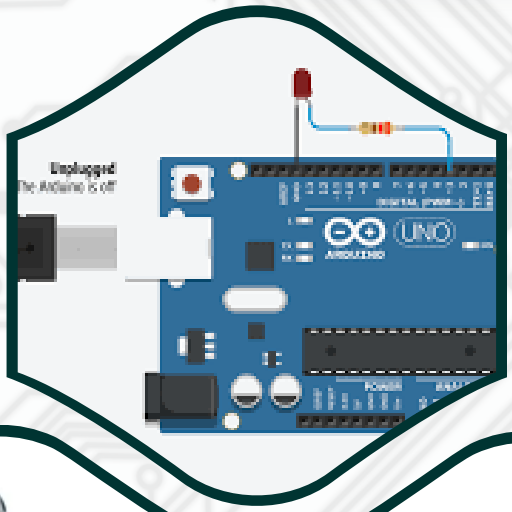
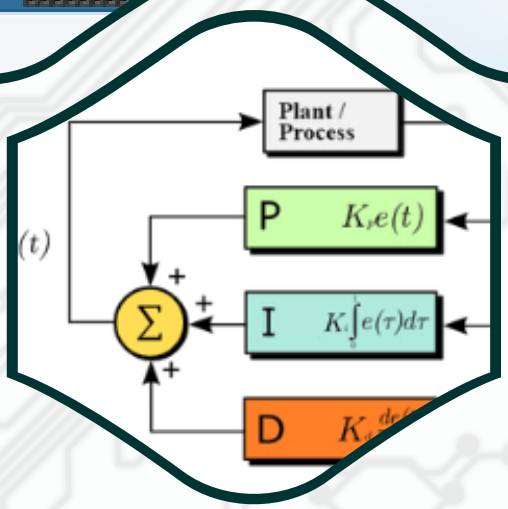
POLITEKNIK MALAYSIA

eNotes

FUNDAMENTALS OF CONTROL SYSTEM





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eNotes

fundamentals of control system

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eNotes Fundamentals of Control System is as general references and readings especially to lecturers and students of polytechnics and colleges Malaysian community to apply best practices in method implementation online teaching and learning.

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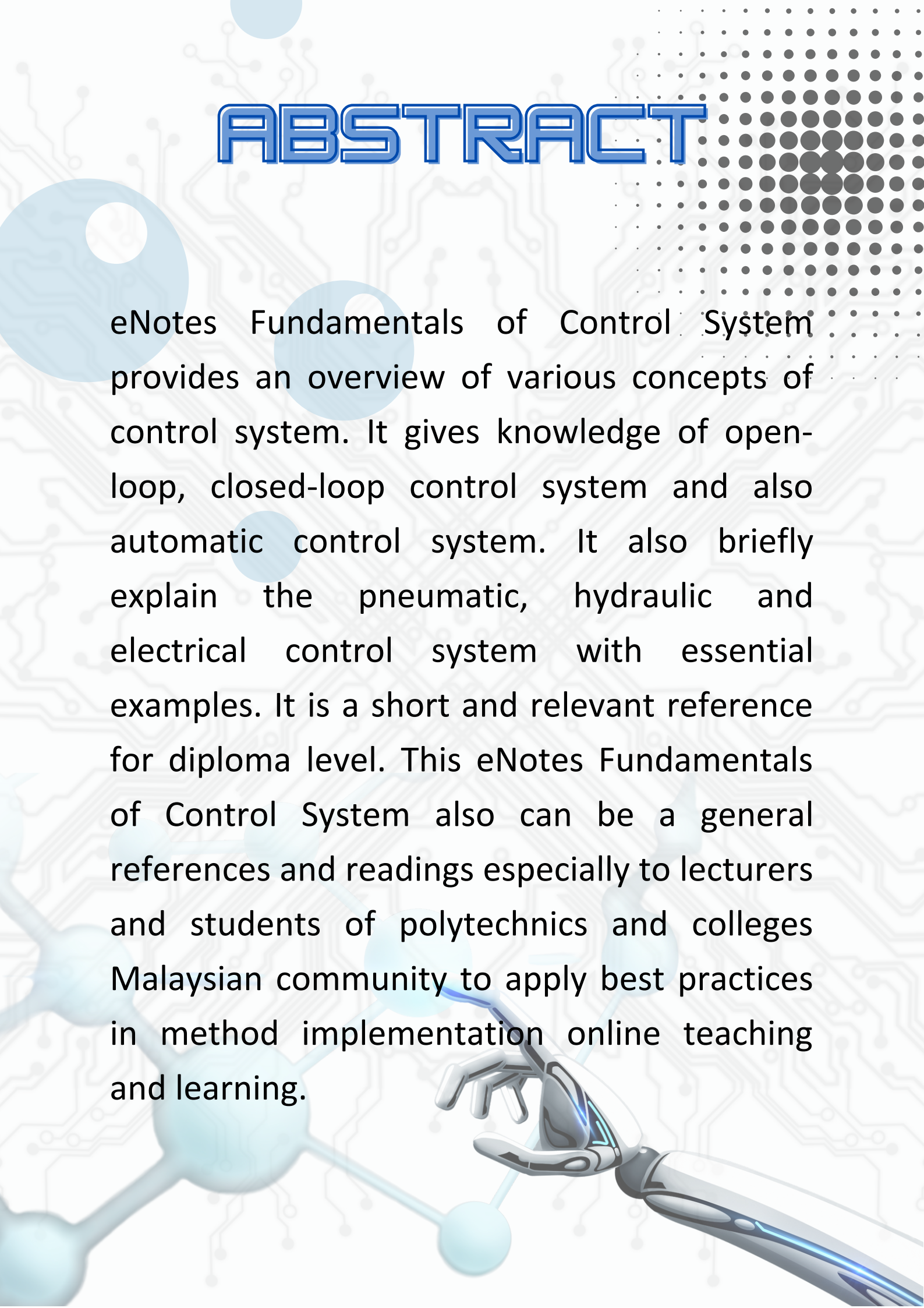
ABSTRACT

eNotes Fundamentals of Control System provides an overview of various concepts of control system. It gives knowledge of open-loop, closed-loop control system and also automatic control system. It also briefly explain the pneumatic, hydraulic and electrical control system with essential examples. It is a short and relevant reference for diploma level. This eNotes Fundamentals of Control System also can be a general references and readings especially to lecturers and students of polytechnics and colleges Malaysian community to apply best practices in method implementation online teaching and learning.



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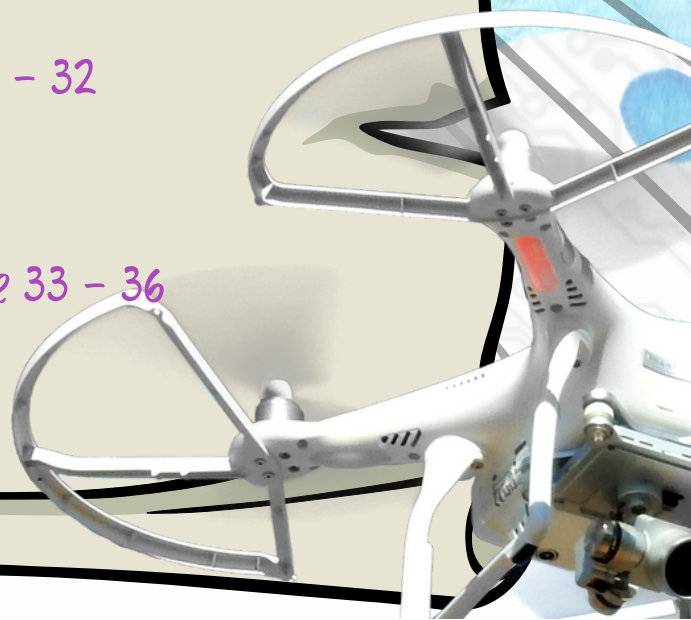


INTRODUCTION TO CONTROL SYSTEM

INTRODUCTION TO CONTROL SYSTEM

SYSTEM

System is a connecting components and technology to achieve a goal

Can you give the differences between SYSTEM and CONTROL SYSTEM?

