Sistemas de Tempo Real - 2024/2025

Practical Assignment No1 - Report
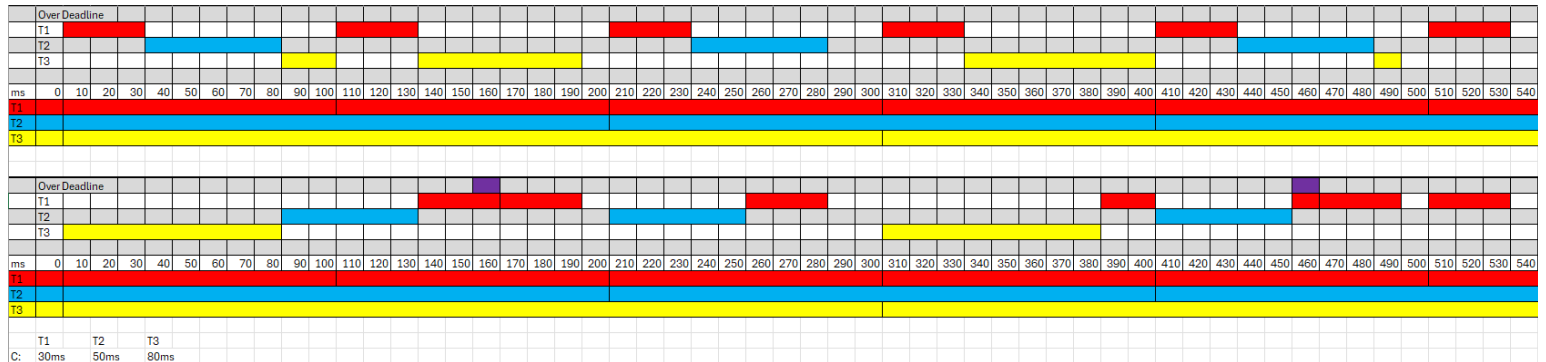
Scheduling, Priorities Assignment, and Measurement of Computation Times

1) Measure the (maximum) computation time of each of the functions

Maximum computation times of functions are:

- C1: 0.0302 s = 30.2 ms
- C2: 0.0502 s = 50.2 ms
- C3: 0.0802 s = 80.2 ms

2) Using the results of point 1 verify if the system is schedulable, for two priority orderings: RMPO (rate monotonic priority ordering) and its inverse.

Picture 1: Top Gantt diagram shows RMPO priority ordering for tasks T1, T2,T3. Bottom Gantt diagram shows inverse of RMPO

Audsley suggests a method where we constantly calculate w_i for a task:

$$w_i^{n+1} = C_i + \sum_{j \in hp(i)} \lceil \frac{w_i^n}{T_j} \rceil C_j$$

Up until $w_i^{n+1} = w_i^n$ and $w_i^{n+1} < T_i$ which would mean we have found a solution and the task can meet its deadline or $w_i^{n+1} > T_i$ which would mean that there is no solution and the task does not meet its deadline.

Where C_i stands for computation time of a function. T_j is a period of activation for a task that has higher priority that task i. And C_j stands for computation time of a task that has higher priority that task i.

Here are the calculations for our functions for RMPO:

R1:

$$R_1 = C_1 = 30.2\,ms$$

R2:

$$w_{T2}^0 = 50.2\,ms$$

$$w_{T2}^1 = 50.2 + \lceil \frac{50.2}{100} \rceil * 30.2 = 80.4\,ms$$

$$w_{T2}^2 = 50.2 + \lceil \frac{80.4}{100} \rceil * 30.2 = 80.4\,ms$$

$$w_{T2}^2 = w_{T2}^1 < 200\ ms \quad -> \quad R_2 = 80.4\,ms$$

R3:

$$w_{T3}^0 = 80.2\,ms$$

$$w_{T3}^1 = 80.2 + \lceil \frac{80.2}{200} \rceil * 50.2 + \lceil \frac{80.2}{100} \rceil * 30.2 = 160.6\,ms$$

$$w_{T3}^2 = 80.2 + \lceil \frac{160.6}{200} \rceil * 50.2 + \lceil \frac{160.6}{100} \rceil * 30.2 = 190.8\,ms$$

$$w_{T3}^3 = 80.2 + \lceil \frac{190.8}{200} \rceil * 50.2 + \lceil \frac{190.8}{100} \rceil * 30.2 = 190.8\,ms$$

$$w_{T3}^3 = w_{T3}^2 < 300\ ms \quad -> \quad R_2 = 190.8\,ms$$

As we can see, every task meets its deadline. Schedule is ok.

Here are the calculations for our functions for inverse RMPO:

R3:

$$R_1 = C_1 = 80.2\,ms$$

R2:

$$w_{T2}^0 = 50.2\,ms$$

$$w_{T2}^1 = 50.2 + \lceil \frac{50.2}{300} \rceil * 80.2 = 130.4 \, ms$$

$$w_{T2}^2 = 50.2 + \lceil \frac{130.4}{300} \rceil * 80.2 = 130.4 \, ms$$

$$w_{T2}^2 = w_{T2}^1 < 200 \text{ ms} \quad \rightarrow \quad R_2 = 130.4 \, ms$$

R1:

$$w_{T3}^0 = 30.2 \, ms$$

$$w_{T3}^1 = 30.2 + \lceil \frac{30.2}{200} \rceil * 50.2 + \lceil \frac{30.2}{300} \rceil * 80.2 = 160.6 \, ms$$

$$w_{T3}^2 \neq w_{T3}^1 \quad w_{T3}^2 > 100 \, ms$$

As we can see, T1 task is not meeting its deadline and as such this schedule is not viable.

3) In the end, the application should also show the largest response times for each task and the response time jitter.

