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Chapter 1, Problem 1P

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Step-by-step solution

Step 1 of 3

Block diagram for the control system generated when a human being steers an automobile.

Let, human being driving an auto mobile on a road. Few meters far away a speed breaker is present on the road.

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Step 2 of 3

Whenever automobile reaches the speed breaker, human being slows down the vehicle and steers further in smooth way with less bounces.

In this process, human being can calibrate the automobile speed with the help of speedo meter. After calibration of speed of automobile, he/she compares the speed with desired speed for smooth journey. To cross the obstacle (speed breaker) human being applies brakes on automobile to slow down it.

To maintain the low speed, pressure on accelerator/gas paddle will decrease and further gear will shift to down as well as fuel injection rate to the engine will also be decreased.

Comment

Step 3 of 3

The above whole process is shown in the following block diagram.

The block diagram illustrates a feedback control system for maintaining a desired speed. The process begins with a 'Set Velocity (Set point)' input to the 'Human Mind (Comparator)'. The 'Human Mind (Comparator)' outputs an 'Error' signal to the 'Breaks (Controller)'. The 'Breaks (Controller)' outputs a 'Command signal' to the 'Accelerator (or) Gas Paddle (Final Control Element)'. A 'Speed Breaker (Load)' is shown as an external input to the system, affecting the 'Gears and Engine (Process)'. The 'Accelerator (or) Gas Paddle (Final Control Element)' and the 'Speed Breaker (Load)' both influence the 'Gears and Engine (Process)'. The 'Gears and Engine (Process)' outputs the 'Desired Speed'. A 'Speedometer (Measuring element)' measures the 'Desired Speed' and provides feedback to the 'Human Mind (Comparator)'.

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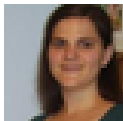
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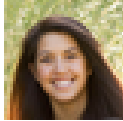
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Problem

Draw a block diagram for the control system generated when a human being shoots a bow and arrow.

Step-by-step solution

Step 1 of 4

Block diagram is the depiction of relationship between the variables of the system. It is useful in interpreting the relationship of input and output signal from a block, and to get an overall idea of information flow through the system.

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Step 2 of 4

Let's understand the functions in human body when an arrow is tied on a bow and aimed at an object or a distance.

Comment

Step 3 of 4

The purpose of shooting an arrow is to aim something. The aim could be a distance, an object, etc. So, the set point is the desire to launch arrow to that distance or hit the object. In order to do so, brain must decide the force and direction with which the arrow should be launched to give the desired output. Brain sends the signal to hands and eyes to do so. Then the arrow is released and eyes are used to observe the deviation of arrow from the aim. Eyes send the signal to brain to adequately change the force and direction to hit the aim. While doing this all, air speed and air resistance is also taken into consideration which acts as disturbance to arrow's movement.

Therefore, we can conclude,

Set point: Distance or object;

Controller: Brain;

Control Signal: Electrical signal carried to eyes and hands;

Final Control Element: Eyes and hands;

Manipulated Variable: Change of direction and force applied on arrow;

Disturbance: Air speed, air resistance;

Process: Shooting of arrow;

Controlled Variable: Actual distance or aim achieved;

