FIRST®
LEGO®
LEAGUE

2017/2018
Challenge Guide

HYDRO
DYNAMICS℠

FIRST®
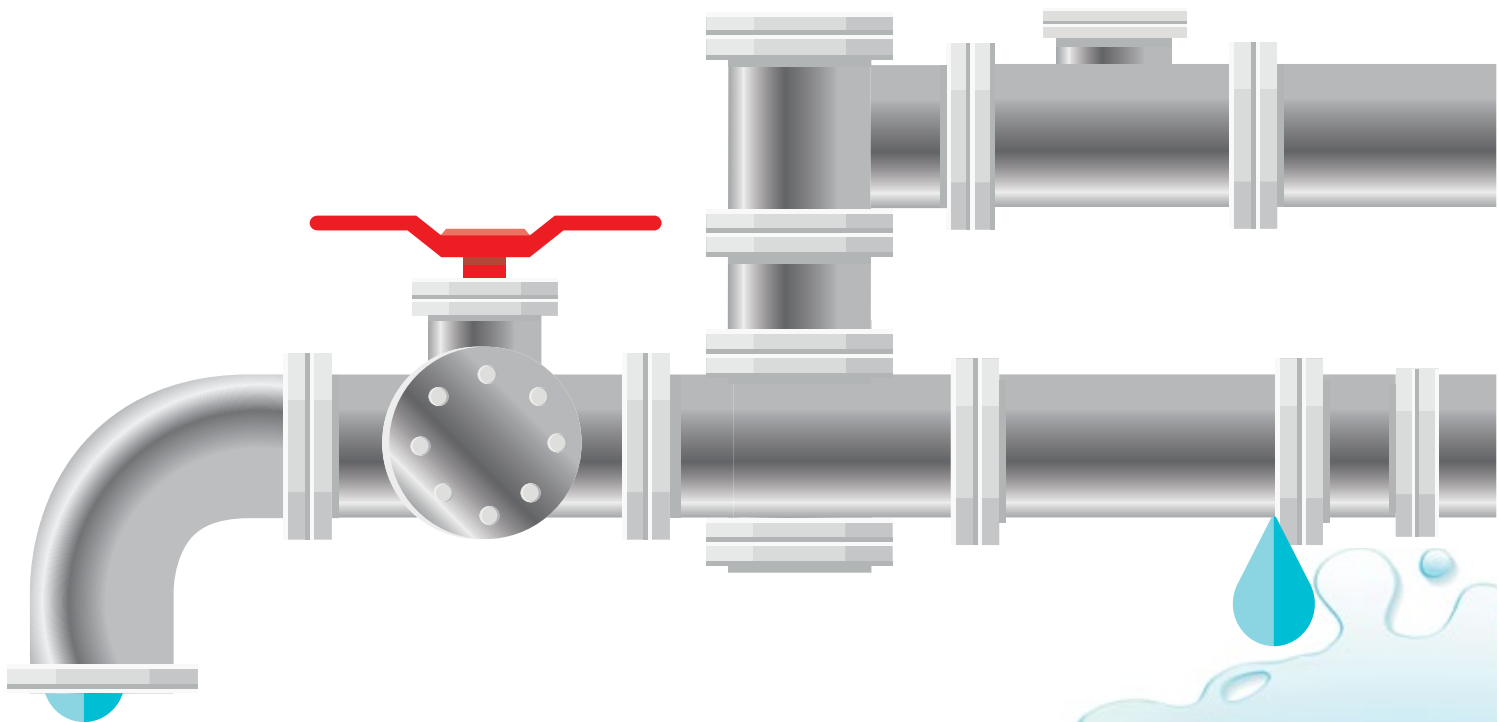
LEGO education
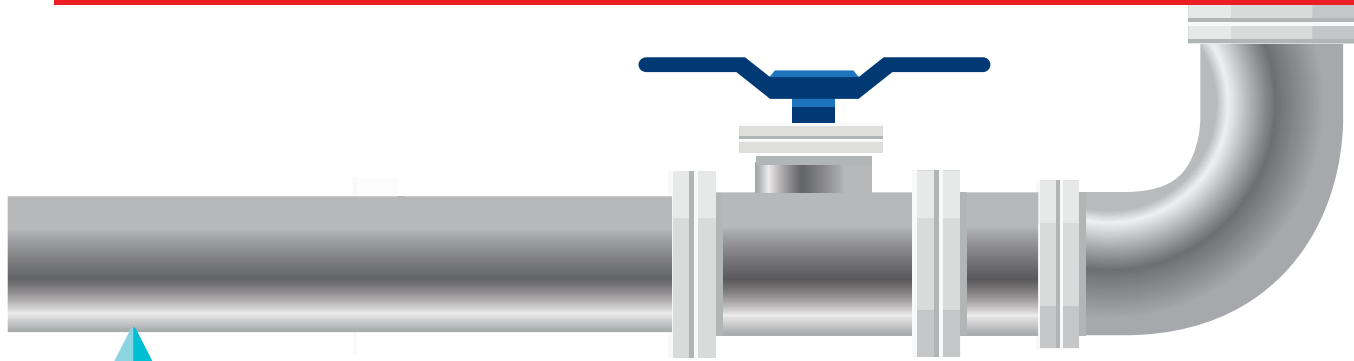
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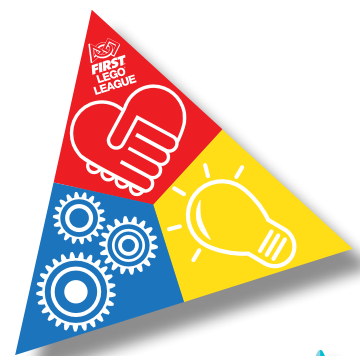
New to *FIRST*® LEGO® League?
This Challenge Guide provides season-specific resources to help you work with your team on this year's Challenge. For a complete step-by-step guide to the season and a helpful selection of strategy worksheets, check out the *FIRST* Steps modules:
http://info.firstinspires.org/fllfirststepsrequest

The Core Values

The Core Values are the heart of *FIRST*® LEGO® League. By embracing the Core Values, participants learn that friendly competition and mutual gain are not separate goals, and that helping one another is the foundation of teamwork. Review the Core Values with your team and discuss them whenever they are needed.

- We are a team.
- We do the work to find solutions with guidance from our coaches and mentors.
- We know our coaches and mentors don't have all the answers; we learn together.
- We honor the spirit of friendly competition.
- What we discover is more important than what we win.
- We share our experiences with others.
- We display *Gracious Professionalism*® *and Coopertition*® in everything we do.
- We have FUN!

The Core Values Poster

The Core Values poster is designed to help the Core Values Judges at your tournament learn more about your team and its unique story.
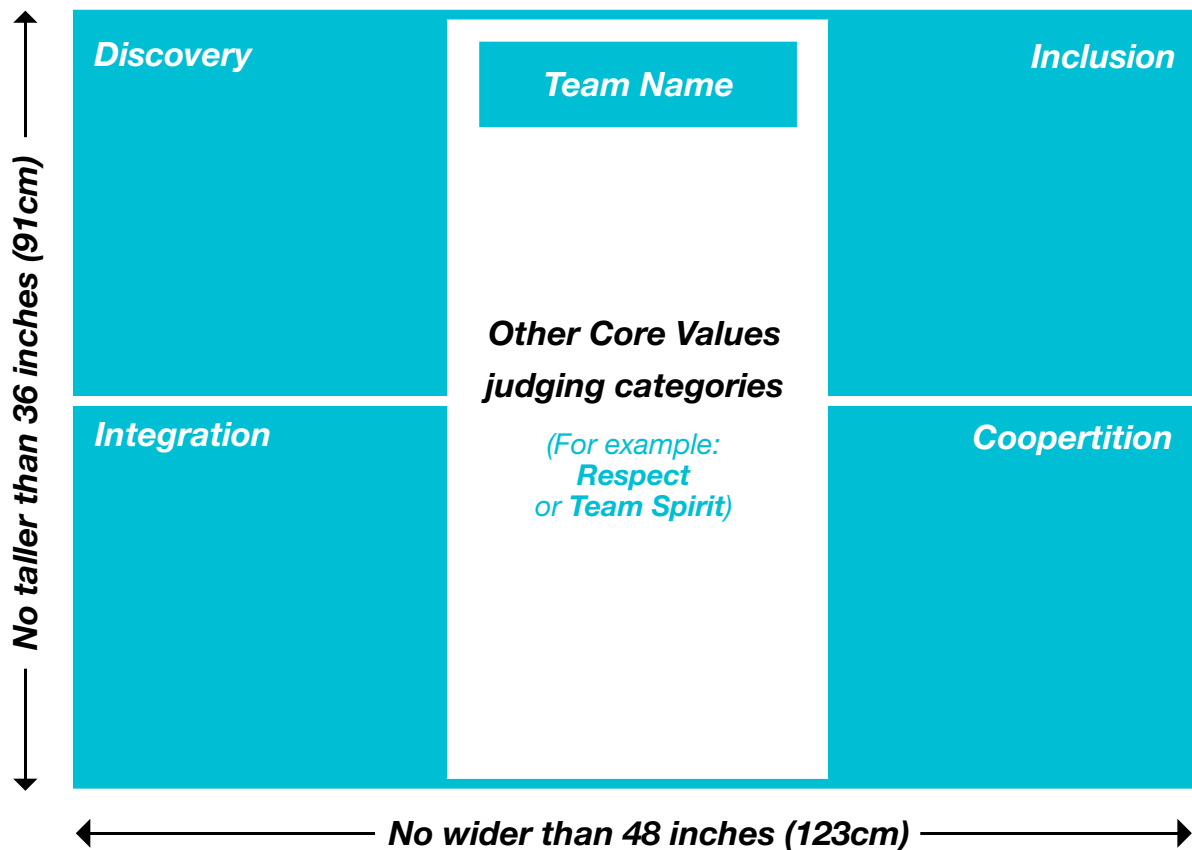
Follow these steps with your team to create a Core Values poster:

1. Discuss ways your team used the Core Values this season – both in team meetings and in other parts of life. Make a list of examples.

2. Ask your team to select examples that highlight the specific Core Values areas below. These are typically the most challenging categories for Judges to explore during judging sessions. The poster can help your team present their successes in an organized format.

   a. *Discovery:* Provide examples from the season about things your team discovered that were not focused on gaining an advantage in the competition or winning an award. Tell the Judges how the team balanced all three parts of *FIRST* LEGO League (Core Values, Project and Robot Game), especially if they were really excited about one part.

   b. *Integration:* Provide examples of how your team applied the Core Values and other things you learned through *FIRST* LEGO League to situations outside of team activities. Let the Judges know how team members integrated new ideas, skills and abilities into their everyday life.

   c. *Inclusion:* Describe how your team listened to and considered ideas from everyone and made each team member feel like a valued part of the team. Share with the Judges how they accomplished more by working together than any team member could have done alone.

Some regions require all teams to prepare a Core Values poster, while others do not. Either way, the poster is a great tool to help your team think about how they implement the Core Values in team meetings and elsewhere. Check with your tournament organizer to see if your team is expected to bring a Core Values poster into the Core Values judging session.

d. **Coopertition:** Describe how your team honors the spirit of friendly competition. Include information about how your team provided assistance to and/or received assistance from other teams. Share with the Judges how your team members help each other, and help other teams to prepare for a potentially stressful competition experience.

e. **Other:** Use the middle of the poster to highlight anything else your team would like to share with the Judges about the remaining Core Values criteria. Maybe consider sharing examples of Team Spirit, Respect, or Teamwork.

3. Have your team create their Core Values poster using the format below. The overall size of the poster should be no more than the measurements shown, and it may be smaller, especially if required for travel needs. The poster may be rolled or assembled on site.

No taller than 36 inches (91cm)

Discovery		Inclusion
	Team Name	
	Other Core Values judging categories *(For example:* **Respect** *or* **Team Spirit***)*	
Integration		Coopertition

No wider than 48 inches (123cm)

Want to Learn More? VISIT www.firstlegoleague.org/challenge

- Find the Core Values listed in the Challenge

- Learn about what to expect from Core Values Judging and read tips from experienced Coaches in the Coaches' Handbook: www.firstlegoleague.org/challenge

- Your team will be assessed in the judging room using a standard rubric. Review the Core Values judging information and rubric: www.firstlegoleague.org/challenge

- If you are completely new, check out the *FIRST* LEGO League Resource page for videos, tips, and additional helpful rookie links: www.firstlegoleague.org/challenge

Think About It

People use water every day, but your team members probably don't think much about how and why they use water. Whether it's directly (drinking or washing) or indirectly (manufacturing the products they use or producing energy), they have a lot of different needs for water.

Your team's Project challenge this season is to improve the way people find, transport, use, or dispose of water.

Gadise lives in a small village outside of Kemba, Ethiopia. The nearest water well is several miles away, and at certain times of the year there is very little rainfall to save for drinking, cooking and washing. Gadise and her little brother used to spend hours walking to the water well, which often kept them from attending school. Gadise's village has now installed several new towers that are each able to collect up to one hundred liters of clean drinking water directly from the air! When the people of Kemba installed these very simple towers that collect water from condensation, they allowed Gadise and her brother to spend more time in school, and less time making the long trip to other villages for water. When you are thinking about an innovative solution, don't rule something out just because it seems simple. Sometimes the simplest solution is the best solution!

Apon lives in Chittagong, a large port city in southern Bangladesh. For years, Chittagong has suffered a water crisis due to an ever-increasing population. A year ago, Apon took his mother to the hospital for treatment, but the hospital had closed because there was no water for the patients, nurses and doctors. The large number of water wells in Chittagong had used so much water that many wells were running dry. To use water from the nearby Karnaphuli River, Chittagong would need a modern water treatment plant, which has just been finished. The new plant, which can treat over 100 million liters of water a day, will not solve all of Chittagong's water problems, but it did allow many homes and businesses, including the hospital, to have a more reliable source of water. Apon's mother was finally able to get the care she needs. When you are considering an innovative solution, try to remember that some problems do require engineers to "think big"!

Samantha lives in Wichita Falls, Texas, in the United States. Her mother works at a local factory that uses up to 75 million liters of water a year making packaging products. Many families in the town, including Samantha's, rely on the factory's jobs. The only problem with this arrangement was that the factory was using expensive "potable" water, or treated water suitable for drinking, to help make their products. This process was continually raising the costs for the businesses and people of Wichita Falls. The solution to this challenge was to use filtered "wastewater" – or "used" water from homes and businesses that can be released back into the environment, but is not clean enough to drink. The city's treated wastewater replaced much of the more expensive potable water in the manufacturing process. Due to this innovation, both the citizens of Wichita Falls and the factory saved money, and helped to ensure that Samantha's mother and many others workers would continue to be able to support their families and pay their water bills. When your team is brainstorming an innovative solution, think about how joining forces with others might solve a problem!

Amahle is from Mothibistad, South Africa. Her school, a few miles north of town, did not have a reliable source of water, since the pumps and pipes that carried water to the school were often broken. This meant that some days the school had to shut down, or students would have to spend time collecting water from nearby wells. To fix this problem, the school installed a water system called the "PlayPump." The PlayPump uses a playground "merry-go-round" to pump water from a well at the school. So, during recess, Amahle and her friends get to play, while at the same time pumping water to a storage tank. This water is used to keep school in session. Engineers have learned a lot by creating the PlayPump system. They have found out that PlayPumps must be inspected and kept in good working order to be of use. They have also discovered that PlayPumps may not be the right solution for every community, since they require several people to operate, and children may not always have the time to play and pump water. However, in some places, like a schoolyard, they can be a great solution to a problem found in many parts of the world. Always remember to consider the "human factors" that might improve your approach to problem solving!

Inventor and engineer Dean Kamen has worked his whole life to try and help others. He has created medical devices, smart wheelchairs, and even founded *FIRST*® to help students around the world learn about careers in science and technology. When Dean learned about the billions of people who lacked access to safe drinking water, he set his sights on creating a machine that can make even the dirtiest water safe to drink. The result was the "SlingShot," a technology that copies nature's water cycle by evaporating and then re-condensing water. This process, called "vapor compression distillation" has a long history of providing clean water for submarines and ships, as well as delivering pure water for medical uses. The SlingShot is a simpler, small-scale version of this proven technology that can produce hundreds of gallons of water per day – enough drinking water for a school, a clinic, or a small village. The SlingShot has shown that although engineers are always trying to make the future better, they can look to the past for inspiration! Don't forget to study the inventions that are already out there. Sometimes engineers can improve on an idea that has been around for decades and still make a big difference!

