Nova - Up and Away

Vincent Meunier

Dec 30, 2020

CONTENTS:

CHAPTER

ONE

WELCOME TO *UP AND AWAY*

This Nova Award explores the world of fluid dynamics, and how it affects your everyday life. Fluid dynamics is the study of how fluids (liquids, gases, and plasmas) behave and interact with other materials.

Note: What is fluid dynamics?

The very informative site kids.kiddle.co offers a great introduction to what *fluid dynamics is*. The authors of that website provide the following definition:

Fluid Dynamics talks about how fluids (liquids and gases) work. It is one of the oldest parts of the study of Physics, and is studied by physicists, mathematicians, and engineers. Mathematics can describe how fluids move using mathematical formulas called equations. The fluid dynamics of gases are called *aerodynamics*.

Fig. 1: Calculated flow around an airfoil. The fluid moves according to specific equations of physics, such as Bernoulli's theorem, Navier-Stokes equations, and Poiseuille's equation (this image was downloaded from kids.kiddle.co).

Understanding how fluids behave helps us understand things like flight or ocean currents. For example, fluid dynamics can be used to understand weather, because clouds and air are both fluids. Fluid dynamics can also be used to understand how aeroplanes fly through the air or how ships and submarines move through water.

Warning: When completing this Award both the youth and involved adult leaders must obey all rules of Safe Scouting. This includes (1) Completing Cyber Chip training prior to starting this activity and (2) **ALWAYS** involve at least 2 adults in all your communications with a leader, including online. If you send an email to your counselor, always add the address of another adult leader or a parent/guardian. Never reply to a message sent by an adult leader unless another adult has been copied on the email. Report any issue to your parents/guardians!

1.1 Instructions

1. Identify a **Nova Counselor** either within your unit, district, or council.
2. This site provides you a platform for learning and you can easily follow all requirements using the navigation menu on the left.
3. Once you have identified a Counselor, you can start working on requirements.
4. The most important aspect in any scientific endeavor is to **properly document progress**. This will be done, here, using a google sheet as described in more details below.

1.2 Documenting your progress

0. You can use the template below to report completion. To work on this Nova Award, you can also use a detailed worksheet provided by the BSA. Click here to have access. The file below is used to record approval.
1. A template worksheet can be found here. This is a *Google document*. **You will not be able to modify it until you make your own copy as I will now describe for you.**
2. Once you have opened the file on google doc, go to `File` → `Make a Copy`.
3. Save the file with the following name: *Nova_designed_to_crunch_FIRSTNAME_LASTNAME*
4. You will use that file to enter your progress and share with your counselor.
5. **You can share your own copy of the worksheet with your counselor using the following procedure.**
    a) Click on the SHARE button on the top-right.
    b) Click on "get link".
    c) Send the link to your counselor.

Note: This document provides you a guide to complete the Nova award! All requirements are marked with the following symbol: $\boxed{\mathbb{REQ} \rightsquigarrow}$. In addition, a number of fun *Additional Challenges* are provided in boxes for your entertainment.

1.3 If you have any question

Contact your counselor or your scoutmaster! If you have questions about the program, contact Vincent Meunier by email (as usual, make sure you copy an additional adult to all your communications with a leader!).

CHAPTER

TWO

REQUIREMENT #1: RESEARCH AND READING

$\boxed{\mathbb{REQ} \rightsquigarrow}$ Choose A or B or C and complete ALL the requirements.

A. Watch not less than three hours total of shows or documentaries that discuss fluid dynamics or a show related to fluid dynamics. 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 with or ideas with your counselor.

Tip: Some examples of shows to watch include—but are not limited to—The STEM of Indoor Skydiving; documentaries produced by PBS (such as "NOVA"), the Discovery Channel, Science Channel, National Geographic Channel, and the History Channel; or lectures or presentations focused on science, technology, engineering, or math (such as TED Talks www.ted.com) using some search terms you might think such as "fluid dynamics for kids" or "the science of skydiving for kids." You may watch online productions with your counselor's approval and under your parent's or guardian's supervision. You may choose to watch a live performance or movie at a planetarium or science museum instead of watching a media production.

