Earth Impact!

Student Activity for the
TI-84 Plus C Silver Edition

Name_______________
Class_______________

Adapted from an activity © 2013 Texas Instruments

Background

In this activity you will play the role of a scientist on an international team of scientists, engineers, computer programmers, mathematicians, and other experts. The problem is that a giant asteroid is on a collision course with Earth. You and your team must evaluate the asteroid and use your knowledge of math and science to figure out a way to deflect it from colliding with Earth. Although this specific scenario is not real, it is important to note that there have been major asteroid impacts on Earth over the life of our planet, and there are teams of experts that constantly monitor Near Earth Objects (NEOs).

You will determine mass from density and volume, time of impact from average velocity and distance, and gravitational force using Newton's law of universal gravitation. Understanding these concepts will help the team determine a plan to avoid disaster!

Send files to your TI-84 Plus C Silver Edition

Using TI-Connect 4.0 or higher, or a classmate's calculator, send the program ERTHIMPT (ERTHIMPT.8xp) and the AppVar EITD (EITD.8xv) to your TI-84 Plus C Silver Edition. Both files should go to your calculator's Archive.

- **Using TI-Connect:** Open TI DeviceExplorer and select your calculator. Drag ERTHIMPT.8xp into the item labeled "Flash/Archive" and wait for the transfer to complete. Drag EITD.8xv into "Flash/Archive" as well.
- **From another calculator:** Put the receiving calculator in Receive mode by pressing [2nd] [XTθn] [▶] [ENTER]. On the sending calculator, go to the `Link` menu with [2nd] [XTθn], choose `2: All-…`, then find "`ERTHIMPT     PRGM`" and "`EITD     AVAR`" and press [ENTER] next to each one. Each one should be marked with a square, indicating that it will be sent. Press [▶] [ENTER] to send the files over.

You will also need Doors CSE 8.1 or higher, which can be found at http://dcs.cemetech.net. The process of sending Doors CSE to your calculator is the same as above, and is also detailed in the Doors CSE readme document.

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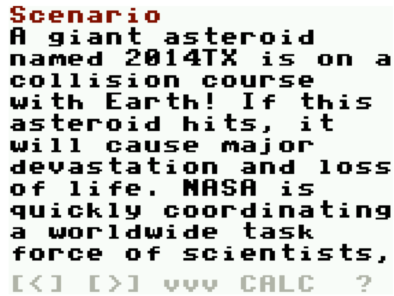
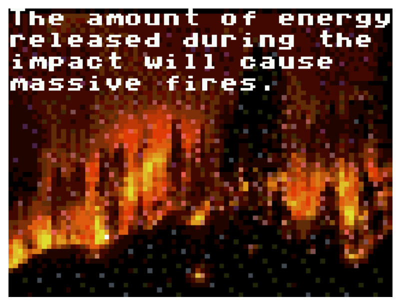
Run the ERTHIMPT program; move to pages 2-6

1. Run Doors CSE 8 from the Apps menu of your calculator, select ERTHIMPT, and run the program. You should see the Earth Impact! title screen. Throughout the Earth Impact activity, you can press the arrow keys (◄ ►) to move between pages, or [ENTER] to advance to the next page.
2. On a text page, press the ▼ and ▲ arrows to scroll down and up, or [ZOOM] or [ENTER] to scroll down.
3. Read the scenario of the collision course of asteroid 2014TX with Earth. Pages 3 to 6 show the potential aftermath of a collision.

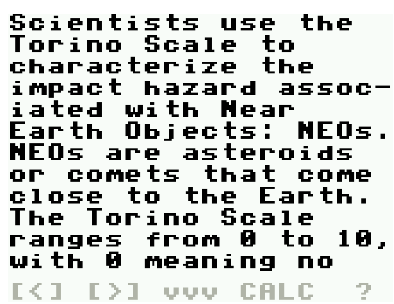




Move to pages 7-10

4. Page 7 describes the Torino Scale, a tool used by astronomers to characterize the impact hazard associated with Near Earth Objects (NEOs).
5. On page 10, you will explore a simulation that one of the team members has created to help understand the impact scenarios. Try changing the different variables to gain insights about what can be done to save Earth. As you explore different combinations, note the change to the trajectory. Can you discover a way to prevent the asteroid from colliding with Earth?

   To set the angle, velocity, and mass of the asteroid, press [ZOOM], under the SET option. Use the arrow keys to move the sliders, then press [ENTER] to save your changes. To run the simulation, press [TRACE], under the RUN option. When you're ready to move to the next page, press [WINDOW] or ►.



Move to pages 11-18. Answer the following questions here, in the space provided.