RMPO:

Logs for task 1	Logs for task 2	Logs for task 3
Max response time: 0.060958170 s Min response time: 0.030149941 s Jitter: 0.030808229 s	Max response time: 0.140675615 s Min response time: 0.080188617 s Jitter: 0.060486998 s	Max response time: 0.234984205 s Min response time: 0.190117063 s Jitter: 0.044867142 s
Desired: 0.000000000 s Activated: 0.003384745 s Finished: 0.033524411 s Desired: 0.100000000 s Activated: 0.100615498 s Finished: 0.130616938 s Desired: 0.200000000 s Activated: 0.200154386 s Finished: 0.230181682 s Desired: 0.300000000 s Activated: 0.300200216 s Finished: 0.330202058 s Desired: 0.400000000 s Activated: 0.408205630 s Finished: 0.438207404 s Desired: 0.500000000 s Activated: 0.510804186 s Finished: 0.540805586 s Desired: 0.600000000 s	Desired: 0.000000000 s Activated: 0.033549736 s Finished: 0.083553001 s Desired: 0.200000000 s Activated: 0.230186199 s Finished: 0.280188617 s Desired: 0.400000000 s Activated: 0.438211143 s Finished: 0.488250518 s Desired: 0.600000000 s Activated: 0.641130004 s Finished: 0.691132413 s Desired: 0.800000000 s Activated: 0.832957120 s Finished: 0.882959521 s Desired: 1.000000000 s Activated: 1.030839026 s Finished: 1.080897633 s Desired: 1.200000000 s	Desired: 0.000000000 s Activated: 0.083570649 s Finished: 0.193625392 s Desired: 0.300000000 s Activated: 0.330207517 s Finished: 0.490254095 s Desired: 0.600000000 s Activated: 0.691135926 s Finished: 0.800333011 s Desired: 0.900000000

Activated: 0.611053340 s	Activated: 1.234163657 s	s
Finished: 0.641124446 s	Finished: 1.284188379 s	Activated: 0.933393236
Desired: 0.700000000 s	Desired: 1.400000000 s	s
Activated: 0.706325714 s	Activated: 1.460963432 s	Finished: 1.092902489
Finished: 0.736327108 s	Finished: 1.540675615 s	s
Desired: 0.800000000 s	Desired: 1.600000000 s	Desired: 1.200000000
Activated: 0.802883088 s	Activated: 1.636020554 s	s
Finished: 0.832952039 s	Finished: 1.686041174 s	Activated: 1.284192578
Desired: 0.900000000 s	Desired: 1.800000000 s	s
Activated: 0.903387159 s	Activated: 1.831929029 s	Finished: 1.393680260
Finished: 0.933388635 s	Finished: 1.882053733 s	s
Desired: 1.000000000 s	Desired: 2.000000000 s	Desired: 1.500000000
Activated: 1.000834006 s	Activated: 2.043501672 s	s
Finished: 1.030835385 s	Finished: 2.096338026 s	Activated: 1.540677668
Desired: 1.100000000 s	Desired: 2.200000000 s	s
Activated: 1.104671173 s	Activated: 2.230566592 s	Finished: 1.700044182
Finished: 1.134765946 s	Finished: 2.280582815 s	s
Desired: 1.200000000 s	Desired: 2.400000000 s	Desired: 1.800000000
Activated: 1.204150191 s	Activated: 2.437359243 s	s
Finished: 1.234153019 s	Finished: 2.487361340 s	Activated: 1.882058240
Desired: 1.300000000 s	Desired: 2.600000000 s	s
Activated: 1.305672859 s	Activated: 2.635969642 s	Finished: 1.991174887
Finished: 1.335674517 s	Finished: 2.685971968 s	s
Desired: 1.400000000 s	Desired: 2.800000000 s	Desired: 2.100000000
Activated: 1.430956644 s	Activated: 2.830350533 s	s
Finished: 1.460958170 s	Finished: 2.880352972 s	Activated: 2.130785164
Desired: 1.500000000 s	Desired: 3.000000000 s	s
Activated: 1.508670545 s	Activated: 3.036186838 s	Finished: 2.290593325
Finished: 1.538671857 s	Finished: 3.086241854 s	s
Desired: 1.600000000 s	Desired: 3.200000000 s	Desired: 2.400000000
Activated: 1.606015595 s	Activated: 3.233343790 s	s
Finished: 1.636017885 s	Finished: 3.283397338 s	Activated: 2.487365729
Desired: 1.700000000 s	Desired: 3.400000000 s	s
Activated: 1.707376872 s	Activated: 3.434874550 s	Finished: 2.596895827
Finished: 1.737378557 s	Finished: 3.485773012 s	s
Desired: 1.800000000 s	Desired: 3.600000000 s	Desired: 2.700000000
Activated: 1.801920984 s	Activated: 3.630584169 s	s
Finished: 1.831923307 s	Finished: 3.680589566 s	Activated: 2.730349480
Desired: 1.900000000 s	Desired: 3.800000000 s	s
Activated: 1.906143433 s	Activated: 3.830497897 s	Finished: 2.890356261
Finished: 1.936145145 s	Finished: 3.880523240 s	s
Desired: 2.000000000 s	Desired: 4.000000000 s	Desired: 3.000000000
Activated: 2.000680819 s	Activated: 4.030910186 s	s
Finished: 2.043495455 s	Finished: 4.080959411 s	Activated: 3.086245831
Desired: 2.100000000 s	Desired: 4.200000000 s	s
Activated: 2.100776485 s	Activated: 4.231698008 s	Finished: 3.195376599
Finished: 2.130778238 s	Finished: 4.281700677 s	s
Desired: 2.200000000 s	Desired: 4.400000000 s	Desired: 3.300000000
Activated: 2.200561417 s	Activated: 4.430790660 s	s
Finished: 2.230562932 s	Finished: 4.481744200 s	Activated: 3.335938071
Desired: 2.300000000 s	Desired: 4.600000000 s	s
Activated: 2.300785387 s	Activated: 4.636207471 s	Finished: 3.534984205
Finished: 2.330790656 s	Finished: 4.686238733 s	s
Desired: 2.400000000 s	Desired: 4.800000000 s	Desired: 3.600000000
Activated: 2.407298598 s	Activated: 4.840411866 s	s

Finished: 2.437354244 s
Desired: 2.500000000 s
Activated: 2.503785656 s
Finished: 2.533787005 s
Desired: 2.600000000 s
Activated: 2.605963142 s
Finished: 2.635964611 s
Desired: 2.700000000 s
Activated: 2.700342994 s
Finished: 2.730345000 s
Desired: 2.800000000 s
Activated: 2.800339334 s
Finished: 2.830345777 s
Desired: 2.900000000 s
Activated: 2.910550473 s
Finished: 2.940552093 s
Desired: 3.000000000 s
Activated: 3.006136577 s
Finished: 3.036181909 s
Desired: 3.100000000 s
Activated: 3.100367176 s
Finished: 3.130368663 s
Desired: 3.200000000 s
Activated: 3.203337494 s
Finished: 3.233338968 s
Desired: 3.300000000 s
Activated: 3.305931443 s
Finished: 3.335933000 s
Desired: 3.400000000 s
Activated: 3.400984676 s
Finished: 3.434868281 s
Desired: 3.500000000 s
Activated: 3.504978661 s
Finished: 3.534980252 s
Desired: 3.600000000 s
Activated: 3.600418270 s
Finished: 3.630578615 s
Desired: 3.700000000 s
Activated: 3.710109226 s
Finished: 3.740110782 s
Desired: 3.800000000 s
Activated: 3.800490171 s
Finished: 3.830491723 s
Desired: 3.900000000 s
Activated: 3.904289560 s
Finished: 3.934291301 s
Desired: 4.000000000 s
Activated: 4.000903555 s
Finished: 4.030905077 s
Desired: 4.100000000 s
Activated: 4.113139015 s
Finished: 4.143142798 s
Desired: 4.200000000 s
Activated: 4.201613955 s
Finished: 4.231692697 s

