

dMAT – Digital Master Assessment Test

Preparatory Materials for Test Takers



dMAT

Digitaler Mastertest

Imprint

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Instructions for the use of the preparation materials for test takers

Dear dMAT participant,

these preparation materials will help you to prepare well for the dMAT exam. Here you get

- general information on the content and structure of the test,
- detailed instructions and hints on how to work through the different task types as well as
- the possibility to work on exercises for each task type in different levels of difficulty including sample solutions.

Read all the information carefully to become well acquainted with the dMAT. The preparation materials are primarily intended to help you to prepare for the exam in terms of content. You can get hints and examples on the digital form of the test in information videos on www.d-mat.de.

Note

The detailed instructions for the individual task types are only available in these preparation materials! In the dMAT exam you will only see short explanations of the processing as a reminder.

We wish you lots of success!

Your dMAT team

General information about the dMAT

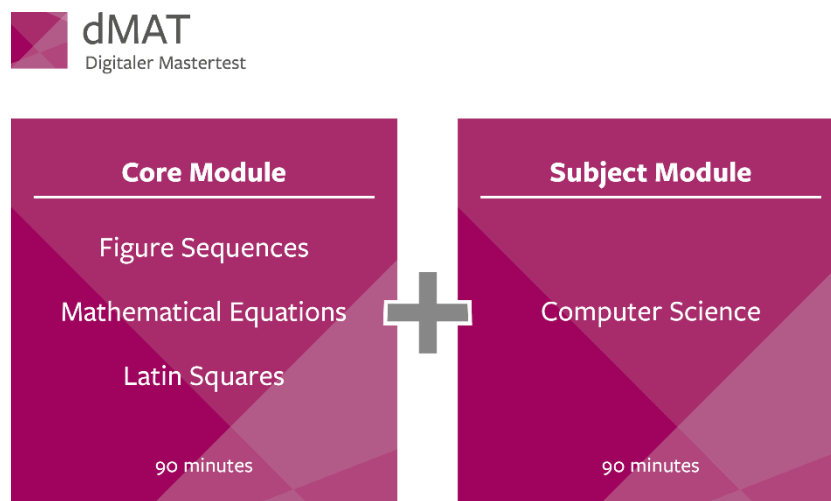
The digital Master Assessment Test (dMAT) is a new study aptitude test used for the admission of international applicants to Master's degree programmes in Germany. Taking the test allows a fair comparison of applicants across different national education systems.

The dMAT is offered digitally. Developed in close professional collaboration with German universities, the test accurately reflects the requirements of the intended degree programmes and is thus a valid instrument for assessing study ability for master's degree programmes.

The dMAT exams are evaluated centrally at the TestDaF Institute in Bochum. The test is standardized, which ensures that all participants can be compared with each other. In addition, the format of the test is based on the internationally recognized standards for psychodiagnostic tests, the test is reliable and objective.

Structure of the dMAT

The dMAT consists of two parts: A Core Module that tests general study aptitude, and subject-specific modules that test subject-specific aptitude as well as the ability to apply the knowledge acquired in the course of study. Currently, the dMAT is offered for the master's degree programme in Computer Science, other examination modules are under development. The following graphic illustrates the structure of the test.



The duration of the exam itself is about three hours with a break of 30 minutes between the two parts of the exam.

The **Core Module** measuring general study ability consists of three subtests that measure general cognitive abilities relevant to a master's degree programme in Germany. To a certain extent, the core module allows participants to be compared across the respective subject modules.

The production of the **Subject Modules** is based on extensive scientific studies by experts, so that the exam content is representative of the respective fields of study. The examination tasks are knowledge-based and consist of a combination of a typical subject-related problem (input) and corresponding single-choice questions. The dMAT therefore requires subject knowledge and application skills, but not memorized factual knowledge. You can familiarize yourself with the exact requirements and instructions of the individual task types in the next sections.

Please note: You may not take notes throughout the exam.

Core Module – Instructions and Exercises

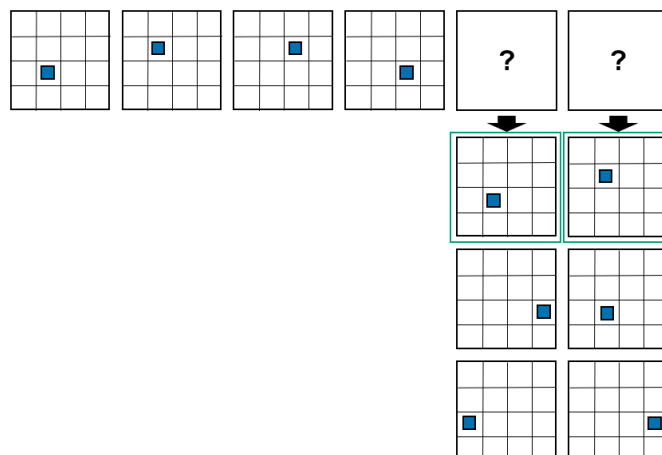
Core Module

Figure Sequences

Instructions

In this task you will see a series of pictures (matrices). The figures in the matrices can change their **position**, **colour**, and/or **orientation** from one matrix to the next according to specific rules. It is your task to continue the series logically and to determine what the next two matrices look like.

Example Task



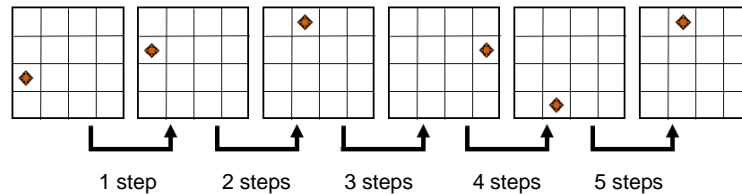
Solution

The blue square always moves one field clockwise within the four middle fields. Therefore, for the fifth matrix the first response option is correct, and for the sixth matrix as well.

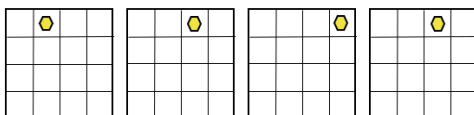
Rules

- Figures can change their colour.
- Figures can rotate around their own axis.
- Figures can move in the matrix. Vertical, horizontal, and diagonal movements are allowed. Figures cannot change from one diagonal movement to another type of movement.

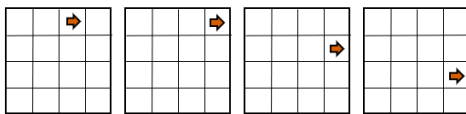
- Figures can also change their movement, colour or orientation by $x + 1$. Example: If a figure moves one step from matrix 1 to matrix 2, it moves 2 steps from matrix 2 to matrix 3, then 3 steps, etc.



