# Mission: Moon Math Challenge

**Grade Levels: 5-8**

**Focus Question:** What kind of measurement can you make of the Moon?

1. Example: What is the diameter of a crater on the Moon?
2. Example: How long does it take the Moon to rotate once on its axis?
3. Example: Does the Moon move at a constant speed in its orbit?

**Instructional Objectives:**

1. Students will acquire basic measurement skills.
2. Students will understand measurement uncertainty in scientific investigations.
3. Students will conduct a scientific investigation in the context of the Moon.
4. Students will research lunar geology, geography, topography and lunar cycles.
5. Students will provide an oral and written presentation summarizing the results of their experiment.

**National Standards**

*Science:*

- Abilities necessary to do scientific inquiry
- Understanding about scientific inquiry
- Earth in the solar system
- Understanding about science and technology

*Mathematics:*

- Understand measurable attributes of objects and the units, systems, and processes of measurement
- Apply appropriate techniques, tools, and formulas to determine measurements
- Formulate questions that can be addressed with data and collect, organize, and display relevant data to answer them
- Develop and evaluate inferences and predictions that are based on data
- Communicate their mathematical thinking coherently and clearly to peers, teachers, and others

*Technology (from International Society for Technology in Education):*

- Students are proficient in the use of technology
- Students use technology tools to enhance learning, increase productivity and promote creativity.
- Students use productivity tools to collaborate in constructing technology-enhanced models, prepare publications and produce other creative works.
- Students use telecommunications to collaborate, publish, and interact with peers, experts, and other audiences.
- Students use technology tools to process data and report results.

# INTRODUCTION

NASA is returning humans to the Moon as early as 2020, with a robotics mission planned as early as 2015. Today's students will be our next generation of explorers and just may be the first people to live and work in a community on the Moon. Since measurement is a fundamental building block for science, technology and engineering, the **Moon Math Challenge** is an opportunity for students to conduct an experiment to enhance their measurement skills. Students can create a project on any aspect of the Moon and its relationship to the Earth and the Solar System. More importantly, is that students must emulate the same procedures as NASA scientists and engineers must go through when conducting a research project. Students must first propose a project to NASA, then conduct an investigation by collecting real data. Students can then "ground-truth" their results by researching data that may already exist in similar context. Finally, the students present their findings to a panel, just as a real scientist would at a professional conference.

What makes the **Moon Math Challenge** a unique activity is the interactivity students receive with a NASA scientist or educator through NASA's Digital Learning Network**.** Bite-sized, mini-lessons on parts of the Challenge are offered every 2-3 weeks by way of videoconferencing events through NASA's Digital Learning Network (DLN). Students participate in hands-on activities with the host to address skills students need to meet national education standards. Also, a Question-and-Answer session will be part of each videoconference to allow teachers and students to ask questions about their specific projects. In addition, there are three video segments available on the **Moon Math Challenge** website for students that coincide with each videoconferencing event. These video segments are a simple introduction and review of basic measuring concepts. They also outline the steps to follow in an experimental procedure, demonstrating the crater measurement project.

- ★ Video 1: Units and Measurement
- ★ Video 2: Measurement Uncertainty
- ★ Video 3: Data Analysis and Presentation

Furthermore, the intent of the **Moon Math Challenge** is to involve not only teachers and students, but at least one family member as well. Family members can contribute to the project in an assortment of ways, from an adult helping conduct literary research to a younger sibling contributing artwork to the project.

Through **Moon Math**, the program culminates to a nation-wide judging event. Students who scored highest in their local challenges have the opportunity to present their projects to a NASA panel of judges through the DLN. The end product is two fold: students develop a sense of pride in the work they accomplished since they have the opportunity to share their work with NASA personnel; and NASA can ascertain first-hand how its education program is being utilized in the classroom and how it may have an effect on a students' outlook on STEM careers.

# CHALLENGE REQUIREMENTS

*Pre-Challenge Requirements*

1. **Online teacher and student registration.** Teachers must register their student teams, provide their research question and write a brief proposal.
2. **Pre-assessment.** A brief assessment is required to be completed by students for instructors to acquire students' level of understanding prior to the Moon Math Challenge.

*Objective One*

- **DLN Event 1: Introduction to the Moon Math Challenge; Measurement tools and units.** During this event, the host introduces the Moon Math Challenge and runs an 'icebreaker' to get to know the students. A short video on measurement skills is presented. The host then leads the class into a lesson about the use of appropriate measurement tools and measurement units corresponding to example scales.
- **Conduct background research.** Students should spend time in a library or computer lab to learn basic lunar characteristics and the history of lunar exploration.
- **Submit Proposals.** Student teams must send a brief proposal explaining their research question and how they plan to conduct their experiments.