Finished: 4.890436577 s
Desired: 5.000000000 s
Activated: 5.030536098 s
Finished: 5.080538229 s
Desired: 5.200000000 s
Activated: 5.233815474 s
Finished: 5.283817885 s
Desired: 5.400000000 s
Activated: 5.431219306 s
Finished: 5.481222049 s
Desired: 5.600000000 s
Activated: 5.630847909 s
Finished: 5.680864762 s
Desired: 5.800000000 s
Activated: 5.831501204 s
Finished: 5.881503611 s

Activated: 3.680593689 s
Finished: 3.790117063 s
Desired: 3.900000000 s
Activated: 3.934299721 s
Finished: 4.093964056 s
Desired: 4.200000000 s
Activated: 4.281704914 s
Finished: 4.391721161 s
Desired: 4.500000000 s
Activated: 4.530160792 s
Finished: 4.690246818 s
Desired: 4.800000000 s
Activated: 4.890448217 s
Finished: 4.999957083 s
Desired: 5.100000000 s
Activated: 5.137191976 s
Finished: 5.296821387 s
Desired: 5.400000000 s
Activated: 5.481227428 s
Finished: 5.592860953 s
Desired: 5.700000000 s
Activated: 5.733258414 s
Finished: 5.892557417 s

Desired: 4.300000000 s Activated: 4.301657475 s Finished: 4.331659000 s Desired: 4.400000000 s Activated: 4.400726979 s Finished: 4.430782347 s Desired: 4.500000000 s Activated: 4.500148224 s Finished: 4.530149941 s Desired: 4.600000000 s Activated: 4.606201227 s Finished: 4.636202723 s Desired: 4.700000000 s Activated: 4.701812608 s Finished: 4.731852007 s Desired: 4.800000000 s Activated: 4.810398689 s Finished: 4.840401656 s Desired: 4.900000000 s Activated: 4.904948643 s Finished: 4.934950350 s Desired: 5.000000000 s Activated: 5.000518954 s Finished: 5.030531782 s Desired: 5.100000000 s Activated: 5.107185266 s Finished: 5.137186735 s Desired: 5.200000000 s Activated: 5.203808555 s Finished: 5.233809988 s Desired: 5.300000000 s Activated: 5.300889047 s Finished: 5.330890852 s Desired: 5.400000000 s Activated: 5.401211021 s Finished: 5.431213287 s Desired: 5.500000000 s Activated: 5.500288485 s Finished: 5.530301021 s Desired: 5.600000000 s Activated: 5.600835275 s Finished: 5.630840986 s Desired: 5.700000000 s Activated: 5.703247323 s Finished: 5.733248991 s Desired: 5.800000000 s Activated: 5.801491460 s Finished: 5.831493011 s Desired: 5.900000000 s Activated: 5.900239384 s Finished: 5.930298921 s		

Inverse RMPO:

Logs for task 1	Logs for task 2	Logs for task 3

Logs for task 1:

```
Desired:   0.000000000 s
Activated: 0.137871406 s
Finished:  0.167873407 s
*** Over deadline
Desired:   0.100000000 s
Activated: 0.170330225 s
Finished:  0.200391521 s
*** Over deadline
Desired:   0.200000000 s
Activated: 0.271202729 s
Finished:  0.301205011 s
*** Over deadline
Desired:   0.300000000 s
Activated: 0.386524305 s
Finished:  0.465877933 s
*** Over deadline
Desired:   0.400000000 s
Activated: 0.465951205 s
Finished:  0.497522096 s
Desired:   0.500000000 s
Activated: 0.500098172 s
Finished:  0.532747362 s
Desired:   0.600000000 s
Activated: 0.730717564 s
Finished:  0.760719086 s
*** Over deadline
Desired:   0.700000000 s
Activated: 0.760786305 s
Finished:  0.790787773 s
Desired:   0.800000000 s
Activated: 0.857486644 s
Finished:  0.887570577 s
Desired:   0.900000000 s
Activated: 0.980863588 s
Finished:  1.060735781 s
*** Over deadline
Desired:   1.000000000 s
Activated: 1.061406253 s
Finished:  1.091407674 s
Desired:   1.100000000 s
Activated: 1.103369331 s
Finished:  1.133424046 s
Desired:   1.200000000 s
Activated: 1.330864609 s
Finished:  1.360866096 s
*** Over deadline
Desired:   1.300000000 s
Activated: 1.360950518 s
Finished:  1.390952489 s
```

Logs for task 2:

```
Desired:   0.000000000 s
Activated: 0.087854969 s
Finished:  0.137866587 s
Desired:   0.200000000 s
Activated: 0.221193476 s
Finished:  0.271197016 s
Desired:   0.400000000 s
Activated: 0.400871566 s
Finished:  0.450874004 s
Desired:   0.600000000 s
Activated: 0.680710465 s
Finished:  0.730713089 s
Desired:   0.800000000 s
Activated: 0.807479689 s
Finished:  0.857482027 s
Desired:   1.000000000 s
Activated: 1.000725947 s
Finished:  1.050732158 s
Desired:   1.200000000 s
Activated: 1.280856454 s
Finished:  1.330859056 s
Desired:   1.400000000 s
Activated: 1.401595412 s
Finished:  1.451598037 s
Desired:   1.600000000 s
Activated: 1.600409146 s
Finished:  1.650466967 s
Desired:   1.800000000 s
Activated: 1.882460779 s
Finished:  1.932463305 s
Desired:   2.000000000 s
Activated: 2.000486036 s
Finished:  2.050491282 s
Desired:   2.200000000 s
Activated: 2.200652984 s
Finished:  2.250661867 s
Desired:   2.400000000 s
Activated: 2.480822149 s
Finished:  2.530877516 s
Desired:   2.600000000 s
Activated: 2.602421546 s
Finished:  2.652423671 s
Desired:   2.800000000 s
Activated: 2.800635700 s
Finished:  2.850638180 s
Desired:   3.000000000 s
Activated: 3.081127784 s
Finished:  3.131130011 s
Desired:   3.200000000 s
```

