6-1 Draw a free-body diagram for the cantilever beam shown in Fig. P6-1 which has a weight $\bar{W}$.

**SOLUTION**

The action of the fixed support at the left end of the beam is represented by force components $\bar{R}_x$ and $\bar{R}_y$ and a moment $\bar{M}_A$. The weight $\bar{W}$ of the beam acts through the center of gravity $G$ of the beam and is directed toward the center of the earth.

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6-2 Draw a free-body diagram for the beam shown in Fig. P6-2 which has a mass $m$.

**SOLUTION**

The action of the pin at support A is represented by force components $\bar{R}_x$ and $\bar{R}_y$. Force $\bar{B}$ acts normal to the supporting surface at B. The weight $\bar{W} = m\bar{g}$ of the beam acts through the center of gravity $G$ of the beam and is directed toward the center of the earth.
6-3 Draw a free-body diagram for the cylinder shown in Fig. P6-3 which has a weight \( \bar{W} \).

**SOLUTION**

Forces \( \bar{N}_1 \) and \( \bar{N}_2 \) act normal to the surface of the cylinder at points of contact with the supporting surfaces. The weight \( \bar{W} \) of the cylinder acts through the center of gravity \( \bar{G} \) of the cylinder and is directed toward the center of the earth.

6-4 Draw a free-body diagram for the curved bar shown in Fig. P6-4.

**SOLUTION**

The action of the pin at support \( A \) is represented by force components \( \bar{A}_x \) and \( \bar{A}_y \). The cable at \( B \) exerts a tensile force \( \bar{T} \) on the bar that is tangent to the cable at point \( B \).
6-5 Draw a free-body diagram for the curved bar shown in Fig. P6-5.

**SOLUTION**

The cable at B exerts a tensile force $T$ on the bar that is tangent to the cable at point B. The action of the pin at support C is represented by force components $C_x$ and $C_y$.

6-6 Draw a free-body diagram for the angle bracket shown in Fig. P6-6.

**SOLUTION**

The action of the pin at support A is represented by force components $A_x$ and $A_y$. The roller at B exerts a compressive force $B$ normal to the surface of the bracket.
6-7 Draw a free-body diagram for the curved bar shown in Fig. P6-7.

SOLUTION

The cable exerts a tensile force $T$ on the bar that is tangent to the cable at the point of attachment. The wheels at A and B exert forces $R$ and $B$ on the bar that are normal to the surfaces supporting the wheels.

6-8 Draw a free-body diagram for the beam shown in Fig. P6-8.

SOLUTION

The action of the pin at support A is represented by force components $A_x$ and $A_y$. The cable is continuous over the pulley; therefore, the force in the cable is constant. At points B and C the cable exerts tensile forces $T$ on the beam that are tangent to the cable.
6-9 Draw a free-body diagram for the sled shown in Fig. P6-9.

**SOLUTION**

The tow rope exerts a force $P$ on the sled that is tangent to the rope at the point of attachment. The box exerts normal and friction forces $N_1$ and $F_1$ on the sled. The support surface would exert only a normal force $N_2$ on the sled since it is assumed to be smooth.

6-10 Draw a free-body diagram for the diving board shown in Fig. P6-10.

**SOLUTION**

The action of the pin at support A is represented by force components $\vec{A}_x$ and $\vec{A}_y$. Support B exerts a normal force $B$ on the board. The diver exerts a normal force $N$ on the board that is equal to his weight.
6-11 Draw a free-body diagram for the cart shown in Fig. P6-11 which has a weight \( W \).

![Cart diagram](image)

**SOLUTION**

The cable exerts a force \( T \) on the cart that is tangent to the cable at the point of attachment. The weight \( W \) of the cart acts through the center of gravity \( G \) of the cart and is directed toward the center of the earth. The support surface exerts normal forces \( N_1 \) and \( N_2 \) on the wheels since the surface is assumed to be smooth.

6-12 Draw a free-body diagram for the lawn mower shown in Fig. P6-12 which has a weight \( W \) and is resting on a rough surface.

