1. Encoding and Decoding using Lempel-Ziv:

Given bit stream:

```
0 0 1 0 1 1 1 0 1 1 0 0 0 1 1 1
```

(a) Sender: (Encoding)

```
0 1 0 0 1 0 1 1 1 0 1 1 0 0 1 1 1
```

(b) Receiver: (Decoding)

* No noise:

```
0 1 0 0 1 0 1 1 1 1 1 1 1 1 1 1
```

* Flip 1 bit:

```
0 1 0 0 1 0 0 1 0 1 1 1 1 1 1 1
```

flipped
Flip 1-bit

0 1

pre-stored 0 0

\[ G = \{ i_1, i_2, i_3, i_4 \} \]
\[ P = \{ \frac{1}{2}, \frac{1}{4}, \frac{1}{8}, \frac{1}{4} \} \]

Represented by: \( 100, 01, 10, 11 \)

Avg. codeword length = 2 bits

Huffman code:

\[ i_1: 0 \]
\[ i_2: 1 1 0 \]
\[ i_3: 1 1 1 \]
\[ i_4: 1 0 \]

Avg. codeword length = \( \left( 1 \times \frac{1}{2} \right) + \left( 2 \times \frac{1}{4} \right) + \left( 3 \times \frac{1}{8} \right) \times 2 \)

= 1.75 bits

Improvement = \( \frac{0.25}{2} \times 100 = 12.5\% \)