Logs for task 3:

```
Desired:   0.000000000 s
Activated: 0.007430679 s
Finished:  0.087831718 s
Desired:   0.300000000 s
Activated: 0.306516120 s
Finished:  0.386519804 s
Desired:   0.600000000 s
Activated: 0.600626978 s
Finished:  0.680704892 s
Desired:   0.900000000 s
Activated: 0.900855708 s
Finished:  0.980859356 s
Desired:   1.200000000 s
Activated: 1.200676194 s
Finished:  1.280851911 s
Desired:   1.500000000 s
Activated: 1.500977291 s
Finished:  1.581013498 s
Desired:   1.800000000 s
Activated: 1.802370414 s
Finished:  1.882454942 s
Desired:   2.100000000 s
Activated: 2.100669614 s
Finished:  2.180745221 s
Desired:   2.400000000 s
Activated: 2.400809485 s
Finished:  2.480816010 s
Desired:   2.700000000 s
Activated: 2.703141080 s
Finished:  2.783145165 s
Desired:   3.000000000 s
Activated: 3.001062732 s
Finished:  3.081122720 s
Desired:   3.300000000 s
Activated: 3.301384239 s
Finished:  3.381454387 s
Desired:   3.600000000 s
Activated: 3.601629768 s
Finished:  3.681691220 s
Desired:   3.900000000 s
Activated: 3.903465492 s
Finished:  3.983485687 s
Desired:   4.200000000 s
Activated: 4.210858513 s
Finished:  4.290862992 s
Desired:   4.500000000 s
Activated: 4.501138796 s
Finished:  4.581142997 s
Desired:   4.800000000 s
```

Desired: 1.400000000 s
Activated: 1.451602256 s
Finished: 1.481606484 s
Desired: 1.500000000 s
Activated: 1.581017383 s
Finished: 1.663472349 s
*** Over deadline
Desired: 1.600000000 s
Activated: 1.666824044 s
Finished: 1.696825644 s
Desired: 1.700000000 s
Activated: 1.703185094 s
Finished: 1.733186696 s
Desired: 1.800000000 s
Activated: 1.932466776 s
Finished: 1.962468332 s
*** Over deadline
Desired: 1.900000000 s
Activated: 1.962626157 s
Finished: 1.992627575 s
Desired: 2.000000000 s
Activated: 2.050494656 s
Finished: 2.080579852 s
Desired: 2.100000000 s
Activated: 2.180751049 s
Finished: 2.260666670 s
*** Over deadline
Desired: 2.200000000 s
Activated: 2.260751480 s
Finished: 2.290752979 s
Desired: 2.300000000 s
Activated: 2.300987336 s
Finished: 2.330988930 s
Desired: 2.400000000 s
Activated: 2.530880739 s
Finished: 2.560882230 s
*** Over deadline
Desired: 2.500000000 s
Activated: 2.562345934 s
Finished: 2.592347503 s
Desired: 2.600000000 s
Activated: 2.652426676 s
Finished: 2.682493308 s
Desired: 2.700000000 s
Activated: 2.783152988 s
Finished: 2.862641629 s
*** Over deadline
Desired: 2.800000000 s
Activated: 2.862731544 s
Finished: 2.892733277 s
Desired: 2.900000000 s
Activated: 2.903385354 s
Finished: 2.933408505 s
Desired: 3.000000000 s
Activated: 3.131135469 s

Activated: 3.200742143 s
Finished: 3.250781107 s
Desired: 3.400000000 s
Activated: 3.406698225 s
Finished: 3.456717691 s
Desired: 3.600000000 s
Activated: 3.681696367 s
Finished: 3.731698826 s
Desired: 3.800000000 s
Activated: 3.804235834 s
Finished: 3.854238384 s
Desired: 4.000000000 s
Activated: 4.000217027 s
Finished: 4.050219561 s
Desired: 4.200000000 s
Activated: 4.290868014 s
Finished: 4.340870821 s
Desired: 4.400000000 s
Activated: 4.405070839 s
Finished: 4.455113280 s
Desired: 4.600000000 s
Activated: 4.609261709 s
Finished: 4.659264497 s
Desired: 4.800000000 s
Activated: 4.885217726 s
Finished: 4.935262759 s
Desired: 5.000000000 s
Activated: 5.000165570 s
Finished: 5.050168439 s
Desired: 5.200000000 s
Activated: 5.200404082 s
Finished: 5.250406591 s
Desired: 5.400000000 s
Activated: 5.484832656 s
Finished: 5.534834972 s
Desired: 5.600000000 s
Activated: 5.602621326 s
Finished: 5.654014147 s
Desired: 5.800000000 s
Activated: 5.803270328 s
Finished: 5.853272475 s

Activated: 4.801462104 s
Finished: 4.885205596 s
Desired: 5.100000000 s
Activated: 5.101062787 s
Finished: 5.181164552 s
Desired: 5.400000000 s
Activated: 5.404735622 s
Finished: 5.484821098 s
Desired: 5.700000000 s
Activated: 5.702332987 s
Finished: 5.782395232 s

Finished: 3.161136938 s *** Over deadline Desired: 3.100000000 s Activated: 3.161212920 s Finished: 3.191214386 s Desired: 3.200000000 s Activated: 3.250785264 s Finished: 3.280831325 s Desired: 3.300000000 s Activated: 3.381459343 s Finished: 3.460721121 s *** Over deadline Desired: 3.400000000 s Activated: 3.462020961 s Finished: 3.492022512 s Desired: 3.500000000 s Activated: 3.500145085 s Finished: 3.530146560 s Desired: 3.600000000 s Activated: 3.731702329 s Finished: 3.761748267 s *** Over deadline Desired: 3.700000000 s Activated: 3.774734414 s Finished: 3.854241656 s *** Over deadline Desired: 3.800000000 s Activated: 3.854315440 s Finished: 3.884316997 s Desired: 3.900000000 s Activated: 3.983497560 s Finished: 4.063222603 s *** Over deadline Desired: 4.000000000 s Activated: 4.063835382 s Finished: 4.093837095 s Desired: 4.100000000 s Activated: 4.107361131 s Finished: 4.137363006 s Desired: 4.200000000 s Activated: 4.340880006 s Finished: 4.370881517 s *** Over deadline Desired: 4.300000000 s Activated: 4.371826509 s Finished: 4.401827931 s *** Over deadline Desired: 4.400000000 s Activated: 4.455116933 s Finished: 4.485118572 s Desired: 4.500000000 s Activated: 4.581148429 s Finished: 4.660268125 s *** Over deadline Desired: 4.600000000 s		