Hint: The Robot Game provides many examples of the way people use water. You could ask your team to brainstorm based on the missions.

Identify a Problem

Ask your team to think about all the ways they use water. These might include everything from quenching their thirst to swimming in a pool or lake. Water might be part of the process to produce their food, energy, mobile phones, or other products. Their use of water probably even includes something as simple as flushing the toilet.

Have your team choose a part of the human water cycle that interests them and identify a specific problem they want to solve.

In the HYDRO DYNAMICS℠ Challenge, the **human water cycle** describes the ways people find, transport, use, and dispose of water in order to meet a specific need or desire.

Not sure where to start?

Try this process to help your team choose and explore a problem with the human water cycle:

Ask your team to draw or create a chart that shows the human water cycle for one or more needs. This might be a need that your team members have, or it could be a need for someone else. How is water used to help fulfill this need?

Consider questions like:

- Where does the water I use come from?
- Do I get my water from a lake or river, or from a water well?
- Does the water need to be cleaned, transported, or stored during the process? How does this happen?
- Where does water go after it is used?
- What type of professionals work to protect our water resources?
- How do people in other parts of the world get their water?
- What happens when people don't have access to clean drinking water?
- Do you notice any ways the human water cycle could be improved?

Hint: Your team may be able to use the scientific method or the engineering design process to tackle your problem. You can find out about the engineering design process at sites like this, or conduct your own research to learn more about how these approaches to problem solving can help your team.

This might be a great time for the team to interview a professional. The professional could be someone who works directly with water or researches water problems for his or her job. Can a professional help your team learn about how people use water for washing, food production, medical treatment, or entertainment?

Hint: field trips are a great way to learn about a new topic. Consider requesting a tour or interview from a local business, educational institution, or other water-related site. However, some locations may have rules restricting visitors, or they may not have someone available to give an interview. If they say "no," ask about virtual tours online or other people you could contact.

Ask your team to select the problem they would like to investigate and solve. You might select a problem in one of these areas (or add your own):

- Finding potable water
- Identifying and removing contamination
- Using water to produce food
- Finding problems with pipes buried in the ground
- Transporting or storing clean water
- Disposing of wastewater
- Controlling industrial or agricultural runoff into natural waterways
- Using water responsibly in manufacturing

After your team selects a problem, the next step is to find out about the current solutions. Encourage them to research their problem using resources like:

- News articles
- Documentaries or movies
- Interviews with professionals working in the field
- Ask your local librarian
- Books
- Online videos
- Websites

Ask your team questions like: Why does this problem still exist? Why aren't the current solutions good enough? What could be improved?

Design a Solution

Next, your team will design a solution to the problem. Any solution is a good start. The ultimate goal is to design an *innovative* solution that adds value to society by improving something that already exists, using something that exists in a new way, or inventing something totally new.

Ask your team to think about:

- What could be done better? What could be done in a new way?
- How can you reimagine the way we clean, transport, use, or dispose of our water?
- Could your solution balance the needs of people, the planet, and prosperity?

Ask your team to think of your problem like a puzzle. Brainstorm! Then turn the problem upside down and think about it in a completely different way. Imagine! Get silly! Even a "silly idea" might inspire the perfect solution. Encourage team members to try one idea (or more), but be prepared that each idea may need some improvements.

Design a Solution (continued)

Make sure your team thinks about how they could make their solution a reality. Try asking them questions like:

- Why would your solution succeed when others have failed?

- What information would you need to estimate the cost?

- Do you need any special technology to make your solution?

- Who would be able to use it?

Remember, your team's solution does not need to be completely new. Inventors often improve an idea that already exists or use something that exists in a new way.

Share with Others

Once the team has designed a solution, the next step is to share it!

It might be helpful for your team to share with someone who could provide real-world feedback about the solution. Getting input and improving a solution are part of the design process for any inventor. It is OK to revise an idea if the team receives some helpful feedback.

Ask your team to think about who your solution might help. How can you let them know that you have solved their problem?

- Can you present your research and solution to people who transport, clean, collect, or use water?

- Can you share with a professional or someone who helped you learn about your problem?

- Can you think of any other people who might be interested in your idea?

When your team plans their presentation, encourage them to use the talents of team members. Teams often explore creative presentation styles, but it is also important to keep the focus on your team's problem and solution. Sharing can be simple or elaborate, serious or designed to make people laugh while they learn.

No matter what presentation style your team chooses, remember to infuse fun wherever you can!

Any inventor must present their idea to people who can help them make it a reality, such as engineers, investors, or manufacturers. Like adult inventors, the Project presentation is your team's chance to share their great Project work with the Judges.

All regions require teams to prepare a Project presentation. As long as your team covers the basic Project information, they may choose any presentation style they like. Check with your tournament organizer to see if there are any size or noise restrictions in the judging rooms.

Your team's presentation may include posters, slideshows, models, multimedia clips, props, costumes, and more. Creativity in the presentation is rewarded, but covering all of the essential information is even more important.

Teams will only be eligible for Project awards if they:

- **Identify** a problem that meets this year's criteria.

- Explain their **innovative solution**.

- Describe how they **shared** with others prior to the tournament.

Presentation requirements:

- All teams must present live. The team may use media equipment (if available) only to enhance the live presentation.

- Include all team members. Each team member must participate in the Project judging session.

- Set up and complete the presentation in **five minutes** or less with no adult help.

The teams who excel at tournaments also use the Project presentation to tell the Judges about their sources of information, problem analysis, review of existing solutions, elements that make their idea innovative, and any plans or analysis related to implementation.

Glossary

Word	Definition (Terms in **bold** can be found elsewhere in the glossary.)
human water cycle	In the HYDRO DYNAMICS℠ Challenge, the *human water cycle* describes the ways people find, transport, use, and dispose of water in order to meet a specific need or desire.
water footprint	The amount of water that a person, family or other group (such as a business) uses in a day.
natural water (hydrologic) cycle	The natural process when water evaporates, condenses into clouds, and then falls back to the ground as **precipitation**. Water never completely disappears. It goes through the natural water cycle over and over.
hydrology	The branch of science that deals with the **hydrologic cycle** in the environment, including land, soil and the atmosphere.
fresh water	Water that contains very low levels of dissolved substances in it. Most people say "fresh water" to mean the water contains little or no salt.
salt water	Water that has a high concentration of dissolved salts in it. (Just like it sounds!) The Earth's oceans are filled with salt water, but salt water is not drinkable by people unless most of the salts are removed through **water treatment**.
brackish water	Water that is considered neither **freshwater** nor **salt water**, but a mixture of the two. Brackish water is usually found in estuaries, where freshwater (rivers and streams) flows into the ocean.
groundwater	Water that flows or seeps downward and saturates soil or rock, supplying springs and **water wells**.
aquifer	A source of **groundwater** in the form of soil, sand or rock below the land's surface that is saturated with water. Aquifers are capable of yielding water in sufficient quantity for human use; **water wells** are dug or drilled into aquifers.
surface water	Surface water includes all sources of the Earth's above-ground water such as streams, rivers, lakes, reservoirs and oceans.
precipitation	Water that comes from Earth's atmosphere as a result of rain, snow, hail, sleet, dew, and frost. Precipitation can be collected directly for use by humans with rooftop drains and other means, but it also recharges **surface water** and **groundwater** supplies.
runoff	Runoff is **precipitation** that flows into sewers, lakes, or other bodies of water as a result of rain, snow melt, or irrigation. Depending on conditions, runoff can carry substances that cause **contamination** in supplies of surface water and groundwater.
drought	A period of water shortage that can be brought about by either natural or human causes. Natural causes could be changes in weather or climate; human factors could include the over-use of **aquifers** or the diversion of rivers for **irrigation** or flood control.
irrigation	The use of water to assist in the growing of crops and pastures, or to maintain recreational areas such as golf courses or even yards.
water quality	Water quality describes the chemical, physical, and biological characteristics of water, usually with respect to its suitability for a particular purpose. Various forms of **water treatment** are required to achieve a particular water quality.
potable water	Water that is safe for drinking, cooking or other home uses.

