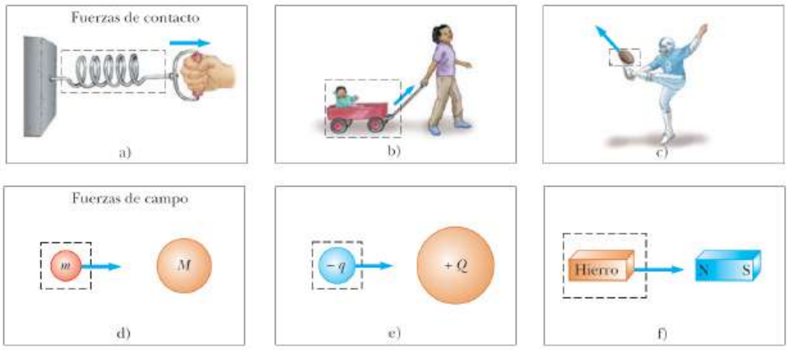
Fuerza : Magnitud física vectorial que mide la interacción entre dos o más cuerpos que intentan mutuamente alterar su estado de movimiento.



Dinámica (de una partícula) : Parte de la mecánica que estudia el movimiento y sus causas (Fuerzas).

Primera Ley de Newton

> Si un objeto no interactúa con otros objetos, es posible identificar un marco de referencia en el que el objeto tiene aceleración cero.

Sistema de referencia inercial (SRI)

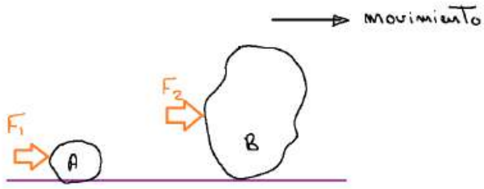
Una definición muy precisa es aquel sistema que está en reposo o movimiento rectilíneo uniforme respecto de un objeto material sobre el cual no actúa fuerza alguna, cualquiera que sea su posición en el espacio.

La dificultad de esta definición está en la imposibilidad física de disponer de un cuerpo libre de interacciones.

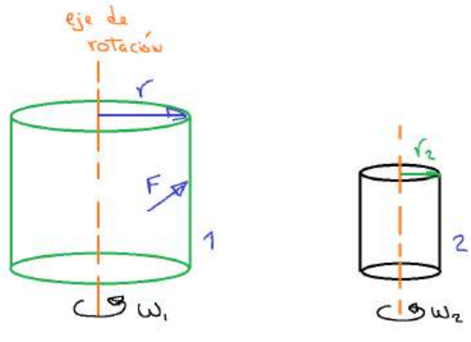
Segunda Ley de Newton

$$\frac{d(m\vec{v})}{dt} = \Sigma\vec{F}$$ $m\vec{v}$ = Cantidad de movimiento lineal

Para un caso particular : $m.\vec{a} = \Sigma\vec{F}$



La masa es una cantidad inercial:
es un valor que se "opone" a la Traslación.



Segunda ley de Newton para rotación:

$m.\vec{a} = \Sigma\vec{F}$ $\vec{\alpha}$: aceleración angular

$\underbrace{I}.\vec{\alpha} = \Sigma\vec{M}$ I: momento de inercia.

$m_1 = m_2$

$\omega_1 = \omega_2$

el momento de inercia es una cantidad inercial:
es un valor que se "opone" a la rotación.

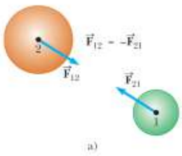
* Como $I_2 < I_1$ el cuerpo 2 es mas facil rotarlo.

