

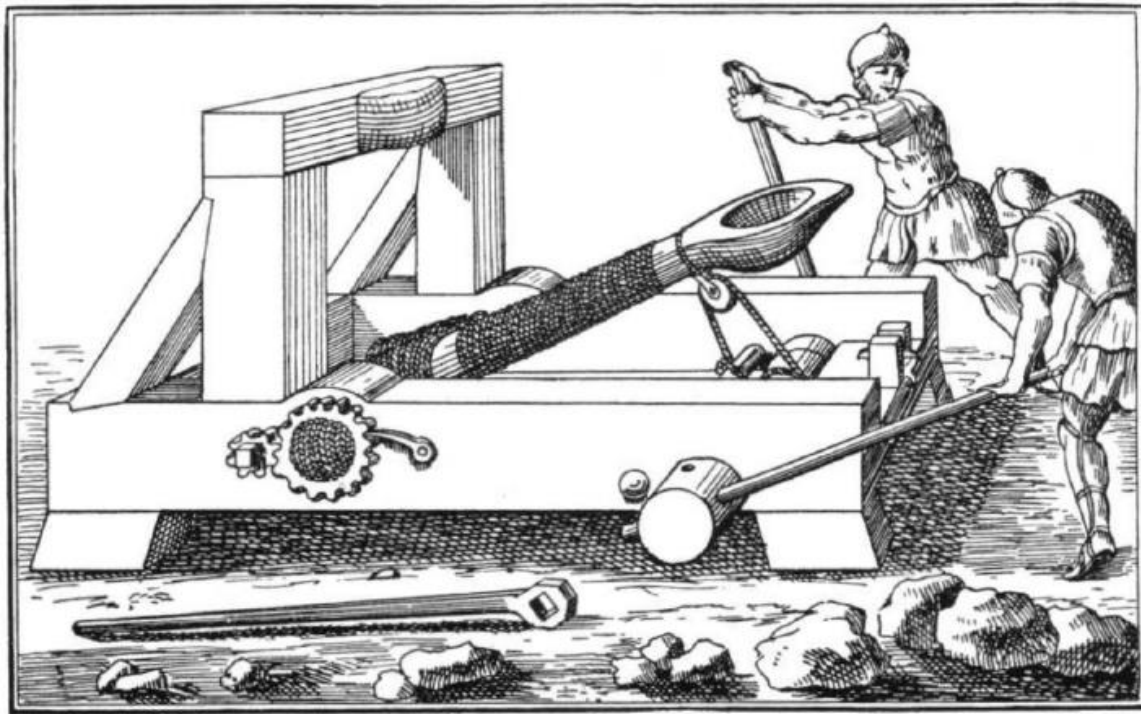
# Engineering Design Project I

## UTA013

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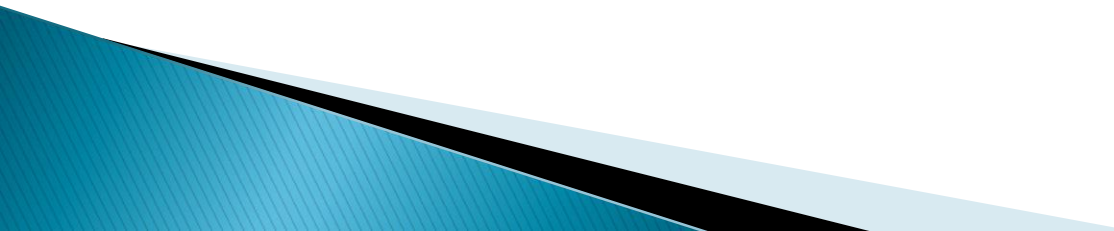
# Engineering Design Project-I: Mangonel

- In Engineering Design Project-I, Mangonel (Roman catapult) is to be designed and implemented.



