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## Earth Impacts in the Movies Worksheet Solutions

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### 1 Scenes from *Armageddon*

In *Armageddon*, an asteroid “the size of Texas” (approximately 1000 km) is about to collide with the Earth. In the scene you will watch, two teams of astronauts are about to land on the asteroid to bury nuclear bombs inside the asteroid; the goal is to split the asteroid into two pieces which will pass on either side of the Earth.

1. *Appearance of the asteroid.*

- (a) *Briefly describe the asteroid’s appearance from a distance. Discuss the accuracy of the appearance.*

The asteroid is very jagged, with spikes sticking out. There are many small pieces flying off of it, including some type of gas.

The appearance is not very accurate. Real asteroids that we have images of are rocky and cratered. They do not have sharp spikes sticking out. They also do not emit clouds of gas.

- (b) *Briefly describe the appearance of the asteroid’s surface (once the astronauts have landed). Discuss the accuracy of the end.*

The surface is also covered with spikes. The spikes seem almost glass-like when the space shuttle collides with them. Gas is emitted from vents in the ground. There don’t seem to be any craters.

The appearance is not very accurate. From the NEAR spacecraft which landed on the asteroid Eros, we know that even from very close-up, asteroids have a rocky, dusty appearance. No spikes or gas clouds.

### 2 Scenes from *Deep Impact*

In *Deep Impact*, a comet about 10 km across is about to collide with the Earth. In the scene you will watch, a US spacecraft lands on the nucleus of the comet. Their goal is to bury nuclear bombs inside the comet then blow up the bombs in order to deflect the comet off course.

1. *Appearance of the comet.*

- (a) *Briefly describe the comet’s appearance from a distance. Discuss the accuracy of the appearance.*

The comet has a long tail. The coma and tail are a shimmering white.

This appearance is pretty accurate. Comets do have long tails and comas, which are whitish in appearance. However, in the movie the comet only has one tail, not two.

- (b) *Briefly describe the appearance of the surface of the nucleus (once the astronauts have landed). Discuss the accuracy of the appearance.*

The surface is bumpy and uneven. Gas is being emitted in some locations.

This appearance is pretty accurate. We know from pictures of comet nuclei that the surfaces are rough and pitted. We have seen jets of gas coming from the nuclei.

2. *Considering the movie scene, do you think a normal space shuttle could survive the trip through the coma to land on the nucleus?*

It would be very difficult for the space shuttle to survive a trip to the nucleus without some type of extra protection. All of the dust and pebbles falling off of the comet are traveling at pretty high velocity compared to the shuttle’s velocity and so they have a lot of kinetic energy. Even small particles could

punch through the hull of the shuttle and cause air leaks. Unfortunately, after the shuttle Columbia disaster, we know that the shuttle can be relatively fragile.

Do boulder-sized pieces of material fall off of comet nuclei? We have not observed this. It's possible that occasional large chunks might fall off, but probably not as many as depicted in the movie. Otherwise, comets would disintegrate down to nothing much sooner than they really do.

Impacts from dust and small particles were a problem for the space probes that have taken pictures of comet nuclei. These small impacts nearly damaged them enough to prevent them from taking images.

3. *Explain why the astronauts are worried about finishing burying the bombs in the nucleus before the Sun rises.*

The radiative energy from sunlight hitting the ice in the comet nucleus will cause the ice to sublime: change from solid to gas. Since the temperature change from night to day will be very large, the sublimation might happen very quickly and be almost explosive. The vapor will shoot off the comet in jets, like we've seen in images. It wouldn't be a good idea to be standing on ice when a lot of it sublimates. However, the ice probably wouldn't warm up and sublimate the instant the Sun rises, as is implied in the movie.

### 3 *Stargate SG-1* episode: "Fail Safe"

*In this **Stargate SG-1** episode, an asteroid is about to collide with the Earth. (The episode has been edited to shorten it.) After the scenes showing the initial discovery of the comet, a military team uses a salvaged alien space ship to land on the asteroid. The plan to save the Earth is explained in the episode.*

1. *How long is the asteroid?*

137 km, as stated in the episode.

2. *Appearance of the asteroid.*

- (a) *Briefly describe the asteroid's appearance from a distance. Discuss the accuracy of the appearance.*  
The asteroid looks rocky with lots of craters. It is irregularly shaped. This appearance is very accurate.

