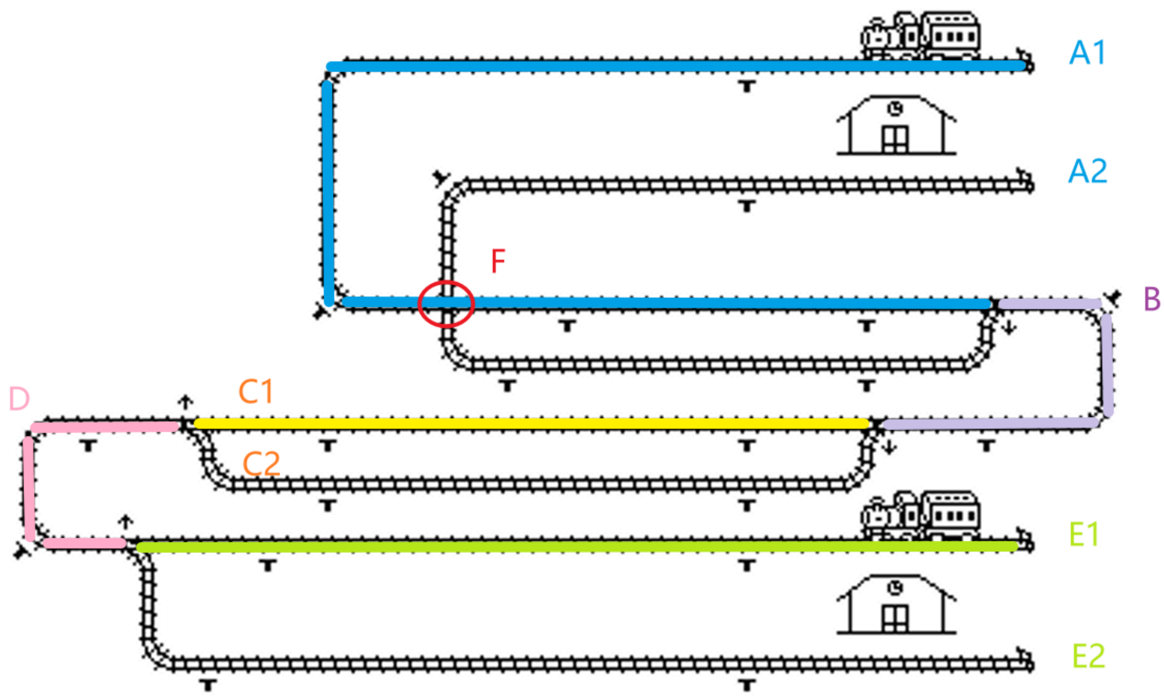
# Lab1 - Trainspotting

Group 13

## Choice of critical sections




Each track segment (A1/A2/B/C1/C2/D/E1/E2) represents a critical section where only one train is allowed at a time. Since tracks A1 and A2 cross each other, the railway crossing point (F) also forms a critical section that requires exclusive access.

In the appendix, we provide the locations of all sensors in our map, with red text indicating positions adjusted during testing.

## Placement of the sensors

We use sensors to monitor trains entering and leaving critical sections. Sensors are positioned before and after each track segment endpoint (near the switches).

We initially placed them at a distance of 2 units to detect trains entering and leaving segments. However, to ensure trains completely clear the switches before triggering sensors, we moved the corner sensors further away, adjusting the distance to 3 units.

For the railway crossing, we place four sensors around it - one on each side. Additionally, sensors are positioned before each station to detect arriving trains.

Each critical section should correspond to one semaphore. In practice, for two parallel track segments, we can use just one semaphore. Semaphore 'a' represents A1 and A2, semaphore 'c' represents C1 and C2, semaphore 'e' represents E1 and E2, and semaphore 'f' represents the crossing. Since there are only two trains, when a train acquires the semaphore, it enters one track; otherwise, it enters the other track.