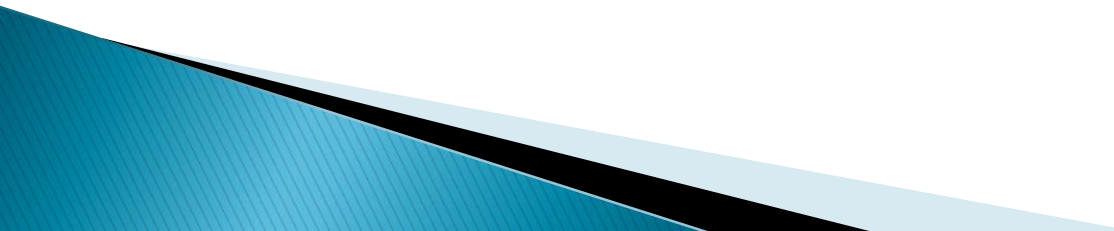
# Mangonel: Electronics Part

The Electronic Part is divided into 4 sections:

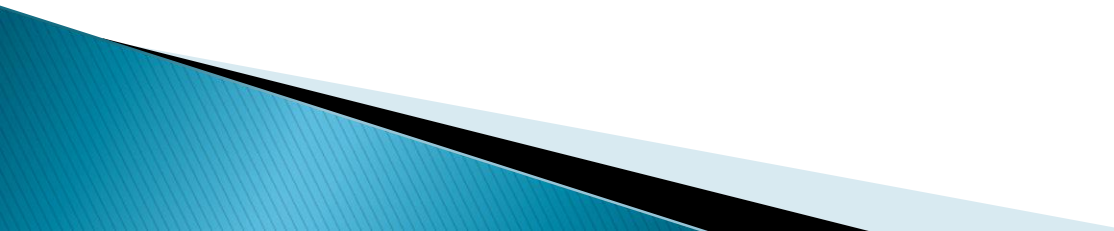
- Programming of Arduino Digital I/O pins for various applications.
  - Sensing any activity through Arduino and instructing accordingly. Also, data capturing through sensors.
  - Interfacing of hardware and software to do a specific task (using 7-segment display)
  - Develop a micro-electronic circuit to determine and display the angular velocity of the throwing arm.
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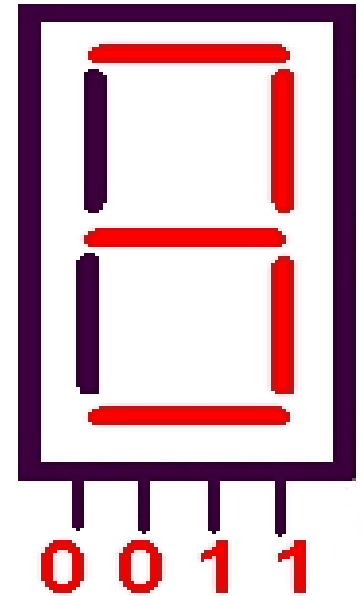
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# Contents

1. Binary Coded Decimal (BCD) Number
  2. 7-segment Display
  3. BCD Adder
  4. Sketch
- 

# Introduction to BCD number

- Although binary data is the most efficient storage scheme; However, some applications may not be desirable to work with binary data.
- For instance, the internal components of digital clocks keep track of the time in binary. The binary value must be converted to decimal before it can be displayed.
- The most common format used to represent decimal data is called binary coded decimal, or BCD.



# Binary Coded Decimal (BCD)

- In BCD representation, every decimal digital is represented by four binary bits.



|||| Data Input Lines

<u>BCD</u>	=	<u>Decimal</u>
0000	=	0
0001	=	1
0010	=	2
0011	=	3
0100	=	4
0101	=	5
0110	=	6
0111	=	7
1000	=	8
1001	=	9

# Decimal to Binary and BCD Conversion

## DECIMAL TO BCD CONVERSION



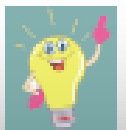
25

$$\begin{array}{r} 2 \overline{) 25} \\ 2 \overline{) 12} - 1 \\ 2 \overline{) 6} - 0 \\ 2 \overline{) 3} - 0 \\ 1 - 1 \end{array}$$

$$(25)_{10} \rightarrow 11001_2$$

$$\begin{array}{cc} \underline{2} & \underline{5} \\ \downarrow & \downarrow \\ 0010 & 0101 \end{array}$$

