Appendix A

Answers to exercises

These answers to the exercises are provided for you to check your work.

- Ask your instructor about access to the solutions of the Practice Exercises #1-4.
- Graphs are not provided, so be sure to compare your graphs with those of a classmate.
- Remember to use whatever method is indicated in the Exercises.

When you're done . . .

- Not sure if your answers are close enough? Compare with a classmate or ask the instructor.
- Getting the wrong answers or stuck on a problem? Re-read the section and try the problem again. If you're still stuck, work with a classmate or go to your instructor's office hours.
- It's normal to find some parts of some problems difficult, but if all the problems are giving you grief, be sure to talk with your instructor or advisor about it. They might be able to suggest strategies or support services that can help you succeed.
- Make a list of key ideas or processes to remember from the section. The "Do you know?" questions can be a good starting point.

A.1 Variables

A.1.1 Variables and functions – Answers to exercises

5. (a) about 17 years ago
   (b) .058, .084
   (c) 20 mph
   (d) in 45 days, early November (ignores daylight savings)

6. (a) 3
   (b) T = temperature (°F) ∼ dep H = time (hours since noon) ∼ indep
   (c) 2:40 p.m.

7. (a) S = Mrs. Nystrom's social security benefit ($) ∼ dep
   Y = time (years since 2009) ∼ indep
   (b) $839.34
   (c) ≈ 2014

8. (a) S = number of stamps ∼ indep
   C = total cost ($) ∼ dep
   (b) C is dependent, S is independent
   (c) 21 stamps

9. (a) M = car's mileage (thousands of miles) ∼ indep
   C = value of Sofía's car ($) ∼ dep
   (b) C is a function of M
   (c) maybe $0 \leq M \leq 250{,}000$
   (d) ≈ another 5 years

10. (a) L = intensity of light (%) ∼ dep
    F = distance (feet) ∼ indep
    (b) M = time (minutes) ∼ dep
    F = thickness (inches) ∼ indep
    (c) W = electricity (watts) ∼ dep
    S = wind speed (mph) ∼ indep

A.1.2 Tables and graphs – Answers to exercises

5. (a) 1.26 billion
   (b) ≈1.35 billion
   (c) ≈ 3 billion
   (d) ≈ 1930
   (e) ≈ 2015
   (f) Y = time (years since 1800) ∼ indep
   P = population of Earth (billions of people) ∼ dep

6. (a) $55.00
   (b) 200 miles
   (c) ≈ $46
   (d) ≈ $20
   (e) ≈ 120 miles
   (f) D = distance (miles) ∼ indep
   R = rental cost ($) ∼ dep
   maybe $0 \leq D \leq 300$
   (g) Graph

(h) ✓

7. (a)

H	0	1	2	3	4	10
F	40	37	34	31	28	10

(b) Graph

(c) 2:40 p.m.

(d) ≈ midnight, unusual but realistic for the midwest

8. (a) See **Table A**, below.

(b) Graph

(c) in 2014

(d) ≈ $1,100

9. (a) 100°F

(b) ≈ 66%

(c) ≈ 78%

(d) maybe $78\% \leq H \leq 100\%$

(e) ≈ 120°F

(f) H = humidity (%) ∼ indep
F = heat index (°F) ∼ dep
$0 \leq H \leq 100$

(g) Graph

(h) ✓

Table A:

year	2009	2010	2011	2012	2013	2014	2015
Y	0	1	2	3	4	5	6
S	746.17	776.02	807.06	839.34	872.91	907.83	944.14

A.1.3 Rate of change – Answers to exercises

5. (a) ✓

(b) ≈ 8.8 feet per second

6. (a) $.35/mile, $.35/mile, $.35/mile

(b) $44.50

(c) $20

7. (a) W = electricity (watts) ∼ dep
S = wind speed (mph) ∼ indep

(b) Graph

(c) 240 watts/mph

(d) 1,680 watts/mph, increasing faster

(e) 4,560 watts/mph, fastest yet

8. 1990-2000

9. (a) C = cost per backpack ($/backpack) ∼ dep
B = number of backpacks ∼ indep

B	10	40	70	100
C	39	18	15	30

(b) -$.70/backpack, -$.10/backpack, +$.50/backpack

(c) maybe $0 \leq B \leq 60$

(d) need more space, another machine, overtime pay?

