Slalom Skiing

Newton's first law says that any moving object wants to continue moving in a straight line at a constant **velocity** (speed). The same is true of athletes on skis. But what happens during events like slalom skiing? Athletes have to complete many quick turns while remaining fast and stable. To do this, alpine skiers use their legs to push on the snow against the force of their own **momentum**—and the more momentum an athlete has, the harder she'll have to push. It isn't unusual for a skier to have to exert hundreds of pounds of force on the snow for several seconds in order to change direction.

So what is momentum, anyway? It's the product of **mass** (weight) and **velocity** (speed), and is represented by the following equation:

p = mv

Where:

- **p** = momentum
- **m** = mass
- **v** = velocity

If you're kind of stumped as to how this is all related, here's one way you can think about it. What's an easier thing to stop: a train moving at 30 miles per hour or a marble moving at 30 miles per hour? If you're a good catch, it's pretty easy to snatch the marble out of the air. But if you tried to grab a moving train, the train would just yank you right along with it! Why? The train has a lot more **mass**, meaning it has more **momentum** than the marble—even if their **velocities** are the same.

So what does this mean for skiers? A heavier skier may be able to accelerate faster, because his momentum helps him overcome forces like friction from the snow. Here's the problem, though—in order to turn or come to a full stop, he has to push a whole lot harder on the snow in order to fight against his own momentum!

Try This!

Have a look at the following pairs of moving objects. Which object has the greater momentum? To find out, multiply each object's mass and velocity and pick the larger number.

1. A 7 kg bowling ball traveling at 8 m/s or 0.15 kg baseball travelling at 46 m/s

The bowling ball. 56 kg m/s > 6.9 kg m/s

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2. A 92 kg sprinter running at 9 m/s or a 63 kg cyclist on an 11 kg road bike traveling at 12 m/s

The bike + rider. 828 kg m/s < 888 kg m/s

3. A 72 kg alpine snowboarder traveling at 21 m/s or a 61 kg skier traveling at 24 m/s

The skier. 1512 kg m/s > 1464 kg m/s

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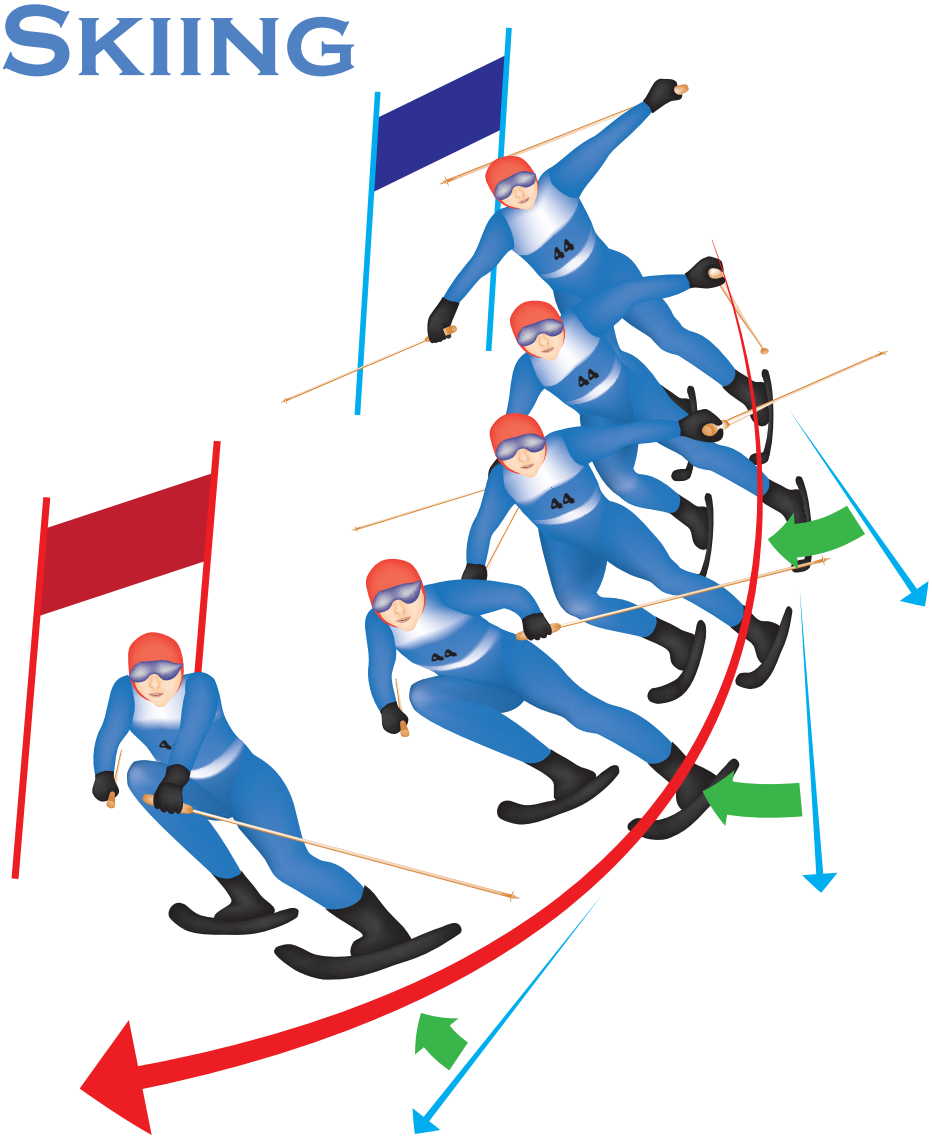

Check out the illustration above showing a slalom skier during various points of a turn. The red line represents the path that the skier travels in. But remember what Newton's second law says—objects don't naturally travel along curved paths! To complete a turn, a skier has to work hard to change the direction of his **momentum** (represented by the straight blue lines) by using his legs to exert a **force** against the snow with the edge of his skis. The force of the snow pushing back on the skis is represented by the green arrow. (This force has a special name. We'll talk about it more when we explore the physics behind speed skating!)

What else do you notice about the diagram above? Do you notice anything the athlete changes about his body positioning throughout the turn? Take note of his hands, torso, and knees. Why do you think he does this?

Explanation: He tucks his arms in front of his body to reduce drag. He leans to the inside of the turn so that he can dig the edges of both skis into the snow, which exerts the frictional force necessary to turn. He bends at the knee on one leg to get into a crouching position, which further reduces drag.