

# Leetcode

Hanhee Lee

April 14, 2025

## Contents

<b>1</b>	<b>General</b>	<b>2</b>
1.1	Interviewer Considerations . . . . .	2
1.2	Steps for Success During the Technical Interview . . . . .	2
1.3	Common Mistakes to Avoid . . . . .	2
1.4	Syntax . . . . .	3
<b>2</b>	<b>Arrays and Hashing</b>	<b>4</b>
2.1	When to Use? . . . . .	4
2.2	Hashing . . . . .	4
2.3	Common Problems . . . . .	5
<b>3</b>	<b>Two Pointers</b>	<b>7</b>
3.1	When to Use? . . . . .	7
3.2	Slow and Fast Pointers . . . . .	7
3.2.1	Common Problems . . . . .	7
3.3	Left and Right Pointers . . . . .	8
3.3.1	Common Problems . . . . .	8
<b>4</b>	<b>Sliding Window</b>	<b>9</b>
4.1	Fixed Sliding Window . . . . .	9
4.1.1	Common Problems . . . . .	10
4.2	Dynamic Sliding Window . . . . .	11
4.2.1	Common Problems . . . . .	12
<b>5</b>	<b>Binary Search</b>	<b>13</b>
5.1	When to Use? . . . . .	13
5.1.1	Common Problems . . . . .	14
<b>6</b>	<b>Linked List</b>	<b>15</b>
6.1	When to Use? . . . . .	15
6.2	Singly Linked List . . . . .	15
6.3	Operations . . . . .	15
6.4	Common Problems . . . . .	16
6.5	Doubly Linked List . . . . .	17
6.6	Circular Linked List . . . . .	17
<b>7</b>	<b>Images</b>	<b>18</b>
7.1	2D Convolution Operations . . . . .	18
7.2	Common Problems . . . . .	18

# 1 General

## 1.1 Interviewer Considerations

### Notes:

- How did the candidate **analyze** the problem?
- Did the candidate miss any special or **edge** cases?
- Did the candidate approach the problem **methodically** and logically?
- Does the candidate have a strong foundation in basic computer science **concepts**?
- Did the candidate produce **working code**? Did the candidate **test** the code?
- Is the candidate's code clean and easy to read and **maintain**?
- Can the candidate **explain** their ideas clearly?

## 1.2 Steps for Success During the Technical Interview

### Summary:

1. **Clarify the question**
  - (a) Understand what the question is asking and gather example inputs and outputs.
  - (b) Clarify constraints such as:
    - i. Can numbers be negative or repeated?
    - ii. Are values sorted or do we need to sort them?
    - iii. Can we assume input validity?
  - (c) Asking clarifying questions shows communication skills and prevents missteps.
2. **Design a solution**
  - (a) Avoid immediate coding; propose an initial approach and refine it.
  - (b) Analyze the algorithm's time and space complexity.
  - (c) Consider and address edge cases.
  - (d) Think aloud to demonstrate logical reasoning and collaboration.
  - (e) Discuss non-optimal ideas to show your thought process.
3. **Write your code**
  - (a) Structure the solution using helper functions.
  - (b) Confirm API details when uncertain.
  - (c) Use your strongest programming language and full syntax.
  - (d) Write complete, working code—not pseudocode.
4. **Test your code**
  - (a) Validate your solution with 1–2 example test cases.
  - (b) Walk through each line using inputs.
  - (c) Do not assume correctness—prove it through testing.
  - (d) Discuss any further optimizations and their trade-offs.

## 1.3 Common Mistakes to Avoid

### Warning:

1. Starting to code without clarifying the problem.
2. Failing to write or discuss sample inputs and outputs.
3. Using pseudocode instead of fully functional code.
4. Misunderstanding the problem or optimizing prematurely.

## 1.4 Syntax

### Summary:

1. `dict.items()`
  - Returns a view object that displays a list of a dictionary's key-value tuple pairs.
2. `sorted(iterable, key=..., reverse=...)`
  - `iterable`: The sequence or collection (e.g., list, dictionary view) to be sorted.
  - `key=...`: A function that extracts a comparison key from each element. Sorting is performed based on the result of this function.
    - `key=lambda x: x[0]`: Sort by the first element of each tuple.
    - `key=lambda x: x[1]`: Sort by the second element of each tuple.
  - `reverse=...`: A boolean value. If `True`, sorted in descending order; otherwise, sorted in ascending order (default is `False`).

