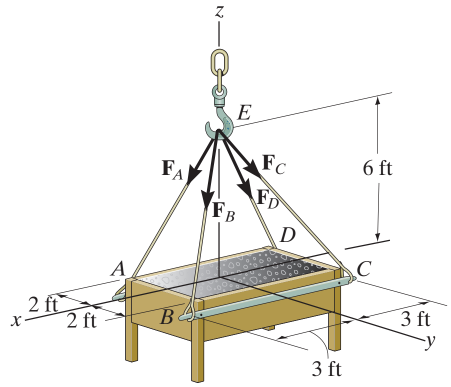


This work is protected by United States copyright laws and is provided solely for the use of instructors in teaching their courses and assessing student learning. Dissemination or sale of any part of this work (including on the World Wide Web) will destroy the integrity of the work and is not permitted.

© 2013 Pearson Education, Inc., Upper Saddle River, NJ. All rights reserved. This publication is protected by Copyright and written permission should be obtained from the publisher prior to any prohibited reproduction, storage in a retrieval system, or transmission in any form or by any means, electronic, mechanical, photocopying, recording, or likewise. For information regarding permission(s), write to: Rights and Permissions Department, Pearson Education, Inc., Upper Saddle River, NJ 07458.

***2–104.**

If the resultant of the four forces is $\mathbf{F}_R = \{-360\mathbf{k}\}$ lb, determine the tension developed in each cable. Due to symmetry, the tension in the four cables is the same.



SOLUTION

Force Vectors: The unit vectors $\mathbf{u}_A$, $\mathbf{u}_B$, $\mathbf{u}_C$, and $\mathbf{u}_D$ of $\mathbf{F}_A$, $\mathbf{F}_B$, $\mathbf{F}_C$, and $\mathbf{F}_D$ must be determined first. From Fig. *a*,

$$\mathbf{u}_A = \frac{\mathbf{r}_A}{r_A} = \frac{(3-0)\mathbf{i} + (-2-0)\mathbf{j} + (0-6)\mathbf{k}}{\sqrt{(3-0)^2 + (-2-0)^2 + (0-6)^2}} = \frac{3}{7}\mathbf{i} - \frac{2}{7}\mathbf{j} - \frac{6}{7}\mathbf{k}$$

$$\mathbf{u}_B = \frac{\mathbf{r}_B}{r_B} = \frac{(3-0)\mathbf{i} + (2-0)\mathbf{j} + (0-6)\mathbf{k}}{\sqrt{(3-0)^2 + (2-0)^2 + (0-6)^2}} = \frac{3}{7}\mathbf{i} + \frac{2}{7}\mathbf{j} - \frac{6}{7}\mathbf{k}$$

$$\mathbf{u}_C = \frac{\mathbf{r}_C}{r_C} = \frac{(-3-0)\mathbf{i} + (2-0)\mathbf{j} + (0-6)\mathbf{k}}{\sqrt{(-3-0)^2 + (2-0)^2 + (0-6)^2}} = -\frac{3}{7}\mathbf{i} + \frac{2}{7}\mathbf{j} - \frac{6}{7}\mathbf{k}$$

$$\mathbf{u}_D = \frac{\mathbf{r}_D}{r_D} = \frac{(-3-0)\mathbf{i} + (-2-0)\mathbf{j} + (0-6)\mathbf{k}}{\sqrt{(-3-0)^2 + (-2-0)^2 + (0-6)^2}} = -\frac{3}{7}\mathbf{i} - \frac{2}{7}\mathbf{j} - \frac{6}{7}\mathbf{k}$$

Since the magnitudes of $\mathbf{F}_A$, $\mathbf{F}_B$, $\mathbf{F}_C$, and $\mathbf{F}_D$ are the same and denoted as F, the four vectors or forces can be written as

$$\mathbf{F}_A = F_A\mathbf{u}_A = F\left(\frac{3}{7}\mathbf{i} - \frac{2}{7}\mathbf{j} - \frac{6}{7}\mathbf{k}\right)$$

$$\mathbf{F}_B = F_B\mathbf{u}_B = F\left(\frac{3}{7}\mathbf{i} + \frac{2}{7}\mathbf{j} - \frac{6}{7}\mathbf{k}\right)$$

$$\mathbf{F}_C = F_C\mathbf{u}_C = F\left(-\frac{3}{7}\mathbf{i} + \frac{2}{7}\mathbf{j} - \frac{6}{7}\mathbf{k}\right)$$

$$\mathbf{F}_D = F_D\mathbf{u}_D = F\left(-\frac{3}{7}\mathbf{i} - \frac{2}{7}\mathbf{j} - \frac{6}{7}\mathbf{k}\right)$$

Resultant Force: The vector addition of $\mathbf{F}_A$, $\mathbf{F}_B$, $\mathbf{F}_C$, and $\mathbf{F}_D$ is equal to $\mathbf{F}_R$. Thus,

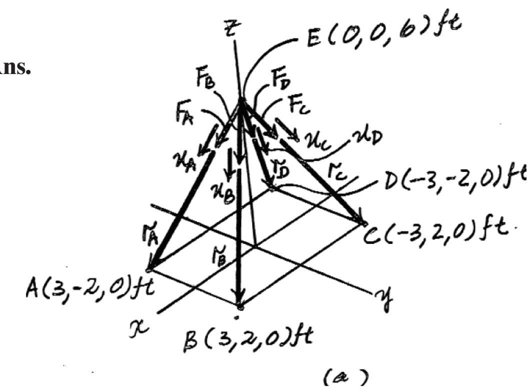
$$\mathbf{F}_R = \mathbf{F}_A + \mathbf{F}_B + \mathbf{F}_C + \mathbf{F}_D$$

$$\{-360\mathbf{k}\} = \left[F\left(\frac{3}{7}\mathbf{i} - \frac{2}{7}\mathbf{j} - \frac{6}{7}\mathbf{k}\right)\right] + \left[F\left(\frac{3}{7}\mathbf{i} + \frac{2}{7}\mathbf{j} - \frac{6}{7}\mathbf{k}\right)\right] + \left[F\left(-\frac{3}{7}\mathbf{i} + \frac{2}{7}\mathbf{j} - \frac{6}{7}\mathbf{k}\right) + \left[F\left(-\frac{3}{7}\mathbf{i} - \frac{2}{7}\mathbf{j} - \frac{6}{7}\mathbf{k}\right)\right]\right]$$

$$-360\mathbf{k} = -\frac{24}{7}\mathbf{k}$$

Thus,

$$360 = \frac{24}{7}F \qquad F = 105 \text{ lb} \qquad \textbf{Ans.}$$



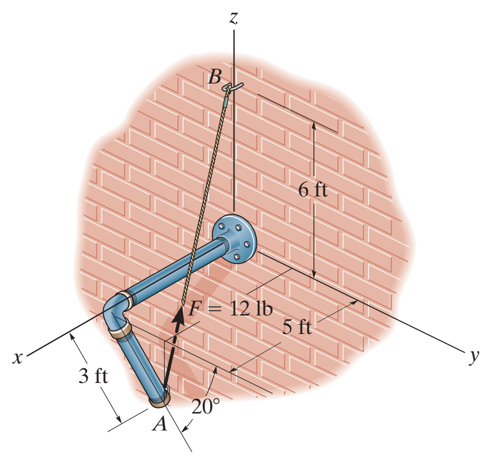
(a)

This work is protected by United States copyright laws and is provided solely for the use of instructors in teaching their courses and assessing student learning. Dissemination or sale of any part of this work (including on the World Wide Web) will destroy the integrity of the work and is not permitted.

© 2013 Pearson Education, Inc., Upper Saddle River, NJ. All rights reserved. This publication is protected by Copyright and written permission should be obtained from the publisher prior to any prohibited reproduction, storage in a retrieval system, or transmission in any form or by any means, electronic, mechanical, photocopying, recording, or likewise. For information regarding permission(s), write to: Rights and Permissions Department, Pearson Education, Inc., Upper Saddle River, NJ 07458.

2–105.

The pipe is supported at its end by a cord AB. If the cord exerts a force of $F = 12$ lb on the pipe at A, express this force as a Cartesian vector.



SOLUTION

Unit Vector: The coordinates of point A are

$$A(5, 3\cos 20°, -3\sin 20°)\text{ ft} = A(5.00, 2.819, -1.206)\text{ ft}$$

Then

$$\mathbf{r}_{AB} = \{(0-5.00)\mathbf{i} + (0-2.819)\mathbf{j} + [6-(-1.206)]\mathbf{k}\}\text{ ft}$$

$$= \{-5.00\mathbf{i} - 2.819\mathbf{j} + 7.026\mathbf{k}\}\text{ ft}$$

$$r_{AB} = \sqrt{(-5.00)^2 + (-2.819)^2 + 7.026^2} = 9.073\text{ ft}$$

$$\mathbf{u}_{AB} = \frac{\mathbf{r}_{AB}}{r_{AB}} = \frac{-5.00\mathbf{i} - 2.819\mathbf{j} + 7.026\mathbf{k}}{9.073}$$

$$= -0.5511\mathbf{i} - 0.3107\mathbf{j} + 0.7744\mathbf{k}$$

Force Vector:

$$\mathbf{F} = F\mathbf{u}_{AB} = 12\{-0.5511\mathbf{i} - 0.3107\mathbf{j} + 0.7744\mathbf{k}\}\text{ lb}$$

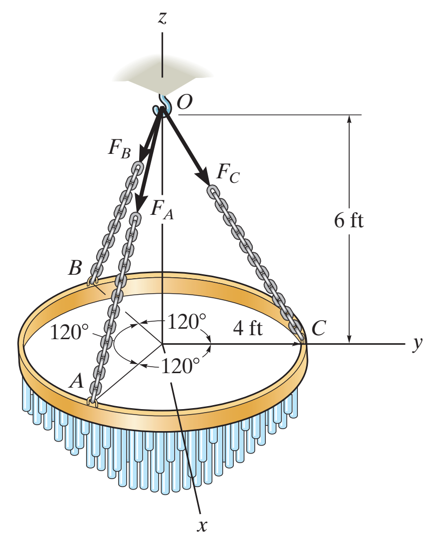
$$= \{-6.61\mathbf{i} - 3.73\mathbf{j} + 9.29\mathbf{k}\}\text{ lb}$$ **Ans.**

This work is protected by United States copyright laws and is provided solely for the use of instructors in teaching their courses and assessing student learning. Dissemination or sale of any part of this work (including on the World Wide Web) will destroy the integrity of the work and is not permitted.

© 2013 Pearson Education, Inc., Upper Saddle River, NJ. All rights reserved. This publication is protected by Copyright and written permission should be obtained from the publisher prior to any prohibited reproduction, storage in a retrieval system, or transmission in any form or by any means, electronic, mechanical, photocopying, recording, or likewise. For information regarding permission(s), write to: Rights and Permissions Department, Pearson Education, Inc., Upper Saddle River, NJ 07458.

2–106.

The chandelier is supported by three chains which are concurrent at point O. If the force in each chain has a magnitude of 60 lb, express each force as a Cartesian vector and determine the magnitude and coordinate direction angles of the resultant force.



SOLUTION

$$\mathbf{F}_A = 60\,\frac{(4\cos 30°\,\mathbf{i} - 4\sin 30°\,\mathbf{j} - 6\,\mathbf{k})}{\sqrt{(4\cos 30°)^2 + (-4\sin 30°)^2 + (-6)^2}}$$

$$= \{28.8\,\mathbf{i} - 16.6\,\mathbf{j} - 49.9\,\mathbf{k}\}\text{ lb} \qquad \textbf{Ans.}$$

$$\mathbf{F}_B = 60\,\frac{(-4\cos 30°\,\mathbf{i} - 4\sin 30°\,\mathbf{j} - 6\mathbf{k})}{\sqrt{(-4\cos 30°)^2 + (-4\sin 30°)^2 + (-6)^2}}$$

$$= \{-28.8\,\mathbf{i} - 16.6\,\mathbf{j} - 49.9\,\mathbf{k}\}\text{ lb} \qquad \textbf{Ans.}$$

$$\mathbf{F}_C = 60\,\frac{(4\,\mathbf{j} - 6\,\mathbf{k})}{\sqrt{(4)^2 + (-6)^2}}$$

$$= \{33.3\,\mathbf{j} - 49.9\,\mathbf{k}\}\text{ lb} \qquad \textbf{Ans.}$$

$$\mathbf{F}_R = \mathbf{F}_A + \mathbf{F}_B + \mathbf{F}_C = \{-149.8\,\mathbf{k}\}\text{ lb}$$

$$F_R = 150\text{ lb} \qquad \textbf{Ans.}$$

$$\alpha = 90° \qquad \textbf{Ans.}$$

$$\beta = 90° \qquad \textbf{Ans.}$$

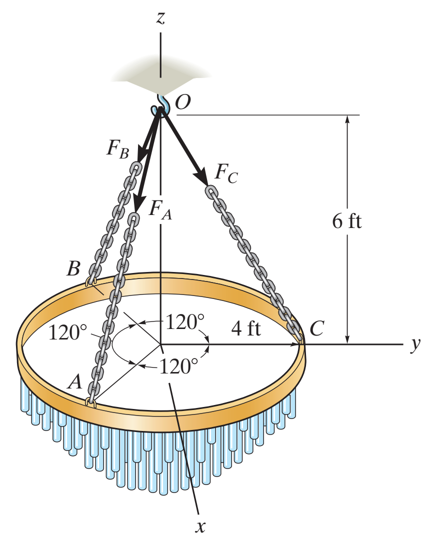
$$\gamma = 180° \qquad \textbf{Ans.}$$

This work is protected by United States copyright laws and is provided solely for the use of instructors in teaching their courses and assessing student learning. Dissemination or sale of any part of this work (including on the World Wide Web) will destroy the integrity of the work and is not permitted.

© 2013 Pearson Education, Inc., Upper Saddle River, NJ. All rights reserved. This publication is protected by Copyright and written permission should be obtained from the publisher prior to any prohibited reproduction, storage in a retrieval system, or transmission in any form or by any means, electronic, mechanical, photocopying, recording, or likewise. For information regarding permission(s), write to: Rights and Permissions Department, Pearson Education, Inc., Upper Saddle River, NJ 07458.

2–107.

The chandelier is supported by three chains which are concurrent at point O. If the resultant force at O has a magnitude of 130 lb and is directed along the negative z axis, determine the force in each chain.



SOLUTION

$$\mathbf{F}_C = F\frac{(4\,\mathbf{j} - 6\,\mathbf{k})}{\sqrt{4^2 + (-6)^2}} = 0.5547\,F\mathbf{j} - 0.8321\,F\mathbf{k}$$

$$\mathbf{F}_A = \mathbf{F}_B = \mathbf{F}_C$$

$$F_{Rz} = \Sigma F_z; \qquad 130 = 3(0.8321F)$$

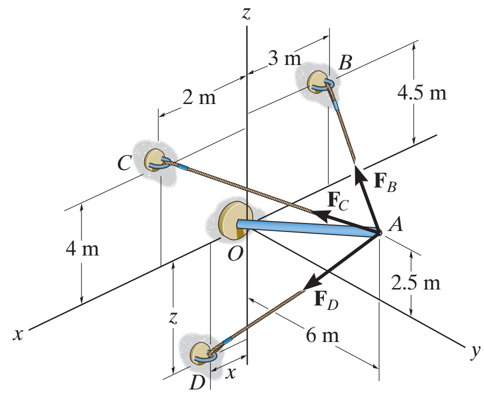
$$F = 52.1P$$ **Ans.**

This work is protected by United States copyright laws and is provided solely for the use of instructors in teaching their courses and assessing student learning. Dissemination or sale of any part of this work (including on the World Wide Web) will destroy the integrity of the work and is not permitted.

© 2013 Pearson Education, Inc., Upper Saddle River, NJ. All rights reserved. This publication is protected by Copyright and written permission should be obtained from the publisher prior to any prohibited reproduction, storage in a retrieval system, or transmission in any form or by any means, electronic, mechanical, photocopying, recording, or likewise. For information regarding permission(s), write to: Rights and Permissions Department, Pearson Education, Inc., Upper Saddle River, NJ 07458.

***2–108.**

Determine the magnitude and coordinate direction angles of the resultant force. Set $F_B = 630$ N, $F_C = 520$ N and $F_D = 750$ N, and $x = 3$ m and $z = 3.5$ m.



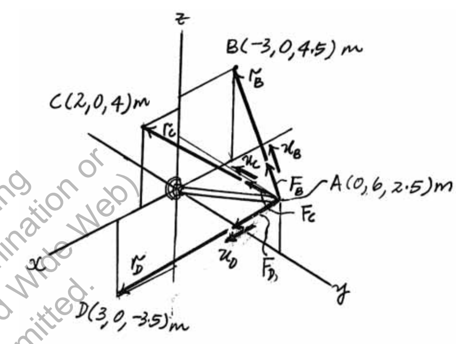
SOLUTION

Force Vectors: The unit vectors $\mathbf{u}_B$, $\mathbf{u}_C$, and $\mathbf{u}_D$ of $\mathbf{F}_B$, $\mathbf{F}_C$, and $\mathbf{F}_D$ must be determined first. From Fig. *a*,

$$\mathbf{u}_B = \frac{\mathbf{r}_B}{r_B} = \frac{(-3-0)\mathbf{i} + (0-6)\mathbf{j} + (4.5-2.5)\mathbf{k}}{\sqrt{(-3-0)^2 + (0-6)^2 + (4.5-2.5)^2}} = -\frac{3}{7}\mathbf{i} - \frac{6}{7}\mathbf{j} + \frac{2}{7}\mathbf{k}$$

$$\mathbf{u}_C = \frac{\mathbf{r}_C}{r_C} = \frac{(2-0)\mathbf{i} + (0-6)\mathbf{j} + (4-2.5)\mathbf{k}}{\sqrt{(2-0)^2 + (0-6)^2 + (4-2.5)^2}} = \frac{4}{13}\mathbf{i} - \frac{12}{13}\mathbf{j} + \frac{3}{13}\mathbf{k}$$

$$\mathbf{u}_D = \frac{\mathbf{r}_D}{r_D} = \frac{(3-0)\mathbf{i} + (0-6)\mathbf{j} + (-3.5-2.5)\mathbf{k}}{\sqrt{(0-3)^2 + (0-6)^2 + (-3.5-2.5)^2}} = \frac{1}{3}\mathbf{i} - \frac{2}{3}\mathbf{j} - \frac{2}{3}\mathbf{k}$$



(a)

Thus, the force vectors $\mathbf{F}_B$, $\mathbf{F}_C$, and $\mathbf{F}_D$ are given by

$$\mathbf{F}_B = F_B\mathbf{u}_B = 630\left(-\frac{3}{7}\mathbf{i} - \frac{6}{7}\mathbf{j} + \frac{2}{7}\mathbf{k}\right) = \{-270\mathbf{i} - 540\mathbf{j} + 180\mathbf{k}\}\text{ N}$$

$$\mathbf{F}_C = F_C\mathbf{u}_C = 520\left(\frac{4}{13}\mathbf{i} - \frac{12}{13}\mathbf{j} + \frac{3}{13}\mathbf{k}\right) = \{160\mathbf{i} - 480\mathbf{j} + 120\mathbf{k}\}\text{ N}$$

$$\mathbf{F}_D = F_D\mathbf{u}_D = 750\left(\frac{1}{3}\mathbf{i} - \frac{2}{3}\mathbf{j} - \frac{2}{3}\mathbf{k}\right) = \{250\mathbf{i} - 500\mathbf{j} - 500\mathbf{k}\}\text{ N}$$

Resultant Force:

$$\mathbf{F}_R = \mathbf{F}_B + \mathbf{F}_C + \mathbf{F}_D = (-270\mathbf{i} - 540\mathbf{j} + 180\mathbf{k}) + (160\mathbf{i} - 480\mathbf{j} + 120\mathbf{k}) + (250\mathbf{i} - 500\mathbf{j} - 500\mathbf{k})$$
$$= [140\mathbf{i} - 1520\mathbf{j} - 200\mathbf{k}]\text{ N}$$

The magnitude of $\mathbf{F}_R$ is

$$F_R = \sqrt{(F_R)_x{}^2 + (F_R)_y{}^2 + (F_R)_z{}^2}$$
$$= \sqrt{140^2 + (-1520)^2 + (-200)^2} = 1539.48\text{ N} = 1.54\text{ kN} \qquad \textbf{Ans.}$$

The coordinate direction angles of $\mathbf{F}_R$ are

$$\alpha = \cos^{-1}\left[\frac{(F_R)_x}{F_R}\right] = \cos^{-1}\left(\frac{140}{1539.48}\right) = 84.8^\circ \qquad \textbf{Ans.}$$

$$\beta = \cos^{-1}\left[\frac{(F_R)_y}{F_R}\right] = \cos^{-1}\left(\frac{-1520}{1539.48}\right) = 171^\circ \qquad \textbf{Ans.}$$

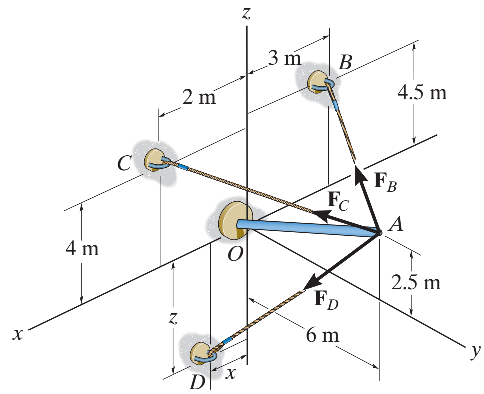
$$\gamma = \cos^{-1}\left[\frac{(F_R)_z}{F_R}\right] = \cos^{-1}\left(\frac{-200}{1539.48}\right) = 97.5^\circ \qquad \textbf{Ans.}$$

This work is protected by United States copyright laws and is provided solely for the use of instructors in teaching their courses and assessing student learning. Dissemination or sale of any part of this work (including on the World Wide Web) will destroy the integrity of the work and is not permitted.

