Appendix C
Answers
Introduction to Scientific Computing and Data Analysis, 2nd Ed, by M. H. Holmes

Chapter 1
Introduction to Scientific Computing

1.14
(c) 101.0050175993734, (e) 100

1.16
a) 1000.03583648424; b) 1000.38056571994; c) 1.92929676762289; d) 0.00100058231560099; e) 500501.210707288; f)1000.45867514539; g) 4.70173884586451

Extras:
1.16(a) Prove that $\frac{1001}{2} < \sum_{k=0}^{1000} \frac{e^k}{1+e^k} < 1001$
1.16(f) Prove that $1000 + \ln\left(\frac{e+1}{e}\right) < \ln\left(\sum_{k=0}^{1000} e^k\right) < 1000 + \ln\left(\frac{e}{e-1}\right)$

1.17
(a) 2.5e-09, (b) 0.25

1.18
(b) 7.07106781186547e+209, (c) 17.07106781186547e-201

1.27
(b) 8 digits

Chapter 2
Solving A Nonlinear Equation

2.2
(f) $a = 1$, $b = e$ (or similar values)
(g) $a = 2$, $b = \pi$ (or similar values)

2.11 (e)
A = -0.808730600479392; B = 2.02097993808977; C =0.569840290998053; D = 0.77288295914921; E =1.31409680433497; F =1.19912073071795

2.12
partial solution: 0.463647609000806, 3.6052402625906

2.13
c) 1.16556118520721

2.14
c) $\theta = \pi/6$, $\varphi = 5.874070380211116$

2.15
e) $w = 16.212125896691699$

2.17
f) t=10 min, $S = 93.518993960281492\,\mathrm{mM}$

2.18
e) $f = 0.063569292626255$

2.19
e) $v = 35.3425966571947\,\mathrm{m/s}$

2.20
e) $v = 24.4408608474134\, m^3$

2.23
(e) A: 1; B: 0.246266172167723; C: -0.662512986344964; D: 0.759404549907607; E: 0.75250555469344

2.24
(d.1) 0.47693627620447, (e.1) 0.643856219147755

Chapter 3
Matrix Equations

Note: The computed value for some of the answers involving very ill-conditioned matrices can depend on which version of MATLAB you are using. The reason is that MATLAB uses the LAPACK library (what is considered to be the best algorithms currently available) and they are often upgraded. So, for example, R2015a uses Intel MKL 11.1.1, R2016a uses Intel MKL 11.2.3, and R2016b uses Intel MKL 11.3.1. Those interested in MKL (also known as the Intel Math Kernel Library) should consult Intel's web-site for this.

3.43
$n = 3$, $||\mathbf{x} - \mathbf{x}_M||/||\mathbf{x}|| = 2.22e - 16$, $\kappa(\mathbf{A}) = 5.33$
$n = 9$, $||\mathbf{x} - \mathbf{x}_I||/||\mathbf{x}|| = 7.77e - 16$, $||\mathbf{r}|| = 5.68e - 14$

3.44
$n = 8$, $||\mathbf{x} - \mathbf{x}_M||/||\mathbf{x}|| = 2.1647e - 10$, $\kappa(\mathbf{A}) = 3.96e + 07$

3.50
(d) x=1.17422174231682

3.51
(d) x=1.9953731700632

Chapter 4
Eigenvalue Problems

4.24
(c) $-5.000049348445e - 01$

4.27
(d) 3141592.65

4.33
(a) $\mathbf{q}_3 = (0, -1, 0)^T$, (c) $\mathbf{q}_3 = (0, -1/\sqrt{2}, -1/\sqrt{2})^T$

4.41
(d) 109, 145, 109, 145, 182, 145, 109, 145, 109
(e) 25
(f) 133, 133, 133, 133, 89, 178, 133, 133, 133

4.43
(b) 0.091083209233362

4.46
$\mathbf{A}_4$: (b) $\begin{pmatrix} 0 & 0 & -1 \\ -1 & 0 & 0 \\ 0 & -1 & 0 \end{pmatrix} \begin{pmatrix} 6 & 0 \\ 0 & 2 \\ 0 & 0 \end{pmatrix} \begin{pmatrix} 1 & 0 \\ 0 & 1 \end{pmatrix}$ (e) relative error is 1/3

