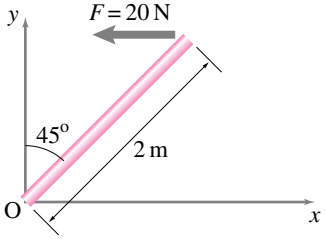
1.4 Moment and Moment about an Axis

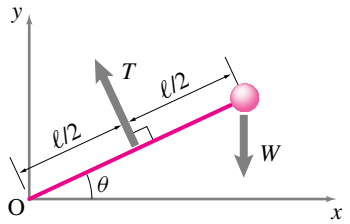
1.4.1 What is the moment $\vec{M}$ produced by a 20 N force F acting in the x direction with a lever arm of $\vec{r} = (16\text{ mm})\hat{j}$?

1.4.2 Find the moment of the force shown on the rod about point O.



Problem 1.4.2

1.4.3 Find the sum of moments of forces $\vec{W}$ and $\vec{T}$ about the origin, given that $W = 100\text{ N}, T = 120\text{ N}, \ell = 4\text{ m}$, and $\theta = 30°$.

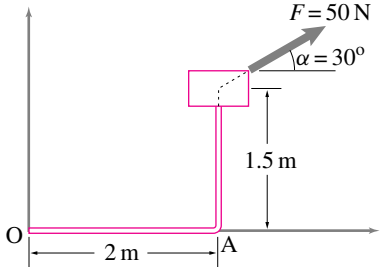


Problem 1.4.3

1.4.4 Find the moment of the force

a) about point A

b) about point O.



Problem 1.4.4

1.4.5 The line of action of a force $\vec{F} = 20\text{ N}\hat{j} - 5\text{ N}\hat{k}$ passes through a point A with coordinates (200 mm, 300 mm, -100 mm). What is the moment $\vec{M}(= \vec{r} \times \vec{F})$ of the force about the origin?

1.4.6 Drawing vectors and computing with vectors. In an xyz coordinate system, let point O be the origin. Point A has xyz coordinates $(0m, 5m, 12m)$ and point B has xyz coordinates $(4m, 5m, 12m)$.

a) Make a neat sketch of the vectors OA, OB, and AB.

b) Find a unit vector in the direction of OA, call it $\hat{\lambda}_{OA}$.

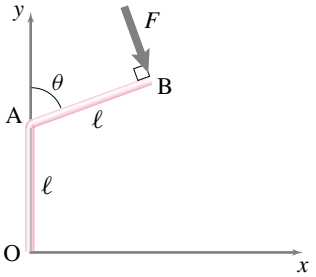
c) Find the force $\vec{F}$ which is 5 N in size and is in the direction of OA.

d) What is the angle between OA and OB?

e) What is $\vec{r}_{BO} \times \vec{F}$?

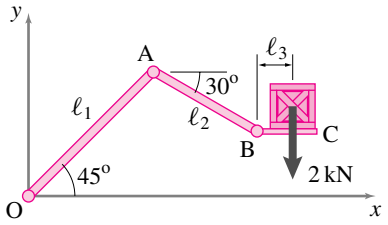
f) Assume $\vec{F}$ acts at O. What is the moment of $\vec{F}$ about a line parallel to the z axis that goes through point B?

1.4.7 In the figure shown, OA = AB = 2 m. The force $F = 40$ N acts perpendicular to the arm AB. Find the moment of $\vec{F}$ about O, given that $\theta = 45°$. If $\vec{F}$ always acts normal to the arm AB, would increasing θ increase the magnitude of the moment? In particular, what value of θ will give the largest moment?



Problem 1.4.7

1.4.8 Calculate the moment of the 2 kNpayload on the robot arm about (i) joint A, and (ii) joint B, if $\ell_1 = 0.8\text{ m}, \ell_2 = 0.4\text{ m}$, and $\ell_3 = 0.1\text{ m}$.

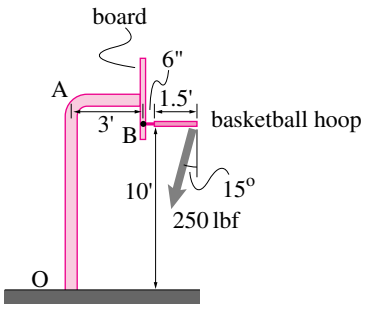


Problem 1.4.8

1.4.9 During a slam-dunk, a basketball player pulls on the hoop with a 250 lbf force at point C of the ring as shown in the figure. Find the moment of the force about

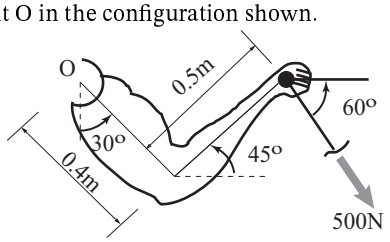
a) the point of the ring attachment to the board (point B), and

b) the root of the pole, point O.



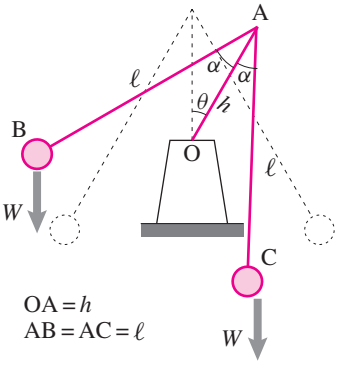
Problem 1.4.9

1.4.10 During weight training, an athlete pulls a weight of 500 N with his arms pulling on a handlebar connected to a universal machine by a cable. Find the moment of the force about the shoulder joint O in the configuration shown.



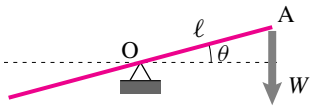
Problem 1.4.10

1.4.11 Find the sum of moments due to the two weights of the teeter-totter when the teeter-totter is tipped at an angle θ from its vertical position. Give your answer in terms of the variables shown in the figure. [Note that AC is not vertical.]



Problem 1.4.11

1.4.12 Find the percentage error in computing the moment of $\vec{W}$ about the pivot point O as a function of θ, if the weight is assumed to act normal to the arm OA (a good approximation when θ is very small).



Problem 1.4.12

1.4.13 Vector Calculations and Geometry. The 5 N force $\vec{F}_1$ is along the line OA. The 7 N force $\vec{F}_2$ is along the line OB.

a) Find a unit vector in the direction OB. *

b) Find a unit vector in the direction OA. *

c) Write both $\vec{F}_1$ and $\vec{F}_2$ as the product of their magnitudes and unit vectors in their directions. *

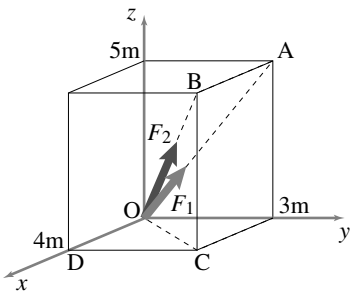
d) What is the angle AOB? *

e) What is the component of $\vec{F}_1$ in the x-direction? *

f) What is $\vec{r}_{DO} \times \vec{F}_1$? ($\vec{r}_{DO} \equiv \vec{r}_{O/D}$ is the position of O relative to D.) *

g) What is the moment of $\vec{F}_2$ about the axis DC? *

h) Again find the moment of $\vec{F}_2$ about the axis DC. This time use either a different reference point on the axis DC or a different point on the line of action OB. Does the solution agree? [Hint: it should.] *



Problem 1.4.13