![Lawn mower diagram](image)

**SOLUTION**

The weight \( W \) of the mower acts through the center of gravity \( G \) of the mower and is directed toward the center of the earth. The support surface exerts normal forces \( N_1 \) and \( N_2 \) and frictional forces \( F_1 \) and \( F_2 \) on the wheels since the surface is assumed to be rough.
6-13 Draw a free-body diagram for
(a) the cylinder shown in
   Fig. P6-13 which has a
   weight \( \mathbf{W} \),
(b) bar ACE shown in Fig.
   P6-13.
(c) bar BCD shown in Fig.
   P6-13.

SOLUTION

(a) The weight \( \mathbf{W} \) of the cylinder acts
   through the center of gravity \( G \) of
   the cylinder and is directed toward
   the center of the earth. Forces \( \mathbf{N}_1 \)
   and \( \mathbf{N}_2 \) act normal to the surface of
   the cylinder at points of contact
   with the supporting bars.

(b) Force \( \mathbf{F} \) acts normal to the smooth
   supporting surface at A. The cable
   at A exerts a force \( \mathbf{T} \) on bar ACE
   that is tangent to the cable at A.
   The action of the pin at C is
   represented by force components
   \( \mathbf{C}_x \) and \( \mathbf{C}_y \). Force \( \mathbf{N}_2 \) acts normal
   to the surface of bar ACE at the
   point of contact with the cylinder.

(c) Force \( \mathbf{B} \) acts normal to the smooth
   supporting surface at B. The cable
   at B exerts a force \( \mathbf{T} \) on bar BCD
   that is tangent to the cable at B.
   The action of the pin at C is
   represented by force components
   \( \mathbf{C}_x \) and \( \mathbf{C}_y \). Force \( \mathbf{N}_1 \) acts normal
   to the surface of bar BCD at the
   point of contact with the cylinder.
6-14 Draw a free-body diagram for
(a) the cylinder shown in Fig. P6-14 which has a mass $m$.
(b) the frame shown in Fig. P6-14. Neglect the weight of the frame.

**SOLUTION**

(a) Forces $N_1$, $N_2$, and $N_3$ act normal to the surface of the cylinder at points of contact with the frame and the wall. The weight $W$ of the cylinder acts through the center of gravity $G$ of the cylinder and is directed toward the center of the earth.

(b) The action of the pin at support $A$ of the frame is represented by force components $P_x$ and $P_y$. Forces $N_1$ and $N_2$ act normal to the surface of the frame at points of contact with the cylinder.
6-15 Draw a free-body diagram for bracket AB shown in Fig. P6-15.

SOLUTION

The action of the pin at support A of the bracket is represented by force components $\mathbf{A}_x$ and $\mathbf{A}_y$. Forces $\mathbf{N}_1$, $\mathbf{N}_2$, and $\mathbf{N}_3$ act normal to the surface of the bracket at points of contact with the cylinders. Support B exerts a normal force $\mathbf{B}$ on the bracket.

In a similar manner, the free-body diagram can be drawn using $x'$ and $y'$ axes as:
6-16 Draw a free-body diagram for
(a) bar AC shown in Fig. P6-16.
(b) bar DE shown in Fig. P6-16.

SOLUTION

(a) The cable exerts a force \( \mathbf{T} \) on bar AC that is tangent to the cable at point A. The action of the pin at support B is represented by force components \( \mathbf{B}_x \) and \( \mathbf{B}_y \). The pin at C exerts a force \( \mathbf{C} \) on bar AC that is normal to the surface of the slot in bar DE.

(b) The action of the pin at support D is represented by force components \( \mathbf{D}_x \) and \( \mathbf{D}_y \). The pin at C exerts a force \( \mathbf{C} \) on bar DE that is normal to the surface of the slot in the bar.
6-17 Draw a free-body diagram for
(a) the cylinder shown in
Fig. P6-17 which has
a weight $W$.
(b) bar AC shown in Fig.
P6-17.
(c) bar BCD shown in Fig.
P6-17.

