



Lecture 11

Fundamentals of Business Mathematics

MATH-114 • BBA 2k26

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Lecture 11 Outline

- Algebra Flashback: rules of exponents
- Definition and characteristics of exponential functions
- Growth: $f(x) = b^x$, $b > 1$
- Decay: $f(x) = b^x$, $0 < b < 1$
- The base- e exponential function and conversion to base e
- Suggested textbook problems and additional practice



Algebra Flashback: Rules of Exponents

For positive a, b and real exponents where expressions are defined:

$$a^m a^n = a^{m+n}$$

$$(a^m)^n = a^{mn}$$

$$\left(\frac{a}{b}\right)^n = \frac{a^n}{b^n} \quad (b \neq 0)$$

$$a^{-n} = \frac{1}{a^n}$$

$$\frac{a^m}{a^n} = a^{m-n} \quad (a \neq 0)$$

$$(ab)^n = a^n b^n$$

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When the base is the same, multiplication adds exponents, division subtracts exponents, and a power raised to a power multiplies exponents.



Algebra Flashback: Simplify

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$$\textcircled{5} \quad \left(\frac{m}{n}\right)^2 = \frac{m^2}{n^2} \quad (n \neq 0).$$

$$\textcircled{6} \quad 5^{-2} = \frac{1}{5^2} = \frac{1}{25}.$$



Algebra Flashback: More Practice

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$$f(x) = b^x, \quad b > 0, \quad b \neq 1.$$

- The variable occurs in the exponent.
- The base is a positive constant other than 1.
- Exponential functions model repeated multiplicative change.



Example 1: Medication Excretion

In many natural processes, the rate at which something grows or decays depends upon its current value. The manner in which the body discharges medications is an example of this type of process. For one particular type of medication, suppose that half of the medication in the body is excreted from the bloodstream by the kidneys every 3 hours. Thus, for an initial dose of 100 milligrams, the content in the body after 3 hours would be

$$100 \left(\frac{1}{2} \right) = 50 \text{ milligrams.}$$



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After 9 hours, the amount remaining would be

$$100 \left(\frac{1}{2} \right)^3 = 12.5 \text{ milligrams.}$$



Example 1: Function and Interpretation

After n three-hour periods, the amount remaining is described by

$$A = f(n) = 100 \left(\frac{1}{2} \right)^n,$$

where A is the number of milligrams remaining and n is the number of three-hour periods since the initial dosage was administered.



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$$\begin{aligned} A &= 100(0.5)^{3.5} \approx 100(0.088388) \\ &\approx 8.84 \text{ milligrams.} \end{aligned}$$



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The independent variable n need not be an integer; the model is valid for noninteger values as well.

Practice Exercise: Medication Excretion

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Solution. Since the half-life is 3 hours, $n = 15/3 = 5$ and $n = 22.5/3 = 7.5$.

$$A(5) = 100(0.5)^5 = 3.125 \text{ mg},$$

$$A(7.5) = 100(0.5)^{7.5} \approx 0.5523 \text{ mg}.$$



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- 6 A larger base b gives a greater rate of increase as x increases.



Example 2: Sketching $f(x) = 2^x$

A table of values for $f(x) = 2^x$ is:

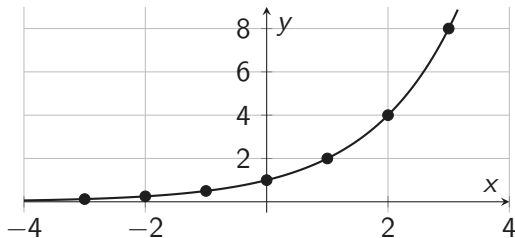
x	0	1	2	3	-1	-2	-3
2^x	1	2	4	8	0.5	0.25	0.125



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Example 3: Comparing Growth Rates

Compare the exponential functions

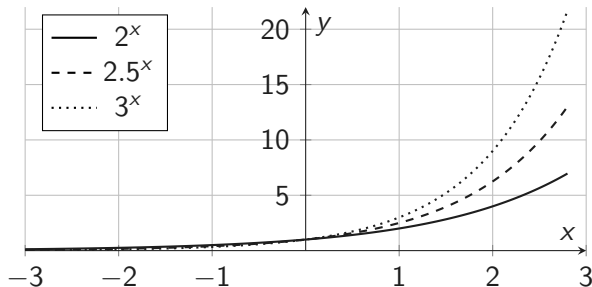
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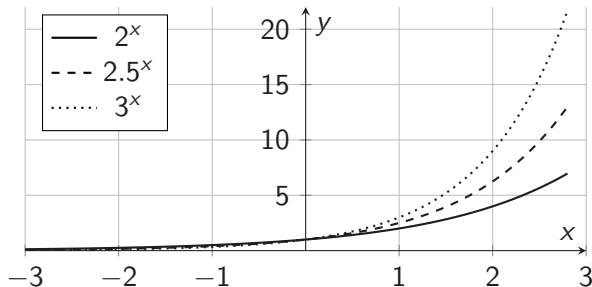
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All three curves pass through (0, 1); the larger base grows more rapidly for positive x.



