Stack

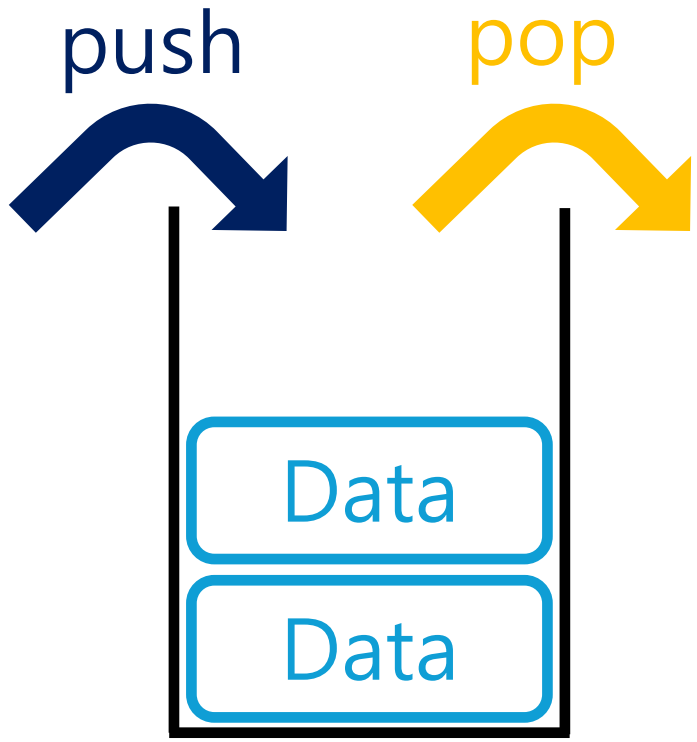
즐겁고 알찬 자료구조 튜터링

Stack

Stack

- 먼저 들어간 것이 나중에 나오는 LIFO(Last-in, First-out)구조의 자료 구조

- 스택의 기본적인 연산
  - push
  - pop

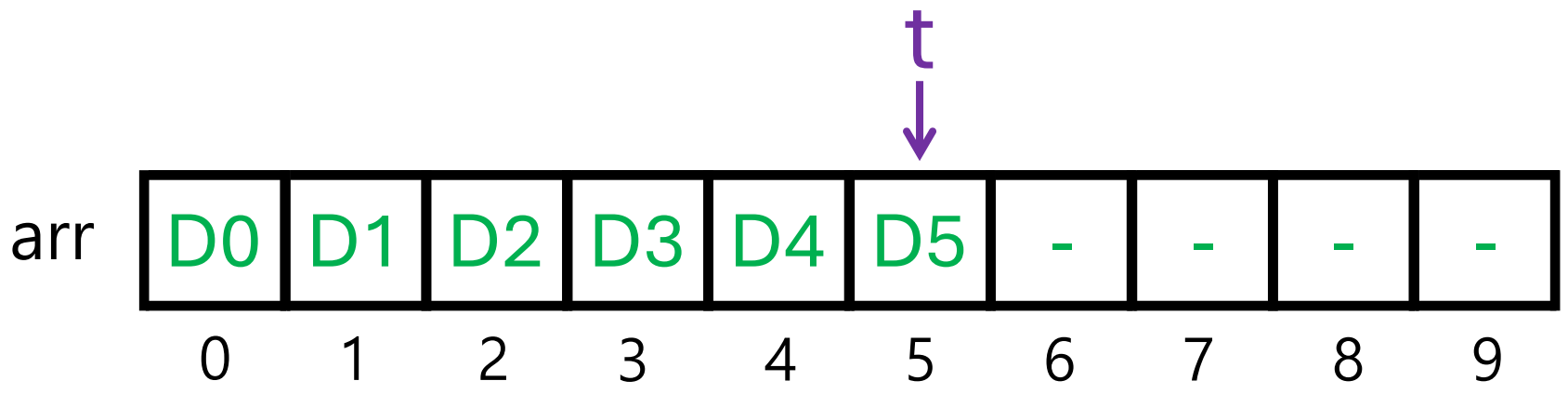


Stack의 ADT

- int size() : 현재 stack에 있는 원소 개수를 반환
- bool empty() : stack에 원소가 비어있는지 여부를 반환
- T& top() : stack에서 마지막으로 저장된 원소를 반환
- void push(T &data) : stack에 인자로 받은 data를 저장하고, stack의 용량을 초과한 경우 예외 발생
- void pop() : stack에 저장된 마지막 요소를 삭제하고, stack이 비어있는 경우 예외 발생

배열 기반의 Stack

- 클래스의 멤버 변수로 배열을 가지고, 이를 Stack으로 사용
- 멤버 변수 t(top)을 활용하여 마지막에 추가된 원소를 가리킴



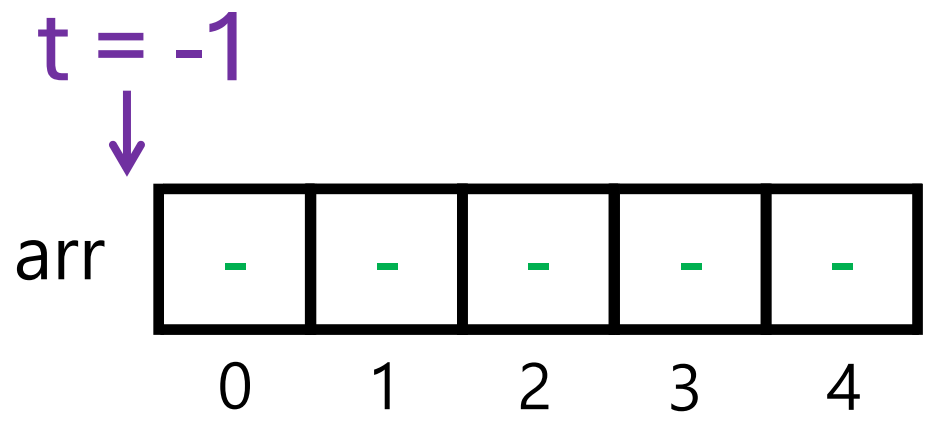
배열 기반의 Stack

```
1  template <typename T>
2  class ArrayStack {
3  private:
4      T *arr;
5      int cap;
6      int t;
```

```
1  ArrayStack(int cap) {
2      this->cap = cap;
3      arr = new T[cap];
4      t = -1;
5  }
```

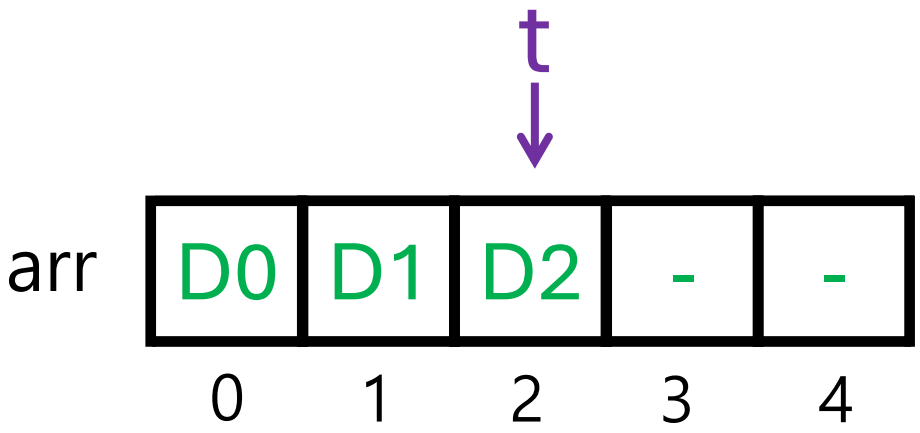
size, empty

```
1  int size() const {
2      return t + 1;
3  }
4
5  bool empty() const {
6      return t == -1;
7  }
```



top, push, pop

```
1 T &top() const {
2     if (empty()) {
3         throw "Stack is empty";
4     }
5
6     return arr[t];
7 }
```




```
1 void push(const T &data) {
2     if (size() == cap) {
3         throw "Stack is full";
4     }
5
6     arr[++t] = data;
7 }
```

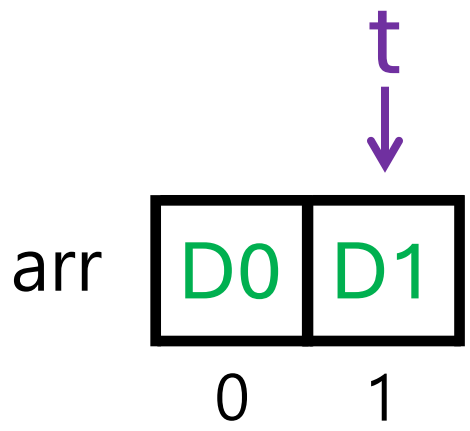
```
1 void pop() {
2     if (empty()) {
3         throw "Stack is empty";
4     }
5
6     --t;
7 }
```

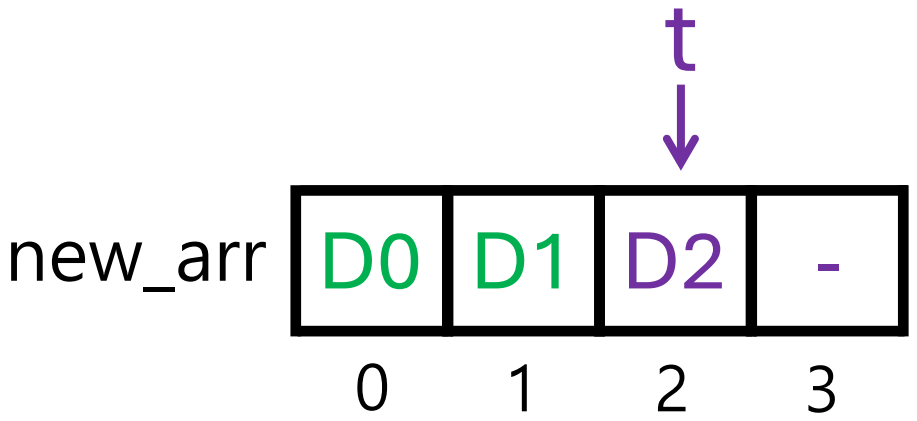
배열의 길이가 증가하는 Stack

- 배열 기반으로 stack을 구현한 경우 배열 크기만큼 원소를 push하지 못함
- push 연산에서 배열의 크기 이상으로 원소를 push하는 경우 배열의 크기를 2배로 늘려 새로운 배열 할당
- 기존의 배열에 있는 원소를 크기가 증가한 새로운 배열에 옮겨주고, 새로운 배열을 stack으로 사용

예외 없는 push

```
1  void push(const T &data) {
2      if (size() == cap) {
3          cap *= 2;
4          T *new_arr = new T[cap];
5          for (int i = 0; i <= t; i++) {
6              new_arr[i] = arr[i];
7          }
8
9          delete[] arr;
10         arr = new_arr;
11     }
12
13     arr[++t] = data;
14 }
```





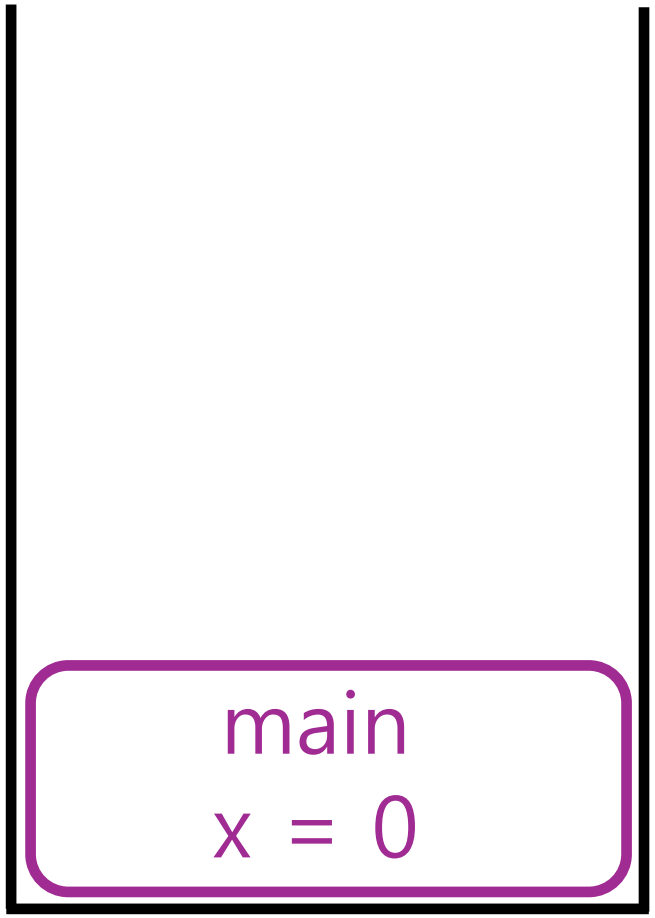
Usage of Stack

Run-Time Stack

- 함수가 실행되면, 함수들은 메모리 공간에 할당
- 함수가 호출되는 순서에 따라 Run-Time Stack에 함수에 필요한 정보(지역변수, 반환값, Program Counter)들을 push
- 함수가 종료되면 Run-Time Stack에서 함수를 pop
- 따라서 현재 실행중인 함수는 Run-Time Stack의 top에 위치

Run-Time Stack

```
1  int main() {
2      int x = 0;
3      foo(x);
4  }
5  void foo(int f) {
6      int y = f;
7      bar(f);
8  }
9  void bar(int b) {
10     int z = b;
11 }
```



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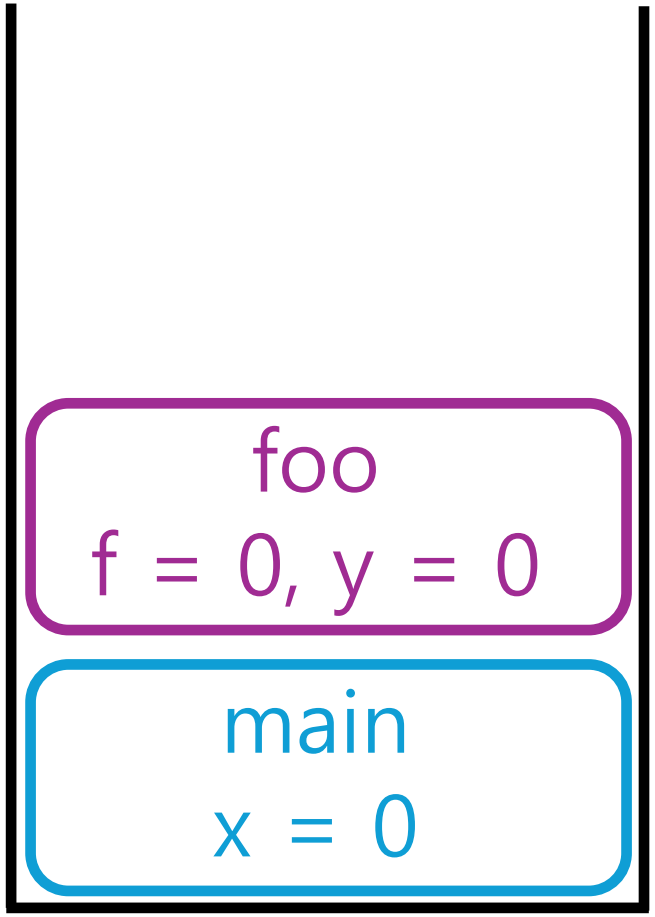

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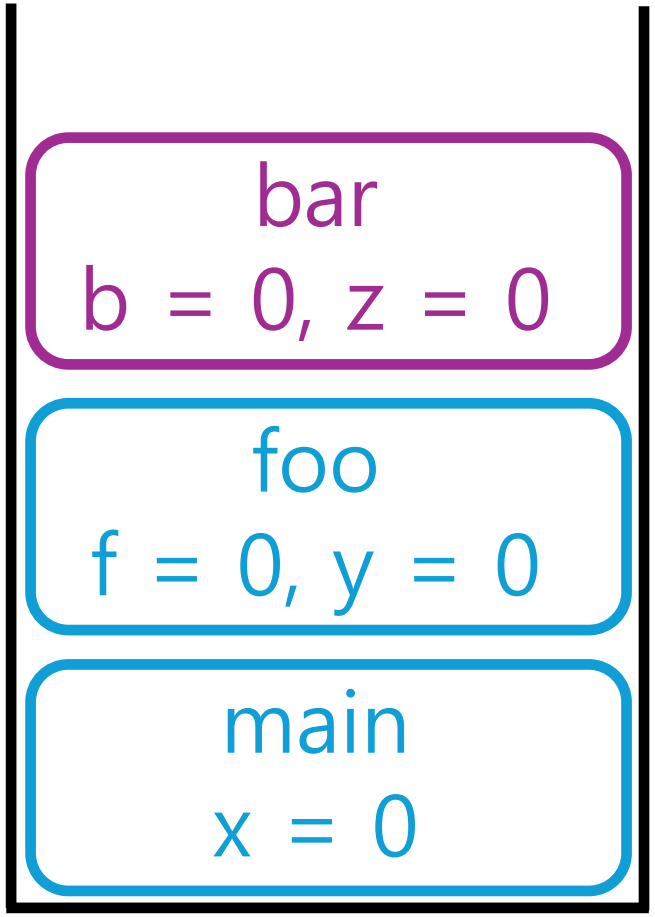