B. Read not less than three hours total about a topic related to fluid dynamics. Then do the following:

   (1) Make a list of at least five questions or ideas from the article(s) you read.

   (2) Discuss two of the questions with or ideas with your counselor.

Tip: 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, Robot, Servo, Nuts and Volts, and Scientific American.

C. Do a combination of reading and watching (not less than three hours total). Then do the following:

   (1) Make a list of at least five questions or ideas from each article or show.

   (2) Discuss two of the questions with or ideas with your counselor.

Note: Andrew Jackson Council compiled a number of links to YouTube videos as references to complete this activity.

#1: Indoor Skydiving: Human Flight, No Plane Required:

#2: Indoor Skydiving: virtual reality

#3: The Physics of Skydiving

#4: A brief history of Skydiving

#5: Bill Nye the Science Guy on Fluids

#6: Science Max: hydraulics

#7: What goes up must go down

Attention: Once you have completed this requirement, make sure you document it in your worksheet!

CHAPTER

THREE

REQUIREMENT #2: MERIT BADGE

ℝ𝔼ℚ ⇝ Complete ONE merit badge from the following list. (Choose one that you have not already used for another Nova award.) After completion, discuss with your counselor how it relates to fluid dynamics.

- Aviation
- Canoeing
- Chemistry
- Kayaking
- Oceanography
- Plumbing
- Rowing
- Scuba Diving
- Swimming

Attention: Once you have completed this requirement, make sure you document it in your worksheet!

CHAPTER

FOUR

REQUIREMENT #3: TERMINAL VELOCITY

Note: What is terminal velocity?

Terminal velocity is the maximum velocity attainable by an object as it falls through a fluid (such as air). It is one important illustration of the principles of fluid dynamics.

Note: How does a parachute work?

Parachutes make clever use of air resistance. Though it's invisible, air is composed of gas molecules and as you move around, they're pushed aside. This allows the open parachute to create more air resistance and to drift toward the ground slowly and safely.

Note: How does a drone work? Drones are a headline-making piece of technology, capable of capturing incredible video in the hands of skilled pilots and providing some serious internet entertainment when a dog mistakes one for a frisbee.

Fig. 1: Image of a drone obtained from this website.

As explained by ctia.org (check it out!), a drone relies on rotors for its vertical motion. Drones use their rotors—which consist of a propeller attached to a motor—to hover, meaning the downward thrust of the drone is equal to the gravitational pull working against it; climb, when pilots increase the speed until the rotors produce an upward force greater than gravity; and descend, when pilots perform the opposite and decrease speed.

Check also this website for more information on drones and this website, that explains the physics behind flying!

$\boxed{\mathbb{REQ} \rightsquigarrow}$ Complete two activities from A or B or C or D. Complete all of the items under each activity.

A. Conduct a Terminal Velocity Investigation.

   1. With your counselor, fill an empty tennis ball tube, or other clear plastic tube at least 12" tall, with clear corn syrup.
   2. Drop two round objects with the same diameter but different masses into the syrup (example: a steel ball and a glass marble).
   3. Note when the two balls reach terminal velocity (it should happen quickly). Did both objects have the same terminal velocity? Try the experiment again to see if it's repeatable.
   4. Discuss your investigation and findings with your counselor.

B. Calculate your terminal velocity on different planets.

   1. Download this worksheet or use a similar worksheet such as the Student Terminal Velocity Worksheet. Calculate the terminal velocity of a 100-pound backpack on the planet earth.
   2. Calculate your terminal velocity on Mars (hint: you will need to look up the values of gravity and atmospheric density on Mars). Compare the two values.
   3. Discuss the differences with your counselor. How would the conditions on Mars affect the engineering design of a Martian landing craft?