*Objective Two*

- **DLN Event 2: Measurement Uncertainty.** This second event should occur two to three weeks after the first. A short video is presented on how to start a project for Moon Math. The host then conducts a hands-on activity with the students to demonstrate how a margin of error can exist, emphasizing measurement uncertainty that occurs in real science investigations.
- **Collect data.** Student teams should begin their investigation and data collection.

*Objective Three*

- **DLN Event 3: Data analysis and presentation.** This event should occur two to three weeks after the second event, or about three to four weeks before projects are due. During this event, a third video is shown and the host demonstrates proper data recording technique and data presentation styles. Students learn about data tables and graphs and how to properly label them.
- **Complete experiment.** Student teams should finish their investigation, tabulate or graph their results and write a report.

*Objective Four*

- **Host a Local Challenge.** Teachers must arrange a local Moon Math Challenge in their class or school. Student teams give an oral presentation about their project to a panel of judges. Team with highest score is recommended to NASA ESC for participation of Regional/National Challenge.

*Post-Challenge Requirements*

1. **Online submission of students' reports and scores.** Teachers must submit scores for each student team from their local challenge and the winning team's written report and oral presentation.
2. **Post assessment.** A post-Challenge assessment must be completed by students who participated in the Challenge. Again, this is for the instructor to evaluate students' level of understanding.
3. **Regional/National Moon Math Challenge.** Winning teams of local challenges will then compete regionally or nationally through additional videoconferencing events.
4. **Certificate of participation.** Each student to successfully complete all requirements of the Moon Math Challenge (including both assessments) will receive a certificate of participation as submitted by registered teacher.

## SAMPLE PROJECTS

Herein is a listing of sample projects. Each question requires a measurement to be made with the Moon. This list is by no means a limit to the types of investigations in context of the Moon. Allow students to explore their own ideas and questions they may have about the Moon.

**Project A**

Your mission is to place solar powered transmitters on the Moon. The receiving stations on Earth (one at your latitude and one at the Equator) need to be able to track the Moon as a function of phase and are programmed to receive signals at a certain time.

- ★ **Question:** At what phase(s) is the Moon at an altitude of 45 degrees above the horizon at the two receiving stations?

- ★ **Measurement:** Measure the altitude above the horizon and record the phase of the Moon at a given time (e.g. 6 PM) from one location. Build your own quadrant with cardboard, a straw, string and a washer.

**Project B**

The Moon, like the Earth, is not a smooth, round ball. It has features like mountains and valleys and seas. You have to decide where your spacecraft should land on the Moon.

- ★ **Question:** Does a spacecraft have to land on the lunar maria, or could it land in a crater?

- ★ **Measurement:** Determine the sizes of the craters on the Moon.

**Project C**
You are looking for a place to land your spacecraft on the Moon.

- ★ **Question:** Is there any difference between the near and far sides of the Moon, other than one faces Earth and one doesn't?

- ★ **Measurement:** Determine if the size distribution of craters is the same on the near and far sides of the Moon using Clementine data.

**Project D**
A landing site has been selected. You need to know about the rotation of the Moon so that the spacecraft can be pointed in the correct direction with the correct speed.

- ★ **Question:** How long does it take the Moon to rotate once on its axis?

- ★ **Measurement:** Track the speed of features across the surface of the Moon throughout a complete lunar cycle.

**Project E**
You need to know where to point your spacecraft and how fast to send it.

- ★ **Question:** Does the Moon move at a constant speed in its orbit?

- ★ **Measurement:** Measure the times between transits (of a pre-determined line) by the Moon over the course of a lunar cycle to determine its orbital speed as a function of time (e.g. date, phase).

**Project F**
You need to know how much fuel you'll need to send a spacecraft from the Earth to the Moon, so you need to know how far the Moon is from the Earth.

- ★ **Question:** Is the Moon always the same distance from the Earth?

- ★ **Measurement:** Measure the size of the Moon over the course of one lunar cycle and determine how much the distance from the Earth to the Moon is changing. Use a digital camera or make your own drawings.

# THE ACTIVITY

In order for students to complete **Moon Math** successfully, they must use the scientific method to conduct their investigation. Numerous times students are unaware of the steps involved in accomplishing the scientific method. Students should understand the following:

**1. Investigate**
All good scientists start an experiment by first doing some background research. Make a list of the questions you have about the Moon. Use the web and the library to learn about the Moon. Are all of your questions answered? Keep track of the books or websites you use while you are doing your background research.

