Tutorial – Mathematics for Social Scientists

Winter semester 2024/25

Basics and Preliminaries

GitHub: https://github.com/joerdisstrack/tutorial_mathematics_social_science

To do

- introduction: problem sets
- weekly recap
  - basics and preliminaries
  - intro to algebra
- hands on practice
- questions

Introduction

Problem Sets:

- There will be four problem sets throughout the semester, each is worth 12.5% of your final grade
- There will be 1 PS for each main block:
  - Algebra – 05/11/2024
  - Calculus ID – 26/11/2024
  - Probability – 07/01/2025
  - Multivariate Calculus – 21/01/2025

- Note that these dates are preliminary and may change throughout the semester

POL-30410: Mathematics for Social Scientists
WiSe 2024-2025

October 2024						
S	M	T	W	T	F	S
		1	2	3	4	5
6	7	8	9	10	11	12
13	14	15	16	17	18	19
20	21	22	23	24	25	26
27	28	29	30	31		

November 2024						
S	M	T	W	T	F	S
					1	2
3	4	5	6	7	8	9
10	11	12	13	14	15	16
17	18	19	20	21	22	23
24	25	26	27	28	29	30

December 2024						
S	M	T	W	T	F	S
1	2	3	4	5	6	7
8	9	10	11	12	13	14
15	16	17	18	19	20	21
22	23	24	25	26	27	28
29	30	31				

January 2025						
S	M	T	W	T	F	S
			1	2	3	4
5	6	7	8	9	10	11
12	13	14	15	16	17	18
19	20	21	22	23	24	25
26	27	28	29	30	31	

February 2025						
S	M	T	W	T	F	S
						1
2	3	4	5	6	7	8
9	10	11	12	13	14	15
16	17	18	19	20	21	22
23	24	25	26	27	28	

March 2025						
S	M	T	W	T	F	S
						1
2	3	4	5	6	7	8
9	10	11	12	13	14	15
16	17	18	19	20	21	22
23	24	25	26	27	28	29
30	31					

DATE	DESCRIPTION	MOORE & SIEGEL	
22/10/24	Introduction and Course Overview Preliminaries	1	
29/10/24	Algebra Review	2	
05/11/24	Functions, Relations, & Utility Limits and Continuity, Sequences & Series, More On Sets	3-4	
12/11/24	Calculus Fundamentals (Differentiation)	5-6	I
19/11/24	The Integral	7	
26/11/24	Extrema in One Dimension	8	
03/12/24	An Introduction to Probability	9	II
10/12/24	Discrete Distributions	10	
17/12/24	Continuous Distributions	11	
07/01/25	Introduction to Linear Algebra	12	III
14/01/25	Vector Spaces and Systems of Equations	13	
21/01/25	Eigenvalues and Markov Chains	14	
28/01/25	Introduction to Multivariate Calculus	15	IV
04/02/25	Multivariate Optimization	16	
20/02/25	Exam		
21/03/25	Resit Exam		

Introduction

Problem Sets:

- You have 1 week to complete each PS and to hand in a **scan** in **pdf format** via Ilias **within** the deadline
- You should name your file → PSX_matrikelnr.pdf e.g. PS1/1234567
- Please write your last name and matrikel nr. /Student ID on the last page of your paper version before you scan it

Introduction

There are a bunch of good helping hands out there to support your learning process:

- Wolfram Alpha
- Symbolab
- R, python, MATLAB
- Chat GPT
- GeoGebra
- etc…

→ Do NOT rely on these too much! You CANNOT use them during the exam

Chapter 1 | Preliminaries

Preliminary vocab

Theory

- a set of statements involving concepts and concern relationships among abstract concepts

Statements

- comprise assumptions, propositions, corollaries, and hypotheses

Assumptions are asserted by us

- **propositions** and corollaries are deduced from these assumptions
  - **hypotheses** are derived from these deductions and then empirically challenged

Preliminary vocab

Concepts

- inventions that human beings create to help them understand the world and may take on different values

Variables

- indicators we develop to measure our concepts
- mathematically they take on different values in given sets

Constants

- concept or a measure that has a single value for a given set

Sets

- describe variables as **discrete** or **continuous**
- **discrete**
  - a variable is discrete if each one of its possible values can be associated with a single integer
- **continuous**:
  - a variable is continuous if its values cannot be assigned a single integer