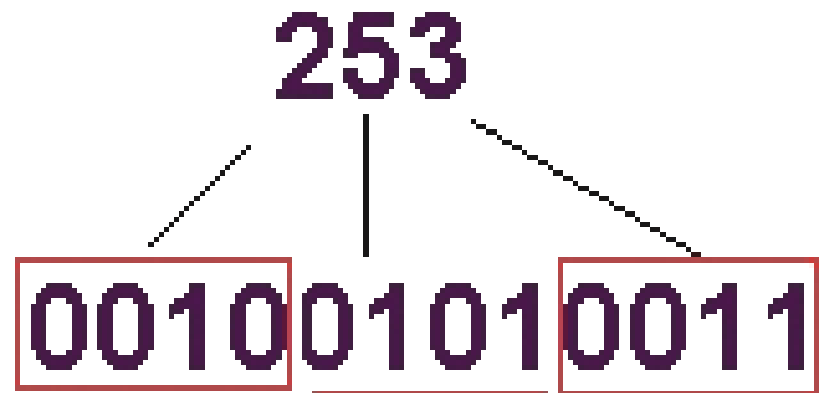
$$(25)_{10} \rightarrow (00100101)_{BCD}$$





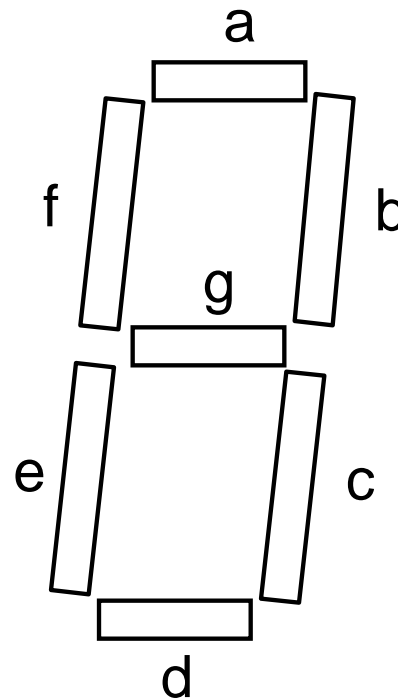
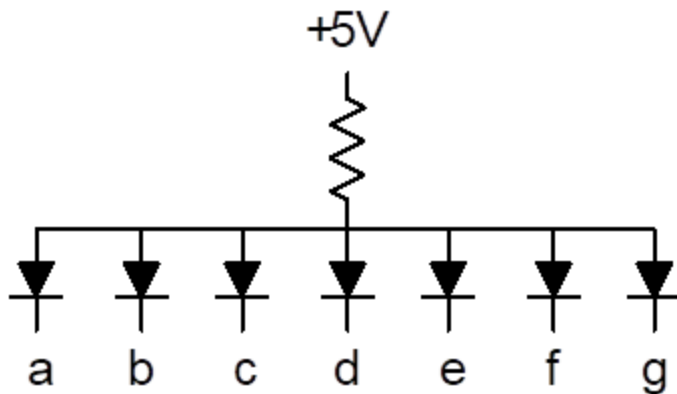
# Multi-digit number to BCD

- Multi-digit decimal numbers are stored as multiple groups of 4 bits per digit.
- BCD is a **signed** notation
- Positive number: +27 as **0**(sign) 0010 0111.
- Negative number: -27 as **1**(sign) 0010 0111.
- BCD does not store negative numbers in two's complement.



