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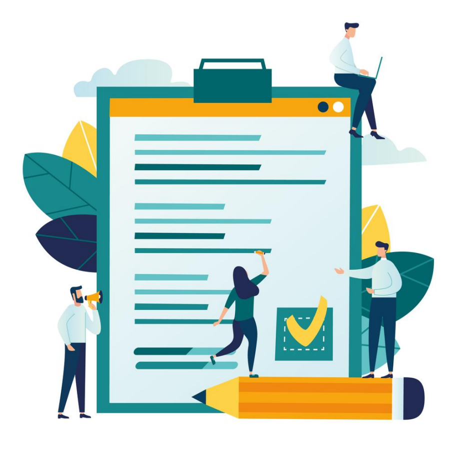
Full-Stack Software Development

Lecture On: Searching Algorithms

Instructor: Arkoprovo Dey

In Last Class, we covered….

- Arrays



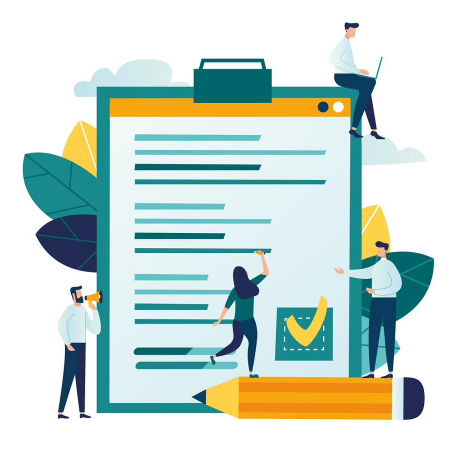
Homework Discussion

1. Find the maximum product of two elements in an array.

   Sample Input:
   5
   2 4 3 14 6
   Sample Output:
   84
   Explanation:
   14*6 is the largest product possible.

Today’s Agenda

1 Searching Algorithms

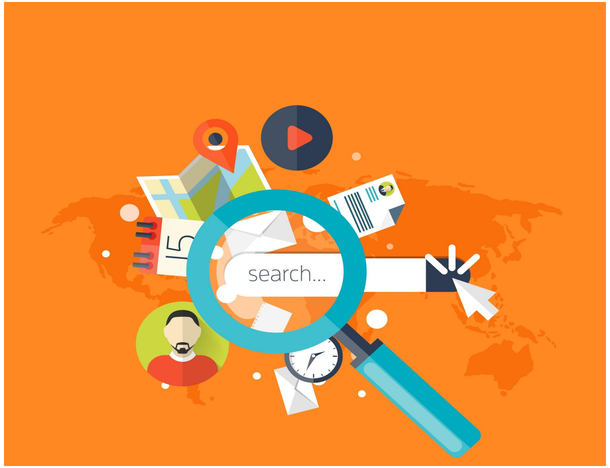


Searching

Libraries have countless books, music stores have several CDs, Google has massive data, Amazon has innumerable things to sell and Myntra has a huge catalogue you can choose from!

Let's say I want to buy a Lego set from Amazon. How would I find the link to the relevant page? I'll probably search it!

Searching is a significant capability that one must be able to perform in this data-driven world!



Searching

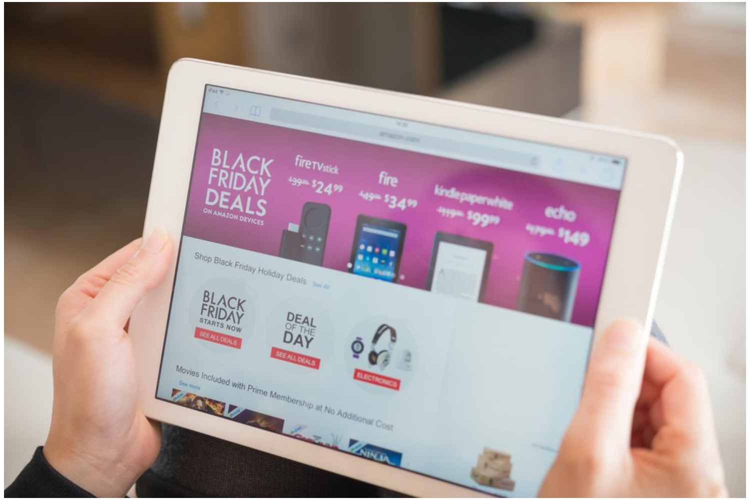
But given the huge amount of data that exists out there, ‘searching’ is not always a trivial task.

Searching

In a bit more formal sense, a Searching problem requires us to locate an element stored in a Data Structure. Let’s learn more about searching for an element in linear data structures.

What happens when you search for a product on Amazon?

Searching for a product on Amazon is looking for it in a database, i.e., on persistent storage network. However, this problem can be broken down by finding its position, where the product details are stored on a data structure.



Searching

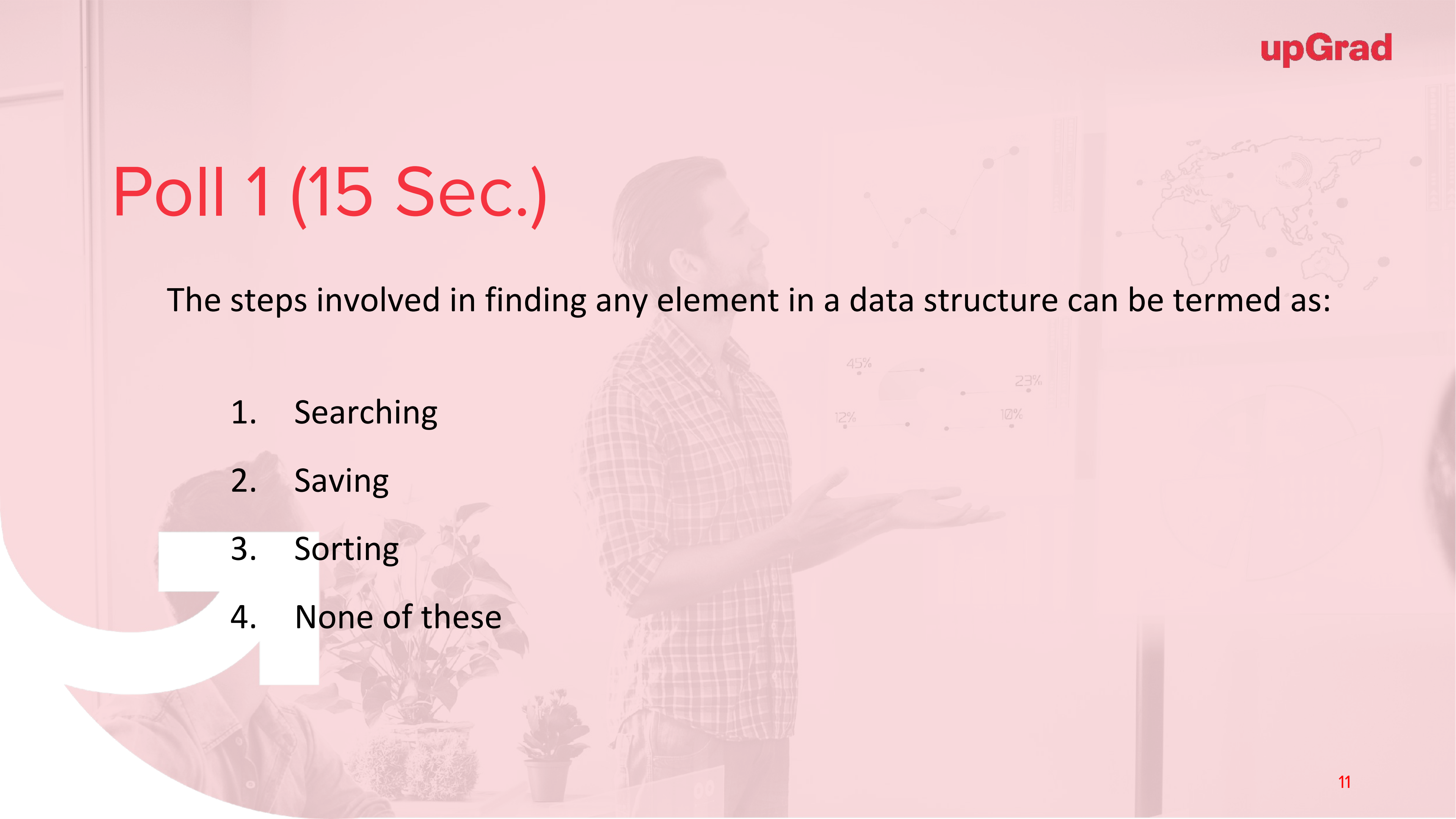
What do you think we mean by ‘**keys**’ while searching?

Searching

What will be the input? The data structure and the ‘key’ (or the data element) to be searched for

What will be the output? The index of the data structure where the ‘key’ is located If the ‘key’ isn’t found, we would need to output accordingly.

As always, we will need to be as efficient as possible while Searching in terms of time and space that we use.

