# Instrumentation and Controls

## ETM 3301

# Lecture 1

Instructor

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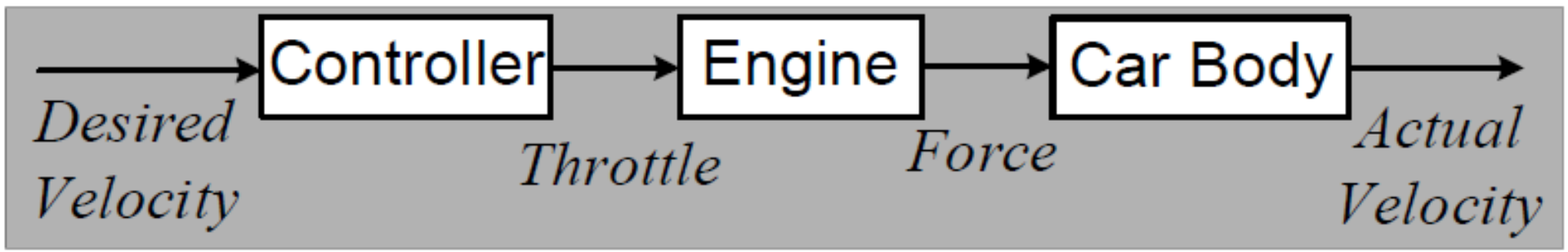
# Chapter 1:What is Control?

## Oxford Dictionary

- The act or power of *directing or regulating; command, regulating influence.*
- The action of holding in check; restraint; self-restraint; prevention of the spread of something unwanted; regulation of the numbers of an animal species etc.
- A standard of comparison for checking inferences drawn from an experiment.
- *A device or mechanism for controlling the operation of a machine, esp. the direction, speed, etc., of an aircraft or vehicle.*

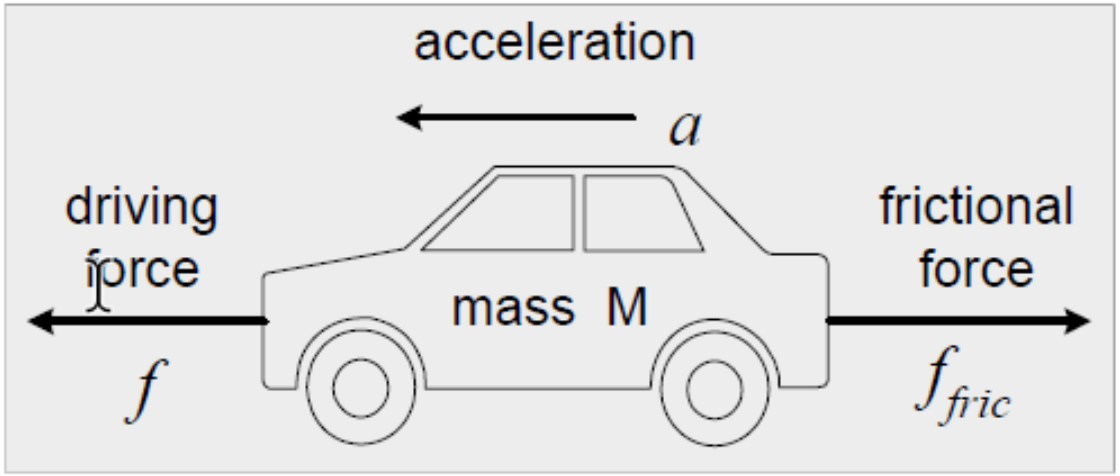
# Cruise Control Example

- To maintain a constant velocity of *20m/s*


- How much driving force the engine need to generate?