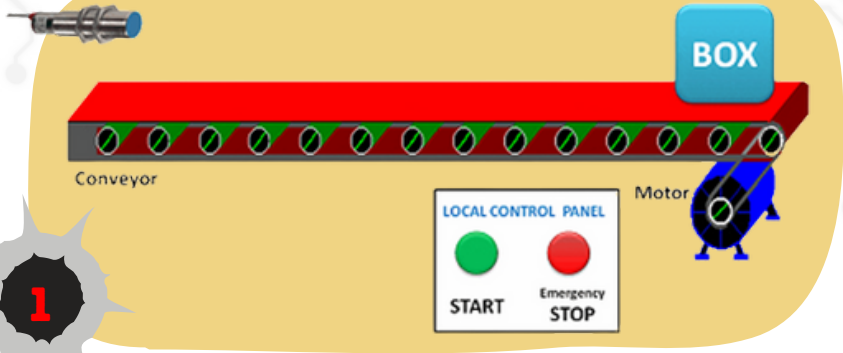
SYSTEM = organized relationship

CONTROL SYSTEM

Control System is a system configuration created by the coupling of components that will deliver the intended

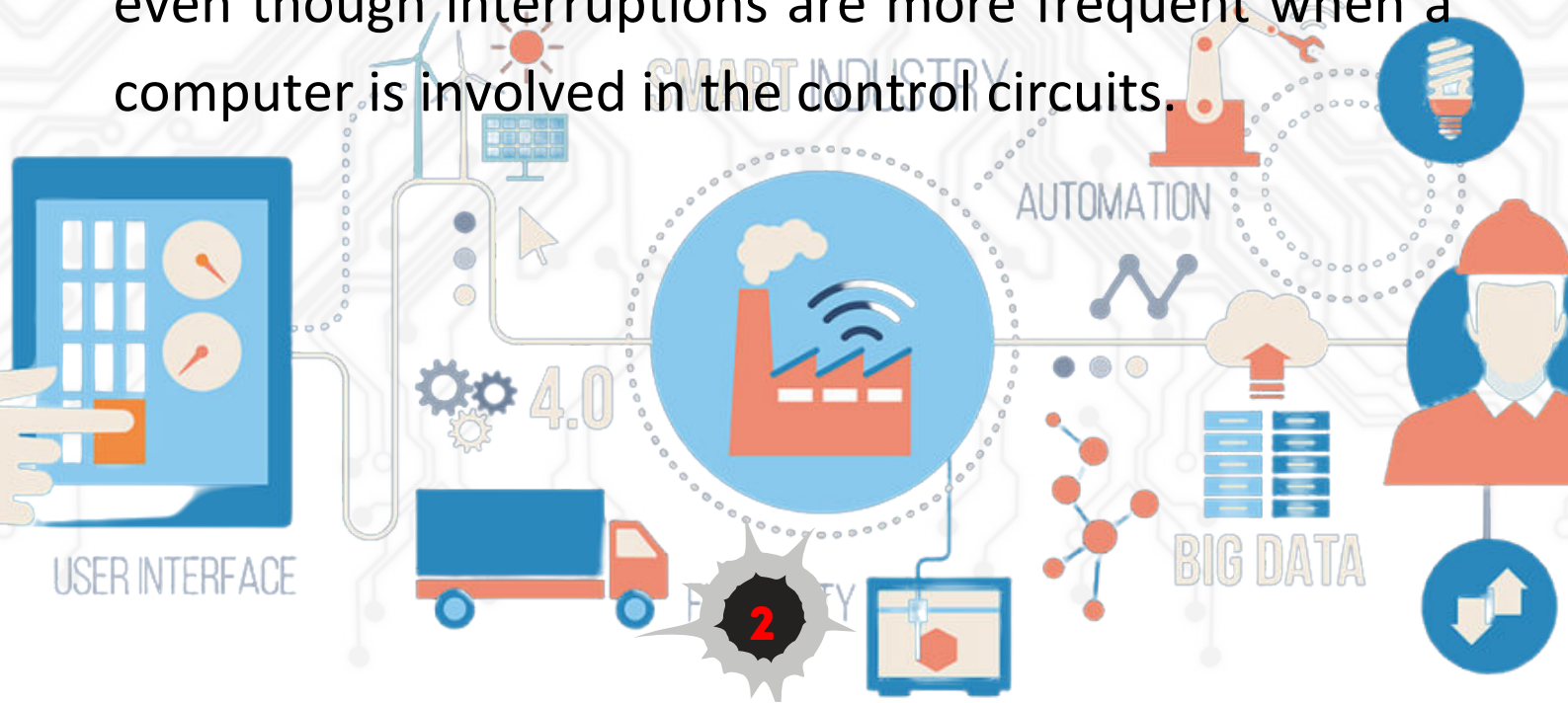
WHAT IS PROCESS?

Process is the cause-and-effect relationship between input and output

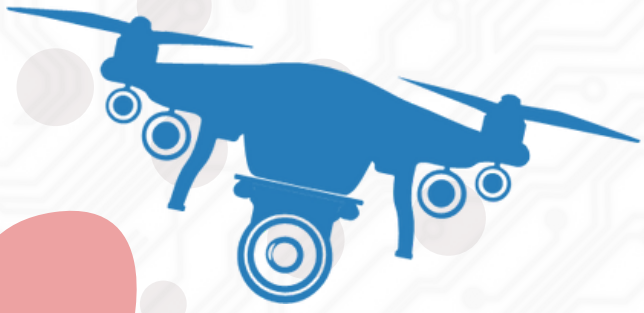


CONTROL SYSTEM

A control system is one that directs the output to produce the desired reaction. A control system is a collection of mechanical or electronic components that operate in control loops to regulate other components or systems. Control systems are typically computerised. Automation and the industrial sector depend heavily on control systems. A feedback controller called continuous modulated control is used to automatically control a process or processes. The control system compares the process value variable or position with the desired value or set point using the plant process variable. It is often more convenient to run all control systems on electricity, even though interruptions are more frequent when a computer is involved in the control circuits.



WHY WE NEED CONTROL SYSTEM?



- advantage for humanity
- regulate the industrial processes efficiently
- strengthened the stability
- improve productivity

INPUT AND OUTPUT

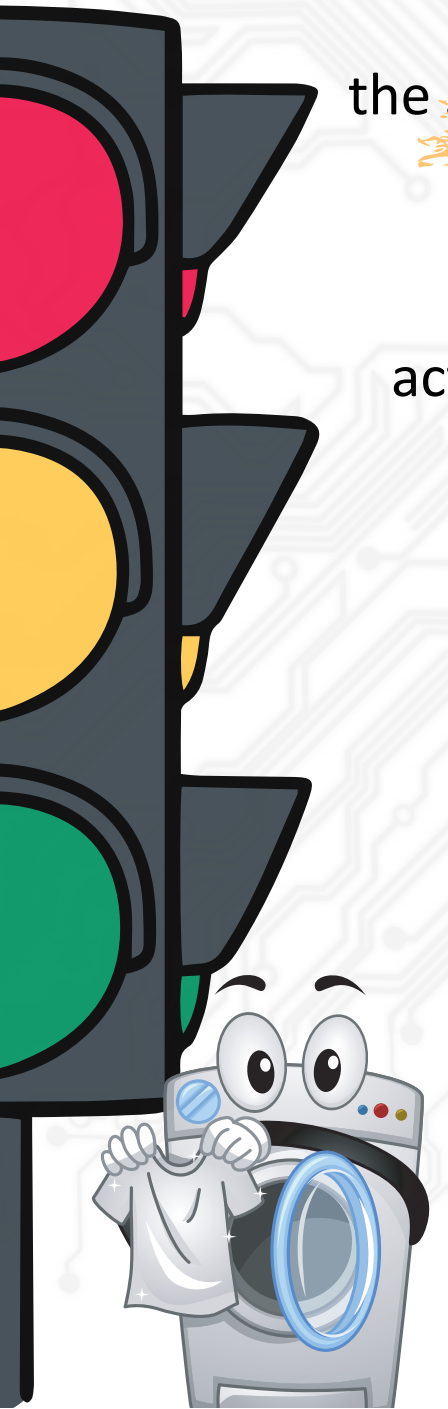
Figure 1 : Input and output for control system

input

the system output's reference value or set point

output

actual response a control system provided



let's try!

