Section 8: Statics - Basics

Fundamental Concepts

- *Time* - definition of an event requires specification of the time and position at which it occurred.

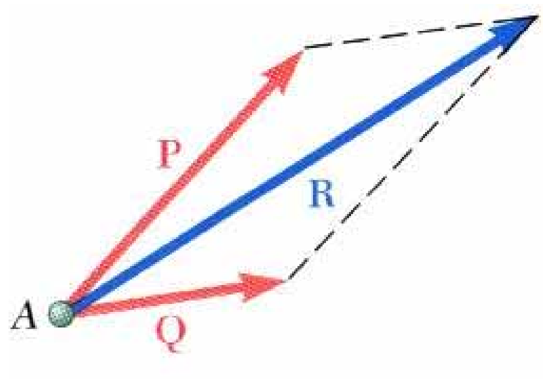
- *Mass* - used to characterize and compare bodies, e.g., response to earth's gravitational attraction and resistance to changes in translational motion.

- *Force* - represents the action of one body on another. A force is characterized by its point of application, magnitude, and direction, i.e., a force is a vector quantity.

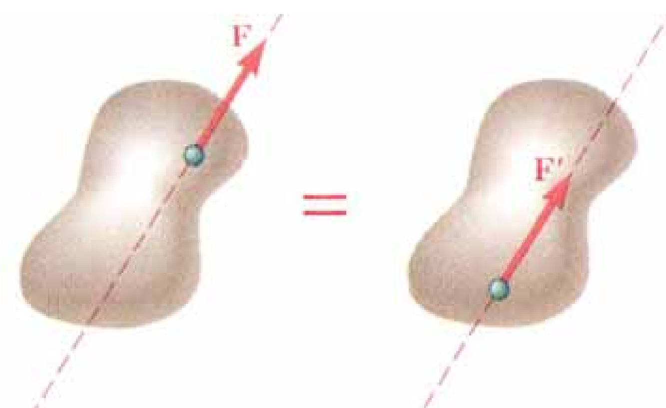
In Newtonian Mechanics, space, time, and mass are absolute concepts, independent of each other. Force, however, is not independent of the other three. The force acting on a body is related to the mass of the body and the variation of its velocity with time.

From: Rabiei, Chapter 1

Fundamental Principles



- *Parallelogram Law*



- *Principle of Transmissibility*

- *Newton's First Law*: If the resultant force on a particle is zero, the particle will remain at rest or continue to move in a straight line.
- *Newton's Second Law*: A particle will have an acceleration proportional to a nonzero resultant applied force.

$$\vec{F} = m\vec{a}$$

- *Newton's Third Law*: The forces of action and reaction between two particles have the same magnitude and line of action with opposite sense.
- *Newton's Law of Gravitation*: Two particles are attracted with equal and opposite forces,