C. Deliver rescue supplies to a community whose roads and bridges have been compromised by a natural disaster.

   1. Use lightweight recycled materials or snap-together building blocks to construct a Platform (or some shape with weight and mass) to carry the supplies. Once you build the "platform," add "supplies" that represent food, water, medicine, etc. and a way to attach a parachute to deliver it to the community from a plane flying overhead.
   2. Use common household materials, such as trash bags, plastic tablecloth, string, paperclips, rubber bands, etc. to design a parachute that will safely deliver your "supplies" to the "community square" (when dropped from the top of a tall structure, such as a playground playscape). The platform must land upright and intact so the supplies are not damaged.
   3. Design your parachute first on paper, then create a prototype and test it.
   4. Record how long it took to land and the condition of the delivered supplies.
   5. What could you do to slow the descent even further? Modify your design and test it out again. Record the results then modify and test again.
   6. Conduct a final test (at least three tests total) and record your best (slowest) time.
   7. Show your parachute to your counselor and explain how you designed and modified it. Talk about how the actual conditions of a rescue mission (flooding, few flat surfaces, downed trees, live wires, high winds, single chance to deliver) would affect a real-world drop of rescue supplies.

D. Test out different air foils

   1. Construct simple airfoil shapes using sheets of plain paper secured with tape.
   2. Make a "testing apparatus" that allows the airfoil to move freely in the vertical direction using drinking straws and skewers.
   3. Using a fan or hair dryer, direct a flow of fast-moving air across the airfoil and observe how high it lifts off from the testing apparatus. Use a ruler marked with centimeters to measure results. Repeat changing the test parameters, e.g., how fast the air flows, the direction of the air flow, etc.

4. Research the Bernoulli Effect and have a discussion about how this phenomenon applies to your observations of the airfoils.
5. Discuss the results with your counselor.

Tip: Bernoulli Equation

You can get a much better understanding of fluid dynamics if you understand the basic concepts embodied by Bernoulli's theorem. The videos below provide a very nice introduction to the problem. If you are looking for a more detailed explanation, skip to the second and third videos! (note: there are many more videos available out there!)

Main principle: Faster fluid means lower pressure and slower fluid means higher pressure!

More advanced descriptions:

Attention: Once you have completed this requirement, make sure you document it in your worksheet!

CHAPTER

FIVE

REQUIREMENT #4: VISIT

Note: Virtual museum visits

Many museums are offering virtual visits. For example, the Smithsonian *National Air and Space Museum* has a very nice collection of online material. Check it out here.

