GENERAL MEASUREMENTS LAB
PHYS 339 – SERVO

Prof. David Cooke

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MARKING SCHEME

Title	Weight
Introduction to the PC report Counting statistics report Calibration of Arduino microcontroller report Calibration of Arduino microcontroller test Properties of laser report **Temperature controller report**	10% 15% 5% 10% 15% **15%**
Project proposal Project report	5% 20%
Log book	5%

Project proposals received will be reviewed and discussed shortly

LAB OVERVIEW

- GOAL OF THIS LAB:
  - Learn about **CONTROL LOOPS**
- WHY?
  - Control loops are used a lot in everyday life
    - Temperature control of a room
    - Cruise control in a car
    - Power distribution in the grid, flight of your stealth bomber.

CLASSICAL CONTROL THEORY

Want to reach a set point in some measurable quantity (e.g. speed of car)

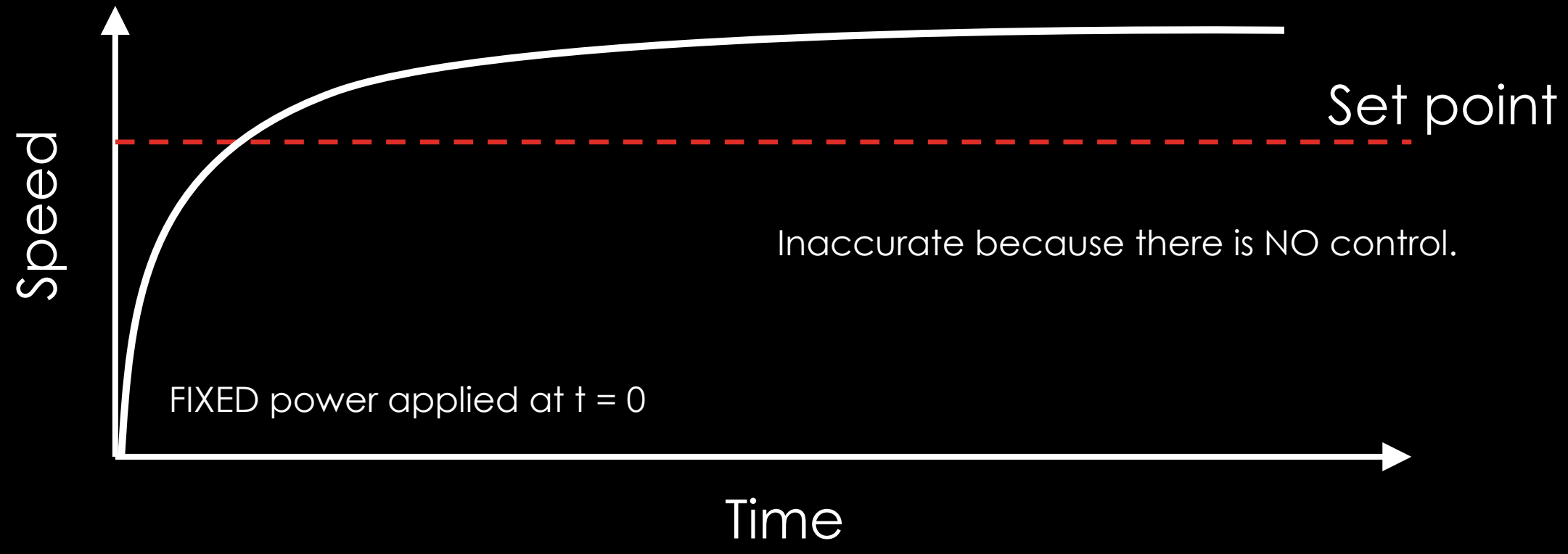
CONTROL ACCURACY – mean speed close to set point
(so you don't get speeding ticket but minimize travel time, maximize comfort)

CONTROL STABILITY – fluctuations about the mean should be small
(so you don't get a ticket and make people behind you very, very angry!)

CONTROL RESPONSE – should respond to set point changes rapidly
(so when you hit a hill, you don't slow down 20 km/hr!)

