Bringing frequency response analysis closer to Chemical Engineering

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What should Chemical Engineering undergraduates remember about process control?

- The need of automatic control
- The elements of a controller, highlighting sensors
- The nature of feedback and how to implement it
- Trade-offs between performance and stability. The limitations imposed by time delays and noise

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Not really. Just unfamiliar, partly because it is taught as for students of automatics/electrical engineering

We tried to make examples that would help understanding the results of frequency response analysis

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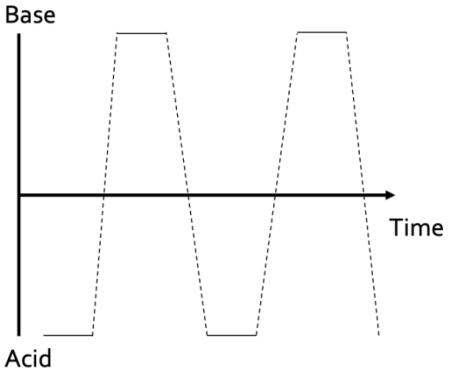
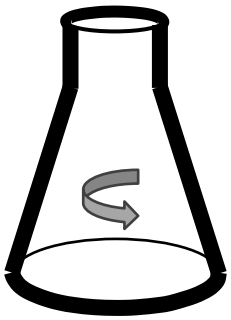
Understanding how the process gain changes with input frequency: a colour changing stirred tank

In particular related to time-delays, which limit the performance of controllers



Quasi-sinusoidal addition of base and acid

$$\frac{dC}{ct} = k_{mix}(C(t) - C_{\infty})$$



Gentle stirring to mix as slowly as possible

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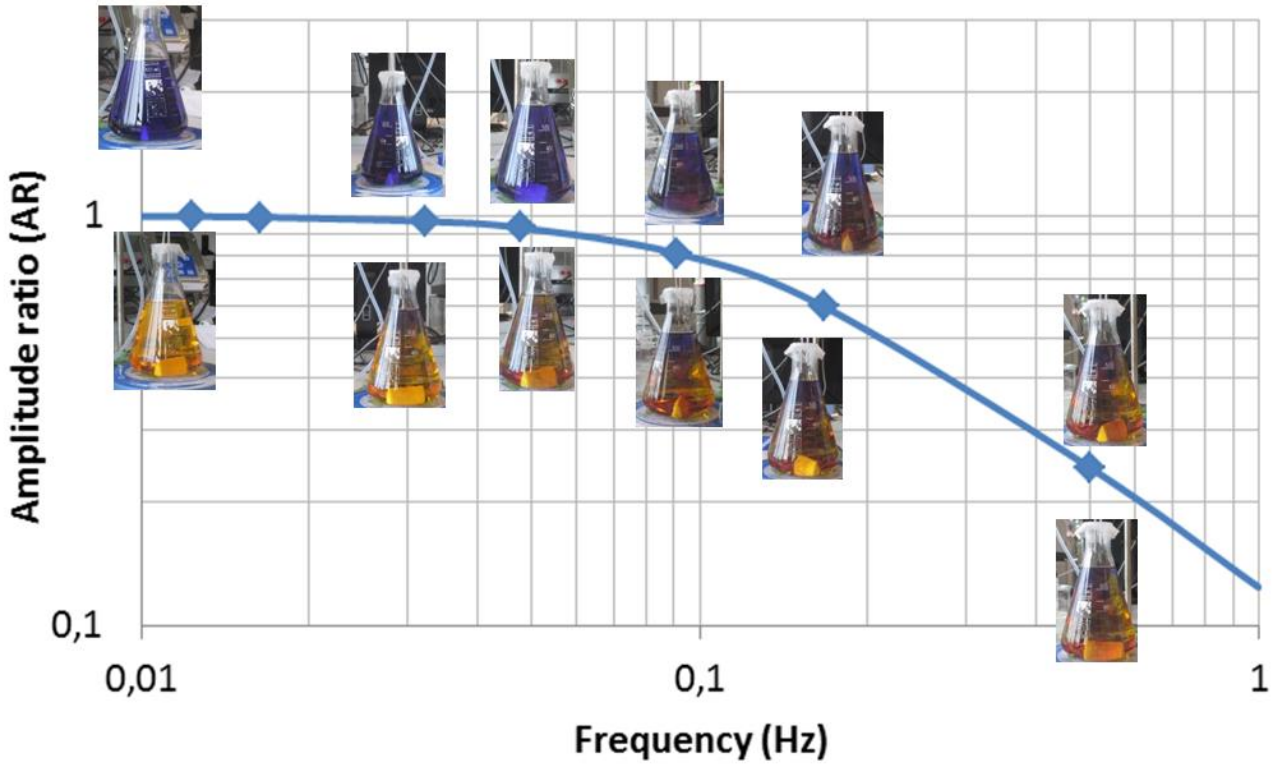
Understanding how the process gain changes with input frequency: a colour changing stirred tank

