#### CS2040S — Algorithms and Data Structures School of Computing National University of Singapore

# Midterm Assessment — Answer Sheet

2022/2023 Semester 2

Time allowed: 2 hours

# Instructions (please read carefully):

- Write down your student number on the right and using ink or pencil, shade the corresponding circle in the grid for each digit or letter. DO NOT WRITE YOUR NAME!
- 2. This answer booklet comprises **TEN** (10) pages, including this cover page.
- All questions must be answered in the space provided; no extra sheets will be accepted as answers. You may use the extra page behind this cover page if you need more space for your answers.
- 4. You must submit only the **ANSWER SHEET** and no other documents. The question set may be used as scratch paper.
- 5. An excerpt of the question may be provided to aid you in answering in the correct box. It is not the exact question. You should still refer to the original question in the question booklet.
- 6. You are allowed to use pencils, ball-pens or fountain pens, as you like as long as it is legible (no red color, please).
- 7. Marks may be deducted for unreadable answers.

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	3333333
	9999999

#### For Examiner's Use Only

Question	Marks
Q1	12 / 12
Q2	<b>15</b> / 18
Q3	12 / 14
Q4	<b>15</b> / 17
Q5	<b>14</b> / 14
Q6	<b>11</b> / 14
Q7	<b>11</b> / 11
Q8	/ 0
Total	90 /100



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Use it ONLY if you need extra space for your answers, and indicate the **question number clearly** as well as in the original answer box. **Do NOT** use it for your rough work.

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	to the parties the purchase of

Question 1A	what sort was used	on Column A:	[2 mar]
O Bubble	eSort	0	MergeSort
O Selecti	onSort	0	QuickSort (first element pivot)
Insertion	onSort	0	None of the above.
Question 1B	What sort was used	on Column B?	[2 mar
O Bubble	eSort	0	MergeSort
O Selecti	ionSort	O	QuickSort (first element pivot)
O Inserti	onSort	O	None of the above.
Question 1C	What sort was used	on Column C?	[2 mai
O Bubbl	eSort	0	MergeSort
Select	ionSort	0	QuickSort (first element pivot)
	ionSort	0	None of the above.
		Ü	
Question 1D	What sort was used	I on Column D?	[2 ma
Question 1D		l on Column D?	[2 ma
O Bubbl		I on Column D?	And a second second second
O Bubbl	leSort	I on Column D?	MergeSort
O Bubbl O Select O Insert	leSort tionSort	0	MergeSort QuickSort (first element pivot)
O Bubbl O Select O Insert  Question 1E	leSort tionSort ionSort	0	MergeSort  QuickSort (first element pivot)  None of the above.
O Bubbl O Select O Insert  Question 1E O Bubbl	leSort tionSort ionSort What sort was used	0	MergeSort QuickSort (first element pivot) None of the above.  [2 ma
O Bubble O Select O Insert  Question 1E O Bubble O Select	leSort tionSort ionSort What sort was used	0	MergeSort QuickSort (first element pivot) None of the above.  [2 ma MergeSort
O Bubble O Select O Insert  Question 1E O Bubble O Select O Insert	leSort tionSort What sort was used leSort tionSort	I on Column E?	MergeSort QuickSort (first element pivot) None of the above.  [2 ma MergeSort QuickSort (first element pivot)
O Bubble O Select O Insert  O Bubble O Select O Insert  O Bubble O Select O Insert	leSort tionSort What sort was used leSort tionSort	I on Column E?	MergeSort QuickSort (first element pivot) None of the above.  [2 ma MergeSort QuickSort (first element pivot) None of the above.
O Bubble O Select O Insert  O Bubble O Select O Insert  O Bubble O Select O Insert  Question 1F	leSort tionSort What sort was used leSort tionSort tionSort What sort was used	I on Column E?	MergeSort QuickSort (first element pivot) None of the above.  [2 ma MergeSort QuickSort (first element pivot) None of the above.

