EL2450 Homework 1

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Q 1: A gain named Tap exists in the Tank 1 model, what is its function?
A: The gain Tap models the bypass tap from the upper tank to the main tank. The value 0 means that it is currently closed. A value of 1 means fully opened.

Q 2: Edit *pid_design.m* and fill in the transfer functions for the upper and lower tank.
A: The figure below shows the result.

```
uppertank=tf([K],[Tau 1]);              % Transfer function for upper tank
lowertank=tf([Gamma],[Gamma*Tau 1]);  % Transfer function for upper tank
```

Q 3: What does the reference signal look like?
A: The signal starts at 40 and recieves a step by 10 at 100 s which sets it to 50.

Q 4: Use the parameter generator to get values and fill in the transfer function F.
A: Done.

Q 5: Use the parameters to get different responses. Which is best?
A: The input parameters and their respecitve system parameters are:

Table 1: Parameter values and performance.

χ	ζ	ω_0	T_r [s]	$M[\%]$	T_s [s]
0.5	0.7	0.1	6.38	6.67	38.1
0.5	0.7	0.2	3.31	22.6	18.8
0.5	0.8	0.2	3.19	20.9	18.4

The last parameter configuration works best. It is the fastest and even though it has quite significant overshoot, it is still within the given tolerance and is thus acceptable.

Q 6: What is the cutoff frequency for the open loop system? How was this derived?
A: The open loop system is $G_o = FG$ and the cutoff frequency is the frequency when the amplitude gain is 0 dB. Using the bode plots this frequency is found to be around $\omega_c = 0.35$rad/s. This is confirmed by the MatLab command *allmargin(Go)* which gives $\omega_c = 0.343$rad/s.

Q 7: A ZOH block is placed after the controller. What is the effect?
A: With a ZOH time at h = 1 the systems shows no difference.
With a ZOH time at h = 5 the system starts oscillating.
With a ZOH time at h = 10 the system is severely affected by the few updates

and oscillates strongly to compensate.
With a ZOH time at h = 50 is unstable.

Q 8: Discretize the continuous controller into state space form. Replace the simulink controller block with this new discrete controller. What differences can be seen?

A: Show images here Andreas. Not of yourself please.

Comparison shows that ZOH method yields overall better results. This may be due to that the continuous system on which the ZOH method is based is more precise.

Q 9: What sampling time should be chosen?

A: The crossover frequency of the open-loop system is $\omega_c = 0.34$ A good sampling frequency is $20\omega_c = 6.8 rad/s$

This gives a samplingtime of $\frac{2\pi}{20\omega_c} = 0.92$ seconds

Q 10: How long can the samplingtime be without affecting the performance?

A: With manual checks the maximum samplingtime before the systems starts to strongly oscillate is around 2 to 3 times the recommended sampling time from question 9.

Q 11: Simulate system with samplingtime at 4 seconds and estimate the control performance.

A: The system is asymptotically stable but oscillating.

Q 12: Sample G, make Gd

A:
a_1	= 0.092
a_2	= 0.074