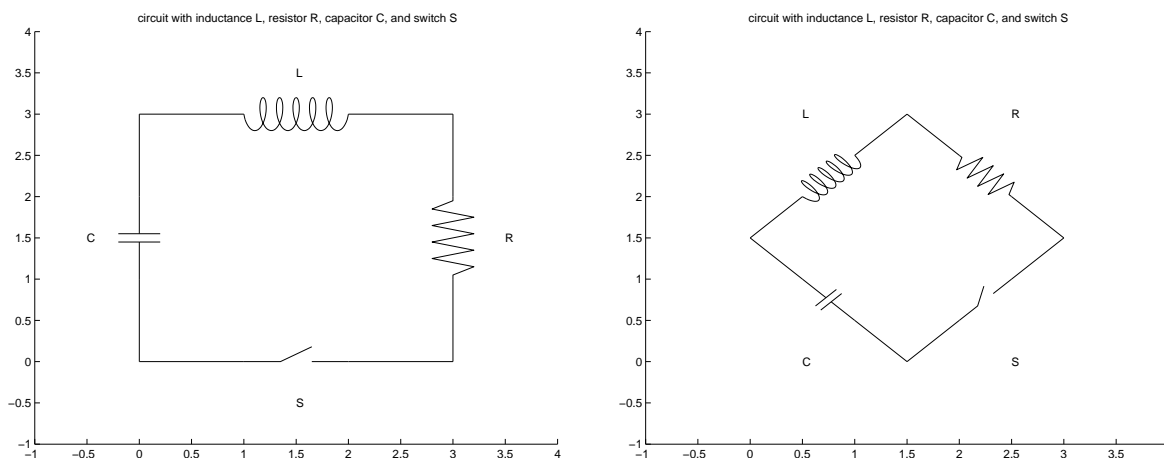


## MCS 320 Project Three: plotting circuit with MATLAB due Friday 2 December 2005, at 2PM.

The purpose of the project is to explore the capabilities of MATLAB to plot electrical circuits. We will create a set of m-files which form a toolkit to plot circuits easily.

### 0. Electrical Circuits, Translations, and Rotations

The typical elements which appear in an electrical circuit are a capacitor (C), an inductor (L), a resistor (R), and a switch (S), graphically represented below:



The two plots above contain these four typical elements, connected by eight lines. The strategy to make the plotting flexible and reliable is to make use of translations and rotations. First we plot the element (S,R,L,C) horizontally, at the line starting at  $(-1, 0)$  and ending at  $(+1, 0)$ . Then, for given new start and end points  $A(x_1, y_1)$  and  $B(x_2, y_2)$  respectively, we translate all points of the horizontal plot to the center of the new line segment defined by  $A$  and  $B$ , followed by a rotation. The coordinate transformation from the original position at  $(x, y)$  to the new position  $(X, Y)$  is given by

$$\begin{bmatrix} X \\ Y \end{bmatrix} = \begin{bmatrix} \frac{x_2-x_1}{2} & -\frac{y_2-y_1}{2} \\ \frac{y_2-y_1}{2} & \frac{x_2-x_1}{2} \end{bmatrix} \begin{bmatrix} x \\ y \end{bmatrix} + \begin{bmatrix} \frac{x_1+x_2}{2} \\ \frac{y_1+y_2}{2} \end{bmatrix}.$$

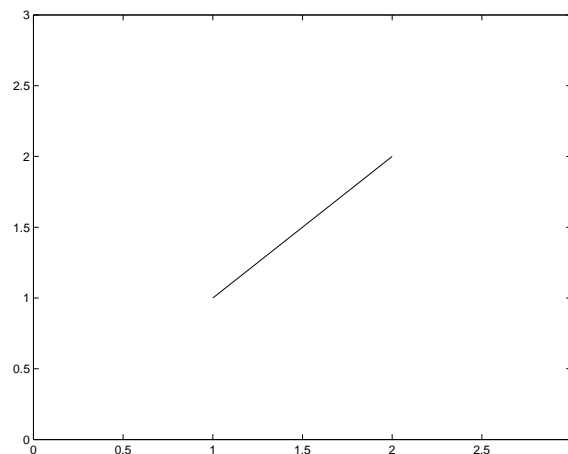
Notice that the rightmost vector in the formula above is the midpoint of the line segment starting at  $A$  and ending at  $B$ . The origin  $(0, 0)$  in our original plot is translated to that midpoint. The matrix defines the rotation. In its columns are the images of the basis vectors  $(1, 0)$  and  $(0, 1)$  in the original coordinate system. Observe that the first column of the matrix contains the coordinates of the endpoints  $B$  minus the coordinates of the midpoint. To preserve orthogonality and proportions, the second column of the matrix is orthogonal to the first column and has the same length.

