



# **Troop Guide for STEM Nova Activities**

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## INTRODUCTION

STEM stands for science, technology, engineering, and mathematics. STEM has been part of Scouting since its very beginnings—building a fire, identifying plants and animals, pioneering, and orienteering are all STEM activities. The Nova Awards program was developed to highlight the STEM inherent in the Scouting program and to expose youth to additional STEM opportunities.

Experts say that our young people need STEM-related skills to compete in the world of tomorrow, where most jobs will require at least a basic understanding of math and science. Additionally, in our increasingly complex world, a STEM background is required to understand complicated issues and to be an informed citizen. To remain competitive in the world economy,

the United States must cultivate the next generation of critical thinkers and innovators. Educating Scouts about STEM is part of our mission—and fun, too!

There are different Nova awards for each STEM area. Scouts can earn as many as they would like, either with their troop or patrol or on their own. After completing their first Nova award, a Scout earns the right to wear the Nova award patch. Completion of an additional Nova award for the remaining stem areas is recognized by a “pi” pin placed on the patch.

Each award builds on STEM-related merit badges, involves hands-on activities, and often includes a field trip. As additional Nova awards are developed, their requirements will be posted at [www.scouting.org/stem](http://www.scouting.org/stem). Scouts who truly excel in these areas may want to earn the Supernova awards.

### Award-Based vs. Activity-Based Implementation

Do your Scouts want to earn patches and pins, or do they just want to do fun activities? STEM can do both! Depending on the interest level of your troop, you can include as much or as little as the Scouts want, at an age-appropriate level.

These are only suggestions and can be modified to fit the unit’s interests and resources.

Each unit will need to determine how best to include the STEM Nova program or STEM in their unit. Some will find it best to have a separate STEM patrol with STEM-focused patrol meetings. Others may prefer to have separate STEM meetings, outside of the normal unit meetings, for Scouts who are interested in STEM. The STEM Nova program is supplemental to Scouting and is not intended to replace normal troop activities.

Interested adult leaders who are willing to do a little research can go a long way in mentoring youth as they develop their own program and activities.

### Demonstration vs. Experiment

When conducting STEM-related activities, remember that the goal is to get the Scouts to explore, ask questions, and learn how to figure out answers on their own.

- A **demonstration** involves showing something interesting and then explaining what happened. The outcome of a demonstration is known in advance.
- An **experiment** happens when you repeat an activity multiple times, changing one parameter each time and measuring how that change affects the outcome. Each condition is usually repeated at least three times to average out random fluctuations. While the experimenter will have a hypothesis as to what will happen, there may be a completely new and unexpected result.

Demonstrations can be used to introduce a topic, but people of all ages learn and retain more with engaging, hands-on experiments. The experiments of Venturers may be more sophisticated than those of Cub Scouts, but they are all experimenting.

## ADULT LEADERSHIP

Nova counselors are the adults who work directly with the Scouts. Counselors do not need to be STEM experts or STEM professionals. Much more important is their ability to work with Scouts BSA and to make the activities fun and challenging at an age-appropriate level. By reading and learning about a STEM topic, almost any adult Scouter can be a STEM counselor.

You can be a Nova counselor if you are:

- At least 21 years of age
- Of good character
- Able and willing to work with Scout-age youth
- Willing to research STEM topics if you are not familiar or comfortable with them, and willing to team up with a subject matter expert if required
- A registered BSA adult (complete the registration form with position code 58; no charge)
- Current in BSA Youth Protection training

In addition to Nova counselors, your troop may want to have a parent serve as a STEM coordinator to keep members aware of district- and council-level Nova Days or STEM Universities, and other STEM-related events. If you have some youth who are very interested in STEM, one of your adult leaders might want to become a trained Supernova mentor (see the “On to Supernova” section).

## IMPLEMENTING THE NOVA AWARDS PROGRAM

This section contains two different lesson plans. Each involves a series of troop meetings where Scouts work on specific Nova award and merit badge requirements, which are then completed at the monthly campout.

### Program Plan I: Shoot! (Science) Nova Award with Weather Merit Badge

The Shoot! Nova Award covers science, focusing on projectiles and space and how science affects everyday life. The following program guide provides a plan for earning this Nova award in four troop meetings and one campout. The meetings may be done in any order, and the plan may be modified to meet your troop’s needs, if the requirements are completed exactly as written—no more and no less.

### Troop Meeting 1

**Opening**—5 minutes

**Program**—Nova requirement 1C

**Introduction.** Watch about three hours total of science-related shows or documentaries that involve projectiles, aviation, weather, astronomy, or space technology.

