

```
1 // William E. Boyce/Richard C. DiPrima, "Elementary Differential
2 // Equations and Boundary Value Problems 10th Ed." 第413頁-416頁
3 using System;
4 using Matrix_0;
5
6 namespace ConsoleApp40
7 {
8     internal class Program
9     {
10         static void Main(string[] args)
11         {
12
13             // 初始值 [y1|y2|y3|y4] = [y1, y2, y3, y4]t
14             double[,] y0Start = { { -1 }, { 4 }, { 1 }, { 1 } };
15
16             // 系統矩陣A0, 並Cast為實數矩陣類別A。
17             double[,] A0 = { { 0, 0, 1, 0 }, { 0, 0, 0, 1 },
18                             { -2, 1.5, 0, 0 }, { 1.33333, -3, 0, 0 } };
19             ReMatrix A = new ReMatrix(A0);
20
21             // 系統特徵值V和特徵向量Q。
22             EIG eig = new EIG(A);
23             CxMatrix D = eig.CxMatrixD;
24             CxMatrix V = eig.CxVector;
25             CxMatrix Q = eig.CxMatrixQ;
26
27             CxToHexp Hexp = new CxToHexp(D, Q, 0);
28             CxMatrix MatTemp = Hexp.GetCxMatrix;
29             CxMatrix d = ~MatTemp * y0Start;
30
31             // 列印系統與狀態狀態參數。
32             Console.WriteLine("\n****{0,7}系{0,5}統{0,5}與{0,5}狀{0,5}態{0,5}參{0,5}數{0,7}****\n", "");
33
34             Console.WriteLine("\n***{0,5}系統特徵值V{0,5}***\n{1}\n", "", new PR(V));
35             Console.WriteLine("\n***{0,5}系統特徵向量Q{0,5}***\n{1}\n", "", new PR(Q));
36             Console.WriteLine("\n***{0,5}係數向量d{0,5}***\n{1}\n", "", new PR(d));
37
38             double step = 0.5;
39             int iRow = (int)(20 / step + 1);
40             int iCol = 4 + 1;
41             ReMatrix Disp = new ReMatrix(iRow, iCol);
42             ReMatrix Vel = new ReMatrix(iRow, iCol);
```

```
43
44 for (int i = 0; i != iRow; i++)
45 {
46     double t = step * i;
47
48     Hexp = new CxToHexp(D, Q, t);
49     MatTemp = Hexp.GetCxMatrix;
50     CxMatrix yh_Cx = MatTemp * d;
51     ReMatrix yh_Re = (ReMatrix)yh_Cx;
52     ReMatrix yhDot_Re = A * yh_Re;
53
54     Vel.Matrix[i, 0] = t;
55     Vel.Matrix[i, 1] = yhDot_Re.Matrix[0, 0];
56     Vel.Matrix[i, 2] = yhDot_Re.Matrix[1, 0];
57     Vel.Matrix[i, 3] = yhDot_Re.Matrix[2, 0];
58     Vel.Matrix[i, 4] = yhDot_Re.Matrix[3, 0];
59
60     Disp.Matrix[i, 0] = t;
61     Disp.Matrix[i, 1] = yh_Re.Matrix[0, 0];
62     Disp.Matrix[i, 2] = yh_Re.Matrix[1, 0];
63     Disp.Matrix[i, 3] = yh_Re.Matrix[2, 0];
64     Disp.Matrix[i, 4] = yh_Re.Matrix[3, 0];
65 }
66
67 // 列印狀態響應，節點之變位與速度。
