This quiz has 3 questions, for a total of 10 points.

1. **3 points** Given the following max heap, turn it into a sorted array. Show the state of
   the array and the heap (as a tree) after each Max-Heapify operation.

   \[4, 2, 3, 1\]

   **Solution:**
   After swapping 4 and 1, removing 4, and Max-Heapify at index 0: (1 point)
   \[3, 2, 1, 4\]
   After swapping 3 and 1, removing 3, and Max-Heapify at index 0: (1 point)
   \[2, 1, 3, 4\]
   After swapping 2 and 1, removing 2, and Max-Heapify at index 0: (1 point)
   \[1, 2, 3, 4\]

2. **3 points** What is a longest common subsequence of TACG and CTCG? Show your
   work by writing down the dynamic programming table.

   **Solution:** (2 points for a valid answer. 1 point for a correct table.)
   The only valid answer is TCG:

<table>
<thead>
<tr>
<th></th>
<th>C</th>
<th>T</th>
<th>C</th>
<th>G</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>←0</td>
<td>←0</td>
<td>←0</td>
<td>←0</td>
</tr>
<tr>
<td>T</td>
<td>↑0</td>
<td>↑0</td>
<td>(\searrow) 1</td>
<td>←1</td>
</tr>
<tr>
<td>A</td>
<td>↑0</td>
<td>↑0</td>
<td>↑1</td>
<td>↑1</td>
</tr>
<tr>
<td>C</td>
<td>↑0</td>
<td>(\searrow) 1</td>
<td>↑1</td>
<td>(\searrow) 2</td>
</tr>
<tr>
<td>G</td>
<td>↑0</td>
<td>↑1</td>
<td>↑1</td>
<td>↑2</td>
</tr>
</tbody>
</table>

3. **4 points** The following code implements DNA sequence alignment using dynamic
   programming. The two input sequences are \(s_1\) and \(s_2\) and \(F\) is the dictionary for representing
   the table of scores. (Don’t worry about traceback.) Fill in the blanks to complete the
   code.

   ```python
   F[(0, 0)] = ____(a)____
   for i in range(1, m+1):
       F[(i, 0)] = SPACE_PENALTY * i
   ```
for j in range(1, n+1):
    F[(0, j)] = SPACE_PENALTY * j
for i in range(1, m+1):
    for j in range(1, n+1):
        match = F[___(b)___] + s(___(c)___, s2[j-1])
        delete = F[(i-1, j)] + SPACE_PENALTY
        insert = F[(i, j-1)] + SPACE_PENALTY
        F[(i, j)] = ___(d)___

**Solution:** (1 point each.)
(a) 0
(b) (i-1, j-1)
(c) s1[i-1]
(d) max(match, delete, insert)