# Cruise Control System: Speed and Force




$f$: driving force

$f_{fric}$: frictional force (e.g. air resistance)

Newton's 2nd law:

$$f - f_{fric} = Ma$$

Assume the frictional force is proportional to velocity (viscous friction)

$$f_{fric} = Bv$$

Remember that

$$a = \frac{dv}{dt}$$

# Cruise Control System Modelling

$$f - Bv = M\frac{dv}{dt}$$

Or

$$\frac{dv}{dt} + \frac{B}{M}v = \frac{1}{M}f$$

Substitute: $M = 1000kg\,; \quad B = 50Ns/m$

$$\frac{dv}{dt} + 0.05v = 0.001f$$

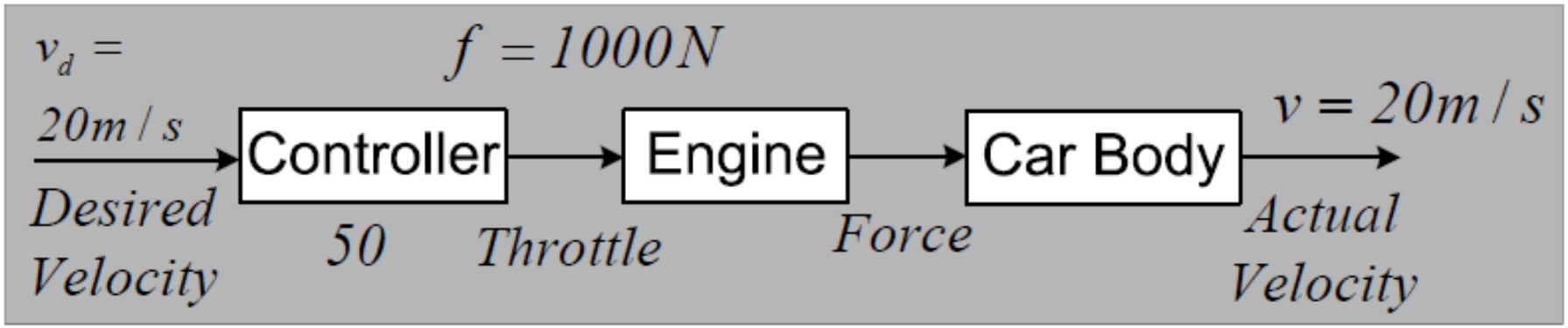
Model

Constant Speed

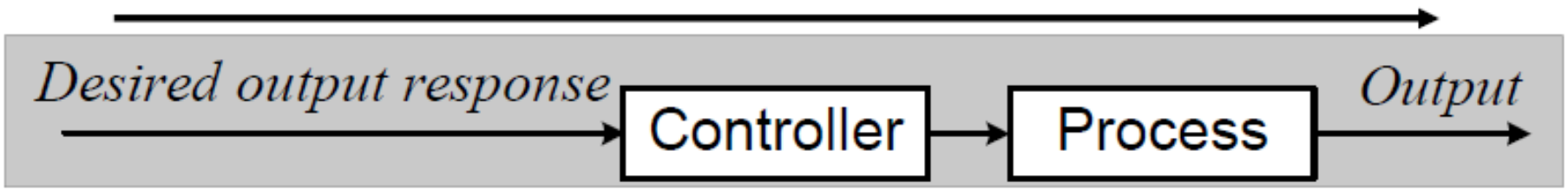
$$\frac{dv}{dt} = 0; \quad v = 20$$

$$f = 1000N$$

# Open-Loop Control Systems

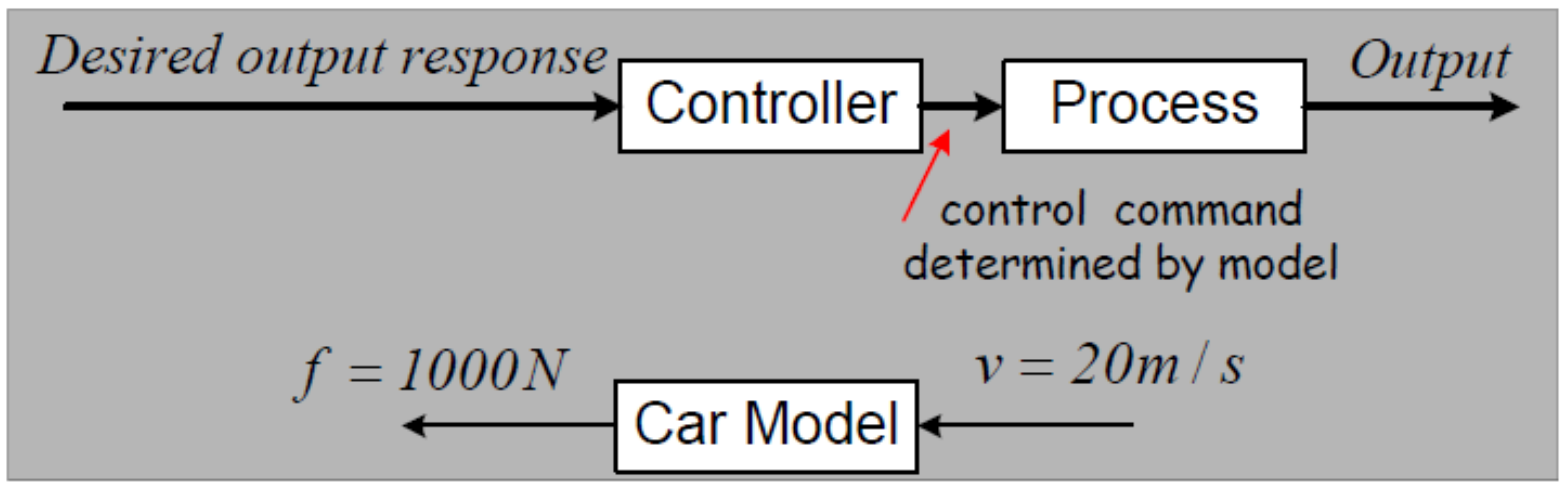



- An *open-loop control system* utilises a controller or control actuator to obtain the desired response.
  - Control command determined by model.
  - Signal only go forward direction.



