University of Petra	جامعة البترا	جامعة البترا · ثلاثون عاما University of Petra
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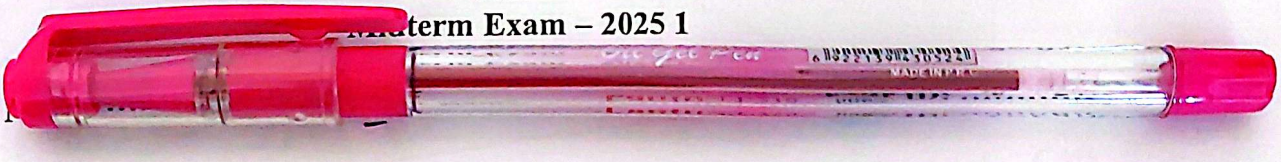
Advanced Algorithms
601326
Midterm Exam – 2025 1



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	2
Q2	K2		4	3
Q3	I1		8	3.75
Q4			5	3.75
Q5			5	4.5
Q6			4	3
Total /30				20

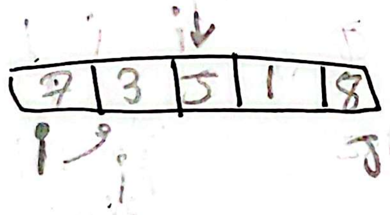
Q1) Discuss median-of-three pivot selection and how it enhances Quick Sort algorithm worst case. **(4 marks)**

2

hoare

```
quicksort(A, L, R)
    if L<R
        partion = partion(A, L, R)
        quicksort(A, L, partion-1)
        quicksort(A, partion+1, R)

partion(A, L, R)
 pivot= (L+R)/2
 i=L-1
```



~~you you take the pivot to be the midd~~

~~when picking the pivot to be in the middle it's going to take longer time to sort since the amount of swaps could be more~~

* worst cas in the quick sort shows when the right place for the partion is near the far right or the far left, cus when that happen it's like you're working with an array of size n-1 which doesn't really make diff. from sorting an array of size n

- the point of the technique used in it -- and ... is to make small by half or around the half

$O(n^2)$?

3

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?

a it goes in a for loop of the size of the element in the array in the number in the index it's in is bigger than val it changes res1 to be that number + res1 and if the number in that index is less than val/2 it changes the value of res2 to be the value of that number multiplied by res1 after executing the loop it returns the value of res1 - res2