$$F = G\frac{Mm}{r^2} \qquad W = mg, \quad g = \frac{GM}{R^2}$$

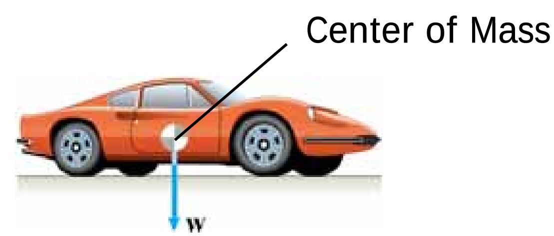
From: Rabiei, Chapter 1

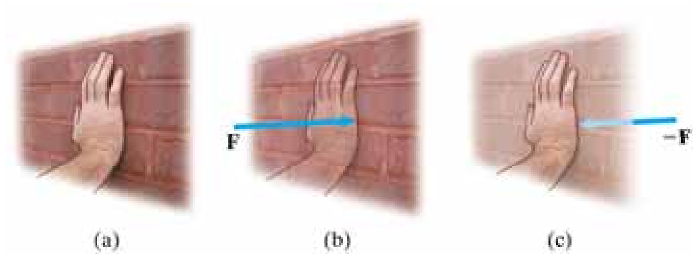
Fundamental Equations

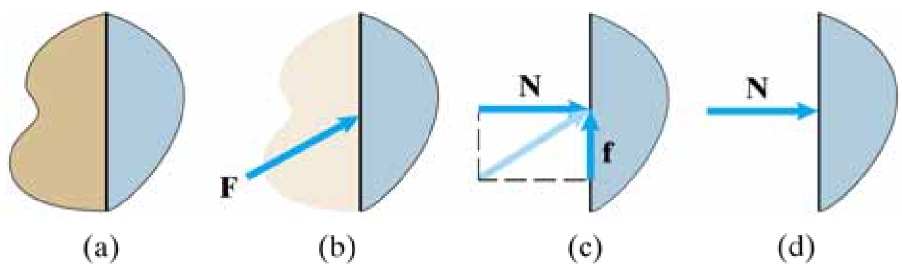
- Statics implies equilibrium
- No Acceleration ➔ $\Sigma F = ma = 0$
  - Sum of Forces in all directions is ZERO!
    - $\Sigma F_x = 0$
    - $\Sigma F_y = 0$
    - $\Sigma F_z = 0$
- No Rotation ➔ $\Sigma M = 0$
  - Sum of Moments in all directions is ZERO!

More Force Terminology

– Gravity
  - W = m*g
  - G = 9.81 m/s^2 = 32.2 ft/s^2
– Body Force
  - Ex: Gravity
– Surface Force
  - Normal Force (N)
  - Frictional Force (f)







From: Gabauer

2.1 Scalars & Vectors

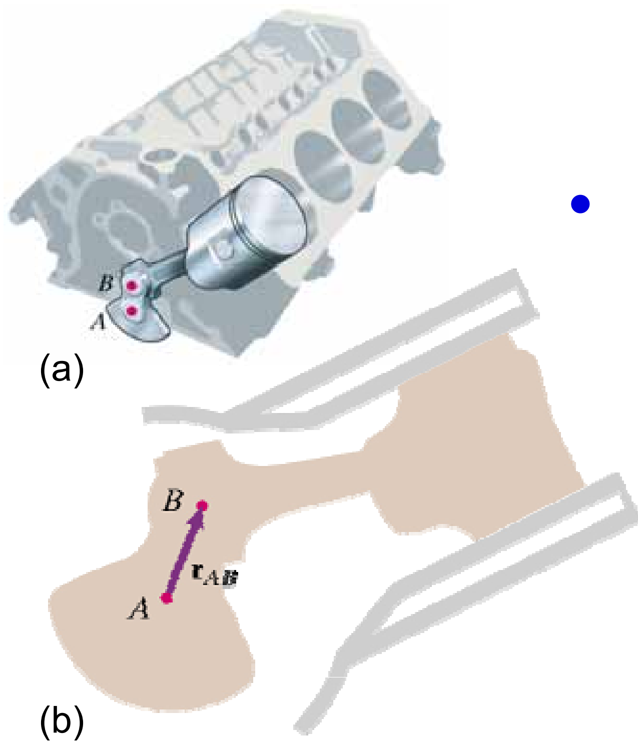
- Scalar – a physical quantity that is completely described by a real number
  - E.g. Time, mass
- Vector – both magnitude (nonnegative real number) & direction
  - E.g. Position of a point in space relative to another point, forces
  - Represented by boldfaced letters: $\mathbf{U}, \mathbf{V}, \mathbf{W}, \ldots$
  - Magnitude of vector $U = |\mathbf{U}|$

From: Katafygiotis

2.1 Scalars & Vectors

– Graphical representation of vectors: arrows
  - Direction of arrow = direction of vector
  - Length of arrow