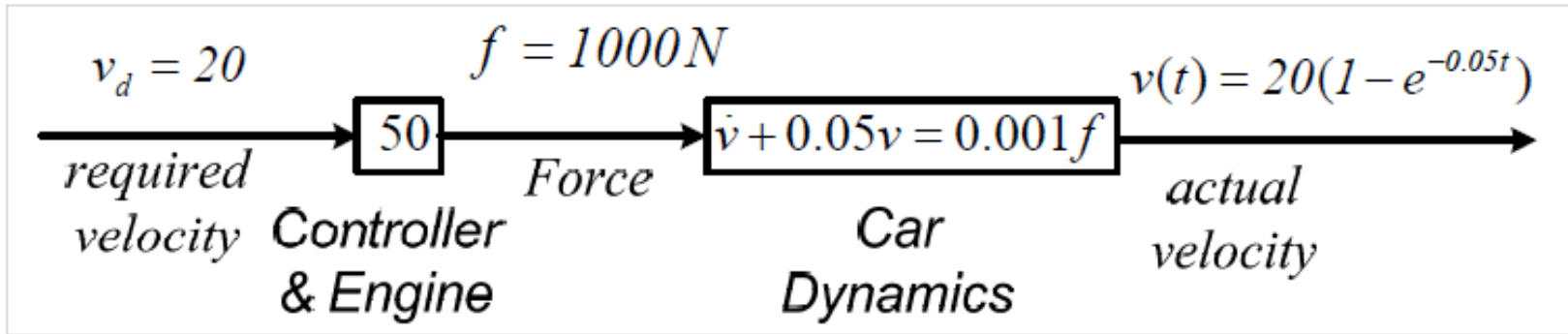
# Open-Loop Control Systems

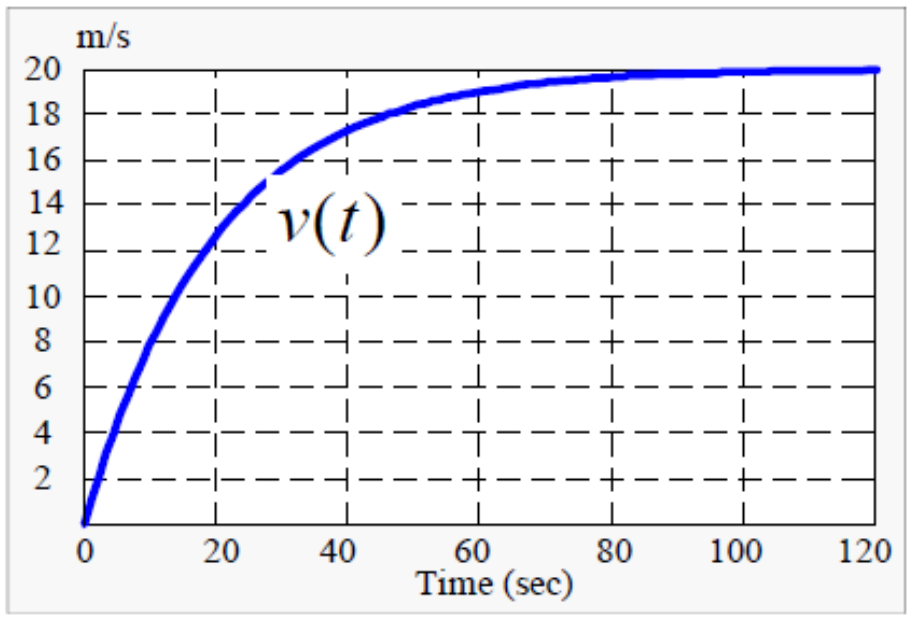
- If we have a model of the system (process) to be controlled, we can work backwards to calculate the input (command) to give the desired output!
  - e.g. *1000*N force is required to maintain car velocity at *20*m/s in cruise control system example



# Control System Responses

- To maintain a constant velocity of *20m/s*.

