1. A mixed martial artist kicks his opponent in the nose with a force of 200 newtons. Identify the action-reaction force pairs in this interchange.

(A) foot applies 200 newton force to nose; nose applies a smaller force to foot because foot has a larger mass.
(B) foot applies 200 newton force to nose; nose applies a smaller force to foot because it compresses.
(C) foot applies 200 newton force to nose; nose applies a larger force to foot due to conservation of momentum.
(D) foot applies 200 newton force to nose; nose applies an equal force to the foot.

2. Joanne exerts a force on a basketball as she throws the basketball to the east. Which of the following is always true?

(A) Joanne accelerates to the west.
(B) Joanne feels no net force because she and the basketball are initially the same object.
(C) The basketball pushes Joanne to the west.
(D) The magnitude of the force on the basketball is greater than the magnitude of the force on Joanne.

3. A book and a feather are pushed off the edge of a cliff simultaneously. The book reaches the bottom of the cliff before the feather. Correct statements about the book include which of the following? Select two answers.

(A) The book has a greater mass than the feather and experiences less air resistance.
(B) The book has a greater mass than the feather and experiences a greater net force.
(C) The book has a greater cross-sectional area than the feather and experiences less air resistance.
(D) The book has a greater cross-sectional area than the feather and experiences more air resistance.

4. A force F is applied perpendicular to the top of a box of mass m sitting on an incline of angle θ. What is the magnitude of F such that the normal force of the incline on the box is equal to the weight of the box?

(A) $mg\cos\theta$
(B) $mg(1-\cos\theta)$
(C) $mg(1-\sin\theta)$
(D) $mg(1+\sin\theta)$

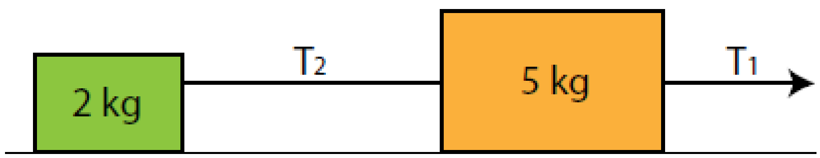
5. In 1654 in Magdeburg, Germany, scientist Otto von Guericke demonstrated the concept of atmospheric pressure by placing two sealed iron hemispheres together and using a vacuum pump to create a partial vacuum inside the spheres. He then attached a team of 15 horses to each of the hemispheres, and had the horses attempt to pull the spheres apart. All 30 horses were not able to separate the spheres. Suppose von Guericke had instead attached both teams (all 30 horses) to one of the hemispheres and attached the remaining hemisphere to a tree. How would the tension in the spheres change?

(A) The tension in the spheres would be reduced by half.
(B) The tension in the spheres would remain the same.
(C) The tension in the spheres would double.
(D) The tension in the spheres would quadruple.

6. Identical fireflies are placed in closed jars in three different configurations as shown below. In configuration A, three fireflies are hovering inside the jar. In configuration B, one firefly is hovering inside the jar. In configuration C, one firefly is sitting at rest on the bottom of the jar. Each jar is placed upon a scale and measured. Rank the weight of each jar according to the scale reading from heaviest to lightest. If jars have the same scale reading, rank them equally.

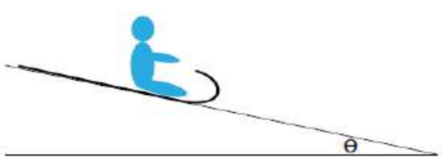
7. The system shown at right is accelerated by applying a tension T_1 to the right-most cable. Assuming the system is frictionless, the tension in the cable between the blocks, T_2, is

