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hello student myself dr. Cruz Varma and today

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called encoding function which is
defined from BM to

Coding Theory

Alphabet : $\{0,1\}$ i.e Binary bit

Message and Code word both can be represe[illegible] by $\{0,1\}$ only.

$$\boxed{\text{message}} \xrightarrow[E]{\text{Encoding Rule}} \boxed{\text{Codeword}} \xrightarrow[D]{\text{Decoding Rule}} \boxed{\text{message}}$$

$E : B^m \to B^n$ m : tuple of message

$D : R \longrightarrow B^m,\ R \subseteq B^n$ n : " " Codeword

$n > m$.

if $m = 3 \Rightarrow |B^3| = 2^3 = 8$

$\Rightarrow$ Set of message $\cdot\ B^3 = \{000, 100, 010, 001,$ [illegible] $, 111, 011\}$

$\Rightarrow \boxed{|B^m| = 2^m}$

if $n = 4 \Rightarrow$ set of Code word $B^4 = \{$ [illegible] of Code word of 4 [illegible] $\}$.

Example : suppose $E(101) = 101101$ [illegible] error detecting case.
$E(100) = 101101$

[illegible] is

we know the Encoding Rule, s[illegible]

$E(a_1 a_2 a_3) =$ [illegible]

$\Rightarrow E(100) =$ 1[illegible]

$E(101) =$ 10[illegible]

This is the cas[illegible] ting and al[illegible]

Coding Theory

Alphabet : $\{0,1\}$ i.e Binary bit

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$E(100) = 101101$

... is

if we know the Encoding Rule, s...

$E(a_1 a_2 a_3) =$ ...

$\Rightarrow$ $E(100) =$ 1...

$E(101) =$ 10...

This is the cas... ting and al...

that the first code is correct but the
second code code is

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Hamming Distance & Hamming Weight.

Hamming Weight: The number of non zero e... in any Code is Called Hamming Weight of the code.

Exam

$x_1 = 110110 \Rightarrow$ H. weight of $x_1 = 4$.

$x_2 = 10101 \Rightarrow$ H. weight of $x_2 = 3$

Hamming distance: Number of position between two code x & y, where the code word have diff. Symbols:

Example: if $x = 101011$ then $d(x,y) =$ ... $z) = 4$.

$y = 101101$ $\quad d(y,z) =$

$z = 1 \ldots 101$

~~Def~~ **Theorem Result**: (Wh...

(i) we can detect K...

(ii) we can correct K...

m...

Example: (6) Given that

$E(00) = 000\ldots$

$E(01) = 0101$

$E(10) = 1010$

$E(11) = 1111$

Find the number of error can be detected and corr...

$d(x_1 x_2) = 3$ ~~$d(x_1 x_2) = 3$~~ $d(x_1 x_3) = 3$ $d(x_1 x_4) = 6$	$3 \geq 2K+\ldots$ $\Rightarrow 2K \leq 3-1$ $2K \leq 2$ $K \leq 1$ $\Rightarrow$ we can c... 1 error...

3 ... 3 ... ing ... $\leq$ ... $\leq$ ... can detect 2 or few error.

Hamming Distance & Hamming Weight.

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Find the number of error can be detected and corr[illegible]

$d(x_1, x_2) = 3$

~~$d(x_1 x_2)$~~

$d(x_1 x_3) = 3$

$d(x_1 x_4) = 6$

$3 \geq 2k+$[illegible]

$\Rightarrow 2k \leq 3-1$

$2k \leq 2$

$k \leq 1$

$\Rightarrow$ we can c[illegible] 1 error.

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Hamming Distance & Hamming Weight.

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Example: if

$x = 101011$ then $d(x,y) = 2$ $d(z,x) = 4$.

$y = 101101$ $d(y,z) = 2$

$z = 110101$

Theorem Result: (where $K \geq 0$.)

(i) we can detect K or fewer error iff min H. distance $\geq K+1$.

(ii) we can correct K or fewer error iff min H. distance $\geq 2K+1$

Example: (6) Given that $E: B^2 \to B^6$ defined

$E(00) = 000000 = x_1$ | $d(x_2, x_3)$ [illegible] 6

$E(01) = $ [illegible]$0101 = x_2$ | $d(x_2, x_4)$ [illegible] 3

$E(10) = $ [illegible]$1010 = x_3$ | $d(x_3, x_4)$ [illegible] 3

$E(11) = $ [illegible] $= x_4$

[illegible] H. dis[illegible] = 3

Find the number of [illegible] can be detected [illegible] [illegible]rror [illegible]tecting

$d(x_1, x_2) = 3$

~~$d(x_1, x_2) = 3$~~

$d(x_1, x_3) = 3$

$d(x_1, x_4) = 6$

[illegible] or fewer

Hamming Distance & Hamming Weight.