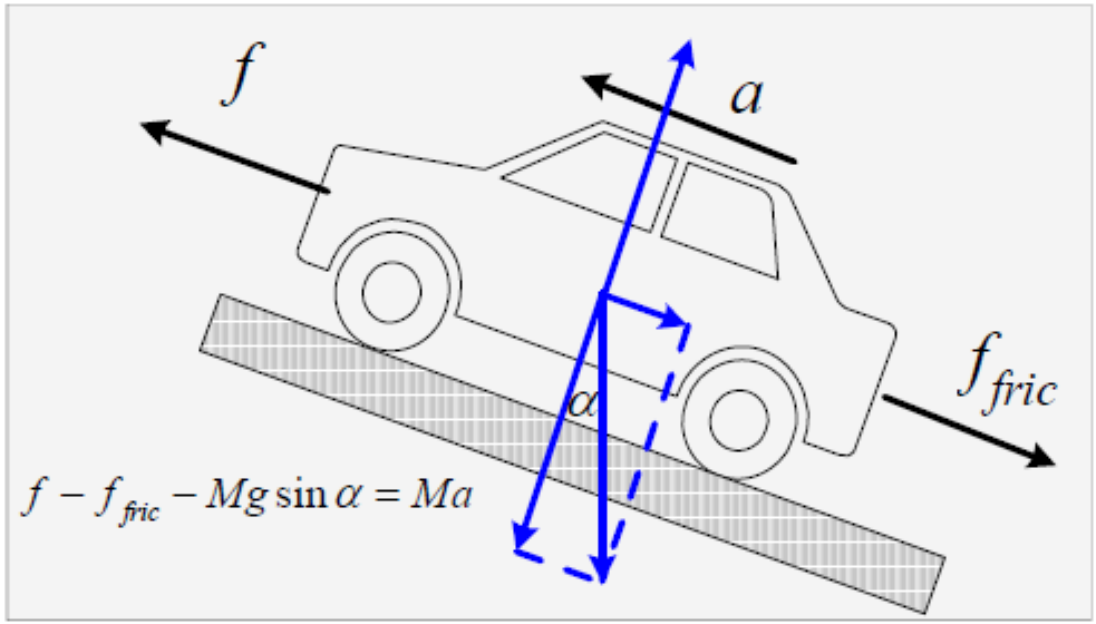


Understanding Control Systems, Part 1: Open-Loop Control Systems

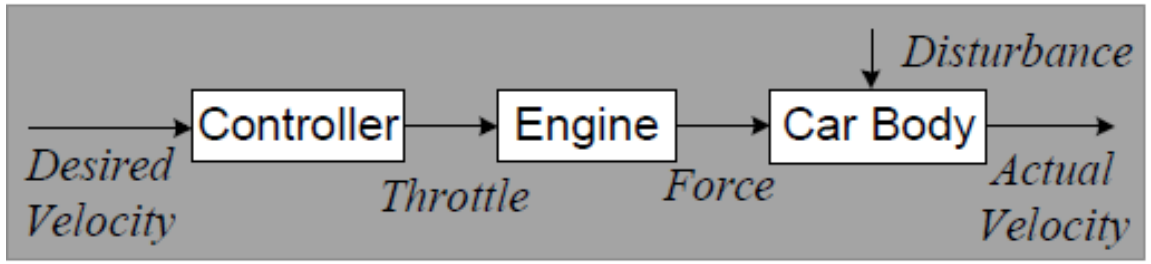
https://www.youtube.com/watch?v=FurC2unHeXI&list=PLn8PRpmsu08q8CE0pbZ-cSrMm_WYJfVGd&index=2

# Problem in Open-Loop Control Systems




$$f - f_{fric} = Ma$$

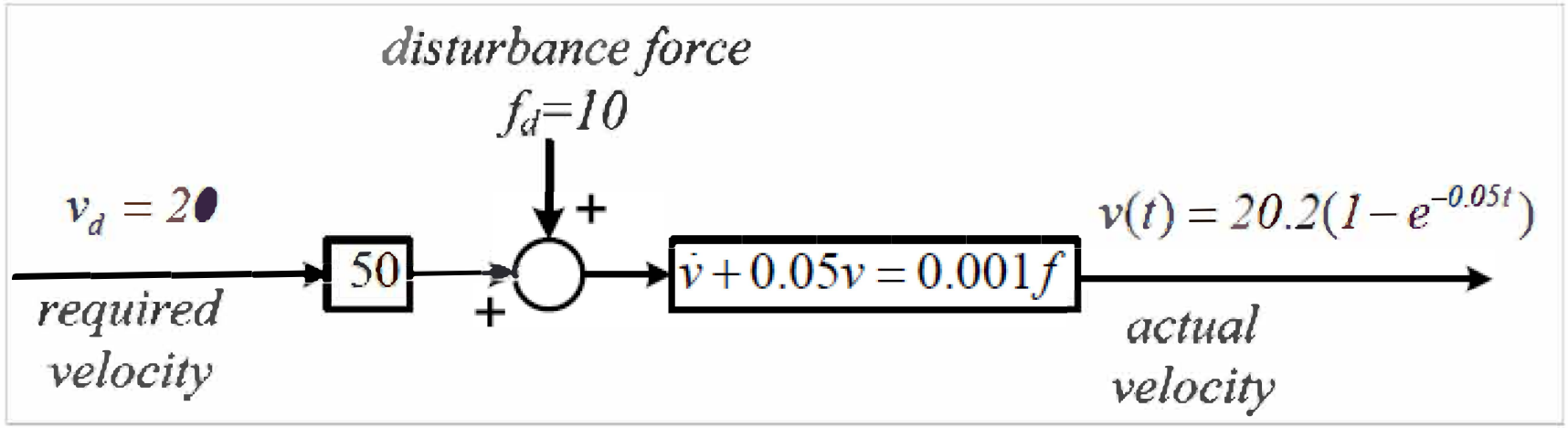
- Due to unexpected disturbances such as modelling errors, an open-loop control system often can not achieve desired goal.




- No compensation for any disturbance.

- The required velocity cannot be achieved. We need a way to compensate for the effect of disturbance.

