Slide 1

Static Equilibrium

Hanging Sign Problems

Slide 2

What is Static Equilibrium?

- Static – an object is at rest
- Equilibrium – the net force in all dimensions is zero.
- Static Equilibrium – An object at rest in all directions, therefore having a net force of zero.

Slide 3

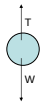
Problem Solving Method

1. Draw a free body diagram including all the forces acting on the object.
2. Break each force that is not completely vertical or horizontal into its x and y components using right triangle math.
3. Write a net force equation including all horizontal forces.
4. Write a net force equation including all the vertical forces.
5. Use either substitution or elimination to solve the system of net force equations for one of the unknown tensions.
6. Find the second tension by plugging the first tension into an equation for the second.

Slide 4

Starting with a simple example

- A 12 kg bowling ball is held vertically downward. What is the force on the person's arm from the ball?



$\Sigma F_x=0$
$0-0 = 0$

$\Sigma F_y = 0$
$W-T = 0$
$W = T$
$mg = T$
$12(9.8) = T$
$117.6\ N = T$

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Upping the Ante

- A 30 kg child sits on a 2.5 kg swing. What is the tension on each of the two chains?

$\Sigma F_x=0$
$0-0 = 0$

$\Sigma F_y = 0$
$T_1 + T_2 -(W_c + W_s) = 0$
Because the child is in the center of the swing and the chains are spaced equally on the seat.
$T_1=T_2$
$T_1 + T_1=(W_c + W_s)$
$2T_1 =(30(9.8) + 2.5(9.8))$
$2T_1 = 294 + 24.5$
$2T_1 = 318.5$
$T_1 = 159.25\ N$

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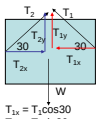
What about angles?

- A 2.5 kg picture is hung so that each end of the wire makes a 30 degree angle with the horizontal. What is the tension in each side of the wire?



$T_{1x} = T_1\cos30$
$T_{1y} = T_1\sin30$
$T_{2x} = T_2\cos30$
$T_{2y} = T_2\sin30$

$\Sigma F_x=0$
$T_{2x}-T_{1x} = 0$
$T_{2x}=T_{1x}$
$T_2\cos 30=T_1\cos30$
$T_2 = T_1$

$\Sigma F_y = 0$
$T_{1y} + T_{2y} - W = 0$
$T_{1y} + T_{2y} = W$
$T_1 \sin 30 + T_2 \sin30= W$
$T_1 \sin 30 + T_1 \sin30= mg$
$T_1 (0.5) + T_1 (0.5) = 2.5(9.8)$
$T_1 = 24.5\ N$
$T_2 = 24.5\ N$

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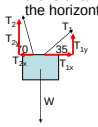
One Last Example

- A 10 kg sign is held by two cables. The right hand cable makes an angle of 35 degrees with the horizontal and the left hand cable makes an angle of 70 degrees with the horizontal. What is the tension in each cable?



$T_{1x} = T_1\cos 35$
$T_{1y} = T_1\sin 35$
$T_{2x} = T_2\cos 70$
$T_{2y} = T_2\sin 70$

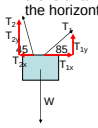
$\Sigma F_x = 0$
$T_{2x} - T_{1x} = 0$
$T_{2x} = T_{1x}$
$T_2\cos 70 = T_1\cos 35$
$T_2 = T_1(\cos 35/\cos 70)$
$T_2 = T_1(0.82/0.34)$
$T_2 = 2.4T_1$
$T_2 = 2.4(34.6)$
$T_2 = 83.1$ N

$\Sigma F_y = 0$
$T_{1y} + T_{2y} - W = 0$
$T_{1y} + T_{2y} = W$
$T_1 \sin 35 + T_2 \sin 70 = W$
$T_1 \sin 35 + 2.4T_1 \sin 70 = mg$
$T_1 (0.57) + 2.4T_1 (0.94) = 10(9.8)$
$T_1 (0.57) + 2.26T_1 = 98$
$2.83\, T_1 = 98$
$T_1 = 98/2.83 = 34.6$ N

Slide 8

Your Turn

- A 24 kg sign is held by two cables. The right hand cable makes an angle of 85 degrees with the horizontal and the left hand cable makes an angle of 45 degrees with the horizontal. What is the tension in each cable?



$T_{1x} = T_1\cos 85$
$T_{1y} = T_1\sin 85$
$T_{2x} = T_2\cos 45$
$T_{2y} = T_2\sin 45$

$\Sigma F_x = 0$
$T_{2x} - T_{1x} = 0$
$T_{2x} = T_{1x}$
$T_2\cos 45 = T_1\cos 85$
$T_2 = T_1(\cos 85/\cos 45)$
$T_2 = T_1(0.087/0.71)$
$T_2 = .123\, T_1$
$T_2 = .123(2172)$
$T_2 = 267.1$ N

$\Sigma F_y = 0$
$T_{1y} + T_{2y} - W = 0$
$T_{1y} + T_{2y} = W$
$T_1 \sin 85 + T_2 \sin 45 = W$
$T_1 \sin 85 + 0.123T_1 \sin 45 = mg$
$T_1 (0.996) + 0.123T_1 (0.71) = 24(9.8)$
$T_1 (0.996) + 0.0873T_1 = 2352$
$1.083\, T_1 = 2352$
$T_1 = 2352/1.083 = 2172$ N