Hamming Weight: The number of non zero [illegible] in any code is called Hamming Weight of the code.

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Example: if

$x = 101011$ then $d(x, y) = 2$ $d(z, x) = 4$.

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$z = 110101$

Theorem Result: (where $K \geq 0$.)

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Example: (6) Given that $E: B^2 \to B^6$ defined

$E(00) = 000000 = x_1$ | $d(x_2, x_3)$ [illegible]

$E(01) = $ [illegible]$0101 = x_2$ | $d(x_2, x_4)$ [illegible]

$E(10) = $ [illegible]$1010 = x_3$ | $d(x_3, x_4)$ [illegible]

$E(11) = $ [illegible]$1 = x_4$ | [illegible] H. dis[illegible] 3

Find the number of [illegible] can be detected a[illegible] [illegible]rror [illegible]ing

$d(x_1, x_2) = 3$

~~$d(x_1, x_2) = 3$~~

$d(x_1, x_3) = 3$

$d(x_1, x_4) = 6$

[illegible] or fewer

Generator Matrix: If $E: B^m \to B^n$ be a Encoding function then the matrix of the form

$$\boxed{G = \left[I_{m \times m} : A_{m \times (n-m)} \right]_{m \times n}}$$

is called generator matrix

where

$I_{m \times m}$: Identity Matrix

* Relation b/w message, code word and G. m...

$$\boxed{b = a \cdot G}$$

row matrix

b : Code...

a : me...

G ...

Parity Check Matrix:- It is denoted

$$H = \left[A^T : I_{(n-m) \times (n-m)} \right]$$

Note: (i) The code word b is valid ... say correctly transmitted if

$$\boxed{b \cdot H^T = 0 \quad \text{or} \quad H b^T = ...}$$

(ii) Here matrix multiplication ... adding modulo 2 i.e ...

Generator Matrix: If $E: B^m \to B^n$ be a Encoding function then the matrix of the form

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Que : Given that $G = \begin{bmatrix} 1 & 0 & 1 & 1 & 1 \\ 0 & 1 & 1 & 0 & 1 \end{bmatrix}$ find

(I) All code words

(II) min H. weight & Min H. Distance.

(III) How many error we can detect and corre[ct]

(IV) Parity check matrix.

(V) Check the following code's are correc[tly] transmitted or n[ot] $a = 01000$ $b = 11010$

Soln $G = \begin{bmatrix} 1 & 0 & 1 & 1 & 1 \\ 0 & 1 & 1 & 0 & 1 \end{bmatrix}_{2\times5}$ ... $G = [I_{m\times m} \quad A_{\ldots}]$

Que : Given that $G = \begin{bmatrix} 1 & 0 & 1 & 1 & 1 \\ 0 & 1 & 1 & 0 & 1 \end{bmatrix}$ find

(I) All Code words

(II) min H. weight & Min H. Distance.

(III) How many error we can detect and corre[ct]

(IV) Parity check Matrix.

(V) Check the following code's are correctly transmitted or not. $a = 01000$ $b = 11010$

Soln $G = \begin{bmatrix} 1 & 0 & 1 & 1 & 1 \\ 0 & 1 & 1 & 0 & 1 \end{bmatrix}_{2\times5}$ $G = [I_{m\times m} \quad A_{m\times(n-m)}]$

ee : Given that $G = \begin{bmatrix} 1 & 0 & 1 & 1 & 1 \\ 0 & 1 & 1 & 0 & 1 \end{bmatrix}$ find

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$\Rightarrow m = 2, n = 5, n-m = 5-2 = 3$

$\Rightarrow G = [I_{2\times2} : A_{2\times(3)}]_{2\times5}$

$\Rightarrow A = \begin{bmatrix} 1 & 1 & 1 \\ 1 & 0 & 1 \end{bmatrix}$

if $m = 2$, $n = 5$ $\Rightarrow E : B^2 \to B^5$

$\Rightarrow |B^2| = 2^2 = 4$

$\Rightarrow$ set of message $B^2 = \{00,$

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(I) All code words

(II) min H. weight & Min H. Distance.