68 Console.WriteLine("\n****{0,10} 狀{0,7} 態{0,7} 響{0,7} 應{0,10}****\n",
    "");
69
70 Console.WriteLine("\n{0,5} ***位移反應量***{0,5}\n{0,8} 時間(秒)" +
71 "{0,8} 第0點位移{0,8} 第1點位移{0,8} 第2點位移{0,8} 第3點位移\n\n{1}",
72 "", new PR(Disp));
73 Console.WriteLine("\n{0,5} ***速度反應量***{0,5}\n{0,8} 時間(秒)" +
74 "{0,8} 第0點速度{0,8} 第1點速度{0,8} 第2點速度{0,8} 第3點速度\n\n{1}",
75 "", new PR(Vel));
76
77 //列印時間、節點變位、和速度等序列。
78 Console.WriteLine("\n時間序列 : \n{0}\n",
79     new PR4(Disp, 0, "{0,8:F2}"));
80
81 Console.WriteLine("\n第0點變位序列 : \n{0}\n", new PR4(Disp, 1));
82 Console.WriteLine("\n第1點變位序列 : \n{0}\n", new PR4(Disp, 2));
83 Console.WriteLine("\n第2點變位序列 : \n{0}\n", new PR4(Disp, 3));
84 Console.WriteLine("\n第3點變位序列 : \n{0}\n", new PR4(Disp, 4));
85
86 Console.WriteLine("\n第0點速度序列 : \n{0}\n", new PR4(Vel, 1));
```

```

87 Console.Write("\n第1點速度序列 : \n{0}\n", new PR4(Vel, 2));
88 Console.Write("\n第2點速度序列 : \n{0}\n", new PR4(Vel, 3));
89 Console.Write("\n第3點速度序列 : \n{0}\n", new PR4(Vel, 4));
90     }
91 }
92 }
93
94 /*
95 ****          系          統          與          狀          態          參          數          ****
96
97 ***          系統特徵值V          ***
98     0.00000 + 2.00000i
99     0.00000 - 2.00000i
100    0.00000 + 1.00000i
101    0.00000 - 1.00000i
102
103 ***          系統特徵向量Q          ***
104    0.26833 + 0.00000i, 0.26833 + 0.00000i,
105    0.58835 + 0.00000i, 0.58835 + 0.00000i
106
107   -0.35777 + 0.00000i, -0.35777 + 0.00000i,
108    0.39223 + 0.00000i, 0.39223 + 0.00000i
109
110    0.00000 + 0.53666i, 0.00000 - 0.53666i,
111    0.00000 + 0.58835i, 0.00000 - 0.58835i
112
113    0.00000 - 0.71554i, 0.00000 + 0.71554i,
114    0.00000 + 0.39223i, 0.00000 - 0.39223i
115
116 ***          係數向量d          ***
117   -4.34791 + 0.15528i
118   -4.34791 - 0.15528i
119    1.13312 - 0.99148i
120    1.13312 + 0.99148i
121
122 *****          狀          態          響          應          *****
123
124 ***位移反應量***
125    時間(秒)      第0點位移      第1點位移      第2點位移      第3點位移
126    0.00000      -1.00000      4.00000      1.00000      1.00000
127    0.50000      0.39861      2.92740      4.22143      -4.85934
128    1.00000      2.59735     -0.05890      3.82114     -6.07807
129    1.50000      3.55628     -2.22559     -0.42391     -1.92973
130    2.00000      2.09422     -1.78033     -5.12071      3.43180
131    2.50000     -0.95195      0.52930     -6.25489      4.87459