    $\propto$ magnitude of vector

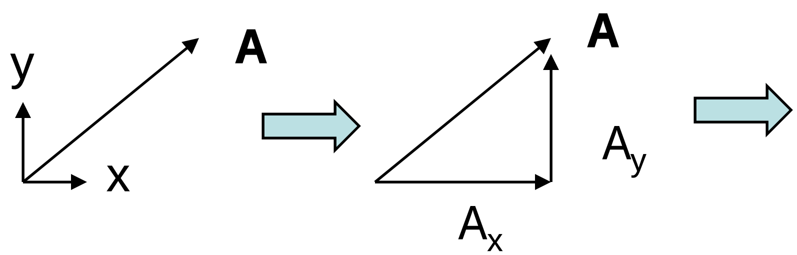


- Example:
  - $\mathbf{r}_{AB}$ = position of point B relative to point A
  - Direction of $\mathbf{r}_{AB}$ = direction from point A to point B
  - $|\mathbf{r}_{AB}|$ = distance between 2 points

From: Katafygiotis

Vector Manipulation

- Components



$\mathbf{A} = A_x\, i + A_y\, j$

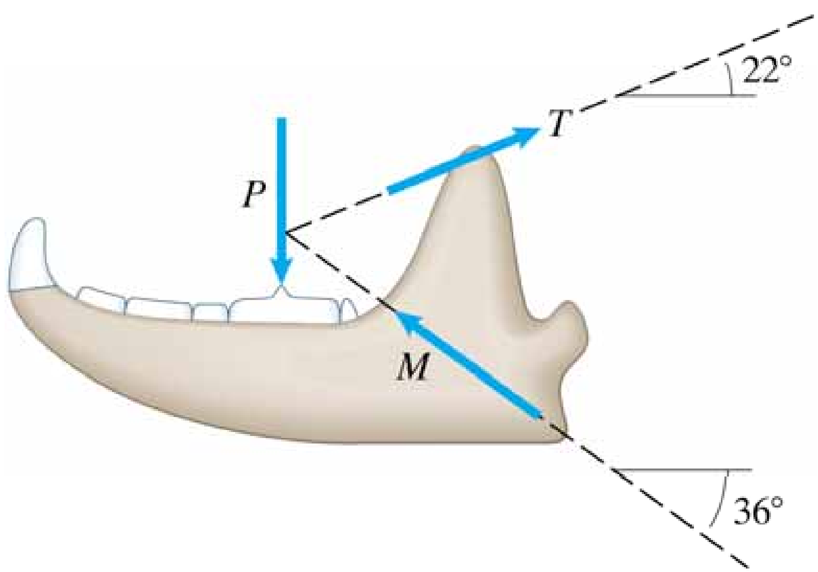
- Addition $\Rightarrow$ $\mathbf{A}+\mathbf{B} = (A_x+B_x)\, i + (A_y+B_y)\, j$

