DEEP SPACE TERRAFORMERS

ROBOCAMP

# Camp-on-a-Disk Guide

## to planning, organizing and operating your own Robocamp

*The Robotics Academy, an educational outreach of Carnegie Mellon University, has been operating LEGO® robotics camps ('Robocamps') for nearly ten years. The formula we've developed has been tested on thousands of children. By following the suggestions in this guide, you can take advantage of procedures that have proven useful in other camps. You also have the flexibility to customize camp operations to suit your own unique learning environment.*

## Camp Sessions

This guide is divided into 10 sessions. A session is an undefined unit of time– it could be a few hours or it could be a day.

Generally, sessions are designed as half-day units of instruction. So, if you are running a two week day-camp that runs from 9:00 A.M. until 11:30 A.M., each day you would complete one session. Session 1 would start the camp. Session 2 would run on day two, and so on through Session 10.

The Robotics Academy recommends half-day camps. However, If your camp is planned for one week only, the goal would be to complete two sessions per day.

At times, it might make sense to run sessions in an order different from the way they are numbered.

**Session Organizers**

- **Session 1**
  Administration, introduction to the camp theme, parts identification, building your first robot
- **Session 2**
  Working in NXT-G, programming the NXT smart motors.
- **Session 3**
  Programming the NXT light sensors
- **Session 4**
  Programming with NXT touch & ultrasonic sensors
- **Session 5**
  Programming with the NXT sound sensor
- **Sessions 6 - 9**
  Main competition – 'Pantheon Missions'
- **Sessions - 10**
  Graduation Celebration!

Teaching is an art; each person does it differently. Every Camp Director has a different set of resources to offer their camp. Feel free to modify any and all of this material to suit your needs.

## Terraformers CD-Rom Navigation

The Terraformers CD is divided into five activity areas: Neos, Xenon, Hydra, Vulcan, & Pantheon. Sessions 1 through 6 are designed to be implemented as students visit the various moons around Pantheon.

Resources on the CD are identified in this document using the following protocol: (example) NEOS/Task/Mission Guide. The first word 'NEOS' indicates that you will find these resources when you click the button 'NEOS'. 'Task' is an organizer within the NEOS section and 'Printable Mission Guide' is a selection found within the Task organizer.

Robotics Academy

**The National Robotics Engineering Center**
**www.education.rec.ri.cmu.edu**
**roboed@rec.ri.cmu.edu**

## Accessing the 'Vault'

Before anything else, take some time to review the material in the Vault (access using the button just to the right of the Pantheon button in the main navigation bar at the bottom of the screen).

There are many useful items in here, ranging from essentials like registration forms and an itinerary overview to promotional posters, scoring guides and more. Here's a quick summary–

- **Resources** *(some editable in Microsoft Word®)*
  - Quickstart guide to running a camp
  - Materials list: the resources you will need to build the gameboard
  - Graduation notice that should be sent out the first day if you are planning a graduation event for your camp, a promotional poster, camp awards, links to other resources, and more.
  - Promotional poster to advertise your camp
  - Project Management documents
  - Awards to print and hand-out at the end of your camp
  - Useful website links
- **Camp Director's Guide**
  A copy of the guide you are currently reading in case it gets misplaced.
- **Forms** *(administrative forms to help run your camp)*
  - Camper Application
  - Liability Release
  - Medical Information
  - Camp Announcement
- **Props**
  Printable art (PDFs) used to create paper props for the gameboard.
- **Gameboard**
  - Map / layout of gameboard with prop positions, etc.
  - Plans for construction of the physical board
  - Full size print quality gameboard art file if you are having your board printed.

The Terraformers CD contains a wealth of resources that allow you to create an engaging educational experience in a non-traditional learning environment. The first time you use a Camp-on-a-Disk CD-Rom you'll want to click through all the links to get a good feel for the available content before you begin the camp.

## Scoring

Scoring sheets for each of the 'Moon' mission (Neos, Xenon, Hydra, and Vulcan) can be found by clicking the TASK organizer after you've navigated to one of the moons, then clicking on 'Printable Mission Guide'.

