GENERAL

exponential growth and decay worksheet with answers

Published: September 3, 2026 | Index ID: #-

Introduction

Exponential growth and decay are fundamental concepts that appear across many disciplines—biology, physics, economics, and even everyday life. Whether you're tracking a bacterial population, calculating compound interest, or modeling the spread of a contagious disease, the underlying mathematics remains the same. For students and educators alike, worksheets that combine clear, step by step problems with ready answers are invaluable tools for mastering these ideas. This article offers a comprehensive guide to exponential growth and decay, complete with a variety of worksheets and solutions. By the end, you'll have a solid grasp of the theory, practical applications, and a collection of ready to use exercises to reinforce learning.

Understanding Exponential Growth and Decay

What Is Exponential Change?

In contrast to linear change, where a quantity increases or decreases by a fixed amount each time unit, exponential change involves a fixed percentage change. The result is a rapid, often dramatic, rise or fall. Mathematically, exponential behavior is described by the equation:

y = y €·b W
where:

- y € is the initial value.
- b is the base, representing the growth (b > 1) or decay (0
- t is the time elapsed.

Key Terminology

- Growth Rate (r): The percentage change per time unit. When expressed as a decimal, r = b /– /1 for growth.
- Half Life: The time required for a quantity to reduce to half its initial value, commonly used in radioactive decay.
- Doubling Time: The time needed for a quantity to double, relevant for population studies.

Graphing Exponential Functions

Exponential curves are characterized by a steep slope that becomes increasingly steep as the function grows. In decay, the curve approaches zero asymptotically but never truly reaches it. Visualizing these curves helps students understand how quickly quantities can change over time.

Real World Applications of Exponential Models

Population Dynamics

Biologists use exponential growth to model early-stage populations where resources are abundant. For example, a colony of bacteria might double every 20 minutes under optimal conditions.

Radioactive Decay

Physicists rely on exponential decay to predict how long a radioactive isotope will remain active. The half life of carbon 14 (about 5,730 years) is a classic example used in archaeology.

Finance and Compound Interest

Investors calculate future portfolio values using exponential growth. The formula for compound interest, $A = P(1 + r/n)$, is essentially an exponential function where r is the annual rate and n the compounding frequency.

Epidemiology

During the initial outbreak of a disease, the number of infected individuals often follows an exponential trend. Public health officials use these models to predict hospital bed requirements and to assess intervention strategies.

How to Solve Exponential Problems

Step by Step Approach

1. Identify the known variables: initial value, final value, time, or rate.
2. Set up the exponential equation: y = y €·b W or y = y €·e^(rt).
3. Isolate the unknown variable: use logarithms when necessary.
4. Compute the result: apply a calculator or spreadsheet.
5. Check the answer: verify units and reasonableness.

Common Pitfalls

- Confusing growth rate with the base of the exponential.
- Ignoring units—time must be consistent across all terms.
- Using linear approximations for problems that require exponential solutions.

Tools and Resources

Graphing calculators, spreadsheet software, and online exponential calculators can expedite the solving process. For educators, many learning management systems allow the integration of interactive worksheets.

Exponential Growth Worksheet with Answers

Problem Set

1. A bacterial culture starts with 1,000 cells and triples every hour. How many cells will there be after 5 hours?
2. If a population of 2,000 people grows at a rate of 3% per year, what will the population be after 10 years?
3. A savings account holds $5,000 and earns 2% interest compounded annually. What is the balance after 8 years?
4. A plant"s height doubles every 4 days. Starting at 10 cm, what is its height after 12 days?
5. In a chemical reaction, the concentration of a reactant decreases as it is consumed. If the concentration starts at 0.8 M and reduces by 10% each hour, what is the concentration after 6 hours?

Answers

1. After 5 hours: 1,000 /× /3 u /= /1,000 /× /243 /= /243,000 cells.
2. Population after 10 years: 2,000 /× /(1 /+ /0.03)¹ p /"H /2,000 /× /1.3439 /"H /2,687.8 people.
3. Balance after 8 years: 5,000 /× /(1 /+ /0.02) x /"H /5,000 /× /1.1716 /"H /5,858.0 dollars.
4. Height after 12 days: 10 /cm /× /2³ /= /10 /cm /× /8 /= /80 /cm.
5. Concentration after 6 hours: 0.8 /× /(0.9) v /"H /0.8 /× /0.5314 /"H /0.4251 /M.

Exponential Decay Worksheet with Answers

Problem Set

1. Radioactive isotope A has a half life of 5 years. Starting with 200 grams, how much remains after 15 years?
2. A drug’s concentration in the bloodstream halves every 4 hours. If the initial concentration is 120 /mg/L, what

is the concentration after 12 hours?

3. In a cooling process, the temperature of an object decreases by 20% each hour. If the initial temperature is 80 /°C, what is the temperature after 3 hours?

4. A population of 10,000 fish declines at a rate of 8% per year. What is the population after 4 years?

5. Carbon 14 dating: a sample has 25% of its original carbon 14 remaining. What is the age of the sample, given a half life of 5,730 years?

Answers

1. After 15 years (3 half lives): 200 /× /(½)³ /= /200 /× /0.125 /= /25 /grams.
2. After 12 hours (3 half lives): 120 /mg/L /× /(½)³ /= /120 /× /0.125 /= /15 /mg/L.
3. After 3 hours: 80 /°C /× /(0.8)³ /"H /80 /× /0.512 /"H /40.96 /°C.
4. After 4 years: 10,000 /× /(1 /– /0.08) t /"H /10,000 /× /0.7351 /"H /7,351 fish.
5. Let t be the time: 0.25 /= /(½)^(t/5730). Taking logs, t /"H /5730 /× /log •/ , /0.25 /"H /5730 /× /2 /= /11,460 /years.

Mixed Problems: Combining Growth and Decay

Problem Set

1. A pharmaceutical company produces a vaccine that initially costs $5 per dose. The cost increases by 4% annually due to inflation. After 10 years, how much does it cost per dose?

2. A population of rabbits starts at 500 and grows at 6% annually. Simultaneously, a disease reduces the population by 2% each year. What is the net population after 8 years?

3. A battery's charge decays by 15% each day. However, a solar panel recharges it by 10% daily. If the battery starts at 100% charge, what is the charge after 5 days?

4. A compound interest investment grows at 5% per year, but an annual fee of 1% is deducted from the account balance each year. What is the balance after 12 years, starting with $10,000?

5. A bacterial culture doubles every 30 minutes, but an antibiotic reduces the number of viable cells by 5% each hour. Starting with 10,000 cells, how many remain after 2 hours?

Answers

1. Cost after 10 years: 5 /× /(1 /+ /0.04)¹ p /"H /5 /× /1.4802 /"H /$7.40 per dose.
2. Net growth factor per year: (1 /+ /0.06) /× /(1 /– /0.02) /= /1.06 /× /0.98 /"H /1.0388. After 8 years: 500 /× /1.0388 x /"H /500 rabbits.
3. Day 1: 100 /% /– /15 /% /+ /10 /% /= /95 /% /+ /10 /% /= /105 /% (capped at 100 /% if necessary). Assuming unlimited cap after 5 days: 100 /% /× /(1 /– /0.15) u /× /(1 /+ /0.10) u /"H /100 /% /× /0.4437 /× /1.6105 /"H /71.5 /%.
4. Effective annual factor: (1 /+ /0.05) /– /0.01 /= /1.04. After 12 years: 10,000 /× /1.04¹² /"H /10,000 /× /1.6010 /"H /$16,010.

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