**2. Create a question**
Now you must ask a question that you can answer by making a measurement. You can choose one of the sample projects, ask your teacher for ideas for a different project, or come up with an idea of your own.

**3. Design an experiment**
It is important to design an experiment that is not too hard. Try to keep your experiment simple. Make it so that someone else could repeat your experiment easily.

For example:

- If you are going to build a stand to set a camera on to keep it pointed at the Moon, make it as simple as possible.
- If you are drawing a wall map of the Moon using the electronic eyepiece on your telescope, mark the spot on the floor where the telescope sits so that it will be the same each time.
- If you are measuring how high the Moon is above the horizon at the same time each night, ask a family member to help by setting an alarm for that time so you don't forget.

**4. Make a prediction**
Now that you have a question that your experiment will try to answer, what do you predict the answer will be? Write this prediction down because you will need to include it in your Final Report.

**5. Make your measurements**
You need to keep a log book for your experiment. What is the quantity you are measuring? If you are measuring the time the Moon rises each night, the quantity would be *Time of Day*. If you are measuring the size of craters you have drawn, the quantity would be *centimeters*.

Units of measure are very important. Are you using inches or centimeters? Minutes or seconds? Because the scientific standard is metric, if you make measurements in English units (such as inches), be sure to include an extra column in your table where you have converted to metric units (such as centimeters).

**6. Analyze your data**

After you make all of your measurements, you must decide what they mean. You will interpret your results. For example, if you are measuring the size of craters on a wall map, and you have made your measurements in centimeters, you have to figure out what that means for the actual size of the craters on the Moon, say, in kilometers.

You must also decide how to best show your results to the judges. Often charts or graphs are easier to explain than tables of numbers. Make sure to include a finished data table(s) and a chart or a graph in your Final Report.

Start to finish, these are the steps to follow to complete the **Moon Math Challenge**:

1. Students begin background research on the Moon.
2. Participate in DLN Event 1.
3. Student must ask a question relating to the Moon that can be answered by making a measurement. Teachers may assist the student in selecting a question to research.
4. Design an experimental investigation around that question.
5. Submit a short proposal (300 words or less) to NASA that includes the question to investigate and the experimental procedure. Student must complete pre-test (evalution).
6. Teacher should review student research. Verify lunar information and validate literary sources.
7. Participate in DLN Event 2.
8. Start project investigation and collect data. This will require at least 30 days, especially if the chosen topic is dependent upon viewing the lunar cycle. Participants must prepare for unobservable days due to inclement weather.
9. Teacher should review student research. Verify students are making their own measurements and recording data.
10. Participate in DLN Event 3.
11. Complete research. Write up results of the investigation. Prepare a written report and oral presentation.
12. Host Local Challenge. Select teachers, administrators or community members to serve as judges. No judge needs background knowledge of the Moon.
13. Select a winning team. Submit names and scores to NASA ESC.
14. One team per school to participate in a National Challenge via videoconference.

Feel like this guide is not enough to give you a complete understanding of the Moon Math Challenge? Teachers may register and participate in a training session through the DLN. Training sessions will be provided by three NASA Centers. Register for one of these events by contacting NASA-ESC@nasa.gov.

## FALL 2006 MOON MATH SCHEDULE

| Event | Date | Notes |
|---|---|---|
| Overview and Training | September 13 | Teachers can participate in a Moon Math training session via the DLN |
| Registration | September 1-30 | Teachers must first register their class prior to student registration |
| DLN Event 1 | October 3-7 | Measurement Basics |
| Letter of intent and pre-assessment due | October 21 | Students can send their proposals as plain text to nasa-esc@nasa.gov |
| DLN Event 2 | October 24 – 28 | Measurement Uncertainty |
| DLN Event 3 | November 14-18 | Data Analysis |
| Final reports due | December 1-16 | Submit written reports to your teacher and complete oral presentations. |
| Local Challenges | December 1-16 | Scores can be submitted to NASA-ESC@nasa.gov |
| Regional/National Challenge | January/February | Judged by NASA scientists and educators via DLN |

## INTERNET RESOURCES:

- Basic Moon facts:
  - http://solarsystem.nasa.gov/planets/profile.cfm?Object=Moon

- NASA's Lunar Reconnaissance Orbiter (LRO) is the first of the Robotic Lunar Exploration (RLE) missions, planned for launch by late Fall 2008 and will orbit the Moon nominally 1 year.
  - http:// lunar.gsfc.nasa.gov/

- Developed by researchers at NASA Ames Research Center, World Wind is a free downloadable program that lets you zoom from satellite altitude into any place on Earth. And now World Wind has the ability to browse Clementine moon data with full 3D terrain.
  - http:// worldwind.arc.nasa.gov/moon.html