# Seven Segment Display

- Contains seven display units to form different numeric number.
- For example to represent number zero, LED a, b, c, d, e, and f must be turned ON (glowing) while g must be OFF.



	a	b	c	d	e	f	g
0	1	1	1	1	1	1	0
1	0	1	1	0	0	0	0
2	1	1	0	1	1	0	1
3	1	1	1	1	0	0	1
4	0	1	1	0	0	1	1
5	1	0	1	1	0	1	1
6	1	0	1	1	1	1	1
7	1	1	1	0	0	0	0
8	1	1	1	1	1	1	1
9	1	1	1	1	0	1	1

# Seven Segment Display

- Contains seven display units to form different numeric

A B C D	a b c d e f g
0 0 0 0	1 1 1 1 1 1 0
0 0 0 1	0 1 1 0 0 0 0
0 0 1 0	1 1 0 1 1 0 1
0 0 1 1	1 1 1 1 0 0 1
0 1 0 0	0 1 1 0 0 1 1
0 1 0 1	1 0 1 1 0 1 1
0 1 1 0	1 0 1 1 1 1 1
0 1 1 1	1 1 1 0 0 0 0
1 0 0 0	1 1 1 1 1 1 1
1 0 0 1	1 1 1 1 0 1 1

# Seven Segment Display

- Contains seven display units to form different numeric

AB \ CD	00	01	11	10
00	1	0	1	1
01	0	1	1	1
11	×	×	×	×
10	1	1	×	×

$$a = A + C + BD + \overline{B}\overline{D}$$

# Seven Segment Display

- Contains seven display units to form different numeric

AB \ CD	CD			
	00	01	11	10
00	1	0	1	1
01	1	0	1	0
11	×	×	×	×
10	1	1	×	×

$$b = \overline{B} + \overline{C} \overline{D} + CD$$

# Seven Segment Display

- Contains seven display units to form different numeric

CD		00	01	11	10
AB					
00		1	1	1	0
01		1	1	1	1
11		×	×	×	×
10		1	1	×	×

$$c = B + \bar{C} + D$$

# Seven Segment Display

- Contains seven display units to form different numeric

AB \ CD	00	01	11	10
00	1	0	1	1
01	0	1	0	1
11	×	×	×	×
10	1	1	×	×

$$d = \overline{B} \overline{D} + C \overline{D} + B \overline{C} D + \overline{B} C + A$$