- Scalar Multiplication $\Rightarrow$ $c\mathbf{A} = cA_x\, i + cA_y\, j$

From: Gabauer

Example Problem

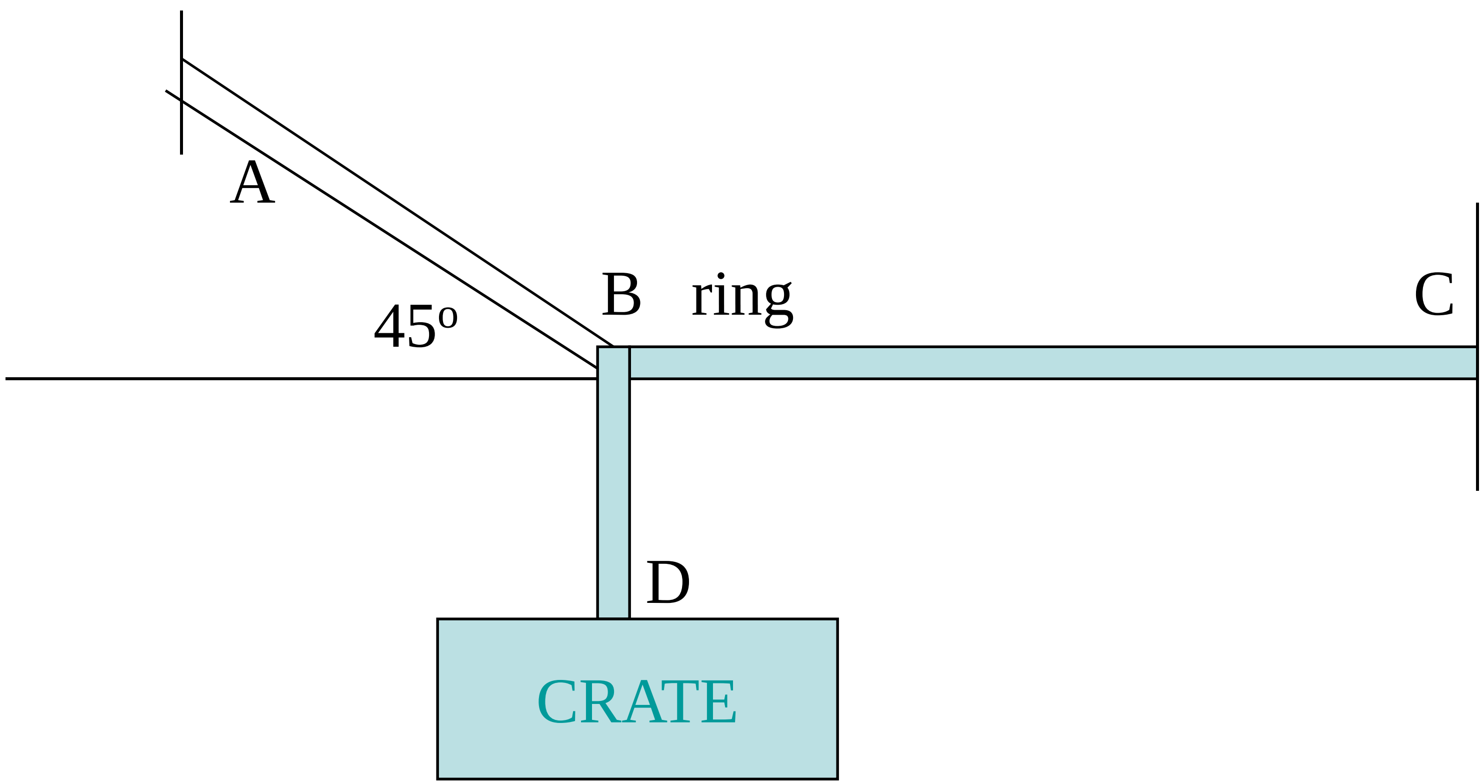
- 2. A zoologist estimates that the jaw of a predator is subjected to a force P as large as 800 N. What forces T and M must be exerted by the temporalis and masseter muscles to support this value of P?