- Research the history of NASA's Apollo Program.
  - http:// spaceflight.nasa.gov/history/apollo/

- View NASA educator guides and lithographs related to the Moon at
  - http://www.nasa.gov/audience/foreducators/topnav/materials/listbytype/Exploring.the.Moon.html

  - http://www.nasa.gov/audience/foreducators/topnav/materials/listbytype/Earths_Moon_Lithograph.html

- Check out this educational resource that provides an assortment of lunar images, each accompanied by a description referring to visible details.
  - http:// www.lpod.org/

# PRE-CHALLENGE ACTIVITIES:

## A. A Mathematical Exercise

If the gravity on the Moon is 1/6$^{th}$ of the gravity here on Earth, then how would that make things different? Use your mathematical skills to answer the following questions.

1. Your mom can jump a pile of laundry that is three feet across. On the Moon how big is the pile of laundry she can jump?
2. Your little brother can leap two feet on Earth. How high can he leap on the Moon if he can leap six times as high?
3. You can spit a watermelon seed one foot on Earth in your back yard. How far might that seed travel on the Moon?
4. If the lunar rover weighs about 460 pound on earth how much does it weigh when it is on the moon?
5. If you are able to lift 30 pounds on Earth how much can you lift when you are on the Moon?

## B. Moon Rotation Exercise – Does the Moon rotate on its own axis?

Select two students to represent the Earth and the Moon. Each student must hold the end of a 5 or 7ft string or jump rope. The Moon orbits the Earth by keeping the rope taunt as it moves around the Earth moves along its orbit. Halt the demonstration and explain that the Moon takes about 27 days to go around the Earth. Ask the students to choose appropriate speed of travel for the moon and how many steps represent on Earth day. (For example, the Earth might take heel-to-toe steps while the Moon takes longer steps.) Now add that the Earth rotates on its axis once every 24 hours and tell the Earth student to spin as required. Next add that the Moon rotates on its axis at the same rate that it revolves around the Earth. Students should determine that this results in the "face" of the Moon always being directed toward the Earth. *The Moon does rotate and the far side of the moon is only dark to us from Earth's perspective.* The sun sees it regularly. Take it one step further and add a third student to represent the Sun.

# GENERAL RULES AND REGULATIONS FOR NASA-ESC

1. All participants must successfully register online.

2. Participation is restricted to students and teachers attending U.S. Schools (this includes U.S. possessions and schools operated by the U.S. for the children of American personnel overseas).

3. Teachers or administrators must register his/her students[a] by emailing NASA-ESC@nasa.gov. Include teacher name, school name, school address, number of students participating, grade level, and email address.

4. There is no limit to the number of student participants from each school.

5. Only students whose names have been submitted through his/her teacher's registration will be allowed to submit entries to the NASA-ESC Challenges.

6. All students must have access to the internet in order to participate in a NASA-ESC Challenge.

7. All entries are evaluated according to the published rubrics and requirements for each respective challenge. Judges' decisions are final.

8. Each registered student/class/school must submit separate entries for their respective challenge.

9. Each document submitted to the NASA-ESC project office must include the student last name, or the school's name, and the challenge abbreviation in the title of the document. Please see the following examples:

| **Challenge:** | **Example:** |
|---|---|
| Name the ISS Node 2 | Name_N2.ppt |
| Moon Math | Name_MM.doc |
| Fuel Your Imagination! | Name_FYI.doc |
| Design a Lunar Outpost | Name_DLO.ppt |
| Teacher Challenge | Name_TC.pdf |

10. All work submitted to the NASA-ESC challenge's must be original and free from copyright.

11. NASA maintains the right to accept or reject any submitted work. All entries become the property of NASA and the Exploring Space Challenges.

12. Final documents for each respective challenge must be electronically submitted by their deadlines, as follows:

| Challenge: | Deadline: | Documents: |
|---|---|---|
| Name the ISS Node 2 | December 1st, 2006 | Slide Presentation & Essay |
| Moon Math | December 16th, 2006 | Slide Presentation & Report |
| Fuel Your Imagination! | January 31st, 2007 | Story |
| Design a Lunar Outpost | February 16th, 2007 | Electronic scrapbook or video |
| Teacher Challenge | March 3rd, 2007 | Instructional guide and proposal |

If you encounter any difficulties, or have any questions please direct them to the NASA-ESC project office at NASA-ESC@nasa.gov.

