

```
1 // .NET 8, Project Name @ C:\2302\Misc_10\App_40
2 // William E. Boyce/Richard C. DiPrima, "Elementary Differential
3 // Equations and Boundary Value Problems 10th Ed." 第413頁-416頁
4
5 using Matrix_0;
6
7 // 已知數據(m=4, r=1), 包含初始值和系統矩陣A
8 double[,] y0Start = { { -1 }, { 4 }, { 1 }, { 1 } };
9 double[,] A0 = { { 0, 0, 1, 0 }, { 0, 0, 0, 1 },
10    {-2, 1.5, 0, 0}, {1.33333, -3, 0, 0 } };
11 ReMatrix A = new ReMatrix(A0);
12
13 // 複數特徵矩陣D和複數模態矩陣Q
14 EIG eig = new EIG(A);
15 CxMatrix D = eig.CxMatrixD;
16 CxMatrix Q = eig.CxMatrixQ;
17
18 // 複數向量係數 d
19 CxHexp Hexp = new CxHexp(D, Q, 0);
20 CxMatrix MatTemp = Hexp.GetCxMatrix;
21 CxMatrix d = ~MatTemp * y0Start;
22
23 // 列印系統特徵矩陣、模態矩陣、和係數向量。
24 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", "");
25 Console.WriteLine("\n***{0,5} 特徵矩陣 D{0,5} ***\n{1}\n", "", new PR (D));
26 Console.WriteLine("\n***{0,5} 模態矩陣 Q{0,5} ***\n{1}\n", "", new PR (Q));
27 Console.WriteLine("\n***{0,5} 向量係數 d{0,5} ***\n{1}\n", "", new PR (d));
28
29 // 建構Disp、Vel、和Acc等三個空的儲存矩陣
30 double step = 0.5;
31 int iRow = (int)(20 / step + 1);
32 int iCol = 5; // 4 + 1
33 ReMatrix Disp = new ReMatrix(iRow, iCol);
34 ReMatrix Vel = new ReMatrix(iRow, iCol);
35
36 //將計算的結果存入Vel、Dis、和Acc矩陣中
37 for (int i = 0; i != iRow; i++)
38 {
39     double t = step * i;
40     Hexp = new CxHexp(D, Q, t);
41     MatTemp = Hexp.GetCxMatrix;
42     ReMatrix yh_Re = (ReMatrix)(MatTemp * d);
43 }
```

```

44 // 位移
45 Disp.Matrix[i, 0] = t;
46 Disp.Matrix[i, 1] = yh_Re.Matrix[0, 0];
47 Disp.Matrix[i, 2] = yh_Re.Matrix[1, 0];
48 Disp.Matrix[i, 3] = yh_Re.Matrix[2, 0];
49 Disp.Matrix[i, 4] = yh_Re.Matrix[3, 0];
50
51 // 速度
52 ReMatrix yhDot_Re = A * yh_Re;
53 Vel.Matrix[i, 0] = t;
54 Vel.Matrix[i, 1] = yhDot_Re.Matrix[0, 0];
55 Vel.Matrix[i, 2] = yhDot_Re.Matrix[1, 0];
56 Vel.Matrix[i, 3] = yhDot_Re.Matrix[2, 0];
57 Vel.Matrix[i, 4] = yhDot_Re.Matrix[3, 0];
58 }
59
60 // 列印節點之狀態響應(變位、速度、和加速度)，適用於Excel繪圖
61 Console.WriteLine("\n****{0,10} 狀{0,7} 態{0,7} 響{0,7} 應{0,10} ****\n",
    "");
62 Console.WriteLine("\n{0,5} ***位移反應量***{0,5} \n{0,8} 時間(秒)" +
63 "{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}",
64 "", new PR(Disp));
65 Console.WriteLine("\n{0,5} ***速度反應量***{0,5} \n{0,8} 時間(秒)" +
66 "{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}",
67 "", new PR(Vel));
68
69 // 列印時間、變位、和速度等序列，使用於Matplotlib.pyplot套件繪圖
70 Console.WriteLine("\n時間序列 : \n{0}\n", new PR4(Disp, 0,
    "{0,8:F2}"));
71 Console.WriteLine("\n第0點變位序列 : \n{0}\n", new PR4(Disp, 1));
72 Console.WriteLine("\n第1點變位序列 : \n{0}\n", new PR4(Disp, 2));
73 Console.WriteLine("\n第2點變位序列 : \n{0}\n", new PR4(Disp, 3));
74 Console.WriteLine("\n第3點變位序列 : \n{0}\n", new PR4(Disp, 4));
75 Console.WriteLine("\n第0點速度序列 : \n{0}\n", new PR4(Vel, 1));
76 Console.WriteLine("\n第1點速度序列 : \n{0}\n", new PR4(Vel, 2));
77 Console.WriteLine("\n第2點速度序列 : \n{0}\n", new PR4(Vel, 3));
78 Console.WriteLine("\n第3點速度序列 : \n{0}\n", new PR4(Vel, 4));
79
80 /* 輸出結果如下 :
81 ****          系          統          與          狀          態          參          數          ****
