**Helicopters** is an event in which students compete to build a balsa wood helicopter powered by a rubber band motor that has the longest flight time possible. It is a [Division C](https://scioly.org/wiki/index.php/Division_C) event in the [2017](https://scioly.org/wiki/index.php/2017) and [2018](https://scioly.org/wiki/index.php/2018) seasons, and has been in both [Division B](https://scioly.org/wiki/index.php/Division_B) and [Division C](https://scioly.org/wiki/index.php/Division_C) in the past.

**Contents**

**Key Components/Terms**

There are some commonly used terms that are useful when describing helicopters.

* **Motor Stick:** This is the body of your helicopter. It holds the rubber band, and the two rotors are attached to this. There are different methods and designs, which are discussed below.
* **Rotors:** These are the horizontally counter-rotating pieces that transform the torque in the rubber band to thrust in order to lift the helicopter. Most designs utilize two of them, one fixed (glued firmly to the motor stick), and one free (attached to the motor stick with a shaft and bearing so that it can rotate when the rubber band is hooked onto it). However some designs use two free counter-rotating rotors, which may be more efficient.
* **Spars:** These are the long, thin wood pieces that span the length of the rotors.
* **Ribs:** these are used to brace the rotors, and are placed between the spars.
* **Prop/Rotor Shaft:** This is a metal wire that is used to connect the free-spinning rotor to the rubber band.
* **Rotor Hanger:** This holds the prop/rotor shaft, allowing it to spin freely.
* **Rubber band:** This is the power source for the helicopter. It is wound using a winder. More is discussed about rubber below.

**Construction Process**

A simple design you can build is the [Wright Bat Flier](http://www.centennialofflight.gov/wbh/wr_experience/1899/past/WBstory.htm). A step-by-step "**Beginner's Guide**" to building a helicopter, written by National Event Supervisor Jeff Anderson, [can be found here](https://scioly.org/wiki/images/f/f1/HelicopterGuide1.docx).

It is important to emphasize that teams cannot use commercially available propellers, as previously stated. This is to preserve the true spirit of Science Olympiad--the engineering creativity of students. Teams may, however, use a kit as long as there are no pre-built parts (also make sure they meet the dimensional requirements of the rules). Don't panic--take time to draw up plans and purchase the materials needed as quickly as possible. At times homemade helicopters can far outperform kit-built models.

It is permitted to use various materials (wood, paper, string, wire, etc.).

**Helicopter Body Building and Designs**



Main body of a typical helicopter. The motor hook on the left is fixed to the body (i.e it cannot move on its own), while the one on the right rotates with the rotors. In the center is the rubber band motor.

Helicopter bodies should be simple and easy to repair if damaged. For the body use the lightest wood possible without it being too brittle; balsa usually works. The top of the helicopter body should be constructed out of stronger wood than the rest of the helicopter frame because it will be under immense strain during flight (balsa which is denser or has larger dimensions may work). Make sure it is thick enough to drill a hole through. This is where the motor hook will be attached.

Pictured at right is a simple but effective body design found at most helicopter competitions.

There are three common designs, each with its own benefits and issues.

* The most common design is a single-stick body. This implies one piece of balsa, that is used as the main body of the helicopter. [This](http://gallery.scioly.org/details.php?image_id=3371) helicopter exhibits the single-stick design. This design is very simple to build, and may possibly be lighter than the next one. However, balancing the helicopter with this method is slightly more difficult, and will result in a wavering helicopter. Carefully balancing the rotors will result in a smooth flight pattern.
* The second most common design is the split-stick body. Two thinner spars, instead of one long one, are used as the body. They are connected at the top and bottom by horizontal pieces. [This frame](http://gallery.scioly.org/details.php?image_id=3313) is for a split-stick helicopter. [Here](http://gallery.scioly.org/details.php?image_id=3313) is a video describing how to wind and fly a split-stick model. The advantage of this design is that it is much more balanced than the previous one. It is slightly more difficult to build but is still within the grasp of many teams. This design could end up weighing more if not carefully built.
* The third design, possibly the most efficient, and also the most difficult to build is a hollow-body or rolled-motorstick design. It is made by taking a thin sheet of balsa wood, soaking it in hot water, rolling it onto a form, then allowing that to dry. This results in a thin tube, which is efficient in terms of weight and balance. The rubber band is wound and placed inside the tube, and the rotors are attached at each end. This [video](http://www.youtube.com/watch?v=xsGwOCiREBU&feature=related) describes a hollow-body design. Once again, it is possibly the best design, but also the most difficult to build. Advanced competitors should try this design.