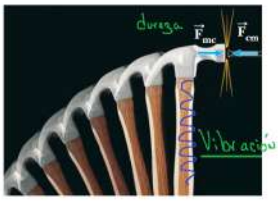
alta inercia Traslación

Tercera ley de Newton

Si dos objetos interactúan, la fuerza $\vec{\mathbf{F}}_{12}$ que ejerce el objeto 1 sobre el objeto 2 es igual en magnitud y opuesta en dirección a la fuerza $\vec{\mathbf{F}}_{21}$ que ejerce el objeto 2 sobre el objeto 1:

$$\vec{\mathbf{F}}_{12} = -\vec{\mathbf{F}}_{21} \tag{5.7}$$





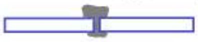
dureza { Rockwell B C, Vickers, Brinell

dureza ⟷ fragilidad

acero { Fe + C + Mn + Cr . . .

máx C es 2%

Soldadura por ejemplo SMAW

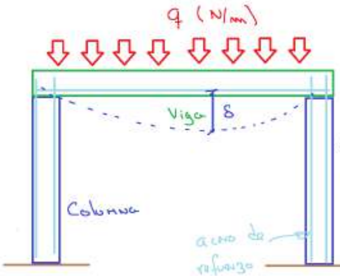


No todos los aceros son soldables

Lo recomendable para soldar un acero es tener un 0.25 < %C.

Por ejemplo ASTM A36

Acero
Varillas corrugadas - Para construcción

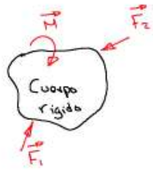


Concreto ⇨ Buena capacidad a la compresión
Malo a Tracción

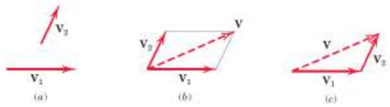
Portico

Introducción a la estática

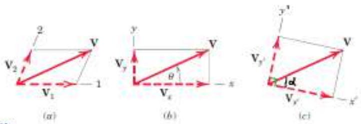
Cuerpo rígido:



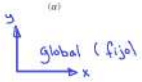
Cuerpo rígido es un elemento no deformable



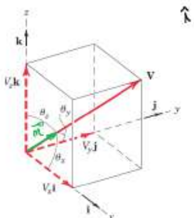
Suma vectorial



x'y': coordenadas locales



Vector tridimensional



$\hat{\imath}, \hat{\jmath}, \hat{k}$: Vectores unitarios

$|\hat{\imath}| = |\hat{\jmath}| = |\hat{k}| = 1$

$\vec{V} = |V_x|\hat{\imath} + |V_y|\hat{\jmath} + |V_z| k$

$\vec{M} = \dfrac{\vec{V}}{|\vec{V}|}$: vector unitario del vector $\vec{V}$

Cosenos directores ⇨ $l = \cos\theta_x \quad m = \cos\theta_y \quad n = \cos\theta_z$ ⇨ $V_x = lV \quad V_y = mV \quad V_z = nV$

where, from the Pythagorean theorem,

$$V^2 = V_x^2 + V_y^2 + V_z^2$$

Note that this relation implies that $l^2 + m^2 + n^2 = 1$.

Sistema de Fuerzas

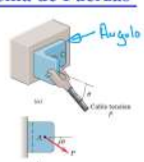
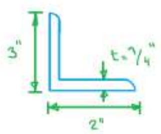


Figure 2/1



L 3" x 2" x 1/4"

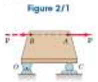


Figure 2/2

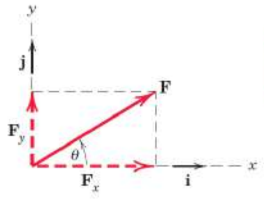


Figure 2/5

$$\mathbf{F} = F_x\mathbf{i} + F_y\mathbf{j}$$

$$\boxed{\mathbf{F} = \mathbf{F}_x + \mathbf{F}_y}$$

$$F_x = F\cos\theta \qquad F = \sqrt{F_x^{\,2} + F_y^{\,2}}$$

$$F_y = F\sin\theta \qquad \theta = \tan^{-1}\frac{F_y}{F_x}$$

$$\mathbf{R} = \mathbf{F}_1 + \mathbf{F}_2 = (F_{1_x}\mathbf{i} + F_{1_y}\mathbf{j}) + (F_{2_x}\mathbf{i} + F_{2_y}\mathbf{j})$$

$$R_x\mathbf{i} + R_y\mathbf{j} = (F_{1_x} + F_{2_x})\mathbf{i} + (F_{1_y} + F_{2_y})\mathbf{j}$$

ıich we conclude that

$$R_x = F_{1_x} + F_{2_x} = \Sigma F_x \qquad R_y = F_{1_y} + F_{2_y} = \Sigma F_y \qquad \textbf{(2/4)}$$

m ΣF_x means "the algebraic sum of the x scalar components". example shown in Fig. 2/7, note that the scalar component F_{2_y} e negative.

