ROSEDALE ACADEMY

The Physics of Downhill Skiing Group Activity

Working in groups of 3-4, read the following article on the physics of downhill skiing. Afterwards, work together to answer the questions provided below. For question 5, you may choose to either have a representative to present your findings to the class, or you may make the presentation as a group.

The Physics of Downhill Skiing

Abstract

Downhill skiing involves forces in a variety of different ways. Skiers race down the mountain as the force of Earth's gravity pulls them toward the bottom of the slope, while air resistance and kinetic friction resist the motion. The skiers stance and equipment help the skier reach the bottom of the slop as quickly as possible by reducing the air resistance on the skier as well as the friction between the skier and the snow. The skier must also maintain control while going down the slope by taking advantage of the friction between the skis and the snow. Finally, the design of the skier's safety equipment must take into account the forces on the skier during a crash.

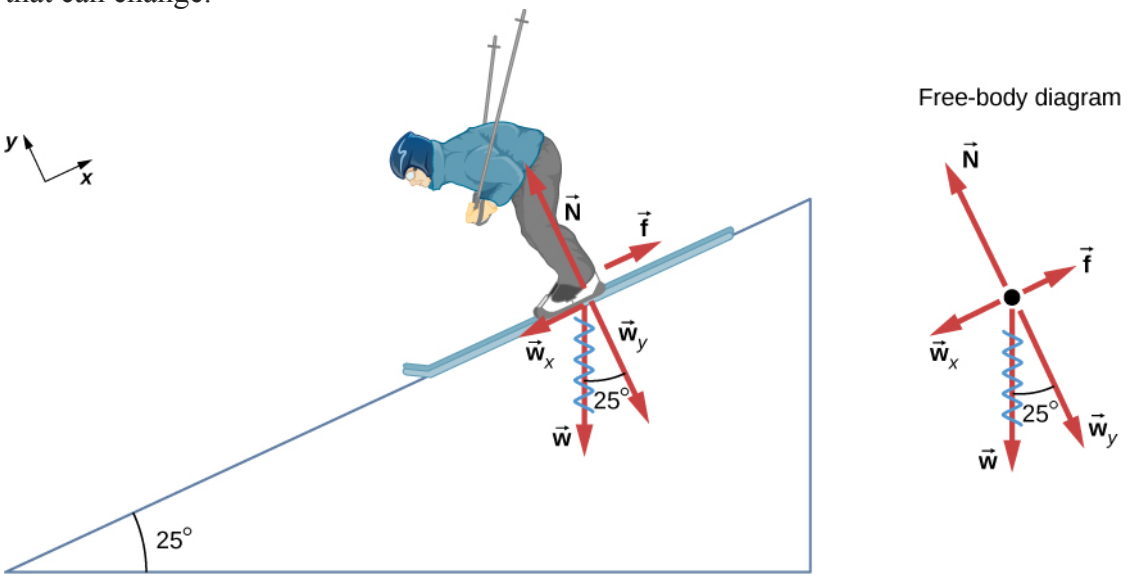
The Forces Acting on a Skier

What are the forces acting on a downhill skier? Gravity acts to accelerate the skier down the hill, while various frictional forces oppose the skier's motion.

Reducing friction is a significant element of downhill skiing. Wax on the bottom of the skis help reduce the kinetic friction between the skis and the snow. This directly increases the acceleration of a skier because any reduction in the coefficient of kinetic friction between the skis and the snow will decrease the fictional force accordingly.

Body position is also important for reducing friction in the form of air resistance. The air resistance of an object is proportional to the area of the object. By making herself as small as possible, a skier can reduce the force of air resistance. This is why skiers go into a courting position, called a tuck, as much as possible.

Having a large mass will not necessarily cause the skier to go faster. The mass of an object does not affect its acceleration due to gravity, but when air resistance becomes important, that can change.



Unlike the forces of gravity and kinetic friction, the force of air resistance does not depend on the mass of an object. So according to the above equation, a more massive skier should have a slightly larger acceleration as the skier's speed increases. However, the ability to make sharp turns is also important for a skier, and a heavier skier might have more trouble making such turns.

Another important aspect of downhill skiing is maintaining control going down the slope. This often requires making many star turns during the descent. A skier turns by using the friction between the skis and snow to slow down and to help make turns. When turning, the skier has to angle the skis to dig up into the snow, making use of the normal force. Leg strength is also important for making sharp, controlled turns that increase overall speed down the slope. Skiers train the muscles that allow them to make the purest possible curves (turns).

Skiers can also use poles to give a boost of extra force when they start from rest. When a skier pushes on the slope with the poles, the slope exerts a force on the skier according to Newton's third law. This force will have components both parallel and perpendicular to the slope (surface of the snow). The parallel force will directly increase acceleration down the slope. The perpendicular force will educe the normal force of the slope on the skier and thus reduce the kinetic friction.

Finally, safety is a major issue in downhill skiing. During a crash, a skier's speed changes from a high speed to zero almost instantly. Newton's second law explains that this large change causes a large force to act on the skier. Safety equipment is intended to reduce the effect of the

sudden slowing felt by the skier and, thus, the force on the skier. Reducing the force on the skier's head is particularly important. A helmet provides a cushion that allows the skier's head to take more time to slow down from full speed to zero during a crash.

Questions

1. List four forces that act on a downhill skier.

2. How does equipment used by downhill skiers reduce friction and resistance?

3. Does a large mass necessarily cause a skier to go faster? Explain your answer.

4. Why is a helmet important for a downhill skier?

5. Research improvements in skiing equipment, technology, and ski suits (clothing). Afterwards, present your findings to the class.

   (a) What is the relationship between improvements in skiing technology and safety?

   (b) Is there any evidence that supports the use of the technology?

   (c) Why do skiers wear special clothing?