```

132	3.00000	-3.37247	2.18591	-2.80712	1.05653
133	3.50000	-3.47172	1.31324	2.31547	-4.33692
134	4.00000	-1.49741	-1.51237	4.88775	-6.02401
135	4.50000	0.67012	-3.73650	3.13254	-2.06181
136	5.00000	1.26265	-3.16458	-0.78940	4.27155
137	5.50000	0.19478	-0.01617	-2.89986	7.40148
138	6.00000	-0.97002	3.20187	-1.15191	4.52138
139	6.50000	-0.59930	3.90525	2.66204	-1.84436
140	7.00000	1.37008	1.71661	4.60360	-6.13102
141	7.50000	3.27492	-1.25354	2.31503	-4.77925
142	8.00000	3.21878	-2.37122	-2.67283	0.58596
143	8.50000	0.85105	-0.87698	-6.20766	4.74287
144	9.00000	-2.21220	1.48150	-5.22715	3.74458
145	9.50000	-3.73672	2.14779	-0.52853	-1.42160
146	10.00000	-2.78174	0.20207	3.93885	-5.75888
147	10.50000	-0.45205	-2.71797	4.61385	-4.91549
148	11.00000	1.17324	-3.88580	1.46388	0.72516
149	11.50000	0.93687	-2.00303	-2.12908	6.30103
150	12.00000	-0.41512	1.55180	-2.59682	6.86227
151	12.50000	-1.04874	3.90439	0.46965	1.87883
152	13.00000	0.12709	3.23080	3.94922	-4.26873
153	13.50000	2.33292	0.35139	4.13413	-6.26749
154	14.00000	3.56151	-2.07266	0.26339	-2.67379
155	14.50000	2.41824	-1.98940	-4.63288	2.85593
156	15.00000	-0.53184	0.20058	-6.38988	5.01313
157	15.50000	-3.16447	2.09180	-3.45480	1.77279
158	16.00000	-3.60526	1.58146	1.70088	-3.73459
159	16.50000	-1.81931	-1.10814	4.79808	-6.13822
160	17.00000	0.44740	-3.57353	3.57138	-2.84011
161	17.50000	1.29869	-3.42282	-0.29067	3.50129
162	18.00000	0.38555	-0.50547	-2.83528	7.32375
163	18.50000	-0.87916	2.87854	-1.57804	5.20953
164	19.00000	-0.76006	3.99971	2.17747	-0.99603
165	19.50000	1.06505	2.11504	4.57430	-5.85699
166	20.00000	3.10328	-0.91931	2.84719	-5.27863
167					
168	***速度反應量***				
169	時間(秒)	第0點速度	第1點速度	第2點速度	第3點速度
170	0.00000	1.00000	1.00000	8.00000	-13.33333
171	0.50000	4.22143	-4.85934	3.59387	-8.25071
172	1.00000	3.82114	-6.07807	-5.28306	3.63983
173	1.50000	-0.42391	-1.92973	-10.45095	11.41847
174	2.00000	-5.12071	3.43180	-6.85893	8.13327
175	2.50000	-6.25489	4.87459	2.69784	-2.85716
176	3.00000	-2.80712	1.05653	10.02381	-11.05435

177	3.50000	2.31547	-4.33692	8.91329	-8.56866
178	4.00000	4.88775	-6.02401	0.72627	2.54057
179	4.50000	3.13254	-2.06181	-6.94499	12.10300
180	5.00000	-0.78940	4.27155	-7.27217	11.17726
181	5.50000	-2.89986	7.40148	-0.41382	0.30822
182	6.00000	-1.15191	4.52138	6.74285	-10.89896
183	6.50000	2.66204	-1.84436	7.05647	-12.51482
184	7.00000	4.60360	-6.13102	-0.16524	-3.32305
185	7.50000	2.31503	-4.77925	-8.43015	8.12717
186	8.00000	-2.67283	0.58596	-9.99438	11.40534
187	8.50000	-6.20766	4.74287	-3.01757	3.76567
188	9.00000	-5.22715	3.74458	6.64665	-7.39409
189	9.50000	-0.52853	-1.42160	10.69513	-11.42566
190	10.00000	3.93885	-5.75888	5.86658	-4.31519
191	10.50000	4.61385	-4.91549	-3.17286	7.55119
192	11.00000	1.46388	0.72516	-8.17518	13.22171
193	11.50000	-2.12908	6.30103	-4.87829	7.25825
194	12.00000	-2.59682	6.86227	3.15794	-5.20890
195	12.50000	0.46965	1.87883	7.95406	-13.11149
196	13.00000	3.94922	-4.26873	4.59201	-9.52294
197	13.50000	4.13413	-6.26749	-4.13876	2.05639
198	14.00000	0.26339	-2.67379	-10.23202	10.96666
199	14.50000	-4.63288	2.85593	-7.82058	9.19252
200	15.00000	-6.38988	5.01313	1.36455	-1.31085
201	15.50000	-3.45480	1.77279	9.46664	-10.49468
202	16.00000	1.70088	-3.73459	9.58271	-9.55138
203	16.50000	4.79808	-6.13822	1.97641	0.89869
204	17.00000	3.57138	-2.84011	-6.25509	11.31711
205	17.50000	-0.29067	3.50129	-7.73160	12.00003
206	18.00000	-2.83528	7.32375	-1.52930	2.03046
207	18.50000	-1.57804	5.20953	6.07614	-9.80784
208	19.00000	2.17747	-0.99603	7.51969	-13.01254
209	19.50000	4.57430	-5.85699	1.04246	-4.92505
210	20.00000	2.84719	-5.27863	-7.58552	6.89562