## 2 Arrays and Hashing

### 2.1 When to Use?

#### Summary:

- To count frequencies in  $O(n)$  time.
- To check membership in constant time.
- To map keys to values (e.g., index, count, group).
- To group elements by shared features (e.g., anagrams).
- To detect duplicates efficiently.

### 2.2 Hashing

#### Algorithm:

```
1 def solve_problem(nums):
2     # Step 1: Initialize the hashmap (e.g., for frequency, index, or existence check)
3     hashmap = {}
4
5     # Step 2: Iterate over the array
6     for i, num in enumerate(nums):
7         # Step 3: Define your condition (e.g., check complement, existence, frequency)
8         if some_condition_based_on_hashmap(num, hashmap):
9             # Step 4: Return or process result as needed
10            return result_based_on_condition
11
12        # Step 5: Update the hashmap
13        hashmap_update_logic(num, i, hashmap)
14
15    # Step 6: Handle the case where the condition is never met
16    return final_result_if_needed
17
18 # Helper functions (replace with actual logic based on the problem)
19 def some_condition_based_on_hashmap(num, hashmap):
20     # Example: return (target - num) in hashmap
21     pass
22
23 def hashmap_update_logic(num, i, hashmap):
24     # Example: hashmap[num] = i
25     pass
```

## 2.3 Common Problems

### Summary:

Problem	Description:
217. Contains Duplicate	<p>Given an integer array <code>nums</code>, return <code>true</code> if any value appears at least twice.</p> <ul style="list-style-type: none"> <li>• Use a set to store the elements. If an element is already in the set, return <code>True</code>.</li> <li>• Otherwise, add it to the set.</li> </ul>
242. Valid Anagram	<p>Given two strings <code>s</code> and <code>t</code>, return <code>true</code> if <code>t</code> is an anagram of <code>s</code> and <code>false</code> otherwise.</p> <ul style="list-style-type: none"> <li>• Use a <code>HashMap</code> to count the frequency of each character in <code>s</code> and <code>t</code>.</li> <li>• If the frequency maps are equal, return <code>True</code>. Otherwise, return <code>False</code>.</li> </ul>
1. Two Sum	<p>Given an array of integers, return indices of the two numbers s.t. they add up to a specific target.</p> <ul style="list-style-type: none"> <li>• <b>Tricks:</b> <ul style="list-style-type: none"> <li>– Use a <code>HashMap</code> to store the indices of the elements, <code>prevMap[nums[i]] = i</code></li> <li>– For each element, check if the <code>target - nums[i]</code> is in the map.</li> <li>– If it is, return the index of the <code>target - nums[i]</code> (from <code>prevMap</code>) and <code>i</code>. Otherwise, add <code>target - nums[i]</code>.</li> </ul> </li> </ul>
**49. Group Anagrams	<p>Given an array of strings, group the anagrams together.</p> <ul style="list-style-type: none"> <li>• Use a <code>HashMap</code> to store a tuple of count of each char as the key and the list of words as the value.</li> <li>• For each word, create a tuple of count of each char and add the word to the list in the map.</li> <li>• Finally, return the values of the map.</li> </ul>
**347. Top K Frequent Elements	<p>Given an integer array <code>nums</code> and an integer <code>k</code>, return the <code>k</code> most frequent elements.</p> <ul style="list-style-type: none"> <li>• Use a <code>HashMap</code> to count the frequency of each element.</li> <li>• Sort the map by frequency and return the top <code>k</code> elements.</li> </ul>
118. Pascal's Triangle	<p>Given an integer <code>numRows</code>, return the first <code>numRows</code> of Pascal's triangle.</p> <ul style="list-style-type: none"> <li>• <b>Initialize:</b> <code>res = [[1]]</code>.</li> <li>• <b>Loop from numRows - 1:</b> <ul style="list-style-type: none"> <li>– <b>Pad the PrevRow:</b> Create <code>dummy_row</code> by padding the last row in <code>res</code> with zeros at both ends.</li> <li>– <b>Loop 2 from len(prevRow) + 1:</b> For each position <code>i</code>, compute the value <code>dummy_row[i] + dummy_row[i+1]</code> and append it to the new row.</li> </ul> </li> </ul>

**Summary:****Problem**

73. Set Matrix Zeroes

**Description:**

Given an  $m \times n$  integer matrix, if an element is 0, set its entire row and column to 0.