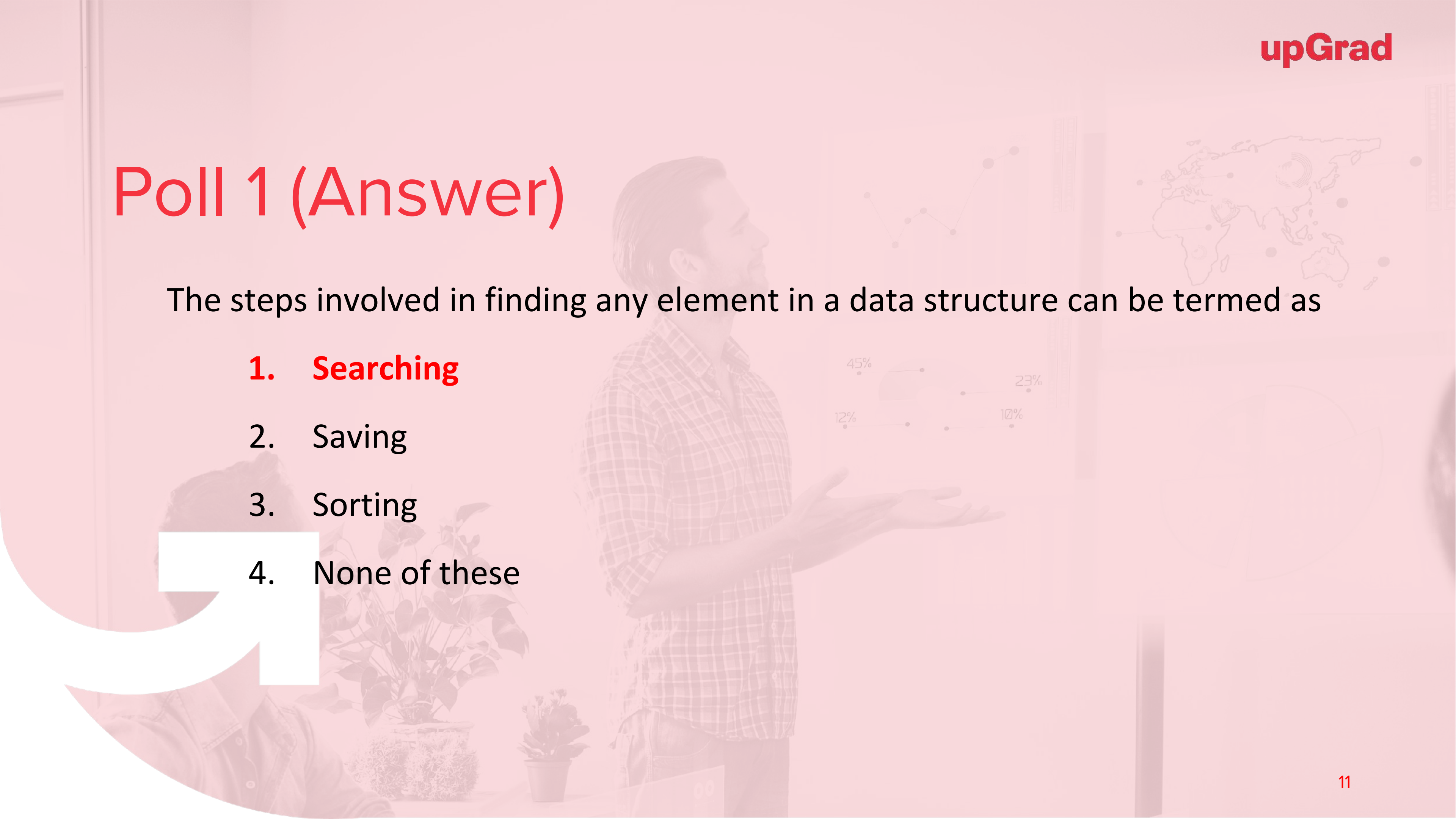


Poll 1 (15 Sec.)

The steps involved in finding any element in a data structure can be termed as:

1. Searching
2. Saving
3. Sorting
4. None of these

Poll 1 (Answer)



The steps involved in finding any element in a data structure can be termed as

1. **Searching**
2. Saving
3. Sorting
4. None of these

Searching

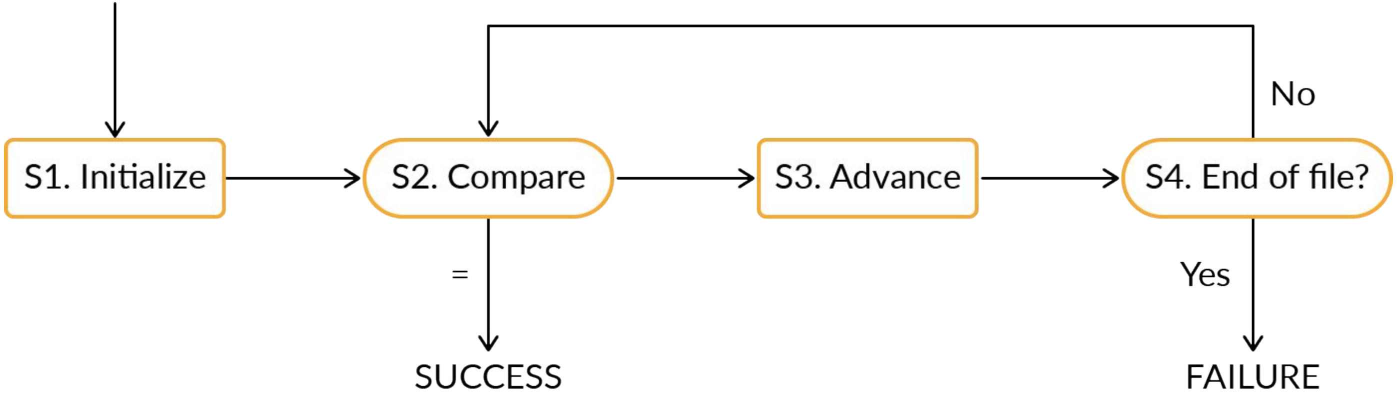
Searching

In this course we will be looking at the following search algorithms:

- **Linear Search**
- **Binary Search**

Linear Search

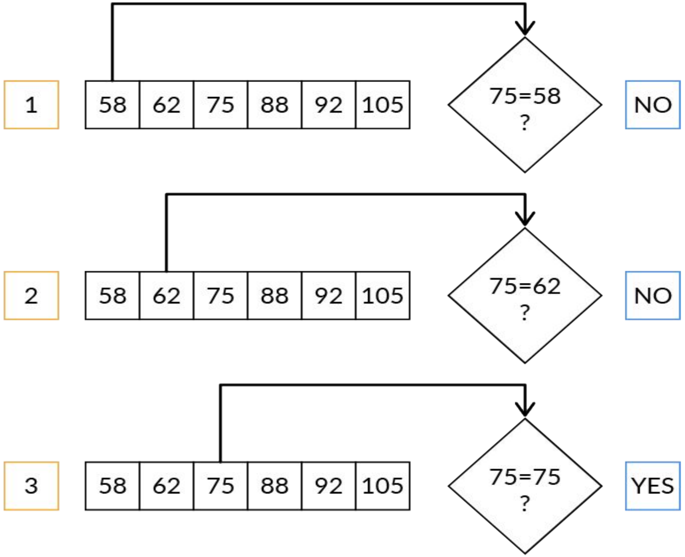
Do you remember how we traversed an array to look for an element in it? Inadvertently, we ended up performing Linear Search. Linear Search, or Sequential Search, as it is aptly called, entails searching through the entire linear data structure, one element at a time, until we find the 'key' or exhaust the entire data structure.