211

212 時間序列：

213	0.00,	0.50,	1.00,	1.50,	2.00,
214	2.50,	3.00,	3.50,	4.00,	4.50,
215	5.00,	5.50,	6.00,	6.50,	7.00,
216	7.50,	8.00,	8.50,	9.00,	9.50,
217	10.00,	10.50,	11.00,	11.50,	12.00,
218	12.50,	13.00,	13.50,	14.00,	14.50,
219	15.00,	15.50,	16.00,	16.50,	17.00,
220	17.50,	18.00,	18.50,	19.00,	19.50,
221	20.00,				

222

223 第0點變位序列：

224	-1.0000,	0.3986,	2.5974,	3.5563,	2.0942,
225	-0.9519,	-3.3725,	-3.4717,	-1.4974,	0.6701,
226	1.2627,	0.1948,	-0.9700,	-0.5993,	1.3701,
227	3.2749,	3.2188,	0.8510,	-2.2122,	-3.7367,
228	-2.7817,	-0.4520,	1.1732,	0.9369,	-0.4151,
229	-1.0487,	0.1271,	2.3329,	3.5615,	2.4182,
230	-0.5318,	-3.1645,	-3.6053,	-1.8193,	0.4474,
231	1.2987,	0.3855,	-0.8792,	-0.7601,	1.0651,
232	3.1033,				

233

234 第1點變位序列：

235	4.0000,	2.9274,	-0.0589,	-2.2256,	-1.7803,
236	0.5293,	2.1859,	1.3132,	-1.5124,	-3.7365,
237	-3.1646,	-0.0162,	3.2019,	3.9053,	1.7166,
238	-1.2535,	-2.3712,	-0.8770,	1.4815,	2.1478,
239	0.2021,	-2.7180,	-3.8858,	-2.0030,	1.5518,
240	3.9044,	3.2308,	0.3514,	-2.0727,	-1.9894,
241	0.2006,	2.0918,	1.5815,	-1.1081,	-3.5735,
242	-3.4228,	-0.5055,	2.8785,	3.9997,	2.1150,
243	-0.9193,				

244

245 第2點變位序列：

246	1.0000,	4.2214,	3.8211,	-0.4239,	-5.1207,
247	-6.2549,	-2.8071,	2.3155,	4.8878,	3.1325,
248	-0.7894,	-2.8999,	-1.1519,	2.6620,	4.6036,
249	2.3150,	-2.6728,	-6.2077,	-5.2271,	-0.5285,
250	3.9389,	4.6138,	1.4639,	-2.1291,	-2.5968,
251	0.4697,	3.9492,	4.1341,	0.2634,	-4.6329,
252	-6.3899,	-3.4548,	1.7009,	4.7981,	3.5714,
253	-0.2907,	-2.8353,	-1.5780,	2.1775,	4.5743,
254	2.8472,				

