1. Exercises

The following scoring policy is suggested. For each exercise, select all correct answers. A selection including all and only correct answers receives full score. A selection including one or more wrong answers receives 0 score, but no penalty.

2. A binary digit (one bit) can be used to represent the following entity:

   (a) The traffic light colors of Red, Yellow, Green.
   (b) The answer to a Yes/No question.
   (c) The state of an On/Off switch.
   (d) The current time displayed on a digital clock.

   Answer: BC

4. Three types of code are shown in Example 1.1: high-level language program, binary program, and command (or shell command). How is each of the three types of code processed by the computer system? Put the correct capital letter in the parentheses of each line below.

   (a) The high-level language program “fib-10.go” is (). X: executed
   (b) The binary program “fib-10.go” is (). Y: interpreted
   (c) The command “go build fib-10.go” is (). Z: compiled

   Answer: (a) Z, (b) X, (c) Y

6. Refer to Example 1.1. Suppose "fibonacci(10)" is changed to "fibonacci(50)" in program fib-10.go. The screen output in Fig. 1.3c should become:

   (a) F(10)= 55
   (b) F(10)= 12586269025
   (c) F(50)= 55
   (d) F(50)= 12586269025

   Answer: B

8. Refer to Example 1.1. Suppose "10" is changed to "50" in program fib-10.go. The screen output in Fig. 1.3c should become:

   (a) F(10)= 55
   (b) F(10)= 12586269025
   (c) F(50)= 55
   (d) F(50)= 12586269025

   Answer: D

10. Refer to Example 1.1. The command “go build fib-10.go” looks like a high-level language statement and seems to directly execute on a computer. Why does this not contradict to the assertion that "computer only understands machine code"?

    (a) A command is not a program, therefore can directly execute on a computer.
    (b) A command is a high-level language program and is interpreted into machine code by a command interpreter called shell. The command seems to execute directly, because the interpretation is done automatically and behind the scene.
    (c) The command is a short statement, and the computer can understand single and short high-level language statements.

    Answer: B

12. Regarding overflow, which of the following statements is correct?

    (a) An overflow error occurs when the result value is too large for the bits available. For instance, the value 9 is too large for a 4-bit integer (overflow), but not too large for a 4-bit unsigned integer (no overflow).
    (b) An overflow error occurs when the absolute value of the result is too large for the bits available. For instance, the absolute value of -9 is $9=1001_2$, which can be held in 4 bits. Thus, -9 does not cause overflow for a 4-bit integer representation.
    (c) Rounding errors (roundoff errors) are a type of overflow errors.
    (d) Overflow errors are a type of roundoff errors.

    Answer: A

14. Two computers compute 2.0/7.0 and obtain two different results. Why?

    (a) An overflow error occurs.
    (b) A compilation error occurs.
    (c) A roundoff error occurs.
    (d) One computer is a human and he made a mistake in computing 2.0/7.0.

    Answer: CD

16. Bit-accuracy in a computational process means:

    (a) Every operation of the computational process generates a result that is accurate and precise up to every bit.
    (b) The computational process generates a correct integer result.
    (c) The computational process generates a final result value that is precise up one binary digit after the decimal point.
    (d) The computational process generates a final result with statistical significance, i.e., the p-value less is than 0.05.

Answer: A

18. The Information Technology (IT) industry provides:

(a) Computer hardware products, such as laptop computers and servers
(b) Network hardware products, such as WIFI routers and network cards
(c) Computer software products, such as operating systems and Web browsers
(d) Internet services, such as search engine and video sharing

Answer: ABCD

20. The worldwide ICT spending in 2019 was about:

(a) 40 billion US dollars
(b) 400 billion US dollars
(c) 4000 billion US dollars, or 4 trillion US dollars
(d) 40 trillion US dollars

Answer: C

22. About how much percentage of the worldwide population are computing professionals (also known as IT professionals)?

(a) 0.01%
(b) 0.1%
(c) 1%
(d) 10%

Answer: B

24. The following explains why computer science has wide impact.

(a) Computer science is useful for many fields, because there are infinite many computer programs. This is known as the Chomsky digital infinity principle.
(b) Computer science is useful for many fields, because many processes in those fields can be viewed as computational processes, i.e., processes of information transformation. This is known as Karp's computational lens thesis.
(c) Wires in microchips of computers should be made of gold, to resist corrosion and provide reliability. This is known as Babayan's gold metaphor.
(d) ICT produces indirect economic value much larger than its direct value. This is analogous to bees producing honey and doing pollination. The indirect value (pollination) is much larger than the direct value (honey). This is known as Boutang's bees metaphor.

Answer: BD

26. The following statements are about wonder of exponentiation.

(a) Computer speed has increased exponentially with time since 1945.

(b) Computer speed has increased exponentially with time since 1800.
(c) Computer speed will increase exponentially with time till 2045.
(d) Computer speed will increase exponentially with time till 2800.

Answer: A

28. The following statements are about wonder of cyberspace.

(a) All things and processes in the cyberspace also appear in the physical world, because Nature computes and Society computes.
(b) All things and processes in the cyberspace also appear in the physical world, because computers can only simulate physical processes governed by scientific laws.
(c) Things and processes in the cyberspace can be absent in the physical world, because a tenet of computer science is to creates artificial constructs, notably those unlimited by physical laws.
(d) The cyberspace can help create *virtual* things different from traditional physical things. An example is the Event Horizon Telescope, which is an Earth-diameter *virtual telescope* that was used to successfully take photographs of a blackhole.