Linear Search

List of elements : 58, 62, 75, 88, 92, 105

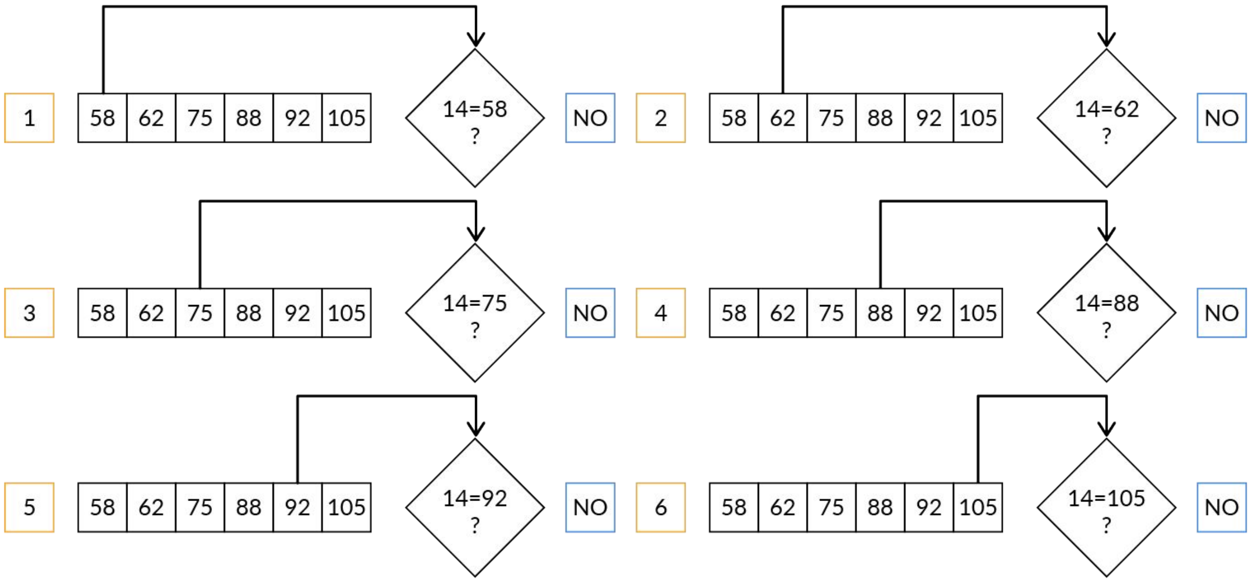
Elements to be searched: 75



Linear Search

List of elements : 58, 62, 75, 88, 92, 105

Elements to be searched: 14



1 | 58 | 62 | 75 | 88 | 92 | 105 | 14=58 ? | NO

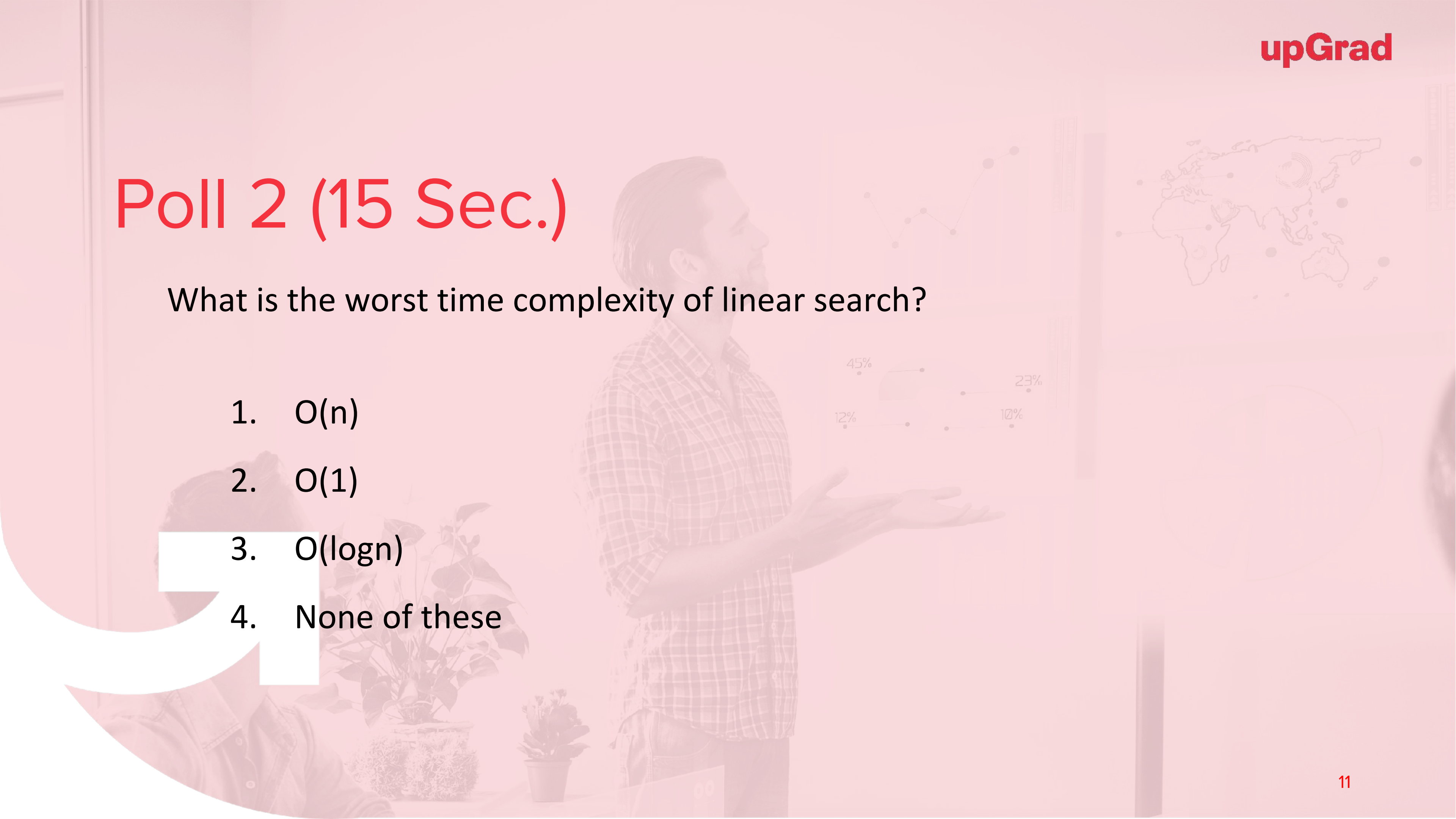
2 | 58 | 62 | 75 | 88 | 92 | 105 | 14=62 ? | NO

3 | 58 | 62 | 75 | 88 | 92 | 105 | 14=75 ? | NO

4 | 58 | 62 | 75 | 88 | 92 | 105 | 14=88 ? | NO

5 | 58 | 62 | 75 | 88 | 92 | 105 | 14=92 ? | NO

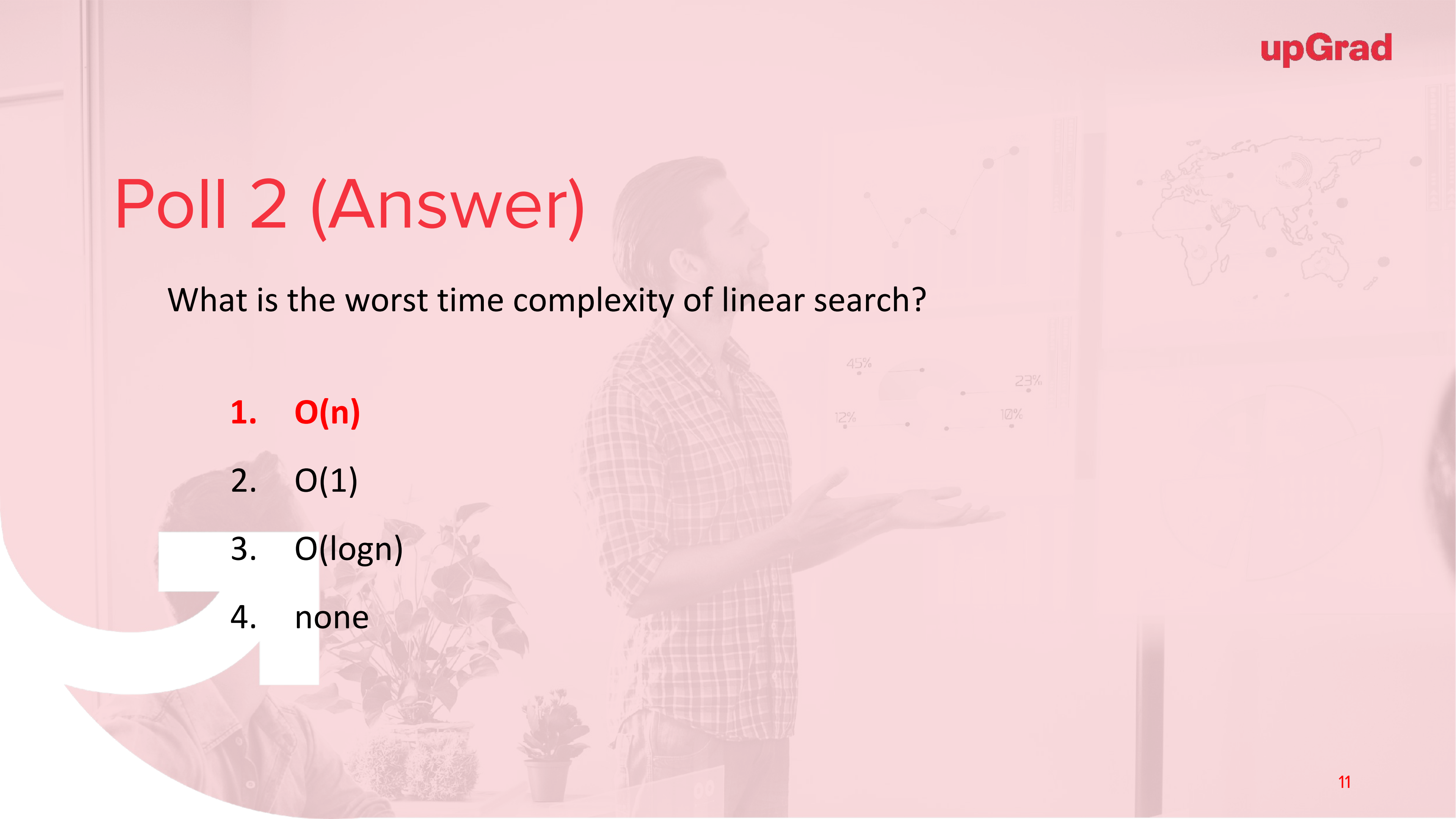
6 | 58 | 62 | 75 | 88 | 92 | 105 | 14=105 ? | NO



Poll 2 (15 Sec.)

What is the worst time complexity of linear search?

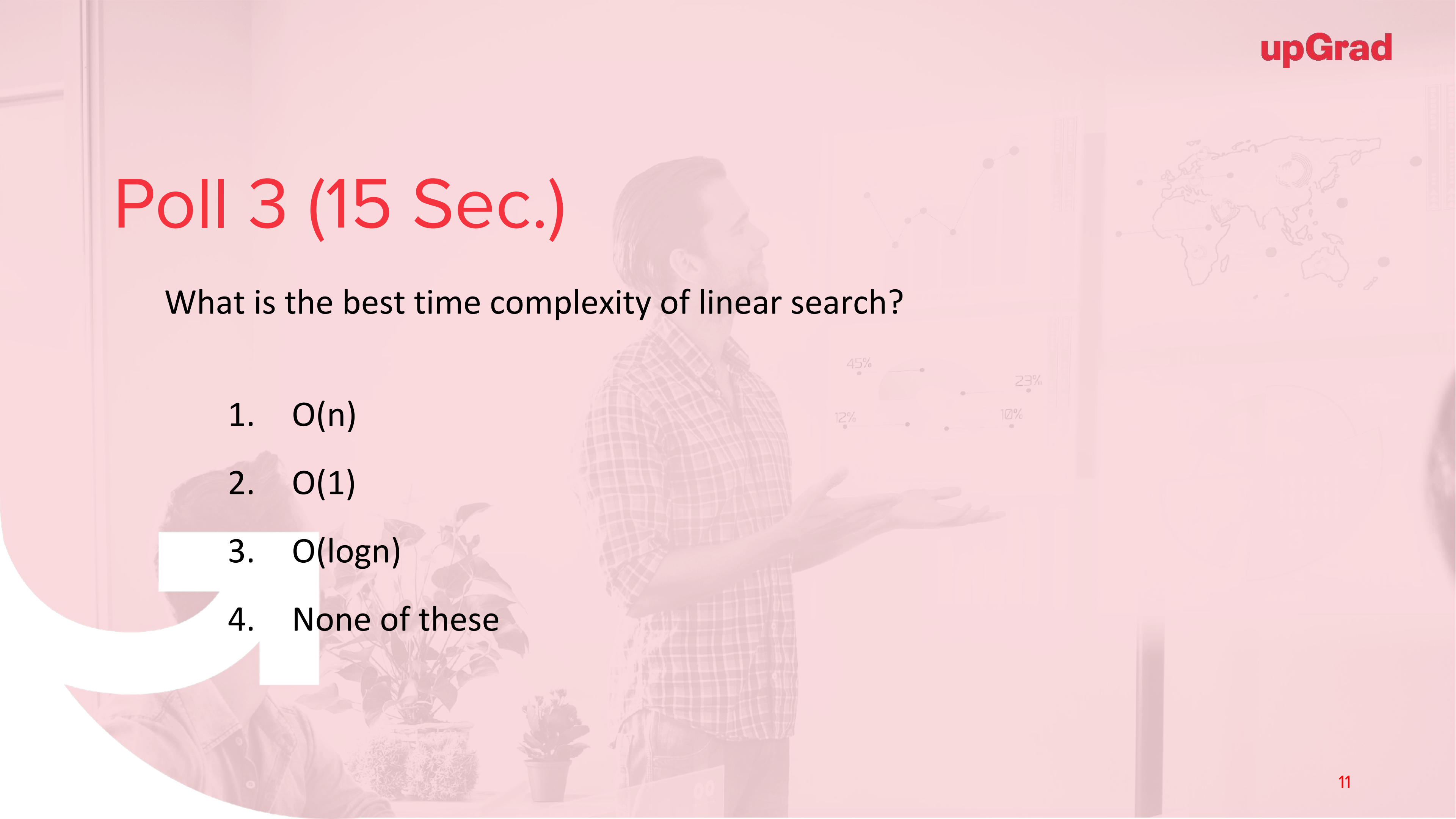
1. O(n)
2. O(1)
3. O(logn)
4. None of these



Poll 2 (Answer)

What is the worst time complexity of linear search?

