

# What is STEM and Nova?

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## STEM—Science, Technology, Engineering and Mathematics

STEM is part of an initiative the Boy Scouts of America has taken on to encourage the natural curiosity of youth members and their sense of wonder about these fields through existing programs. From archery to welding, Scouts can't help but enjoy the wide range of STEM-related activities. To support this initiative, the BSA developed the Nova Awards program so that youth members have fun and receive recognition for their efforts.

## Why STEM?

We live in a time of great opportunity. The spirit of innovation can help us overcome challenges and ensure a prosperous and secure future. To seize this opportunity, we must position ourselves at the cutting edge of scientific discovery and technological innovation.

Yet our country is falling behind in science, technology, engineering and mathematics. This is why many professionals and educators in science, technology, engineering, and mathematics believe the United States should do more now than ever to encourage students to enter STEM-related fields. These experts say our young people need strong STEM skills to compete in the world market. We must work together to cultivate the next generation of critical thinkers and innovators.

Ten-year employment projections by the U.S. Department of Labor show that of the 20 fastest-growing occupations projected for 2014, 15 of them require significant mathematics or science preparation.

## STEM is the future

Fostering a strong STEM education is our best opportunity to boost the spirit of innovation. It's what we need to help ensure this country continues on a prosperous and secure journey. STEM literacy is also critical because it has a profound and growing impact on our day-to-day lives. Nature, space exploration, and any STEM-related interest reveals to us the beauty and power of the world we inhabit.

## What Are the Nova Awards?

The Boy Scouts of America developed the Nova Awards program to excite and expand a sense of wonder in our Scouts. By working with an adult counselor or mentor, the various modules allow them to explore the basic principles of STEM and discover how fun and fascinating STEM can be. The Supernova awards are offered for those who enjoy a super challenge. For more information about STEM and the Nova Awards program, visit [www.scouting.org/stem](http://www.scouting.org/stem). Discover how the Nova Awards program helps youth be "*Prepared. For Life.*"

## Boy Scout Nova Pins

*Please use the Advancement Report, No.34403, as documentation for the Nova Award. Submit the Supernova Award Application, below, as instructed in the requirements.*

*Submit any questions regarding the Nova or Supernova awards to [program.content@scouting.org](mailto:program.content@scouting.org)*

### Shoot!

This module is designed to help you explore how science affects your life each day.

1. Choose A or B or C and complete ALL the requirements.
  - A. Watch about three hours total of science-related shows or documentaries that involve projectiles, aviation, weather, astronomy, or space technology. Then do the following:
    1. Make a list of at least five questions or ideas from the show(s) you watched.
    2. Discuss two of the questions or ideas with your counselor.

*Some examples include—but are not limited to—shows found on PBS ("NOVA"), Discovery Channel, Science Channel, National Geographic Channel, TED Talks (online videos), and the History Channel. You may choose to watch a live performance or movie at a planetarium or science museum instead of watching a media production. You may watch online productions with your counselor's approval and under your parent's supervision.*

- B. Read (about three hours total) about projectiles, aviation, space, weather, astronomy, or aviation or space technology. Then do the following:

1. Make a list of at least two questions or ideas from each article.
2. Discuss two of the questions or ideas with your counselor.

*Examples of magazines include—but are not limited to—Odyssey, Popular Mechanics, Popular Science, Science Illustrated, Discover, Air & Space, Popular Astronomy, Astronomy, Science News, Sky & Telescope, Natural History, Robot, Servo, Nuts and Volts, and Scientific American.*

- C. Do a combination of reading and watching (about three hours total). Then do the following:
  1. Make a list of at least two questions or ideas from each article or show.
  2. Discuss two of the questions or ideas with your counselor.
2. Complete ONE merit badge from the following list. (Choose one that you have not already used toward another Nova award.) After completion, discuss with your counselor how the merit badge you earned uses science.