© 2013 Pearson Education, Inc., Upper Saddle River, NJ. All rights reserved. This publication is protected by Copyright and written permission should be obtained from the publisher prior to any prohibited reproduction, storage in a retrieval system, or transmission in any form or by any means, electronic, mechanical, photocopying, recording, or likewise. For information regarding permission(s), write to: Rights and Permissions Department, Pearson Education, Inc., Upper Saddle River, NJ 07458.

2–109.

If the magnitude of the resultant force is 1300 N and acts along the axis of the strut, directed from point A towards O, determine the magnitudes of the three forces acting on the strut. Set $x = 0$ and $z = 5.5$ m.



SOLUTION

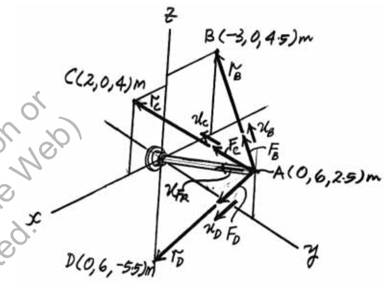
Force Vectors: The unit vectors $\mathbf{u}_B$, $\mathbf{u}_C$, $\mathbf{u}_D$, and $\mathbf{u}_{F_R}$ of $\mathbf{F}_B$, $\mathbf{F}_C$, $\mathbf{F}_D$, and $\mathbf{F}_R$ must be determined first. From Fig. *a*,

$$\mathbf{u}_B = \frac{\mathbf{r}_B}{r_B} = \frac{(-3-0)\mathbf{i} + (0-6)\mathbf{j} + (4.5-2.5)\mathbf{k}}{\sqrt{(-3-0)^2 + (0-6)^2 + (4.5-2.5)^2}} = -\frac{3}{7}\mathbf{i} - \frac{6}{7}\mathbf{j} + \frac{2}{7}\mathbf{k}$$

$$\mathbf{u}_C = \frac{\mathbf{r}_C}{r_C} = \frac{(2-0)\mathbf{i} + (0-6)\mathbf{j} + (4-2.5)\mathbf{k}}{\sqrt{(2-0)^2 + (0-6)^2 + (4-2.5)^2}} = \frac{4}{13}\mathbf{i} - \frac{12}{13}\mathbf{j} + \frac{3}{13}\mathbf{k}$$

$$\mathbf{u}_D = \frac{\mathbf{r}_D}{r_D} = \frac{(0-0)\mathbf{i} + (0-6)\mathbf{j} + (-5.5-2.5)\mathbf{k}}{\sqrt{(0-0)^2 + (0-6)^2 + (-5.5-2.5)^2}} = -\frac{3}{5}\mathbf{j} + \frac{4}{5}\mathbf{k}$$

$$\mathbf{u}_{F_R} = \frac{\mathbf{r}_{AO}}{r_{AO}} = \frac{(0-0)\mathbf{i} + (0-6)\mathbf{j} + (0-2.5)\mathbf{k}}{\sqrt{(0-0)^2 + (0-6)^2 + (0-2.5)^2}} = -\frac{12}{13}\mathbf{j} + \frac{5}{13}\mathbf{k}$$



(a)

Thus, the force vectors $\mathbf{F}_B$, $\mathbf{F}_C$, $\mathbf{F}_D$, and $\mathbf{F}_R$ are given by

$$\mathbf{F}_B = F_B\mathbf{u}_B = -\frac{3}{7}F_B\mathbf{i} - \frac{6}{7}F_B\mathbf{j} + \frac{2}{7}F_B\mathbf{k}$$

$$\mathbf{F}_C = F_C\mathbf{u}_C = \frac{4}{13}F_C\mathbf{i} - \frac{12}{13}F_C\mathbf{j} + \frac{3}{13}F_C\mathbf{k}$$

$$\mathbf{F}_D = F_D\mathbf{u}_D = -\frac{3}{5}F_D\mathbf{j} - \frac{4}{5}F_D\mathbf{k}$$

$$\mathbf{F}_R = F_R\mathbf{u}_R = 1300\left(-\frac{12}{13}\mathbf{j} - \frac{5}{13}\mathbf{k}\right) = [-1200\mathbf{j} - 500\mathbf{k}]\ \text{N}$$

Resultant Force:

$$\mathbf{F}_R = \mathbf{F}_B + \mathbf{F}_C + \mathbf{F}_D$$

$$-1200\mathbf{j} - 500\mathbf{k} = \left(-\frac{3}{7}F_B\mathbf{i} - \frac{6}{7}F_B\mathbf{j} + \frac{2}{7}F_B\mathbf{k}\right) + \left(\frac{4}{13}F_C\mathbf{i} - \frac{12}{13}F_C\mathbf{j} + \frac{3}{13}F_C\mathbf{k}\right) + \left(-\frac{3}{5}F_D\mathbf{j} - \frac{4}{5}F_D\mathbf{k}\right)$$

$$-1200\mathbf{j} - 500\mathbf{k} = \left(-\frac{3}{7}F_B + \frac{4}{13}F_C\right)\mathbf{i} + \left(-\frac{6}{7}F_B - \frac{12}{13}F_C - \frac{3}{5}F_D\mathbf{j}\right) + \left(\frac{2}{7}F_B + \frac{3}{13}F_C - \frac{4}{5}F_D\right)\mathbf{k}$$

Equating the **i**, **j**, and **k** components,

$$0 = -\frac{3}{7}F_B + \frac{4}{13}F_C \qquad (1)$$

$$-1200 = -\frac{6}{7}F_B - \frac{12}{13}F_C - \frac{3}{5}F_D\mathbf{j} \qquad (2)$$

$$-500 = \frac{2}{7}F_B + \frac{3}{13}F_C - \frac{4}{5}F_D \qquad (3)$$

Solving Eqs. (1), (2), and (3), yields

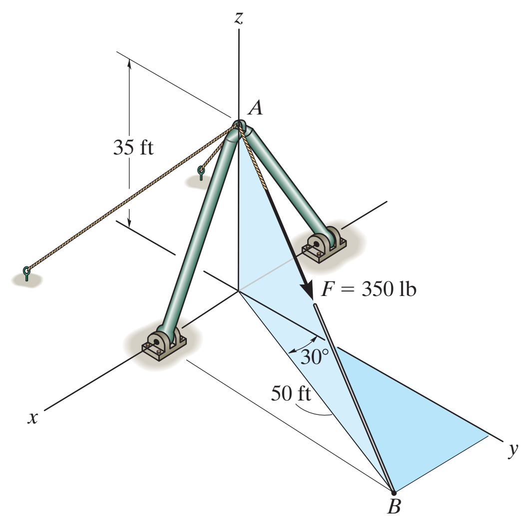
$F_C = 442$ N $\qquad F_B = 318$ N $\qquad F_D = 866$ N **Ans.**

This work is protected by United States copyright laws and is provided solely for the use of instructors in teaching their courses and assessing student learning. Dissemination or sale of any part of this work (including on the World Wide Web) will destroy the integrity of the work and is not permitted.

© 2013 Pearson Education, Inc., Upper Saddle River, NJ. All rights reserved. This publication is protected by Copyright and written permission should be obtained from the publisher prior to any prohibited reproduction, storage in a retrieval system, or transmission in any form or by any means, electronic, mechanical, photocopying, recording, or likewise. For information regarding permission(s), write to: Rights and Permissions Department, Pearson Education, Inc., Upper Saddle River, NJ 07458.

2–110.

The cable attached to the shear-leg derrick exerts a force on the derrick of $F = 350$ lb. Express this force as a Cartesian vector.



SOLUTION

Unit Vector: The coordinates of point B are

$$B(50 \sin 30°, 50 \cos 30°, 0) \text{ ft} = B(25.0, 43.301, 0) \text{ ft}$$

Then

$$\mathbf{r}_{AB} = \{(25.0 - 0)\mathbf{i} + (43.301 - 0)\mathbf{j} + (0 - 35)\mathbf{k}\} \text{ ft}$$

$$= \{25.0\mathbf{i} + 43.301\mathbf{j} - 35.0\mathbf{k}\} \text{ ft}$$

$$r_{AB} = \sqrt{25.0^2 + 43.301^2 + (-35.0)^2} = 61.033 \text{ ft}$$

$$\mathbf{u}_{AB} = \frac{\mathbf{r}_{AB}}{r_{AB}} = \frac{25.0\mathbf{i} + 43.301\mathbf{j} - 35.0\mathbf{k}}{61.033}$$

$$= 0.4096\mathbf{i} + 0.7094\mathbf{j} - 0.5735\mathbf{k}$$

Force Vector:

$$\mathbf{F} = F\mathbf{u}_{AB} = 350\{0.4096\mathbf{i} + 0.7094\mathbf{j} - 0.5735\mathbf{k}\} \text{ lb}$$

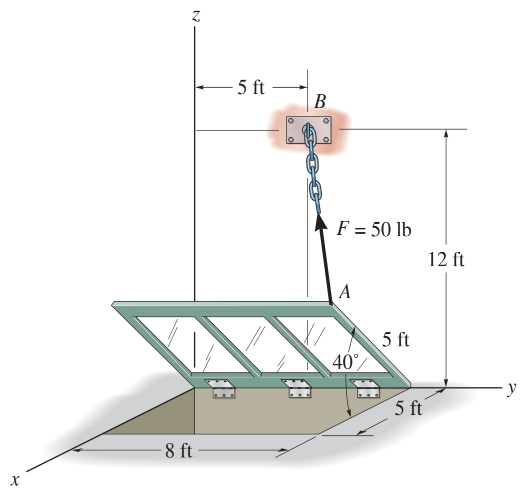
$$= \{143\mathbf{i} + 248\mathbf{j} - 201\mathbf{k}\} \text{ lb}$$ **Ans.**

This work is protected by United States copyright laws and is provided solely for the use of instructors in teaching their courses and assessing student learning. Dissemination or sale of any part of this work (including on the World Wide Web) will destroy the integrity of the work and is not permitted.

© 2013 Pearson Education, Inc., Upper Saddle River, NJ. All rights reserved. This publication is protected by Copyright and written permission should be obtained from the publisher prior to any prohibited reproduction, storage in a retrieval system, or transmission in any form or by any means, electronic, mechanical, photocopying, recording, or likewise. For information regarding permission(s), write to: Rights and Permissions Department, Pearson Education, Inc., Upper Saddle River, NJ 07458.

2–111.

The window is held open by chain AB. Determine the length of the chain, and express the 50-lb force acting at A along the chain as a Cartesian vector and determine its coordinate direction angles.



SOLUTION

Unit Vector: The coordinates of point A are

$$A(5\cos 40°, 8, 5\sin 40°)\text{ ft} = A(3.830, 8.00, 3.214)\text{ ft}$$

Then

$$\mathbf{r}_{AB} = \{(0 - 3.830)\mathbf{i} + (5 - 8.00)\mathbf{j} + (12 - 3.214)\mathbf{k}\}\text{ ft}$$

$$= \{-3.830\mathbf{i} - 3.00\mathbf{j} + 8.786\mathbf{k}\}\text{ ft}$$

$$r_{AB} = \sqrt{(-3.830)^2 + (-3.00)^2 + 8.786^2} = 10.043\text{ ft} = 10.0\text{ ft} \qquad \textbf{Ans.}$$

$$\mathbf{u}_{AB} = \frac{\mathbf{r}_{AB}}{r_{AB}} = \frac{-3.830\mathbf{i} - 3.00\mathbf{j} + 8.786\mathbf{k}}{10.043}$$

$$= -0.3814\mathbf{i} - 0.2987\mathbf{j} + 0.8748\mathbf{k}$$

Force Vector:

$$\mathbf{F} = F\mathbf{u}_{AB} = 50\{-0.3814\mathbf{i} - 0.2987\mathbf{j} + 0.8748\mathbf{k}\}\text{ lb}$$

$$= \{-19.1\mathbf{i} - 14.9\mathbf{j} + 43.7\mathbf{k}\}\text{ lb} \qquad \textbf{Ans.}$$

Coordinate Direction Angles: From the unit vector $\mathbf{u}_{AB}$ obtained above, we have

$$\cos\alpha = -0.3814 \qquad \alpha = 112° \qquad \textbf{Ans.}$$

$$\cos\beta = -0.2987 \qquad \beta = 107° \qquad \textbf{Ans.}$$

$$\cos\gamma = 0.8748 \qquad \gamma = 29.0° \qquad \textbf{Ans.}$$

This work is protected by United States copyright laws and is provided solely for the use of instructors in teaching their courses and assessing student learning. Dissemination or sale of any part of this work (including on the World Wide Web) will destroy the integrity of the work and is not permitted.

© 2013 Pearson Education, Inc., Upper Saddle River, NJ. All rights reserved. This publication is protected by Copyright and written permission should be obtained from the publisher prior to any prohibited reproduction, storage in a retrieval system, or transmission in any form or by any means, electronic, mechanical, photocopying, recording, or likewise. For information regarding permission(s), write to: Rights and Permissions Department, Pearson Education, Inc., Upper Saddle River, NJ 07458.

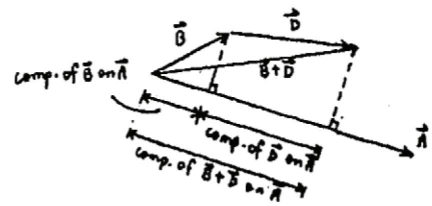
***2–112.**

Given the three vectors **A**, **B**, and **D**, show that $\mathbf{A}\cdot(\mathbf{B}+\mathbf{D}) = (\mathbf{A}\cdot\mathbf{B}) + (\mathbf{A}\cdot\mathbf{D})$.

SOLUTION

Since the component of $(\mathbf{B}+\mathbf{D})$ is equal to the sum of the components of **B** and **D**, then

$$\mathbf{A}\cdot(\mathbf{B}+\mathbf{D}) = \mathbf{A}\cdot\mathbf{B} + \mathbf{A}\cdot\mathbf{D} \qquad \textbf{(QED)}$$



Also,

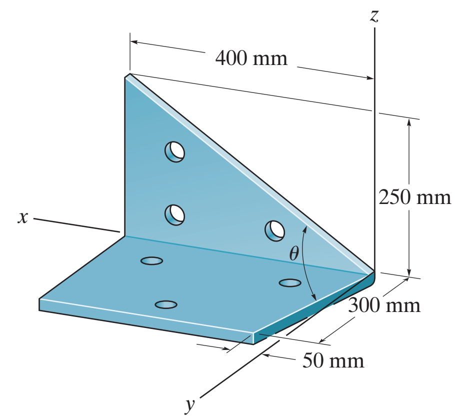
$$\begin{aligned}\mathbf{A}\cdot(\mathbf{B}+\mathbf{D}) &= (A_x\mathbf{i} + A_y\mathbf{j} + A_z\mathbf{k})\cdot[(B_x + D_x)\mathbf{i} + (B_y + D_y)\mathbf{j} + (B_z + D_z)\mathbf{k}] \\ &= A_x(B_x + D_x) + A_y(B_y + D_y) + A_z(B_z + D_z) \\ &= (A_xB_x + A_yB_y + A_zB_z) + (A_xD_x + A_yD_y + A_zD_z) \\ &= (\mathbf{A}\cdot\mathbf{B}) + (\mathbf{A}\cdot\mathbf{D}) \qquad \textbf{(QED)}\end{aligned}$$

This work is protected by United States copyright laws and is provided solely for the use of instructors in teaching their courses and assessing student learning. Dissemination or sale of any part of this work (including on the World Wide Web) will destroy the integrity of the work and is not permitted.

© 2013 Pearson Education, Inc., Upper Saddle River, NJ. All rights reserved. This publication is protected by Copyright and written permission should be obtained from the publisher prior to any prohibited reproduction, storage in a retrieval system, or transmission in any form or by any means, electronic, mechanical, photocopying, recording, or likewise. For information regarding permission(s), write to: Rights and Permissions Department, Pearson Education, Inc., Upper Saddle River, NJ 07458.

2–113.

Determine the angle θ between the edges of the sheet-metal bracket.