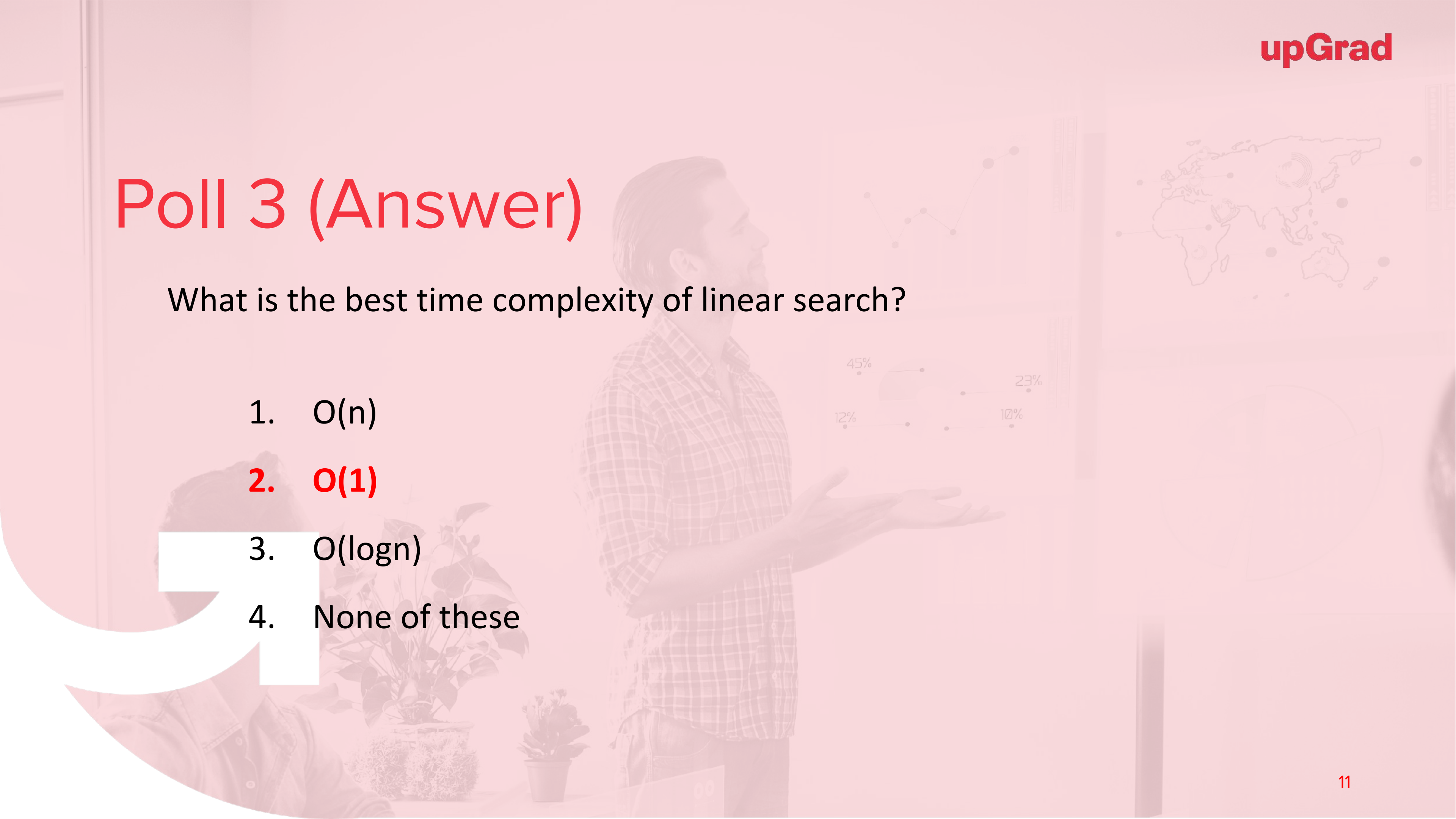
1. **O(n)**
2. O(1)
3. O(logn)
4. none



Poll 3 (15 Sec.)

What is the best time complexity of linear search?

1. O(n)
2. O(1)
3. O(logn)
4. None of these



Poll 3 (Answer)

What is the best time complexity of linear search?

1. O(n)
2. **O(1)**
3. O(logn)
4. None of these

Binary Search

Suppose we want to know what the word ‘weftage’ means.

Earlier, without knowing how to search we would have started with the first page of the dictionary and tried to match the word ‘weftage’ with all the other words in the dictionary one by one.

How long do you think this would take us? (The Oxford dictionary has over 1,80,000 words)

Binary Search

Binary Search

Let’s explore better ways at performing this search rather than scanning the entire data set. Binary Search provides a much faster algorithm and guarantees better performance than Linear Search.

What would you do if you had to search for a word in the dictionary yourself? You would start with a more efficient method for starters, right?

Which component of the dictionary enables us to to do this?

A dictionary is sorted in alphabetical order!

Binary Search

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Binary Search

Binary Search as a concept is similar to the method of searching for a word in a dictionary. As you would have guessed, Binary Search only works on sorted arrays.

Let’s say we randomly opened the dictionary and landed on a page with words beginning with the letter ‘S’. If we are looking for ‘weftage’, we now know for sure that we will not find the word in this portion of the dictionary.

So, we repeat the same exercise that we did before, i.e., scan the left or the right portion of the dictionary until we find the word.

Can you identify an algorithmic concept that would be useful here?

Binary Search

🤔 What about now?

Yes! Recursion!

Binary Search

Binary Search

Let’s look at how Binary Search actually works.

The way we opened the dictionary to see which word we arrived at, we first check the **middle** element of the array to look for the ‘key’. If it is found, we return the index. If it is not found, we can now know which **half** of the array might contain the ‘key’ that we are searching for, by comparing the ‘key’ and the data element we just checked.

Now, we proceed to perform Binary Search on the remaining half until we find the data element that we are looking for.

Binary Search

Linear Search always allows us to discard only one element from the search space (the one we just checked) in each iteration. Comparatively, **Binary Search** always always allows us to reduce the search space by almost half.

If we use recursion to solve the problem, can you tell what will be the

- **Base Case**, and
- **Recursive Call**

for this problem?

Binary Search

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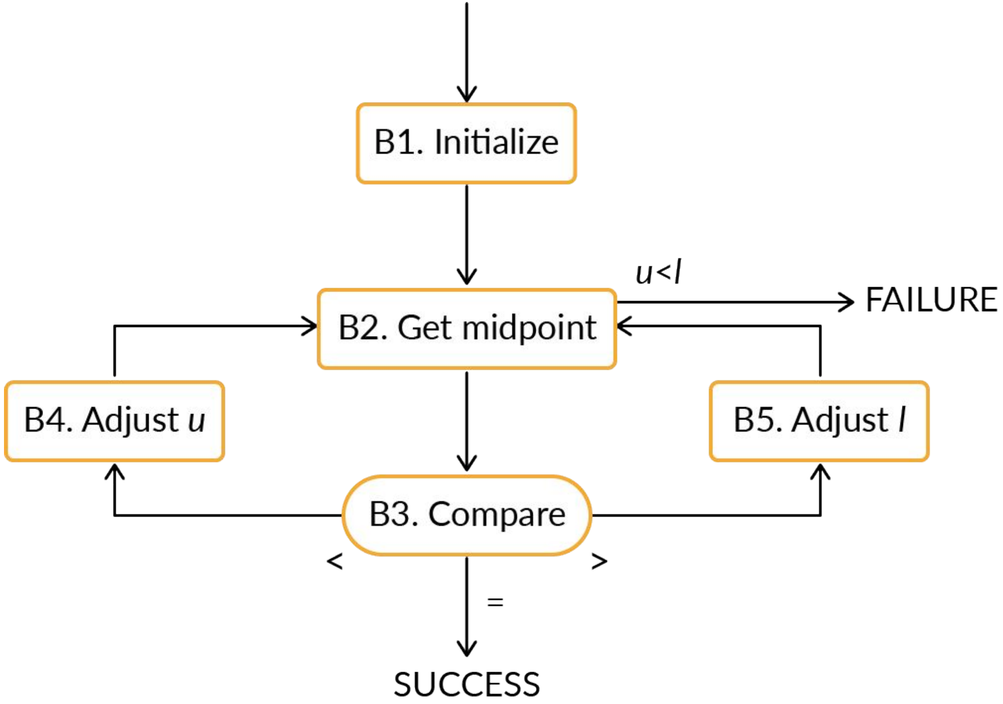
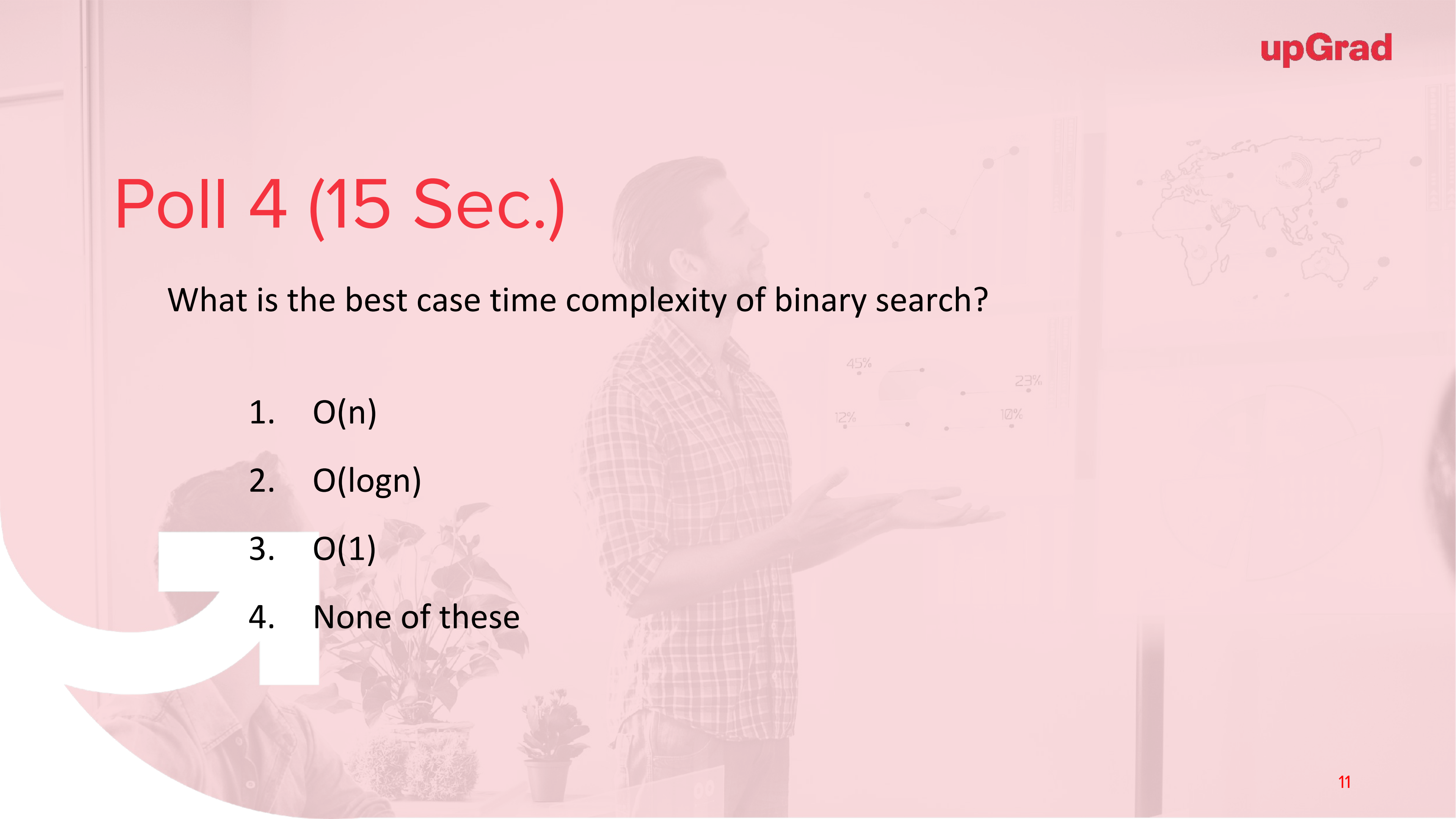
Binary Search