Archery	Aviation	Rifle Shooting	Shotgun Shooting	Weather
Astronomy	Athletics	Robotics	Space Exploration	

3. Choose A or B and complete ALL the requirements.
  - A. Simulations. Find and use a projectile simulation applet on the Internet (with your parent’s or guardian’s permission). Then design and complete a hands-on experiment to demonstrate projectile motion.
    1. Keep a record of the angle, time, and distance.
    2. Graph the results of your experiment. (Note: Using a high-speed camera or video camera may make the graphing easier, as will doing many repetitions using variable heights from which the projectile can be launched.)

### Helpful Links

Be sure you have your parent’s or guardian’s permission before using the Internet. Some of these websites require the use of Java runtime environments. If your computer does not support this program, you may not be able to visit those sites.

- Projectile Motion Applets  
Website: <http://www.mhhe.com/physsci/physical/qiambattista/proj/projectile.html>
- Fowler’s Physics Applets  
Website: [http://galileoandstein.physics.virginia.edu/more\\_stuff/Applets/ProjectileMotion/enapplet.html](http://galileoandstein.physics.virginia.edu/more_stuff/Applets/ProjectileMotion/enapplet.html)
- Java Applets on Physics  
Website: <http://www.walter-fendt.de/ph14e/projectile.htm>

3. Discuss with your counselor:
  - a. What a projectile is
  - b. What projectile motion is
  - c. The factors affecting the path of a projectile
  - d. The difference between forward velocity and acceleration due to gravity
- B. Discover. Explain to your counselor the difference between escape velocity (not the game), orbital velocity, and terminal velocity. Then answer TWO of the following questions. (With your parent’s or guardian’s permission, you may explore websites to find this information.)
  1. Why are satellites usually launched toward the east, and what is a launch window?
  2. What is the average terminal velocity of a skydiver? (What is the fastest you would go if you were to jump out of an airplane?)
  3. How fast does a bullet, baseball, airplane, or rocket have to travel in order to escape Earth’s gravitational field? (What is Earth’s escape velocity?)
4. Choose A or B and complete ALL the requirements.
  - A. Visit an observatory or a flight, aviation, or space museum.
    1. During your visit, talk to a docent or person in charge about a science topic related to the site.
    2. Discuss your visit with your counselor.

- B. Discover the latitude and longitude coordinates of your current position. Then do the following:
  1. 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 [www.heavens-above.com](http://www.heavens-above.com).)
  2. 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. Then discuss your viewing with your counselor.
5. Choose A or B or C and complete ALL the requirements.
  - A. Design and build a catapult that will launch a marshmallow a distance of 4 feet. Then do the following:
    1. Keep track of your experimental data for every attempt. Include the angle of launch and the distance projected.
    2. Make sure you apply the same force every time, perhaps by using a weight to launch the marshmallow. Discuss your design, data, and experiments—both successes and failures - with your counselor.
  - B. Design a pitching machine that will lob a softball into the strike zone. Answer the following questions, then discuss your design, data, and experiments - both successes and failures—with your counselor.
    1. At what angle and velocity will your machine need to eject the softball in order for the ball to travel through the strike zone from the pitcher’s mound?
    2. How much force will you need to apply in order to power the ball to the plate?
    3. If you were to use a power supply for your machine, what power source would you choose and why?
  - C. 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. Do the following, then discuss your design, data, and experiments—both successes and failures—with your counselor.
    1. Keep track of your experimental data for every attempt. Include the vertical angle between the two parts of the chute and the horizontal distance between the two parts of the chute.
    2. Experiment with different starting heights for the marble. How do the starting heights affect the velocity of the marble? How does the starting height affect the jump distance?
6. Discuss with your counselor how science affects your everyday life.

### Start Your Engines!

This module is designed to help you explore how technology affects your life each day.

1. Choose A or B or C and complete ALL the requirements.
  - A. Watch about three hours total of technology-related shows or documentaries that involves transportation or transportation technology. Then do the following:
    1. Make a list of at least two questions or ideas from each show.
    2. Discuss two of the questions or ideas with your counselor.

