A bloom filter consists of:
1. 

2. 

---

**Bloom Filter: Insertion**

Example: \( S = \{16, 8, 4, 13, 29, 11, 22\} \), \(|S| = n\)
\[ h(k) = k \mod 7, \quad |Array| = N \]

---

**Bloom Filter: Deletion**

Bloom filters do not support the deletion operation because:

---

**Bloom Filter: Search**

With \( h(k) = k \mod 7 \), find(16), find(20), find(3)

<table>
<thead>
<tr>
<th>Array</th>
</tr>
</thead>
<tbody>
<tr>
<td>[0] 0</td>
</tr>
<tr>
<td>[1] 1</td>
</tr>
<tr>
<td>[2] 1</td>
</tr>
<tr>
<td>[3] 0</td>
</tr>
<tr>
<td>[4] 1</td>
</tr>
<tr>
<td>[5] 0</td>
</tr>
<tr>
<td>[6] 1</td>
</tr>
</tbody>
</table>

---

**Probabilistic Accuracy**

What are the four possible outcomes for a probabilistic function?

1. 

2. 

3. 

4. 

Which outcome can a bloom filter NOT have?
**Bloom Filter: Repeated Trial Insertion**

Example: \( S = \{ 16, 8, 4, 13, 29, 11, 22 \} \)

\( h_1(x) = x \mod 10, h_2(x) = 2x \mod 10, h_3(x) = (5 + 3x) \mod 10 \)

<table>
<thead>
<tr>
<th>0</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
</tr>
</thead>
<tbody>
<tr>
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<td>1</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>0</td>
</tr>
</tbody>
</table>

Given \( k \) hashes and a bit vector of length \( m \), what is the run time for insert and find:

---

**False Positive Rate**

What is the expected false positive rate in terms of \( k \) (hashes), \( m \) (bit vector length), and \( n \) (number of inserted items)?

---

**Optimal Bloom Filters**

What equation describes the relationship between \( m \) bits, \( n \) items, and \( k \) hashes for an optimal bloom filter?

---

**Combining bloom filters**

Given the following bloom filters, write a bloom filter which contains all the items present in both filters.

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<th>0</th>
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</thead>
<tbody>
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</tr>
</tbody>
</table>

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**CS 225 – Things To Be Doing:**

1. Continue working on mp_schedule
2. Either work on your final project or prepare for final exam