

## Reaction Time

**What to do:** Test your reaction speed against an ice hockey goalie.

### What's the big idea?

Reaction time is the time between a stimulus and our actions in response to this stimulus. Once the nerves in the eyes and ears register the signal, they transform it into the nerve impulse and send it to the brain. The brain must then send a signal along the nerves to the muscles, telling them to start moving. If only one response is possible, it is simple reaction (e.g. sprint start). When alternative reactions are available, it is called choice reaction time. Choice reaction time can be improved by practice and training. Skilled players reduce reaction time by selecting the most important information, and by anticipating other players' actions and the path of the ball or puck quickly.

### Did you know?

Baseball is a game played just within the limits of a human's ability to react. A major league pitcher can throw a baseball up to 95 miles per hour. At this speed it takes about four-tenths of a second for the ball to travel from the pitcher's mound to home plate. By the time the ball has traveled a dozen feet from the pitcher's mound, the batter has a good visual fix on it and must time the ball and decide where to swing. If the batter decides to swing, he must start when the ball is approximately 25 to 30 feet in front of the plate. The ball will arrive at the plate about 250 thousandths of a second later – about the limit of human reaction time. The bat must make contact with the ball within an even smaller time range; a few thousandths of a second error in timing will result in a foul ball. Position is important, too. Hitting the ball only a few millimeters too high or too low results in a fly ball or a grounder.

In a high-speed sport such as hockey, a player's reaction time can often determine the outcome of the game. A notable example of this is the reaction time of a professional hockey goalie whose job is to stop a six-ounce piece of frozen rubber traveling at speeds over 100 miles per hour. Goalies make several different types of saves depending on the situation: stick-saves, glove-saves, blocker-saves, and kick-saves. Having only a fraction of a second to make the decision, they use whatever part of the body or equipment is closest.

### Find out more:

- Topend Sports [[link to: http://www.topendsports.com/testing/reactime.htm](http://www.topendsports.com/testing/reactime.htm)]
- Biological Baseball at Exploratorium [[link to: http://exploratorium.edu/baseball/biobaseball.html](http://exploratorium.edu/baseball/biobaseball.html)]
- Science of Hockey at Exploratorium [[link to: http://www.exploratorium.edu/hockey/save1.html](http://www.exploratorium.edu/hockey/save1.html)]

## **Olympic Sprint**

**What to do:** Test your speed against that of Olympic silver medalist and local track star Lauryn Williams.

### **What's the big idea?**

The hundred meter (100 m) sprint is a track-and-field event. It is the shortest outdoor track race, and the athletes are known to develop the highest speeds on this track. The Olympic 100 m champion can be called “the fastest man/woman in the world.” Sprinters typically reach top speeds between 50–60 meters into the race and tend to slow down toward the finish line. Maintaining the top speed for as long as possible is a primary focus of training for the race.

In sprinting events, an efficient start is important. While on the starting blocks, the foot must be correctly located on the blocks, and fingers must not cross the line. Hands must be positioned wider than the shoulder width, while head and neck should be kept in line with the spine. The eyes must be focused on the track approximately 1–2 meters ahead.

In the set stage, the runner must raise hips slowly to a position above the shoulders, keeping a 90-degree angle for the front leg knee, and 120 degrees for the rear leg knee. Both feet must be pushed back into the blocks. As the runner hears the signal, he must extend the whole body so there is a straight line through the head, spine and extended rear leg. It is important to run out of the blocks, not step or jump. Driving hard with the elbows and legs will help to accelerate.

### **Did you know?**

Efficient sprinting technique does not always come naturally to everybody; it needs to be trained. Sprint training is not only about running fast. The athlete has to be in good overall shape to do well on the track. Flexibility and bodily strength must be developed first, before starting any rigorous training. Sprint training sessions involve sprinting drills, acceleration, plyometrics (power training), and resisted training. Also, a proper warm-up is essential to avoid injuries on the track.