water well	A water well is a human-made hole dug in the ground for the purpose of withdrawing **groundwater**. Wells are often bored or drilled with machines to reach deep **aquifers**. Depending on the quality of the water, water collected from water wells may or may not undergo water treatment before use.
surface water intake	Intakes are structures or devices designed to collect **surface water** for human use. Ideally, surface water undergoes some type of **water treatment** before it is used by humans because it is often more likely than **groundwater** to contain harmful **contaminants**.
water distribution system	A water distribution system is a set of devices, such as **water pumps**, **water towers**, and **water pipes** that move water from one place to another for human use.
water pump	A water pump is a machine designed to transport water by putting it under pressure. Different types of water pumps use a variety of mechanisms to move water, and they can be powered by hand, electricity, wind or other sources of energy.
water tower	Part of an urban or suburban **potable water** distribution system that includes a tower supporting an elevated water tank, whose height creates the pressure required to distribute the water through **water pipes** to homes and businesses.
water pipes	A water pipe is a tube that moves water through a **water distribution system**. Water pipes can be made of a variety of materials including plastic, copper, iron, lead, concrete or even "fired" clay.
contamination	The presence of unwanted or unsafe materials in a substance. Contamination of water may include harmful bacteria, parasites, chemicals, or other materials which may hurt humans or the environment.
turbidity	Turbidity is a measure of the amount of solid particles that are suspended in water. Water that is very turbid causes light rays shining through the water to scatter, making the water cloudy or even opaque in extreme cases. The turbidity of water is one important measure of **water quality**.
water treatment	Water treatment is the process of making water suitable for a particular purpose, such as drinking water, water for industrial uses or even purifying **wastewater** so that it can be returned to lakes and rivers to re-enter the **hydrologic cycle**. Some type of water treatment is also often required before **groundwater** or **surface water** is fit for human use.
chlorination	Chlorination is a type of **water treatment** where chlorine is added to a **potable water** supply primarily for the purpose of killing harmful organisms.
fluoridation	Fluoridation is a type of **water treatment** where fluoride is added to a **potable water** supply to reduce tooth decay.
wastewater	Water that has been used in homes, industries, and businesses that is not normally for reuse unless it undergoes **water treatment**.
blackwater	Blackwater is **wastewater** that is contaminated by human, animal or food waste.
greywater	Greywater is **wastewater** from clothes washing machines, showers, bathtubs, and sinks. In some instances, if it is not too contaminated, greywater can be reused for activities like flushing a toilet, or irrigating plants.

sediment	Solid material, often sand, silt or clay, moved or suspended in water. Water high in sediment content will usually have **high turbidity**.
septic system	A method of **water treatment** for household **wastewater** that uses a settling (septic) tank. Septic systems allow solids to sink or stay trapped in the settling tank, and liquids to be distributed to a drain field for soil absorption.
sanitary sewer	A sanitary sewer is a system of underground pipes that carries **wastewater** from homes, factories and businesses to a wastewater treatment plant where it is filtered, treated and discharged.
storm sewer	A storm sewer carries **runoff** such as street wash and snow melt from the land to a discharge point. In a separate storm sewer system, storm sewers are completely isolated from **sanitary sewers**, and discharge into lakes, rivers, streams, or the ocean. However, some cities and towns send the water from storm sewers to a water treatment plant to protect the environment from harmful **runoff** that might come from **contamination**, such as motor oil on roads, or fertilizers in gardens.
manhole cover	A removable plate or lid that allows access to a **sanitary sewer** system for maintenance and inspection. Manhole covers are usually located in streets and made of heavy cast iron.
infiltration	The process in which water enters the soil. This could be from **precipitation**, **runoff**, **irrigation**, or other sources. Infiltration is also a term that describes when runoff enters a sanitary sewer by accident, potentially overwhelming the sewer system, and resulting in sewage **contamination** in the environment.
water treatment plant	A facility designed to improve the quality of water. The most common types of water treatment plants are those used to make **groundwater** and **surface water** suitable for use in homes and businesses (making **potable water**), and those used to make **wastewater** clean enough to be returned to the environment. **Wastewater** treatment usually involves a series of steps, most commonly **filtration**, **aeration** and **sedimentation**.
filtration	Filtration is the process of removing solid **contamination** from water, most often through the use of screens, sand filters and activated charcoal.
aeration	Aeration is the process of adding oxygen back to **wastewater** to return it to a more natural state.
sedimentation	Sedimentation is the process of using gravity or chemicals to settle-out large solid **contaminants** during the water treatment process in order to reduce its **turbidity**.
sewage sludge	A thick mixture of solids and liquid that is a by-product of a wastewater **treatment plant** or a **septic system**. Sewage sludge is the solid matter that has been separated from the **wastewater**, it can contain **contamination**, and is usually disposed of through incineration or by spreading it over land or burying it in landfills.
desalination	Desalination is the removal of salts from **salt water** to provide **fresh water**. This method is becoming a popular way of providing fresh water to populations with a ready supply of salt water, but it can be expensive and current methods require a large amount of energy.
reverse osmosis	A type of desalination that removes salts from **salt water** using a membrane. With reverse osmosis, salt water is forced through a fine membrane that traps dissolved salts, and the salt waste (or brine) is removed and disposed.

Resources

Video

National Science Foundation
Environmental Engineer: Profiles of Scientists and Engineers
https://www.youtube.com/watch?v=k2epvAUEdCI

The University of Maryland, Baltimore County (UMBC)
What do Environmental Engineers do?
https://www.youtube.com/watch?v=MUT8zya53Vg

The Open University: Fresh Water Filtration:
Water Supply and Treatment in the UK
https://www.youtube.com/watch?v=dtHw5_5z51w

The Open University: Waste Water Filtration:
Water Supply and Treatment in the UK
https://www.youtube.com/watch?v=5J7Cysnluv0&list=P-L361A68D81AAB6162&index=7

City of Winnipeg
Virtual Tour of a Drinking Water Treatment Plant
https://www.youtube.com/watch?v=20VvpASC2sU

City of Grand Island, Nebraska
Wastewater Treatment Plant Tour - "Flush to Finish"
https://www.youtube.com/watch?v=pRaptzcp9G4

The Water Project – YouTube Channel
https://www.youtube.com/thewaterproject

water.org® – YouTube Channel
https://www.youtube.com/water

National Science Foundation Science 360
Transformational Building Design Energizes Water Recycling.
https://news.science360.gov/obj/video/b515996a-6699-44a1-babd-8e94dffe714d/transformational-building-design-energizes-water-recycling-literally

Websites and Articles

Aquapedia
Check out the Aquapedia or Water Topics sections of the Water Education Foundation website to learn about water topics in California, USA and beyond.
http://www.watereducation.org/water-topics

Calculate Your Water Footprint
Answer some questions to estimate how much water you really use every day (and learn some fun facts along the way). You might be surprised by what you discover!
http://www.gracelinks.org/1408/water-footprint-calculator

Learn About Water
The US Environmental Protection Agency provides resources to learn about bodies of water, drinking water, wastewater, and water quality.
https://www.epa.gov/learn-issues/learn-about-water

Water Science Glossary of Terms
The United State Geological Service (USGS) has a list of water-related terms that might help you understand our water resources.
https://water.usgs.gov/edu/dictionary.html

Melbourne Water
Melbourne (Australia) Water has numerous resources that describe the water supply, infrastructure and resources.
https://www.melbournewater.com.au/Pages/home.aspx

The World Bank's Water Global Practice
Launched in 2014, the World Bank's Water Global Practice site discusses the knowledge and implementation of water projects from around the world.
http://www.worldbank.org/en/topic/water

The UN and Water
This United Nations sites explores the global crisis caused by insufficient water supply to satisfy basic human needs and growing demands on the world's water resources to meet human, commercial and agricultural needs.
http://www.un.org/en/sections/issues-depth/water/index.html

National Geographic's Environment: Freshwater Site
This site includes numerous case studies from around the world to help you understand the global challenges faced in finding and protecting water for human use.
http://environment.nationalgeographic.com/environment/freshwater/

*A chemist testing
for water quality*

Websites and Articles *(continued)*

The Water Sustainability and Climate Project (WSC)
at the University of Wisconsin-Madison
The Water Sustainability and Climate Project (WSC) at the University of Wisconsin-Madison is an integrated effort to understand how water and the many other benefits people derive from nature could change over time.
The project is focused on the Yahara Watershed in southern Wisconsin, but has many scenarios and case studies that are useful for exploring a variety of water issues.
https://wsc.limnology.wisc.edu/

What is an Environmental Engineer?
EnvironmentalScience.org's site contains information about environmental science education and careers, as well as vetted research on water and other environmental issues.
http://www.environmentalscience.org/