Initially, we acquire the semaphores for the segments where trains start (A1 and E1). Before entering the next track segment or crossing, trains must acquire the semaphore for that next segment or crossing. After leaving a track segment or crossing, trains release the previous semaphore. When trains enter a station, they stop, wait for a time between 1-2 seconds, and then turn around.

## Maximum train speed and the reason for it

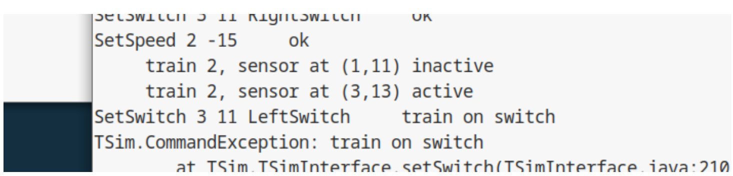
Braking Distance and Sensor Placement: The distance between sensors and switches must be sufficient for trains to stop completely before entering critical sections. If train speed exceeds a certain threshold, trains may be unable to stop in time when reaching critical track segments or switches, potentially causing collisions. Higher speeds require longer braking distances, which directly relates to sensor detection and response time.

System Response Time: Train speed affects the simulation's ability to process sensor events and execute control commands. If trains move too fast, the program may not have enough time to update speeds or switch tracks before the train reaches the next sensor, causing trains to overshoot critical sections.

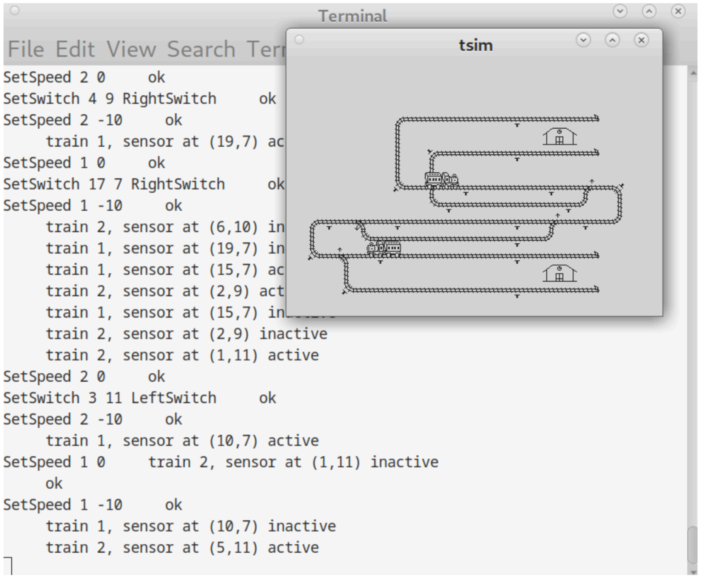
## How you tested your solution

We conducted testing with different speed combinations over extended periods, including (5, 5), (10, 10), (15, 15), (5, 10), and (5, 15).

We encountered "train on switch" errors, which occurred when one train attempted to set the switch direction while another train had not yet completely cleared the switch area. To resolve this issue, we modified the sensor positions at each corner, placing them further away from the switches to ensure that trains have completely cleared the switch before reaching the sensors. Finally, we repeated the above experiment with the same speed pair and succeeded.



```
SetSwitch 3 11 RightSwitch     ok
SetSpeed 2 -15     ok
     train 2, sensor at (1,11) inactive
     train 2, sensor at (3,13) active
SetSwitch 3 11 LeftSwitch     train on switch
TSim.CommandException: train on switch
        at TSim.TSimInterface.setSwitch(TSimInterface.java:210
```




# Appendix

North Station: (15,4) terminal sensor position:(13,3) (13,5)
South Station: (15,12) terminal sensor position:(13,11) (13,13)
Switch: (3,11) (4,9) (15,9) (17,7)  crossing: (8,7)

Other sensor position：
A1: (15,7)
A2: (16,8) → (15, 8)
B: (19,7) (17,9)
C1: (13,9) (6,9)
C2: (13,10) (6,10)
D: (2,9) (1,11)
E1: (5,11)
E2: (3,13) → (4, 13)
F(crossing): (6,7) (8,5) (9,8) (10,7)