SOLUTION

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1. **Question 1**

   Cut-off frequency: $\frac{\pi}{(d_0+2)} = \frac{\pi}{7}$

   Length: 21

   Coefficients:

   0xFFFF
   0xFFF8
   0xFFEE
   0x0001
   0x008A
   0x0221
   0x054E
   0x0A10
   0x0F78
   0x13D9
   0x158A
   0x13D9
   0x0F78
   0x0A10
   0x054E
   0x0221
   0x008A
   0x0001
   0xFFEE
   0xFFF8
   0xFFFF

2. **Question 2**

   i. An input signal is quantized to $(d_1 + 1 = 3)$ binary fractional bits

      So the quantization step is : $\mathrm{Q} = \frac{1}{2^3} = \frac{1}{8} = 0.125$

   ii. Variance of the quantization error is : $\sigma^2 = \frac{Q^2}{12} = \frac{1}{768} = 0.0013$

   iii. The output noise variance is: $\sigma^2 = \frac{1}{7} * \sigma_q{}^2 = \frac{1}{5376}$

3. **Question 3**

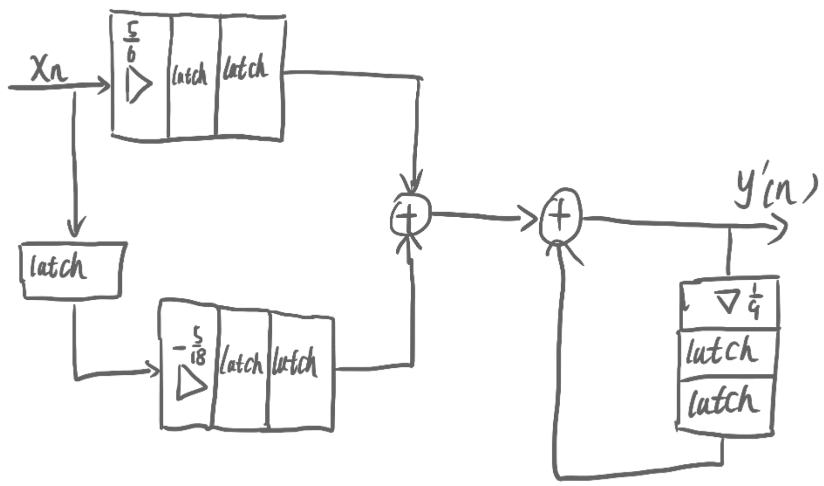
   The recursive filter is $\mathrm{y(n)} = \frac{5}{6}x(n) - \frac{1}{3}y(n-1)$

i. $y(n-1) = \frac{5}{6}x(n-1) - \frac{1}{3}y(n-2)$

So the output y(n) without using y(n-1) for such a pipelining is :

$$y(n) = \frac{5}{6}x(n) - \frac{5}{18}x(n-1) + \frac{1}{9}y(n-2)$$

ii. Pipelining structure



$$y(n) = \frac{5}{6}x(n) - \frac{5}{18}x(n-1) + \frac{1}{9}y(n-2)$$

$$y'(n) = \frac{5}{6}x(n-2) - \frac{5}{18}x(n-3) + \frac{1}{9}y'(n-2)$$

So the output is : $y'(n) = y(n-2)$