(III) How many error we can detect and correct

(IV) Parity check Matrix.

(V) Check the following code's are correctly transmitted or not $a = 01000$ $b = 110...$

Soln: $G = \begin{bmatrix} 1 & 0 & 1 & 1 & 1 \\ 0 & 1 & 1 & 0 & 1 \end{bmatrix}_{2\times 5}$ & $G = [I_{m\times m} : A_{m\times(n-m)}]_{m\times n}$

$\Rightarrow m = 2,\ n = 5,\ n-m = 5-2 = 3$

$\Rightarrow G = [I_{2\times 2} : A_{2\times(3)}]_{2\times 5}$

$\Rightarrow A = \begin{bmatrix} 1 & 1 & 1 \\ 1 & 0 & 1 \end{bmatrix}$

if $m = 2$, $n = 5$ $\Rightarrow E : B^2 \to B^5$

$\Rightarrow |B^2| = 2^2 = 4 = 2^m$

$\Rightarrow$ set of message $B^2 = \{00, 10, 01, 11\}$.

Now $b = a\,G$

b : code word

a : message

G : Generator

$\Rightarrow b_1 = (00)\,G = (00)\begin{bmatrix} 1 & 0 & \ldots \\ 0 & 1 & \ldots \end{bmatrix}$

$= [0\ 0\ 0\ 0\ 0]$

$b_2 = (10)\,G = (10)\begin{bmatrix} 1 & 0 & \ldots \\ 0 & 1 & \ldots \end{bmatrix}$

$= [1 \ldots$

Que : Given that G = $\begin{bmatrix} 1 & 0 & 1 & 1 & 1 \\ 0 & 1 & 1 & 0 & 1 \end{bmatrix}$ find

(I) All code words
(II) min H. weight & Min H. Distance.
(III) How many error we can detect and correct
(IV) Parity check Matrix.
(V) Check the following code's are correctly transmitted or not   a = 01000   b = 110...

Soln: $G = \begin{bmatrix} 1 & 0 & 1 & 1 & 1 \\ 0 & 1 & 1 & 0 & 1 \end{bmatrix}_{2\times5}$ & $G = [I_{m\times m} : A_{m\times(n-m)}]_{m\times n}$

$\Rightarrow m = 2,\ n = 5,\ n-m = 5-2 = 3$

$\Rightarrow G = [I_{2\times2} : A_{2\times(3)}]_{2\times5}$

$\Rightarrow A = \begin{bmatrix} 1 & 1 & 1 \\ 1 & 0 & 1 \end{bmatrix}$

if $m = 2$, $n = 5$ $\Rightarrow E : B^2 \to B^5$

$\Rightarrow |B^2| = 2^2 = 4 = 2^m$

$\Rightarrow$ set of message $B^2 = \{00, 10, 01, 11\}$.