Activated: 4.660346471 s Finished: 4.690359403 s Desired: 4.700000000 s Activated: 4.700265463 s Finished: 4.730266930 s Desired: 4.800000000 s Activated: 4.935267431 s Finished: 4.965294604 s *** Over deadline Desired: 4.900000000 s Activated: 4.965361775 s Finished: 4.995363201 s Desired: 5.000000000 s Activated: 5.050177886 s Finished: 5.080179378 s Desired: 5.100000000 s Activated: 5.181175105 s Finished: 5.260412443 s *** Over deadline Desired: 5.200000000 s Activated: 5.260486089 s Finished: 5.290487496 s Desired: 5.300000000 s Activated: 5.300786274 s Finished: 5.330788068 s Desired: 5.400000000 s Activated: 5.534839851 s Finished: 5.564841359 s *** Over deadline Desired: 5.500000000 s Activated: 5.564911589 s Finished: 5.594914746 s Desired: 5.600000000 s Activated: 5.654019863 s Finished: 5.684272706 s Desired: 5.700000000 s Activated: 5.782432785 s Finished: 5.862286497 s *** Over deadline Desired: 5.800000000 s Activated: 5.862380717 s Finished: 5.892384982 s Desired: 5.900000000 s Activated: 5.904119000 s Finished: 5.934120502 s		

4)

a) Alternative A: Change the code developed in Item 3 in order to change the priorities (between RMPO and the inverse) during the execution of the tasks at instant t = 1.95 [s] and at t = 3.95 [s]. Comment the obtained results.

Results show a stable task schedule where tasks are completed inside their deadlines up until the change in priorities. After the change, task 1 has significant problems with meeting its deadlines. After another switch, task 1 stabilizes and meets its deadlines.

Logs for task 1	Logs for task 2	Logs for task 3
Max response time: 0.165443113 s	Max response time: 0.131730003 s	Max response time: 0.233944737 s
Min response time: 0.030186609 s	Min response time: 0.050217364 s	Min response time: 0.080218705 s
Jitter: 0.135256504 s	Jitter: 0.081512639 s	Jitter: 0.153726032 s

b) Alternative B: Change the code developed in Item 3 in order to run in any number of processors (CPU cores). Try also to invert the priorities (to invert RMPO priorities). Comment the obtained results, namely the largest response times for each task and if they met the deadlines.

RMPO:

Logs for task 1	Logs for task 2	Logs for task 3
Max response time: 0.060318821 s	Max response time: 0.081193708 s	Max response time: 0.091786757 s
Min response time: 0.030104317 s	Min response time: 0.050234353 s	Min response time: 0.080249713 s
Jitter: 0.030214504 s	Jitter: 0.030959355 s	Jitter: 0.011537044 s

Inverse RMPO:

Logs for task 1	Logs for task 2	Logs for task 3
Max response time: 0.046305601 s	Max response time: 0.080219226 s	Max response time: 0.106070639 s

Min response time: 0.030168881 s Jitter: 0.016136720 s	Min response time: 0.050054098 s Jitter: 0.030165128 s	Min response time: 0.080249006 s Jitter: 0.025821633 s

Tasks have their largest response times well inside their deadlines. This is a configuration where each task gets his own CPU, due to that, response times are low for each task. There is a small deviation between RMPO and inverse RMPO, mainly in the response times of task 1 and task 3. This can be due to other tasks running in the background and we believe that there shouldn't be any particular difference between RMPO and inverse RMPO unless tasks try to run on the same CPU.

5. Develop a source code func2.c of a module func2.o that imitates the functioning of the module func.o. Comment the obtained results.

Results obtained from Item 3 while using our own module gives us similar results as when using given module func.o. The only difference is lower *Max response time* by a small margin.

RMPO:

Logs for task 1	**Logs for task 2**	**Logs for task 3**
Max response time: 0.034655781 s Min response time: 0.030036254 s Jitter: 0.004619527 s	Max response time: 0.084663925 s Min response time: 0.080086723 s Jitter: 0.004577202 s	Max response time: 0.183245505 s Min response time: 0.160171844 s Jitter: 0.023073661 s
Desired: 0.000000000 s Activated: 0.000584634 s Finished: 0.030585416 s Desired: 0.100000000 s Activated: 0.100747088 s Finished: 0.130747331 s Desired: 0.200000000 s Activated: 0.200759855 s Finished: 0.230760431 s Desired: 0.300000000 s Activated: 0.301038653 s Finished: 0.331082775 s Desired: 0.400000000 s Activated: 0.400549835 s Finished: 0.430550119 s	Desired: 0.000000000 s Activated: 0.030615372 s Finished: 0.080615906 s Desired: 0.200000000 s Activated: 0.230763972 s Finished: 0.280764178 s Desired: 0.400000000 s Activated: 0.430553531 s Finished: 0.480553805 s Desired: 0.600000000 s Activated: 0.634663511 s Finished: 0.684663925 s Desired: 0.800000000 s Activated: 0.830221284 s Finished: 0.880221436 s	Desired: 0.000000000 s Activated: 0.080639978 s Finished: 0.160640221 s Desired: 0.300000000 s Activated: 0.331087521 s Finished: 0.480556156 s Desired: 0.600000000 s Activated: 0.684669412 s Finished: 0.764669629 s Desired: 0.900000000 s Activated: 0.931010282 s Finished: 1.080099232 s Desired: 1.200000000 s Activated: 1.282089723 s Finished: 1.362089845 s

Desired: 0.500000000 s
Activated: 0.500469638 s
Finished: 0.530470259 s
Desired: 0.600000000 s
Activated: 0.604655054 s
Finished: 0.634655781 s
Desired: 0.700000000 s
Activated: 0.702360809 s
Finished: 0.732361144 s
Desired: 0.800000000 s
Activated: 0.800215525 s
Finished: 0.830216034 s
Desired: 0.900000000 s
Activated: 0.901005578 s
Finished: 0.931005887 s
Desired: 1.000000000 s
Activated: 1.000075885 s
Finished: 1.030076755 s
Desired: 1.100000000 s
Activated: 1.101046910 s
Finished: 1.131047717 s
Desired: 1.200000000 s
Activated: 1.202071968 s
Finished: 1.232072996 s
Desired: 1.300000000 s
Activated: 1.300548569 s
Finished: 1.330548745 s
Desired: 1.400000000 s
Activated: 1.400964598 s
Finished: 1.430964951 s
Desired: 1.500000000 s
Activated: 1.500540972 s
Finished: 1.530541172 s
Desired: 1.600000000 s
Activated: 1.601057609 s
Finished: 1.631057939 s
Desired: 1.700000000 s
Activated: 1.700759560 s
Finished: 1.730759800 s
Desired: 1.800000000 s
Activated: 1.800593356 s
Finished: 1.830593961 s
Desired: 1.900000000 s
Activated: 1.900036039 s
Finished: 1.930036254 s
Desired: 2.000000000 s
Activated: 2.001714609 s
Finished: 2.031715228 s
Desired: 2.100000000 s
Activated: 2.102297676 s
Finished: 2.132298243 s
Desired: 2.200000000 s
Activated: 2.200137609 s
Finished: 2.230137909 s
Desired: 2.300000000 s

