University of Petra	جامعة البترا	جامعة البترا - ثلاثون عاما University of Petra
Faculty of Information Technology		كلية تكنولوجيا المعلومات
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Advanced Algorithms
601326
Midterm Exam – 2025 1

Your Name: .....

Your Instructor Name: .....

Instructions for the Exam:

- Write your name and ID number on the exam and answer sheets.
- Write the number of the section that you enrolled in.
- Write the name of your instructor.
- Questions in the exam not allowed.
- Using any type of technology (mobiles, smart watches) not allowed
- Using extra papers or sheets not allowed
- The exam consists of Six questions.

For instructor use only:

Question number	Course ILO	Program ILO	Question weight	Student mark
Q1			4	1
Q2	K2		4	4
Q3	I1		8	8
Q4			5	5
Q5			5	3.5
Q6			4	4
Total /30				25.5

لا تكتب المقارنات بالتفصيل .؟؟

Q1) Discuss median-of-three pivot selection and how it enhances Quick Sort algorithm worst case.

(4 marks)

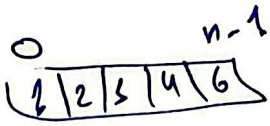
1

هاذا نوع مختار

مش كيف بأثر partition algorithm

that it take the best point that depend on it it will diwide the array to two halfs by the i, j is the best point and ensure it is in the correct place, this enhonce the Complexity time and already in the Correct place pivot point.

How??



Q2) Consider the following algorithm. **(4 marks)**

```
Algorithm XYZ (A [0..n − 1])
//Input: An array A[0..n − 1] of n real numbers
val ← 10
res1 ← 0
res2 ← 1
for i ← 0 to n − 1 do
    if A[i] >= val
    res1 ← A[i]+res1
    if A[i] < val/2
    res2 ← A[i]*res2
return res1 – res2
```

a. What does this algorithm compute?
b. What is the time complexity for the algorithm?

- it loops along the array elements find the sum of the numbers greater than or equal 10 and calculate the sums of them
- and loop along it fin to find Multiplication of elements that is less than five. which is Val/2
- then return the Sum subtract the Multiplication and.

$T(n) = 1+1+1+n+n-1+n+1+n-1+n-1+1$

$T(n) = 5n$

$O(n)$

A: 0 1 2 3 4 5, n = 6: [1 | 2 | 3 | 4 | 5 | 6]

$\frac{6}{2} = 3$ → mid

$\frac{n}{2}$ → قسم على اثنين

A: 0, [1]

Q3) Design a divide-and-conquer algorithm to compute the summation of elements in an array. **(8 marks)**

Setup and solve a recurrence relation for the number of summations made by your algorithm **(use Master Theorem)**

8

A: 0 1 2 [1 | 2 | 3]   3 4 5 [4 | 5 | 6]

recursive مرتين → a = 2

كل مرة اقسم → b = 2

$S_{left} = 6$ Sumright = 15

\+ → total sum.

```
SumArray(A, n){
  Sum = 0
  //Base Case → حالة معروفة
  if n == 1
    Sum = A[0]
    return Sum

  //Divide
  mid = n/2
  Leftarray = A[0 .. mid-1]
  rightarray = A[mid .. n-1]
  //Conquer (Solve using recursive)
  SumLeft = SumArray(Leftarray, mid)
  SumRight = SumArray(rightarray, mid)

  //Combine (solution)(right answer)
  TotalSum = SumLeft + SumRight   ~> 1
  return TotalSUM   ~> 1
```

Q5

- طبق Quick على array

Quick ولا تضيع وقت فلان أعرف فيه

$T(n) = aT\left(\frac{n}{b}\right) + f(n)$ ← how we need to done combination.

$T(n) = aT\left(\frac{n}{b}\right) + O(n^d)$ → constant = 1+1 = 2, d = 0

a = 2   b = 2   d = 0

$T(n) = 2T\left(\frac{n}{2}\right) + O(n^0)$

a = 2   b = 2   d = 0 $\log_b a$

$\log_2 2 = ?? = 1$ ← power

~~$d \; \square \; \log_b a$~~

$0 \; \boxed{<} \; 1$

$T(n) = n^{\log_b a}$ → $T(n) = n^1 = n$ ⟹ $T(n) = n$ → $O(n)$

5

Q4) Consider the following recursive algorithm: **(5 marks)**

```
Algorithm Q(n)
//Input: A positive integer n
if n =1
    return 1
else
    return Q(n − 1) + 2 * n − 1
```

a) **Setup** a recurrence relation for the number of multiplications made by this algorithm.

b) **Solve** the recurrence relation using backward substitution and find Big O.