### **Find out more:**

1. Sports Coach [link to: <http://www.brianmac.co.uk/sprints/index.htm>]
2. Topend Sports [link to: <http://www.topendsports.com/fitness/speed.htm>]

## Hang Time

**What to do:** Select the correct bar for your height, and see how many pull-ups or chin-ups you can do.

### What's the big idea?

Pull-ups and chin-ups are body weight exercises that use the body's mass to build upper body strength. Upper body strength is not only important for the development of cardiovascular system, but also for building overall muscle strength to help support the skeleton.

Pull-ups and chin-ups differ by the grip. The grip makes chin-ups slightly easier to do. When doing a chin-up, hold the bar with palms facing inward and use the biceps to lift the body up. When doing pull-ups, the palms must be facing away, and it is the muscles in the back that are working. Both exercises are fairly difficult to do. Without training it is hard to stay up off the ground for a long time. Use the legs' force to gain momentum. These simple techniques will help you get started.

### Chin-ups

Grab a bar with both hands placed at shoulder width away from each other, palms facing toward yourself. Looking upward, pull yourself up until the chin is above the bar, with both elbows tucked at the sides of the body, pointing downward. Then, lower yourself in a controlled fashion until the arms are straight.

### Pull-ups

Start with both hands positioned on the bar at slightly wider than shoulder width. Contracting the muscles in the back as much as possible, pull yourself up till the chin is above the bar and the clavicle has just touched the bar. Then, let yourself down.

### Find out more:

- Chin-ups at Complete Strength Training [[link to: http://www.complete-strength-training.com/chin-ups.html](http://www.complete-strength-training.com/chin-ups.html)]
- Pull-ups at Complete Strength Training [[link to: http://www.complete-strength-training.com/pull-up-exercise.html](http://www.complete-strength-training.com/pull-up-exercise.html)]

## Pitching Speed

**What to do:** Step on the mound and see how fast you can throw a ball.

### What's the big idea?

When throwing a baseball, our arms undoubtedly play a significant role, but we get most power from the muscles in our lower torso and upper legs. The legs start the motion and give the most power to the pitch. They generate the first 50 miles an hour. The back and the shoulder generate the next 20 miles an hour. The next 15 miles an hour are generated in the arm and the elbow. Only the last 10 miles an hour are actually generated by the hand and the wrist.

In order to pitch well, the entire body needs to be used in a well-balanced and coordinated fashion. The power of the big muscles in legs, back, and shoulders needs to be coordinated with fine movements of fingers and the wrist, which control the precise location and spin of the ball as it leaves the hand.

### Sports connection

- Baseball is the oldest professional sport in the U.S.
- A baseball is made out of yarn that is wound around a piece of cork. It is then covered with pieces of leather that are tightly stitched together. The mass of a typical baseball is around 5 oz., and its circumference is about nine inches. In the major leagues, the ball is pitched a distance of 60 feet, 6 inches at speeds anywhere from 60 to 100 mph.
- A baseball in flight is subject to three distinct forces. The first is gravity, which causes the ball to accelerate vertically downward at the speed of  $9.8 \text{ m/s}^2$ . The second is air drag, which impedes the ball's motion through the air. The third is the Magnus force, which permits the ball to curve laterally. Air drag (or air resistance) acts in the direction opposite to the motion and depends on the velocity of the ball. Magnus force acts perpendicular to the ball and makes the ball spin around its axis.
- Different types of pitches include fastball, change-up, curveball, slider, screwball, and knuckleball. Fastball is the fastest pitch that does not have a lot of movement and goes directly from the release to the plate. Change-up is thrown like a fastball but at a much slower speed. The idea is to fool the batter by making him think that a fastball has been thrown and make him swing before the ball gets to the plate. Curveballs, sliders, and screwballs are all pitches that put a spin on the ball, while a knuckleball is a slow yet unpredictable pitch.

### Find out more:

- The Physics of Baseball Pitching [link to: <http://farside.ph.utexas.edu/teaching/329/lectures/node41.html>]
- Physics of Pitching at SEED [link to: <http://www.seed.slb.com/subcontent.aspx?id=6118&terms=pitching>]
- The Physics of Baseball [link to: <http://library.thinkquest.org/11902/physics/curve2.html>]

## Rock Wall

**What to do:** Strap yourself into a professional harness, and climb to the top of this 25-foot rock wall.

### What's the big idea?

In rock climbing, bones, joints, and muscles combine to provide wedges and levers as you are making your way to the top. The most sophisticated climbing piece of equipment is the human hand. Hand jams allow climbers to grab holds in seemingly impossible places. However, the key to the right grip is to keep hands relaxed. Many people unconsciously squeeze the hold a little tighter than they should. Over-gripping wears out the forearms, and when that happens, it is impossible to advance any further.