  → typically assumed to be drawn from subset of real numbers

- sets give the domain – the range of values – a concept may take

Table 1.1: Common Sets

Notation	Meaning
$\mathbb{N}$	Natural numbers
$\mathbb{Z}$	Integers
$\mathbb{Q}$	Rational numbers
$\mathbb{R}$	Real (rational and irrational) numbers
$\mathbb{C}$	Complex numbers
Subscript: $\mathbb{N}_+$	Positive (negative) values of the set
Superscript: $\mathbb{N}^d$	Dimensionality (number of dimensions)

Moore and Siegel, 2013, p. 5

Types of sets

Solution set

- all solutions to a problem

Sample space

- contains all values a variable can take on

Spaces

- sets with some structure – e.g. the difference between elements in $\mathbb{Z}$

Finite sets

- have fixed cardinality – e.g. all integers between 1 and 10

Infinite sets … do not

- all numbers in $\mathbb{Z}$

Uncountable sets

- cannot be classified using cardinality – e.g. all decimal numbers between 1 and 3

Tuple

- an ordered pair

Singleton

- only one element

Empty set

- contains no element

Universal set

- contains ALL elements

Ordered sets

- order of elements must be maintained

Unordered sets

- order does not matter

Operators

The classics:

- addition, subtraction, multiplication, division

Sum operator

$$\sum_{i}^{n} x_i$$

- the sum of x_i over the range from $i = 1$ through $i = 4$

$$\sum_{i=1}^{4} x_{i=1+2+3+4=10}$$

Multiplication operator

$$\prod_{i}^{n} x_i$$

- the product of x_i over the range from $i = 1$ through $i = 4$

$$\prod_{i=1}^{4} x_i = 1 \cdot 2 \cdot 3 \cdot 4 = 24$$

Set operators

Union

- $A \cup B$

Intersection

- $A \cap B$

Difference

- $A \setminus B$

Complement

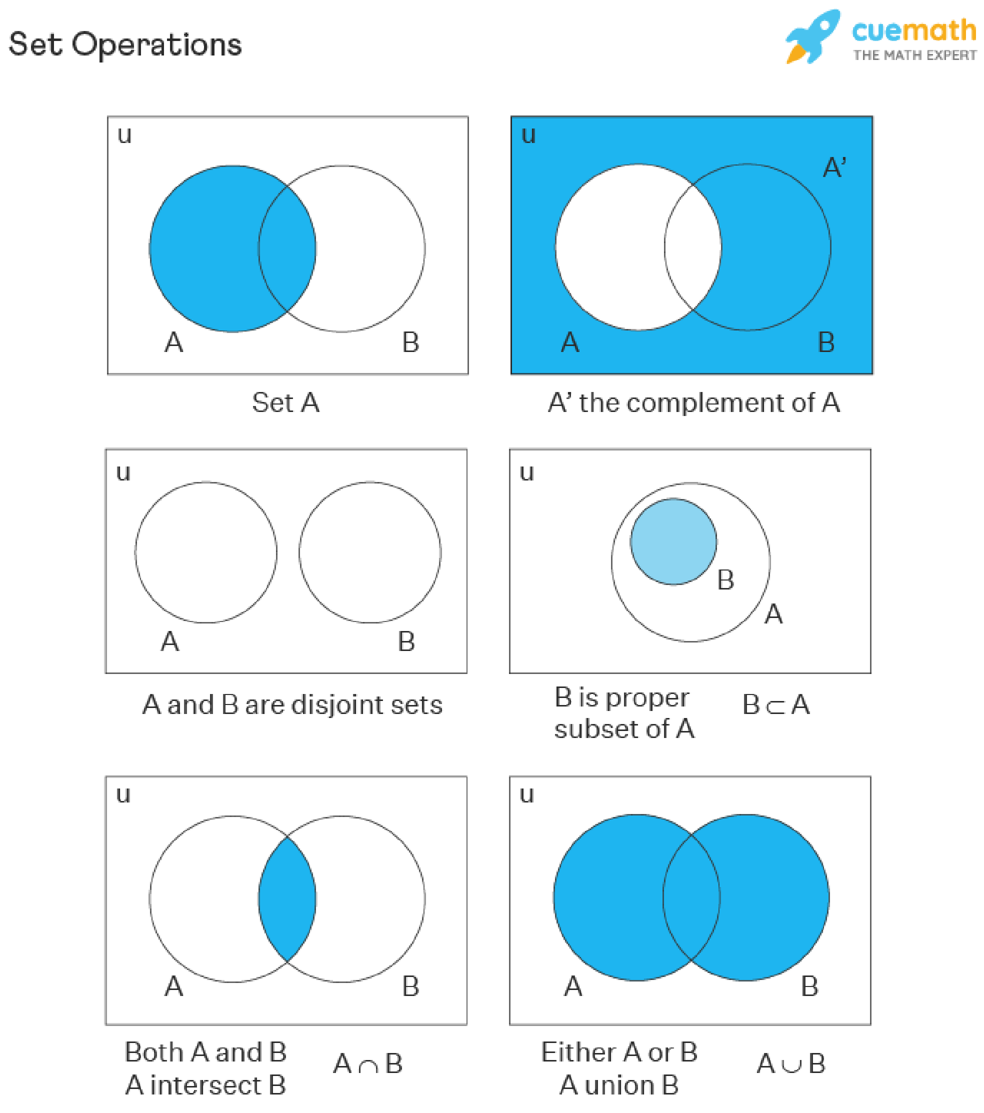
- $\neg B$

Partition P of M

- $P = \{\{blue\}, \{green\}\}\ and\ M = \{blue, green\}$

Cartesian Product

- $A \times B$



Hands on – Set operators

Task: Let $A = \{1, 3, 5, 7, 9\}$, $B = \{2, 4, 6, 8, 10\}, C = \{2, 5, 8, 9\}$ from the universal set U= $\{1, 2, 3, 4, 5, 6, 7, 8, 9, 10\}$. Assuming that we do not include the same number as duplicates, find the following:

- $A \cap C$
- $A \cup C$
- $B \cap C$
- $A \setminus C$