[a] The NASA-ESC Project Office understands that some students may drop out during the course of their Challenge. If such an event occurs please notify the NASA-ESC Project Office. If this event leaves a team with only one student, the student remaining in the Challenge will not be penalized and may have the choice to continue with their project of his/her own or join another team. It is the teacher's responsibility to contact the NASA-ESC Project Office if any changes occur in a teams' participation status.

## SPECIFIC RULES FOR MOON MATH CHALLENGE

1. Only students in grades 5-8 may participate.

2. Each *Mission: Moon Math* challenge team must be composed of two students and one family member.

3. Each registered team must submit a letter of intent[b] to the NASA ESC. Please see your challenge timeline for this deadline. Please see your challenge timeline for this deadline.

4. Only one team from each school may be selected from the Local Challenge to participate in the Regional/National Challenge hosted through the Digital Learning Network (DLN).

5. All registered schools are expected to be involved in each videoconferencing event. Missing a scheduled videoconference *could* disqualify your teams.

6. All Local Challenges must be completed by December 16th, 2006. The National Challenge will be completed by February 28th, 2007.

7. An all-expenses paid trip to Space Camp will be awarded to only two students of the winning team from the National Challenge. No family members or teachers will be included in this award.

8. All Local Challenges and judging panels for the local event must be arranged by the teacher and completed by December 16th, 2006

[b] The letter of intent is to be submitted by each team through the NASA ESC website. This letter must state in 300 words or less the student(s)'s project choice (project title or question) and a short outline of how the student(s) plans to proceed with the project (i.e. their methods).

# JUDGING RUBRIC
# ORAL PRESENTATION

| CATEGORY | 4 | 3 | 2 | 1 |
|---|---|---|---|---|
| **Content** | Information presented by both team members is accurate, concise and relevant to the Moon Math Challenge. **Project is described completely.** | Information presented by both team members is accurate, concise and relevant to the Moon Math Challenge. **Presentation lacks a statement of the question** being answered OR **lacks the answer to the question** in the conclusion. | Information presented by both team members has **minor** errors. Project is not described completely. | Information presented by both team members has **major** errors. Project is not described completely. |
| **Comprehension** | Both team members demonstrate understanding with **superior** answers, pertaining to the history, relevance to NASA efforts to return to the moon, application and theory of the Moon Math Project. | Both team members demonstrate understanding with **adequate** answers, pertaining to the history, relevance to NASA efforts to return to the moon, application and theory of the Moon Math Project. | Team members have **minor errors** in their understanding of history, relevance to NASA efforts to return to the moon, application and theory of the Moon Math Project. | Team members have **major errors** in their understanding of history, relevance to NASA efforts to return to the moon, application and theory of the Moon Math Project. |
| **Speaks Clearly** | Speaks clearly and distinctly all (100-95%) the time, and mispronounces no words. | Speaks clearly and distinctly all (100-95%) the time, but mispronounces one word. | Speaks clearly and distinctly most (94-85%) of the time. Mispronounces no more than one word. | Often mumbles or cannot be understood OR mispronounces more than one word. |
| **Preparedness** | Students are completely prepared and have obviously rehearsed. There is a logical order and smooth transitions. | Students seems pretty well prepared but might have needed a couple more rehearsals. Presentation has a logical order. Presenters have slight hesitation during transitions. | The students are somewhat prepared, but it is clear that rehearsals were lacking. Hesitation and disorganization are distractions. | Students do not seem at all prepared to present. Presentation lacks organization and smooth transitions. |

**Oral presentation rubric continued.**

| CATEGORY | 4 | 3 | 2 | 1 |
|---|---|---|---|---|
| **Visual Aids** | Student uses several visual aids that show considerable work/creativity and which make the presentation better. These aid in understanding the presentation. | Student uses 1 visual aid that shows considerable work/creativity and which make the presentation better. This aids in the understanding of some of the presentation. | Student uses 1 visual aid, which makes the presentation better. This aid helps very little in understanding the presentation. | The student uses no visual aids or the visual aids chosen detract from the presentation. |
| **Posture & Eye Contact** | Stands up straight, looks relaxed and confident. Establishes eye contact with everyone in the room during the presentation. | Stands up straight and establishes eye contact with everyone in the room during the presentation. | Sometimes stands-up straight and establishes eye contact with most people in the room. | Slouches and/or does not look at people during the presentation. |
| **Family Member Participation** | At least one family member has participated in the completion of the Moon Math Project and oral presentation. | | | No family member participated in the completion of the Moon Math Project and oral presentation. |
| **Time Limit** | Presentation is 8-10 minutes in length. | Presentation is 6-7 minutes in length. | Presentation is 5 minutes in length. | Presentation is less than 5 minutes OR more than 10 minutes in length. |