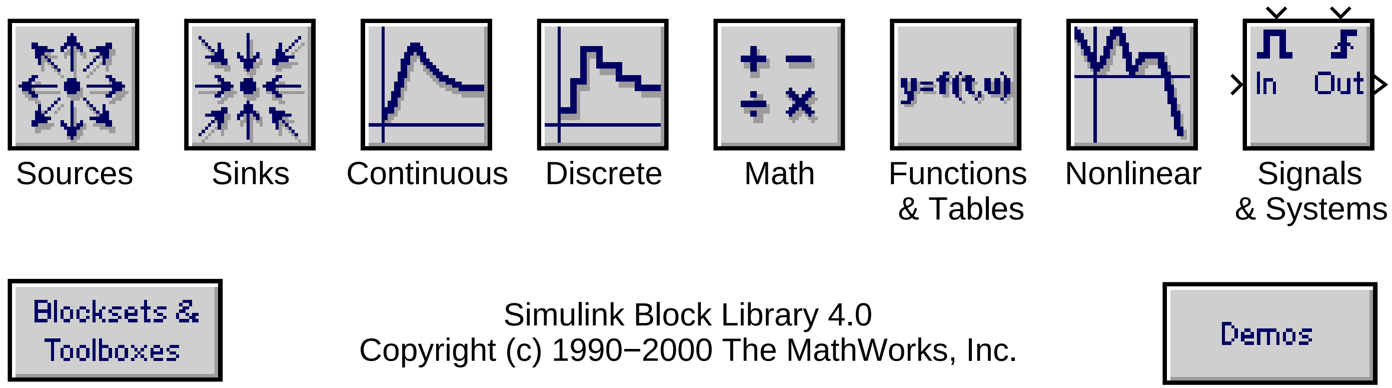
Simulink

- Matlab is a numerical package well suited for solving linear systems, differential equations, and engineering design problems.
- Simulink is a specialized package in Matlab with graphical user interface for design and study of engineering control systems especially for modularly designed hierarchical systems..
- The basic option list which will be found when Simulink is calledup from Matlab as illustrated below.



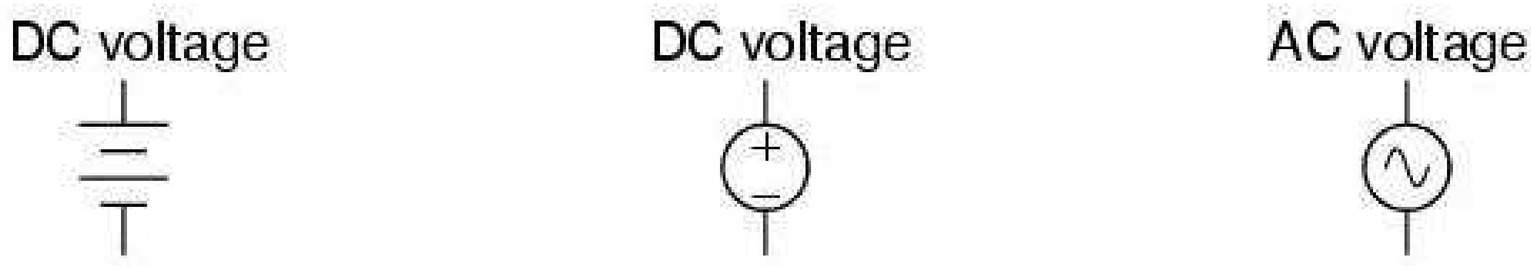
Electrical symbols I

Traditional approaches to Control Design evolved from engineering fields, primarily electrical engineering. Indeed, early linear system theory borrowed heavily from electrical terminology and schematic diagrams as did early applications in physiology. There are useful analogies between electrical systems and other dynamic systems as can be seen in Table 1.

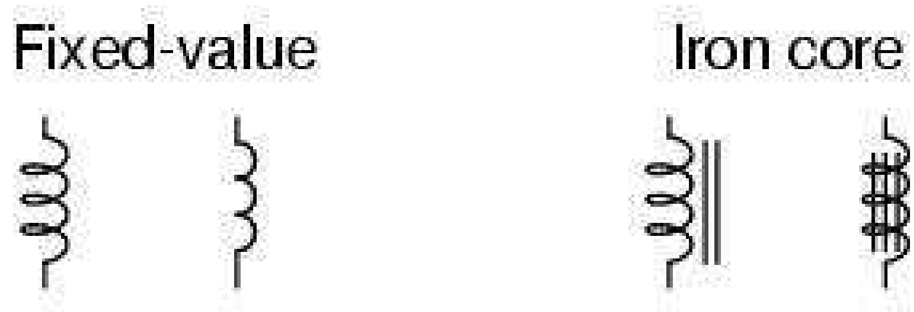
Electrical	Physiological
Voltage	Fluid Pressure
Resistance	Vascular Resistance
Capacitance	Compliance
Inductance	Fluid Mass or Inertia

Electrical symbols II

The following symbols are used for the electrical quantity voltage:

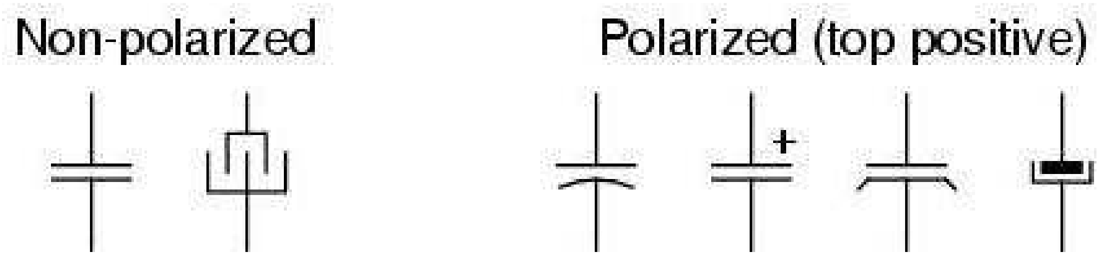


The following symbols are used for the electrical quantity inductance:

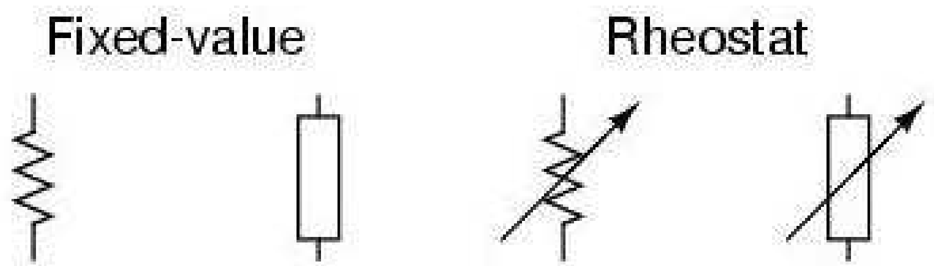


Electrical symbols III

The following symbols are used for the electrical quantity capacitance:



The following symbols are used for the electrical quantity resistance:



Electrical symbols IV

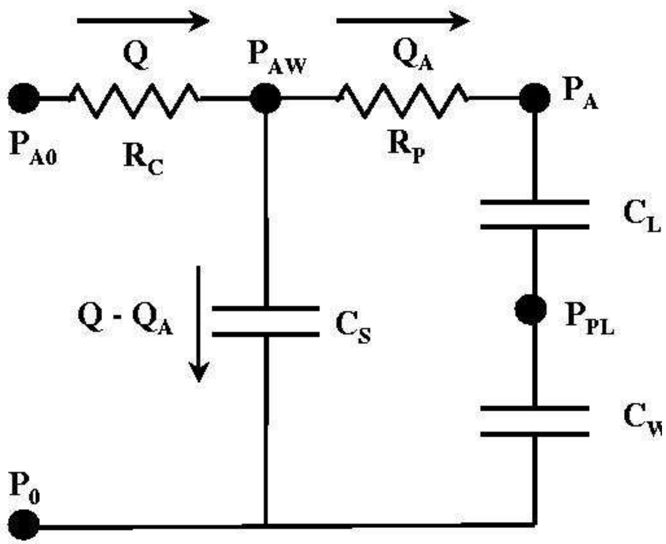
We also will apply Kirchhoff's Laws to set up flow relations.

Definition 1 ***Kirchhoff's First Law*** *states that the algebraic sum of the across-variable values (voltages) around any* ***closed*** *loop must be zero.*

Definition 2 ***Kirchhoff's Second Law*** *states that the algebraic sum of all through-variable values (currents) into any given node must be zero.*

Lung mechanics model I

The lung mechanics model considers the relation between air flow volumes Q and various pressures in the lungs. The model considers air flow resistance R, compliances C of air flow compartments, and pressures P. An electrical analogy schematic diagram is given in the Figure and the Table gives the meaning of the parameter symbols.



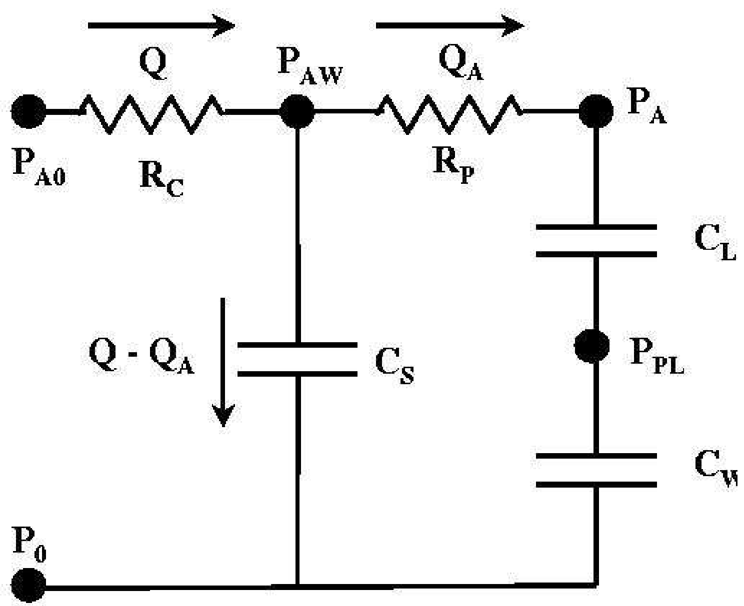
Lung mechanics model II

Table 1: Physiological parameters

Parameter	Symbol
C_W	chest wall compliance
C_L	lung compliance
C_S	shunt compliance
R_P	peripheral airway resistance
R_C	central airway resistance
P_{ao}	pressure at airway opening
P_{pl}	pressure in pleural space
P_{aw}	pressure in central airway
P_A	pressure in alveoli
P_0	ambient pressure
Q_A	airflow in alveoli
Q	total airflow