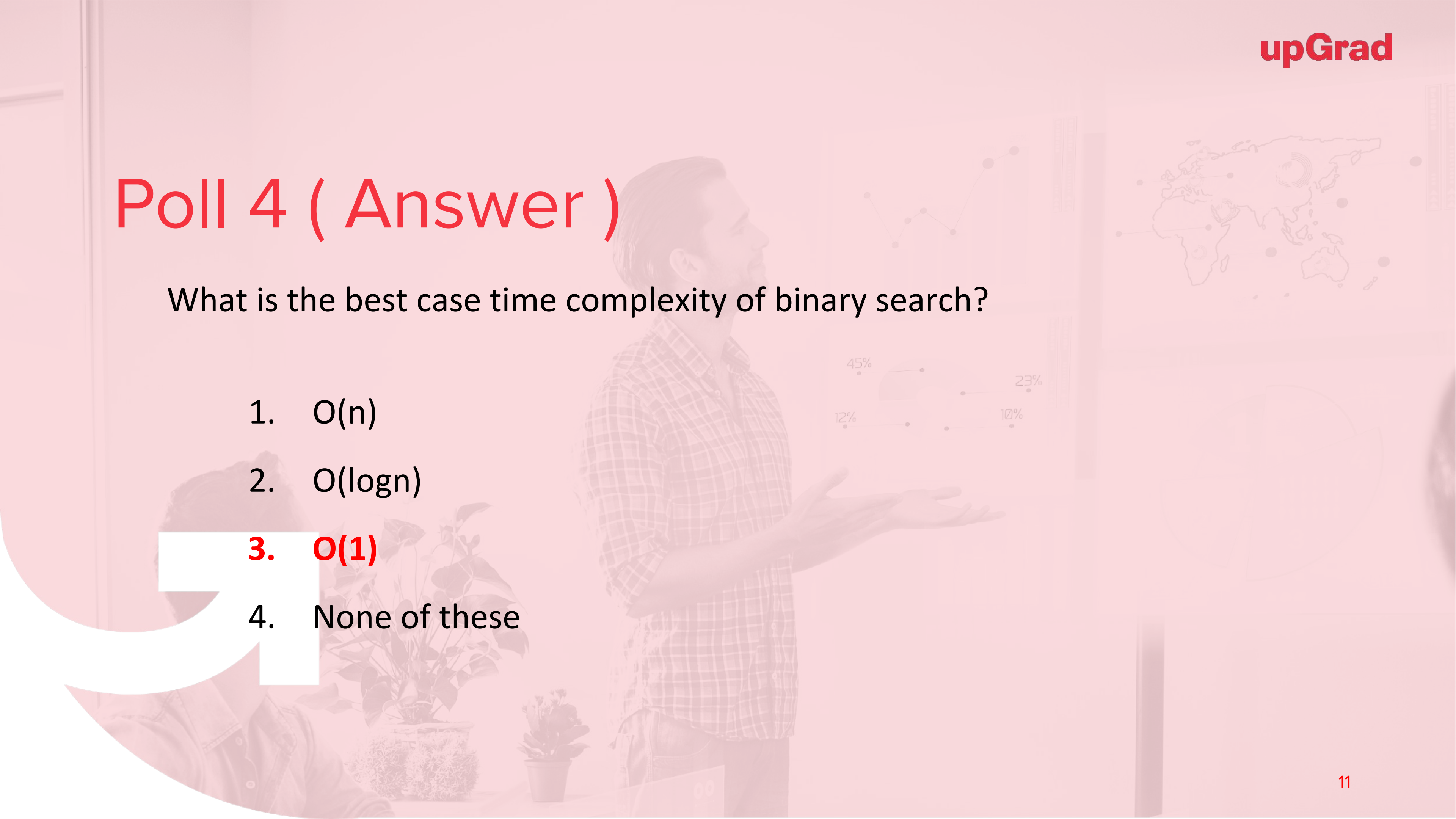




Poll 4 (15 Sec.)

What is the best case time complexity of binary search?

1. O(n)
2. O(logn)
3. O(1)
4. None of these



Poll 4 (Answer)

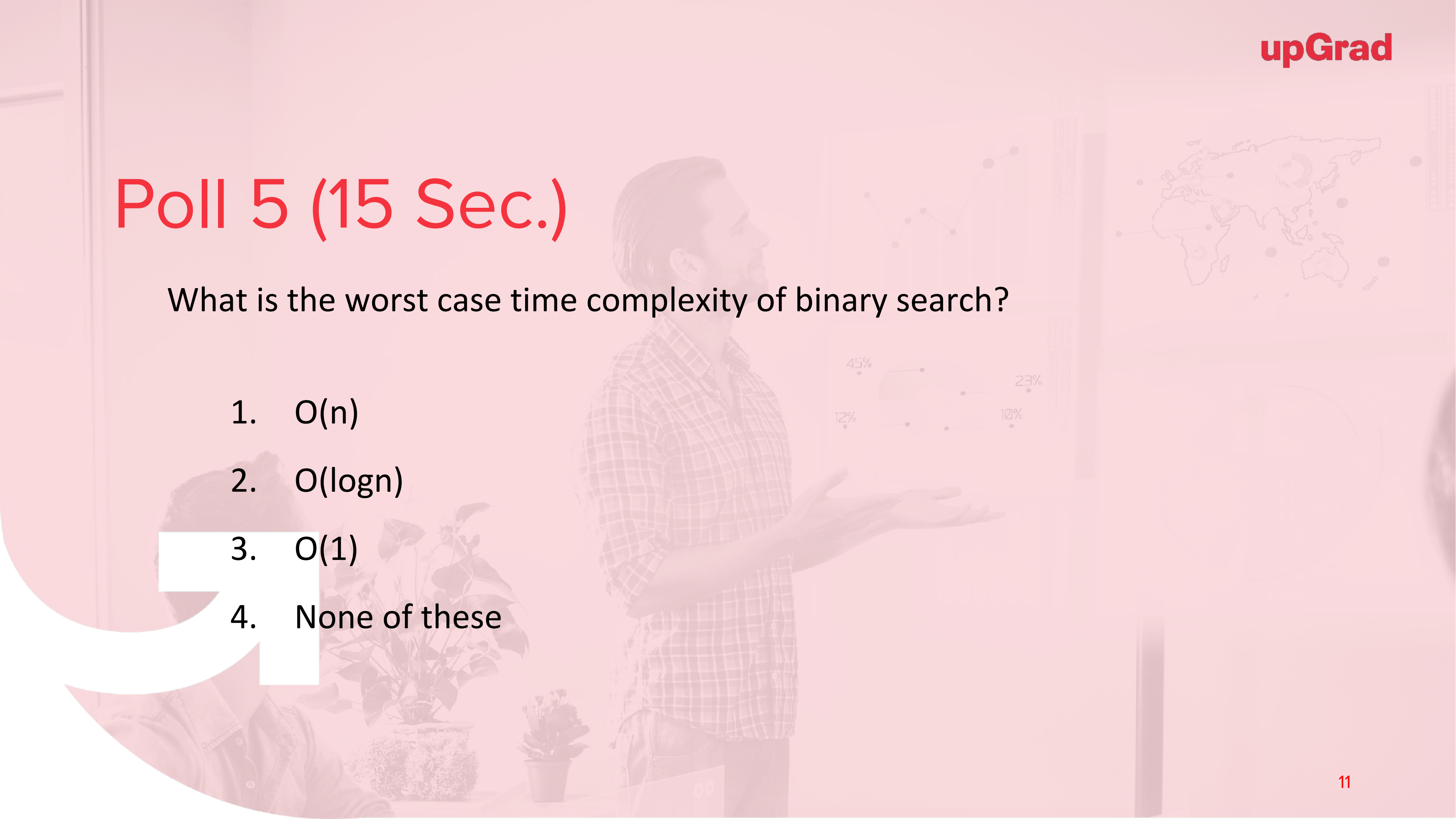
What is the best case time complexity of binary search?

