Modelling:

Models can be based on equation, data.

Different types of modelling using Simulink:

i) Mathematical Models (Writing equations)

1.First Principles

2.Component-based physical models

ii) Black Box Models (Solely based on input and output data)

1.Lookup Tables

2.System Identification *(Dynamically changing functions using curve fitting)

iii)Grey Box Models (We know some eqns. but not sure about the parameters so we write eqns. and collect data so that the data can be used to tune the parameters)

1.Parameter estimation*

*Powerful tools

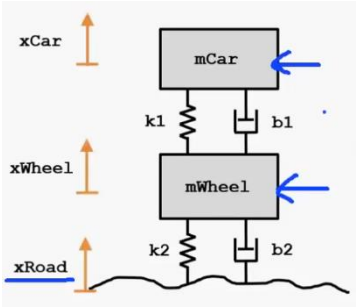
Models can be generally divided into 2 parts:

i) Plant Model- Virtual Prototype of a real physical System and these systems can be modelled with the help of data collected from the real system (or) getting the mathematical equation from physics

ii) Algorithm- Control and Logic systems, Design in Simulink and then generate code for the embedded system

Simulink helps us to combine these 2 parts

Suspension System of Cars:



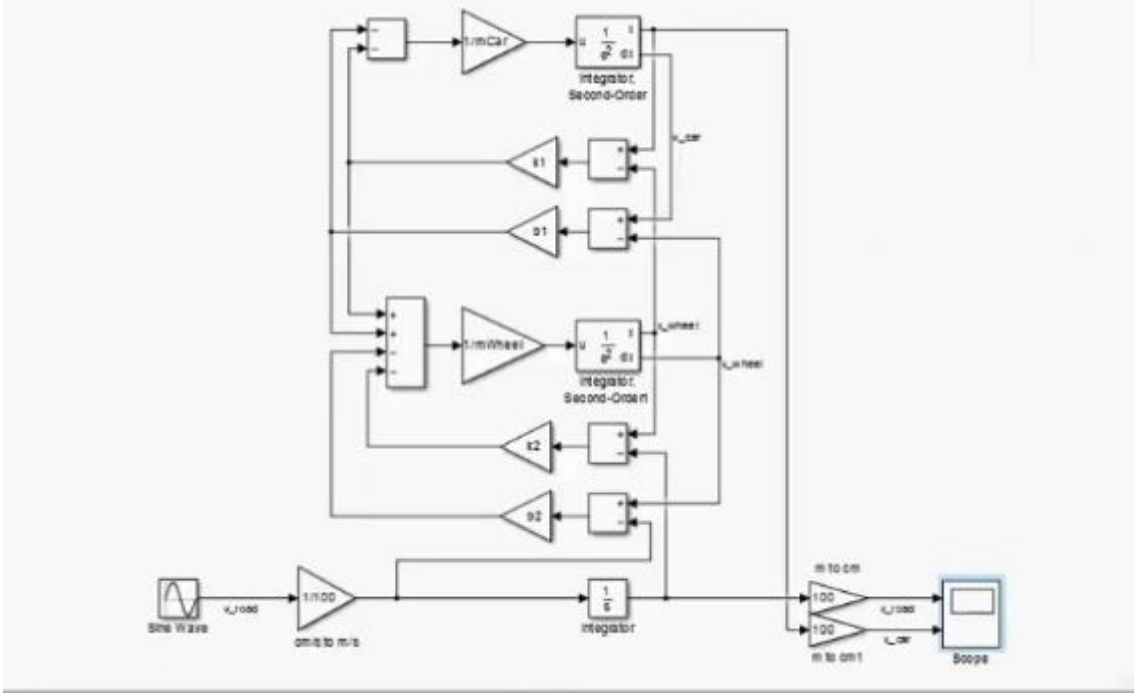
There is assumed to be one extra set of spring and damper one between the wheel and the road and the other which is physically present

