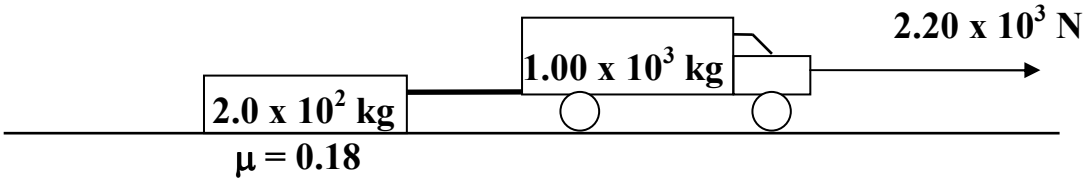
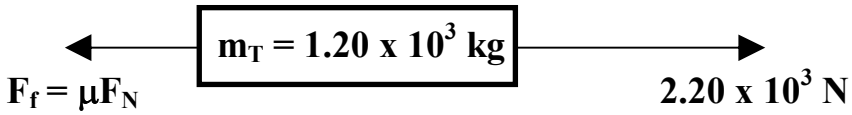
Connected Mass Problems

Consider this problem: a truck pulls a log with a force of 2.2×10^3 N. Sliding friction exists between log and road, and friction between truck's tires and road can be ignored. The mass of the truck is 1.0×10^3 kg, while the mass of the log is 2.0×10^2 kg. Find the acceleration of the system, and the tension in the rope connecting the two masses.

Start with a sketch of the system: (choose → as positive)



- To find acceleration, consider a f.b. diagram of the system:



→first, find $\mathbf{F_f = \mu F_N}$ where $\mathbf{F_N}$ = the weight of the log

$$\mathbf{F_f = 0.18(2.0 \times 10^2)(9.8) = 353\ N}$$

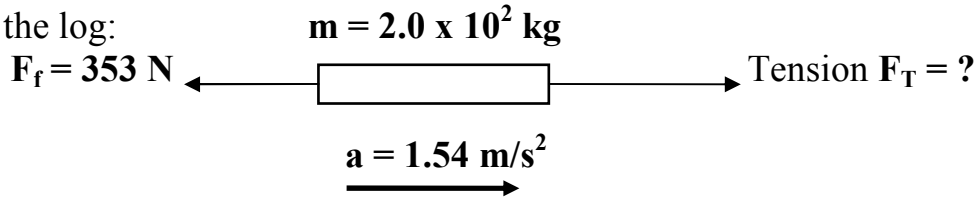
→so $\mathbf{F_{Net} = 2200 - 353 = 1847\ N}$

→finally, $\mathbf{F_{Net} = m_T a}$ $\mathbf{\rightarrow 1847 = 1200a}$ $\mathbf{\rightarrow a = 1.54\ m/s^2\ (right)}$

→ this acceleration is the same for any part of the system.

- To find tension, consider a f.b. diagram of only the log OR only the truck:

→ for the log:

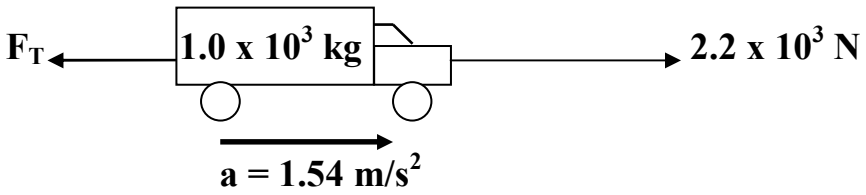


→First, find $\mathbf{F_{Net} = ma = 200(1.54) = 308\ N}$

→Now use the f.b.d. to make an equation:

$$\mathbf{F_{Net} = F_T - 400 \rightarrow 308 = F_T - 353 \rightarrow F_T = 6.5 \times 10^2\ N}$$

The same answer would result if only the truck was analyzed. The f.b.d. for the truck would appear as:



(these are the only horizontal forces acting on the truck; with no friction force here, the vertical forces have no effect on the net force)

→First, find $\mathbf{F_{Net} = ma = 1000(1.54) = 1540\ N}$

→Now use the f.b.d. to make an equation:

$$\mathbf{F_{Net} = 2200 - F_T \quad \rightarrow \quad 1540 = 2200 - F_T \quad \rightarrow \quad F_T = 6.6 \times 10^2\ N}$$

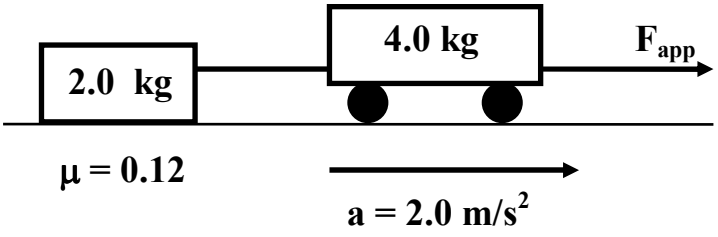
The difference between the two values for $\mathbf{F_T}$ results from rounding off answers as the problem is worked out. To avoid this, carry extra sig. figs. as you proceed through your calculations.

Example #11. A Truck pulls a log with a force of 2500 N. The log drags back with a 800 N force of friction. The mass of the truck is 2500 kg, the mass of the log is 600 kg. Find:

a) the acceleration of the truck & log system.
b) the tension in the rope.

(see Dynamics Ex 11 for answer)

Example #12. Two masses shown below are connected together and pulled by an applied force to the right, causing an acceleration of 2.0 m/s^2. There is a coefficient of friction between the 2.0 kg mass and the floor, while the friction between the cart and the floor is negligible. Find:



a) the tension in the string attaching the two masses.
b) the applied force used to pull the system.

(see Dynamics Ex 12 for answer)