Desired: 1.000000000 s
Activated: 1.030086403 s
Finished: 1.080086723 s
Desired: 1.200000000 s
Activated: 1.232084102 s
Finished: 1.282084461 s
Desired: 1.400000000 s
Activated: 1.430968646 s
Finished: 1.480968805 s
Desired: 1.600000000 s
Activated: 1.631062595 s
Finished: 1.681062970 s
Desired: 1.800000000 s
Activated: 1.830599640 s
Finished: 1.880599932 s
Desired: 2.000000000 s
Activated: 2.031724927 s
Finished: 2.081725334 s
Desired: 2.200000000 s
Activated: 2.230141714 s
Finished: 2.280141943 s
Desired: 2.400000000 s
Activated: 2.430300407 s
Finished: 2.480300815 s
Desired: 2.600000000 s
Activated: 2.630654849 s
Finished: 2.680655159 s
Desired: 2.800000000 s
Activated: 2.830262485 s
Finished: 2.880270781 s
Desired: 3.000000000 s
Activated: 3.030499641 s
Finished: 3.080499955 s
Desired: 3.200000000 s
Activated: 3.230608962 s
Finished: 3.280609103 s
Desired: 3.400000000 s
Activated: 3.430344132 s
Finished: 3.480344280 s
Desired: 3.600000000 s
Activated: 3.630600845 s
Finished: 3.680601152 s
Desired: 3.800000000 s
Activated: 3.830945363 s
Finished: 3.880945574 s
Desired: 4.000000000 s
Activated: 4.030112964 s
Finished: 4.080113156 s
Desired: 4.200000000 s
Activated: 4.230413384 s
Finished: 4.280413626 s
Desired: 4.400000000 s
Activated: 4.431644520 s
Finished: 4.481644704 s
Desired: 4.600000000 s

Desired: 1.500000000 s
Activated: 1.530544580 s
Finished: 1.681067286 s
Desired: 1.800000000 s
Activated: 1.880603435 s
Finished: 1.960603655 s
Desired: 2.100000000 s
Activated: 2.132305229 s
Finished: 2.280145100 s
Desired: 2.400000000 s
Activated: 2.480304843 s
Finished: 2.560305012 s
Desired: 2.700000000 s
Activated: 2.730905204 s
Finished: 2.880274229 s
Desired: 3.000000000 s
Activated: 3.080514621 s
Finished: 3.160514820 s
Desired: 3.300000000 s
Activated: 3.330210718 s
Finished: 3.480347980 s
Desired: 3.600000000 s
Activated: 3.680606059 s
Finished: 3.760606262 s
Desired: 3.900000000 s
Activated: 3.930632665 s
Finished: 4.080120115 s
Desired: 4.200000000 s
Activated: 4.280418246 s
Finished: 4.360435836 s
Desired: 4.500000000 s
Activated: 4.530456644 s
Finished: 4.680768110 s
Desired: 4.800000000 s
Activated: 4.880171630 s
Finished: 4.960171844 s
Desired: 5.100000000 s
Activated: 5.131032327 s
Finished: 5.283245505 s
Desired: 5.400000000 s
Activated: 5.481062072 s
Finished: 5.561062193 s
Desired: 5.700000000 s
Activated: 5.730696359 s
Finished: 5.882038475 s

Activated: 2.300521860 s Finished: 2.330522099 s Desired: 2.400000000 s Activated: 2.400295317 s Finished: 2.430296066 s Desired: 2.500000000 s Activated: 2.500966683 s Finished: 2.530966850 s Desired: 2.600000000 s Activated: 2.600649064 s Finished: 2.630649436 s Desired: 2.700000000 s Activated: 2.700898353 s Finished: 2.730898981 s Desired: 2.800000000 s Activated: 2.800256317 s Finished: 2.830256666 s Desired: 2.900000000 s Activated: 2.902901569 s Finished: 2.932901765 s Desired: 3.000000000 s Activated: 3.000485449 s Finished: 3.030486254 s Desired: 3.100000000 s Activated: 3.100705567 s Finished: 3.130705729 s Desired: 3.200000000 s Activated: 3.200603678 s Finished: 3.230604200 s Desired: 3.300000000 s Activated: 3.300206120 s Finished: 3.330206578 s Desired: 3.400000000 s Activated: 3.400339170 s Finished: 3.430339386 s Desired: 3.500000000 s Activated: 3.501371186 s Finished: 3.531371467 s Desired: 3.600000000 s Activated: 3.600593653 s Finished: 3.630594329 s Desired: 3.700000000 s Activated: 3.701210931 s Finished: 3.731211140 s Desired: 3.800000000 s Activated: 3.800937563 s Finished: 3.830938229 s Desired: 3.900000000 s Activated: 3.900627954 s Finished: 3.930628267 s Desired: 4.000000000 s Activated: 4.000101548 s Finished: 4.030102113 s Desired: 4.100000000 s Activated: 4.100768840 s	Activated: 4.630763283 s Finished: 4.680763516 s Desired: 4.800000000 s Activated: 4.830167377 s Finished: 4.880167663 s Desired: 5.000000000 s Activated: 5.031321466 s Finished: 5.081321782 s Desired: 5.200000000 s Activated: 5.233242395 s Finished: 5.283242625 s Desired: 5.400000000 s Activated: 5.431058490 s Finished: 5.481058843 s Desired: 5.600000000 s Activated: 5.630327830 s Finished: 5.680327999 s Desired: 5.800000000 s Activated: 5.831991640 s Finished: 5.881994820 s	

