# Solutions for *Elementary Mathematical Analysis*

You'll need to create a new file for the solution of each problem in the solutions subdirectory. Also, if you rename your main file, change TextbookExample in this document (two places) to your new name.

# Contents

# Chapter 1

# Solutions

## 1.1 Introduction

## 1.2 Functions

### 1.2.1 1.1 - Patterns All Around Us

**L1** (0101LabPick)

Answer vary. Ex. “I am choosing to model ceiling tiles in my classroom, directly above my head.” or “I choose to count fence posts on the picket-fence in the hallway.”

**L2** (0101LabMeasure)

Individual results will vary.

**L3** (0101LabVar)

It makes the most sense for length to be dependent upon the number of items, not the other way around. We can freely choose the number of item we want to measure, so that is independent.

**L4** (0101LabPlot)

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**L5** (lab:L5)

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**L6** (lab:L6)

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### 1.2.2 1.4 - Through the Looking Glass

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### 1.2.3 Section 1.5 Exercises

**P1** (0105Quad1)

a. $y \approx 1.09578x^2 - 2.69643x + 1.13637$

b. $y \approx -1.48736x^2 + 5.86598x - 8.11229$

**P2** (0105Quad2)

a. $y \approx -0.57142x^2 + 2.2x + 1.94286$

b. $y \approx -1.48736x^2 + 5.86598x - 8.11229$

**P3** (0105Arch)

a. $23.557x - 24.427$

b. 1248 cm

**P4** (0105ModelDay)

From day 28 to 314, hence 286 days.

**P5** (0105Hourly)

a. insert graphic

b. $y \approx .4089x + 9.8601$

c. 98.6%. It would seem so...

d. $0.0124x^2 + .2473x + 10.1241$

e. 99.8%. Yes, more so than the linear.

f. Individual results will vary.

**P6** (0105traffic)

a. $y \approx -0.00746x^2 + 1.14821 + 4.80714$

b. 47.9 ft

**P7** (0105LM1)

a. $\frac{2}{5}x + \frac{5}{2} = y$

b. $0 = y$

c. $\frac{23}{11}x - \frac{27}{22} = y$

d. $\frac{9}{23}x - \frac{19}{5} = y$

**P8** (0105LM2)

a. $-\frac{5}{4}x - \frac{3}{4} = y$

b. $x = y$

c. $-4x + \frac{11}{3} = y$

d. $-\frac{484}{225} + \frac{7894}{5625} = y$

**P9** (0105high)

**NY** $y \approx 25.61 \cdot \sin(.5090x - 2.0685) + 56.8797$

**DC** $y \approx 22.7410 \cdot \sin(.4946x - 1.9503) + 65.3889$

**TX** $y \approx 17.742 \cdot \sin(.5043x - 2.0110) + 79.1803$

They will never intersect.

**P10** (0105sun)

a. $y \approx 32.2267 \sin(.3993x - .5706) + 26.9744$

b. 40.3

**P11** (0105newton)

a. insert graphic

b. $r^2$=99.98%

c. $T(x) \approx 118.0705 \cdot .9511^x + 72.$

d. It seems exceedingly close to the data.

## 1.3 Limits

### 1.3.1 2.1 - Removing the Hole

**L1** (lab:L1)

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**L2** (lab:L2)

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**L3** (lab:L3)

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**L4** (lab:L4)

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**L5** (lab:L5)

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**L6** (lab:L6)

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**L7** (lab:L7)

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**L8** (lab:L8)

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**L9** (lab:L9)

No Solution File Found

**L10** (lab:L10)

No Solution File Found

**L11** (lab:L11)

No Solution File Found

### 1.3.2 Section 2.1 Exercises

**P1** (0201Remove1)

a. 5

b. $\frac{1}{6}$

c. 5

d. $\frac{11}{12}$

e. $-\frac{1}{9}$

f. $-\frac{1}{2}$

**P2** (0201Remove2)

a. 3

b. $\frac{3}{2}$

c. 0

d. $\frac{3}{7}$

e. $-\frac{4}{5}$

f. $\frac{1}{8}$

### 1.3.3 2.5 - Extremely Average

**L1** (lab:L1)

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**L2** (lab:L2)