Example 4: $f(x) = b^x$ Where $0 < b < 1$

Figure 7.3 illustrates the graphs of the three exponential functions

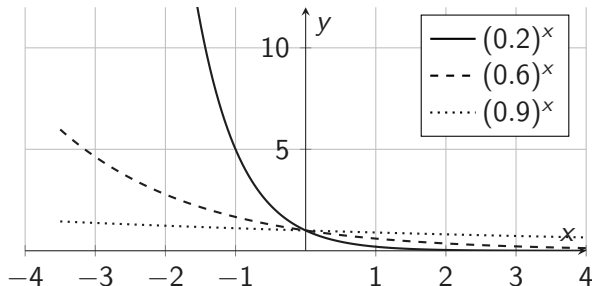
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- 4 The y -intercept is $(0, 1)$.
- 5 The function is decreasing: if $x_1 < x_2$, then $f(x_1) > f(x_2)$.
- 6 For $0 < b < 1$, the function represents exponential decay as x increases.



Growth or Decay?

Classify each function as increasing or decreasing, and state the horizontal asymptote.

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Answers: (1) increasing; (2) decreasing; (3) increasing; (4) decreasing. In all four cases, the horizontal asymptote is $y = 0$.



Base- e Exponential Functions

A special class of exponential functions has the form

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where e is an irrational number approximately equal to

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The number e can be described by the limit $e = \lim_{n \rightarrow \infty} \left(1 + \frac{1}{n}\right)^n$.



Practice Exercise: Approximating e

The number e is the value of $\left(1 + \frac{1}{n}\right)^n$ as n approaches infinity. Calculate approximate values for:

$$n = 1, \quad 2, \quad 5, \quad 10, \quad 100.$$



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n	$(1 + \frac{1}{n})^n$
1	2.0000
2	2.2500
5	2.4883
10	2.5937
100	2.7048



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2	2.2500
5	2.4883
10	2.5937
100	2.7048

As n becomes larger, the values approach $e \approx 2.71828$.



Conversion to Base e

For any positive base b ,

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- ① $2^x = e^{x \ln 2} \approx e^{0.6931x}.$
- ② $5^{3t} = e^{3t \ln 5} \approx e^{4.8283t}.$



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- ③ $(0.4)^x = e^{x \ln(0.4)} \approx e^{-0.9163x}.$



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- ③ $(0.4)^x = e^{x \ln(0.4)} \approx e^{-0.9163x}$.

The coefficient in the exponent is $\ln b$, not b . If $0 < b < 1$, then $\ln b < 0$.



Conversion to Base e : Practice

Rewrite each expression in the form e^{kx} (or e^{kt}).

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① 3^x

② 10^{2x}

③ $(0.25)^t$

④ $7^{0.5x}$

Solutions:

$$3^x = e^{x \ln 3} \approx e^{1.0986x},$$

$$10^{2x} = e^{2x \ln 10} \approx e^{4.6052x},$$

$$(0.25)^t = e^{t \ln 0.25} \approx e^{-1.3863t},$$

$$7^{0.5x} = e^{0.5x \ln 7} \approx e^{0.9730x}.$$



Suggested Textbook Problems

Section 7.1 Follow-up Exercises :

- Identifying exponential functions and comparing graphs: Problems 1–3
- Evaluating exponential functions: Problems 6–21
- Sketching exponential functions: Problems 22–31
- Converting to equivalent base- e functions: Problems 32–37



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- Evaluating exponential functions: Problems 6–21
- Sketching exponential functions: Problems 22–31
- Converting to equivalent base- e functions: Problems 32–37

For a focused assignment, select at least two problems from each category.



Additional Practice Problems

- 1 Simplify $\frac{a^5 a^{-2}}{a}$ for $a \neq 0$.
- 2 Evaluate 2^{-3} and $16^{3/4}$.
- 3 For $f(x) = 3^x$, find $f(-2)$, $f(0)$, and $f(2)$.
- 4 State the domain, range, intercept, monotonicity, and horizontal asymptote of $g(x) = (0.4)^x$.
- 5 Rewrite 8^x using base e .
- 6 Rewrite $(0.3)^{2t}$ using base e .
- 7 Sketch $y = 2^x$ and $y = (0.5)^x$ on the same axes. Compare their shapes.