Finished: 4.130769235 s Desired: 4.200000000 s Activated: 4.200406212 s Finished: 4.230406706 s Desired: 4.300000000 s Activated: 4.301828595 s Finished: 4.331828884 s Desired: 4.400000000 s Activated: 4.401639488 s Finished: 4.431640006 s Desired: 4.500000000 s Activated: 4.500452238 s Finished: 4.530452509 s Desired: 4.600000000 s Activated: 4.600758730 s Finished: 4.630759032 s Desired: 4.700000000 s Activated: 4.700526034 s Finished: 4.730526444 s Desired: 4.800000000 s Activated: 4.800159731 s Finished: 4.830160527 s Desired: 4.900000000 s Activated: 4.900513722 s Finished: 4.930513865 s Desired: 5.000000000 s Activated: 5.001307904 s Finished: 5.031308512 s Desired: 5.100000000 s Activated: 5.101025815 s Finished: 5.131026700 s Desired: 5.200000000 s Activated: 5.203239119 s Finished: 5.233239296 s Desired: 5.300000000 s Activated: 5.300093001 s Finished: 5.330093371 s Desired: 5.400000000 s Activated: 5.401052028 s Finished: 5.431052452 s Desired: 5.500000000 s Activated: 5.500312266 s Finished: 5.530312485 s Desired: 5.600000000 s Activated: 5.600320919 s Finished: 5.630321176 s Desired: 5.700000000 s Activated: 5.700692577 s Finished: 5.730692804 s Desired: 5.800000000 s Activated: 5.801986986 s Finished: 5.831987314 s Desired: 5.900000000 s Activated: 5.900143815 s Finished: 5.930144196 s		

Inverse RMPO:

Logs for task 1	Logs for task 2	Logs for task 3
Max response time: 0.168004566 s Min response time: 0.030115131 s Jitter: 0.137889435 s	Max response time: 0.137999864 s Min response time: 0.050205963 s Jitter: 0.087793901 s	Max response time: 0.087993744 s Min response time: 0.080231724 s Jitter: 0.007762020 s
Desired: 0.000000000 s Activated: 0.131042052 s Finished: 0.161042368 s *** Over deadline Desired: 0.100000000 s Activated: 0.161120149 s Finished: 0.191120233 s Desired: 0.200000000 s Activated: 0.250946368 s Finished: 0.280946512 s Desired: 0.300000000 s Activated: 0.380955871 s Finished: 0.452338997 s *** Over deadline Desired: 0.400000000 s Activated: 0.453411976 s Finished: 0.483447520 s Desired: 0.500000000 s Activated: 0.500356222 s Finished: 0.530356470 s Desired: 0.600000000 s Activated: 0.733645893 s Finished: 0.763646153 s *** Over deadline Desired: 0.700000000 s Activated: 0.763705377 s Finished: 0.793705505 s Desired: 0.800000000 s Activated: 0.850697545 s Finished: 0.880697805 s Desired: 0.900000000 s Activated: 0.981165708 s Finished: 1.050629132 s *** Over deadline Desired: 1.000000000 s Activated: 1.050692616 s Finished: 1.080692754 s Desired: 1.100000000 s Activated: 1.101711358 s Finished: 1.131712066 s Desired: 1.200000000 s Activated: 1.330767266 s Finished: 1.360767407 s *** Over deadline	Desired: 0.000000000 s Activated: 0.081030810 s Finished: 0.131031168 s Desired: 0.200000000 s Activated: 0.200942492 s Finished: 0.250942677 s Desired: 0.400000000 s Activated: 0.402336715 s Finished: 0.452336837 s Desired: 0.600000000 s Activated: 0.683640075 s Finished: 0.733640313 s Desired: 0.800000000 s Activated: 0.800685850 s Finished: 0.850686612 s Desired: 1.000000000 s Activated: 1.000622121 s Finished: 1.050622509 s Desired: 1.200000000 s Activated: 1.280762004 s Finished: 1.330762339 s Desired: 1.400000000 s Activated: 1.400249576 s Finished: 1.450249770 s Desired: 1.600000000 s Activated: 1.605110050 s Finished: 1.655110197 s Desired: 1.800000000 s Activated: 1.880358938 s Finished: 1.930359259 s Desired: 2.000000000 s Activated: 2.003012996 s Finished: 2.053013847 s Desired: 2.200000000 s Activated: 2.200205784 s Finished: 2.250205963 s Desired: 2.400000000 s Activated: 2.481176382 s Finished: 2.531176515 s Desired: 2.600000000 s Activated: 2.600339848 s Finished: 2.650340118 s Desired: 2.800000000 s Activated: 2.802294652 s	Desired: 0.000000000 s Activated: 0.001010808 s Finished: 0.081011366 s Desired: 0.300000000 s Activated: 0.300951752 s Finished: 0.380952063 s Desired: 0.600000000 s Activated: 0.603635237 s Finished: 0.683635814 s Desired: 0.900000000 s Activated: 0.901159084 s Finished: 0.981159461 s Desired: 1.200000000 s Activated: 1.200754780 s Finished: 1.280755527 s Desired: 1.500000000 s Activated: 1.500597931 s Finished: 1.580598204 s Desired: 1.800000000 s Activated: 1.800351821 s Finished: 1.880352244 s Desired: 2.100000000 s Activated: 2.101006378 s Finished: 2.181007154 s Desired: 2.400000000 s Activated: 2.401170724 s Finished: 2.481171438 s Desired: 2.700000000 s Activated: 2.700836938 s Finished: 2.780837331 s Desired: 3.000000000 s Activated: 3.003963008 s Finished: 3.083963506 s Desired: 3.300000000 s Activated: 3.300935271 s Finished: 3.380935625 s Desired: 3.600000000 s Activated: 3.607993122 s Finished: 3.687993744 s Desired: 3.900000000 s Activated: 3.901172601 s Finished: 3.981172989 s Desired: 4.200000000 s Activated: 4.200561840 s

Desired: 1.300000000 s
Activated: 1.362226412 s
Finished: 1.392226709 s
Desired: 1.400000000 s
Activated: 1.450252846 s
Finished: 1.480253008 s
Desired: 1.500000000 s
Activated: 1.580601801 s
Finished: 1.655112390 s
*** Over deadline
Desired: 1.600000000 s
Activated: 1.658095359 s
Finished: 1.688095655 s
Desired: 1.700000000 s
Activated: 1.700291513 s
Finished: 1.730291751 s
Desired: 1.800000000 s
Activated: 1.930362930 s
Finished: 1.960363314 s
*** Over deadline
Desired: 1.900000000 s
Activated: 1.965378215 s
Finished: 1.995378450 s
Desired: 2.000000000 s
Activated: 2.053027323 s
Finished: 2.083027576 s
Desired: 2.100000000 s
Activated: 2.181015015 s
Finished: 2.250210091 s
*** Over deadline
Desired: 2.200000000 s
Activated: 2.251170047 s
Finished: 2.281170337 s
Desired: 2.300000000 s
Activated: 2.300114922 s
Finished: 2.330115131 s
Desired: 2.400000000 s
Activated: 2.531179951 s
Finished: 2.561180092 s
*** Over deadline
Desired: 2.500000000 s
Activated: 2.561258559 s
Finished: 2.591258647 s
Desired: 2.600000000 s
Activated: 2.650342635 s
Finished: 2.680342768 s
Desired: 2.700000000 s
Activated: 2.780844788 s
Finished: 2.852302953 s
*** Over deadline
Desired: 2.800000000 s
Activated: 2.852379539 s
Finished: 2.882379678 s
Desired: 2.900000000 s
Activated: 2.900433829 s