SOLUTION

$\mathbf{r}_1 = \{400\mathbf{i} + 250\mathbf{k}\}$ mm ; $\quad r_1 = 471.70$ mm

$\mathbf{r}_2 = \{50\mathbf{i} + 300\mathbf{j}\}$ mm ; $\quad r_2 = 304.14$ mm

$$\mathbf{r}_1 \cdot \mathbf{r}_2 = (400)\,(50) + 0(300) + 250(0) = 20\,000$$

$$\theta = \cos^{-1}\left(\frac{\mathbf{r}_1 \cdot \mathbf{r}_2}{r_1 r_2}\right)$$

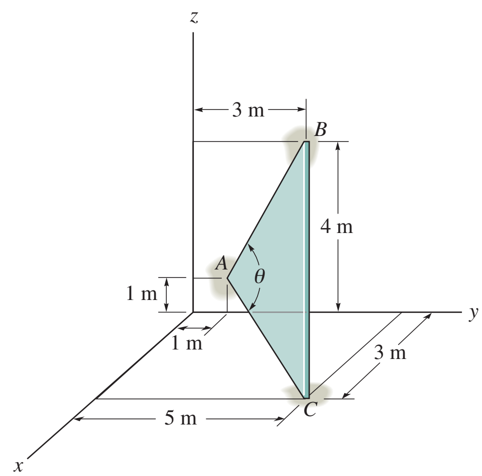
$$= \cos^{-1}\left(\frac{20\,000}{(471.70)\,(304.14)}\right) = 82.0^\circ$$ **Ans.**

This work is protected by United States copyright laws and is provided solely for the use of instructors in teaching their courses and assessing student learning. Dissemination or sale of any part of this work (including on the World Wide Web) will destroy the integrity of the work and is not permitted.

© 2013 Pearson Education, Inc., Upper Saddle River, NJ. All rights reserved. This publication is protected by Copyright and written permission should be obtained from the publisher prior to any prohibited reproduction, storage in a retrieval system, or transmission in any form or by any means, electronic, mechanical, photocopying, recording, or likewise. For information regarding permission(s), write to: Rights and Permissions Department, Pearson Education, Inc., Upper Saddle River, NJ 07458.

2–114.

Determine the angle θ between the sides of the triangular plate.



SOLUTION

$\mathbf{r}_{AC} = \{3\,\mathbf{i} + 4\,\mathbf{j} - 1\,\mathbf{k}\}$ m

$r_{AC} = \sqrt{(3)^2 + (4)^2 + (-1)^2} = 5.0990$ m

$\mathbf{r}_{AB} = \{2\,\mathbf{j} + 3\,\mathbf{k}\}$ m

$r_{AB} = \sqrt{(2)^2 + (3)^2} = 3.6056$ m

$\mathbf{r}_{AC} \cdot \mathbf{r}_{AB} = 0 + 4(2) + (-1)(3) = 5$

$$\theta = \cos^{-1}\left(\frac{\mathbf{r}_{AC} \cdot \mathbf{r}_{AB}}{r_{AC}r_{AB}}\right) = \cos^{-1}\frac{5}{(5.0990)(3.6056)}$$

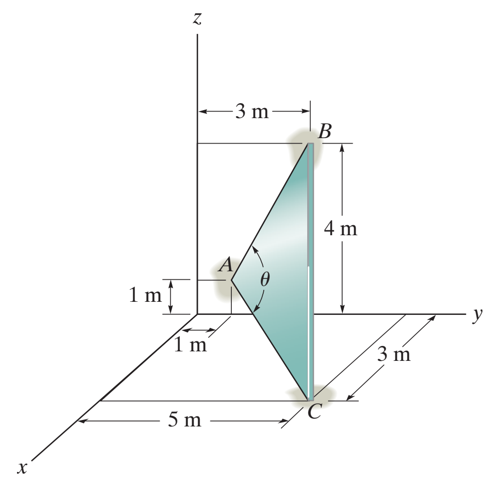
$\theta = 74.219° = 74.2°$ **Ans.**

This work is protected by United States copyright laws and is provided solely for the use of instructors in teaching their courses and assessing student learning. Dissemination or sale of any part of this work (including on the World Wide Web) will destroy the integrity of the work and is not permitted.

© 2013 Pearson Education, Inc., Upper Saddle River, NJ. All rights reserved. This publication is protected by Copyright and written permission should be obtained from the publisher prior to any prohibited reproduction, storage in a retrieval system, or transmission in any form or by any means, electronic, mechanical, photocopying, recording, or likewise. For information regarding permission(s), write to: Rights and Permissions Department, Pearson Education, Inc., Upper Saddle River, NJ 07458.

2–115.

Determine the length of side BC of the triangular plate. Solve the problem by finding the magnitude of $\mathbf{r}_{BC}$; then check the result by first finding θ, r_{AB}, and r_{AC} and then using the cosine law.



SOLUTION

$$\mathbf{r}_{BC} = \{3\,\mathbf{i} + 2\,\mathbf{j} - 4\,\mathbf{k}\}\text{ m}$$

$$r_{BC} = \sqrt{(3)^2 + (2)^2 + (-4)^2} = 5.39\text{ m}$$ **Ans.**

Also,

$$\mathbf{r}_{AC} = \{3\,\mathbf{i} + 4\,\mathbf{j} - 1\,\mathbf{k}\}\text{ m}$$

$$r_{AC} = \sqrt{(3)^2 + (4)^2 + (-1)^2} = 5.0990\text{ m}$$

$$\mathbf{r}_{AB} = \{2\,\mathbf{j} + 3\,\mathbf{k}\}\text{ m}$$

$$r_{AB} = \sqrt{(2)^2 + (3)^2} = 3.6056\text{ m}$$

$$\mathbf{r}_{AC}\cdot\mathbf{r}_{AB} = 0 + 4(2) + (-1)(3) = 5$$

$$\theta = \cos^{-1}\left(\frac{\mathbf{r}_{AC}\cdot\mathbf{r}_{AB}}{r_{AC}\,r_{AB}}\right) = \cos^{-1}\frac{5}{(5.0990)(3.6056)}$$

$$\theta = 74.219°$$

$$r_{BC} = \sqrt{(5.0990)^2 + (3.6056)^2 - 2(5.0990)(3.6056)\cos 74.219°}$$

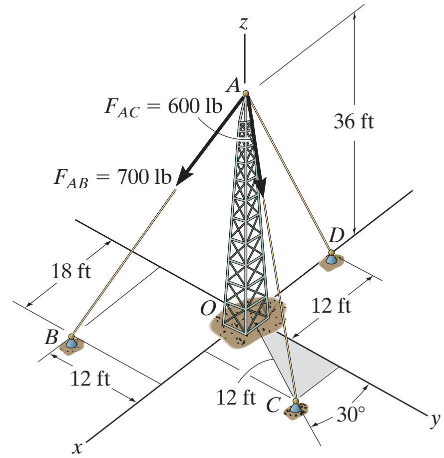
$$r_{BC} = 5.39\text{ m}$$ **Ans.**

This work is protected by United States copyright laws and is provided solely for the use of instructors in teaching their courses and assessing student learning. Dissemination or sale of any part of this work (including on the World Wide Web) will destroy the integrity of the work and is not permitted.

© 2013 Pearson Education, Inc., Upper Saddle River, NJ. All rights reserved. This publication is protected by Copyright and written permission should be obtained from the publisher prior to any prohibited reproduction, storage in a retrieval system, or transmission in any form or by any means, electronic, mechanical, photocopying, recording, or likewise. For information regarding permission(s), write to: Rights and Permissions Department, Pearson Education, Inc., Upper Saddle River, NJ 07458.

***2–116.**

Determine the magnitude of the projected component of force $\mathbf{F}_{AB}$ acting along the z axis.



SOLUTION

Unit Vector: The unit vector $\mathbf{u}_{AB}$ must be determined first. From Fig. a,

$$\mathbf{u}_{AB} = \frac{\mathbf{r}_{AB}}{r_{AB}} = \frac{(18-0)\mathbf{i} + (-12-0)\mathbf{j} + (0-36)\mathbf{k}}{\sqrt{(18-0)^2 + (-12-0)^2 + (0-36)^2}} = \frac{3}{7}\mathbf{i} - \frac{2}{7}\mathbf{j} - \frac{6}{7}\mathbf{k}$$

Thus, the force vector $\mathbf{F}_{AB}$ is given by

$$\mathbf{F}_{AB} = F_{AB}\,\mathbf{u}_{AB} = 700\left(\frac{3}{7}\mathbf{i} - \frac{2}{7}\mathbf{j} - \frac{6}{7}\mathbf{k}\right) = \{300\mathbf{i} - 200\mathbf{j} - 600\mathbf{k}\}\text{ lb}$$

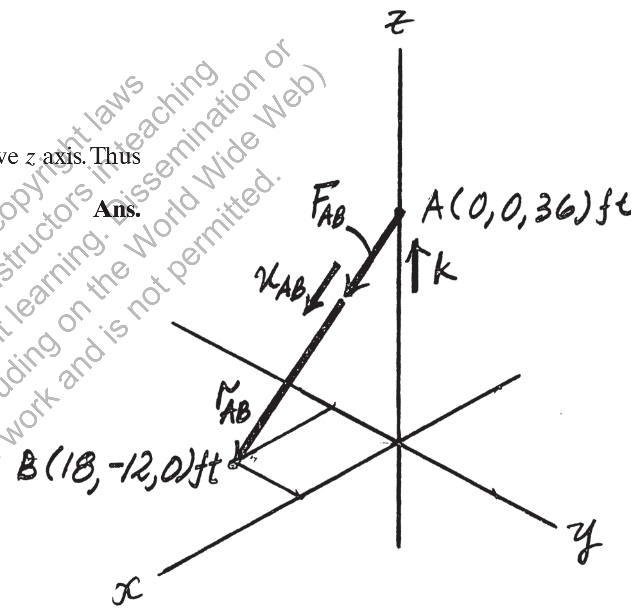
Vector Dot Product: The projected component of $\mathbf{F}_{AB}$ along the z axis is

$$(F_{AB})_z = \mathbf{F}_{AB}\cdot\mathbf{k} = \left(300\mathbf{i} - 200\mathbf{j} - 600\mathbf{k}\right)\cdot\mathbf{k}$$

$$= -600\text{ lb}$$

The negative sign indicates that $(\mathbf{F}_{AB})z$ is directed towards the negative z axis. Thus

$$(F_{AB})_z = 600\text{ lb} \qquad \textbf{Ans.}$$

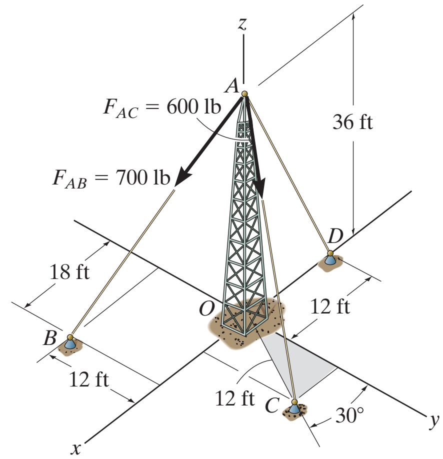


This work is protected by United States copyright laws and is provided solely for the use of instructors in teaching their courses and assessing student learning. Dissemination or sale of any part of this work (including on the World Wide Web) will destroy the integrity of the work and is not permitted.

© 2013 Pearson Education, Inc., Upper Saddle River, NJ. All rights reserved. This publication is protected by Copyright and written permission should be obtained from the publisher prior to any prohibited reproduction, storage in a retrieval system, or transmission in any form or by any means, electronic, mechanical, photocopying, recording, or likewise. For information regarding permission(s), write to: Rights and Permissions Department, Pearson Education, Inc., Upper Saddle River, NJ 07458.

***2–117.**

Determine the magnitude of the projected component of force $\mathbf{F}_{AC}$ acting along the z axis.



SOLUTION

Unit Vector: The unit vector $\mathbf{u}_{AC}$ must be determined first. From Fig. *a*,

$$\mathbf{u}_{AC} = \frac{\mathbf{r}_{AC}}{r_{AC}} = \frac{(12 \sin 30^\circ - 0)\mathbf{i} + (12 \cos 30^\circ - 0)\mathbf{j} + (0 - 36)\mathbf{k}}{\sqrt{(12 \sin 30^\circ - 0)^2 + (12 \cos 30^\circ - 0)^2 + (0 - 36)^2}} = 0.1581\mathbf{i} + 0.2739\mathbf{j} - 0.9487\mathbf{k}$$

Thus, the force vector $\mathbf{F}_{AC}$ is given by

$$\mathbf{F}_{AC} = F_{AC}\mathbf{u}_{AC} = 600\big(0.1581\mathbf{i} + 0.2739\mathbf{j} - 0.9487\mathbf{k}\big) = \{94.87\mathbf{i} + 164.32\mathbf{j} - 569.21\mathbf{k}\}\text{ N}$$

Vector Dot Product: The projected component of $\mathbf{F}_{AC}$ along the z axis is

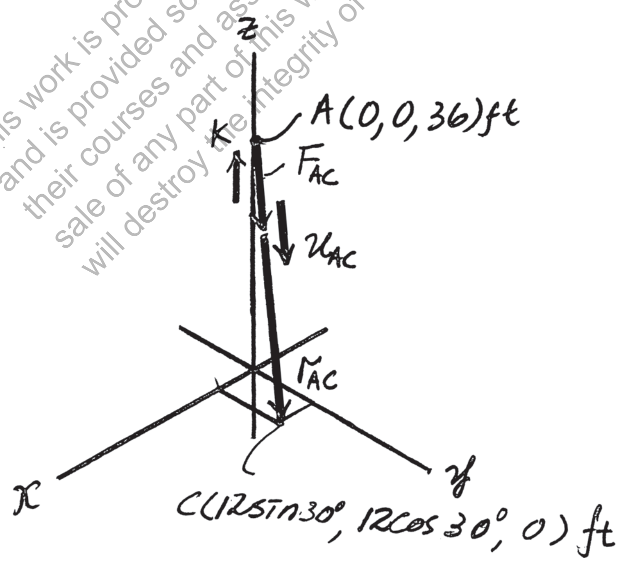
$$(F_{AC})_z = \mathbf{F}_{AC} \cdot \mathbf{k} = \big(94.87\mathbf{i} + 164.32\mathbf{j} - 569.21\mathbf{k}\big) \cdot \mathbf{k}$$

$$= -569 \text{ lb}$$

The negative sign indicates that $(\mathbf{F}_{AC})_z$ is directed towards the negative z axis. Thus

$$(F_{AC})_z = 569 \text{ lb} \qquad \textbf{Ans.}$$

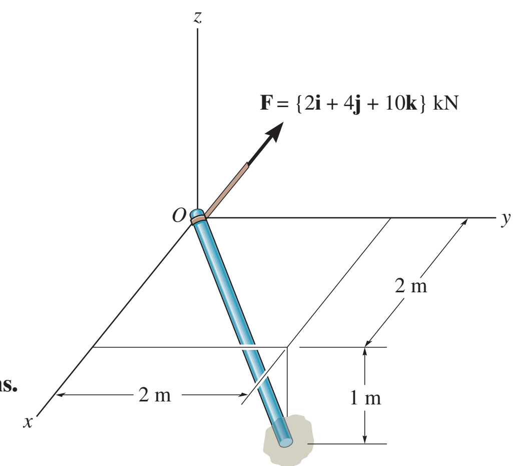
This work is protected by United States copyright laws and is provided solely for the use of instructors in teaching their courses and assessing student learning. Dissemination or sale of any part of this work (including on the World Wide Web) will destroy the integrity of the work and is not permitted.



© 2013 Pearson Education, Inc., Upper Saddle River, NJ. All rights reserved. This publication is protected by
Copyright and written permission should be obtained from the publisher prior to any prohibited reproduction, storage in a retrieval system,
or transmission in any form or by any means, electronic, mechanical,
photocopying, recording, or likewise. For information regarding permission(s), write to:
Rights and Permissions Department, Pearson Education, Inc., Upper Saddle River, NJ 07458.

2–118.

Determine the projection of the force **F** along the pole.



SOLUTION

$$\text{Proj } F = \mathbf{F} \cdot \mathbf{u}_a = (2\,\mathbf{i} + 4\,\mathbf{j} + 10\,\mathbf{k}) \cdot \left(\frac{2}{3}\mathbf{i} + \frac{2}{3}\mathbf{j} - \frac{1}{3}\mathbf{k}\right)$$

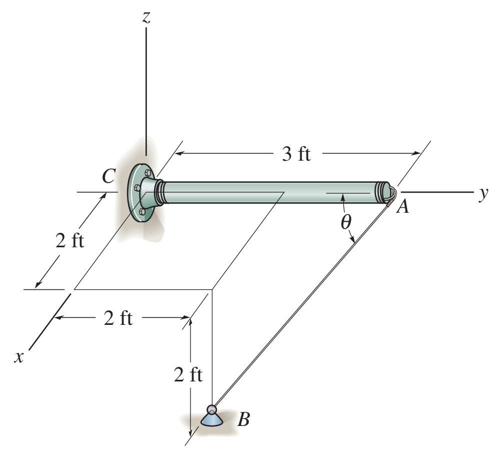
$$\text{Proj } F = 0.667 \text{ kN}$$ **Ans.**

This work is protected by United States copyright laws and is provided solely for the use of instructors in teaching their courses and assessing student learning. Dissemination or sale of any part of this work (including on the World Wide Web) will destroy the integrity of the work and is not permitted.

© 2013 Pearson Education, Inc., Upper Saddle River, NJ. All rights reserved. This publication is protected by Copyright and written permission should be obtained from the publisher prior to any prohibited reproduction, storage in a retrieval system, or transmission in any form or by any means, electronic, mechanical, photocopying, recording, or likewise. For information regarding permission(s), write to: Rights and Permissions Department, Pearson Education, Inc., Upper Saddle River, NJ 07458.

2–119.

Determine the angle θ between the y axis of the pole and the wire AB.



SOLUTION

Position Vector:

$$\mathbf{r}_{AC} = \{-3\mathbf{j}\} \text{ ft}$$

$$\mathbf{r}_{AB} = \{(2-0)\mathbf{i} + (2-3)\mathbf{j} + (-2-0)\mathbf{k}\} \text{ ft}$$

$$= \{2\mathbf{i} - 1\mathbf{j} - 2\mathbf{k}\} \text{ ft}$$

The magnitudes of the position vectors are

$$r_{AC} = 3.00 \text{ ft} \qquad r_{AB} = \sqrt{2^2 + (-1)^2 + (-2)^2} = 3.00 \text{ ft}$$

The Angles Between Two Vectors θ: The dot product of two vectors must be determined first.

$$\mathbf{r}_{AC} \cdot \mathbf{r}_{AB} = (-3\mathbf{j}) \cdot (2\mathbf{i} - 1\mathbf{j} - 2\mathbf{k})$$

$$= 0(2) + (-3)(-1) + 0(-2)$$

$$= 3$$

Then,

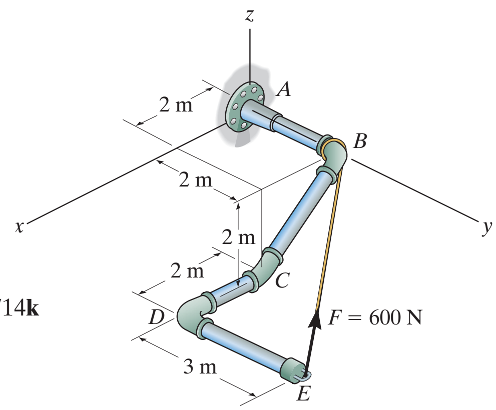
$$\theta = \cos^{-1}\left(\frac{\mathbf{r}_{AO} \cdot \mathbf{r}_{AB}}{r_{AO} r_{AB}}\right) = \cos^{-1}\left[\frac{3}{3.00(3.00)}\right] = 70.5° \qquad \textbf{Ans.}$$

This work is protected by United States copyright laws and is provided solely for the use of instructors in teaching their courses and assessing student learning. Dissemination or sale of any part of this work (including on the World Wide Web) will destroy the integrity of the work and is not permitted.