The Pantheon missions scoring guide is accessible throughout the Pantheon section. Go to PANTHEON/Mission Profiles, a link available at the far right. This same document can be found on each of the Pantheon mission pages, identified as the 'Printable Scoring Guide'.

## Extra Robocamp Activities

You can implement these into the robocamp at your discretion.

**Robots to Build**

It's difficult for students who are unfamiliar with LEGO parts to build structurally sound robots in their first attempts. The Terraformers CD-Rom includes step-by-step instructions for building 3 robot chassis at the ENTROPY/Robots link; REM, Taskbot, and Cattbot. Our intention is to give campers basic robot structures to work with initially and then to challenge them to modify the robots to accomplish more specialized tasks.

**Campers Team Pages on the Web**

Not all Robocamps will have the resources to have attendees post web-based home pages, but this is a great activity that children love to participate in. If you have the capability, consider having each team create a website of their week's challenges and triumphs.

## Engineering & Time Management

Critical thinking, problem solving, and clear communications are all skills that children can learn at your camp. These skill sets can be taught by turning you camp into an engineering camp. We've included resources that allow you to teach engineering and time management in your camp if you choose to.

Go to the VAULT/Resources link to find several project management handouts for students: Brainstorming, Engineering Journal, Problem Solving, Responsibilities Matrix, and Timeline. These can be used to give you camp an engineering theme. We've also included two video resources that were produced for our Guided Research and Engineering CD. These videos can be found in ENTROPY/Basics section of the product: *Engineering Process* and *Project Planning*.

***Engineering Process* video** - provides campers with a friendly guide on how engineers plan projects. The video speaks to a five step methodology to solving engineering design problems: research, plan, prototype, test, and commercialize.

***Project Planning* video** - is appropriate for viewers of any age and contains useful tips and fundamentals for planning work on any type of project.

## Teams & Teamwork

Children are assigned to teams at the beginning of the Robocamp. Counselors should try to create compatible teams. The camp only lasts a week (or two) and the better each team gets along with its members the easier the learning and fun will be.

Team members are encouraged to assume different roles each day: programmer, engineer, project manager, communications specialist. There's no need to follow this rule to the letter, but we do encourage campers to share roles. Some campers only want to build, others 'hog' the computer and only do programming. We monitor the situation so that all have a chance to do both.

**NOTE:**
*There are children that will go home and tell their parents that they didn't get the opportunity to try programming or building robots. If you assign roles campers must fill throughout the week, changing their responsibilities once or twice, you will eliminate this problem to a large degree.*

## Graduation Day

At the end of each camp, a 'graduation' can be held. The graduation ceremony does several things:

1. Gives the children an opportunity to present what they have done / learned.
2. Gives the parents an opportunity to see what their children did.
3. Brings prestige to your camp; bring the media if possible– we identify a keynote speaker who makes opening remarks.

## Session 1

***Welcoming campers / Building with LEGO***

This next section covers the first day of camp, and is directed especially at the first time camp director. Remember that Robocamp is intended to be fun. It's a camp!

**Opening Day**

As parents drop children off for the first day of camp remind them when they will need to come back to pick up their children. Be sure to tell parents that if they are going to have someone else pick up their children that you should be notified in advance.

Campers will not all arrive at the same time. Have something for the 'early birds' to do while waiting for the rest of the campers. Showing camp related videos on a TV or big screen (if possible) is a great way to fill this time.

The first day will involve many administrative tasks– you'll want to have everything prepared and rehearsed with your staff in advance.

- Provide NAME TAGS for your campers and staff.
- Assuming that most of the campers may not know each other, it's a good idea to have some activity to allow them to ease into their new environment. A good ICEBREAKER ACTIVITY is to have campers interview each other and then have one camper introduce the other camper. You may want to prepare a LIST OF QUESTIONS for the children depending on their ages.
- Hand-out a WRITTEN ITINERARY of how the camp will proceed. (What's happening on day 1, day 2, etc.) Campers can take this home for parents to review.
- If your camp includes a graduation ceremony, send an INVITATION to the camper's parents allowing them some "lead time" to schedule the day if they wish to attend. When campers know there is a graduation ceremony where they are responsible for presentations, it serves as motivation to complete activities.
- Welcome your campers & INTRODUCE YOURSELF and the staff..
- Assign campers to TEAMS. Our suggestion is to pair boys with boys and girls with girls and also to separate children according to age.
- ASSIGN KITS to teams; Have an organized cleanup procedure; and remind campers they are responsible to follow it. Remember that whatever campers don't clean up– you get to clean up!