*Some examples include—but are not limited to—shows found on PBS ("NOVA"), Discovery Channel, Science Channel, National Geographic Channel, TED Talks (online videos), and the History Channel. You may choose to watch a live performance or movie at a planetarium or science museum instead of watching a media production. You may watch online productions with your counselor’s approval and under your parent’s supervision.*

- B. Read (about three hours total) about transportation or transportation technology. Then do the following:
  1. Make a list of at least two questions or ideas from each article.
  2. Discuss two of the questions or ideas with your counselor.

*Examples of magazines include—but are not limited to—Odyssey, Popular Mechanics, Popular Science, Science Illustrated, Discover, Air & Space, Popular Astronomy, Astronomy, Science News, Sky & Telescope, Natural History, Robot, Servo, Nuts and Volts, and Scientific American.*

- C. Do a combination of reading and watching (about three hours total). Then do the following:
  1. Make a list of at least two questions or ideas from each article or show.
  2. Discuss two of the questions or ideas with your counselor.

2. Complete ONE merit badge from the following list. (Choose one that you have not already used toward another Nova award.) After completion, discuss with your counselor how the merit badge you earned uses technology.

Automotive Maintenance	Drafting	Motorboating	Space Exploration
Aviation	Electricity	Nuclear Science	Truck Transportation
Canoeing	Energy	Railroading	
Cycling	Farm Mechanics	Small - Boat Sailing	

3. Do ALL of the following.
- Using the requirements from the above list of merit badges:
    - Tell your counselor the energy source(s) used in these merit badges.
    - Discuss the pros and cons of each energy source with your counselor.
  - Make a list of sources of energy that may be possible to use in transportation.
  - With your counselor:
    - Discuss alternative sources of energy.
    - Discuss the pros and cons of using alternative energy sources.
4. Design and build a working model vehicle (not from a kit).
- Make drawings and specifications of your model vehicle before you begin to build.
  - Include one of the following energy sources to power your vehicle (do not use gasoline or other combustible fuel source): solar power, wind power, or battery power.
  - Test your model. Then answer the following questions:
    - How well did it perform?
    - Did it move as well as you thought it would?
    - Did you encounter problems? How can these problems be corrected?
  - Discuss with your counselor:
    - Any difficulties you encountered in designing and building your model
    - Why you chose a particular energy source
    - Whether your model met your specifications
    - How you would modify your design to make it better
5. Discuss with your counselor how technology affects your everyday life.

### Whoosh!

This module is designed to help you explore how engineering affects your life each day.

- Choose A or B or C and complete ALL the requirements.
  - Watch about three hours total of engineering-related shows or documentaries that involve motion or motion-inspired technology. Then do the following:
    - Make a list of at least five questions or ideas from the show(s) you watched.
    - Discuss two of the questions or ideas with your counselor.

*Some examples include—but are not limited to—shows found on PBS ("NOVA"), Discovery Channel, Science Channel, National Geographic Channel, TED Talks (online videos), and the History Channel. You may choose to watch a live performance or movie at a planetarium or science museum instead of watching a media production. You may watch online productions with your counselor's approval and under your parent's supervision. One example is the NOVA Lever an Obelisk page on ancient Egypt and the use of levers, available at [www.pbs.org/wgbh/nova/egypt/raising/lever.html](http://www.pbs.org/wgbh/nova/egypt/raising/lever.html) Examples of magazines include—but are not limited to—Odyssey, Popular Mechanics, Popular Science, Science Illustrated, Discover, Air & Space, Popular Astronomy, Astronomy, Science News, Sky & Telescope, Natural History, Robot, Servo, Nuts and Volts, and Scientific American.*

- Read (about three hours total) about motion or motion-inspired technology. Then do the following:
  - Make a list of at least two questions or ideas from each article.
  - Discuss two of the questions or ideas with your counselor.
- Do a combination of reading and watching (about three hours total). Then do the following:
  - Make a list of at least two questions or ideas from each article or show.

