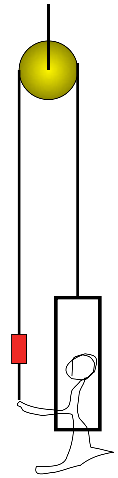
Problem 4.81

A kid pulls on a rope that has passed over a pulley as shown. If the scale attached to the rope reads 250 newtons, and if the kid's weight is 320 newtons and the swing's weight is 160 newtons:

a.) What's the system's acceleration?

b.) What's the force exerted by the chair on the kid?



A kid pulls on a rope that has passed over a pulley as shown. If the scale attached to the rope reads 250 newtons, and if the kid's weight is 320 newtons and the swing's weight is 160 newtons:

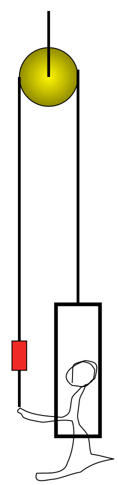
a.) What's the system's acceleration?

To begin with, we will need to know the mass of both the kid and the swing. Those values are:

$$W_{kid} = m_{kid} g$$
$$\Rightarrow \quad m_{kid} = \frac{320 \text{ nt}}{9.8 \text{ m/s}^2} = 32.65 \text{ kg}$$

AND

$$W_{swing} = m_{swing} g$$
$$\Rightarrow \quad m_{swing} = \frac{160 \text{ nt}}{9.8 \text{ m/s}^2} = 16.33 \text{ kg}$$



A kid pulls on a rope that has passed over a pulley as shown. If the scale attached to the rope reads 250 newtons, and if the kid's weight is 320 newtons and the swing's weight is 160 newtons:

a.) What's the system's acceleration?

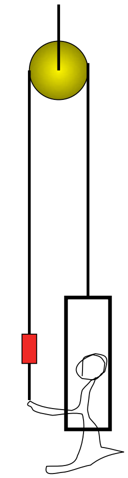
We don't really care what the kid does to other parts of the system. All we are interested in are the forces acting on the kid. So what is going on with the kid? Well:

Assuming we take the kid and swing to be one entity, the scale is applying what is essentially a tension force on the kid/swing system that is upward. This tension force is connected to the system via the kid's hand.

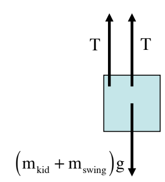
There is a second tension force also being applied to the kid/swing system. That is from the rope that is attached to the swing (look at the sketch).

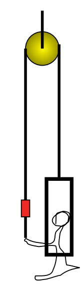
We also have to take into account the weight of both the kid and swing.

With all this in mind:



A f.b.d. on the swing/kid system yields:



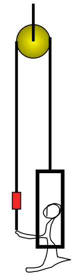


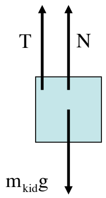
Assuming the kid/swing system is accelerating upward in the positive direction, N.S.L. produces:

$$\sum F_y :$$
$$T + T - (m_{kid} + m_{swing})g = (m_{kid} + m_{swing})a$$
$$\Rightarrow \quad a = \frac{2T - (m_{kid} + m_{swing})g}{(m_{kid} + m_{swing})}$$
$$\Rightarrow \quad a = \frac{2(250 \text{ nt}) - (32.65 \text{ kg} + 16.33 \text{ kg})(9.8 \text{ m/s}^2)}{(32.65 \text{ kg} + 16.33 \text{ kg})}$$
$$\Rightarrow \quad a = .408 \text{ m/s}^2$$

As I assumed that the acceleration was upward, and as the calculated value for "a" turned out to be positive, evidently my assumed direction for the acceleration was correct.

To get the normal force on the kid, we have to do a f.b.d. on just the kid, sum the forces on him and put that equal to his mass times the calculated acceleration. Doing so yields the f.b.d. shown:





N.S.L. yields:

$$\sum F_y :$$

$$N + T - m_{kid}g = m_{kid}a$$

$$\Rightarrow \quad N = -T + m_{kid}g + m_{kid}g$$

$$\Rightarrow \quad N = -(250 \text{ nt}) + (32.65 \text{ kg})(9.8 \text{ m/s}^2) + (32.65 \text{ kg})(.408 \text{ m/s}^2)$$

$$\Rightarrow \quad N = .83.3 \text{ nts}$$