

TEACHER AND STUDENT RESOURCE

Logic Truth Tables and Circuits



DCS.L.1

Logic

Seven instructional sections. Thirty multiple-choice and thirty open or performance tasks, original mathematical visuals, generous workspaces, teaching scripts, and worked keys.

Free sample | Contents

DCS.L.1 | NC Discrete Mathematics for Computer Science mathematics

This sample contains 19 complete selected pages from the 97-page resource, plus this sample contents page. Original printed page numbers are retained. Gaps are intentional.

Included original pages: 1-15, 31-32, 61, 76

Representative activities

M01: sample PDF page(s) 16; original page(s) 15

M02: sample PDF page(s) 16; original page(s) 15

O01: sample PDF page(s) 17; original page(s) 31

O02: sample PDF page(s) 18; original page(s) 32

Selected teacher prompts and keys: original page(s) 61, 76

Using this sample

Read the preparation and access guidance before using a selected activity.
Keep teacher keys and private preparation pages separate from student copies.
Use the original resource contents to see the scope of the complete packet.

Complete paid download

The complete resource includes the full PDF task bank and teaching materials.

ALIGNMENT

Standard and learning targets

Evaluate mathematical logic to model and solve problems.

DCS.L.1.1 Construct truth tables that encode the truth and falsity of two or more statements.

DCS.L.1.2 Critique logic arguments (e.g., determine if a statement is valid or whether an argument is a tautology or contradiction).

DCS.L.1.3 Check 1s and 0s to determine whether a statement is true or false using Boolean logic circuits.

DCS.L.1.4 Judge whether two statements are logically equivalent using truth tables.

The decimal codes are the official objectives. All are represented in the item bank. These materials support several sessions, not one 60-task lesson.

NAVIGATION

Choose evidence deliberately

Warm-up: M01-M04 and O01-O04

I Do: M05-M08 and O05-O08

We Do: M09-M13 and O09-O13

Collaborative practice: M14-M18 and O14-O18

Independent practice: M19-M23 and O19-O23

Small-group reteach: M24-M27 and O24-O27

Exit ticket: M28-M30 and O28-O30

DCS.L.1.1: M01, M02, M03, M04, M05, M06, M07, M25, O01, O02, O03, O04, O26

DCS.L.1.2: M11, M12, M13, M14, M15, M16, M17, M18, M26, M27, O08, O09, O10, O11, O12, O13, O14, O15, O16, O29

DCS.L.1.3: M19, M20, M21, M22, M29, O17, O18, O19, O20, O21, O22, O23

DCS.L.1.4: M08, M09, M10, M23, M24, M28, M30, O05, O06, O07, O24, O25, O27, O28, O30

DAILY LEARNING TARGETS

A multi-session teaching path

Session 1 Build and interpret representations

Learning target: Construct truth tables that encode the truth and falsity of two or more statements. Critique logic arguments (e.g., determine if a statement is valid or whether an argument is a tautology or contradiction).

Use selected Warm-up and I Do tasks; compare an initial prediction with the worked model.

Session 2 Apply and explain methods

Learning target: Check 1s and 0s to determine whether a statement is true or false using Boolean logic circuits. Judge whether two statements are logically equivalent using truth tables.

Use We Do and collaborative tasks across the objectives. Require each learner to explain one mathematical choice.

Session 3 Transfer and collect independent evidence

Learning target: Apply the listed objectives with accurate representations, justified methods, and contextual checks.

Choose independent tasks covering each objective. Reteach an evidenced gap, then use a fresh exit task without answer-supplying cues.

PLANNING

Materials, access and pacing

Materials

Pencils, erasers, straightedge, printed tasks, and optional scratch paper. A calculator may support arithmetic after the method is stated. Use graph paper or movable labels when useful without supplying the requested construction.

Prerequisites

Binary truth values and reading parentheses in compound statements.

Pacing

Select two to four tasks for a session. Preserve first independent evidence, discuss a model, and revisit with a fresh task. The full banks are reusable choices, not a timed requirement.

Neutral access

Read directions aloud without identifying a method or answer. Enlarge diagrams, allow dictated or typed reasoning, and provide accessible tables. Preserve all mathematical conditions.

Keep evidence interpretable

Record neutral supports separately from answer-supplying cues. Retain first responses. A selected distractor is not by itself a diagnosis.

Conventions

1=true, 0=false; $\neg$ means NOT, $\wedge$ AND, $\vee$ inclusive OR, and $\rightarrow$ implication. Implication is false only for true antecedent and false consequent. Validity and equivalence require all relevant assignments. Circuit diagrams use labeled functional blocks; crossing wires do not connect without a node. $\text{NAND}(t,t)$ means the same signal feeds both inputs.

TEACHER MODEL

Keep premises and conclusion in the same row

Test $p \rightarrow q$ and q , therefore p , using all truth assignments.

p	q	$p \rightarrow q$	Both premises	Conclusion p
1	1	1	1	1
1	0	0	0	1
0	1	1	1	0
0	0	1	0	0

At $p=0, q=1$, both premises $p \rightarrow q$ and q are true while conclusion p is false. That one row proves invalidity. A false conclusion in a row with a false premise would not be a counterexample.