Now $b = a\,G$ b : code word, a : message, G : Generator matrix

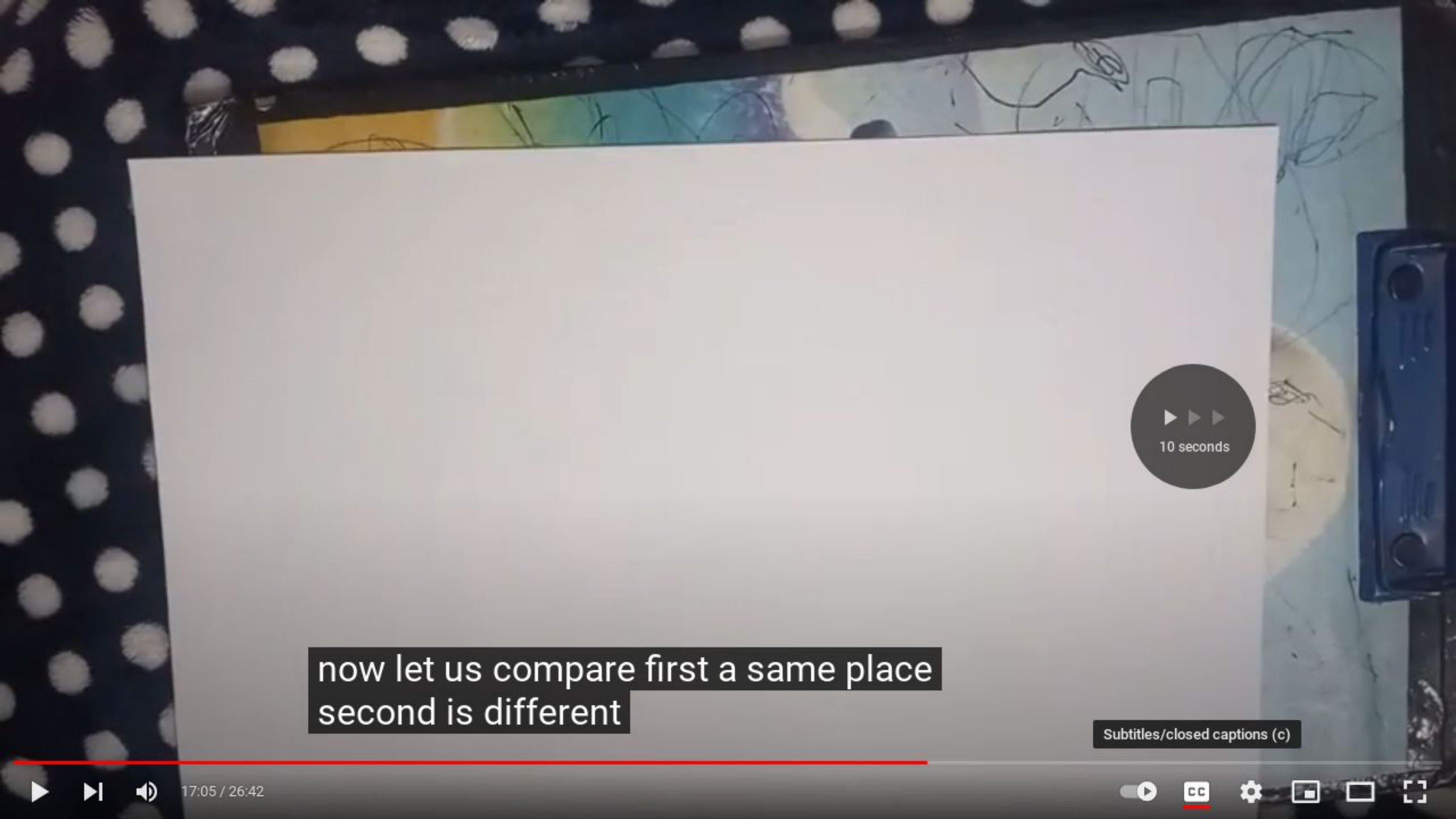
$\Rightarrow$ $b_1 = (00)\,G = (00)\begin{bmatrix} 1 & 0 & \cdots \\ 0 & 1 & \cdots \end{bmatrix}$

$= [0\ 0\ 0\ 0\ 0]$

$b_2 = (10)\,G = (10)\begin{bmatrix} 1 & 0 & \cdots \\ 0 & 1 & \cdots \end{bmatrix}$