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**L3** (lab:L3)

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**L4** (lab:L4)

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**L5** (lab:L5)

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**L6** (lab:L6)

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**L7** (lab:L7)

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## 1.4 Parents

### 1.4.1 3.1 - In Pieces

**L1** (lab:L1)

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**L2** (lab:L2)

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**L3** (lab:L3)

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**L4** (lab:L4)

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**L5** (lab:L5)

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**L6** (lab:L6)

No Solution File Found

**L7** (lab:L7)

No Solution File Found

**L8** (lab:L8)

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### 1.4.2 Section 3.1 Exercises

**P1** (0301ParaPerpA)

a. a) $y = -x - 1$ b) $y = x + 5$

b. a) $y = -\frac{5}{3}x + \frac{53}{24}$ b) $y = \frac{3}{5}x + \frac{9}{40}$

c. a) $x = 2$ b) $y = 5$

d. a) $y = 1$ b) $x = 2$

e. a) $y = -3x - 13.1$ b) $y = \frac{1}{3}x - 0.1$

**P2** (0301ParaPerpB)

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**P3** (0301GrapherA)

$a$ is parallel to $c$ and $b$ is perpendicular to them both

**P4** (0301GrapherB)

No Solution File Found

**P5** (0301GrapherC)

$a$ is parallel to $b$ and $c$ is perpendicular to both

**P6** (0301:GrapherD)

No Solution File Found

**P7** (0301TFA)

False. Steepness is measured by the absolute value of the slope/derivative.

**P8** (0301TFB)

False. They do not have opposite-reciprocal slope.

**P9** (0301TFC)

True.

**P10** (0301TFD)

True.

### 1.4.3 3.2 - Zoomed Straight

**L1** (lab:L1)

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**L2** (lab:L2)

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**L3** ()

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**L4** (lab:L4)

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**L5** (lab:L5)

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**L6** (lab:L6)

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**L9** ()

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### 1.4.4 3.3 - Another Definition of Parabolas

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**L2** ()

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**L4** ()

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### 1.4.5 3.4 - Classic Ladder Problem

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**L2** (lab:L2)

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**L3** (lab:L3)

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**L4** (lab:L4)

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**L9** (lab:L9)

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**L10** (lab:L10)

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## 1.5 Transformations

### 1.5.1 4.1 - I'm Batman

**L1** (lab:L1)

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**L2** (lab:L2)

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**L3** (lab:L3)

No Solution File Found

**L4** (lab:L4)

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**L5** (lab:L5)

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**L6** (lab:L6)

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**L8** (lab:L8)

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**L10** (lab:L10)

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**L11** (lab:L11)

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### 1.5.2 Section 4.1 Exercises

**P1** (0401ClassA)

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**P2** (0401ClassB)

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**P3** (0401X)

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**P4** (0401Para)

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**P5** (0401Cube)

No Solution File Found

**P6** (0401Sym)

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**P7** (0401Football)

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**P8** (0401Chain)

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### 1.5.3 4.2 - x, y, ...t?

**L1** (lab:L1)

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**L2** (lab:L2)

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**L3** (lab:L3)

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**L4** (lab:L4)

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### 1.5.4 4.4 - “Upside Down”

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**L4** (lab:L4)

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**L5** (lab:L5)

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**L6** (lab:L6)

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**L7** (lab:L7)

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## 1.6 Powers

### 1.6.1 5.1 - Work Smarter, Not Harder

**L1** (lab:L1)

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**L2** (lab:L2)

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**L3** (lab:L3)

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**L4** (lab:L4)

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**L6** (lab:L6)

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**L7** (lab:L7)

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**L8** (lab:L8)

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**L9** (lab:L9)