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

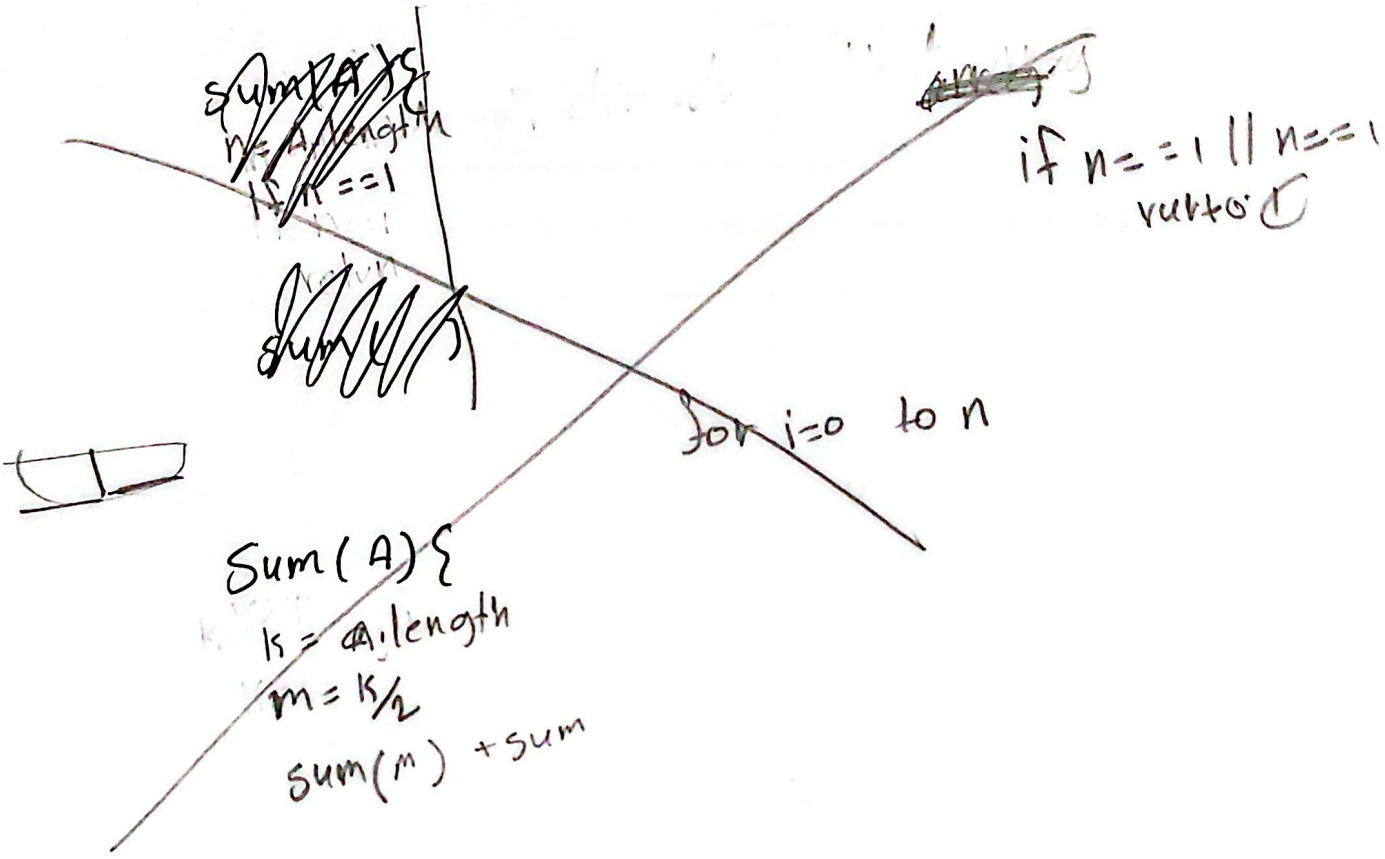
$T(n) = 5n+4$

$O(?)$

3.75

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)**



mak algo that sum numbers in arra

```
sum(n,A) → if n == 1
    retun A[1]
else
  n = n/2
  sum(n, A)
```

```
        length  → Array
ls=0 ← sum (n, A){
    if n == 1;
      retun A[i];
    else
      m = n/2
      sum
!!  for i=0 to m
      sum(n, A)
ls=ls+A[i] ← for j=m to n
      sum( n, A }
    ← ls = ls + A[j]
```

3

$T(n) = a\,T(\frac{n}{b}) + f(n)$

$T(n) = ?\,T(\frac{n}{2}) + 1$

0.75

3.75

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.

1.75

$$T(n) \begin{cases} 0, & n=1 \\ T(n-1)+2*n-1, & n>1 \end{cases}$$

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

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

$T(n-2) = T(n-3) + 2(n-3)$

$T(n) = T(n-3) + 2(n-3) + 2(n-2) + 2(n-1)$

$2((n-3)+(n-2)+(n-1))$

let $3=i$

$$T(n-i) + \sum_{i=3}^{n} n-i$$

$T(n-n)$

$T(0)$

$$1 + \sum_{i=1}^{n} n-i \quad \rightarrow (1)$$

using base case:

$T(1)=0$

$n-i=0$

$n=i$

2

$$1 + \sum_{i=1}^{n} n - \sum_{i=1}^{n} i$$

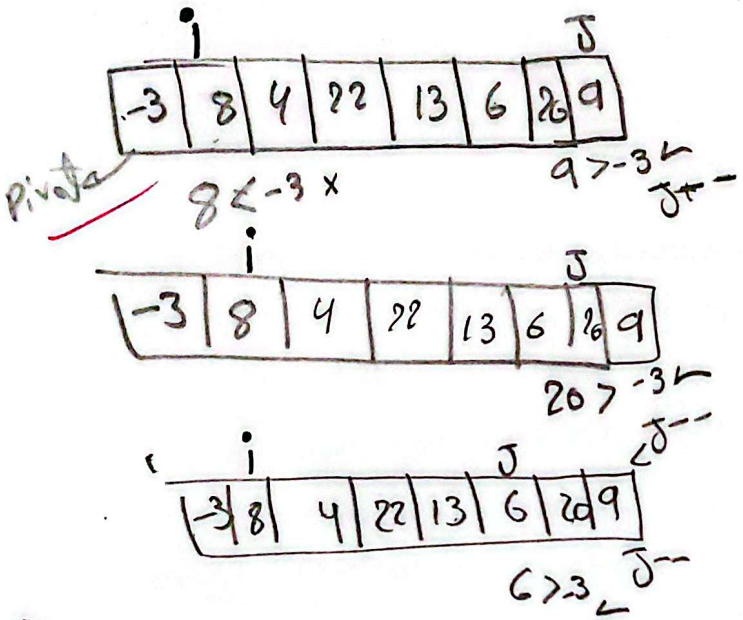
$$1 + n\sum_{i=1}^{n} 1 - \frac{n(n+1)}{2}$$