**Review camp rules:**

- Campers will treat everyone with respect.
- Cleanup and storage procedures
- Rules for leaving the room or camp facility
- Parent pickup procedures
- Lunch or snack rules
- Your specific camp rules

**Review the big picture of what campers should be learning:**

- Technological literacy
- Programming
- Project Management
- Teamwork
- Problem solving
- Time management

(All qualities future employers will be looking for)

**Presenting the Big Picture**

***The DEEP SPACE TERRAFORMERS Robotics Camp***

By adding your own enthusiasm to the 'kick off' of the Robocamp, you can set a mood that will help your campers learn and have fun.

This week, campers will be travelling on the starship ENTROPY to the planet Pantheon to begin to TERRAFORM that planet. Robots will be used once campers get to Pantheon so for the first couple days of camp they will practice programming on the moons that surround the planet; NEOS, XENON, HYDRA, and VULCAN. Each moon has a special characteristic and robot challenge to overcome. They will be designing and programming robots to help accomplish tasks at the moons, and experience roles as engineers, programmers, designers, and researchers.

Roxie S. Rivetminder, the Entropy Commander-in-Chief, provides an overview in the Preview slideshow, found when you click the ENTROPY button.

Encourage campers to explore ENTROPY– there they will find a wealth of resources. Campers can watch a 'cinematic' video that explains the concept of terraforming at ENTROPY/Terraforming. They will also find lessons on programming and an explanation of what engineering is all about.

Remind campers that they'll be working in teams of two, three, or four depending on how the camp is set up. Since campers are encouraged to exchange roles each day, let them know the various tasks they can expect to be engaged in. Note what engineering entails, and how robots can be designed before they are built, but also the importance of 'seeing' how the design might work or not as you actually put the pieces together. There's more than one way to do something right! Remind campers that one of the goals is to develop teamwork, and it is important they work as a team, giving everyone a chance to contribute equally.

Let campers know that they will complete one or two exercises / challenges each day. (You can present awards at the graduation ceremony for participation in the challenges.)

**What to cover in this session**
Remember this is a camp– keep your formal presentation to a minimum, and teach concepts on a 'need-to-know' basis.

- Part identification (they can learn these by reading the names as they find the parts) encourage campers to use proper terminology when they discuss parts. ENTROPY/Robots.
- Parts of the NXT (this can be taught on a need-to-know basis)
- Systems of the robot (this depends on the age of your campers)
- Smart Motor demonstration
- Have campers write a few simple NXT-G programs. Example programs can be found at: ENTROPY/Programming.

**Learning Objectives for Session 1**

- Learn camp rules.
- Identify what makes a robot a robot: SPA (Sense / Plan / Act)
- Identify the major components of the NXT.
- Identify the systems that make up NXT robot.
  - NXT: the controller
  - The Chassis: supports all systems on the robot.
  - The Motors: move the robot (mention polarity here).
  - The Connecting Leads: send the signals from the NXT to the motors and from the sensors to the NXT.
  - Sensors: give feedback to the NXT.
- Identify parts and build a complete NXT robot.

## Session 2

***Campers first attempts at programming***

In Session 2, campers learn how to navigate using the NXT programming language used to program LEGO robots. (You can also use other programming languages; ROBOTC, etc., if you desire.)

Campers can begin attempting the simple programming challenges on the first moon, NEOS. This challenge is designed to use only the 'move block' to solve the problem: move forward, backward, turn, and the 'wait for' bock. There are programming examples at ENTROPY/Programming/Motor Block programs. Depending on the age and skill of your campers you may either point them to the sample programs, or challenge them to develop program solutions on their own. Based on the limited amount of time for Session 2 (one day) we suggest a demonstration of writing basic code to achieve certain robot 'moves' and then challenging campers to revise the programming in some way.