2/2	Questio	n 2A	Tight	est bo	und fro	om the availa	ble optic	ons:				[2 ma	ırks]
	0 0	$(\log n)$	0	O(n)	0	$O(n \log n)$	0	$(n^2)$	0	$O(n^3)$	0	$O(2^n)$	
2/2	Questio	n 2B	Tight	est bou	and fro	om the availa	ble optio	ons:				[2 ma	arks]
	0 0(	(n)	O(r	$n\log n$	0	$O(n\log^2 n)$	0	$O(n^2)$	0	$O(n^3)$	С	$O(2^n)$	
2/2	Questio	n 2C	True	or fals	e:							[2 ma	arks]
				0	Γrue	di In		Ø.F	alse	l Peril		n ()	
3/3	Questio	n 2D	Tight	est bo	und fro	om the availa	ible optic	ons:		in Prof		[3 ma	arks]
	0	O(1)			000	O(n)	0	O(n1	$og^2 n$	)	0.	$O(n^3)$	
	0	$O(\log$	n)		0 0	$O(n\log n)$	0	$O(n^2$	)		0	$O(2^n)$ .	
3/3	Questio	n 2E	Tight	est bou	and fro	om the availa	ble optio	ons:		o hadi Guztua		[3 ma	ırks]
	0	O(1)			$\circ$	O(n)	0	O(n1	$og^2 n$	)	0	$O(n^3)$	
	0	$O(\log$	n)		0,0	$O(n\log n)$	0	$O(n^2$	)		0	$O(2^n)$	
0/3	Questio	n 2F	Asym	ptotic	runnir	ng time.				74.5		[3 ma	irks]
	0	O(1)			0 0	$\mathcal{O}(n)$		$O(n^2)$	6)2	ing Project	0	$O(2^n)$	
	0	$O(\log$	n)		$\bigcirc o$	$O(n\log n)$	0	$O(n^3)$	)				
3/3	Questio	n 2G	Whic	h recu	rrence	best describ	es this fu	nction	1?	n (W		[3 ma	rks]
	0	$T(n) \leq$	$\leq T(n/$	(2) + C	O(n).		0	T(n)	$\leq T($	n/4) + 6	$O(n^2)$	).	
	0	$T(n) \leq$	$\leq T(n/$	(2) + C	$O(n^2)$ .		0	T(n)	$\leq 4T$	(n/4) +	O(n	).	
	0	$T(n) \leq$	$\leq 2T(n)$	/2) +	$O(n^2)$	,O	0	T(n)	$\leq 2T$	(n/4) +	O(n	<sup>2</sup> ).	
	0	$T(n) \leq$	$\leq T(n/n)$	(4) + C	O(n).		0	None	of th	e above	•:		
2	Question	n 3A	Worst	-case f	for Ins	ertionSort or	n array co	ontaini	ng or	nly 2 ele	ment	s: [2 ma	rks]
	0	O(1)			0	(n)	0	$O(n \log n)$	$\log^2 n$		0	$O(n^3)$	
	0	$O(\log n)$	n)		0	$(n \log n)$		$O(n^2)$				$O(2^n)$	

Questi	on 3]	В	MergeS	ort on p	artially s	orted arra	y:			e C		[2 marks]
	0(1	1)		<b>Q</b>	O(n)		0	$O(n\log^2 n)$		0	0(	$(n^3)$
C	0(1	33	ı)	0	$O(n\log$	(n)	0	$O(n^2)$		0	0(	$(2^n)$
Quest	ion 3	C	Paranoi	d Quic	kSort on	a deck of	kn cai	rds:				[3 marks]
	) Θ(1	n)	1.0		0	$\Theta(nk)$			0	$\Theta(nk)$	og (	nk))
	Θ()	nlog	g(k)		0	$\Theta(nk\log$	(k))					
	) Θ(	nlog	g(n)		0	$\Theta(nk\log$	(n))	:5\\ 	0	None o	of tl	ne above.
Quest	ion 3	D	Worst-	case rui	nning tim	e for inser	rting a	a string of le	ngth	?		[2 marks]
. (	) 0(	1)			0	$O(\log n)$			0	$O(\log$	n +	L)
	0(	L)				$O(L\log r)$	ı)		0	O(nL)		
Quest	ion 3	BE	Rotatio	ons on i	nsertion.					* * 2 *		[2 marks
	0(	(1)		C	) O(n)	Trabic pl	0	$O(n^2)$				
	) 0(	log	n)	C	$O(n \log n)$	g n)				114		
Quest	tion 3	3F	Buildir	ng an A	VL tree.					= 1		[3 marks
(	) 0(	(1)		(	O(n)		C	$O(n\log^2 n)$	.)	0	0	$O(n^3)$
	) 0(	log	(n)		$O(n \log n)$	gn)	C	$O(n^2)$				
Ques	tion 4	4A	Good	loop in	variant?			×			.00	[3 marks
(	) Fo	or al	l k such	that k <	< i: A[k]	$\leq A[k+1]$				ji.		
(	Fo	or al	l k such	that $k \leftarrow$	< i: A[k]	$\geq A[k+1]$						
(	Tr C	ne si	ubarray	A[0i]	contains	the $i+1$ s	malle	st elements	n the	e array.		
(	TT C	ne s	ubarray	A[0i-	- 1] conta	ins the i s	malle	st elements	in the	e array.		
(	TT C	ne s	ubarray	A[0i]	contains	the $i+1$ la	argest	elements in	the	array.		
(	TT C	ne s	ubarray	A[0i -	- 1] conta	ins the i la	argest	elements in	the	array.		
(			of the a									