- $\neg B$
- $(A \cup C) \setminus \mathrm{B}$
- $(A \cap B) \setminus C$
- $\neg (A \cup C)$

Hands on – Set operators

Solution:

- $A \cap C = \{5, 9\}$
- $A \cup C = \{1, 2, 3, 5, 7, 8, 9\}$
- $B \cap C = \{2, 8\}$
- $A \backslash C = \{1, 3, 7\}$
- $\neg B = A$
- $(A \cup C) \backslash \mathrm{B} = A$
- $(A \cap B) \backslash C = \{\quad\}$
- $\neg(A \cup C) = \{4, 6, 10\}$

Hands on – Partitions

Task: Find all partitions of $M = \{1, 3, 5\}$

Hands on – Partitions

Solution: M has five partitions:

- $P_1 = \{\{1,3,5\}\}$
- $P_2 = \{\{1\},\{3,5\}\}$
- $P_3 = \{\{3\},\{1,5\}\}$
- $P_4 = \{\{5\},\{1,3\}\}$
- $P_5 = \{\{1\},\ \{3\},\ \{5\}\}$

Set operators

Mutually exclusive

- intersection equal to the empty set, i.e., sets with no elements in their intersection

Collectively exhaustive

- a group of sets is collectively exhaustive if together the sets constitute the universal set

Relations

- **used to compare** variables, constants and concepts via >, ≥, ≤, <, =, ≠
- **binary relation**
  - ordered by size (a, b) or a > b

- **functions** are relations, too!
- **consider a function f(x)**
  - **domain**
    → The domain consists of all possible values that x can take on
  - **range**
    → The range consists of all possible values y takes on given x

Level of measurement

Difference of kind

- nominal – distinction by name, type [Greens, SPD, CDU, …]

Difference of degree

- ordinal – distinction by order, size [language ability on your CV]
- interval – same difference between each element [$\mathbb{Z}$ - set of all integers, temperature]
- ratio – ‚meaningful‘ or true 0 as starting point [length in metres]

	Distinct categories	Meaningful order	Equal spacing	True zero
Nominal	✓			
Ordinal	✓	✓		
Interval	✓	✓	✓	
Ratio	✓	✓	✓	✓

Proofs

Axioms and assumptions

- stated to begin and assumed as true

Proposition

- considered as true based on prior assumptions

Theorem

- a proven proposition

Lemma

- a theorem of ‚little interest‘ used as a prior step to solve another problem

Corollary

- proposition following from the proof of a 2nd proposition which requires no further proof