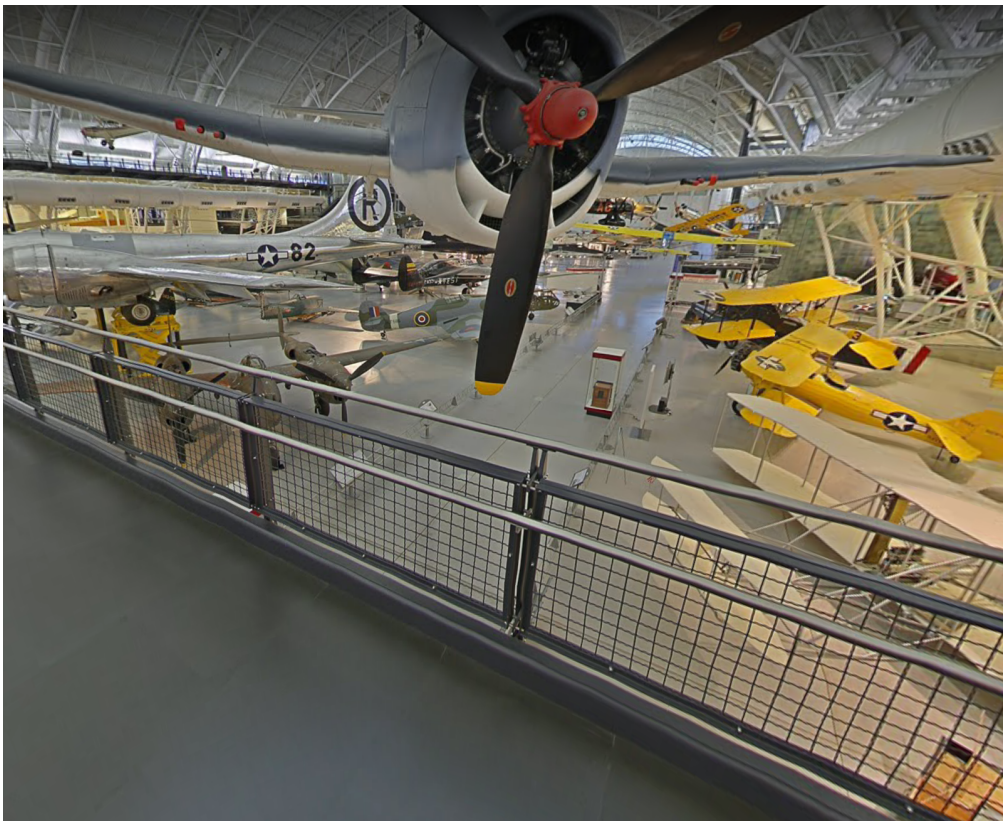
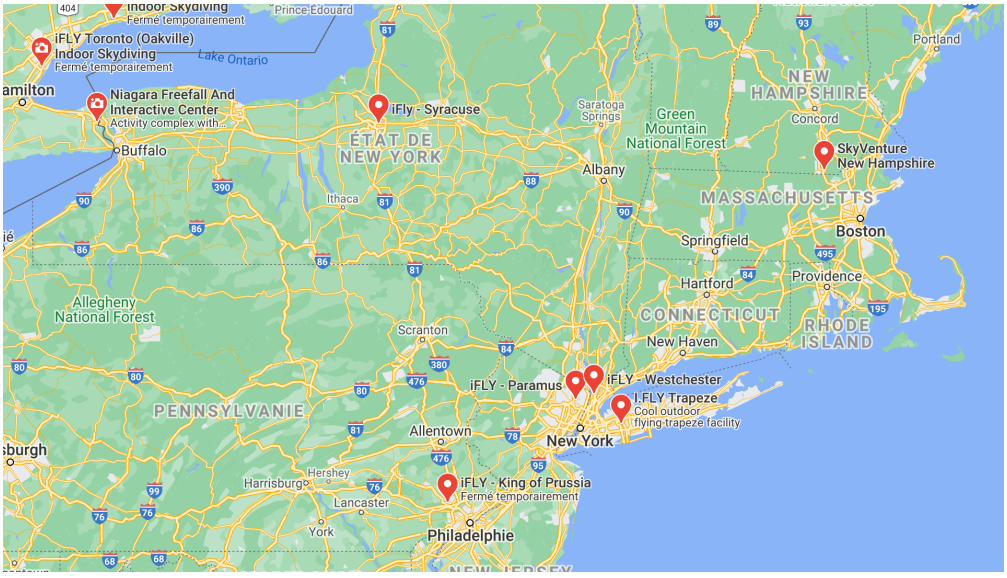


Fig. 1: A google street view of the Smithsonian *National Air and Space Museum*.

$\boxed{\mathbb{REQ} \rightsquigarrow}$ Complete one of the following A or B or C.

A. Visit an iFLY Indoor Skydiving wind tunnel facility or other BSA approved indoor skydiving wind tunnel and participate in a STEM Education program. Discuss the STEM concepts related to the tunnel with your counselor.

Tip: A list of iFly centers in the North East (according to google map).



B. Visit an observatory, research facility, or a museum that highlights flight, aviation, or space. During your visit, talk to a docent or staff member about flight and fluid dynamics concepts covered at the site. Discuss what you learned with your counselor.

