3.2.6: Uniform Acceleration

Figure 2.5.1

After jumping, this cliff diver undergoes effective free fall. Cliff diving is a sport in which athletes twist and flip on their way down. Even with the air resistance, these divers will accelerate the whole way down.

Constant Acceleration

Acceleration that does not change in time is called uniform or **constant acceleration.** The velocity at the beginning of the time interval is called initial velocity, v_i, and the velocity at the end of the time interval is called final velocity, vf. In a velocity versus time graph for uniform acceleration, the slope of the line is the acceleration. The equation that describes the curve is $v_f = v_i + at$.

Example 2.5.1

If an automobile with a velocity of 4.0 m/s accelerates at a rate of 4.0 m/s^2 for 2.5 s, what is the final velocity?

Solution

$v_f = v_i + at = 4.0 \text{ m/s} + (4.0 \text{ m/s2})(2.5 \text{ s}) = 4.0 \text{ m/s} + 10. \text{ m/s} = 14 \text{ m/s}$

Example 2.5.2

If a cart slows from 22.0 m/s with an acceleration of -2.0 m/s^2, how long does it require to get to 4 m/s?

Solution

$t = (v_f - v_i)/a = (-18 \text{ m/s} - 2.0 \text{ m/s})/2 = 9.0 \text{ s}$

Use the simulation below to further explore the uniform acceleration of a cliff diver. Observe the relationship between position, velocity, and acceleration as the diver falls under the influence of gravity. Begin by turning off the air resistance and see what happens when the diver falls as if he is in a vacuum. Then, if you are up for a challenge, turn the air resistance on and consider its effects on the diver.

Misconception Alert: Deceleration versus Negative Acceleration

Deceleration refers to the reduction in the speed or velocity of an object. It occurs when an object slows down, either due to the application of a force in the opposite direction of its motion or due to a change in direction. Deceleration can be caused by various factors involving force such as friction, air resistance, or the application of brakes.

Negative acceleration, on the other hand, is a more general term that refers to any *acceleration in the direction opposite to the direction of motion*. It can represent either a decrease in speed (deceleration) or a change in direction. Negative acceleration may or may not be deceleration, and deceleration may or may not be considered negative acceleration. For example, consider Figure 2.14.

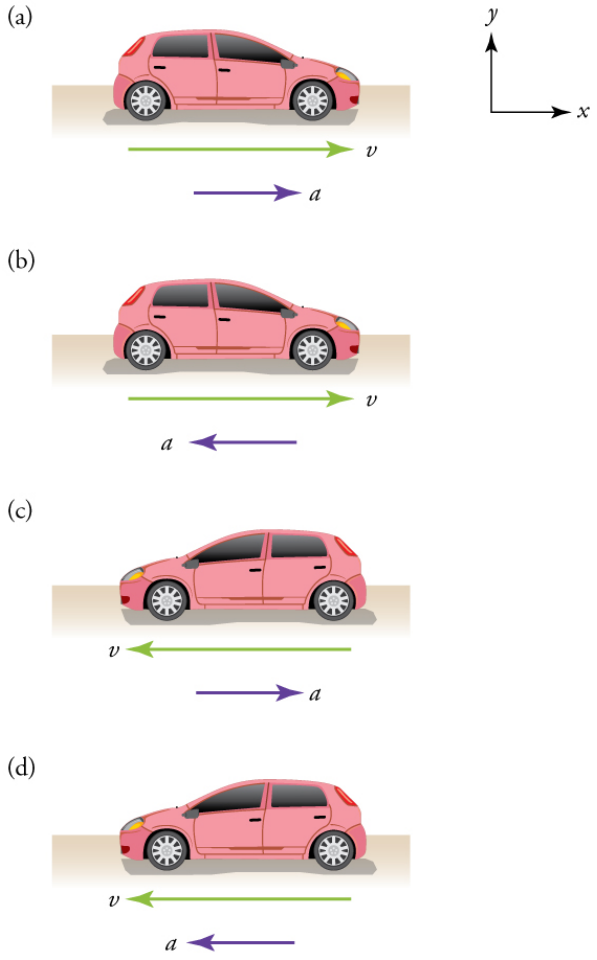

Figure 2.14

(a) This car is speeding up as it moves toward the right (positive x-direction), so it has positive acceleration in our coordinate system. (b) This car is slowing down as it moves toward the right, so it has negative acceleration in our coordinate system because the acceleration is toward the left (negative x-direction). The car is decelerating because the acceleration is opposite to its motion. (c) This car is moving toward the left but slowing down over time, so its acceleration is positive in our coordinate system because it is toward the right. The car is decelerating because the acceleration is opposite to its motion. (d) This car is speeding up as it moves toward the left, so it has negative acceleration because it is accelerating toward the left. The car is speeding up because the acceleration is in the same direction as its motion.

Summary

- Acceleration that does not change in time is uniform, or constant, acceleration.
- The equation relating initial velocity, final velocity, time, and acceleration is $v_f = v_i + at$.

Review

1. If an object has zero acceleration, does that mean it has zero velocity? Give an example.
2. If an object has zero velocity, does that mean it has zero acceleration? Give an example.
3. If the acceleration of a motorboat is 4.0 m/s^2, and the motorboat starts from rest, what is its velocity after 6.0 s?
4. The friction of the water on a boat produces an acceleration of -10. m/s^2. If the boat is traveling at 30. m/s and the motor is shut off, how long does it take the boat to slow down to 5.0 m/s?

Additional Resources

PLIX: Play, Learn, Interact, eXplore: Uniform Acceleration

Real World Application: Race to The Finish

Video:

Study Guide: Motion Study Guide