No Solution File Found

**L10** (lab:L10)

No Solution File Found

**L11** (lab:L11)

No Solution File Found

### 1.6.2 Section 5.1 Exercises

**P1** (0501xA)

a. $-\frac{125}{114}$

b. $-\frac{3}{76}$

c. $-\frac{222}{725}$

d. $\frac{51}{125}$

e. $-\frac{220}{12201}$

**P2** (0501xB)

a. $\frac{119}{925}$

b. $-\frac{149450}{1955239}$

c. $-\frac{161168}{95227}$

d. $\frac{2662}{1593}$

e. $-\frac{564}{295}$

### 1.6.3 5.2 - The Power of Powers

**L1** (lab:L1)

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**L2** (lab:L2)

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**L3** (lab:L3)

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**L4** (lab:L4)

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**L5** (lab:L5)

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**L6** (lab:L6)

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**L7** (lab:L7)

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**L9** (lab:L9)

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**L10** (lab:L10)

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**L11** (lab:L11)

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**L12** (lab:L12)

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**L13** (lab:L13)

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**L14** (lab:L14)

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**L15** (lab:L15)

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**L16** (lab:L16)

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### 1.6.4 5.3 - With Great Power

**L1** (lab:L1)

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**L2** (lab:L2)

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**L3** (lab:L3)

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**L4** (lab:L4)

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**L6** (lab:L6)

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**L12** (lab:L12)

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**L13** (lab:L13)

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### 1.6.5 5.4 - Truth to Power

**L1** (lab:L1)

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**L2** (lab:L2)

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**L3** (lab:L3)

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**L4** (lab:L4)

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**L6** (lab:L6)

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**L7** (lab:L7)

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**L9** (lab:L9)

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## 1.7 Polynomials

### 1.7.1 6.1 - In the End

**L1** (lab:L1)

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**L2** (lab:L2)

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**L3** (lab:L3)

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**L4** (lab:L4)

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### 1.7.2 6.3 - Twists and Turns

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**L3** (lab:L3)

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**L4** (lab:L4)

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**L9** (lab:L9)

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**L10** (lab:L10)

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## 1.8 Logarithms

### 1.8.1 7.1 - 3-in-1

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**L6** ()

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**L7** ()

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**L8** ()

No Solution File Found

### 1.8.2 Section 7.1 Exercises

**P1** (0701Identity)

a. identity

b. conditional

c. identity

d. conditional

e. false

**P2** (0701Graph)

a. $y = x^3$

b. ${}^{3}_{y}\triangle_{x}$

c. Swap the position of $x$ and $y$.

### 1.8.3 7.2 - Money Matters

**L1** (lab:L1)

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**L2** (lab:L2)

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**L3** (lab:L3)

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**L4** (lab:L4)

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**L6** (lab:L6)

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**L9** (lab:L9)

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### 1.8.4 7.3 - Triangular Tables

**L1** (lab:L1)

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**L2** (lab:L2)

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**L3** (lab:L3)

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**L4** (lab:L4)

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**L5** (lab:L5)

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### 1.8.5 Section 7.3 Exercises

**P1** (0703All6)

a. graphs

b. yup

c. infinite, infinite, infinite, two, infinite, two

d. roots and powers, logs and exponents, the other two

e. $9^y = x$ and $x^y = 9$

**P2** (0703:LogProofs)

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**P3** (0703SolveLogs)

a. 3 or -2

b. 999,999,999

**P4** (0703SimplifyLogs)

No Solution File Found

**P5** (0703DescribeDifference)

Graphs up 2 vs left 2.${}_5\triangle_x$+2 vs.${}_5\triangle_{x+2}$

**P6** (0703DescribeCalclog)

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### 1.8.6 7.4 - Log Infection

**L1** (lab:L1)

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**L2** (lab:L2)

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**L3** (lab:L3)

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**L4** (lab:L4)

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**L6** (lab:L6)

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**L7** (lab:L7)