# Seven Segment Display

- Contains seven display units to form different numeric

		CD			
		00	01	11	10
AB	00	1	0	0	1
	01	0	0	0	1
	11	×	×	×	×
	10	1	0	×	×

$$e = \overline{B} \overline{D} + C \overline{D}$$



# Seven Segment Display

- Contains seven display units to form different numeric

CD		00	01	11	10
AB	00	1	0	0	0
	01	1	1	0	1
	11	×	×	×	×
	10	1	1	×	×

$$f = A + \bar{C}\bar{D} + B\bar{C} + B\bar{D}$$

# Seven Segment Display

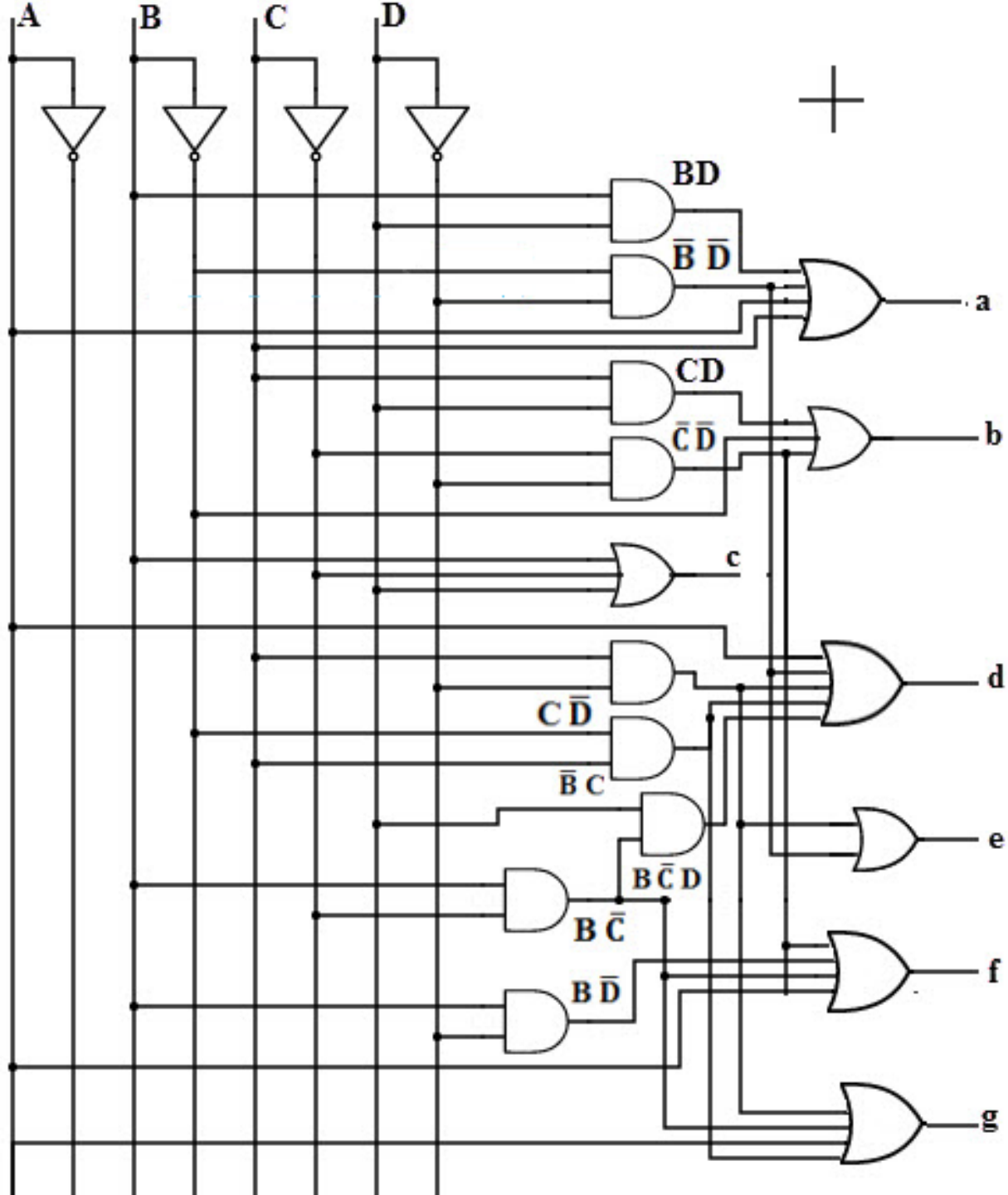
- Contains seven display units to form different numeric

AB \ CD	00	01	11	10
00	0	0	1	1
01	1	1	0	1
11	×	×	×	×
10	1	1	×	×

$$g = \overline{B} C + C \overline{D} + B \overline{C} + B \overline{C} + A$$

# Circuit Diag.

- Circuit can be implemented using few AND, OR and NOT gates only.



# IC CD4543

- Latch Disable:
  - To latch the data on the output pins
- Phase:
  - Should be zero for common cathode while 1 for common anode 7-segment display.
- Blanking:
  - To blank the display by giving high input.
  - Normally connected to ground.