- Figures cannot disappear or overlap.
- Figures cannot leave the matrix. If they come up against an outer boundary, they can EITHER
- bounce off OR



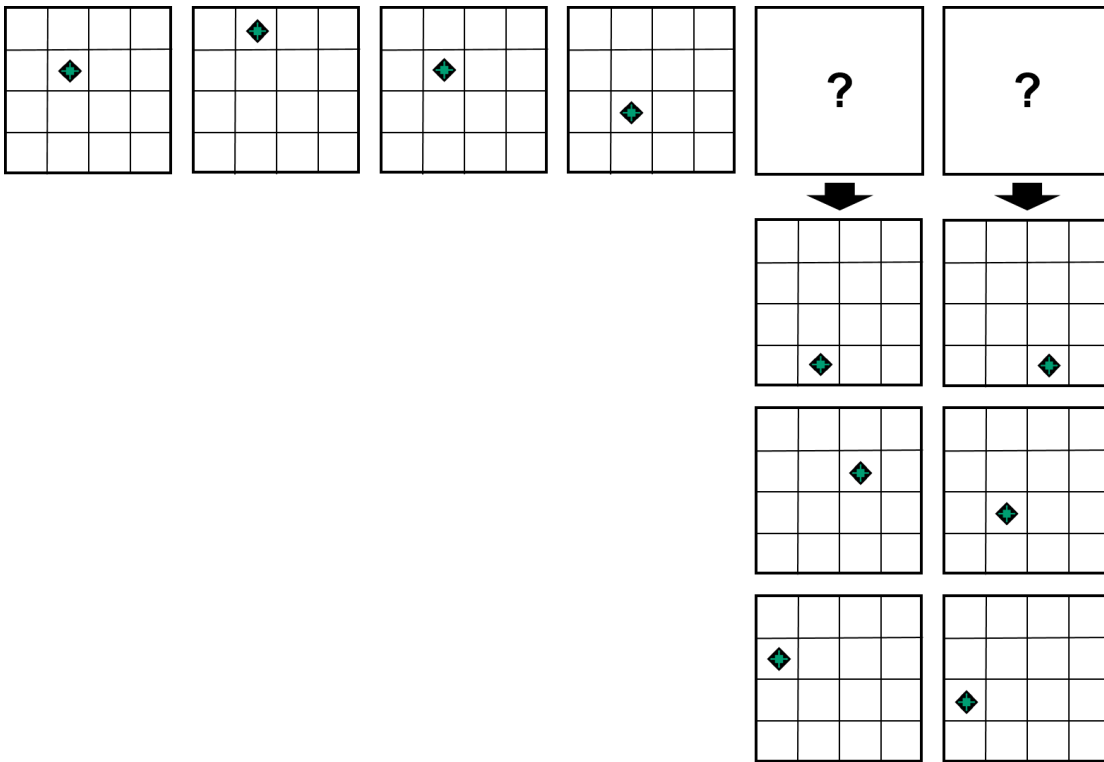
- move along the outer boundary.



In the exam you have a total of **25 minutes** for **20** series of matrices. Please be as quick and accurate as possible. If you do not know an answer, please guess which answer might be correct. You are not allowed to take notes in the exam.

For the task type **Figure Sequences** there are six exercises available, two each in the difficulty levels low, medium and high. On the following pages you can see the solutions including the solution paths. Practice with these exercises without taking notes, as you will not have any helping tools available to you in the exam either.

