# 6TH GRADE

# MATH

Tytiana Young

# Preface

Artificial Intelligence (AI) and Machine Learning (ML) are rapidly transforming the world we live in. From healthcare to entertainment, finance to education, the ability to understand and build ML models is an essential skill for the 21st century. This book, **AI/ML Literacy and Train ML Model Using Web Browser**, is designed to empower readers with practical knowledge and hands-on experience, using just a web browser.

This journey would not have been possible without the support and inspiration of many remarkable individuals. I would like to express my deepest gratitude to **Dr. Whu**, whose guidance and encouragement have been pivotal throughout this project. Special thanks also go to **Garret Godwin**, **Ayodeji Williams**, **Tionna Freeman**, and **Stevie Scott** for their invaluable insights, feedback, and support during the development of this book.

I am also profoundly grateful to **Albany State University** for sponsoring the class and providing the environment and resources that made this work possible. Their commitment to advancing technology education is inspiring and deeply appreciated.

To all readers: I hope this book ignites your curiosity and helps you unlock the transformative power of AI and ML.

Tytiana Young

*Thank you and enjoy the journey ahead!*

# Table of contents

The book is also available online at
https://www.backupspirit.com/camp/2025/completion/TytianaYoung.html

## Part 1 - Arithmetic of whole numbers

## Part 2 - Arithmetic of fractions

Ratio Tables
Rates
Problem-Solving with Proportions

## Part 3 - Arithmetic of decimals

Decimal Place Value and Rounding
Changing Fractions to Decimals
Changing Decimals to Fractions
Comparing and Ordering Decimals
Adding Decimals
Subtracting Decimals
Adding and Subtracting Money
Estimating Decimal Sums and Differences
Multiplying Decimals
Multiplying Money
Estimating Decimal Products
Dividing Decimals by Whole Numbers
Dividing Whole Numbers by Decimals
Dividing Decimals by Decimals
Dividing Money
Estimating Decimal Quotients
Understanding Percent
Percents and Fractions
Percents and Decimals
Multiplying Percents and Fractions

## Part 4 - Laws and properties of arithmetic

Exponents
Scientific Notation
Order of Operations
Commutative and Associative Properties
Distributive Property and Identity
Zero Property, Equality Properties
Factors and Multiples
Understanding Variable Expressions
Solving Equations by Addition and Subtraction
Solving Equations by Multiplication and Division
Inequalities
Solving Equations and Inequalities by Substitution

## Part 5 - Measurements and Units

Customary Units of Length
Customary Units of Liquid Volume
Customary Units of Weight
Perimeter
Area
Volume of a Solid
Time
Temperature
Metric Units of Length
Metric Units of Liquid Volume
Metric Units of Mass
Perimeter, Area, and Volume of a Solid: Metric
Changing from Customary Units to Metric Units
Changing from Metric Units to Customary Units

## Part 6 - Planar Geometry

Points and Lines
Line Segments and Rays
Measuring Angles
Types of Angles
Triangles
Quadrilaterals
Polygons
Circles
Solid Figures
Surface Area
Graphing Figures

## Part 7 Single Neuron Linear Regression Trainer

https://www.backupspirit.com/camp/2025/completion/tytianaModel1.html

## Part 8 Train a Convolutional Neural Network in Your Browser

https://www.backupspirit.com/camp/2025/completion/tytianaModel2.html

# Fractions & Proportions
# Textbook-Style Chapters

Your complete guide to mastering fractions and proportions, one chapter at a time.

## 1 Changing Improper Fractions to Mixed Numbers

*Learn how to convert an improper fraction into a mixed number, step by step.*

**Improper Fraction:** A fraction where the numerator is larger than the denominator (for example, 9/4).

**Mixed Number:** A whole number and a fraction together.

**How to Change an Improper Fraction to a Mixed Number:**

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3. The remainder becomes the numerator of the fraction part. The denominator stays the same.

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Divide: 9 ÷ 4 = 2 remainder 1

So, 9/4 = 2 1/4

**Visual:** 9/4 = 2 whole 1/4

## Changing Mixed Numbers to Improper Fractions

**Example:** 2 1/4 = (2 × 4 + 1) / 4 = 9/4

## Adding Fractions with Like Denominators

**Example:** 3/8 + 2/8 = (3 + 2)/8 = 5/8

## Subtracting Fractions with Like Denominators

**Example:** 7/10 - 3/10 = (7 - 3)/10 = 4/10 = 2/5

## Adding or Subtracting Fractions with Unlike Denominators

**Example:** 1/4 + 1/6

Find LCD (12): 3/12 + 2/12 = 5/12

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Convert: 4/3 + 13/6 → LCD 6: 8/6 + 13/6 = 21/6 = 3 1/2

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## 8 Estimating Sums and Differences of Fractions and Mixed Numbers

Round to the nearest half or whole number.

**Example:** 2 5/8 + 1 1/3 ≈ 3 + 1 = 4

## 9 Multiplying Fractions and Whole Numbers

**Example:** 3 × 2/5 = 6/5 = 1 1/5

## 10 Multiplying Fractions: Reciprocals

**Reciprocal:** Flip the fraction.

> **Example:** $2/3 \times 3/2 = 1$

## 11 Multiplying Fractions and Mixed Numbers: Reducing

> **Example:** $1\ 1/2 \times 2/3$
>
> Convert: $3/2 \times 2/3 = 6/6 = 1$

## 12 Dividing Fractions by Whole Numbers

> **Example:** $3/4 \div 2 = 3/4 \times 1/2 = 3/8$

## 13 Dividing Whole Numbers by Fractions

> **Example:** $5 \div 2/3 = 5 \times 3/2 = 15/2 = 7\ 1/2$

## 14 Dividing Fractions by Fractions

**Example:** $3/5 \div 1/2 = 3/5 \times 2/1 = 6/5 = 1\ 1/5$

## 15 Dividing Mixed Numbers

**Example:** $2\ 1/2 \div 1\ 1/4$

Convert: $5/2 \div 5/4 = 5/2 \times 4/5 = 2$

## 16 Ratios

**Example:** Ratio of 8 to 12 = 8:12 = 2:3

## 17 Proportions and Cross-Multiplying

**Example:** $2/3 = 4/6$

Cross multiply: $2 \times 6 = 3 \times 4 \rightarrow 12 = 12$

## Ratio Tables

| Input | Output |
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**Ratio:** 1:3

## Rates

**Example:** 60 miles in 2 hours = 30 miles/hour

## Problem-Solving with Proportions

**Example:** If 3 apples cost $6, how much do 5 apples cost?

$3/6 = 5/x \rightarrow 3x = 30 \rightarrow x = \$10$

# Examples of Fractions and Proportions

## Changing Improper Fractions to Mixed Numbers

**Improper Fraction:** Numerator is larger than denominator (e.g., 9/4).

**Mixed Number:** Whole number and a fraction.

**How to:** Divide numerator by denominator. The quotient is the whole number, the remainder is the new numerator.

**Example:** 9/4

$9 \div 4 = 2$ remainder 1, so 9/4 = 2 1/4

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**Example:** 2 1/4 = (2 × 4 + 1) / 4 = 9/4

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Convert: $4/3 + 13/6 \rightarrow$ LCD 6: $8/6 + 13/6 = 21/6 = 3\ 1/2$

### Subtracting Mixed Numbers with Unlike Denominators

**Example:** $3\ 1/2 - 1\ 1/3$

Convert: $7/2 - 4/3 \rightarrow$ LCD 6: $21/6 - 8/6 = 13/6 = 2\ 1/6$

### Estimating Sums and Differences of Fractions and Mixed Numbers

Round to the nearest half or whole.

**Example:** $2\ 5/8 + 1\ 1/3 \approx 3 + 1 = 4$

### Multiplying Fractions and Whole Numbers

**Example:** $3 \times 2/5 = 6/5 = 1\ 1/5$

## Multiplying Fractions: Reciprocals

**Reciprocal:** Flip the fraction.

**Example:** $2/3 \times 3/2 = 1$

## Multiplying Fractions and Mixed Numbers: Reducing

**Example:** $1\ 1/2 \times 2/3$

Convert: $3/2 \times 2/3 = 6/6 = 1$

## Dividing Fractions by Whole Numbers

**Example:** $3/4 \div 2 = 3/4 \times 1/2 = 3/8$

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## Practice: 40 Questions

1. Change **11/3** to a mixed number.

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2. Write **3 2/5** as an improper fraction.

   | Your answer |

3. Simplify: **5/9 + 2/9**

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4. Simplify: **8/15 - 3/15**

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5. Add: **1/6 + 1/4**

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6. Add: **3/5 + 2/3**

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7. Add: **2 1/2 + 1 3/4**

Your answer

8. Subtract: **4 1/2 - 2 2/3**

Your answer

9. Estimate the sum: **4 2/7 + 3 3/5**

Your answer

10. Estimate: **6 5/8 - 2 1/3**

Your answer

11. Multiply: **4 × 3/8**

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12. Multiply: **2 1/4 × 1/2**

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13. Find the reciprocal of **5/9** and multiply it by **9/5**.

Your answer

14. Simplify: **3/7 × 14/9**

Your answer

15. Multiply and reduce: **1 2/3 × 9/4**

Your answer

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17. Divide: $7 \div 1/3$

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21. Write the ratio of 32:40 in simplest form.

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# Decimals, Fractions, Percents – Mastery Guide

Place Value, Rounding, Conversions, Operations, Percents, and More!

## Chapter 1: Explanations of Concepts

### Decimal Place Value and Rounding

- Each digit in a decimal has a value based on its place (tenths, hundredths, thousandths, etc.).
- Example: In 3.427, 4 is tenths, 2 is hundredths, 7 is thousandths.
- To round, look at the digit to the right of your rounding place: 5 or more, round up.

### Changing Fractions to Decimals

- Divide numerator by denominator: 3/4 = 0.75
- Some fractions repeat: 1/3 = 0.333…

### Changing Decimals to Fractions

- Write the decimal as a fraction (0.25 = 25/100), then reduce (25/100 = 1/4).

## Comparing and Ordering Decimals

- Line up the decimal points, add zeros to make the same number of decimal places, then compare.
- Example: 0.36 < 0.4 (because 0.36 < 0.40)

## Adding & Subtracting Decimals & Money

- Align decimal points. Fill in zeros if needed.
- Estimate by rounding decimals before adding/subtracting.

