Forces - Success Criteria

1. Draw a FBD, choose your positive directions

2. Write an F_{net} equation based on the DIAGRAM

3. Substitute values and F=ma into the F_{net} equation

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Unit Two - Chapter 3 - Forces

Using Newton's Laws to Solve Problems

Let the thinking begin...mu ha ha.

Learning Goal: By the end of today, I will be able to use the 5 kinematic equations and Newton's laws, together, to solve motion problems.

Kinematics and Newton's Laws

When using any of the kinematics equations from Unit 1, it is essential that the acceleration remain constant. Now we can extend this restriction by stating that the net force on an object must also remain constant if you use one of the kinematics equations. This is a direct consequence of Newton's second law, $F_{net} = ma$, which shows that net force is constant when the acceleration is constant.

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Sample Problem 2

A worker pushes two large boxes across the floor from rest with an applied force of 160.0 N [right] on the larger box (**Figure 9**). The boxes are touching. The mass of the larger box is $m_1 = 32.0$ kg and the mass of the smaller box is $m_2 = 8.0$ kg. The force of friction on the large box is 80.0 N [left] and the force of friction on the smaller box is 20.0 N [left].

(a) Calculate the acceleration of the two boxes. Assume that the boxes start to move.
(b) Determine the force exerted by the larger box on the smaller box.
(c) Determine the velocity of the boxes after 4.0 s.

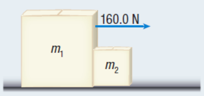

Figure 9

1. Draw a FBD, choose your positive directions
2. Write an F_{net} equation based on the DIAGRAM
3. Substitute values and F=ma into the F_{net} equation

Kinematics

System

Parts

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(Pause and Try)

Practice

1. Two dynamics carts are placed end to end. Cart 1 (1.2 kg) is stuck to cart 2 (1.8 kg). Cart 1 is pushed with a force of 18.9 N [W], causing cart 1 to push cart 2 forward. Ignore the force of friction. T/I
   (a) Calculate the acceleration of each cart.
   (b) Calculate the force that cart 1 exerts on cart 2.
   (c) Would your answers change if cart 2 were pushed with an equal but opposite force instead of cart 1? If your answers change, calculate the new results.

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(Pause and Try)

2. A 1200 kg car is moving at 95 km/h when the driver notices a deer down the road. He immediately moves his foot toward the brake pedal, taking only 0.50 s before the car starts slowing down. The brakes cause a net force of 2400 N [backwards] on the car for 2.0 s. The deer then jumps out of the way and the driver lifts his foot off the brake pedal. How far does the car move in the 2.5 s starting from when the driver sees the deer? T/I

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3.5 Questions

1. You hold one end of a rope and pull horizontally with a force of 65 N. Calculate the tension in the rope if the other end is
   (a) tied to a wall
   (b) held by a friend who pulls with 65 N in the opposite direction
   (c) tied to a 12 kg object on smooth ice T/I
2. A 72 kg sled is pulled forward from rest by a snowmobile and accelerates at 2.0 m/s^2 [forward] for 5.0 s. The force of friction acting on the sled is 120 N [backwards]. The total mass of the snowmobile and driver is 450 kg. The drag force acting on the snowmobile is 540 N [backwards]. T/I
   (a) Determine the tension in the rope.
   (b) Calculate the force exerted by the snowmobile that pushes the sled forward.
3. Two people, each with a mass of 70 kg, are wearing inline skates and are holding opposite ends of a 15 m rope. One person pulls forward on the rope by moving hand over hand and gradually reeling in more of the rope. In doing so, he exerts a force of 35 N [backwards] on the rope. This causes him to accelerate toward the other person. Assuming that the friction acting on the skaters is negligible, how long will it take for them to meet? Explain your reasoning. T/I
4. A 1200 kg car pulls an 820 kg trailer over a rough road. The force of friction acting on the trailer is 650 N [backwards]. Calculate the force that the car exerts on the trailer if
   (a) the trailer is moving at a constant velocity of 30 km/h [forward]
   (b) the trailer is moving at a constant velocity of 60 km/h [forward]
   (c) the trailer is moving forward at 60 km/h and starts accelerating at 1.5 m/s^2 [forward]
   (d) the trailer is moving forward at 60 km/h and starts accelerating at 1.2 m/s^2 [backwards] T/I
5. An old rope can now only safely suspend 120 kg. When the rope is tied to a beam, it hangs down with a vertical length of 12.0 m. Calculate the minimum time required for an 85 kg person starting from rest to climb the entire length of the rope without breaking it. T/I
6. Three dynamics carts have force sensors placed on top of them. Each force sensor is tied to a string that connects all three carts together (**Figure 10**). You use a sixth force sensor to pull the three dynamics carts forward. The reading on force sensor 2 is 3.3 N. Assume that the force sensors are light and that there is negligible friction acting on the carts. T/I

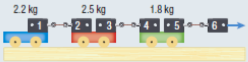

Figure 10

   (a) What is the acceleration of all the carts?
   (b) What is the reading on each force sensor?
   (c) What force are you applying to force sensor 6?
7. A locomotive (6.4×10^5 kg) is used to pull two railway cars (**Figure 11**). Railway car 1 (5.0×10^5 kg) is attached to railway car 2 (3.6×10^5 kg) by a locking mechanism. A railway engineer tests the mechanism and estimates that it can only withstand 2.0×10^5 N of force. Determine the maximum acceleration of the train that does not break the locking mechanism. Explain your reasoning. Assume that friction is negligible. T/I C

Figure 11

8. A skier (68 kg) starts from rest but then begins to move downhill with a net force of 92 N for 8.2 s. The hill levels out for 3.5 s. On this part of the hill, the net force on the skier is 22 N [backwards]. T/I
   (a) Calculate the speed of the skier after 8.2 s.
   (b) Calculate the speed of the skier at the end of the section where the hill levels out.
   (c) Calculate the total distance travelled by the skier before coming to rest.

Section 3.5

#5,6,8

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