

# Lesson 5: De Morgan's Laws

45 minutes

## Overview

### What are De Morgan's Laws?

Students learn about De Morgan's Laws and how they are applied to Boolean expressions. Students explore how equivalent Boolean expressions evaluate to the same value in all cases. Students then use truth tables to evaluate compound Boolean expressions and prove De Morgan's Laws.

## Standards

Full Course Alignment

### CSA Conceptual Framework

- **CON-1** - The way variables and operators are sequenced and combined in an expression determines the computed result.

## Agenda

### Warm Up (5 minutes)

#### Growth Reflection

### Activity (30 minutes)

#### De Morgan's Laws

#### Simplifying Boolean Expressions

### Wrap Up (10 minutes)

#### Closing the Loop

#### Assessment: Check for Understanding

#### AP Classroom Topic Questions

## Objectives

Students will be able to:

- Construct truth tables to evaluate Boolean expressions
- Evaluate compound Boolean expressions for equivalence
- Use truth tables to prove De Morgan's Laws

## Preparation

- Print copies of the De Morgan's Laws handout (one for each student)
- Check the **Teacher's Lounge** for verified teachers on the CSA Forum to find additional strategies or resources shared by fellow teachers

## Links

**Heads Up!** Please make a copy of any documents you plan to share with students.

For the students

- **De Morgan's Laws** - Handout
- **U4L5 Extra Practice** - Handout

## Vocabulary

- **De Morgan's Laws** - a set of rules that describe how to simplify complex Boolean expressions


## Teaching Guide

## Warm Up (5 minutes)

### Growth Reflection

#### Remarks

We have learned a lot about Java! Let's take a moment to reflect on what you know now compared to what you knew at the beginning of the year.

 **Discuss:** Click through the animated slide to display the prompts. Use the Retrieve-Pair-Share strategy to discuss the prompts.

- *What are things you now know how to do that you didn't know at the beginning of the year?*
- *What are you looking forward to learning more about?*

**Discussion Goal:** Students share the concepts and skills they have learned so far and any concepts they want to learn more about.

#### Teaching Tip


Encourage students to consider and celebrate how much they have grown and the knowledge they have gained in just a few units.


## Activity (30 minutes)

### De Morgan's Laws (10 minutes)

#### Remarks

As our Boolean expressions become more complex, we may need to find ways to make them easier to understand and make our programs run more efficiently.


 **Do This:** Review the lesson objectives.


 **Do This:** Click through the animated slide to demonstrate the truth tables for `!(A && B)` and `!A || !B`.

 **Discuss:** Use the Retrieve-Pair-Share strategy to discuss the prompt.

- *How can truth tables help us determine if two Boolean expressions are equivalent?*

**Discussion Goal:** Students realize that since the last column of the truth table shows the resulting Boolean values for the expression, they could compare the last column of both truth tables to check for equivalence.

 **Do This:** Define *De Morgan's Laws* and explain how to find equivalent expressions.

 **Do This:** Explain how to use truth tables to prove the Boolean expressions `!(A || B)` and `!A && !B` are equivalent.

#### Remarks

De Morgan's Laws can also be applied to Boolean expressions with relational operators.

 **Do This:** Click through the animated slide to demonstrate simplifying the Boolean expressions.

#### 💡 Teaching Tip

Have students predict the result before showing the equivalent expression.

## Simplifying Boolean Expressions (20 minutes)

### 🎤 Remarks

Let's use De Morgan's Laws to practice simplifying Boolean expressions and proving the equivalence of compound Boolean expressions.

**Group:** Place students in pairs.

**Distribute:** Give each student a copy of the De Morgan's Laws handout.

**Do This:** Explain the instructions for the Around the World activity.

1. Students find a station (they do not need to go in order).
2. Students follow the instructions at that station and complete the corresponding section of the De Morgan's Laws handout.
3. Students find another group who has completed the same station and explain their completed truth table to that group. The second group initials their handout if they agree with their solution. If they believe there is an error, the groups revise the truth table together before the second group signs off.
4. Students answer the question(s) in each section before moving to the next station.
5. Pairs repeat steps 1 through 4 for each station (or until the time is up).

#### 💡 Teaching Tip

As students work, circulate the room to check that they are successfully following the Around the World steps and are not getting stuck at a station.

Allow pairs who may need more time on each part to complete two stations instead of all four. Students should complete (A or B) AND (C or D).

**Discuss:** Look at your solution for Station A or B. Were the two expressions equivalent? How do you know?

**Discussion Goal:** Students note that the two expressions were equivalent at both Stations A and B because their resulting truth tables had the same final truth values.

#### 💡 Teaching Tip

Have students who did not complete both A and B look at a neighbor's solution.

## Wrap Up (10 minutes)

### Closing the Loop

### 🎤 Remarks

We have learned a lot about using conditionals and logical operators to evaluate multiple conditions. Let's recap some of the key concepts we have learned.

 **Discuss:** Click through the animated slide to display the prompts.

- *What are some differences between using nested `if` statements and using logical operators? What are some similarities?*
- *What are some scenarios you have encountered before where logical operators would have been useful?*
- *What were you confident about in this lesson? What would you like to practice?*

**Discussion Goal:** Students identify similarities and differences between nested `if` statements and logical operators. Both nested `if` statements and logical operators can be used to evaluate multiple conditions before executing a block of code. Logical operators make the process simpler and easier to read and maintain. Students suggest using logical operators to evaluate multiple conditions when analyzing data and making decisions about visualizations. Students share concepts from the lesson and the unit they are confident about and concepts they might be confused about.

 **Do This:** Review the concepts covered in this lesson.

 **Display:** Key Vocabulary

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## Assessment: Check for Understanding

*Check For Understanding Question(s) and solutions can be found in each lesson on Code Studio. These questions can be used for an exit ticket.*



Check for Understanding

## AP Classroom Topic Questions

To assign questions from the AP Classroom Question Bank that align with this lesson, create a custom quiz in AP Classroom by searching the Question Bank for the Essential Knowledge statements listed at the top of this lesson plan. You can find instructions and video demonstrations to do this on **AP Central**.

The following Topic Questions in AP Classroom can be assigned as a formative assessment for this lesson:

- Topic Questions 3.6

**Note:** *Some Learning Objectives and Essential Knowledge statements in the suggested Topic Questions are covered in later units.*



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