Find the input and output for these control system :

- traffic light
- washing machine

BLOCK DIAGRAM

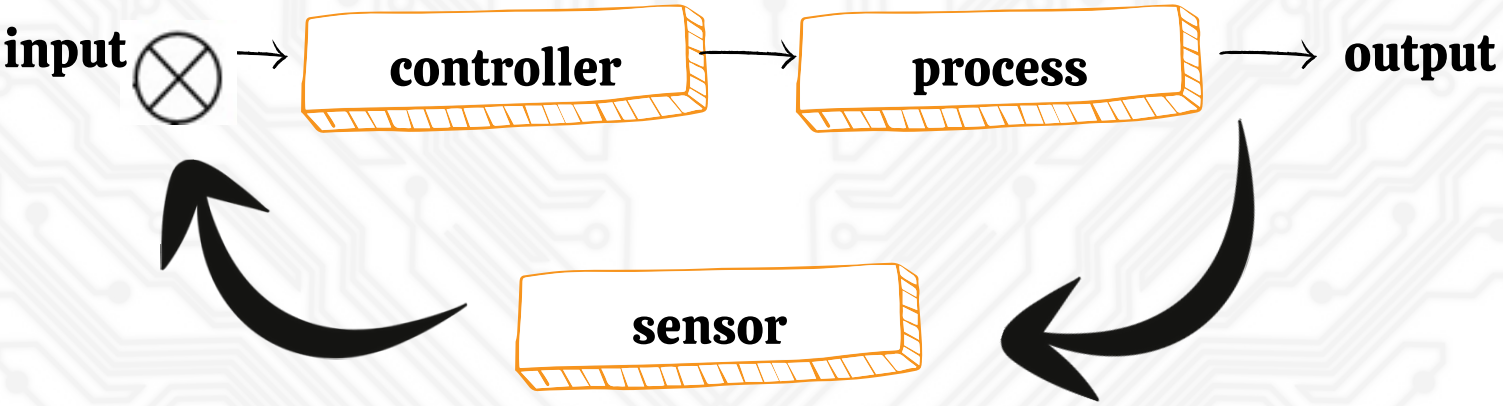


Figure 2 : Block diagram of a control system

Controller - device that control a process

Sensor - device that can be used to evaluate the outcome

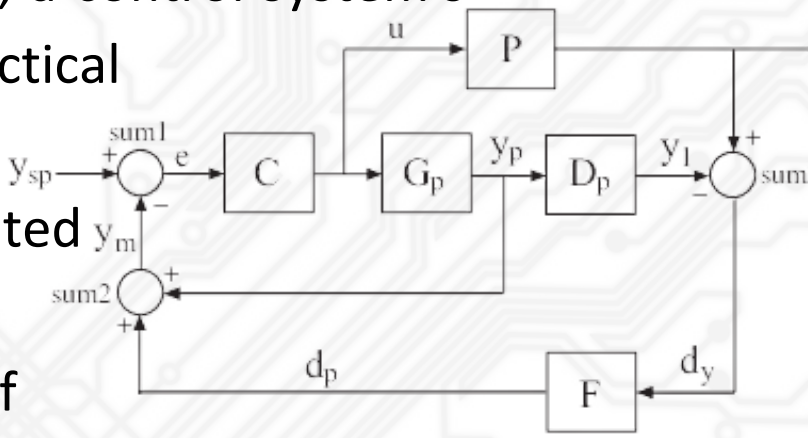
Disturbance - signals that tends to give negative impact on production of the system

Error - the difference between the measured and required values

Set point - the desired or target value for a system's essential variable

BLOCK DIAGRAM

A control system is shown in diagram form using a block diagram. In other words, a control system's block diagram serves as its practical representation. Each control system component is represented by a block, which serves as a symbolic representation of the component's transfer function.



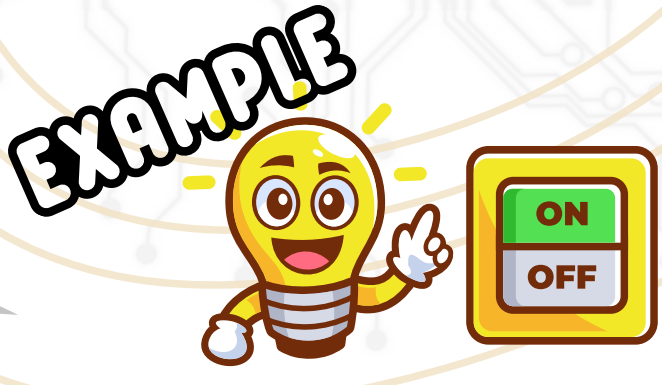
transfer function

An input signal and an output signal make up a control system. A function known as the transfer function connects the output to the input. The entire diagram of the control system utilising these blocks, which represent the transfer function, and arrows, which represent the various signals, is referred to as the block diagram of the control system.

OPEN-LOOP control system

OPEN-LOOP CONTROL SYSTEM :
system that functions without feedback and creates output immediately in response to an input signal

An open-loop system, also known as a control system where the output quantity has no impact on the input quantity, is any physical system which does not automatically correct the fluctuation in its output. This indicates that the output is not a correctional feedback to the input. The output of an open-loop control system can be changed by changing the input.



OPEN-LOOP control system

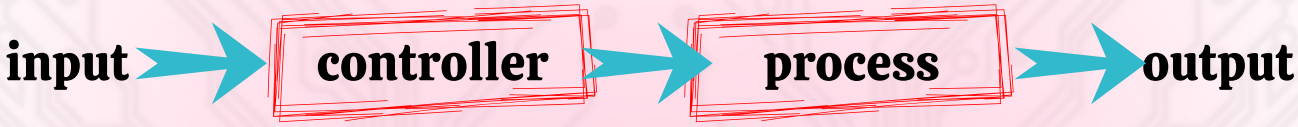
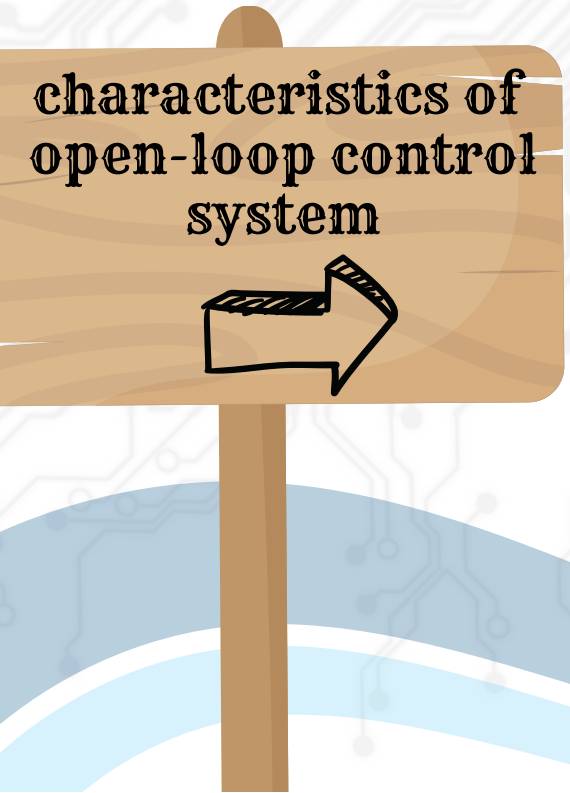


Figure 3 : Block diagram of open-loop control system

The open-loop system output may alter as a result of outside disturbances. Changes in input are not made in response to output changes brought on by disturbances. Open-loop systems require manual input modifications in order to fix output changes.