Exercise 1 – Difficulty: low



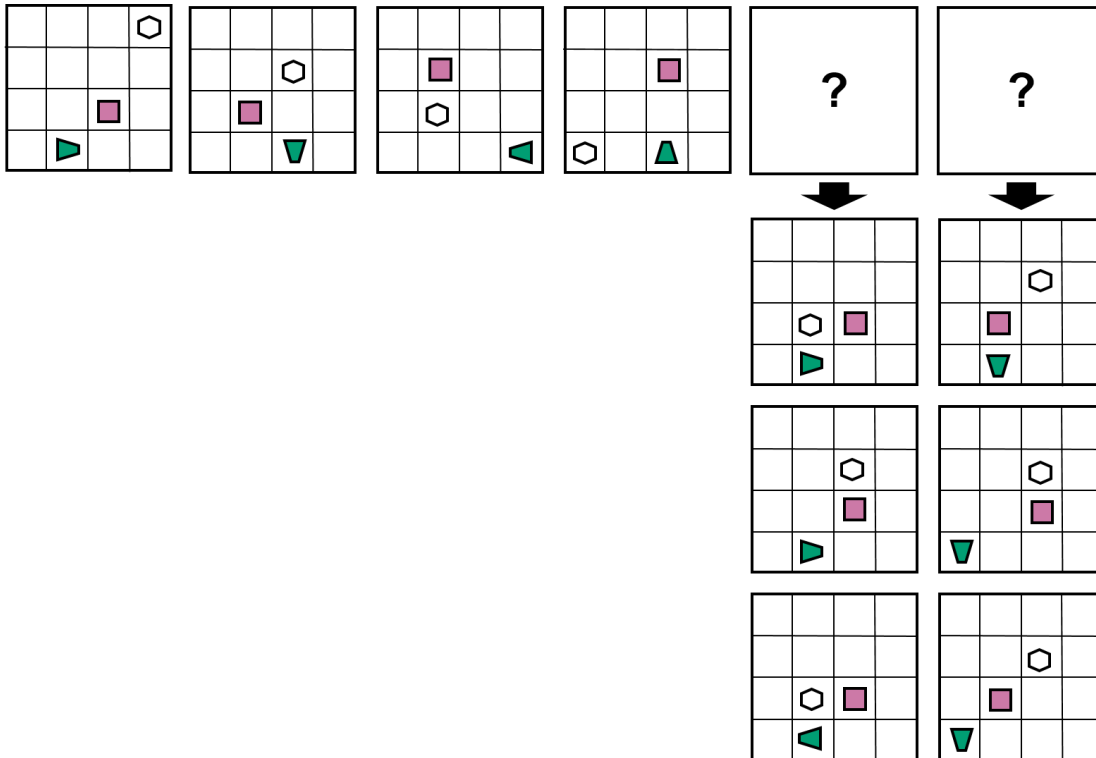
Exercise 2 – Difficulty: low

				↓	↓

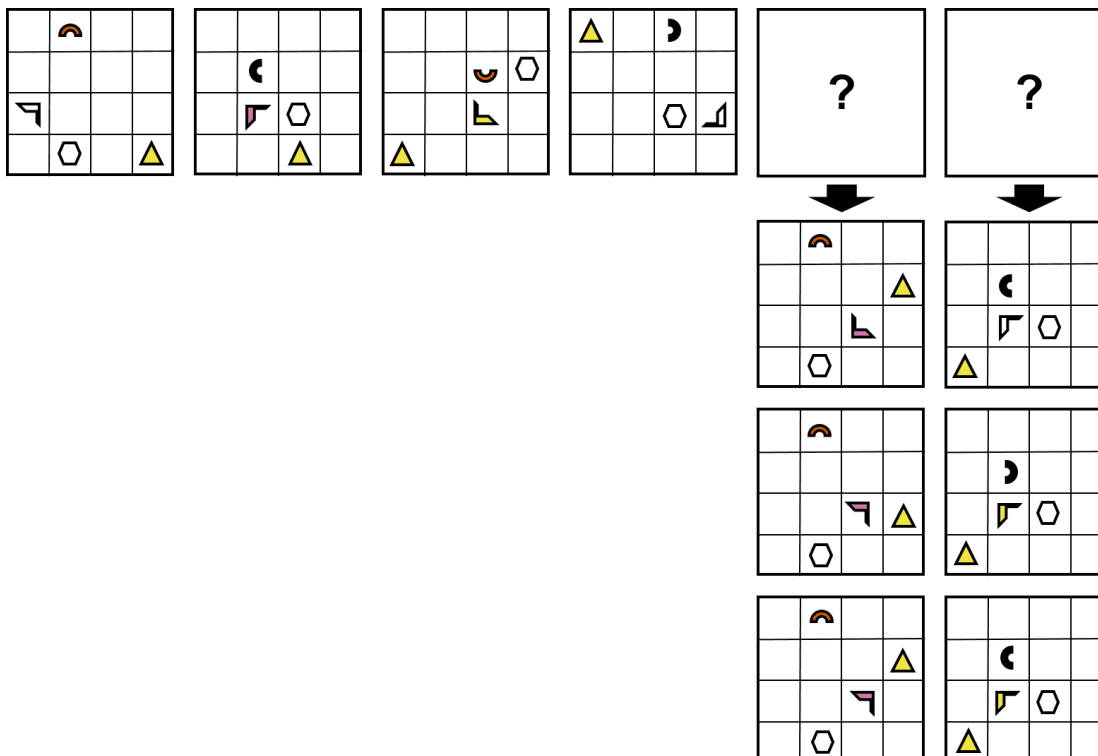
Exercise 3 – Difficulty: medium

				↓	↓

Exercise 4 – Difficulty: medium



Exercise 5 – Difficulty: high



Exercise 6 – Difficulty: high

The puzzle consists of a sequence of 3x3 grids. The first four grids show a pattern of objects moving from one grid to the next. The fifth and sixth grids are empty with question marks. Below them are three rows of two possible options each, indicated by downward arrows from the question marks.

Grid 1: Row 1: Arrow (right), L-shape (top-right), empty. Row 2: empty, empty, empty. Row 3: empty, empty, Diamond (white).

Grid 2: Row 1: empty, empty, L-shape (top-right). Row 2: empty, Arrow (down), empty. Row 3: empty, Triangle (green), empty.

Grid 3: Row 1: empty, empty, empty, Diamond (white). Row 2: empty, empty, L-shape (top-right). Row 3: Triangle (orange), empty, Arrow (up).

Grid 4: Row 1: Triangle (yellow), empty, Diamond (white). Row 2: empty, empty, empty. Row 3: empty, Arrow (left), L-shape (top-right).

Grid 5: ?

Grid 6: ?

Option Row 1:

- Option 1: Row 1: Diamond (white), Triangle (green), empty. Row 2: Arrow (left), empty, empty. Row 3: empty, empty, L-shape (top-right).
- Option 2: Row 1: Diamond (white), empty, empty. Row 2: empty, empty, empty. Row 3: empty, Arrow (up), L-shape (top-right).

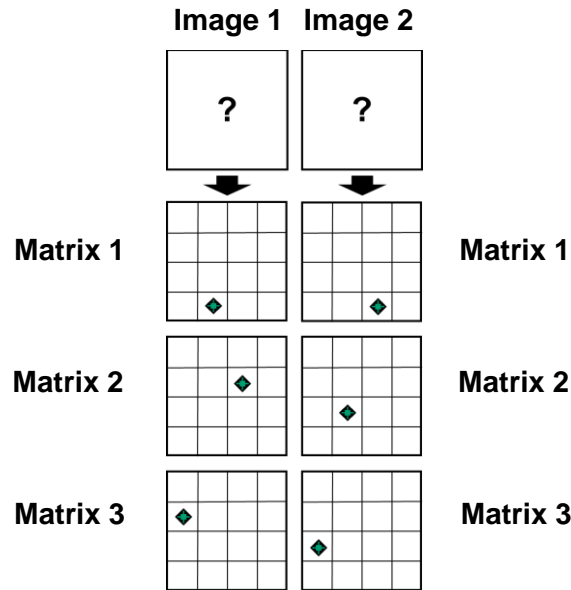
Option Row 2:

- Option 1: Row 1: empty, Diamond (white), Triangle (green). Row 2: Arrow (left), empty, empty. Row 3: empty, empty, L-shape (top-right).
- Option 2: Row 1: Diamond (white), empty, empty. Row 2: empty, empty, empty. Row 3: empty, Arrow (right), L-shape (top-right).

Option Row 3:

- Option 1: Row 1: empty, Diamond (white), Triangle (green). Row 2: Arrow (left), empty, empty. Row 3: empty, empty, L-shape (top-right).
- Option 2: Row 1: Diamond (white), empty, Triangle (orange). Row 2: empty, empty, empty. Row 3: empty, Arrow (up), L-shape (top-right).

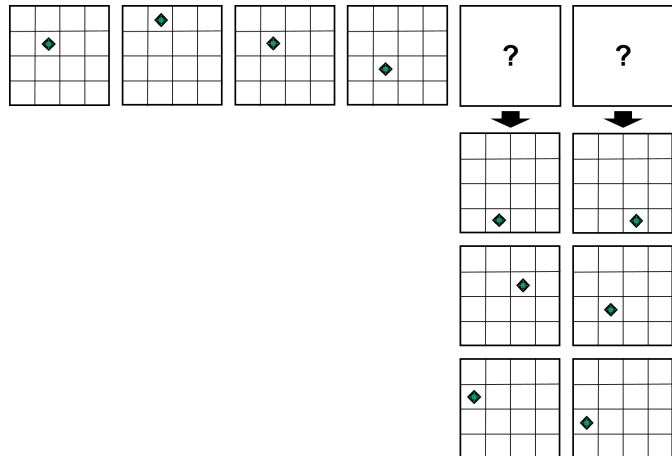
Note on the solution key




Solution – Exercise 1

Image 1: Matrix 1

Image 2: Matrix 2

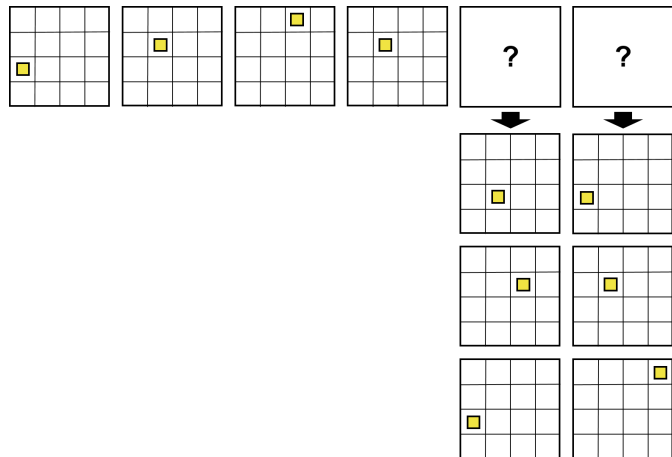



The symbol  moves vertically one field at a time in the second column and bounces off the upper or lower boundary.