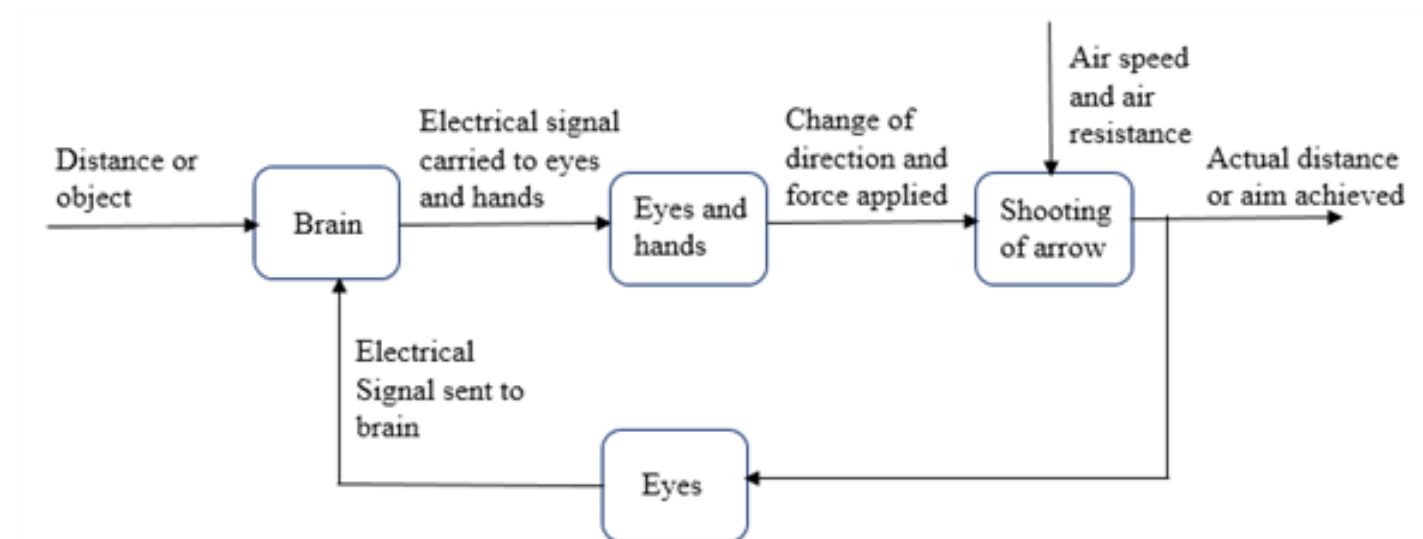
Measurement Device: Eyes;

Measurement Signal: Electrical Signal sent to brain.

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Step 4 of 4

So, the block diagram of control system generated when a human being shoots an arrow is,



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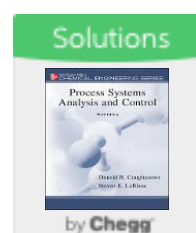
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Problem

Draw a block diagram for an automobile cruise control system.

Step-by-step solution

Step 1 of 3

The cruise control system is used to maintain the constant speed of the vehicle without the need of using accelerator. This system is particularly important when someone wants to drive at constant speed and reduces the stress on driver to maintain the speed. Let's understand the mechanism of cruise control system.

Comment

Step 2 of 3

The cruise control system is only activated after achieving the desired speed, though it can depend on manufactures. The system gets deactivated as soon as brakes and clutch are used. When the desired speed is achieved cruise control system is activated. The cruise control computer sends the signal to vacuum actuator which controls the flow of fuel into the combustion chamber. Disturbances like, heat losses and friction on vehicle affect the performance of engine (combustion chamber). The speed of the vehicle is monitored by vehicle speed monitor (speedometer) and it sends vehicle speed signal to cruise control computer creating a closed loop control system.

Therefore, we can conclude,

Set point: Desired speed;

Controller: Cruise Control Computer;

Control Signal: Vacuum Valve Control Signal;

Final Control Element: Vacuum Actuator;

Manipulated Variable: Manipulated fuel flow to combustion chamber;

Disturbance: Heat losses, friction;

Process: Combustion chamber (engine);

Controlled Variable: Actual speed;

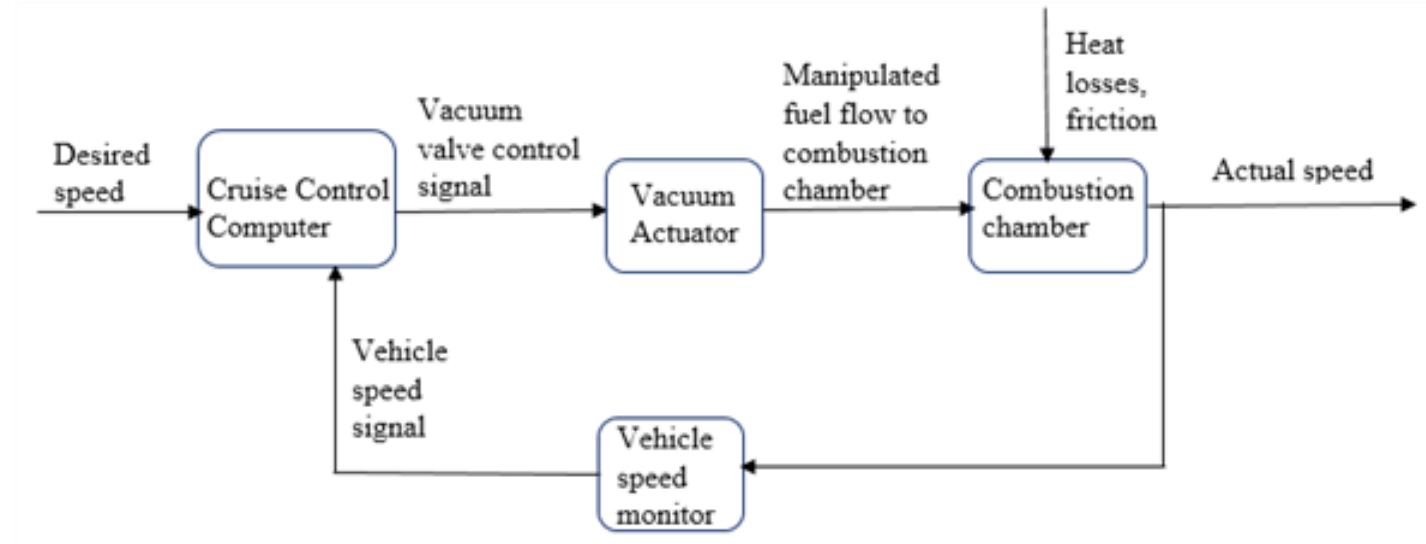
Measurement Device: Vehicle speed monitor (speedometer);