© 2013 Pearson Education, Inc., Upper Saddle River, NJ. All rights reserved. This publication is protected by Copyright and written permission should be obtained from the publisher prior to any prohibited reproduction, storage in a retrieval system, or transmission in any form or by any means, electronic, mechanical, photocopying, recording, or likewise. For information regarding permission(s), write to: Rights and Permissions Department, Pearson Education, Inc., Upper Saddle River, NJ 07458.

***2–120.**

Determine the magnitudes of the components of $F = 600$ N acting along and perpendicular to segment DE of the pipe assembly.



SOLUTION

Unit Vectors: The unit vectors $\mathbf{u}_{EB}$ and $\mathbf{u}_{ED}$ must be determined first. From Fig. a,

$$\mathbf{u}_{EB} = \frac{\mathbf{r}_{EB}}{r_{EB}} = \frac{(0-4)\mathbf{i} + (2-5)\mathbf{j} + [0-(-2)]\mathbf{k}}{\sqrt{(0-4)^2 + (2-5)^2 + [0-(-2)]^2}} = -0.7428\mathbf{i} - 0.5571\mathbf{j} + 0.3714\mathbf{k}$$

$$\mathbf{u}_{ED} = -\mathbf{j}$$

Thus, the force vector $\mathbf{F}$ is given by

$$\mathbf{F} = F\mathbf{u}_{EB} = 600\left(-0.7428\mathbf{i} - 0.5571\mathbf{j} + 0.3714\mathbf{k}\right) = [-445.66\mathbf{i} - 334.25\mathbf{j} + 222.83\mathbf{k}]\text{ N}$$

Vector Dot Product: The magnitude of the component of $\mathbf{F}$ parallel to segment DE of the pipe assembly is

$$(F_{ED})_{\text{paral}} = \mathbf{F}\cdot\mathbf{u}_{ED} = \left(-445.66\mathbf{i} - 334.25\mathbf{j} + 222.83\mathbf{k}\right)\cdot\left(-\mathbf{j}\right)$$

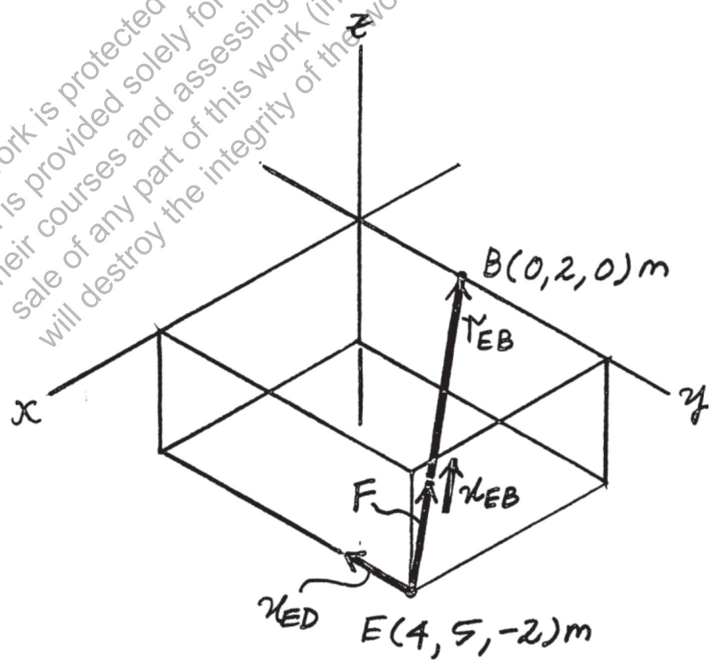
$$= (-445.66)(0) + (-334.25)(-1) + (222.83)(0)$$

$$= 334.25 = 334\text{ N} \qquad \textbf{Ans.}$$

The component of $\mathbf{F}$ perpendicular to segment DE of the pipe assembly is

$$(F_{ED})_{\text{per}} = \sqrt{F^2 - (F_{ED})_{\text{paral}}{}^2} = \sqrt{600^2 - 334.25^2} = 498\text{ N} \qquad \textbf{Ans.}$$

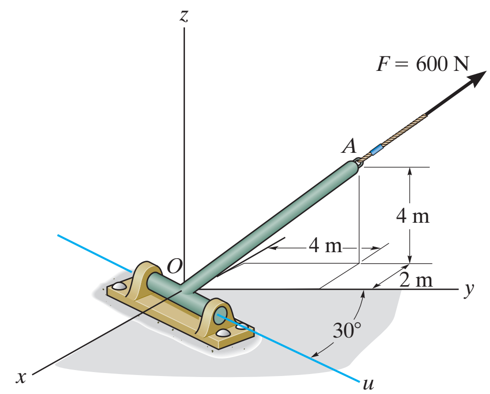
This work is protected by United States copyright laws and is provided solely for the use of instructors in teaching their courses and assessing student learning. Dissemination or sale of any part of this work (including on the World Wide Web) will destroy the integrity of the work and is not permitted.



© 2013 Pearson Education, Inc., Upper Saddle River, NJ. All rights reserved. This publication is protected by Copyright and written permission should be obtained from the publisher prior to any prohibited reproduction, storage in a retrieval system, or transmission in any form or by any means, electronic, mechanical, photocopying, recording, or likewise. For information regarding permission(s), write to: Rights and Permissions Department, Pearson Education, Inc., Upper Saddle River, NJ 07458.

2–121.

Determine the magnitude of the projection of force $F = 600$ N along the u axis.



SOLUTION

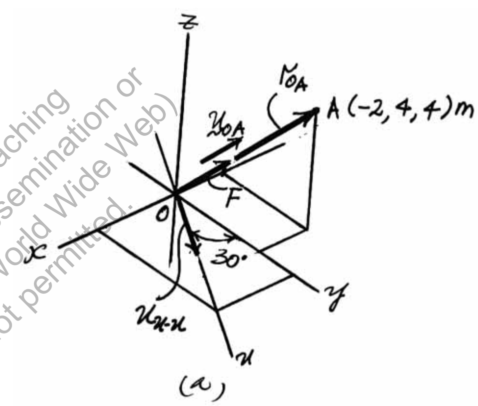
Unit Vectors: The unit vectors $\mathbf{u}_{OA}$ and $\mathbf{u}_u$ must be determined first. From Fig. *a*,

$$\mathbf{u}_{OA} = \frac{\mathbf{r}_{OA}}{r_{OA}} = \frac{(-2-0)\mathbf{i} + (4-0)\mathbf{j} + (4-0)\mathbf{k}}{\sqrt{(-2-0)^2 + (4-0)^2 + (4-0)^2}} = -\frac{1}{3}\mathbf{i} + \frac{2}{3}\mathbf{j} + \frac{2}{3}\mathbf{k}$$

$$\mathbf{u}_u = \sin 30°\mathbf{i} + \cos 30°\mathbf{j}$$

Thus, the force vectors $\mathbf{F}$ is given by

$$\mathbf{F} = F\mathbf{u}_{OA} = 600\left(-\frac{1}{3}\mathbf{i} - \frac{2}{3}\mathbf{j} + \frac{2}{3}\mathbf{k}\right) = \{-200\mathbf{i} + 400\mathbf{j} + 400\mathbf{k}\} \text{ N}$$



Vector Dot Product: The magnitude of the projected component of $\mathbf{F}$ along the u axis is

$$F_u = F \cdot \mathbf{u}_u = (-200\mathbf{i} + 400\mathbf{j} + 400\mathbf{k}) \cdot (\sin 30°\mathbf{i} + \cos 30°\mathbf{j})$$

$$= (-200)(\sin 30°) + 400(\cos 30°) + 400(0)$$

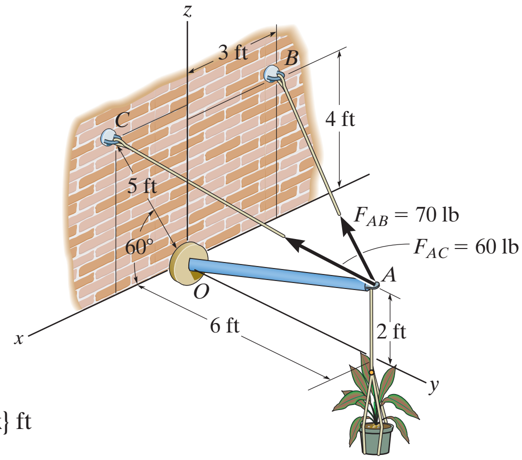
$$= 246 \text{ N}$$ **Ans.**

This work is protected by United States copyright laws and is provided solely for the use of instructors in teaching their courses and assessing student learning. Dissemination or sale of any part of this work (including on the World Wide Web) will destroy the integrity of the work and is not permitted.

© 2013 Pearson Education, Inc., Upper Saddle River, NJ. All rights reserved. This publication is protected by Copyright and written permission should be obtained from the publisher prior to any prohibited reproduction, storage in a retrieval system, or transmission in any form or by any means, electronic, mechanical, photocopying, recording, or likewise. For information regarding permission(s), write to: Rights and Permissions Department, Pearson Education, Inc., Upper Saddle River, NJ 07458.

2–122.

Determine the angle θ between cables AB and AC.



SOLUTION

Position Vectors: The position vectors $\mathbf{r}_{AB}$ and $\mathbf{r}_{AC}$ must be determined first. From Fig. *a*,

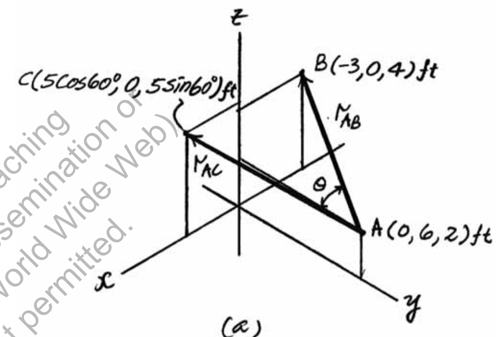
$$\mathbf{r}_{AB} = (-3 - 0)\mathbf{i} + (0 - 6)\mathbf{j} + (4 - 2)\mathbf{k} = \{-3\mathbf{i} - 6\mathbf{j} + 2\mathbf{k}\}\text{ ft}$$

$$\mathbf{r}_{AC} = (5\cos 60^\circ - 0)\mathbf{i} + (0 - 6)\mathbf{j} + (5\sin 60^\circ - 2)\mathbf{k} = \{2.5\mathbf{i} - 6\mathbf{j} + 2.330\mathbf{k}\}\text{ ft}$$

The magnitudes of $\mathbf{r}_{AB}$ and $\mathbf{r}_{AC}$ are

$$r_{AB} = \sqrt{(-3)^2 + (-6)^2} = 7\text{ ft}$$

$$r_{AC} = \sqrt{2.5^2 + (-6)^2 + 2.330^2} = 6.905\text{ ft}$$



Vector Dot Product:

$$\mathbf{r}_{AB}\cdot\mathbf{r}_{AC} = (-3\mathbf{i} - 6\mathbf{j} + 2\mathbf{k})\cdot(2.5\mathbf{i} - 6\mathbf{j} + 2.330\mathbf{k})$$

$$= (-3)(2.5) + (-6)(-6) + (2)(2.330)$$

$$= 33.160\text{ ft}^2$$

Thus,

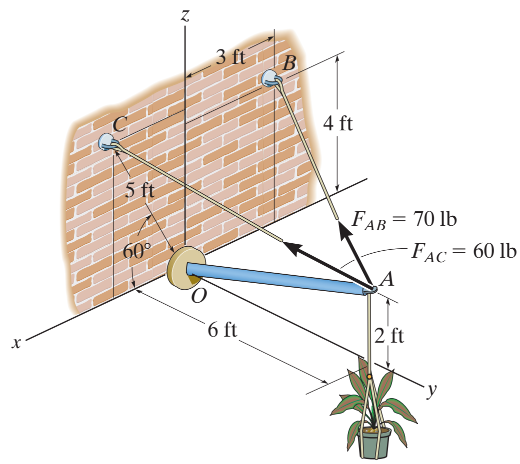
$$\theta = \cos^{-1}\left(\frac{\mathbf{r}_{AB}\cdot\mathbf{r}_{AC}}{r_{AB}\,r_{AC}}\right) = \cos^{-1}\left[\frac{33.160}{7(6.905)}\right] = 46.7^\circ \qquad \textbf{Ans.}$$

This work is protected by United States copyright laws and is provided solely for the use of instructors in teaching their courses and assessing student learning. Dissemination or sale of any part of this work (including on the World Wide Web) will destroy the integrity of the work and is not permitted.

© 2013 Pearson Education, Inc., Upper Saddle River, NJ. All rights reserved. This publication is protected by Copyright and written permission should be obtained from the publisher prior to any prohibited reproduction, storage in a retrieval system, or transmission in any form or by any means, electronic, mechanical, photocopying, recording, or likewise. For information regarding permission(s), write to: Rights and Permissions Department, Pearson Education, Inc., Upper Saddle River, NJ 07458.

2–123.

Determine the angle ϕ between cable AC and strut AO.



SOLUTION

Position Vectors: The position vectors $\mathbf{r}_{AC}$ and $\mathbf{r}_{AO}$ must be determined first. From Fig. *a*,

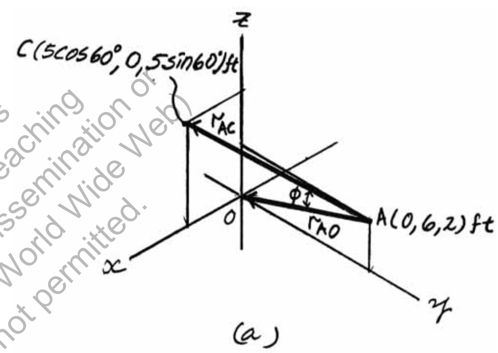
$$\mathbf{r}_{AC} = (5\cos 60^\circ - 0)\mathbf{i} + (0 - 6)\mathbf{j} + (5\sin 60^\circ - 2)\mathbf{k} = \{2.5\mathbf{i} - 6\mathbf{j} + 2.330\mathbf{k}\}\text{ ft}$$

$$\mathbf{r}_{AO} = (0 - 0)\mathbf{i} + (0 - 6)\mathbf{j} + (0 - 2)\mathbf{k} = \{-6\mathbf{j} - 2\mathbf{k}\}\text{ ft}$$

The magnitudes of $\mathbf{r}_{AC}$ and $\mathbf{r}_{AO}$ are

$$\mathbf{r}_{AC} = \sqrt{2.5^2 + (-6)^2 + 2.330^2} = 6.905\text{ ft}$$

$$\mathbf{r}_{AO} = \sqrt{(-6)^2 + (-2)^2} = \sqrt{40}\text{ ft}$$



Vector Dot Product:

$$\mathbf{r}_{AC}\cdot\mathbf{r}_{AO} = (2.5\mathbf{i} - 6\mathbf{j} + 2.330\mathbf{k})\cdot(-6\mathbf{j} - 2\mathbf{k})$$

$$= (2.5)(0) + (-6)(-6) + (2)(2.330)(-2)$$

$$= 31.34\text{ ft}^2$$

Thus,

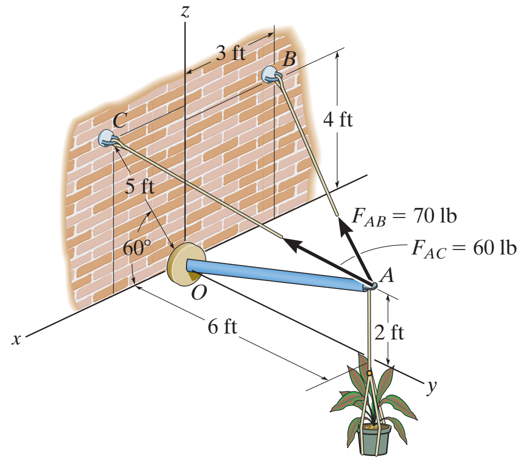
$$\phi = \cos^{-1}\left(\frac{\mathbf{r}_{AC}\cdot\mathbf{r}_{AO}}{\mathbf{r}_{AC}\,\mathbf{r}_{AO}}\right) = \cos^{-1}\left[\frac{31.34}{6.905\sqrt{40}}\right] = 44.1^\circ \quad \textbf{Ans.}$$

This work is protected by United States copyright laws and is provided solely for the use of instructors in teaching their courses and assessing student learning. Dissemination or sale of any part of this work (including on the World Wide Web) will destroy the integrity of the work and is not permitted.

© 2013 Pearson Education, Inc., Upper Saddle River, NJ. All rights reserved. This publication is protected by Copyright and written permission should be obtained from the publisher prior to any prohibited reproduction, storage in a retrieval system, or transmission in any form or by any means, electronic, mechanical, photocopying, recording, or likewise. For information regarding permission(s), write to: Rights and Permissions Department, Pearson Education, Inc., Upper Saddle River, NJ 07458.

***2–124.**

Determine the projected component of force $\mathbf{F}_{AB}$ along the axis of strut AO. Express the result as a Cartesian vector.