(A) $2T_1/7$
(B) $2T_1/5$
(C) $5T_1/7$
(D) $7T_1/5$

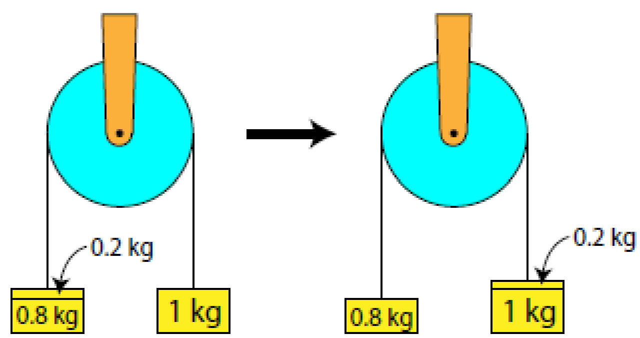


8. Jane rides a sled down a slope of angle θ at constant speed v. Determine the coefficient of kinetic friction between the sled and the slope. Neglect air resistance.

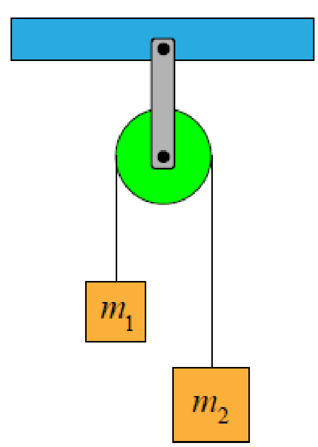
(A) $\mu = g\sin\theta$
(B) $\mu = mg\cos\theta$
(C) $\mu = \tan\theta$
(D) $\mu = g\cos\theta$



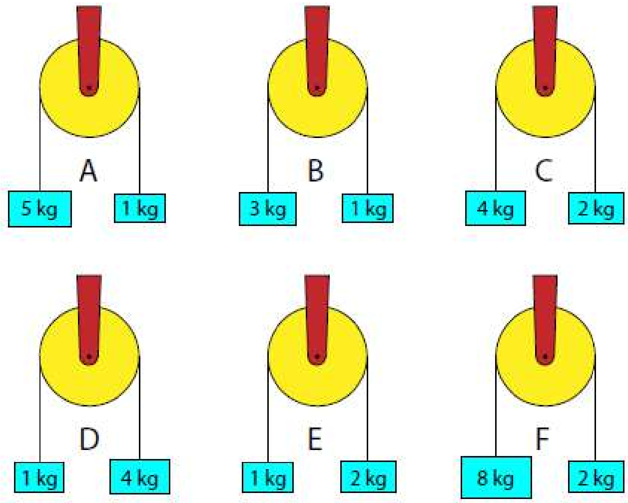
9. Masses are hung on a light string attached to an ideal massless pulley as shown in the diagram at right. The total mass hanging from the left string is equal to that on the right. At time t=0, the 0.2-kg mass is moved from the left to the right side of the pulley. How far does each mass move in one second?



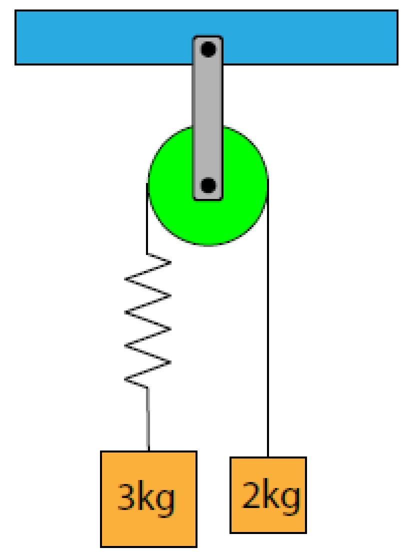
10. The Atwood machine shown to the right consists of a massless, frictionless pulley, and a massless string. If m_1 = 3 kg and m_2 = 5 kg, find the force of tension in the string.



11. Two masses are hung from a light string over an ideal frictionless massless pulley. The masses are shown in various scenarios in the diagram at right. Rank the acceleration of the masses from greatest to least.



12. Students build a wind-powered vehicle as shown in the diagram at right. A fan attached to the vehicle is powered by a battery located inside the vehicle. Describe the motion of the vehicle when the fan is powered on. Justify your answer in a clear, coherent, paragraph-length explanation.