This is done in real cars because to account for the wheel squishing against the road, but we can choose to neglect this in shadow bot

Mathematical Modelling of Car suspension:

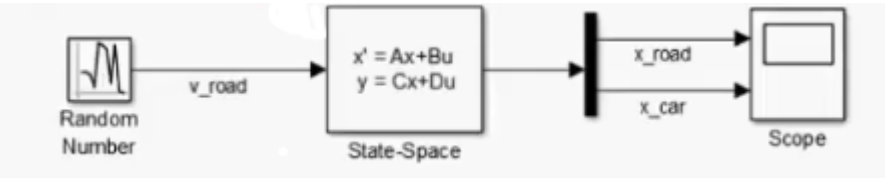
$$m_{car}\ddot{x}_{car} + b_1(\dot{x}_{car} - \dot{x}_{wheel}) + k_1(x_{car} - x_{wheel}) = 0$$

$$m_{wheel}\ddot{x}_{wheel} - b_1(\dot{x}_{car} - \dot{x}_{wheel}) - k_1(x_{car} - x_{wheel}) + b_2(\dot{x}_{wheel} - \dot{x}_{road}) + k_2(x_{wheel} - x_{road}) = 0$$



Instead of this type of modelling we can also use transfer functions or state space model

State Space Model:



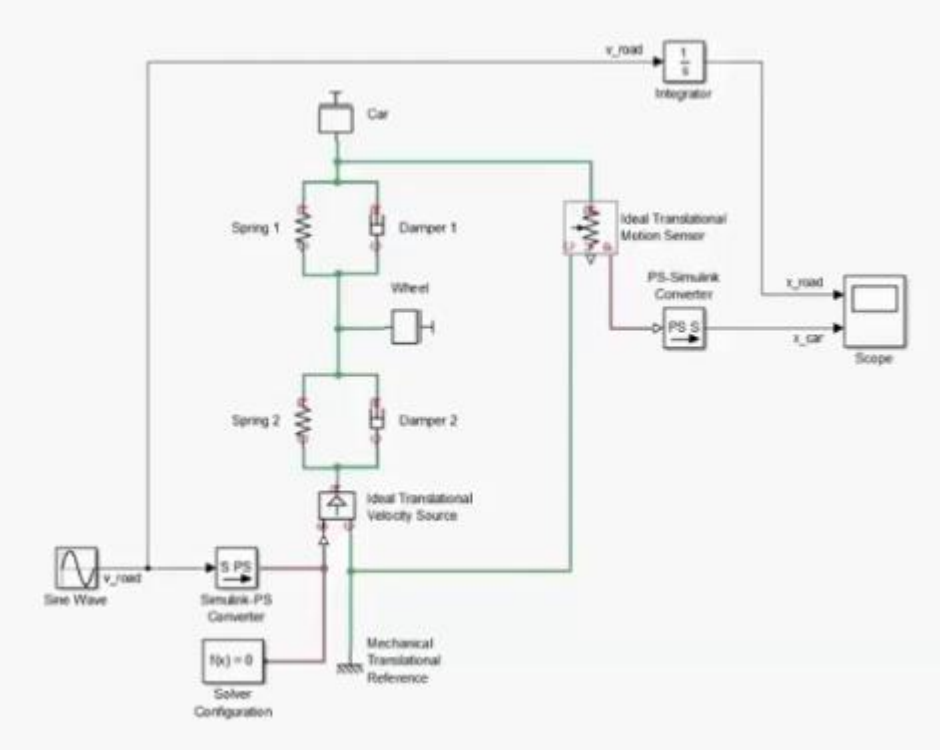
We can see that the previously huge block became a linear one

The state-space block contains the equation in 4 matrices (A, B, C, D)

Component Based Modelling (Simscape):