Finished: 2.852295054 s
Desired: 3.000000000 s
Activated: 3.083970113 s
Finished: 3.133970447 s
Desired: 3.200000000 s
Activated: 3.200318495 s
Finished: 3.250318709 s
Desired: 3.400000000 s
Activated: 3.400467845 s
Finished: 3.450468010 s
Desired: 3.600000000 s
Activated: 3.687999489 s
Finished: 3.737999864 s
Desired: 3.800000000 s
Activated: 3.805321034 s
Finished: 3.855321330 s
Desired: 4.000000000 s
Activated: 4.000364521 s
Finished: 4.050364679 s
Desired: 4.200000000 s
Activated: 4.280567888 s
Finished: 4.330568045 s
Desired: 4.400000000 s
Activated: 4.400563961 s
Finished: 4.450564383 s
Desired: 4.600000000 s
Activated: 4.600682603 s
Finished: 4.650682755 s
Desired: 4.800000000 s
Activated: 4.880622111 s
Finished: 4.930622658 s
Desired: 5.000000000 s
Activated: 5.000843405 s
Finished: 5.050843851 s
Desired: 5.200000000 s
Activated: 5.200899561 s
Finished: 5.250899864 s
Desired: 5.400000000 s
Activated: 5.480236080 s
Finished: 5.530236258 s
Desired: 5.600000000 s
Activated: 5.600823595 s
Finished: 5.650824026 s
Desired: 5.800000000 s
Activated: 5.800483648 s
Finished: 5.850483899 s

Finished: 4.280562528 s
Desired: 4.500000000 s
Activated: 4.500441488 s
Finished: 4.580441861 s
Desired: 4.800000000 s
Activated: 4.800608074 s
Finished: 4.880608655 s
Desired: 5.100000000 s
Activated: 5.100682388 s
Finished: 5.180683038 s
Desired: 5.400000000 s
Activated: 5.400231358 s
Finished: 5.480231724 s
Desired: 5.700000000 s
Activated: 5.700475679 s
Finished: 5.780476149 s

Finished: 2.930434543 s Desired: 3.000000000 s Activated: 3.133978458 s Finished: 3.163978693 s *** Over deadline Desired: 3.100000000 s Activated: 3.165056251 s Finished: 3.195056577 s Desired: 3.200000000 s Activated: 3.250323180 s Finished: 3.280323385 s Desired: 3.300000000 s Activated: 3.380940151 s Finished: 3.450471063 s *** Over deadline Desired: 3.400000000 s Activated: 3.454433950 s Finished: 3.484434167 s Desired: 3.500000000 s Activated: 3.500362573 s Finished: 3.530362877 s Desired: 3.600000000 s Activated: 3.738004416 s Finished: 3.768004566 s *** Over deadline Desired: 3.700000000 s Activated: 3.768460108 s Finished: 3.798460296 s Desired: 3.800000000 s Activated: 3.855329073 s Finished: 3.885329284 s Desired: 3.900000000 s Activated: 3.981178942 s Finished: 4.050369235 s *** Over deadline Desired: 4.000000000 s Activated: 4.050745882 s Finished: 4.080746066 s Desired: 4.100000000 s Activated: 4.103793967 s Finished: 4.133794663 s Desired: 4.200000000 s Activated: 4.330571563 s Finished: 4.360571788 s *** Over deadline Desired: 4.300000000 s Activated: 4.360651701 s Finished: 4.390651826 s Desired: 4.400000000 s Activated: 4.450573625 s Finished: 4.480573756 s Desired: 4.500000000 s Activated: 4.580452866 s Finished: 4.650685930 s *** Over deadline		

Desired: 4.600000000 s		
Activated: 4.650768190 s		
Finished: 4.680768319 s		
Desired: 4.700000000 s		
Activated: 4.700594513 s		
Finished: 4.730594779 s		
Desired: 4.800000000 s		
Activated: 4.930627422 s		
Finished: 4.960627562 s		
*** Over deadline		
Desired: 4.900000000 s		
Activated: 4.960742890 s		
Finished: 4.990743050 s		
Desired: 5.000000000 s		
Activated: 5.050851427 s		
Finished: 5.080851647 s		
Desired: 5.100000000 s		
Activated: 5.180693142 s		
Finished: 5.250904103 s		
*** Over deadline		
Desired: 5.200000000 s		
Activated: 5.251018139 s		
Finished: 5.281018307 s		
Desired: 5.300000000 s		
Activated: 5.300905764 s		
Finished: 5.330906062 s		
Desired: 5.400000000 s		
Activated: 5.530239457 s		
Finished: 5.560239695 s		
*** Over deadline		
Desired: 5.500000000 s		
Activated: 5.560562949 s		
Finished: 5.590563343 s		
Desired: 5.600000000 s		
Activated: 5.650827901 s		
Finished: 5.680828066 s		
Desired: 5.700000000 s		
Activated: 5.780516415 s		
Finished: 5.850498746 s		
*** Over deadline		
Desired: 5.800000000 s		
Activated: 5.851026283 s		
Finished: 5.881026960 s		
Desired: 5.900000000 s		
Activated: 5.900289544 s		
Finished: 5.930289913 s		

6. Assigning equal priorities to the tasks, test the application developed in Item 3 with the Round Robin scheduling method. Comment the results, namely the largest response times for each task and the response time jitter.

Results given by this configuration:

Logs for task 1	Logs for task 2	Logs for task 3
Max response time: 0.160780867 s Min response time: 0.030341511 s Jitter: 0.130439356 s	Max response time: 0.163017266 s Min response time: 0.050454025 s Jitter: 0.112563241 s	Max response time: 0.160995837 s Min response time: 0.080131321 s Jitter: 0.080864516 s

The largest response times are somewhat similar because of the Round Robin method and equal priorities. That is because each task has a chance to wait for other tasks to end before it can be resolved. Jitter time is interesting but also explainable. If we take into account that they all have similar max response times, then the jitter for each task is nothing more than the sum of the computation times of two other tasks. That is because in the best scenario, each task is first in line to receive CPU time but in the worst case scenario they are the last of three tasks in a line. That means that the first task is going to have problems in meeting its deadline.