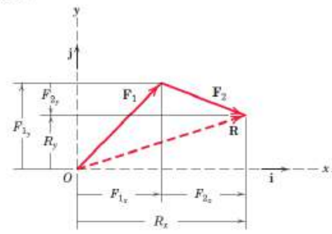
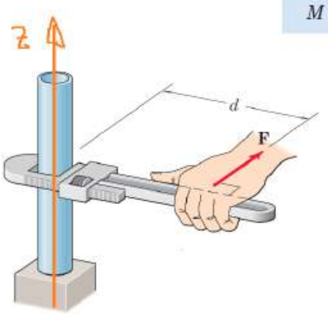
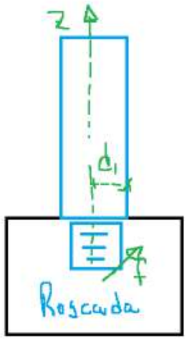


Figure 2/7

Momento

$$M = Fd$$





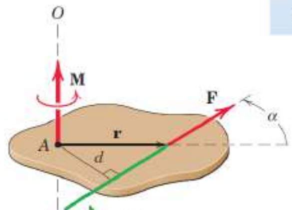
El momento que se opone al giro:

f . d

Para girarlo

M > f.d

$$\mathbf{M} = \mathbf{r} \times \mathbf{F}$$

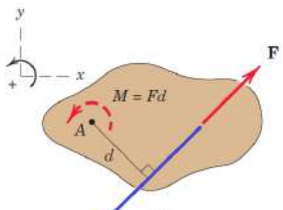


(b)

linea de acción

|M| = |F|.|d|

(c)



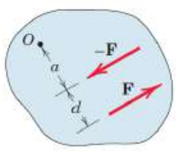
(d)

linea de acción

+M

-M

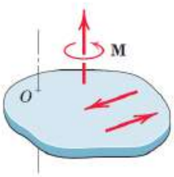
Par



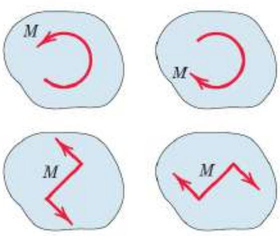
(a)

$$M = F(a + d) - Fa$$

$$\boxed{M = Fd}$$



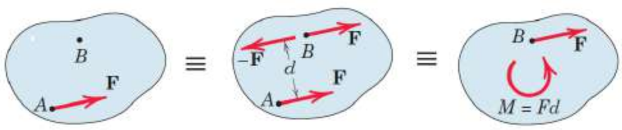
(c)

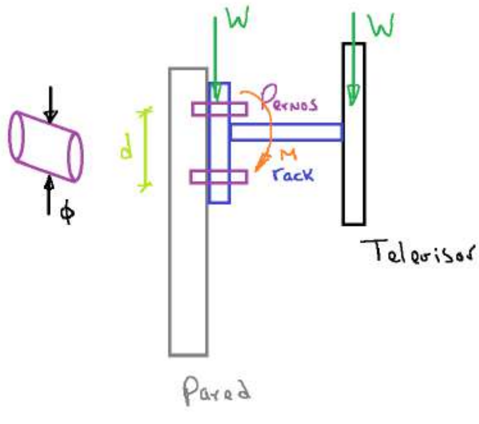


Counterclockwise couple (+)

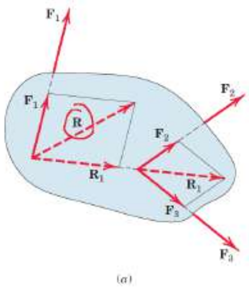
Clockwise couple (-)

(d)

