WORKSHEET

U10.5 Feedforward and feedback

BugBotLab

Following a trajectory · University · about 30 min

Name _____ Class _____ Date _____

What this lesson is about

A ramp leaves a proportional controller permanently behind, and the model knows how to fix it.

- The arithmetic
- The better answer
- Where the model comes from
- What feedforward cannot do

Questions

6 marks in all

1. A proportional controller with K = 1.5 per second chases a reference moving at 10 cm/s. How far behind does it settle, in cm to 2 decimal places? [1 mark]

2. The reference speed is now fed forward, but the model is 10 percent out. With the same v = 10 cm/s and K = 1.5, what steady error is left, in cm to 2 decimal places? [1 mark]

3. Why can a proportional controller never catch a reference moving at constant speed? [1 mark]

☐ **A** It only produces a command when there is an error, and the command must stay non-zero to keep moving

☐ **B** Its gain is always too low

☐ **C** The drive's dead band stops it moving at constant speed

☐ **D** The reference is sampled too slowly

4. This simulates a robot whose real speed is 90 percent of the model's, chasing a 10 cm/s ramp, first with gain alone and then with the reference fed forward. What does it print? [1 mark]

```
V, K, DT = 10.0, 1.5, 0.1
for ff in (0.0, 1.0):
    pos = 0.0
    for tick in range(300):
        ref = V * tick * DT
        err = ref - pos
        pos += 0.9 * (ff * V + K * err) * DT
    print(ff, round(err, 2))
```

5. Which statements about feedforward and feedback are right? [1 mark]

Tick every answer that is true.

- ☐ **A** Feedforward has no stability cost because it is not in the loop
- ☐ **B** Feedforward alone drifts, because nothing measures the result
- ☐ **C** Feedback handles what the model does not know, such as a slope or a flat battery
- ☐ **D** With good feedforward the feedback loop can be removed
- ☐ **E** Feedforward reduces the steady error by raising the loop gain

6. A robot running feedforward plus feedback is stuck against a chair leg. What does the feedforward term do? [1 mark]

- ☐ **A** It keeps commanding cruise speed, because it never sees what actually happened
- ☐ **B** It drops to zero, because the error has grown
- ☐ **C** It reverses, because the model predicts a collision
- ☐ **D** It doubles, to push past the obstacle

The task: how far behind a ramp

Drive the same 10 cm/s ramp twice: once with proportional control alone, once with the reference speed fed forward as well. Average the size of the error over the last few seconds of each leg, and print `p only:` and `with ff:`. Plot `ref`, `actual` and `error`.

```
from bugbot import *
import math
connect()

DT = 0.1
V_REF, K = 10.0, 1.5
```

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

Do it on the robot

www.bugbotlab.com/learn/u10-5-feedforward/

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

Challenges

1. Check `v / K` against your measured `p only` number. How close is the prediction?

2. Run the proportional leg at `K = 5`. Does the error fall by the factor the formula says, and what does the motion look like?
3. Deliberately break the feedforward by using 30 cm/s instead of 20 in the model. Where does that show up?