The rotors will be attached to the unfixed motor hook by a shaft in the middle. Often times the wire (paper clips work nicely for this purpose and they are quite pliable) is bent or glued around the shaft that connects the rotors.

When gluing the joints together, **use CA glue** (not gorilla glue, which is far heavier and also takes longer to dry)! The helicopter will be taking some rough falls so it is best to guarantee its hardiness to avoid constant repair. In addition, super glue dries somewhat slowly and it can be hard to hold in place while gluing joints. Buy CA glue accelerator from a local hobby shop. Apply it on wet super glue and it instantly sets. This is essential to achieving a perfect angle when gluing.

**Helicopter Rotor Building and Designs**

There are many different approaches to building helicopter rotors, but all successful designs have a few things in common:

* A regularly shaped frame that can be easily replicated. Odd shapes are not encouraged.
* A strong frame on each rotor. Cross beams can be added for extra support. If you curve the balsa, the rotor becomes an airfoil and therefore has higher efficiency, but this adds some unnecessary weight to the helicopter.
* There are many ways to attach the free rotor to the body. One popular option is to use a pigtail hangar, as can be seen [here](http://www.youtube.com/watch?v=IAnm1gXUyx4).

**Flight**

**Rubber**

Matching rubber width and torque to rotor pitch is the key to being successful in this event. Rubber for indoor-duration models comes in many different widths that must be contemplated before purchasing. For example, if your rotors have a high pitch, then it would be wise to use a thicker rubber. However if your rotors have a low/shallow pitch, then you will be able to use a thinner rubber.

Thicker rubber will not take as many winds, but will provide much more power. Thinner rubber will store many more winds, but will release the energy slowly and at much less power.

Also, it would be wise to lubricate your rubberbands before flying them. You will able to place more winds into the rubber, and it will not cut itself over multiple uses. Do not use WD-40 for this, as it will degrade the rubber. A popular lubricant used by many is ArmorAll lube.

Simply spray the lubricant onto the rubber band, and rub it gently between your palms. Store in a plastic bag, to prevent the rubber from drying out.

**Winding your Helicopter**

Buy a winder or wind manually. Winding manually takes an agonizingly long time, so winders are worth the money. Do not buy a battery-powered winder that needs to be put directly on the rotor! Use a hand-crank winder with a 10:1 or 15:1 ratio.

Additionally, a good single person winding process is to construct a winding jig. It consists of a plank of wood with 2 perpendicular wood peices. In one of the perpendicular peices, drill a hole and put in a hook that can hold the O-ring. On the other end cut a hole so the winder and fit in while winding. The distance between hooks of the hook and winder should be equal to the length of the motor stick.

**Flight Logs and the Test Flight Process**

Data for 10 test flights is required before the competition for each helicopter that is checked in. Get permission to go to your school gym and test if there are not obstructions on the roof. Any room without obstructions is preferred over high ceilings with lots of obstructions. Fans, beams, contact with the ceiling, and furniture can negatively affect a helicopter's flight time. **Do not test outside**.

If a suitable testing location is not available, or you want to test just rotor efficiency, consider building a static testing jig. Place the helicopter in the jig, place the jig on a scale, and zero it out with the weight of the helicopter too. Wind up the rubber, and let the helicopter spin. The negative amount the scale displays is the comparative amount of lift the rotors generate.

6 data parameters are required for each test flight. 3 are required, 3 are up to choice.

The required data parameters for each flight are:

* Flight time
* Number of turns in motor before liftoff
* Motor size (length) before windup

Some suggested parameters are:

* Torque at launch
* Number of turns remaining after helicopter lands
* Estimated peak flight height
* Variance from starting point (how far your helicopter drifted.)
* Rubber weight

You can pick three of the above or any of your own. Feel free to add your own ideas to this list.

**Scoring**

**Only the better flight (out of the 2) will be scored.** Teams will have eight minutes to fly their helicopter(s) once or twice. If that time expires and teams still have not completed a second flight, they will not get to test either of their helicopters again.