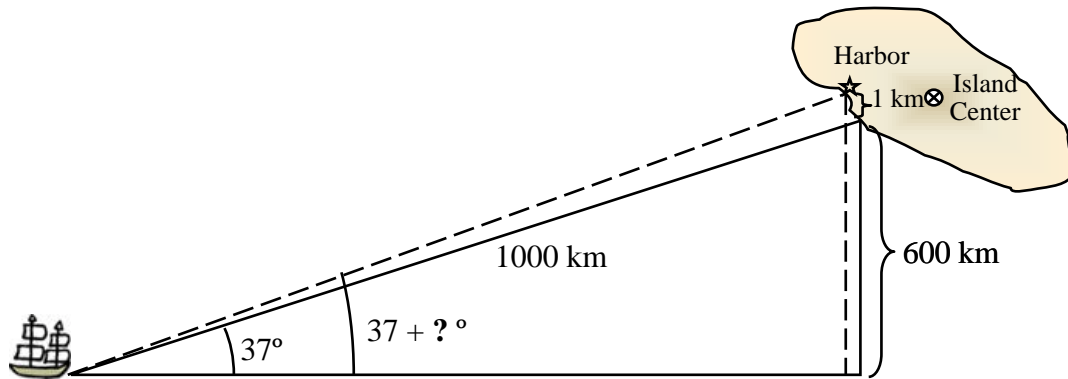


# Increasing the Accuracy of Measurements

## Sailing to an Island Harbor!

Name: \_\_\_\_\_

Date: \_\_\_\_\_



Angle Adjustment (in degrees)	Known Angle	Corrected Angle	Find sine of Angle (use trig table or a calculator)	Mult by 1000km	Length of Side Opposite Angle	Subtract Known Value	Final distance away from Island Center: (km)	Within 0.1 km from the harbor?
?	+ 37.0	= ?	> ?	x 1000.0	= ?	- ?	= 1.0	Yes
0.0	+ 37.0	= 37.0	> 0.60	x 1000.0	= 600.00	- 600.0	= 0.0	No

To do this problem by hand would mean guessing and doing all the calculations multiple times until the proper distance is found. While the calculation is not that difficult, doing it over and over is time consuming. Instead, a computer can be used to do all the calculating (once the equations have been programmed in).

### AT THE COMPUTER:

To solve the problem, you simply supply the guesses in the highlighted box → press ENTER → get the calculated result immediately (computers do math much faster than humans). As the captain of the ship, you know that you are exactly 1000 km from the center of the island and at an angle of 37°. You also know that the harbor is 1km **north** of the center. Therefore you need to adjust the 37° angle so that your ship arrives within 1km of the center of the island, **and 0.1km of the harbor!**

Have each person in your group write down something they would search for on this mystery island!:

\_\_\_\_\_

\_\_\_\_\_

\_\_\_\_\_

\_\_\_\_\_

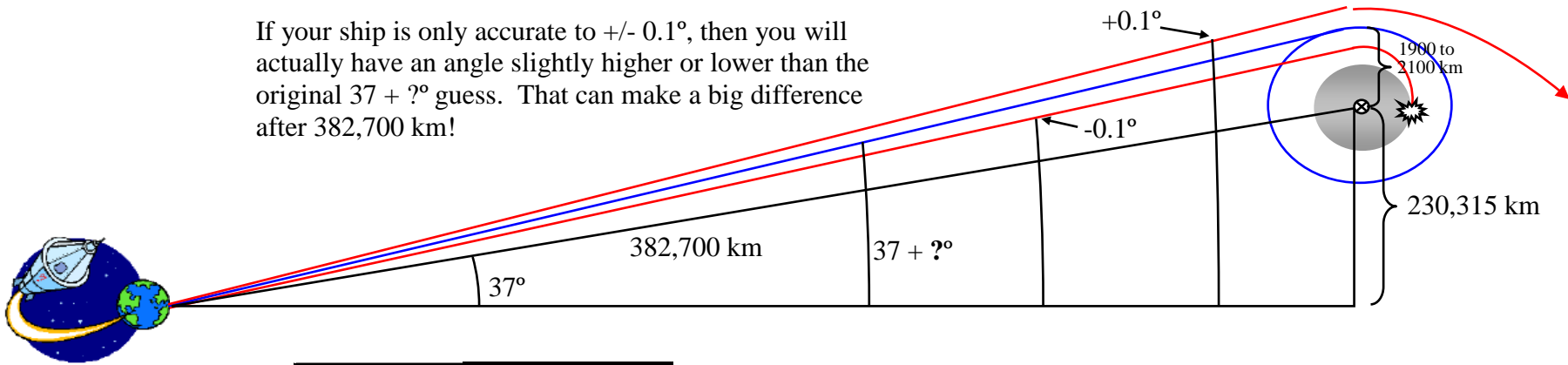
\_\_\_\_\_

\_\_\_\_\_

# Increasing the Accuracy of Measurements

## Rocket Ship to a Moon Orbit!

If your ship is only accurate to  $\pm 0.1^\circ$ , then you will actually have an angle slightly higher or lower than the original  $37 + ?^\circ$  guess. That can make a big difference after 382,700 km!