- **Record Zero Positions:** Iterate through all elements. If `matrix[i][j] == 0`, append `[i, j]` to list.
- **Row/Column Zeroing:** Set all elements in column `col_ind` to zero and all elements in row `row_ind` to zero using two helpers.

54. Spiral Matrix

Given an  $m \times n$  matrix, return all elements of the matrix in spiral order.

- **Initialize:** Create an empty list `res`, set boundaries: `top`, `bottom`, `left`, `right`, and current pos  $(i, j)$ .
- **Loop:** While `top <= bottom` and `left <= right`. Use helper functions to achieve the following:
  - Traverse from left to right along the top row and adjust top bdy and check if `top > bottom`.
  - Traverse from top to bottom along the right column and adjust right bdy and check if `left > right`.
  - Traverse from right to left along the bottom row and adjust bottom bdy and check if `top > bottom`.
  - Traverse from bottom to top along the left column and adjust left bdy and check if `left > right`.

## 3 Two Pointers

### 3.1 When to Use?

#### Summary:

- If we need to find a pair of elements that satisfy a condition.
- If we need to find a subarray that satisfies a condition.

### 3.2 Slow and Fast Pointers

#### Algorithm:

1.

#### 3.2.1 Common Problems

#### Summary:

Problem	Description:
15. 3Sum	Given an array of integers, return all the triplets [nums[i], nums[j], nums[k]] s.t. $i \neq j$ , $i \neq k$ , and $j \neq k$ .
<ul style="list-style-type: none"> <li>• <b>Tricks:</b></li> </ul>	
125. Valid Palindrome	Given a string, determine if it is a palindrome, considering only alphanumeric characters and ignoring cases.
<ul style="list-style-type: none"> <li>• <code>s_new = ".join(char.lower() for char in s if char.isalnum())</code> to remove non-alphanumeric and lowercase.</li> <li>• Use front and back pointers. If they not equal, return False. If equal move both pointers.</li> </ul>	
167. Two Sum II - Input array is sorted	Given an array of integers that is already sorted in ascending order, find two numbers such that they add up to a target.
<ul style="list-style-type: none"> <li>• Use front and back pointers. If <math>&gt;</math> target, move back pointer left. If <math>&lt;</math> target, move front pointer right.</li> </ul>	

### 3.3 Left and Right Pointers

#### Algorithm:

1. Initialize two pointers. Some common choices:
  - One at the front and one at the back of the array.
  - Both at the front of the array.
  - Both at the back of the array.

#### 3.3.1 Common Problems

##### Summary:

Problem	Description:
15. 3Sum	Given an array of integers, return all the triplets [nums[i], nums[j], nums[k]] s.t. $i \neq j$ , $i \neq k$ , and $j \neq k$ .
<ul style="list-style-type: none"> <li>• <b>Tricks:</b></li> </ul>	
125. Valid Palindrome	Given a string, determine if it is a palindrome, considering only alphanumeric characters and ignoring cases.
<ul style="list-style-type: none"> <li>• <code>s_new = ".join(char.lower() for char in s if char.isalnum())</code> to remove non-alphanumeric and lowercase.</li> <li>• Use front and back pointers. If they not equal, return False. If equal move both pointers.</li> </ul>	
167. Two Sum II - Input array is sorted	Given an array of integers that is already sorted in ascending order, find two numbers such that they add up to a target.
<ul style="list-style-type: none"> <li>• Use front and back pointers. If <math>&gt;</math> target, move back pointer left. If <math>&lt;</math> target, move front pointer right.</li> </ul>	



## 4 Sliding Window

### 4.1 Fixed Sliding Window

#### Summary:

- Find a subarray/substring of a fixed size that satisfies a condition.
- Find the maximum or minimum of a subarray of a fixed size.