$= [1 \ldots$

we have to find the minimum Hamming
distance minimum Hamming distance


10 seconds
now let us compare first a same place
second is different
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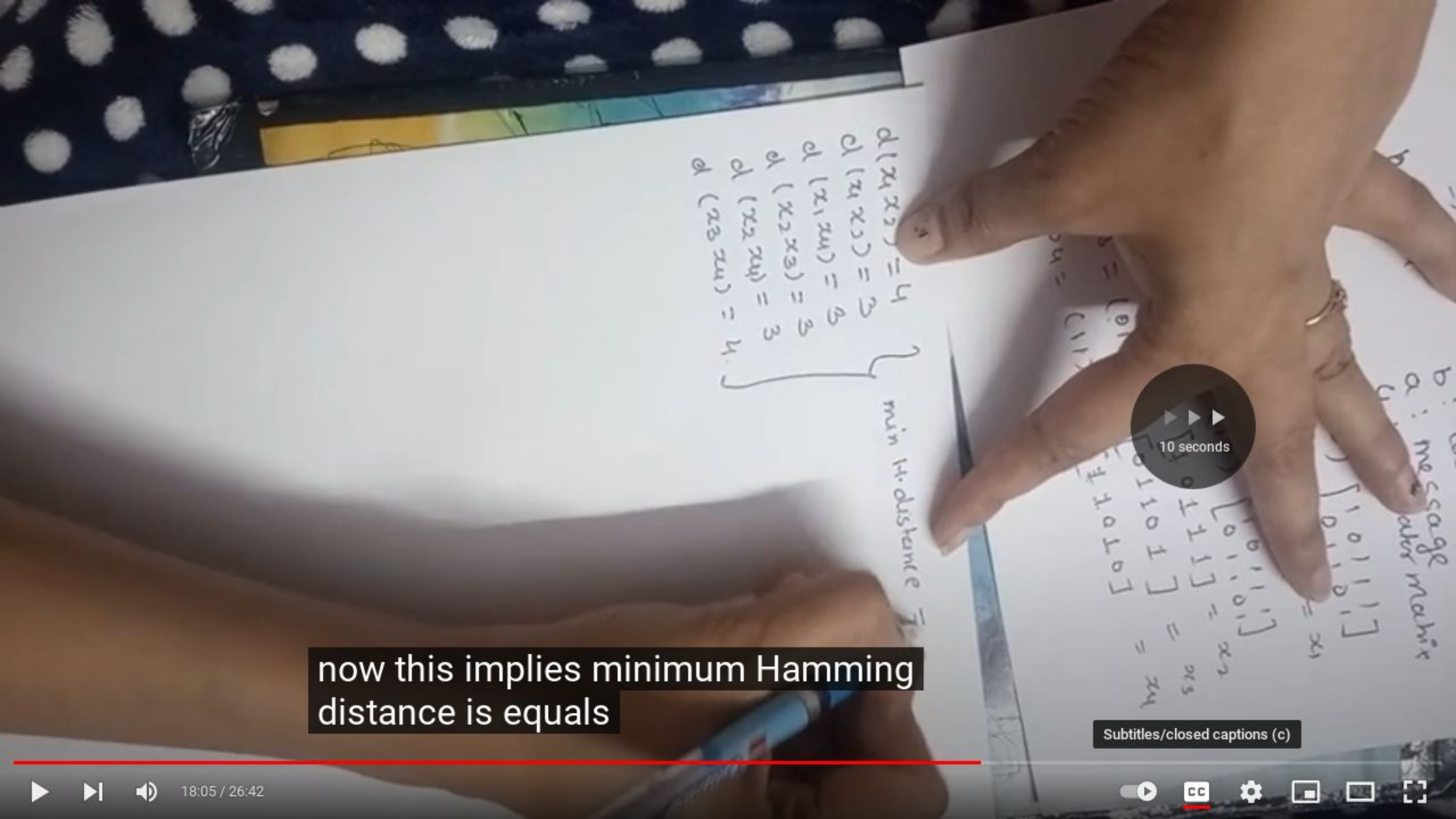
a : message
$d(x_1 x_2) = 4$
$d(x_1 x_3) = 3$
$d(x_1 x_4) = 3$
$d(x_2 x_3) = 3$
$d(x_2 x_4) = 3$
$d(x_3 x_4) = 4.$
min H. distance =
$[1\ 0\ 1\ 1\ 1] = x_1$
$[0\ 1\ 1\ 1\ 1] = x_2$
$[0\ 1\ 1\ 0\ 1] = x_3$
$[1\ 1\ 0\ 1\ 0] = x_4$
now this implies minimum Hamming
distance is equals
10 seconds
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a : message

...ator matrix

$$\begin{bmatrix} 1 & 0 & 1 & 1 & 1 \\ 0 & 1 & 1 & 0 & 1 \end{bmatrix}$$

$= x_1$

$= x_2$

$= x_3$

$= x_4$

$[0\,1\,1\,0\,1] = $

$[1\,1\,0\,1\,0] =$

$$\left.\begin{aligned} d(x_1 x_2) &= 4 \\ d(x_1 x_3) &= 3 \\ d(x_1 x_4) &= 3 \\ d(x_2 x_3) &= 3 \\ d(x_2 x_4) &= 3 \\ d(x_3 x_4) &= 4. \end{aligned}\right\} \text{min H. distance} =$$

how many error we can

$b_3 = (01)G = [\;\ldots$

$b_4 = (11)G = [1\;1\;0\;1\;\ldots$

$d(x_1 x_2) = 4$

$d(x_1 x_3) = 3$

$d(x_1 x_4) = 3$

$d(x_2 x_3) = 3$

$d(x_2 x_4) = 3$

$d(x_3 x_4) = 4.$

min H. distance $= 3$.

How many error we can detect

$3 \geq K+1 \Rightarrow K \leq 3-1$

$\Rightarrow K \leq 2$

$\Rightarrow$ we can detect 2 or fewer error Here.