255

256 第3點變位序列：

257	1.0000,	-4.8593,	-6.0781,	-1.9297,	3.4318,
258	4.8746,	1.0565,	-4.3369,	-6.0240,	-2.0618,
259	4.2716,	7.4015,	4.5214,	-1.8444,	-6.1310,
260	-4.7792,	0.5860,	4.7429,	3.7446,	-1.4216,
261	-5.7589,	-4.9155,	0.7252,	6.3010,	6.8623,
262	1.8788,	-4.2687,	-6.2675,	-2.6738,	2.8559,
263	5.0131,	1.7728,	-3.7346,	-6.1382,	-2.8401,
264	3.5013,	7.3237,	5.2095,	-0.9960,	-5.8570,
265	-5.2786,				

266

267 第0點速度序列：

268	1.0000,	4.2214,	3.8211,	-0.4239,	-5.1207,
269	-6.2549,	-2.8071,	2.3155,	4.8878,	3.1325,
270	-0.7894,	-2.8999,	-1.1519,	2.6620,	4.6036,
271	2.3150,	-2.6728,	-6.2077,	-5.2271,	-0.5285,
272	3.9389,	4.6138,	1.4639,	-2.1291,	-2.5968,
273	0.4697,	3.9492,	4.1341,	0.2634,	-4.6329,
274	-6.3899,	-3.4548,	1.7009,	4.7981,	3.5714,
275	-0.2907,	-2.8353,	-1.5780,	2.1775,	4.5743,
276	2.8472,				

277

278 第1點速度序列：

279	1.0000,	-4.8593,	-6.0781,	-1.9297,	3.4318,
280	4.8746,	1.0565,	-4.3369,	-6.0240,	-2.0618,
281	4.2716,	7.4015,	4.5214,	-1.8444,	-6.1310,
282	-4.7792,	0.5860,	4.7429,	3.7446,	-1.4216,
283	-5.7589,	-4.9155,	0.7252,	6.3010,	6.8623,
284	1.8788,	-4.2687,	-6.2675,	-2.6738,	2.8559,
285	5.0131,	1.7728,	-3.7346,	-6.1382,	-2.8401,
286	3.5013,	7.3237,	5.2095,	-0.9960,	-5.8570,
287	-5.2786,				

288

289 第2點速度序列：

290	8.0000,	3.5939,	-5.2831,	-10.4510,	-6.8589,
291	2.6978,	10.0238,	8.9133,	0.7263,	-6.9450,
292	-7.2722,	-0.4138,	6.7429,	7.0565,	-0.1652,
293	-8.4302,	-9.9944,	-3.0176,	6.6467,	10.6951,
294	5.8666,	-3.1729,	-8.1752,	-4.8783,	3.1579,
295	7.9541,	4.5920,	-4.1388,	-10.2320,	-7.8206,
296	1.3646,	9.4666,	9.5827,	1.9764,	-6.2551,
297	-7.7316,	-1.5293,	6.0761,	7.5197,	1.0424,
298	-7.5855,				

299

300 第3點速度序列：

301	-13.3333,	-8.2507,	3.6398,	11.4185,	8.1333,
302	-2.8572,	-11.0544,	-8.5687,	2.5406,	12.1030,
303	11.1773,	0.3082,	-10.8990,	-12.5148,	-3.3230,
304	8.1272,	11.4053,	3.7657,	-7.3941,	-11.4257,
305	-4.3152,	7.5512,	13.2217,	7.2582,	-5.2089,
306	-13.1115,	-9.5229,	2.0564,	10.9667,	9.1925,
307	-1.3109,	-10.4947,	-9.5514,	0.8987,	11.3171,
308	12.0000,	2.0304,	-9.8078,	-13.0125,	-4.9250,
309	6.8956,				

310

311 請按任意鍵繼續 . . .

---

312 \*/