## Multiplying Decimals & Money

- Ignore decimals, multiply as whole numbers. Count total decimal places from the factors, put in the answer.
- Estimate by rounding decimals before multiplying.

## Dividing Decimals

- To divide by a decimal, move the decimal in both divisor and dividend to make divisor a whole number.
- Estimate by rounding decimals before dividing.

## Understanding Percent

- Percent means "per 100." 45% = 45 out of 100 = 0.45 = 45/100

## Percents and Fractions/Decimals

- To convert percent to fraction: Write over 100 and reduce (60% = 60/100 = 3/5)
- To convert percent to decimal: Move decimal point two places left (60% = 0.60)

**Multiplying Percents and Fractions**

- Convert percent to fraction or decimal, then multiply (25% × 2/5 = 0.25 × 2/5)

# Chapter 2: Worked Examples

**Decimal Place Value:** In 5.382, 3 is tenths, 8 is hundredths, 2 is thousandths.

**Rounding:** 4.678 rounded to tenths is 4.7 (since 7 ≥ 5, round up).

**Fraction to Decimal:** 7/8 = 0.875

**Decimal to Fraction:** 0.2 = 2/10 = 1/5

**Comparing Decimals:** 0.53 > 0.5

**Adding Decimals:** 1.45 + 2.6 = 4.05

**Subtracting Decimals:** 5.2 - 3.16 = 2.04

**Adding Money:** $3.67 + $5.45 = $9.12

**Estimating Decimal Sums:** 5.78 + 6.21 ≈ 6 + 6 = 12

**Multiplying Decimals:** 0.6 × 0.4 = 0.24

**Multiplying Money:** $2.75 × 3 = $8.25

**Estimating Decimal Products:** 2.98 × 4.01 ≈ 3 × 4 = 12

**Dividing Decimals by Whole Numbers:** 2.4 ÷ 3 = 0.8

**Dividing Whole Numbers by Decimals:** 6 ÷ 0.2 = 30

**Dividing Decimals by Decimals:** 0.84 ÷ 0.12 = 7

**Dividing Money:** $8.40 ÷ 7 = $1.20

**Estimating Decimal Quotients:** 9.1 ÷ 2.02 ≈ 9 ÷ 2 = 4.5

**Percent to Fraction:** 32% = 32/100 = 8/25

**Percent to Decimal:** 56% = 0.56

**Multiplying Percents and Fractions:** 20% × 1/2 = 0.20 × 0.5 = 0.10

## Chapter 3: Pre-Test (Multiple Choice, 40 Questions)

**Q1. What is the value of the 3 in 4.382?**

○ A. 3 ones
○ B. 3 tenths
○ C. 3 hundredths
○ D. 3 thousandths

**Q2. Round 5.687 to the nearest tenth.**

○ A. 5.6
○ B. 5.7
○ C. 5.68
○ D. 5.69

**Q3. Which decimal is greatest?**

○ A. 0.47

B. 0.074

C. 0.407

D. 0.704

## Q4. Write 5/8 as a decimal.

A. 0.625

B. 0.58

C. 0.64

D. 0.85

## Q5. Which is equivalent to 0.4?

A. 4/10

B. 2/5

C. 40%

D. All of these

## Q6. Which shows 0.305 in word form?

A. Three hundred five thousandths

B. Thirty-five hundredths

C. Three and five tenths

D. Thirty-five thousandths

## Q7. Compare: 0.56 ___ 0.506

A. <

B. >

C. =

D. ≤

## Q8. Order from least to greatest: 0.7, 0.67, 0.76

A. 0.67, 0.7, 0.76

B. 0.7, 0.67, 0.76

C. 0.76, 0.7, 0.67

D. 0.7, 0.76, 0.67

## Q9. 0.3 + 0.47 = ?

A. 0.77

B. 0.74

C. 0.8

D. 0.85

**Q10. 2.4 - 1.78 = ?**

○ A. 0.62
○ B. 0.66
○ C. 0.56
○ D. 0.68

**Q11. Estimate: 3.21 + 4.68**

○ A. 7
○ B. 8
○ C. 6
○ D. 9

**Q12. Add: $5.75 + $2.60**

○ A. $8.35
○ B. $7.35
○ C. $7.25
○ D. $8.25

**Q13. Subtract: $9.10 - $3.45**

○ A. $5.65
○ B. $6.55
○ C. $5.55
○ D. $6.65

**Q14. Which is closest to 2.87 + 4.12?**

○ A. 7
○ B. 6
○ C. 8
○ D. 5

**Q15. Multiply: 0.3 × 0.6**

○ A. 0.18
○ B. 0.09
○ C. 0.24
○ D. 0.06

**Q16. Estimate: 4.05 × 1.97**

○ A. 8
○ B. 4

○ C. 6

○ D. 2

## Q17. $2.25 × 4 = ?

○ A. $8.00

○ B. $9.00

○ C. $7.00

○ D. $8.25

## Q18. Which is closest to 8.8 × 0.51?

○ A. 5

○ B. 9

○ C. 8

○ D. 4

## Q19. Multiply: 0.4 × 0.7

○ A. 0.28

○ B. 0.21

○ C. 0.14

○ D. 0.7

## Q20. 2.1 ÷ 3 = ?

○ A. 0.7

○ B. 0.3

○ C. 0.6

○ D. 0.9

## Q21. 8 ÷ 0.2 = ?

○ A. 40

○ B. 4

○ C. 16

○ D. 80

## Q22. 0.9 ÷ 0.3 = ?

○ A. 0.6

○ B. 2.7

○ C. 3

○ D. 0.3

**Q23. $6.40 ÷ 4 = ?**

○ A. $1.60
○ B. $1.50
○ C. $2.00
○ D. $1.80

**Q24. Estimate: 9.8 ÷ 2.1**

○ A. 5
○ B. 4
○ C. 7
○ D. 3

**Q25. 7.2 ÷ 0.6 = ?**

○ A. 12
○ B. 13
○ C. 10
○ D. 9

**Q26. Which is 56% as a decimal?**

○ A. 0.56
○ B. 0.056
○ C. 5.6
○ D. 56.0

**Q27. 45% of 80 is:**

○ A. 36
○ B. 40
○ C. 45
○ D. 35

**Q28. Which equals 0.2?**

○ A. 2%
○ B. 2/10
○ C. 20%
○ D. 0.02

**Q29. Change 0.75 to a fraction in simplest form.**

○ A. 3/4
○ B. 7/10

C. 1/4
D. 2/5

## Q30. Change 1/5 to a decimal.

A. 0.5
B. 0.2
C. 0.25
D. 0.4

## Q31. What is 30% of 50?

A. 15
B. 20
C. 30
D. 10

## Q32. Which is largest?

A. 0.7
B. 0.67
C. 0.76
D. 0.706

## Q33. Estimate: 5.49 + 2.51

A. 8
B. 7
C. 9
D. 6

## Q34. Which is the same as 0.6?

A. 60%
B. 6/10
C. 3/5
D. All of these

## Q35. Round 7.348 to the nearest hundredth.

A. 7.34
B. 7.35
C. 7.4
D. 7.3

**Q36. 0.33 + 0.44 = ?**

○ A. 0.77
○ B. 0.76
○ C. 0.78
○ D. 0.67

**Q37. 0.09 × 0.8 = ?**

○ A. 0.072
○ B. 0.72
○ C. 0.07
○ D. 0.018

**Q38. Which is closest to 5.94 ÷ 1.97?**

○ A. 3
○ B. 2
○ C. 4
○ D. 1

**Q39. Change 0.125 to a fraction in simplest form.**

○ A. 1/8
○ B. 1/4
○ C. 1/2
○ D. 1/3

**Q40. Which is equal to 0.5?**

○ A. 5%
○ B. 1/5
○ C. 50%
○ D. 2/5

**Q41. Which is the decimal for 3/5?**

○ A. 0.6
○ B. 0.5
○ C. 0.3
○ D. 0.8

**Q42. What is 25% of 64?**

○ A. 16
○ B. 12

**Submit Pre-Test**

# Chapter 4: Review Missed Pre-Test Questions

# Chapter 5: Post-Test (Multiple Choice, 40 Questions)

**Q1. What is the value of the 7 in 8.472?**

A. 7 ones

B. 7 tenths

C. 7 hundredths

D. 7 thousandths

**Q2. Round 3.486 to the nearest tenth.**

A. 3.4

B. 3.5

C. 3.48

D. 3.49

**Q3. 0.25 as a fraction in simplest form is:**

A. 1/2

B. 1/4

C. 2/5

D. 1/5

**Q4. 45% as a decimal is:**

A. 4.5

B. 0.45

C. 0.045

D. 45.0

**Q5. Which decimal is smallest?**

A. 0.6

B. 0.65

C. 0.56

O D. 0.605

**Q6. Which is equal to 0.75?**

O A. 3/4
O B. 75%
O C. 0.750
O D. All of these

**Q7. Change 0.2 to a fraction in simplest form.**

O A. 1/5
O B. 1/2
O C. 2/10
O D. 2/5

**Q8. Which is greatest: 0.38, 0.083, 0.8, 0.38?**

O A. 0.38
O B. 0.083
O C. 0.8
O D. 0.38

**Q9. Order least to greatest: 0.9, 0.79, 0.8**

O A. 0.8, 0.79, 0.9
O B. 0.79, 0.8, 0.9
O C. 0.79, 0.8, 0.9
O D. 0.79, 0.9, 0.8

**Q10. Which is equal to 60%?**

O A. 0.6
O B. 3/5
O C. 60/100
O D. All of these

**Q11. Add: 0.56 + 0.34**

O A. 0.9
O B. 0.8
O C. 0.7
O D. 1.0

**Q12. Subtract: 1.2 - 0.47**

- ○ A. 0.83
- ○ B. 0.73
- ○ C. 0.93
- ○ D. 0.77

## Q13. Estimate: 6.23 + 2.98

- ○ A. 9
- ○ B. 8
- ○ C. 7
- ○ D. 10

## Q14. Add: $3.45 + $6.50

- ○ A. $10.05
- ○ B. $9.95
- ○ C. $9.05
- ○ D. $10.15

## Q15. Subtract: $8.00 - $3.25

- ○ A. $4.75
- ○ B. $5.75
- ○ C. $4.25
- ○ D. $5.25

## Q16. Estimate: 4.8 + 3.1

- ○ A. 8
- ○ B. 7
- ○ C. 9
- ○ D. 6

## Q17. Multiply: 0.7 × 0.5

- ○ A. 0.35
- ○ B. 0.14
- ○ C. 0.25
- ○ D. 0.45

## Q18. Estimate: 5.98 × 2.03

- ○ A. 12
- ○ B. 10
- ○ C. 8

○ D. 14

## Q19. $4.75 × 3 = ?

○ A. $14.25
○ B. $13.50
○ C. $15.00
○ D. $12.75

## Q20. Which is closest to 7.25 × 0.49?

○ A. 4
○ B. 3
○ C. 5
○ D. 6

## Q21. Multiply: 0.35 × 0.8

○ A. 0.28
○ B. 0.21
○ C. 0.14
○ D. 0.7

## Q22. 3.6 ÷ 4 = ?

○ A. 0.9
○ B. 0.4
○ C. 1.2
○ D. 0.6

## Q23. 7 ÷ 0.5 = ?

○ A. 14
○ B. 3.5
○ C. 13
○ D. 17

## Q24. 0.81 ÷ 0.09 = ?

○ A. 9