#1 system without feedback

#2 output has no impact on control action

#3 output not being compared with input

OPEN-LOOP control system

do You know?

Timer-based toaster is an open-loop control system. Bread is put into the toaster, a timer is set, and a lever is pushed down acting as a switch to start the process.

The majority of automated traffic control systems use time-based open loop control, which means that each signal has a set time window during which it runs regardless of the volume of traffic.

CLOSED-LOOP control system

CLOSED-LOOP
CONTROL SYSTEM :
system that generates an error signal for the actuator by measuring the output signal and comparing it to the desired output

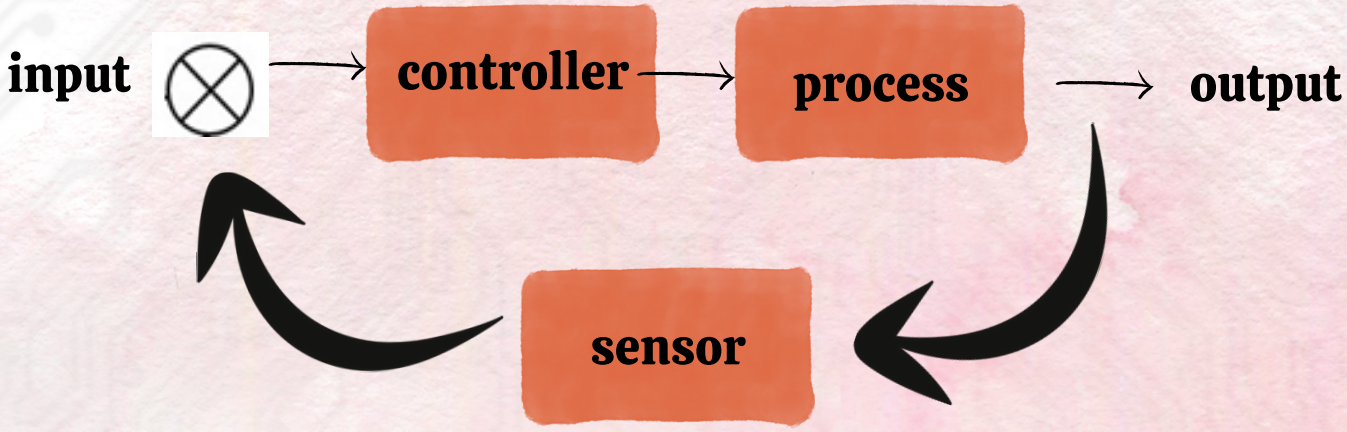


Figure 4 : Block diagram of closed-loop control system

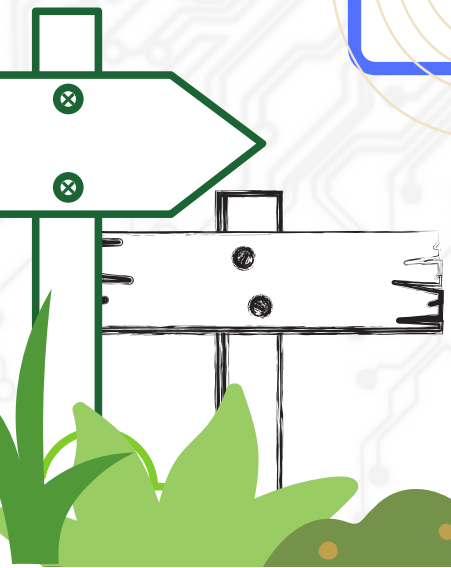
CLOSED-LOOP control system

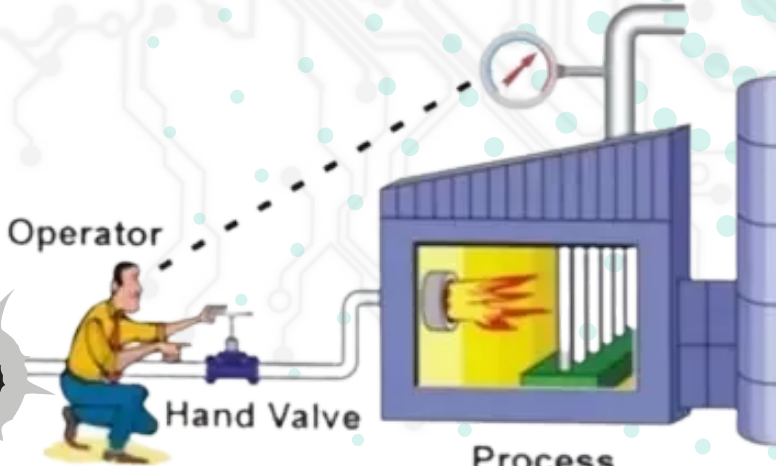
The feedback path components sample the output and change it to the reference signal's type. The feedback signal is proportional to the output signal and it is fed to the error detector. The error signal generated by the error detector is the difference between the reference signal and the feedback signal. The controller modifies and amplifies the error signal to produce better control.

characteristic:

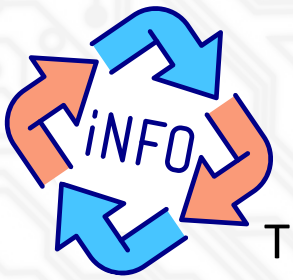
has feedback

and error signal



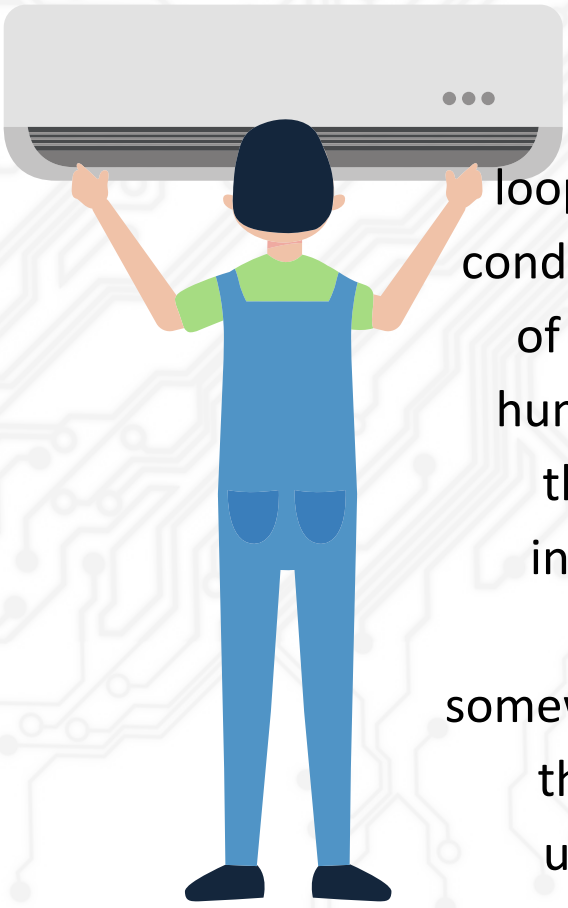


CLOSED-LOOP control system



The primary attributes of closed-loop control may then be stated as follows:

- To minimise errors by automatically modifying the system's input
- To make an unstable system more stable
- To alter the sensitivity of the system
- To make the process more resilient to outside disruptions

