

Project 2

```
% clear; clc;
```

Problem 6

```
m = 100000;
y_0 = 1000;
k = 2e-6;
t_i = 0;
t_f = 30;

syms t y
f(t, y) = k*m*y - k*y^2;

N = 15;
[t_Ralston_case1, w_Ralston_case1] = Ralston(f, t_i, t_f, N, y_0);
[t_Heun_case1, w_Heun_case1] = Heun(f, t_i, t_f, N, y_0);
[t_RK38_case1, w_RK38_case1] = RK38(f, t_i, t_f, N, y_0);
[t_RK4_case1, w_RK4_case1] = RK4(f, t_i, t_f, N, y_0);

N = 30;
[t_Ralston_case2, w_Ralston_case2] = Ralston(f, t_i, t_f, N, y_0);
[t_Heun_case2, w_Heun_case2] = Heun(f, t_i, t_f, N, y_0);
[t_RK38_case2, w_RK38_case2] = RK38(f, t_i, t_f, N, y_0);
[t_RK4_case2, w_RK4_case2] = RK4(f, t_i, t_f, N, y_0);

TOL = 1e-2;
hmax = 2;
hmin = 1;
[t_RKF45, w_RKF45, h_RKF45] = RKF45(f, t_i, t_f, y_0, TOL, hmax, hmin);

tableGen("Ralston with h = 2", t_Ralston_case1, w_Ralston_case1);
```

```
Ralston with h = 2
i      t      w
1      0      1000
2      2      1473.406912
3      4      2166.349885
4      6      3175.36656
5      8      4633.507291
6      10     6717.612826
7      12     9649.73179
8      14     13683.81293
9      16     19064.89833
10     18     25949.91898
11     20     34296.9513
12     22     43768.44791
13     24     53729.28586
14     26     63393.46
15     28     72063.7384
16     30     79319.345
```

```
tableGen("Heun with h = 2", t_Heun_case1, w_Heun_case1);
```

Heun with h = 2

i	t	w
1	0	1000
2	2	1483.476947
3	4	2195.580913
4	6	3238.402916
5	8	4752.718476
6	10	6924.972447
7	12	9986.883079
8	14	14197.63672
9	16	19795.49586
10	18	26910.70818
11	20	35454.67349
12	22	45039.86068
13	24	55006.59604
14	26	64585.52021
15	28	73121.5041
16	30	80231.35432

```
tableGen("Runge-Kutta 3/8 with h = 2", t_RK38_case1, w_RK38_case1);
```

Runge-Kutta 3/8 with h = 2

i	t	w
1	0	1000
2	2	1484.439053
3	4	2198.351628
4	6	3244.307299
5	8	4763.694516
6	10	6943.611543
7	12	10016.22019
8	14	14240.50536
9	16	19853.42098
10	18	26982.77728
11	20	35537.29954
12	22	45127.89761
13	24	55094.73239
14	26	64668.54443
15	28	73194.14719
16	30	80289.29072

```
tableGen("Runge-Kutta 4th Order with h = 2", t_RK4_case1, w_RK4_case1);
```

Runge-Kutta 4th Order with h = 2

i	t	w
1	0	1000
2	2	1484.438695
3	4	2198.350324
4	6	3244.303729
5	8	4763.685843
6	10	6943.591958
7	12	10016.17847
8	14	14240.42138
9	16	19853.26202
10	18	26982.49677
11	20	35536.84283
12	22	45127.22092
13	24	55093.8364
14	26	64667.50379
15	28	73193.09644
16	30	80288.36099

```
tableGen("Ralston with h = 1", t_Ralston_case2, w_Ralston_case2);
```

Ralston with $h = 1$

i	t	w
1	0	1000
2	1	1217.377864
3	2	1481.316424
4	3	1801.457069
5	4	2189.279915
6	5	2658.379531
7	6	3224.745456
8	7	3907.026527
9	8	4726.746421
10	9	5708.422715
11	10	6879.523353
12	11	8270.174076
13	12	9912.511242
14	13	11839.56266
15	14	14083.54399
16	15	16673.49287
17	16	19632.24123
18	17	22972.85805
19	18	26694.877
20	19	30780.82839
21	20	35193.76506
22	21	39876.52283
23	22	44753.3098
24	23	49733.84182
25	24	54719.69593
26	25	59611.99746
27	26	64319.19117
28	27	68763.61985
29	28	72885.95858
30	29	76647.09778
31	30	80027.63253

```
tableGen("Heun with  $h = 1$ ", t_Heun_case2, w_Heun_case2);
```