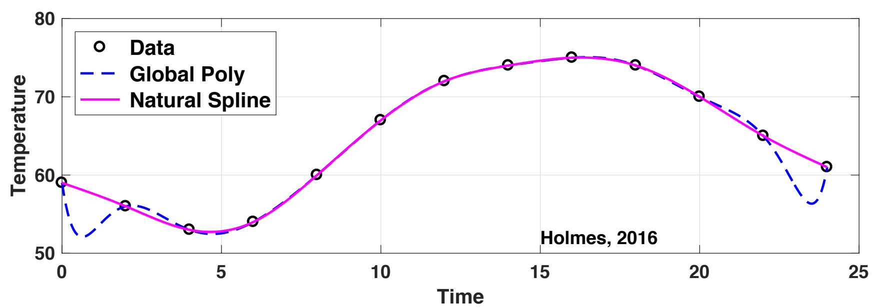
4.51
$\mathbf{A}^+ = \sum_{i=1}^{m} \frac{1}{\sigma_i} \mathbf{v}_i \mathbf{u}_i^T$

Chapter 5
Interpolation

5.13
(a) $s_2 = x^3 - 6x^2 + 8x - 1$

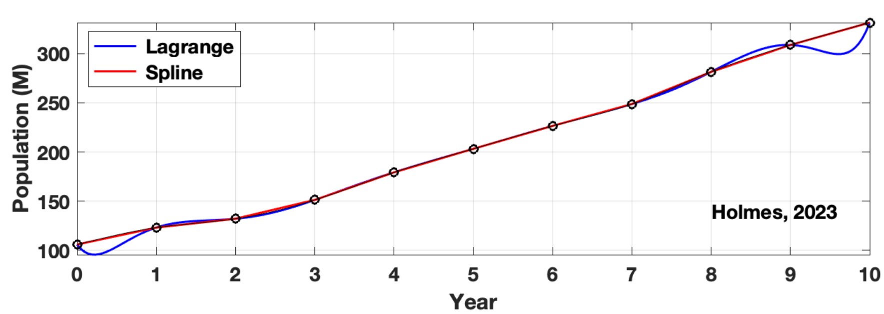
5.14
(a) $y_1 = y_2 = y_3 = y_4 = 0$

5.23
(a) see plot



(c) GP: 152.0489, NS: 58.0296

5.24
(a) see plot



(b) GP: 3.003643524200622e+02, NS: 3.202884797377673e+02

5.27
(a) $n > 55$, b) $n > 5$

5.33
(c) $\delta = 1.6 \times 10^{-11}$

Chapter 6
Numerical Integration

6.3
$W(8)$: b) 83, c) 72, d) 238/3

6.12
a) 238/3

6.17
(b) $hc * 4.058674557357435e + 03$

6.19
(c) $nt = 40$; $y(3) - y_{21} = -0.2242$

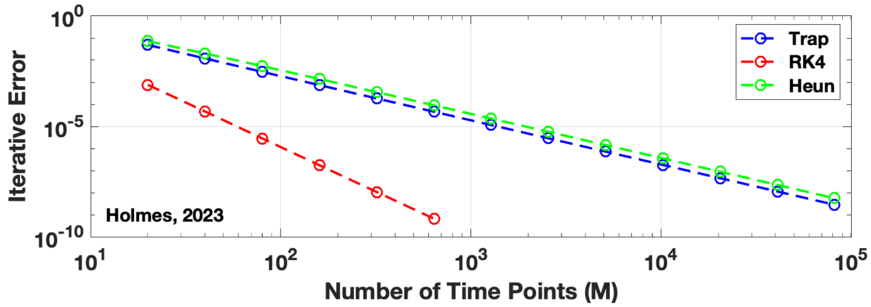
6.20
(c) $nt = 40$; $y(3) - y_{21} = -0.2505$