(e) Graph

(f) ≈ 60

10. (a) -3.75 feet/year, -3.75 feet/year, -3.75 feet/year

(b) Erosion makes the beach less deep.

(c) 3.75 feet/year

(d) Graph

A.1.4 Units – Answers to exercises

5. (a) ≈ 1.913 minutes

(b) ≈ 104.5 meters/min

(c) ≈ 3.9 mph

(d) 1.9 minutes

(e) ≈ 105.3 meters/min

(f) ≈ 3.9 mph

6. (a) 44 pounds

(b) ≈ 17 servings

(c) just over 5 cans

7. (a) 1,320 yards

(b) 1.125 feet

(c) 4.2 inches

8. (a) See **Table B**, below.

(b) 3 hours and 35 minutes

9. ≈ 700,000 heartbeats/week
≈ 37 million heartbeats/year
(calculated 705,600 and 36,792,000)

10. (a) ≈ 24.5 mph

(b) ≈ 9 square miles

(c) ≈ $2.38/gallon

Table B:

Day	Mon	Tue	Wed	Thu	Fri
Minutes	35	71	15	0	98
Hours	.583	1.183	.25	0	1.683
H:MM	0:35	1:11	0:15	0:00	1:38

A.1.5 Metric prefixes and scientific notation – Answers to exercises

5. (a) ≈ 24 files

(b) just over 1 hour

(c) ≈ 5.5 KB

6. (a) ≈ 11 days, ≈ 32 years, ≈ 32,000 years

(b) 32 years old

(c) *Hint: use 31 years, 259 days, 1 hour, and 47 minutes from the*

day and time of your birth. Leap years have an extra day: 2012, 2008, 2004, 2000, 1996, ...

7. (a) See below
   (b) proton
   (c) about 1,800 times heavier
   (d) $\approx 1.69 \times 10^{25}$
8. (a) 8 servings
   (b) $\approx$ 5 servings
9. (a) $\approx 6.4 \times 10^{19}$ cells
   (b) $\approx$ 64 quintillion cells
10. (a) ✓
    (b) Yes
    (c) $\approx$ 25.2 BMI, no
    (d) "Jared, you're right on the upper limit for normal BMI."

proton .000 000 000 000 000 000 000 000 001 672 62

electron .000 000 000 000 000 000 000 000 000 000 910 938

A.2 Equations

A.2.1 A first look at linear equations – Answers to exercises

5. (a) $P = 50 + 120T$
   (b) $P = 45 + 55T$
   (c) $P = 90T$
   (d) $P = 150$
6. (a) No
   (b) A = Abduwali's profit (\$) $\sim$ dep
   M = time (months) $\sim$ indep
   $A = 6{,}300M - 82{,}500$
   (c) Slope is \$6,300/month; it's how much money he earns in a month. Intercept is -\$82,500; it's his start up costs.
   (d) See **Table C**, below.
7. (a) 287.5 calories
   (b) C = energy (calories) $\sim$ dep
   M = distance (miles) $\sim$ indep
   $C = 125M$
   (c) Slope is 125 cal/mile; it's the rate at which Gretchen burns calories. Intercept is 0; it's how many calories she burns walking 0 miles.
   (d)

M	0	1	2	3	4
C	125	250	375	500	625

8. (a) H = daily high temperature (°F) $\sim$ indep
   B = price bacon double cheeseburger (\$) $\sim$ dep
   $B = 7.16 - .02H$
   (b) decreasing

(c)

H	65	75	90
B	5.86	5.66	5.36

(d) Graph

9. (a) B = number of beds $\sim$ dep
Y = time (years since 1975) $\sim$ indep

(b) $B = 1{,}466{,}000 - 16{,}000Y$

(c) decreasing

(d) See **Table D**, below.

(e) guess in 2040? actually in 2036

10. (a) C = traffic (cars/hour)$\sim$ dep
W = time (weeks) $\sim$ indep
$C = 1{,}450 + 130W$

(b) See **Table E**, below.