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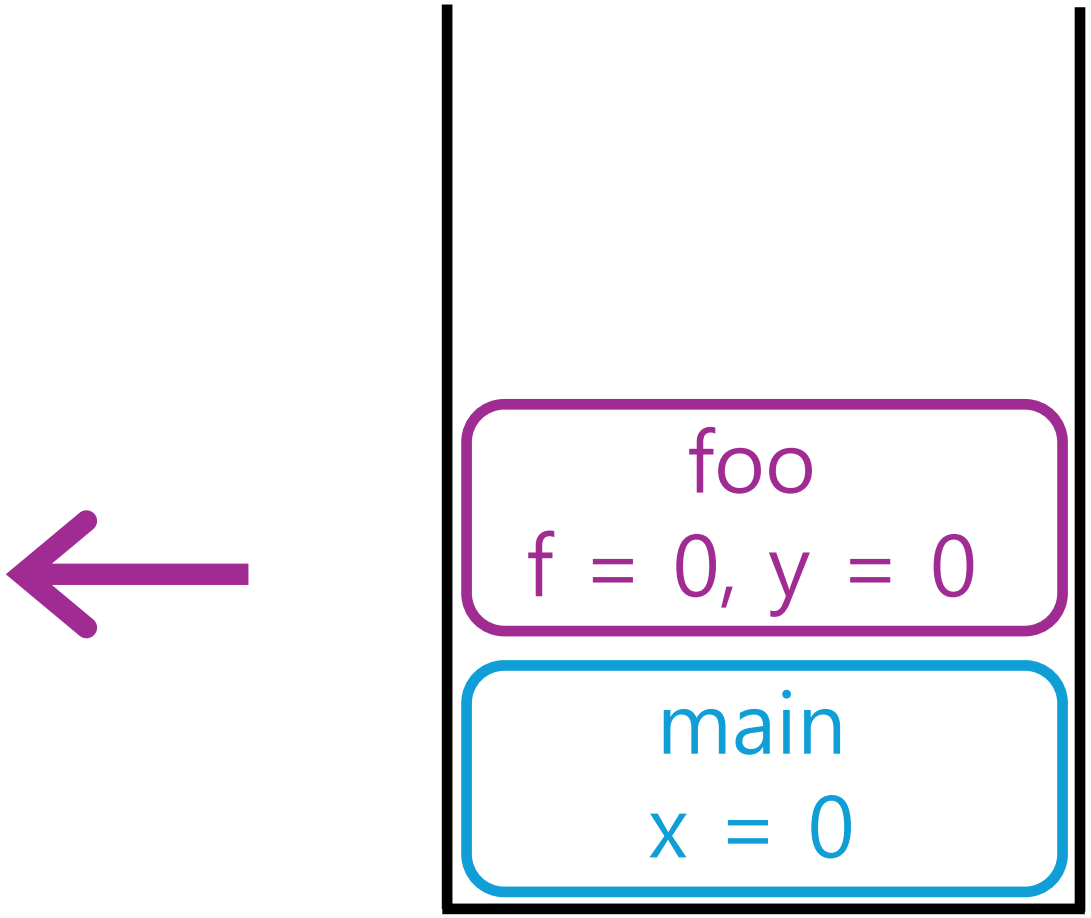

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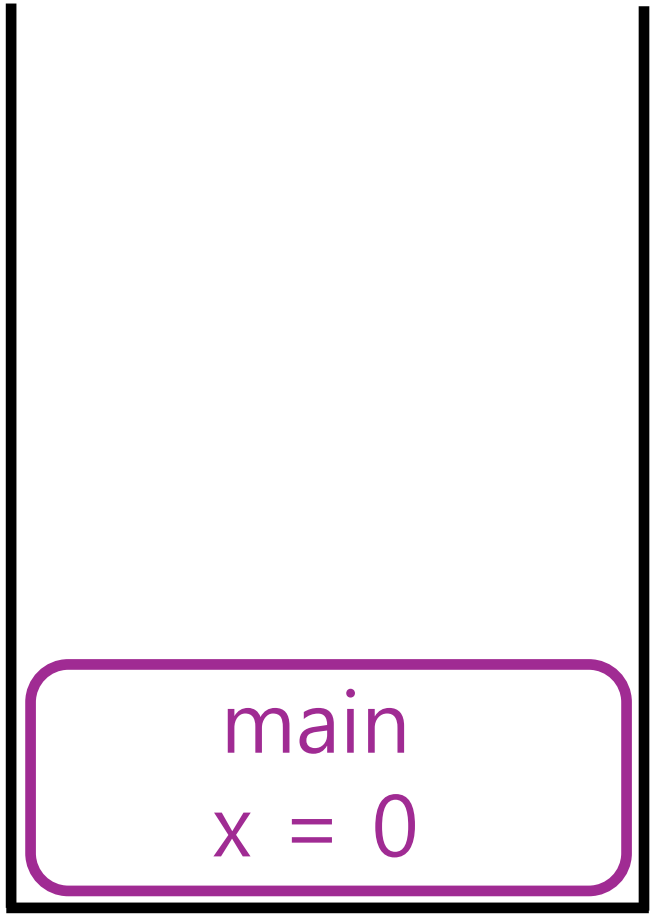


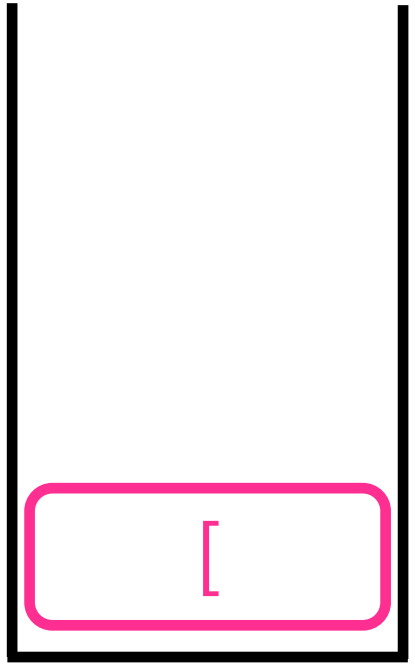
Parentheses Matching

- 괄호 '(', '{', '['은 각각 ')', '}', ']'과 쌍이 맞게 이루어 져야 함
- 문장에서 괄호의 쌍이 맞는지 stack을 통해 점검
- 여는 괄호를 만나면 stack에 push
- 닫는 괄호를 만나면 stack에 top에 있는 괄호와 쌍이 맞으면 pop하고, 쌍이 맞지 않으면 matching 실패
- 문장을 모두 점검하고 stack에 여는 괄호가 남아있지 않다면 matching 성공

Parentheses Matching

[{ 인생에서 중요한 점은
(넘어짐)이 아닌 (일어섬)
에 있다. }

{ by JO. W. Y. }]



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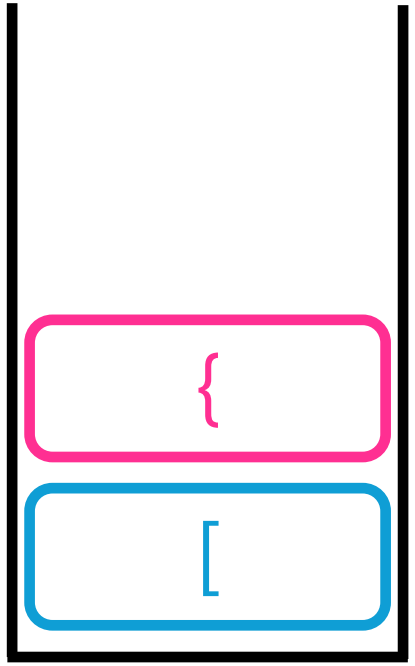

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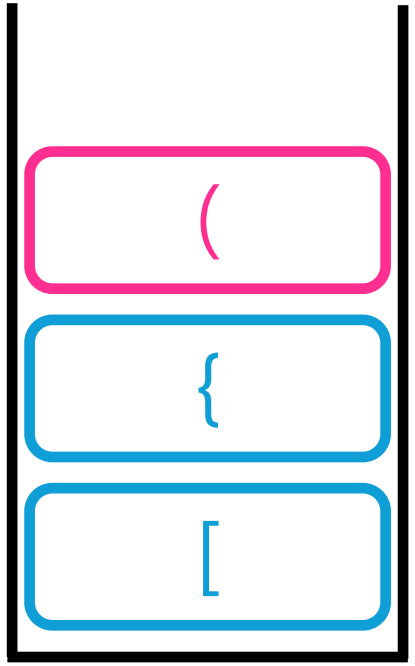

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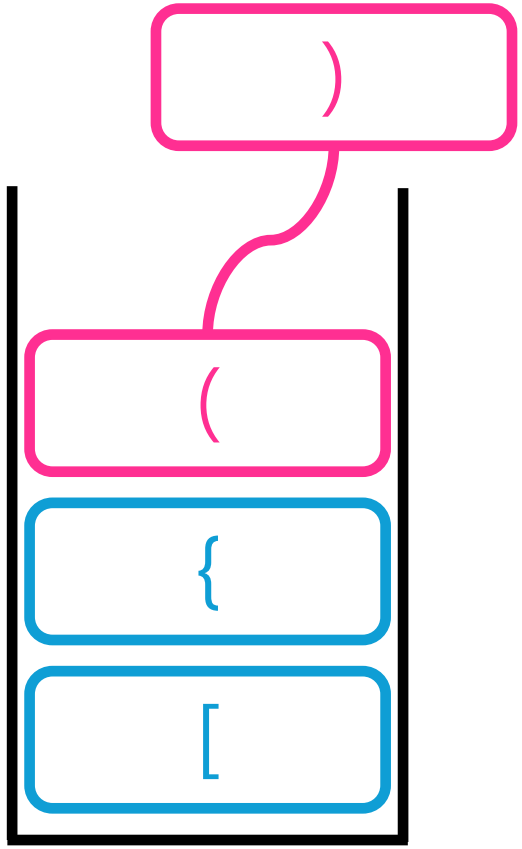

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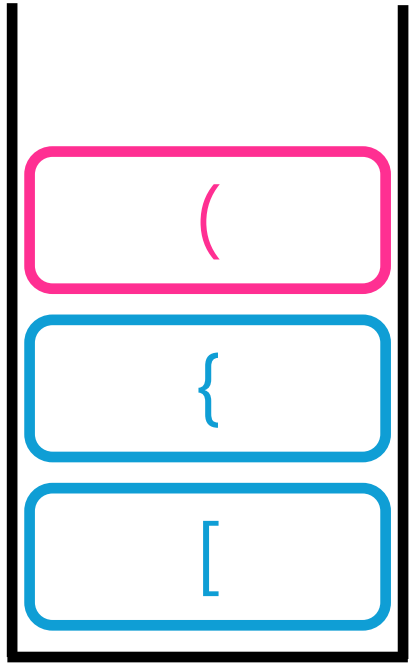

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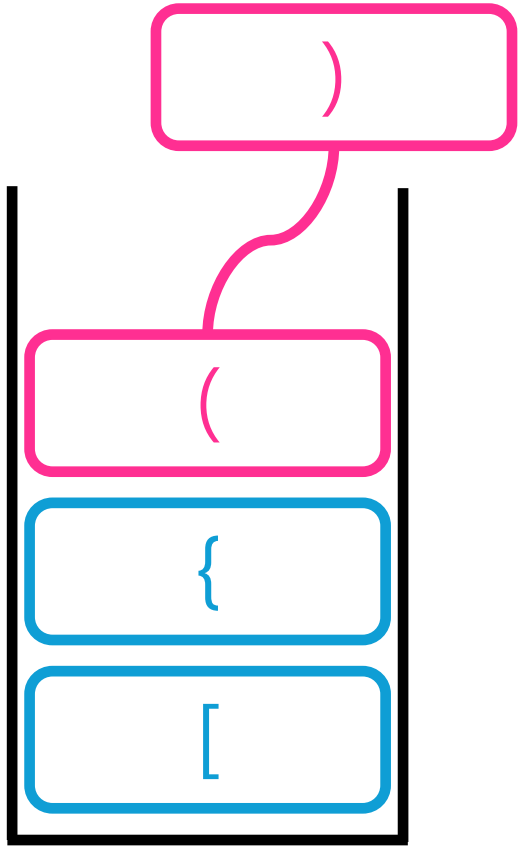

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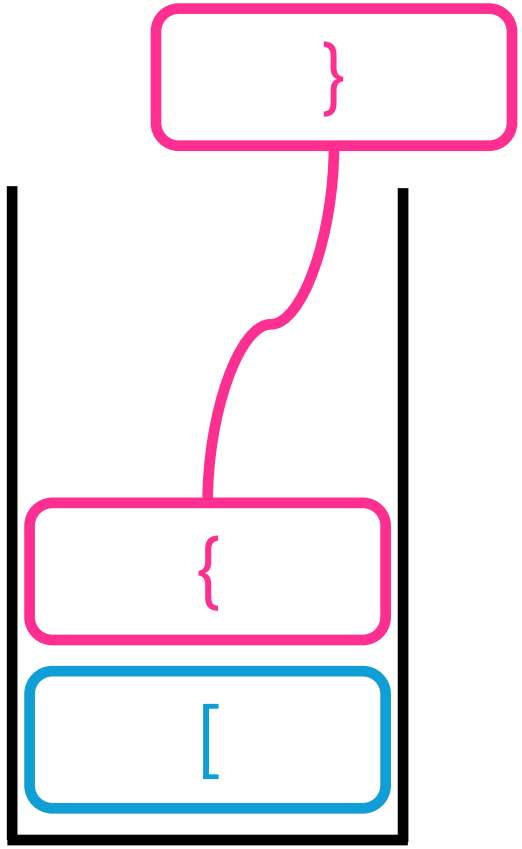

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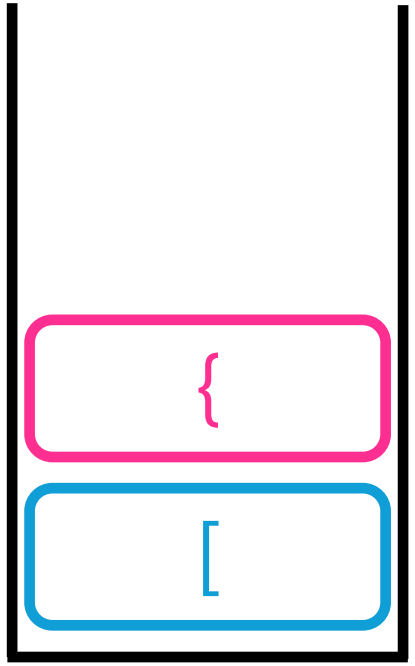

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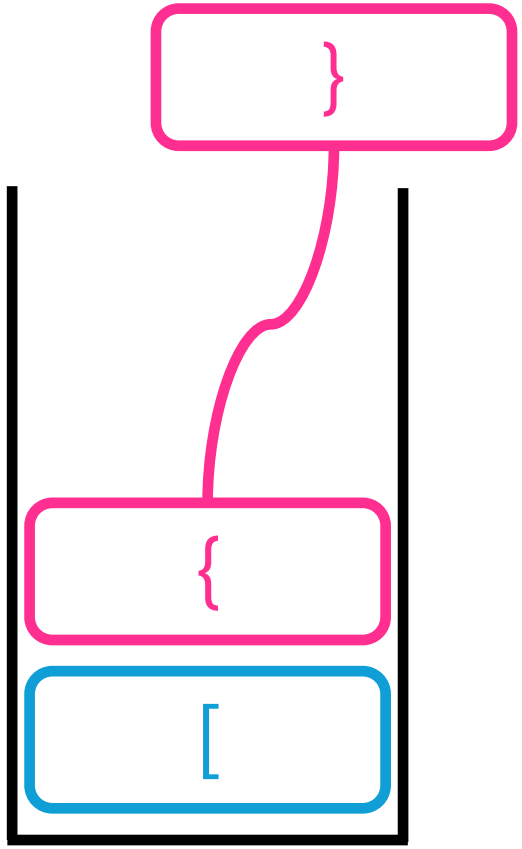

