$$+\swarrow \sum F_{\parallel} = ma_{\parallel} = F_{W\parallel}$$

and $$a_{\parallel} = \frac{F_{W\parallel}}{m} = \frac{(mg \sin \theta)}{m} = g \sin 30.0° \qquad (4.8)$$

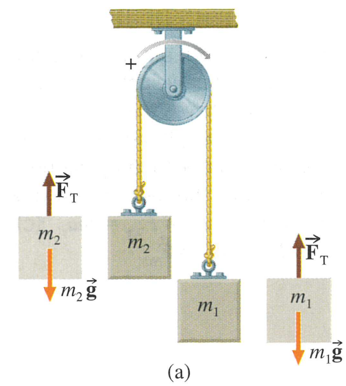
or $\boxed{a_{\parallel} = \frac{1}{2}g}$. This result is independent of the mass and applies to any body sliding down a frictionless incline at $\theta = 30°$.

Quick Check: We can think of the inclined plane as a kind of "gravity reducer." With $\sin 30° = \frac{1}{2}$ in Eq. (4.7), the body behaves as if it were in free-fall (down the slope) at $\frac{1}{2}g$. Since the skier's weight is 490 N, in this tilted world it's driven down by $\frac{1}{2}$490 N. A normal force of 425 N at a small incline is also reasonable.

4.7 Coupled Motions

The two masses in Fig. 4.22 are attached together by an unstretchable rope. The pulleys are weightless and frictionless, and the tensions are therefore constant throughout each rope. For the moment, we'll require that the surfaces be frictionless as well. Suppose the motion takes place in the direction shown by the arrow in each case. The leading mass m_1 pulls the connecting rope along, and the rope pulls the trailing mass m_2. The trailing mass can never overtake and slacken the rope, nor can it lag behind, accelerating slower than the rope; each mass must accelerate at the same rate. With two masses, we can write two coupled Second-Law equations and solve for two unknowns, usually F_T and a, although any two parameters could be unknown.

If there is any ambiguity about how the system moves, ***guess at the direction of the overall motion and make that positive***, even if it means down is positive for one part and up for another. If you guess wrong, the values of the unknowns will just come out negative.



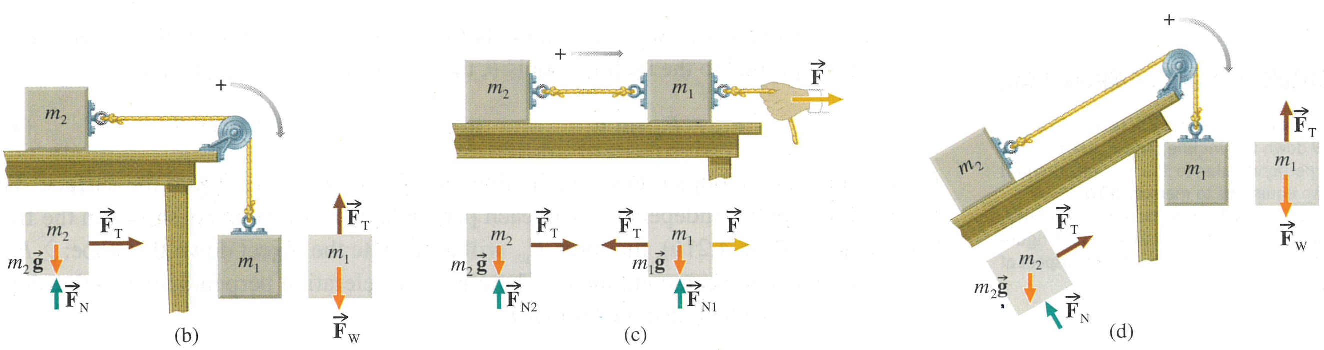


Figure 4.22 Four examples of coupled arrangements where two masses are attached together by a rope. The free-body diagram for every mass is drawn. In each of the four examples, the same tension acts on both masses and both accelerate at the same rate.

Example 4.7 [II] Mary ($m_M = 50$ kg) and her boyfriend, Don ($m_D = 70$ kg), are tied together (we won't ask why) by a rope of negligible mass. She is standing on a frictionless horizontal sheet of wet ice when Don, who is not too smart, accidentally steps off a cliff (Fig. 4.23*a*). Assume the unlikely possibility that the tree limb is frictionless and that her length of the rope is horizontal. Determine (a) the tension in the rope and (b) the accelerations of the ill-fated lovers. What would happen if she cut the rope?

Solution Whenever you see the words "tension" and "acceleration" in a problem, think of $F = ma$. Here there are two moving objects, and so we'll have to apply $F = ma$ to them separately. (1) TRANSLATION—Two known masses are tied together such that the falling one pulls the other; determine (a) the tension and (b) the accelerations. (2) GIVEN: $m_M = 50$ kg, and $m_D = 70$ kg. FIND: (a) F_T, (b) a_M, and a_D. (3) PROBLEM TYPE—Newton' Laws/coupled motion. (4) PROCEDURE—Draw free-body diagrams (Figs. 4.23*b* and *c*). Apply $\sum F = ma$

continued