○ B. 8
○ C. 7
○ D. 10

## Q25. $4.80 ÷ 6 = ?

A. $0.80
B. $0.70
C. $0.60
D. $0.90

## Q26. Estimate: 8.7 ÷ 2.1

A. 4
B. 3
C. 5
D. 2

## Q27. 6.4 ÷ 0.8 = ?

A. 8
B. 7
C. 6
D. 5

## Q28. Which is 34% as a decimal?

A. 0.34
B. 0.034
C. 3.4
D. 34.0

## Q29. 25% of 60 is:

A. 15
B. 12
C. 18
D. 10

## Q30. Which equals 0.3?

A. 30%
B. 3/10
C. 0.30
D. All of these

## Q31. Change 0.8 to a fraction in simplest form.

A. 4/5
B. 2/5
C. 3/4

○ D. 1/2

## Q32. Change 2/5 to a decimal.

○ A. 0.2
○ B. 0.25
○ C. 0.4
○ D. 0.5

## Q33. What is 40% of 30?

○ A. 12
○ B. 15
○ C. 10
○ D. 9

## Q34. Which is smallest?

○ A. 0.23
○ B. 0.32
○ C. 0.12
○ D. 0.21

## Q35. Estimate: 4.56 + 5.44

○ A. 10
○ B. 9
○ C. 8
○ D. 11

## Q36. Which is the same as 0.4?

○ A. 4/10
○ B. 2/5
○ C. 40%
○ D. All of these

## Q37. Round 6.789 to the nearest hundredth.

○ A. 6.79
○ B. 6.78
○ C. 6.8
○ D. 6.7

## Q38. 0.22 + 0.56 = ?

A. 0.78
B. 0.68
C. 0.77
D. 0.66

## Q39. 0.07 × 0.9 = ?

A. 0.063
B. 0.63
C. 0.007
D. 0.09

## Q40. Which is closest to 4.98 ÷ 2.01?

A. 2.5
B. 3
C. 2
D. 1

## Q41. Change 0.2 to a percent.

A. 20%
B. 2%
C. 0.2%
D. 200%

## Q42. Which is equal to 0.25?

A. 25%
B. 1/4
C. 0.250
D. All of these

## Q43. Which is the decimal for 4/5?

A. 0.8
B. 0.4
C. 0.5
D. 0.2

## Q44. What is 10% of 90?

A. 9
B. 10
C. 8

○ D. 11

**Submit Post-Test**

# Algebra Foundations: Concepts, Examples, and Tests

Exponents, Scientific Notation, Properties, Factors, Variable Expressions, Equations, and Inequalities

## Concept Explanations

- **Exponents:** Exponents express repeated multiplication. For example, $2^4 = 2 \times 2 \times 2 \times 2 = 16$.
- **Scientific Notation:** A way to write very large or small numbers as a product of a number between 1 and 10 and a power of 10, e.g. $3.2 \times 10^5$.
- **Order of Operations:** The standard order for evaluating expressions: Parentheses, Exponents, Multiplication/Division, Addition/Subtraction (PEMDAS).
- **Commutative and Associative Properties:**
    - **Commutative:** Order doesn't matter for addition/multiplication: $a + b = b + a$, $ab = ba$.
    - **Associative:** Grouping doesn't matter for addition/multiplication: $(a + b) + c = a + (b + c)$.
- **Distributive Property and Identity:**
    - **Distributive:** $a(b + c) = ab + ac$.
    - **Identity:** The identity for addition is 0 ($a + 0 = a$), for multiplication is 1 ($a \times 1 = a$).
- **Zero Property, Equality Properties:**
    - **Zero Property:** Any number times zero is zero: $a \times 0 = 0$.
    - **Equality Properties:** If $a = b$, then $a + c = b + c$, $a - c = b - c$, etc.
- **Factors and Multiples:**
    - **Factor:** A number that divides another number exactly.
    - **Multiple:** A product of a number and an integer.
- **Understanding Variable Expressions:** Expressions with variables (letters) that represent numbers. For example, $2x + 3$.
- **Solving Equations by Addition and Subtraction:** Isolate the variable by reversing addition or subtraction.
- **Solving Equations by Multiplication and Division:** Isolate the variable by reversing multiplication or division.
- **Inequalities:** Statements comparing two values, using symbols like $>$, $<$, $\geq$, or $\leq$.

- **Solving Equations and Inequalities by Substitution:** Replace the variable with a number to see if the equation or inequality holds true.

## Examples

- **Exponents:** $3^2 = 9$; $5^0 = 1$
- **Scientific Notation:** $0.0007 = 7 \times 10^{-4}$
- **Order of Operations:** $2 + 3 \times 4 = 2 + 12 = 14$
- **Commutative Property:** $7 + 5 = 5 + 7$
- **Associative Property:** $(1 + 2) + 3 = 1 + (2 + 3)$
- **Distributive Property:** $2(x + 5) = 2x + 10$
- **Identity Property:** $8 \times 1 = 8$; $4 + 0 = 4$
- **Zero Property:** $12 \times 0 = 0$
- **Factors:** Factors of 18: 1, 2, 3, 6, 9, 18
- **Multiples:** Multiples of 4: 4, 8, 12, 16, …
- **Variable Expressions:** For $x = 4$, $2x + 3 = 2 * 4 + 3 = 11$
- **Solving by Addition:** $x - 3 = 7 \Rightarrow x = 10$
- **Solving by Multiplication:** $3y = 12 \Rightarrow y = 4$
- **Inequalities:** $x + 2 > 7 \Rightarrow x > 5$
- **Substitution:** If $y = 2$, does $y + 3 = 5$? Yes.

## Pre-Test (40 Multiple Choice Questions)

1. What is $2^5$?
   - ○ A) 7
   - ○ B) 10
   - ○ C) 32
   - ○ D) 25

2. Write 45,000 in scientific notation.
   - ○ A) $4.5 \times 10^4$
   - ○ B) $4.5 \times 10^5$
   - ○ C) $45 \times 10^3$
   - ○ D) $0.45 \times 10^5$

3. Evaluate: $6 + 2 \times 3$
   - ○ A) 24
   - ○ B) 12
   - ○ C) 18
   - ○ D) 12

4. Simplify: $(4 + 5) + 7$

    ○ A) 9 + 7

    ○ B) 16

    ○ C) 15

    ○ D) 11

5. Use the distributive property to expand: $3(x + 2)$

    ○ A) $3x + 2$

    ○ B) $3x + 6$

    ○ C) $x + 6$

    ○ D) $x + 2$

6. What is the identity property of multiplication?

    ○ A) $a \times 1 = a$

    ○ B) $a + 0 = a$

    ○ C) $a \times 0 = 0$

    ○ D) $a + 1 = a$

7. What is $9 \times 0$?

    ○ A) 1

    ○ B) 9

    ○ C) 0

    ○ D) -9

8. Which of the following is NOT a factor of 24?

    ○ A) 2

    ○ B) 8

    ○ C) 12

    ○ D) 7

9. What is the least common multiple of 4 and 6?

    ○ A) 12

    ○ B) 24

    ○ C) 18

    ○ D) 6

10. Evaluate: $2x + 3$ for $x = 5$

A) 10
B) 13
C) 8
D) 15

11. Solve: $x + 7 = 12$
    A) 5
    B) 12
    C) 7
    D) 19

12. Solve: $4y = 20$
    A) 16
    B) 5
    C) 24
    D) 80

13. Is $3x > 15$ true for $x = 6$?
    A) Yes
    B) No
    C) Sometimes
    D) Not enough information

14. Substitute $a = 2$ into $a^2 + 3$.
    A) 5
    B) 7
    C) 4
    D) 9

15. What is $5^{-1}$?
    A) 5
    B) -5
    C) 0.2
    D) 1

16. Convert $0.0003$ to scientific notation.
    A) $3 \times 10^{-4}$

B) $3 \times 10^{-5}$
C) $3 \times 10^4$
D) $0.3 \times 10^{-3}$

17. Which property is this: $a + b = b + a$?
    A) Associative
    B) Commutative
    C) Distributive
    D) Identity

18. Simplify: $7 + (3 + 2)$
    A) 12
    B) 10
    C) 9
    D) 14

19. Expand: $2(4 + y)$
    A) $8 + 2y$
    B) $4 + 2y$
    C) $2y + 4$
    D) $2y + 8$

20. What is the identity property of addition?
    A) $a + 0 = a$
    B) $a + 1 = a$
    C) $a \times 1 = a$
    D) $a \times 0 = a$

21. What is the result of $8 \times 0$?
    A) 0
    B) 8
    C) 1
    D) -8

22. Which is NOT a multiple of 3 up to 18?
    A) 6
    B) 9

- C) 12
- D) 17

23. Which is a factor of 10?
- A) 3
- B) 4
- C) 5
- D) 7

24. For $x = 3$, what is $4x - 2$?
- A) 10
- B) 5
- C) 12
- D) 14

25. Solve: $z - 8 = 9$
- A) 1
- B) 17
- C) -1
- D) 8

26. Solve: $5b = 35$
- A) 7
- B) 35
- C) 30
- D) 5

27. Is $x - 2 < 5$ true for $x = 10$?
- A) Yes
- B) No
- C) Sometimes
- D) Always

28. Substitute $m = 4$ into $3m + 5$.
- A) 17
- B) 12
- C) 15

O D) 7

29. What is $10^0$?
   O A) 1
   O B) 0
   O C) 10
   O D) 100

30. Write 0.006 in scientific notation.
   O A) $6 \times 10^{-2}$
   O B) $6 \times 10^{-3}$
   O C) $0.6 \times 10^{-2}$
   O D) $60 \times 10^{-4}$