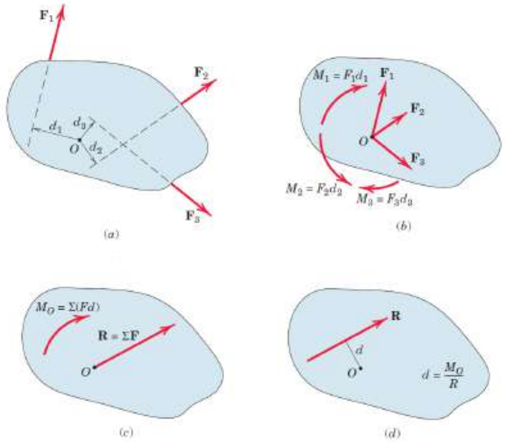




Resultante



(a)



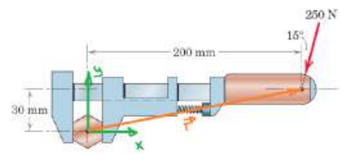
(a) (b)

(c) (d)

Problema 01

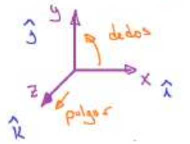
Calculate the moment of the 250-N force on the handle of the monkey wrench about the center of the bolt.

$\vec{M} = \vec{r} \times \vec{F}$



$\vec{r} = 200\,\hat{i} + 30\,\hat{j}$

$\vec{F} = -250 \cdot \operatorname{Sen} 15\,\hat{i} - 250 \cdot \operatorname{Cos} 15\,\hat{j}$



Regla mano derecha

$\hat{i} \times \hat{j} = \hat{k}$

$\hat{k} \times \hat{i} = \hat{j}$

$\hat{j} \times \hat{i} = -\hat{k}$

$\hat{i} \times \hat{i} = 0$

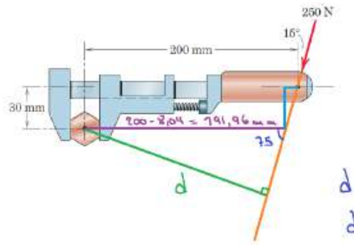
$\vec{M} = \vec{r} \times \vec{F}$

$\vec{M} = (200\,\hat{i} + 30\,\hat{j}) \times (-250 \cdot \operatorname{Sen} 15\,\hat{i} - 250 \cdot \operatorname{Cos} 15\,\hat{j})$

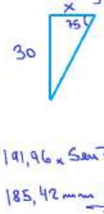
$\vec{M} = -48296{,}29\,\hat{k} - 1941{,}14\,(-\hat{k})$

$\vec{M} = -46355{,}15 \text{ N.mm } (\hat{k})$

$\vec{M} = -46{,}36 \text{ N.m } (\hat{k})$



$30 \cdot \operatorname{cotg} 75 = 8{,}04 \text{ mm}$



$d = 191{,}96 \times \operatorname{Sen} 75$

$d = 185{,}42 \text{ mm}$

$M = F \cdot d$

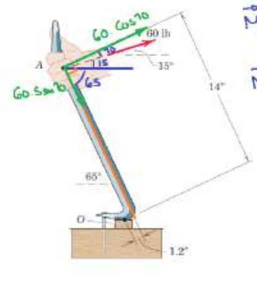
$M = 250 \text{ N} \times 185{,}42 \text{ mm}$

$\vec{M} = -46355 \text{ N.mm } \hat{k}$

$\vec{M} = -46{,}36 \text{ N.m } \hat{k}$

Problema 02

A prybar is used to remove a nail as shown. Determine the moment of the 60-lb force about the point O of contact between the prybar and the small support block.

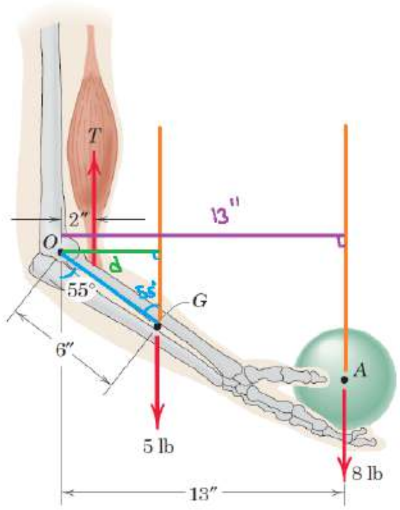


$\vec{M}_o = -60 \cdot \cos 10 \times 14''\,\hat{k} - 60 \cdot \operatorname{Sen} 10 \times 1{,}2\,\hat{k}$

$\vec{M}_o = -839{,}79 \text{ lbf-pulg } \hat{k}$

Problema 05

Elements of the lower arm are shown in the figure. The weight of the forearm is 5 lb with mass center at G. Determine the combined moment about the elbow pivot O of the weights of the forearm and the sphere. What must the biceps tension force be so that the overall moment about O is zero?