Q1. Adjust the variables to have the asteroid collide with Earth and then run the simulation again. Now explore the graphs on the next pages. What do you notice about the velocity of 2014TX compared to its distance from Earth? Circle one of the following:

A. Velocity is always constant.

B. Velocity decreases as distance decreases.

C. Velocity increases as distance decreases.

Q2. Look at the data on the velocity vs. time graph on the next page, which is based on the last parameters you set in the simulation. What point on the graph represents the point at which the asteroid is farthest from Earth? Which point represents the point at which the asteroid is closest to Earth? (Note: If you were able to make the asteroid miss Earth, your graph will look slightly different than your classmates. Can you explain what the graph is showing?)

Farthest =

Closest =

Q3. From the graph on page 13 (from Q2), how can we tell the asteroid is getting faster or slower (your answer from Q1) as it approaches Earth?

Q4. On the following two graphs, “FORCE” on the Y-axis represents the gravitational force between 2014TX and Earth. What can you say about the gravitational force as the asteroid gets closer to Earth?

Q5. Based on the data in the FORCE graphs, how are distance and gravitational force related?

A. Directly. As distance decreases, so does gravitational force.

B. Inversely. As distance decreases, gravitational force increases .

Move to the beginning of Section 2 on pages 19-22. Answer the following questions here, in the space provided.

6. After exploring the simulation of the asteroid–Earth collision, the team needs to study the physical characteristics of the actual asteroid. Page 19 describes the density and volume, and the team asks that you determine the mass of 2014TX.

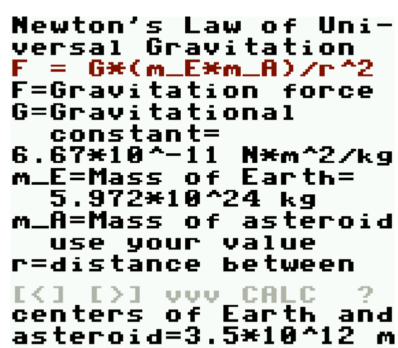
Q6. If 2014TX has a density of 8 g/cm^3 (8,000 kg/m^3) and a volume of 6 km^3 or 6 x 10^9 m^3, calculate the mass of the asteroid. If you need a calculator, you can press [TRACE] to access one inside the Earth Impact! activity. If you exit Earth Impact! using [CLEAR], it will resume where you left off when you run it again.

Q7. The asteroid is traveling at an average velocity of 25 km/sec. Based on a distance of 3.5 billion km from Earth, when will the asteroid hit Earth? Express your answer in days, and remember that there are 10^3 meters per kilometer.

Q8. Based on your answer to the previous question, it may seem odd to worry about something that is years away. In your opinion, why is the team so worried about this situation?

Move to pages 23-30. Answer the following questions here, in the space provided.

7. Pages 23 and 24 introduce Newton's law of universal gravitation as a tool to determine the gravitational force between Earth and the asteroid. Remember to scroll down to read each entire page by pressing [▼] or [ENTER].



Q9. Use the calculator to determine the force between the asteroid and Earth, and write the force you calculate here.

Q10. Now, determine the force between the asteroid and Earth if you cut the distance between them in half. Write your answer here.

Q11. Divide the last force you calculated, when the distance was cut in half, by the first force you calculated. In other words, divide the answer to Q10 by the answer to Q9. Round to the nearest whole number. Why is this number significant?

Q12. The forces you calculated in the previous problem were very small due to the great distances. See what happens when $r = 3.5 \times 10^6$ m and re-calculate the force. This is equivalent to the asteroid being only 3500 km from Earth!

Q13. NASA's Jet Propulsion Laboratory (JPL) constantly monitors asteroids and other NEOs and their trajectories. They are working on a project that will enable us to learn how to deflect these objects if they threaten to strike Earth. What are some possible methods you think JPL should consider when thinking about deflecting a real asteroid from hitting Earth?

Q14. When the distance between Earth and the asteroid is cut in half, its gravitational force increases by the amount you calculated in Q11 (based on the inverse-square law). Based on this, what would you say about the importance of when to divert the asteroid?

Move to the final three pages, pages 31-33.

8. Thanks to the work done by your team, the asteroid was diverted. Page 32 lets you test the results when the asteroid is diverted by a few extra degrees, narrowly missing Earth. Congratulations!

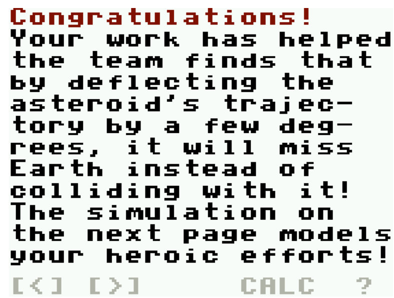


Image Credits: NASA.gov. See readme.txt for full links.