31. Which property? $(a + b) + c = a + (b + c)$
   O A) Associative
   O B) Commutative
   O C) Identity
   O D) Distributive

32. Simplify: $(2 \times 3) \times 4$
   O A) 18
   O B) 24
   O C) 20
   O D) 14

33. Expand: $4(x - 2)$
   O A) $4x - 2$
   O B) $4x - 8$
   O C) $x - 8$
   O D) $4x + 2$

34. What is the zero property of multiplication?
   O A) $a \times 1 = a$
   O B) $a \times 0 = 0$
   O C) $a + 0 = a$
   O D) $a \times a = a$

35. Which is a factor of 16?

   ○ A) 3
   ○ B) 4
   ○ C) 5
   ○ D) 6

36. What is the greatest common factor (GCF) of 12 and 18?

   ○ A) 2
   ○ B) 3
   ○ C) 6
   ○ D) 12

37. For $y = 7$, evaluate $2y + 1$

   ○ A) 14
   ○ B) 15
   ○ C) 13
   ○ D) 17

38. Solve: $x/2 = 6$

   ○ A) 3
   ○ B) 8
   ○ C) 12
   ○ D) 18

39. Solve: $3a = 21$

   ○ A) 24
   ○ B) 7
   ○ C) 18
   ○ D) 6

40. Is $x + 5 \geq 12$ true for $x = 6$?

   ○ A) Yes
   ○ B) No
   ○ C) Sometimes
   ○ D) Always

## Pre-Test Answer Key

1. C) 32
2. A) $4.5 \times 10^4$
3. B) 12
4. B) 16
5. B) $3x + 6$
6. A) $a \times 1 = a$
7. C) 0
8. D) 7
9. A) 12
10. B) 13
11. A) 5
12. B) 5
13. A) Yes
14. B) 7
15. C) 0.2
16. A) $3 \times 10^{-4}$
17. B) Commutative
18. A) 12
19. A) $8 + 2y$
20. A) $a + 0 = a$
21. A) 0
22. D) 17
23. C) 5
24. A) 10
25. B) 17
26. A) 7
27. B) No
28. A) 17
29. A) 1
30. B) $6 \times 10^{-3}$
31. A) Associative
32. B) 24
33. B) $4x - 8$

34. B) $a \times 0 = 0$
35. B) 4
36. C) 6
37. B) 15
38. C) 12
39. B) 7
40. B) No

*Use this key to check your answers after taking the Pre-Test.*

## Questions & Answers

**Q:** What is the difference between a factor and a multiple?
**A:** A factor divides a number exactly, but a multiple is the product of a number and any integer.

**Q:** How do you convert a number to scientific notation?
**A:** Move the decimal so there is one nonzero digit to the left, then multiply by 10 raised to the number of places moved.

**Q:** When solving equations, what is the first step?
**A:** Isolate the variable by using inverse operations (undo addition/subtraction or multiplication/division).

**Q:** What does the distributive property allow you to do?
**A:** Multiply a number by a sum or difference: $a(b + c) = ab + ac$.

**Q:** What is the order of operations and why is it important?
**A:** PEMDAS tells you which operations to perform first so everyone solves problems the same way.

**Q:** How do you check if your solution to an equation is correct?
**A:** Substitute your solution back into the original equation and see if both sides are equal.

**Q:** What happens if you multiply both sides of an equation by 0?

> **A:** Both sides become zero, which is not helpful for solving equations.

> **Q:** How do you solve inequalities?
> **A:** Similar to equations, but if you multiply or divide by a negative, reverse the inequality sign.

## Post-Test (40 Multiple Choice Questions)

1. What is $3^3$?
   - ○ A) 6
   - ○ B) 9
   - ○ C) 27
   - ○ D) 18

2. Which is $7 \times 10^2$ in standard form?
   - ○ A) 700
   - ○ B) 70
   - ○ C) 7,000
   - ○ D) 710

3. Evaluate: $4 + 3 \times 2$
   - ○ A) 14
   - ○ B) 10
   - ○ C) 12
   - ○ D) 7

4. Which property? $a \times b = b \times a$
   - ○ A) Identity
   - ○ B) Associative
   - ○ C) Commutative
   - ○ D) Distributive

5. Expand: $2(y + 5)$
   - ○ A) $2y + 5$
   - ○ B) $2y + 10$
   - ○ C) $y + 10$
   - ○ D) $2 + 5y$

6. What is the additive identity?

   ○ A) 1

   ○ B) 0

   ○ C) -1

   ○ D) None

7. What is $8 \times 0$?

   ○ A) 8

   ○ B) 0

   ○ C) 1

   ○ D) -8

8. Which is NOT a factor of 20?

   ○ A) 2

   ○ B) 4

   ○ C) 6

   ○ D) 5

9. Least common multiple of 6 and 8?

   ○ A) 24

   ○ B) 12

   ○ C) 48

   ○ D) 18

10. For $y = 4$, value of $5y - 1$?

    ○ A) 19

    ○ B) 21

    ○ C) 20

    ○ D) 14

11. Solve: $z + 9 = 15$

    ○ A) 24

    ○ B) 6

    ○ C) -6

    ○ D) 9

12. Solve: $3x = 27$

A) 9

B) 24

C) 30

D) 81

13. Is $4x > 20$ true for $x = 6$?

A) Yes

B) No

C) Sometimes

D) Always

14. Substitute $b = 2$ in $b^2 + 4$

A) 8

B) 6

C) 10

D) 12

15. What is $4^{-1}$?

A) 4

B) 0.25

C) -4

D) 2

16. 0.003 in scientific notation:

A) $3 \times 10^{-2}$

B) $3 \times 10^{-3}$

C) $0.3 \times 10^{-3}$

D) $30 \times 10^{-4}$

17. Which property? $(a + b) + c = a + (b + c)$

A) Commutative

B) Associative

C) Distributive

D) Identity

18. Simplify: $9 + (1 + 3)$

A) 13

- B) 10
- C) 12
- D) 11

19. Expand: $4(y + 3)$
- A) $4y + 12$
- B) $4y + 3$
- C) $y + 12$
- D) $12y + 3$

20. What is the multiplicative identity?
- A) 1
- B) 0
- C) -1
- D) 2

21. $8 \times 0 = ?$
- A) 0
- B) 8
- C) 1
- D) -8

22. Which is NOT a multiple of 6?
- A) 18
- B) 24
- C) 30
- D) 20

23. Which is a factor of 18?
- A) 2
- B) 5
- C) 7
- D) 8

24. If $k = 5$, $k^2 - 3 = ?$
- A) 25
- B) 23

C) 22

D) 28

25. Solve: $x - 7 = 6$
    - A) 13
    - B) 1
    - C) -1
    - D) 7

26. Solve: $9a = 27$
    - A) 3
    - B) 9
    - C) 1
    - D) 6

27. Is $x + 4 > 10$ true for $x = 7$?
    - A) Yes
    - B) No
    - C) Sometimes
    - D) Never

28. $n = 3$, $2n + 7 = ?$
    - A) 13
    - B) 6
    - C) 12
    - D) 9

29. What is $7^0$?
    - A) 1
    - B) 0
    - C) 7
    - D) 49

30. 0.0009 in scientific notation:
    - A) $9 \times 10^{-3}$
    - B) $9 \times 10^{-4}$
    - C) $0.9 \times 10^{-3}$

D) $90 \times 10^{-5}$

31. Which property? $(a + b) + c = a + (b + c)$
    - A) Commutative
    - B) Associative
    - C) Distributive
    - D) Identity

32. Simplify: $(7 + 2) + 5$
    - A) 12
    - B) 14
    - C) 9
    - D) 15

33. Expand: $2(x - 3)$
    - A) $2x - 3$
    - B) $2x - 6$
    - C) $x - 6$
    - D) $2x + 3$

34. Zero property of multiplication:
    - A) $x \times 0 = 0$
    - B) $x \times 1 = x$
    - C) $x + 0 = x$
    - D) $x - 0 = 0$

35. Which is a factor of 16?
    - A) 5
    - B) 8
    - C) 6
    - D) 12

36. Greatest common factor of 15 and 25?
    - A) 5
    - B) 10
    - C) 15
    - D) 25

37. $w = 4$, value of $3w + 2$?
   - A) 10
   - B) 14
   - C) 12
   - D) 8

38. Solve: $x/2 = 11$
   - A) 2
   - B) 11
   - C) 22
   - D) 13

39. Solve: $4a = 24$
   - A) 6
   - B) 4
   - C) 8
   - D) 12

40. Is $x + 4 \leq 15$ true for $x = 12$?
   - A) Yes
   - B) No
   - C) Sometimes
   - D) Never

Submit Post-Test

# Measurement Concepts and Conversions

Customary and Metric Units, Perimeter, Area, Volume, and More!

## Chapter 1: Key Concepts

- **Customary Units of Length:** Inches (in), feet (ft), yards (yd), and miles (mi) are used to measure length in the United States.
- **Customary Units of Liquid Volume:** Cups, pints, quarts, and gallons are used to measure liquid volume.
- **Customary Units of Weight:** Ounces (oz), pounds (lb), and tons (T) measure weight.
- **Perimeter:** The total distance around a shape.
- **Area:** The amount of surface a shape covers.
- **Volume of a Solid:** The amount of space a solid object occupies.
- **Time:** Measured in seconds, minutes, and hours.
- **Temperature:** Measured in degrees Fahrenheit (°F) or Celsius (°C).
- **Metric Units of Length:** Millimeters (mm), centimeters (cm), meters (m), and kilometers (km).
- **Metric Units of Liquid Volume:** Milliliters (mL) and liters (L).
- **Metric Units of Mass:** Milligrams (mg), grams (g), and kilograms (kg).
- **Perimeter, Area, and Volume (Metric):** Use metric units (mm, cm, m, etc.) for measurements.
- **Changing Customary to Metric:** Use conversion factors (e.g., 1 inch = 2.54 cm).
- **Changing Metric to Customary:** Use conversion factors (e.g., 1 kilometer = 0.621 miles).