(c) just over 4 years

(d) slightly over 8 years

Table C:

M	0	1	6	10	12	24
A	-82,500	-76,200	-44,700	-19,500	-6,900	68,700

Table D:

year	1980	1990	2000	2010	2020
Y	5	15	25	35	45
B	1,386,000	1,226,000	1,066,000	906,000	746,000

Table E:

W	0	2	4	6	8	10
C	1,450	1,710	1,970	2,230	2,490	2,750

A.2.2 A first look at exponential equations – Answers to exercises

5. (a) \$83,920.20

(b) 7.59%

(c) same

(d) 6% first because get higher salary in year 2

6. (a) 1.03

(b) 1,495 children

(c) Y = time (years since 2010) $\sim$ indep
C = number of children from single parent households $\sim$ dep
$C = 1{,}290 * 1.03^Y$

(d)

year	2010	2015	2020	2030
Y	0	5	10	20
C	1,290	1,495	1,733	2,329

(e) Graph

7. (a) U = earnings (\$ billions) $\sim$ dep
Y = time (years since 2012) $\sim$ indep
$Y = 42.7 * 1.17^Y$

(b) $\approx$ \$149.9 billion

(c) 17% is too high; they earned much less than expected.

(d) Graph

8. (a) P = poultry population (millions of tons) $\sim$ dep
Y = time (years since 2005) $\sim$ indep
$P = 78 * 1.016^Y$

(b)

year	2005	2010	2020	2050
Y	0	5	15	45
P	78	84.4	99.0	159.3

9. (a) E = ebook sales ($ million) $\sim$ dep
M = time (months since Jan. 2008) $\sim$ indep

(b) 1.063

(c) $E = 5.1 * 1.063^Y$

(d) It's just a little lower than the equation predicted ($\approx$ $22.1 million)

(e) $414.9 million

A.2.3 Using equations – Answers to exercises

5. (a) 398.6 feet

(b) 234.6 feet

(c) No

(d) No, 146.7 feet behind car but it takes 183.2 feet to stop. Crash.

6. (a) 100%, 25%, $\approx$ 11%

(b) $\approx$ 20%

(c) $\approx -21\%$ so the light intensity drops about 21%/foot in the 2 foot range

(d) Graph

7. (a) .25 feet

(b) 344 square feet

(c) 86 cubic feet

(d) ✓

(e) 39 cubic feet, 61.5 cubic feet, 73.5 cubic feet

8. (a) 1,945 newspapers
1,805 newspapers
1,594 newspapers
1,344 newspapers.

(b) 1995-2010

(c) Graph

9. (a) $\approx$ 8 minutes, $\approx$ 12 minutes,$\approx$ 16 minutes,$\approx$ 20 minutes

(b) It takes about 8 minutes to grill a piece of fish that's only .25 inch. For a piece of fish 1 inch thick it takes about 12 minutes. For 1.5 inches it takes about 16 minutes and for 2 inches it takes about 20 minutes.

(c) Graph

(d) The thicker the piece of fish, the longer it takes to grill.

10. (a) $15.60/hour, $13.00/hour

(b) E = hourly wage earned (\$/hour) $\sim$ dep
H = time (hours) $\sim$ indep
$E = \dfrac{780}{H}$

(c) The more hours he works in a week, the less he is (effectively) paid per hour.

A.2.4 Approximating solutions of equations – Answers to exercises

5. (a) in 2035
   (b) in 2015
   (c) start = 1.343 billion and growth factor = 1.0131
   (d) Graph

6. (a) \$104.4 billion, \$128 billion, \$94.5 billion
   (b) in 2010
   (c) in 2008

7. (a) Each thickness is one inch.
   75% of 56.25% = $.75 \times 56.25 = 42.1875 \approx 42.19\%$
   (b) 3 inches thick, $\approx 31.64\%$
   (c) L = light (%) $\sim$ dep
   W = thickness of window glass (inches) $\sim$ indep
   $L = 100 * .75^W$
   (d) $\approx$ 8 inches
   (e) Graph

8. (a)

S	10	25	40
W	2,400	37,500	153,600

   (b) Graph
   (c) $\approx$ 17.4 mph

9. (a) See **Table F**, below.
   (b) Graph
   (c) in about $2^1/_2$ hours

10. (a) 2.94 feet
    (b) $\approx$ 2'11" Yes

Table F:

H	0	1	2	3	4
S	.040	.058	.084	.122	.177

A.2.5 Finance formulas – Answers to exercises

5. (a) ✓
   (b) ✓
   (c) ✓
   (d) $\approx$ 4.594 APR

6. (a) \$41,883.82, \$48,610.75, \$37,051.28
   (b) R = interest rate $\sim$ indep
   A = Ayah's account balance (\$) $\sim$ dep
   See **Table G**, below. Graph
7. (a) \$1,024.74/month
   (b) \$875.64/month
   (c) \$1,370.20/month
8. (a) See **Table H**, below.
   (b) Y = time (years) $\sim$ indep
   K = Kurt's balance (\$) $\sim$ dep
   Graph
9. (a) 3.45% APR
   (b) 8.19% APR
   (c) 21.70% APR

Table G:

R	0	1.9	6	11
A	35,000	41,883.82	\$48,610.75	\$37,051.28

Table H:

Y	0	1	5	12
K	\$50,000	\$52,437.84	\$63,437.19	\$88,525.30

A.3 Solving equations

A.3.1 Solving linear equations – Answers to exercises

5. (a)

P	0	4	10	20
C	135	182.80	254.50	374

   (b) Cost to rent the boat, in \$
   (c) Cost per passenger, in \$/person
   (d) 16 passengers
   (e) Graph ✓
6. (a) 14 months
   (b) 29 months
7. (a)

S	5	10	20
C	2.95	5.15	9.55

   (b) S = number of stamps $\sim$ indep
   C = total cost (\$) $\sim$ dep
   $C = .44S + .75S$
   (c) 15 stamps
   (d) 21 stamps
8. (a) 2.4 miles
   (b) $\approx$ 43 minutes
   (c) $\approx$ 7.3 miles
9. (a) 145 pints
   (b) See **Table I**, below.
   (c) Graph
   (d) \$1.30/pint
10. (a) in just over 4 weeks
    (b) in just over 8 weeks

Table I:

P	2.00	2.25	2.50	2.75	3.00	3.25	3.50
D	205	192	180	167	155	142	130

A.3.2 Solving linear inequalities – Answers to exercises

5. (a) ✓
   (b) 177°F
   (c) 50°F, sweatshirt
   (d) between -29°C and -4°C
   (e) between 13°C and 41°C
6. (a) in 9 months
   (b) in 17 months
7. (a) Graph
   (b) 1.6 miles
   (c) See graph
8. in 18 weeks
9. (a) $\approx$ -1.84
   (b) $\approx$ 204.5 grams
   (c) between 203.2 and 210.8 grams
   (d) just over 7 servings
10. (a) \$4,688
    (b) the cost of airfare for Ciara and Seamus, in \$
    (c) the cost of hotel or other daily expenses, in \$/day
    (d) 23 days

A.3.3 Solving power equations (and roots) – Answers to exercises

5. (a) Graph
   (b) $\approx 7\frac{1}{2}$ inches
   (c) $\approx$ 15 inches
6. (a) 17.4 mph
   (b) 26.6 mph
7. (a) $\approx$ 1.2 feet, or 1'2"
   (b) $\approx$ 1.7 feet, or 1'8"
8. (a) $g \approx 1.223$ so 22.3%
   (b) $g \approx 1.259$ so 25.9%
9. (a) 64 feet, 256 feet
   (b) from $T = 2$ to $T = 4$
   (c) No
   (d) 400 feet, which really means it had hit the ground already
10. (a)

H	40	50	60
E	19.50	15.60	13.00

    (b) $\approx$ 84 hours/week
    (c) $\approx$ 56 hours/week
    (d) Graph

A.3.4 Solving exponential equations (and logs) – Answers to exercises

5. (a) E = employee-paid cost of health insurance (\$/month) $\sim$ dep
   Y = time (years since 2003) $\sim$ indep
   $E = 420 * 1.07^Y$
   (b) in 2007
   (c) in 2009
   (d) Graph
6. (a) in 2039
   (b) in 2039 (again)
   (c) in 2044
7. (a) $\approx$ 8 inches
   (b) $\approx$ 2.4 inches
   (c) ✓
8. (a) in 2017
   (b) in 2032
9. (a) about 8 washes
   (b) about 28 washes (or 1 month)
   (c) Graph