Proofs

Direct proofs

- proof by deduction
- proof by exhaustion
- proof by construction
- proof by induction

Indirect proofs

- counterexample
- contradiction

Proof by induction

Initial step

- provide base case for assumption $A(1)$
- necessary to show validity often for n = 1

Inductive hypothesis

- assume that $A(n)$ for $n \in \mathbb{N}$ is true
- this step requires no computation, it can be a sentence you learn by heart ☺

Inductive step

- increment n by one and prove that $A(n+1)$ is true

→ if case is true for both n and $n+1$ we know our case is true for $\mathrm{n} \in \mathbb{N}$

Proof by induction

Let's look at Gauss $\sum_{k=0}^{n} k = \frac{n \cdot (n+1)}{2}$ holds for $\forall\, n \in \mathbb{N}$

Initial step for $n = 1$

$$\sum_{k=0}^{1} 0 + 1 = \frac{1 \cdot (1+1)}{2} = 1$$

Inductive hypothesis

→ statement A(n) holds for any $n \in \mathbb{N}$

Inductive step for $n + 1$

$$\sum_{k=0}^{n+1} k = (n+1) + \sum_{k=0}^{n} k = (n+1) + \frac{n \cdot (n+1)}{2}$$

$$= \frac{2\,(n+1)}{2} + \frac{n\,(n+1)}{2} = \frac{2\,(n+1) + n(n+1)}{2} = \frac{(n+2)(n+1)}{2}$$

Proof by induction – an example

$$\frac{n(n+1)}{2}$$

1. Initial step: $n=1$ $\quad \sum_{k=0}^{1} k = 0+1 = \frac{1(1+1)}{2} = \frac{2}{2} = 1$

2. Inductive hypothesis: $\quad \sum_{k=0}^{n} k = \frac{n(n+1)}{2}$ holds $\forall n \in \mathbb{N}$

3. Inductive step: for $n+1$

$$\sum_{k=0}^{n+1} k = (n+1) + \sum_{k=0}^{n} k = \frac{(n+1)}{1} + \frac{n(n+1)}{2} = \frac{2(n+1)}{2} + \frac{n(n+1)}{2} \to (n+2)(n+1)$$

$$2n + 2 + n^2 + n$$

$$= \frac{2(n+1) + n(n+1)}{2} = \frac{(n+2)(n+1)}{2} = \frac{(n+1)((n+1)+1)}{2}$$

Chapter 2 | Algebra

Algebraic properties

Associative properties

- $a + (b + c) = (a + b) + c$ and $a(b \cdot c) = (a \cdot b)c$

Commutative property

- $a + b = b + a$ and $a \cdot c = c \cdot a$

Distributive property

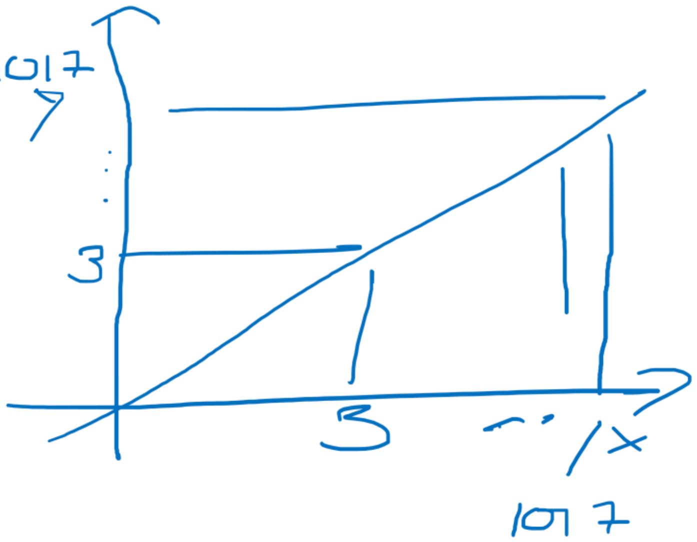
- $a(b + c) = ab + ac$

Identity property

- there exists a zero such that $x + 0 = x$ and $x \cdot 1 = x$

Inverse property

- there exists a $-x$ such that $-x \ \cdot x = 0$ and $x^{-1} \cdot x = 1$



FOIL and PEMDAS

FOIL

→ First, Outer, Inner, Last

$$(3y-4)(5+2y)=3y\cdot 5=15y$$
$$(3y-4)(5+2y)=3y\cdot 2y=6y^2$$
$$(3y-4)(5+2y)=(-4)\cdot 5=(-20)$$
$$(3y-4)(5+2y)=(-4)\cdot 2y=(-8y)$$
$$=15y+6y^2-20-8y$$
$$=6y^2+7y-20$$

