# LONG DISTANCE DETECTIVE

**Activity 4**
**Student section**

## MATERIALS

**Each group will need**

- **crater sample**
- **modeling clay**
- **cardboard base**
- **ruler**
- **lamp or spotlight**
- **protractor**
- **calculator with tangent function or tangent tables**

**OBJECTIVE**
To develop techniques for measuring topographic features at a distance.

**BACKGROUND**

Here's the problem: you're a planetary scientist working for NASA's new Moon explorer project, in which a robot vehicle will land on the Moon's surface to collect information about possible mineral deposits. You're part of a team charged with finding a location for the explorer to land. This is an important assignment. If the explorer lands in a crater that is unsuitable, it won't be able to climb out and do any exploring. If your explorer got stuck, you'd have a very expensive and embarrassing mistake to explain.

Geologists think the area shown in Figure 1 is a good place to look for valuable minerals. Mission planners want to know whether or not it's a safe place to land the explorer. Your task is to prepare a report for them about the depth of large craters in the area. In particular, they want to know about the depth of craters labeled A, B. and C. (To give you a sense of scale, crater A is about 56 km wide.)


**FIGURE 1 Potential landing site for new Moon explorer. You've been asked to decide whether or not this location is a good choice.**

**PROCEDURE**

*Part I—Testing Your Idea*

1. Discuss possible methods for measuring crater depths with members of your group. Is there a solution that immediately comes to mind? Describe your solution in your Plan of Action box.

2. Have a member of your group collect the tray of materials.

**PLAN OF ACTION**

How would you remotely determine crater depth?

3. Place the crater example in front of your group. Examine it closely to identify its key features.

4. Using modeling clay, construct an accurate crater model on your cardboard base. Your model should be at least several centimeters deep and should replicate as many features from your sample crater as possible. Also compare what you build with photographs of craters.

5. Test your solution for measuring crater depths using your model. How well does it work? Evaluate your plan in the Evaluation box.

6. There are several ways to solve the problem you've been assigned. After the evaluation of the technique you developed is complete, obtain from your teacher the procedure for Part II of this activity.

**EVALUATION**

How well did your plan work?

**PROCEDURE**

*Part II—A Technique for Remote Investigation*

One technique to solve the problem you've been assigned involves simple geometry. After the evaluation of the technique you developed is complete, try this approach.

7. Place your model crater at the center of your workspace. Set a lamp nearby, arranging it at an angle between 5 and 15 degrees off the table (as shown in Figure 2) so that a shadow will be created by your crater.

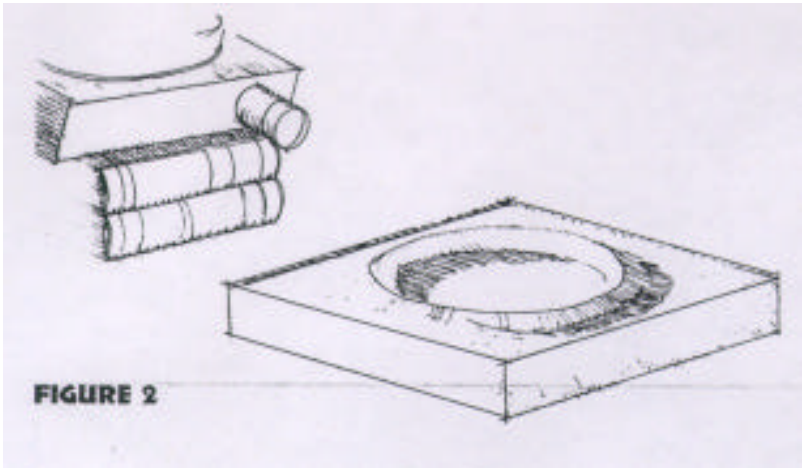


FIGURE 2

8. The crater's depth can be determined if you know the length of the shadow it casts and the angle of the incoming light source (Figure 3). Use the following mathematical relationship:

**depth of crater (d) = [length of shadow (L)] multiplied by [tangent of angle of incoming light (α)]**

For example: if the angle of incoming light is 15 degrees and the measured shadow length is 18 cm, the crater depth will be

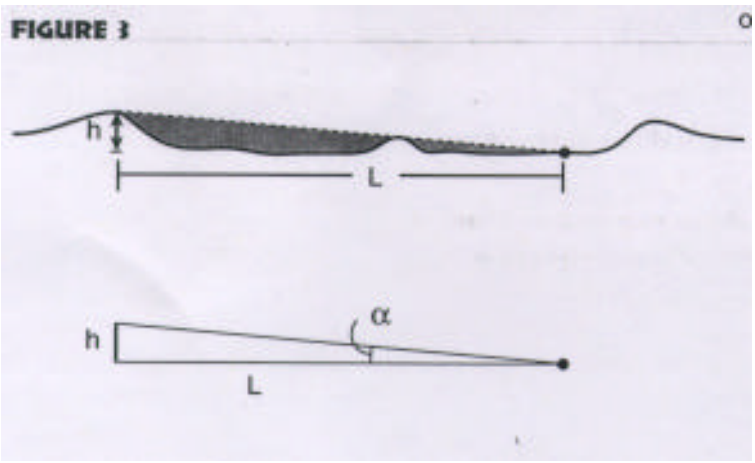
$$d = L \cdot \tan(\alpha)$$

depth = 18 cm • tan (15 degrees)

depth = 4.8 cm

(This can be checked against measurements using your clay model.)

**FIGURE 3**




9. Measure the length of the shadow cast by your model crater. Record your result in Data Table 1.

10. Measure the angle of your light source.

11. Follow the formula in Step 8 to determine your model crater's depth. Record your determination in Data Table 1.

12. Repeat this experiment using different angles for the incoming light. Record your measurements in Data Table 1.

13. Verify your calculations by directly measuring the depth of your model crater. How do the results compare?

**DATA TABLE 1**

| | Trial 1 | Trial 2 | Trial 3 |
|---|---|---|---|
| Length of Shadow Cast | ____ | ____ | ____ |
| Angle of Incoming Light | ____ | ____ | ____ |
| Calculation of Crater Depth | ____ | ____ | ____ |
| Directly Measured Depth (top of rim to floor) | ____ | ____ | ____ |

## PROCEDURE

***Part III—Advice for the Moon Exploration Project***

14. Now that you have a technique for remotely determining crater depth, you are ready to calculate the depth of craters in the possible landing site for the new Moon explorer (Figure 1). Obtain from your teacher a full page image of the site (Figure 4). This image will include data about scale and the angle of incoming light. Calculate crater depth according to the method described in Part II of this Procedure, recording your results in Data Table 2. (Remember to change the scale of your measurement by converting your answer to kilometers.)

**DATA TABLE 2**

| | Crater A | Crater B | Crater C |
|---|---|---|---|
| Diameter of Crater | ____ | ____ | ____ |
| Length of Shadow Cast | ____ | ____ | ____ |
| Angle of Incoming Light | ____ | ____ | ____ |
| Calculation of Crater Depth (top of rim to floor) | ____ | ____ | ____ |

## QUESTIONS/CONCLUSIONS

1. Summarize the results of you investigations:

| Craters: | A | B | C |
|---|---|---|---|
| Calculation of Crater Depth: | _____ | _____ | _____ |

2. Crater depth is not the only variable that might make it difficult for the new Moon explorer to climb out of a crater. What other problems could there be? How could you collect information about these hazards?