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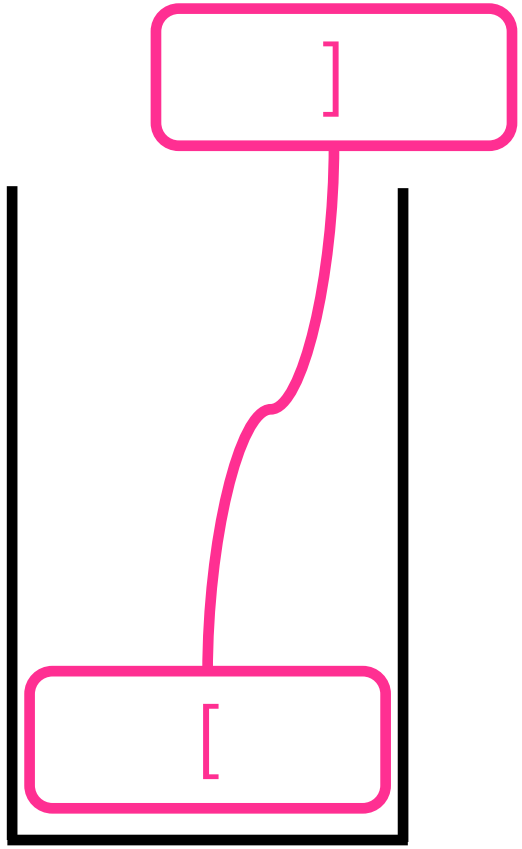

Parentheses Matching Fail

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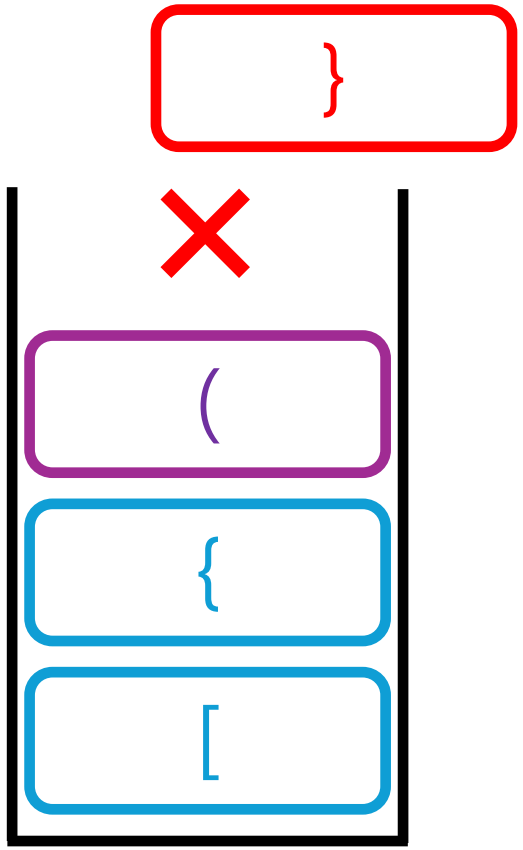

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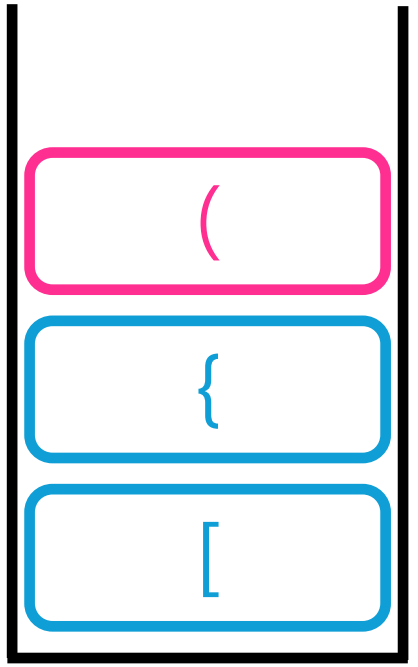

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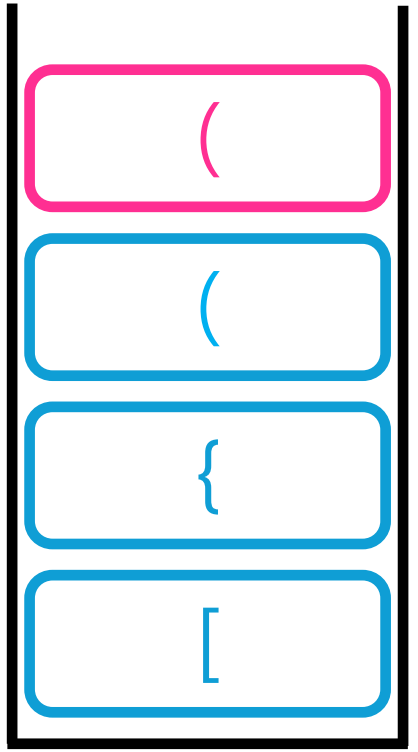

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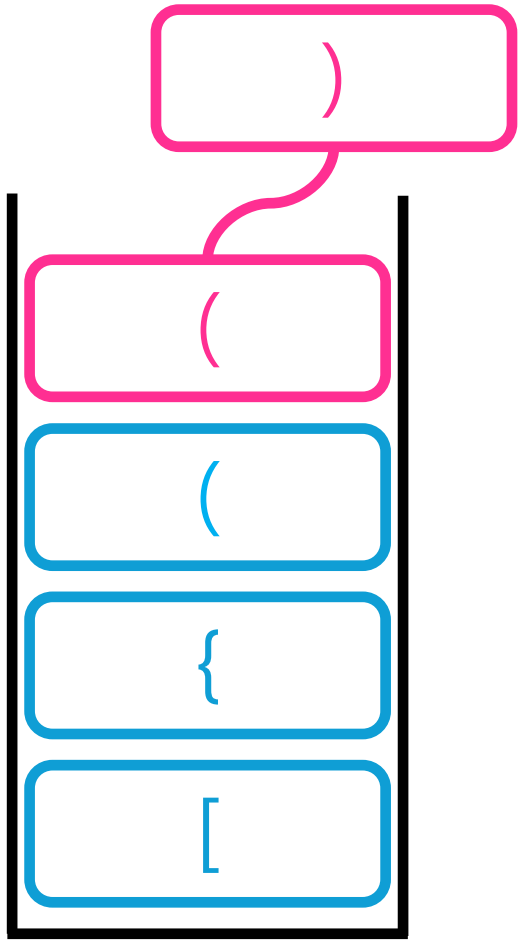

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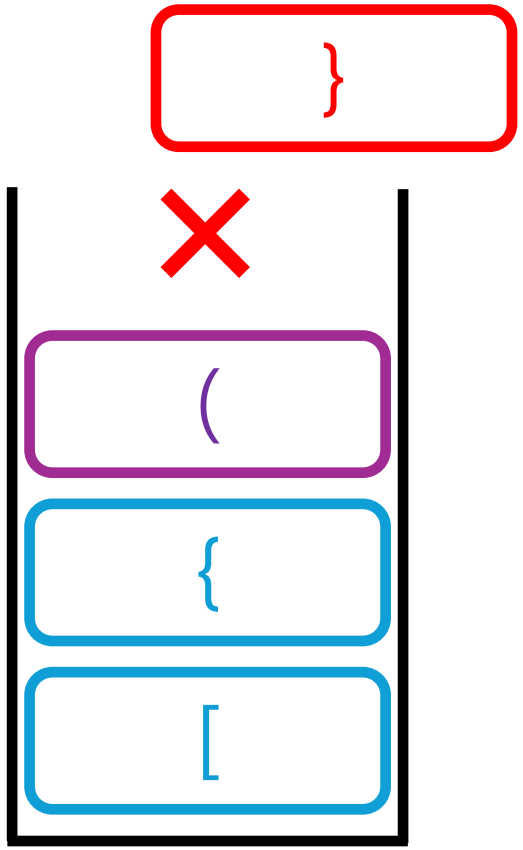

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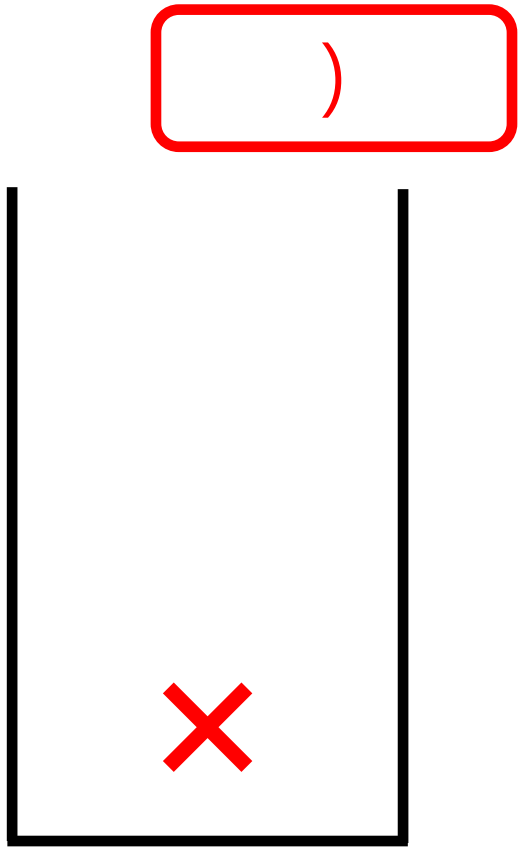


Parentheses Matching Code

```
1 bool paretheses_matching(string str) {
2     ArrayStack2<char> stack;
3 
4     char open[3] = {'[', '{', '('};
5     char close[3] = {']', '}', ')'};
6     for (int i = 0; i < str.length(); i++) {
7         if (!is_parentheses(str[i]))
8             continue;
```

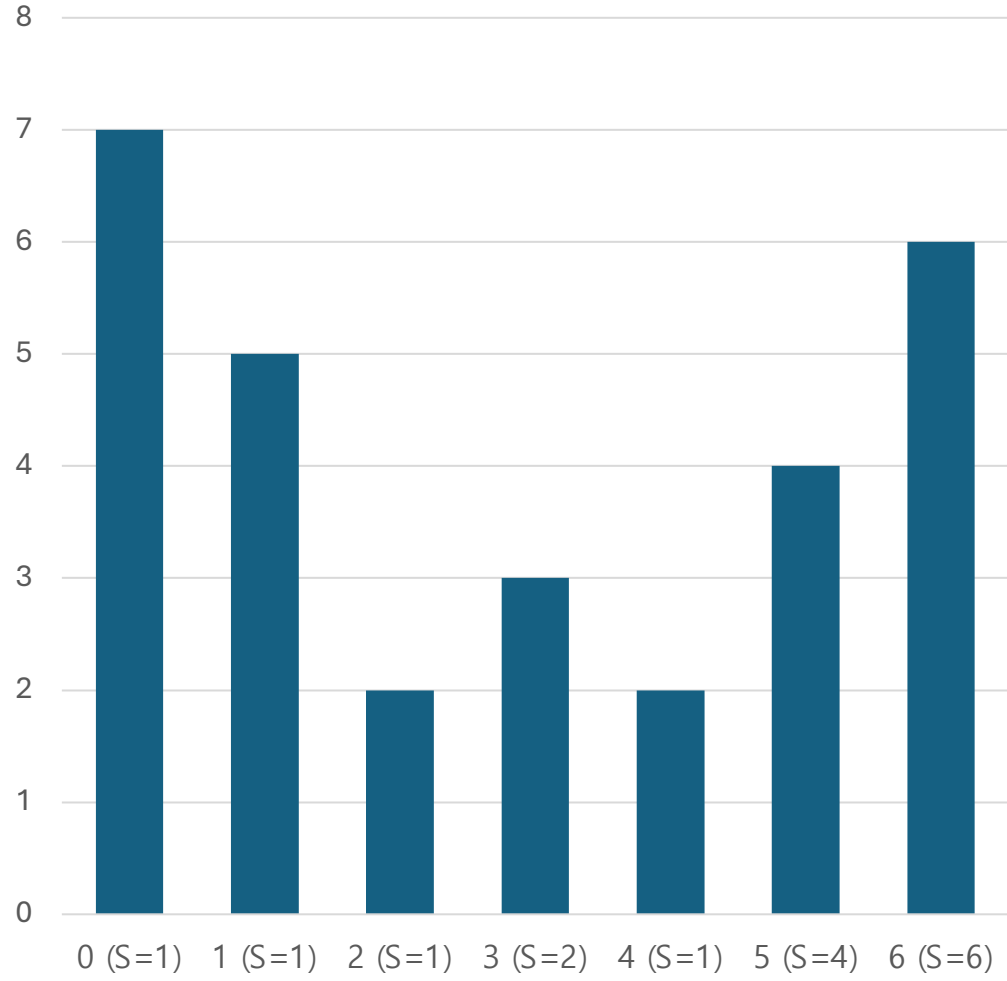
Parentheses Matching Code

```
1           for (int j = 0; j < 3; j++) {
2               if (str[i] == close[j] && !stack.empty() && stack.top() == open[j]) {
3                   stack.pop();
4                   break;
5               }
6               else if (j == 3) {
7                   stack.push(str[i]);
8               }
9           }
10      }
11
12      return stack.empty();
13  }
```

Stock Span Problem

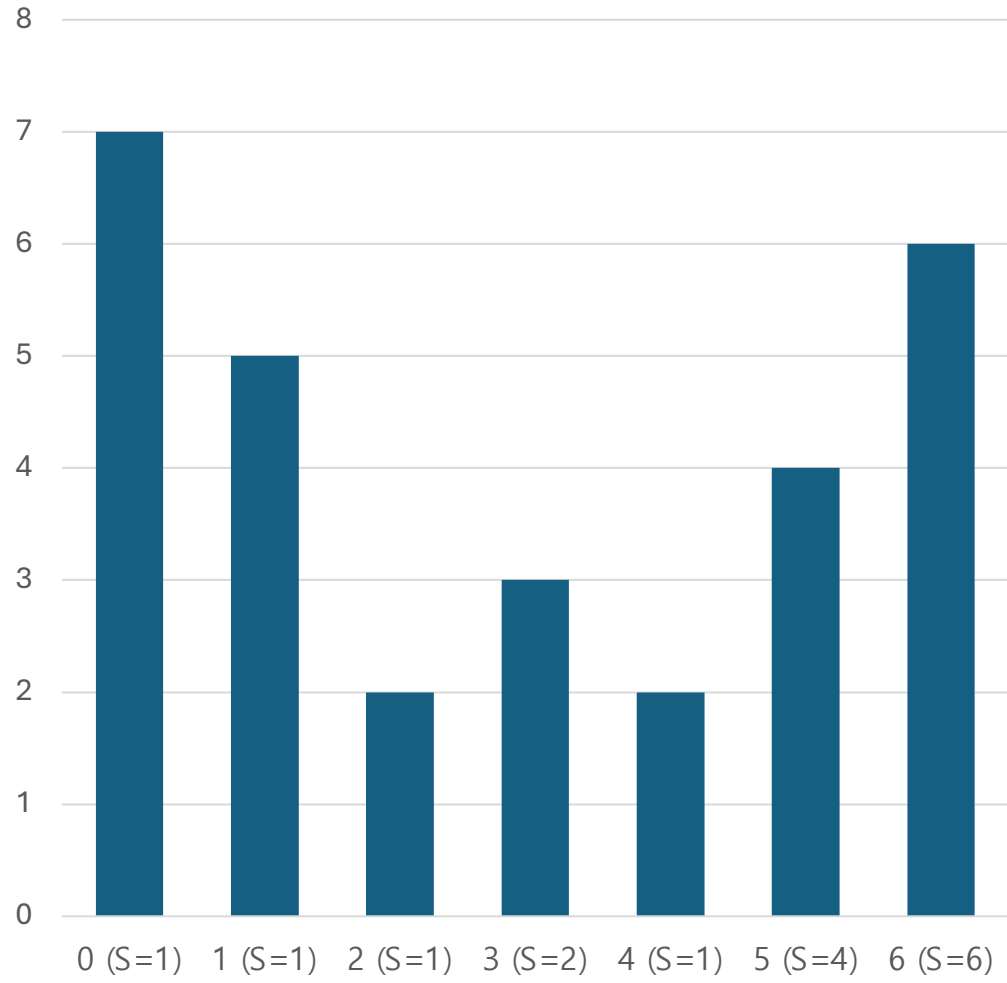
- 일별로 주식의 가격이 주어지고, 일별로 주식 가격의 span을 구하는 문제

- i일에 대한 span s_i는 i일 직전의 연속된 최대 일수이며, 연속될 수 있음의 조건은 i일의 주식 가격보다 작거나 같아야 함



Quadratic Algorithm

- 현재 날짜보다 이전 날들의 주식 가격을 탐색
- 이전 날짜에서 현재 날짜보다 주식 가격이 낮다면 $s_i := s_i + 1$ 을 하고 주식 가격을 계속 탐색
- 이전 날짜의 주식 가격이 현재보다 높다면 탐색 종료