A.3.5 Solving quadratic equations – Answers to exercises

5. (a) $\approx$ .17 seconds, .77 seconds
   once going up, the other down
   (b) The calculator says ERROR because there's a square root of a negative number. The max height of the beanbag was 6'6", so it is never 8' up.
   (c) 6.0625 feet, just over 6'
6. (a) $\approx$ 52 mph
   (b) $\approx$ 52 mph (again)
7. (a) 35 backpacks
   (b)

B	10	40	70	100
C	39	18	15	30

   Graph, Yes
   (c) \$14/backpack
8. (a) about 2 inches
   (b) about .6 inches
9. (a) in 2010
   (b) in 2008
   (c) in 2000
10. (a) 10.7272 feet, 9.2128 feet
    (b) $\approx$ 11.3852 feet
    (c) just under 2 seconds (1.581 seconds)
    (d) in just over 1 seond (1.065 seconds)

A.4 A closer look at linear equations

A.4.1 Modeling with linear equations – Answers to exercises

5. (a) $A = 64{,}100 + 6{,}200Y$
   14 years

   (b) $A = 48{,}700 + 6{,}200Y$
   17 years

   (c) 8,442 apartment/year

6. (a) T = total tuition (\$) $\sim$ dep
   C = number of credit hours $\sim$ indep
   $T = 870C + 560$

   (b) Slope is \$870/credit; it's how much each credit hour costs.

   (c) Intercept is \$560; it's the one-time fee.

   (d)

C	3	12	16
T	3,170	11,000	14,480

   (e) $T = 415C$

   (f) Slope is \$415/credit; it's how much each credit hour costs.

   (g) Intercept is \$0 because there's no fee.

   (h)

C	3	12	16
T	1,245	4,980	6,640

   (i) Graph

   (j) The line for the community college tuition is always below the line for the state university tuition.

7. (a) linear: shrub grows at constant rate of .4 inches/week.

   (b) nonlinear: increases but less and less as add more gold.

   (c) (probably) linear: sea-ice is decreasing around .043 millions of square miles per year.

   (d) nonlinear: it's increasing, then decreasing, then increasing ...

8. (a) 2:40 p.m.

   (b) 1:20 a.m.

9. (a)

M	0	1	12	36
B	382	385	418	490

   (b) B = size of Shanille's collection (book) $\sim$ dep
   M = time (months) $\sim$ indep
   $B = 382 + 3M$

   (c) just over 17 years

   (d) Graph, ✓

A.4.2 Systems of linear equations – Answers to exercises

5. (a) $E = 1.55L$

   (b) \$10,667 locks

   (c) \$7,200 locks

6. (a) T = time to wash floor (seconds)

$\sim$ dep
S = size of floor (square feet) $\sim$ indep
rag: $T = 80S$
mop: $T = 180 + 75S$

(b) 36 squarefeet

(c) bathroom: use rag
kitchen & laundry room: use mop

7. (a) M = time (months) $\sim$ indep
C = total cost (\$) $\sim$ dep
CFL bulb: $C = 1 + .95M$
LED bulb: $24 + .60M$

(b) See **Table J**, below.

(c) Graph

(d) 5½ years

(e) 5½ years

8. (a) See **Table K**, below. Graph

(b) $\approx$ 27 exercise classes

(c) 26 exercise classes

(d) 26 exercise classes

(e) If you're going to take at least 26 classes, it is worth it to buy the membership. That's just 2 times a week for about 3 months.

9. (a) surplus at \$3.25/dozen
shortage at \$1.75/dozen

(b) \$2.08/dozen

(c)

P	1	2	3	4
S	7.5	9	19.5	12
D	10.1	9.2	8.3	7.4

Graph, ✓

10. (a) 33 years

(b) 20 years

(c) \$9,750

Table J:

M	1	6	18	36
C (CFL bulb)	1.95	6.70	18.10	35.20
C (LED bulb)	24.60	26.60	34.80	45.60

Table K:

E	0	10	50	100
T (pay as-you-go)	20	170	770	1,520
T (member)	150	350	650	1,150

A.4.3 Intercepts and direct proportionality – Answers to exercises

5. (a) $\approx$ 3.108 miles

(b) 7 min, 8 min, 3 min, 5 min, 0 min, 9 min

(c) Galen, Aziz, Hitomi, Yannick, Olga, Fiona

6. (a) H = time (hours since 10 a.m.) $\sim$

indep
S = total snow depth (inches) $\sim$ dep

(b) $S = 4 + {}^{2}/_{3}H$ or $S = 4 + .6667H$

(c) 4:00 a.m.