Watch an episode of “NOVA” (for example, “The Great Robot Race,” one hour). See <http://www.pbs.org/show/nova> for full episodes you can watch online or borrow a CD from your local library.

Watch one hour at a troop meeting, then assign two more hours of watching or reading at home. Set up the meeting with popcorn and drinks and have everyone bring a camp chair. During the show, have Scouts make a list of at least five questions or ideas to discuss with their counselor after they have completed watching all three hours (or two questions if they are doing a combination of watching and reading).

It may be best to have a meeting separate from normal troop meetings to watch a video and discuss. Another option would be to have an interactive guest speaker be a part of the meeting; the “watching” requirement does not have to involve watching a video or television.

**Game**—20 minutes (as time permits)

**Closing**—5 minutes

Remind Scouts to research projectile motion before the next meeting.

## Troop Meeting 2

**Opening**—5 minutes

**Program**—Nova requirement 3A, simulations

**Introduction.** The counselor leads a discussion on requirement 3A3. Ideally, Scouts will have researched this topic in advance. Have the counselor bring some examples of projectile motion for the Scouts to use; paddle balls or even a simple game of catch can demonstrate how much they already know about projectile motion.

- A. What is a projectile? (Any object thrown into space, upon which gravity is the only force acting. Examples include a thrown baseball, an object dropped off a cliff, and an arrow after it leaves the bow.)
- B. What is projectile motion? (The curved path an object takes when launched near Earth’s surface.)
- C. What factors affect a projectile’s path? (In an ideal world, the horizontal motion will remain constant, and the object will move down due to gravity. See [http://en.wikipedia.org/wiki/Projectile\\_motion](http://en.wikipedia.org/wiki/Projectile_motion) for equations to predict the path of a projectile.)
- D. What is the difference between forward velocity and acceleration due to gravity? (Forward velocity has a constant speed. Acceleration due to gravity slows down things that are moving upward and speeds up things that are moving downward.)

Set up two stations, and split Scouts between them. Rotate Scouts after 30

minutes. **Station 1.** Find and use a projectile simulation applet on the internet.

Some possible sources are listed below (or search for “projectile” or “projectile motion”), and the app can be downloaded onto a smartphone before the meeting. At the meeting, let the Scouts play with the apps, and perhaps develop a competition between them.

- <http://www.mhhe.com/physsci/physical/giambattista/proj/projectile.html>
- Fowler’s Physics Applets—[http://galileoandinstein.physics.virginia.edu/more\\_stuff/Applets/Projectile/projectile.html](http://galileoandinstein.physics.virginia.edu/more_stuff/Applets/Projectile/projectile.html)
- Java applets on physics—<http://www.walter-fendt.de/ph14e/projectile.htm>

**Station 2.** Design and complete a catapult to demonstrate projectile motion.

Provide tongue depressors or paint stir sticks (usually free from local hardware stores; about 10 sticks per Scout), rubber bands (assorted sizes), and plastic spoons (one per Scout). Dried lima beans make projectiles that are easy to clean up, and you will need graph paper and pencils to track the results. Scouts can compete for distance, accuracy, or both.

- Have Scouts record their data, including angle, time of flight, and distance traveled for each launch.
- Have Scouts graph the results of their experiment, with time and distance as a function of angle and height. Scouts should then draw conclusions about the relationship.

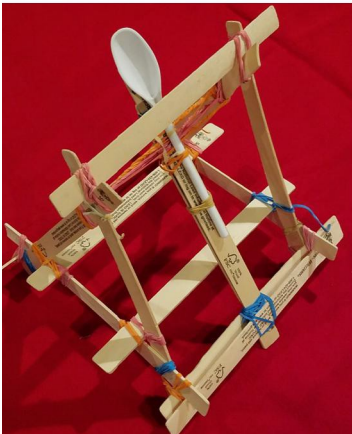
**Note:** Using a high-speed camera or video camera may make the graphing easier. Be sure Scouts conduct at least three repetitions of each condition, including varying the height from which the projectile is launched.

1.

2.

3.

Catapult physics is basically the use of stored energy to hurl a projectile without the use of an explosive. The energy is stored as tension (in the rubber bands and wood), torsion (twist in the rubber bands), and gravity. The main types of catapults are the trebuchet, mangonel, and ballista, but a slingshot is also a type of catapult. Here are a few images of several different possible designs, but let Scouts use their own creativity before sharing these designs with them.



Catapult physics is basically the use of stored energy to hurl a projectile. See [http://www.teachengineering.org/view\\_lesson.php?url=collection/cub\\_/lessons/cub\\_catapult/cub\\_catapult\\_lesson01.xml](http://www.teachengineering.org/view_lesson.php?url=collection/cub_/lessons/cub_catapult/cub_catapult_lesson01.xml).

