① a)

$n = 5$
$k = 3$

$$G = \begin{bmatrix} 1 & 0 & 0 & 1 & 1 \\ 0 & 1 & 1 & 1 & 0 \\ 1 & 0 & 1 & 0 & 0 \end{bmatrix} \longrightarrow (R_1 + R_3)$$

$$G = \begin{bmatrix} 1 & 0 & 0 & 1 & 1 \\ 0 & 1 & 1 & 1 & 0 \\ 0 & 0 & 1 & 1 & 1 \end{bmatrix} \longrightarrow (R_3 + R_2)$$

$$S = \begin{bmatrix} 1 & 0 & 0 & 1 & 1 \\ 0 & 1 & 0 & 0 & 1 \\ 0 & 0 & 1 & 1 & 1 \end{bmatrix} \updownarrow k \qquad A = \begin{bmatrix} 1 & 1 \\ 0 & 1 \\ 1 & 1 \end{bmatrix}$$

$\underset{I}{\longleftarrow} \qquad \underset{A}{\qquad}$
$\underset{n}{\longleftarrow\qquad\longrightarrow}$

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

b) $d(k) = 2$

$d(k) \geq s + 1$

$s = 1$

$d(k) \geq 2t + 1$

$t = \left\lfloor \dfrac{d(k) - 1}{2} \right\rfloor$

$t = \left\lfloor \dfrac{2 - 1}{2} \right\rfloor = 0$

c) $M = 2^k = 2^3 = 8$

$$M = \frac{2^n}{\binom{n}{0}} = \frac{2^5}{\binom{5}{0}} = \frac{32}{1} = 32$$

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$32 \neq 8$

d)

$$H = [A^T \mid I_{6k}] = \begin{bmatrix} 1 & 0 & 1 & 1 & 1 & 0 \\ 1 & 1 & 1 & 0 & 0 & 1 \end{bmatrix}$$

$$G \; H^T = \begin{bmatrix} 1 & 0 & 0 & 1 & 1 \\ 0 & 1 & 0 & 0 & 1 \\ 0 & 0 & 1 & 1 & 1 \end{bmatrix} \begin{bmatrix} 1 & 1 \\ 0 & 1 \\ 1 & 1 \\ 1 & 0 \\ 0 & 1 \end{bmatrix} =$$

$$3 \times 6 \times 6 \times 2$$

$$= \begin{bmatrix} 0 & 0 \\ 0 & 0 \\ 0 & 0 \end{bmatrix} = [0] \qquad \boxed{G \cdot H^T = 0}$$

② HAMM (4) $r = 4$ $n - k = \textcircled{r}$ $k = 7$
                          $n - k = 4$ $n = 11$

$P_1 \; P_2 \; m_1 \; P_3 \; m_2 \; m_3 \; m_4 \; P_4 \; m_5 \; m_6 \; m_7 \; m_8 \; m_9 \; m_{10} \; m_{11}$

HAMM $(15, 11)$

b) $x = [\,1\,1\,0\,0\,1\,0\,1\,0\,1\,0\,1\,]$

c. $G = [\,0\,1\,1\,1\,1\,0\,0\,0\,1\,0\,1\,0\,1\,0\,1\,]$

d) $p_g = 0.02$

$$P_{IPD} = \binom{15}{0} \cdot p_g^{0}(1-p_g)^{15} + \binom{15}{1} \cdot p_g \cdot (1-p_g)^{14}$$

$P_{IPD} = 0.964661$

c) $[0 \ 1 \ 1 \ 0 \ 1 \ 0 \ 0 \ 11 \ 00 \ 11 \ 01] = c'$

$c' \cdot H^T = 0$

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

$c' H^T = [0 \ 1 \ 1 \ 0 \ 1 \ 0 \ 0 \ 1 \ 1 \ 0 \ 0 \ 1 \ 1 \ 0 \ 1] \cdot \begin{bmatrix} 1 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 \\ 1 & 1 & 0 & 0 \\ 0 & 0 & 1 & 0 \\ 1 & 0 & 1 & 0 \\ 0 & 1 & 1 & 0 \\ 1 & 1 & 1 & 0 \\ 0 & 0 & 0 & 1 \\ 1 & 0 & 0 & 1 \\ 0 & 1 & 0 & 1 \\ 1 & 1 & 0 & 1 \\ 0 & 0 & 1 & 1 \\ 1 & 0 & 1 & 1 \\ 0 & 1 & 1 & 1 \\ 1 & 1 & 1 & 1 \end{bmatrix} = [1 \ 1 \ 1 \ 1]$

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d)

z_1	z_2	m_1	p_3	m_2	m_3	m_4	p_4	m_5	m_6	m_7	m_8	m_9	m_{10}	p_{11}
1	1	1	0	0	0	0	0	0	0	0	0	0	0	0
1	0	0	1	1	0	0	0	0	0	0	0	0	0	0
0	1	0	1	0	1	0	0	0	0	0	0	0	0	0
1	1	0	1	0	0	1	0	0	0	0	0	0	0	0
1	0	0	0	0	0	0	1	1	0	0	0	0	0	0
0	1	0	0	0	0	0	1	0	1	0	0	0	0	0
1	1	0	0	0	0	0	1	0	0	1	0	0	0	0
0	0	0	1	0	0	0	1	0	0	0	1	0	0	0
1	0	0	1	0	0	0	1	0	1	0	0	1	0	0
0	1	0	1	0	0	0	1	0	0	0	0	1	0	0
1	1	0	1	0	0	0	1	0	0	0	0	0	1	0
1	1	0	1	0	0	0	1	0	0	0	0	0	0	1

③ a) $g(x) = 1 + x + x^3 + x^4$ $r = 4$

b) $x^4(x^4 + x^3 + x + 1) : (x^4 + x^3 + x + 1)$

$x^4(x^5 + x^4 + x^2 + 1) : (x^4 + x^3 + x + 1) =$

$c' = 1 + x^2 + x^4 + x^5 =$

$(x^9 + x^8 + x^6 + x^4) : (x^4 + x^3 + x + 1) = x^5 + x$

$\underline{x^9 + x^8 + x^6 + x^5}$

$x^5 + x^4$

$\underline{x^5 + x^4 + x^2 + x}$

$x^2 + x$ $\Rightarrow$ $\boxed{r = g}$

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$$\left[\, 110101 \,\middle|\, 0110 \,\right]$$

$\quad\quad\; d \quad\quad\quad\quad r$