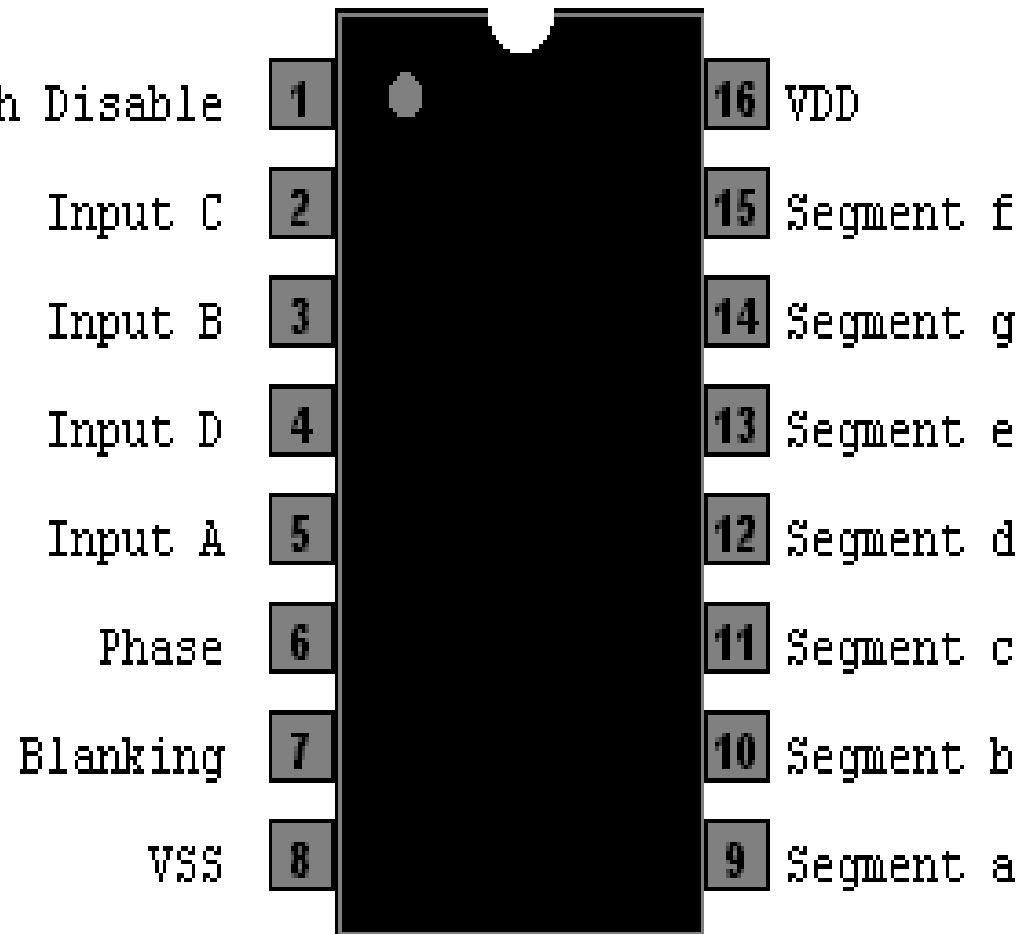


Table 3.    Function table [\[1\]](#)