Water Resources Research Center, University of Arizona
A research and extension unit of the College of Agriculture and Life Sciences, the WRRC is the designated state water resources research center for Arizona established under the 1964 Federal Water Resources Research Act. The site has a wealth of resources for teachers and students on all types of water resource issues.
http://wrrc.arizona.edu/

National Academy of Engineering (NAE)
The NAE has compiled a list of fourteen "Grand Challenges for Engineering." Providing access to clean water for the one out of every six people living today who do not have adequate access to water, and the one out of every three who lack basic sanitation, for which water is needed, has been designated as a "grand challenge." This site contains resources and videos that describe the global nature of these issues.
http://engineeringchallenges.org/

US Environmental Protection Agency (EPA)
The water topics page of the US EPA site provides detailed information on preventing water contamination, water treatment and water conservation.
https://www.epa.gov/environmental-topics/water-topics

The Water Project
The Water Project is an organization that tries to find solutions to the local water problems in Africa. Their web site contains information about the challenges faced by many African communities, and the innovative way that these challenges are being met.
https://thewaterproject.org/

The Water Project: Teaching Tools & Resources
This Water Project site has numerous lesson plans for grade K-12 students. The topics include water scarcity, contamination and the local solutions used by people in Africa to solve these difficulties.
https://thewaterproject.org/resources/

water.org ®
water.org is a non-profit dedicated to finding clean water and sanitation solutions for communities in Africa, Asia, Latin America and the Caribbean. This site has case studies and other resources that detail the struggle to maintain a reliable source of clean drinking water in many parts of the world.
http://water.org/

Books

How Did That Get to My House? Water
By Nancy Robinson Masters, Cherry Lake Publishing (2014)
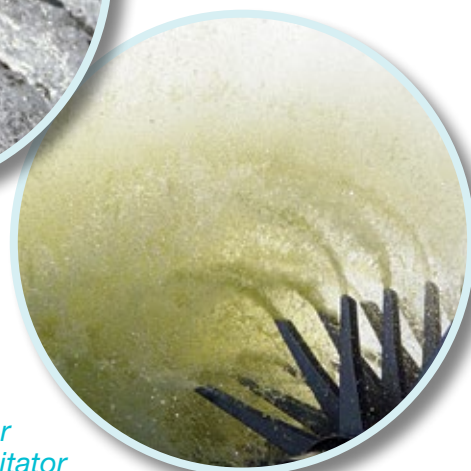
What's Up® With Conserving Water
Channing Bete Company

National Geographic Kids: Water
Melissa Stewart, National Geographic Society (2014)

A sewage water treatment plant

A wastewater treatment agitator

Ask a Professional

Talking with professionals (people who work in the field of this year's Challenge theme) is a great way for your team to:

- Learn more about this season's theme.
- Find ideas for your HYDRO DYNAMICS℠ problem.
- Discover resources that might help with your research.
- Get feedback on your innovative solution.

Examples of Professionals

Consider contacting people who work in the following professions. See if your team can brainstorm any other jobs to add to the list. Many company, professional association, government, and university websites include contact information for professionals.

Job	What they do	Where they may work
environmental engineer	Environmental engineers use engineering, soil science, biology, and chemistry to develop solutions to environmental and natural resource problems.	government offices, private companies that must ensure compliance with laws and regulations
civil engineer	Civil engineers design, build, supervise, operate, and maintain large-scale infrastructure projects including dams, bridges, and systems for water supply and sewage treatment.	government offices, private companies
environmental compliance specialist	Environmental compliance specialists help ensure that companies and governments follow laws and regulations designed to protect water, the environment and natural resources. Most compliance specialists work for governments, but there are many who also work for private companies.	government offices, departments of public health, private companies that must ensure compliance with laws and regulations
water treatment plant manager	Water treatment plant managers run facilities designed to improve the quality of water. Water treatment plants generally fall into two broad categories: those that make potable water for distribution to homes and businesses, and those that treat wastewater before it is returned to the environment.	Usually local government offices, or water/wastewater districts that represent several cities or towns
public utilities director or manager	Utilities directors oversee the distribution of potable water, the collection of wastewater, and water treatment systems for a city or region.	Usually local government offices, or water/wastewater districts that represent several cities or towns
hydrologist	A hydrologist is a scientist who studies how water flows and interacts with the Earth.	Government agencies, universities, environmental consulting companies

Who Do You Know?

Use the list of professionals above to help you brainstorm ideas. Think about the people who study, transport, clean, or use water in their jobs. Think about the technology that people use to manage water. Who makes that technology?

One of the best recruiting tools for your Project is your own team. Think about it. Who do you know? Chances are good that someone on your team knows a professional who works with water in some way. Ask your team members to think about family, friends, or mentors who work in a job that involves water.

Make a list of people your team might want to interview.

How Should You Ask?

As a team, talk about your list of professionals and choose one or more who you think could help your team learn about how people use water. Have the team do a little research about each professional. Find out how the person works with this year's theme and think about what questions the team might want to ask in an interview.

Next, work with team members to contact the professional you chose. Explain a little about *FIRST*® LEGO® League. Tell the professional about the team's research goals and ask if they can interview him or her.

What Should You Ask?

Have the team prepare a list of questions for the interview. When you think about questions to ask:

- Use the research the team has already done to brainstorm questions about the professional's area of expertise. It's important to ask questions that the person can answer.
- Keep the team's Project goal in mind. Ask questions that will help the team learn more about their topic and design an innovative solution.
- Keep questions short and specific. The more direct team members can be, the more likely they are to receive a useful answer.
- Do NOT ask the professional to design an innovative solution for your team. The team's solution must be the work of team members. If they already have an innovative solution though, it is ok for the professional to provide feedback on the idea.

At the end of the interview, ask the professional if your team may contact him or her again. They might think of more questions later. Maybe the person would be willing to meet with your team again or give you a tour. Don't be afraid to ask.

And finally, make sure your team shows *Gracious Professionalism*® during the interview and thanks the professional for his or her time!
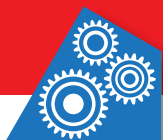
2017/2018 Robot Game Rules

Guiding Principles

GP1 - *GRACIOUS PROFESSIONALISM®*

You are *"Gracious Professionals."* You compete hard against **problems**, while treating **all people** with respect and kindness. If you joined *FIRST* LEGO League with a main goal of "winning a Robotics competition," you're in the wrong place!

GP2 - INTERPRETATION

- **If a detail isn't mentioned, then it doesn't matter**.
- Robot Game text means exactly and only what it plainly says.
- If a word isn't given a game definition, use its common conversational meaning.

GP3 - BENEFIT OF THE DOUBT - If the Referee (Ref) feels something is a "very tough call," and no one can point to strong text in any particular direction, you get the **Benefit Of The Doubt**. This good-faith courtesy is not to be used as a strategy.

GP4 - VARIABILITY - Our suppliers and volunteers try hard to make all Fields correct and identical, but you should always expect little defects and differences. Top teams design with these in mind. Examples include Border Wall splinters, lighting changes, and Field Mat wrinkles.

GP5 - INFORMATION SUPERIORITY - If two official facts disagree, or confuse you when read together, here's the order of their authority (with #1 being the strongest):

#1 = Current Robot Game **UPDATES**

#2 = **MISSIONS** and **FIELD SETUP**

#3 = **RULES**

#4 = **LOCAL HEAD REF** - In unclear situations, local Head Referees may make good-faith decisions after discussion, with Rule GP3 in mind.

- Pictures and video have no authority, except when talked about in #1, #2, or #3.
- Emails and Forum comments have no authority.

Definitions

D01 - MATCH - A "Match" is when two teams play opposite each other on two Fields placed north to north.

- Your Robot LAUNCHES one or more times from Base and tries as many Missions as possible.
- Matches last 2-1/2 minutes, and the timer never pauses.

D02 - MISSION - A "Mission" is an opportunity for the Robot to earn points. Missions are written in the form of requirements.

- Most requirements are **RESULTS** that must be visible to the Ref at the **END OF THE MATCH**.
- Some requirements are **METHODS** that must be observed by the Ref **AS THEY HAPPEN**.

D03 - EQUIPMENT - "Equipment" is everything **YOU BRING** to a Match for Mission-related activity.

D04 - ROBOT - Your "Robot" is your LEGO MINDSTORMS controller and all the Equipment you've combined with it by hand which is not intended to separate from it, except by hand.

