AP Computer Science A
2000 Student Samples

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1. A mode is a value in an array that is larger than both the value immediately before it in the array and the value immediately after it. In other words, a mode occurs at index $k$ in the array $A$ if $A[k] > A[k - 1]$ and $A[k] > A[k + 1]$. The array is unimodal if the values increase until they reach a mode, then decrease, so that there is only one mode. For example, the array $A$ shown below is unimodal with its mode occurring at index 4. Assume that the mode does not occur at the first or last entry in the array.

<table>
<thead>
<tr>
<th>Index $k$</th>
<th>$A[k]$</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>3</td>
</tr>
<tr>
<td>1</td>
<td>5</td>
</tr>
<tr>
<td>2</td>
<td>9</td>
</tr>
<tr>
<td>3</td>
<td>10</td>
</tr>
</tbody>
</table>
| 4         | 12     | ← mode
| 5         | 11     |
| 6         | 9      |
| 7         | 4      |

(a) Write function `IsMode`, as started below. `IsMode` returns `true` if $data[k]$ is larger than $data[k - 1]$ and larger than $data[k + 1]$; otherwise, it returns `false`. In the example above, the call `IsMode(A, 4)` returns `true` and the call `IsMode(A, 5)` returns `false`.

Complete function `IsMode` below.

```cpp
bool IsMode(const apvector<int> & data, int k) {
    // precondition: 0 < k < data.length() - 1
    return (data[k] > data[k-1]) && (data[k] > data[k+1]);
}
```
(b) Write function `ModeIndex`, as started below. `ModeIndex` returns the index of the mode of data. You may assume that `data` is unimodal and the mode occurs at an index `k`, where `0 < k < data.length() - 1`. In the example above, the call `ModeIndex(A)` returns 4.

In writing `ModeIndex`, you may call function `IsMode` specified in part (a). Assume that `IsMode` works as specified, regardless of what you wrote in part (a).

Complete function `ModeIndex` below.

```cpp
int ModeIndex(const apvector<int> & data)
// precondition: data is unimodal and data.length() ≥ 3
{
    int k;
    for (k=1; k< data.length() - 1; k++)
    {
        if (IsMode(data,k))
            return(k);
    }
}
```

Part (c) begins on page 6.
Complete function PrintHistogram below.

```cpp
void PrintHistogram(const apvector<int>& data,
                    int longestBar, char barChar)
// precondition: data is unimodal and data.length() >= 3;
// data[k] >= 0 for 0 <= k < data.length()
{
    double c; int k, j, numChars;
    c = double(longestBar)/data[ModeIndex(data)];
    for (k = 0; k < data.length(); k++)
    {
        numChars = data[k] * c;
        for (j = 0; j < numChars; j++)
        {
            cout << barChar;
        }
        cout << endl;
    }
}
```
1. A mode is a value in an array that is larger than both the value immediately before it in the array and the value immediately after it. In other words, a mode occurs at index \( k \) in the array \( A \) if \( A[k] > A[k - 1] \) and \( A[k] > A[k + 1] \). The array is unimodal if the values increase until they reach a mode, then decrease, so that there is only one mode. For example, the array \( A \) shown below is unimodal with its mode occurring at index 4. Assume that the mode does not occur at the first or last entry in the array.

<table>
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<tr>
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<th>( A[k] )</th>
</tr>
</thead>
<tbody>
<tr>
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<td>1</td>
<td>5</td>
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<tr>
<td>2</td>
<td>9</td>
</tr>
<tr>
<td>3</td>
<td>10</td>
</tr>
<tr>
<td>4</td>
<td>12 ( \leftarrow ) mode</td>
</tr>
<tr>
<td>5</td>
<td>11</td>
</tr>
<tr>
<td>6</td>
<td>9</td>
</tr>
<tr>
<td>7</td>
<td>4</td>
</tr>
</tbody>
</table>

(a) Write function \( \text{IsMode} \), as started below. \( \text{IsMode} \) returns \( \text{true} \) if \( \text{data}[k] \) is larger than \( \text{data}[k - 1] \) and larger than \( \text{data}[k + 1] \); otherwise, it returns \( \text{false} \). In the example above, the call \( \text{IsMode}(A, \ 4) \) returns \( \text{true} \) and the call \( \text{IsMode}(A, \ 5) \) returns \( \text{false} \).