82
83 ***          系統特徵值V          ***
84 0.00000 + 2.00000i
85 0.00000 - 2.00000i
86 0.00000 + 1.00000i
87 0.00000 - 1.00000i
88

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89  ***      系統特徵向量Q      ***
90      0.26833 + 0.00000i, 0.26833 + 0.00000i,
91      0.58835 + 0.00000i, 0.58835 + 0.00000i
92
93     -0.35777 + 0.00000i, -0.35777 + 0.00000i,
94      0.39223 + 0.00000i, 0.39223 + 0.00000i
95
96      0.00000 + 0.53666i, 0.00000 - 0.53666i,
97      0.00000 + 0.58835i, 0.00000 - 0.58835i
98
99      0.00000 - 0.71554i, 0.00000 + 0.71554i,
100     0.00000 + 0.39223i, 0.00000 - 0.39223i
101
102  ***      係數向量d      ***
103     -4.34791 + 0.15528i
104     -4.34791 - 0.15528i
105      1.13312 - 0.99148i
106      1.13312 + 0.99148i
107
108  ****      狀      態      響      應      ****
109
110  ***位移反應量***
111  時間(秒)      第0點位移      第1點位移      第2點位移      第3點位移
112      0.00000      -1.00000      4.00000      1.00000      1.00000
113      0.50000      0.39861      2.92740      4.22143      -4.85934
114      1.00000      2.59735      -0.05890      3.82114      -6.07807
115      1.50000      3.55628      -2.22559      -0.42391      -1.92973
116      2.00000      2.09422      -1.78033      -5.12071      3.43180
117      2.50000      -0.95195      0.52930      -6.25489      4.87459
118      3.00000      -3.37247      2.18591      -2.80712      1.05653
119      3.50000      -3.47172      1.31324      2.31547      -4.33692
120      4.00000      -1.49741      -1.51237      4.88775      -6.02401
121      4.50000      0.67012      -3.73650      3.13254      -2.06181
122      5.00000      1.26265      -3.16458      -0.78940      4.27155
123      5.50000      0.19478      -0.01617      -2.89986      7.40148
124      6.00000      -0.97002      3.20187      -1.15191      4.52138
125      6.50000      -0.59930      3.90525      2.66204      -1.84436
126      7.00000      1.37008      1.71661      4.60360      -6.13102
127      7.50000      3.27492      -1.25354      2.31503      -4.77925
128      8.00000      3.21878      -2.37122      -2.67283      0.58596
129      8.50000      0.85105      -0.87698      -6.20766      4.74287
130      9.00000      -2.21220      1.48150      -5.22715      3.74458
131      9.50000      -3.73672      2.14779      -0.52853      -1.42160
132     10.00000      -2.78174      0.20207      3.93885      -5.75888
133     10.50000      -0.45205      -2.71797      4.61385      -4.91549
134     11.00000      1.17324      -3.88580      1.46388      0.72516
135     11.50000      0.93687      -2.00303      -2.12908      6.30103

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136	12.00000	-0.41512	1.55180	-2.59682	6.86227
137	12.50000	-1.04874	3.90439	0.46965	1.87883
138	13.00000	0.12709	3.23080	3.94922	-4.26873
139	13.50000	2.33292	0.35139	4.13413	-6.26749
140	14.00000	3.56151	-2.07266	0.26339	-2.67379
141	14.50000	2.41824	-1.98940	-4.63288	2.85593
142	15.00000	-0.53184	0.20058	-6.38988	5.01313
143	15.50000	-3.16447	2.09180	-3.45480	1.77279