Measurement Signal: Vehicle speed signal.

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Step 3 of 3

Hence, block diagram for the cruise control system is,



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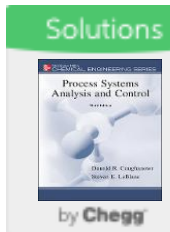
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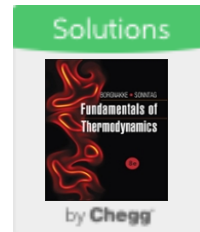
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Problem

Draw a block diagram for the control system that maintains the water level in a toilet tank.

Step-by-step solution

Step 1 of 3

Ever wonder, despite having no electrical connection to toilet tank, how it automatically gets filled and dumps water to the bowl. There are different components in a toilet tank, i.e. handle arm, fill valve, refill tube, float arm, float ball, overflow tube, flush valve, flapper, drain hole; which combinely forms a very highly effcent design of toilet tank.

Let us first understand the mechanism of toilet tank and layout all the components that we will be using as blocks for our block diagram of maintaing water in the toilet tank.

Comment

Step 2 of 3

When the handle arm is pressed, a chain attached to handle arm and flapper, pulls up the flapper and opens the drain hole. As the water drains out, the float ball attached to handle lowers down with the level of water in the tank and restores the handle arm to its initial position. Restoring of handle arm pushes the flapper down and closes the drain hole. The piston attached to handle arm gets opened because of lowering of float ball and fills the tank. When the tank is filled, the float ball lies in horizontal position and closes the piston to water inlet.

Therefore, the following conclusions can be drawn,

Set point: Keeping the tank filled with water;

Controller: Handle arm;

Control Signal: Chain loosening to push flapper down;

Final Control Element: Flapper;

Manipulated Variable: Float ball downward movement to open piston to water inlet;

Disturbance: Keeping the handle arm pressed;

Process: Toilet tank filling;

Controlled Variable: Actual water level reached in tank;