#### Notes for the Counselor

Hand-out the requirements for the Weather merit badge (or another approved merit badge), and explain which requirements are to be completed before the next troop meeting. For Weather, requirements 2 (family discussion) and 9a (daily weather log for one week) might best be done at home, while requirements 5 and 10 could be done on a campout. The council-approved merit badge counselor is the ultimate authority on what work is allowed for each requirement, so follow that individual's advice.

**Game**—20 minutes

Red Rover, to illustrate escape velocity, and/or British Bulldog. See [http://en.wikipedia.org/wiki/British\\_Bulldog\\_\(game\)](http://en.wikipedia.org/wiki/British_Bulldog_(game)) to learn more.

**Closing**—5 minutes

## Troop Meeting 3

**Opening**—5 minutes

**Program**—Nova requirement 2, Weather merit badge

Weather merit badge session—60 minutes. Introduction of the Weather merit badge by a council-registered merit badge counselor. Some requirements may be completed at the meeting where each Scout must personally complete the requirement. All other requirements will be completed outside of the troop meeting. Scouts will need to complete this merit badge on their own.

**Game**—20 minutes

**Closing**—5 minutes

## Troop Meeting 4 Opening—

5 minutes **Program**—Nova requirement 5C

Design and build a marble run or roller coaster that includes an empty space where the marble has to jump from one part of the chute to the other. For example, the Scouts could use pool noodles (sometimes available at a dollar store), pipe insulation, or paper towel rolls cut in half lengthwise to make a path for the marbles and put them together with duct tape. Use boxes, chairs, and tables to adjust heights, and have a plastic cup to catch the marbles at the end. Paper plates and cardstock can be used to make sharp turns.

Scouts can work in teams with an architect, inspector, and one or more builders. The marble runs should be at least 4 feet long and include a gap that the marble must “jump” over.

Once they get a general arrangement they like, the Scouts must launch the marble from at least three different angles and keep track of their data for each attempt, including:

- Length of time it takes for the marble to reach the end of the run
- Vertical angle between the two parts of the chute
- Horizontal distance of the two parts of the chute
- Height of the starting point

They should also experiment with different starting heights for the marble.

- How does the starting height affect the velocity of the marble?
- How does the starting height affect the jump distance?

At the end, the Scouts should discuss their design, data, and experiments—both successes and failures—with the counselor, including a discussion of what they think will work best.

**Game**—20 minutes

Using what they have learned, have each Scout (or pairs or teams) build a new track and compete against each other for longest run, largest gap, and so on.

**Closing**—5 minutes

## Weekend Campout

With some advance planning, the following requirements can be done as part of a weekend campout.

**Nova requirement 4B:** Discover the latitude and longitude coordinates of your current position and find out what time a satellite will pass over your area. (A good resource to find the times for satellite passes is the Heavens Above website at <http://www.heavens-above.com>.) Watch the satellite using

binoculars. Record the time of your viewing, the weather conditions, how long the satellite was visible, and the path of the satellite. Discuss your viewing with your counselor.

**Weather merit badge requirements:** This session will probably include a discussion of requirements 2 and 9a (if they were completed at home), as well as any other requirements not completed at the troop meeting.

**Nova requirements 1 and 6:** Around the evening campfire, discuss the questions and ideas Scouts came up with during their watching and reading of science-based shows and books (requirement 1C), and use that to lead into a discussion of how science affects their everyday lives (requirement 6).

## **Program Plan II: Designed to Crunch (Math) Nova Award with Chess Merit Badge**

The Designed to Crunch Nova Award encourages Scouts to explore mathematics and learn how they use math in their everyday lives. The following program guide provides a plan for earning this Nova award in three troop meetings and one campout. The meetings may be done in any order, and the plan may be modified to meet your troop's needs, if the requirements are completed exactly as written—no more and no less.

### **Troop Meeting 1**

**Opening**—5 minutes

**Program**—Nova requirement 1C

**Introduction.** Watch about three hours total of math-related shows or documentaries that involve scientific models and modeling, physics, sports equipment design, bridge building, or cryptography.

Watch an episode of "NOVA" (something like "Rise of the Hackers," one hour). See <http://www.pbs.org/show/nova> for full episodes you can watch online or borrow a CD from your local library. Watch one hour at a troop meeting and assign two more hours of watching or reading at home. Set up the meeting with popcorn and drinks and have everyone bring a camp chair. During the show, have Scouts make a list of at least five questions or ideas to discuss with their counselor after they have completed watching all three hours (or two questions if they are doing a combination of watching and reading).