Similarily How many error we can correct Here

$3 \geq 2K+1 \Rightarrow 2K \leq 3-1$

$\Rightarrow 2K \leq 3-1$

$\Rightarrow K \leq 1$

$\Rightarrow$ we can correct 1 error Here.

$H = [A^T : \ldots$

$3 = (01)4 =$ [

$b_4 = (11)4 = [1\ 1\ 0\ 1$

$d(x_1 x_2) = 4$
$(x_1 x_3) = 3$
$(x_1 x_4) = 3$
$d(x_2 x_3) = 3$
$d(x_2 x_4) = 3$
$d(x_3 x_4) = 4.$

min H. distance $= 3$.

How many error we can detect [illegible] or fewer

$3 \geq k+1 \Rightarrow k \leq 3-1$

$\Rightarrow k \leq 2$

$\Rightarrow$ we can detect [illegible] fewer error Here.

Similarily How many error we can [illegible]rrect Here

$3 \geq 2k+1 \Rightarrow 2k \leq 3-1$

$\Rightarrow 2k \leq 3-1$

$\Rightarrow k \leq 1$

$\Rightarrow$ we can co[illegible] 1 error Here.

$H = [A^T :$ [illegible]

cos 5 matrix and we when we write the value of a what will

10 seconds

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(4) Check the following transmitted or not $a = 01000$ $b = 11010$

Soln: $G = \begin{bmatrix} 1 & 0 & 1 & 1 & 1 \\ 0 & 1 & 1 & 0 & 1 \end{bmatrix}_{2\times5}$ ~ $G = [I_{m\times m} : A_{m\times(n-m)}]_{m\times n}$

$\Rightarrow m = 2,\ n = 5,\ n-m = 5-2 =$

$\Rightarrow G = [I_{2\times2} : A_{2\times(3)}]_{2\times5}$

$\Rightarrow A = \begin{bmatrix} 1 & 1 & 1 \\ 1 & 0 & 1 \end{bmatrix}$

if $m = 2$, $n = 5$ $\Rightarrow E : B^2 \to B^5$

$\Rightarrow |B^2| = 2^2 = 4$

$\Rightarrow$ set of message $B^2 = \{00, 10, 01$

$b = aG$

b : code word

a : message

G : Generator matrix

$(00)G = (00)\begin{bmatrix} 1 & 0 & 1 & & \\ 0 & 1 & 1 & & \end{bmatrix}$ x_1

$= [0\ 0\ 0\ 0\ 0]$

$= (10)G = (10)\begin{bmatrix} 1 & 0 & 1 & 1 & \\ 0 & 1 & 1 & & \end{bmatrix}$ x_2

$= [1\ 0\ 1\ 1\ 1]$

$b_3 = (01)G = [0\ 1\ 1\ 0\ 1]$ x_3

$b_4 = (11)G = [1\ 1\ 0\ 1\ 0]$ x_4

$= [A^T : I_{3\times3}]_{3\times5}$

$$\boxed{H = \begin{bmatrix} 1 & 1 & 1 & 0 & 0 \\ 1 & 0 & 0 & 1 & 0 \\ 1 & 1 & 0 & 0 & 1 \end{bmatrix}_{3\times5}}$$

$H \cdot b$

between the code word and parity check matrix that is if H into B

(4) Check the following ... transmitted or not $a = 01000$ $b = 11010$

Soln: $G = \begin{bmatrix} 1 & 0 & 1 & 1 & 1 \\ 0 & 1 & 1 & 0 & 1 \end{bmatrix}_{2\times5}$ ~ $G = [I_{m\times m} : A_{m\times(n-m)}]_{m\times n}$

$\Rightarrow m = 2,\ n = 5,\ n-m = 5-2 = 3$

$\Rightarrow G = [I_{2\times2} : A_{2\times(3)}]_{2\times5}$

$\Rightarrow A = \begin{bmatrix} 1 & 1 & 1 \\ 1 & 0 & 1 \end{bmatrix}$

if $m = 2$, $n = 5$ $\Rightarrow E : B^2 \to B^5$

$\Rightarrow |B^2| = 2^2 = 4$

$\Rightarrow$ set of message $B^2 = \{00, 10, 01, ...\}$

$b = a\,G$

b : code word

a : message

G : Generator matrix

$b_1 = (00)\,G = (00)\begin{bmatrix} 1 & 0 & 1 & 1 & 1 \\ 0 & 1 & 1 & 0 & 1 \end{bmatrix}$ x_1

