Tutorial #1

Control Systems CIE-318

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Organization

Assessment

- Midterm Exam + Quizzes 30%
- Final Exam 40%
- Labs 20%.
- Project 10%.

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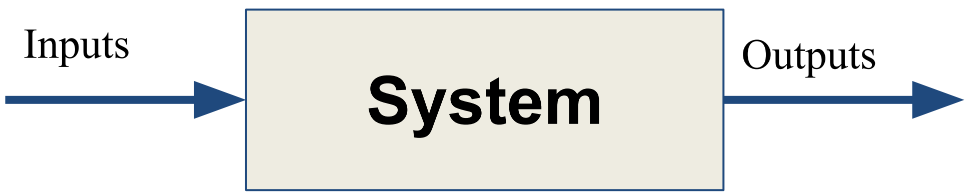
Introduction

A system is an abstract object that accepts inputs and produces outputs in response



Control deals with applying/choosing the inputs to a given system to achieve a desired output.

What is included in this course?

Modeling

• Represent the input-output behavior of the system in a way that is suitable for mathematical analysis.

Analysis

• Basic understanding of what the model tells us about the system response to input signals.

• Formulate how exactly we want the output to get to its desired value.

Design

• Study ways to design controllers to supply appropriate control (input) signals to the system so that the output behaves as we want it to.

Examples

Automatic control is an important and integral part of space-vehicle systems, robotic systems, modern manufacturing systems, and any industrial operations involving control of temperature, pressure, humidity, flow, etc. It is desirable that most engineers and scientists are familiar with theory and practice of automatic control.

Terminology

Plant.
A plant may be a piece of equipment, perhaps just a set of machine parts functioning together, the purpose of which is to perform a particular operation. In this book, we shall call any physical object to be controlled (such as a mechanical device, a heating furnace, a chemical reactor, or a spacecraft) a plant.

Processes.
The Merriam–Webster Dictionary defines a process to be a natural, progressively continuing operation or development marked by a series of gradual changes that succeed one another in a relatively fixed way and lead toward a particular result or end; or an artificial or voluntary, progressively continuing operation that consists of a series of controlled actions or movements systematically directed toward a particular result or end. In this book we shall call any operation to be controlled a process. Examples are chemical, economic, and biological processes.

Terminology

Systems

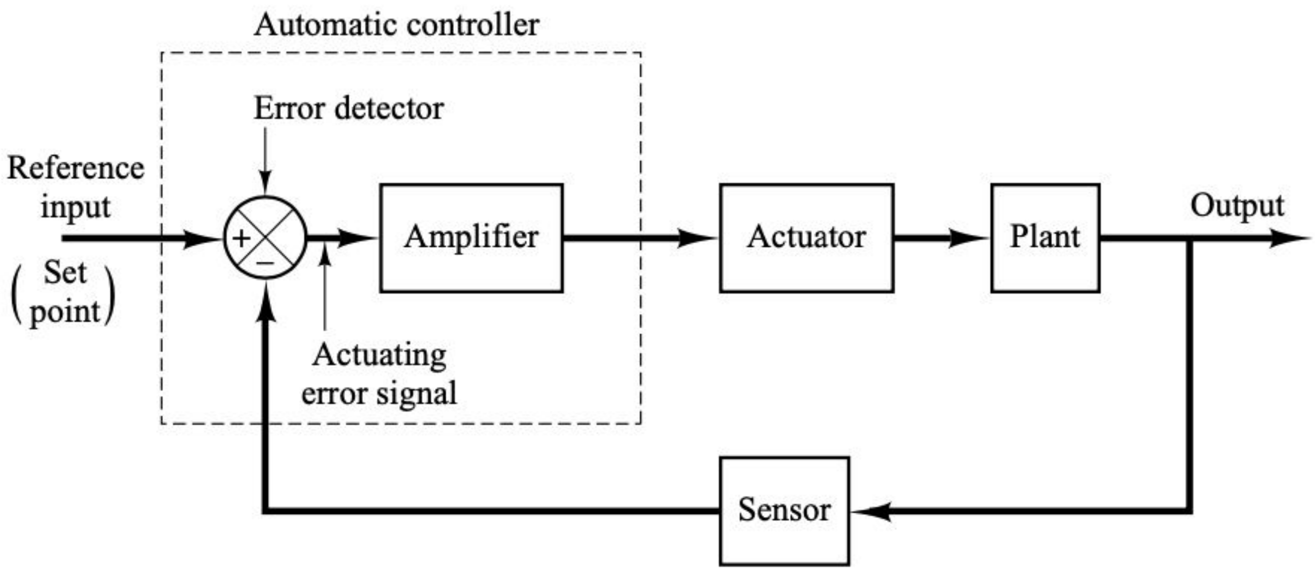
A system is a combination of components that act together and perform a certain objective. A system need not be physical. The concept of the system can be applied to abstract, dynamic phenomena such as those encountered in economics. The word system should, therefore, be interpreted to imply physical, biological, economic, and the like, systems.