Solution – Exercise 2

Image 1: Matrix 3

Image 2: Matrix 2

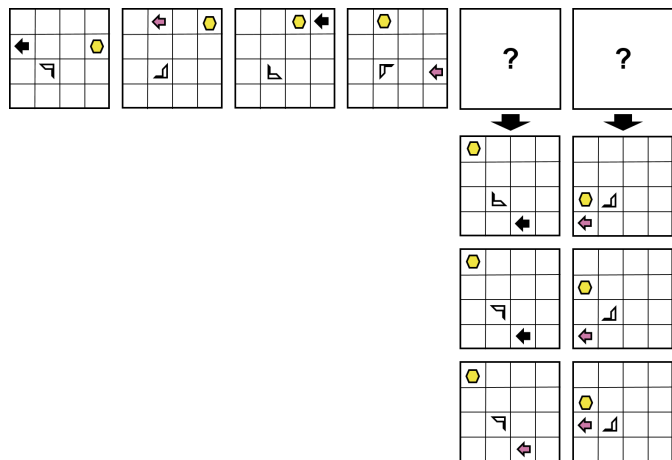





The symbol  always moves one space diagonally upwards to the right from its starting position until it bounces off the upper boundary and returns to the starting position in the same way (diagonally downwards to the left). Once there, it bounces off the lower boundary and moves diagonally upwards to the right again.


Solution – Exercise 3

Image 1: Matrix 2

Image 2: Matrix 2



The symbol  moves along the outer borders clockwise by two squares at a time. It changes its colour alternately from black  to pink .

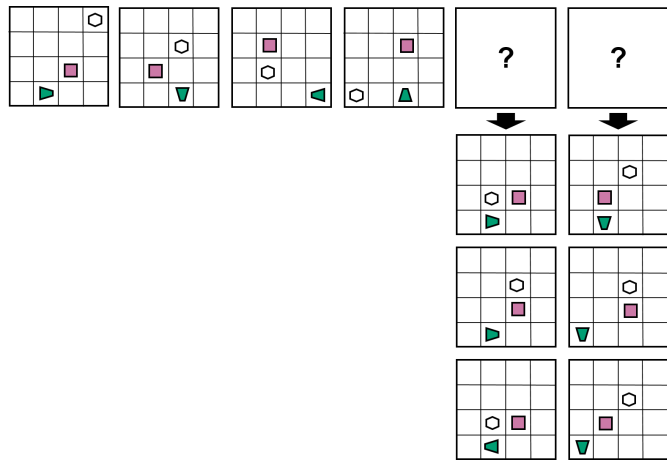
The symbol  rotates 90 degrees to the right from image to image.


The symbol  moves along the outer borders counter clockwise one space at a time.


Solution – Exercise 4


Image 1: Matrix 1

Image 2: Matrix 3



The symbol  moves horizontally by one field in the fourth row and bounces off the right or left border. It rotates 90 degrees to the right from image to image.

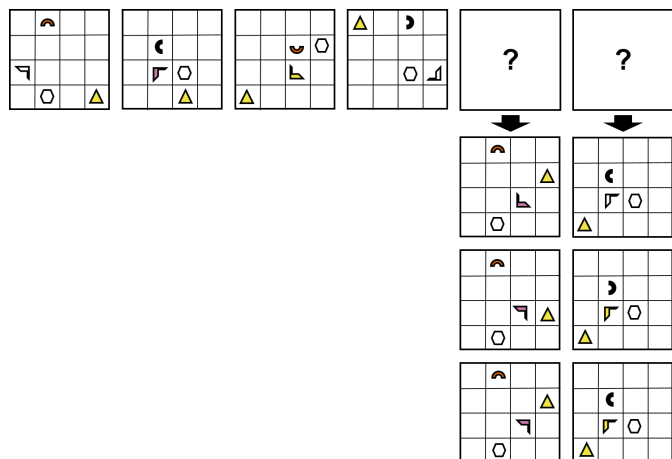
The symbol  moves from its starting position one field at a time from image to image. The order of the directions in which the symbol moves is: left, up, right, down, and so on.


The symbol  moves from its starting position diagonally downwards to the left until it bounces off the bottom left corner and returns the same way to the top right corner (diagonally upwards to the right).





Solution – Exercise 5




Image 1: Matrix 3


Image 2: Matrix 3



The symbol  moves along the outer borders clockwise by $x + 1$ fields (i.e. from matrix 1 to matrix 2 one field, from matrix 2 to matrix 3 two fields, and so on).

The symbol  moves horizontally by one field in the third row and bounces off the right or left border. In doing so, it turns 90 degrees to the left from image to image and changes its colour from white  to pink  to yellow , and so on.

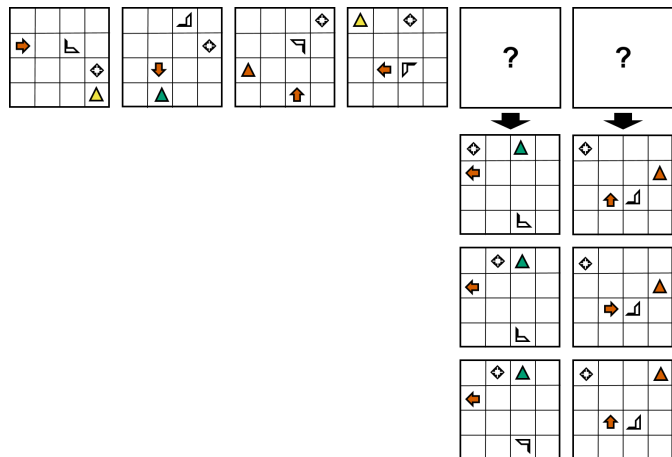
The symbol  moves from its starting position one field at a time from image to image. The sequence of directions in which the symbol moves is: down, right, up, left, and so on. It turns 90 degrees to the left and changes its colour alternately from orange  to black .