Quadratic Algorithm Code

```
1  int *quadratic_span(int *price, int len) {
2      int *span = new int[len];
3
4      for (int i = 0; i < len; i++) {
5          span[i] = 1;
6          for (int j = i - 1; j >= 0 && price[j] <= price[i]; j--) {
7              span[i]++;
8          }
9      }
10
11     return span;
12 }
```

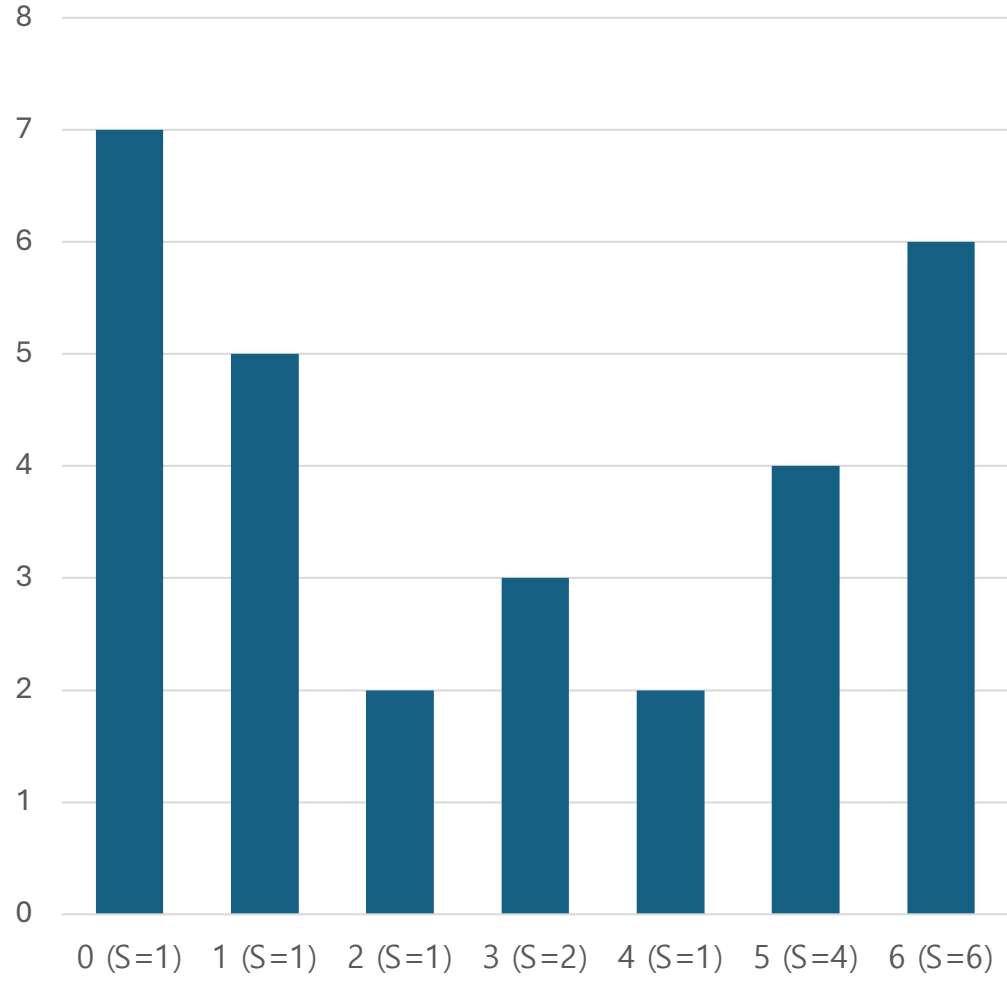
Quadratic Algorithm 분석

- 단위연산 : 이전 날짜의 가격과 현재 날짜의 가격 비교
- 입력크기 : 날짜의 길이 len

- 날짜별로 span을 계산하는 바깥 for문은 len번 실행
- span을 구하기 위해 안쪽 for문의 최악의 경우는 주식 가격이 오름차순이 되어 마지막 날짜에 모든 일자에 대해 가격을 비교하여 len번 실행
- $W(n) = n \times n \in O(n^2)$

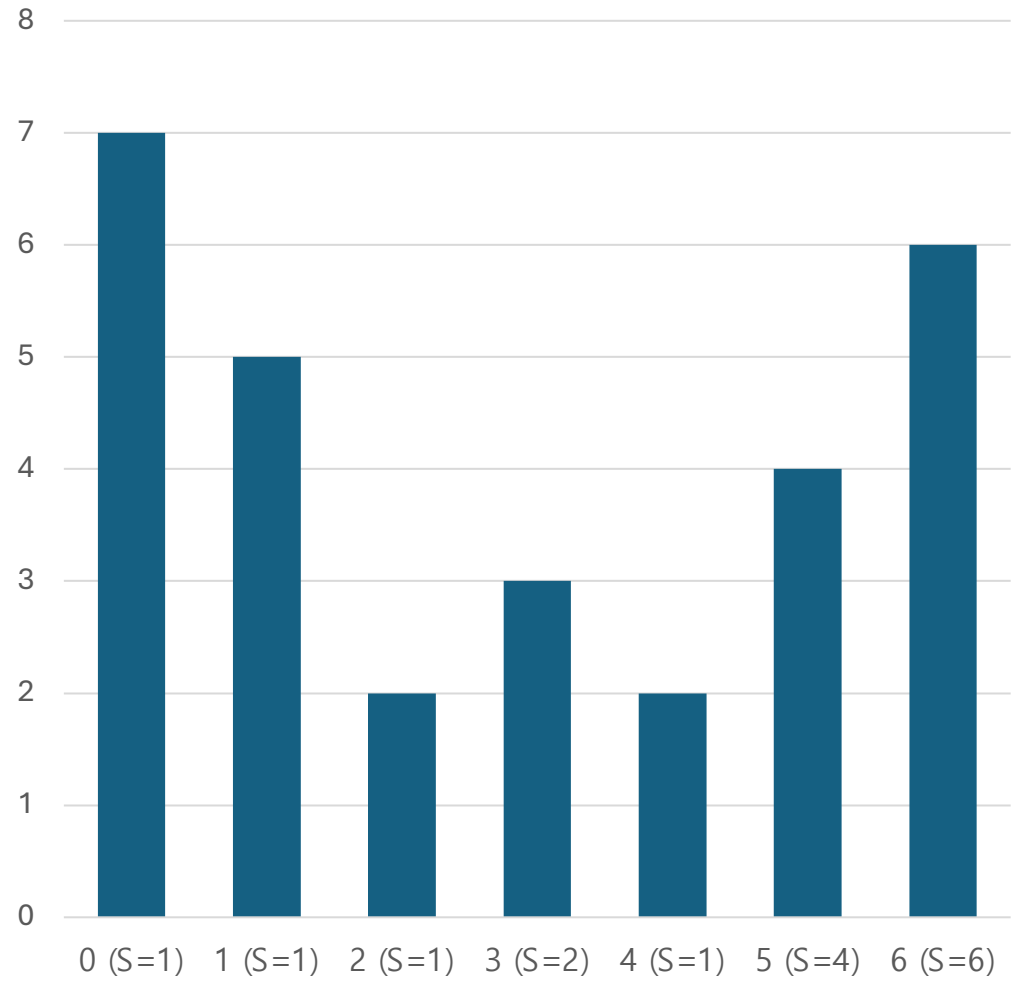
Linear Algorithm

- stack을 사용해 선형시간에 span을 계산
- 일자별로 span을 계산하고 현재 날짜를 push
- span을 계산할 때 stack의 마지막 원소가 현재 날짜의 원소보다 큰 가격의 날짜가 나오기 전까지 pop

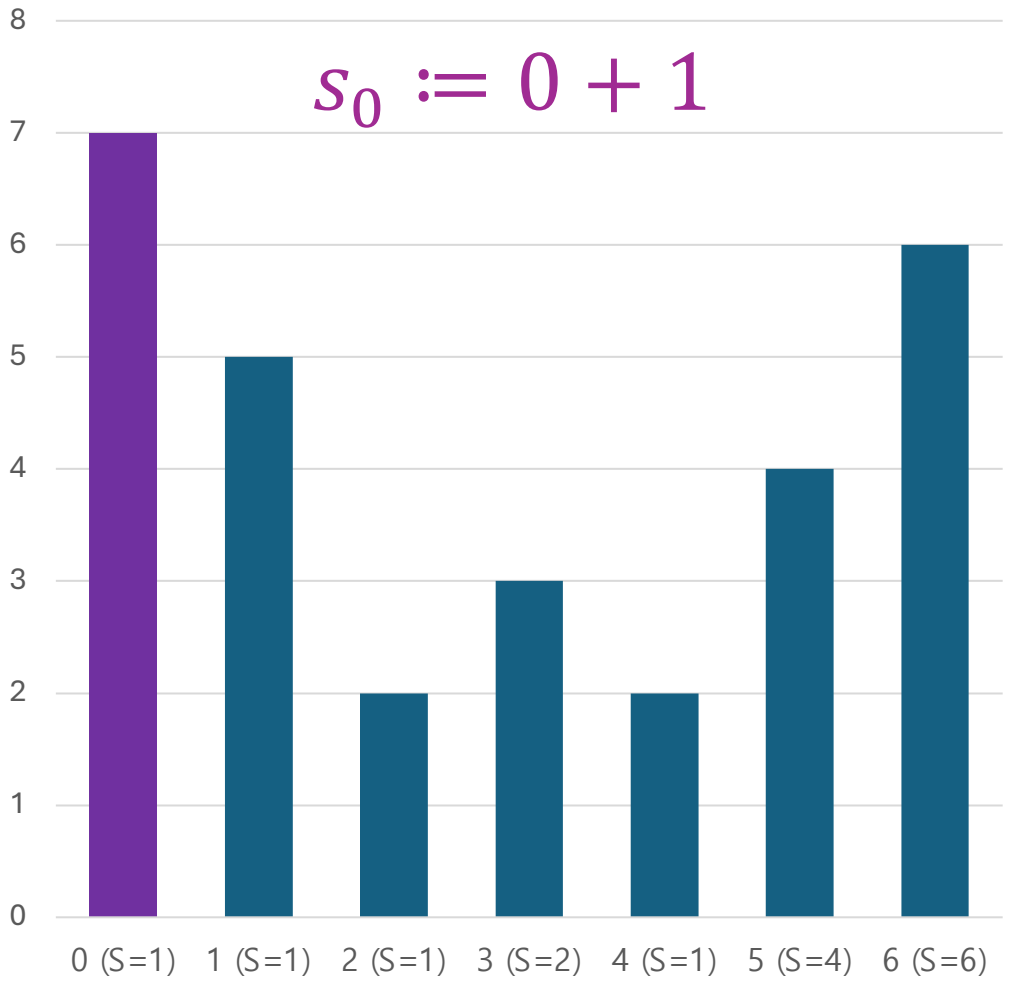


Linear Algorithm

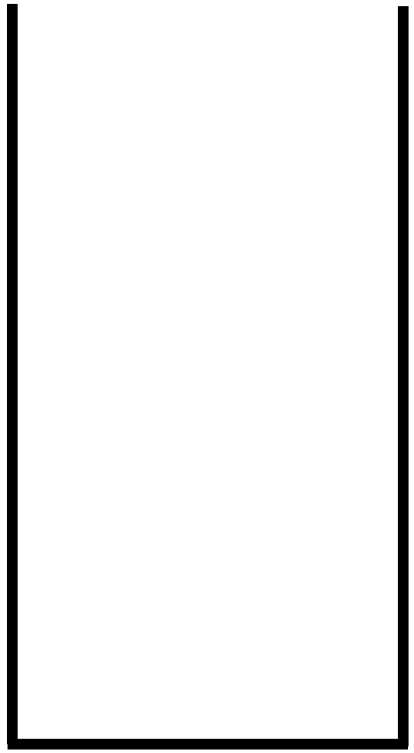
- i일에 대해 pop을 완료하고 stack이 비어 있다면 $s_i := i + 1$
  - stack이 비어 있다는 의미는 i이전에 i일보다 높은 가격이 없음을 의미
- stack에 원소가 있다면 $s_i := i - stack.top$
  - stack에 원소가 있다는 의미는 i 이전에 가장 가격이 높은 날짜는 $stack.top$에 해당하는 날