D05 - MISSION MODEL - A "Mission Model" is any LEGO element or structure **ALREADY AT THE FIELD** when you get there.

D06 - FIELD - The "Field" is the Robot's game environment, consisting of Mission Models on a Mat, surrounded by Border Walls, all on a Table. "Base" is part of the Field. For full details, see FIELD SETUP. Download the Field Setup Guide at www.firstlegoleague.org/challenge.

D07 - BASE - "Base" is the space directly above the Field's quarter-circle region, in the southwest. It extends southwest from the curved line TO the corner walls (no farther). The diagrams below define **"COMPLETELY IN"** for Base, but apply for **ANY** area.

YES	**YES**	**NO**	**NO**	**NO**	**NO**	**NO**
(COMPLETELY IN)	(COMPLETELY IN)	(PARTLY IN)	(PARTLY IN)	(PARTLY IN)	(OUT)	(OUT)
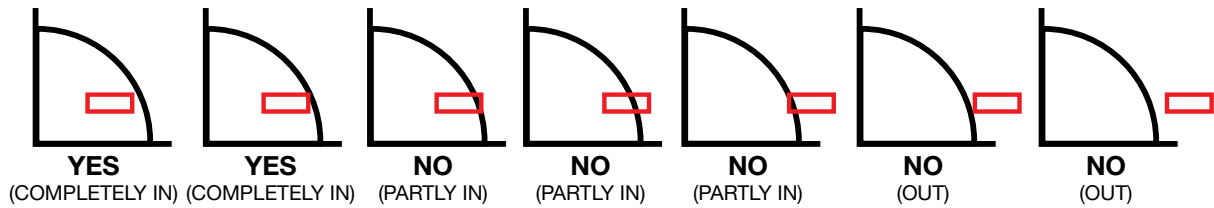
D08 - LAUNCH - Whenever you're done handling the Robot and then you make it GO, that's a "Launch."

D09 - INTERRUPTION - The next time you interact with the Robot after Launching it, that's an "Interruption."

D10 - TRANSPORTED - When a thing **(anything)** is purposefully/strategically being…
• taken from its place, and/or
• moved to a new place, and/or
• being released in a new place,

it is being "Transported." The process of being Transported ends when the thing being transported is no longer in contact with whatever was transporting it.

Equipment, Software and People

R01 - ALL EQUIPMENT - All Equipment must be made of LEGO-made building parts in original factory condition.
Except: LEGO string and tubing may be cut shorter.
Except: Program reminders on paper are okay (off the Field).
Except: Marker may be used in hidden areas for identification.

R02 - CONTROLLERS - You are allowed only ONE individual controller in any particular Match.
• It must exactly match a type shown below (**Except:** Color).
• ALL other controllers must be left in the PIT AREA for that Match.
• All remote control or data exchange with Robots (including Bluetooth) in the competition area is illegal.
• This rule limits you to only ONE individual ROBOT in any particular Match.

EV3	NXT	RCX

R03 - MOTORS - You are allowed up to FOUR individual motors in any particular Match.
• Each one must exactly match a type shown below.
• You may include more than one of a type, but again, your grand total may not be greater than FOUR.
• ALL other motors must be left in the PIT AREA for that Match, NO EXCEPTIONS.

EV3 "LARGE"	EV3 "MEDIUM"	NXT	RCX

R04 - EXTERNAL SENSORS - Use as many external sensors as you like.
- Each one must exactly match a type shown below.
- You may include more than one of each type.

EV3 TOUCH	EV3 COLOR	EV3 ULTRASONIC	EV3 GYRO/ANGLE
NXT TOUCH	NXT LIGHT	NXT COLOR	NXT ULTRASONIC
RCX TOUCH	RCX LIGHT	RCX ROTATION	

R05 - OTHER ELECTRIC/ELECTRONIC THINGS - No other electric/electronic things are allowed in the competition area for Mission-related activity.
Except: LEGO wires and converter cables are allowed as needed.
Except: Allowable power sources are ONE controller's power pack or SIX AA batteries.

R06 - NON-ELECTRIC ELEMENTS - Use as many non-electric LEGO-made elements as you like, from any set.
Except: Factory-made wind-up/pull-back "motors" are not allowed.
Except: Additional/duplicate Mission Models are not allowed.

R07 - SOFTWARE - The Robot may only be programmed using LEGO MINDSTORMS RCX, NXT, EV3, or RoboLab software (any release). No other software is allowed. Patches, add-ons, and new versions of the allowable software from the manufacturers (LEGO and National Instruments) are allowed, but tool kits, including the LabVIEW tool kit, are not allowed.

R08 - TECHNICIANS
- Only two team members, called "Technicians," are allowed at the competition Field at once.
  Except: Others may step in for true emergency repairs during the Match, then step away.

- The rest of the team must stand back as directed by tournament officials, with the expectation of fresh Technicians being able to switch places with current Technicians at any time if desired.

R09 - BEFORE THE MATCH TIMER STARTS
- After getting to the Field on time, you have at least one minute to prepare. During this special time only, you may also...
- ask the Ref to be sure a Mission Model or setup is correct, and/or
- calibrate light/color sensors anywhere you like.

R10 - HANDLING DURING THE MATCH
- You are not allowed to interact with any part of the Field that's not COMPLETELY in Base.

Except: You may Interrupt the Robot any time.

Except: You may pick up Equipment that BROKE off the Robot UNINTENTIONALLY, anywhere, any time.

- You are not allowed to cause anything to move or extend over the Base line, even partly.

Except: Of course, you may LAUNCH the Robot.

Except: You may move/handle/STORE things off the Field, any time.

Except: If something accidentally crosses the Base line, just calmly take it back - no problem.

- Anything the Robot affects (good or bad!) or puts completely outside Base **stays as is** unless the Robot changes it. Nothing is ever repositioned so you can "try again."

R11 - MISSION MODEL HANDLING
- You are not allowed to take Mission Models apart, even temporarily.
- If you combine a Mission Model with something (including the Robot), the combination must be loose enough that if asked to do so, you could pick the Mission Model up and nothing else would come with it.

R12 - STORAGE
- Anything completely in Base may be moved/stored off the Field, but must stay in view of the Ref, on a stand.
- Everything in off-Field Storage "counts" as being completely in Base.

R13 - LAUNCHING
- A proper Launch (or re-Launch) goes like this:

- READY SITUATION
  - Your Robot and everything in Base it's about to move or use is arranged by hand as you like, all fitting **"COMPLETELY IN BASE"** and measuring no taller than 12 inches" (30.5 cm).
  - The Ref can see that nothing on the Field is moving or being handled.

- GO!
  - Reach down and touch a button or signal a sensor to activate a program.

FIRST LAUNCH OF THE MATCH – Here, accurate fair timing is needed, so the exact time to Launch is the beginning of the last word/sound in the countdown, such as "Ready, set, GO!" or BEEEEP!

R14 - INTERRUPTING
- If you **INTERRUPT** the Robot, you must stop it immediately, *then calmly pick it up for a re-Launch (*if you intend one). Here's what happens to the Robot and anything it was Transporting, depending on where each was at the time:

- **ROBOT**

o Completely in Base:	Re-Launch
o NOT completely in Base:	Re-Launch + Penalty

- **TRANSPORTED THING**

o Completely in Base:	Keep it
o NOT completely in Base:	Give it to the Ref

The "PENALTY" is described with the MISSIONS.

R15 - STRANDING
- If the **UNINTERRUPTED** Robot loses something it was Transporting, that thing must be allowed to come to rest. Once it does, here's what happens to that thing, depending on its rest location:

- **TRANSPORTED THING**

o Completely in Base:	Keep it
o Partly in Base:	Give it to the Ref
o Completely outside Base:	Leave as is

R16 - INTERFERENCE

- You are not allowed to negatively affect the other team except as described in a Mission.
- Missions the other team tries but fails because of illegal action by you or your Robot will count for them.

R17 - FIELD DAMAGE

- If the Robot separates Dual Lock or breaks a Mission Model, Missions obviously made possible or easier by this damage or the action that caused it do not score.

R18 - END OF THE MATCH - As the Match ends, everything must be preserved exactly as-is.

- If your Robot is moving, stop it ASAP and leave it in place. (Changes after the end don't count.)
- After that, hands off everything until after the Ref has given the okay to reset the table.