The symbol  moves diagonally upwards to the right from its starting position until it bounces off the right boundary and returns to the starting position in the same way (diagonally downwards to the left). Once there, it bounces off the lower boundary and moves diagonally upwards to the right again.


Solution – Exercise 6

Image 1: Matrix 2





Image 2: Matrix 1



The symbol  moves from its starting position diagonally downwards to the right until it bounces off the lower boundary and returns to the starting position in the same way (diagonally upwards to the left). Once there, it bounces off the left boundary and moves diagonally down to the right again. The symbol always turns $x + 1$ times to the right by 90 degrees. I.e. from matrix 1 to matrix 2 it rotates once by 90 degrees to the right. From matrix 2 to matrix 3 it rotates twice by 90 degrees to the right, and so on.

The symbol  moves vertically by one field in the third column and bounces off the upper or lower border. It rotates 90 degrees to the left from image to image.

The symbol  moves along the outer borders counter clockwise one space at a time.

The symbol  moves along the outer borders clockwise by two spaces at a time. In the process, it changes colour from yellow  to green  to orange , etc.

In this task, you are supposed to solve systems of equations in such a way that all requirements are met. One system of equations always consists of several single equations.

Your task is to find out which numbers must be used for the unknowns (letters) in the equations so that all equations are correct.

There is always only one solution for each letter, in which all requirements are met.

Each letter can have be an integer between 1 and 20.

Example 1

$$\mathbf{A} + 2 = \mathbf{B}$$

$$\mathbf{B} = 6$$

What number does **A** correspond to so that the equations are solved correctly?

Solution of Example 1

Because of the second equation, you know that $\mathbf{B} = 6$. Replace **B** with the number 6 in the first equation and you get $\mathbf{A} + 2 = 6$. Solve the first equation and you get $\mathbf{A} = 6 - 2 = 4$. Therefore, the solution of the first example is $\mathbf{A} = 4$. Any other solution is wrong.

Example 2

$$\mathbf{B} = 2 \times \mathbf{A}$$

$$\mathbf{B} + \mathbf{A} = 12$$

What numbers do **A** and **B** correspond to so that the equations are solved correctly?

Solution of Example 2

The first equation defines that $\mathbf{B} = 2 \times \mathbf{A}$. Putting this information in the second equation gives $2 \times \mathbf{A} + \mathbf{A} = 12$ or $3 \times \mathbf{A} = 12$. Rearranging this equation gives $\mathbf{A} = 12 \div 3 = 4$. Putting the number 4 into the first or second equation for **A** gives $\mathbf{B} = 8$. Therefore, the solution of the second example is $\mathbf{A} = 4$ and $\mathbf{B} = 8$. Any other solution is wrong.

In the exam you have **25 minutes** to solve **20 systems of equations**. Please be as quick and accurate as possible. You are not allowed to take notes in the exam.

For the task type **Mathematical Equations**, six exercises are available, two each in the difficulty levels low, medium and high. On the following pages you can see the solutions including the solution paths. Practice with these exercises without taking notes, as you will not have any helping tools available to you in the exam either.

Exercise 1 – Difficulty: low

$$7 + A = 14$$

$$B - 3 = A$$

Exercise 2 – Difficulty: low

$$B \div 2 = A$$

$$B - A = 8$$

Exercise 3 – Difficulty: medium

$$3 \times C = A$$

$$A + C = 8$$

$$2 \times A + 2 \times C = B$$

Exercise 4 – Difficulty: medium

$$18 - B = A$$

$$3 \times A = C$$

$$B \div 2 = A$$

Exercise 5 – Difficulty: high

$$A - B + C - D = 2$$

$$10 \times B = C$$

$$5 \times B = A$$

$$11 + B = D$$

Exercise 6 – Difficulty: high

$$C + D - A = 1$$

$$5 \times C = D$$

$$13 - C = A$$

$$3 \times C - 1 = B$$

Solution – Exercise 1

$$7 + A = 14$$

$$B - 3 = A$$

$$A = 7$$

$$B = 10$$

The first equation makes it clear that $A = 7$ if you subtract 7 on both sides. If you insert this information into the second equation, you get $B - 3 = 7$. If you add 3 on both sides, you get the solution $B = 10$.

Solution – Exercise 2

$$B \div 2 = A$$

$$B - A = 8$$

$$A = 8$$

$$B = 16$$

Multiplying by 2 on both sides in the first equation gives $B = 2A$. Replacing the variable B in the second equation with this information gives $2A - A = 8$. This means $A = 8$. Substituting the solution for A in the first equation gives $B \div 2 = 8$. Multiplying both sides by 2 gives $B = 16$.

Solution – Exercise 3

$$3 \times C = A$$

$$A + C = 8$$

$$2 \times A + 2 \times C = B$$

$$A = 6$$

$$B = 16$$

$$C = 2$$

With the information from the first equation ($3 \times C = A$ or $A = 3C$), A can be replaced in the second equation so that it can be solved for C: $3C + C = 8$ or $4C = 8$. If you divide by 4 on both sides, you get $C = 2$. Thus, the solution of A can be calculated by substituting the value of C into the first equation: $3 \times 2 = A$. Therefore, $A = 6$. By substituting the solutions for A and C, the third equation can be solved for B: $2 \times 6 + 2 \times 2 = B$. Therefore, $B = 16$.

Solution – Exercise 4

$$18 - B = A$$

$$3 \times A = C$$

$$B \div 2 = A$$

$$A = 6$$

$$B = 12$$

$$C = 18$$

If you multiply by 2 on both sides in the third equation, you get $B = 2A$ (alternatively, you can also continue the calculation with $0.5B = A$, for example). If you replace B with this information in the first equation, you get $18 - 2A = A$. If you add $2A$ on both sides, you get $18 = 3A$. If you now divide by 3, you get $A = 6$. This information can be inserted into the third equation, so that you get $B \div 2 = 6$. If you multiply by 2 on both sides, you get $B = 12$. If you insert the result for A into the second equation, you get $3 \times 6 = C$, so $C = 18$.

Solution – Exercise 5

$$A - B + C - D = 2$$

$$10 \times B = C$$

$$5 \times B = A$$

$$11 + B = D$$

$$A = 5$$

$$B = 1$$

$$C = 10$$

$$D = 12$$

The information given in equations two, three and four for the variables A , B and C can be inserted into the first equation so that it can be solved for B : $5B - B + 10B - (11 + B) = 2$. If you dissolve the bracket, you get $5B - B + 10B - 11 - B = 2$ or $13B - 11 = 2$. If you add 11 on both sides, you get $13B = 13$. If you divide by 13, you get the solution $B = 1$. This information can be inserted into the other equations and solved for the respective missing variable: $10 \times 1 = C$ or $C = 10$, $5 \times 1 = A$ or $A = 5$ and $11 + 1 = D$ or $D = 12$.