## Chapter 2: Examples

- 12 inches = 1 foot; 3 feet = 1 yard; 1 mile = 5280 feet.
- 4 quarts = 1 gallon; 2 cups = 1 pint.
- 16 ounces = 1 pound; 2000 pounds = 1 ton.
- Perimeter of rectangle: $P = 2(l + w)$
- Area of rectangle: $A = l \times w$
- Volume of a cube: $V = s^3$; Volume of a rectangular prism: $V = l \times w \times h$
- 60 seconds = 1 minute; 60 minutes = 1 hour.
- 0°C = 32°F (freezing); 100°C = 212°F (boiling).
- 1 meter = 100 centimeters; 1 kilometer = 1000 meters.
- 1000 milliliters = 1 liter.
- 1000 grams = 1 kilogram.

- Area (metric): A = l × w (with l and w in meters).
- Convert 10 inches to centimeters: 10 × 2.54 = 25.4 cm.
- Convert 5 kilometers to miles: 5 × 0.621 = 3.105 miles.

# Chapter 3: Pre-Test (40 Questions)

**Q1:** How many inches are in a foot?
- ○ 10
- ○ 12
- ○ 24
- ○ 36

**Q2:** How many feet are in a yard?
- ○ 2
- ○ 3
- ○ 4
- ○ 5

**Q3:** How many yards are in a mile?
- ○ 1,000
- ○ 880
- ○ 1,760
- ○ 5,280

**Q4:** How many ounces are in a pound?
- ○ 8
- ○ 12
- ○ 16
- ○ 20

**Q5:** How many quarts are in a gallon?
- ○ 2
- ○ 3
- ○ 4
- ○ 8

**Q6:** The perimeter of a rectangle with length 5 ft and width 3 ft is:
- ○ 8 ft
- ○ 15 ft
- ○ 16 ft
- ○ 10 ft

**Q7:** The area of a rectangle with length 7 m and width 2 m is:
- ○ 5 m²
- ○ 14 m²
- ○ 9 m²
- ○ 12 m²

**Q8:** What is the volume of a rectangular prism 2 cm × 3 cm × 4 cm?
- ○ 24 cm³
- ○ 18 cm³
- ○ 9 cm³
- ○ 12 cm³

**Q9:** How many seconds are in one minute?
- ○ 60
- ○ 100
- ○ 30
- ○ 120

**Q10:** What is the freezing point of water in Fahrenheit?
- ○ 32°F
- ○ 0°F
- ○ 100°F
- ○ 212°F

**Q11:** How many centimeters in a meter?
- ○ 10
- ○ 100
- ○ 1,000
- ○ 1

**Q12:** How many milliliters in a liter?
- ○ 10
- ○ 100
- ○ 1,000
- ○ 10,000

**Q13:** How many grams are in a kilogram?
- ○ 10
- ○ 100
- ○ 1,000

○ 10,000

**Q14:** Convert 10 inches to centimeters (1 in = 2.54 cm):
○ 15.4 cm

○ 20.54 cm

○ 25.4 cm

○ 2.54 cm

**Q15:** Convert 5 kilometers to miles (1 km ≈ 0.621 mi):
○ 3.105 mi

○ 6.21 mi

○ 8.05 mi

○ 2.5 mi

**Q16:** How many cups are in a pint?
○ 1

○ 2

○ 3

○ 4

**Q17:** How many pints are in a quart?
○ 1

○ 2

○ 3

○ 4

**Q18:** How many pounds are in a ton?
○ 100

○ 1,000

○ 2,000

○ 10,000

**Q19:** The boiling point of water in Celsius is:
○ 0°C

○ 32°C

○ 100°C

○ 212°C

**Q20:** How many meters are in a kilometer?
○ 10

○ 100
○ 1,000
○ 10,000

**Q21:** What is the formula for the perimeter of a rectangle?
○ l × w

○ 2(l + w)

○ l + w

○ l × w × h

**Q22:** What is the formula for the area of a rectangle?
○ l × w

○ 2(l + w)

○ l + w

○ l × w × h

**Q23:** What is the formula for the volume of a cube?
○ l × w

○ l × w × h

○ $s^3$

○ 2(l + w)

**Q24:** How many minutes are in 2 hours?
○ 60

○ 90

○ 120

○ 180

**Q25:** How many milligrams are in a gram?
○ 100

○ 1,000

○ 10,000

○ 100,000

**Q26:** Convert 3 feet to inches:
○ 24 in

○ 30 in

○ 36 in

○ 48 in

**Q27:** Convert 2 liters to milliliters:
- ○ 200 mL
- ○ 2,000 mL
- ○ 20 mL
- ○ 200,000 mL

**Q28:** Convert 5000 grams to kilograms:
- ○ 0.5 kg
- ○ 5 kg
- ○ 50 kg
- ○ 500 kg

**Q29:** How many quarts are in a gallon?
- ○ 2
- ○ 3
- ○ 4
- ○ 8

**Q30:** What is 25°C in Fahrenheit? (°F = °C × 1.8 + 32)
- ○ 57°F
- ○ 77°F
- ○ 82°F
- ○ 97°F

**Q31:** What is the basic unit of mass in the metric system?
- ○ Gram
- ○ Ounce
- ○ Pound
- ○ Ton

**Q32:** How many centimeters are in a kilometer?
- ○ 1,000
- ○ 10,000
- ○ 100,000
- ○ 1,000,000

**Q33:** How many meters are in 5 kilometers?
- ○ 500
- ○ 5,000
- ○ 50,000

○ 500,000

**Q34:** How many ounces are in a cup?
○ 4

○ 6

○ 8

○ 12

**Q35:** Which is larger: 1 quart or 1 liter?
○ 1 quart

○ 1 liter

○ They are equal

○ Cannot be compared

**Q36:** How many seconds are in 3 minutes?
○ 90

○ 120

○ 180

○ 240

**Q37:** Convert 2 miles to feet (1 mile = 5,280 feet):
○ 2,280 ft

○ 10,560 ft

○ 5,280 ft

○ 7,280 ft

**Q38:** How many millimeters are in a centimeter?
○ 1

○ 10

○ 100

○ 1,000

**Q39:** What is the area of a square 5 cm on each side?
○ 10 cm²

○ 20 cm²

○ 25 cm²

○ 5 cm²

**Q40:** How many hours are in 3 days?
○ 24

○ 48

○ 60

○ 72

**Q41:** What is 100°F in Celsius? (°C = (°F – 32) ÷ 1.8)

○ 37.8°C

○ 40°C

○ 50°C

○ 60°C

Submit

# Chapter 4: Questions & Answers

*Take the pre-test; any incorrect answers will appear here with explanations.*

# Chapter 5: Post-Test (40 Questions)

**Q1:** How many inches are in a foot?

○ 10

○ 12

○ 24

○ 36

**Q2:** How many feet are in a yard?

○ 2

○ 3

○ 4

○ 5

**Q3:** How many yards are in a mile?

○ 1,000

○ 880

○ 1,760

○ 5,280

**Q4:** How many ounces are in a pound?

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○ 12

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○ 3

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**Q6:** The perimeter of a rectangle with length 5 ft and width 3 ft is:

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○ 15 ft

○ 16 ft

○ 10 ft

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○ 24 cm³

○ 18 cm³

○ 9 cm³

○ 12 cm³

**Q9:** How many seconds are in one minute?

○ 60

○ 100

○ 30

○ 120

**Q10:** What is the freezing point of water in Fahrenheit?

○ 32°F

○ 0°F

○ 100°F

○ 212°F

**Q11:** How many centimeters in a meter?

- ○ 10
- ○ 100
- ○ 1,000
- ○ 1

**Q12:** How many milliliters in a liter?
- ○ 10
- ○ 100
- ○ 1,000
- ○ 10,000

**Q13:** How many grams are in a kilogram?
- ○ 10
- ○ 100
- ○ 1,000
- ○ 10,000

**Q14:** Convert 10 inches to centimeters (1 in = 2.54 cm):
- ○ 15.4 cm
- ○ 20.54 cm
- ○ 25.4 cm
- ○ 2.54 cm

**Q15:** Convert 5 kilometers to miles (1 km ≈ 0.621 mi):
- ○ 3.105 mi
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- ○ 8.05 mi
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- ○ 1
- ○ 2
- ○ 3
- ○ 4

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- ○ 1
- ○ 2
- ○ 3
- ○ 4

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- ○ 100
- ○ 1,000
- ○ 2,000
- ○ 10,000

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- ○ 2(l + w)
- ○ l + w
- ○ l × w × h

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- ○ 2(l + w)
- ○ l + w
- ○ l × w × h

**Q23:** What is the formula for the volume of a cube?
- ○ l × w
- ○ l × w × h
- ○ $s^3$
- ○ 2(l + w)

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- ○ 60
- ○ 90
- ○ 120

○ 180

**Q25:** How many milligrams are in a gram?
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○ 1,000

○ 10,000

○ 100,000

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○ 24 in

○ 30 in

○ 36 in

○ 48 in

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○ 200 mL

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○ 0.5 kg

○ 5 kg

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○ Pound

○ Ton

**Q32:** How many centimeters are in a kilometer?
○ 1,000

○ 10,000

○ 100,000

○ 1,000,000

**Q33:** How many meters are in 5 kilometers?
○ 500

○ 5,000

○ 50,000

○ 500,000

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○ 4

○ 6

○ 8

○ 12

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○ They are equal

○ Cannot be compared

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○ 10,560 ft

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○ 10

○ 100

○ 1,000

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○ 10 cm²

○ 20 cm²

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○ 5 cm²

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○ 24

○ 48

○ 60

○ 72

**Q41:** What is 100°F in Celsius? (°C = (°F - 32) ÷ 1.8)

○ 37.8°C

○ 40°C

○ 50°C

○ 60°C

Submit

# Geometry Essentials

# Points, Lines, Angles, Polygons & Solids

## 1. Concepts

### Points and Lines

- **Point:** An exact location in space, with no size or dimension.
- **Line:** A straight path extending infinitely in both directions, with no thickness.
- **Collinear Points:** Points that lie on the same straight line.

### Line Segments and Rays

- **Line Segment:** Part of a line between two endpoints.
- **Ray:** A part of a line that starts at an endpoint and extends infinitely in one direction.

### Measuring Angles

- **Angle:** Formed by two rays (sides) sharing a common endpoint (vertex).
- **Measured in degrees (°):** Full turn = 360°, right angle = 90°.

# Types of Angles

- **Acute:** 0° < angle < 90°
- **Right:** angle = 90°
- **Obtuse:** 90° < angle < 180°
- **Straight:** angle = 180°
- **Reflex:** 180° < angle < 360°

# Triangles

- 3 sides, 3 angles. Sum of angles = 180°.
- **Types by sides:** Equilateral, Isosceles, Scalene.
- **Types by angles:** Acute, Right, Obtuse.