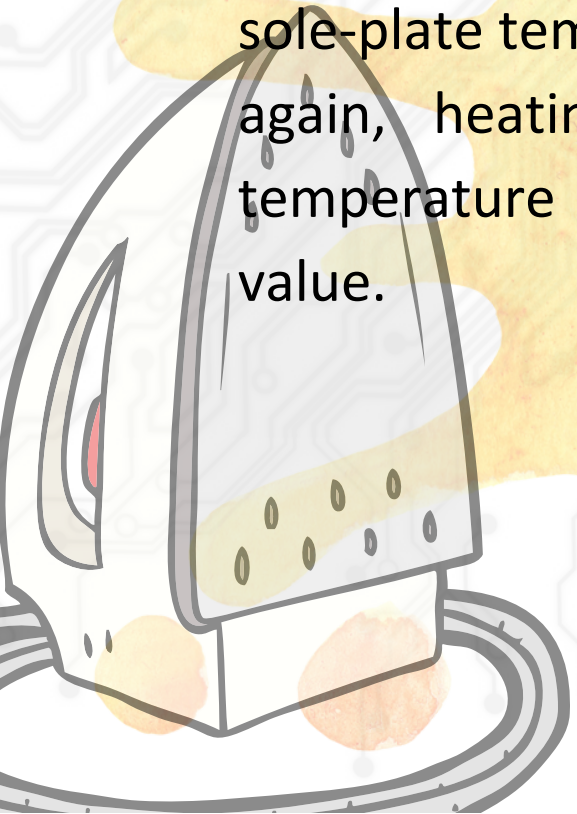


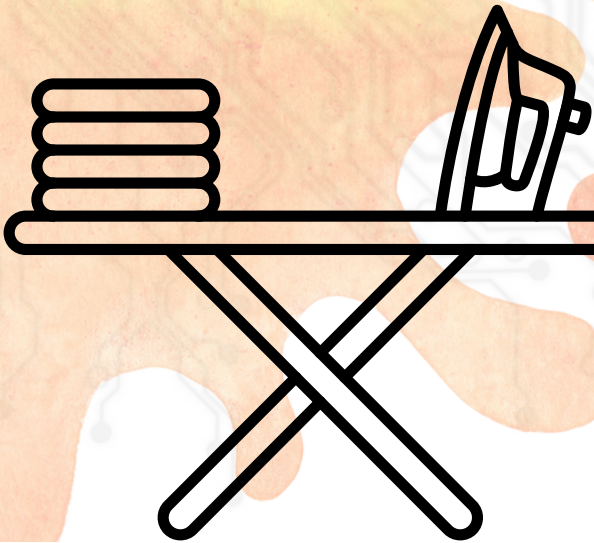
air conditioning system

Air conditioning system is a closed-loop control system. The basic goal of the air conditioning system is to improve the comfort of the space by regulating the temperature, humidity, and airflow. These devices turn off the air conditioner's compressor when the intended temperature is reached, and they restart it when the temperature deviates somewhat from that goal. The user can change the temperaturemanually or automatically using the air conditioning system's remote control.

CLOSED-LOOP control system

As a closed-loop system, an automatic electric iron operates. It comprises of a resistive heating element that produces heat and a thermostat that controls the system. The sole-plate of the iron instrument functions as a system process. An automatic electric iron's fundamental operation is such that the heating activity is automatically terminated when the sole-plate temperature reaches a set level. And again, heating begins inside it when the temperature falls below a specific defined value.





OPEN-LOOP control system VS CLOSED-LOOP control system

OPEN-LOOP		CLOSED-LOOP
simple & economical	#1	complex & costlier
consume less power	#2	consume more power
inaccurate & unreliable	#3	accurate & more reliable
easy to construct	#4	complicated construction

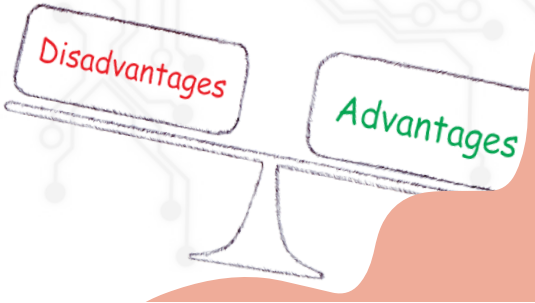
feedback control system advantages & disadvantages

ADVANTAGES

- The steady-state error of the system can be relatively small
- The feedback is compared with the desired state in order to take corrective measures
- The change in the performance of the system due to parameter variations is reduced

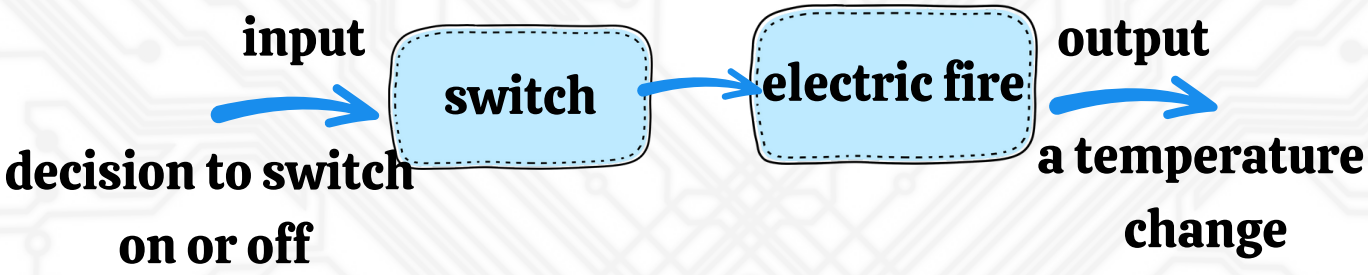
DISADVANTAGES

- System is complicated by the increased number of components
- If there is a change in an output, it will affect the system input
- The error detector is necessary in order to compare two states



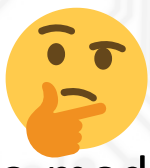
converting OPEN-LOOP to CLOSED-LOOP control system

SYSTEM : HEATING A ROOM



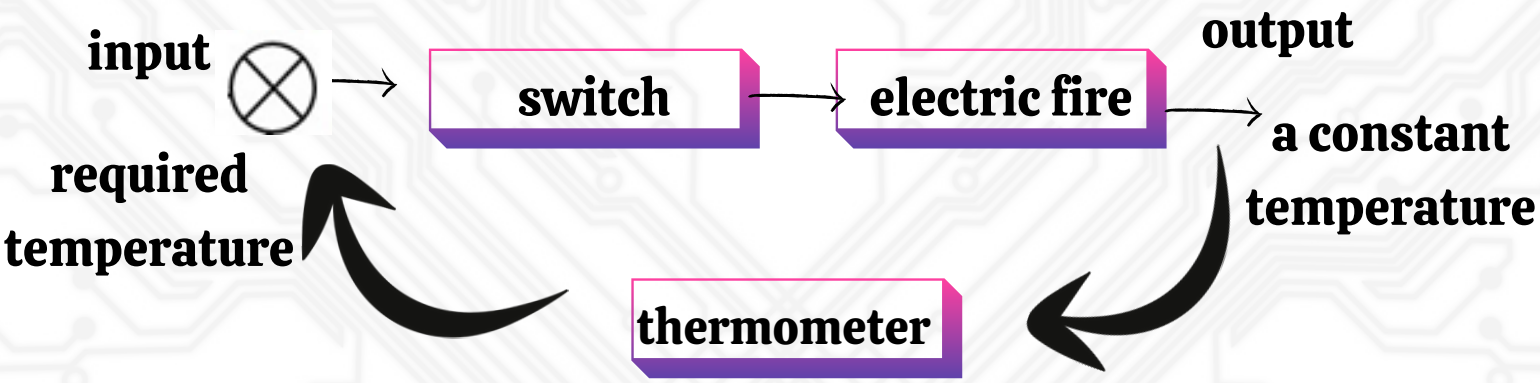
Consider an electric fire with a selection switch that allows you to choose between a 1 kW or a 2 kW heating element. If someone wanted to heat a room with a heating element, he might just turn on the 1 kW element if a high temperature was not necessary. Only the fact that the 1 kW element was turned on and not the 2 kW element will determine the temperature the room will attain during the heating process.

What will happen if a window is opened?



There is no way to modify the heat output to make up for this because there is no feedback to the element.