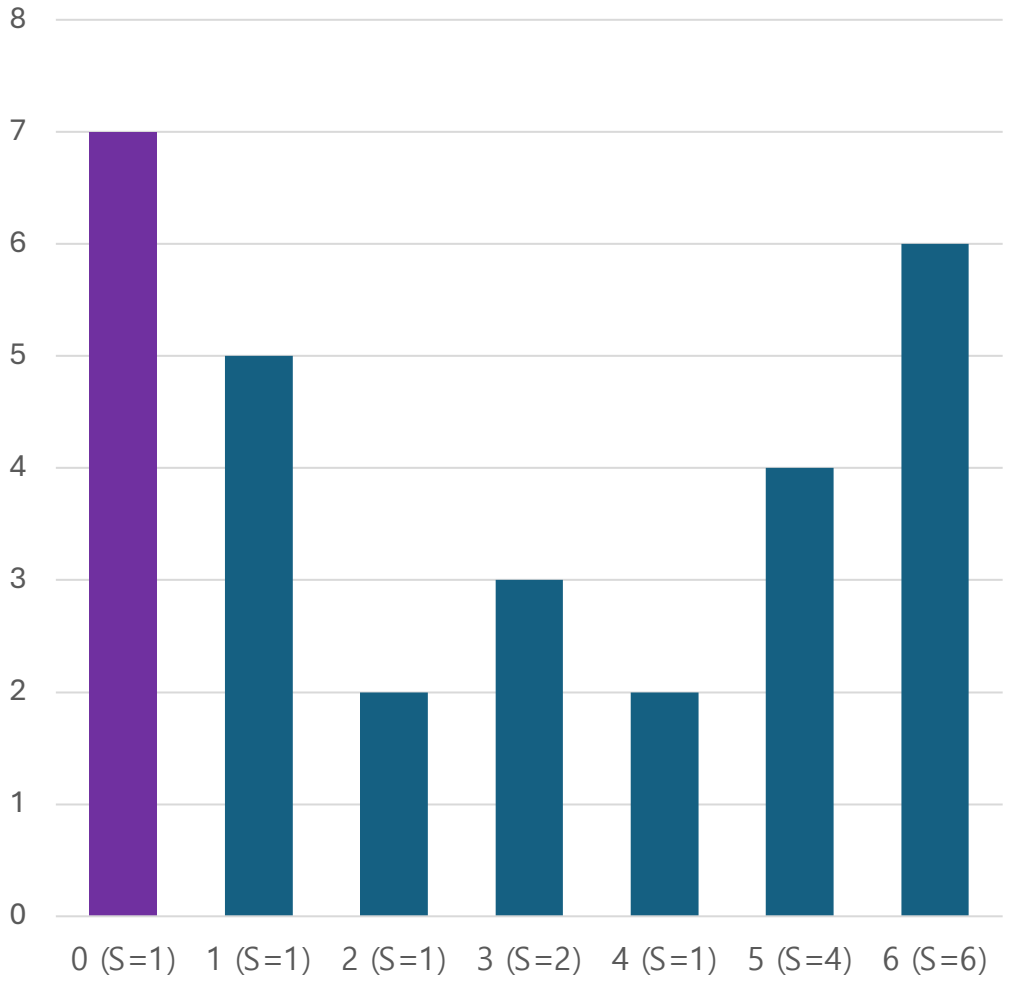
Linear Algorithm



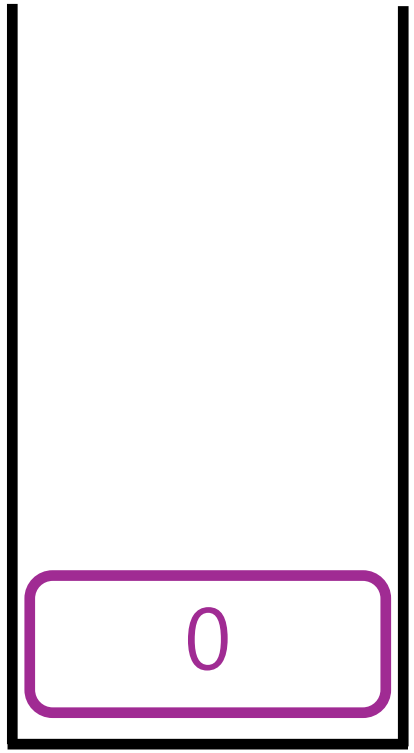
$s_i := i + 1$



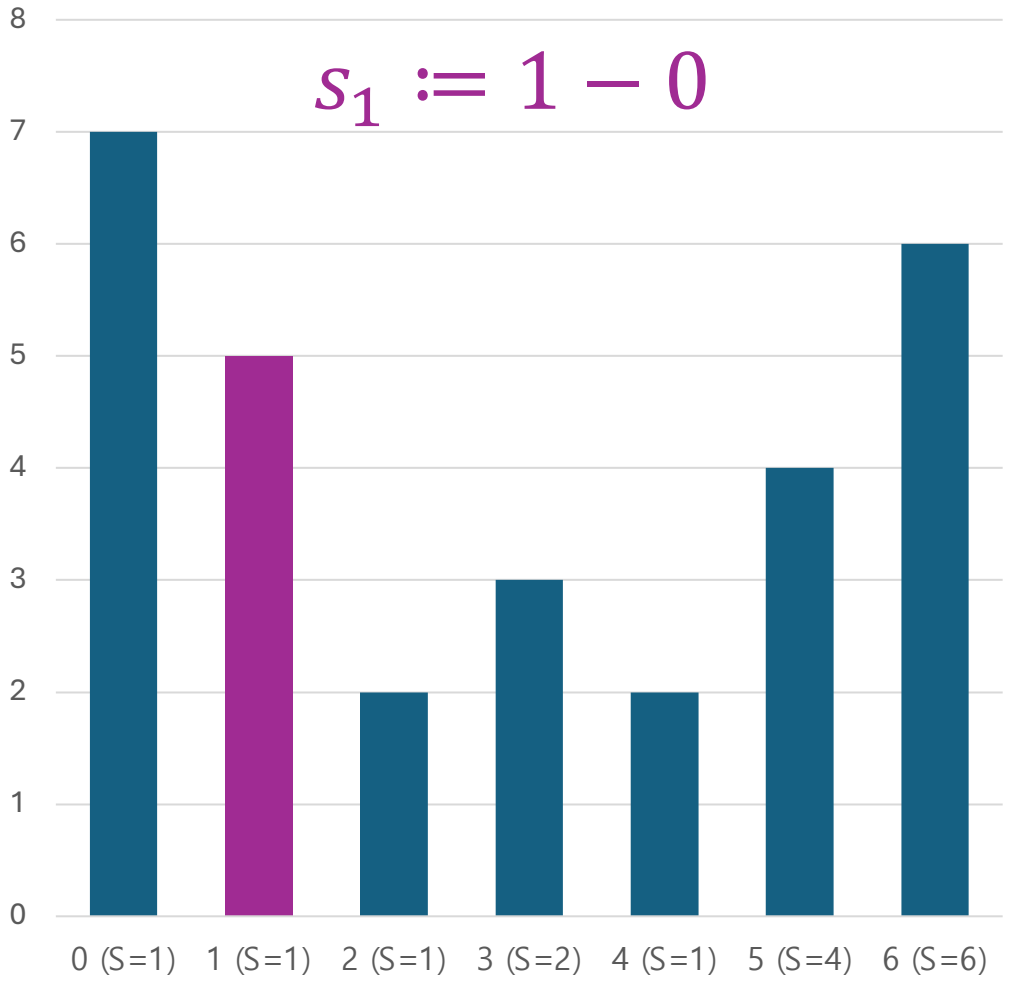
Linear Algorithm



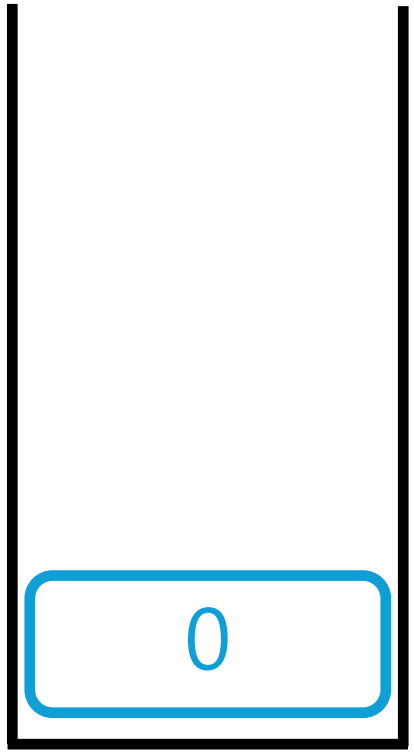
$s_i := i + 1$



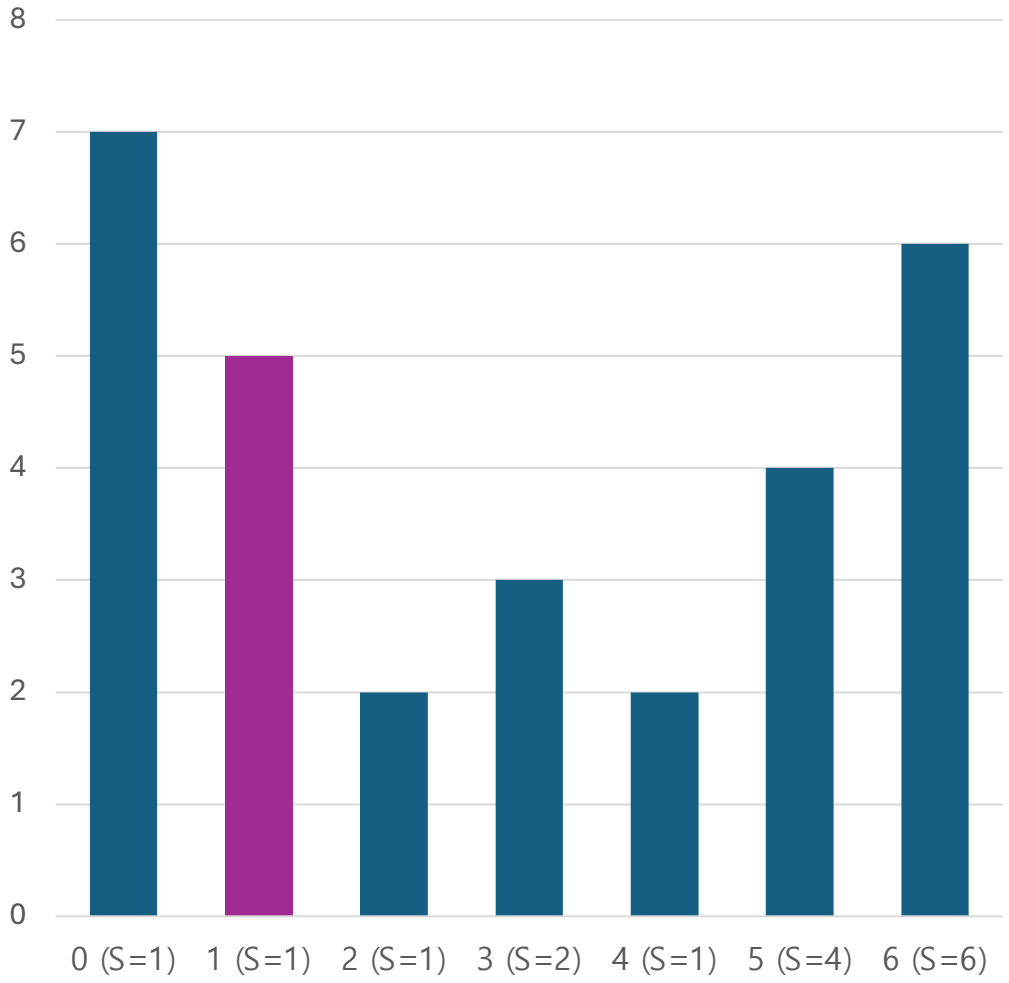
Linear Algorithm



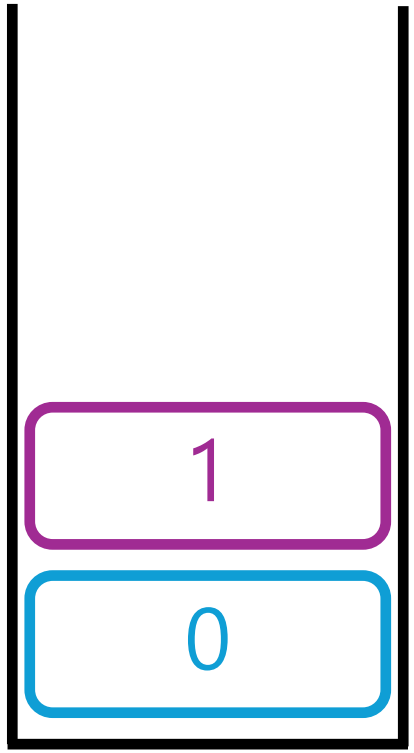
$s_i := i - stack.top$



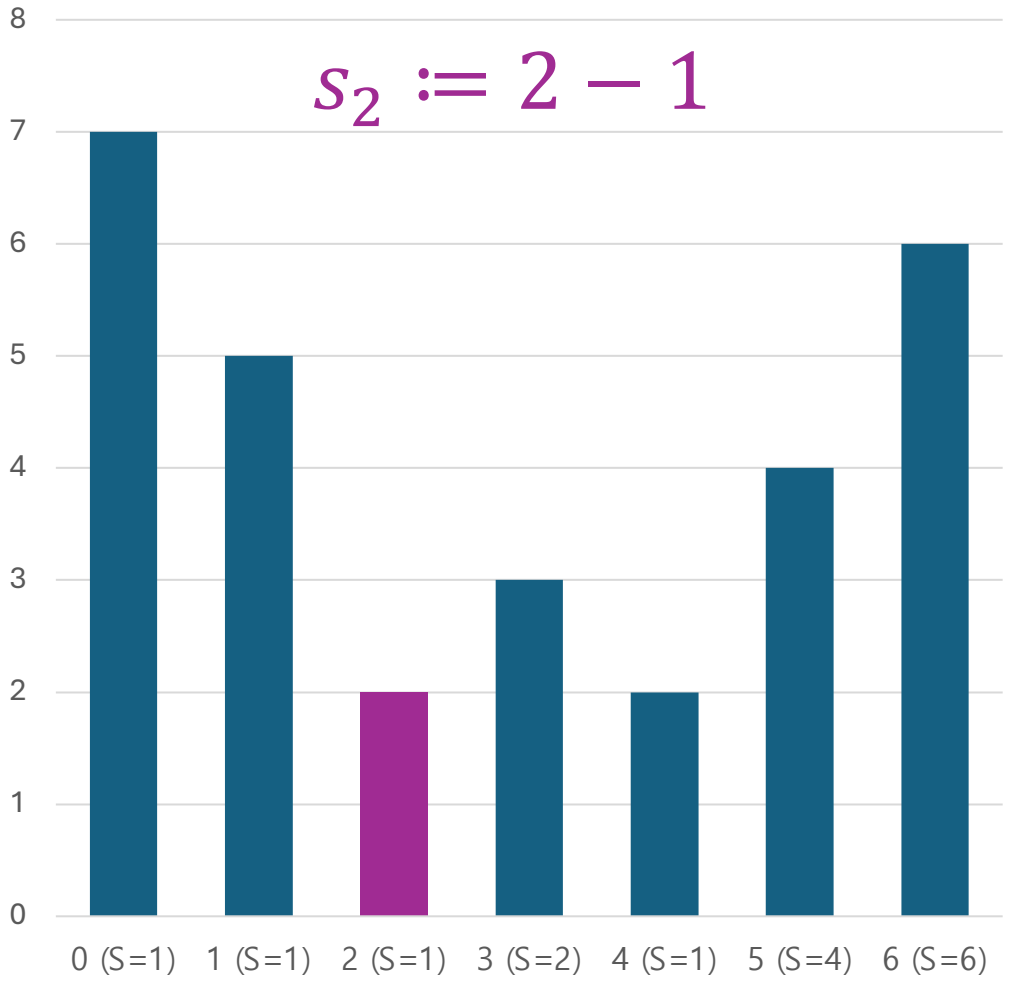
Linear Algorithm



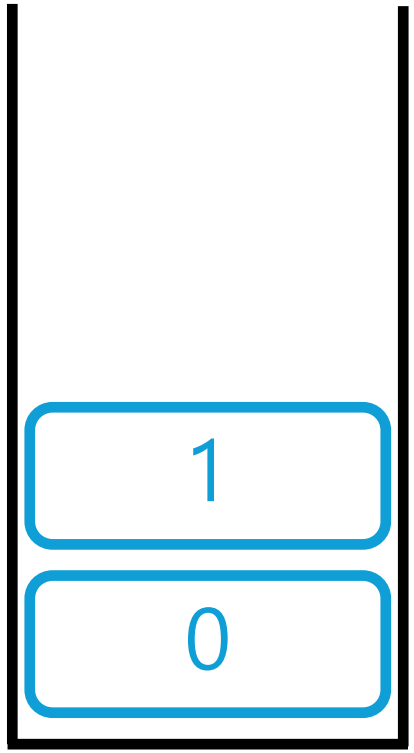
$$s_i := i - stack.top$$



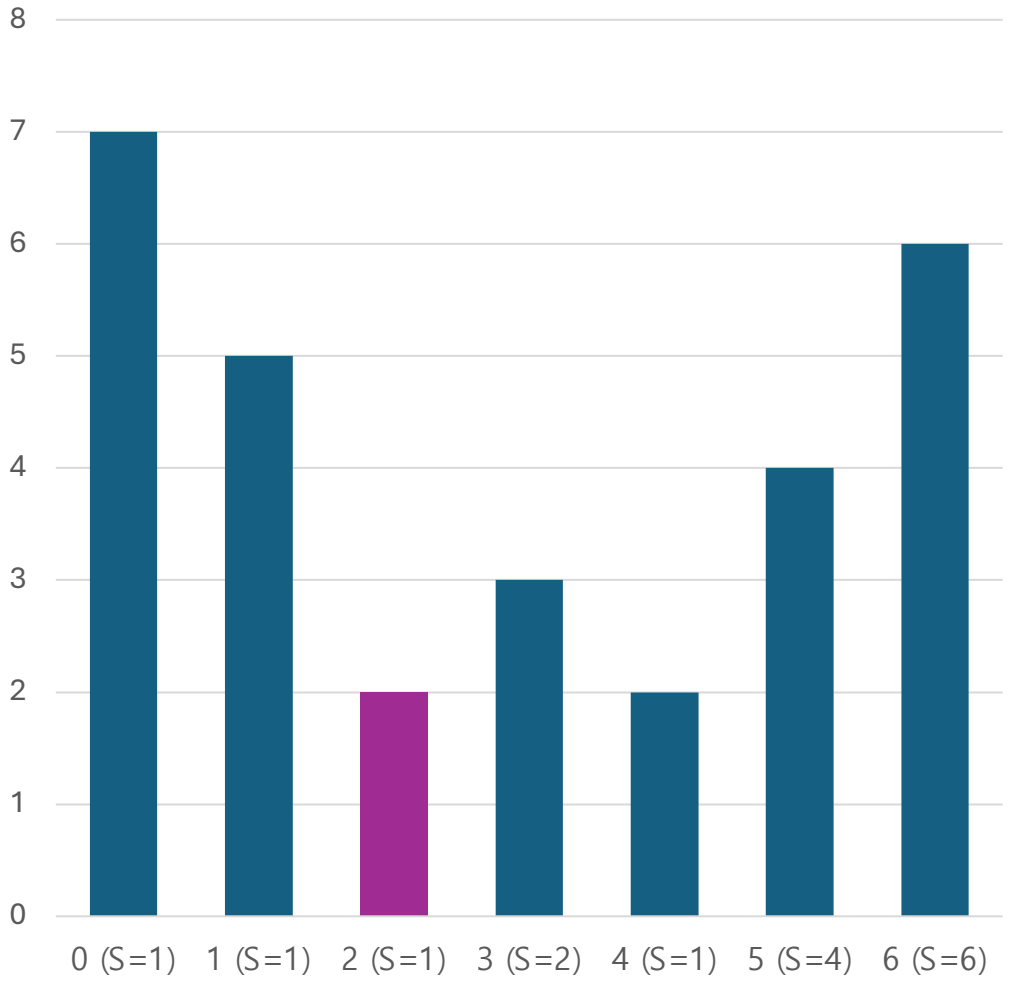
Linear Algorithm



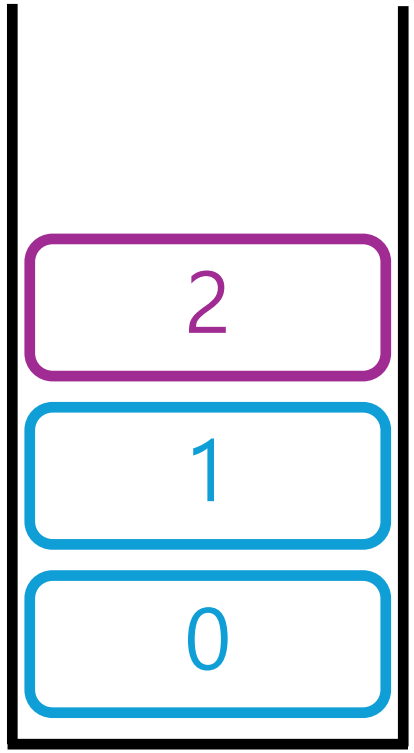
$s_i := i - stack.top$



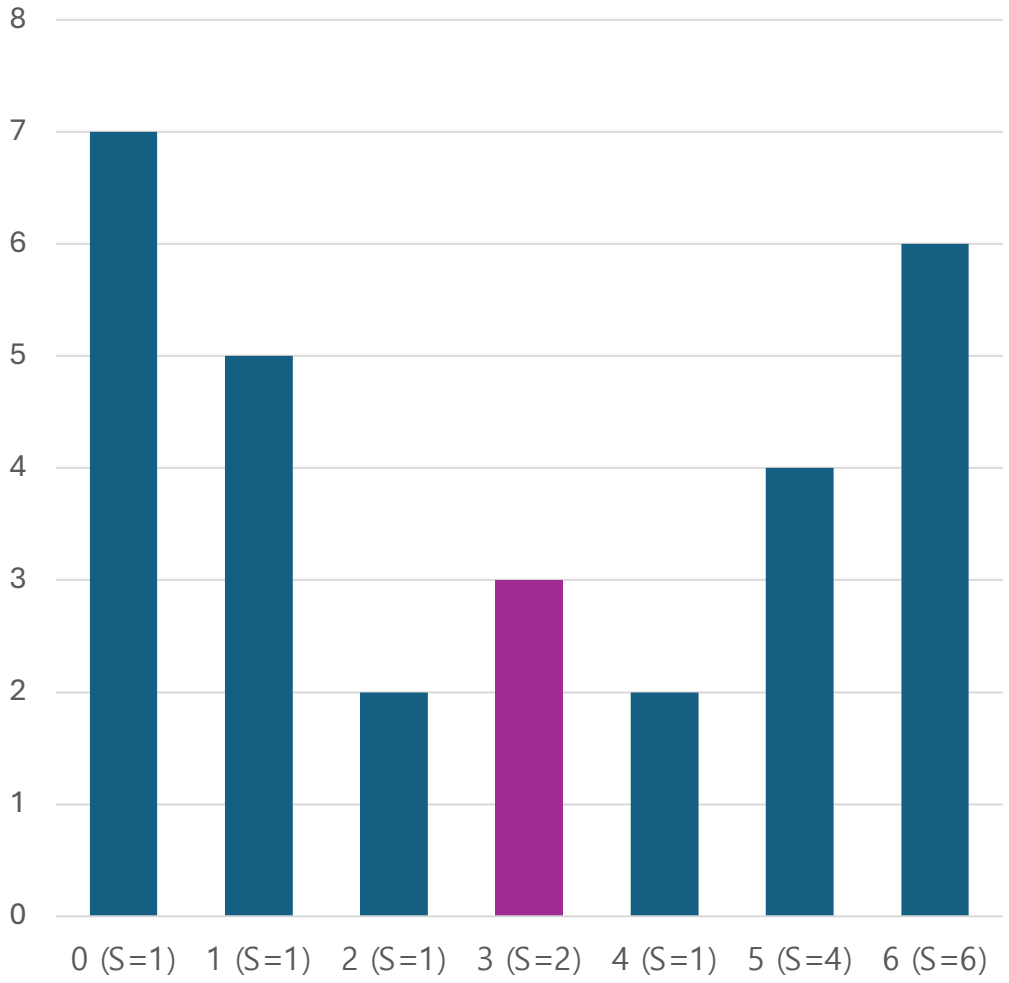
Linear Algorithm



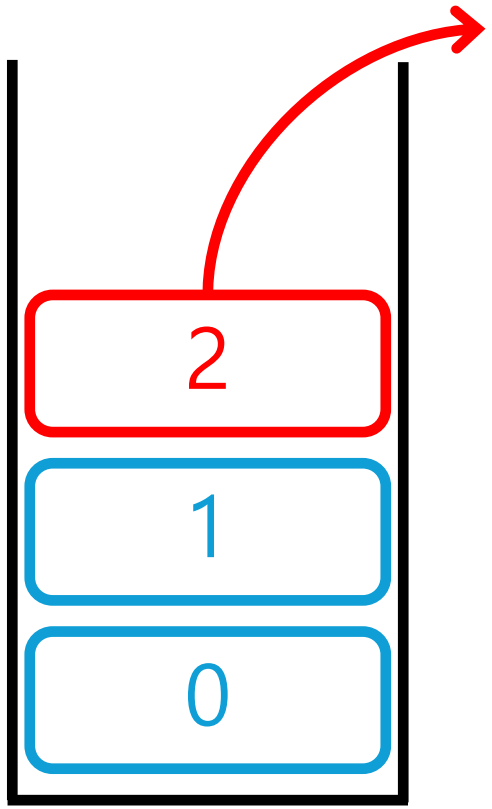
