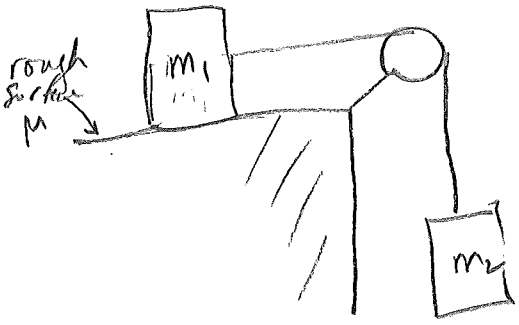
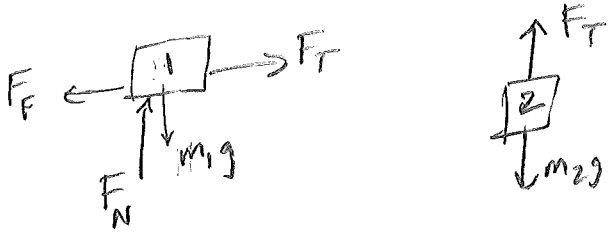
Coupled systems



(1) Do blocks move? If so, w/what accel?

(1) Draw FBD for each object



(2) Calc net force for each

$$F_{1z}^{net} = F_N - m_1 g = 0 \Rightarrow F_N = m_1 g$$

$$F_{1x}^{net} = F_T - F_F = m_1 a_{1x}$$

$$F_{2z}^{net} = F_T - m_2 g = m_2 a_{2z}$$

(3) Assume situation is static $\Rightarrow F_F = F_{SF}$

$$a_{1x} = 0 \Rightarrow F_{SF} = F_T$$
$$a_{2z} = 0 \Rightarrow F_T = m_2 g$$
$$\Big\} \; F_{SF} = m_2 g$$

Is this possible? Yes, if $F_{SF} \le F_{SF,max} = \mu_s F_N$

$$m_2 g \le \mu_s m_1 g$$

If $m_2 \le \mu_s m_1$, blocks don't move

If $\mu_2 > \mu_s m_1$ blocks will move : $F_F = F_{KF} = \mu_K F_N = \mu_K m_1 g$

$$F_{1x}^{net} = F_T - F_{KF} = m_1 a_{1x}$$

$$F_T = \mu_K m_1 g + m_1 a_{1x}$$

$$F_{2z}^{net} = F_T - m_2 g = m_2 a_{2z}$$

Eliminate F_T $\Rightarrow$ $\mu_K m_1 g + m_1 a_{1x} - m_2 g = m_2 a_{2z}$

Length of string remains constant $\Rightarrow$ $a_{2z} = -a_{1x}$

$$\Rightarrow m_1 a_{1x} + m_2 a_{1x} = m_2 g - \mu_K m_1 g$$

$$a_{1x} = \frac{m_2 g - \mu_K m_1 g}{m_1 + m_2}$$

Demo: Vroom's chain

Draw FBD for person in chain in each case

Demo: Swing rope

If time [N7.T8]

[N3.T7]^{C}
[N3.T8]^{B}

[N7.T9]$_{B}$

N7T.1 A jet airplane flies at a constant velocity through the air. Its jet engines exert a constant force forward on the plane that exactly balances the force of air friction exerted backward on the plane. These forces are equal in magnitude and opposite in direction. Do we know this because of Newton's second law or Newton's third law?

A. Newton's second law
B. Newton's third law
C. Both laws
D. Neither (explain)

N7T.2 Which of the following pairs of forces are third-law partners? Answer T if the two forces described are third-law partners, F if they are not.

a. A thrust force from its propeller pulls a plane forward; a drag force pushes it backward.
b. A car exerts a forward force on a trailer; the trailer tugs backward on the car.
c. A motorboat propeller pushes backward on the water; the water pushes forward on the propeller.
d. Gravity pulls down on a person sitting in a chair; the chair pushes back up on the person.

N7T.3 A box B sits in the back of a truck T as the truck slows down for a stop (the box remains motionless relative to the truck). What is the appropriate symbol for the horizontal force that the contact interaction between the box and the truck exerts on the truck?

A. $\vec{F}_{\mathrm{N}}^{B(T)}$
B. $\vec{F}_{\mathrm{N}}^{T(B)}$
C. $\vec{F}_{\mathrm{SF}}^{B(T)}$
D. $\vec{F}_{\mathrm{SF}}^{T(B)}$
E. $\vec{F}_{\mathrm{KF}}^{B(T)}$
F. Other (specify)

N7T.4 A child C pulls on a wagon W, using a string S; the wagon moves forward at a constant speed as a result. The third-law partner to the forward force exerted on the wagon is which of the following forces? (R = road.)

A. $\vec{F}_{T}^{S(W)}$
B. $\vec{F}_{T}^{W(S)}$
C. $\vec{F}_{T}^{W(C)}$
D. $\vec{F}_{T}^{C(W)}$
E. $\vec{F}_{\mathrm{KF}}^{W(R)}$
F. Other (specify)

N7T.5 A small car pushes on a disabled truck, accelerating it slowly forward. Each exerts a force on the other as a result of their contact interaction. Which vehicle exerts the *greater* force on the other?

A. The car.
B. The truck.
C. Both forces have the same magnitude.
D. The truck doesn't exert any force on the car.
E. There is not enough information for a meaningful answer.

N7T.6 A physicist and a chemist are playing tug-of-war. For a certain length of time during the game, the participants are essentially at rest. During this time, each person pulls on the rope (which can be treated as an ideal string) with a force of 350 N. What is the tension on the rope?

A. 700 N
B. 350 N
C. 175 N
D. Other (specify)

N7T.7 Object A ($m_A = 1.0$ kg) hangs at rest from an ideal string A connected to the ceiling. Object B ($m_B = 2.0$ kg) hangs at rest from an ideal string B connected to object A. The tension on string A is

A. Twice the tension on string B
B. 3/2 times the tension on string B
C. Equal to the tension on string B
D. $\frac{2}{3}$ the tension on string B
E. Other (specify)

N7T.8 Two people are attempting to break a rope, which will break if the tension on the rope exceeds 360 N. If each person can exert a pull of 200 N,

A. They can break the rope if they each take an end and pull.
B. They can break the rope if they tie one end to the wall and both pull on the other.
C. They can break the rope if they use either of the strategies above.
D. They cannot break the rope.

N7T.9 A spring scale typically indicates the magnitude of the tension force exerted on its bottom hook. What will the scale read in each of the cases shown in the diagram? (*Hint:* Construct a free-body or free-particle diagram for the scale in each case.)

A. 49 N
B. 98 N
C. 186 N
D. Other (specify)