2. Discuss two of the questions or ideas with your counselor.
2. Choose ONE merit badge from the following list. (Choose one you have not already used for another Nova award.) After completion, discuss with your counselor how the merit badge you earned uses engineering.

Archery	Drafting	Inventing	Rifle Shooting
Aviation	Electronics	Model Design and Building	Robotics
Composite Materials	Engineering	Railroading	Shotgun Shooting

3. Do ALL of the following:
  - A. Make a list or drawing of the six simple machines.
  - B. Be able to tell your counselor the name of each machine and how each machine works.

#### Helpful Link

"Six Simple Machines": *ConstructionKnowledge.net*. Website:

[http://www.constructionknowledge.net/general\\_technical\\_knowledge/general\\_tech\\_basic\\_six\\_simple\\_machines.php](http://www.constructionknowledge.net/general_technical_knowledge/general_tech_basic_six_simple_machines.php)

- C. Discuss the following with your counselor:
  1. The simple machines that were involved with the motion in your chosen merit badge (Hint: Look at the moving parts of an engine to find simple machines.)
  2. The energy source causing the motion for the subject of your merit badge
  3. What you learned about motion from earning your merit badge
4. Choose A or B and complete ALL the requirements.
  - A. Visit an amusement park. Then discuss the following with your counselor:
    1. The simple machines present in at least two of the rides
    2. The forces involved in the motion of any two rides
  - B. Visit a playground. Then discuss the following with your counselor:
    1. The simple machines present in the playground equipment
    2. The forces involved in the motion of any two playground fixtures
5. Do the following:
  - A. On your own, design one of the following and include a drawing or sketch: an amusement park ride OR a playground fixture OR a method of transportation.
  - B. Discuss with your counselor:
    1. The simple machines present in your design
    2. The energy source powering the motion of your creation
6. Discuss with your counselor how engineering affects your everyday life.

#### Designed to Crunch

This module is designed to help you explore how math affects your life each day.

1. Choose A or B or C or D and complete ALL the requirements.
  - A. Watch about three hours total math-related shows or documentaries that involve scientific models and modeling, physics, sports equipment design, bridge building, or cryptography. Then do the following:
    1. Make a list of at least five questions or ideas from the show(s) you watched.
    2. Discuss two of the questions or ideas with your counselor

*Some examples include—but are not limited to—shows found on PBS ("NOVA"), Discovery Channel, Science Channel, National Geographic Channel, TED Talks (online videos), and the History Channel. You may choose to watch a live performance or movie at a planetarium or science museum instead of watching a media production. You may watch online productions with your counselor's approval and under your parent's supervision.*

- B. Research (about three hours total) several websites (with your parent’s or guardian’s permission) that discuss and explain cryptography or the discoveries of people who worked extensively with cryptography. Then do the following:
1. List and record the URLs of the websites you visited and the major topics covered on the websites you visited. (You may use the copy and paste function—eliminate the words—if you include your sources.)
  2. Discuss with your counselor how cryptography is used in the military and in everyday life and how a cryptographer uses mathematics.

**Helpful Link**

"The Mathematics of Cryptology": University of Massachusetts  
 Website: <http://www.math.umass.edu/~qunnells/talks/crypt.pdf>

- C. Read at least three articles (about three hours total) about physics, math, modeling, or cryptography. You may wish to read about how technology and engineering are changing sports equipment, how and why triangles are used in construction, bridge building, engineering, climate and/or weather models, how banks keep information secure, or about the stock market. Then do the following:
1. Make a list of at least two questions or ideas from each article.
  2. Discuss two of the questions or ideas with your counselor.