$$s_i := i - stack.top$$



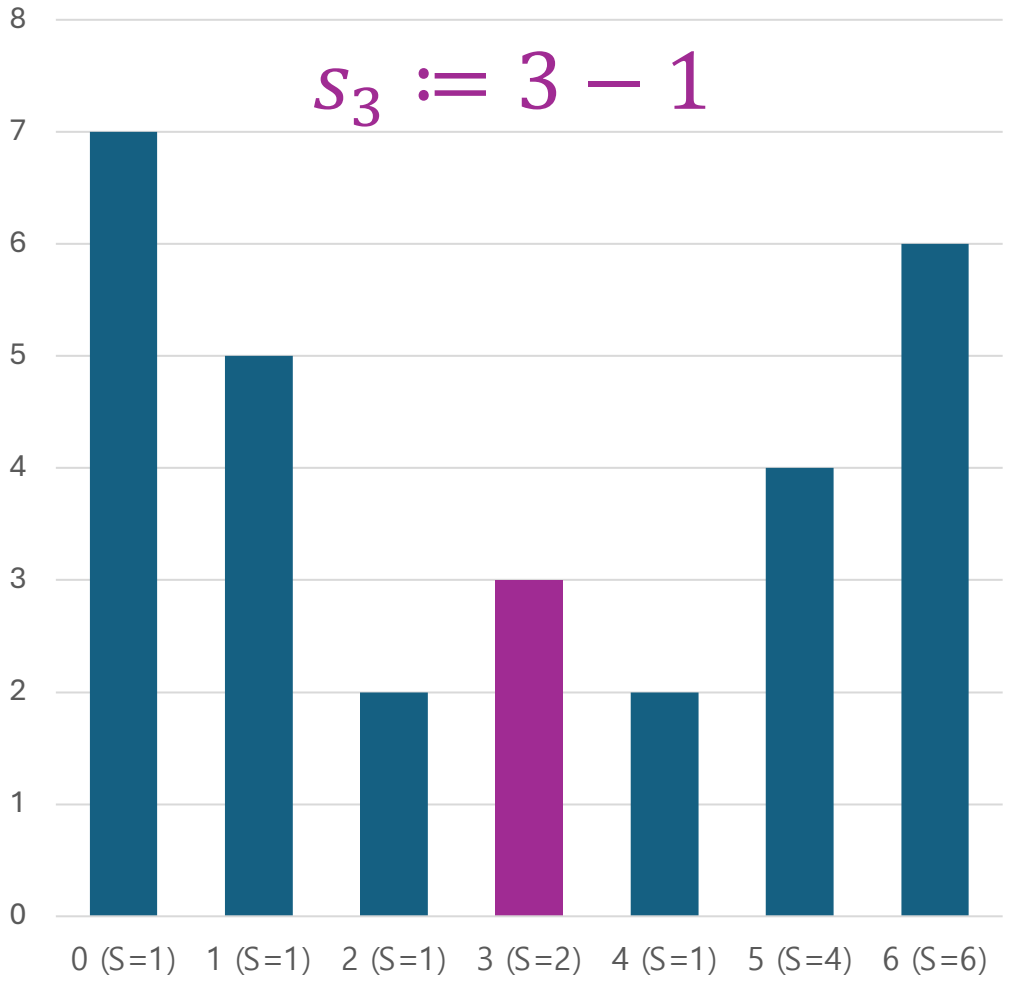
Linear Algorithm



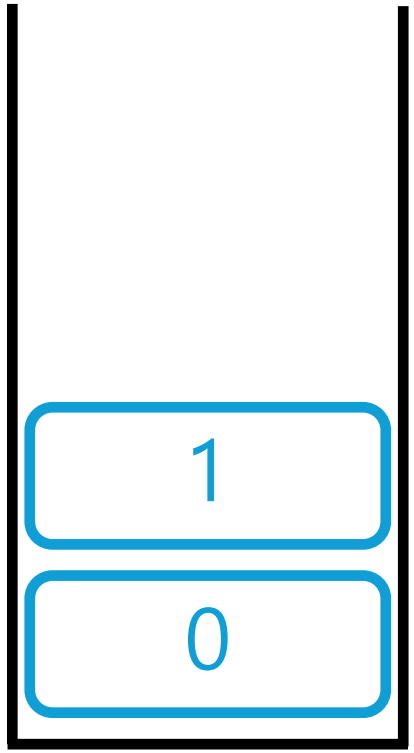
$$s_i := i - stack.top$$



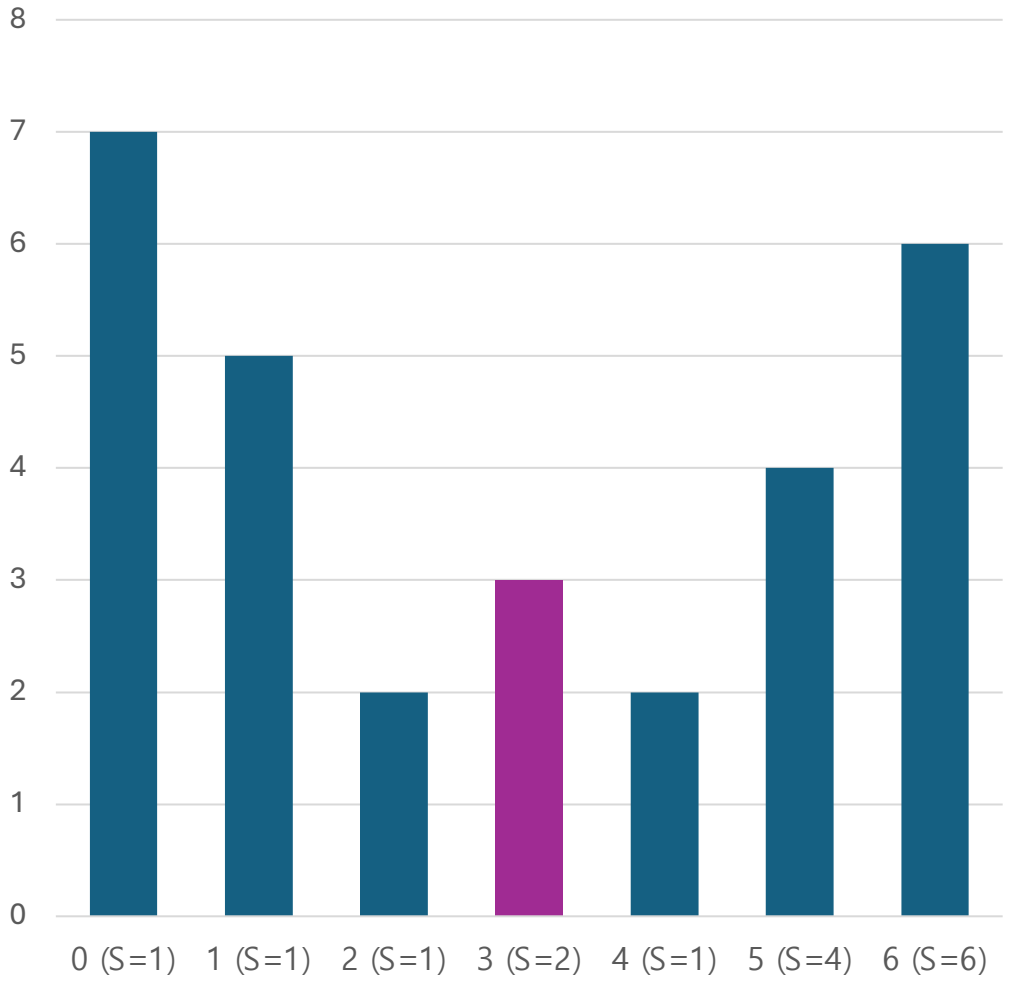
Linear Algorithm



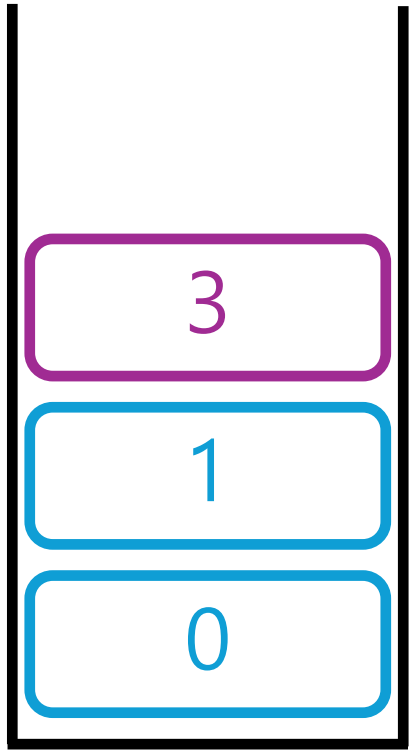
$s_i := i - stack.top$



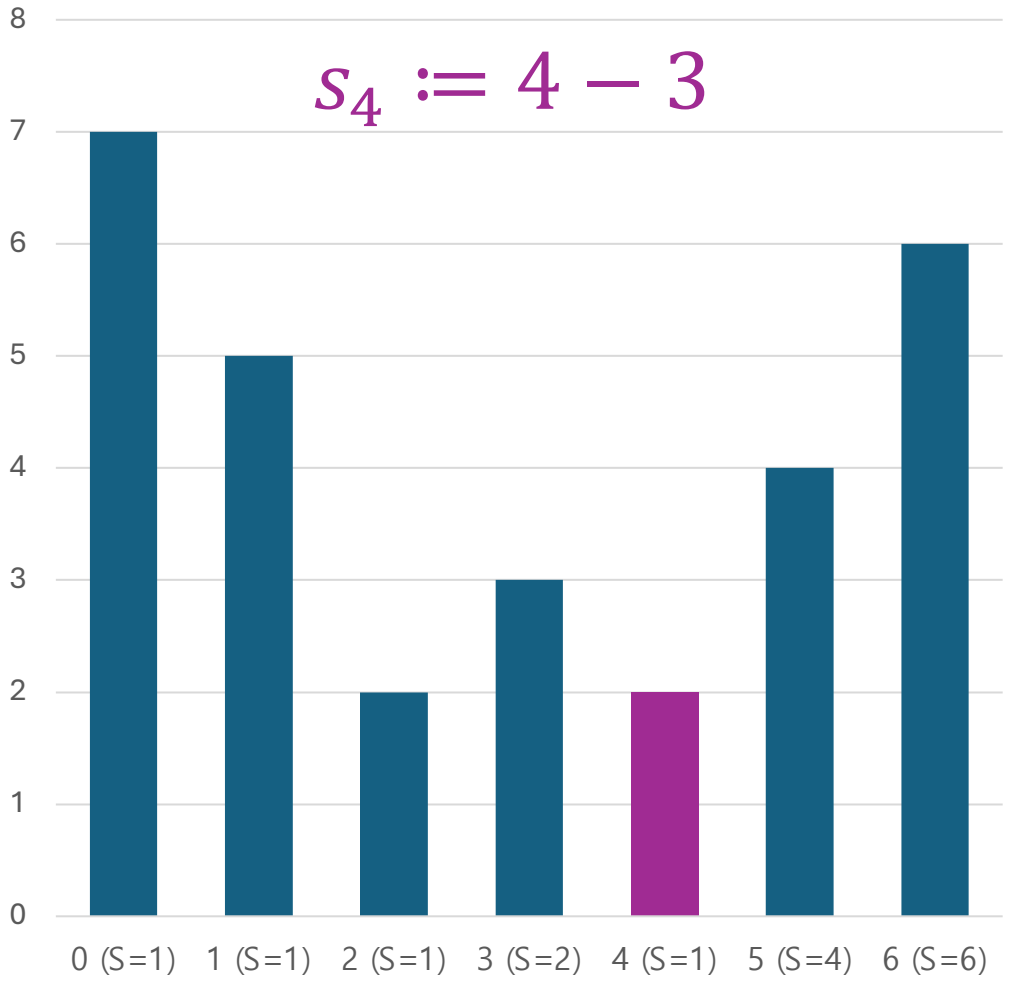
Linear Algorithm



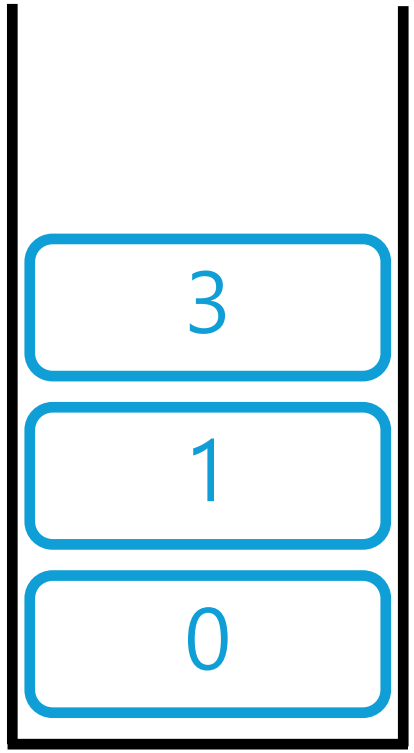
$$s_i := i - stack.top$$



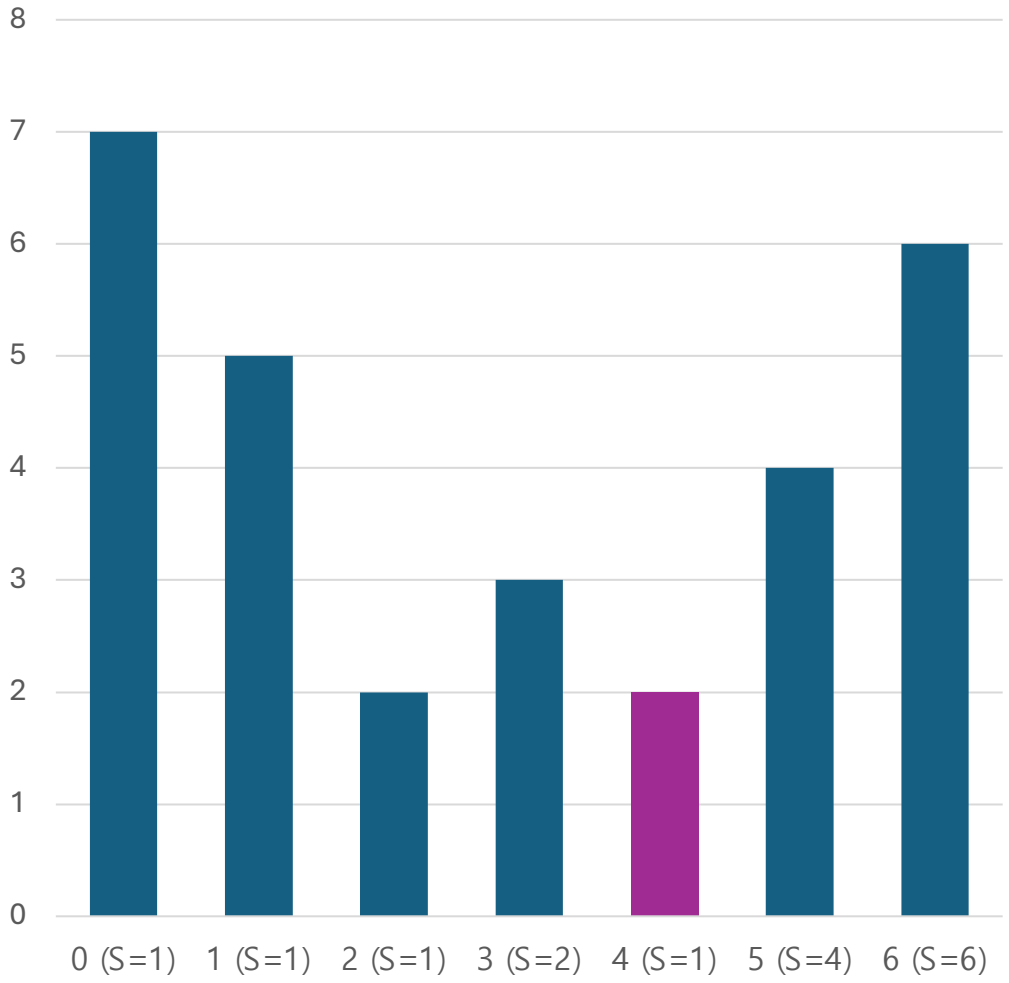
Linear Algorithm



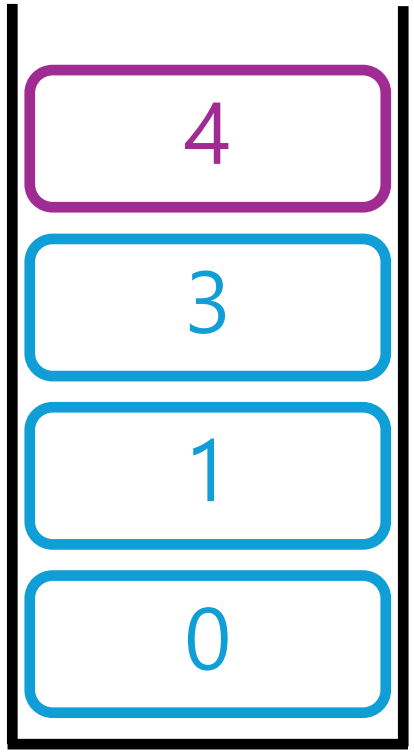
$$s_i := i - stack.top$$



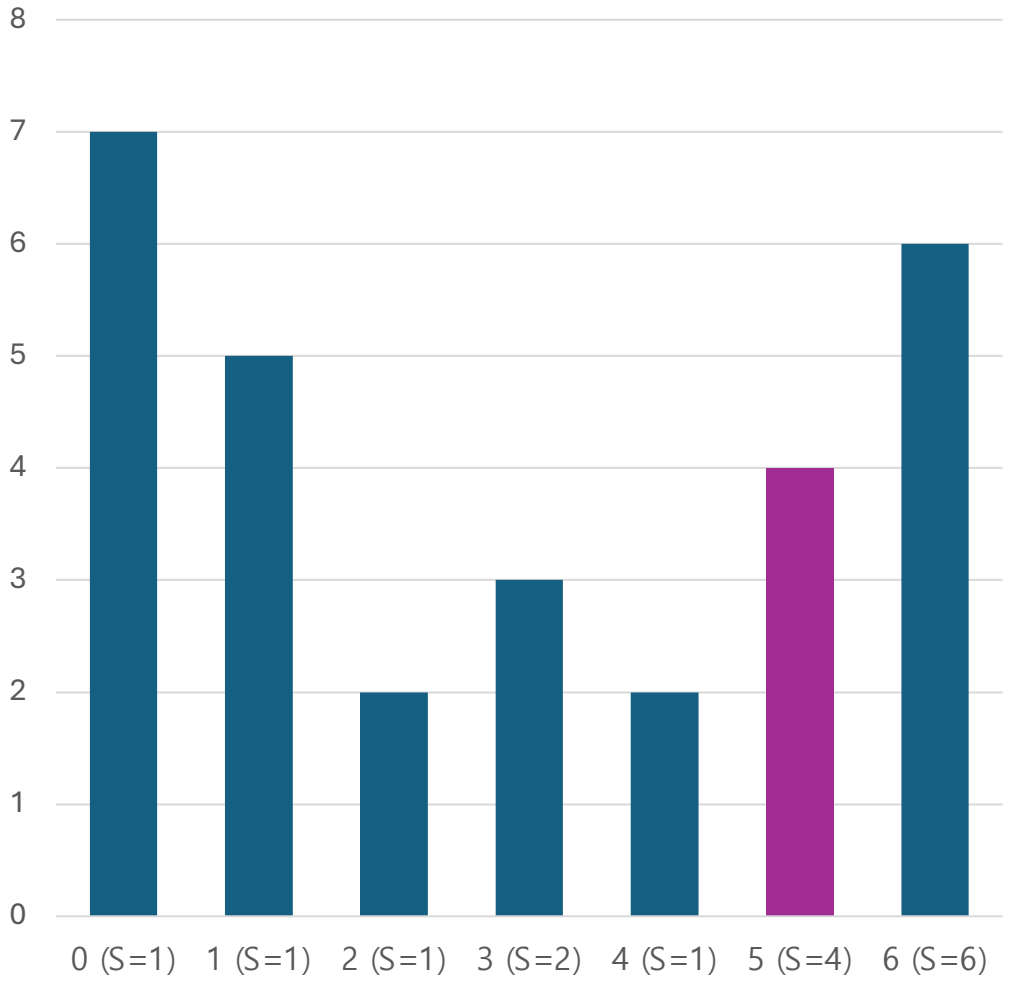
Linear Algorithm



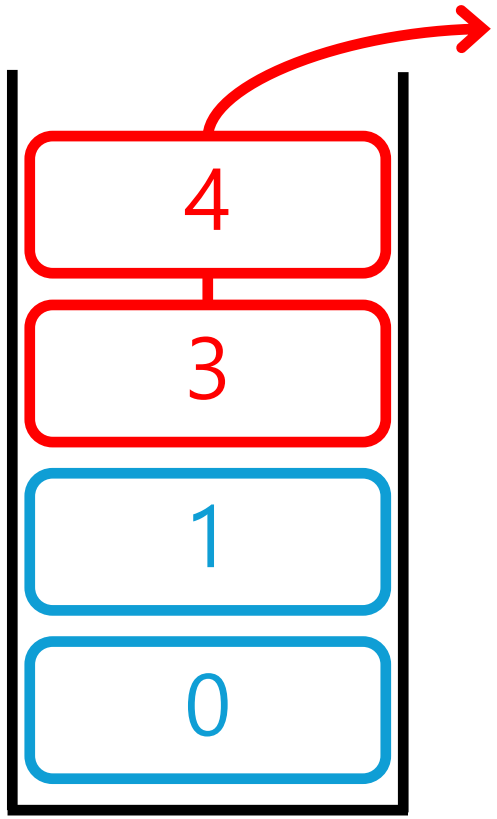
$$s_i := i - stack.top$$