# Quadrilaterals

- 4 sides, 4 angles. Sum of angles = 360°.
- **Types:** Square, Rectangle, Rhombus, Parallelogram, Trapezoid, Kite.

# Polygons

- Closed shape with 3+ straight sides.
- **Regular:** All sides and angles are equal.
- **Irregular:** Sides and/or angles are not all equal.

# Circles

- Set of points equidistant from a center.
- **Radius:** Center to edge.
- **Diameter:** Edge through center to opposite edge (2 × radius).
- **Circumference:** Distance around a circle.

# Solid Figures

- Three-dimensional shapes: Cube, Rectangular Prism, Sphere, Cylinder, Cone, Pyramid.

# Surface Area

- Total area covering the outside of a solid figure.
- Varies by shape; e.g., Cube: $6a^2$, Rectangular Prism: $2(lw + lh + wh)$

**Graphing Figures**

- Plotting points, lines, and shapes on the coordinate plane.
- Coordinates: (x, y).
- Used to visualize and solve geometric problems.

# 2. Examples

**Example 1: Line Segment**

Given points A(2,3) and B(5,7), the length of segment AB is:

*Solution:* Use distance formula:

```
AB = √[(5-2)² + (7-3)²] = √[9 + 16] = √25 = 5
```

**Example 2: Types of Angles**

An angle measuring 110° is an **obtuse angle** because it is more than 90° but less than 180°.

**Example 3: Area of a Triangle**

Triangle with base 8, height 5.

*Area = (1/2) × base × height = (1/2)×8×5 = 20*

**Example 4: Perimeter of a Square**

Square with side 6.

*Perimeter = 4 × side = 24*

**Example 5: Surface Area of a Cube**

Cube with side a = 3.

*Surface area = 6a² = 6×9 = 54*

> **Example 6: Graphing a Triangle**
> Plot points A(1,2), B(4,2), C(4,6) on the coordinate plane to form triangle ABC.

## 3. Pre-Test

**Q1:** Which of these is a quadrilateral?

○ Circle

○ Rectangle

○ Triangle

○ Pentagon

**Q2:** What is the area of a triangle with base 10, height 6?

○ 36

○ 16

○ 60

○ 30

**Q3:** Which is always the longest chord in a circle?

○ Tangent

○ Diameter

○ Radius

○ Arc

**Q4:** Which is an irregular polygon?

○ Regular hexagon

○ A shape with unequal sides/angles

○ Square

○ Equilateral triangle

**Q5:** A parallelogram has:

○ All sides equal

○ No parallel sides

○ Opposite sides parallel and equal

○ Three sides

**Q6:** A line segment is:

○ A point

○ A part of a line between two endpoints

○ A 3D shape

○ A line going forever

**Q7:** Which of these is a reflex angle?

○ 180°

○ 220°

○ 90°

○ 80°

**Q8:** If you plot (4,2) and (4,8), the line segment is:

○ Vertical

○ Diagonal

○ Horizontal

○ Curved

**Q9:** The unit to measure angles is:

○ Liters

○ Seconds

○ Meters

○ Degrees

**Q10:** An angle smaller than 90° is called:

○ Straight

○ Acute

○ Obtuse

○ Right

---

**Q11:** A triangle with all angles less than 90° is called:

○ Obtuse triangle

○ Right triangle

○ Acute triangle

○ Equilateral triangle

---

**Q12:** A polygon with 6 sides is called a:

○ Hexagon

○ Pentagon

○ Octagon

○ Heptagon

---

**Q13:** The surface area of a cube with edge 4 units is:

○ 96 units$^2$

○ 16 units$^2$

○ 24 units$^2$

○ 64 units$^2$

---

**Q14:** Which is NOT a type of quadrilateral?

○ Triangle

○ Square

○ Trapezoid

○ Rhombus

---

**Q15:** A solid figure with 2 circular faces and 1 curved surface is a:

○ Cone

○ Cube

○ Sphere

○ Cylinder

**Q16:** Collinear points are:

○ Points on a circle

○ Points in space

○ Points in the same plane

○ Points on the same line

**Q17:** How many sides does a quadrilateral have?

○ 6

○ 3

○ 5

○ 4

**Q18:** Which is the x-axis?

○ The diagonal axis

○ The curved axis

○ The vertical axis

○ The horizontal axis

**Q19:** A rectangular prism has how many edges?

○ 8

○ 10

○ 6

○ 12

**Q20:** Which of the following extends infinitely in both directions?

○ Line Segment

○ Angle

○ Ray

○ Line

**Q21:** What is a chord?

○ A line joining any two points on a circle

○ Tangent

○ Radius

○ Diameter

**Q22:** The sum of the angles in a quadrilateral is:

○ 270°

○ 180°

○ 360°

○ 540°

**Q23:** A cone has how many faces?

○ 4

○ 1

○ 3

○ 2 (1 circular, 1 curved)

**Q24:** An angle measuring 145° is:

○ Acute

○ Right

○ Reflex

○ Obtuse

**Q25:** Which angle is a right angle?

○ 45°

○ 180°

○ 90°

○ 120°

**Q26:** A triangle with two equal sides is:

○ Scalene

○ Isosceles

○ Equilateral

○ Right

---

**Q27:** The distance around a circle is called the:

○ Diameter

○ Area

○ Chord

○ Circumference

---

**Q28:** A sphere has:

○ No faces, edges, or vertices

○ 8 vertices

○ 12 edges

○ 6 faces

---

**Q29:** A triangle plotted at (1,1), (3,1), (2,4) is on:

○ A cube

○ A line

○ A circle

○ The coordinate plane

---

**Q30:** A regular polygon has:

○ Different sides

○ Different angles

○ No sides

○ All sides and angles equal

---

**Q31:** A pentagon has how many sides?

○ 5

○ 7

○ 8

○ 6

---

**Q32:** The distance from the center of a circle to any point on it is called the:

○ Radius

○ Diameter

○ Chord

○ Arc

---

**Q33:** Area of a rectangle with length 8, width 5?

○ 35

○ 13

○ 40

○ 30

---

**Q34:** The coordinate (3,5) means:

○ 3 units up, 5 units right

○ 3 units left, 5 units up

○ 5 units right, 3 units up

○ 3 units right, 5 units up

---

**Q35:** A triangle with all sides equal is:

○ Equilateral

○ Obtuse

○ Isosceles

○ Scalene

---

**Q36:** What is the perimeter of a square with side 7?

○ 21

○ 14

○ 49

○ 28

**Q37:** A cube has how many faces?

○ 4

○ 8

○ 12

○ 6

---

**Q38:** What is a point in geometry?

○ A straight path extending forever

○ A closed shape

○ A flat surface

○ An exact location with no size

---

**Q39:** A ray starts at a point and:

○ Forms a closed shape

○ Ends at another point

○ Has no direction

○ Extends infinitely in one direction

---

**Q40:** A diameter is:

○ Half the radius

○ Quarter of the radius

○ Equal to the radius

○ Twice the radius

---

Submit Pre-Test

# 4. Questions & Answers

Complete the Pre-Test in Chapter 3. Each incorrect answer will appear here with the correct answer and an explanation.

# 5. Post-Test

**Q1:** Which is an irregular polygon?

○ Square

○ Regular hexagon

○ Equilateral triangle

○ A shape with unequal sides/angles

**Q2:** A diameter is:

○ Quarter of the radius

○ Half the radius

○ Twice the radius

○ Equal to the radius

**Q3:** A cone has how many faces?

○ 4

○ 3

○ 1

○ 2 (1 circular, 1 curved)

**Q4:** Which of these is a quadrilateral?

○ Triangle

○ Pentagon

○ Circle

○ Rectangle

**Q5:** Collinear points are:

○ Points on a circle

○ Points in the same plane

○ Points on the same line

○ Points in space

---

**Q6:** A ray starts at a point and:

○ Ends at another point

○ Has no direction

○ Extends infinitely in one direction

○ Forms a closed shape

---

**Q7:** What is the area of a triangle with base 10, height 6?

○ 36

○ 60

○ 16

○ 30

---

**Q8:** An angle of 180° is called:

○ Reflex angle

○ Right angle

○ Acute angle

○ Straight angle

---

**Q9:** What is the perimeter of a square with side 7?

○ 21

○ 28

○ 49

○ 14

---

**Q10:** A polygon with 6 sides is called a:

○ Octagon

○ Hexagon

○ Heptagon

○ Pentagon

**Q11:** A line segment is:

○ A part of a line between two endpoints

○ A line going forever

○ A point

○ A 3D shape

**Q12:** Surface area of a rectangular prism formula:

○ 2(lw + lh + wh)

○ $4\pi r^2$

○ l × w

○ $\pi r^2$

**Q13:** An angle smaller than 90° is called:

○ Right

○ Obtuse

○ Straight

○ Acute

**Q14:** A triangle plotted at (1,1), (3,1), (2,4) is on:

○ The coordinate plane

○ A line

○ A cube

○ A circle

**Q15:** The unit to measure angles is:

○ Degrees

○ Seconds

○ Liters

○ Meters

---

**Q16:** A cube has how many faces?

○ 8

○ 12

○ 6

○ 4

---

**Q17:** Which of the following extends infinitely in both directions?

○ Line

○ Line Segment

○ Ray

○ Angle

---

**Q18:** The coordinate (3,5) means:

○ 3 units right, 5 units up

○ 3 units up, 5 units right

○ 5 units right, 3 units up

○ 3 units left, 5 units up

---

**Q19:** The surface area of a cube with edge 4 units is:

○ 64 units²

○ 24 units²

○ 16 units²

○ 96 units²

---

**Q20:** A sphere has:

○ 8 vertices

○ 6 faces

○ No faces, edges, or vertices

○ 12 edges

**Q21:** What is a point in geometry?

○ A flat surface

○ A straight path extending forever

○ An exact location with no size

○ A closed shape

---

**Q22:** What is the origin on a graph?

○ (0,1)

○ (0,0)

○ (1,1)

○ (1,0)