Solution – Exercise 6

$$C + D - A = 1$$

$$5 \times C = D$$

$$13 - C = A$$

$$3 \times C - 1 = B$$

$$A = 11$$

$$B = 5$$

$$C = 2$$

$$D = 10$$

The information given in equations two and three for the variables A and D can be inserted into the first equation, so that it can be solved for C: $C + 5C - (13 - C) = 1$. Dissolving the bracket gives $C + 5C - 13 + C = 1$ or $7C - 13 = 1$. Adding 13 on both sides gives $7C = 14$. Dividing by 7 gives the solution $C = 2$. This information can be inserted into the other equations and solved for the respective missing variable: $5 \times 2 = D$ or $D = 10$, $13 - 2 = A$ or $A = 11$ and $3 \times 2 - 1 = B$ or $B = 5$.

Core Module

Latin Squares

Instructions

In this task you will see a 5x5 grid (a square containing 5 rows and 5 columns).

Some fields of the grid contain letters. Each letter can only appear once in each row and each column. Only the letters that are shown as response options (the row next to the grid) can appear in the grid.

Your task is to decide which letter belongs in the field with the question mark. Sometimes you need to fill in other fields in your mind before you can figure out what letter should replace the question mark.

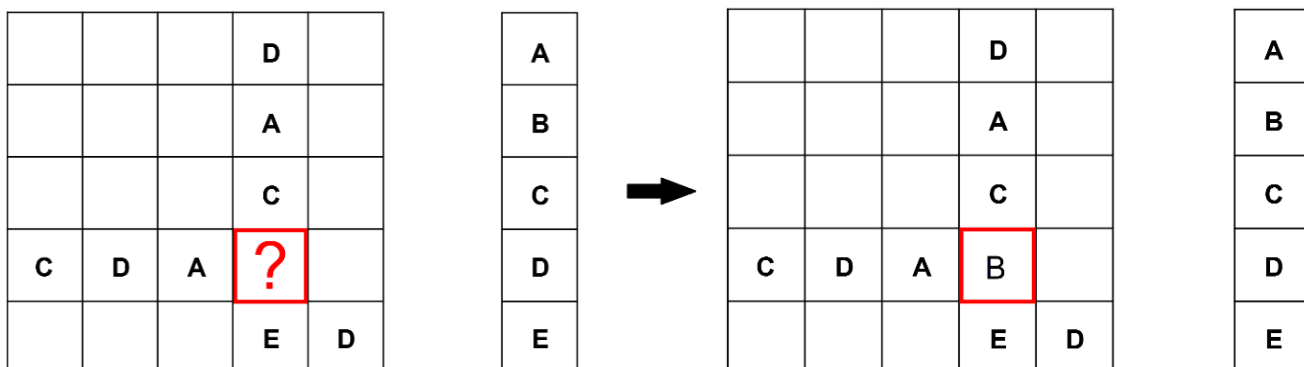
If you know what the correct solution for the question mark field is, click on the correct response in the solution row.

	?			
	A			
	E			
	D			
C	B			

A
B
C
D
E

Next, you will see two examples.

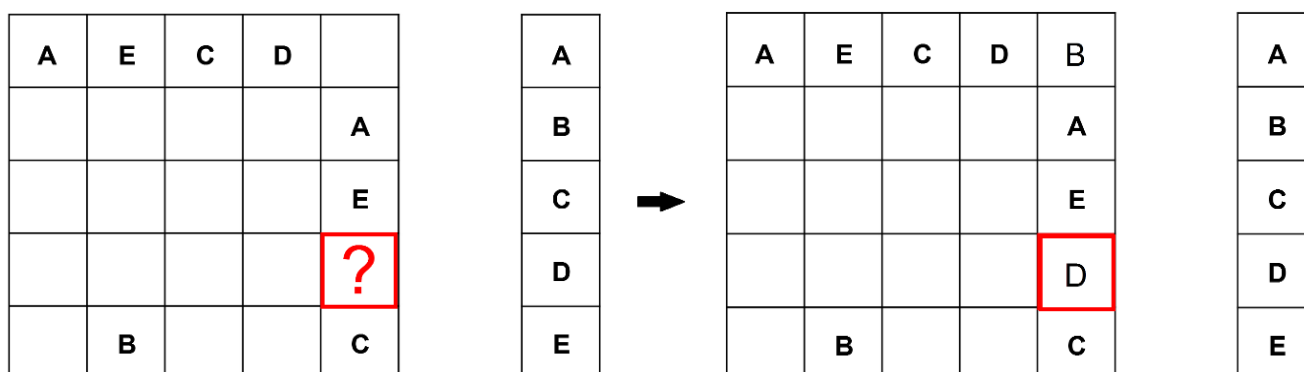
Example 1



Solution of Example 1

In the first example, “B” needs to replace the red question mark, because all other letters D, A, C, and E already appear in this column.

Example 2



Solution of Example 1

In the second example, you first need to fill in “B” in the first row of the last column. “B” is the only letter, which does not already appear in this row and column. Then you can replace the question mark with “D”, because it is the only letter that does not appear in the last column.

In the exam you have 20 minutes for 16 tasks. Please be as quick and accurate as possible! If you do not know an answer, please guess which answer might be correct. You are not allowed to take notes in the exam.

For the task type **Latin Squares**, six exercises are available, two each in the difficulty levels low, medium and high. On the following pages you can see the solutions including the solution paths. Practice with these exercises without taking notes, as you will not have any helping tools available to you in the exam either.

Exercise 1 – Difficulty: low

B	?	A	D	
A	B	E	C	
	A			
C				
D	E		B	

Exercise 2 – Difficulty: low

		?		
			D	A
		E		D
A	D			B
D	B		C	

Exercise 3 – Difficulty: medium

A			B	
	B	A		
	E	D		
E	C		A	D
		E		?

Exercise 4 – Difficulty: medium

	E		C	B
?			A	
		A	E	D
B	A		D	
	D	C		

Exercise 5 – Difficulty: high

			C	
	C	?	E	
	E		B	C
A	B		D	E
	D	E	A	

Exercise 6 – Difficulty: high

?				C
	D	E	B	A
B		D	A	
	B	C		D

Note on the solution key

	α	β	γ	δ	ϵ
1	B	?	A	D	
2	A	B	E	C	
3		A			
4	C				
5	D	E		B	

Solution – Exercise 1

Solution = C

B	?	A	D	
A	B	E	C	
	A			
C				
D	E		B	

Solution path:

- In column β , C and D are missing.
- C is already in row 4, so D must be inserted in $\beta 4$.
- Consequently, C must be inserted in the place of the question mark.

