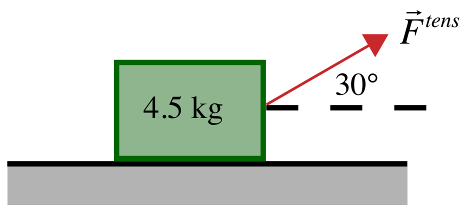
Unit 7 Homework Problems

Learning Goals:

F.7 Identify the forces acting on an object and draw an accurately scaled free-body diagram and acceleration vector for a variety of 2D situations which may involve friction, ramps, ropes, uniform circular motion, stationary objects, objects with constant velocity, or objects with constant acceleration.

A.7 Apply Newton's Laws to a 2-dimensional physical situation to solve for an unknown quantity.

7-1) A string is attached to a 4.5 kg block and it is pulling on the block at an angle of 30° above the horizontal. Assume the tension in the string is 22 N and the block is not moving.

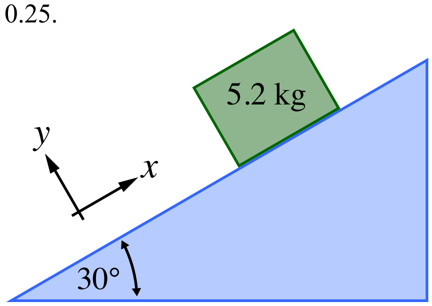


(a) Represent the block as a point and draw a free body diagram showing the forces on the block.

(b) Find the magnitude and direction of the normal force on the box. (Hint: It isn't equal to the gravitational force, 44 N.)

(c) Find the static friction force.

7-2) A 5.2 kg box is sliding down a ramp to a loading dock, as shown below. The coefficient of kinetic friction μ^{kin} is given by 0.25.



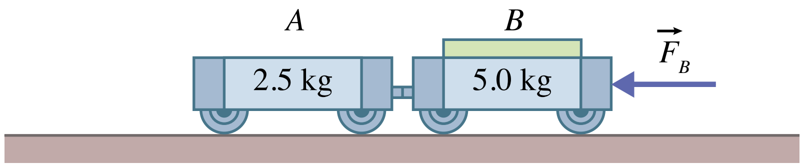
(a) Represent the block as a point and draw a free body diagram showing all the forces on the block. **Hint**: Use a coordinate system with the *x*-axis along the incline (as shown above), instead of along the horizontal.

(b) Find the normal force on the block. What angle does it make with respect to the horizontal?

(c) Find the friction force on the block. What angle does it make with respect to the horizontal?

(d) Find the acceleration of the block.

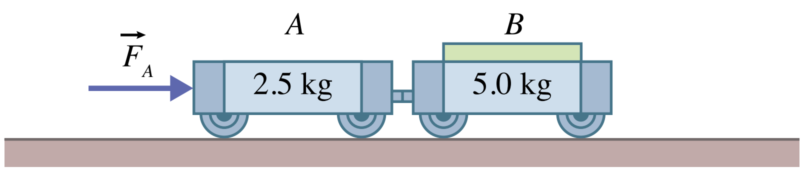
7-3) Two low friction carts A and B have masses of 2.5 kg and 5.0 kg respectively. Initially a student is pushing them with an applied force of $\vec{F}_B = -20\text{N}\,\hat{x}$ which is exerted on cart B as shown in the diagram that follows. (For both parts (a) and (b), remember to draw separate free body diagrams for each of the carts, A and B, showing all the forces acting on each cart.)



(a)

(a) Find the magnitude and direction of the interaction forces between the two carts $\vec{F}_{AB}$ and $\vec{F}_{BA}$ where $\vec{F}_{AB}$ represents the force on cart A due to cart B and $\vec{F}_{BA}$ represents the force on cart B due to cart A.

(b) If the student pushes on cart A with an applied force of $\vec{F}_A = +20\text{N}\,\hat{x}$ instead, determine the magnitude and direction of the interaction forces between the two carts $\vec{F}_{AB}$ and $\vec{F}_{BA}$ for this situation.



(b)

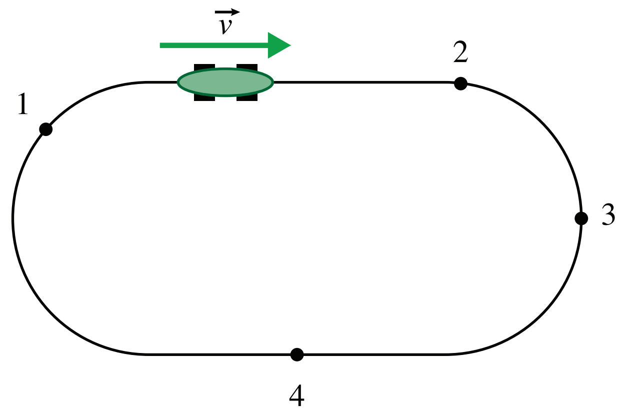
(c) Explain why the interaction forces in (a) are different than the interaction forces in (b). **Hint**: If you consider the two carts together as a system with mass 7.5 kg, what is the acceleration of each of the carts A and B? What does the *net* force on cart A have to be to result in this acceleration?

7-4) (a) Refer to the words of the *Bricklayer's Song*. Assuming there is no friction in the bricklayer's pulley and rope system, *estimate* the total amount of time that elapses during the injurious events described by the poor bricklayer in the song. **Hint**: there are four separate injurious events that the bricklayer experiences – you will need to find the time interval for each and then add them up.

(b) If friction were considered, what effect would this have on your estimated time? Would the actual time be smaller, larger or the same as the one you estimated? Why?

Hints: (1) To make this estimate you need to figure out approximate values for the height to the floor of the 14th floor, the mass of the bricklayer, and the mass of the bricks and the barrel. (2) You'll need to split this up in to 4 separate motions: two motions using the Atwood's equation to determine the Bricklayer's acceleration (1-bricklayer going up, 2-bricklayer going down) and two motions for free-fall (3-bricks falling, 4-barrel falling). You cannot simply assume that all of the bricklayer's travels occur at $|\vec{a}| = 9.8\text{m/s}^2$. (3) Although your answer should be similar to that obtained by others, there is no single "right" answer as you are being asked to make reasonable estimates.

7-5) **Constant Speed On A Race Track:** The racetrack shown in the diagram below has two straight sections connected by semicircular ends. A car is traveling in a clockwise direction around the track at a constant speed. Draw three sets of diagrams each having a sketch of the racetrack:



(a) One sketch should show the velocity vector at each of the numbered points 1-4. Use the same length as that of the sample velocity vector shown in the diagram for your velocity vectors.

(b) Another sketch should show the acceleration vectors at each of the numbered points 1-4. **Hint**: Use the techniques developed in Section 7.11.1 of the Activity Guide to draw vectors representing the acceleration or change in velocity.

(c) Horizontal forces are needed to maintain the car's motion around the track. These are provided by road friction and by road forces where the track is banked at the curves. Draw another sketch showing the vectors representing the required horizontal force (*i.e.*, the net force) at each of the numbered points 1-4.

Note: This exercise is adapted from Arons, A., Homework and Test Questions for Introductory Physics Teaching, Wiley, New York, 1994. Ch 3.

7-6) Problem 7.13.1 from the Activity Guide.

Hint: The car is moving in a circle at constant speed. What is the expression for its acceleration?

Hint: When driving a car, should the tires be *sliding* across the pavement? What does that mean about the *type* of friction that is relevant when you are driving?

7-7) Problem 7.13.2 from the Activity Guide.