Climbers also must have a good sense of balance and be able to control it. The center of balance is centered on the body mass, which is approximately the middle of the body around the stomach. The climber's center of gravity should be centered in a forward-backward as well as a left-right direction. By knowing where the center of gravity is, the climber can anticipate the direction of force on a hand or foot hold while making the move. As a rule, keeping the body close to the wall is a good climbing technique. Another indicator of the climber's position is the direction where the knees point. The more erect the body posture is, and the more the knees point into the wall and the further the center of gravity will be out away from the wall. However, some climbers tend to climb a little more erect to take advantage of their height.

### Did you know?

- Doing warm-up exercises and stretching before rock climbing is important, because they improve blood circulation and flexibility. Warm-up exercises help prevent injury and make the joints, ligaments, and muscles move and last a little longer.
- Climbing techniques put a variety of forces to work. In "face climbing," the most common technique, climbers pull down on handholds and push up on footholds to advance up the rock. By keeping their weight balanced over their feet, the climbers remain stable. In "stemming," climbers push their legs outward against the two opposing rock faces. Their outward push forces their shoes into the walls, and the shoes generate an upward frictional force that opposes gravity and allows the climbers to ascend.
- Many climbers choose nylon ropes, because they stretch and absorb the shock of a fall. Good climbing ropes will stretch to double their original length before breaking and have a breaking strength of more than three tons of force.

### Find out more:

- Rock Climbing [link to: <http://www.reachoutmichigan.org/funexperiments/agesubject/lessons/newton/rckclimb.html>]
- Indoor Rock Climbing [link to: [http://www.indoorclimbing.com/Climbing\\_Technique.html](http://www.indoorclimbing.com/Climbing_Technique.html)]
- Newton's Apple [link to: <http://www.newtonsapple.tv/TeacherGuide.php?id=1175>]

## Skateboard Stability

**What to do:** Test your skills as you adjust your center of gravity to ‘hang ten.’

### What’s the big idea?

Skateboarders make skateboarding look easy, but learning to balance on the board with wheels takes a lot of effort. Skateboarders make use of different forces to help them perform simple moves and do the tricks. In a basic move called pumping, the body is used to gain speed without the rider's feet leaving the board. By using their bodies as physical instruments, skateboarders put energy back into the ride.

When skating on a ramp, skateboarders rely on gravity to supply the force needed to get them moving. They push off the ramp's ledge. Gravity pulls on the board and they accelerate down the ramp. The faster a skateboarder goes, the higher he can fly when he launches off the ramp's opposite side. More height means more time to execute tricks. The taller the ramp, the more gravitational potential energy will be stored when the skateboarder is at the top. Skateboarding half-pipe ramps are typically 15 feet high. All that potential energy converts into kinetic energy on the way down. The kinetic energy gained is converted back into potential energy as the skateboarder shoots up the opposite side of the ramp.

### Did you know?

- Skateboarders make turns by “carving,” meaning they lean their weight on their toes to push that side of the board into the ground, causing the edge of the board beneath their heels to pop off the ground. Pushing against the ground on the left will produce an equal and opposite reaction to the right. The more force is exerted on one side of the board, the greater acceleration will be in the direction of that force. So the more a skateboarder leans to one side, the quicker he will turn in that direction.
- The biggest challenge is to keep the skateboard near the feet at all times. The secret is Newton's third law of equal and opposite reactions. When a skateboarder reaches the far side of a ramp, he stomps down on the tail end of the board. The ramp will respond with an equal and opposite force, pushing the board off the ramp and into the air. Even in midair, the friction from the shoe soles and the upward push of the skateboard will keep the board close to the feet.

