LED matrixes are fun and compact components that allow a designer to display various shapes and colors. This lesson will only work with the Galileo Gen 2 because of its native speed on the Arduino pins. The pins on Gen 1 are not fast enough to display the LEDs for multiplexing and persistence of vision.

How it works

The LTP-2158AHR is a 5x8 LED matrix. The orientation of the LED matrix in the following diagrams and exercises has been chosen for simplicity.

Two sets of pins, represented by **RED** and **BLACK** in the above diagram, are used to determine which LEDs are illuminated. You can determine the LED matrix orientation by finding the ‘1’ on the back of the matrix next to pin 1.

The first set of pins control what pattern is displayed on a row of the LED matrix. The **RED** pins from the above diagram are used for this purpose.
The other set of pins control which row(s) display the pattern. The **BLACK** pins from the above diagram are used for this purpose. If a **BLACK** pin is grounded, then the pattern present on the **RED** pins will be displayed on the column associated with the grounded **BLACK** pin.

Below are some examples of the behavior of the LED matrix.

![LED Matrix Diagram](image)

**NOTE:** You must use shift registers.

**IMPORTANT:** Connect resistors between the shift register pins and the LED matrix pins. Without the resistors in place, there is a risk of burning out the LEDs in the LED matrix.
Refer to the diagram below for reference when wiring the LED Matrix and shift registers.

**IMPORTANT:** Use pins 12, 11, 10 and 6, 5, 4 from the Intel Galileo to the shift registers. These pins transmit data fast enough unlike other pins that won’t light the Matrix fast enough.

<table>
<thead>
<tr>
<th>PINS 1-7, 15</th>
<th>Q0 &quot; Q7</th>
<th><strong>Output Pins</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>PIN 8</td>
<td>GND</td>
<td>Ground, Vss</td>
</tr>
<tr>
<td>PIN 9</td>
<td>Q7&quot;</td>
<td>Serial Out</td>
</tr>
<tr>
<td>PIN 10</td>
<td>MR</td>
<td>Master Reclear, active low</td>
</tr>
<tr>
<td>PIN 11</td>
<td>SH_CP</td>
<td>Shift register clock pin (Clock Pin)</td>
</tr>
<tr>
<td>PIN 12</td>
<td>ST_CP</td>
<td>Storage register clock pin (latch pin)</td>
</tr>
<tr>
<td>PIN 13</td>
<td>OE</td>
<td>Output enable, active low</td>
</tr>
<tr>
<td>PIN 14</td>
<td>DS</td>
<td>Serial data input (Data Pin)</td>
</tr>
<tr>
<td>PIN 16</td>
<td>Vcc</td>
<td>Positive supply voltage</td>
</tr>
</tbody>
</table>

```c
7 //First Shift Register
8 #define LATCHPINONE 10
9 #define CLOCKPINONE 12
10 #define DATAPINONE 11
11
12 //Second Shift Register
13 #define LATCHPINTWO 4
14 #define CLOCKPINTWO 6
15 #define DATAPINONE 5
```
NOTE: Do not dismantle your circuit once this lab is completed. The LED matrix will be using in the next lab with the addition of a joystick.

Video Demonstration:  https://youtu.be/RfKFDC1CQ1U
Exercise 1: Shifting Rows

Design a system where an illuminated row of the LED matrix can be shifted up or down based on button presses.

Criteria:
- Two buttons control the system: One button shifts the illuminated row up. The other button shifts the illuminated row down.
- The illuminated row cannot be shifted off of the matrix. (i.e. If the illuminated row reaches the top of the LED matrix, if the "up" button is pressed again, the illuminated row will remain at the top of the LED matrix.)

Exercise 2: Shifting Columns

Design a system where an illuminated column of the LED matrix can be shifted left or right based on a button press.

Criteria:
- Two buttons control the system: One button shifts the illuminated column right. The other button shifts the illuminated column left.
- The illuminated column cannot be shifted off of the LED matrix. (i.e. if the illuminated column reaches the far left side of the LED matrix, if the “left” button is pressed again, the illuminated column remains at the far left of the LED matrix.)

Exercise 3: Displaying a Rectangle

Design a system where a 3x4 hollow rectangle is displayed in the center of the LED matrix like the photo below: Note: The varying brightness of the LEDs is only present in the photo. The completed exercise will not have varying brightness.
Hints:
- Since only one row pattern can be displayed on the LED matrix at a time, to display the rectangle, different patterns need to be displayed at different times.
- Every one ms, update the pattern to be displayed and the row that the pattern will be displayed on.
- Use two arrays to store relevant data for the square. One array stores the patterns for each row. The other array stores the row that displays the pattern.
- Ground only one row at a time.

Exercise 4: Shifting a Hollow Rectangle

Expand upon exercise 3 of the lab by introducing four buttons that control the position of the hollow rectangle.

Criteria:
- One button shifts the rectangle up
- One button shifts the rectangle down
- The other two buttons shift the rectangle left or right
- The rectangle cannot be shifted off of the LED matrix

Hints:
- Use two synchSMs. One synchSM controls the pattern displayed on the LED matrix. The other synchSM monitors button presses.