The gain of the process is the colour change. It decreases when we increase the frequency of the input



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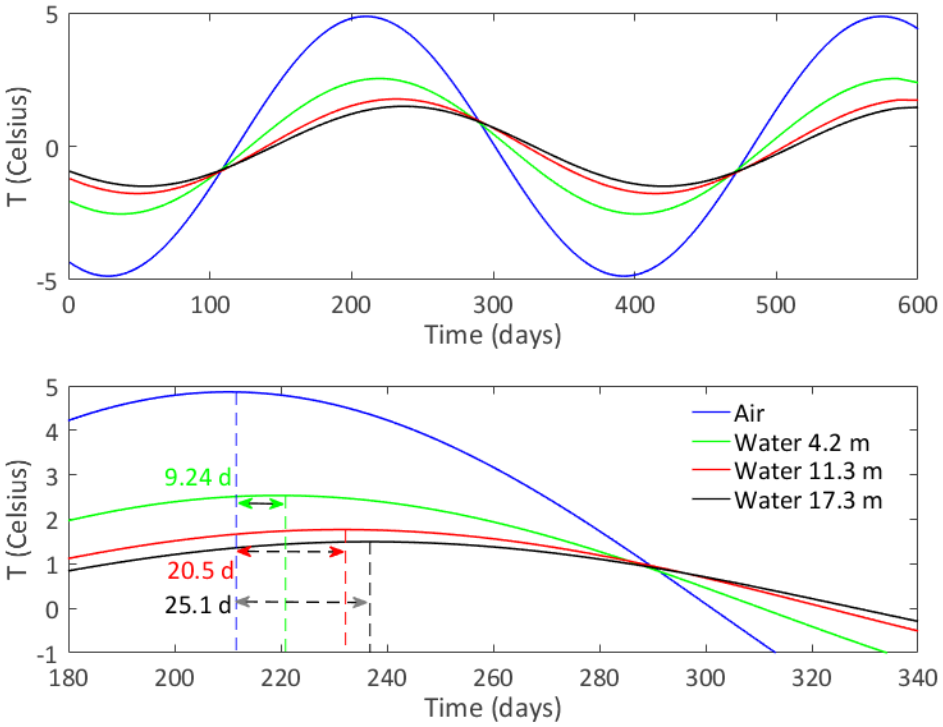
Understanding the meaning of the phase shift: it is basically a delay

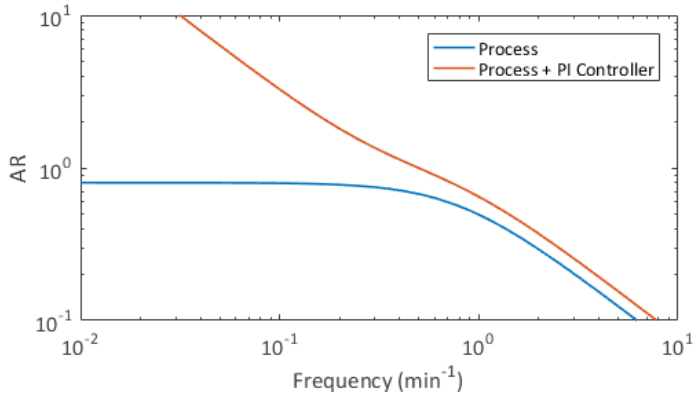
The temperature change along the year is *delayed* at lower depths