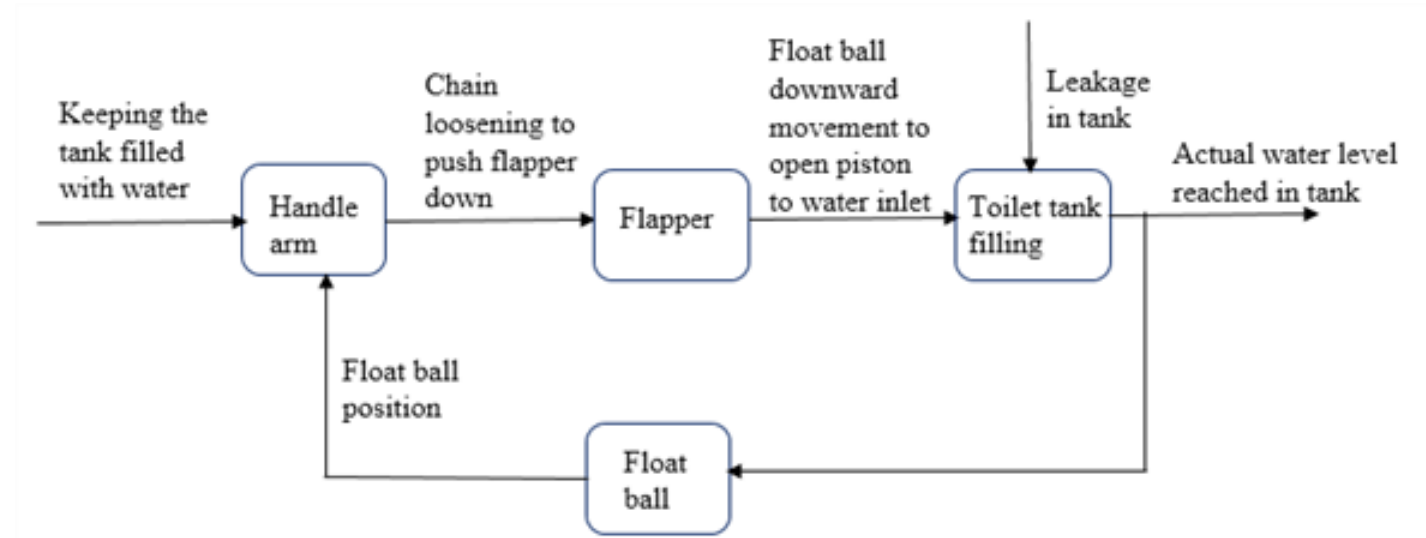
Measurement Device: Float ball;

Measurement Signal: Float ball position.

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Step 3 of 3

Now, let's construct the block diagram of maintaining water in toilet tank.



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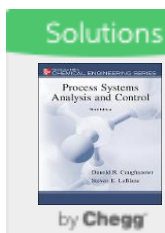
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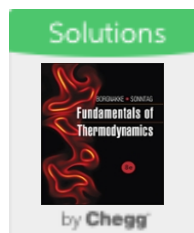


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Problem

Draw a block diagram for a security lighting system that activates at dusk and turns off at dawn.

Step-by-step solution

Step 1 of 4

We have seen in animated series that a bird sits in the light and when the night comes, it turn on the light and go to sleep. Fascinating, isn't it? In real life, this bird is witched with a circuit, so when the light falls below a threshold limit, the security light system (automatic lights) automatically turns on.

Comment

Step 2 of 4

Let's understand the mechanism, how this works and create a control system block diagram for it.

Comment

Step 3 of 4

The security light system uses the following components: a photo resistor (e.g. cadmium sulfide or CdS), a relay, a transistor, bulb and a power source.

During dawn, the high intensity of sunlight falling on the photo resistor reduces its resistance and allows the current to flow through it. The current is then amplified by the transistor which activates the relay. The activation of relay opens the bulb circuit and turn off the light.

Set point: Lights off;

Controller: Transistor;

Control Signal: Large amplified current;

Final Control Element: Relay;

Manipulated Variable: Relay activation;

Disturbance: Artificial light;

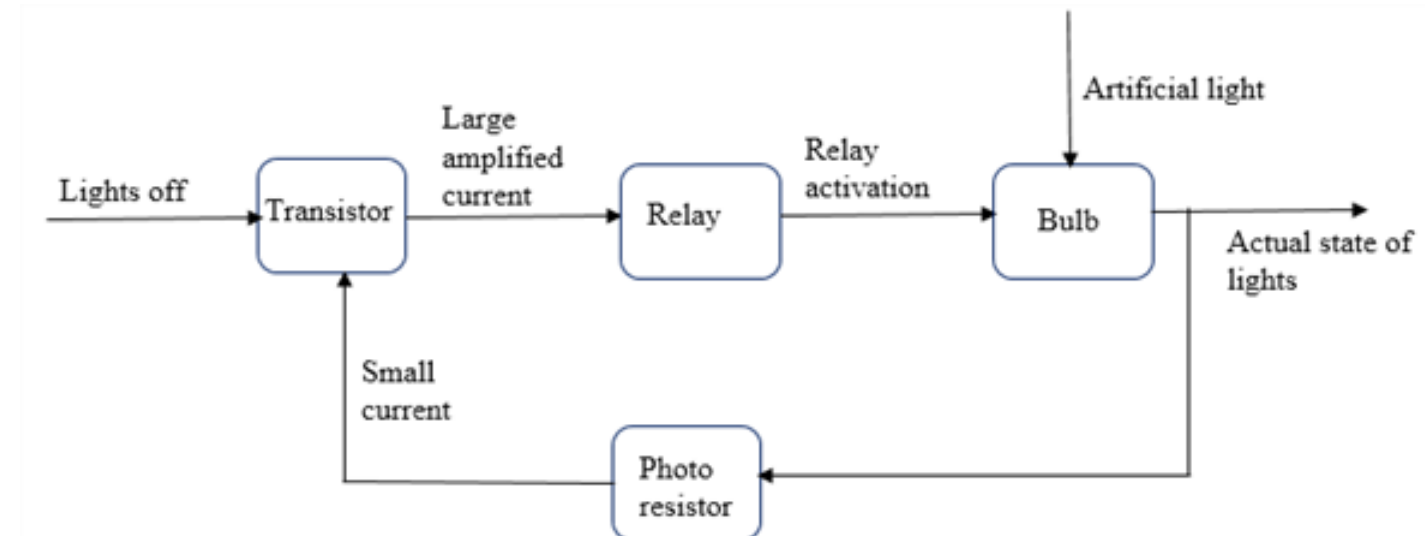
Process: Bulb;