Answer: CD

30. The following statements are about Bush's Problem.

(a) When a user is browsing the Web using a home PC, the user-computer is working in the batch mode for scientific computing applications.
(b) When a user is browsing the Web using a home PC, the user-computer is working in the interactive mode for consumer computing applications.
(c) C2C stands for Computer-to-Computer applications.
(d) C2C stands for Consumer-to-Consumer applications.

Answer: BD

32. What does it mean that "computer science is a symphony"?

(a) It means that multiple computers on the Internet can work together in real time to play Beethoven's Ninth Symphony.
(b) It means that multiple laptop computers in the same classroom can work together in real time to play Beethoven's Ninth Symphony.
(c) It means that computer science is the synergy of logic thinking, algorithmic thinking and systems thinking.
(d) Designing a computer application system only involves systems thinking, to make the application system practical. It does not need to involve logic thinking or algorithmic thinking, which are too theoretical.

Answer: C

2. Exercises

2. The binary representation of the two's complement of integer -12 is:

   (a) 00001100
   (b) 10001100
   (c) 01110100
   (d) 11110100

   Answer: D

4. Consider the design of a digital display for a thermometer. We need to convert analog temperature signals between -50°C to 50°C into digital display symbols. In other words, we need to be able to display all temperature readings: -50, -49, …, -01, 00, 01, …, 49, 50. How many bits are needed with each of the following three number representations? Put the correct capital letter in the parentheses of each line below.

   (a) The unsigned integer format needs ()
   (b) The simple signed integer format needs ()
   (c) The two's complement format needs ()

   X: 6 bits
   Y: Cannot be done
   Z: 7 bits

   Answer: (a) Y, (b) Z, (c) Z

6. Consider the three number representations for eight-bit numbers. To show overflow conditions, put the correct capital letter in the parentheses of each line below.

   (a) For unsigned integers, the result is larger than ()
   (b) For simple signed integers, the result is smaller than ()
   (c) For simple signed integers, the result is larger than ()
   (d) For two's complement integers, the result is smaller than ()
   (e) For two's complement integers, the result is larger than ()

   V: -128
   W: -127
   X: 127
   Y: 128
   Z: 255

   Answer: (a) Z, (b) W, (c) X, (d) V, (e) X

8. Refer to the algorithm for 8-bit integer adder in Section 2.1. Design an algorithm for a two's complement subtractor computing C=A-B, where A, B, C are 8-bit integers in two's complement representation. Verify the correctness of the subtractor by putting the correct capital letter in the parentheses of each line below.

   (a) When A=63 and B=64, the result of 63-64 is ()
   (b) When A=-63 and B=64, the result of (-63)-64 is ()
   (c) When A=64 and B=63, the result of 64-63 is ()
   (d) When A=64 and B=-63, the result of 63-(-64) is ()
   (e) When A=-64 and B=-63, the result of (-64)-(-63) is ()

   V: 00000000
   W: 00000001
   X: 01111111
   Y: 10000001
   Z: 11111111

   Answer: (a) Z, (b) Y, (c) W, (d) X, (e) Z

10. To display the question mark symbol, the correct statements are:

(a) fmt.Printf(“%c”, ‘?’)
(b) fmt.Printf(“%b”, 63)
(c) fmt.Printf(“%c”, 63)
(d) fmt.Printf(“%d”, 63)
(e) fmt.Printf(“%c”, ?)
(f) fmt.Printf(“%c”, ‘63’)

Answer: AC

12. Regarding integer division and the mod operation, which of the following statements are/is correct?

(a) 18 / 10 = 1.8
(b) 18 / 10 = 1
(c) 18 % 10 = 8
(d) 18 mod 10 = 1

Answer: BC

14. The following program does the same thing as Exercise 13. However, it follows good programming practice and is easier for human to understand.

```
package main
import "fmt"
const studentName        = "Alan Turing"
const  targetString      = "Computer Science"
func main() {
        sum := 0
        for i := 0; i < len(studentName); i++ {
                for j := 0; j < len(targetString); j++ {
                        if studentName[i]==targetString[j] {
                                sum = sum + 1
                        }
                }
        }
        fmt.Printf("%d\n", sum)
}
```

How has the new code improved over the code in Exercise 13?

(a) The two const statements use descriptive names studentName and targetString, instead of using non-descriptive name and cs.
(b) The two const statements use constant declaration, instead of variable declaration. Constant declaration is more appropriate since the two entities studentName and targetString do not change their values in the code.

(c) In the outer for loop, the expression i < len(studentName) gets rid of the magic number 11 in the expression i < 11 of the old code.
(d) Code of the main function does not depend on the specific values of studentName and targetString. We can compare a new student name, e.g., by changing "Alan Turing" to "Gordon Moore". The old code will fail.
(e) The new code has no improvement, because the code is longer.

Answer: ABCD

16. The von Neumann model of computer has the following features:

(a) A computer consists of interconnected processor, memory and I/O devices.
(b) Symbols are represented as binary digits (bits).
(c) Data and programs are stored in memory.
(d) A program is serially executed by executing one instruction after another.

Answer: ABCD

18. Which of the following statements are/is correct regarding the *state* of a von Neumann computer?

(a) The state of a computer refers to the contents of the registers.
(b) The state of a computer refers to the contents of the memory.
(c) The state of a computer refers to the contents of the I/O devices.
(d) The state of a computer refers to the contents of the registers, the memory, and the I/O devices. However, Chapter 2 focuses on the contents of the registers and the memory.