(d) T = time (hours since 4 a.m.) $\sim$ indep

(e) $S = {}^{2}/_{3}T$ or $S = .6667T$

(f) ✓

(g) H starts at 10 a.m. so the intercept represents that there were 4 inches at 10 a.m. but T starts at 4 a.m. so the intercept represents that there were 0 inches at 4 a.m.

7. (a) 435 feet

(b) T = time (from 60 years ago) $\sim$ indep
D = depth of beach (feet)
$D = 435 - 3.75T$

(c) in another 8 years

(d) Graph

(e) Slope is -3.75 feet/year; it's how much beach depth is lost to erosion each year
Intercept is 435 feet; it's how deep the beach was 60 years ago.

8. (a) 17 pounds

(b) B = number of bricks $\sim$ indep
W = total weight (pounds) $\sim$ dep
$W = 17 + 4.5B$

(c) 152 pounds

(d) 42 bricks

(e) Graph, ✓

9. (a) \$.6475/ride

(b) No, it's just a discounted rate of 64.75¢ per ride.

(c) direct proportionality

10. (a) 18 minutes

(b) 2 hours and 18 minutes

(c) B = number of batches $\sim$ indep
T = time to make cookies (min) $\sim$ dep
$M = 18 + 12B$

(d) Slope is 12 minutes/batch; it's how long each batch bakes.
Intercept is 18 minutes; it's how long it takes to prepare the dough.

A.4.4 Slopes – Answers to exercises

5. (a) \$42.50 per case

(b) 55 pounds

(c) delivered \$54.99

(d) $C = 42.50N$

(e)

N	4	13
C (delivered)	174.96	534.87
C (store)	170.00	552.50

(f) Graph

(g) For 6 cases or more, delivered is cheaper.

6. (a) ≈ 3.61 million tons per year
   (b) T = amount of garbage (million tons) $\sim$ dep
   Y = time (years since 1960 $\sim$ indep
   $T = 3.61Y + 88.1$
   (c) ≈ 268.6 million tons
   ≈ 304.7 million tons
   (d) in 2019
   (e) There was more recycling and composting, or maybe because of the downturn in the economy?

7. (a) 10%
   (b) \$930.64
   (c) $P = 930.64 - .10H$
   (d) $T = 93064 + .90H$
   (e) \$299.29
   (f) at least 37 hours

8. D = distance (miles) $\sim$ indep
   R = cost of rental (\$) $\sim$ dep
   $R = 20 + .35D$
   \$23.50

9. (a) \$429/year
   (b) Y = time (years since 2008) $\sim$ indep
   M = median household income (\$) $\sim$ dep
   $M = 50{,}303 - 429Y$
   (c) in 2014
   (d) Graph, ✓

10. (a) L = sea level (mm above historical level) $\sim$ dep
    Y = time (years since 2005 $\sim$ indep
    (b)

Y	0	7
L	51.7	73.4

    (c) 3.1 mm/year
    (d) $L = 51.7 + 3.1Y$
    (e) in 2015

A.4.5 Fitting lines to data – Answers to exercises

5. (a) ✓
   (b) ✓
   (c)

L	600	1,000
S	8,915	16,795

   ✓

6. (a) Graph
   (b) $W = 4{,}296 - 65.17T$
   (c) 1,298 acres, 1,689 acres
   (d) Graph, seems too low and/or too flat
   (e)

T	35	40	47
W	2,188	1,776	1,199

   Graph
   (f) Down slightly to 1,281 acres. Up quite a bit to 1,776 acres

7. (a) Graph
   (b) Graph
   (c) Graph, later because it's not as steep a line. That means it will

take longer to increase to 300 million tons.

8. (a) Graph

   (b) Graph

   (c) $R = 625 - 70N$
   \$625, \$65

   (d)

N	0	4	8
R	733	352	~~-29~~

   Graph

   (e) \$733, \$0 I guess (was negative)

9. (a) Graph, too flat (almost decreasing)

   (b) Graph, too high and maybe too steep

   (c) Graph, yes!