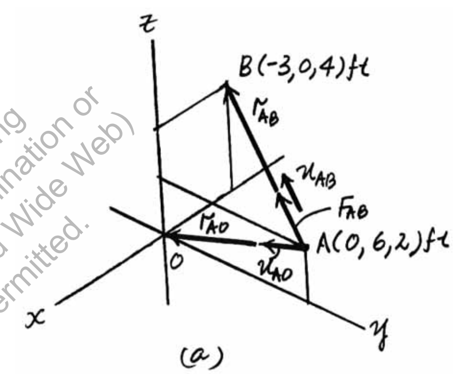


SOLUTION

Unit Vectors: The unit vectors $\mathbf{u}_{AB}$ and $\mathbf{u}_{AO}$ must be determined first. From Fig. *a*,

$$\mathbf{u}_{AB} = \frac{(-3-0)\mathbf{i} + (0-6)\mathbf{j} + (4-2)\mathbf{k}}{\sqrt{(-3-0)^2 + (0-6)^2 + (4-2)^2}} = -\frac{3}{7}\mathbf{i} - \frac{6}{7}\mathbf{j} + \frac{2}{7}\mathbf{k}$$

$$\mathbf{u}_{AO} = \frac{(0-0)\mathbf{i} + (0-6)\mathbf{j} + (0-2)\mathbf{k}}{\sqrt{(0-0)^2 + (0-6)^2 + (0-2)^2}} = -0.9487\mathbf{j} - 0.3162\,\mathbf{k}$$



Thus, the force vectors $\mathbf{F}_{AB}$ is

$$\mathbf{F}_{AB} = F_{AB}\mathbf{u}_{AB} = 70\left(-\frac{3}{7}\mathbf{i} - \frac{6}{7}\mathbf{j} + \frac{2}{7}\mathbf{k}\right) = \{-30\mathbf{i} - 60\mathbf{j} + 20\mathbf{k}\}\text{ lb}$$

Vector Dot Product: The magnitude of the projected component of $\mathbf{F}_{AB}$ along strut AO is

$$(F_{AB})_{AO} = \mathbf{F}_{AB}\cdot\mathbf{u}_{AO} = (-30\mathbf{i} - 60\mathbf{j} + 20\mathbf{k})\cdot(-0.9487\mathbf{j} - 0.3162\mathbf{k})$$

$$= (-30)(0) + (-60)(-0.9487) + (20)(-0.3162)$$

$$= 50.596\text{ lb}$$

Thus, $(\mathbf{F}_{AB})_{AO}$ expressed in Cartesian vector form can be written as

$$(\mathbf{F}_{AB})_{AO} = (F_{AB})_{AO}\mathbf{u}_{AO} = 50.596(-0.9487\mathbf{j} - 0.3162\mathbf{k})$$

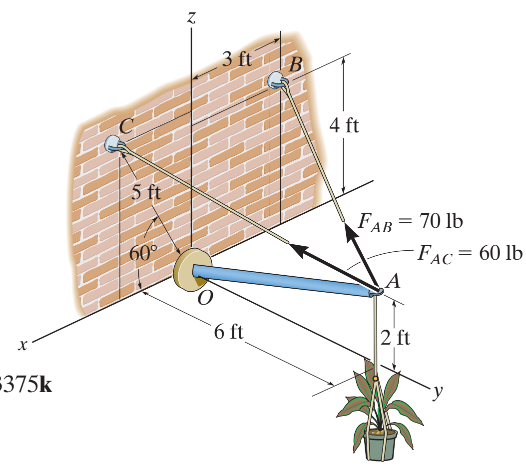
$$= \{-48\mathbf{j} - 16\mathbf{k}\}\text{ lb}$$ **Ans.**

This work is protected by United States copyright laws and is provided solely for the use of instructors in teaching their courses and assessing student learning. Dissemination or sale of any part of this work (including on the World Wide Web) will destroy the integrity of the work and is not permitted.

© 2013 Pearson Education, Inc., Upper Saddle River, NJ. All rights reserved. This publication is protected by Copyright and written permission should be obtained from the publisher prior to any prohibited reproduction, storage in a retrieval system, or transmission in any form or by any means, electronic, mechanical, photocopying, recording, or likewise. For information regarding permission(s), write to: Rights and Permissions Department, Pearson Education, Inc., Upper Saddle River, NJ 07458.

2–125.

Determine the projected component of force $\mathbf{F}_{AC}$ along the axis of strut AO. Express the result as a Cartesian vector.

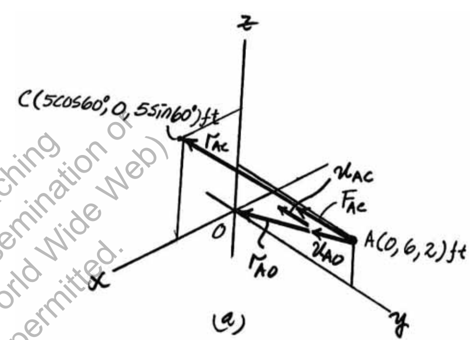


SOLUTION

Unit Vectors: The unit vectors $\mathbf{u}_{AC}$ and $\mathbf{u}_{AO}$ must be determined first. From Fig. *a*,

$$\mathbf{u}_{AC} = \frac{(5\cos 60° - 0)\mathbf{i} + (0-6)\mathbf{j} + (5\sin 60° - 2)\mathbf{k}}{\sqrt{(5\cos 60° - 0)^2 + (0-6)^2 + (0-2)^2}} = 0.3621\mathbf{i} - 0.8689\mathbf{j} + 0.3375\mathbf{k}$$

$$\mathbf{u}_{AO} = \frac{(0-0)\mathbf{i} + (0-6)\mathbf{j} + (0-2)\mathbf{k}}{\sqrt{(0-0)^2 + (0-6)^2 + (0-2)^2}} = -0.9487\mathbf{j} - 0.3162\,\mathbf{k}$$



Thus, the force vectors $\mathbf{F}_{AC}$ is given by

$$\mathbf{F}_{AC} = F_{AC}\mathbf{u}_{AC} = 60(0.3621\mathbf{i} - 0.8689\mathbf{j} + 0.3375\mathbf{k}) = \{21.72\mathbf{i} - 52.14\mathbf{j} + 20.25\mathbf{k}\}\text{ lb}$$

Vector Dot Product: The magnitude of the projected component of $\mathbf{F}_{AC}$ along strut AO is

$$\begin{aligned}(F_{AC})_{AO} = \mathbf{F}_{AC}\cdot\mathbf{u}_{AO} &= (21.72\mathbf{i} - 52.14\mathbf{j} + 20.25\mathbf{k})\cdot(-0.9487\mathbf{j} - 0.3162\mathbf{k}) \\ &= (21.72)(0) + (-52.14)(-0.9487) + (20.25)(-0.3162) \\ &= 43.057\text{ lb}\end{aligned}$$

Thus, $(\mathbf{F}_{AC})_{AO}$ expressed in Cartesian vector form can be written as

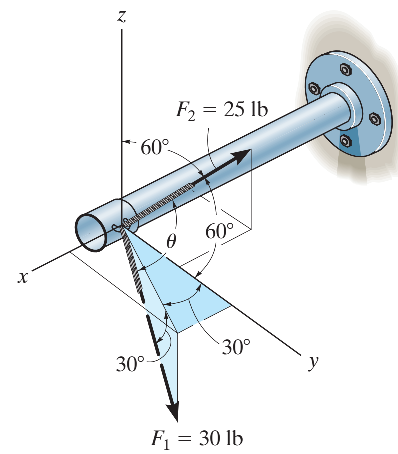
$$\begin{aligned}(\mathbf{F}_{AC})_{AO} = (F_{AC})_{AO}\mathbf{u}_{AO} &= 43.057(-0.9487\mathbf{j} - 0.3162\mathbf{k}) \\ &= \{-40.8\mathbf{j} - 13.6\mathbf{k}\}\text{ lb}\end{aligned}$$ **Ans.**

This work is protected by United States copyright laws and is provided solely for the use of instructors in teaching their courses and assessing student learning. Dissemination or sale of any part of this work (including on the World Wide Web) will destroy the integrity of the work and is not permitted.

© 2013 Pearson Education, Inc., Upper Saddle River, NJ. All rights reserved. This publication is protected by Copyright and written permission should be obtained from the publisher prior to any prohibited reproduction, storage in a retrieval system, or transmission in any form or by any means, electronic, mechanical, photocopying, recording, or likewise. For information regarding permission(s), write to: Rights and Permissions Department, Pearson Education, Inc., Upper Saddle River, NJ 07458.

2–126.

Two cables exert forces on the pipe. Determine the magnitude of the projected component of $\mathbf{F}_1$ along the line of action of $\mathbf{F}_2$.



SOLUTION

Force Vector:

$$\mathbf{u}_{F_1} = \cos 30° \sin 30°\mathbf{i} + \cos 30° \cos 30°\mathbf{j} - \sin 30°\mathbf{k}$$

$$= 0.4330\mathbf{i} + 0.75\mathbf{j} - 0.5\mathbf{k}$$

$$\mathbf{F}_1 = F_R\mathbf{u}_{F_1} = 30(0.4330\mathbf{i} + 0.75\mathbf{j} - 0.5\mathbf{k})\text{ lb}$$

$$= \{12.990\mathbf{i} + 22.5\mathbf{j} - 15.0\mathbf{k}\}\text{ lb}$$

Unit Vector: One can obtain the angle $\alpha = 135°$ for $\mathbf{F}_2$ using Eq. 2–8. $\cos^2\alpha + \cos^2\beta + \cos^2\gamma = 1$, with $\beta = 60°$ and $\gamma = 60°$. The unit vector along the line of action of $\mathbf{F}_2$ is

$$\mathbf{u}_{F_2} = \cos 135°\mathbf{i} + \cos 60°\mathbf{j} + \cos 60°\mathbf{k} = -0.7071\mathbf{i} + 0.5\mathbf{j} + 0.5\mathbf{k}$$

***Projected Component of* $\mathbf{F}_1$ *Along the Line of Action of* $\mathbf{F}_2$:**

$$(F_1)_{F_2} = \mathbf{F}_1 \cdot \mathbf{u}_{F_2} = (12.990\mathbf{i} + 22.5\mathbf{j} - 15.0\mathbf{k}) \cdot (-0.7071\mathbf{i} + 0.5\mathbf{j} + 0.5\mathbf{k})$$

$$= (12.990)(-0.7071) + (22.5)(0.5) + (-15.0)(0.5)$$

$$= -5.44\text{ lb}$$

Negative sign indicates that the projected component of $(F_1)_{F_2}$ acts in the opposite sense of direction to that of $\mathbf{u}_{F_2}$.

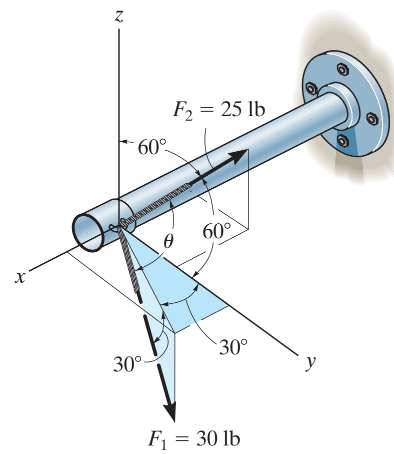
The magnitude is $(F_1)_{F_2} = 5.44$ lb **Ans.**

This work is protected by United States copyright laws and is provided solely for the use of instructors in teaching their courses and assessing student learning. Dissemination or sale of any part of this work (including on the World Wide Web) will destroy the integrity of the work and is not permitted.

© 2013 Pearson Education, Inc., Upper Saddle River, NJ. All rights reserved. This publication is protected by Copyright and written permission should be obtained from the publisher prior to any prohibited reproduction, storage in a retrieval system, or transmission in any form or by any means, electronic, mechanical, photocopying, recording, or likewise. For information regarding permission(s), write to: Rights and Permissions Department, Pearson Education, Inc., Upper Saddle River, NJ 07458.

2–127.

Determine the angle θ between the two cables attached to the pipe.



SOLUTION

Unit Vectors:

$$\mathbf{u}_{F_1} = \cos 30^\circ \sin 30^\circ \mathbf{i} + \cos 30^\circ \cos 30^\circ \mathbf{j} - \sin 30^\circ \mathbf{k}$$

$$= 0.4330\mathbf{i} + 0.75\mathbf{j} - 0.5\mathbf{k}$$

$$\mathbf{u}_{F_2} = \cos 135^\circ \mathbf{i} + \cos 60^\circ \mathbf{j} + \cos 60^\circ \mathbf{k}$$

$$= -0.7071\mathbf{i} + 0.5\mathbf{j} + 0.5\mathbf{k}$$

The Angles Between Two Vectors θ:

$$\mathbf{u}_{F_1} \cdot \mathbf{u}_{F_2} = (0.4330\mathbf{i} + 0.75\mathbf{j} - 0.5\mathbf{k}) \cdot (-0.7071\mathbf{i} + 0.5\mathbf{j} + 0.5\mathbf{k})$$

$$= 0.4330(-0.7071) + 0.75(0.5) + (-0.5)(0.5)$$

$$= -0.1812$$

Then,

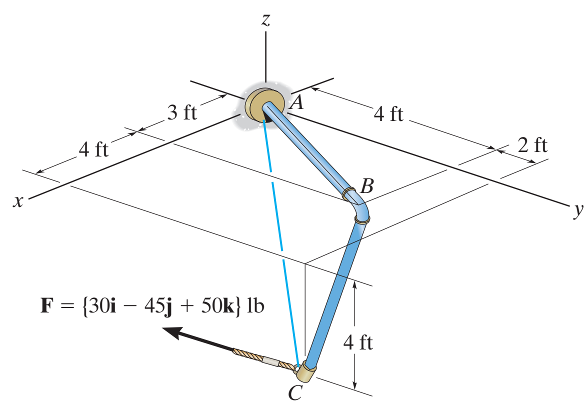
$$\theta = \cos^{-1}\left(\mathbf{u}_{F_1} \cdot \mathbf{u}_{F_2}\right) = \cos^{-1}(-0.1812) = 100^\circ \qquad \textbf{Ans.}$$

This work is protected by United States copyright laws and is provided solely for the use of instructors in teaching their courses and assessing student learning. Dissemination or sale of any part of this work (including on the World Wide Web) will destroy the integrity of the work and is not permitted.

© 2013 Pearson Education, Inc., Upper Saddle River, NJ. All rights reserved. This publication is protected by
Copyright and written permission should be obtained from the publisher prior to any prohibited reproduction, storage in a retrieval system,
or transmission in any form or by any means, electronic, mechanical,
photocopying, recording, or likewise. For information regarding permission(s), write to:
Rights and Permissions Department, Pearson Education, Inc., Upper Saddle River, NJ 07458.

***2–128.**

Determine the magnitudes of the components of **F** acting along and perpendicular to segment BC of the pipe assembly.



SOLUTION

Unit Vector: The unit vector $\mathbf{u}_{CB}$ must be determined first. From Fig. *a*

$$\mathbf{u}_{CB} = \frac{\mathbf{r}_{CB}}{r_{CB}} = \frac{(3-7)\mathbf{i} + (4-6)\mathbf{j} + [0-(-4)]\mathbf{k}}{\sqrt{(3-7)^2 + (4-6)^2 + [0-(-4)]^2}} = -\frac{2}{3}\mathbf{i} - \frac{1}{3}\mathbf{j} + \frac{2}{3}\mathbf{k}$$

Vector Dot Product: The magnitude of the projected component of **F** parallel to segment BC of the pipe assembly is

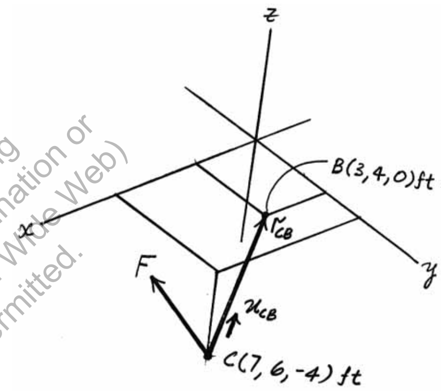
$$(F_{BC})_{pa} = \mathbf{F}\cdot\mathbf{u}_{CB} = (30\mathbf{i} - 45\mathbf{j} + 50\mathbf{k})\cdot\left(-\frac{2}{3}\mathbf{i} - \frac{1}{3}\mathbf{j} + \frac{2}{3}\mathbf{k}\right)$$

$$= (30)\left(-\frac{2}{3}\right) + (-45)\left(-\frac{1}{3}\right) + 50\left(\frac{2}{3}\right)$$

$$= 28.33 \text{ lb} = 28.3 \text{ lb} \qquad \textbf{Ans.}$$

The magnitude of **F** is $F = \sqrt{30^2 + (-45)^2 + 50^2} = \sqrt{5425}$ lb. Thus, the magnitude of the component of **F** perpendicular to segment BC of the pipe assembly can be determined from

$$(F_{BC})_{pr} = \sqrt{F^2 - (F_{BC})_{pa}^2} = \sqrt{5425 - 28.33^2} = 68.0 \text{ lb} \qquad \textbf{Ans.}$$



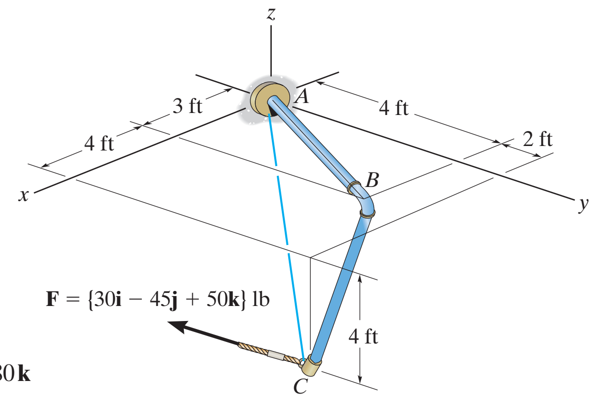
(a)

This work is protected by United States copyright laws and is provided solely for the use of instructors in teaching their courses and assessing student learning. Dissemination or sale of any part of this work (including on the World Wide Web) will destroy the integrity of the work and is not permitted.

© 2013 Pearson Education, Inc., Upper Saddle River, NJ. All rights reserved. This publication is protected by Copyright and written permission should be obtained from the publisher prior to any prohibited reproduction, storage in a retrieval system, or transmission in any form or by any means, electronic, mechanical, photocopying, recording, or likewise. For information regarding permission(s), write to: Rights and Permissions Department, Pearson Education, Inc., Upper Saddle River, NJ 07458.

2–129.

Determine the magnitude of the projected component of **F** along AC. Express this component as a Cartesian vector.



SOLUTION

Unit Vector: The unit vector $\mathbf{u}_{AC}$ must be determined first. From Fig. *a*

$$\mathbf{u}_{AC} = \frac{(7-0)\mathbf{i} + (6-0)\mathbf{j} + (-4-0)\mathbf{k}}{\sqrt{(7-0)^2 + (6-0)^2 + (-4-0)^2}} = 0.6965\,\mathbf{i} + 0.5970\,\mathbf{j} - 0.3980\,\mathbf{k}$$

Vector Dot Product: The magnitude of the projected component of **F** along line AC is

$$F_{AC} = \mathbf{F}\cdot\mathbf{u}_{AC} = (30\mathbf{i} - 45\mathbf{j} + 50\mathbf{k})\cdot(0.6965\mathbf{i} + 0.5970\mathbf{j} - 0.3980\mathbf{k})$$

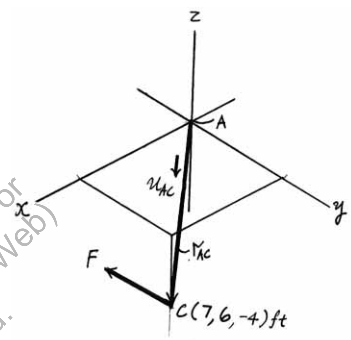
$$= (30)(0.6965) + (-45)(0.5970) + 50(-0.3980)$$

$$= 25.87 \text{ lb}$$ **Ans.**

Thus, $\mathbf{F}_{AC}$ expressed in Cartesian vector form is

$$\mathrm{F}_{AC} = F_{AC}\mathbf{u}_{AC} = -25.87(0.6965\mathbf{i} + 0.5970\mathbf{j} - 0.3980\mathbf{k})$$

$$= \{-18.0\mathbf{i} - 15.4\mathbf{j} + 10.3\mathbf{k}\} \text{ lb}$$ **Ans.**



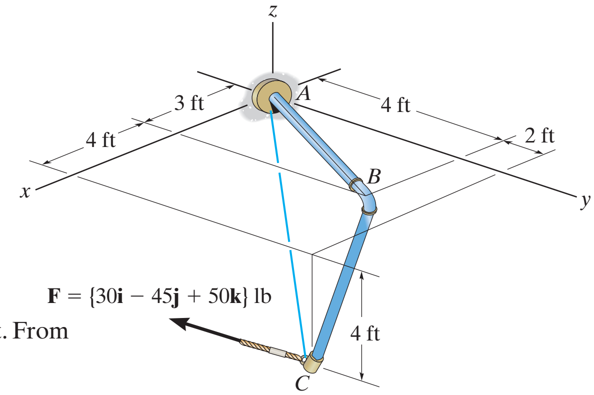
(a)

This work is protected by United States copyright laws and is provided solely for the use of instructors in teaching their courses and assessing student learning. Dissemination or sale of any part of this work (including on the World Wide Web) will destroy the integrity of the work and is not permitted.