Answer: D

20. Consider the loop body fib[i] = fib[i-1] + fib[i-2] in Fig. 2.8. Suppose the address of fib[i] is R0+R2*8. Which of the following statements are/is correct?

(a) The address of fib[i-1] is R0+R2*8-8.
(b) The address of fib[i-2] is R0+R2*8-8.
(c) The address of fib[i-1] is R0+R2*8-16.
(d) The address of fib[i-2] is R0+R2*8-16.

Answer: AD

22. Refer to Table 2.5 and associated explanation text. Assume part of the initial computer state is shown in the following table.

CPU Contents					Memory Contents			
FLAGS	PC	R0	R1	R2	M[12]	M[20]	M[28]	M[[36]
<	0	12	6	3	2	1	2	3

How will the computer state change after executing each of the following instructions? Put the correct capital letter in the parentheses of each line below.

(a) MOV 0, R1 makes ()
(b) MOV R1, M[R0+R2*8+8] makes ()
(c) ADD M[R0+R2*8-16], R1 makes ()
(d) INC R2 makes ()
(e) CMP 51, R2 makes ()
(f) JL 5 makes ()

U: PC=0
V: PC=1
W: PC=2
X: PC=3
Y: PC=4
Z: PC=5

Answer: (a) V, (b) V, (c) V, (d) V, (e) V, (f) Z

24. Fill out the following form of von Neumann model with data from your personal computer. Some example parameters of the lecturer's computer are shown in Table 2.4.

Processor		
Memory		
I/O devices	Storage	
	Keyboard	
	Display	
	Mouse	
	Network	

Hints: This exercise helps students to understand the differences among processor, memory and I/O device. Exact parameters of each component are not important.

3. Exercises

2. What is NOT a possible truth value of proposition formula $(P \vee \neg Q) \rightarrow P$?

   (a) 0
   (b) 1
   (c) Either 0 or 1
   (d) Both 0 and 1

   Answer: D

4. Let the proposition formula G be $(\neg Q \vee R) \leftrightarrow (\neg P \wedge R)$. How many assignments of the truth value to P, Q, R are there to make G **false**? Here, $A \leftrightarrow B$ is defined as $(A \rightarrow B) \wedge (B \rightarrow A)$.

   (a) 2
   (b) 3
   (c) 4
   (d) 5

   Answer: C

6. Write down the disjunctive normal form of the two proposition formulae $P \vee Q$ and $P \wedge Q$.

   Answer: $(P \wedge Q) \vee (P \wedge \neg Q) \vee (\neg P \wedge Q), (P \wedge Q)$

8. The conjunctive normal form of proposition formula $\neg(P \rightarrow Q)$ is

   (a) $(P \vee Q) \wedge (P \vee \neg Q) \wedge (\neg P \vee \neg Q)$
   (b) $P \vee \neg Q$
   (c) $(P \vee Q) \wedge (\neg P \vee Q) \wedge (\neg P \vee \neg Q)$
   (d) $P \wedge \neg Q$

   Answer: A

10. Which of the following formula is not a tautology? Tautology refers to the proposition formula that is **true** in every possible assignment.

    (a) $(P \oplus P) \leftrightarrow (Q \wedge \neg Q)$
    (b) $(P \oplus \neg P) \leftrightarrow (Q \vee \neg Q)$
    (c) $((P \vee Q) \rightarrow P) \leftrightarrow (R \rightarrow R)$
    (d) $((P \wedge Q) \rightarrow P) \leftrightarrow (R \rightarrow R)$

    Answer: C

12. Which of the following equations about "exclusive or" is correct?

(a) $(x \oplus y) \wedge z = (x \wedge z) \oplus (y \wedge z)$
(b) $(x \oplus y) \vee z = (x \vee z) \oplus (y \vee z)$
(c) $\neg(x \oplus y) = (\neg x) \oplus (\neg y)$
(d) $(x \vee y) \oplus z = (x \oplus z) \vee (y \oplus z)$

Answer: A

14. Every playing card has two sides. One side is a number and the other side is a letter. Now there are four cards on the table, with A, 3, S, 8 facing up. **In the worst case**, how many cards do you need to turn over to confirm whether the following proposition is true for these four cards: the number on the vowel card (cards with letters AEIOU) must be even.

(a) 3
(b) 2
(c) 1
(d) 4

Answer: B

16. Is the following logic correct? That is, assuming that the premise is true, is the conclusion also true? Please explain your answer.

- Premise (1): Students who take the course of Introduction to Computer Science can master Golang.
- Premise (2): Some students who master Golang can serve as the teaching assistants in the course of Introduction to Computer Science next year.
- Conclusion: Some students who take the course of Introduction to Computer Science can serve as teaching assistants next year.

Answer: No. A student may master Golang from another course. Let us show a counter example.

Let {A, B, C} denote the set of all students; P(x), Q(x), R(x) denote the following statements:

P(x): x masters Golang.

Q(x): x takes the course of Introduction to Computer Science.

R(x): x can serve as a teaching assistant in the course of Introduction to Computer Science next year.

Suppose the following factual table is given, which lists the truth values for $P(x), Q(x)$ and $R(x)$.

x	$P(x)$	$Q(x)$	$R(x)$	
A	1	1	0	A masters Golang and takes CS, but does not become TA
B	1	0	1	B masters Golang and does not take CS; yet becomes TA
C	0	0	0	C does not master Golang, take CS, or become TA

Premise (1) is True, because all students (only A in the table) take the course of Introduction to Computer Science and master Golang.

Premise (2) is True, because there exists a student, B in the table, who masters Golang (from another course) and can serve as a teaching assistant in the course of Introduction to Computer Science next year.