From: Gabauer

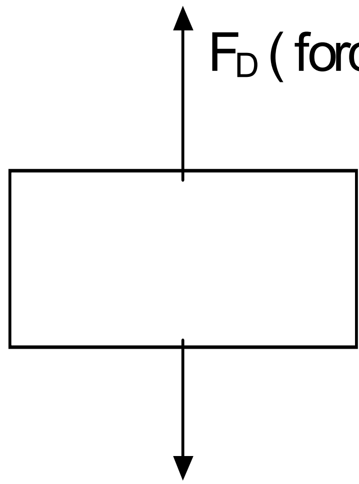
Example

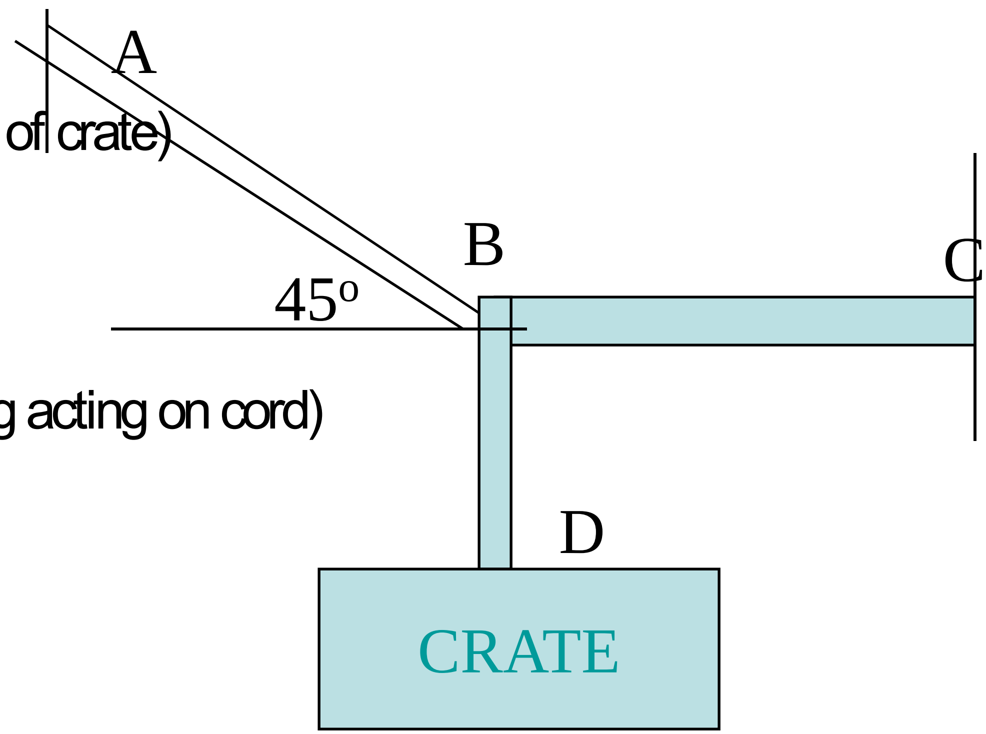
- The crate below has a weight of 50 kg. Draw a free body diagram of the crate, the cord BD and the ring at B.



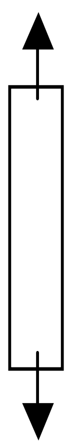
From: Ekwue

(a) Crate





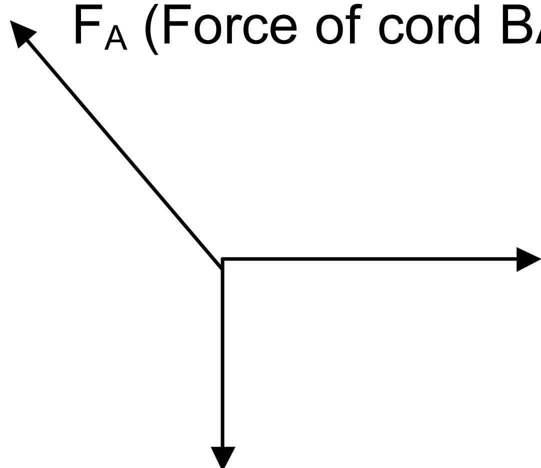
(b) Cord BD



From: Ekwue

Solution Contd.

