



U5.1 The feedback loop

What this lesson is about

Setpoint, error, controller, plant, measurement: the block diagram and the names.

- The first loop
- The sign
- What makes a good loop

Questions

6 marks in all

1. The first loop is run on a list of distances instead of the sensor. What does it print? [1 mark]

```
TARGET = 20.0
for d in (60, 45, 30, 22, 18):
    error = d - TARGET
    print(error, max(-50, min(50, 2.0 * error)))
```

Answer:

```
40.0 50
25.0 50
10.0 20.0
2.0 4.0
-2.0 -4.0
```

The errors are 40, 25, 10, 2 and -2 cm. At gain 2 the first asks for 80 and is clipped to 50; then 50, 20, 4 and -4. The command shrinks as the robot approaches.

2. With `error = distance() - TARGET`, positive `drive()` forwards, and the gain made negative by mistake, what happens? [1 mark]
- ☐ A The robot drives away from the target as fast as the gain allows
 - ☐ B The robot approaches the target slowly
 - ☐ C The robot oscillates around the target
 - ☐ D Nothing, because the sign convention does not matter

Answer: A. Too far away now produces a backwards command, which makes the error larger, which makes the command larger. That is positive feedback.

3. When does open loop control work? [1 mark]

- ☐ A When the plant is perfectly known and nothing disturbs it
- ☐ B When the gain is small
- ☐ C When the sensor is noisy
- ☐ D When the actuator saturates

Answer: A. Open loop has nothing coming back, so any mismatch or disturbance goes uncorrected. On a real robot that condition is never met.

4. Follow a signal once round the feedback loop, starting at the comparison.

[1 mark]

Number the lines 1 to 5 to put them in the right order.

- ___ plant
- ___ sensor
- ___ error = setpoint compared with measurement
- ___ controller
- ___ actuator

Answer:

```
error = setpoint compared with measurement
controller
actuator
plant
sensor
```

The error goes through the controller to the actuator, which moves the plant; the sensor measures the output and feeds it back to the comparison.

5. Raising the gain of this loop typically buys which two qualities?

[1 mark]

Tick every answer that is true.

- ☐ A Speed
- ☐ B Accuracy
- ☐ C Stability
- ☐ D Less actuator effort

Answer: A, B. More gain responds harder, so it arrives faster and closer. It spends stability and usually effort, which is why the four qualities fight.

6. In the lesson's table, what is the name for the robot and the mat, the thing being controlled?

[1 mark]

Answer: plant. The plant is the physical system being controlled, here with a time constant of about 0.25 s.

The task: close the loop

Settle 20 cm from the wall, plotting the `error` as you go. The wall's face is 150 cm up the mat and the robot starts at 60.

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

```
TARGET = 20.0
```

The hint students can ask for: The wall's face is 150 cm up the mat and the robot starts at 60, so 20 cm from the wall is 70 cm of travel. Error is where you want to be minus where you are; drive in proportion to it.

A solution

```
from bugbot import *  
connect()  
  
TARGET = 20.0          # cm from the wall  
for tick in range(300):  
    gap = distance()  
    error = gap - TARGET  
    plot("error", error)  
    drive(max(-50.0, min(50.0, 2.0 * error)), 0, 0)  
    wait(0.1)  
stop()
```

Any program that meets the task's checks is marked correct in the simulator; this is one way, not the only way.