#### Algorithm:

```
1 initialize window_sum = 0
2 initialize max_result (or other required value)
3
4 # Set up initial window
5 for i in range(0, k):
6     window_sum += arr[i]
7
8 max_result = window_sum # Initialize result
9
10 # Slide the window
11 for i in range(k, n):
12     window_sum += arr[i] - arr[i - k] # Add new element and remove 1st element of prev window
13     max_result = max(max_result, window_sum) (or other computation)
14
15 return max_result (or other required value)
16
```

## 4.1.1 Common Problems

## Summary:

Problem	Description:
643. Maximum Average Subarray I	Given an integer array <code>nums</code> and an integer <code>k</code> , return the maximum average value of a subarray of length <code>k</code> . <ul style="list-style-type: none"> <li>• Follow template.</li> </ul>
567. Permutation in String	Given two strings <code>s1</code> and <code>s2</code> , return true if <code>s2</code> contains a permutation of <code>s1</code> , or false otherwise. <ul style="list-style-type: none"> <li>• <b>Init:</b> Follow template with <code>window_valid</code>, <code>freqMap_window</code>, <code>freqMap_s1</code>, and fixed size <code>k</code> of <code>len(s1)</code>. Rather than sum, get freq of chars.</li> <li>• <b>Special Case:</b> If <code>len(s1) &gt; len(s2)</code>, return False.</li> <li>• <b>For:</b> Since contiguous, slide through <code>s2</code> and update <code>freqMap_window</code> by adding new char and removing old char (make sure to del key if freq = 0).</li> <li>• <b>Condition:</b> If <code>freqMap_window == freqMap_s1</code>, return True.</li> </ul>
219. Contains Duplicate II	Given an integer array <code>nums</code> and an integer <code>k</code> , return true if there are two distinct indices <code>i</code> and <code>j</code> in the array such that <code>nums[i] == nums[j]</code> and <code>abs(i - j) &lt;= k</code> . <ul style="list-style-type: none"> <li>• <b>Init:</b> Follow template with <code>window_freq</code> and fixed size <code>k</code>.</li> <li>• <b>Special Case:</b> If <code>len(nums) &lt; 2</code>, return False.</li> <li>• <b>Initial window:</b> <code>Range(min(k+1, len(nums)))</code> since first window can be smaller than <code>k</code>.</li> </ul>

## 4.2 Dynamic Sliding Window

### Summary:

- Find longest or shortest subarray/substring that satisfies a condition.

### Algorithm:

```
1 initialize left = 0
2 initialize window_state (sum, count, frequency map, etc.)
3 initialize min_or_max_result
4
5 for right in range(n):
6     update window_state to include arr[right] # Expand the window
7
8     while window_state violates the condition:
9         update min_or_max_result (if needed)
10        update window_state to exclude arr[left] # Shrink the window
11        move left pointer forward
12
13 return min_or_max_result
```

