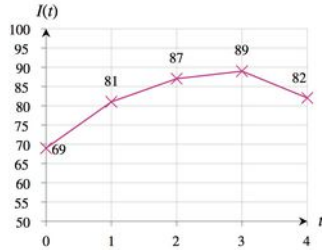


Math 61 Learning Unit 2 Hand-In Assignment for Section 3.4

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1. **Emigration from Ireland** The following graph shows the approximate number (in thousands) of people who emigrated from Ireland during the period 2010–2014 (t is time in years since 2010):¶



- During which 2-year interval(s) was the magnitude of the average rate of change of $E(t)$ a. greatest b. least? Interpret your answers by referring to the rates of change.

¶ Source: European Migration Network Ireland <http://emn.ie>.

Hint: See Section 3.4 Exercise 31 for a similar problem in the book.

2. ▼ **Science Research in Europe** The following table shows the number of science research articles authored by researchers in the European Union during the period 1980–2010‡ ($t = 0$ represents 1980):

t (Year since 1980)	0	5	10	15	20	25	30
$N(t)$ (Articles, thousands)	140	170	190	260	300	340	430

- a. Find the interval(s) over which the average rate of change of N was the least positive. What was that rate of change? Interpret your answer.
b. The **percentage change of N over the interval $[a, b]$** is defined to be

$$\text{Percentage change of } N = \frac{\text{Change in } N}{\text{First value}} = \frac{N(b) - N(a)}{N(a)}.$$

Compute the percentage change of N over the interval $[10, 30]$ and also the average rate of change. Interpret the answers.

‡ 1980 data estimated. Source: <http://www.sciencewatch.com>

Hint: Similar to Section 3.4 Exercise 33 in the book.

3. **The 2014 Ebola Outbreak** In the first six months of the 2014 Ebola outbreak, the total number of reported cases could be approximated by

$$C(t) = 95.9e^{0.72t} \quad (0 \leq t \leq 6),$$

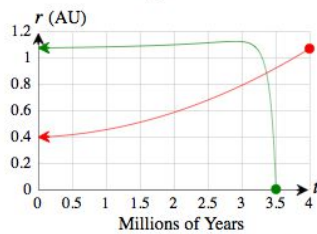
where t is time in months since April 1, 2014.¶

- a. Calculate the average rates of change of $C(t)$ over the successive two-month periods $[0, 2]$, $[1, 3]$, $[2, 4]$, $[3, 5]$, and $[4, 6]$. (Round answers to two decimal places.)
b. What kind of model would best describe the successive rates of change obtained in part (a): Linear, quadratic, or exponential? What does your answer tell you about the 2014 ebola outbreak?

¶ Exponential model is the authors' Source for data: Wikipedia/Centers for Disease Control and Prevention/WHO

Hint: Similar to Section 3.4 Exercise 45 in the book.

- 4. End of the Earth** In 5 billion years the Sun will have run out of hydrogen fuel and begin to expand into a red giant, eventually engulfing the Earth and causing it to spiral into the core of the Sun 7.5 billion years from now. The following graph* shows the expanding radius of the red giant Sun (in red) and the radius of the earth's orbit about the Sun (in green) during its final three and a half million years of existence. The radii are measured in AU (astronomical units; 1 AU is the current radius of the Earth around the sun, around 93 million miles) and time is measured in million of years.



The curve representing the Sun's radius has equation

$$r = 0.037t^2 + 0.02t + 0.4.$$

($t = 4$ marks the end of the red giant expansion phase.) Exercises 4 and 5 are based on this curve.

* The actual astrophysical models, of which the curves shown here are merely rough graphical representations, are described in *Distant future of the Sun and Earth revisited* by K-P Schröder and Robert Cannon Smith, *Monthly Notices of the Royal Astronomical Society* **386** (1): 155–163.

- Calculate the rate of change of the radius of the Sun over the successive intervals $[0, 1]$, $[1, 2]$, $[2, 3]$, $[3, 4]$.
- the successive rates of change are a linear function of t . What is the slope of that linear function? How fast will the rate of change of the Sun's radius be increasing in the final 4 million years?