

## Exponential Growth & Decay

Math 111

Repeated growth by a constant growth factor is called **exponential growth**. If the growth factor is less than 1, it is called **exponential decay**. When you add a fixed amount at each step, you get **linear growth**.

1. From 1980 to 2010, China's average annual real economic growth rate was 9.98%. By what factor did China's economy grow during this 30-year period?
2. Which of the following patterns are **arithmetic sequences** and which are **geometric sequences**? For the arithmetic sequences, determine the step size, for the geometric sequences determine the common ratio.
  - (a) 1, 5, 9, 13, 17, 21, ...
  - (b) 10, 30, 90, 270, ...
  - (c) 1000, 2000, 3000, 4000, ...
3. According to **Newton's law of cooling**, the temperature difference between a small object and its surroundings decays exponentially. Suppose a fresh cup of coffee is 60° Celsius warmer than room temperature. Ten minutes later it is only 50°C warmer than room temperature. Assuming the cup is left alone to cool, complete the table to show the temperature of the coffee at different times.

Time (minutes)	0	10	20	30
°C (above room temperature)	60	50		

**Hint:** If you said the coffee would be exactly 30°C above room temperature after 30 minutes, that is wrong. That would be linear decrease, not exponential decrease.

4. If the coffee continues to cool undisturbed, what would the temperature be after 1 hour?

5. **Rule of 70** The rule of 70 is a method for estimating how long it will take an investment to double. You take 70 and divide it by the interest rate. For example, if the interest rate is 7% per year, then it will take about  $70/7 = 10$  years for the investment to double.
- (a) According to the rule of 70, how long will it take an investment with a 5% annual yield to double?
  - (b) If you really earn 5% interest every year, then how much will your investment grow in 14 years as an exact percentage? Does this answer fit with part (a)? Explain.
  - (c) Given that China's economy grew by approximately 10% per year, for 30 years, how many times did it double according to the rule of 70?
6. Sometimes when we work with percentages we convert the percentage to a growth factor. Other times, we just convert the percentage to a decimal and don't add 1 to make it a growth factor. Explain why we do these two different things and under what circumstances each one is appropriate. *Hint: your answer should mention the difference between a “percentage change” versus a “percentage of something”.*