$d = 6'' \cdot \text{Sen } 55$

$d = 4{,}915$

el momento que genera las fuerzas 5 lbf y 8 lbf:

$M_o = -5\,\text{lbf} \cdot 4{,}915\,\text{pulg}\,\hat{k} - 8\,\text{lbf} \times 13\,\text{pulg}\,\hat{k}$

$M_o = -128{,}57\ \text{lbf}\cdot\text{pulg}\cdot\hat{k}$

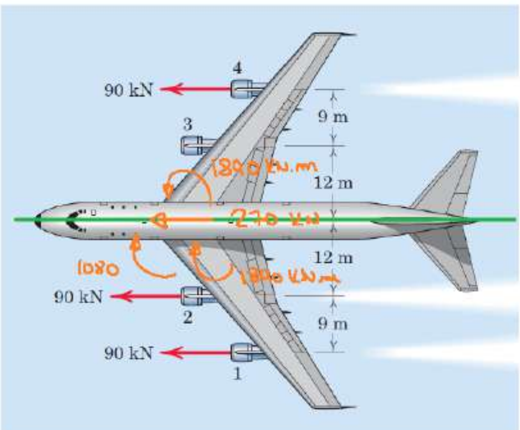
Para garantizar equilibrio $\sum M_o = 0$

$-128{,}57 + 2 \times T = 0$

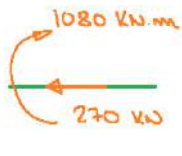
$T = 64{,}29\ \text{lbf}$

Problema 12

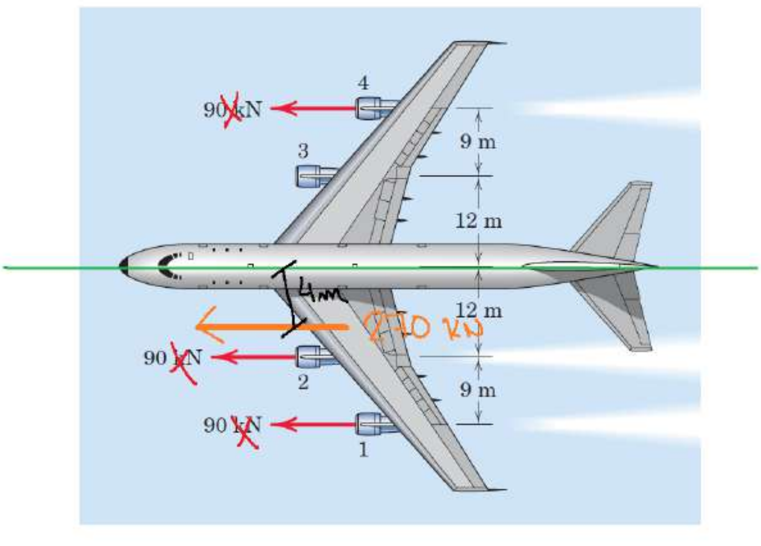
A commercial airliner with four jet engines, each producing 90 kN of forward thrust, is in a steady, level cruise when engine number 3 suddenly fails. Determine and locate the resultant of the three remaining engine thrust vectors. Treat this as a two-dimensional problem.



eje de simetria



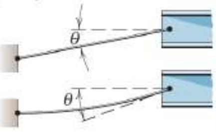
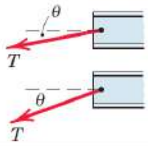
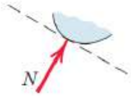
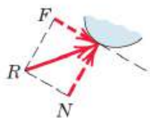
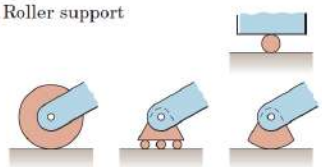
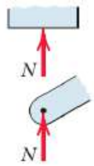
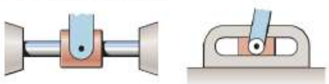
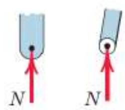
$d = \frac{M}{F} = \frac{1080}{270} = 4\,m$