But the Conclusion is False, because no students in the table who take the course of Introduction to Computer Science and can serve as a teaching assistant.

18. Let $P(x)$ denote the statement "x masters Golang", $Q(x)$ denote the statement "x takes the course of Introduction to Computer Science", and $R(x)$ denote the statement "x can serve as a teaching assistant in the course of Introduction to Computer Science next year". Let f be the statement "students who take the course of Introduction to Computer Science can master Golang" and g be the statement "some people who master Golang can serve as teaching assistants in the course of Introduction to Computer Science next year". Which is the correct symbolization of f and g?

(a) $f: \forall x\big(Q(x) \wedge P(x)\big); g: \exists x(P(x) \wedge R(x))$
(b) $f: \forall x\big(Q(x) \rightarrow P(x)\big); g: \exists x(P(x) \rightarrow R(x))$
(c) $f: \forall x\big(Q(x) \rightarrow P(x)\big); g: \exists x(P(x) \wedge R(x))$
(d) $f: \forall x\big(Q(x) \wedge P(x)\big); g: \exists x(P(x) \rightarrow R(x))$

Answer: C.

The key to correctly solve this problem is to appreciate a subtle difference between conjunction ($\wedge$) and implication ($\rightarrow$). $P \wedge Q$ is True only when P is True; while $P \rightarrow Q$ is True when P is False.

For universal quantifier, $\forall x\big(Q(x) \wedge P(x)\big)$ is True means all students master Golang and take CS. But, f is True means "students who take CS master Golang, and students who do not take CS may or may not master Golang".

For existential quantifier, $\exists x\big(P(x) \rightarrow R(x)\big)$ is True, when no students master Golang. But, g is True means "there exists a student who masters Golang and can serve as a teaching assistant". Thus, g is False when no students master Golang.

Let us use a detailed example to show why the symbolization of f is not $\forall x\big(Q(x) \wedge P(x)\big)$ and that of g is not $\exists x\big(P(x) \rightarrow R(x)\big)$.

Let {A, B, C} denote the set of all students. Suppose the following factual table is given, which lists the truth values for $P(x), Q(x)$ and $R(x)$.

x	$P(x)$	$Q(x)$	$R(x)$	$Q(x) \wedge P(x)$	$Q(x) \rightarrow P(x)$	$P(x) \wedge R(x)$	$P(x) \rightarrow R(x)$
A	0	0	1	0	1	0	1
B	0	0	1	0	1	0	1
C	0	0	1	0	1	0	1

Given the above table, we have the fact that f is True, because no students take CS. To prove this, let us use the method of proof by contradiction. Suppose f is False, which means "there exists a student who takes CS but does not master Golang", which is contrary to the fact that "no students take CS".

Given the above table, we have the fact that g is False, because no students take CS. That is, Q(x)=0 for x=A, x=B, x=C.

If the symbolization of f is $\forall x\big(Q(x) \wedge P(x)\big)$, f is False because there exists a student A such that $Q(A) \wedge P(A) = 0 \wedge 0 = 0$. This contradicts the fact that f is True. Hence, $\forall x\big(Q(x) \wedge P(x)\big)$ is not the correct symbolization of f.

If the symbolization of g is $\exists x\big(P(x) \rightarrow R(x)\big)$, g is True because there exists a student A such that $P(A) \rightarrow R(A) = (0 \rightarrow 1) = 1$. This contradicts the fact that g is False. Hence, $\exists x\big(P(x) \rightarrow R(x)\big)$ is not the correct symbolization of g.

20. Design a Turing machine to accept the language $L = \{0^n \mid n \geq 1\}$ where the input alphabet is $\Sigma = \{0, 1\}$ and B represents the blank symbol. That is, the Turing machine should accept 0 or 000, but reject 010 or 100.

Hints: refer to Example 3.16 and give the 7-tuple representation of the Turing machine.

22. (***) In the definition of Turing machine, if the transition function is specified as $Q \times \Gamma \rightarrow Q \times \Gamma \times \{\rightarrow\}$, which means that the Turing machine can only move its head to the right and cannot move its head to the left in each state, we call it a **right-moving Turing machine**. Which of the following propositions about right-moving Turing machine and Turing machine is correct?

(a) There is a computing task which can be decided by Turing machine, but not by right-moving Turing machine.
(b) There is a computing task which can be decided by the right-moving Turing machine, but not by Turing machine.
(c) Right-moving Turing machine and Turing machine have the equivalent computing power.
(d) None of the above three propositions has been proved at present.

Answer: A

24. Regarding the Church-Turing Hypothesis, which of the following is correct?

(a) The Hypothesis shows the generality feature of logic thinking. It says that Turing machine is a general-purpose model of computation.
(b) The Hypothesis says that Turing machine is not as general purpose as my laptop computer, because a Turing machine cannot create a PowerPoint presentation file.
(c) The Hypothesis says that Turing machine is general-purpose. Thus, one can use Turing machine to automatically prove the Goodstein theorem.
(d) The Hypothesis says that Turing machine and my laptop computer have equal power, in terms of computability.

Answer: A

4. Exercises

2. Refer to Example 4.1. Show that Euclid's algorithm is indeed an algorithm, because it satisfies Knuth's five properties.

   Answer:
   (1) *Finiteness:* Euclid's algorithm will always stop because y is strictly decreasing in each step.
   (2) *Definiteness:* Each step of Euclid's algorithm is precisely defined by while loop, assign statement, logical operators and arithmetic operators.
   (3) *Input:* Two positive integers *x* and *y*.
   (4) *Output:* A positive integer *z* such that $x \% z = 0$ and $y \% z = 0$.
   (5) *Effectiveness:* Each operation can be done by a human using paper and pencil as in exercise 4.1.