Think aloud: I first mark rows where all premises are true, then inspect the conclusion only in those rows. The truth table tests validity, not whether the story happens to be true.

REUSABLE REASONING GUIDE

Represent justify interpret

Givens and conditions

Model and calculation

Justification and independent check

Conclusion in context

WARM-UP

Teaching script

Core 001 | DCS.L.1.1

Collect a short first response before discussion. Ask learners what is given and which condition controls the method.

Display and ask

Construct the complete truth table for $p \wedge \neg q$ with columns $p, q, \neg q$, and final output. Use row order 11,10,01,00 and explain which row makes the expression true.

Work and discuss

Rows($p, q, \neg q, p \wedge \neg q$): (1,1,0,0),(1,0,1,1),(0,1,0,0),(0,0,1,0). Only $p=1, q=0$ makes both AND inputs true.

Listen for evidence

All assignments, an intermediate negation column, and the unique true case.

Probe and respond

Ask for an intermediate column or gate output. If a learner uses one matching row to claim equivalence, seek a differing row. For an invalid argument, require true premises and a false conclusion in the same row.

Next: use M01 for contrast after discussion. Select another task from M01-M04 or O01-O04 to check transfer. Record support and the new evidence separately.

I DO

Teaching script

Core 005 | DCS.L.1.4

Make a prediction before modeling. Think aloud through the core task, making each calculation and check visible.

Display and ask

Prove by truth tables that $p \rightarrow q$ and $\neg q \rightarrow \neg p$ are equivalent. Also compute the converse $q \rightarrow p$ and explain why it is different.

Work and discuss

Over 11,10,01,00, $p \rightarrow q$ gives 1,0,1,1; $\neg q \rightarrow \neg p$ gives 1,0,1,1; $q \rightarrow p$ gives 1,1,0,1. Original and contrapositive agree in all rows; the converse differs at 10 and 01.

Listen for evidence

Three correctly aligned columns and an all-row equivalence conclusion.

Probe and respond

Ask for an intermediate column or gate output. If a learner uses one matching row to claim equivalence, seek a differing row. For an invalid argument, require true premises and a false conclusion in the same row.

Next: use M05 for contrast after discussion. Select another task from M05-M08 or O05-O08 to check transfer. Record support and the new evidence separately.

WE DO

Teaching script

Core 009 | DCS.L.1.2

Ask learners to propose the next step and have a partner verify it against the original conditions.

Display and ask

Classify $(p \vee q) \wedge \neg(p \vee q)$, showing an intermediate column and the final truth values. Explain the general contradiction structure.

Work and discuss

Let $s = p \vee q$, whose column is 1,1,1,0. Then $\neg s$ is 0,0,0,1 and $s \wedge \neg s$ is 0,0,0,0. Thus it is a contradiction: no truth value can be both true and false in the same assignment.

Listen for evidence

Intermediate computation and all-false classification.

Probe and respond

Ask for an intermediate column or gate output. If a learner uses one matching row to claim equivalence, seek a differing row. For an invalid argument, require true premises and a false conclusion in the same row.

Next: use M09 for contrast after discussion. Select another task from M09-M13 or O09-O13 to check transfer. Record support and the new evidence separately.

COLLABORATIVE PRACTICE

Teaching script

Core O14 | DCS.L.1.2

Assign reader, modeler, checker, and explainer roles. Require a private first attempt before comparing approaches.

Display and ask

A learner argues $p \rightarrow q, \neg p$ therefore $\neg q$. Supply a valid counterexample, then explain why the row $p=1, q=0$ would not be an acceptable counterexample to this argument.

Work and discuss

At $p=0, q=1$, the implication and $\neg p$ are true, while $\neg q$ is false, so the argument is invalid. At 10, $p \rightarrow q$ is false and $\neg p$ is false; a row with false premises cannot witness invalidity.

Listen for evidence

Correct counterexample and a precise rejection of the proposed wrong row.

Probe and respond

Ask for an intermediate column or gate output. If a learner uses one matching row to claim equivalence, seek a differing row. For an invalid argument, require true premises and a false conclusion in the same row.

Next: use M14 for contrast after discussion. Select another task from M14-M18 or O14-O18 to check transfer. Record support and the new evidence separately.

INDEPENDENT PRACTICE

Teaching script

Core O19 | DCS.L.1.3

Provide only neutral access supports. Keep the first response and ask for justification without selecting a method.

Display and ask

Construct XOR using only AND, OR, and NOT. Draw the gate connections, give the expression, and verify all four input combinations.

Work and discuss

Use $z = (p \vee q) \wedge \neg(p \wedge q)$. One OR and one AND receive p, q ; negate the AND output; combine it with the OR output using a final AND. Over 11,10,01,00, outputs 0,1,1,0. Thus exactly one true input activates z .

Listen for evidence

Complete circuit structure and full truth-table verification.

