Newton's Second Law

For each problem, draw a free-body diagram showing all external forces. Apply Newton's second law and use kinematics when necessary. Show your calculations, including units and directions. If the forces change during a problem, draw a separate diagram for each stage.

Mild

1. Ryan pushes a 10 kg box to the right on a frictionless horizontal floor, accelerating it at 8.5 m/s². What force is he applying?

2. A 10 kg box is pushed to the right with 90 N on a level floor. Friction acts to the left with 25 N. Determine the acceleration of the box.

3. A 40.0 kg box is pushed to the right along a level floor with a force of 550 N.
   a) Assuming no friction, determine the acceleration.
   b) If friction is 80.0 N to the left, determine the acceleration now.

4. Ryan pushes a 10 kg box to the right across a horizontal floor with 85 N. The box accelerates at 7.5 m/s² to the right. Determine the force of friction.

Medium

5. A 0.80 kg pair of pants falls from a clothesline. Air resistance is a constant 4.0 N upward. Determine the acceleration of the pants.

6. A 1.2 kg ball falls toward Earth with a measured downward acceleration of 6.8 m/s². Determine the upward air resistance acting on it.

7. While skating, Jason pushes Ajay horizontally with 120 N, causing Ajay to accelerate at 1.5 m/s². Neglect friction and air resistance.
   a) Determine Ajay's mass.
   b) Determine Ajay's weight.
   c) Describe Ajay's motion after Jason stops pushing.

8. The "Hellevator" ride accelerates a 50 kg rider upward at 15 m/s². Determine the upward force the ride exerts on the rider.

9. A 60 kg passenger stands on the floor of an elevator accelerating downward at 3.0 m/s². Determine the normal force exerted by the elevator floor on the passenger.

Spicy

10. Amy and Naomi pull a 75 kg sled horizontally in the same direction across a frozen pond. Amy pulls with 175 N and Naomi with 125 N. Friction acts backward with 140 N, while the wind exerts another 120 N backward. Determine the acceleration of the sled.

11. A 2.4×10^5 kg rocket is accelerating upward with a thrust of 5.0×10^6 N. Neglect air resistance. Determine the acceleration of the rocket at this instant.

12. A 1500 kg lift is pulled upward by a cable with a tension of 2.2×10^4 N. Friction from the rails acts downward with a force of 2.0×10^3 N. Determine the acceleration of the lift.

13. Angus pushes a 450 kg crate to the right with 1500 N, while Scott pushes to the left with 300 N. The crate is moving right and accelerating right at 0.30 m/s^2. Determine the force of friction acting on the crate.

Extra-Spicy

14. A 55 kg skater starts from rest, 40 m from a bench. A friend pushes the skater horizontally with a constant force of 110 N for 2.0 s, then lets go. Assume friction is negligible. How much total time passes before the skater reaches the bench?

15. A 2300 kg car travels along a level road at 20 m/s. The driver takes 0.75 s to react before braking. The car maintains its speed during the reaction time, then stops over 50 m under a constant braking force. Neglect air resistance.
    a) Determine the magnitude and direction of the frictional braking force exerted by the road.
    b) Determine the total stopping distance, including reaction distance.