## 4.2.1 Common Problems

## Summary:

Problem	Description:
121. Best Time to Buy and Sell Stock	<p>Given an array where the <math>i</math>th element is the price of a stock on day <math>i</math>, find the maximum profit you can achieve. You may not engage in multiple transactions.</p> <ul style="list-style-type: none"> <li>• <b>Buy low, sell high principle</b> <ul style="list-style-type: none"> <li>– Use <math>left = buy</math> and <math>right = sell</math>, initialized at 0, 1.</li> <li>– If <math>price[right] \geq price[left]</math>, update max profit. Move right pointer since we can still sell for a profit.</li> <li>– If <math>price[right] &lt; price[left]</math>, move left pointer since we need to find a lower price to buy.</li> <li>– Continue until right pointer reaches the end of the array.</li> </ul> </li> </ul>
3. Longest Substring W/O Repeating Characters	<p>Given a string <math>s</math>, find the length of the longest substring without repeating characters.</p> <ul style="list-style-type: none"> <li>• <b>Init:</b> Follow template and use frequency map of chars for <code>window_state</code>.</li> <li>• <b>While:</b> If a char is repeated, move left pointer to right by 1 and adjust <code>freqMap</code> until current char is unique.</li> <li>• <b>Change:</b> Compare substring length outside of while with <code>max_res = max(max_res, right - left + 1)</code>.</li> </ul>
424. Longest Repeating Character Replacement	<p>Given a string <math>s</math> that consists of only uppercase English letters, you can replace any letter with another letter. Find the length of the longest substr containing the same letter after performing at most <math>k</math> replacements.</p> <ul style="list-style-type: none"> <li>• <b>Init:</b> Follow template and use <code>freqMap</code> of chars for <code>window_state</code>.</li> <li>• <b>While:</b> If the number of replacements needed exceeds <math>k</math>, i.e. <math>(r - l + 1) - \max\_freq &gt; k</math> <ul style="list-style-type: none"> <li>– Move left pointer to right by 1 and adjust <code>freqMap</code> until the condition is satisfied.</li> </ul> </li> <li>• <b>Change:</b> Compare substring length outside of while with <code>max_res = max(max_res, right - left + 1)</code>.</li> </ul>
**76. Minimum Window Substring	<p>Given two strings <math>s</math> and <math>t</math>, return the minimum window substr of <math>s</math> such that every character in <math>t</math> (including duplicates) is included in the window. If there is no such substring, return ""</p> <ul style="list-style-type: none"> <li>• <b>Init:</b> Set <math>left = 0</math>. Initialize <code>count_t</code> as frequency map of <math>t</math>, <code>count_s</code> for current window, and variables <code>have = 0</code>, <code>required = len(count_t)</code>, <code>res = [-1, -1]</code>, and <code>resLen = \infty</code>.</li> <li>• <b>For right in range(n):</b> Expand window by adding <math>s[right]</math> to <code>count_s</code>. If frequency matches <code>count_t</code>, increment <code>have</code>.</li> <li>• <b>While have == required:</b> <ul style="list-style-type: none"> <li>– Update result if current window is smaller.</li> <li>– Shrink window by decrementing <code>count_s[s[left]]</code>; if below <code>count_t</code>, decrement <code>have</code>; increment <code>left</code>.</li> </ul> </li> <li>• <b>Return:</b> <math>s[res[0]:res[1]+1]</math> if valid window found, else empty string.</li> </ul>
239. Sliding Window Maximum	<p>Given an integer array <math>nums</math> and an integer <math>k</math>, return the maximum value in each sliding window of size <math>k</math>.</p> <ul style="list-style-type: none"> <li>• <b>Init:</b> Use deque to store indices of elements in the current window.</li> <li>• <b>For right in range(n):</b> <ul style="list-style-type: none"> <li>– Remove indices that are out of the current window.</li> <li>– Remove indices from the back of the deque while the current element is greater than the element at those indices.</li> <li>– Append the current index to the deque.</li> <li>– If the window size is reached, append the maximum (element at the front of the deque) to the result list.</li> </ul> </li> </ul>

## 5 Binary Search

### 5.1 When to Use?

#### Summary:

- Use when the input is **sorted** or can be **monotonically mapped**.
- Common for problems involving **searching for a target**, **finding boundaries**, or **min/max constraints**.
- Works on arrays, answer ranges, or implicit search spaces with  $\mathcal{O}(\log n)$  complexity.

#### Algorithm:

```
1 def binary_search(nums, target):
2     left, right = 0, len(nums) - 1
3
4     while left <= right:
5         mid = left + (right - left) // 2
6
7         if nums[mid] == target:
8             return mid
9         elif nums[mid] < target:
10            left = mid + 1
11        else:
12            right = mid - 1
13
14    return -1
```

### 5.1.1 Common Problems

**Summary:**

## 6 Linked List

**Summary:** Data structure for storing objects in linear order.

- **Object:** Data and a pointer to the next object.

### 6.1 When to Use?

**Summary:**

- Implement other DS: stacks, queues, hash tables.
- Dynamic memory allocation.