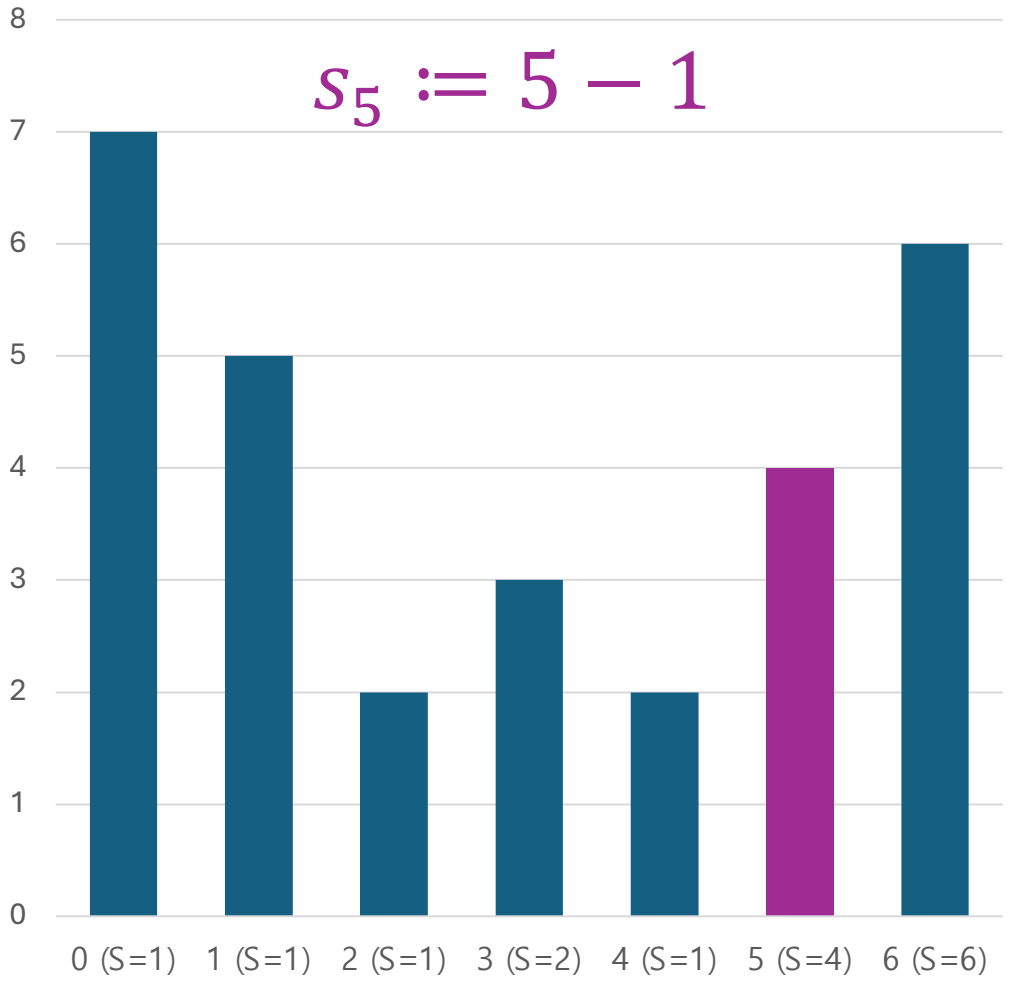
Linear Algorithm



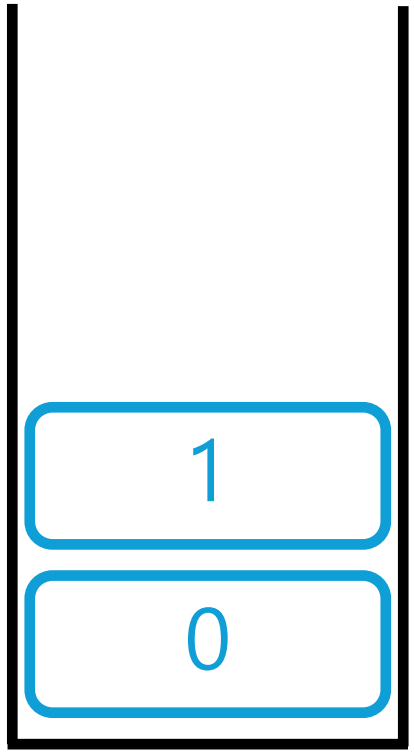
$$s_i := i - stack.top$$



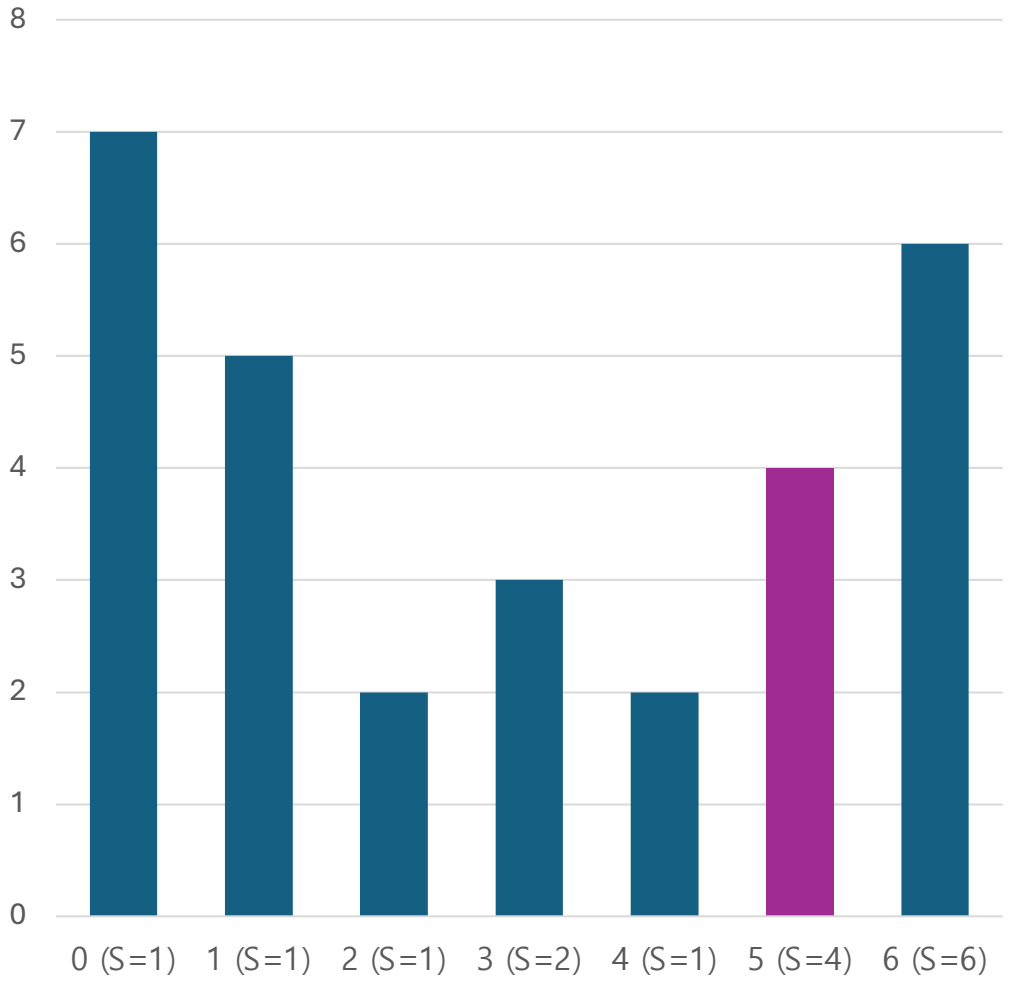
Linear Algorithm



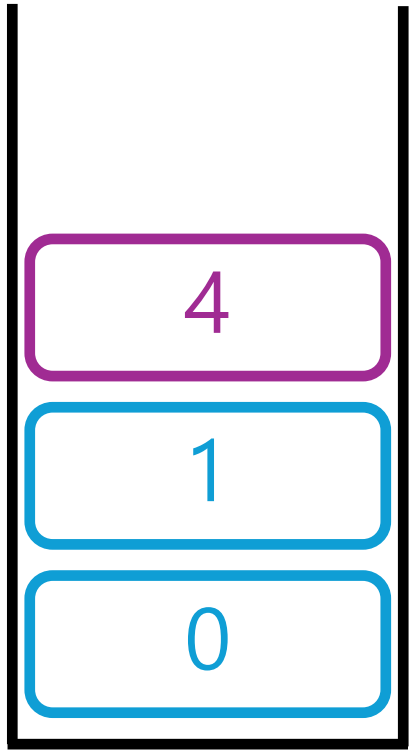
$$s_i := i - stack.top$$



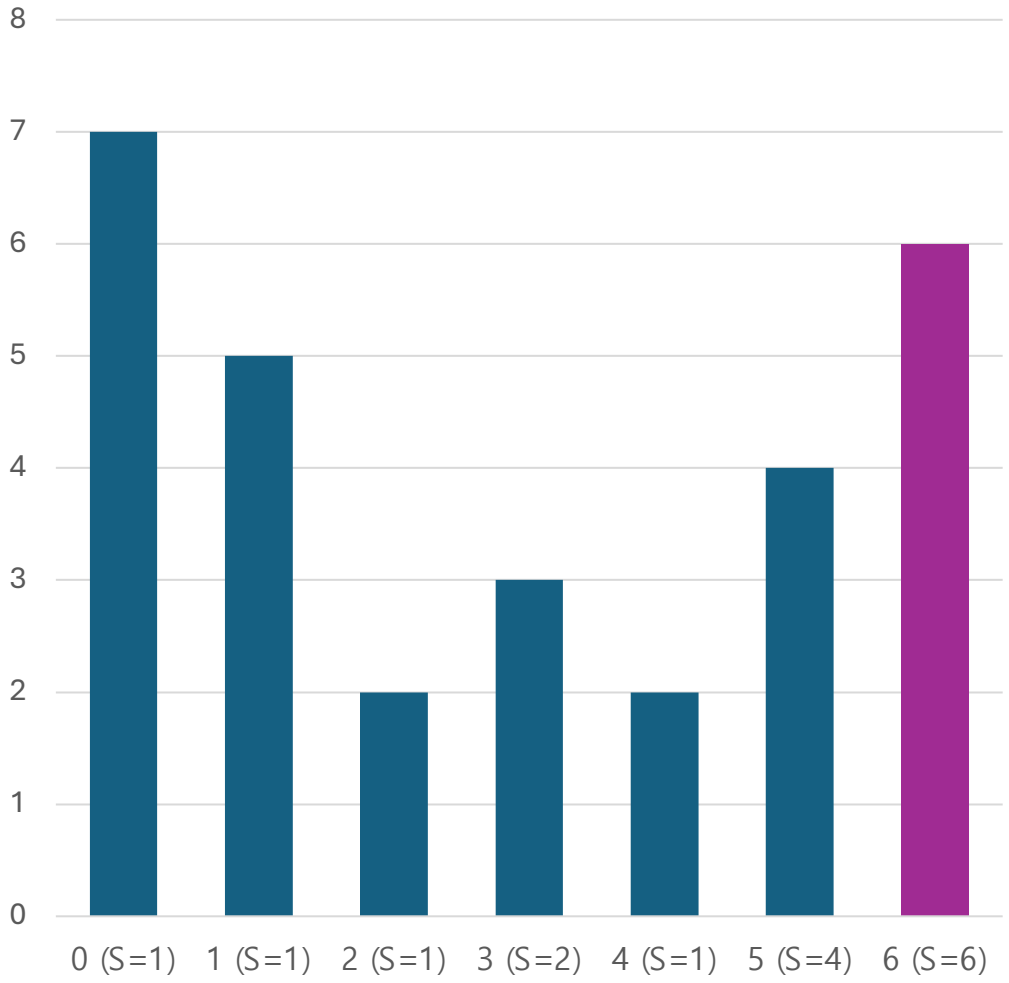
Linear Algorithm



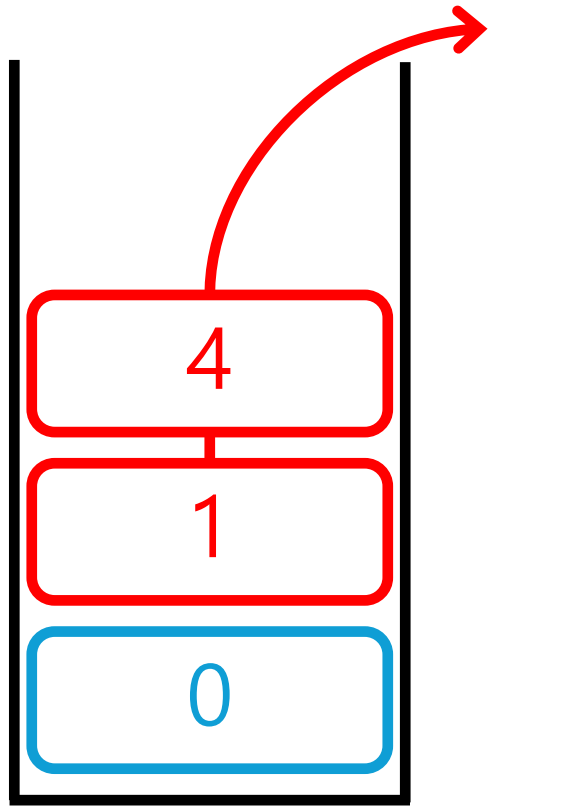
$$s_i := i - stack.top$$



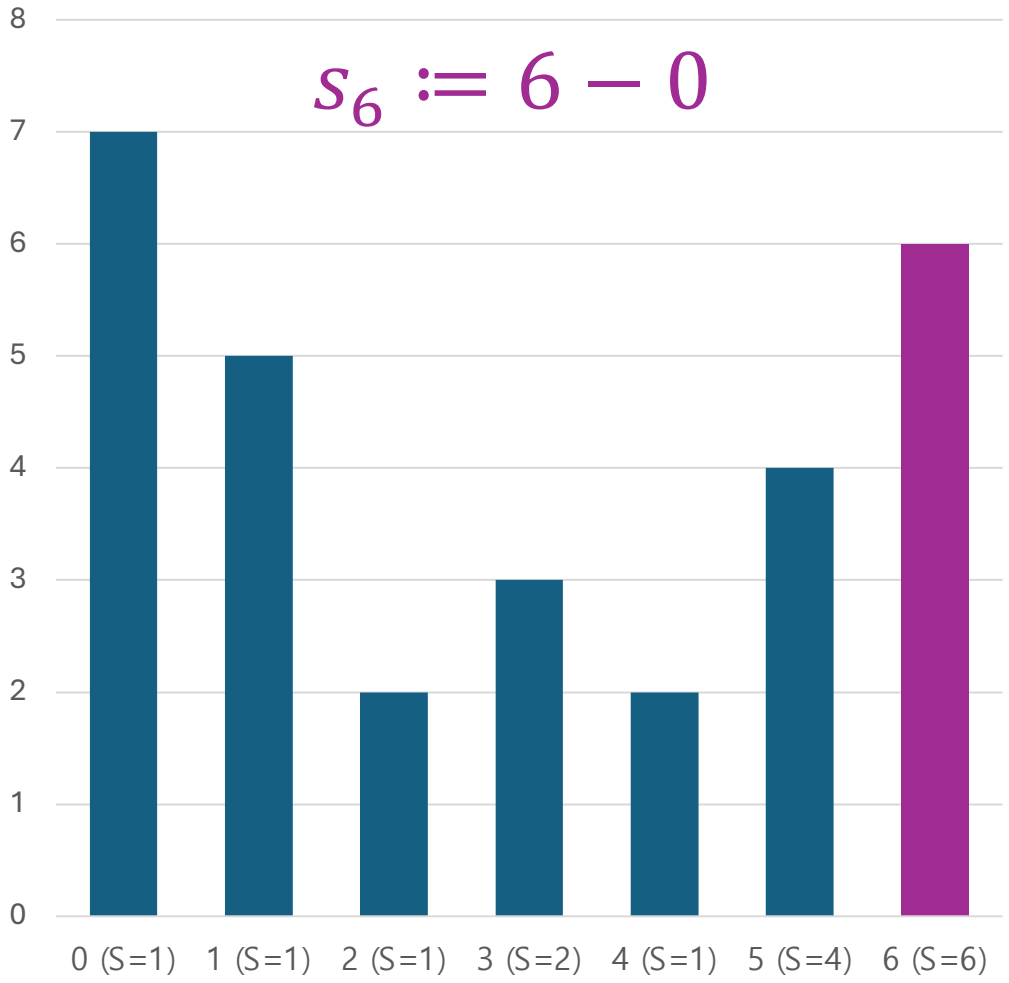
Linear Algorithm



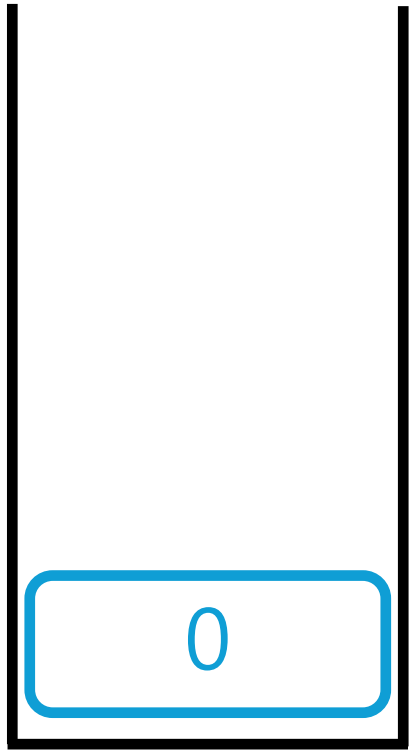
$$s_i := i - stack.top$$



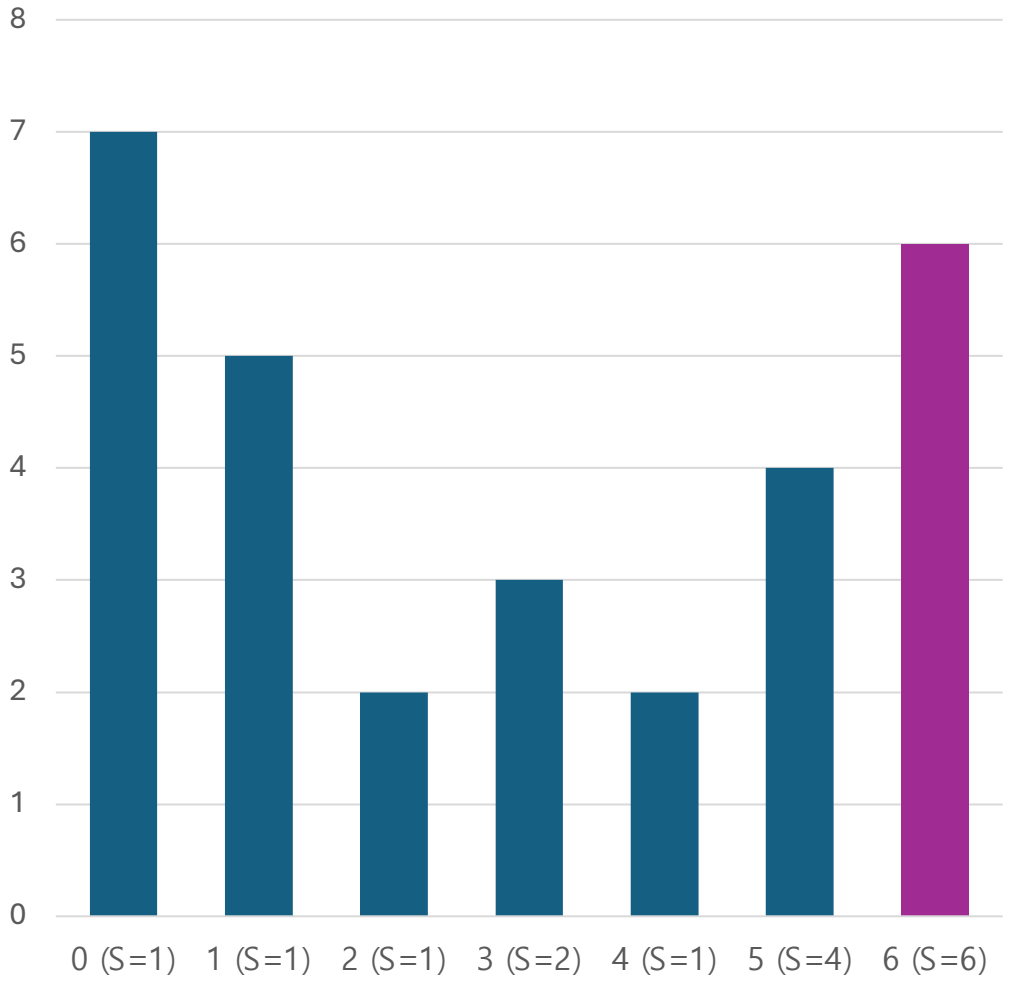
Linear Algorithm



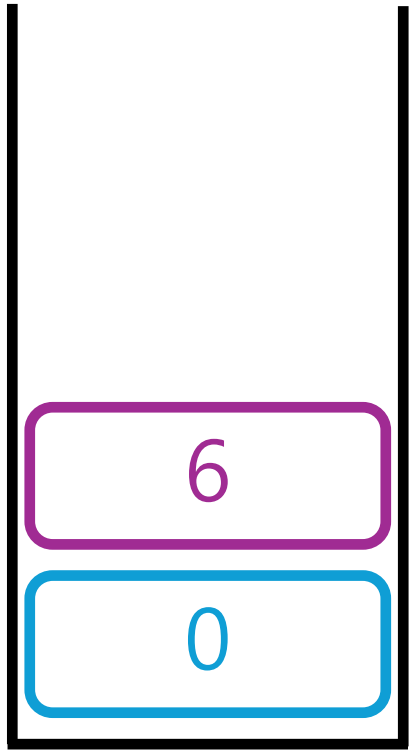
$s_i := i - stack.top$



Linear Algorithm



$$s_i := i - stack.top$$



Linear Algorithm Code

```
1  int *linear_span(int *price, int len) {
2      int *span = new int[len];
3      ArrayStack2<int> stack;
4
5      for (int i = 0; i < len; i++) {
6          while (!stack.empty() && price[stack.top()] <= price[i]) {
7              stack.pop();
8          }
9
10         if (stack.empty()) {
11             span[i] = i + 1;
12         }
13         else {
14             span[i] = i - stack.top();
15         }
16     }
17 }
```

Linear Algorithm 분석

- 단위연산 : 현재 날짜의 가격과 stack의 마지막 원소에 해당하는 날짜의 가격 비교
- 입력크기 : 날짜의 길이 len

- 날짜별로 span을 계산하는 바깥 for문은 len번 실행
- stack에 들어가는 원소는 날짜별로 한번씩 들어가 stack의 최대 크기는 len을 초과하지 않음
- 단위연산의 횟수는 len을 초과하지 않고, stack을 pop하기 위한 while문은 바깥 for문과 독립적으로 최악의 경우 len번 실행
- $W(n) = n + \ n \in O(n)$