R19 - SCORING

- SCORESHEET - The Ref discusses what happened and inspects the Field with you, Mission by Mission.
  - o If you agree with everything, you sign the sheet, and the scoresheet is final.
  - o If you don't agree with something, the Head Ref makes the final decision.
- IMPACT - Only your BEST score from regular Match play counts toward awards/advancement. Playoffs, if held, are just for extra fun.
- TIES - Ties are broken using 2nd, then 3rd best scores. If still not settled, tournament officials decide what to do.

CHANGES FOR 2017

- The word "objects" has been replaced with the word "things" for parallelism with the term "anything."
- Definition of "Transporting" is opened up for situations not directly involving the Robot.
- Maximum Equipment height UPON LAUNCH is now limited.

2017/2018 Robot Game Missions
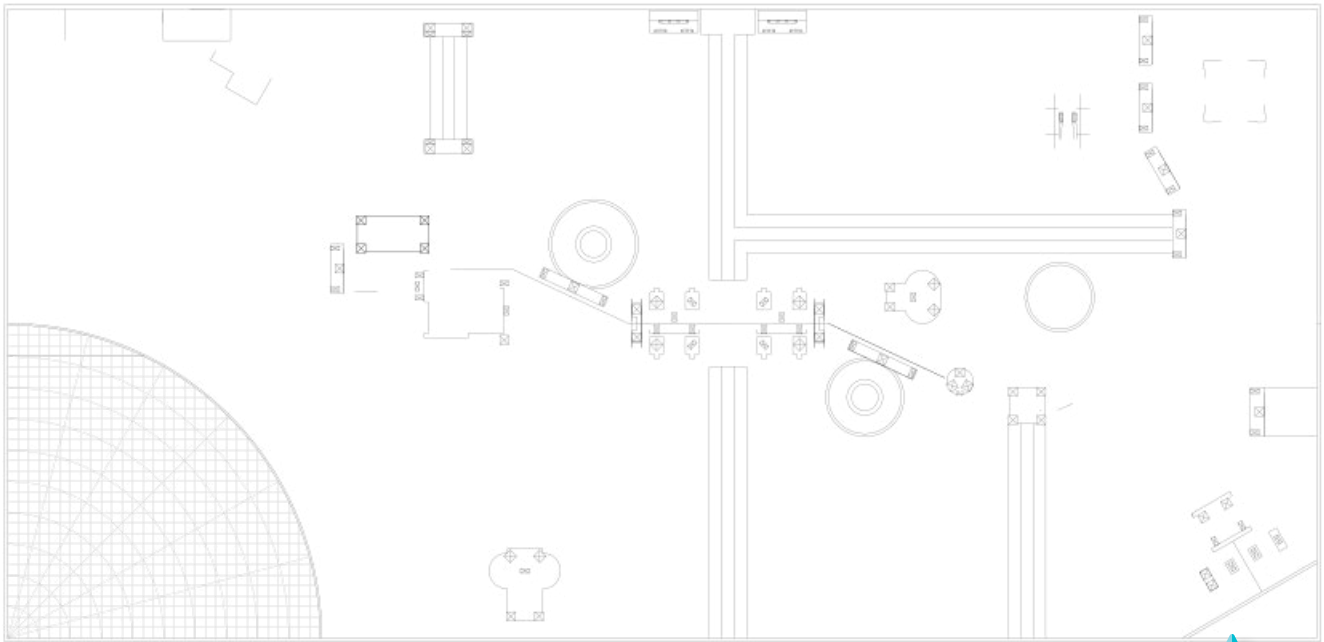
M01 - PIPE REMOVAL
Move the Broken Pipe so it is <u>completely in Base</u>.
20 Points

SCORE

M04 - RAIN
Make at least one Rain come <u>out of the Rain Cloud</u>.
20 Points
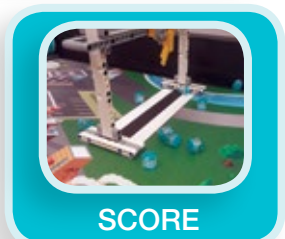
SCORE

M02 - FLOW
*Move a Big Water (one time maximum) to the other team's field *only by turning the Pump System's valve(s).
25 Points

SCORE

M05 - FILTER
Move the Filter north until the lock <u>latch drops</u>.
30 Points

SCORE

M03 - PUMP ADDITION
Move the Pump Addition so it has <u>contact with the mat and that contact is completely in the Pump Addition target</u>. **20 Points**

SCORE

M06 - WATER TREATMENT
Make the Water Treatment model <u>eject its Big Water</u>, *only by moving the Toilet's lever.
20 Points

SCORE

M07 - FOUNTAIN
Make the Fountain's middle layer rise <u>some obvious height and stay there, due only to a Big Water in the gray tub</u>. **20 Points**
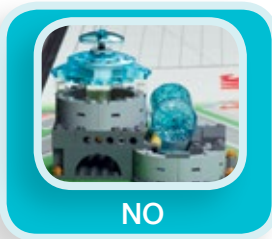
NO	SCORE

M08 - MANHOLE COVERS
Flip Manhole cover(s) <u>over, obviously past vertical</u> *without it/them ever reaching Base. **15 Points** EACH
Each cover is scored individually.
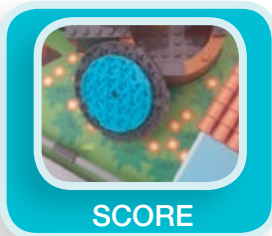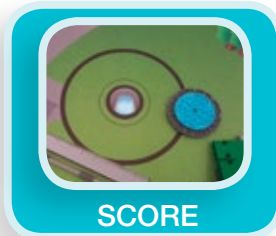
SCORE	SCORE

FOR BONUS: Score 30 Manhole Cover points as described above.
WITH <u>both covers completely in separate Tripod targets</u>. **30 Points Added**
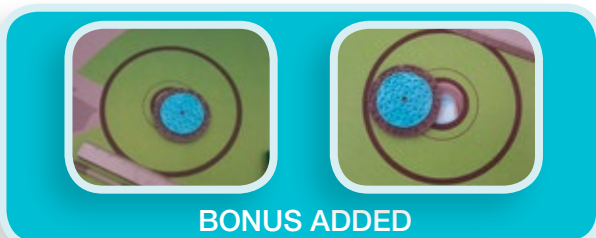
BONUS ADDED
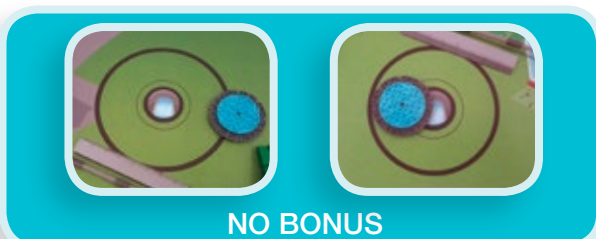
NO BONUS

M09 - TRIPOD
Move the inspection camera Tripod so it is FOR PARTIAL SCORE: <u>partly in either Tripod target, with all of its feet touching the mat</u>. **15 Points**
FOR FULL SCORE: <u>completely in either Tripod target, with all of its feet touching the mat</u>. **20 Points**

FULL	PARTIAL
PARTIAL	NO

M10 - PIPE REPLACEMENT (Install the Optional Loop first, in Base, if you wish.)
Move a New Pipe so it is <u>where the broken one started, in full/flat contact with the mat</u>. **20 Points**

"FULL /FLAT CONTACT"	SCORE
SCORE	NO

M11 - PIPE CONSTRUCTION (Install the Optional Loop first, in Base, if you wish.)
Move a New Pipe so it is

FOR PARTIAL SCORE: partly in its target, in full/flat contact with the mat. **15 Points**
FOR FULL SCORE: completely in its target, in full/flat contact with the mat. **20 Points**
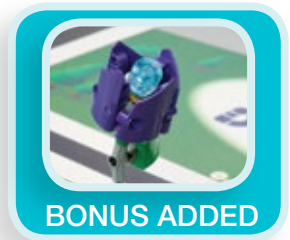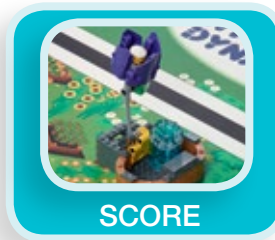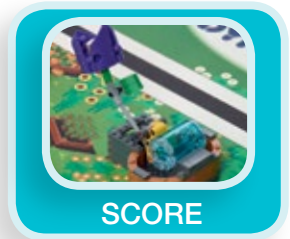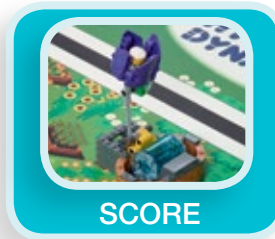