Solution – Exercise 2

Solution = D

		?		
			D	A
		E		D
A	D			B
D	B		C	

Solution path:

- In the place of the question mark, D must be inserted because D is already given in all other columns and rows.

Solution – Exercise 3

Solution = B

A			B	
	B	A		
	E	D		
E	C		A	D
		E		?

Solution path:

- In column γ , B and C are missing. At position γ_4 , only B can be inserted, since there is already a B in row 1. This also applies in γ_4 , or line 4 vice versa for C. Consequently, only a C can be inserted in γ_1 .
- A and D are missing in column β . A can only be in position β_5 , because A is already present in row 1. Consequently, only a D can be in position β_1 .
- From this follows that only one E can be inserted in ϵ_1 .
- In row 3 it is now noticeable that A can only be in position ϵ_3 , as it is already present in all columns and rows.

- Since a B still has to be inserted in column ϵ , and there is already a B in line 2, it can only be inserted at the position of the question mark.

Solution – Exercise 4

Solution = D

	E		C	B
?			A	
		A	E	D
B	A		D	
	D	C		

Solution path:

- A and D are missing in the first row. A can only be inserted at position $\alpha 1$, since it is already in column γ . Consequently, D must be in position $\gamma 1$.
- It is now noticeable that D is already present in four different rows and columns and can thus only be used in the place of the question mark.

Solution – Exercise 5

Solution = D

			C	
	C	?	E	
	E		B	C
A	B		D	E
	D	E	A	

Solution path:

- Only C can be inserted at position $\gamma 4$.
- In row 3, A and D are missing. At position $\gamma 3$, only an A can be inserted because it is already present in column α . Consequently, only a D can be inserted at position $\alpha 1$.
- Only A can be inserted at position $\beta 1$.
- Only E can be inserted at position $\alpha 1$, as it is already present in all other rows and columns.
- Furthermore, C and B are missing in row 5, whereby only a C is inserted at position $\alpha 5$, since it is already present in column ϵ . Consequently, there is a B at position $\epsilon 5$.
- In row 1, D and B are still missing. Since B is already in column ϵ , B must be inserted at position $\gamma 1$ and D at position $\epsilon 1$.
- At the position of the question mark, D must be inserted, since all other letters are already present in column γ .

Solution – Exercise 6

Solution = E

?				C
	D	E	B	A
B		D	A	
	B	C		D

Solution path:

- At position $\alpha 3$, only a C can be inserted, since all other letters are already in line 3.
- In row 5, A and E are missing. A must be in position $\alpha 5$ because it is already in column δ . Consequently, E is in position $\delta 5$.
- In row 4, C and E are missing. Only a C can be inserted at position $\beta 4$, as it is already present in column ϵ . Consequently, there is an E at position $\epsilon 4$.
- At position $\epsilon 2$, only a B can be inserted, as all other letters in column ϵ are already present.
- In column γ , A and B are missing. At position $\gamma 1$, only a B can be inserted, since there is already a B in the second row. Consequently, A must be inserted in $\gamma 2$.
- In the first row, A, D and E must be inserted. A must be inserted in $\beta 1$ because it is already present in all the other columns. Since E is already present in column δ , it must therefore be inserted in the position of the question mark.

Subject Module – Instructions and Exercises

Subject Module	Computer Science
General Instructions	

In this task type you see a text and a number of questions which you have to answer. There are 4 answer options for each question.

For each question, there is only one correct solution.

The text, the questions and the answer options may contain figures, tables and formulas.

For working on the entire subject test in the exam, you have 90 minutes in total. If you do not know an answer, please guess which answer might be correct. You are not allowed to take notes in the exam.

For practice and illustration of the subject module tasks, two exercises are available here.

Goals of computer security

Computer security is a branch of information technology, whose main goal is to protect systems and users from being compromised or attacked. In order to define precise protection mechanisms and attack countermeasures, computer security defines the following main security goals:

1. Integrity ensures that data cannot be modified.
2. Authenticity ensures that identity of the data issuer can be verified.
3. Confidentiality ensures that data are only visible by individuals with a key.
4. Availability ensures that data are guaranteed to be accessible to the users/systems when needed.

Question 1

One of the most famous attacks on TLS is the Heartbleed bug from 2014. The bug allowed an attacker to read random bytes from the server, which could potentially include usernames, passwords, and cryptographic material. What security goal does Heartbleed primarily violate?

- a) Confidentiality
- b) Integrity
- c) Authenticity
- d) Availability

Question 2

Some typical attacks affecting the security of currently used systems are different forms of ransomware. These attacks change the behaviour of the running system so that the system becomes unusable or its functionality differs. In addition to availability, what security goals does a ransomware primarily violate?

- a) Confidentiality
- b) Integrity
- c) Authenticity
- d) None of the above

Question 3

Single Sign-On is a typical mechanism to identify users in a system / in a set of systems. Assume there is an attacker who is able to bypass a Single Sign-On mechanism and log in as an arbitrary user. What security goal does such an attacker primarily violate?

- a) Confidentiality
- b) Integrity
- c) Authenticity
- d) Availability

Question 4

Denial-of-Service is a common security attack. With this attack, an adversary sends, for example, a large amount of data to a specific server. What security goal does a Denial-of-Service attack primarily violate?

- a) Confidentiality
- b) Integrity
- c) Authenticity
- d) Availability

Question 1

Solution: A

Heartbleed allowed any attackers to get in possession of usernames, passwords, and cryptographic material. Those data should only be visible to the server hosting the application. Because of this, Heartbleed targeted confidentiality.

Question 2

Solution: B

Ransomware affects and modifies the running system and changes its behavior. Since the system gets modified, Ransomware primarily affects system integrity.

Question 3

Solution: C

The primary goal of a Single Sign-On system is to ensure that users can authenticate to specific systems. Thus it primarily ensures authenticity. If an attacker is able to log in as a different user, the authenticity property is violated.

Question 4

Solution: D

Denial-of-Service attacks have the goal to make a system unavailable, by issuing a lot of requests to the target system. If the attack is successful, the server is not able to respond to requests sent by other parties and becomes unavailable. Thus, this attack targets the availability goal.

Combinational Logic

Remember the boolean operation AND, OR and NOT. Their representation as logical gates in circuits is shown in Figure 1 below.