### Find out more:

Adapted from “Science of Skateboarding” on ScienceDaily. See full article [[link to: http://www.sciencedaily.com/videos/2007/0701-science\\_of\\_skateboarding.htm](http://www.sciencedaily.com/videos/2007/0701-science_of_skateboarding.htm)]

**Impact!**

**What to do:** Test your karate chop on the padded impact sensor.

**What's the big idea?**

The secret to karate lies in the speed and exceptional focus of the strike. A beginner can throw a karate chop at about 20 feet per second—just enough to break a one-inch board. Typically, a black belt can chop at 46 feet per second. At that speed, a one-pound hand can deliver a wallop of up to 2,800 newtons (one newton is roughly equal to the force exerted by the weight of an apple). Splitting a typical concrete slab one inch thick takes on average only 1,900 newtons.

The best boxers can punch as quickly and powerfully as any black belt. However, they cannot break concrete blocks due to the nature of their punches. When a boxer throws his fist, he usually ends the movement by following through. This gives the punch maximum momentum (golf and tennis players follow through for the same reason), and it can help knock an opponent down. But the impact itself is diffused – meaning it's meant to stun the opponent, not hurt him.

A karate chop, on the other hand, has no follow-through at all. It lashes out like a cobra and then withdraws instantly. When a black belt hits a slab of concrete, for instance, his fist touches the block for fewer than five milliseconds, and yet the block breaks. A well-thrown fist reaches its maximum velocity when the arm is about 80 percent extended. As the punch is thrown, it must be focused (in your imagination) so that it terminates inside the object rather than on the surface. For maximum power, make contact before the slowdown begins.

**Did you know?**

Many athletes worldwide have excellent karate skills and claim to be the world record holders. However, it is difficult to find the undisputed champion, because there is no world-accepted standard for bricks and wooden boards to make a comparison. Therefore, each record must be achieved under the strict rules and verified. Here are some of them:

- Kevin Taylor from the United States broke 584 cement bricks in 57.5 seconds in Mount Clemens on Aug. 4, 2007.
- Larry Fields from the United States broke 354 cement patio blocks in one minute with his elbows in Kansas City on April 3, 2004. The blocks were eight inches tall by 16 inches wide by two inches thick.
- Kevin Shelley from the United States broke 31 boards on his forehead on Aug. 16, 1999. The boards were 12 inches wide by 12 inches tall by one inch thick and made of pine. He had 30 seconds to break as many boards as possible.

**Find Out More:**

- Adapted from “The Physics of ... Karate” by Curtis Rist. See full article [[link to: http://discovermagazine.com/2000/may/featphysics](http://discovermagazine.com/2000/may/featphysics)]
- World Record List [[link to: http://www.recordholders.org/en/list/karate.html](http://www.recordholders.org/en/list/karate.html)]

## Vertical Jump

**What to do:** Jump as high as you can and try to hit the highest button.

### What's the big idea?

Vertical jump is the ability to raise one's center of gravity higher in the vertical plane with the use of one's own muscles. This jump occurs without much momentum. Vertical jump measurements are used in sports to measure athletes' performance. The most common sports in which the jump is measured are track and field, basketball, football, and volleyball.

One of the best ways to exert a powerful vertical jump is to spring upward as quickly as possible from a crouched position. The more power the jumper can exert on the ground when taking off, the higher he will go. The power is the key. In physics terms, the power is defined as a product of force and acceleration. So the greater the force is exerted, and the faster it is applied, the higher the jump will be.

### Did you know?

Most popular jumping techniques are countermovement and static jump. Countermovement is commonly used for the vertical jump test. To perform this type of jump, the athlete must bend the knees immediately prior to the jump and use the arms to help propel the body upwards. During the countermovement the muscles in the legs are first stretched and then shortened, resulting in greater acceleration power. This action of the muscle is called a stretch-shortening cycle.

In addition to the countermovement technique, the test can also be performed as a static jump. For this technique, the athlete starts from a stationary semi-squatting position, or pauses at the lower level of the squat before jumping upward. This removes the factor of the stretch-shortening cycle, and the jump result will be smaller. The difference in jump height is typically 1–2.5 inches.

### Find out more:

- VertCoach [link to: <http://vertcoach.com/vertical-leap-equations.html>]
- Topend Sports [link to: <http://www.topendsports.com/testing/vertical-jump-technique.htm>]