© 2013 Pearson Education, Inc., Upper Saddle River, NJ. All rights reserved. This publication is protected by Copyright and written permission should be obtained from the publisher prior to any prohibited reproduction, storage in a retrieval system, or transmission in any form or by any means, electronic, mechanical, photocopying, recording, or likewise. For information regarding permission(s), write to: Rights and Permissions Department, Pearson Education, Inc., Upper Saddle River, NJ 07458.

2–130.

Determine the angle θ between the pipe segments BA and BC.

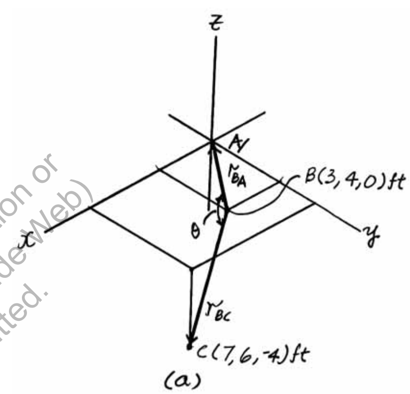


SOLUTION

Position Vectors: The position vectors $\mathbf{r}_{BA}$ and $\mathbf{r}_{BC}$ must be determined first. From Fig. *a*,

$$\mathbf{r}_{BA} = (0-3)\mathbf{i} + (0-4)\mathbf{j} + (0-0)\mathbf{k} = \{-3\mathbf{i} - 4\mathbf{j}\}\text{ ft}$$

$$\mathbf{r}_{BC} = (7-3)\mathbf{i} + (6-4)\mathbf{j} + (-4-0)\mathbf{k} = \{4\mathbf{i} + 2\mathbf{j} - 4\mathbf{k}\}\text{ ft}$$



The magnitude of $\mathbf{r}_{BA}$ and $\mathbf{r}_{BC}$ are

$$r_{BA} = \sqrt{(-3)^2 + (-4)^2} = 5\text{ ft}$$

$$r_{BC} = \sqrt{4^2 + 2^2 + (-4)^2} = 6\text{ ft}$$

Vector Dot Product:

$$\mathbf{r}_{BA}\cdot\mathbf{r}_{BC} = (-3\mathbf{i} - 4\mathbf{j})\cdot(4\mathbf{i} + 2\mathbf{j} - 4\mathbf{k})$$

$$= (-3)(4) + (-4)(2) + 0(-4)$$

$$= -20\text{ ft}^2$$

Thus,

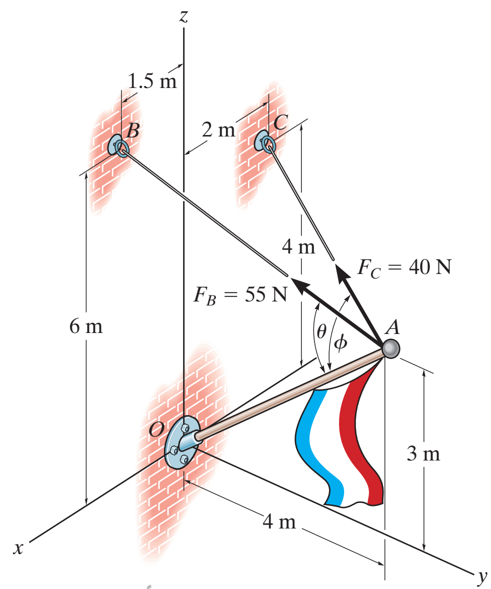
$$\theta = \cos^{-1}\left(\frac{\mathbf{r}_{BA}\cdot\mathbf{r}_{BC}}{r_{BA}\,r_{BC}}\right) = \cos^{-1}\left[\frac{-20}{5(6)}\right] = 132^\circ \qquad \textbf{Ans.}$$

This work is protected by United States copyright laws and is provided solely for the use of instructors in teaching their courses and assessing student learning. Dissemination or sale of any part of this work (including on the World Wide Web) will destroy the integrity of the work and is not permitted.

© 2013 Pearson Education, Inc., Upper Saddle River, NJ. All rights reserved. This publication is protected by Copyright and written permission should be obtained from the publisher prior to any prohibited reproduction, storage in a retrieval system, or transmission in any form or by any means, electronic, mechanical, photocopying, recording, or likewise. For information regarding permission(s), write to: Rights and Permissions Department, Pearson Education, Inc., Upper Saddle River, NJ 07458.

2–131.

Determine the angles θ and ϕ made between the axes OA of the flag pole and AB and AC, respectively, of each cable.



SOLUTION

$\mathbf{r}_{AC} = \{-2\mathbf{i} - 4\mathbf{j} + 1\mathbf{k}\}$ m ; $\qquad r_{AC} = 4.58$ m

$\mathbf{r}_{AB} = \{1.5\mathbf{i} - 4\mathbf{j} + 3\mathbf{k}\}$ m; $\qquad r_{AB} = 5.22$ m

$\mathbf{r}_{AO} = \{-4\mathbf{j} - 3\mathbf{k}\}$ m; $\qquad r_{AO} = 5.00$ m

$$\mathbf{r}_{AB} \cdot \mathbf{r}_{AO} = (1.5)(0) + (-4)(-4) + (3)(-3) = 7$$

$$\theta = \cos^{-1}\left(\frac{\mathbf{r}_{AB} \cdot \mathbf{r}_{AO}}{r_{AB}\, r_{AO}}\right)$$

$$= \cos^{-1}\left(\frac{7}{5.22(5.00)}\right) = 74.4° \qquad \textbf{Ans.}$$

$$\mathbf{r}_{AC} \cdot \mathbf{r}_{AO} = (-2)(0) + (-4)(-4) + (1)(-3) = 13$$

$$\phi = \cos^{-1}\left(\frac{\mathbf{r}_{AC} \cdot \mathbf{r}_{AO}}{r_{AC}\, r_{AO}}\right)$$

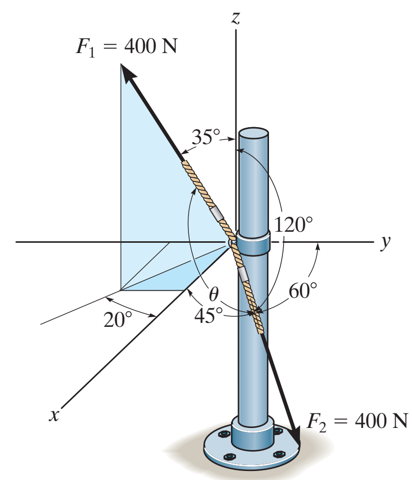
$$= \cos^{-1}\left(\frac{13}{4.58(5.00)}\right) = 55.4° \qquad \textbf{Ans.}$$

This work is protected by United States copyright laws and is provided solely for the use of instructors in teaching their courses and assessing student learning. Dissemination or sale of any part of this work (including on the World Wide Web) will destroy the integrity of the work and is not permitted.

© 2013 Pearson Education, Inc., Upper Saddle River, NJ. All rights reserved. This publication is protected by Copyright and written permission should be obtained from the publisher prior to any prohibited reproduction, storage in a retrieval system, or transmission in any form or by any means, electronic, mechanical, photocopying, recording, or likewise. For information regarding permission(s), write to: Rights and Permissions Department, Pearson Education, Inc., Upper Saddle River, NJ 07458.

***2–132.**

The cables each exert a force of 400 N on the post. Determine the magnitude of the projected component of $\mathbf{F}_1$ along the line of action of $\mathbf{F}_2$.



SOLUTION

Force Vector:

$$\mathbf{u}_{F_1} = \sin 35° \cos 20° \mathbf{i} - \sin 35° \sin 20° \mathbf{j} + \cos 35° \mathbf{k}$$

$$= 0.5390\mathbf{i} - 0.1962\mathbf{j} + 0.8192\mathbf{k}$$

$$\mathbf{F}_1 = F_1 \mathbf{u}_{F_1} = 400(0.5390\mathbf{i} - 0.1962\mathbf{j} + 0.8192\mathbf{k}) \text{ N}$$

$$= \{215.59\mathbf{i} - 78.47\mathbf{j} + 327.66\mathbf{k}\} \text{ N}$$

Unit Vector: The unit vector along the line of action of $\mathbf{F}_2$ is

$$\mathbf{u}_{F_2} = \cos 45° \mathbf{i} + \cos 60° \mathbf{j} + \cos 120° \mathbf{k}$$

$$= 0.7071\mathbf{i} + 0.5\mathbf{j} - 0.5\mathbf{k}$$

Projected Component of $\mathbf{F}_1$ Along Line of Action of $\mathbf{F}_2$:

$$(F_1)_{F_2} = \mathbf{F}_1 \cdot \mathbf{u}_{F_2} = (215.59\mathbf{i} - 78.47\mathbf{j} + 327.66\mathbf{k}) \cdot (0.7071\mathbf{i} + 0.5\mathbf{j} - 0.5\mathbf{k})$$

$$= (215.59)(0.7071) + (-78.47)(0.5) + (327.66)(-0.5)$$

$$= -50.6 \text{ N}$$

Negative sign indicates that the force component $(\mathbf{F}_1)F_2$ acts in the opposite sense of direction to that of $\mathbf{u}_{F2}$.

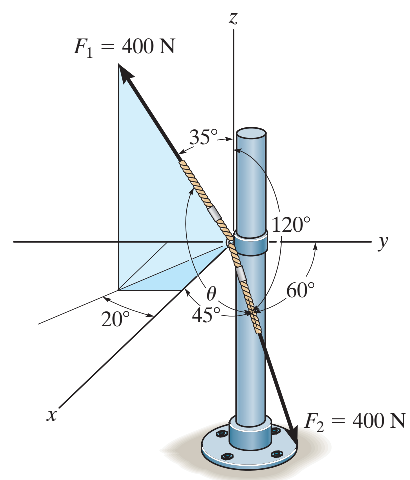
thus the magnitude is $(F_1)_{F_2} = 50.6 \text{ N}$ **Ans.**

This work is protected by United States copyright laws and is provided solely for the use of instructors in teaching their courses and assessing student learning. Dissemination or sale of any part of this work (including on the World Wide Web) will destroy the integrity of the work and is not permitted.

© 2013 Pearson Education, Inc., Upper Saddle River, NJ. All rights reserved. This publication is protected by Copyright and written permission should be obtained from the publisher prior to any prohibited reproduction, storage in a retrieval system, or transmission in any form or by any means, electronic, mechanical, photocopying, recording, or likewise. For information regarding permission(s), write to: Rights and Permissions Department, Pearson Education, Inc., Upper Saddle River, NJ 07458.

2–133.

Determine the angle θ between the two cables attached to the post.



SOLUTION

Unit Vector:

$$\mathbf{u}_{F_1} = \sin 35° \cos 20°\mathbf{i} - \sin 35° \sin 20°\mathbf{j} + \cos 35°\mathbf{k}$$

$$= 0.5390\mathbf{i} - 0.1962\mathbf{j} + 0.8192\mathbf{k}$$

$$\mathbf{u}_{F_2} = \cos 45°\mathbf{i} + \cos 60°\mathbf{j} + \cos 120°\mathbf{k}$$

$$= 0.7071\mathbf{i} + 0.5\mathbf{j} - 0.5\mathbf{k}$$

The Angle Between Two Vectors θ: The dot product of two unit vectors must be determined first.

$$\mathbf{u}_{F_1} \cdot \mathbf{u}_{F_2} = (0.5390\mathbf{i} - 0.1962\mathbf{j} + 0.8192\mathbf{k}) \cdot (0.7071\mathbf{i} + 0.5\mathbf{j} - 0.5\mathbf{k})$$

$$= 0.5390(0.7071) + (-0.1962)(0.5) + 0.8192(-0.5)$$

$$= -0.1265$$

Then,

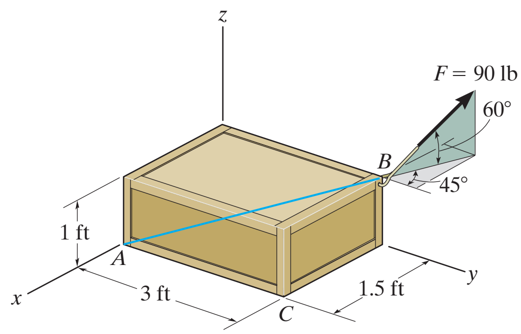
$$\theta = \cos^{-1}\left(\mathbf{u}_{F_1} \cdot \mathbf{u}_{F_2}\right) = \cos^{-1}(-0.1265) = 97.3° \qquad \textbf{Ans.}$$

This work is protected by United States copyright laws and is provided solely for the use of instructors in teaching their courses and assessing student learning. Dissemination or sale of any part of this work (including on the World Wide Web) will destroy the integrity of the work and is not permitted.

© 2013 Pearson Education, Inc., Upper Saddle River, NJ. All rights reserved. This publication is protected by Copyright and written permission should be obtained from the publisher prior to any prohibited reproduction, storage in a retrieval system, or transmission in any form or by any means, electronic, mechanical, photocopying, recording, or likewise. For information regarding permission(s), write to: Rights and Permissions Department, Pearson Education, Inc., Upper Saddle River, NJ 07458.

2–134.

Determine the magnitudes of the components of force $F = 90$ lb acting parallel and perpendicular to diagonal AB of the crate.



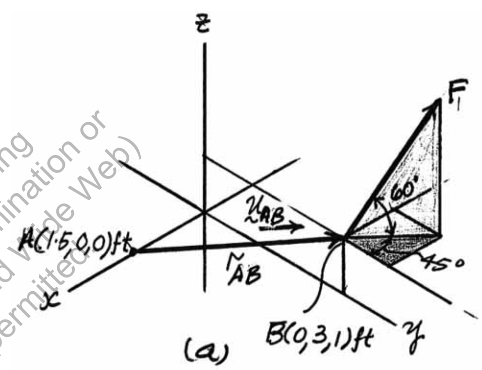
SOLUTION

Force and Unit Vector: The force vector **F** and unit vector $\mathbf{u}_{AB}$ must be determined first. From Fig. *a*

$$\mathbf{F} = 90(-\cos 60^\circ \sin 45^\circ \mathbf{i} + \cos 60^\circ \cos 45^\circ \mathbf{j} + \sin 60^\circ \mathbf{k})$$

$$= \{-31.82\mathbf{i} + 31.82\mathbf{j} + 77.94\mathbf{k}\} \text{ lb}$$

$$\mathbf{u}_{AB} = \frac{\mathbf{r}_{AB}}{r_{AB}} = \frac{(0 - 1.5)\mathbf{i} + (3 - 0)\mathbf{j} + (1 - 0)\mathbf{k}}{\sqrt{(0 - 1.5)^2 + (3 - 0)^2 + (1 - 0)^2}} = -\frac{3}{7}\mathbf{i} - \frac{6}{7}\mathbf{j} + \frac{2}{7}\mathbf{k}$$



Vector Dot Product: The magnitude of the projected component of **F** parallel to the diagonal AB is

$$[(F)_{AB}]_{pa} = \mathbf{F} \cdot \mathbf{u}_{AB} = (-31.82\mathbf{i} + 31.82\mathbf{j} + 77.94\mathbf{k}) \cdot \left(-\frac{3}{7}\mathbf{i} + \frac{6}{7}\mathbf{j} + \frac{2}{7}\mathbf{k}\right)$$

$$= (-31.82)\left(-\frac{3}{7}\right) + 31.82\left(\frac{6}{7}\right) + 77.94\left(\frac{2}{7}\right)$$

$$= 63.18 \text{ lb} = 63.2 \text{ lb}$$ **Ans.**

The magnitude of the component **F** perpendicular to the diagonal AB is

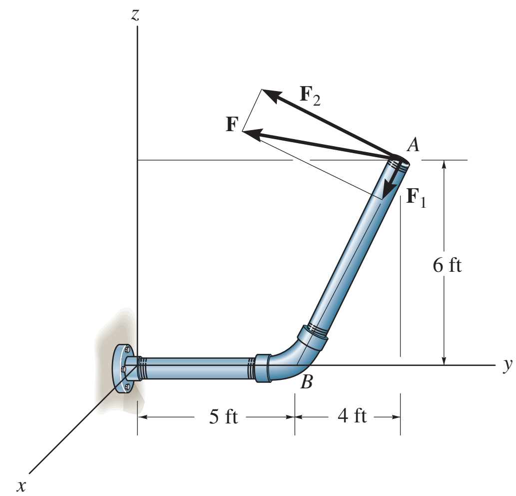
$$[(F)_{AB}]_{pr} = \sqrt{F^2 - [(F)_{AB}]_{pa}{}^2} = \sqrt{90^2 - 63.18^2} = 64.1 \text{ lb}$$ **Ans.**

This work is protected by United States copyright laws and is provided solely for the use of instructors in teaching their courses and assessing student learning. Dissemination or sale of any part of this work (including on the World Wide Web) will destroy the integrity of the work and is not permitted.

© 2013 Pearson Education, Inc., Upper Saddle River, NJ. All rights reserved. This publication is protected by Copyright and written permission should be obtained from the publisher prior to any prohibited reproduction, storage in a retrieval system, or transmission in any form or by any means, electronic, mechanical, photocopying, recording, or likewise. For information regarding permission(s), write to: Rights and Permissions Department, Pearson Education, Inc., Upper Saddle River, NJ 07458.

2–135.

The force $\mathbf{F} = \{25\mathbf{i} - 50\mathbf{j} + 10\mathbf{k}\}$ lb acts at the end A of the pipe assembly. Determine the magnitude of the components $\mathbf{F}_1$ and $\mathbf{F}_2$ which act along the axis of AB and perpendicular to it.



SOLUTION

Unit Vector: The unit vector along AB axis is

$$\mathbf{u}_{AB} = \frac{(0-0)\mathbf{i} + (5-9)\mathbf{j} + (0-6)\mathbf{k}}{\sqrt{(0-0)^2 + (5-9)^2 + (0-6)^2}} = -0.5547\mathbf{j} - 0.8321\mathbf{k}$$

Projected Component of* F *Along AB Axis:

$$F_1 = \mathbf{F}\cdot\mathbf{u}_{AB} = (25\mathbf{i} - 50\mathbf{j} + 10\mathbf{k})\cdot(-0.5547\mathbf{j} - 0.8321\mathbf{k})$$

$$= (25)(0) + (-50)(-0.5547) + (10)(-0.8321)$$

$$= 19.415 \text{ lb} = 19.4 \text{ lb} \qquad \textbf{Ans.}$$

Component of* F *Perpendicular to AB Axis: The magnitude of force **F** is $F = \sqrt{25^2 + (-50)^2 + 10^2} = 56.789$ lb.