Complete function \( \text{IsMode} \) below.

```cpp
bool IsMode(const apvector<int> & data, int k)
// precondition: 0 < k < data.length() - 1
{
    for (k=1; k < data.length()-1; k++)
    {
        if (data[k] > data[k-1] && data[k] > data[k+1])
            return true;
    }
    return false;
}
```
(b) Write function `ModeIndex`, as started below. `ModeIndex` returns the index of the mode of data. You may assume that `data` is unimodal and the mode occurs at an index `k`, where `0 < k < data.length()-1`. In the example above, the call `ModeIndex(A)` returns `4`.

In writing `ModeIndex`, you may call function `IsMode` specified in part (a). Assume that `IsMode` works as specified, regardless of what you wrote in part (a).

Complete function `ModeIndex` below.

```cpp
int ModeIndex(const apvector<int> & data)
// precondition: data is unimodal and data.length() ≥ 3

int ModeIndex (const apvector < int > & data) 
{
    int k;
    for (k=1; k < data.length()-1; k++)
    {
        if (IsMode(A,k) == true)
            return k;
    }
}
```

Part (c) begins on page 6.
Complete function `PrintHistogram` below.

```cpp
void PrintHistogram(const apvector<int> & data,
                    int longestBar, char barChar)
// precondition: data is unimodal and data.length() \geq 3;
//               data[k] \geq 0 for 0 \leq k < data.length()
{
  int maxBars;
  for (int k = 0; k < data.length(); k++)
  {
    maxBars = (longestBar / data[ModeIndex(data)]) \times data[k];
    for (int j = 0; j \leq maxBars; j++)
      cout << barChar;
  }
}
```
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(a) Write function IsMode, as started below. IsMode returns true if \( data[k] \) is larger than \( data[k - 1] \) and larger than \( data[k + 1] \); otherwise, it returns false. In the example above, the call \( IsMode(A, 4) \) returns true and the call \( IsMode(A, 5) \) returns false.

Complete function IsMode below.

```c
bool IsMode(const apvector<int> & data, int k)
{// precondition: 0 < k < data.length() - 1
  for ( int i = 0; i < data.length() - 1; i++ )
    if ( data[k] < data[k-1] && data[k] > data[k+1] )
      return true;
  return false;
}
```

GO ON TO THE NEXT PAGE.
(b) Write function `ModeIndex`, as started below. `ModeIndex` returns the index of the mode of data. You may assume that data is unimodal and the mode occurs at an index `k`, where `0 < k < data.length() - 1`. In the example above, the call `ModeIndex(A)` returns 4.

In writing `ModeIndex`, you may call function `IsMode` specified in part (a). Assume that `IsMode` works as specified, regardless of what you wrote in part (a).

Complete function `ModeIndex` below.

```cpp
int ModeIndex(const apvector<int> & data)
// precondition: data is unimodal and data.length() ≥ 3
{
    for (int k = 0; k < data.length(); k++)
    {
        if (IsMode(data, k))
            return k;
    }
    else return -1;
}
```

Part (c) begins on page 6.
Complete function PrintHistogram below.

```c
void PrintHistogram(const apvector<int> & data,
                    int longestBar, char barChar)
// precondition: data is unimodal and data.length() ≥ 3;
//                data[k] ≥ 0 for 0 ≤ k < data.length()

  3  for (int i = 0; i < data.length(); i++)
  3    if ( IsMode(data, i) )
  3      longestBar = ModeIndex(data);
  3  for (int k = 0; k <= longestBar; k++)
  3    cout << "x";
  3  cout << endl;
  3  else
  3      for (int p = 0; p <= (20 / data[p]); p++)
  3        cout << "x";
  3  cout << endl;
```

GO ON TO THE NEXT PAGE.