, , , , , , , , , , , , , , , , , , , ,	Not st	O Stable
[3 mark	or an AVL tree.	Question 4C Invariants
O II, III, and IV.	O I and IV.	Only I.
I, II, III, and IV.	○ II and III.	Only II.
O None of the above	○ II and IV.	Only III.
is accurate.	O III and IV.	Only IV.
	I, II, and III.	I and II.
	○ I, II, and IV.	I and III.
[3 mark	or an (a,b)-tree.	Question 4D Invariants
	○ I and IV.	Only I.
○ II, III, and IV.	O Tand IV.	
○ II, III, and IV. ○ I, II, III, and IV.	II and III.	Only II.
_		Only II. Only III.
O I, II, III, and IV.	O II and III.	
<ul><li>I, II, III, and IV.</li><li>None of the above</li></ul>	<ul><li>○ II and III.</li><li>○ II and IV.</li></ul>	Only III.
<ul><li>I, II, III, and IV.</li><li>None of the above</li></ul>	<ul><li>○ II and III.</li><li>○ II and IV.</li><li>○ III and IV.</li></ul>	Only III. Only IV.

Ques	tion 4F	Special search?			[4 marks]
	The a  A.length -  otherwise	Algorithm works correctly: when $-1$ , a search for a key $k$ will $-1$ .	en invoked or return the in	on array A dex of k it	with $low = 0$ and $high = 6$ f $k$ is in $A$ and return $-1$
	and <i>high</i> : in A.	algorithm sometimes fails to fi $= A.length - 1$ , a search for a	key k will s	ometimes	return $-1$ even when $k$ is
	$ \bigcirc \text{ The a } low = 0 \text{ a } where A[] $	algorithm sometimes returns that $a_i$ and $b_i$ are $b_i$ and $b_i$ and $b_i$ are $b_i$ are $b_i$ are $b_i$ are $b_i$ are $b_i$ and $b_i$ are $b_i$ are $b_i$ are $b_i$ and $b_i$ are $b_i$ are $b_i$ and $b_i$ are $b_i$ are $b_i$ and $b_i$ are $b_i$ and $b_i$ are $b_i$ and $b_i$ are $b_i$ are $b_i$ and $b_i$ are $b_i$ are $b_i$ are $b_i$ are $b_i$ are $b_i$ and $b_i$ are $b_i$ are $b_i$ are $b_i$ are $b_i$ and $b_i$ are $b_i$ are $b_i$ are $b_i$ are $b_i$ are $b_i$ and $b_i$ are $b_i$ are $b_i$ are $b_i$ and $b_i$ are $b_i$ are $b_i$ are $b_i$ and $b_i$ are $b_i$ are $b_i$ are $b_i$ and $b_i$ are $b_i$ are $b_i$ and $b$	the wrong in srch for a key	dex: when k will sor	invoked on array $A$ with metimes return an index $j$
	high = A.	algorithm does not terminate $length-1$ , a search for a key	k will some	times neve	er return.
	O None	e of the above options is a goo	d description	n of the sit	uation.
Que	stion 5A	Highest out-of-balance nod	le?	-0	[4 marks]
	O F	○ P	0	U	O None of
	ОН	O Q	0	W	these listed.
	O L	<b>○</b> R	0	X	
	$\bigcirc$ M	O S		Y	
	O N	ОТ	O	Z	- sylve through
Que	stion 5B	How to balance?			[4 marks
	) right	r-rotate(R)	0	left-rotate	e(K), right-rotate(N)
	O left-	rotate(H)	0	right-rota	ite(N), left-rotate(K)
	O right	t-rotate(N)	0	right-rota	ate(K), left-rotate(H)
-	O left-	rotate(T)	$\circ$	left-rotate	e(T), right-rotate(R)
	right	t-rotate(R), left-rotate(H)	0	No rotati	ons occur.
	O left-	rotate(H), right-rotate(R)	0	None of	the above.
Que	stion 50	C How many split?			[2 marks
	O 0	3			O 6
	O 1	<b>O</b> 4			



