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.

16. Heather pushes a book to the right across a horizontal table with a constant force of 15 N. Starting from rest, she pushes for 5.0 s. After she stops pushing, the book slides for another 3.0 s before stopping. Assume the magnitude of kinetic friction remains constant throughout. Determine the frictional force acting on the book.