*Examples of magazines include—but are not limited to—Odyssey, Popular Mechanics, Popular Science, Science Illustrated, Discover, Air & Space, Popular Astronomy, Astronomy, Science News, Sky & Telescope, Natural History, Robot, Servo, Nuts and Volts, and Scientific American.*

- D. Do a combination of reading, watching, or researching (about three hours total). Then do the following:
1. Make a list of at least two questions or ideas from each article, website, or show.
  2. Discuss two of the questions or questions with your counselor.
2. Complete ONE merit badge from the following list. (Choose one that you have not already used toward another Nova award.) After completion, discuss with your counselor how the merit badge you earned uses mathematics.

American Business	Drafting	Personal Management	Weather
Chess	Entrepreneurship	Radio	
Computers	Orienteering	Surveying	

3. Choose TWO from A or B or C or D or E and complete ALL the requirements. (Write down your data and calculations to support your explanation to your counselor. You may use a spreadsheet. Do not use someone else’s data or calculations.)
- A. Calculate your horsepower when you run up a flight of stairs.

**Helpful Links**

"How to Calculate Your Horsepower": wikiHow Website: <http://www.wikihow.com/Calculate-Your-Horsepower>  
 Haplosciences.net Website: <http://onlinephys.com/labpower1.html>

1. How does your horsepower compare to the power of a horse?
2. How does your horsepower compare to the horsepower of your favorite car?

Share your calculations with your counselor, and discuss what you learned about horsepower.

- B. Attend at least two track, cross-country, or swim meets.
1. For each meet, time at least three racers. (Time the same racers at each meet.)
  2. Calculate the average speed of the racers you timed. (Make sure you write down your data and calculations.)

3. Compare the average speeds of your racers to each other, to the official time, and to their times at the two meets you attended.

Share your calculations with your counselor, and discuss your conclusions about the racers' strengths and weaknesses.

- C. Attend a soccer, baseball, softball, or basketball game. Choose two players and keep track of their efforts during the game. (Make sure you write down your data and calculations.) Calculate their statistics using the following as examples:
  1. Soccer—Goals, assists, corner kicks, keeper saves, fouls, off sides
  2. Baseball or softball—Batting average, runs batted in, fielding statistics, pitching statistics
  3. Basketball—Points, baskets attempted, rebounds, steals, turnovers, and blocked shots

Share your calculations with your counselor, and discuss your conclusions about the players' strengths and weaknesses.

- D. Attend a football game or watch one on TV. (This is a fun activity to do with a parent or friend! ) Keep track of the efforts of your favorite team during the game. (Make sure you write down your data and calculations.) Calculate your team's statistics using the following as examples:
  1. Kicks/punts
    - a. Kickoff—Kick return yards
    - b. Punt—Number, yards
    - c. Field goals—Attempted, percent completed, yards
    - d. Extra point—Attempted, percent completed
  2. Offense
    - a. Number of first downs
    - b. Forward passes—Attempted, percent completed, total length of passes, longest pass, number and length of passes caught by each receiver, yardage gained by each receiver after catching a pass
    - c. Running plays—Number, yards gained or lost for each run, longest run from scrimmage line, total yards gained or lost, and number of touchdowns
  3. Defense—Number of quarterback sacks, interceptions turnovers, and safeties

Share your calculations with your counselor, and discuss your conclusions about your team's strengths and weaknesses.

- E. How starry are your nights? Participate in a star count to find out. This may be done alone but is more fun with a group. Afterward, share your results with your counselor.
  1. Visit the website of the Astronomical Society of the Pacific at <http://www.astrosociety.org/education/hands-on-astronomy-activities/> for instructions on performing a star count.
  2. Do a star count on five clear nights at the same time each night.
4. Do ALL of the following.
  - A. Investigate your calculator and explore the different functions.
  - B. Discuss the functions, abilities, and limitations of your calculator with your counselor. Talk about how these affect what you can and cannot do with a calculator. (See your counselor for some ideas to consider.)
5. Discuss with your counselor how math affects your everyday life.