4. Which of the following statement is correct?

   (a) $0.1n^2$ is $O(n)$
   (b) $10000n$ is $O(n^2)$
   (c) $n \log n$ is $\Omega(n)$
   (d) $10n^2 - 10n + 1$ is $\Theta(n)$

   Answer: BC

6. Please sort the following asymptotic formulas from small to large: $\Theta(\log n)$, $\Theta(n)$, $\Theta\left(\frac{n}{\log n}\right)$, $\Theta(n \log n)$.

   Answer: $\Theta(\log n), \Theta\left(\frac{n}{\log n}\right), \Theta(n), \Theta(n \log n)$

8. The Sunway TaihuLight supercomputer was the world's fastest supercomputer from June 2016 to June 2018. It can finish 93 million billion operations per second. If we use this supercomputer to compute Steiner tree problem with 1000 vertices, how long do we need? The best algorithm for Steiner tree problem runs in $n^{\log_2 n}$ time where n is the number of vertices.

   Answer:

$$\frac{1000^{\log_2 1000}}{93 * 10^{6+9} * 60 * 60 * 24 * 365}\ years = 269192.71\ years$$

10. The insertion sort algorithm and the merge sort algorithm have a time complexity of $O(n^2)$ and $O(n \log n)$, respectively. What is the main reason that merge sorting is more efficient than insertion sorting?

Answer: Both algorithms use divide-and-conquer. Insertion sort divides a problem into a 1-subproblem and an (n-1)-subproblem. Merge sort divides a problem into two almost equal sized subproblems.

12. For the integer multiplication problem, what is the main reason that the naïve algorithm of divide and conquer is not efficient?

    Answer: The naïve algorithm of divide and conquer needs to perform two (n/2)-digit integer multiplications 4 times in total and n-digit integer additions 3 times. which makes T(n) = $O(n^2)$.

14. Consider the sorting problem of n numbers. In the worst case, how many comparisons do we need in the quicksort and the bubble sort algorithms?

    (a) $O(n \log n)$, $O(n^2)$
    (b) $O(n^2)$, $O(n^2)$
    (c) $O(n)$, $O(n \log n)$
    (d) $O(n \log n)$, $O(n \log n)$

    Answer: B

16. Solve the following recursion: $T(n) = (\ )$

$$\begin{cases} T(1) = 1 \\ T(n) = 2T(n-1) \end{cases}$$

    Answer: 2^{n-1}

18. Solve the following recursion: $T(n) = (\ )$

$$\begin{cases} T(1) = 1 \\ T(n) = 2T\left(\lfloor \frac{n}{\sqrt{2}} \rfloor\right) + n^2 \end{cases}$$

    Answer: $\Theta(n^2 log n))$

20. There are 16 bottles of liquid and one of them is poisonous. The poisonous one can make the mouse die immediately. Now we want to know which bottle is poisonous. Each time, we can mix the liquid from several bottles and let one mouse drink it. For each mouse, it can only drink once. In the worst case, how many mice do we need to find the poisonous bottle?

    Answer: 4

22. In the stable matching problem, is the stable matching unique? If it is not unique, please give an instance where there are at least two different stable matching.

    Answer: Not unique. In the following situation, there are at least two different configurations of stable matching.

M1: W1 W2 W1: M2 M1
M2: W2 W1 W2: M1 M2

One stable matching is M1 W1 and M2 W2.
Another stable matching is M1 W2 and M2 W1.

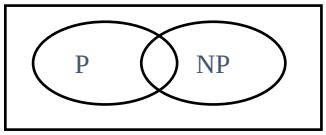
24. Does the following decision problem belong to NP?

- Problem: Given 2n integers, decide whether we can partition them into two sets (each set contains n integers) where the sum of two sets is equal.

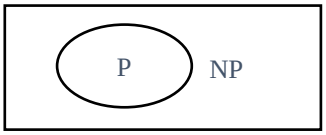
Answer: Yes.

26. What is the relation between P and NP? Assume the rectangle represents all decision problems which can be computed by Turing machine.

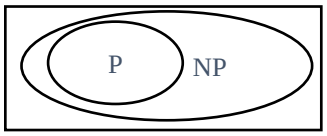
(a)



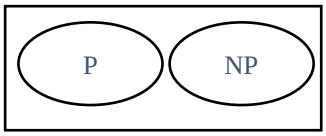
(b)



(c)



(d)



Answer: C.

5. Exercises

2. Consider the big endian vs. little endian representations of numbers. Which of the following statements are/is correct?

   (a) Big endian places the least significant byte in the smallest address.
   (b) Big endian places the most significant byte in the smallest address.
   (c) Big endian is better than little endian.
   (d) Neither the big endian nor the little endian representation is better than the other representation.

   Answer: BD

4. Which of the following list orders abstractions from high-level to low-level?

   (a) Computer, transistor, logic gate, memory
   (b) Computer, logic gate, memory, transistor
   (c) Computer, memory, logic gate, transistor
   (d) Transistor, memory, logic gate, computer

   Answer: C

6. The operating system of a computer uses one abstraction to manage all application software programs. What is it?

   (a) Instruction
   (b) Program
   (c) Code
   (d) Process

   Answer: D

8. In a positional number system, the two 6's in 0x06F6 denote different values, as they are in different positions. Which of the following statements are/is correct?