**What to cover in this session**
Review from Session 1. Have campers answer these questions:

**A.** What is a Robot?
**B.** What does the NXT do?
**C.** What is a system?
**D.** Name a few basic LEGO parts.

**Starting the NXT Programming Software**
Campers will find an introductory video on how to use the NXT programming language at: ENTROPY/Basics/Intro to Programming. Open the link and watch the video to begin. Staff from the camp can also demonstrate how to use the software.

**Storing programs**
Campers should be shown where they should store their programs on the computer. They need to learn how to make a folder, name it, and save all their work into the folder.

**Basic programming**

***Moving Forward***

- To introduce campers to NXT software, have them write a simple program to make the robot move forward. This can be found in ENTROPY/Programming/Motor Block Programs/Motors/Move forward 720 degrees
- After they have completed this, have the campers modify their program so that the robot's movement is different.
  - Teach the campers to find, connect, and delete the icons.
  - Teach them to use the modifier pallet at the bottom of the 'motor' and 'wait for' icons. This is very intuitive, but you can find examples of programs with different modifiers in the programming example section.
- Encourage campers to use language that is appropriate to programming, such as modifier, icon, loop, conditional statement...
- Demonstrate how to download the program to the NXT.

***Moving Backward***

- Have campers write a program to make the robot move backwards after it has gone forward. This exercise is located in ENTROPY/Programming/Motor Block Programs/Motors/Forward then reverse

***Turning***

This exercise encourages campers to think about the physics of turning. They can study the physical robot for clues.

- Students must first decide which direction the wheels must turn in order to make a left turn or right turn, and note how this is different from a car. They should understand that there are three ways to make the robot turn:
  - One wheel remains stationary while the other wheel moves forward. (resulting in a wide turn)
  - One wheel moves backward while the other wheel moves forward. (resulting in a point turn)
  - One wheel remains stationary while the other wheel moves backward. (resulting in a wide turn)
- An example of how to program turns can be found at: ENTROPY/Programming/Motor Block Programs/Motors/Swing turn left

**Challenge for the Day**

- Gather and transport rocks to the extraction area...! NEOS/Task

  *Note: we are assuming that you are starting with novice programmers. You will move through these exercises quickly if your campers are more experienced.*

- Campers will need to write a program that allows them to get to the rocks and then move them to a specified location.
- Campers will need to construct something to push the rocks.

**What might your students have trouble with today?**

- Finding the icons and wiring them.
- Troubleshooting their solution. It is important that campers learn scientific method and use it regularly when operating their robots. Do things the same way every time.
- Downloading the program to the NXT– campers may forget to turn their robots on.
- Getting their robots to move point to point accurately. Encourage them to use degrees when programming. Depending on the age of the campers you may want to teach them to calculate how far the robot will travel based on wheel rotations.
- Building an attachment to push the rocks.

**Learning Objectives for Session 2**

- Open up the NXT Programming software
- Write basic programs to move forward, backward, turn, and navigate to pick up the surface rocks
- Building an attachment to push the rocks
- Use proper terminology
- Upload code to robots
- Troubleshoot programming problems

## Session 3

***Light sensors and conditional statements***

In Session 3, campers will get their first experience programming sensors. Encourage campers to program using feedback from sensors instead of timing– children like timing and will try to use timing for everything. This challenge may take multiple sessions. Break teaching the light sensor down into smaller challenges. Campers also have to build a gripper for this challenge which can be difficult...!

**What to cover in this session**
Demonstrate how the light sensor works. Technical data can be found at: XENON/Task/Light Sensor Tech Data.
Programming example can be found at:
ENTROPY/Programming/Sensors/Light: Timed line track.

Explain to campers that:

- The photoresistor that is located in the light sensor acts as a transducer and converts light values into an electrical signal. That is shown graphically at: XENON/Task/Light Sensor Tech Data.
- What a conditional statement is. You will need to look that up. Search 'Boolean Logic' on the Robotics Academy web site.
- What a threshold is. Search 'Threshold' at the Robotics Academy web site.
- The NXT shows the feedback the robot is getting on the view screen.