$= [0\ 0\ 0\ 0\ 0]$

$b_2 = (10)\,G = (10)\begin{bmatrix} 1 & 0 & 1 & 1 & 1 \\ 0 & 1 & 1 & 0 & 1 \end{bmatrix}$ x_2

$= [1\ 0\ 1\ 1\ 1]$

$b_3 = (01)\,G = [0\ 1\ 1\ 0\ 1]$ x_3

$b_4 = (11)\,G = [1\ 1\ 0\ 1\ 0]$ x_4

$= [A^T : I_{3\times3}]_{3\times5}$

$$\boxed{H = \begin{bmatrix} 1 & 1 & 1 & 0 & 0 \\ 1 & 0 & 0 & 1 & 0 \\ 1 & 1 & 0 & 0 & 1 \end{bmatrix}_{3\times5}}$$

$H \cdot b$

0 and B is given 1 1 0 1 0 if you start
this check here 1 1 1 1 0 1 1

10 seconds

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$G = (00)\begin{bmatrix}1&0&1&1&1\\0&1&1&0&1\end{bmatrix}$

$= [0\;0\;0\;0\;0] = \ldots$

$b_2 = (10)G = (10)\begin{bmatrix}1&0&1&1&1\\0&1&1&0&1\end{bmatrix}$

$= [1\;0\;1\;1\;1] = x_2$

$b_3 = (0\ldots)G = [0\;1\;1\;0\;1] = x_3$

$\ldots = [1\;1\;0\;1\;0] = x_4$

$H = [A^T : I_{(n-m)\times(n-m)}]_{(n-m)\times n}$

$\Rightarrow H = [A^T : I_{(5-2)\times(5-2)}]_{(5-2)\times 5}$

$= [A^T : I_{3\times 3}]_{3\times 5}$

$$\boxed{H = \begin{bmatrix}1&1&1&0&0\\1&0&0&1&0\\1&1&0&0&1\end{bmatrix}_{3\times 5}}$$

$H \cdot b^T = 0 \Rightarrow$ Code b is co…ly trans-mitted

if $Hb^T \neq 0 \Rightarrow$ code is not …lid.

$a = 01000$ $\qquad$ $b = 11010$

$$\begin{bmatrix}1&1&1&0&0\\1&0&0&1&0\\1&1&0&0&1\end{bmatrix}\begin{bmatrix}0\\1\\0\\0\\0\end{bmatrix} = \begin{bmatrix}1\cdot0+1\cdot1+1\cdot\ldots\;0+0\cdot0\\1\cdot0+0\cdot1+0\ldots\end{bmatrix}$$

into 0 second place 0 into 1 plus 0 into
0 and last one into

$G = (00) \begin{bmatrix} 1 & 0 & 1 & 1 & 1 \\ 0 & 1 & 1 & 0 & 1 \end{bmatrix}$
$= [0\ 0\ 0\ 0\ 0]$

$b_2 = (10)G = (10)\begin{bmatrix} 1 & 0 & 1 & 1 & 1 \\ 0 & 1 & 1 & 0 & 1 \end{bmatrix}$
$= [1\ 0\ 1\ 1\ 1]$

$b_3 = (01)G = [0\ 1\ 1\ 0\ 1]$
$= [1\ 1\ 0\ 1\ 0]$

$H = [A^T : I_{(n-m)\times(n-m)}]_{(n-m)\times n}$

$\Rightarrow H = [A^T : I_{(5-2)\times(5-2)}]_{(5-2)\times 5}$

$= [A^T : I_{3\times 3}]_{3\times 5}$

$$\boxed{H = \begin{bmatrix} 1 & 1 & 1 & 0 & 0 \\ 1 & 0 & 0 & 1 & 0 \\ 1 & 1 & 0 & 0 & 1 \end{bmatrix}_{3\times 5}}$$