# Disturbance in Open-Loop Control Systems




- Speed control error:

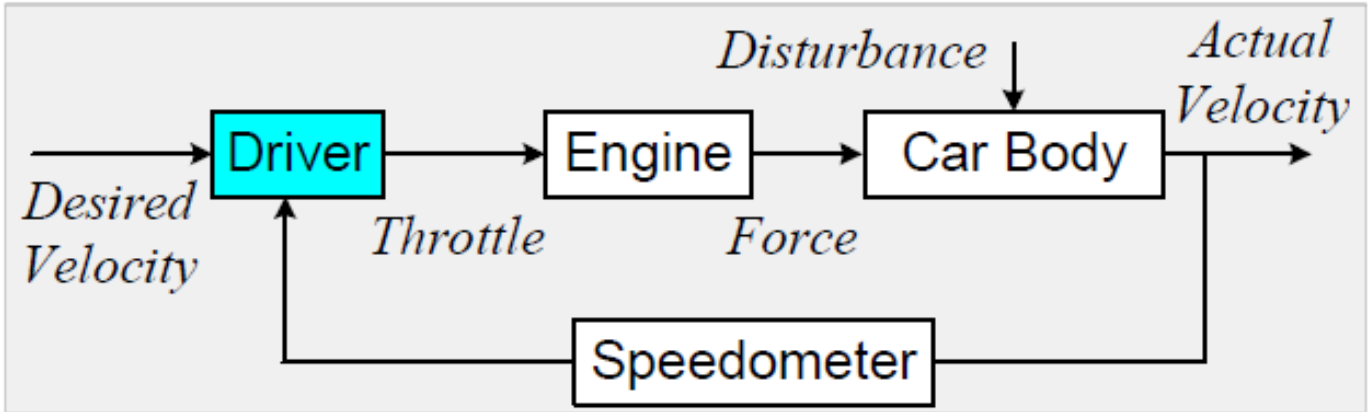
$$e(t) = 20 - 20.2(1 - e^{-0.05t}) = -0.2\,(1 - e^{-0.05t}) \rightarrow -0.2$$

- No compensation for any disturbance.

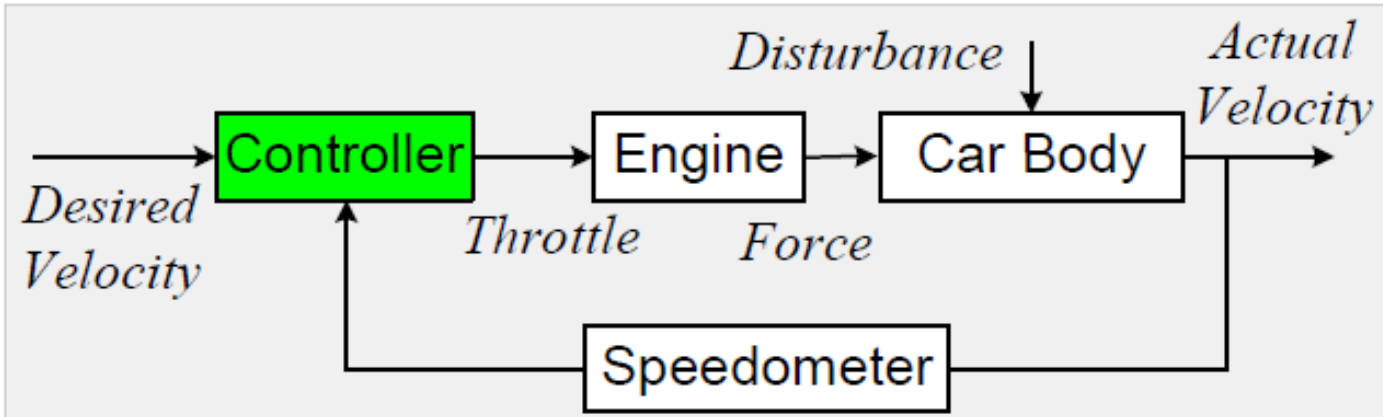
# Closed-Loop Control System: Driver and Cruise Control System

- How does a driver maintain a constant car speed?

Driver




Automatic control



Understanding Control Systems, Part 2: Feedback Control Systems

https://www.youtube.com/watch?v=5NVjIIi9fkY&list=PLn8PRpmsu08q8CE0pbZ-cSrMm_WYJfVGd&index=3