Multiple examples of how a light sensor is programmed can be found at: ENTROPY/Programming.

**Programming Exercises**

***Wait for Dark***
Have campers attach the light sensor to their robot and test the ENTROPY/Programming/Sensors/Light: Wait for light program.

Next, challenge the campers to write a program that will make their robot stop when it sees a black line. Explain what a threshold is and have them test it out.

*Note: begin to instruct students to build robot behaviors in small parts. Write a simple behavior (move forward until light), test the behavior, and make sure that one behavior works before adding other behaviors.*

***Table Bot Challenge***
Give the campers the Tablebot Challenge to introduce the concept of a loop: ENTROPY/Programming/Challenges/Tablebot

***Line Tracking Training Task***
Have campers build the line tracking program and test it. ENTROPY/Programming/Sensors/Light: Timed line track. This program consists of a nested conditional statement and can be confusing to students.

***Recover the Moon Buggy***
Assign campers the goal to rescue the moon buggy. *This is a hard challenge and it may take multiple sessions.* XENON/Task.

**What might your students have trouble with today?**

- Since this is their first time working with sensors, students may have a difficult time remembering to make sure that they modified the icon to connect with the correct sensor port.
- You will need to teach what the default port is for each sensor (Port 1 default is the touch sensor). It may be easier for you to have students build their robots with the sensors wired correctly into the default ports.
- The icons may be confusing. You can do all of the programming to complete most tasks in the common pallet which only has six icons.
- Campers will need to be able to calculate threshold values.
- The concept of the loop and the conditional statement being used at the same time will be confusing. Have them do the Table Bot challenge before they attempt the line track program.
- Building a gripper to grab the moon buggy.

**Learning Objectives for Session 3**

Campers should be able to:

- Describe what a sensor is.
- Describe a conditional statement.
- Describe how modifiers are used with the light sensors.
- Read the feedback from the view screen on their robot.
- Use conditional statements to control robot behavior.
- Calculate a threshold.
- Cooperatively work in teams.

## Session 4

***Introduction to the Touch and Ultrasonic Sensors***
The touch sensor give digital feedback; it is either on or it is off. Technical data can be found at: HYDRA/Task/Touch Sensor Tech Data. In this challenge campers will be asked to use feedback from their touch sensor to identify that they reached a particular spot. .

A programming example for the touch sensor can be found at:
ENTROPY/Programming/ Sensors/Touch: Wait for push

**In this session campers will be challenged to:**

- Design a robot that will reach the water tower and position the water extraction pipeline. HYDRA/Task/Printable Mission Guide
- Program their robots to use combination
  ENTROPY/Programming/Sensors/Touch: Wait for Push
  ENTROPY/Programming/ Sensors/Light: Timed line track
- Design and build an extraction pipe as well as a touch sensor apparatus to contact the water tower.

**What to cover in this session**
Build a robot with a touch sensor attachment on the front of the robot and demonstrate how it works:

- Point the campers to the technical data page that shows how the touch sensor works, HYDRA/Task/Touch Sensor Tech Data
- Explain the difference between analog and digital feedback.
- Have the campers build prototypes of their mechanical solutions for both the extraction pipe as well as their touch sensor apparatus.
- Many campers will have a hard time designing an arm. Discuss 'form follows function'.
- Demonstrate how to make things move and how gears work.
- Encourage campers to research how other people make things move.

## Ultrasonic Sensor

Campers can also identify where the water storage tank is using the Ultrasonic Sensor. Technical data for the ultrasonic sensor can be found at: HYDRA/Task/Ultrasonic Sensor Tech Data

Programming examples for using the ultrasonic sensor can be found at:
ENTROPY/Programming/Sensors/Ultrasonic: Wait for near

- Campers will need to remember that the ultrasonic sensor requires the programmer to calculate a threshold value.
- Tell the campers to try the ultrasonic sensor in different environments. The signal from the sensor can vary based on where it is being used.

**What might your students have trouble with today?**

- Integrating sensors, grippers, etc. on to their robot. These are mechanical design problems; many campers will need direction implementing their ideas.
- Assigning the proper port to the icon and then actually connecting the sensor to the right port. Often campers will modify their robot and it will no longer work the same because it may be wired differently.
- Designing a mechanical solution that extends the reach of the touch sensor. The touch sensor is very reliable when it is able to be pressed. If the button doesn't get pressed, then the sensor doesn't activate.