   (a) The leftmost 6 denotes 6_{10} and the rightmost 6 denotes 1536_{10}.
   (b) The leftmost 6 denotes 1536_{10} and the rightmost 6 denotes 6_{10}.
   (c) The leftmost 6 denotes 6×16^2 and the rightmost 6 denotes 6×16^0.
   (d) The leftmost 6 denotes six hundreds and the rightmost 6 denotes six ones.

   Answer: BC

10. In IEEE 754 floating-point single precision format, the string of 32 bits 01000000010010010000111111011011 represents the decimal value 3.1415927. Assume a string S = 11000000010000000000000000000000 of 32 bits are given. Which of the following statements are/is correct?

    (a) String S is a negative number.
    (b) String S is a positive number.

(c) String *S* has an exponent value of 10000000 = 128_{10}.
(d) String *S* has an exponent value of 1.
(e) String *S* has a significant value of 0.1 = 0.5_{10}.
(f) String *S* has a significant value of 1.1 = 1.5_{10}.

Answer: ADF

12. (***) Consider representing 0 as an IEEE 754 floating-point number in single precision format. Which of the following statements are/is correct?

(a) The representation is 00000000000000000000000000000000.
(b) The representation is 10000000000000000000000000000000.
(c) The representation is 00000000100000000000000000000000.
(d) The representation is 10000000100000000000000000000000.

Answer: A

14. Mathematically, 2×2=4 and 0.1×0.1=0.01. This is not always true in cyberspace. What does the following code output?

```
X := 2
Y := 0.1
fmt.Println(X*X == 4, Y*Y == 0.01)
```

(a) false false
(b) false true
(c) true false
(d) true true

Answer: C

16. Assume the following code is given.

```
X := 53
P := &X
fmt.Println(*P)
```

Which of the following statements are/is correct?
(a) X is an integer variable.
(b) Expression &X returns the address value of variable X.
(c) P is a pointer variable holding the address of variable X.
(d) Expression *P returns the value of variable X, i.e., 53.
Answer: ABCD

18. Write a Go program to invert the first bit of 00111111 to obtain 10111111.

Hints: modify the program of Example 5.8, which inverts the last bit of a byte. Students can also use the bitwise XOR operator to invert a bit.

20. Refer to the image file Autumn.bmp. Which of the following is NOT metadata?

    (a) The photographer's name Li Chundian
    (b) The access permission -rw-rw-rw-, i.e., 0666
    (c) The size of the file
    (d) The pixels of the image

    Answer: D

22. Refer to Example 5.12. The textbook says: the first character is t[0]='H', which is hidden in p[86:90]. Now let us consider the fourth character, which of the following statement is correct?

    (a) The fourth character is t[3]='L', which is hidden in p[89:93].
    (b) The fourth character is t[3]='L', which is hidden in p[90:94].
    (c) The fourth character is t[3]='L', which is hidden in p[98:102].
    (d) The fourth character is t[4]='E', which is hidden in p[98:102].

    Answer: C

24. Precedence, sequencing, selection, and loop are four control abstractions. Which of the following refers to loop?

    (a) Check a Boolean condition to determine which part of code to execute next.
    (b) Execute one statement after another in the syntactical order of the code.
    (c) Evaluate an expression in the order given by the precedence of operators or parentheses.
    (d) Repetitive execution of a body of code for a specific number of times.

    Answer: D

26. Refer to the recursive program fib-5.go to compute F(5). How many times is the function fibonacci called in executing fib-5.go?

    (a) 11
    (b) 12
    (c) 13
    (d) 14
    (e) 15

    Answer: E

28. Regarding combinational circuits discussed in Section 5.3.1, which of the following statements are/is correct?

    (a) A combinational circuit is a number of interconnected logic gates.
    (b) A combinational circuit is a number of logic gates interconnected by wires, with no feedback wires.

(c) A combinational circuit is driven by a clock signal.
(d) A flip flop is a combinational circuit, since it consists of a number of interconnected logic gates.

Answer: B

30. How many N-input-1-output combinational circuits are there? If two combinational circuits realize the same truth table, they are equivalent and counted as one circuit.

(a) N
(b) N^2
(c) 2^N
(d) 2^{2^N}

Answer: D

32. Refer to the fast adder in Fig. 5.24. Denote $G_0 = X_0 \cdot Y_0$, $G_1 = X_1 \cdot Y_1$, and $P_0 = X_0 \oplus Y_0$, $P_1 = X_1 \oplus Y_1$. Which of the following equations are correct?

(a) $C_2 = C_0 \cdot P_0 \cdot P_1 + P_1 \cdot G_0 + G_1$
(b) $C_2 = C_0 \cdot G_0 \cdot G_1 + G_1 \cdot P_0 + P_1$
(c) $C_2 = X_1 \cdot Y_1 + (X_1 \oplus Y_1) \cdot C_1$
(d) $C_2 = C_0 \cdot X_0 \cdot Y_0 + X_1 \cdot Y_1 + C_1$

Answer: AC

34. Regarding sequential circuits discussed in Section 5.3.2, which of the following statements are/is correct?

(a) Sequential circuits consist of combinational circuits and state circuits.
(b) A state circuit is realized by one or more memory cells or flip flops.
(c) A flip flop is a combinational circuit.
(d) A flip flop is an augmented combinational circuit with feedback wires.