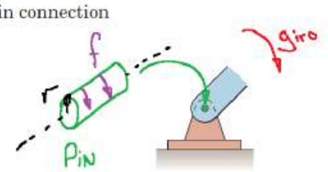
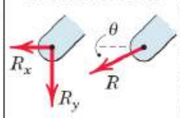
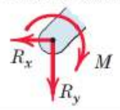
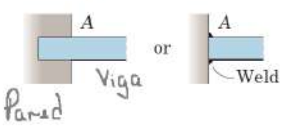
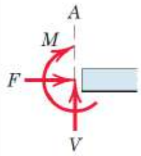
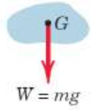
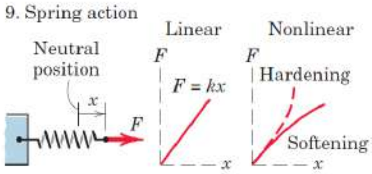


Equilibrio

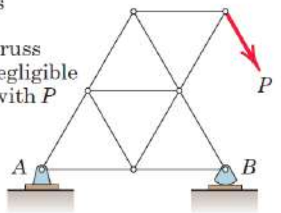
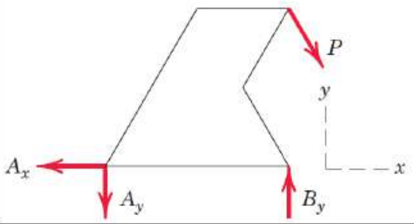
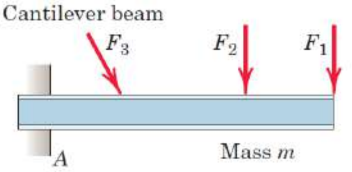
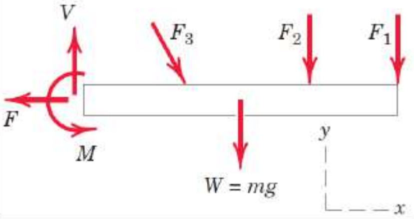
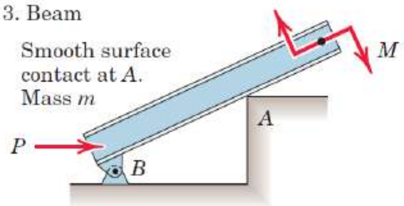
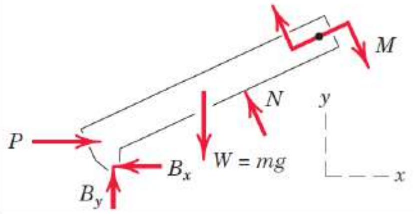
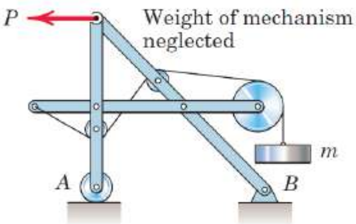
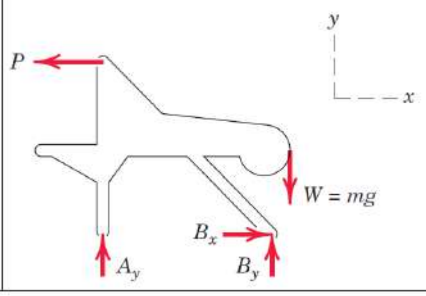
Condición de equilibrio

$$\mathbf{R} = \Sigma\mathbf{F} = \mathbf{0} \qquad \mathbf{M} = \Sigma\mathbf{M} = \mathbf{0}$$