### **Dr. Bernard Harris Supernova Award**

1. Complete any three of the Boy Scout Nova awards. (Note: These may be done at any time after becoming a Boy Scout.)
2. Earn the Scholarship merit badge.
3. Earn four of the Supernova approved merit badges from the above list. (Note: These may be earned at any time after becoming a Boy Scout.)
4. Complete TWO Supernova activity topics, one each in two different STEM areas.

A Supernova activity topic is a two-part, hands-on, high-level activity related to one of the STEM fields. Part 1 involves research, preparation, set up, coordination, and/or organization. Part 2 involves analysis and reflection, culminating in the creation of a report in any one of the available format options. See the "Supernova Activity Topics" chapter.

5. Participate in a local, state, or national science fair or mathematics competition OR in any equally challenging STEM-oriented competition or workshop approved by your mentor. An example of this would be an X-Prize type competition.
6. Do ONE of the following:
  - A. With your parent's permission and your mentor's approval, spend at least one day "shadowing" a local scientist or engineer and report on your experience and what you learned about STEM careers to your mentor.
  - B. Learn about a career that is heavily involved with STEM. Make a presentation to your mentor about what you learned.
7. Working with your mentor, organize and present a Nova award or other STEM-related program to a Cub Scout den or pack meeting. Be sure to receive approval from the appropriate unit leader and agree on a time and place for the presentation. If a Cub Scout den or pack is not available, your presentation may be given to another youth group, such as your troop or at your place of worship.
8. Review the scientific method (you may know this as the scientific process) and note how scientists establish hypotheses, theories, and laws. Compare how the establishment of "facts" or "rules" using the scientific method differs from the establishment of "facts" or "rules" in other environments, such as legal, cultural, religious, military, mathematical, or social environments. Then do the following:
  - A. Choose a modern scientific subject with at least two competing theories on the subject and learn as much as possible about each theory.
  - B. Analyze the competing theories, decide which one is most convincing to you, and explain why to your mentor.
  - C. Make a presentation to your mentor that describes the controversy, the competing theories, and your conclusions about how the scientific method can or cannot contribute to the resolution of the controversy.
9. Submit a [Supernova award application](#) to the district or council Nova or advancement committee for approval. See the "Supernova Activity Topics" chapter for more information about activity topics.

## Thomas Edison Supernova Award

1. Earn the Dr. Bernard Harris Supernova Award.
2. Complete ONE additional Boy Scout Nova award for a total of four. (Note: This may be done at any time after becoming a Boy Scout.)
3. Earn FOUR additional Supernova-approved merit badges from the list provided, other than the four earned while working on the Harris Supernova Award for a total of eight. (Note: These may be earned at any time after becoming a Boy Scout.)
4. Complete TWO additional Supernova activity topics, one each in the two STEM areas NOT completed for the Harris Supernova Award. (Note: The intent is that upon completion of the Edison Supernova Award the Scout will have completed one Supernova activity topic in each of the four STEM areas.)
5. Participate in a local, state, or national science fair or mathematics competition OR any other equally challenging STEM-oriented competition or workshop approved by your mentor. An example of this would be an X-Prize type competition. (**Note:** The intent is that upon completion of the Edison Supernova Award, the Scout will have participated in two such events.)
6. Working with your mentor, organize and present a Nova award or other STEM-related program to a Cub Scout den or pack meeting. Be sure to receive approval from the appropriate unit leader. If a Cub Scout den or pack is not available, your presentation may be given to another youth group, such as your troop or at your place of worship. (**Note:** The intent is that upon completion of the Edison Supernova Award the Scout will have completed two such presentations.)
7. Research a scientific, technical, engineering, or mathematical breakthrough or invention of the past 100 years that has affected our society in a meaningful way and present your hypothesis on how it might further affect our society during your lifetime. Present either a 30-minute oral report or a 1,500-word written report to your mentor.
8. Submit an [application](#)  to the district or council Nova or advancement committee for approval.