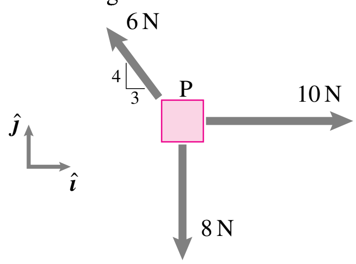
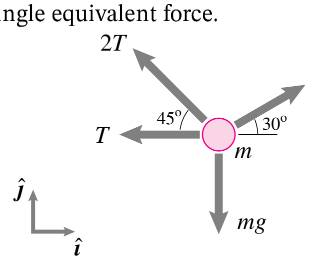
2.1 Equivalent force systems and couples

2.1.1 Find the net force on the particle shown in the figure.



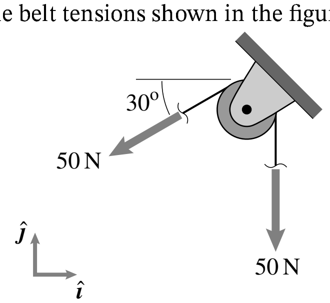
Problem 2.1.1

2.1.2 Replace the forces acting on the particle of mass m shown in the figure by a single equivalent force.



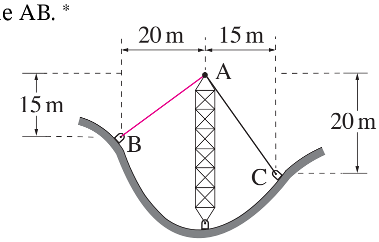
Problem 2.1.2

2.1.3 Find the net force on the pulley due to the belt tensions shown in the figure.



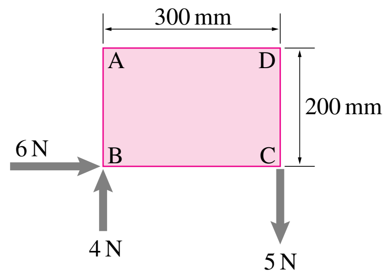
Problem 2.1.3

2.1.4 The net force on A from the two cables is a force that points down and has magnitude of 125 N. Find the tension in cable AB. *



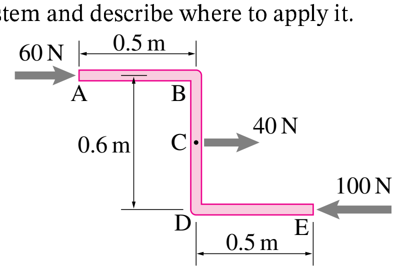
Problem 2.1.4

2.1.5 Replace the forces shown on the rectangular plate by a single equivalent force. Where should this equivalent force act on the plate and why?



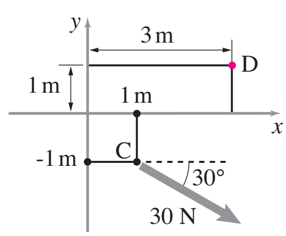
Problem 2.1.5

2.1.6 Three forces act on a Z-section ABCDE as shown in the figure. Point C lies in the middle of the vertical section BD. Find any equivalent force-couple system and describe where to apply it.



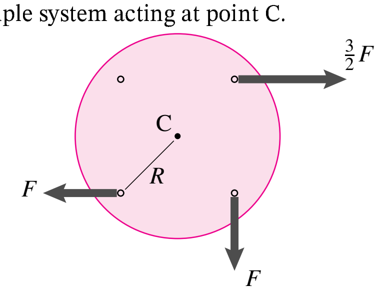
Problem 2.1.6

2.1.7 Find a force-couple system at D that is equivalent to the single force at C shown. *



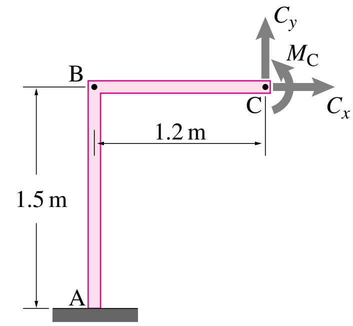
Problem 2.1.7

2.1.8 The three forces acting on the circular plate are shown. They act at the corners of a square which is concentric with the plate. Find an equivalent force-couple system acting at point C.



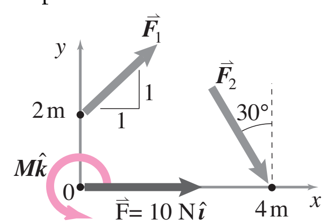
Problem 2.1.8

2.1.9 The forces and the moment acting on point C of the frame ABC shown in the figure are $C_x = 48\,\text{N}$, $C_y = 40\,\text{N}$, and $M_c = 20\,\text{N·m}$. Find an equivalent force couple system at point B.