- (b) *Briefly describe the appearance of the asteroid's surface. Discuss the accuracy of the appearance.*  
The asteroid's surface is rocky and dusty. There are many deep fissures.

The accuracy of the appearance is pretty good. From close-up images, we know the surfaces of asteroids are rocky and dusty. Are there such deep fissures? That's more uncertain. There were grooves and fissures observed on the asteroid Eros, but not as deep. However, Eros is only about 30 km long. It's possible larger asteroids have deeper features.

3. *Explain the team's **original** plan for keeping the asteroid from colliding with the Earth.*

The team was going to place a nuclear bomb in a deep crater and explode the bomb to deflect the asteroid off-course. They placed it in a crater such that when the bomb exploded, the force would be perpendicular to the asteroid's current course. Additionally, they were hoping the crater walls would help direct the force of the explosion even more in a direction perpendicular to the path of the asteroid.

4. *In one scene, a meteor shower bombards the astronauts and spaceship on the asteroid. The meteors in a meteor shower are typically pea-sized or smaller. Why were they so dangerous on the asteroid? Why aren't meteor showers dangerous on Earth?*

The small meteors were traveling at a very high relative velocity to the asteroid, so they had a lot of kinetic energy. That means they can easily poke right through the astronauts' suits or through the ship's hull.

The meteors were very dangerous on the asteroid (but not on Earth) because there was no atmosphere on the asteroid. On Earth, small meteors like in the meteor shower burn up in the atmosphere before they reach the surface, so they don't hit anything.

5. *Explain the line of reasoning that led the team to discover the asteroid was made of the fictional, extremely dense material "naquaadah".*

When the ship approached the asteroid, one person noted that the ship was approaching with a higher velocity than they expected. Later, that officer reasoned that the high velocity was because the ship was accelerated from the gravitational force of the asteroid more than expected. That means that the gravitational force of the asteroid was unexpectedly high. Since gravitational force depends on mass, that means that the asteroid's mass was larger than expected. However, the diameter of the asteroid had not changed, so that must mean the density of the asteroid was much higher than expected. In fact, the density was so high that no real-life material could have been in the center of the asteroid, leading to the determination that "naquaadah" was in the asteroid.

## 4 Comparing the Excerpts

1. *List the sizes of the asteroid/comet in each show. Which of the three sizes is the most realistic? (You may consult your textbook or lecture notes.) Are any of the sizes impossible?*

Show	Size
<i>Armageddon</i>	"the size of Texas", about 1000 km across
<i>Deep Impact</i>	10 km across
<i>Stargate SG-1</i>	137 km across

The comet in *Deep Impact* is a possible size: the nucleus of Comet Halley is about 10 km, from Figure 9.8 in the textbook.

The asteroid in *Stargate SG-1* is a possible size: the largest asteroid we know of is Ceres, which is a little less than 1000 km in diameter (pg. 237 of textbook). However, it is on the large end of possible sizes; most asteroids are less than 100 km across.

The asteroid in *Armageddon* is just barely possible: Ceres is less than 1000 km in diameter, and the asteroid in *Armageddon* is at least that large.

2. *Using Figure 9.19 in your textbook, briefly describe the level of damage to the Earth if each of the three objects hit the Earth.*

If the asteroid from *Armageddon* hit the Earth, it would be a mass extinction event. In fact, objects of 1000 km in size aren't even on the graph. Probably all life on Earth would be killed off from the ensuing effects.

If the comet from *Deep Impact* hit the Earth, it would also be a mass extinction event. This comet is about the same size as the object that caused the K-T mass extinction, so we would expect similar effects.

If the asteroid from *Stargate SG-1* hit the Earth, it would be another mass extinction event. The asteroid is a lot bigger than the K-T impactor, so more destruction would be caused.

3. *Which of the three plans do you think would be the best to keep the object from hitting the Earth? Explain.*

The plans in both *Deep Impact* and *Stargate SG-1* are similar and are the best. They use bombs to try to deflect the object off-course.

The plan in *Armageddon* is to split the asteroid into two pieces that pass on either side of the Earth. It would be very difficult to split the asteroid into only two pieces instead of shattering it. As we discussed in class, shattering the asteroid into many pieces probably would not be any advantage if they all hit the Earth anyway.