NO

PARTIAL

FULL
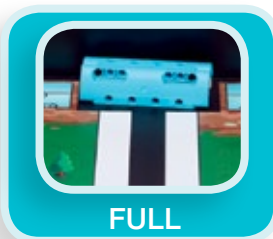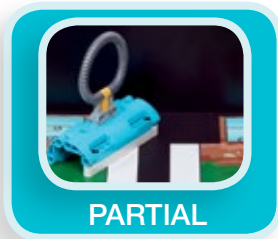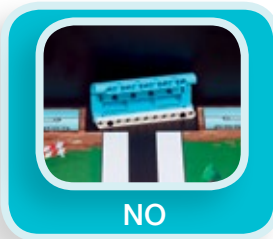
M12 - SLUDGE
Move the Sludge so it is touching the visible wood of any of the six drawn garden boxes. **30 Points**

SCORE

SCORE

NO
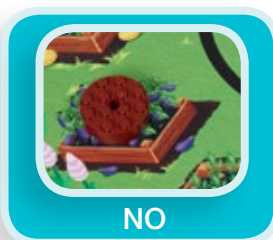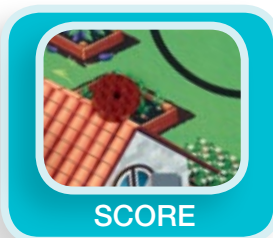
M13 - FLOWER
Make the Flower rise some obvious height and stay there, due only to a Big Water in the brown pot. **30 Points**

SCORE

SCORE

SCORE

BONUS ADDED

FOR BONUS: Score Flower Points as described above WITH at least one Rain in the purple part, touching nothing but the Flower model. **30 Points Added**

M14 - WATER WELL
Move the Water Well so it has contact with the mat and that contact is
FOR PARTIAL SCORE: partly in the Water Well target. **15 Points**
FOR FULL SCORE: completely in the Water Well target. **25 Points**

FULL

FULL

PARTIAL
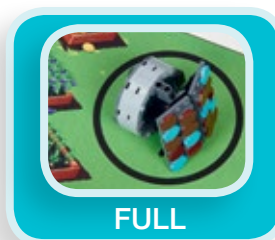
M15 - FIRE
Make the <u>fire drop</u> *only by making the Firetruck apply direct force to the House's lever. **25 Points**

SCORE

M16 - WATER COLLECTION
Move or catch Big Water and/or Rain water (one Rain maximum; no Dirty Water) so it is <u>touching the mat in the Water Target</u>, *without the target ever reaching the white Off-Limits Line shown below. Water may be touching the target, and/or other water, <u>but not be touching nor guided by anything else</u>. Each water model is scored as an individual.

At least one Rain: **10 Points**   Big Water: **10 Points EACH**

OFF-LIMITS LINE EXTENDS ALL THE WAY NORTH/SOUTH INCLUDING UNDER RAMPS	NO SCORE	SCORE: TWO BIG WATER AND AT LEAST ONE RAIN	NO SCORE	SCORE: AT LEAST ONE RAIN
SCORE: TWO BIG WATER	SCORE: ONE BIG WATER	SCORE: AT LEAST ONE RAIN	SCORE: TWO BIG WATER	

FOR BONUS: Score at least one Big Water in its target as described above WITH <u>one on top, which is touching nothing but other water</u>. **30 Points (Maximum only one Bonus can score)**
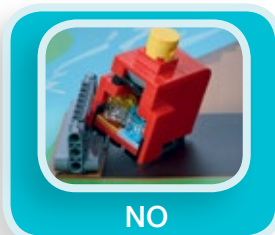
BONUS ADDED	BONUS ADDED	NO BONUS	NO BONUS

M17 - SLINGSHOT

Move the SlingShot so it is <u>completely in its target</u>. **20 Points**
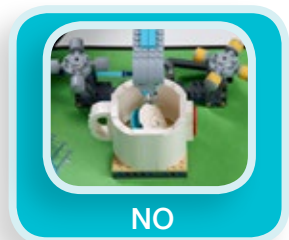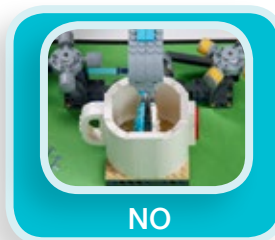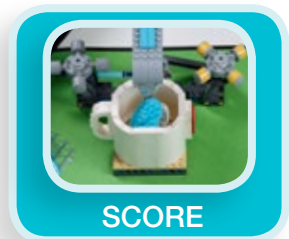

SCORE

SCORE

NO

FOR BONUS: Score SlingShot points as described above WITH the Dirty Water and a Rain <u>completely in the SlingShot target</u>.
15 Points Added

BONUS ADDED

BONUS ADDED

M18 - FAUCET

Make the water level <u>obviously more blue than white as seen from above the cup</u>, *only by turning the Faucet handle. **25 Points**

SCORE

SCORE

NO

NO

PENALTIES - Before the match starts, the Ref removes the six red Penalty discs from the Field, and holds on to them. If you Interrupt the Robot, the Ref places one of the removed Samples in the white triangle, in the southeast, as a permanent/untouchable Interruption Penalty. You can get up to six such penalties, worth -5 Points EACH

Robot Design Executive Summary

An "executive summary" is often used by engineers to briefly outline the key elements of a product or project. The purpose of the Robot Design Executive Summary (RDES) is to give the Robot Design Judges a quick overview of your team's robot and all that it can do.

Some regions require all teams to prepare a Robot Design Executive Summary, while others do not. Either way, the RDES is a great tool to help your team organize their thoughts about the robot and the design process they used. Check with your tournament organizer to see if your team is expected to present your RDES in the Robot Design judging session.

Unlike the Core Values Poster, teams do not need to create a poster or written material for the RDES. However, if the team would like to share pictures of the design process, records of strategy sessions, or examples of programming (either printed or on a laptop), the RDES presentation is an appropriate time.

Have your team prepare a short presentation (no longer than four (4) minutes) covering the elements below:

1. **Robot Facts:** Share a little bit about your robot, such as the number and type of sensors, drivetrain details, number of parts and the number of attachments. The Judges also like to know what programming language your team used, the number of programs, and the Robot Game mission where your team had the most success.

2. **Design Details:**

   a. Fun: Describe the most fun or interesting part of robot design as well as the most challenging parts. If your team has a fun story about your robot please feel free to share.

   b. **Strategy**: Explain your team's strategy and reasoning for choosing and accomplishing missions. Talk a little bit about how successful the robot was in completing the missions that were chosen.

   c. **Design Process:** Describe how your team designed their robot and what process they used to make improvements to the design over time. Briefly share how different team members contributed to the design.

   d. **Mechanical Design:** Explain the robot's basic structure. Explain to the Judges how the robot moves (drivetrain), what attachments and mechanisms it uses to operate or complete missions, and how your team makes sure it is easy to add/remove attachments.

   e. **Programming:** Describe how your team programmed the robot to ensure consistent results. Explain how the team organized and documented programs. Mention if the programs use sensors to know the location of the robot on the field.

   f. **Innovation:** Describe any features of the robot's design that the team feels are special or clever.

3. **Trial Run:** Run the robot briefly to demonstrate how it completes the mission(s) of your team's choice. Please do not do an entire robot round. The Judges need time to ask questions after the RDES.

Want to learn more?

- Find the essential details of the Robot Game in the Challenge: www.firstlegoleague.org/challenge.
- Check the Robot Game Updates often: www.firstlegoleague.org/challenge. Here *FIRST*® LEGO® League staff will clarify common questions. Updates supersede anything in this Challenge document and will be in effect at tournaments.
- Your team will be assessed in the judging room using a standard rubric. Review the Robot Design judging information and rubric: www.firstlegoleague.org/challenge.
- Your team will also compete in at least three Robot Performance matches. Learn more about Robot Performance, how to approach the Robot Game with your team, and tips from experienced Coaches in the Coaches' Handbook: www.firstlegoleague.org/challenge.
- If you are completely new, check out the *FIRST* LEGO League Resource page for videos, tips, and additional helpful rookie links: www.firstlegoleague.org/challenge.

Notes

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