Problem 2.1.9

2.1.10 The force system $(\vec{F}_1, \vec{F}_2)$ is equivalent to a force $\vec{F} = 10\hat{\imath}\,\text{N}$ at the origin and a couple $M\hat{k}$. Find M. *

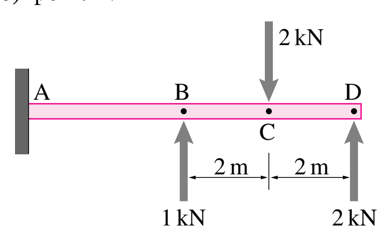


Problem 2.1.10

2.1.11 Find an equivalent force-couple system for the forces acting on the beam shown in the figure, if the equivalent system is to act at

a) point B,

b) point D.

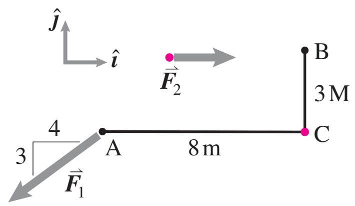


Problem 2.1.11

2.1.12 $\vec{F}_1$ acts at A and $\vec{F}_2 = 7\,\text{N}\hat{\imath}$ acts at an unknown location. Together they are equivalent to a force $\vec{F}_B$ and moment $\vec{M}_B = 48\,\text{N·m}\hat{k}$ at B. Together they are also equivalent to a force $\vec{F}_C$ and moment $\vec{M}_C = 75\,\text{N·m}\hat{k}$ at C.

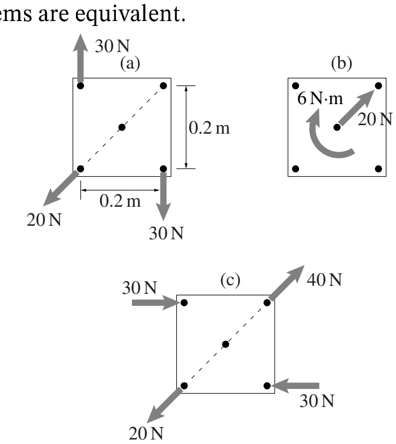
a) Find $\vec{F}_C$. *

b) Find the line of action of $\vec{F}_2$. *



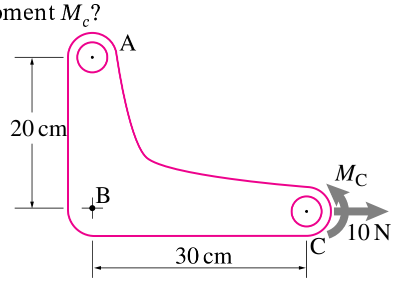
Problem 2.1.12

2.1.13 The figure shows three different force-couple systems acting on a square plate. Identify which force-couple systems are equivalent.



Problem 2.1.13

2.1.14 The force and moment acting at point C of a machine part are shown in the figure where M_c is not known. It is found that if the given force-couple system is replaced by a single horizontal force of magnitude 10 N acting at point A then the net effect on the machine part is the same. What is the magnitude of the moment M_c?



Problem 2.1.14

2.1.15 2D. Assume a force system is equivalent to a force $\vec{F}_1 \neq \vec{0}$ and couple $\vec{M}_1 = M_1\hat{k}$ acting at point $\vec{r}_1$.

a) Find some point $\vec{r}_2$, and force $\vec{F}_2$ so that $\vec{F}_2$ acting at $\vec{r}_2$ is equivalent to $\vec{F}_1$ and $\vec{M}_1$ acting at $\vec{r}_1$. *

b) Find all possible wrenches (combinations of point location, force and moment) equivalent to the system with $\vec{F}_1$ and $\vec{M}_1$ acting at the point with position vector $\vec{r}_1$. *

c) Describe the situation in the special case when $\vec{F}_1 = \vec{0}$. *

2.1.16 3D. Assume a force system is equivalent to a force $\vec{F}_1$ and couple $\vec{M}_1$ acting at point with position vector $\vec{r}_1$.

a) Find a point P with position vector $\vec{r}_2$, so that an equivalent force system $\vec{F}_2$ and $\vec{M}_2$ acting at P has $\vec{F}_2$ is parallel to $\vec{M}_2$. (Finding such a point, force and moment is called "reducing the force system to a *wrench*"). *

b) Find all possible wrenches (combinations of point location, force and moment) equivalent to the system with $\vec{F}_1$ and $\vec{M}_1$ acting at $\vec{r}_1$. *

Note, one special case with a slightly different result than the other cases is if $\vec{F}_1 = \vec{0}$, so it should be treated separately.