Algebra 1

Chapter 9: Exponents and Powers

**9e: Applications of Exponents**

**CCSS**

• **HSF-LE.A.1**  
Distinguish between situations that can be modeled with linear functions and with exponential functions.

• **HSF-LE.A.2**  
Construct linear and exponential functions, including arithmetic and geometric sequences, given a graph, a description of a relationship, or two input-output pairs

• **HSF-LE.B.5**  
Interpret the parameters in a linear or exponential function in terms of a context.

• **HSA-SSE.A.1**  
Interpret expressions that represent a quantity in terms of its context.**★**

• **HSF-BF.A.1**  
Write a function that describes a relationship between two quantities.**★**

**• *HSF-BF.A.2***Write arithmetic and geometric sequences both recursively and with an explicit formula, use them to model situations, and translate between the two forms.★

Lesson

**Ex Oil Spills**

Begin discussing the oil spills of the Exxon Valdez (1989) and the BP Deep Water Horizon (2010).

The BP Deepwater Horizon was the US’s largest oil spill ever. After the Deep Water drilling rig exploded--killing 11 people--the oil well continued to release oil into the ocean for another 87 days. All in all, 206 million gallons of crude oil were put into the ocean in the summer and fall of 2010.

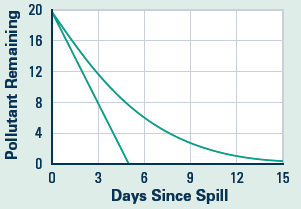
However, the worst oil US spill in terms of environmental damage happened in 1989 when the oil tanker Exxon Valdez ran aground in waters near the Kenai Peninsula of Alaska. An estimated 11 million gallons of oil spread on the waters and shoreline of the area, endangering wildlife. That oil spill was eventually mostly cleaned up—some of the oil evaporated, some was picked up by specially equipped boats, and some sank to the ocean floor as sludge. For scientists planning environmental cleanups, it is important to be able to predict the pattern of dispersion in such contaminating spills.

**Experiment**

Think about the following experiment that simulates pollution of a lake or river by some poison and the cleanup.

* Mix 20 black checkers (the pollution) with 80 red checkers (the clean water).
* On the first “day” after the spill, remove 20 checkers from the mixture (without looking at the colors) and replace them with 20 red checkers (clean water). Count the number of black checkers remaining. Then shake the new mixture. This simulates a river draining off some of the polluted water and a spring or rain adding clean water to a lake.
* On the second “day” after the spill, remove 20 checkers from the new mixture (without looking at the colors) and replace them with 20 red checkers (more clean water). Count the number of black checkers remaining. Then stir the new mixture.
* Repeat the remove/replace/mix process for several more “days”.

The graphs below show two possible outcomes of the pollution and cleanup simulation.



a) What pattern of change is shown by each graph?

b) Which graph shows the pattern of change that you would expect for this situation?

c) Test your idea by running the experiment several times. Fill in the table below AND plot the (*time, pollutant remaining*) data.

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| Time (Number of Days) | 0 | 1 | 2 | 3 | 4 | 5 |
| Pollution remaining | 20 |  |  |  |  |  |

d) What sort of equation relating pollution *P* and time *t*would you expect to match your plot of data? Explain?

**Formalizing the Concepts**

This is the 25th anniversary of the Exxon Valdez oil spill. 25 years later, there is estimated to be between 16 and 21 thousand gallons of oil still in the environment.

e) Create an equation modeling the amount of oil in the Prince William Sound since the Exxon Valdez oil spill.

f) How might we make a similar model/equation for the BP oil spill?

**Ex Fukushima Power Plant Meltdown**

In 2011, following a major earthquake, a major tsunami hit the coast of Japan causing widespread destruction and killing over 28,000 people. In the aftermath, the nuclear reactors at the Fukushima power plant in Japan were damaged. They began to leak radiation to the surrounding community for about 3 weeks. Some of the radiation came from Strontium-90 (a byproduct of nuclear fission), and some came from the exposed plutonium and uranium fuel rods. Most of the initial radiation happened in the forms of Iodine-131 and Cesium-134 and Cesium-137 (<http://www.world-nuclear.org/info/Safety-and-Security/Safety-of-Plants/Fukushima-Accident/>) Iodine 131 has a half-life of about 8 days. Caesium-134 has a half-life of 2.07 years. Caesium-137 on the other hand has a half-life of 30.17 years. Strontium-90 has a half-life of 29.1 years.