---

**Q23:** Area of a rectangle with length 8, width 5?

○ 35

○ 30

○ 40

○ 13

---

**Q24:** A closed shape with straight sides is a:

○ Polygon

○ Curve

○ Circle

○ Ray

---

**Q25:** How many sides does a quadrilateral have?

○ 6

○ 3

○ 5

○ 4

---

**Q26:** A triangle with all angles less than 90° is called:

○ Equilateral triangle

○ Acute triangle

○ Obtuse triangle

○ Right triangle

---

**Q27:** A regular polygon has:

○ Different sides

○ Different angles

○ No sides

○ All sides and angles equal

---

**Q28:** Which is NOT a type of quadrilateral?

○ Triangle

○ Trapezoid

○ Rhombus

○ Square

---

**Q29:** Which of these is a reflex angle?

○ 90°

○ 180°

○ 220°

○ 80°

---

**Q30:** The distance from the center of a circle to any point on it is called the:

○ Chord

○ Arc

○ Radius

○ Diameter

---

**Q31:** The distance around a circle is called the:

○ Circumference

○ Diameter

○ Chord

○ Area

---

**Q32:** Which is the x-axis?

○ The vertical axis

○ The curved axis

○ The diagonal axis

○ The horizontal axis

---

**Q33:** A triangle with all sides equal is:

○ Scalene

○ Isosceles

○ Obtuse

○ Equilateral

---

**Q34:** If you plot (4,2) and (4,8), the line segment is:

○ Horizontal

○ Diagonal

○ Vertical

○ Curved

---

**Q35:** Which angle is a right angle?

○ 90°

○ 45°

○ 180°

○ 120°

---

**Q36:** An angle measuring 145° is:

○ Reflex

○ Right

○ Obtuse

○ Acute

**Q37:** Which is always the longest chord in a circle?

○ Radius

○ Tangent

○ Diameter

○ Arc

**Q38:** A triangle with two equal sides is:

○ Right

○ Equilateral

○ Scalene

○ Isosceles

**Q39:** A solid figure with 2 circular faces and 1 curved surface is a:

○ Cube

○ Sphere

○ Cylinder

○ Cone

**Q40:** What is a chord?

○ Radius

○ Tangent

○ A line joining any two points on a circle

○ Diameter

Submit Post-Test

# Single Neuron Linear Regression Trainer

## Chapter 1: Introduction to Linear Regression

Linear regression is a fundamental technique in machine learning and statistics. It models the relationship between a dependent variable **y** and one or more independent variables **x** using a straight line: $y = wx + b$, where **w** is the weight (slope), and **b** is the bias (intercept). The goal is to find the best **w** and **b** to minimize the difference between the predicted values and actual data points.

## Chapter 2: Train a Single Neuron (Linear Regression)

Try entering your own data points and see how a single neuron (just **w** and **b**) learns to fit them!

Input x values (comma separated):

| 1, 2, 3, 4, 5 |

Input y values (comma separated):

| 3, 5, 7, 9, 11 |

Train Neuron
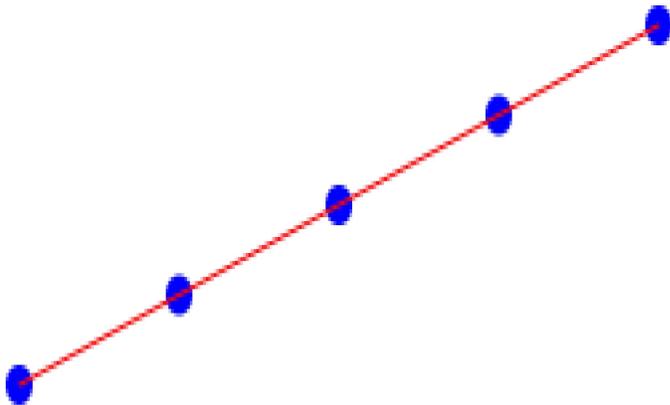


## Chapter 3: Discussion: TensorFlow for JavaScript

TensorFlow.js is an open-source library that brings machine learning capabilities to JavaScript. It enables training and deploying models directly in the browser or in Node.js environments. This allows developers to leverage GPU acceleration, maintain privacy (since data doesn't need to leave the user's device), and create interactive ML-powered applications without backend dependencies. With TensorFlow.js, you can implement, train, and run machine learning models entirely in JavaScript.

# Chapter 4: Key Libraries for Model Training and Visualization

When building machine learning demos in the browser, especially for linear regression and neural networks, several JavaScript libraries are particularly important:

- **TensorFlow.js (Early versions: `0.x, 1.x`):**
  This is the primary library for defining, training, and running machine learning models directly in the browser or in Node.js. It provides flexible APIs to create layers, compile models, and train using backpropagation.

  ```
  <script src="https://cdn.jsdelivr.net/npm/@tensorflow/tfjs@0.15.0"></script>
  ```
  *Early versions provided basic layers, optimizers, and tensor operations for rapid prototyping.*

- **Chart.js (Early versions: `1.x, 2.x`):**
  For visualization, Chart.js is a widely-used library for drawing charts and graphs in the web browser. It helps visualize training progress, predicted values, and the fitted regression line.

  ```
  <script src="https://cdn.jsdelivr.net/npm/chart.js@1.1.1"></script>
  ```
  *Early versions enabled simple line, bar, and scatter plots for data and model outputs.*

By combining early versions of **TensorFlow.js** for computation and **Chart.js** for visualization, you could already build interactive machine learning experiences in the browser. As these libraries evolved, they introduced more features and improved performance, but their early versions are still valuable for understanding the basics.

[ Run ]

By combining early versions of **TensorFlow.js** for computation and **Chart.js** for visualization, you could already build interactive machine learning experiences in the browser. As these libraries evolved, they introduced more features and improved performance, but their early versions are still valuable for understanding the basics.

# Chapter 5: Using and Loading the Cars Dataset

The cars dataset contains records of various car models with attributes such as **mpg** (miles per gallon) and **horsepower**. We will focus on these two fields. Some records may have missing or invalid values, so we will clean the data before using it.

[ Load Dataset ]

# Chapter 6: Visualizing the Cars Dataset

Now that we've loaded and cleaned the cars dataset, let's visualize the relationship between **Miles_per_Gallon** and **Horsepower**. Each car will be a point on the scatter plot.

**Visualize Dataset**

# Chapter 7: Splitting the Dataset into Training and Testing Sets

To evaluate the performance of a machine learning model, it's standard practice to split your dataset into two parts:

- **Training set**: Used to train the model.
- **Testing set**: Used to assess how well the model generalizes to new, unseen data.

A common split ratio is 80% for training and 20% for testing.

**Split the dataset**

# Chapter 8: Building an Artificial Neural Network Model

Neural networks are a family of machine learning models that learn complex relationships between inputs and targets. Here, we will define a simple neural network that models the relationship between a car's **horsepower** (input) and its **miles per gallon** (output).

**Define Neural Network Model**

## What does this model do?

This artificial neural network (ANN) is designed to learn the relationship between a car's **horsepower** and its **fuel efficiency (miles per gallon)**. It consists of:

- **Input:** Horsepower value for each car.
- **One hidden layer:** 10 neurons with `relu` activation to capture non-linear relationships.
- **Output:** The predicted miles per gallon for a given horsepower.
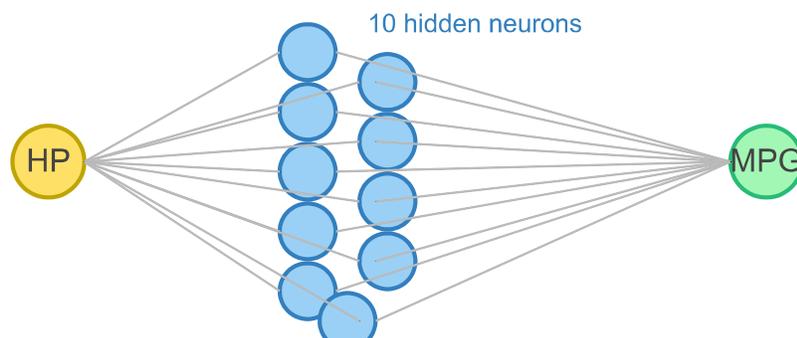
> **How does this work?**
> When you train this model using the **training set** (from the previous section), the network learns to estimate the car's miles per gallon from its horsepower value. The hidden layer allows it to capture more complex, non-linear trends that a simple straight line might miss.

# Chapter 9: Training the Neural Network Model

After defining the model, the next step is to train it using your dataset. Training helps the model learn the mapping between your input (horsepower) and output (miles per gallon) values.

> Train Model

## What happens during training?

Each time you click **Train Model**, the model uses the **cleaned dataset**, gradually adjusting its weights to minimize the error between its predictions and the actual miles per gallon values. The chart above shows how the loss (error) decreases with each epoch, indicating the model is learning.

# Chapter 10: Evaluating the Trained Neural Network Model

After training, it's important to evaluate how well the model performs on data it hasn't seen before. This helps determine if the model can generalize or if it has simply memorized the training data.

> Evaluate Model

## What do the results mean?

**Loss** is a measure of the model's prediction error on the test data — lower values are better. The example above shows how the model's prediction compares to the actual value from the test set. If the loss is much higher than it was during training, the model may be overfitting.

# Chapter 11: Understanding the Confusion Matrix

When evaluating classification models, the **confusion matrix** is a valuable tool for visualizing the performance of your model. It summarizes predictions by showing where the model made correct guesses and where it made mistakes.

## What is a Confusion Matrix?

A confusion matrix is a table that compares the predicted classes to the actual classes. Each row represents the instances in a predicted class, while each column represents the instances in an actual class (or vice versa).

| | Predicted: Positive | Predicted: Negative |
|---|---|---|
| Actual: Positive | True Positive (TP) | False Negative (FN) |
| Actual: Negative | False Positive (FP) | True Negative (TN) |

## How to Read the Confusion Matrix

- **True Positive (TP):** Model correctly predicts the positive class.
- **True Negative (TN):** Model correctly predicts the negative class.
- **False Positive (FP):** Model incorrectly predicts positive when it is actually negative (Type I error).
- **False Negative (FN):** Model incorrectly predicts negative when it is actually positive (Type II error).

## Key Metrics from the Confusion Matrix

- **Accuracy:** `(TP + TN) / (TP + TN + FP + FN)` — Overall, how often is the classifier correct?
- **Precision:** `TP / (TP + FP)` — Of all predicted positives, how many are correct?
- **Recall (Sensitivity):** `TP / (TP + FN)` — Of all actual positives, how many did the model identify?
- **F1 Score:** `2 * (Precision * Recall) / (Precision + Recall)` — The harmonic mean of Precision and Recall.