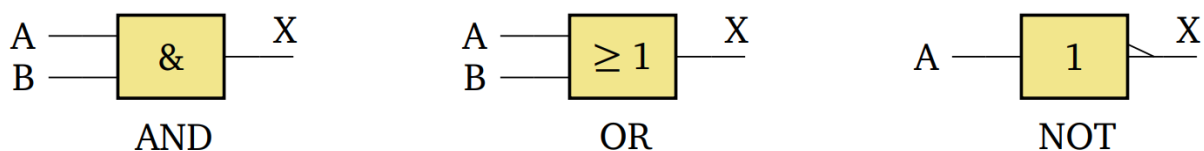


Figure 1. Logical gates in circuits of boolean operations

They are represented formally as functions $X = A \wedge B$ for AND, $X = A \vee B$ for OR and $X = \bar{A}$ for NOT. The output X can be given by the combinations of the possible inputs. For boolean operations the input can only be 0 or 1 (sometimes also referred to as *false* and *true*). For completeness, the output of all three operations is presented using truth tables:

A	B	$A \wedge B$	$A \vee B$
0	0	0	0
0	1	0	1
1	0	0	1
1	1	1	1

A	\bar{A}
0	1
1	0

Table 1. Truth table

These three boolean operations are the building blocks for more complex boolean functions or boolean circuits. As long as there are no cycles in the circuit, these circuits implement combinational logic. The resulting circuits are called combinatorial circuits.

From a truth table, we can immediately derive a boolean function or the combinatorial circuit by using what is called the canonical disjunctive normal form "(CDNF)". For each 1 that results from a function a *minterm* is created. A minterm is an AND operation over all inputs,

where 0-inputs are negated while 1-inputs are not. All minterms are finally combined with an OR operation.

As an example, the CDNF of AND derived from its truth table has only one minterm $X = A \wedge B$. It thus does not need to be used in an OR. However, the OR operation as CDNF has three minterms that need to be combined with OR: $X = (A \wedge \bar{B}) \vee (A \wedge \bar{A}) \vee (A \wedge B)$.

Question 1

Given the following truth table, which Boolean function does the table represent?

A	B	X
0	0	1
0	1	0
1	0	0
1	1	0

- a) $X = \bar{A} \wedge \bar{B}$
- b) $X = \overline{A \wedge B}$
- c) $X = A \vee B$
- d) $X = \bar{A} \vee B$

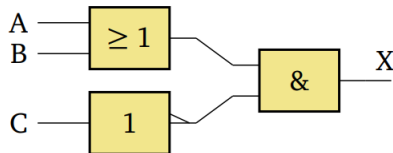
Question 2

Imagine a jewelry shop that has sensors at all of its windows, doors, and showcases. Its burglar alarm should go off if one of the sensors detects unusual conditions. Which Boolean operation best describes the behavior of the alarm system?

- a) AND operation
- b) OR operation
- c) one AND combined with several OR operations
- d) one OR combined with several AND operations

Question 3

The following combinatorial circuit has three inputs A, B and C. The corresponding truth table has some missing entries. What are these missing values?

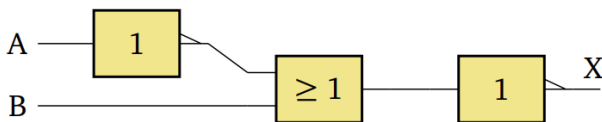


A	B	C	X
0	0	0	0
0	0	1	{i}
0	1	0	1
0	1	1	{ii}
1	0	0	{iii}
1	0	1	0
1	1	0	1
1	1	1	0

- a) $i = 0; ii = 1; iii = 1$
- b) $i = 1; ii = 1; iii = 1$
- c) $i = 0; ii = 0; iii = 0$
- d) $i = 0; ii = 0; iii = 1$

Question 4

What is the correct boolean function for the shown combinatorial circuit?



- a) $X = \overline{\overline{A} \vee B}$
- b) $X = \overline{A \vee \overline{B}}$
- c) $X = \overline{A \wedge \overline{B}}$
- d) $X = \overline{\overline{A} \wedge B}$

Question 5

What is the CDNF for the following truth table?

A	B	X
0	0	0
0	1	1
1	0	1
1	1	0

- a) $X = X = (\bar{A} \wedge B) \vee (A \wedge \bar{B}) \vee (A \wedge B)$
- b) $X = (\bar{A} \wedge \bar{B}) \vee (A \wedge B)$
- c) $X = (\bar{A} \wedge B)$
- d) $X = (\bar{A} \wedge B) \vee (A \wedge \bar{B})$

Question 6

You have a truth table with four inputs A, B, C and D. In one of the lines the result X is 1 for the following combination of inputs:

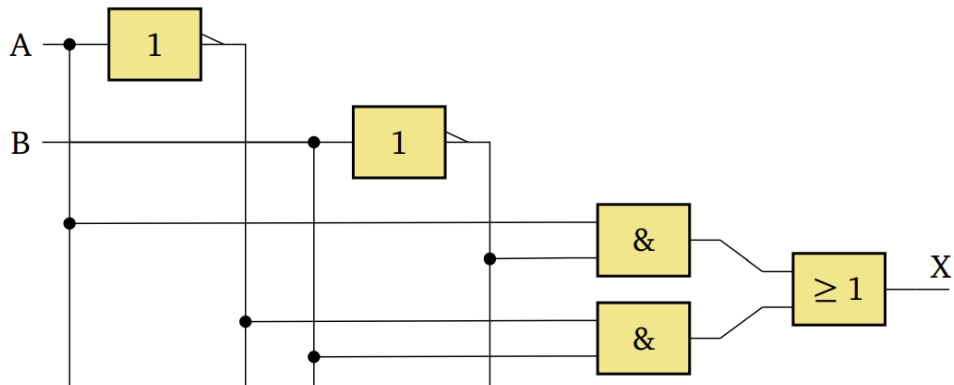
A	B	C	D	X
1	0	1	1	1

What is the correct minterm for this line?

- a) $A \wedge \bar{B} \wedge C \wedge D$
- b) $A \vee \bar{B} \vee C \vee D$
- c) $\bar{A} \wedge B \wedge \bar{C} \wedge \bar{D}$
- d) $A \wedge C \wedge D$

Question 7

What is the truth table for the following circuit?:



a)

A	B	X
0	0	1
0	1	1
1	0	0
1	1	0

b)

A	B	X
0	0	1
0	1	0
1	0	0
1	1	1

c)

A	B	X
0	0	0
0	1	1
1	0	1
1	1	0

d)

A	B	X
0	0	0
0	1	0
1	0	1
1	1	1

Question 1

Solution: A

(Explanation following in January 2024)

Question 2

Solution: B

(Explanation following in January 2024)

Question 3

Solution: D

(Explanation following in January 2024)

Question 4

Solution: A

(Explanation following in January 2024)

Question 5

Solution: D

(Explanation following in January 2024)

Question 6

Solution: A

(Explanation following in January 2024)

Question 7

Solution: C

(Explanation following in January 2024)

Subject Module

Computer Science

Exercise 3

(Following in January 2024)

The dMAT is offered by the Gesellschaft für Akademische Studienvorbereitung und Testentwicklung e.V. (Society for Academic Study Preparation and Test Development; g.a.s.t.). The worldwide organisation of the dMAT lies with the TestDaF Institut in Bochum.

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