   (d) If a movie costs more, then maybe it has a better screenplay or actors or special effects or advertising and so it earn more.

10. (a) Graph

    (b) Beef line goes through 1985 and 2009 points.
    Chicken line goes through 1975 and 1995 points.

    (c) in 2005?

    (d) in 2004, slightly earlier than estimated

    (e) Beef consumption has been fairly constant over the past 40 years.

A.5 A closer look at exponential equations

A.5.1 Modeling with exponential equations – Answers to exercises

5. (a) around 1982

   (b) in 1982

   (c) in 1982

6. (a) S = Mrs. Nystrom's social security benefit (\$) $\sim$ dep
   Y = time (years since 2009) $\sim$ indep
   $S = 746.17 * 1.04^Y$

   (b) \$1,148.69

   (c) in 2014

   (d) in 2017

7. (a)

W	0	2	4	6
N	2	5	12	30

   (b) 8 weeks

   (c) 7.55 weeks

   (d) Graph

8. (a) 1.005

   (b) 5.33 million, 5.58 million

   (c) $M = 5.2 * 1.005^Y$
   Y = time (years since 2006) $\sim$ indep
   M = population of Minnesota (million) $\sim$ dep

(d) See **Table L**, below.

(e) Graph

(f) in 2145 (if model continues that long, which is doubtful)

9. (a) in 2015, in 2018

10. growth factor is 1.072
V = number of viewers (millions of households) $\sim$ dep
Y = time (years since 1990) $\sim$ indep
$V = 2.5 * 1.072^Y$
around 5 million, around 10 million

Table L:

year	2006	2008	2010	2012	2014	2016	2018	2020
Y	0	2	4	6	8	10	12	14
M	5.2	5.25	5.30	5.36	5.41	5.47	5.5.2	5.58

A.5.2 Exponential growth and decay – Answers to exercises

5. (a) C = caffeine (mg) $\sim$ dep
H = time (hours) $\sim$ indep
$C = 160 * .88^H$

(b) about 5 1/2 hours

(c) The caffeine would leave quicker, so it wouldn't take as long to get rid of half of it. So, the half-life would be shorter.

6. (a) B = number of bacteria $\sim$ dep
D = time (days) $\sim$ indep

(b) See **Table M**, below.

(c) $B = 2{,}000 * 3^D$

(d) 3

(e) See **Table N**, below.

(f) 5 days, 16 hours

(g) Graph, see **Table M**, below.

7. (a) Y = time (years since he bought house $\sim$ indep
H = value of Tenzin's house ($) $\sim$ dep
$H = 291{,}900 * .959^Y$

(b) 5 years

(c) 4 years, 8 months

8. (a) 2 grams, .5 grams, .125 grams

(b) M = time (months) $\sim$ indep
C = amount of contaminant (grams) $\sim$ dep
$C = 8 * .25^M$

(c) .25

(d) 8 months, 1 year

(e) Graph

9. (a) .996

(b) H = population Hibbing (people) $\sim$ dep
Y = time (years since 2000) $\sim$ indep
$H = 17{,}071 * .996^Y$

(c) 16,400

(d) faster than expected, so more than .4% decay rate

10. (a) T = time (years since last year) $\sim$ indep
L = donations to local food shelf (pounds) $\sim$ dep

(b) $L = 3{,}400 * 1.35^T$

(c) $\approx$ 4,600 pounds, $\approx$ 6,200 pounds, $\approx$ 8,400 pounds

(d) 2 years, 4 months

(e) in 4 more years

Table M:

D	0	1	2	3	4	5	6
B	2,000	6,000	18,000	54,000	162,000	486,000	~~1,458,000~~

Table N:

D	10	20	30
B	1.2×10^8	6.9×10^{12}	4.1×10^{17}

A.5.3 Growth factors – Answers to exercises

5. (a) 1.0412, 4.12%

(b) $C = 1.1 * 1.0412^Y$

(c) around 3.4 out of every ten children

(d) Graph

6. (a) 25% decrease per inch

(b) 200% increase per day

(c) 75% decrease per month

7. (a) 1.06496121...

