The University of Nottingham Ningbo China

Centre for English Language Education

Semester One 2021-2022

MID-SEMESTER EXAMINATION

INTRODUCTION TO ALGORITHMS

Time allowed 60 Minutes

Candidates may complete the information required on the front page of this booklet but must NOT write anything else until the start of the examination period is announced.

This paper comprises THIRTY questions. Answer all questions.

Checkmark (✓) your answers in this booklet.

All questions carry equal marks.

No calculators are permitted in this exam.

Dictionaries are not allowed with one exception.Those whose first language is not English may use a standard translation dictionary to translate between that language and English provided that neither language is the subject of this examination. Subject specific translation dictionaries are not permitted.

No electronic devices capable of storing and retrieving text, including electronic dictionaries, may be used.

Do not turn examination paper over until instructed to do so.

ADDITIONAL MATERIAL: None.

INFORMATION FOR INVIGILATORS:

1. *Please advise students at the start of the exam that they can do rough work on the last page.*
2. *Please give a 15 minutes warning.*
3. *Please collect this booklet at the end of the exam.*

Student ID: _____

Seminar Group (*e.g.* **A35):** _____ **Marks (out of 30):** _____

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NOTE: Answer each question by choosing the most appropriate option.

1. Which of the following options gives a complete description for an algorithm?

   ☐ an algorithm is a sequence of commands

   ☐ an algorithm is a finite sequence of commands

   ☑ an algorithm is a finite sequence of instructions for achieving a task

   ☐ an algorithm is only used for programming in computers and robots

2. The language in which algorithms are often written is known as:

   ☐ lingo ☐ machine code ☑ pseudocode ☐ program

3. Suppose you have a computer that can only perform subtraction; i.e. `a-b`. How would you then implement `x%y,(x>y)`?

   ☐ keep subtracting `y` from `x` until you get to `0`

   ☐ keep subtracting `x` from `y` until you get to `0` or `1`

   ☑ keep subtracting `y` from `x` until you get to a value less than `x`

   ☐ keep subtracting `y` from `x` until you get to a value less than `y`

4. What is the result of `x%y` when `x<y`?

   ☑ `x` ☐ `y` ☐ `0` ☐ `y-x`

5. What is the result of `(3%5) + (5/3) + (5%3) + (3/5)`?

   ☐ `6.60` ☐ `6.66` ☑ `6` ☐ `4`

6. What can be said about the value of the following compounded statement:

   ```
   (!A && !B) || (A || !A)
   ```

   ☐ it is True only when both `A` and `B` are False

   ☐ it is True only when both `A` and `B` are True

   ☑ this statement is always True

   ☐ this statement is always False

7. Which of the following statements about binary search on lists is NOT correct?

☐ binary search is faster than linear search
☐ binary search can only be applied to sorted lists
☐ binary search has order *O(lg(n))*
☑ binary search has order *O(n/2)*

8. Consider the following function `f(x,y)`, where `x` and `y` are both integers greater than zero.

```
Algorithm: f(x,y)
1.  if (x/y) == 0 then
2.    return x*y
3.  else
4.    return x+y
5.  endif
```

What are the return values of `f(3,5)`, `f(5,3)` and `f(5,5)` respectively?

☑ 15, 8, 10
☐ 15, 15, 25
☐ 8, 8, 25
☐ 8, 8, 10

9. Consider the following algorithm:

```
**************************
1.  Let num=0
2.  if (q>r) then
3.    if (p>q) then
4.        num=p
5.    else
6.        num=q
7.    endif
8.  endif
9.  return num
```

What value will the algorithm return when `q=6, r=2, p=10`?

☐ 0
☐ 6
☑ 10
☐ 2

10. Reconsider the algorithm in Question 9. Which of the following compounded statements will correctly replace the nested if-block?

☑ `if (p>q) && (q>r) then`
☐ `if (p>q) && (q>r) && (num==0) then`
☐ `if (p>q) || (q>r) then`
☐ `if (p>q) || (q>r) || (num==0) then`

11. In general, what can be said about the algorithm in Question 9?

- ☐ it always returns 0
- ☐ it always returns the maximum of `(p, q, r)`
- ☑ it sometimes returns the maximum of `(p, q, r)`
- ☐ it always returns the minimum of `(p, q, r)`

12. Consider the following algorithm:

```
*************************
1.  Let x=10
2.  Let y=20
3.  if (x=10) || (y=20) then
4.     return x+y
5.  endif
```

In which line(s) do you spot a logical error?

☐ lines 1, 2 ☑ line 3 ☐ line 4 ☐ no error

13. In a recursive algorithm when do we encounter an infinite recursion?

- ☐ when there is no base case
- ☐ when the recursive formula does not approach the base case
- ☑ all of the above
- ☐ never

14. Consider the following two functions `S(n)` and `C(n)`:

Algorithm: `S(n)`

```
1. if (n>1) then
2.    return n*n
3. else
4.    return 1-(n*n)
```

Algorithm: `C(n)`

```
1. if (n<0) then
2.    return n
3. else
4.    return n-1
```

What is the value of: `C(S(1)) + S(C(0)) + S(S(0)) + C(C(1))`?

