

Section 4.5: Forces Applied to Sports and Research

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1. (a) In the case of a spike in volleyball or hitting a golf ball, the player must use good technique to hit the ball as fast as possible.

(b) In the case of a slapshot in hockey or striking a golf ball, the player raises the stick and makes a powerful swing to hit the puck or ball to move it as quickly as possible in the intended direction.

2. (a) The sweet spot of a baseball bat is the point on the bat where most power can be generated. This implies that the ball will travel the farthest distance after the swing if it strikes the bat on the sweet spot.

(b) Answers may vary. Sample answer:

When a batter hits a ball, the bat will rebound from the force of the collision. If the ball is hit closer to the handle end, a straight-line force will occur at the pivot point. If the ball is hit nearer to the barrel end, a rotational force will occur at the handle end, causing the handle to move away from the batter. If the ball impacts at the sweet spot, these two opposite forces will balance, causing a net force of zero.

3. In the photograph of a typical swing, the golfer shows good technique as he is making the club head move really fast. The faster the club head is moving when it strikes the ball, the farther the ball can travel.

4. (a) Physicists now know that the thin layer of slushy water exists when the ice is exactly $0\text{ }^{\circ}\text{C}$. When the ice is cooled, this layer gets thinner and disappears when the temperature is $-250\text{ }^{\circ}\text{C}$.

(b) Skate blades are now made slightly curved at the bottom so that they can dig into the ice, which in turn provides a normal force that pushes the skater forwards.

(c) The slushy water on ice at $0\text{ }^{\circ}\text{C}$ reduces the coefficient of kinetic friction of a skate blade on ice to as low as 0.005. At extremely cold temperatures, this layer does not exist. The coefficient of kinetic friction of a steel skate blade on ice becomes 0.6, which means that the blade can no longer slide easily.

5. Answers may vary. Sample answers:

(a) When the skate blade is heated, it melts the ice below, forming a thin layer of slushy water that reduces the friction of the blade on the ice.

(b) The insertion of a battery into the hollow plastic is a disadvantage as the temperature of the blade, or the speed of the blade, is now electricity based and the skater will not be in full control of the performance of the blade using her skills or techniques.

(c) Therma Blade is designed to maintain a consistent temperature of approximately $5\text{ }^{\circ}\text{C}$ using a small battery and a microprocessor stored within each skate blade holder. The warm blade increases the thickness of the slushy water layer between the blade and the ice, reducing the kinetic friction of sliding and the static friction at the start of the skating motion for skaters. The blade is still being tested and will be tested by a group of NHL hockey players during NHL game conditions. The advantages of the blade are that the reduced friction allows players to reach top speed faster and to skate using less energy, resulting in less fatigue over the course of a hockey game. The disadvantage of this blade is that it is battery-powered, making the performance of a player dependent on the battery providing the right temperature. What if the battery fails to warm up the blade during a hockey game?

(d) I do not think the Therma Blade should be allowed in hockey leagues across Canada. In these games, hockey players are using their skills and techniques. Relying on battery power to increase their speeds should not be recommended.

6. Answers may vary. Sample answer:

To move large blocks of stones, ancient Egyptians had to find ways to overcome the strong force of friction between the stone and the ground. The use of rolling logs allowed the two surfaces to be separated. Since the friction between the rolling logs and the stones and that between the rolling logs and the ground are much smaller, the stone blocks could be moved more easily. The rolling element bearing does a similar task. It uses the same principle to reduce the friction between two surfaces that slide or roll across each other.

7. Answers may vary. Sample answers:

(a) A typical fluid bearing separates two surfaces using a fluid to reduce the friction between surfaces.

(b) A thin layer of fluid that reduces the friction between two sliding or rolling surfaces is similar to the thin layer of slushy water formed between the skate blade and the ice surface. A fluid bearing requires a seal or pump to keep the fluid in place between the two surfaces in contact whereas the layer of slushy water that reduces the friction

between the blade and ice comes from the melted ice when the skater digs the blade into the ice.

8. (a) Magnetic bearings use magnetic fields, instead of rolling elements or fluids, to keep two surfaces separated.

(b) Answers may vary. Sample answer: One disadvantage of magnetic bearings over rolling element bearings is that electricity is required to operate the electromagnets so a back-up bearing system is needed. Another disadvantage is that magnetic bearings require electric energy to keep them working, whereas rolling element bearings do not.

9. Answers may vary. Sample answers:

(a) Some of the reasons why people with artificial limbs should be allowed and encouraged to compete with athletes in the Olympics and in other sports events are as follows. Disabled people should be given the chance, or the right, to compete with other people in events that are supposed to be open for all people. Participating in the Olympics is the dream for most athletes so this should also be made the dream for disabled athletes. Allowing people with artificial limbs to participate in events that disabled people normally could not participate in will make these people feel that with hard work and strong will, they can always make their dreams come true.

(b) Professional athletes using artificial limbs should not be allowed to compete with athletes that do not use these limbs. As technology improves, artificial limbs can continuously be made of materials that are lighter, more durable, and more flexible than before. With appropriate design, an artificial limb could be much lighter and stronger than a human leg. This might allow an athlete to run faster and for a longer time without getting exhausted, giving the athlete an unfair advantage over other athletes that do not use artificial limbs.

10. Answers may vary.

(a) Students' answers should include new advances in prostheses other than those mentioned in this unit.

(b) Students' answers should include the benefits of prostheses to people who have lost parts of their body, how government can get involved in the expensive research and the body part replacement with training for its operation, and some legislations that should be passed about insurance plans or health benefits for the users.

11. Answers may vary. Sample answer:

When a person sits, the hip has to support the upper body's weight and the hip slides quite often on different seat surfaces. So the material used in hip replacement must be strong, flexible but sturdy, wear resistant, and durable to function properly and last a long time.

12. Answers may vary. Sample answer:

Near-frictionless carbon is a solid material that can resist wear and has a very low coefficient of friction of 0.001. Due to these properties, near-frictionless carbon can be applied to different surfaces of the parts in machines to reduce the need for repair and replacement. Its application in the space program and aircraft design is being researched. In the future, the technology of using near-frictionless carbon for coating surfaces may eventually be inexpensive enough to be applied to cars or household items.