(b) V = value of Whitney's table ($) $\sim$ dep
A = age of table (years) $\sim$ indep
$V = 560 * 1.065^A$
$\approx$ \$6,900

8. (a) 10 mg

(b) 3 days

(c) .46415888...

(d) $\approx$ 53.6%

(e) M = amount of morphine (mg) $\sim$ dep
H = time (hours) $\sim$ indep
$M = 100 * .4641588^H$ ✓

(f) just under 22 hours

(g) Graph

9. (a) 1.0665051...

(b) M = time (months) $\sim$ indep
U = number of unemployed adults $\sim$ dep
$U = 20{,}517 * 1.0665051^M$

(c) 57,481 unemployed

(d) See **Table O**, below. Graph.

10. (a) Y = time (years since 1850) ∼ indep
A = wetlands (acres) ∼ dep
.99547987...
$A = 18.6 * .99547987^Y$

(b) T = time (years since 2003) ∼ indep
A = wetlands (acres) ∼ dep
1.0146439...
$A = 9.3 * 1.0146439^T$

Table O:

time	10 mo ago	now	in 6 mos	in 1 year	in 2 yrs
M	0	10	16	22	32
U	20,517	39,061	57,481	84,586	161,038

A.5.4 Linear vs. exponential models – Answers to exercises

5. M = time on diet (months) ∼ indep
W = weight (pounds) ∼ dep

(a) **linear:** $W = 165 - 4M$
≈ 12 months if linear
exp: $W = 165 * .97514491^M$
≈ 13 months if exponential

(b) **linear:** $W = 253 - 6M$
≈ 13 months if linear
exp: $W = 253 * .97569882^M$
≈ 15 months if exponential

(c) You tend to lose more weight at first and then it slows down.

6. (a) i. 8.295 ppt/year
ii. $C = 11.1 + 8.295Y$
iii. ≈ 467 ppt
iv. linear

(b) i. 1.14850400...
ii. $C = 11.1 * 1.14850400^Y$
iii. ≈ 22,500 ppt
iv. exponential

7. (a) C = recommended intake (calories) ∼ dep
A = age (years since 30) ∼ indep

(b) ≈ 1,960 calories, ≈ 1,780 calories, ≈ 1,600 calories

(c) ≈ 1,962 calories, ≈ 1,782 calories, ≈ 1,618 calories

(d) The two models give almost exactly the same numbers.

8. (a) $T = 4.35 + .22375Y$
\$8.83, \$11.06

(b) $T = 4.35 * 1.038243^Y$
\$9.21, \$13.41

(c) Graph

(d) linear

9. In 2015, linear is 189 million and exponential is 227 million.
In 2030, linear is 251 million and exponential is 411 million.
Graph

10. (a) $H = 17 + 11{,}501Y$
    $\approx$ 138,000 cars sold
    (b) $H = 17 * 12.663239^Y$
    $\approx$ 290 trillion cars, which is not realistic!
    (c) Sales might be down because of the economy, or because many people who want to own a hybrid already do.

A.5.5 Logistic and other growth models – Answers to exercises

5. ✓

6. (a) See **Table P**, below.
   (b) January
   (c) Graph
   (d) People stopped calling.

7. (a) See **Table Q**, below.
   (b) 98%, 99.9%
   (c) day 69 (March 11)
   (d) day 69 (March 11)

8. (a) 3.5 kg, 4.3 kg, 6.3 kg, 10.1 kg
   (b) 7 lb & 11 oz, 9 lb & 7 oz, 13 lb & 15 oz, 22 lb & 2 oz
   (c) Graph.
   The curve levels off which would mean that the infant does not gain any more weight.

9. (a) See **Table R**, below.
   (b) Graph
   (c) saturation
   (d) logistic

Table P:

day	Jan 1	Feb 1	Mar 1	Apr 1	May 1	Nov 8
D	0	31	59	90	120	311
C	7	741	837	837	837	837

Table Q:

day	Jan 1	Mar 1	Aug 1	Oct 1	Nov 8
D	0	59	212	273	311
P	13	46	84	90	93

Table R:

year	10 yrs ago	now	in 10 yrs	in 20 yrs	in 30 yrs
Y	0	10	20	30	40
B (saturation)	400	3,700	3,975	3,998	4,000
B (logistic)	400	2,285	3,765	3,979	3,998