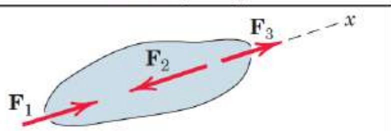
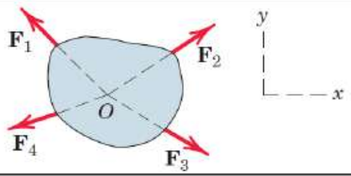
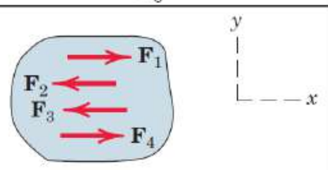
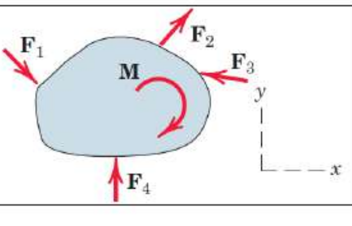
MODELING THE ACTION OF FORCES IN TWO-DIMENSIONAL ANALYSIS	
Type of Contact and Force Origin	**Action on Body to Be Isolated**
1. Flexible cable, belt, chain, or rope Weight of cable negligible Weight of cable not negligible  	 Force exerted by a flexible cable is always a tension away from the body in the direction of the cable.
2. Smooth surfaces 	 Contact force is compressive and is normal to the surface.
3. Rough surfaces 	 Rough surfaces are capable of supporting a tangential component F (frictional force) as well as a normal component N of the resultant contact force R.
4. Roller support 	 Roller, rocker, or ball support transmits a compressive force normal to the supporting surface.
5. Freely sliding guide 	 Collar or slider free to move along smooth guides; can support force normal to guide only.

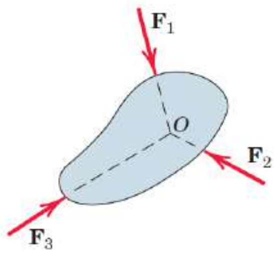
MODELING THE ACTION OF FORCES IN TWO-DIMENSIONAL ANALYSIS (*cont.*)	
Type of Contact and Force Origin	**Action on Body to Be Isolated**
6. Pin connection  M = f×r ✓	Pin free to turn  Pin not free to turn  A freely hinged pin connection is capable of supporting a force in any direction in the plane normal to the pin axis. We may either show two components R_x and R_y or a magnitude R and direction θ. A pin not free to turn also supports a couple M.
7. Built-in or fixed support  	 A built-in or fixed support is capable of supporting an axial force F, a transverse force V (shear force), and a couple M (bending moment) to prevent rotation.
8. Gravitational attraction  	 The resultant of gravitational attraction on all elements of a body of mass m is the weight $W = mg$ and acts toward the center of the earth through the center mass G.
9. Spring action  	 Spring force is tensile if spring is stretched and compressive if compressed. For a linearly elastic spring the stiffness k is the force required to deform the spring a unit distance.

Ejemplos de diagrama de cuerpo libre

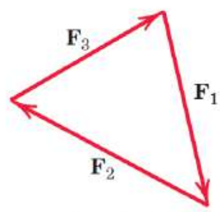
SAMPLE FREE-BODY DIAGRAMS	
Mechanical System	Free-Body Diagram of Isolated Body
1. Plane truss Weight of truss assumed negligible compared with P 	
2. Cantilever beam 	
3. Beam Smooth surface contact at A. Mass m 	
4. Rigid system of interconnected bodies analyzed as a single unit 	

Categorias de equilibrio

CATEGORIES OF EQUILIBRIUM IN TWO DIMENSIONS		
Force System	Free-Body Diagram	Independent Equations
1. Collinear		$\Sigma F_x = 0$
2. Concurrent at a point		$\Sigma F_x = 0$ $\Sigma F_y = 0$
3. Parallel		$\Sigma F_x = 0 \quad \Sigma M_z = 0$
4. General		$\Sigma F_x = 0 \quad \Sigma M_z = 0$ $\Sigma F_y = 0$