Disturbances. A disturbance is a signal that tends to adversely affect the value of the output of a system. If a disturbance is generated within the system, it is called internal, while an external disturbance is generated outside the system and is an input.

Feedback Control

Feedback control refers to an operation that, in the presence of disturbances, tends to reduce the difference between the output of a system and some reference input and does so on the basis of this difference. Here only unpredictable disturbances are so specified, since predictable or known disturbances can always be compensated for within the system.

Feedback System (Closed Loop)



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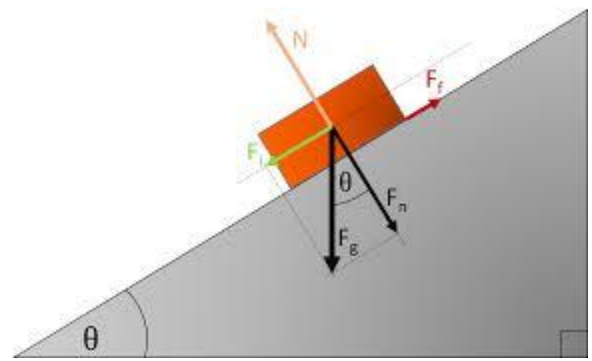
Feedback VS Open Loop Systems

Now let's see how a feedback control loop can improve a system's performance. Imagine that you want to control the speed of a car and you know that:

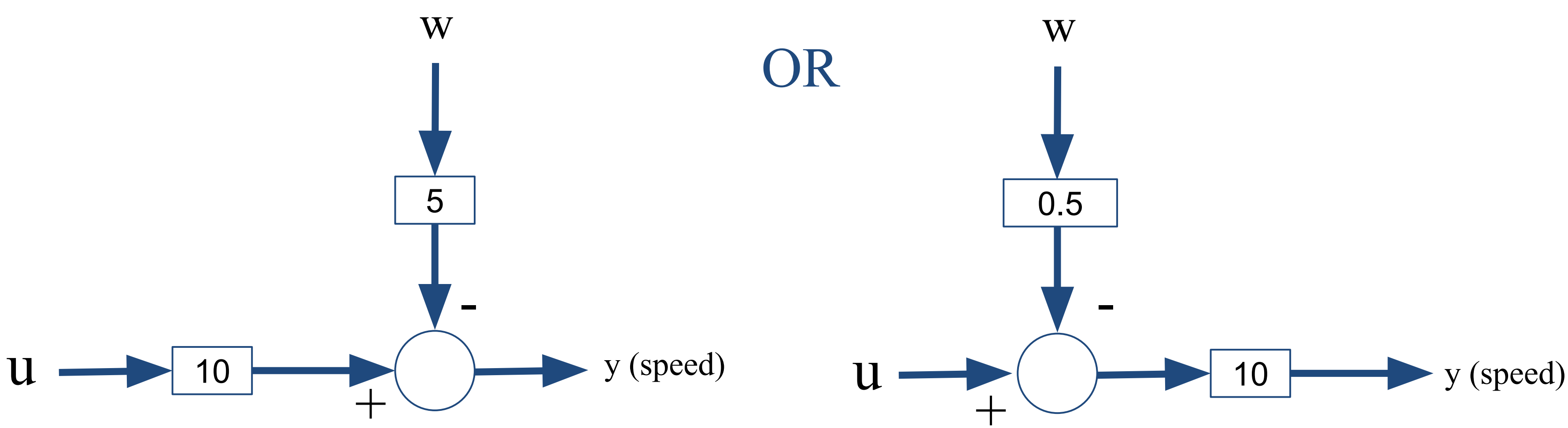
1° change in pedal= +10Mph

1°change in elevation= -5MPh



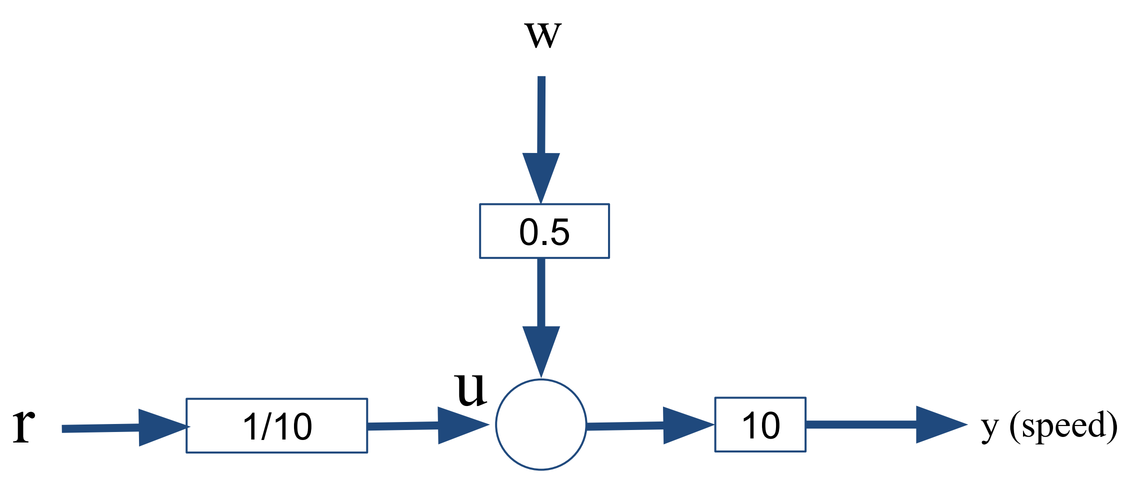
Feedback VS Open Loop Systems

This can be illustrated as:



Feedback VS Open Loop Systems

A new variable r (reference speed) can be seen as the pedal degree (u) multiplied by 10 :



y = r+5w

If reference speed r =65 Mph

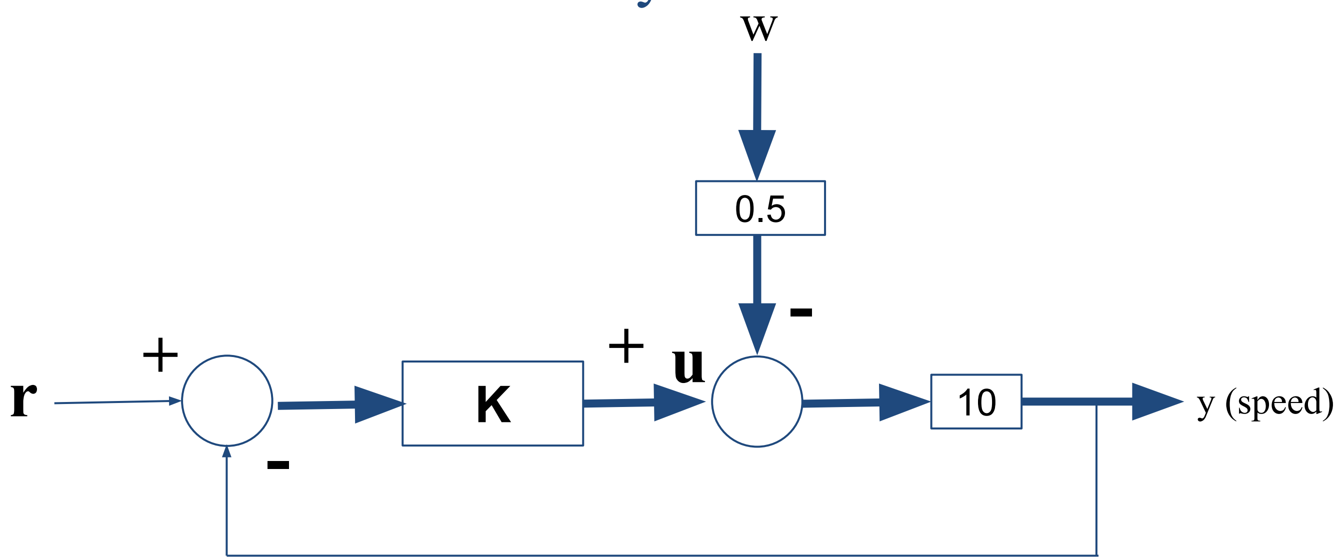
0° elevation(w) will yield y= 65 Mph ----> 0% Error

