1. A cannonball is shot straight up at an initial speed of 98 m/s. What are its velocity and speed after (a) 5.0 s? (b) 10 s? (c) 15 s? (d) 20 s?

2. How many seconds does it take a pebble released from rest from a bridge to fall 9.8 m? What is the pebble’s speed when it has fallen 9.8 m?

3. An astronaut is on a planet on which the acceleration due to gravity is unknown. To find this acceleration, she drops a rock, which falls 1.0 m in 2.0 s. What is the acceleration due to gravity on this planet?

4. With what minimum speed must a ball be thrown straight up in order to reach a height of 25 m above the launch position? How many seconds does the ball take to reach this height?

5. A snowshoer falls off a ridge into a snowbank 9.6 m below and penetrates 0.80 m into the snow before stopping. What is her average acceleration in the snowbank?

6. A woman steps outside one winter day to go to work. Her icy driveway is 8.0 m long from top to mailbox, and it slopes downward at 20° from the horizontal. She sets her briefcase on the ice at the top while opening the garage, and it slides down the driveway. (a) What is its acceleration? (b) How many seconds does it take to get halfway to the mailbox? (c) How many seconds until it reaches the mailbox? (d) What is its speed at the instant it reaches the mailbox?

7. A box is at the lower end of a ramp of length $L$ that makes a nonzero angle $\theta$ with the horizontal. A worker wants to give the box a shove so that it reaches the top of the ramp. (a) How fast must the box be going after the shove (assumed to be instantaneous) for it to reach its goal? (b) What is its speed halfway up the ramp?
8. A prankster drops a water balloon from the top of a building 40 m high. What is the balloon’s speed just before it hits the ground? (Ignore air resistance.)

9. A logger wants to determine the height of a tree to be sure that it will fit onto her logging trailer after she cuts it down. She throws a rock straight up with a speed great enough that the rock just reaches the top of the tree. She times the rock’s motion from the instant of release until it returns to the level at which she released it. If that time interval is 5.0 s and she released the rock 2.0 m above the ground, what is the tree’s height?

10. An elevator cable breaks, and the elevator car falls ten floors (from rest) before the emergency brakes kick in. If the car falls one more floor before it stops, what is its average acceleration during braking?

11. Cart A, of inertia 1 kg, is initially at rest on a low-friction track. Cart B, of unknown inertia, has an initial velocity of +3 m/s \( \hat{i} \) in your coordinate system. After the two carts collide, the final velocities are \( \vec{v}_A = +2 \text{ m/s } \hat{i} \) and \( \vec{v}_B = -3 \text{ m/s } \hat{i} \). What is the inertia of Cart B?
12. The figure below shows the $v(t)$ curves for two carts colliding on a low-friction track. What is the ratio of their inertias?

13. A 1 kg standard cart collides with a cart A of unknown inertia. Both carts seem to be rolling with significant wheel friction, because their velocities change with time as shown below. (a) What are the carts’ velocities at $t = 0$, $t = 5$ s, $t = 6$ s, and $t = 10$ s? (b) When not colliding, are the carts speeding up or slowing down? (c) Is the acceleration vector of each cart the same before and after the collision? (d) What is the inertia of cart A?

14. Which has more momentum, a 0.14 kg baseball pitched at 45 m/s or a 0.012 kg bullet fired at 480 m/s?
15. Is it possible for the momentum of a system consisting of two carts on a low-friction track to be zero even if both carts are moving? Explain.

16. A 1 kg standard cart A collides with a 0.1 kg cart B. The velocity of cart A is +0.6 m/s \( \hat{i} \) before the collision and +0.5 m/s \( \hat{i} \) after the collision. Cart B is initially traveling toward cart A at 0.4 m/s, and after the collision it has a velocity of +0.6 m/s \( \hat{i} \). What are (a) the change in the momentum of A, (b) the change in momentum of B, (c) the sum of these two changes in momentum?

17. From what height would a car have to fall in order for the magnitude of its momentum to equal the magnitude of its momentum when it is moving on a highway at 30 m/s? (30 m/s = 108 kph \( \approx \) 67 mph.)

18. A 4 kg rifle fires a 10 g bullet at 800 m/s. With what speed does the rifle recoil?

19. A cart moving on a low-friction track has a momentum of +6 kg \( \cdot \) m/s. At the end of the track is a wall. (a) What is the momentum of the system consisting of the cart and the wall? (b) After the cart collides with the wall, the cart’s momentum is −6 kg \( \cdot \) m/s. What is the wall’s momentum after impact? (c) Is the system defined in part (a) an isolated system? Why doesn’t the wall move?

20. Estimate the magnitude of impulse that you impart to a nail (and to whatever the nail is buried in) when you hit it with a hammer.

21. Two male moose charge at each other with the same speed and meet on an icy patch of tundra. As they collide, their antlers lock together and they slide together with one-third of their original speed. What is the ratio of their inertias?

22. A load of coal is dropped from a bunker into a railroad hopper of inertia 3.0 \( \times \) 10\(^4\) kg coasting at 0.50 m/s on a level track. The car’s speed is 0.30 m/s after the coal falls. What is the inertia of the load of coal?
23. A 400 kg shipboard cannon fires a 20 kg ball at 60 m/s. The cannon’s resulting recoil speed across the deck is regarded as excessive. How much inertia (sandbags, etc.) must be added to the cannon if its recoil speed must be reduced to 2.0 m/s?

24. What is the magnitude of the momentum of Earth at any location in its orbit around the sun? The inertia of Earth is $6.0 \times 10^{24}$ kg. Earth’s orbit is approximately a circle of radius $1.5 \times 10^8$ km.

25. The speed of a bullet can be measured by firing it at a wooden cart initially at rest and measuring the speed of the cart with the bullet embedded in it. The figure below shows a 12 g bullet fired at a 4 kg cart. After the collision, the cart rolls at 1.8 m/s. What is the bullet’s speed before it strikes the cart?