(a) Three-force member

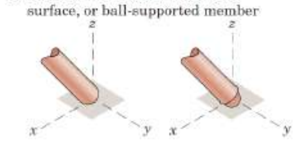
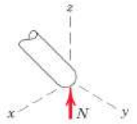
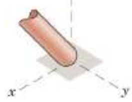
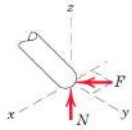
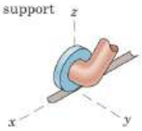
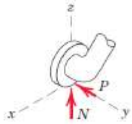
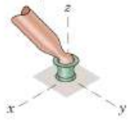
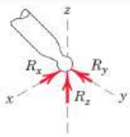
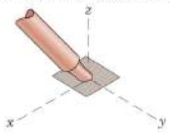
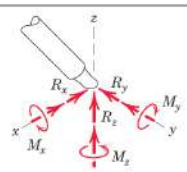
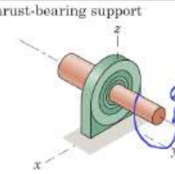
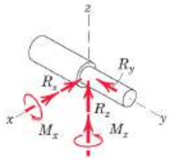


(b) Closed polygon satisfies $\Sigma\mathbf{F} = \mathbf{0}$

Equilibrio en 3 dimensiones

$$\Sigma \mathbf{F} = \mathbf{0} \quad \text{or} \quad \begin{cases} \Sigma F_x = 0 \\ \Sigma F_y = 0 \\ \Sigma F_z = 0 \end{cases}$$

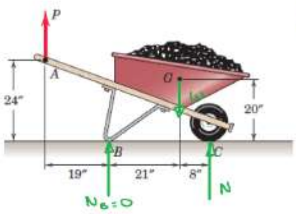
$$\Sigma \mathbf{M} = \mathbf{0} \quad \text{or} \quad \begin{cases} \Sigma M_x = 0 \\ \Sigma M_y = 0 \\ \Sigma M_z = 0 \end{cases}$$

MODELING THE ACTION OF FORCES IN THREE-DIMENSIONAL ANALYSIS	
Type of Contact and Force Origin	Action on Body to Be Isolated
1. Member in contact with smooth surface, or ball-supported member 	 Force must be normal to the surface and directed toward the member.
2. Member in contact with rough surface 	 The possibility exists for a force F tangent to the surface (friction force) to act on the member, as well as a normal force N.
3. Roller or wheel support with lateral constraint 	 A lateral force P exerted by the guide on the wheel can exist, in addition to the normal force N.
4. Ball-and-socket joint 	 A ball-and-socket joint free to pivot about the center of the ball can support a force **R** with all three components.
5. Fixed connection (embedded or welded) 	 In addition to three components of force, a fixed connection can support a couple **M** represented by its three components.
6. Thrust-bearing support  eje gira libremente	 Thrust bearing is capable of supporting axial force R_y as well as radial forces R_x and R_z. Couples M_x and M_z must, in some cases, be assumed zero in order to provide statical determinacy.

y

Problema 23

Determine the magnitude P of the vertical force required to lift the wheelbarrow free of the ground at point B. The combined weight of the wheelbarrow and its load is 240 lb with center of gravity at G.



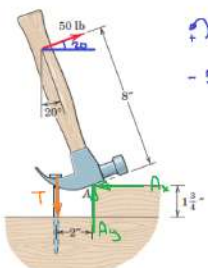
$\circlearrowleft +\ \Sigma M_C = 0$

$-P \cdot 48 + W \cdot 8 = 0$

$P = 40 \text{ lbf}$

Problema 24

A block placed under the head of the claw hammer as shown greatly facilitates the extraction of the nail. If a 50-lb pull on the handle is required to pull the nail, calculate the tension T in the nail and the magnitude A of the force exerted by the hammer head on the block. The contacting surfaces at A are sufficiently rough to prevent slipping.



$\circlearrowleft +\ \Sigma M_A = 0$

$-50 \cdot 8 + T \cdot 2 = 0$

$T = 200 \text{ lbf}$

$\Sigma F_x = 0$

$+50 \cdot \cos 20 - A_x = 0$

$A_x = 46{,}98 \text{ lbf}$

$\Sigma F_y = 0$

$50 \cdot \text{sen}\, 20 + A_y - 200 = 0$

$A_y = 182{,}9 \text{ lbf}$

$A = \sqrt{A_x^2 + A_y^2} = 188{,}83 \text{ lbf}$