Heun with $h = 1$

i	t	w
1	0	1000
2	1	1218.641214
3	2	1484.370978
4	3	1806.986203
5	4	2198.157349
6	5	2671.708115
7	6	3243.898368
8	7	3933.687977
9	8	4762.947053
10	9	5756.562411
11	10	6942.371244
12	11	8350.832555
13	12	10014.32852
14	13	11965.97821
15	14	14237.85495
16	15	16858.53945
17	16	19850.02628
18	17	23224.14035
19	18	26978.80439
20	19	31094.69654
21	20	35532.98777
22	21	40234.87066
23	22	45123.41404
24	23	50107.88653
25	24	55090.16104

26	25	59972.29821
27	26	64664.09518
28	27	69089.39671
29	28	73190.29467
30	29	76928.86006
31	30	80286.57585

```
tableGen("Runge-Kutta 3/8 with h = 1", t_RK38_case2, w_RK38_case2);
```

Runge-Kutta 3/8 with h = 1

i	t	w
1	0	1000
2	1	1218.70194
3	2	1484.517232
4	3	1807.249738
5	4	2198.578231
6	5	2672.336127
7	6	3244.794336
8	7	3934.924828
9	8	4764.610314
10	9	5758.749788
11	10	6945.190825
12	11	8354.399151
13	12	10018.75774
14	13	11971.37805
15	14	14244.31532
16	15	16866.12036
17	16	19858.74664
18	17	23233.96968
19	18	26989.65969
20	19	31106.44588
21	20	35545.46022
22	21	40247.86982
23	22	45136.73109
24	23	50121.30925
25	24	55103.47766
26	25	59985.2982
27	26	64676.57114
28	27	69101.15071
29	28	73201.14968
30	29	76938.67369
31	30	80295.25235

```
tableGen("Runge-Kutta 4th Order with h = 1", t_RK4_case2, w_RK4_case2);
```

Runge-Kutta 4th Order with h = 1

i	t	w
1	0	1000
2	1	1218.701934
3	2	1484.517215
4	3	1807.249704
5	4	2198.578169
6	5	2672.336022
7	6	3244.794166
8	7	3934.924559
9	8	4764.609895
10	9	5758.749147
11	10	6945.189859
12	11	8354.397713
13	12	10018.75562
14	13	11971.37497
15	14	14244.3109
16	15	16866.11408

17	16	19858.73788
18	17	23233.95764
19	18	26989.64347
20	19	31106.42449
21	20	35545.43271
22	21	40247.83541
23	22	45136.68936
24	23	50121.26032
25	24	55103.42229
26	25	59985.23779
27	26	64676.5076
28	27	69101.08622
29	28	73201.08639
30	29	76938.61347
31	30	80295.1966

```
RKF45_print(t_RKF45, w_RKF45, h_RKF45);
```

Runga-Kutta-Fehlberg

i	t	w	h
1	0	1000	NaN
2	2	1484.53	2
3	3.98195	2190.866	1.98195
4	5.793882	3117.911	1.811933
5	7.454612	4293.501	1.66073
6	8.998258	5757.038	1.543646
7	10.45361	7555.156	1.455351
8	11.84445	9742.111	1.39084
9	13.19176	12381.92	1.347311
10	14.51569	15551.77	1.323927
11	15.83751	19347.29	1.321822
12	17.18223	23891.17	1.34472
13	18.583	29348.86	1.400773
14	20.09089	35964.1	1.507889
15	21.80482	44173.19	1.713933
16	23.80482	54137.12	2
17	25.80482	63780.81	2
18	27.80482	72429.42	2
19	29.31261	78030.12	1.507792
20	30	80296.02	0.6873852

```
function tableGen(name, t, w)

    fprintf("%s\n", name);
    fprintf("%-15s%-15s%-15s\n", "i", "t", "w");

    for j = 1:length(t)
        fprintf("%-15.7g%-15.7g%-15.10g\n", j, t(j), w(j));
    end

end

function RKF45_print(t_RKF45, w_RKF45, h_RKF45)

    fprintf("%s\n", "Runga-Kutta-Fehlberg");
    fprintf("%-15s%-15s%-15s%-15s\n", "i", "t", "w", "h");
    for j = 1:length(t_RKF45)
```

```
        fprintf("%-15.7g%-15.7g%-15.7g%-15.7g\n", j, t_RKF45(j), w_RKF45(j),  
h_RKF45(j));  
    end  
  
end
```