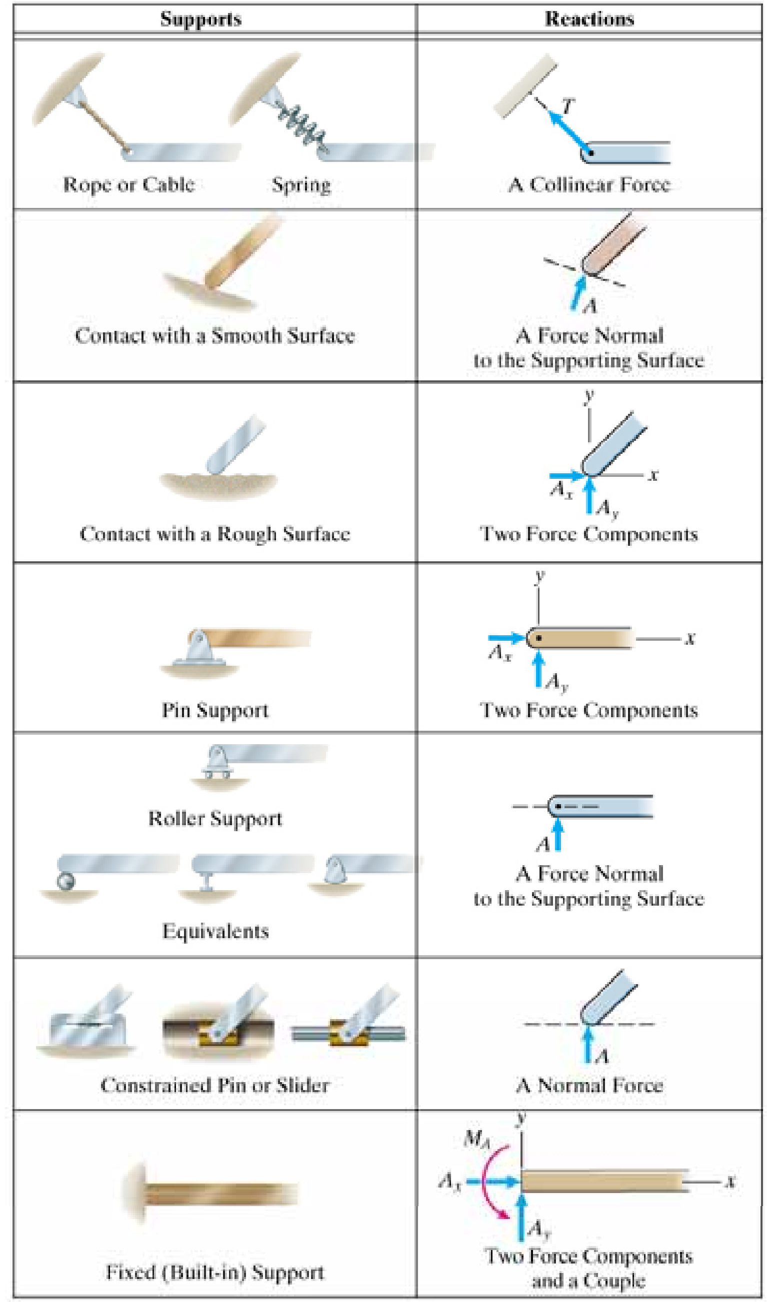
(c) Ring



Supports

- When drawing free body diagram…
  - If you remove a support, you must replace it with appropriate reaction forces
  - <u>Think</u>: What movements does the support restrict?