SYSTEM : HEATING A ROOM



From previous example of open-loop system, if someone has a thermometer and controls the 1 kW and 2 kW elements on or off based on the difference between the actual temperature and the desired temperature to keep the room's temperature constant, the heating system with the heating element might be converted into a closed-loop system. There is feedback in this circumstance, and the system's input is changed based on whether or not its output is the desired temperature.

exercise

- Give some examples for open-loop control system and closed-loop control system.
- Identify the input, output, controller, process and sensor for the selected control system.

AUTOMATIC control system

AUTOMATIC CONTROL SYSTEM :
a type of closed-loop control system that use the correction step, the mistake is automatically reduced

advantages

- reduce production cost
- excellent quality products
- usability for human life

disadvantages

- high maintenance
- difficult to construct
- cut back on empolyment

AUTOMATIC control system

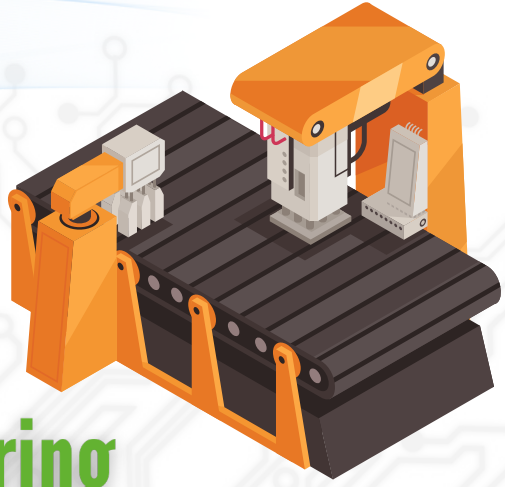
WHAT IS THE NEED FOR AN AUTOMATIC CONTROL SYSTEM?

To maintain a process at the necessary operating conditions safely and successfully, an automatic control system is required. The quality of the product can be maintained through the control system. A control system would enable us to obtain high-value items while also increasing yield. It can adhere to environmental safety standards, such as lowering pollutants and ensuring safety. Repeated tasks in many industrial processes can be completed quite easily with the aid of automatic control systems.

WHAT ARE THE APPLICATIONS OF AUTOMATIC CONTROL SYSTEM?

- AUTOMOBILE
- REFRIGERATION
- PROCESS INDUSTRIES

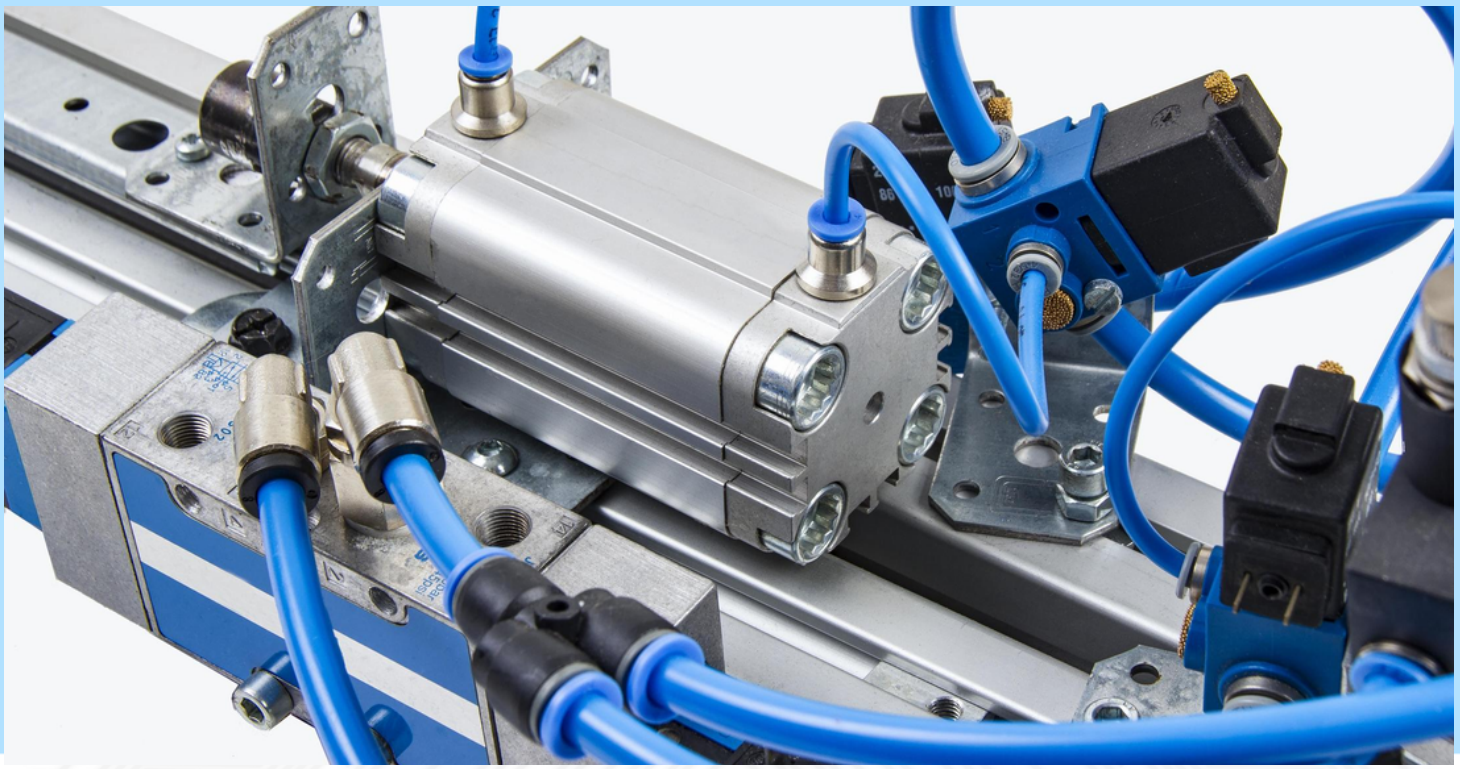
example of AUTOMATIC control system



Assembly robots in manufacturing

Robotic assembly is the process of building various goods, from large-scale systems to microscopic objects, using the most effective method possible. Each robotic assembly process is customised for the particular part, application, and production needs. It's usual for an assembly robot to be integrated with a parts feeding system, machine vision technology, tooling, and/or grippers. For activities requiring quickness, accuracy, and precision, such as those involving the assembly of automobiles, consumer goods, medical equipment, or other products, assembly robots are suitable. Assembly robots offer human-like dexterity while providing greater control, accuracy, and precision at a faster rate than manual processes allow. Some of the many advantages of using robotics are increased productivity and quality, and also improved efficiency.

PNEUMATIC SYSTEM



A pneumatic system is one that transmits power using compressed air. Typically, cylinders, rotary actuators, and other pneumatic devices are powered by a centrally situated compressor via a network of tanks, pipelines, and valves.

PNEUMATIC SYSTEM

FUN FACT

Pneumatics was first introduced into the sector of public transportation in 1867 by an inventor who showed how several passengers could take a trip from one place to another across a subway.

The word pneumatic originally comes from Greek. The specific Greek word is pneuma, one which signifies "air, wind or breath"

application of pneumatic system

Bicycle pumps

These pumps are used to pump air into things like footballs, basketballs, and bicycle wheels. Air-filled chambers can be found inside bicycle pumps. The capacity of the chamber inside the bike pump is reduced as you squeeze the handle, raising the pressure. The air will then exit the chamber's higher pressure and enter the tyre through the nozzle since air flows from high pressure to low pressure. The pressure in the camber is then reduced as you raise the handle, which lets air flow in from the outside. Bicycle pumps include a valve that only allows air to travel one way; normally, when the pressure in the chamber reduced, air would flow backwards from the tyre into the chamber.

application of pneumatic system

Brakes on buses and trucks

Large trucks and buses typically utilise pneumatic air brakes, while smaller cars and trucks typically have hydraulic brakes. The key benefit is that whereas a car won't be able to stop if its hydraulic brakes fail, a truck will stop on its own if its air brakes fail. Because of this, air brakes are more potent and have a safety advantage.

application of pneumatic system

Dental drills

Most people don't want to think about dental drills, but they are a great illustration of pneumatic technology. Since compressed air is nothing more than air, it is naturally clean. When working within a patient's mouth, you can't take the chance of having a deadly substance leak, which has made dental drills a popular application of compressed air. These iconic tools may not even be liked by most people for the sound they create, but because they rely on such a reliable and established form of technology, they are actually fairly safe.