SOLUTION

(a) Forces $N_1$, $N_2$, and $N_3$ act normal to
the surface of the cylinder at points of contact with the bars and the
wall. The weight $W$ of the cylinder
acts through the center of gravity $G$
of the cylinder and is directed toward
the center of the earth.

(b) The action of the pin at support $A$
of bar AC is represented by force
components $A_x$ and $A_y$. A force $N_1$
acts normal to the surface of bar
AC at the point of contact with the
cylinder. The action of the pin at
C is represented by force components
$C_x$ and $C_y$.

(c) A force $N_2$ acts normal to the
surface of bar BD at the point
of contact with the cylinder.
The action of the pin at C is
represented by force components
$C_x$ and $C_y$. The roller at B
exerts a force $B$ on bar BD that
is normal to the supporting surface.
6-18 Draw a free-body diagram for
(a) bar AB shown in Fig. P6-18.
(b) bar CB shown in Fig. P6-18.

Fig. P6-18

SOLUTION

(a) The action of the pin at support A of bar AB is represented by force components $A_x$ and $A_y$. The action of the pin at support B of bar AB is represented by force components $B_x$ and $B_y$.

(b) The action of the pin at support C of bar CB is represented by force components $C_x$ and $C_y$. The pin at the right end of bar BC transmits forces $B_x$ and $B_y$ from bar AB to bar CB and supports load $F_2$. The free-body diagram for bar CB shows pin B as part of the bar.
6-19 Draw a free-body diagram for
(a) bar BE shown in Fig. P6-19.
(b) bar DF shown in Fig. P6-19.

**SOLUTION**

(a) The link at the left end of bar BE exerts a force \( \mathbf{B} \) on the bar that is directed along the axis of the link. The action of the pin support at point C of bar BE is represented by forces \( \mathbf{C}_x \) and \( \mathbf{C}_y \). The pin at E exerts a force \( \mathbf{E} \) on bar BE that is normal to the surface of the slot in bar DF.

(b) The action of the pin support at the right end of bar DF is represented by force components \( \mathbf{F}_x \) and \( \mathbf{F}_y \). The pin at E exerts a force \( \mathbf{E} \) on bar DF that is normal to the surface of the slot in the bar.
6-20 Draw a free-body diagram for
(a) bar AC shown in Fig. P6-20.
(b) bar DF shown in Fig. P6-20.

SOLUTION

(a) The cable at A exerts a force \( T \) on bar AC that is tangent to the cable at the point of attachment. The action of the pin at support B is represented by force components \( B_x \) and \( B_y \). Bar DF exerts a force \( D_x \) at point D that is normal to bar AC at the point of contact.

(b) The cable at F exerts a force \( T \) on bar DF that is tangent to the cable at the point of attachment. The action of the pin at support E is represented by force components \( E_x \) and \( E_y \). Bar AC exerts a force \( B_x \) at point D that is normal to bar AC at the point of contact.
6-21  Draw a free-body diagram for the bent bar shown in Fig. P6-21 which is fixed at the wall at A.

**SOLUTION**

The action of the fixed support at the left end A of the bar is represented by force components \( \bar{A}_x, \bar{A}_y, \) and \( \bar{A}_z \) and by moment components \( \bar{M}_{Ax}, \bar{M}_{Ay}, \) and \( \bar{M}_{Az} \).

6-22  Draw a free-body diagram for the bent bar shown in Fig. P6-22 which is fixed at the wall at A.

**SOLUTION**

The action of the fixed support at the left end A of the bar is represented by force components \( \bar{A}_x, \bar{A}_y, \) and \( \bar{A}_z \) and by moment components \( \bar{M}_{Ax}, \bar{M}_{Ay}, \) and \( \bar{M}_{Az} \).
6-23 Draw a free-body diagram for the shaft shown in Fig. P6-23. The bearing at A is a thrust bearing and the bearing at D is a ball bearing. Neglect the weights of the shaft and the levers.