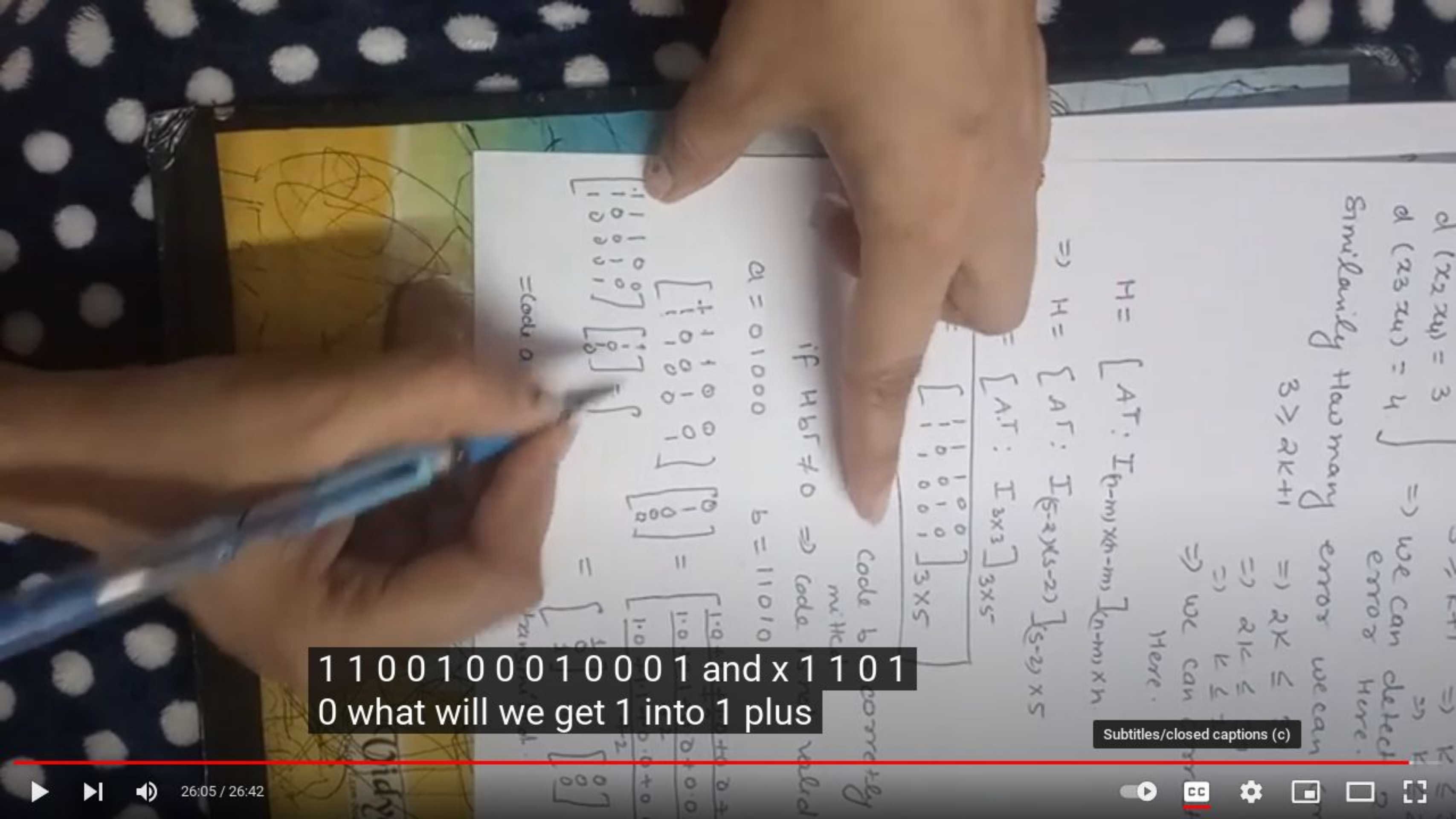
$H \cdot b^T = 0 \Rightarrow$ Code b is correctly transmitted

if $Hb^T \neq 0 \Rightarrow$ code is not valid.

$a = 01000$ $\qquad$ $b = 11010$

$$\begin{bmatrix} 1 & 1 & 1 & 0 & 0 \\ 1 & 0 & 0 & 1 & 0 \\ 1 & 1 & 0 & 0 & 1 \end{bmatrix} \begin{bmatrix} 0 \\ 1 \\ 0 \\ 0 \\ 0 \end{bmatrix} = \begin{bmatrix} 1\cdot 0 + 1\cdot 1 + 1\cdot 0 + 0 + 0 \\ 1\cdot 0 + 0\ 1 + 0 \ldots \\ \end{bmatrix}$$

equals to 1 0 and which is not equal to
0 0 0 that


Similarly How many error
3 ≥ 2k+1
Here.
a = 01000
b = 11010
1 1 0 0 1 0 0 0 1 0 0 0 1 and x 1 1 0 1
0 what will we get 1 into 1 plus
Subtitles/closed captions (c)
26:05 / 26:42