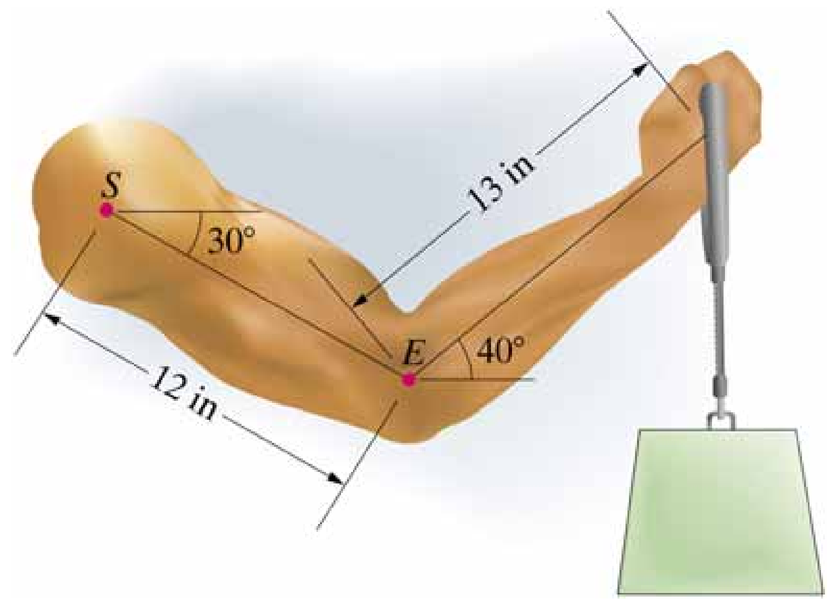
Table 5.1



From: Gabauer

Homework Problem 8.1

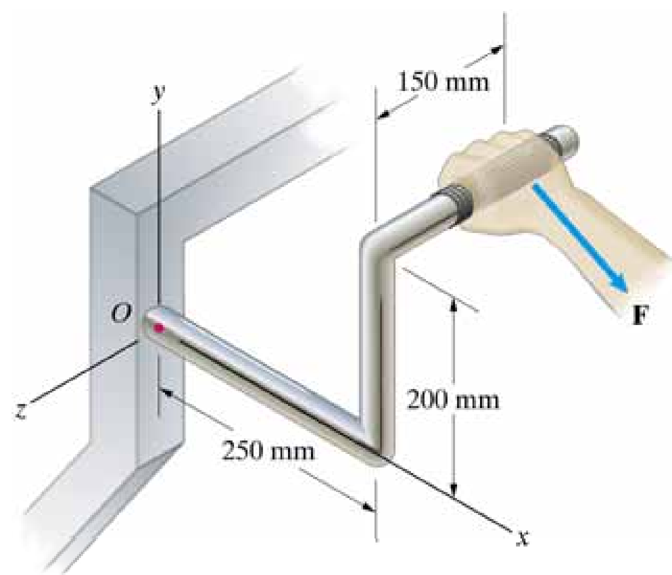
- 6. The moment exerted about point E by the weight is 299 lb-in. What moment does the weight exert about point S?



From: Gabauer

Homework Problem 8.2

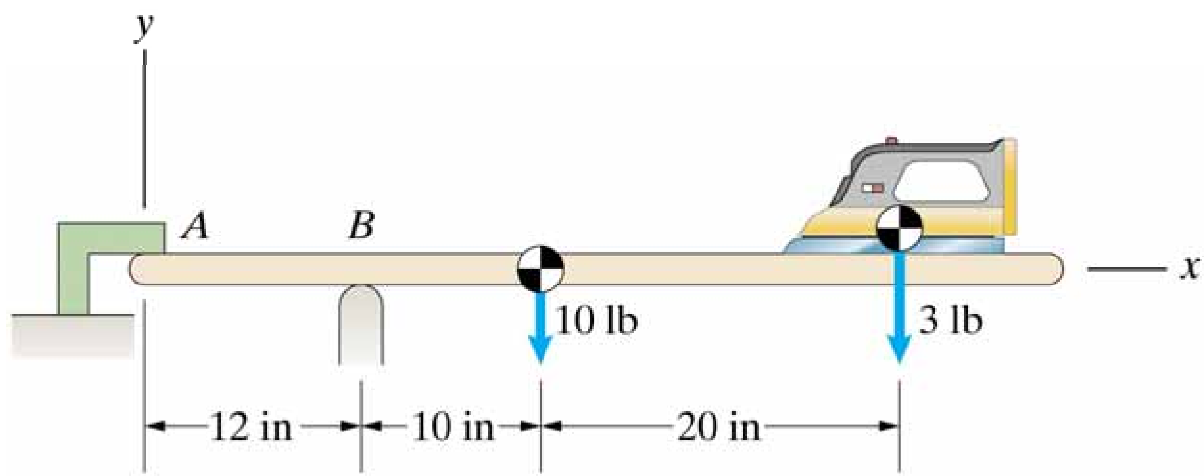
- 7. The force F points in the direction of the unit vector e = 2/3*i* - 2/3*j* + 1/3*k.* The support at O will safely support a moment of 560 N-m magnitude. Based on this criterion, what is the largest safe magnitude of F?