-	,	-
	/	1
_	•	-

#### Question 5D What keys are in the root node?

[2 marks]

0	(17,	50,	91
$\cup$	(17,	50,	91



- (17, 50, 78, 91)
- $\bigcirc$  (50, 78, 82)
- $\bigcirc$  (86)

- (90)
- $\bigcirc$  (17, 50, 90, 91)
- $\bigcirc$  (50, 78)
- None of the above.

 $\bigcirc$  6

#### 2/2

## Question 5E What is the height of the tree?

[2 marks]

- 0
- $\bigcirc$  1
- $\frac{1}{2}$

- 3
  - $\bigcirc$  4
- 0 5



#### Question 6A Worst-case tree height:

[3 marks]

- $\bigcirc$  O(1)
- $\bigcirc O(\log^2 n)$
- O(n)
- $O(n^2)$

- $\bigcirc O(\log n)$
- $\bigcirc O(\sqrt{n})$
- $O(n\log n)$

0/3

## Question 6B Which statements are true?

[3 marks]

- O I only.
- O II only. Y
- O III only.
- O I and II.
- I and III.

- O II and III.
- I and II and III.
- O None of the three statements are true.

3/3

# Question 6C Upper bound on (3/4)-weight-balanced tree?

[3 marks]

- $\bigcirc \log_2(n) + 1$
- $\bigcirc 2\log_2(n) + 1$
- $\log_{4/3}(n) + 1$
- $\log_{3/4}(n) + 1$
- $\bigcap \log_{3/2}(n) + 1$
- $\bigcirc$  (4/3) log<sub>2</sub>(n) + 1

- $\bigcirc$  (4/3)  $\log_{4/3}(n) + 1$
- $\bigcirc$  (4/3)log<sub>3/4</sub>(n) + 1
- $\bigcirc$  (3/4)  $\log_{3/4}(n) + 1$
- O None of the above is a reasonable upper bound on the height.

3/3

2/2

3/3

Question 6D Random ter	mperatures?		A CONTRACTOR	[3 marks]
O 0	1/2		$\bigcirc$ 1	with co
0 1/4	2/3			
O 1/3	○ 3/4		O None	of the above.
Question 6E Does it wor	rk?		1 m. 1 m. 4 m 199.	[2 marks]
O Yes, after the rota property both hold.	ation, the temperature	orderin	g property and bina	ry search tree
No, after the rotati				
O No, after the rotat	ion, there may be bina	ry-searc	h-tree property viola	tions.
Question 7A What is the	e best use of the specia	al variab	le?	[3 marks]
O The maximum rig	ht endpoint of any inte	erval sto	red in $I[k]$ where $k \le$	$\leq j$ .
O The maximum rig	tht endpoint of any into	erval sto	red in $I[k]$ where $k \ge$	$\geq j$ .
O The minimum left	t endpoint of any inter	val store	ed in $I[k]$ where $k \leq 1$	j.
	t endpoint of any inter			
O None of these are	useful.			
Question 7B Which pro	perties are true of the	Intervall	Ray?	[3 marks
Only I.			II and III.	
Only II.			II and IV.	
Only III.		0	I, II and III.	
Only IV.		0	II, III and IV.	
O I and II.		$\bigcirc$	None of the above i	indicates prop-
I and III.		1000000	s that are always tru	8 100
Question 7C Which do	you think will work?			[3 marks
O Binary search I, o	comparing $I[j].left$ to	х.		
○ Binary search <i>I</i> , o	comparing $I[j]$ .right to	) x.		
$\bigcirc$ Binary search $I$ , $\alpha$	comparing $I[j]$ .special	to $x$ .		
$\bigcirc$ Binary search $I$ , $\alpha$	comparing $I[j]$ .count to	o x.		
O None of these str	ategies work properly.			

2/2

Ouestion 7D What is your evaluation of this approach? [2 marks]

The approach works, and is a reasonable alternative, assuming that the binary search does not work.

The approach works, but even assuming binary search does not work, there are better solutions.

The approach does not work.

**Question 8** 

[0 marks]

The Dark Room

Take 26 cords and put 13 each into each bux.
Highest expected publishing of winning.