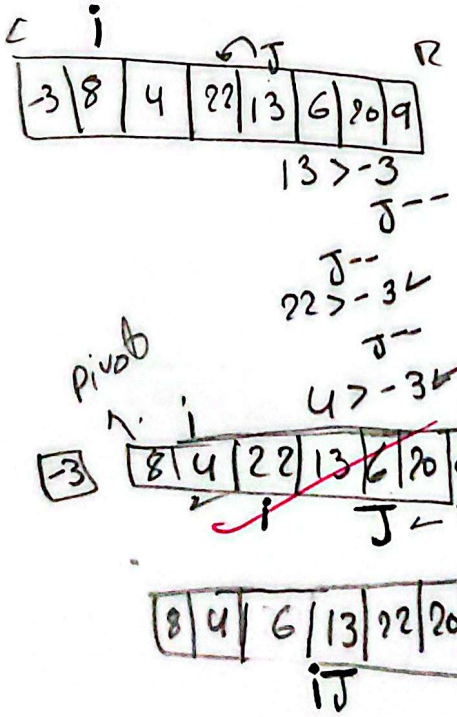
$$T(n) = 1 + n^2 - \frac{n^2+1}{2}$$

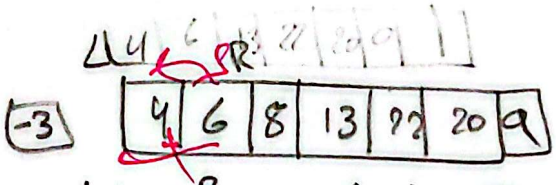
$O(n^2)$

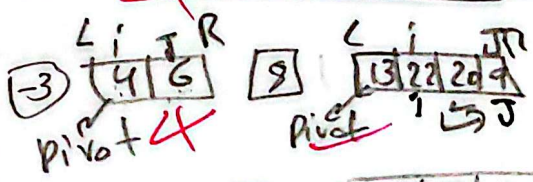
4.5

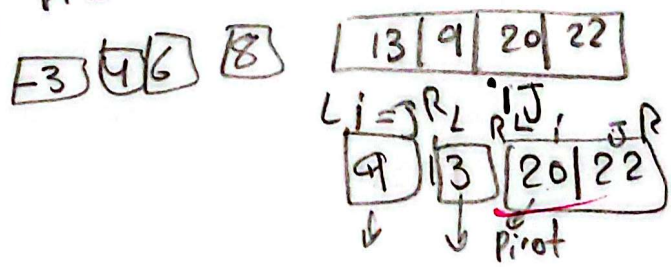
Q5) Given the following array, A= -3 ,8, 4, 22, 13, 6, 20, 9
Apply Quick Sort algorithm to sort the array elements in ascending order **(show detailed steps)** **(5 marks)**

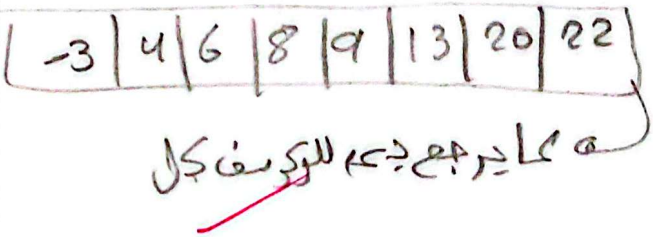












Q6) Based on your understanding of the covered algorithms, answer the following:

(4 marks)

3

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

2

	Selection sort	Sequential search
Best case	$O(n^2)$ ✓	$O(1)$ ✓
Worst case	$O(n^2)$ ✓	$O(n)$ ✓

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

1

Best case is when the array is sortte in the order you want

cus then you wouldn't have to go thrau the swaping loop - since it's sorted it's going to comper it only with The first number on it's right, finds it smaller then goes to the next index ✓