From: Gabauer

Homework Problem 8.3

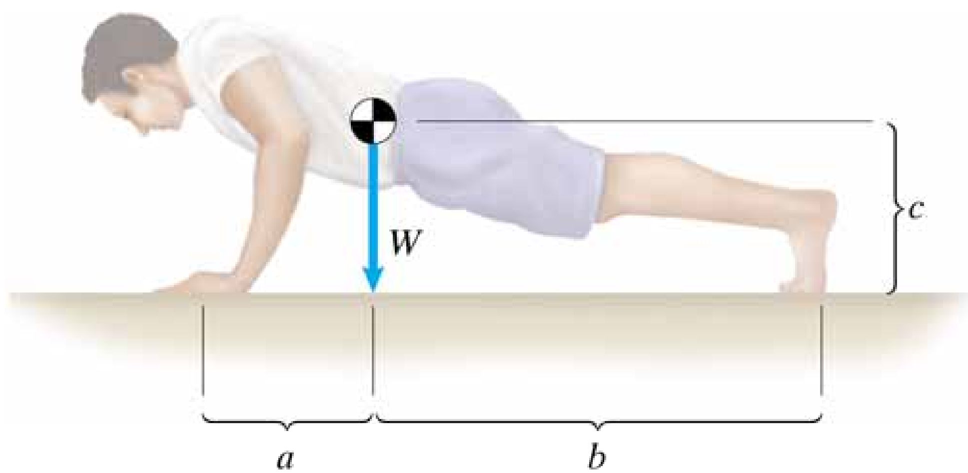
- 8. The ironing board has supports at A and B that can be modeled as roller supports. Draw a free body diagram of the ironing board and determine the reactions at A and B.



From: Gabauer

Homework Problem 8.4

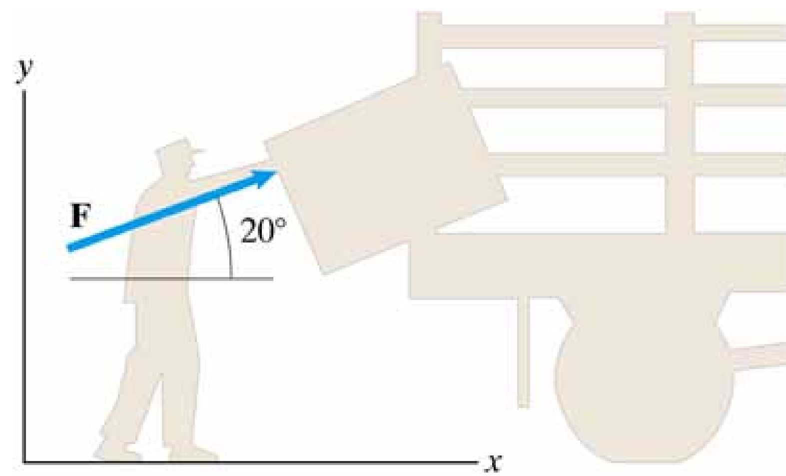
- 9. The person doing push-ups pauses in the position shown. His mass is 80 kg. Assume that his weight, W, acts at the point shown. The dimensions shown are a = 250 mm, b = 740 mm, and c = 300 mm. Find the normal force exerted by the floor on each hand and each foot.



From: Gabauer

Homework Problem 8.5

- A person exerts a 60-lb force F to push a crate onto a truck. Express F in terms of components.



From: Gabauer