HYDRAULIC SYSTEM

Hydraulic systems use a pressured fluid to operate and carry out duties. Another way to say this is that fluid under pressure is what drives everything. Because liquid fuel has such a huge impact on hydraulics, heavy machinery frequently uses hydraulics.

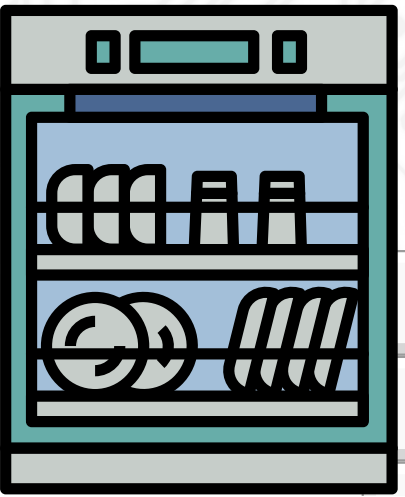
Hydraulic in everyday items

GARDEN HOSE

A hydraulic hose puts in to work the water distribution and its pressure allows water to be pushed out of the hose.

DISHWASHER

Hydraulics is used to increase water pressure for better cleaning. Dishwashers fitted with hydraulics are also generally quieter.



TOILET SEAT

Hydraulics are used in some toilet seats for those with mobility issues that stop them from assessing the bathroom, using a hydraulic lift mechanism to adjust the seat's height accordingly.

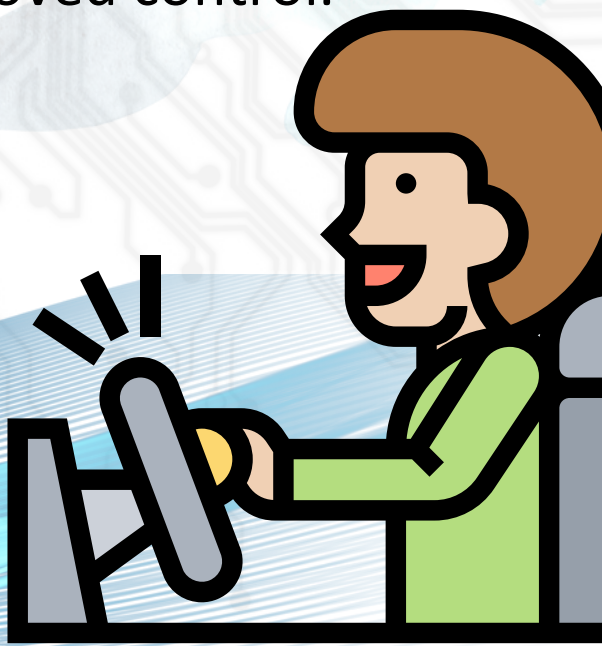
OFFICE CHAIR

Hydraulics makes it possible for the chair to rise up or go down, lean backwards and forwards as you adjust its levers.

application of hydraulic system

Hydraulic power steering

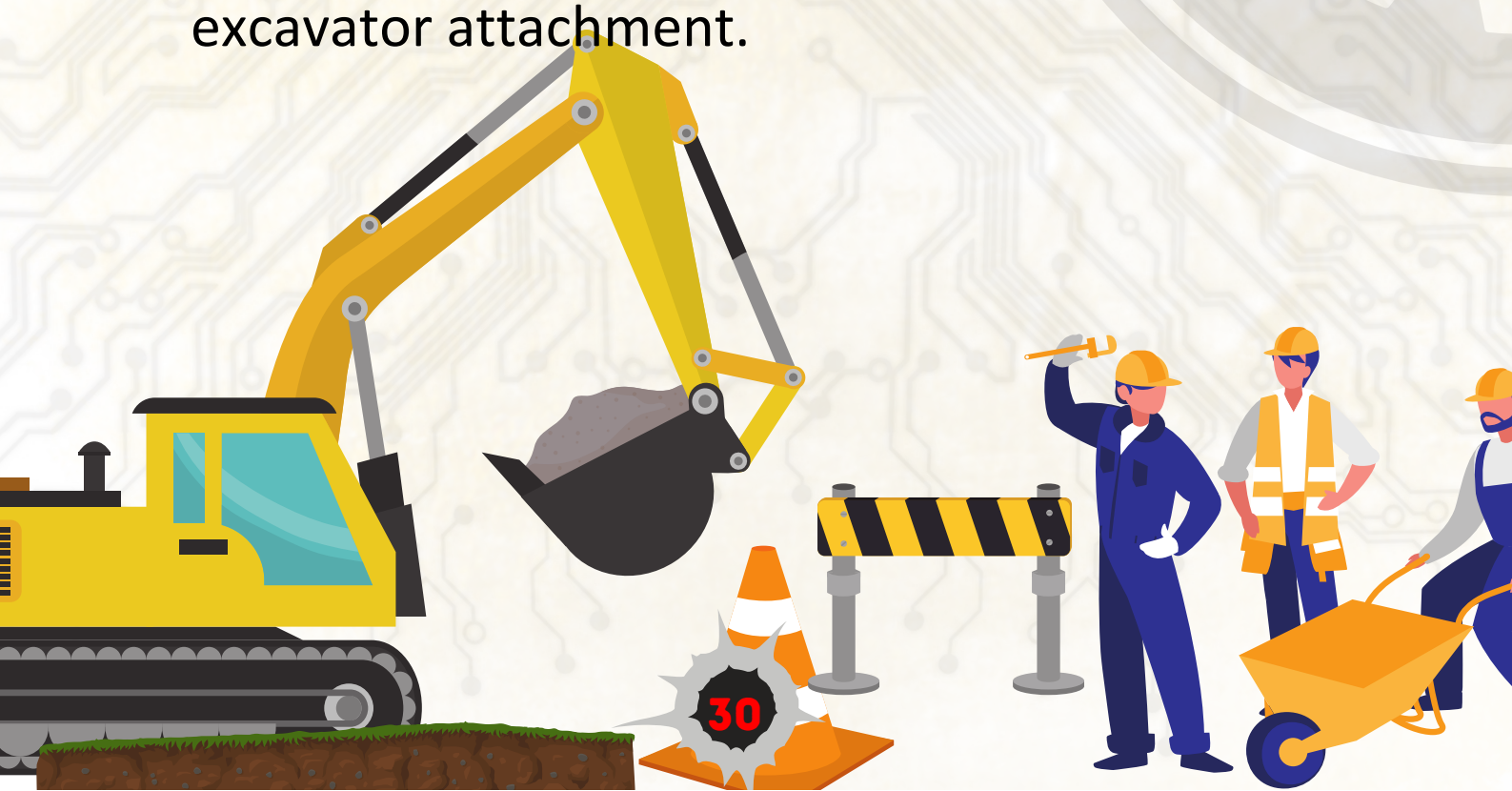
Hydraulics have many interesting applications in the automobile industry such as power steering. We gain extra power that makes it simpler for us to control our car when we pressurise the steering fluid and employ them wisely (more on that later). In essence, hydraulic power steering pressurises hydraulic fluid to offer us additional power that facilitates easier steering. It is a tool for safer manoeuvrability and improved control.