It may be best to have a meeting separate from normal troop meetings to watch a video and discuss. Another option would be to have an interactive guest speaker be a part of the meeting; the "watching" requirement does not have to involve watching a video or television.

**Game**—20 minutes (as time permits)

**Closing**—5 minutes

### **Troop Meeting 2 Opening**—

5 minutes **Program**—Nova requirement 3A

Calculate your horsepower when you run up a flight of stairs. Horsepower is a unit of measure for power. The amount of energy a horse uses to raise 550 pounds 1 foot is a unit of work called one foot-pound. The amount of energy a horse uses to raise 550 pounds 1 foot per second is a measure of power called foot-pounds per second.

To calculate your own horsepower:

1. Weigh yourself in kilograms (or in pounds) and then multiply by 0.454 kg (or lbs).
2. Measure the height of the staircase from base to top in meters (or in feet), then multiply by 0.3048 m (or ft).
3. Take a running start and time how long it takes you to run to the top in seconds.

0. Your energy, or wattage = (mass x 9.81 x height)/time.

1. Your horsepower = watts/746.

A healthy human should be able to get up to 1.2 horsepower for a short period of time. How does your horsepower change as you run the stairs over and over?

**Game**—Nova requirement 4

**Calculator games**—20 minutes

Have the Scouts bring their calculators (or use the ones on their phone) to solve math problems. It may be prudent to group the Scouts by age or current math class in school for this activity, as their abilities will vary significantly. Here are some sample problems.

**Order of operations:**  $2 + 4 + 6/2 - 1 =$   
 $25 \times \frac{1}{2} - 2 \quad 3/2/6 =$

**Fractions:**  $\frac{1}{2} + \frac{5}{6} =$   
 $-\frac{1}{3} / \frac{2}{3} =$

**Negative numbers:**  $5 + -3 =$   
 $5 \times -4 =$

**Percentages:** 50% of 324 =

Suppose you sell your house for \$247,000 and you agreed to pay the Realtor a 6 percent commission. How much should you pay the Realtor?

Discuss the following with the Scouts:

- Does your calculator have a memory function? Why?
- What is the area of a 4.5-foot square?
- Calculate the area and perimeter of a square, circle, and triangle.
- Suppose only the 2, 3, x, +, and = buttons on your calculator work. How would you make the following numbers: 6, 7, 8, 10, 12, 15, 20, 50?
- Suppose only the 2, 5, x, -, and = button your calculator work. How would you make -10, 1, 3, 10, 24, 32, 100, 625?

**Closing**—5 minutes

### Troop Meeting 3

**Opening**—5 minutes

**Nova requirement 2**—Chess Merit Badge

**Chess merit badge session**—60 minutes. Introduction of the Chess merit badge by a council-registered merit badge counselor. Some requirements may be completed at the meeting where each Scout must personally complete the requirement. All other requirements will be completed outside of the troop meeting. Scouts will need to complete this merit badge on their own.

**Game**—20 minutes

**Closing**—5 minutes

### Weekend Campout

With some advance planning, the following requirements can be done as part of the weekend campout.

**Nova requirement 3E:** Participate in a star count. To find out how to do a star count, search online for "how to do a star count." Ideally, you will find a site where you can enter your results and compare them to the results of other star counters.



**Nova requirements 1 and 5:** Around the evening campfire, discuss the questions and ideas Scouts came up with during their watching and reading of math-based shows and books (requirement 1C2), and use that to lead into a discussion of how math affects their everyday lives (requirement 5).

**Chess merit badge requirement 6a:** Play at least three games of chess with other Scouts and/or your merit badge counselor. Replay the games from your score sheets and discuss with your counselor how you might have played each game differently.

Set up a chess tournament for those Scouts who are interested to play during downtime at the campout.

## HIGHLIGHTING THE STEM IN SCOUTS BSA

This section discusses the STEM activities that are already in Scouting and describes how you can raise awareness among the youth that they are using STEM much more than they think.

STEM applications can be found throughout the Scouting program. A few examples are:

- **Science:** Plant and animal identification, astronomy
- **Technology:** GPS tools to augment compasses
- **Engineering:** Building bridges and camp gadgets
- **Math:** Calculating how much food to buy for a campout and how much you can afford to spend

The following ideas provide some easy ways for you to highlight the STEM already embedded in the Scouting program. This can be as simple as pointing out that Scouts are using math or building on your unit's normal activities and provide more in-depth explanations of STEM components.