**Learning Objectives for Session 4**

- Students should be able to explain the ultrasonic sensor.
- Calculate threshold values.
- Program their robot, to complete the challenge

## Session 5

***Introduction to the Sound Sensor***

The sound sensor can hear a range of sounds. There is technical data at: VULCAN/Task/Sound Sensor Tech Data. In this challenge campers will be challenged to use feedback from the sound sensor to trigger the motor to shut down the solar station.
VULCAN/Task/Printable Mission Guide

**What to cover in this Session**

A sound sensor also uses a threshold value in order to determine what will trigger the motor to turn on and off. Depending on how noisy it is in camp you may not have much luck with sound senors. If you need to modify the challenge to use feedback from a sonar sensor that will work.

**What might your campers have trouble with today?**

- Navigation through the volcanoes. This should be done using the smart motors.
- Threshold– campers often have difficulty understanding this important concept.
- Using multiple sensors– As campers begin to use multiple sensors, they often forget to identify the ports the sensors are connected to.
- The design of the mechanism that shuts down the solar station.
- Nested conditional statements– this is powerful programming concept. It is important to give campers plenty of practice reinforcing this topic.

**Learning Objectives for Session 5**

Campers should be able to:

- Explain how the sound sensor works.
- Write a program to navigate through the volcanoes.
- Use the view screen on the NXT to read the feedback from the sound sensor
- Calculate threshold
- Design a mechanism to shut down the solar station.

## Extension activities for advanced campers

Typically, camps will contain a mix of campers with diverse skill sets. In order to challenge more advanced campers, you can modify any of the activities to make them simpler or more difficult. More challenges can be found in the programming section: ENTROPY/Programming/Challenges

These challenges are designed to incorporate all camper-learning to date. Continually encourage campers to use feedback from sensors. Campers will want to use timing.

***Problem solving, Sensor integration, Advanced programming***

Campers use their growing knowledge of light sensors, smart motors, ultrasonic sensors, sound sensors, and touch sensors to complete the multiple camp challenges. Depending on the skill level of your campers and staff they may or may not have completed all of the challenges found on the first four moons; NEOS, XENON, HYDRA, and VULCAN. Some of these challenges are fairly difficult.

You might want to institute a checklist of all programming/engineering challenges and have campers attempt to complete all of them. Each camp is run differently and so the decision will be left to the camp director. (In the camps run by the Robotics Academy we give multiple awards at the end of the camp to all campers.)

## Sessions 6-9

***Terraforming Pantheon***

***Culminating Competition / Challenges / Activity***

The culminating event of Robotics Academy camps is the final set of challenges, which unfolds as a competition and adventure. The Terraforming challenge has ten missions that campers can attempt to solve. We always let the campers decide the missions that they want to attempt. They need to look at the difficulty of the mission, the amount of points awarded, and their interest in the challenge.

We hold the competition either on graduation day or the day before graduation. The advantage of holding the competition on graduation day is that parents get to see the campers compete. The disadvantage is that the camp director may get stuck sorting everything at the end of the day because parents and campers will want to leave after the competition.

The game board can either be made by you before camp or it can be part of the camp activity. You may assign campers that are ahead of other campers to build the artifacts & props that make up the camp. We would caution camp directors that this can take considerable time.

**The Terraformer 'game day' missions are:**

Plant the Flag
Rescue the Moon Buggy
Plug the Volcano
Pulverize the Rocks
Analyze the Fumaroles
Deploy the Habitats
Retrieve the Batteries
Extract the Lake Water
Align the Solar Panel
Power up the Satellite

These missions are located on planet PANTHEON

The camp director is able to modify or change any of the activities to fit the needs of their robotics camp. Awards should be given during the graduation ceremony. Our goal is that every camper takes multiple awards home.

## Session 10 Graduation Celebration

*Definitely plan a graduation celebration. Parents like to come and see what their campers did...!*

Good luck,
***The Robotics Academy staff***