## Using a Confusion Matrix in Code

Here's how you can compute a confusion matrix in JavaScript, assuming you have arrays of predicted and actual labels:

```
// Example arrays
const yTrue = [1, 0, 1, 0, 1, 1, 0];
const yPred = [1, 0, 0, 0, 1, 1, 1];

function confusionMatrix(yTrue, yPred) {
  let TP = 0, TN = 0, FP = 0, FN = 0;
  for (let i = 0; i < yTrue.length; i++) {
    if (yTrue[i] === 1 && yPred[i] === 1) TP++;
    else if (yTrue[i] === 0 && yPred[i] === 0) TN++;
    else if (yTrue[i] === 0 && yPred[i] === 1) FP++;
    else if (yTrue[i] === 1 && yPred[i] === 0) FN++;
  }
  return {TP, TN, FP, FN};
}

const matrix = confusionMatrix(yTrue, yPred);
console.log(matrix);
```

## Why Use the Confusion Matrix?

The confusion matrix provides insight into **how** your model is making errors, which helps you fine-tune and improve your model's performance, especially when classes are imbalanced.

# Train a Convolutional Neural Network in Your Browser

## Introduction to Convolutional Neural Networks

Convolutional Neural Networks (CNNs) are a specialized type of deep learning model best suited for processing data with a grid-like topology, such as images. CNNs use layers with learnable filters (kernels) that scan across the input, automatically learning features like edges, textures, and shapes. The main building blocks of CNNs include convolutional layers, activation functions (e.g., ReLU), pooling layers, and fully connected layers. CNNs have achieved state-of-the-art performance in computer vision tasks such as image classification, object detection, and segmentation.

### How to Train a CNN

1. Prepare a labeled dataset of images (e.g., handwritten digits, cats vs. dogs).
2. Define the architecture: stack convolutional & pooling layers, flatten the output, and add dense layers.
3. Choose a loss function (e.g., categorical crossentropy) and an optimizer (e.g., Adam).
4. Feed batches of input data through the network, compute the loss, and update weights using backpropagation.
5. Evaluate the model's performance on validation data, then adjust hyperparameters and retrain as needed.

## TensorFlow.js for CNNs

[TensorFlow.js](#) is an open-source library that brings machine learning capabilities to JavaScript. Using TensorFlow.js, you can build, train, and run neural networks directly in the browser or in Node.js without any server-side code. **For training CNNs in the browser, TensorFlow.js provides:**

- High-level APIs such as `tf.sequential()` and `tf.model()` for easy model construction
- Layers like `tf.layers.conv2d()`, `tf.layers.maxPooling2d()`, and `tf.layers.dense()`
- Built-in optimizers (Adam, SGD, etc.) and loss functions
- Support for GPU acceleration via WebGL for faster training

By leveraging TensorFlow.js, developers can experiment with deep learning models, visualize results, and even deploy models to users entirely within the browser environment.

## Example: Build and Train a Simple CNN (MNIST digits)

**Note:** This example creates a simple CNN for digit classification. For demonstration, synthetic random data is used; in practice, replace this with real image data.

```
// Define the CNN model
const model = tf.sequential();
model.add(tf.layers.conv2d({
  inputShape: [28, 28, 1],
  filters: 16,
  kernelSize: 3,
  activation: 'relu'
}));
model.add(tf.layers.maxPooling2d({ poolSize: 2 }));
model.add(tf.layers.flatten());
model.add(tf.layers.dense({ units: 10, activation: 'softmax' }));

model.compile({
  optimizer: 'adam',
  loss: 'categoricalCrossentropy',
  metrics: ['accuracy']
});

// Generate random training data (replace with real images)
const xs = tf.randomNormal([100, 28, 28, 1]);
const ys = tf.oneHot(tf.randomUniform([100], 0, 10, 'int32'), 10);

// Train the model
await model.fit(xs, ys, {
  epochs: 5,
```

```
    callbacks: { onEpochEnd: (epoch, logs) => console.log(logs) }
});
```

## Try It Yourself

Train CNN

## How to Train a CNN

1. Prepare a labeled dataset of images (e.g., handwritten digits, cats vs. dogs).
2. Define the architecture: stack convolutional & pooling layers, flatten the output, and add dense layers.
3. Choose a loss function (e.g., categorical crossentropy) and an optimizer (e.g., Adam).
4. Feed batches of input data through the network, compute the loss, and update weights using backpropagation.
5. Evaluate the model's performance on validation data, then adjust hyperparameters and retrain as needed.

**Visualizing a Simple CNN**

The image below shows a very simplified structure of a CNN. Each circle represents a "neuron" (unit) in each layer. The input image is processed through convolutional and pooling layers to extract features, then passed to dense (fully connected) layers for classification.
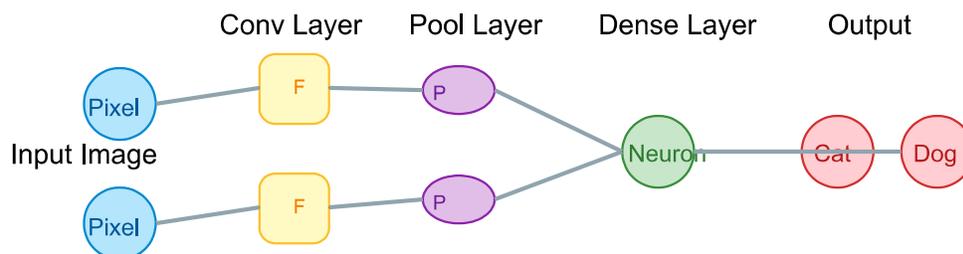


**Easy-to-Understand Example: Cat vs. Dog Image Classifier**

Imagine you want to teach a computer to tell apart pictures of cats and dogs. A CNN model is like a set of smart filters that automatically learn the features that make cats and dogs different—like detecting ears, fur patterns, and shapes. At first, the network knows nothing. You show it thousands of labeled pictures, and after training, it learns which visual patterns most often appear with "cat" and which with "dog." When you give it a new photo, it can predict whether it's more likely a cat or a dog—just like a simple visual detective!

# Libraries for Model Definition, Training, and Visualization

To build, train, and visualize deep learning models in the browser, you'll need a few important JavaScript libraries:

- **TensorFlow.js** (model definition & training): Enables the creation and training of neural network models using JavaScript.
  `https://cdn.jsdelivr.net/npm/@tensorflow/tfjs@1.7.4/dist/tf.min.js`
- **TensorFlow.js Vis** (visualization): Useful for visualizing data, model training progress, and other metrics right in the browser.
  `https://cdn.jsdelivr.net/npm/@tensorflow/tfjs-vis@1.0.1/dist/tfjs-vis.umd.min.js`

These libraries are essential for building interactive machine learning demos and tools in JavaScript.

Run

# Discussion: The MNIST Image Dataset and Labels

The **MNIST dataset** is a large collection of 28x28 pixel grayscale images of handwritten digits (0 through 9). It is commonly used for training and evaluating image classification systems. Each image represents a single digit and is paired with a corresponding label indicating which digit is shown.

- **Images:** mnist_images.png contains all the digit images, stored as a single large PNG file.

- **Labels:** [mnist_labels_uint8](#) is a binary file containing the labels (0-9) for each image in the dataset.

Each image in `mnist_images.png` is placed sequentially in rows, and each is paired with its label from `mnist_labels_uint8`. The dataset is often used to teach and test Convolutional Neural Networks (CNNs) and other machine learning models in recognizing handwritten digits.

Load MNIST Dataset

# Visualization of the Cleaned MNIST Dataset

After loading the MNIST data, it's helpful to visualize some samples to better understand the dataset. Below, you can display a selection of handwritten digit images from `cleanedData` along with their labels.

Visualize Sample Images

# Splitting the Dataset: Training and Testing Sets

When building machine learning models, it's essential to separate your data into **training** and **testing** sets. The training set is used to teach the model, while the testing set evaluates how well the model can generalize to unseen data. A common practice is to use 80% of the data for training and 20% for testing.

Split the dataset

# Building a Convolutional Neural Network (CNN) Model

Convolutional Neural Networks (CNNs) are a type of deep learning model especially effective for image recognition tasks like classifying handwritten digits. In this section, you can define a simple CNN model, review its architecture, and learn how it processes images.

Define CNN Model

## What is a CNN Model?

CNNs are inspired by how the human brain processes visual information. They use layers that automatically learn to detect features in images, such as edges, shapes, or even complex objects. Here's how a typical CNN processes an image:

- **Convolutional layers** apply filters to the input image to extract features (like edges or textures).
- **Pooling layers** reduce the size of the data, keeping only the most important information.
- **Flatten and Dense layers** convert the feature maps into a flat vector and classify the image into categories (digits 0–9).
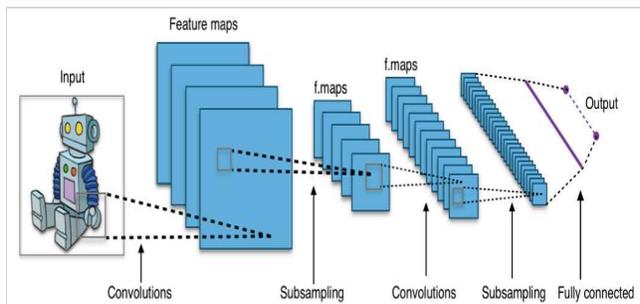


*Illustration:* The CNN takes a 28×28 grayscale digit image, extracts features through a series of filters and pooling, then classifies the digit using fully connected layers.
*(Source: Wikimedia Commons)*

# Training the CNN Model

Once your model and dataset are ready, training is the process where the model learns patterns from the training data. The model adjusts its internal parameters to minimize the difference between its predictions and the actual labels. This process repeats over several **epochs** (full passes through the training data).

Train the Model

## How Training Works

During training, the CNN model receives batches of images and their correct labels. It predicts the classes for the images, calculates how far its predictions are from the correct ones (loss), and uses an optimizer to adjust its internal weights. This process is repeated over several epochs, continually improving the model's accuracy.

CNN training animation

*Illustration:* The CNN is shown learning from labeled images, adjusting filters and connections to improve performance every epoch.

# Testing the CNN Model

After training, it's important to check how well the CNN model performs on data it hasn't seen before. This is done with the **test set**, which helps you understand the model's generalization power and ensure it hasn't just memorized the training data.

Test the Model

## How to Read the Confusion Matrix

- The **rows** show the **true classes** (actual labels).
- The **columns** show the **predicted classes** (model's outputs).
- The number in cell (i, j) tells how many samples of class **i** were predicted as class **j**.
- Large numbers on the diagonal mean the model is correctly classifying those classes.