144	16.00000	-3.60526	1.58146	1.70088	-3.73459
145	16.50000	-1.81931	-1.10814	4.79808	-6.13822
146	17.00000	0.44740	-3.57353	3.57138	-2.84011
147	17.50000	1.29869	-3.42282	-0.29067	3.50129
148	18.00000	0.38555	-0.50547	-2.83528	7.32375
149	18.50000	-0.87916	2.87854	-1.57804	5.20953
150	19.00000	-0.76006	3.99971	2.17747	-0.99603
151	19.50000	1.06505	2.11504	4.57430	-5.85699
152	20.00000	3.10328	-0.91931	2.84719	-5.27863
153					
154	***速度反應量***				
155	時間(秒)	第0點速度	第1點速度	第2點速度	第3點速度
156	0.00000	1.00000	1.00000	8.00000	-13.33333
157	0.50000	4.22143	-4.85934	3.59387	-8.25071
158	1.00000	3.82114	-6.07807	-5.28306	3.63983
159	1.50000	-0.42391	-1.92973	-10.45095	11.41847
160	2.00000	-5.12071	3.43180	-6.85893	8.13327
161	2.50000	-6.25489	4.87459	2.69784	-2.85716
162	3.00000	-2.80712	1.05653	10.02381	-11.05435
163	3.50000	2.31547	-4.33692	8.91329	-8.56866
164	4.00000	4.88775	-6.02401	0.72627	2.54057
165	4.50000	3.13254	-2.06181	-6.94499	12.10300
166	5.00000	-0.78940	4.27155	-7.27217	11.17726
167	5.50000	-2.89986	7.40148	-0.41382	0.30822
168	6.00000	-1.15191	4.52138	6.74285	-10.89896
169	6.50000	2.66204	-1.84436	7.05647	-12.51482
170	7.00000	4.60360	-6.13102	-0.16524	-3.32305
171	7.50000	2.31503	-4.77925	-8.43015	8.12717
172	8.00000	-2.67283	0.58596	-9.99438	11.40534
173	8.50000	-6.20766	4.74287	-3.01757	3.76567
174	9.00000	-5.22715	3.74458	6.64665	-7.39409
175	9.50000	-0.52853	-1.42160	10.69513	-11.42566
176	10.00000	3.93885	-5.75888	5.86658	-4.31519
177	10.50000	4.61385	-4.91549	-3.17286	7.55119
178	11.00000	1.46388	0.72516	-8.17518	13.22171
179	11.50000	-2.12908	6.30103	-4.87829	7.25825
180	12.00000	-2.59682	6.86227	3.15794	-5.20890
181	12.50000	0.46965	1.87883	7.95406	-13.11149
182	13.00000	3.94922	-4.26873	4.59201	-9.52294

183	13.50000	4.13413	-6.26749	-4.13876	2.05639
184	14.00000	0.26339	-2.67379	-10.23202	10.96666
185	14.50000	-4.63288	2.85593	-7.82058	9.19252
186	15.00000	-6.38988	5.01313	1.36455	-1.31085
187	15.50000	-3.45480	1.77279	9.46664	-10.49468
188	16.00000	1.70088	-3.73459	9.58271	-9.55138
189	16.50000	4.79808	-6.13822	1.97641	0.89869
190	17.00000	3.57138	-2.84011	-6.25509	11.31711
191	17.50000	-0.29067	3.50129	-7.73160	12.00003
192	18.00000	-2.83528	7.32375	-1.52930	2.03046
193	18.50000	-1.57804	5.20953	6.07614	-9.80784
194	19.00000	2.17747	-0.99603	7.51969	-13.01254
195	19.50000	4.57430	-5.85699	1.04246	-4.92505
196	20.00000	2.84719	-5.27863	-7.58552	6.89562

197

198 時間序列：

199	0.00,	0.50,	1.00,	1.50,	2.00,
200	2.50,	3.00,	3.50,	4.00,	4.50,
201	5.00,	5.50,	6.00,	6.50,	7.00,
202	7.50,	8.00,	8.50,	9.00,	9.50,
203	10.00,	10.50,	11.00,	11.50,	12.00,
204	12.50,	13.00,	13.50,	14.00,	14.50,
205	15.00,	15.50,	16.00,	16.50,	17.00,
206	17.50,	18.00,	18.50,	19.00,	19.50,
207	20.00,				

208

209 第0點變位序列：

210	-1.0000,	0.3986,	2.5974,	3.5563,	2.0942,
211	-0.9519,	-3.3725,	-3.4717,	-1.4974,	0.6701,
212	1.2627,	0.1948,	-0.9700,	-0.5993,	1.3701,
213	3.2749,	3.2188,	0.8510,	-2.2122,	-3.7367,
214	-2.7817,	-0.4520,	1.1732,	0.9369,	-0.4151,
215	-1.0487,	0.1271,	2.3329,	3.5615,	2.4182,