### Hiking

While on a hike, why not guide a discussion about the technology of hiking boots? Leaders should not lecture (that's too much like school!) but rather lead a discussion by asking questions to get the Scouts thinking about how and why boots have changed over time. Asking leading questions gets the Scouts thinking and teaches them how to approach and solve problems on their own. It will also increase their curiosity level and build confidence when they see they can figure things out. Here are some questions you might ask to get the conversation started:

- How have hiking boots changed over time?
- How has the weight of boots changed?
- How has waterproofing advanced? Why would you want that?
- Do you "break in" your hiking boots? How? Why?
- How does having better equipment allow Scouts to do more?

At the beginning or the end of the discussion, the leader could point out that because of science, we now have better boots, and we can hike farther and longer and get to new places.

Other possible topics for discussion include locating wildlife or discussing the natural environment (how did that mountain form?), appropriate trail building (engineering), water treatment (science), trail food (nutrition and packaging, rise of allergies), and so on.

### Engineering (Pioneering, Knots and Lashings)

While working on pioneering projects, you can talk about stress testing, average load vs. peak load, and why it's important to build for maximum load rather than average load. Ask the Scouts to imagine what would happen if the subway or highway system were designed to accommodate only the average load.

You can also talk about the breaking strength of ropes and how tying a knot in any type of rope reduces its strength. For example, tying a bowline can reduce the strength of the rope up to 60 percent, but splicing two ropes together can increase the strength. (Search for “rope knot breaking strength” online.) When deciding what type of knot to use when pitching tents, consider both utility and strength. Scouts can use this information during pioneering activities, and maybe even design and conduct some experiments to test rope strengths on their own.

### **Fire Building**

Fire building is a great topic for teaching Scouts how to conduct experiments. They can try different types of fire lay (loose vs. dense), different sizes of wood, etc. Have them develop their plan of what they want to try (hypothesis), then test it out and see what they learn.

### **First Aid**

Learning proper first-aid techniques is important in Scouting to be prepared. Knowing what to do in an emergency is good but knowing why we do it is even better. Recommended best practices change over time as medical professionals learn more about what works, and it’s important to keep up with those recommendations. For example, at one time putting butter on a burn was recommended, but we now know that keeping a burn clean and dry promotes better healing.

Accredited organizations such as the American Heart Association and the American Red Cross publish guidelines of best practices, which are updated as better practices are developed. This could lead into a discussion of medical research and medical advances currently in the news, as well as how to critically evaluate the sources and biases of health information.

### **Camping**

A campout is a great time to show the youth that STEM is all around them. Plant and animal identification (as in the Second Class and First Class requirements) can lead into a discussion of taxonomy, how nature adapts to environmental changes, aerodynamics of bird flight, and much more. Poking at a fallen tree and seeing what creatures are eating it and breaking it down can lead into a discussion of the life cycle.

### **Money and Mathematics**

The Second Class requirement to earn and save money provides a good introduction for a discussion about how math permeates all aspects of our lives. Planning menus and buying food for a patrol weekend campout leads into a natural discussion of the quantity or amount of each item you need for the number of Scouts expected, how much each item costs, when buying in bulk is economical, and much more. Even calculating the number of tents required or the square footage needed for a campsite involves basic math skills. Especially for Scouts who say they don’t like or never use math, just pointing out how much they actually use it can be eye-opening.

## **ON TO SUPERNOVA**

Once a First Class Scouts BSA has earned three Nova awards, he may want to think about earning a Supernova award. The Supernova awards require superior achievement in the STEM fields and significantly more effort than the Nova awards. Supernova awards are earned on an individual basis or within a group when a Scout completes a more in-depth exploration under the direction of an approved Supernova mentor.

Please visit [http://www.scouting.org/stem/Council/Volunteer\\_Support.aspx](http://www.scouting.org/stem/Council/Volunteer_Support.aspx) or contact your local council to find out how to become a Supernova mentor.

To earn the Supernova awards within a group setting, one option is to conduct Supernova activities immediately preceding the regular Scouting meeting. Scouts who are interested in earning Supernova awards can arrive to the meeting 30 minutes early and work with the Supernova mentor on a requirement. (Keep BSA Youth Protection guidelines in mind.) These meetings can be spread out, perhaps once per month. While some individual work will still be required, meeting regularly can keep the momentum going and provide some positive peer pressure.

By adding a "Supernova session" to the regular meeting, you eliminate the need for extra meetings and extra meeting space to accommodate the Nova Awards program. Interested Scouts can participate; those who are not interested simply arrive at the normally scheduled time.

For more information, see the <https://www.scouting.org/stem-nova-awards/>.