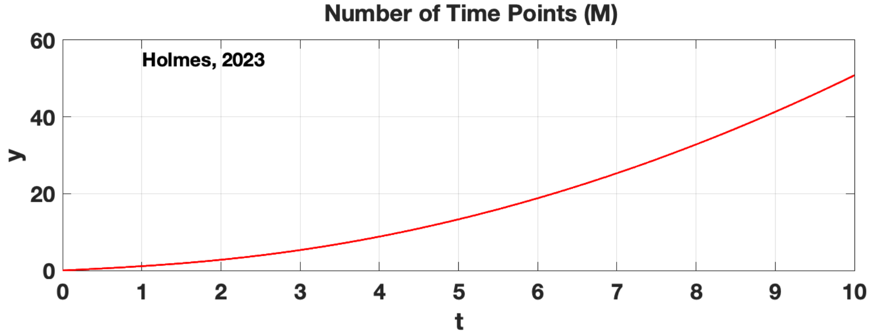
6.21
3.118169429070039

6.29
(b) $K = 1/216$

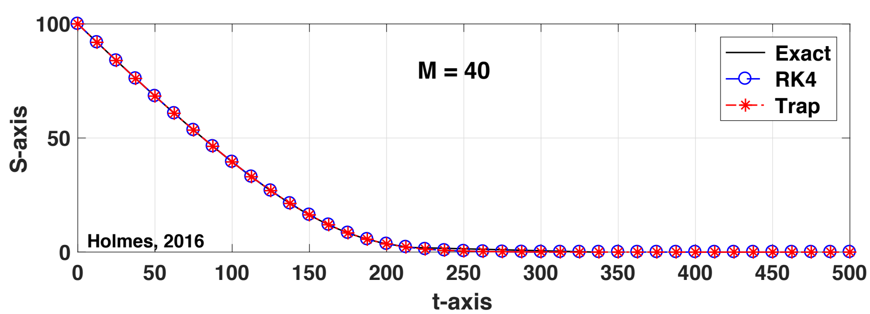
Chapter 7
Initial Value Problems

7.28
(II) see plots





7.29
(d)



e) $e_\infty \approx 0.1458$ when $M = 20$ for the trapezoidal method, and $e_\infty \approx 0.0014$ when $M = 40$ for RK4.

7.35
(c) Taking R to be the volumetric mean radius, $v(0) = 8.89619614e+03\,\text{m/s}$

7.36
(c) $r(1) = 1.26775487\,\text{au}$

Chapter 8
Optimization: Regression

8.3
a) 1, -1, b) 1/16, -1/16, c) 1, -1, d) -1, 2

8.4
a) 1, 2, b) -1, 1, c) 1, -3, -2, d) -1

8.5
a) $\begin{pmatrix} \frac{2}{3} & -\frac{1}{3} & \frac{1}{3} \\ \frac{1}{3} & \frac{1}{3} & \frac{2}{3} \end{pmatrix}$, b) $\begin{pmatrix} \frac{1}{14} & \frac{5}{14} & \frac{2}{7} \\ \frac{2}{7} & -\frac{4}{7} & \frac{1}{7} \end{pmatrix}$, c) $\begin{pmatrix} \frac{1}{6} & -\frac{1}{3} & -\frac{1}{6} \end{pmatrix}$

8.19
a) $\frac{1}{13}\begin{pmatrix} 12 & 3 & -4 \\ 3 & 4 & 12 \\ -4 & 12 & -3 \end{pmatrix}$, $b)$ $\begin{pmatrix} -\frac{11}{21} & \frac{8}{21} & -\frac{16}{21} \\ \frac{8}{21} & \frac{19}{21} & \frac{4}{21} \\ -\frac{16}{21} & \frac{4}{21} & \frac{13}{21} \end{pmatrix}$, $c)$ $\begin{pmatrix} -1 & 0 & 0 \\ 0 & 1 & 0 \\ 0 & 0 & 1 \end{pmatrix}$

8.20
a) $\mathbf{R} = \begin{pmatrix} 2 & -2 \\ 0 & 0 \end{pmatrix}, \quad \mathbf{Q} = \begin{pmatrix} 0 & 1 \\ 1 & 0 \end{pmatrix}$

b) $\mathbf{R} = \sqrt{2}\begin{pmatrix} 1 & 2 \\ 0 & 0 \end{pmatrix}, \quad \mathbf{Q} = \frac{\sqrt{2}}{2}\begin{pmatrix} 1 & 1 \\ 1 & -1 \end{pmatrix}$