216	-0.5318,	-3.1645,	-3.6053,	-1.8193,	0.4474,
217	1.2987,	0.3855,	-0.8792,	-0.7601,	1.0651,
218	3.1033,				

219

220 第1點變位序列：

221	4.0000,	2.9274,	-0.0589,	-2.2256,	-1.7803,
222	0.5293,	2.1859,	1.3132,	-1.5124,	-3.7365,
223	-3.1646,	-0.0162,	3.2019,	3.9053,	1.7166,
224	-1.2535,	-2.3712,	-0.8770,	1.4815,	2.1478,
225	0.2021,	-2.7180,	-3.8858,	-2.0030,	1.5518,
226	3.9044,	3.2308,	0.3514,	-2.0727,	-1.9894,
227	0.2006,	2.0918,	1.5815,	-1.1081,	-3.5735,
228	-3.4228,	-0.5055,	2.8785,	3.9997,	2.1150,
229	-0.9193,				

230

231 第2點變位序列：

232	1.0000,	4.2214,	3.8211,	-0.4239,	-5.1207,
233	-6.2549,	-2.8071,	2.3155,	4.8878,	3.1325,
234	-0.7894,	-2.8999,	-1.1519,	2.6620,	4.6036,
235	2.3150,	-2.6728,	-6.2077,	-5.2271,	-0.5285,
236	3.9389,	4.6138,	1.4639,	-2.1291,	-2.5968,
237	0.4697,	3.9492,	4.1341,	0.2634,	-4.6329,
238	-6.3899,	-3.4548,	1.7009,	4.7981,	3.5714,
239	-0.2907,	-2.8353,	-1.5780,	2.1775,	4.5743,
240	2.8472,				

241

242 第3點變位序列：

243	1.0000,	-4.8593,	-6.0781,	-1.9297,	3.4318,
244	4.8746,	1.0565,	-4.3369,	-6.0240,	-2.0618,
245	4.2716,	7.4015,	4.5214,	-1.8444,	-6.1310,
246	-4.7792,	0.5860,	4.7429,	3.7446,	-1.4216,
247	-5.7589,	-4.9155,	0.7252,	6.3010,	6.8623,
248	1.8788,	-4.2687,	-6.2675,	-2.6738,	2.8559,
249	5.0131,	1.7728,	-3.7346,	-6.1382,	-2.8401,
250	3.5013,	7.3237,	5.2095,	-0.9960,	-5.8570,
251	-5.2786,				

252

253 第0點速度序列：

254	1.0000,	4.2214,	3.8211,	-0.4239,	-5.1207,
255	-6.2549,	-2.8071,	2.3155,	4.8878,	3.1325,
256	-0.7894,	-2.8999,	-1.1519,	2.6620,	4.6036,
257	2.3150,	-2.6728,	-6.2077,	-5.2271,	-0.5285,
258	3.9389,	4.6138,	1.4639,	-2.1291,	-2.5968,
259	0.4697,	3.9492,	4.1341,	0.2634,	-4.6329,
260	-6.3899,	-3.4548,	1.7009,	4.7981,	3.5714,
261	-0.2907,	-2.8353,	-1.5780,	2.1775,	4.5743,
262	2.8472,				

263

264 第1點速度序列：

265	1.0000,	-4.8593,	-6.0781,	-1.9297,	3.4318,
266	4.8746,	1.0565,	-4.3369,	-6.0240,	-2.0618,
267	4.2716,	7.4015,	4.5214,	-1.8444,	-6.1310,
268	-4.7792,	0.5860,	4.7429,	3.7446,	-1.4216,
269	-5.7589,	-4.9155,	0.7252,	6.3010,	6.8623,
270	1.8788,	-4.2687,	-6.2675,	-2.6738,	2.8559,
271	5.0131,	1.7728,	-3.7346,	-6.1382,	-2.8401,
272	3.5013,	7.3237,	5.2095,	-0.9960,	-5.8570,
273	-5.2786,				

274

275 第2點速度序列：

276	8.0000,	3.5939,	-5.2831,	-10.4510,	-6.8589,
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277 2.6978, 10.0238, 8.9133, 0.7263, -6.9450,
278 -7.2722, -0.4138, 6.7429, 7.0565, -0.1652,
279 -8.4302, -9.9944, -3.0176, 6.6467, 10.6951,
280 5.8666, -3.1729, -8.1752, -4.8783, 3.1579,
281 7.9541, 4.5920, -4.1388, -10.2320, -7.8206,
282 1.3646, 9.4666, 9.5827, 1.9764, -6.2551,
283 -7.7316, -1.5293, 6.0761, 7.5197, 1.0424,
284 -7.5855,
285
286 第3點速度序列 :
287 -13.3333, -8.2507, 3.6398, 11.4185, 8.1333,
288 -2.8572, -11.0544, -8.5687, 2.5406, 12.1030,
289 11.1773, 0.3082, -10.8990, -12.5148, -3.3230,
290 8.1272, 11.4053, 3.7657, -7.3941, -11.4257,
291 -4.3152, 7.5512, 13.2217, 7.2582, -5.2089,
292 -13.1115, -9.5229, 2.0564, 10.9667, 9.1925,
293 -1.3109, -10.4947, -9.5514, 0.8987, 11.3171,
294 12.0000, 2.0304, -9.8078, -13.0125, -4.9250,
295 6.8956,
296 */
297
```