Probe and respond

Ask for an intermediate column or gate output. If a learner uses one matching row to claim equivalence, seek a differing row. For an invalid argument, require true premises and a false conclusion in the same row.

Next: use M19 for contrast after discussion. Select another task from M19-M23 or O19-O23 to check transfer. Record support and the new evidence separately.

SMALL-GROUP RETEACH

Teaching script

Core O24 | DCS.L.1.4

Use the earlier work to identify a specific gap. Model that connection, then remove the cue on a fresh item.

Display and ask

Two expressions match on rows 11,10,00 but have not been tested on 01. Construct a pair that fits those observations yet is not equivalent, and evaluate the untested row.

Work and discuss

Choose p and $p \vee q$. At 11 both 1; at 10 both 1; at 00 both 0. At 01, $p=0$ but $p \vee q=1$, so they differ. Matching on three rows is still insufficient without the fourth.

Listen for evidence

A valid constructed pair matching exactly the stipulated observations and a decisive missing-row test.

Probe and respond

Ask for an intermediate column or gate output. If a learner uses one matching row to claim equivalence, seek a differing row. For an invalid argument, require true premises and a false conclusion in the same row.

Next: use M24 for contrast after discussion. Select another task from M24-M27 or O24-O27 to check transfer. Record support and the new evidence separately.

EXIT TICKET

Teaching script

Core O28 | DCS.L.1.4

Collect a concise claim and supporting computation before showing the key. Use the evidence to select a next task.

Display and ask

Simplify $p \vee (p \wedge q)$ using a complete truth table, then describe how this removes unnecessary gates from a circuit without changing its function.

Work and discuss

Over 11,10,01,00 the expression outputs 1,1,0,0, exactly p . Therefore the AND branch and final OR can be replaced by a direct p signal. This preserves all four possible input outputs, not just one tested case.

Listen for evidence

All-row equivalence and a function-preserving circuit simplification.

Probe and respond

Ask for an intermediate column or gate output. If a learner uses one matching row to claim equivalence, seek a differing row. For an invalid argument, require true premises and a false conclusion in the same row.

Next: use M28 for contrast after discussion. Select another task from M28-M30 or O28-O30 to check transfer. Record support and the new evidence separately.

MULTIPLE-CHOICE BANK

M01 / M02 Select and justify**M01 | Warm-up | DCS.L.1.1****If $p=1$ and $q=0$, what is the pair $(p \wedge q, p \vee q)$?**

- A. (0,0)
- B. (0,1)
- C. (1,0)
- D. (1,1)

Reasoning: _____

M02 | Warm-up | DCS.L.1.1**For inclusive OR, what is $1 \vee 1$?**

- A. 1, because at least one input is 1.
- B. 2, because the inputs add.
- C. Undefined, because the inputs match.
- D. 0, because both inputs are 1.

Reasoning: _____

WARM-UP

001 Show your reasoning

DCS.L.1.1 | Construct truth tables that encode the truth and falsity of two or more statements.

Construct the complete truth table for $p \wedge \neg q$ with columns $p, q, \neg q$, and final output. Use row order 11,10,01,00 and explain which row makes the expression true.

Representation and calculation

Explanation and check

WARM-UP

002 Show your reasoning

DCS.L.1.1 | Construct truth tables that encode the truth and falsity of two or more statements.

Build a three-variable truth table for $(p \wedge q) \vee r$ using row order 111,110,101,100,011,010,001,000. Show the inner AND column before the output.

Representation and calculation

Explanation and check

WORKED TEACHER KEYS

M01 / M02**M01 | DCS.L.1.1****Answer B: (0,1)**

$p \wedge q = 1$ AND $0 = 0$; $p \vee q = 1$ OR $0 = 1$.

- A. OR is 1 because p is 1.
- B. Correct. AND needs both inputs 1; inclusive OR needs at least one.
- C. This reverses the connective rules.
- D. AND is 0 because q is 0.

Evidence: Apply the two distinct connective rules.

M02 | DCS.L.1.1**Answer A: 1, because at least one input is 1.**

Inclusive OR is false only when both inputs are 0.

- A. Correct. "At least one" includes both.
- B. Boolean OR produces a truth bit, not ordinary addition.
- C. OR is defined for every pair of truth bits.
- D. That is exclusive OR, not inclusive OR.

Evidence: Distinguish Boolean OR from XOR and arithmetic addition.

WORKED TEACHER KEYS

001 / 002**001 | DCS.L.1.1**

Rows($p, q, \neg q, p \wedge \neg q$): (1,1,0,0), (1,0,1,1), (0,1,0,0), (0,0,1,0). Only $p=1, q=0$ makes both AND inputs true.

Evidence: All assignments, an intermediate negation column, and the unique true case.

002 | DCS.L.1.1

The $p \wedge q$ column is 1,1,0,0,0,0,0,0. Final outputs are 1,1,1,0,1,0,1,0. In any row with $r=1$ the OR is true; with $r=0$ the output equals $p \wedge q$.

Evidence: Eight exhaustive rows and a correct intermediate column.