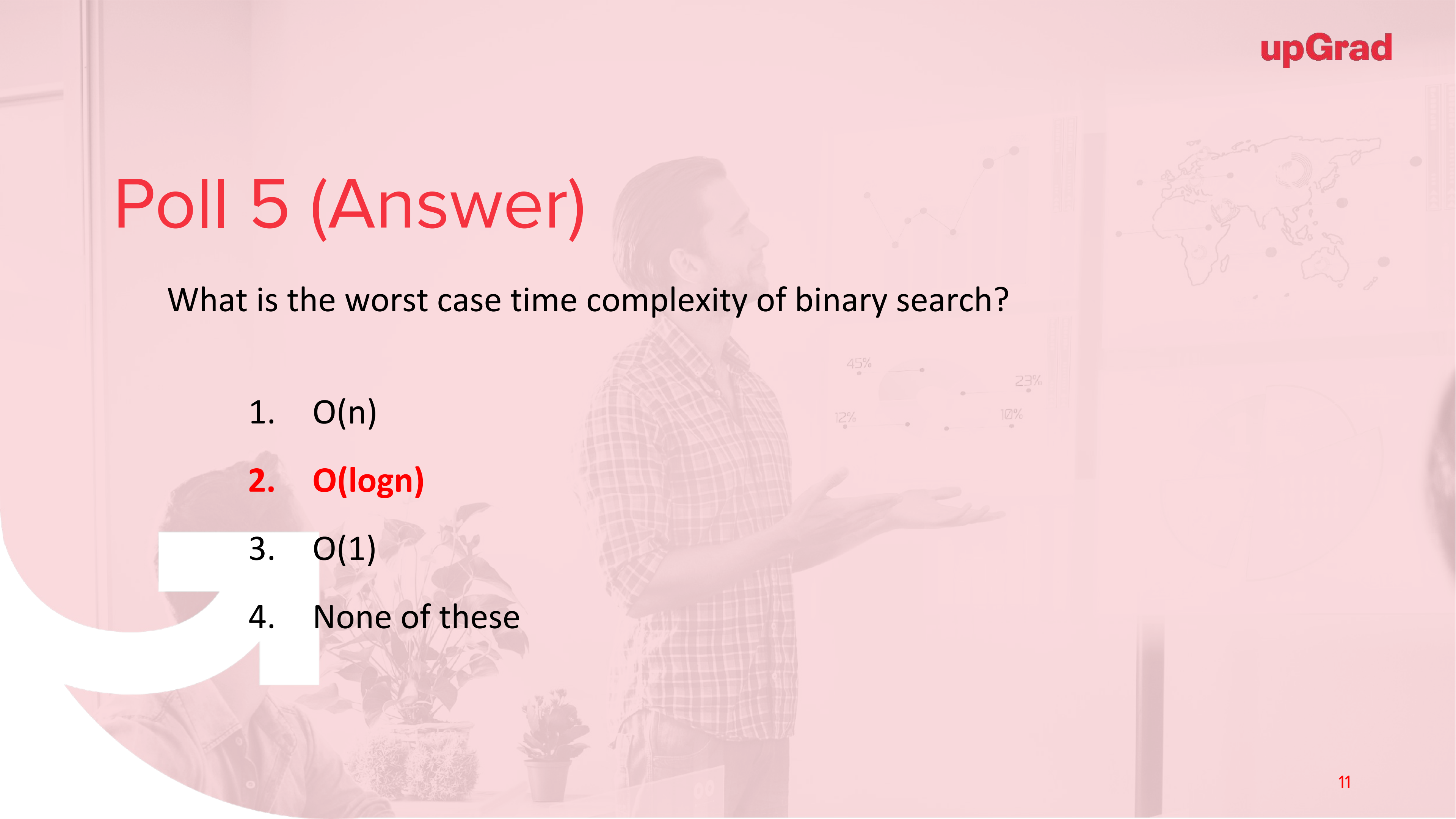
1. O(n)
2. O(logn)
3. **O(1)**
4. None of these

Poll 5 (15 Sec.)

What is the worst case time complexity of binary search?

1. O(n)
2. O(logn)
3. O(1)
4. None of these





Poll 5 (Answer)

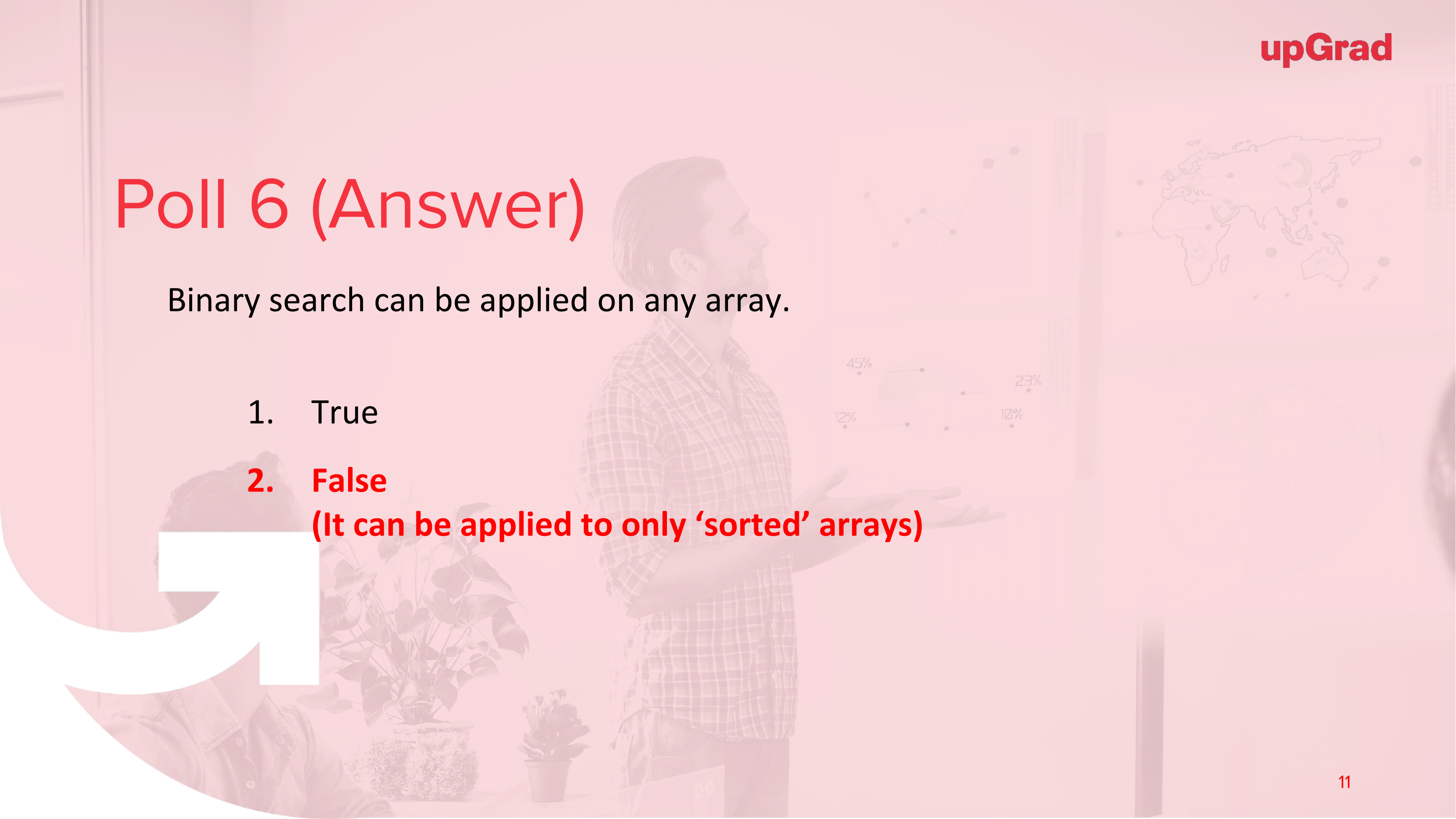
What is the worst case time complexity of binary search?

1. O(n)
2. **O(logn)**
3. O(1)
4. None of these

Poll 6 (15 Sec.)

Binary search can be applied on any array.