We don’t completely know the amount of radioactive material released at the Fukushima nuclear plant in the initial meltdown. We do know that most of the radiation was released into the environment through discharged cooling water. The nuclear plant changed out millions of gallons of radioactive cooling water with ocean water in order to prevent a catastrophic meltdown and the resulting subsequent explosion (as in Chernobyl). There is also still an underground leak at the power plant were 300 tons of radioactive water each day continue to drain from the plant.( <http://news.nationalgeographic.com/news/energy/2013/08/130807-fukushima-radioactive-water-leak/>)

Since I don’t understand the exact ways in which radiation is measured. Let’s just talk about how long we have to worry about the radiation from these isotopes.

1. Do we have to worry long-term about Iodine-131? Why or why not?
2. Do we have to worry long-term about any of the other radioactive isotopes? How do you know?
3. Create equations for each of the 4 radioactive isotopes released by the Fukushima nuclear plant (and that are still continuing to be released).
4. What is the amount of radioactive material remaining for each of the 4 isotopes after 1 year?
5. After 30 years?
6. After 100 years?

Information on the 2011 Japanese Tsunami:

<http://www.youtube.com/watch?v=foxww-tMoNg>

Information on Caesium-137 and its effects on the human body: (<http://www.epa.gov/radiation/radionuclides/cesium.html>)

The following is details on radiation from the National Geographic site just in case students have specific questions I don’t know how to answer. <http://news.nationalgeographic.com/news/energy/2013/08/130807-fukushima-radioactive-water-leak/>)

TEPCO said Monday that [radiation levels in its groundwater observation hole](http://www.tepco.co.jp/en/press/corp-com/release/2013/1229511_5130.html) on the east side of the turbine buildings had reached 310 becquerels per liter for cesium-134 and 650 becquerels per liter for cesium-137. That marked nearly a 15-fold increase from readings five days earlier, and exceeded Japan’s provisional emergency standard of 60 becquerels per liter for cesium radiation levels in drinking water. (Drinking water at 300 becquerels per liter would be approximately equivalent to one year’s exposure to natural background radiation, or 10 to 15 chest X-rays, [according to the World Health Organization](http://www.who.int/hac/crises/jpn/faqs/en/index8.html). And it is far in excess of WHO’s guideline advised maximum level of radioactivity in drinking water, [10 becquerels per liter.](http://www.who.int/water_sanitation_health/dwq/GDW9rev1and2.pdf))  Readings fell somewhat on Tuesday. A similar spike and fall preceded TEPCO’s July admission that it was

grappling with leakage of the radioactive water. (See related:["Would a New Nuclear Plant Fare Better than Fukushima?"](http://news.nationalgeographic.com/news/energy/2011/03/110323-fukushima-japan-new-nuclear-plant-design/))

Scientists who have been studying the situation were not surprised by the revelation, since radiation levels in the sea around Japan have been holding steady and not falling as they would if the situation were under control. In a[2012 study](http://www.nature.com/news/ocean-still-suffering-from-fukushima-fallout-1.11823), Jota Kanda, an oceanographer at Toyko University of Marine Science and Technology, calculated that the plant is leaking 0.3 terabecquerels (trillion becquerels) of cesium-137 per month and a similar amount of cesium-134. While that number sounds mind-boggling, it’s actually thousands of times less than the level of radioactive contamination that the plant was spewing in the immediate aftermath of the disaster, estimated to be from 5,000 to 15,000 terabecquerels, according to Buesseler. For a comparison, the atomic bomb dropped on Hiroshima released 89 terabecquerels of cesium-137 when it exploded. (See related: "[Animals Inherit a Mixed Legacy at Chernobyl](http://news.nationalgeographic.com/news/energy/2011/04/pictures/110426-chernobyl-25th-anniversary-wildlife/).")

Another potential worry: The makeup of the radioactive material being leaked by the plant has changed. Buesseler said the initial leak had a high concentration of cesium isotopes, but the water flowing from the plant into the ocean now is likely to be proportionally much higher in strontium-90, another radioactive substance that is absorbed differently by the human body and has different risks. The tanks (on the plant site) have 100 times more strontium than cesium, Buesseler said. He believes that the cesium is retained in the soil under the plant, while strontium and tritium, another radioactive substance, are continuing to escape. (Related: "[Japan's Nuclear Refugees](http://ngm.nationalgeographic.com/2011/12/japan-nuclear-zone/craft-text)")

HW: worksheet 9e—Applications of Exponential Functions