



U1.6 Measuring your robot

The robot as a system · University · about 30 min

Name _____

Class _____

Date _____

What this lesson is about

A step response: top speed, time constant and dead band, measured rather than assumed.

- The experiment
- The two numbers
- The third number
- Doing it honestly

Questions

6 marks in all

1. A first order system follows $v(t) = v_{\max} * (1 - \exp(-t / \tau))$. This prints the fraction of the final value reached after 1, 2 and 3 time constants. What does it print? [1 mark]

```
import math
for n in (1, 2, 3):
    print(n, round(1 - math.exp(-n), 3))
```

2. A step response settles at 20 cm/s with a time constant of 0.25 s. What is the speed at $t = 0.25$ s, in cm/s to one decimal place? [1 mark]

3. Step response readings are taken every 0.1 s from the moment of the step. This estimates $v_{\max}$ from the last five readings and τ from the first reading at or above 63.2 percent of it. What does it print? [1 mark]

```
speeds = [0.0, 6.8, 11.5, 14.5, 16.6, 18.0, 18.9, 19.3, 19.7, 19.9, 20.1, 19.9, 20.0, 20.1, 19.9]
dt = 0.1
v_max = sum(speeds[-5:]) / 5
target = 0.632 * v_max
for i, v in enumerate(speeds):
    if v >= target:
        break
print("v_max:", round(v_max, 1))
print("tau:", round(i * dt, 1))
```

4. The time constant is 0.25 s. How long after the step, in seconds, should you wait before readings measure the settled level rather than the rise? [1 mark]

5. The dead band is 15. A controller's output spends most of its time around 10. What does the robot do? [1 mark]
- ☐ A Nothing, which looks exactly like a bug in the controller's arithmetic
 - ☐ B Moves at 10 percent of its top speed
 - ☐ C Moves slowly, but only after the lag
 - ☐ D Moves for half a second and then the deadman stops it
6. Which of these are part of measuring a step response honestly? [1 mark]

Tick every answer that is true.

- ☐ A Repeat the run and report the spread
- ☐ B Ignore readings taken during the first 3 tau when finding the level
- ☐ C Record the battery level at the time
- ☐ D Take the single last reading as `v_max`, since it is the most settled
- ☐ E Use the catalogue value when your runs disagree

The task: the step response

Run a step to full forward power, plot the speed as `speed`, and print two lines: `v_max:` and `tau:`.

```
from bugbot import *
connect()

speeds = []
forward(100)
```

Plan your program here, then type it in and press Run.



Do it on the robot

www.bugbotlab.com/learn/u1-6-measuring-your-robot/

The simulator checks it and tells you when it passes. Nothing to install, no account.

Challenges

1. Do the same for rotation, using `imu()[1]` as the measurement. Is `tau` the same?
2. Step down as well as up: full speed, then zero. Does it slow with the same time constant?
3. Step to 50 percent instead of 100. Is `tau` a property of the machine or of the size of the step?