### 6.2 Singly Linked List

**Algorithm:**

```
1 class Node:
2     def __init__(self, data):
3         self.data = data # Value stored in the node
4         self.next = None # Pointer to the next node
5
6 class SinglyLinkedList:
7     def __init__(self, data):
8         self.head = Node(data) # Head of the list
9
10    def operations(self):
11        pass
```

Listing 1: Singly Linked List in Python

**Summary:**

Operation	Time Complexity
Search	$O(n)$
Insert	$O(1)$
Delete	$O(1)$
Access	$O(n)$

### 6.3 Operations

## 6.4 Common Problems

### Summary:

Problem	Description:
206. Reverse Linked List	Given the head of a singly linked list, reverse the list and return the reversed list.
<ul style="list-style-type: none"> <li>• <b>Iterative:</b> <ul style="list-style-type: none"> <li>– Init: <math>\underbrace{\text{None}}_{\text{prev}} \rightarrow \underbrace{1}_{\text{cur}} \rightarrow 2 \rightarrow 3 \rightarrow 4 \rightarrow 5</math></li> <li>– While loop: <ul style="list-style-type: none"> <li>* Temp: <math>\underbrace{\text{None}}_{\text{prev}} \rightarrow \underbrace{1}_{\text{cur}} \rightarrow \underbrace{2}_{\text{temp}} \rightarrow 3 \rightarrow 4 \rightarrow 5</math></li> <li>* Switch link: <math>\underbrace{\text{None}}_{\text{prev}} \leftarrow \underbrace{1}_{\text{cur}} \rightarrow \underbrace{2}_{\text{temp}} \rightarrow 3 \rightarrow 4 \rightarrow 5</math></li> <li>* Swap positions: <math>\underbrace{1}_{\text{prev} = \text{cur}} \rightarrow \underbrace{2}_{\text{cur} = \text{temp}} \rightarrow 3 \rightarrow 4 \rightarrow 5</math></li> </ul> </li> </ul> </li> </ul>	
21. Merge Two Sorted Lists	Given two sorted linked lists, merge them into one sorted list.
<ul style="list-style-type: none"> <li>• <b>Initialize a dummy head:</b> <ul style="list-style-type: none"> <li>– <code>dummy = ListNode()</code>: Placeholder node to simplify edge case handling.</li> <li>– <code>current = dummy</code>: Build the merged list step-by-step.</li> </ul> </li> <li>• <b>Iterate through both lists while neither is empty:</b> <ul style="list-style-type: none"> <li>– <b>Compare current nodes:</b> <ul style="list-style-type: none"> <li>* If <code>list1.val &lt;= list2.val</code>, attach <code>list1</code>'s node to <code>current.next</code>, and move <code>list1</code> forward.</li> <li>Otherwise, do the same for <code>list2</code>.</li> </ul> </li> <li>– Move the <code>current</code> pointer forward.</li> </ul> </li> <li>• <b>Attach remaining nodes (if any):</b> After the loop, only one of <code>list1</code> or <code>list2</code> may still have nodes left. <ul style="list-style-type: none"> <li>– <code>current.next = list1</code> if <code>list1</code> else <code>list2</code> ensures the remainder is attached.</li> </ul> </li> <li>• <b>Return the merged list:</b> return <code>dummy.next</code> returns actual start of the merged list.</li> <li>– <b>Visualization:</b> <ul style="list-style-type: none"> <li>* <b>Initial state:</b> <ul style="list-style-type: none"> <li>· List1: <math>\underbrace{1}_{\text{list1}} \rightarrow 2 \rightarrow 4</math></li> <li>· List2: <math>\underbrace{1}_{\text{list2}} \rightarrow 3 \rightarrow 4</math></li> <li>· Merged List: <math>\underbrace{\text{dummy}}_{\text{start}} \rightarrow</math></li> </ul> </li> <li>* <b>Step 1: Compare list1 and list2 (<math>1 \leq 1</math>), take list1</b> <ul style="list-style-type: none"> <li>· <code>dummy</code> <math>\rightarrow \underbrace{1}_{\text{current}} \rightarrow</math></li> <li>· list1 <math>\rightarrow \underbrace{2}_{\text{list1}} \rightarrow 4</math></li> <li>· list2 unchanged: <math>\underbrace{1}_{\text{list2}} \rightarrow 3 \rightarrow 4</math></li> </ul> </li> <li>* <b>Step 2: Compare 2 and 1 (<math>2 &gt; 1</math>), take list2</b> <ul style="list-style-type: none"> <li>· <code>dummy</code> <math>\rightarrow 1 \rightarrow \underbrace{1}_{\text{current}} \rightarrow</math></li> <li>· list1 remains: <math>\underbrace{2}_{\text{list1}} \rightarrow 4</math></li> <li>· list2 <math>\rightarrow \underbrace{3}_{\text{list2}} \rightarrow 4</math></li> </ul> </li> </ul> </li> </ul>	