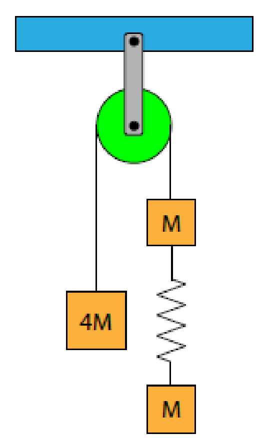
13. The Atwood machine shown to the right consists of a massless, frictionless pulley, a massless string, and a massless spring. The spring has a spring constant of 200 N/m. How far will the spring stretch when the masses are released? →

14. Paisley the horse gets stuck in the mud. Her rider, Linda, ties a rope around Paisley and pulls with a force of 500 newtons, but isn't strong enough to get Paisley out of the mud.

In a flash of inspiration, Linda thinks back to her physics classes and ties one end of the rope to Paisley, and the other end to a nearby fence post. She then applies the same force of 500 newtons to the middle of the rope at an angle of $\theta=6°$, just barely freeing Paisley from the mud, as shown in the diagram at right.

Determine the minimum amount of tension the rope must support.

15. Curves can be banked at just the right angle that vehicles traveling a specific speed can stay on the road with no friction required. Given a radius for the curve and a specific velocity, at what angle should the bank of the curve be built?

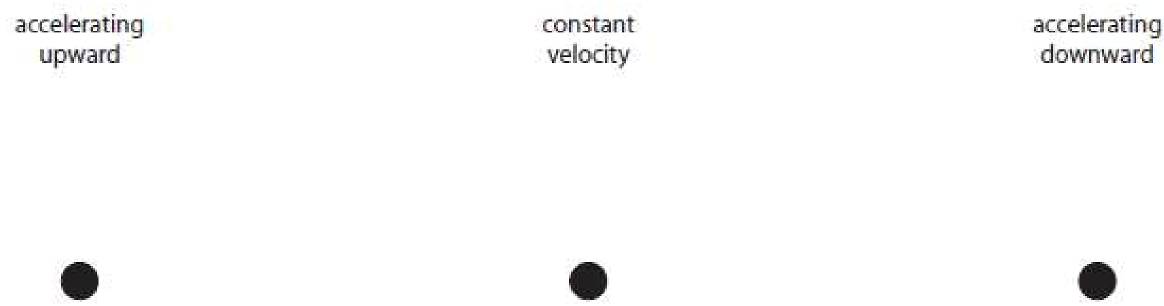


16. The Atwood machine shown to the right consists of a massless, frictionless pulley, a massless string, and a massless spring. The spring has a spring constant of 100 N/m. Calculate the stretch of the spring in terms of M.

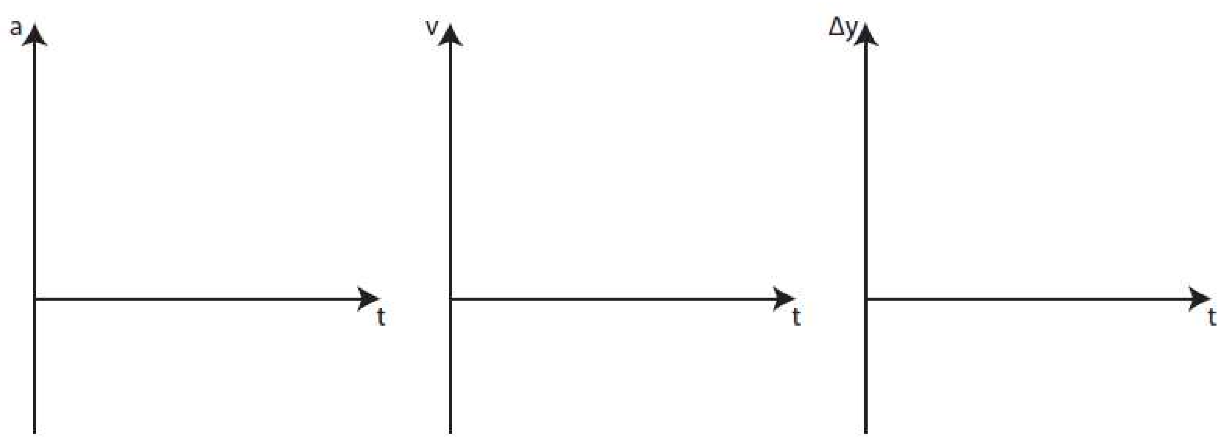
17. A student, standing on a scale in an elevator at rest, sees that the scale reads 840 N. As the elevator rises, the scale reading increases to 945 N for 2 seconds, then returns to 840 N for 10 seconds. When the elevator slows to a stop at the 10th floor, the scale reading drops to 735 N for 2 seconds while coming to a stop.