(c) $\mathbf{R} = \begin{pmatrix} \sqrt{3} & -\frac{2\sqrt{3}}{3} & \frac{2\sqrt{3}}{3} \\ 0 & \frac{\sqrt{6}}{3} & \frac{\sqrt{6}}{6} \\ 0 & 0 & \frac{\sqrt{2}}{2} \end{pmatrix}, \quad \mathbf{Q} = \begin{pmatrix} \frac{\sqrt{3}}{3} & -\frac{\sqrt{6}}{6} & \frac{\sqrt{2}}{2} \\ \frac{\sqrt{3}}{3} & \frac{\sqrt{6}}{3} & 0 \\ \frac{\sqrt{3}}{3} & -\frac{\sqrt{6}}{6} & -\frac{\sqrt{2}}{2} \end{pmatrix}$

(d) $\mathbf{R} = \begin{bmatrix} 2 & -1 & 1 \\ 0 & 1 & 1 \\ 0 & 0 & 0 \end{bmatrix}, \quad \mathbf{Q} = \begin{bmatrix} 0 & 1 & 0 \\ 0 & 0 & 1 \\ 1 & 0 & 0 \end{bmatrix}$

e) $\mathbf{R} = \begin{pmatrix} 1 & -1 \\ 0 & \sqrt{5} \\ 0 & 0 \end{pmatrix}, \quad \mathbf{Q} = \begin{pmatrix} 0 & 1/\sqrt{5} & -2/\sqrt{5} \\ 0 & 2/\sqrt{5} & 1/\sqrt{5} \\ 1 & 0 & 0 \end{pmatrix}$

f) $\mathbf{R} = \begin{bmatrix} \sqrt{3} \\ 0 \\ 0 \end{bmatrix}, \quad \mathbf{Q} = \begin{bmatrix} \frac{\sqrt{3}}{3} & \frac{\sqrt{6}}{3} & 0 \\ \frac{\sqrt{3}}{3} & -\frac{\sqrt{6}}{6} & \frac{\sqrt{2}}{2} \\ \frac{\sqrt{3}}{3} & -\frac{\sqrt{6}}{6} & -\frac{\sqrt{2}}{2} \end{bmatrix}$

8.32
(c) $(p, \varepsilon) = (1.2319, 0.9660)$, (d) $(p, \varepsilon) = (1.2429, 0.9232)$

8.33
(a) $v_1 = 22.64$, $v_2 = -0.25$ (b) $v_1 = 24.91$, $v_2 = -0.33$

8.34
(a) using E: $(\alpha, \beta) = $ (3.8913e-09, 2.0847),
using E_S: $(\alpha, \beta) = $ (1.6113e-09, 2.2132)
(d) $\beta = 3$

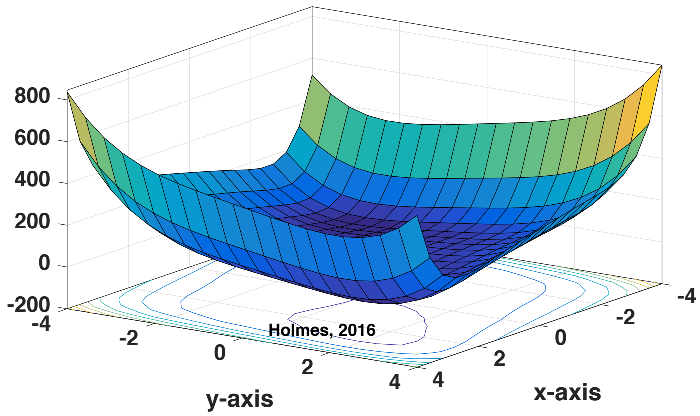


Figure C.1 Surface for Exercise 9.25(a).

Chapter 9
Optimization: Descent Methods

9.25
(a) The surface plot is shown in Figure C.1.

Chapter 10
Data Analysis

10.3
(b) 62/51, 160/51

10.2
(c) $z = 2.5$

10.13
(b) $\mathbf{x}_1^* = (-1/2, 1/2)^T$

(d) $\mathbf{y}_i^* = \frac{1}{\sqrt{2}} \begin{pmatrix} 2 & 2 \\ 4/\sqrt{5} & -4/\sqrt{5} \end{pmatrix} \mathbf{x}_i^*$