1. True
2. False

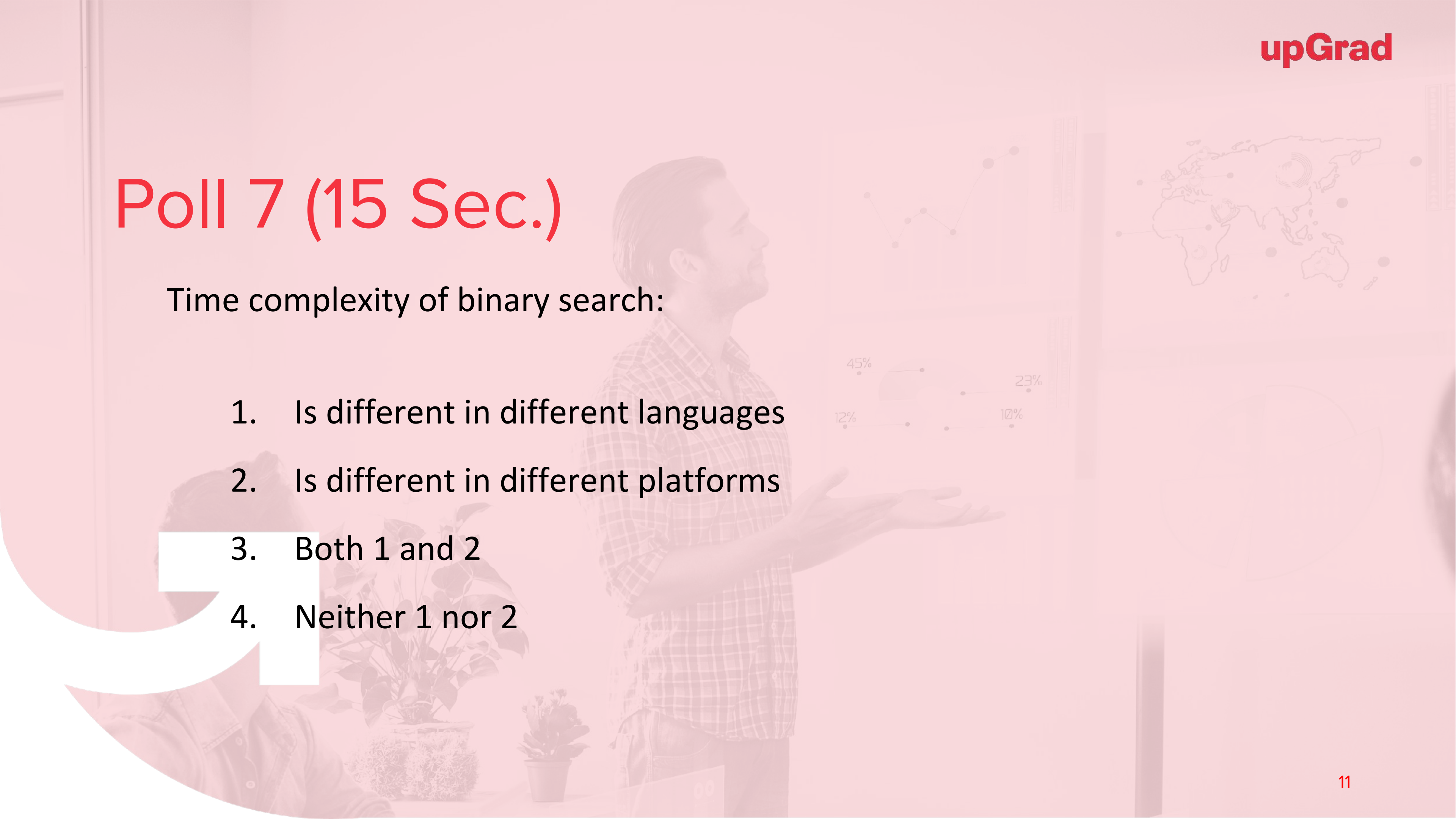


Poll 6 (Answer)

Binary search can be applied on any array.

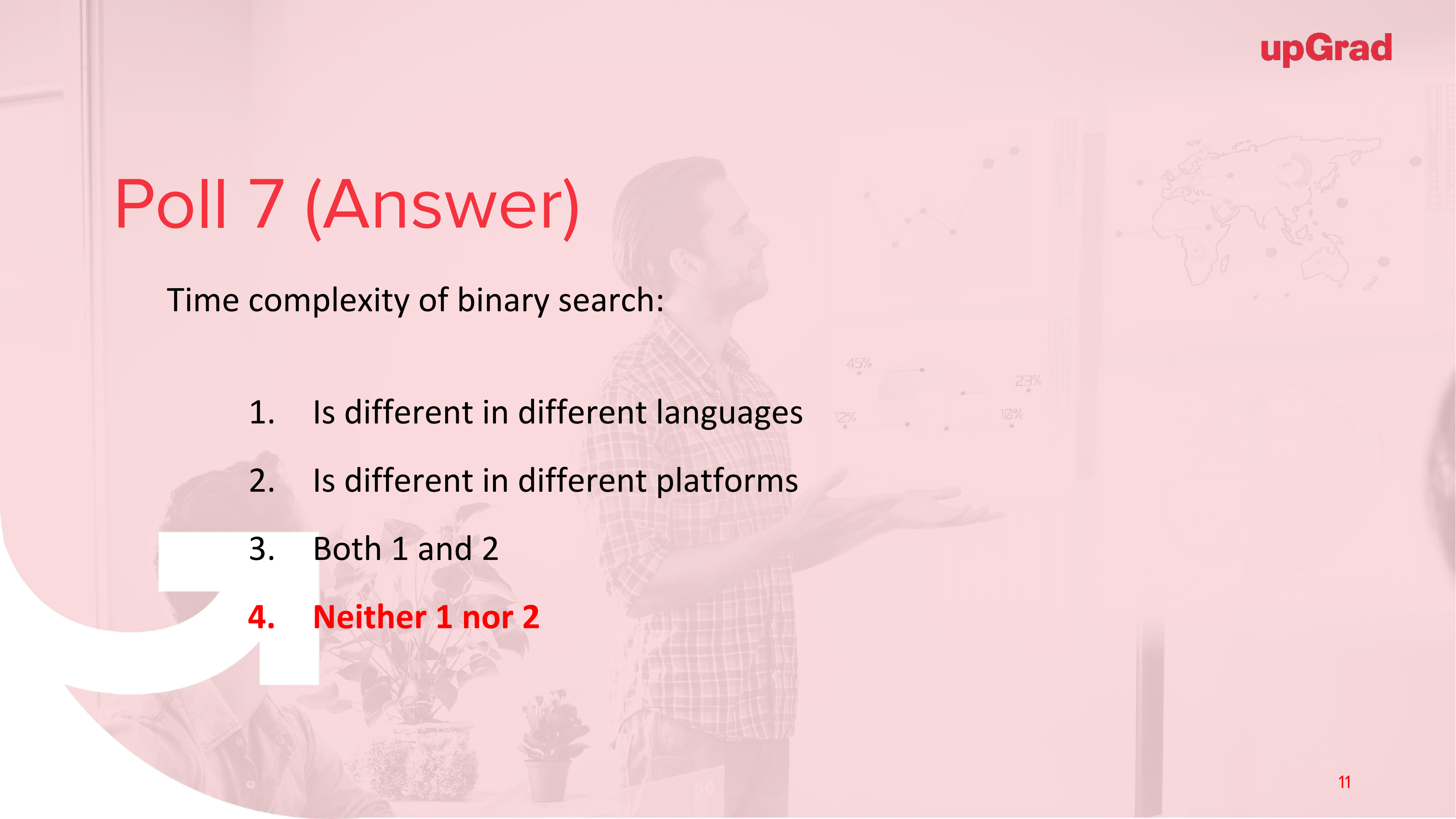
1. True
2. **False**
   (It can be applied to only ‘sorted’ arrays)

Poll 7 (15 Sec.)



Time complexity of binary search:

1. Is different in different languages
2. Is different in different platforms
3. Both 1 and 2
4. Neither 1 nor 2



Poll 7 (Answer)

Time complexity of binary search:

1. Is different in different languages
2. Is different in different platforms
3. Both 1 and 2
4. **Neither 1 nor 2**

Binary Search

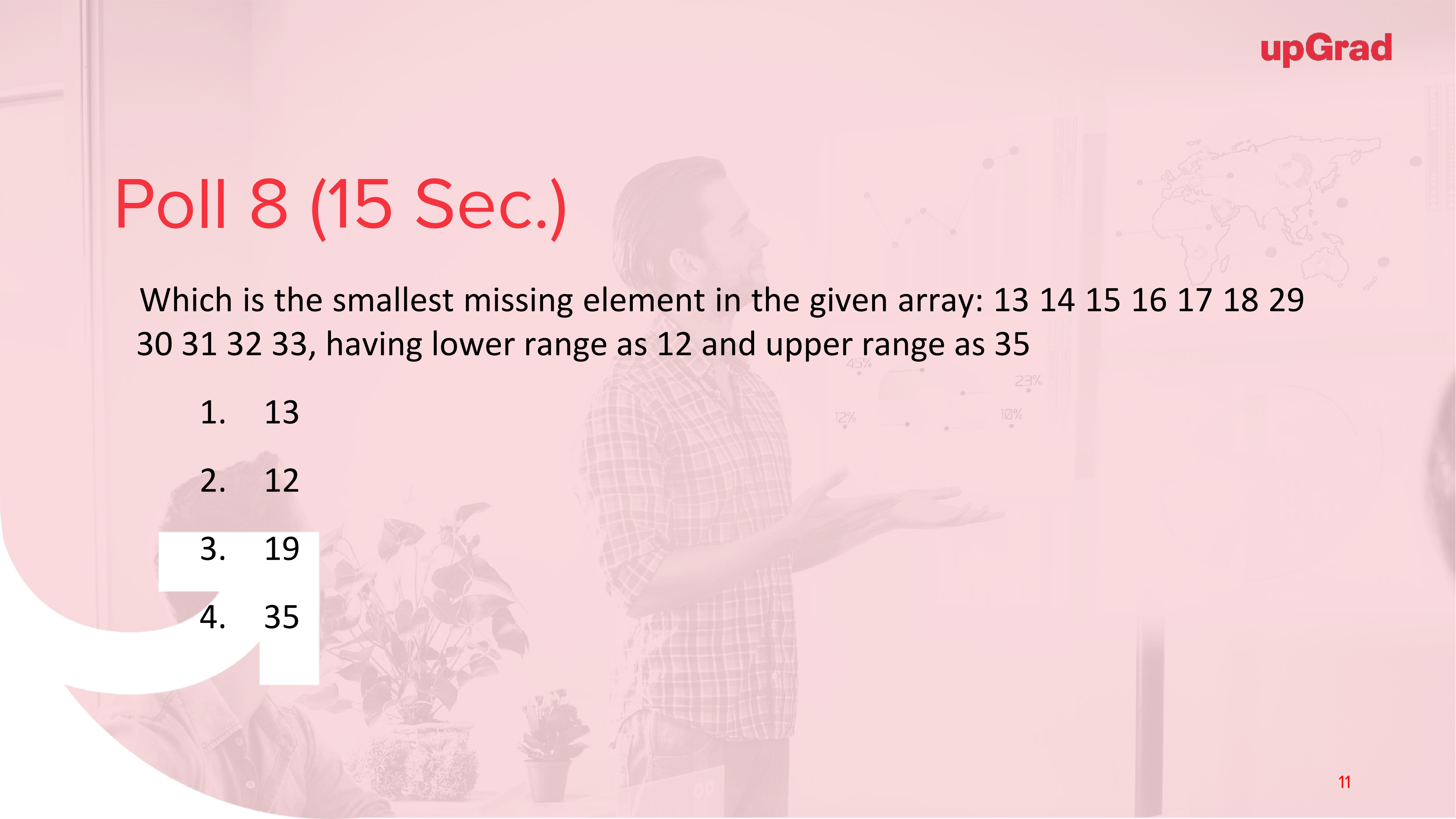
Coding Question

Find an element in a sorted array using:

- Iterative approach
- Recursive approach

Now perform binary search on array which we took for linear search and find the number of comparisons to find an element.

