

## Lecture S4 Muddiest Points

### General Comments

Not many students in class today, presumably because of Spring Break. Enjoy Spring Break, but please be prepared when you come back to learn more Signals!

### Responses to Muddiest-Part-of-the-Lecture Cards

(20 cards)

1. **Is there a more intelligent 18.03 way of solving the impulse response? (1 student)** Yes, you can use Laplace techniques, which we will get to shortly.
2. **What does convolution physically represent? (1)** That's a tough question to answer, and here's why: We've made two (physical) assumptions about our systems, namely, that they are both linear and time-invariant. At least when we're dealing with generic LTI systems, that's all the physics we can assume. So everything that we derive thereafter is a consequence of those two assumptions. So the simplest answer is that convolution is a consequence of the LTI assumption, and not much more can be said.

However, if you look carefully at the convolution integral, you can begin to get some insight into what's going on. The equation is

$$y(t) = \int_{-\infty}^t g(t - \tau)u(\tau) d\tau$$

(Here I've made one more assumption — that the system is causal.) In words, this equation says that the output of a system at time  $t$  depends on the entire past history of inputs ( $u(\tau)$ , for  $\tau \leq t$ ). The output at time  $t$  is a weighted sum of the previous inputs, where the weighting function is the impulse response of the system.

3. **Need more practice / reading. (2)** OK.
4. **Confused about limits of integration. (3)** Here's the point. The convolution integral is

$$y(t) = \int_{-\infty}^{\infty} g(t - \tau)u(\tau) d\tau$$

If we now assume that  $g(t) = 0$  for  $t < 0$ , because the system is causal, and  $u(t) = 0$  for  $t < 0$  by choice or problem definition, then  $g(t - \tau) = 0$  for  $\tau > t$ , and  $u(\tau) = 0$  for  $\tau < 0$ . Then the integrand is zero if *either*  $\tau < 0$  or  $\tau > t$ . Hence, the limits of integration are  $[0, t]$  for  $t > 0$ , and there is no region of integration if  $t < 0$ .

5. **You said that the impulse response would be different if there is a discontinuity at  $t = 0$ . How? (1)** Suppose the step response were

$$g_s(t) = \begin{cases} 0, & t < 0 \\ e^{-t}, & t \geq 0 \end{cases}$$

Then the impulse response is given by

$$g(t) = \frac{dg_s(t)}{dt} = -e^{-t}\sigma(t) + \delta(t)$$

The impulse is due to the discontinuity in  $g_s(t)$  at  $t = 0$ .

6. ***What is  $y(t)$  again? (1)***  $y(t)$  is the output of the system  $G$  in response to the input  $u(t)$ .
7. ***What is an example of a noncausal system that we might study? (1)*** See the responses to the muddy cards for Lecture S3.

8. ***When solving for the particular solution, you set***

$$0 + 1.5c = 1$$

***Where did the 1 [on the right hand side] come from? (1)*** We are (initially) solving for the step response. The step input  $\sigma(t)$  equals 1 for  $t \geq 0$ . That's where the 1 comes from.

9. ***If we are rusty at circuits, what's the best resource to refresh ourselves? (1)*** Please go back and look at the notes from the Fall. We won't do anything in circuits that's outside the scope of those notes.
10. ***Are there any additional readings I can do? I'm confused! (1)*** Read Section 2.2 of Oppenheim.
11. ***No Mud. (7)*** A couple of people commented, ***Don't use PRS questions where there are no available multiple choices, i.e., are open-ended.*** Interestingly, I got just the opposite comment a couple of lectures ago. I agree that multiple choice questions are sometimes easier to work with. However, some questions are naturally open-ended. In the real world, of course, all questions are open-ended. So I'll continue to mix it up.