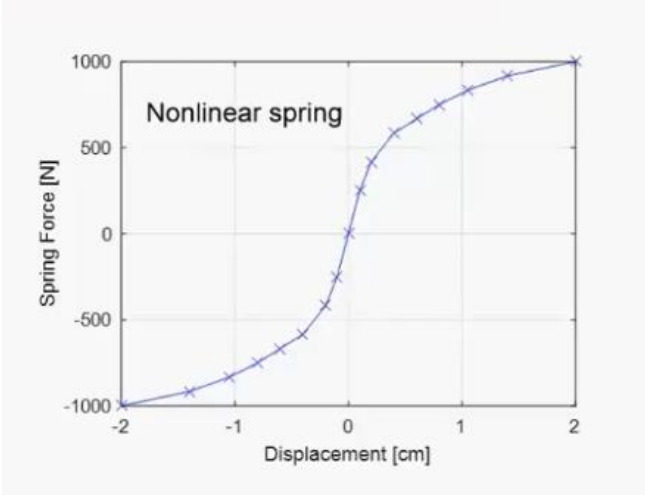
Simscape a tool for physical modelling which has blocks which has the equations inside it i.e. we don't need to know the equations and if there are any changes in the system then we don't need to re formulate the eqns. again from scratch we can just alter the blocks

Both Simulink and Simscape are compatible i.e. we can integrate plant model in Simscape and control in Simulink with the help of interface blocks



Black Box Approach:

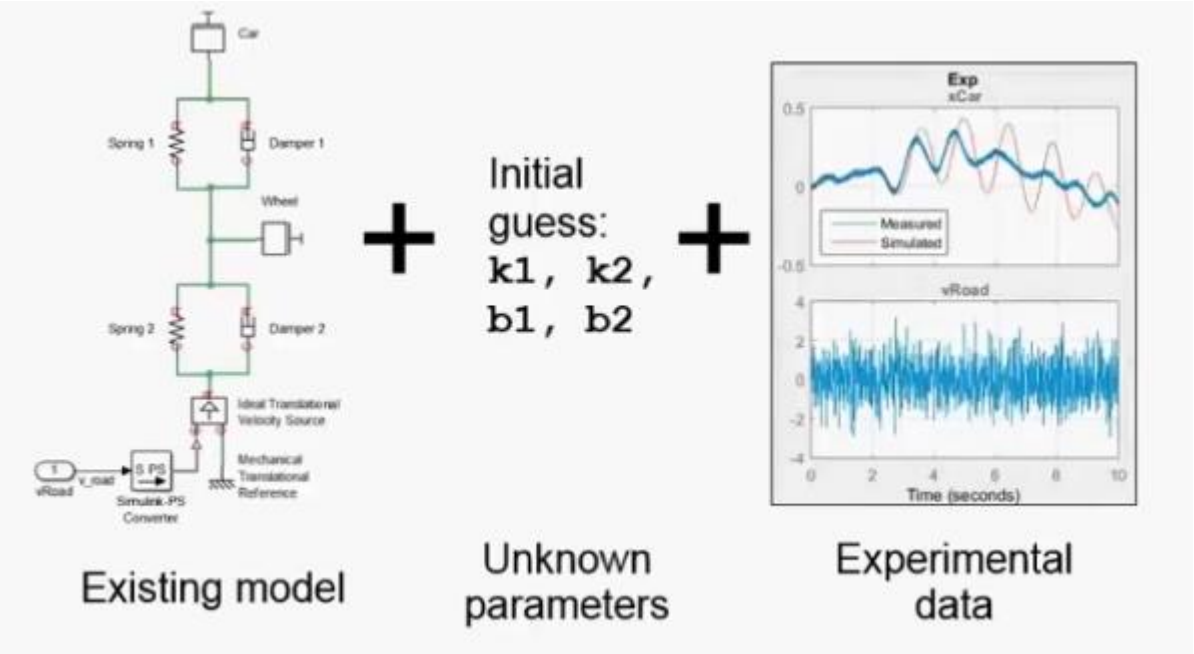
We have this data:



We can import data from excel sheets or text file

We simply insert a block stating the parameters from the file which has the plots

Parameter Estimation:



In this method if it takes too long for the computer to iterate and simulate the data we could something called as parallel computing &|| GPU computing which would be really cool.

