

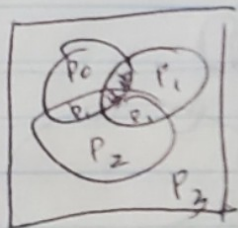
## Assignment 5 Hamming Code

- Hamming Codes help find and fix "noise". Used in most broadcasting mediums. Noise are incorrect bits

The Hamming code being used is 4/4.  
4 parity bits 4 data bits. Parity bits are xors of data bits

### Hamming

Index	7	6	5	4	3	2	1	0
Hamming	$P_3$	$P_2$	$P_1$	$P_0$	$D_3$	$D_2$	$D_1$	$D_0$



$$P_0 = D_1 \oplus D_2 \oplus P_1$$

$$P_1 = D_0 \oplus D_2 \oplus D_3$$

$$P_2 = D_0 \oplus D_1 \oplus D_3$$

$$P_3 = D_0 \oplus D_1 \oplus D_2 \oplus D_3 \oplus P_0 \oplus P_1 \oplus P_2$$

### Encoding

Encoding is done through matrix multiplication

$$\vec{C} = \begin{pmatrix} 0 & 1 & 2 & 3 \\ 0 & 0 & 1 & 1 \end{pmatrix} \begin{pmatrix} 1 & 0 & 0 & 0 & 0 & 1 & 1 & 1 \\ 0 & 1 & 0 & 0 & 1 & 0 & 1 & 1 \\ 0 & 0 & 1 & 0 & 1 & 1 & 0 & 1 \\ 0 & 0 & 0 & 1 & 1 & 1 & 1 & 0 \end{pmatrix} = \begin{pmatrix} 0 & 0 & 1 & 1 & 2 & 2 & 1 & 1 \\ 0 & 0 & 1 & 1 & 0 & 0 & 1 & 1 \end{pmatrix}$$

xor

Binary is read right to left  
Vectors are read left to right

de coding

(0011 0011)

0	1	1	1
1	0	1	1
1	1	0	1
1	1	1	0
1	0	0	0
0	1	0	0
0	0	1	0
0	0	0	1

= 0000 = No errors

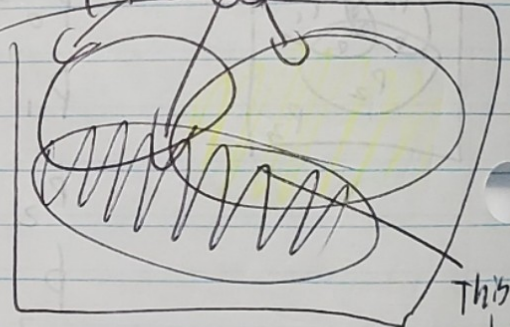
(0011 0011)

↳ correct

(0111 0011)

0	1	1	1
1	0	1	1
1	1	0	1
1	1	1	0
1	0	0	0
0	1	0	0
0	0	1	0
0	0	0	1

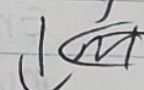
= (1011)



This is what's wrong

(0111)

Flip it



(0011)

"but the msb lsb order is racking my brain"



## Bit Vector

bv - set - bit (v, i)

vector[i/8] = vector[i/8] or 1 left shift i

bv - clr - bit (v, i)

vector[i/8] = vector[i/8] & ~(1 left shift i)

bv - xor - bit (v, i)

vector[i/8] = vector[i/8] ^ 1 left shift i

bv - get - bit

return vector[i/8] right shift i

## Bit Matrix

bm - set - bit

bv set (vector, r, cols + c);

bm clr

bv clr (vector, r, cols + c);

bm from data

for i in length

~~if vector~~

bv set (vector, i)

bm to data

for i in cols

data = data + get bit (i)

return data



## Hamming

1.	0	Ham ok	2. 11100011 • H	
	1	4	<div style="border: 1px solid black; padding: 2px;">H100011</div>	<div style="border: 1px solid black; padding: 2px;">0111 1011 1101 1110 1000 0100 0010 0001</div>
	2	5		Match
	3	Ham err		
	4	6	(1100011) •	$1233+2=$
	5	Ham err		
	6	Ham err		1011
	7	3		Bit 4 should be flipped
	8	7		
	9	Ham err		no match
	10	Ham err	<div style="border: 1px solid black; padding: 2px;">11011000</div>	
	11	2	(00011011) •	<div style="border: 1px solid black; padding: 2px;">0111 1011 1101 1110 1000 0100 0010 0001</div>
	12	Ham err		2121+2=
	13	1		0101
	14	0		Ham Err
	15	Ham err		

Ham encode (G, msg)  
return matrixmult (G, msg)

ham decode (H+, code, msg)

a = matrixmult (H+, code)

if a = 1 flip

a = 2 flip

a = 4 flip

a = 5 flip

a = 7 flip

a = 8 flip

a = 11 flip

a = 13 flip

a = 14 flip