☐ 0 ☐ 1 ☐ 2 ☑ -2

15. Which of the algorithms in Question 14 is recursive?

☑ neither ☐ both ☐ only `S(n)` ☐ only `C(n)`

16. Consider the following recursive algorithm:

Algorithm: `f(x)`
`1. if (x>100) then`
`2.  return x-5`
`3. else`
`4.  return f(x+5)`
`5. endif`

Why is this algorithm recursive?

☐ because it has a base case

☐ because it returns two different values

☑ because the function `f(x)` calls itself

☐ all of the above

17. What is the value of `f(0)` in Question 16?

☑ 100 ☐ 105 ☐ 95 ☐ 500

18. To compute `f(0)` in Question 16 how many recursive calls are made?

☐ 19 ☐ 20 ☑ 21 ☐ 22

19. Consider the following algorithm:

Algorithm: `func(n)` Requires: a positive integer n ≥ 0
`1. if (n<10) then`
`2.  return 1`
`3. else`
`4.  return 1+func(n/10)`
`5. endif`

What type of variable does this algorithm return? Choose the most specific option.

☐ an integer ☐ a positive integer ☑ an integer≥ 1 ☐ an integer> 1

20. In Question 19, what is the output for calling `func(444)`?

☑ 3 ☐ 4 ☐ 44 ☐ 40

21. What is the actual action of the function `func(n)` in Question 19?

☐ divides the input number `n` by 10

☑ counts the number of digits of the input number `n`

☐ deletes the last digit of the input number `n`

☐ finds the largest digit in the input number `n`

22. Consider the following recursive algorithm:

Algorithm: g(n) Requires: a positive integer n $\geq$ 0
1. if (n==0) then 2. return 1 3. elseif (n==1) then 4. return 0 5. else 6. return g(n-2) 7. endif

Which of the following statements about the above algorithm is NOT true?

☐ the algorithm has two base cases

☐ the algorithm returns 1 if `n` is even

☑ the recursive formula does not approach the base case

☐ all of the above

23. A list of colours is given as per below:

`colours=[red,blue,green,purple,gray,violet,yellow,orange,pink]`

Which of the following commands will return `gray`?

☐ `tail(tail(tail(tail(colours))))`

☑ `head(tail(tail(tail(tail(colours)))))`

☐ `tail(tail(tail(tail(tail(head(colours))))))`

☐ `(head(head(head(head(head(colours)))))`

24. Reconsider the list given in Question 23. What is the output of `head(tail(head(colours)))`?

☐ `green` ☐ `red` ☐ `blue` ☑ error

25. Consider the following algorithm:

Algorithm: `show(x)`
Requires: a positive integer x $\geq$ 0
1. `if (x>10) then`
2. `  return nil`
3. `else`
4. `  return cons(x,show(x+1))`
5. `endif`
.....

what is the output of calling `show(5)`?

☐ `[9,8,7,6,5]` ☐ `[5,6,7,8,9]` ☐ `[10,9,8,7,6]` ☑ `[5,6,7,8,9,10]`

26. Which of the following statements about the algorithm `show(x)` in Question 25 is TRUE?

☐ for any input value x$\geq$10, the algorithm will return `nil`

☐ the recursive formula goes to infinity if x$\geq$10

☑ for input value x=0 the recursion stops when x reaches 11

☐ none of the above

27. Which of the following statements is TRUE?

☐ the command `head(list)` returns a new list

☐ the command `tail(nil)` returns an empty list `nil`

☐ the command `head(nil)` always returns zero

☑ the command `cons(x,nil)` makes a list with single element.

28. Suppose that you want to write a recursive algorithm called `join(L1,L2)`, which takes two lists and attaches `L1` onto the front of `L2`. For example: `join([1,2],[5,0,4])=[1,2,5,0,4]`. Which one of the following cases serves as the most appropriate base case?

☐ `join([ ],[ ])=[ ]` ☑ `join([ ],[1,2])=[1,2]`

☐ `join([1,2],[ ])=[1,2]` ☐ `join([3],[1])=[3,1]`

29. Consider the following algorithm, which takes two nonempty lists as its input.

```
Algorithm:  dow(L1,L2)
Requires: two nonempty lists, L1 and L2
1.  if isEmpty(L1) && isEmpty(L2) then
2.    return True
3.  elseif isEmpty(L1) || isEmpty(L2) then
4.    return False
5.  else
6.    return dow(tail(L1),tail(L2))
4.  endif
.............................
```

What is the output of calling `dow([1,2],[1,2,3]`?

☐ [3] ☐ [1,2] ☐ True ☑ False

30. What is the task performed by the algorithm `dow(L1,L2)` in Question 29?

☐ it compares L1 and L2 and returns the shortest list

☐ it compares L1 and L2 and returns the extra element in one of the lists

☑ it compares L1 and L2 and returns True if both lists are of the same length

☐ it compares L1 and L2 and returns False if one of the lists is empty

This page is for rough work.