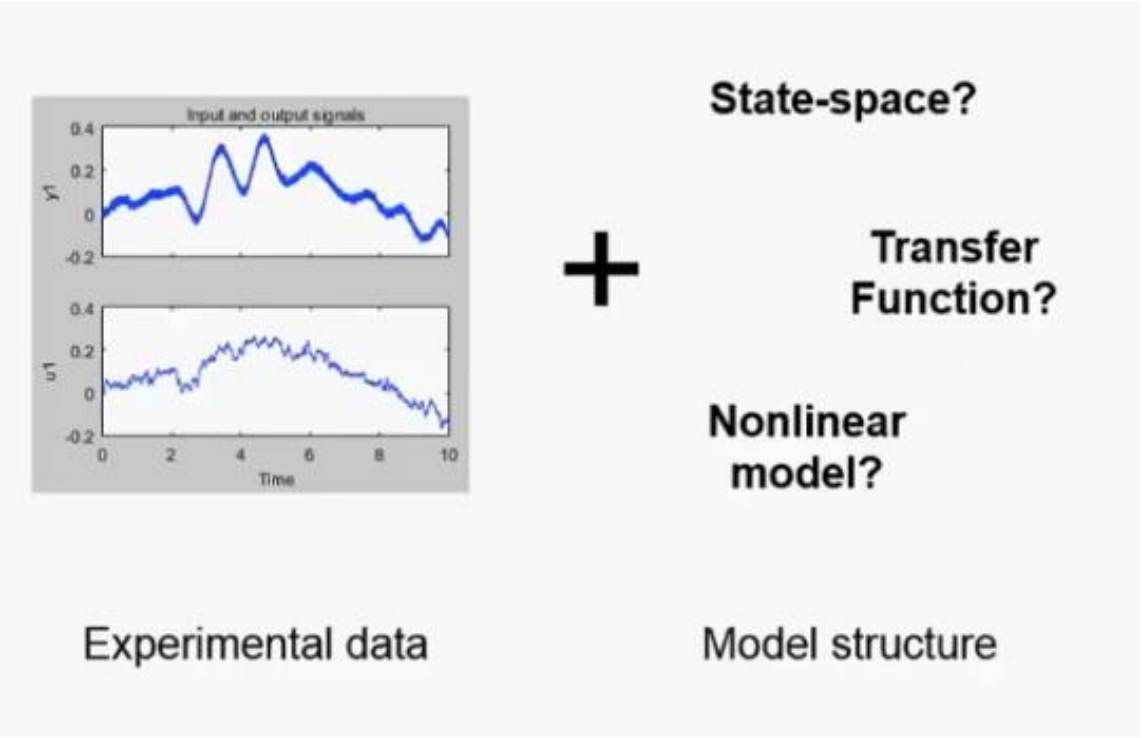
Here the parameters are given an initial guess and MATLAB iterates the simulation many number of times to get an **optimised** value for those parameters (We will have to read about optimisation theory)

System Identification:

This type of modelling is done when we don't know anything about the system except for input and output data

Here we could really play around with MATLAB and write different Model structures such as state space/ transfer function/ Non-linear model, but for a particular system a particular model structure will work flawlessly, so we'll have to decide which structure we are going to use in case we are going to use system identification modelling.

To get the best model structure we start with the simpler linear model (State Space) and if it does not work fine then we go to transfer function or non-linear structure



System Identification by state space approach:

By using state space model, we could know the different states of the system at any instant

Here we specify the order of the system, i.e. the number of system variables

Guidelines for choosing from the different model approach

1.How much we know about the model (Physics of the model)

> If we know everything then we could use the mathematical approach in which the model will be the most accurate to real world, but In case we don't know anything about the model it is okay to use system identification approach

2.How much detail we want from the model.