a) $T(n) = \begin{cases} 0 & , n = 1 \\ T(n-1)+1 & , n > 1 \end{cases}$

General case

General Case

$T(n) = T(n-1) + 1$

$T(n-1) = T(n-1-1) + 1$

$= T(n-2) + 1$

$T(n-2) = T(n-2-1) + 1$

$= T(n-3) + 1$

$T(n-3) = T(n-3-1) + 1$

$= T(n-4) + 1$ → Stop

$T(n) = (((T(n-4)+1)+1)+1)+1$

Base Case

$T(n) = T(n-4) + 4$

let $i = 4$

$T(n) = T(n-i) + i$

$T(n) = n - 1$

$O(n)$

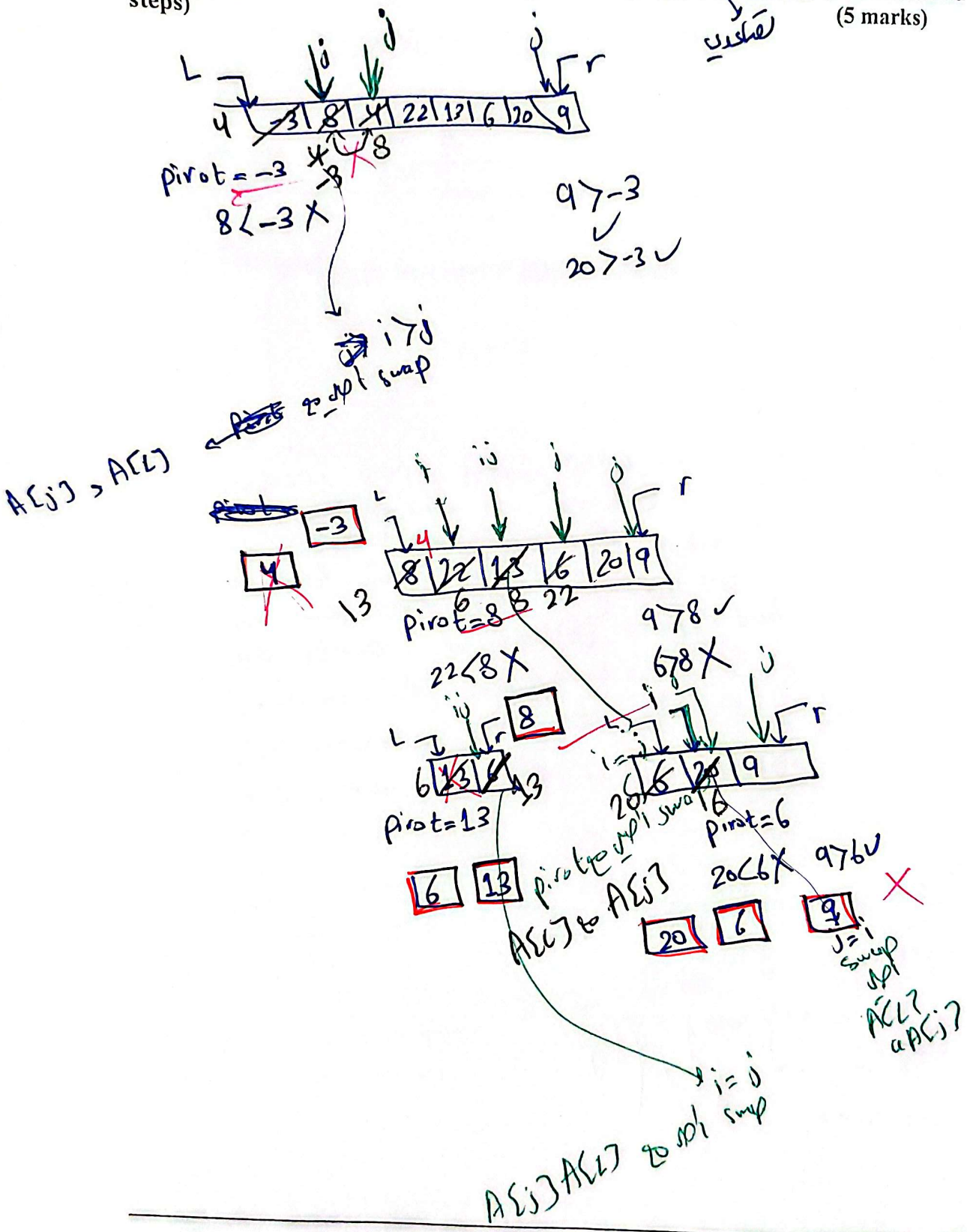
$T(n=1) = T(n-i)$

$n - i = 1$

$i = n - 1$

$i = -1 + n$

Q5) Given the following array, A= -3 ,8, 4, 22, 13, 6, 20, 9
Apply Quick Sort algorithm to sort the array elements in ascending order **(show detailed steps)** **(5 marks)**



Q6) Based on your understanding of the covered algorithms, answer the following: (4 marks)

4

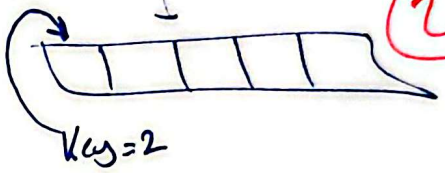
a) **Compare** Selection Sort to Sequential Search algorithms in terms of best and worst cases.

	Selection sort	Sequential search
Best case	n^2	1
Worst case	n^2	n

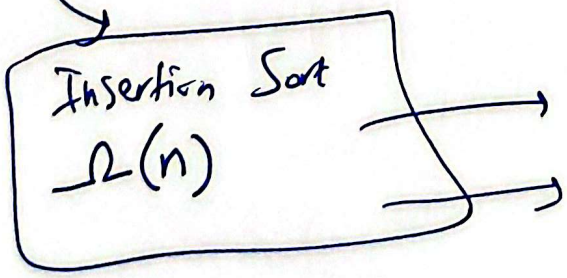
2

b) **Discuss** briefly the Best Case of Insertion Sort algorithm.

2



that the array is already Sorted if I want to Sorte it acending it is sorted acending So here no need for Comparison the Outer for loop while loop along all the array elements So bigΩ(n) always but the inner while Only not get inside Only need One Comparison with the left elemt true is less than not get inside while.



array already Sorted

From for loop outer loop along array elcds to n the array size.