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## 1.9 Infinities

### 1.9.1 8.1 - Magic Number

**L1** (lab:L1)

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**L2** (lab:L2)

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**L3** (lab:L3)

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**L4** (lab:L4)

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**L5** (lab:L5)

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**L6** (lab:L6)

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**L7** (lab:L7)

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**L8** (lab:L8)

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**L9** (lab:L9)

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### 1.9.2 8.2 - It Don't Stop

**L1** (lab:L1)

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**L2** (lab:L2)

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**L3** (lab:L3)

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**L4** (lab:L4)

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**L6** (lab:L6)

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**L7** (lab:L7)

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### 1.9.3 Section 8.2 Exercises

**P1** (0802Hotel)

a. have each of the existing guests move to their room number plus $n$

b. many solutions. ex. have each existing guest move to 2 times his or her room number. The new guests can fill in the odds

c. many solutions. ex. having numbered each bus with a prime number starting with 3 (call it $P_n$), and having numbered each person the bus with a number (call it $m$), assign each new guest a room number $P_n^m$. Have all the existing guests move from their room (call it $q$) to $2^q$.

d. many solution

**P2** (0802BFF)

$1+x+x^2+x^3+x^4+x^5+\ldots$. Many answers, ex. by six terms it resembles the original from $-1/2$ to $1/2$. Even with vastly large numbers, it still only works from (-1,1).

**P3** (0802Grandi)

No Solution File Found

**P4** (0802Gabriel)

Infinite surface, finite area. The surface never stops, so the painting would never stop. But the area sums to a finite number.

**P5** (0802Primes)

No Solution File Found

**P6** (0802Power)

Make a table of booleans (T/F) for whether a number is included or not.

**P7** (0802Aleph2)

Most functions and relations map the real numbers onto the real numbers. Like a power set, all possible combinations of the reals should yield a higher cardinality than the reals.

### 1.9.4 8.3 - Inverse of e

**L1** (lab:L1)

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**L2** (lab:L2)

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**L3** (lab:L3)

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**L4** (lab:L4)

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**L5** (lab:L5)

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**L6** (lab:L6)

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**L7** (lab:L7)

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### 1.9.5 8.4 - Limits by Derivative

**L1** (lab:L1)

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**L2** (lab:L2)

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**L3** (lab:L3)

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**L4** (lab:L4)

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**L6** (lab:L6)

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**L7** (lab:L7)

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**L8** (lab:L8)

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### 1.9.6 8.5 - To Infinity, and Beyond

**L1** (lab:L1)

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**L2** (lab:L2)

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**L3** (lab:L3)

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**L4** (lab:L4)

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**L5** (lab:L5)

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**L6** (lab:L6)

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## 1.10 Circles

## 1.11 Identities

### 1.11.1 10.3 - Cosine, cosine, sine, sine

**L1** (lab:L1)

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**L2** (lab:L2)

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**L3** (lab:L3)

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**L4** (lab:L4)

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**L6** (lab:L6)

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**L7** (lab:L7)

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**L8** (lab:L8)

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**L9** (lab:L9)

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**L10** (lab:L10)

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**L11** (lab:L11)

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## 1.12 Triangles

## 1.13 Polar

## 1.14 Regressions

## 1.15 Probabilities

## 1.16 Sequences

## 1.17 Radices

### 1.17.1 Section 16.1 Exercises

**P1** (probP1)

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**P2** (probP2)

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**P3** (probP3)

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# 1.18 Prerequisites

## 1.18.1 Section A.1 Exercises

**P1** (AASet1)

(i) x : x is an even natural numbers less than 12
(ii) x : x is a prime numbers less than 12
(iii) x : x is a month whose name starts with letter J
(iv) x : x is a vowel in English alphabets
(v) x : x is a day of the week whose name starts with letter T
(vi) x : x is a perfect square natural number up to 25
(vii) x : x is a natural number up to 30 and divisible by 5

**P2** (AASet2)

(i) A = x | x is an odd number less than 10.
(ii) B = x | x is a perfect square natural number between 15 and 65
(iii) C = x | x is a vowel in English small alphabet.
(iv) D = x | x is a color in rainbow.
(v) E = x | x is a month having 31 days.