Controlled Variable: Actual state of light;

Measurement Device: Photo resistor;

Measurement Signal: Small current.

Hence, block diagram for the above system is as follows:



Comment

Step 4 of 4

During dusk, the low intensity of sunlight increases the resistance of photo resistor and allows very small amount of current to pass through it. The current is so small that it can't be amplified enough by the transistor to activate relay. Hence, relay gets deactivated, the bulb circuit gets closed and turns on the light.

Set point: Lights on;

Controller: Transistor;

Control Signal: Small amplified current;

Final Control Element: Relay;

Manipulated Variable: Relay deactivation;

Disturbance: Daytime overcast;

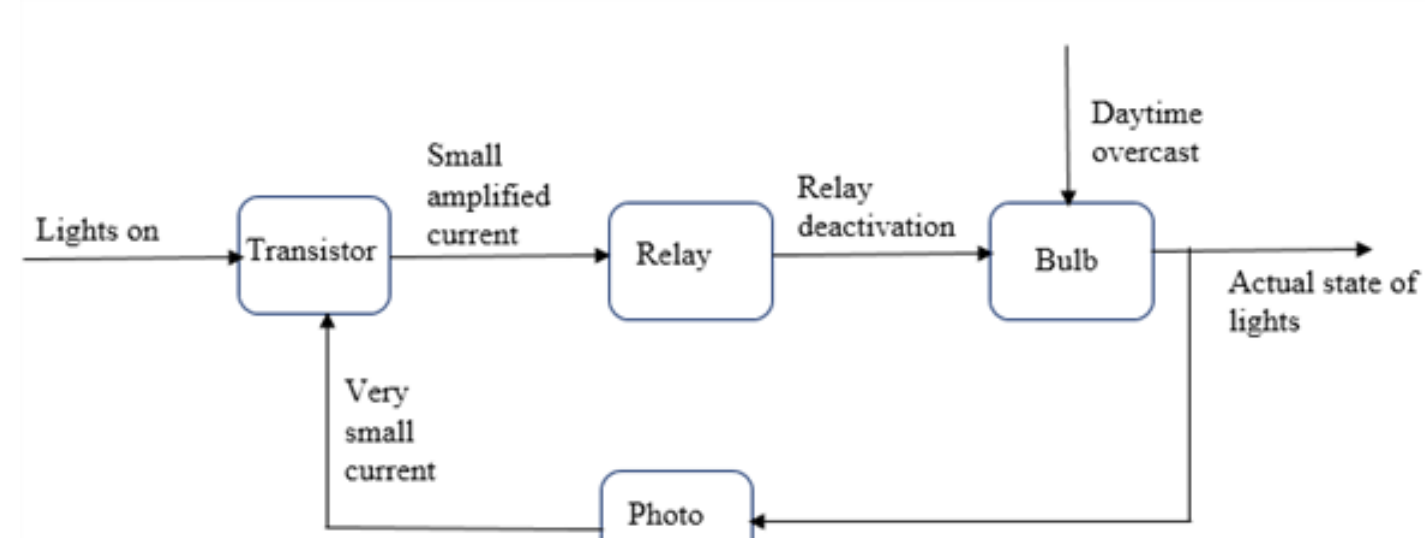
Process: Bulb;

Controlled Variable: Actual state of light;

Measurement Device: Photo resistor;

Measurement Signal: Very small current.