1° change y= 70 Mph ----> 7.7% Error

2° change y= 75 Mph ----> ~15% error

Feedback VS Open Loop Systems

Now consider a feedback system:



$y = 10*((r-y)*K-0.5*w)$

$y = 10Kr - 10Ky - 5w$

$(1+10K)y = 10Kr - 5w$

$y = (10Kr - 0.5w) / (1+10K)$

let r= 65 Mph

and K=10

0°elevation(w) will yield y= 65 Mph--> 0% Error

1° change y= 64.35 Mph ----> 0.98% Error

2° change y= 64.31 Mph ----> ~1.05% error

Modelling

Simplicity Versus Accuracy

In obtaining a mathematical model, we must make a compromise between the simplicity of the model and the accuracy of the results of the analysis. In deriving a reasonably simplified mathematical model, we frequently find it necessary to ignore certain inherent physical properties of the system. In particular, if a linear lumped-parameter mathematical model.

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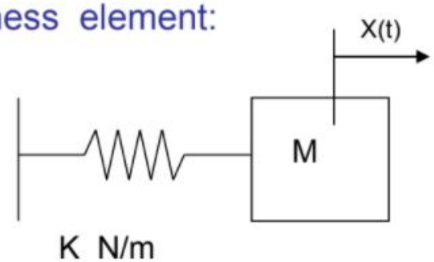
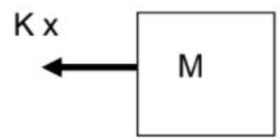
Modelling A Mechanical system

Inertia element:

Mass element

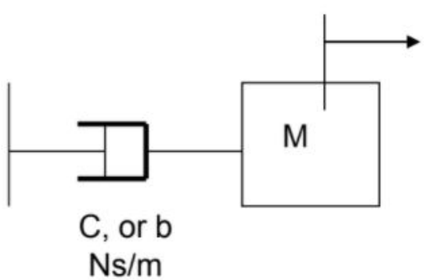
Stiffness element:

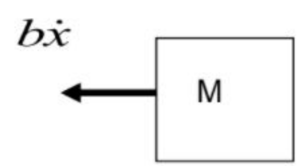




F.B.D

Damping element:





F.B.D

Modelling A Mechanical system

$\Sigma F = m * a$

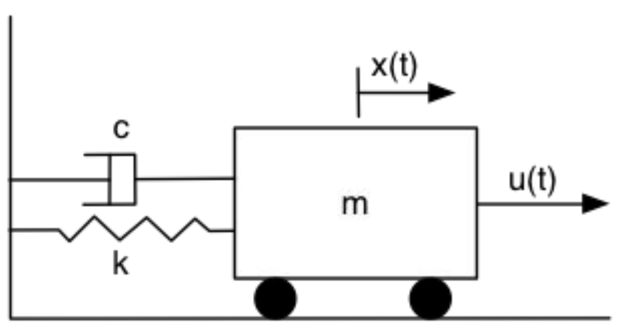
$c * \dot{x} + k * x = m * \ddot{x}$

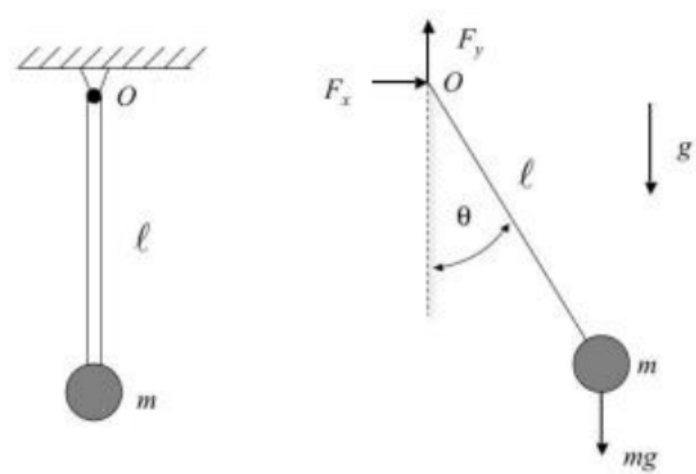
$\Sigma M = J * \alpha$

$-m * g * l * \sin\theta = J * \alpha$

Let $J = m * l^2$

$m * l^2 \ddot{\theta} + m * g * l * \sin\theta = 0$





Task 1:

- Install Matlab & Simulink.