Answer: ABD

36. Regarding memory circuits discussed in Section 5.3.2, which of the following statements are/is correct?

(a) DRAM needs constant refreshing, to compensate for electric leakage.
(b) A DRAM cell needs six transistors.
(c) A 1KB DRAM memory contains over 8000 capacitors.
(d) A 1KB SRAM memory contains over 8000 capacitors.
(e) SRAM does not need refreshing, meaning its content is not lost when the power is turned off.

Answer: AC

38. Refer to Example 5.16. Design a 4-bit serial subtractor and verify its correctness by executing 11 – 9 = 2 and 9 – 11 = -2.

Answer: This exercise asks students to extend knowledge learned to new situations. Therefore, teachers should provide only hints, but not a complete solution. Hints: refer to Examples 5.15 and 5.16.

40. Refer to Example 5.17. Design the instruction set architecture for an Accumulator Computer to execute the following computation, assuming X=[1, 2, 3,…, *N*].

```
sum := 0
for i := 0; i < N; i++ {
  sum = sum + X[i]
}
```

Hints: refer to Example 5.17 and simplify. N can be set to a small positive integer, such as N=64.

42. Regarding the software stack used in this book, which of the following statements are/is correct?

(a) The Web browser is a piece of firmware.
(b) The Web browser is a piece of middleware.
(c) The Linux operating system is a piece of system software.
(d) The Linux operating system is a piece of application software.

Answer: BC

44. Regarding the robustness principle in Section 5.4, which of the following statements are/is correct?

(a) Be conservative in what you do to others, be liberal in what you accept from others.
(b) Be conservative in what you accept from others, be liberal in what you do to others.
(c) Be tolerant of inputs, be strict on outputs.
(d) Be tolerant of outputs, be strict on inputs.

Answer: AC

46. After a jump instruction finishes, the destination instruction should be executed. What happens when the jump instruction finishes but before the next instruction starts?

(a) The address of the jump instruction is assigned to the program counter PC.
(b) The address of the destination instruction is assigned to the program counter PC.
(c) The address of the destination instruction is assigned to the instruction register IR.
(d) The difference of the addresses of the destination instruction and of the jump instruction is assigned to the instruction register IR.

Answer: B

48. (***) When the Fibonacci Computer is executing code and the following situation happens, what exception occurs? Put the correct capital letter in the parentheses of each line below.

(a) The code does not terminate ()
(b) ID stage sees opcode 111 ()
(c) The power is turned off ()
(d) The user clicks the mouse ()

W: Hardware Error
X: Interrupt
Y: Machine Check
Z: No exception

Answer: (a) Z, (b) X, (c) X, (d) X

6. Exercises

2. Which of the following statements is NOT true?

   (a) An accessing point (AP) is not a host, but a networking device, which converts wired and wireless signals to each other.
   (b) A network switch connects multiple devices running the same protocol, to form a homogeneous network.
   (c) A network switch can be used to connect a LAN running Ethernet and another LAN running WiFi, to form a heterogeneous network.
   (d) Several functions can be packed into a product. For instance, a WiFi device can combine the AP, switch, and router functions into the same the product, called a **WiFi router**.

   Answer: C

4. Determine uniqueness and user-friendliness of each of the following naming schemes of networks. Identify the four wrong answers in the following table.

Namespace	Example	Uniqueness	User-Friendliness
Personal name	Joan Smith	Not unique	Friendly
URL	www.ict.ac.cn/cs101	(a) No	(f) Somewhat friendly
Internet site	www.ict.ac.cn	(b) Yes	(g) Somewhat friendly
Email address	zxu@ict.ac.cn	(c) No	(h) Somewhat friendly
IP address	159.226.97.84	(d) Yes	(i) Somewhat friendly
Phone number	189-6666-8888	(e) No	(j) No
MAC address	00-1E-C9-43-24-42	Unique	Not user friendly

   Answer: ACEI

6. Which of the following is NOT a legitimate IP address when using IPv4?

   (a) 0.0.0.0
   (b) 127.0.0.1
   (c) 159.226.97.84
   (d) 159.279.97.84

   Answer: D

8. What is the role of the Domain Name Service (DNS)?

   (a) Converting an Internet domain name into an Internet Protocol address.
   (b) Converting an Internet Protocol address into an Internet domain name.
   (c) Converting an IP address into a domain name.
   (d) Converting a cellphone number into an Internet domain name.

   Answer: A

10. All scientific literature of the world forms a graph. Let us call this graph the *scientific literature graph* (SLG), where a paper (or a book) is a node (vertex), and a citation is an edge pointing from the citing work to the cited work. According to network thinking, is the SLG a network?

    (a) No. A computer network is used to pass messages. No message is communicated in the SLG. The citations are just marks.
    (b) Yes. The SLG depicts the connectivity of the network of scientific literature.
    (c) No. Network thinking must utilize both abstractions of connectivity and protocol stack.
    (d) No. The SLG is not network because scientific literature keeps growing.

    Answer: B

12. Albert Einstein published in 1905 a paper on special relativity, with the title *On the Electrodynamics of Moving Bodies* when translated into English. This paper contains no citation. Recall that in the SLG, a citation is an edge pointing from the citing work to the cited work. Which of the following statements is correct?

    (a) In the SLG, Einstein's paper is a node with no incoming edges.
    (b) In the SLG, Einstein's paper is a node with no outgoing edges.
    (c) In the SLG, Einstein's paper is an isolated node, with neither incoming nor outgoing edges.
    (d) Einstein was wrong not citing prior work.

    Answer: B

14. Let us define a search network as follows: the nodes are the search engine and all search engine users, and there exists an edge between each user and the search engine. Which of the following statements is NOT correct?