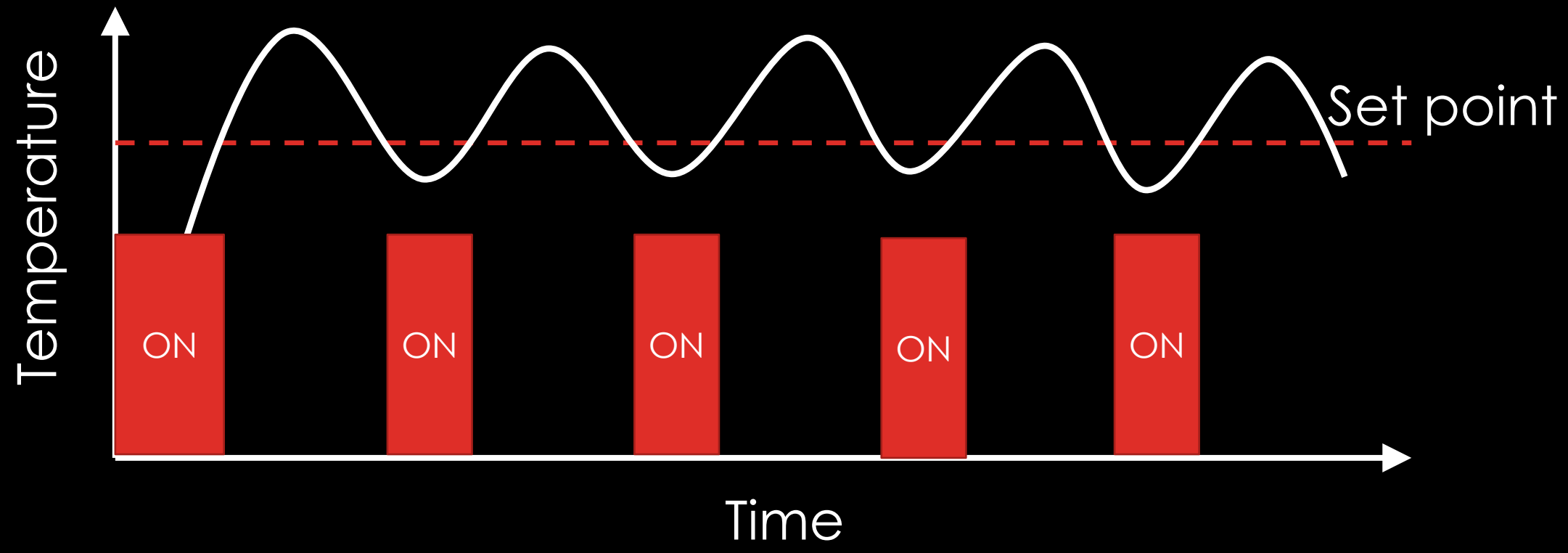
TYPES OF CONTROL

Open loop – a brick on the pedal, basically a projectile



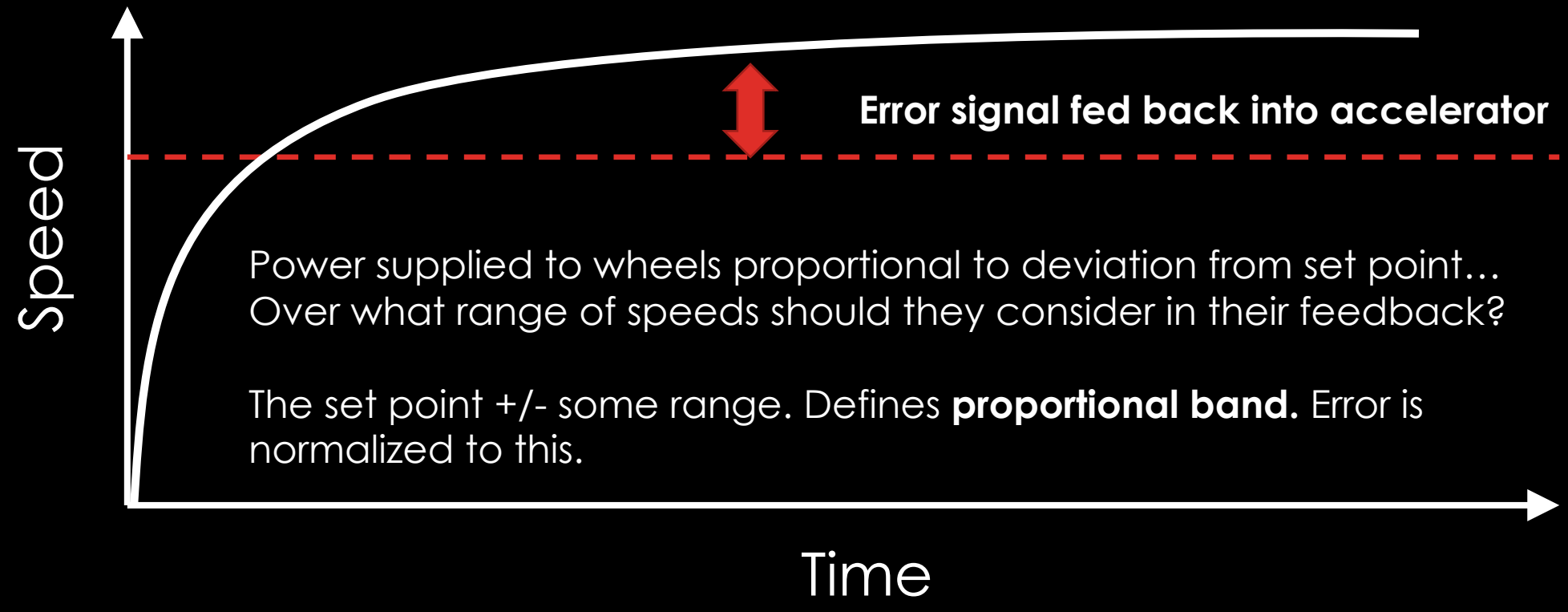
TYPES OF CONTROL

<u>On-off control:</u> Sticky gas pedal



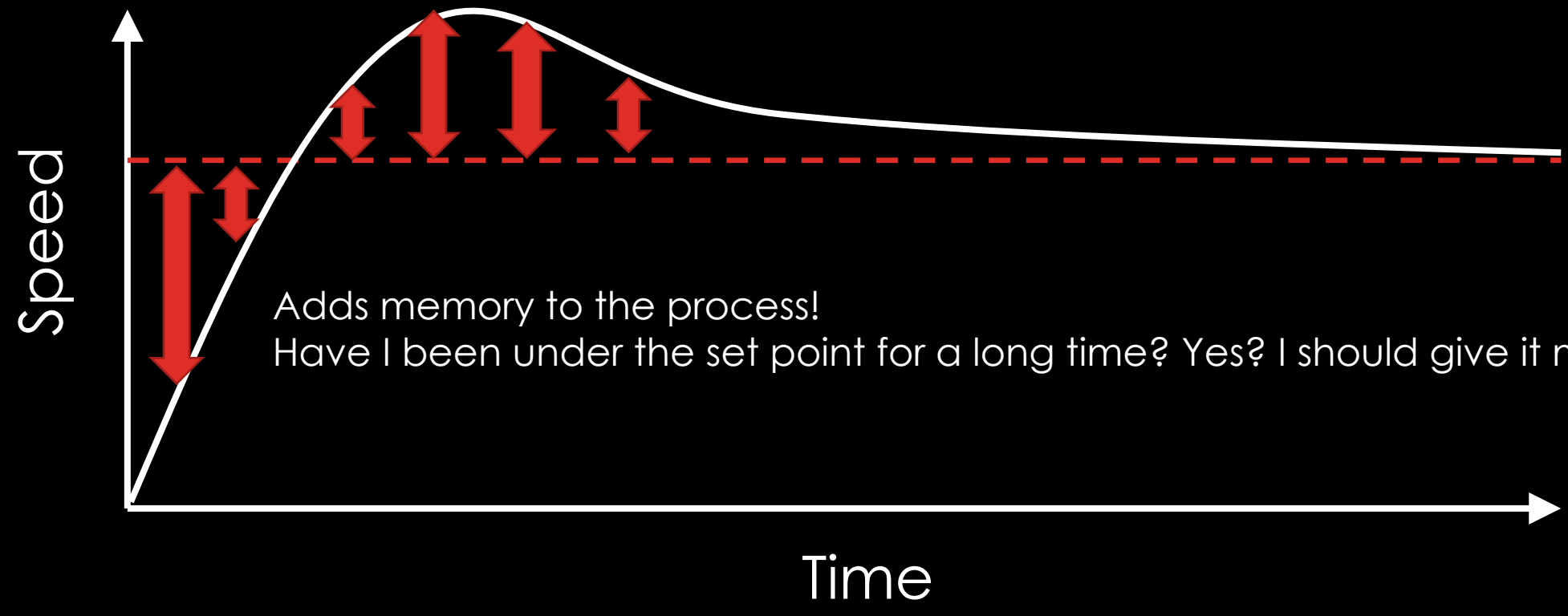
TYPES OF CONTROL

Proportional control: Learner's permit



TYPES OF CONTROL

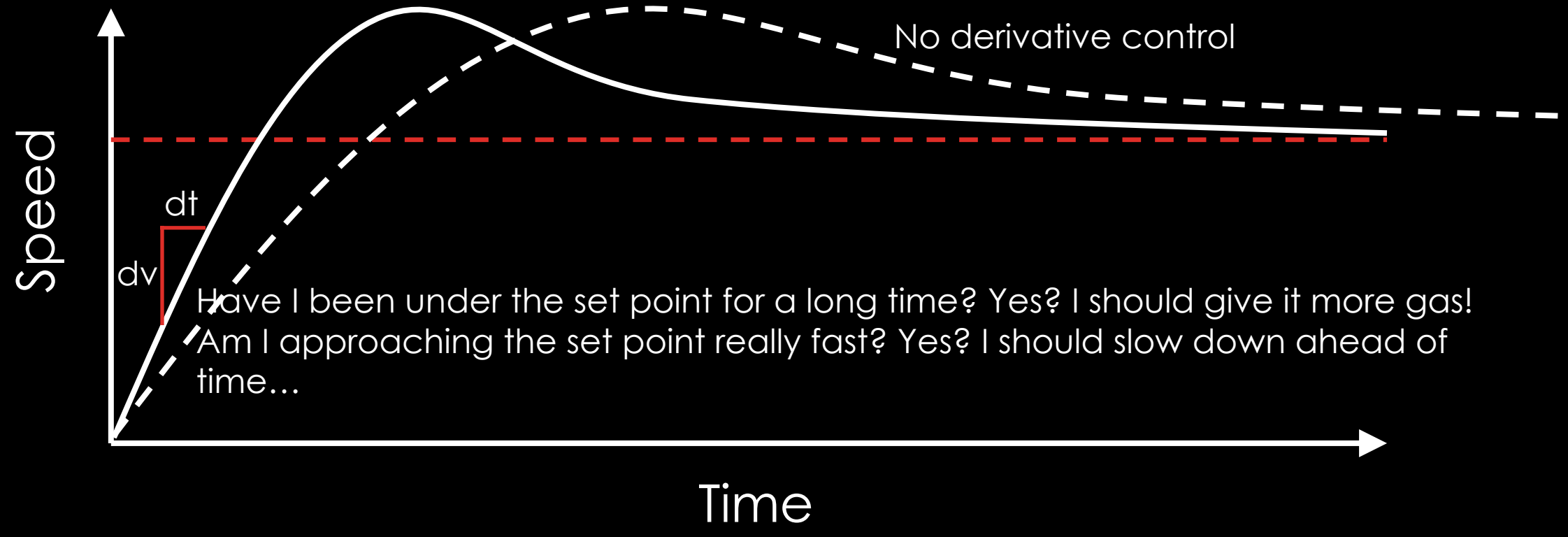
Proportional-integral control: Slow but steady



Adds memory to the process!
Have I been under the set point for a long time? Yes? I should give it more gas!

TYPES OF CONTROL

Proportional-Integral-Derivative Control: The alert driver!



THE IMPLEMENTATION

$$\mathrm{MV}(t) = K_\mathrm{p} e(t) + K_\mathrm{i} \int_0^t e(\tau)\,d\tau + K_\mathrm{d} \frac{de(t)}{dt}$$

e(t) = setpoint – measured temperature
MV(t) = manipulated variable (heater power)

K_p = propertional gain, tuning parameter
K_i = integral gain, tuning parameter
K_d = derivative gain, tuning parameter

THE EXPERIMENT

- Control the temperature of an aluminum block wound with a heater and in contact with a thermocouple.
- Provided with example code: schmitt.ino (remember the Schmitt trigger?)
- Explore different schemes of temperature control by adding routines to this code.
- Keep in mind what you have learned about statistical analysis of data.