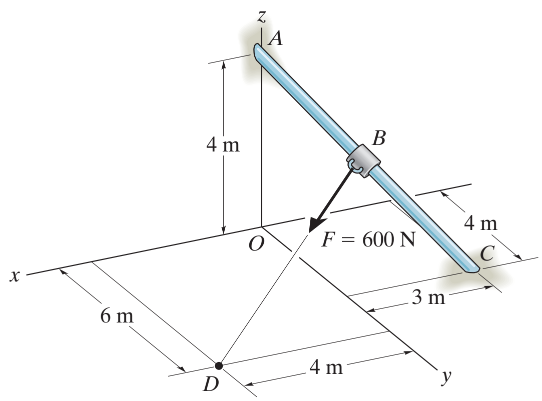
$$F_2 = \sqrt{F^2 - F_1^2} = \sqrt{56.789^2 - 19.414^2} = 53.4 \text{ lb} \qquad \textbf{Ans.}$$

This work is protected by United States copyright laws and is provided solely for the use of instructors in teaching their courses and assessing student learning. Dissemination or sale of any part of this work (including on the World Wide Web) will destroy the integrity of the work and is not permitted.

© 2013 Pearson Education, Inc., Upper Saddle River, NJ. All rights reserved. This publication is protected by Copyright and written permission should be obtained from the publisher prior to any prohibited reproduction, storage in a retrieval system, or transmission in any form or by any means, electronic, mechanical, photocopying, recording, or likewise. For information regarding permission(s), write to: Rights and Permissions Department, Pearson Education, Inc., Upper Saddle River, NJ 07458.

***2–136.**

Determine the components of **F** that act along rod AC and perpendicular to it. Point B is located at the midpoint of the rod.



SOLUTION

$\mathbf{r}_{AC} = (-3\mathbf{i} + 4\mathbf{j} - 4\mathbf{k}), \qquad r_{AC} = \sqrt{(-3)^2 + 4^2 + (-4)^2} = \sqrt{41}\text{ m}$

$$\mathbf{r}_{AB} = \frac{\mathbf{r}_{AC}}{2} = \frac{-3\mathbf{i} + 4\mathbf{j} + 4\mathbf{k}}{2} = -1.5\mathbf{i} + 2\mathbf{j} - 2\mathbf{k}$$

$\mathbf{r}_{AD} = \mathbf{r}_{AB} + \mathbf{r}_{BD}$

$\mathbf{r}_{BD} = \mathbf{r}_{AD} - \mathbf{r}_{AB}$

$= (4\mathbf{i} + 6\mathbf{j} - 4\mathbf{k}) - (-1.5\mathbf{i} + 2\mathbf{j} - 2\mathbf{k})$

$= \{5.5\mathbf{i} + 4\mathbf{j} - 2\mathbf{k}\}\text{ m}$

$r_{BD} = \sqrt{(5.5)^2 + (4)^2 + (-2)^2} = 7.0887\text{ m}$

$$\mathbf{F} = 600\left(\frac{\mathbf{r}_{BD}}{r_{BD}}\right) = 465.528\mathbf{i} + 338.5659\mathbf{j} - 169.2829\mathbf{k}$$

Component of **F** along $\mathbf{r}_{AC}$ is $\mathbf{F}_{||}$

$$F_{||} = \frac{\mathbf{F}\cdot\mathbf{r}_{AC}}{r_{AC}} = \frac{(465.528\mathbf{i} + 338.5659\mathbf{j} - 169.2829\mathbf{k})\cdot(-3\mathbf{i} + 4\mathbf{j} - 4\mathbf{k})}{\sqrt{41}}$$

$F_{||} = 99.1408 = 99.1\text{ N}$ **Ans.**

Component of F perpendicular to $\mathbf{r}_{AC}$ is $F_{\perp}$

$F_{\perp}^2 + F_{||}^2 = F^2 = 600^2$

$F_{\perp}^2 = 600^2 - 99.1408^2$

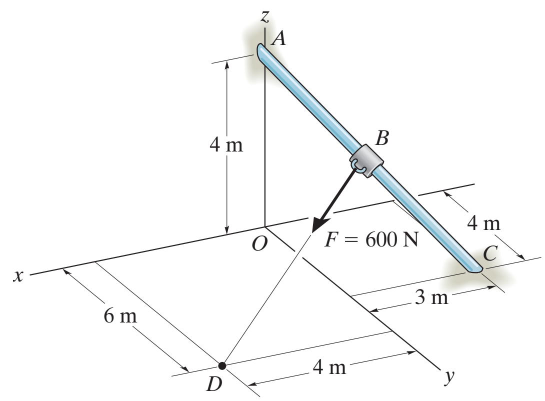
$F_{\perp} = 591.75 = 592\text{ N}$ **Ans.**

This work is protected by United States copyright laws and is provided solely for the use of instructors in teaching their courses and assessing student learning. Dissemination or sale of any part of this work (including on the World Wide Web) will destroy the integrity of the work and is not permitted.

© 2013 Pearson Education, Inc., Upper Saddle River, NJ. All rights reserved. This publication is protected by Copyright and written permission should be obtained from the publisher prior to any prohibited reproduction, storage in a retrieval system, or transmission in any form or by any means, electronic, mechanical, photocopying, recording, or likewise. For information regarding permission(s), write to: Rights and Permissions Department, Pearson Education, Inc., Upper Saddle River, NJ 07458.

2–137.

Determine the components of **F** that act along rod AC and perpendicular to it. Point B is located 3 m along the rod from end C.



SOLUTION

$\mathbf{r}_{CA} = 3\mathbf{i} - 4\mathbf{j} + 4\mathbf{k}$

$r_{CA} = 6.403124$

$$\mathbf{r}_{CB} = \frac{3}{6.403124}(\mathbf{r}_{CA}) = 1.40556\mathbf{i} - 1.874085\mathbf{j} + 1.874085\mathbf{k}$$

$\mathbf{r}_{OB} = \mathbf{r}_{OC} + \mathbf{r}_{CB}$

$= -3\mathbf{i} + 4\mathbf{j} + \mathbf{r}_{CB}$

$= -1.59444\mathbf{i} + 2.1259\mathbf{j} + 1.874085\mathbf{k}$

$\mathbf{r}_{OD} = \mathbf{r}_{OB} + \mathbf{r}_{BD}$

$\mathbf{r}_{BD} = \mathbf{r}_{OD} - \mathbf{r}_{OB} = (4\mathbf{i} + 6\mathbf{j}) - \mathbf{r}_{OB}$

$= 5.5944\mathbf{i} + 3.8741\mathbf{j} - 1.874085\mathbf{k}$

$$r_{BD} = \sqrt{(5.5944)^2 + (3.8741)^2 + (-1.874085)^2} = 7.0582$$

$$\mathbf{F} = 600\left(\frac{\mathbf{r}_{BD}}{r_{BD}}\right) = 475.568\mathbf{i} + 329.326\mathbf{j} - 159.311\mathbf{k}$$

$\mathbf{r}_{AC} = (-3\mathbf{i} + 4\mathbf{j} - 4\mathbf{k}), \qquad r_{AC} = \sqrt{41}$

Component of **F** along $\mathbf{r}_{AC}$ is $\mathbf{F}_{||}$

$$F_{||} = \frac{\mathbf{F}\cdot\mathbf{r}_{AC}}{r_{AC}} = \frac{(475.568\mathbf{i} + 329.326\mathbf{j} - 159.311\mathbf{k})\cdot(-3\mathbf{i} + 4\mathbf{j} - 4\mathbf{k})}{\sqrt{41}}$$

$F_{||} = 82.4351 = 82.4 \text{ N}$ **Ans.**

Component of **F** perpendicular to $\mathbf{r}_{AC}$ is $\mathbf{F}_{\perp}$

$F_{\perp}^2 + F_{||}^2 = F^2 = 600^2$

$F_{\perp}^2 = 600^2 - 82.4351^2$

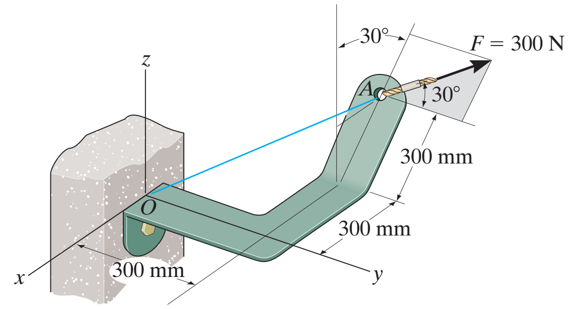
$F_{\perp} = 594 \text{ N}$ **Ans.**

This work is protected by United States copyright laws and is provided solely for the use of instructors in teaching their courses and assessing student learning. Dissemination or sale of any part of this work (including on the World Wide Web) will destroy the integrity of the work and is not permitted.

© 2013 Pearson Education, Inc., Upper Saddle River, NJ. All rights reserved. This publication is protected by
Copyright and written permission should be obtained from the publisher prior to any prohibited reproduction, storage in a retrieval system, or transmission in any form or by any means, electronic, mechanical,
photocopying, recording, or likewise. For information regarding permission(s), write to:
Rights and Permissions Department, Pearson Education, Inc., Upper Saddle River, NJ 07458.

2–138.

Determine the magnitudes of the projected components of the force $F = 300$ N acting along the x and y axes.



SOLUTION

Force Vector: The force vector $\mathbf{F}$ must be determined first. From Fig. a,

$$\mathbf{F} = -300 \sin 30° \sin 30° \mathbf{i} + 300 \cos 30° \mathbf{j} + 300 \sin 30° \cos 30° \mathbf{k}$$

$$= [-75\mathbf{i} + 259.81\mathbf{j} + 129.90\mathbf{k}] \text{ N}$$

Vector Dot Product: The magnitudes of the projected component of $\mathbf{F}$ along the x and y axes are

$$F_x = \mathbf{F} \cdot \mathbf{i} = \left(-75\mathbf{i} + 259.81\mathbf{j} + 129.90\mathbf{k}\right) \cdot \mathbf{i}$$

$$= -75(1) + 259.81(0) + 129.90(0)$$

$$= -75 \text{ N}$$

$$F_y = \mathbf{F} \cdot \mathbf{j} = \left(-75\mathbf{i} + 259.81\mathbf{j} + 129.90\mathbf{k}\right) \cdot \mathbf{j}$$

$$= -75(0) + 259.81(1) + 129.90(0)$$

$$= 260 \text{ N}$$

The negative sign indicates that $\mathbf{F}_x$ is directed towards the negative x axis. Thus

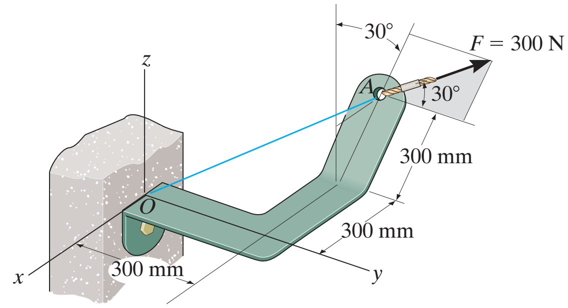
$$F_x = 75 \text{ N}, \qquad F_y = 260 \text{ N}$$ **Ans.**

This work is protected by United States copyright laws and is provided solely for the use of instructors in teaching their courses and assessing student learning. Dissemination or sale of any part of this work (including on the World Wide Web) will destroy the integrity of the work and is not permitted.

© 2013 Pearson Education, Inc., Upper Saddle River, NJ. All rights reserved. This publication is protected by Copyright and written permission should be obtained from the publisher prior to any prohibited reproduction, storage in a retrieval system, or transmission in any form or by any means, electronic, mechanical, photocopying, recording, or likewise. For information regarding permission(s), write to: Rights and Permissions Department, Pearson Education, Inc., Upper Saddle River, NJ 07458.

2–139.

Determine the magnitude of the projected component of the force $F = 300$ N acting along line OA.



SOLUTION

Force and Unit Vector: The force vector **F** and unit vector $\mathbf{u}_{OA}$ must be determined first. From Fig. a

$$\mathbf{F} = (-300 \sin 30° \sin 30°\mathbf{i} + 300 \cos 30°\mathbf{j} + 300 \sin 30° \cos 30°\mathbf{k})$$

$$= \{-75\mathbf{i} + 259.81\mathbf{j} + 129.90\mathbf{k}\} \text{ N}$$

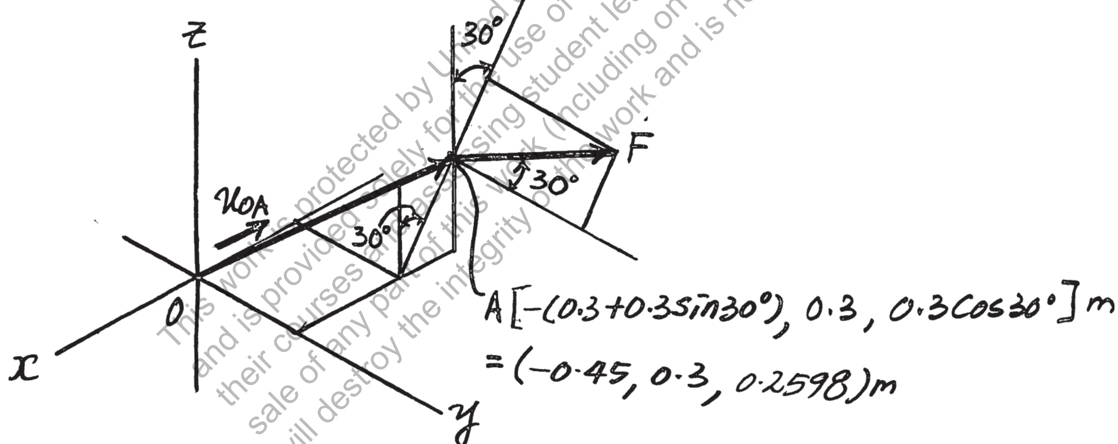
$$\mathbf{u}_{OA} = \frac{\mathbf{r}_{OA}}{r_{OA}} = \frac{(-0.45 - 0)\mathbf{i} + (0.3 - 0)\mathbf{j} + (0.2598 - 0)\mathbf{k}}{\sqrt{(-0.45 - 0)^2 + (0.3 - 0)^2 + (0.2598 - 0)^2}} = -0.75\mathbf{i} + 0.5\mathbf{j} + 0.4330\mathbf{k}$$

Vector Dot Product: The magnitude of the projected component of **F** along line OA is

$$F_{OA} = \mathbf{F} \cdot \mathbf{u}_{OA} = \left(-75\mathbf{i} + 259.81\mathbf{j} + 129.90\mathbf{k}\right) \cdot \left(-0.75\mathbf{i} + 0.5\mathbf{j} + 0.4330\mathbf{k}\right)$$

$$= (-75)(-0.75) + 259.81(0.5) + 129.90(0.4330)$$

$$= 242 \text{ N}$$ **Ans.**

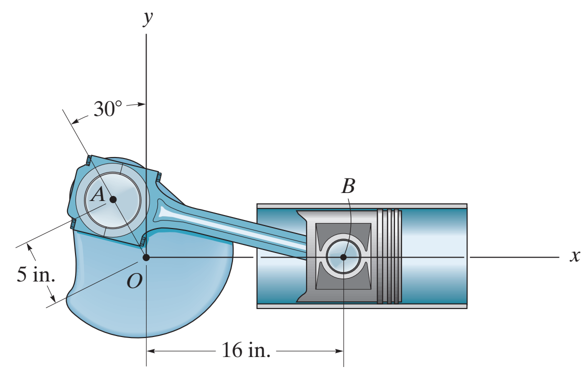


This work is protected by United States copyright laws and is provided solely for the use of instructors in teaching their courses and assessing student learning. Dissemination or sale of any part of this work (including on the World Wide Web) will destroy the integrity of the work and is not permitted.

© 2013 Pearson Education, Inc., Upper Saddle River, NJ. All rights reserved. This publication is protected by Copyright and written permission should be obtained from the publisher prior to any prohibited reproduction, storage in a retrieval system, or transmission in any form or by any means, electronic, mechanical, photocopying, recording, or likewise. For information regarding permission(s), write to: Rights and Permissions Department, Pearson Education, Inc., Upper Saddle River, NJ 07458.

***2–140.**

Determine the length of the connecting rod AB by first formulating a Cartesian position vector from A to B and then determining its magnitude.



SOLUTION

$$\mathbf{r}_{AB} = [16 - (-5\sin 30°)]\mathbf{i} + (0 - 5\cos 30°)\,\mathbf{j}$$

$$= \{18.5\,\mathbf{i} - 4.330\,\mathbf{j}\}\text{ in.}$$

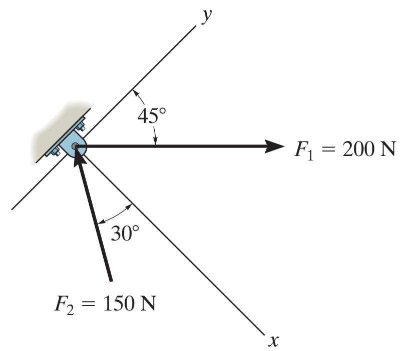
$$r_{AB} = \sqrt{(18.5)^2 + (4.330)^2} = 19.0\text{ in.}$$ **Ans.**

This work is protected by United States copyright laws and is provided solely for the use of instructors in teaching their courses and assessing student learning. Dissemination or sale of any part of this work (including on the World Wide Web) will destroy the integrity of the work and is not permitted.

© 2013 Pearson Education, Inc., Upper Saddle River, NJ. All rights reserved. This publication is protected by Copyright and written permission should be obtained from the publisher prior to any prohibited reproduction, storage in a retrieval system, or transmission in any form or by any means, electronic, mechanical, photocopying, recording, or likewise. For information regarding permission(s), write to: Rights and Permissions Department, Pearson Education, Inc., Upper Saddle River, NJ 07458.

2–141.

Determine the x and y components of $\mathbf{F}_1$ and $\mathbf{F}_2$.



SOLUTION

$F_{1x} = 200 \sin 45° = 141 \text{ N}$ **Ans.**

$F_{1y} = 200 \cos 45° = 141 \text{ N}$ **Ans.**

$F_{2x} = -150 \cos 30° = -130 \text{ N}$ **Ans.**

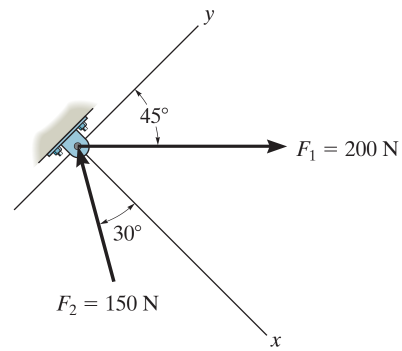
$F_{2y} = 150 \sin 30° = 75 \text{ N}$ **Ans.**

This work is protected by United States copyright laws and is provided solely for the use of instructors in teaching their courses and assessing student learning. Dissemination or sale of any part of this work (including on the World Wide Web) will destroy the integrity of the work and is not permitted.

© 2013 Pearson Education, Inc., Upper Saddle River, NJ. All rights reserved. This publication is protected by Copyright and written permission should be obtained from the publisher prior to any prohibited reproduction, storage in a retrieval system, or transmission in any form or by any means, electronic, mechanical, photocopying, recording, or likewise. For information regarding permission(s), write to: Rights and Permissions Department, Pearson Education, Inc., Upper Saddle River, NJ 07458.