Accuracy Error =

Plus and Minus Errors (degrees)	Known Angle	Angle used	Find sine of Angle (use trig table or a calculator)	Mult by 382,700 km	Length of Side Opposite Angle	Subtract Exact Value	Final distance off by: (km)	Roughly 1900 to 2100 km from the Moon center?
<input style="border: 1px solid black; padding: 2px 10px;" type="text" value="0.1"/>	+	37.1	= 37.1 + ? > <input <="" style="border: 1px solid black; padding: 2px 10px;" td="" type="text" value="?"/> <td>x 382700.0</td> <td>= <input <="" style="border: 1px solid black; padding: 2px 10px;" td="" type="text" value="?"/> <td>- 230,314.6 km</td> <td>= <input <="" style="border: 1px solid black; padding: 2px 10px;" td="" type="text" value="?"/> <td><input style="border: 1px solid black; padding: 2px 10px;" type="text"/></td> </td></td>	x 382700.0	= <input <="" style="border: 1px solid black; padding: 2px 10px;" td="" type="text" value="?"/> <td>- 230,314.6 km</td> <td>= <input <="" style="border: 1px solid black; padding: 2px 10px;" td="" type="text" value="?"/> <td><input style="border: 1px solid black; padding: 2px 10px;" type="text"/></td> </td>	- 230,314.6 km	= <input <="" style="border: 1px solid black; padding: 2px 10px;" td="" type="text" value="?"/> <td><input style="border: 1px solid black; padding: 2px 10px;" type="text"/></td>	<input style="border: 1px solid black; padding: 2px 10px;" type="text"/>
<input <="" style="border: 1px solid black; padding: 2px 10px;" td="" type="text" value="?"/> <td>+</td> <td>37.0</td> <td>= 37 + ? &gt; <input <="" style="border: 1px solid black; padding: 2px 10px;" td="" type="text" value="?"/> <td>x 382700.0</td> <td>= <input <="" style="border: 1px solid black; padding: 2px 10px;" td="" type="text" value="?"/> <td>- 230,314.6 km</td> <td>= 2000.0</td> <td>Yes</td> </td></td>	+	37.0	= 37 + ? > <input <="" style="border: 1px solid black; padding: 2px 10px;" td="" type="text" value="?"/> <td>x 382700.0</td> <td>= <input <="" style="border: 1px solid black; padding: 2px 10px;" td="" type="text" value="?"/> <td>- 230,314.6 km</td> <td>= 2000.0</td> <td>Yes</td> </td>	x 382700.0	= <input <="" style="border: 1px solid black; padding: 2px 10px;" td="" type="text" value="?"/> <td>- 230,314.6 km</td> <td>= 2000.0</td> <td>Yes</td>	- 230,314.6 km	= 2000.0	Yes
<input style="border: 1px solid black; padding: 2px 10px;" type="text" value="-0.1"/>	+	36.9	= 37.1 - ? > <input <="" style="border: 1px solid black; padding: 2px 10px;" td="" type="text" value="?"/> <td>x 382700.0</td> <td>= <input <="" style="border: 1px solid black; padding: 2px 10px;" td="" type="text" value="?"/> <td>- 230,314.6 km</td> <td>= <input <="" style="border: 1px solid black; padding: 2px 10px;" td="" type="text" value="?"/> <td><input style="border: 1px solid black; padding: 2px 10px;" type="text"/></td> </td></td>	x 382700.0	= <input <="" style="border: 1px solid black; padding: 2px 10px;" td="" type="text" value="?"/> <td>- 230,314.6 km</td> <td>= <input <="" style="border: 1px solid black; padding: 2px 10px;" td="" type="text" value="?"/> <td><input style="border: 1px solid black; padding: 2px 10px;" type="text"/></td> </td>	- 230,314.6 km	= <input <="" style="border: 1px solid black; padding: 2px 10px;" td="" type="text" value="?"/> <td><input style="border: 1px solid black; padding: 2px 10px;" type="text"/></td>	<input style="border: 1px solid black; padding: 2px 10px;" type="text"/>

### AT THE COMPUTER:

First, your engineers know the distance and the angle from the Earth to the center of the Moon very accurately. You are trying to get your rocket into orbit around the Moon, so you need to adjust your  $37^\circ$  angle. However, you cannot be entirely sure of your new measurements. That means your measurement will be within  $\pm 0.1^\circ$ . **First:** Enter this number in the highlighted outlined Accuracy Error box. Will this  $\pm 0.1^\circ$  make a difference? Try to find the needed adjustment to the  $37^\circ$  angle that puts your rocket in orbit.

Is it possible to launch safely if you can only aim your rocket to within  $\pm 0.1^\circ$ ? \_\_\_\_\_

What is your best angle? \_\_\_\_\_

**Second:** Upgrade your navigation system so it is accurate within  $\pm 0.01^\circ$  (enter this number in the Accuracy Error box).

Can you get both the plus and minus errors within the safe zone? \_\_\_\_\_

Is it possible to launch safely now? \_\_\_\_\_ What is your best angle? \_\_\_\_\_