Tip: You can find a list of some US museums at the bottom of this page!

C. Take a real or online tour of a wind tunnel facility. A real tour may be obtained by contacting a local university that offers a degree in aerospace engineering or similar field.

Tip: A vitual Wind Tunnel: the physical facility is replaced by a computational (or virtual one).

Developing military aircraft in a wind tunnel

Note: Best Aviation Museums in the Country

According to this website, here are some of the best aviation museums to visit in the U.S.

1. EAA AirVenture Museum — Oshkosh, Wisconsin
2. Smithsonian National Air and Space Museum — Washington, D.C., and Chantilly, Virginia
3. The National Museum of the United States Air Force — Dayton, Ohio
4. National Naval Aviation Museum — Pensacola, Florida
5. Aerospace Discovery at Florida Air Museum — Lakeland, Florida
6. Wings Over the Rockies Air & Space Museum — Denver, Colorado
7. Southern Museum of Flight — Birmingham, Alabama
8. Air Zoo — Portage, Michigan
9. The Museum of Flight — Seattle, Washington
10. Evergreen Aviation Museum — McMinnville, Oregon

11. Intrepid Sea, Air & Space Museum — New York, New York
12. Virginia Air and Space Center — Hampton, Virginia
13. Wings of Eagles Discovery Center — Horseheads, New York

Attention: Once you have completed this requirement, make sure you document it in your worksheet!

CHAPTER

SIX

REQUIREMENT #5: FLUID DYNAMICS @ LIFE

$\boxed{\mathbb{REQ} \rightsquigarrow}$ Discuss with your counselor how fluid dynamics is present in your everyday life and what you learned by working on this Nova.

Note: How do planes fly?

Fluid Dynamics and Art

According to this site (where this information was obtained), "Starry Night interactive animation" shown below in a YouTube video aims to provide an immersive interpretation of Van Gogh's original masterpiece; the iconic flows of original painting come to life, in a hypnotic animation. The viewer is further engaged by interacting with the painting; almost infinite variations can occur, as the flows are driven by his hand. The background ambient music is also responsive, making the experience even more intense.

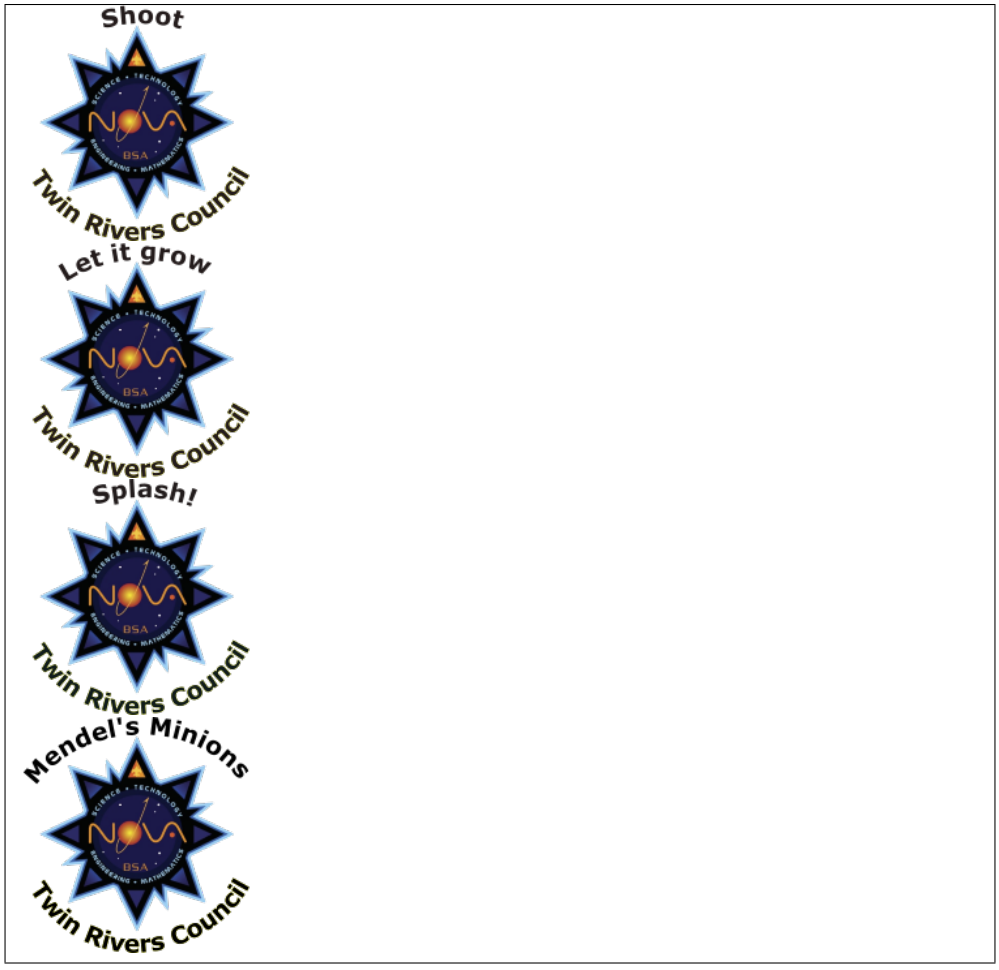
Attention: Once you have completed this requirement, make sure you document it in your worksheet!