Hence, block diagram for the above system is as follows:



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Problem

Draw a block diagram for the control system for a home oven.

Step-by-step solution

Step 1 of 3

Home (electric) oven is a very useful device for our daily purposes. Oven is used to cook food at desired temperature for desired time. This control of temperature and time not only saves energy and money but improves the quality of cooked food by delivering it the way we want it.

Let's understand the mechnaism of home oven and create a control system diagram for it.

Comment

Step 2 of 3

In oven, there are two knobs given; one to set temperature and another to set time. We here will be dealing with temperature knob because time knob is just a simple addition of on/off switch over the temperature control system which is the most basic and most important part of oven design.

With temperature knob, we set the desired temperature, the thermostat which acts as controller sends signal to heating element to start heating the chamber. Heating chamber according to the difference in temperature then decides the energy flow rate with which the heating should be done. The temperature sensor measures the actual temperature and sends the signal to the controller to calculate error. And that's how the oven maintains its temperature.

Therefore, we can deduct the following things:

Set point: Knob position for desired temperature;

Controller: Thermostat;

Control Signal: Error between the desired temperature and actual temperature

Final Control Element: Heating element;

Manipulated Variable: Energy flow rate;

Disturbance: Heat absorbed by food, ambient temperature, door opening/closing;

Process: Baking;

Controlled Variable: Actual temperature;

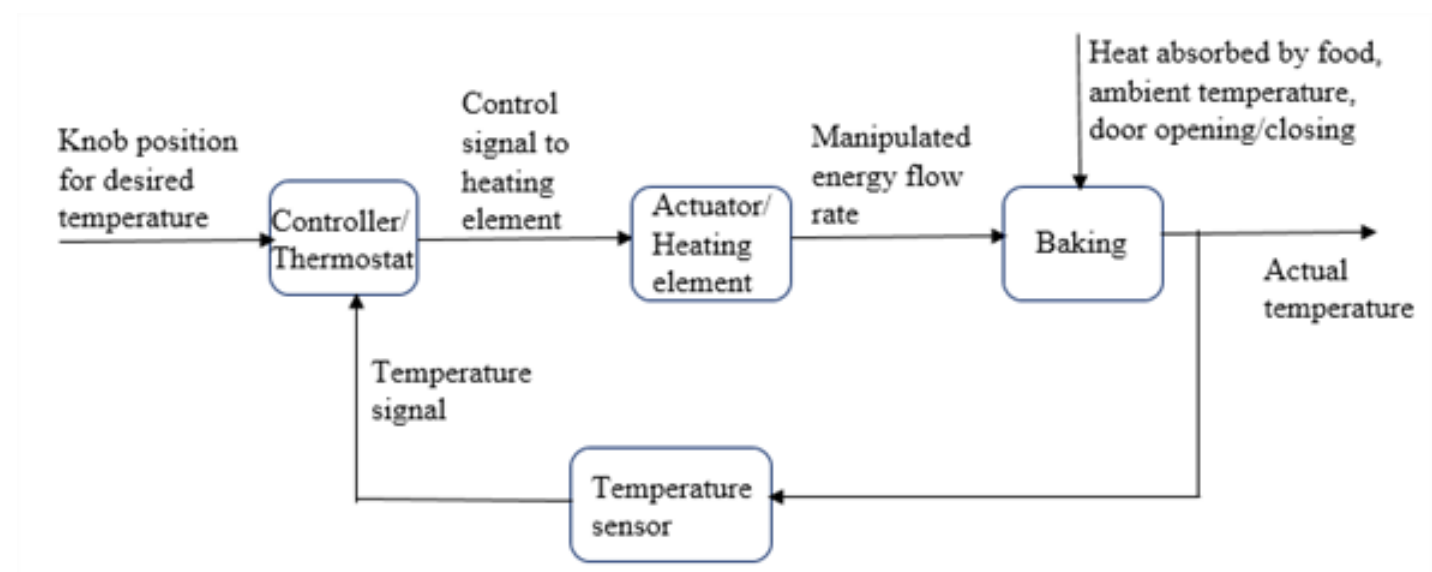
Measurement Device: Temperature sensor;

Measurement Signal: Temperature signal.

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Step 3 of 3

Hence, construct the control system for electric oven.



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