## 1.18.2 Section A.2 Exercises

**P1** (probP1)

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**P2** (probP2)

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**P3** (probP3)

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**P4** (probP4)

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**P5** (probP5)

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**P6** (probP6)

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## 1.18.3 Section A.3 Exercises

**P1** (probP1)

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**P2** (probP2)

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**P3** (probP3)

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**P4** (probP4)

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**P5** (probP5)

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**P6** (probP6)

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**P7** (probP7)

No Solution File Found

**P8** (probP8)

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**P9** (probP9)

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**P10** (probP10)

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**P11** (probP11)

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## 1.18.4 Section A.4 Exercises

**P1** (probP1)

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**P2** (probP2)

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**P3** (probP3)

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**P4** (probP4)

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**P5** (probP5)

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**P6** (probP6)

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### 1.18.5 Section A.6 Exercises

**P1** (AA06CubeDifference)

There are three prisms left over, when a cube is taken out of a larger cube. Their dimensions are $(a-b)(a)(a)$, $(a-b)(a)(b)$, and $(a-b)(b)(b)$. This can be factored into $a^3-b^3=(a-b)(a^2+ab+b^2)$.

**P2** (AA06CubeSum)

Because the difference of cubes is $a^3-b^3=(a-b)(a^2+ab+b^2)$, we might guess that the sum of cubes would be mostly opposite, $(a+b)(a^2-ab-b^2)$, but that produces $a^3-2ab^2-b^3$. The correct formula is $a^3+b^3=(a+b)(a^2-ab+b^2)$.

**P3** (AA06CS)

$$\begin{aligned} x^2+bx+c&=0\\ x^2+bx&=-c\\ x^2+bx+\frac{b^2}{4}&=\frac{b^2}{4}-c\\ \left(x+\frac{b}{2}\right)^2&=\frac{b^2-4c}{4}\\ x+\frac{b}{2}&=\pm\frac{\sqrt{b^2-4c}}{2}\\ x&=\frac{-b\pm\sqrt{b^2-4c}}{2} \end{aligned}$$

**P4** (AA06QF)

$$\begin{aligned} ax^2+bx+c&=0\\ a(x^2+\frac{b}{a}x&=-c \end{aligned}$$

$$\begin{aligned} x^2+bx+\frac{b^2}{4}&=\frac{b^2}{4}-\frac{c}{a}\\ \left(x+\frac{b}{2}\right)^2&=\frac{b^2-4ac}{4a}\\ x+\frac{b}{2}&=\pm\frac{\sqrt{b^2-4ac}}{2}\\ x&=\frac{-b\pm\sqrt{b^2-4ac}}{2} \end{aligned}$$

**P5** (AA06Root)

Because $504=2^3\cdot3^2\cdot7$, we can "take out" one of each pair. That is $2\cdot3\sqrt{2\cdot7}$ or $6\sqrt{14}$.

**P6** (AA06Factor)

a. 15,5

b. 9,-5

c. -8,-10

d. -7,-9

**P7** (AA06Split)

a. $(2r-11)(2r+7)$

b. $(2x-13)(2x+5)$

c. $(3k-4)(3k+10)$

d. $2(2y-5)(2y+1)$

**P8** (AA06Hard)

a. $\frac{-5\pm4\sqrt{30}}{5}$

b. $2\pm i\sqrt{2}$

c. $10\pm\sqrt{29}$

**P9** (AA06Disc)

Because the term $b^2-4ac$ is under the radical, there are three cases. If it is a perfect square, then there will be two rational solutions. If it is otherwise positive, there will be two irrational solutions. If it is negative, there will be two imaginary solutions.

## 1.19 Matrices

## 1.20 Vectors

## 1.21 Conics

## 1.22 Solutions

## 1.23 Bibliography