    (a) At any single moment, the search network is a star network.
    (b) At any single moment, the search network is a static network.
    (c) At any single moment, the search network is a dynamic network.
    (d) The search network is an evolving network.

    Answer: C

16. Which of the following statements is correct regarding packet switching?

    (a) It splits multiple users' multiple messages into packets, and statistically transmits the packets in turn.
    (b) It splits only one user's multiple messages into packets, and statistically transmits the packets in turn.
    (c) It packs one user's multiple messages into one packet and transmits it.
    (d) It packs multiple users' multiple messages into one packet and transmits it.

Answer: A

18. Refer to Example 6.2. Observe that for both circuit switching and packet switching, all three downloading tasks finish at the moment of 8.11 second. In other words, packet switching does not save time. Then, why bother with inventing packet switching? Select all reasonable explanations.

(a) With packet switching, the three communication tasks proceed simultaneously, without waiting for one another to finish.
(b) With circuit switching, user Wang feels as if his computer is frozen. He needs to wait for 7.31 seconds before seeing any bits transmitted.
(c) With circuit switching, user Zhang feels as if her computer is frozen. She needs to wait for 7.46 seconds before seeing any bits transmitted.
(d) In many applications using circuit switching, e.g., two people having a telephone conversation over a circuit, the channel capacity of the circuit is often not fully utilized. Packet switching can more efficiently utilize the channel capacity, by having multiple communication tasks sharing the same circuit.

Answer: ABCD

20. Which of the following statements is NOT correct?

(a) The Web over Internet protocol stack is a technical foundation of data communication for the World Wide Web.
(b) The HTTP peering interface is used between two peers: a Web browser and a Web server. This peering interface provides an abstraction, such that the two peers do not need to worry about the layers of protocols below.
(c) The service interface between HTTP and TCP is used for the TCP layer to support the HTTP layer.
(d) All packets of an HTTP message from a browser to a server travels along the same physical path.

Answer: D

22. Refer to Fig. 6.10. Suppose only routers (shown as brown boxes) may become faulty. What is the minimal number of faulty routers required to disable communication between host A to host B?

(a) 1
(b) 2
(c) 3
(d) 4

Answer: B

24. A student subscribes to an optical fiber plan from a reputable ISP, which connects his apartment to the Internet with a 1-Gbps bandwidth connection. How-

ever, he often only experiences a 5-Mbps bandwidth when accessing the Internet. Why is there this huge disparity? Which of the following is NOT a reasonable explanation?

(a) The 1-Gbps bandwidth optic connection is only a portion of the full path from the student's laptop to the accessed website. The rest of the path could be much slower.
(b) The student may be sharing a network switch with neighbors.
(c) Assume the rest of the Internet is fast enough and there is no sharing. The 1-Gbps bandwidth is the maximal bandwidth, i.e., r_∞ in Hockney's formula. User-experienced bandwidth can be much lower.
(d) The student has a fast laptop computer.

Answer: D

26. Which of the following statements is true about network effect?

(a) A laptop computer connected to the Internet has more value to the user than a standalone computer, because it benefits from network effect.
(b) The total value of a network is the linear sum of the values of its nodes.
(c) Reed's law is wrong because Facebook and Tencent data do not support it.
(d) Viral marketing is absolutely harmful, like biologic viruses hurting people.

Answer: A

28. Which of the following statements is true?

(a) Software bugs are a form of malware.
(b) Malware is a form of software bugs.
(c) Computer viruses are a form of malware.
(d) Spam is a form of software bugs.

Answer: C

30. I receive an email where the Subject part says a famous charity is asking for donation. Which of the following actions is proper?

(a) I should ignore the email since it is a phishing email.
(b) I should donate by clicking the URL in the email and fill out the form with my credit card information and donation amount.
(c) I should find out more details by clicking the attachment of the email.
(d) I should double check before the donation action.

Answer: D

32. (***) Which of the following statements is true about HTTPS?

(a) It uses public-key encryption.

(b) It uses symmetric-key encryption.
(c) It uses a combination of public-key and symmetric-key encryption.
(d) It uses no encryption.

Answer: C

34. (***) A student has found a bug in Example 6.6. The eavesdropper CAN decode the ciphertext by using a computer program to try all pairs of prime numbers smaller than $n = 2773$, to discover that the crucial hidden fact that $n = p \times q = 47 \times 59 = 2773$. Suggest a proper way to fix this "bug".

(a) Inform the class that this Example is from an authority, i.e., from RSA, the famous Turing Award winners.
(b) Inform the class that no such computer program exists, because prime factorization is a hard problem.
(c) Inform the class that Example 6.6 uses small numbers to illustrate the principle of the RSA method. Real applications use much larger *n*, much harder to break. For instance, breaking RSA-250 into two prime numbers needs 1000 years on a laptop computer. HTTPS uses larger numbers.

Answer: C

36. Which of the following is NOT an example of personally identifiable information (PII), when discussing privacy protection?

(a) The password of a student's personal computer
(b) A student's full name
(c) A student's university ID number
(d) A student's full face photo

Answer: A

38. Refer to Example 6.9. Is the act of releasing the Morris worm wrong, according to the ACM Code of Conduct?

(a) No, because Morris was just doing his research work, intending no harm.
(b) No, because he was an outstanding academic, as demonstrated by his later achievements.
(c) No, because the damage-causing bug was an accident. Nobody can guarantee that a sophisticated program is bug free.
(d) Yes, because he was convicted and had served his sentence.
(e) Yes, because his action did not do enough to avoid harm, contravening Principle 2 of the ACM Code of Conduct.

Answer: E