Lung mechanics model III

As the air flows into the air passages, it encounters different resistances in the central and peripheral airways. Furthermore, spatial volumes are effected by the compliant nature of these structures. The model also includes the effect of shunting of a portion of the air away from the alveoli compartment as a result of disstention of the conducting airways and gas compression.

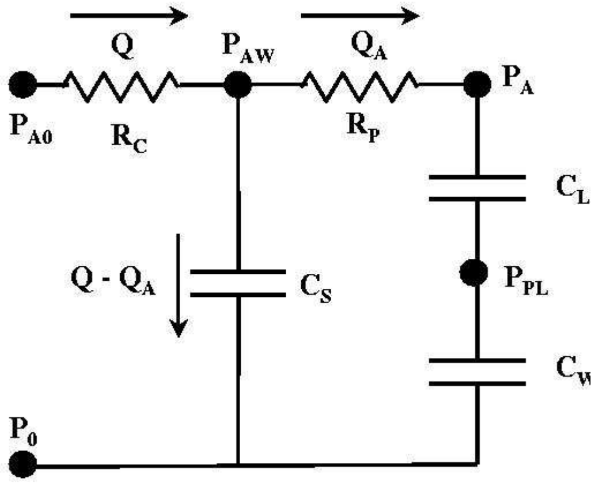


Lung mechanics model IV

The model equation takes the form:

$$\frac{d^2 P_{ao}(t)}{dt^2} + \frac{1}{R_P C_T}\frac{dP_{ao}(t)}{dt} = R_C \frac{d^2 Q(t)}{dt^2} + (\frac{1}{C_S} + \frac{R_C}{R_P C_T})\frac{dQ(t)}{dt} + \frac{1}{R_P C_S}(\frac{1}{C_L} + \frac{1}{C_W})Q. \quad (1)$$

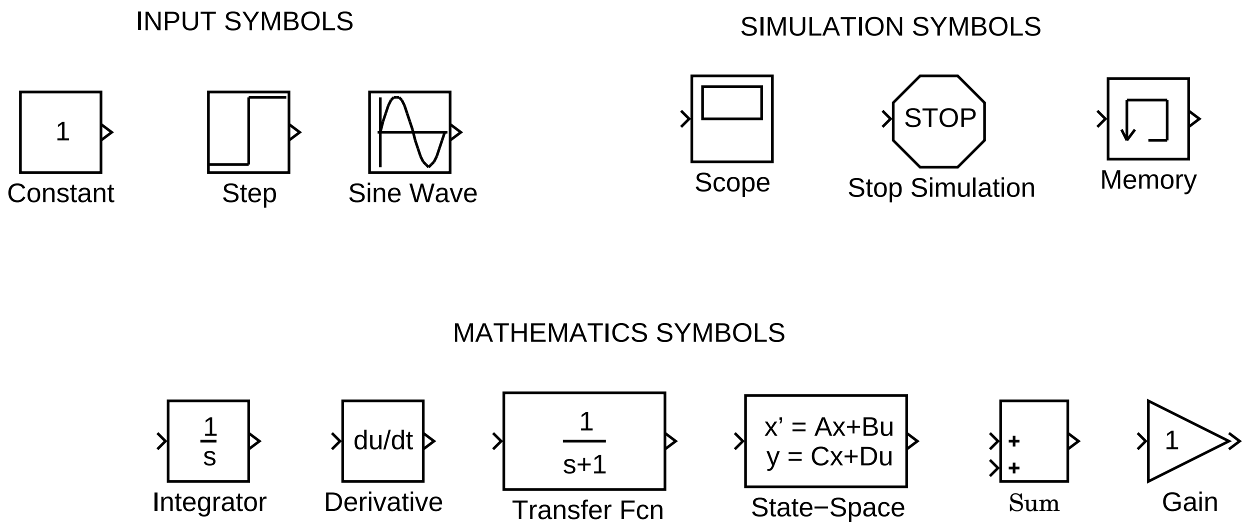
The derivation of the lung model equation is made via Kirchhoff's Laws applied to the electrical circuit representation given in the Figure.



Simulink II

To translate an electrical or physiological system to a Simulink flow diagram one needs to keep in mind the following points.

- In a certain sense, Simulink diagrams are "calculation flow charts" which describe the interrelation between quantities in the system.
- The lung mechanics model below shows computational relations between pressures P, resistances R, capacitances C, and flows Q.



Simulink Lung Model