WORKSHEET

U10.2 Velocity profiles

Following a trajectory · University · about 30 min

Name _____ Class _____ Date _____

What this lesson is about

The trapezoid, the triangle when there is no room to reach cruise, and what jerk costs you.

- The trapezoid
- The BugBot has no acceleration limit
- Jerk
- Choosing the numbers

Questions

7 marks in all

1. A trapezoidal move covers 80 cm with an acceleration limit of 10 cm/s/s and a cruise speed of 15 cm/s. How long is the cruise (flat top) phase, in seconds to 2 decimal places? [1 mark]

2. What does this print? It works out the whole duration of the same profile. [1 mark]

```
D, A, V = 80.0, 10.0, 15.0
t_acc = V / A
d_acc = V * V / (2 * A)
t_flat = (D - 2 * d_acc) / V
print(round(2 * t_acc + t_flat, 2))
```

3. The same limits (10 cm/s/s, 15 cm/s) are used for an 8 cm move. What peak speed does the profile reach, in cm/s to 2 decimal places? [1 mark]

4. A trapezoid generator works on long moves, but every short move overshoots. What is the most likely bug? [1 mark]

- ☐ **A** It always assumes a cruise phase, even when 2 d_acc does not fit inside the distance
- ☐ **B** The acceleration limit is too low
- ☐ **C** It samples the profile too often
- ☐ **D** The deceleration ramp uses a different a from the acceleration ramp

5. The BugBot's drive is a first order lag with a time constant of 0.25 s. Roughly what initial acceleration does a step command to 20 cm/s produce, in cm/s/s? [1 mark]

6. The drive has no acceleration limit of its own. Which are good reasons to impose one anyway? [1 mark]

Tick every answer that is true.

- ☐ **A** Demanding more than friction supplies makes the robot slip, which dead reckoning cannot see
- ☐ **B** A step demand is a current spike that can sag the battery and reset the robot
- ☐ **C** A profile the machine can follow leaves an error you can reason about
- ☐ **D** It makes the move finish sooner than a step command would
- ☐ **E** The drive rejects step commands above 10 cm/s

7. A robot arm rings for a moment at the start and end of every trapezoidal move. What change addresses the cause? [1 mark]

- ☐ **A** Limit the jerk with an S-curve so the acceleration ramps instead of switching instantly
- ☐ **B** Raise the cruise speed so the move is over sooner
- ☐ **C** Use a triangle profile instead of a trapezoid
- ☐ **D** Sample the trapezoid at a finer time step

The task: a trapezoidal profile

Build a trapezoidal profile that covers 80 cm with an acceleration limit of 10 cm/s/s and a cruise speed of 15 cm/s, sampled every 0.05 s. Plot `v` and `s` at every sample, with a `wait(0.1)` after every second one so the chart has a time axis (the simulator runs in 0.02 s steps, so a `wait(0.05)` would last 0.04 s), and print `peak:`, `duration:` and `distance:`, the last being the area under your own speed profile.

```
from bugbot import *
connect()

DISTANCE, A_MAX, V_MAX, DT = 80.0, 10.0, 15.0, 0.05
```

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

Do it on the robot

www.bugbotlab.com/learn/u10-2-velocity-profiles/

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

Challenges

1. Ask for 8 cm with the same limits. Does your code produce a triangle, and is the peak `sqrt(a * d)`?
2. Work out the peak acceleration a step command to 20 cm/s really produces, using the 0.25 s lag.

3. Add a jerk limit by ramping the acceleration over 0.3 s at each corner. How much longer does the move take?