SOLUTION

The action of the thrust bearing at support A is represented by force components $\mathbf{R}_x$, $\mathbf{R}_y$, and $\mathbf{R}_z$. The action of the lever at B is represented by a force component $\mathbf{B}_z$ and a moment component $\mathbf{M}_{By}$. The action of the lever at C is represented by a force component $\mathbf{C}_x$ and a moment component $\mathbf{M}_{Cy}$. The action of the ball bearing at support D is represented by force components $\mathbf{D}_x$ and $\mathbf{D}_z$. 
6-24 Draw a free-body diagram for the block shown in Fig. P6-24 which has a mass $m$. The support at $A$ is a ball and socket. The support at $B$ is a pin and bracket.

**SOLUTION**

The action of the ball and socket joint at support $A$ is represented by force components $\vec{A}_x$, $\vec{A}_y$, and $\vec{A}_z$. The action of the pin and bracket at support $B$ is represented by force components $\vec{B}_y$ and $\vec{B}_z$. The cable at $C$ exerts a force $T$ on the block that is tangent to the cable at the point of attachment. The weight $\vec{W} = m\vec{g}$ of the block acts through the center of gravity $G$ of the block and is directed toward the center of the earth.
6-25 Draw a free-body diagram for the bent bar shown in Fig. P6-25. The support at A is a journal bearing and the supports at B and C are ball bearings.

**SOLUTION**

The action of the journal bearing at support A is represented by force components $A_x$ and $A_z$ and moment components $M_y$ and $M_z$. The ball bearings at supports B and C are represented by force components $B_x$ and $B_y$ at bearing B and force components $C_x$ and $C_z$ at bearing C.
6-26 Draw a free-body diagram for the bar bracket shown in Fig. P6-26. The support at B is a ball and socket joint. The ends of the bars at A and C rest against smooth surfaces.

SOLUTION

The action of the ball-and-socket joint at support B is represented by force components $B_x$, $B_y$, and $B_z$. The smooth surfaces at A and C exert forces $A$ and $C$ on the bar bracket that are normal to the surfaces.
6-27 Draw a free-body diagram for the bar shown in Fig. P6-27. The bar rests against a smooth vertical wall at end D. The support at A is a ball and socket. The cable is not continuous at B.

SOLUTION

The action of the ball and socket joint at support A is represented by force components $A_x$, $A_y$, and $A_z$. The smooth surface at D exerts a force $D$ normal to the surface. The cables at B exert forces $T_1$ and $T_2$ on the bar that are tangent to the cables at the points of attachment.
6-28 Draw a free-body diagram for the door shown in Fig. P6-28 which has a weight $W$.

**SOLUTION**

The cable at A exerts a force $T$ on the door that is tangent to the cable at the point of attachment. The action of the hinge at C is represented by force components $C_x$, $C_y$, and $C_z$ and moment components $M_x$ and $M_z$. The weight $W$ of the door acts through the center of gravity $G$ of the door and is directed toward the center of the earth.
6-29 Draw a free-body diagram for the bent bar shown in Fig. P6-29. The support at A is a ball and socket joint, the supports at B are a cable and a link, and the support at C is a link.

**SOLUTION**

The action of the ball and socket joint at support A is represented by force components $\mathbf{A}_x$, $\mathbf{A}_y$, and $\mathbf{A}_z$. The cable at B exerts a force $\mathbf{T}$ on the bar that is tangent to the cable at the point of attachment. The links at B and C exert forces $\mathbf{B}$ and $\mathbf{C}$ on the bar that are directed along the axes of the links.
6-30 Draw a free-body diagram for the bent bar shown in Fig. P6-30. Supports at B and C are ball bearings. The horizontal and vertical surfaces at A are smooth.

SOLUTION

The smooth horizontal and vertical surfaces at A exert forces $\bar{A}_x$ and $\bar{A}_z$ on the bar that are normal to the two surfaces. The ball bearings at supports B and C are represented by force components $\bar{B}_x$ and $\bar{B}_y$ at bearing B and force components $\bar{C}_x$ and $\bar{C}_y$ at bearing C.