## 1. Lines and Frames

The frames of the circuits are made up out of lines, plotted by the following m-file.

```
function plot_line(A,B)
%
% plot_line(A,B) plots a line,
% starting at position A and ending at B.
%
% ON ENTRY:
%   A      x and y coordinates of start position;
%   B      x and y coordinates of end position.
```

The commands `plot_line([1,1],[2,2])` and `axis([0 3 0 3])` give the plot:



**Assignment One.** Complete the function `plot_line`. Use `plot_line` to make the frames of the circuits plotted on page 1.

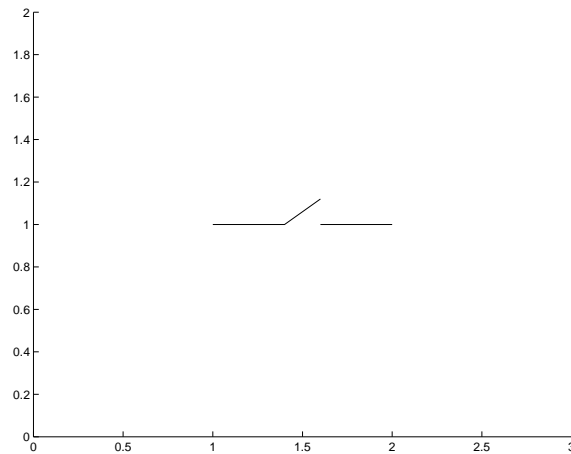
## 2. Switch and Capacitor

To plot a switch, we use the following function:

```
function plot_switch(s,h,A,B)
%
% plot_switch(s,h,A,B) plots a switch,
% of size s and relative height h,
% starting at position A and ending at B.
%
% ON ENTRY:
%   s      size of the switch is the gap;
%   h      relative height of the switch,
```

```
%      the height of the opening is h*s*0.5;
%  A    x and y coordinates of start position;
%  B    x and y coordinates of end position.
```

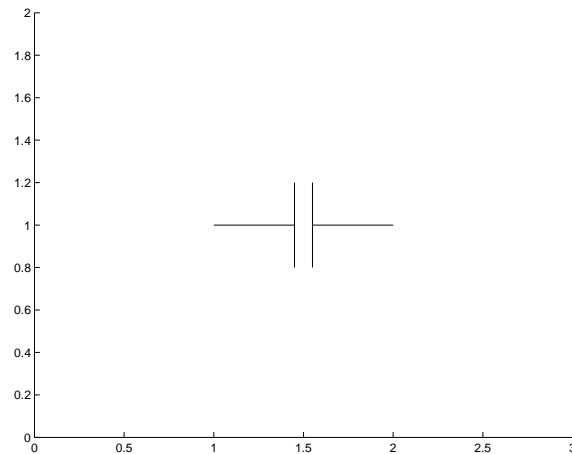
The commands `plot_switch(0.4,1.2,[1,1],[2,1])` and `axis([0 3 0 2])` give the plot:



To plot a capacitor, the following function must be implemented:

```
function plot_capacitor(w,h,A,B)
%
% plot_capacitor(w,h,A,B) plots a capacitor,
% using width w and height h,
% starting at position A and ending at B.
%
% ON ENTRY:
%  w      width of the capacitor;
%  h      height of the capacitor;
%  A      x and y coordinates of start position;
%  B      x and y coordinates of end position.
```

The commands `plot_capacitor(0.1,0.4,[1,1],[2,1])` and `axis([0 3 0 2])` give the plot:



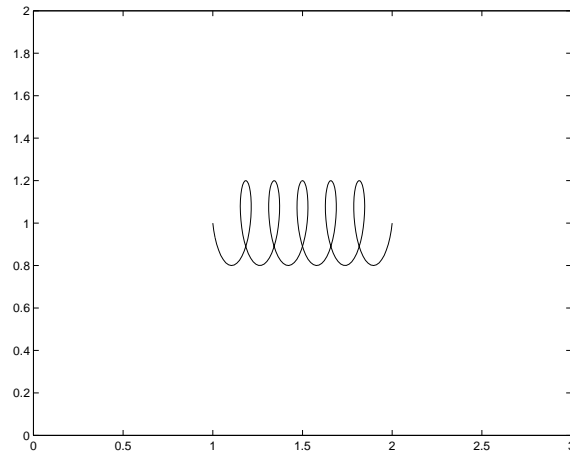
**Assignment Two.** Implement the functions `plot_switch` and `plot_capacitor`, using the given prototypes. Make plots to demonstrate that your functions also work for skew positions.

### 3. Inductor and Resistor

Finally, we plot the inductor and resistor, completing the prototypes listed below.

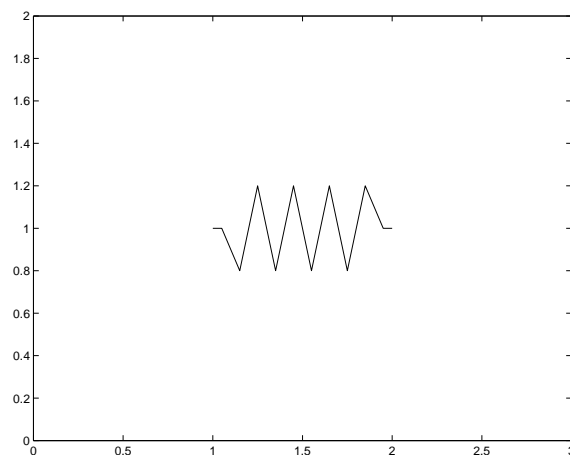
```
function plot_inductor(n,w,A,B)
%
% plot_inductor(n,w,A,B) plots an inductor,
% starting at position A and ending at B.
%
% ON ENTRY:
%   n      number of loops in the coil;
%   w      width of the coil, amplitude;
%   A      x and y coordinates of start position;
%   B      x and y coordinates of end position.
```

The commands `plot_inductor(5,0.4,[1,1],[2,1])` and `axis([0 3 0 2])` give the plot:



```
function plot_resistor(n,w,A,B)
%
% plot_resistor(n,L,w,A,B) plots a resistor,
% starting at position A and ending at B.
%
% ON ENTRY:
%   n      number of turns in the resistor;
%   w      width of the resistor, amplitude;
%   A      x and y coordinates of start position;
%   B      x and y coordinates of end position;
```

The commands `plot_resistor(5,0.4,[1,1],[2,1])` and `axis([0 3 0 2])` produce the plot below:



**Assignment Three.** Implement the functions `plot_inductor` and `plot_resistor`, using the given prototypes. Make plots to demonstrate that your functions also work for skew positions.

**Assignment Four.** Create two scripts to make the plots on page 1. Use `text` and `title` to decorate the plots. Make sure to give these final plots in your answer.

#### 4. The deadline is Friday 2 December 2004, at 2PM.

The solutions to the project will be collected at the beginning of our class meeting on Friday 2 December at 2PM. If you cannot come to class that day, then you must arrange to hand in your solution before the deadline. Otherwise, your solution will be discounted with 10 points if it is turned in on the same day before 5PM, and will no longer be accepted afterwards.

Bring to class the printout of your MATLAB session which illustrate the good working of your m-files. With the command **type** you can bring the listing of an m-file in your session, i.e.: execute as **type plot\_line.m** to show the content of your m-file.

It is good practice to use one m-file which generates all answers to the assignments.

Also provide printout of the plots to demonstrate the correctness of the functions.

To avoid any misunderstanding, this project must be solved individually. Under no circumstances is it allowed to copy or to collaborate. Regardless of who copied from whom, all caught in the act of plagiarism will be penalized.

If you have questions, comments, or difficulties, feel free to come to my office for help.