(a) Explain why the apparent weight of the student increased at the beginning of the motion.

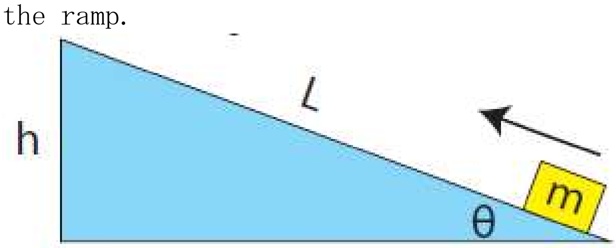
(b) Draw the free body diagram for the student while the student is accelerating upward, then moving at a constant velocity, and finally accelerating downward at the end. Draw the length of the force vectors to show when forces are balanced or unbalanced.



(c) Sketch acceleration vs. time, velocity vs. time, and displacement vs. time graphs of the student during the elevator ride.



18. A block of mass m, is pushed up an incline with an initial speed of v_0. The incline has a height of h and the length of the ramp is L. The coefficient of kinetic friction between the incline and block is μ_k and the coefficient of static friction is μ_s. The block does not leave the ramp.



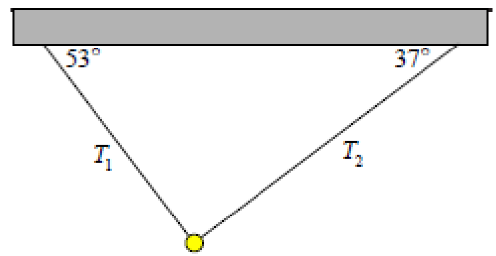
Answer the following questions using the variables listed above and fundamental constants.

(a) What is the angle of the ramp in terms of h and L?

(b) What is the minimum angle of the ramp such that the block slides back down the ramp after sliding up? (Hint: the answer is not in terms of h and L.)

(c) Assume the distance the block travels down the ramp is the same distance the block traveled up the ramp. Does it take more time for the block to travel up or down the ramp? Explain your answer.

19. A ball of mass 0.5 kg is suspended by two strings as shown in the diagram at right.

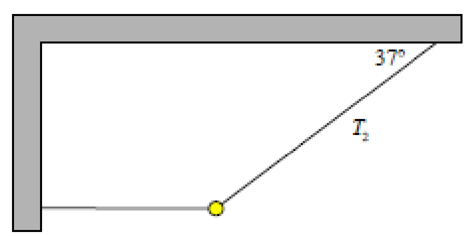


(a) Determine the weight of the ball.

(b) In the space below, draw and clearly label all the forces (not components) acting on the ball.

(c) Determine the magnitude of each of the forces labeled in your diagram from part (b).

The left-hand string is now attached to a wall at a right angle as shown.



(d) Indicate whether T_2 is now greater than, equal to, or less than the value reported in part (c). Justify your answer qualitatively, without using equations or calculations.

(e) Determine the new vertical component of T_2 without using equations or calculations. Justify your answer qualitatively.