CHAPTER

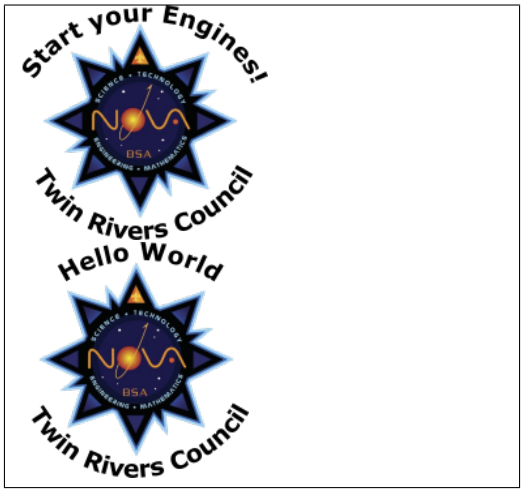
SEVEN

OTHER NOVA MODULES IN THIS SERIES

Science



Technology



Engineering

Math


Designed to crunch
Twin Rivers Council
BSA

CHAPTER

EIGHT

ABOUT THE AUTHOR

These pages were written by Vincent Meunier, the Chair of the STEM committee of Twin Rivers Council in New York State.

Vincent Meunier is a Professor of physics at Rensselaer Polytechnic Institute. If you have any questions, feel free to contact him by email.

Note: Most of the material used here was obtained from a number of external scouting sources, including scouting.org

Note: The Wright Brothers

The Wright brothers—Orville (August 19, 1871 – January 30, 1948) and Wilbur (April 16, 1867 – May 30, 1912)—were two American aviation pioneers generally credited with inventing, building, and flying the world's first successful motor-operated airplane. They made the first controlled, sustained flight of a powered, heavier-than-air aircraft with the Wright Flyer on December 17, 1903, 4 mi (6 km) south of Kitty Hawk, North Carolina. The Wright brothers were also the first to invent aircraft controls that made fixed-wing powered flight possible (Text adapted from wikipedia).

Fig. 1: First flight of the Wright Flyer, December 17, 1903, Orville piloting, Wilbur running at wingtip. Image copied from wikipedia.

If you travel to North Carolina, along the Atlantic shorelines, spend a few hours at the terrific museum, managed by the US National Park Service. As the website reminds the visitors: *They Taught the World to Fly!*