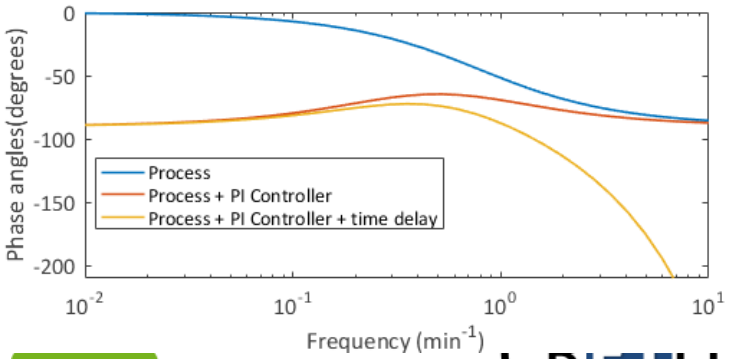
If the delay reaches -180º, the signal is inverted (upside-down)

How are the gain, the phase shift and the performance related?

The gain tends to decrease with frequency



The phase shift tends to become more negative with frequency.



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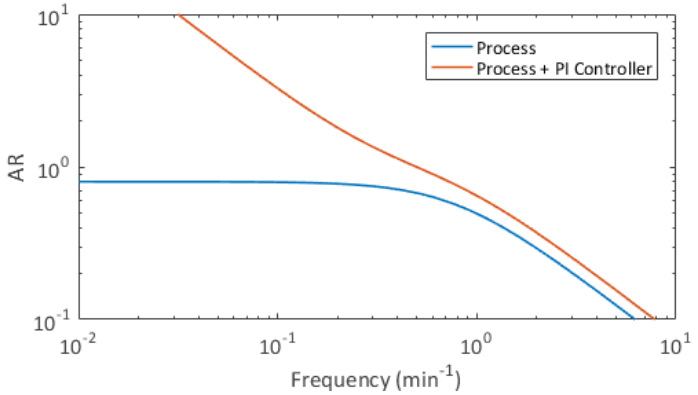
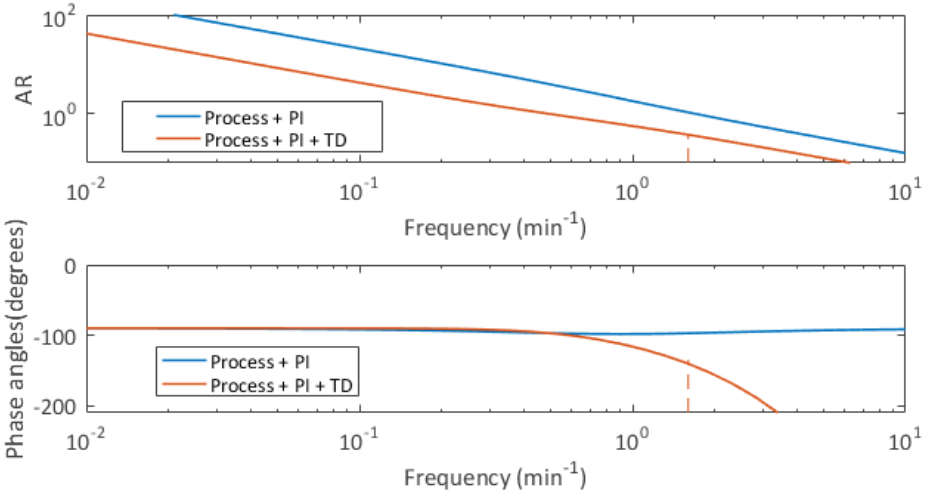


When the phase reaches -180º the gain must be low



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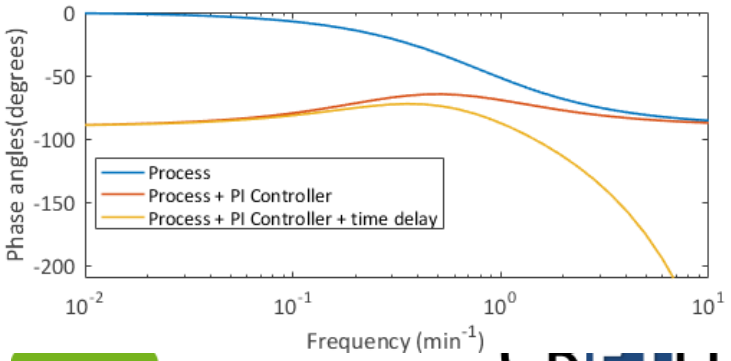

TAKE HOME MESSAGE: Frequency response analysis can help understanding many process control ideas

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