2–142.

Determine the magnitude of the resultant force and its direction, measured counterclockwise from the positive x axis.



SOLUTION

$+\searrow F_{Rx} = \Sigma F_x;\qquad F_{Rx} = -150\cos 30° + 200\sin 45° = 11.518\text{ N}$

$\nearrow + F_{Ry} = \Sigma F_y;\qquad F_{Ry} = 150\sin 30° + 200\cos 45° = 216.421\text{ N}$

$F_R = \sqrt{(11.518)^2 + (216.421)^2} = 217\text{ N}$ **Ans.**

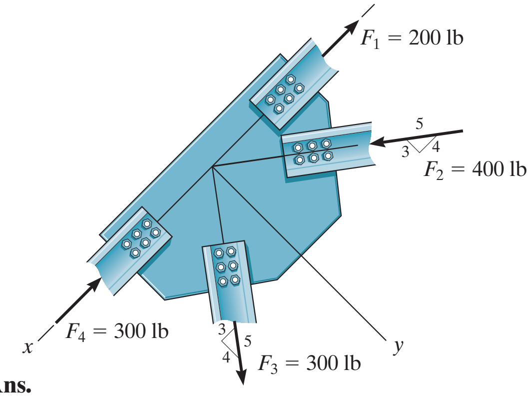
$\theta = \tan^{-1}\left(\dfrac{216.421}{11.518}\right) = 87.0°$ **Ans.**

This work is protected by United States copyright laws and is provided solely for the use of instructors in teaching their courses and assessing student learning. Dissemination or sale of any part of this work (including on the World Wide Web) will destroy the integrity of the work and is not permitted.

© 2013 Pearson Education, Inc., Upper Saddle River, NJ. All rights reserved. This publication is protected by Copyright and written permission should be obtained from the publisher prior to any prohibited reproduction, storage in a retrieval system, or transmission in any form or by any means, electronic, mechanical, photocopying, recording, or likewise. For information regarding permission(s), write to: Rights and Permissions Department, Pearson Education, Inc., Upper Saddle River, NJ 07458.

2–143.

Determine the x and y components of each force acting on the *gusset plate* of the bridge truss. Show that the resultant force is zero.



SOLUTION

$F_{1x} = -200$ lb **Ans.**

$F_{1y} = 0$ **Ans.**

$F_{2x} = 400\left(\frac{4}{5}\right) = 320$ lb **Ans.**

$F_{2y} = -400\left(\frac{3}{5}\right) = -240$ lb **Ans.**

$F_{3x} = 300\left(\frac{3}{5}\right) = 180$ lb **Ans.**

$F_{3y} = 300\left(\frac{4}{5}\right) = 240$ lb **Ans.**

$F_{4x} = -300$ lb **Ans.**

$F_{4y} = 0$ **Ans.**

$F_{Rx} = F_{1x} + F_{2x} + F_{3x} + F_{4x}$

$F_{Rx} = -200 + 320 + 180 - 300 = 0$

$F_{Ry} = F_{1y} + F_{2y} + F_{3y} + F_{4y}$

$F_{Ry} = 0 - 240 + 240 + 0 = 0$

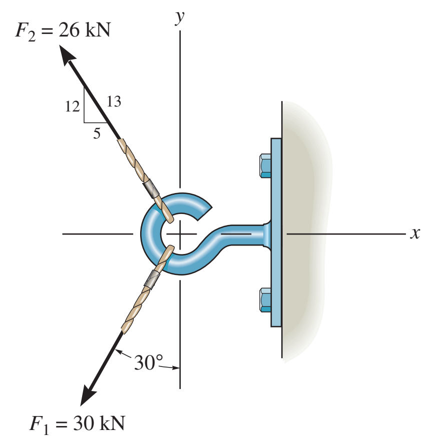
Thus, $F_R = 0$

This work is protected by United States copyright laws and is provided solely for the use of instructors in teaching their courses and assessing student learning. Dissemination or sale of any part of this work (including on the World Wide Web) will destroy the integrity of the work and is not permitted.

© 2013 Pearson Education, Inc., Upper Saddle River, NJ. All rights reserved. This publication is protected by Copyright and written permission should be obtained from the publisher prior to any prohibited reproduction, storage in a retrieval system, or transmission in any form or by any means, electronic, mechanical, photocopying, recording, or likewise. For information regarding permission(s), write to: Rights and Permissions Department, Pearson Education, Inc., Upper Saddle River, NJ 07458.

***2–144.**

Express $\mathbf{F}_1$ and $\mathbf{F}_2$ as Cartesian vectors.



SOLUTION

$$\mathbf{F}_1 = -30 \sin 30° \,\mathbf{i} - 30 \cos 30° \,\mathbf{j}$$

$$= \{-15.0\,\mathbf{i} - 26.0\,\mathbf{j}\} \text{ kN} \qquad \textbf{Ans.}$$

$$\mathbf{F}_2 = -\frac{5}{13}(26)\,\mathbf{i} + \frac{12}{13}(26)\,\mathbf{j}$$

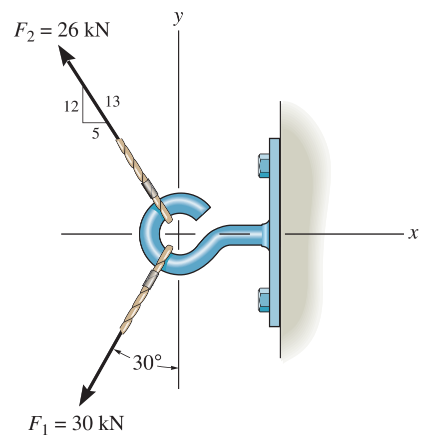
$$= \{-10.0\,\mathbf{i} + 24.0\,\mathbf{j}\} \text{ kN} \qquad \textbf{Ans.}$$

This work is protected by United States copyright laws and is provided solely for the use of instructors in teaching their courses and assessing student learning. Dissemination or sale of any part of this work (including on the World Wide Web) will destroy the integrity of the work and is not permitted.

© 2013 Pearson Education, Inc., Upper Saddle River, NJ. All rights reserved. This publication is protected by Copyright and written permission should be obtained from the publisher prior to any prohibited reproduction, storage in a retrieval system, or transmission in any form or by any means, electronic, mechanical, photocopying, recording, or likewise. For information regarding permission(s), write to: Rights and Permissions Department, Pearson Education, Inc., Upper Saddle River, NJ 07458.

2–145.

Determine the magnitude of the resultant force and its direction measured counterclockwise from the positive x axis.

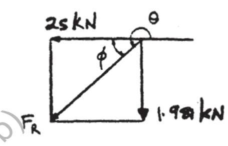


SOLUTION

$\xrightarrow{+} F_{Rx} = \Sigma F_x;\quad F_{Rx} = -30 \sin 30° - \frac{5}{13}(26) = -25 \text{ kN}$

$+\uparrow F_{Ry} = \Sigma F_y;\quad F_{Ry} = -30 \cos 30° + \frac{12}{13}(26) = -1.981 \text{ kN}$

$$F_R = \sqrt{(-25)^2 + (-1.981)^2} = 25.1 \text{ kN}$$ **Ans.**



$$\phi = \tan^{-1}\left(\frac{1.981}{25}\right) = 4.53°$$

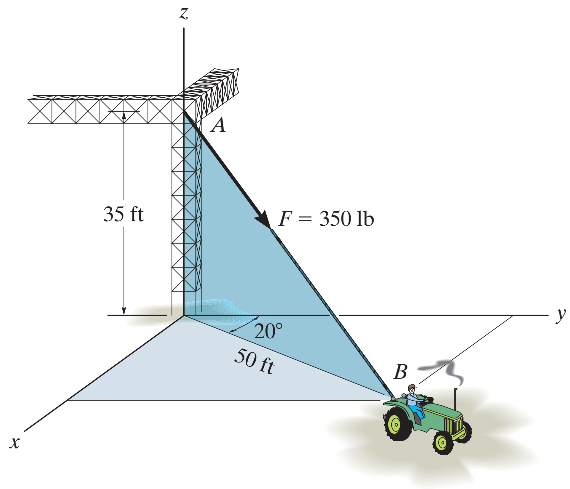
$$\theta = 180° + 4.53° = 185°$$ **Ans.**

This work is protected by United States copyright laws and is provided solely for the use of instructors in teaching their courses and assessing student learning. Dissemination or sale of any part of this work (including on the World Wide Web) will destroy the integrity of the work and is not permitted.

© 2013 Pearson Education, Inc., Upper Saddle River, NJ. All rights reserved. This publication is protected by Copyright and written permission should be obtained from the publisher prior to any prohibited reproduction, storage in a retrieval system, or transmission in any form or by any means, electronic, mechanical, photocopying, recording, or likewise. For information regarding permission(s), write to: Rights and Permissions Department, Pearson Education, Inc., Upper Saddle River, NJ 07458.

2–146.

The cable attached to the tractor at *B* exerts a force of 350 lb on the framework. Express this force as a Cartesian vector.



SOLUTION

$$\mathbf{r} = 50 \sin 20°\mathbf{i} + 50 \cos 20°\mathbf{j} - 35\mathbf{k}$$

$$\mathbf{r} = \{17.10\mathbf{i} + 46.98\mathbf{j} - 35\mathbf{k}\} \text{ ft}$$

$$r = \sqrt{(17.10)^2 + (46.98)^2 + (-35)^2} = 61.03 \text{ ft}$$

$$\mathbf{u} = \frac{\mathbf{r}}{r} = (0.280\mathbf{i} + 0.770\mathbf{j} - 0.573\mathbf{k})$$

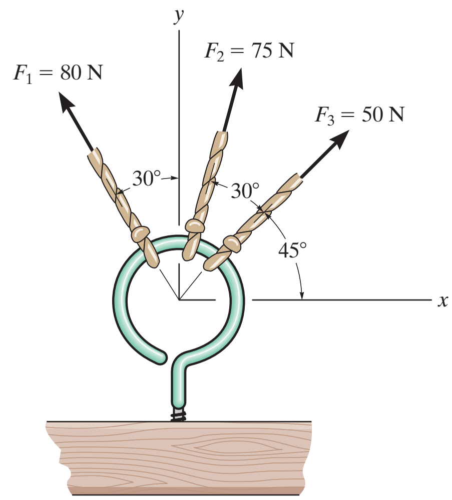
$$\mathbf{F} = F\mathbf{u} = \{98.1\mathbf{i} + 269\mathbf{j} - 201\mathbf{k}\} \text{ lb}$$ **Ans.**

This work is protected by United States copyright laws and is provided solely for the use of instructors in teaching their courses and assessing student learning. Dissemination or sale of any part of this work (including on the World Wide Web) will destroy the integrity of the work and is not permitted.

© 2013 Pearson Education, Inc., Upper Saddle River, NJ. All rights reserved. This publication is protected by Copyright and written permission should be obtained from the publisher prior to any prohibited reproduction, storage in a retrieval system, or transmission in any form or by any means, electronic, mechanical, photocopying, recording, or likewise. For information regarding permission(s), write to: Rights and Permissions Department, Pearson Education, Inc., Upper Saddle River, NJ 07458.

2–147.

Determine the magnitude and direction of the resultant $\mathbf{F}_R = \mathbf{F}_1 + \mathbf{F}_2 + \mathbf{F}_3$ of the three forces by first finding the resultant $\mathbf{F}' = \mathbf{F}_1 + \mathbf{F}_3$ and then forming $\mathbf{F}_R = \mathbf{F}' + \mathbf{F}_2$. Specify its direction measured counterclockwise from the positive x axis.



SOLUTION

$$F' = \sqrt{(80)^2 + (50)^2 - 2(80)(50)\cos 105^\circ} = 104.7 \text{ N}$$

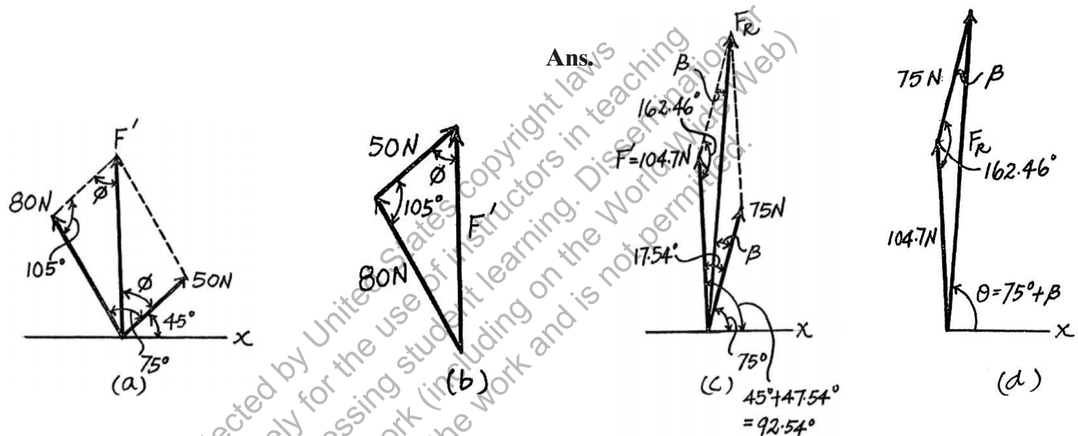
$$\frac{\sin\phi}{80} = \frac{\sin 105^\circ}{104.7}; \qquad \phi = 47.54^\circ$$

$$F_R = \sqrt{(104.7)^2 + (75)^2 - 2(104.7)(75)\cos 162.46^\circ}$$

$$F_R = 177.7 = 178 \text{ N}$$ **Ans.**

$$\frac{\sin\beta}{104.7} = \frac{\sin 162.46^\circ}{177.7}; \qquad \beta = 10.23^\circ$$

$$\theta = 75^\circ + 10.23^\circ = 85.2^\circ$$ **Ans.**

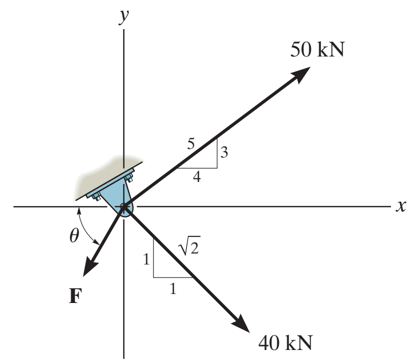


This work is protected by United States copyright laws and is provided solely for the use of instructors in teaching their courses and assessing student learning. Dissemination or sale of any part of this work (including on the World Wide Web) will destroy the integrity of the work and is not permitted.

© 2013 Pearson Education, Inc., Upper Saddle River, NJ. All rights reserved. This publication is protected by Copyright and written permission should be obtained from the publisher prior to any prohibited reproduction, storage in a retrieval system, or transmission in any form or by any means, electronic, mechanical, photocopying, recording, or likewise. For information regarding permission(s), write to: Rights and Permissions Department, Pearson Education, Inc., Upper Saddle River, NJ 07458.

***2–148.**

If $\theta = 60°$ and $F = 20$ kN, determine the magnitude of the resultant force and its direction measured clockwise from the positive x axis.



SOLUTION

$$\xrightarrow{+} F_{Rx} = \Sigma F_x; \qquad F_{Rx} = 50\left(\frac{4}{5}\right) + \frac{1}{\sqrt{2}}(40) - 20\cos 60° = 58.28 \text{ kN}$$

$$+\uparrow F_{Ry} = \Sigma F_y; \qquad F_{Ry} = 50\left(\frac{3}{5}\right) - \frac{1}{\sqrt{2}}(40) - 20\sin 60° = -15.60 \text{ kN}$$

$$F_R = \sqrt{(58.28)^2 + (-15.60)^2} = 60.3 \text{ kN}$$ **Ans.**

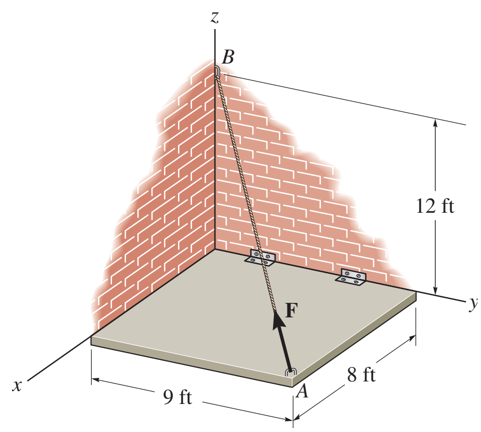
$$\phi = \tan^{-1}\left[\frac{15.60}{58.28}\right] = 15.0°$$ **Ans.**

This work is protected by United States copyright laws and is provided solely for the use of instructors in teaching their courses and assessing student learning. Dissemination or sale of any part of this work (including on the World Wide Web) will destroy the integrity of the work and is not permitted.

© 2013 Pearson Education, Inc., Upper Saddle River, NJ. All rights reserved. This publication is protected by Copyright and written permission should be obtained from the publisher prior to any prohibited reproduction, storage in a retrieval system, or transmission in any form or by any means, electronic, mechanical, photocopying, recording, or likewise. For information regarding permission(s), write to: Rights and Permissions Department, Pearson Education, Inc., Upper Saddle River, NJ 07458.

2–149.

The hinged plate is supported by the cord AB. If the force in the cord is $F = 340$ lb, express this force, directed from A toward B, as a Cartesian vector. What is the length of the cord?



SOLUTION

Unit Vector:

$$\mathbf{r}_{AB} = \{(0-8)\mathbf{i} + (0-9)\mathbf{j} + (12-0)\mathbf{k}\}\text{ ft}$$

$$= \{-8\mathbf{i} - 9\mathbf{j} + 12\mathbf{k}\}\text{ ft}$$

$$r_{AB} = \sqrt{(-8)^2 + (-9)^2 + 12^2} = 17.0\text{ ft}$$ **Ans.**

$$\mathbf{u}_{AB} = \frac{\mathbf{r}_{AB}}{r_{AB}} = \frac{-8\mathbf{i} - 9\mathbf{j} + 12\mathbf{k}}{17} = -\frac{8}{17}\mathbf{i} - \frac{9}{17}\mathbf{j} + \frac{12}{17}\mathbf{k}$$

Force Vector:

$$\mathbf{F} = F\mathbf{u}_{AB} = 340\left\{-\frac{8}{17}\mathbf{i} - \frac{9}{17}\mathbf{j} + \frac{12}{17}\mathbf{k}\right\}\text{ lb}$$

$$= \{-160\mathbf{i} - 180\mathbf{j} + 240\mathbf{k}\}\text{ lb}$$ **Ans.**

This work is protected by United States copyright laws and is provided solely for the use of instructors in teaching their courses and assessing student learning. Dissemination or sale of any part of this work (including on the World Wide Web) will destroy the integrity of the work and is not permitted.

© 2013 Pearson Education, Inc., Upper Saddle River, NJ. All rights reserved. This publication is protected by Copyright and written permission should be obtained from the publisher prior to any prohibited reproduction, storage in a retrieval system, or transmission in any form or by any means, electronic, mechanical, photocopying, recording, or likewise. For information regarding permission(s), write to: Rights and Permissions Department, Pearson Education, Inc., Upper Saddle River, NJ 07458.