## 6.5 Doubly Linked List

Algorithm:

## 6.6 Circular Linked List

Algorithm:

## 7 Images

### 7.1 2D Convolution Operations

Notes:

1. **1. Output Dimensions**

The output height and width of a 2D convolution are given by:

$$\text{out\_height} = \left\lfloor \frac{\text{in\_height} + 2 \cdot \text{padding}_h - \text{effective\_kernel}_h}{\text{stride}_h} \right\rfloor + 1$$

$$\text{out\_width} = \left\lfloor \frac{\text{in\_width} + 2 \cdot \text{padding}_w - \text{effective\_kernel}_w}{\text{stride}_w} \right\rfloor + 1$$

2. **2. Effective Kernel Size (with Dilation)**

The effective kernel size when dilation is applied:

$$\text{effective\_kernel}_h = \text{kernel\_height} + (\text{kernel\_height} - 1) \cdot (\text{dilation}_h - 1)$$

$$\text{effective\_kernel}_w = \text{kernel\_width} + (\text{kernel\_width} - 1) \cdot (\text{dilation}_w - 1)$$

3. **3. Convolution Operation (Batch, Channel-aware)**

The general convolution operation for a batch of input tensors is:

$$\text{output}[b, c_{\text{out}}, h_{\text{out}}, w_{\text{out}}] = \sum_{c_{\text{in}}} \sum_{k_h} \sum_{k_w} (\text{input}[b, c_{\text{in}}, h_{\text{in}} + k_h \cdot \text{dilation}_h, w_{\text{in}} + k_w \cdot \text{dilation}_w] \cdot \text{filter}[c_{\text{out}}, c_{\text{in}}, k_h, k_w])$$

where:

$$h_{\text{in}} = h_{\text{out}} \cdot \text{stride}_h, \quad w_{\text{in}} = w_{\text{out}} \cdot \text{stride}_w$$

### 7.2 Common Problems

**Summary:**

Problem	Description
661. Image Smoother	<p>Given an image represented by a 2D array, smooth the image by averaging the pixel values of each pixel and its neighbors.</p> <ul style="list-style-type: none"> <li>• Loop through the cols and rows of the image, then             <ul style="list-style-type: none"> <li>– total sum for each pixel = <math>\sum_{x,y \in \text{neighbours}} \text{image}[x][y] = \sum_{x=i-1}^{i+1} \sum_{y=j-1}^{j+1} \text{image}[x][y]</math> <ul style="list-style-type: none"> <li>* If <math>x</math> or <math>y</math> is out of bounds, ignore it.</li> </ul> </li> <li>– count = <math>\sum_{x=i-1}^{i+1} \sum_{y=j-1}^{j+1} 1</math></li> <li>– average = total sum // count</li> </ul> </li> <li>• result[i][j] = average</li> </ul>
832. Flipping an Image	<p>Given a binary matrix, flip the image horizontally and invert it.</p> <ul style="list-style-type: none"> <li>• Loop through the rows of the image, then use .reverse() to flip the row horizontally.</li> <li>• Double for loop to invert image (change 0 to 1 and 1 to 0).</li> </ul>
48. Rotate Image	<p>Given an n x n 2D matrix, rotate the image 90 degrees clockwise.</p> <ul style="list-style-type: none"> <li>• Transpose the matrix (swap rows and columns) if <math>i &lt; j</math>, then <math>\text{matrix}[i][j] \xleftrightarrow{\text{swap}} \text{matrix}[j][i]</math>.</li> <li>• Reverse each row.</li> </ul>
**835. Image Overlap	<p>Given two images represented by 2D arrays, find the maximum overlap between the two images.</p> <ul style="list-style-type: none"> <li>• Try all possible translations of img1.</li> <li>• For each translation, calculate the overlap with img2.</li> </ul>