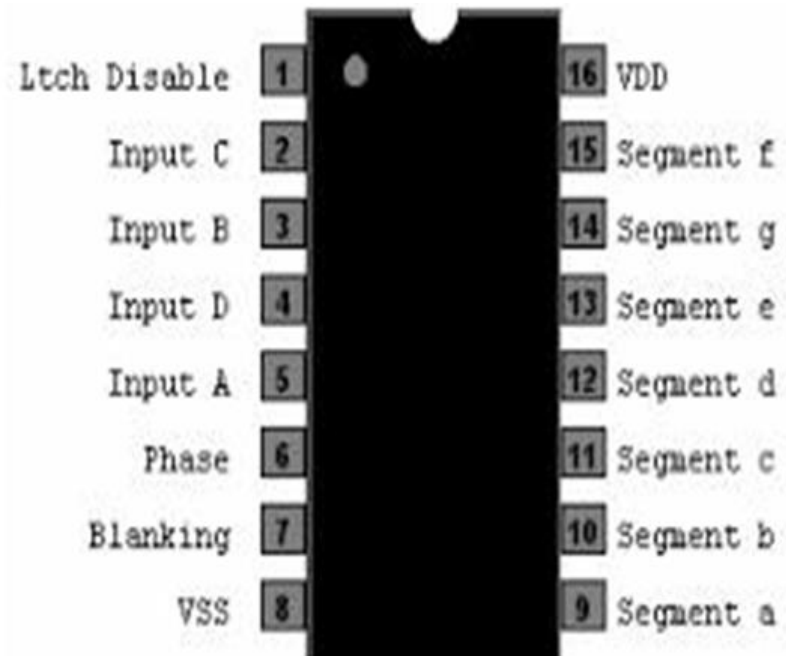
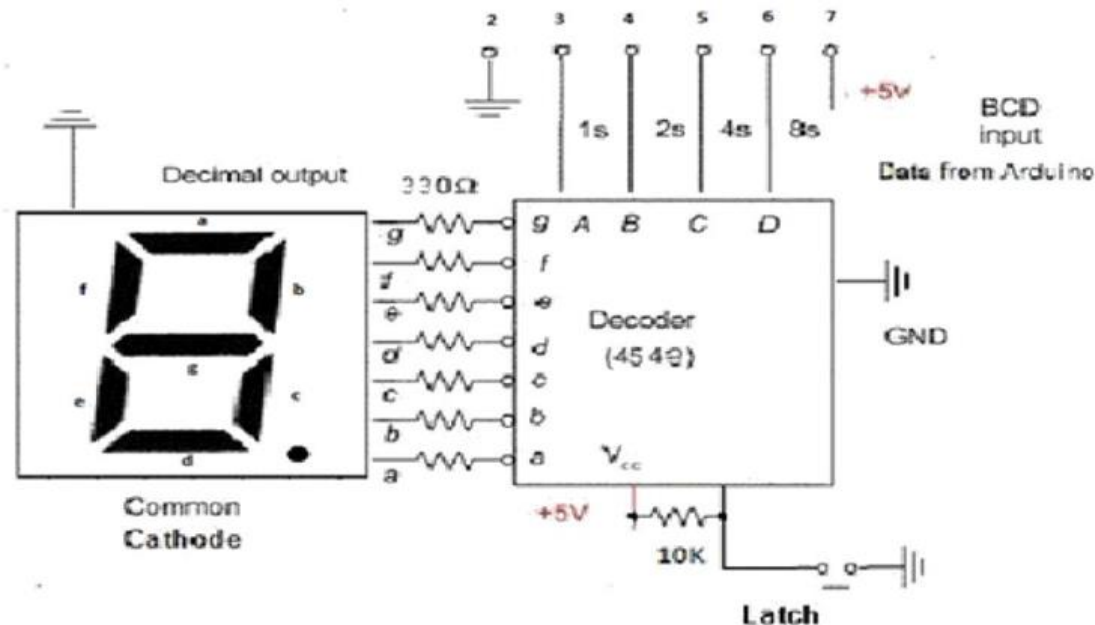
Inputs							Outputs							Display
LE	BL	PH <a href="#">[2]</a>	D3	D2	D1	D0	Qa	Qb	Qc	Qd	Qe	Qf	Qg	
X	H	L	X	X	X	X	L	L	L	L	L	L	L	blank
H	L	L	L	L	L	L	H	H	H	H	H	H	L	0
H	L	L	L	L	L	H	L	H	H	L	L	L	L	1
H	L	L	L	L	H	L	H	H	L	H	H	L	H	2
H	L	L	L	L	H	H	H	H	H	H	L	L	H	3
H	L	L	L	H	L	L	L	H	H	L	L	H	H	4
H	L	L	L	H	L	H	H	L	H	H	L	H	H	5
H	L	L	L	H	H	L	H	L	H	H	H	H	H	6
H	L	L	L	H	H	H	H	H	H	L	L	L	L	7
H	L	L	H	L	L	L	H	H	H	H	H	H	H	8
H	L	L	H	L	L	H	H	H	H	H	L	H	H	9
H	L	L	H	L	H	X	L	L	L	L	L	L	L	blank
H	L	L	H	H	X	X	L	L	L	L	L	L	L	blank
L	L	L	X	X	X	X	n.c.							n.c
as above		H	as above				inverse of above							as above

[1]    H = HIGH voltage level; L = LOW voltage level; X = don't care; n.c. = no change.

[2]    For liquid crystal displays, apply a square-wave to PH;  
For common cathode LED displays, select PH = LOW;  
For common anode LED displays, select PH = HIGH.

# BCD-7-segment decoder

- The decoder (CD4543) is a combinational digital circuit that decodes an 4-bit binary input in the range 0000-1001 (BCD) in to its corresponding decimal level.
- It can latch (maintain the output) when the latch is low.



# Code example

- The decimal integer can be converted into 4-bit binary number as follows
  - `int a=i%2; // calculate LSB`
  - `int b=i/2 %2;`
  - `int c=i/4 %2;`
  - `int d=i/8 %2; //calculate MSB`

**Thanks**