

1.4 DATA TYPES & STRUCTURES · 1.4.3

Simplifying Boolean expressions & De Morgan's laws — expanded worksheet

Original practice questions · 40 marks · about 55 minutes · spec 1.4.3(a)(c)

Instructions. Answer all questions. Marks are shown in brackets []. Notation: $\cdot$ = AND, $+$ = OR, $\neg$ = NOT. When simplifying, state the rule used at each step where asked.

1

Total: 8 marks

X, Y and Z are Boolean variables (1 or 0). Complete the right-hand side of each rule of Boolean algebra.

$X \cdot 0 =$	
$X \cdot 1 =$	
$X \cdot X =$	
$X \cdot \neg X =$	
$X + 0 =$	
$X + 1 =$	
$X + X =$	
$X + \neg X =$	
$\neg(\neg X) =$	
$X \cdot (X + Y) =$	
$X + (X \cdot Y) =$	
$X \cdot (Y + Z) =$	

1 mark per 1½ correct rows (12 rows → 8 marks).

2

Total: 3 marks

- (a) Write De Morgan's first law (negation of an AND). _____ [1]
- (b) Write De Morgan's second law (negation of an OR). _____ [1]
- (c) State, in words, the two-step process De Morgan's law describes. _____ [1]

Simplify each expression to its simplest form (one line each — no working required).

(a) $A \cdot (B + 1)$ _____ [1]

(b) $\neg(\neg A + \neg B)$ _____ [1]

(c) $(A \cdot A \cdot B) + (A \cdot B \cdot B)$ _____ [1]

(d) $A + (\neg A \cdot B)$ _____ [1]

4

Total: 6 marks

Simplify each expression, **stating the rule used at each step**.

(a) $(A \cdot \neg B) + (A \cdot (B + C))$ [3]

(b) $A \cdot (A + B) + B$ [3]

5

Total: 6 marks

Complete the truth table to prove that $A + (\neg A \cdot B) = A + B$.

A	B	$\neg A$	$\neg A \cdot B$	$A + (\neg A \cdot B)$	$A + B$
0	0				
0	1				
1	0				
1	1				

The two right-hand columns are _____ for every row, which proves the identity.

6

Total: 7 marks

A logic circuit produces the output $F = A \cdot \neg B + A \cdot (B + C)$.

(a) Simplify F to its simplest form. _____ [3]

(b) Draw a logic circuit for the **simplified** expression. How many gates does it now need? [2]



(c) With reference to this example, explain why De Morgan's laws and the rules of Boolean algebra have commercial significance for hardware manufacturers. [2]

.....

.....

7

Total: 6 marks

Use De Morgan's laws and the rules of Boolean algebra to simplify each expression. Show your working.

(a) $\neg(A \cdot B) \cdot \neg(\neg A + B)$ [3]

.....

.....

.....

(b) $(A + B) \cdot (A + \neg B)$ [3]

.....

.....

.....

END OF WORKSHEET · 40 MARKS