application of hydraulic system

Excavator

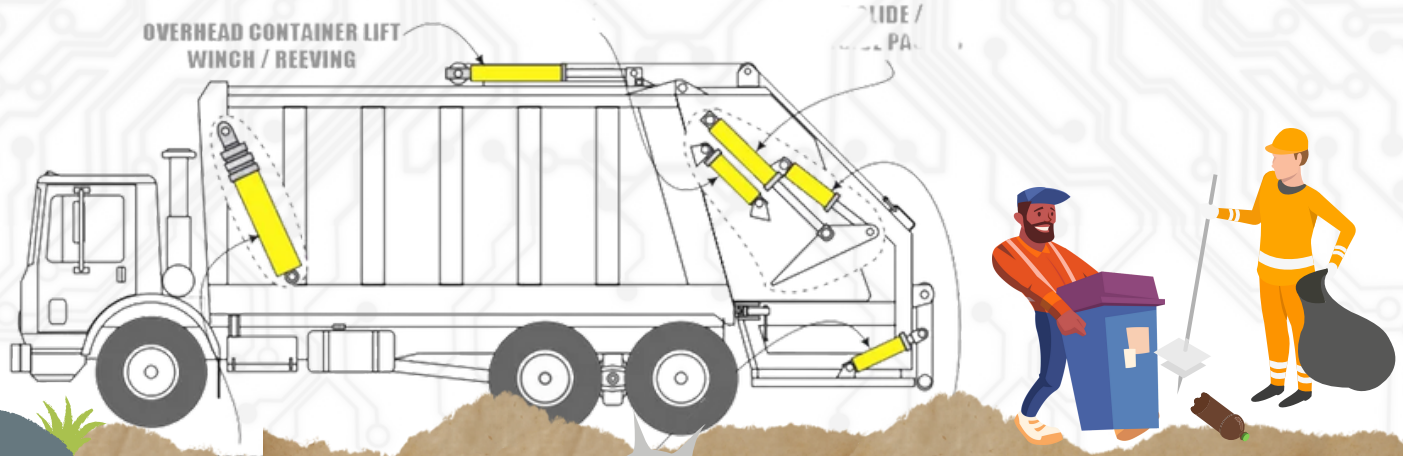
Excavators need hydraulics to carry out their many tasks. These tools are not only used for digging. Additionally, they move and lift bulky items like building panels, equipment, and sewer lines. An upper carriage with an upper deck that rotates 360 degrees hydraulically and an attachment are immediately affixed to a wheeled or crawler undercarriage to form a hydraulic excavator. A bucket, grapple, scrap shear, or similar tool may be found on the front end of an excavator attachment.



application of hydraulic system

Trash compactors

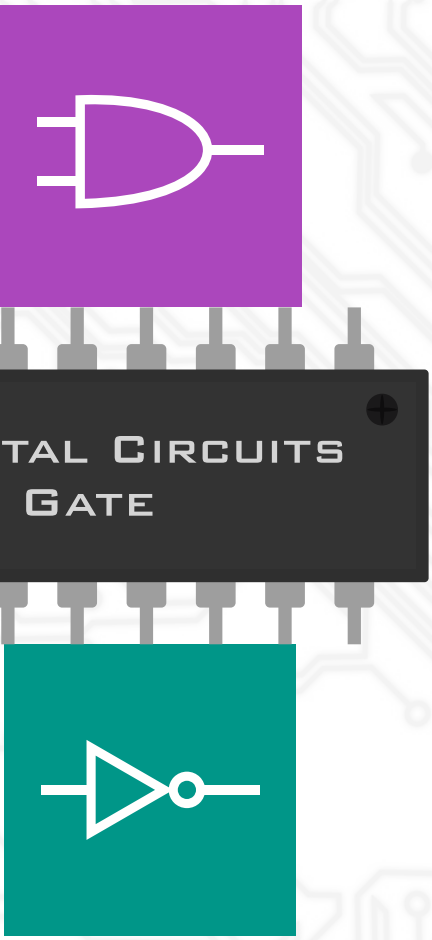
The management of waste is a global problem. Indeed, as we look for greener, more sustainable choices, landfill space is becoming increasingly limited around the world. Hydraulic systems, meanwhile, can help reduce the pressure. Huge amounts of trash are compressed by garbage trucks and compactors using hydraulic force so that it occupies less space. This might help slow down the rate of landfill fill-up. This won't work as a long-term fix. However, it is only a short-term fix that might improve sustainability.



PNEUMATIC SYSTEM VS HYDRAULIC SYSTEM

pneumatic		hydraulic
working fluid is air	#1	working fluid is hydraulic oil
no pump at all	#2	pump is necessary
less expensive	#3	more expensive
produce less power	#4	produce more power

ELECTRICAL SYSTEM



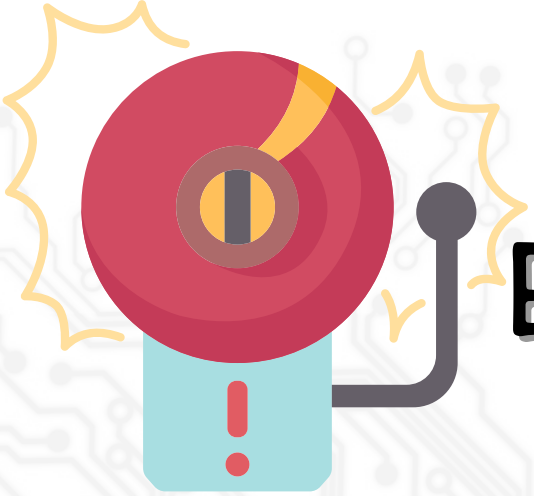
A physical network of connected devices that regulates the behaviour of other systems or devices is known as an electrical control system. Three components make up a basic electronic system: an input, a process, and an output. The system's input and output variables are both signals.

To ensure that the process operates in the most effective and efficient manner possible, electrical control systems are necessary to monitor and change the whole spectrum of process variables. They consist of a network of electrical and electromechanical parts that regulate the behaviour of dynamic process systems via control loops.

application of ELECTRICAL system

Voltage stabilizer

If the supply voltage changes or fluctuates within a certain range, a voltage stabiliser regulates or stabilises the voltage. It is a piece of electrical equipment that delivers steady voltage to a load under overvoltage and undervoltage situations. These voltage conditions are recognised by this device, which then adjusts the voltage to the desired range. Voltage stabilisers offer a way to control the load's supply voltage. These operate the load or system within an appropriate voltage range rather than being designed to output a constant voltage. These are offered as specialised stabilisers for a variety of appliances, including air conditioners, LCD/LED TVs, refrigerators, washing machines, and also as a single, sizable device for all appliances.



application of ELECTRICAL system

HOW FIRE ALARM SYSTEM WORKS?

“detect alert monitor control”

KNOW THE FACTS

Fire alarm system

A fire alarm is a collection of equipment that employs visual and audible signalling to alert people to potential fire, smoke, or carbon monoxide hazards in the vicinity of the alarm. In order to offer residential and commercial buildings with zoned coverage, fire alarms are typically installed in fire alarm systems. By keeping track of all inputs and controlling all outputs, the fire alarm control unit acts as the fire alarm system's brain. This may also be referred to as a fire alarm panel or fire alarm control panel. Detectors for heat, smoke, and carbon monoxide are a few types of fire alarm systems

test yourself

1.Express the block diagram of the direction control system of a bicycle rider.

2.Differentiate the pneumatic, hydraulic and electrical control system.

3.Express a suitable diagram for a windshield wiper control system

4. Consider a semi-auto washing machine as shown in figure. Identify whether the system is an open loop or closed loop system. Hence, sketch the relevant block diagram

REFERENCES

Bolton, W. (2015). Instrumentation and Control Systems. Oxford: Newnes.

Ogata, K. (2010). Modern Control Engineering (5th ed). One Lake Street, Upper Saddle River, New Jersey: Prentice Hall.

Nise, N.S. (2015). Control Systems Engineering. New York: John Wiley.

Bolton, W. (2002). Control Engineering. Harlow, Essex, England: Longman.

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