Poll 8 (15 Sec.)



Which is the smallest missing element in the given array: 13 14 15 16 17 18 29 30 31 32 33, having lower range as 12 and upper range as 35

1. 13
2. 12
3. 19
4. 35

Poll 8 (Answer)

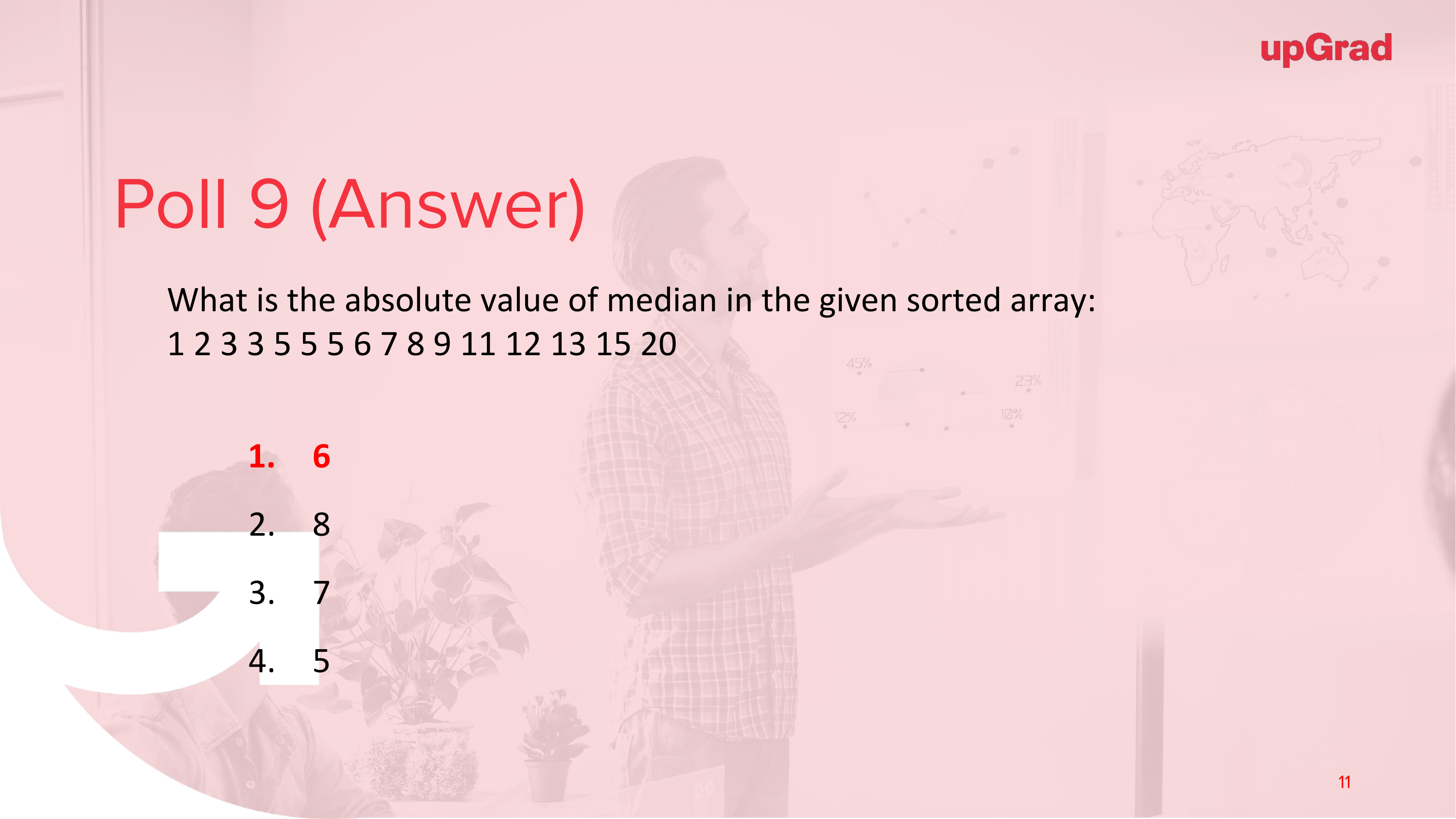
Which is the smallest missing element in the given array: 13 14 15 16 17 18 29 30 31 32 33, having lower range as 12 and upper range as 35

1. 13
2. **12**
3. 19
4. 35

Poll 9 (30 Sec.)

What is the absolute value of median in the given sorted array:
1 2 3 3 5 5 5 6 7 8 9 11 12 13 15 20

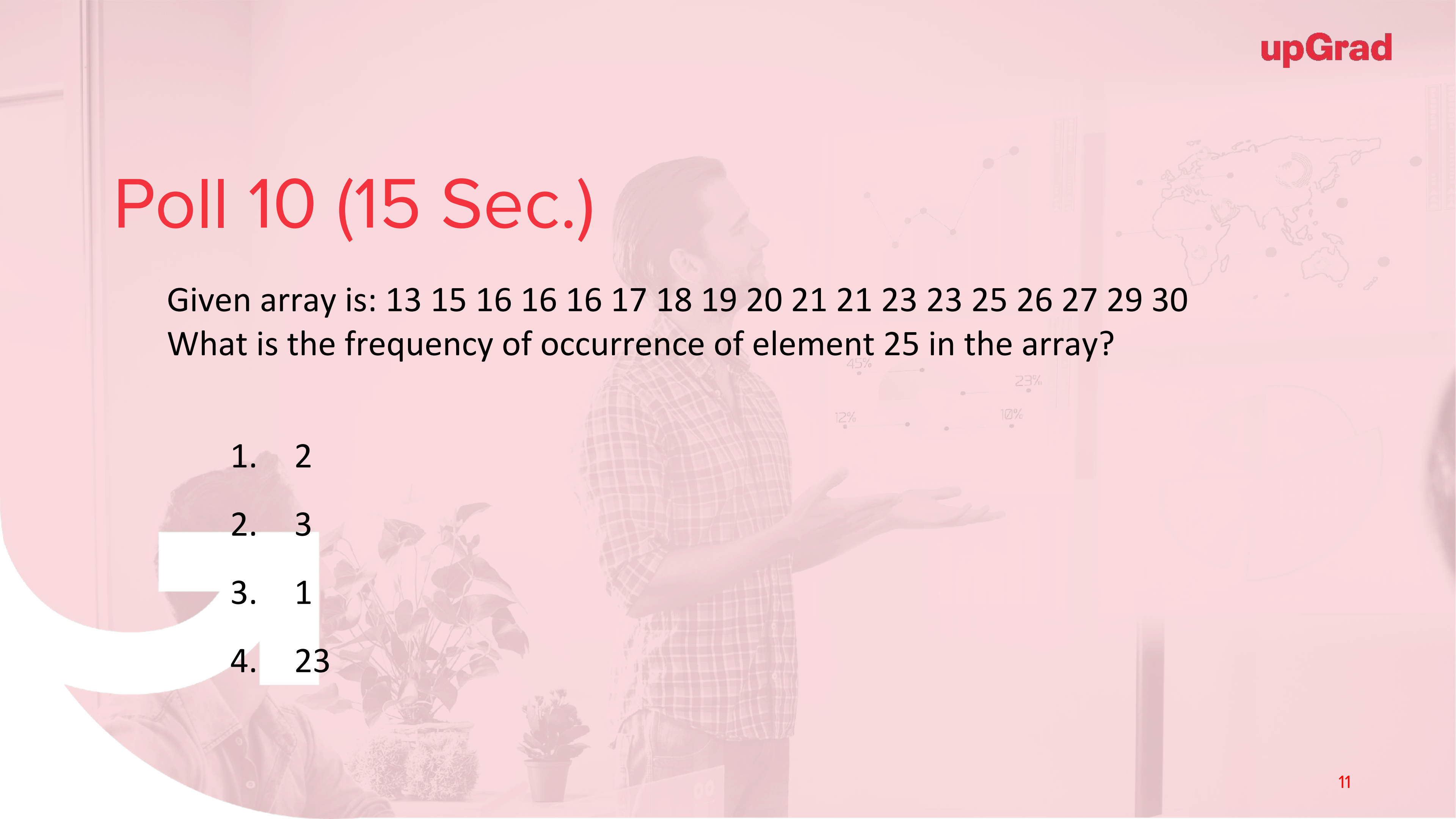
1. 6
2. 8
3. 7
4. 5



Poll 9 (Answer)

What is the absolute value of median in the given sorted array:
1 2 3 3 5 5 5 6 7 8 9 11 12 13 15 20

1. **6**
2. 8
3. 7
4. 5



Poll 10 (15 Sec.)

Given array is: 13 15 16 16 16 17 18 19 20 21 21 23 23 25 26 27 29 30
What is the frequency of occurrence of element 25 in the array?

1. 2
2. 3
3. 1
4. 23

Poll 10 (Answer)

Given array is: 13 15 16 16 16 17 18 19 20 21 21 23 23 25 26 27 29 30
What is the frequency of occurrence of element 25 in the array?

1. 2
2. 3
3. **1**
4. 23

Binary Search

Hands-on Coding

- Finding the smallest missing element from the sorted array of n distinct elements. Elements are in the range of 0 to m-1, where m>n.

- Find median of two sorted arrays.

Homework

1. Count frequency of number in sorted array using binary search.

Tasks to complete after the session

Homework Questions

MCQs

Coding Questions

In the next class...

- Introduction to sorting algorithms
    - Bubble sort
    - Selection sort
    - Insertion sort

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Thank You!