PEMDAS

→ Please Excuse My Dear Aunt Sally

1) Parentheses
2) Exponents
3) Multiplication
4) Division
5) Addition
6) Subtraction

Ratios, proportions and percentages

Ratio of x to y = $\frac{x}{y}$

→ may be negative, range typically between 0 and ∞

Proportion of x and y = $\frac{x}{x+y}$

→ ranges from 0 to 1

Percentage $\frac{x}{x+y} \cdot 100$

→ ranges from 0 to 100

Proportional change $\frac{x_{t+1}-x_t}{x_t}$

→ $\frac{80.3-75.4}{75.4} \cdot 100 \cong 6.5\%$ ← **percentage change** ☺

Fractions

Addition

Same denominator

$$\frac{a}{b}+\frac{c}{b}=\frac{a+c}{b}$$

Different denominator

$$\frac{a}{b}+\frac{c}{d}=\frac{a\cdot d}{b\cdot d}+\frac{c\cdot b}{d\cdot b}=\frac{ad+cb}{bd}$$

Subtraction

Same denominator

$$\frac{a}{b}-\frac{c}{b}=\frac{a-c}{b}$$

Different denominator

$$\frac{a}{b}-\frac{c}{d}=\frac{a\cdot d}{b\cdot d}-\frac{c\cdot b}{d\cdot b}=\frac{ad-cb}{bd}$$

Multiplication

$$\frac{a}{b}\cdot\frac{c}{d}=\frac{ac}{bd}$$

Division

$$\frac{a}{b}:\frac{c}{d}=\frac{a}{b}\cdot\frac{d}{c}=\frac{ad}{bc}$$

Fractions

Expanding fractions

$$\frac{a}{b} = \frac{a}{b} \cdot \frac{e}{e} = \frac{ae}{be}$$

What about double fractions?

$$\frac{\frac{a}{b}}{c} = \frac{\frac{a}{b} \cdot b}{c \cdot b} = \frac{a}{cb}$$

or…

$$\frac{\frac{a}{b}}{\frac{c}{1}} = \frac{a \cdot 1}{c \cdot b} = \frac{a}{cb}$$

→ let‘s build ‚bridges‘

Shortening fractions

$$\frac{a}{b} = \frac{c \cdot e}{d \cdot e} = \frac{c}{d}$$

$$\frac{\frac{a}{b}}{\frac{c}{d}} = \frac{a \cdot d}{c \cdot b} = \frac{ad}{bc}$$

$$\frac{\frac{a}{b}}{\frac{c}{d}}$$

Factoring

Algorithm:

1) Look for **common factors** and ‚factor them out‘
2) Check if a **binomial/identity** applies
3) **Repeat steps 1** and **2** until completion

$$(a+b)(a-b) = (a-b)^2$$
$$(a+b)(a+b) = a^2 + 2ab + b^2$$
$$(a-b)(a-b) = a^2 - 2ab + b^2$$
$$(a+b)(a^2 - ab + b^2) = a^3 + b^3$$
$$(a-b)(a^2 + ab + b^2) = a^3 - b^3$$
$$a^3 + 3a^2b + 3ab^2 + b^3 = (a+b)^3$$
$$a^3 - 3a^2b + 3ab^2 - b^3 = (a-b)^3$$

Factoring

$$4z^2 + 20z$$
$$= \; 4(z^2 + 5z)$$
$$= \; 4z(z + 5)$$

Both of these are correct!

→ we often choose the version without exponent

$$9z^2 - 36$$
$$= \; (9z)^2 - 6^2$$
$$= \; (9z + 6)(9z - 6)$$

It may come in handy to know certain factor identities and (quadratic) binomials

→ $(a + b)(a - b) = \; (a - b)^2$

Quadratic polynomials

Typically of form: $ax^2 + bx + c = 0$

→note that a cannot be 0!

Quadratic formula

$$x_{1,2} = \frac{-b \pm \sqrt{b^2 - 4ac}}{2a}$$

p/q formula

$$x_{1,2} = -\frac{p}{2} \pm \sqrt{\left(\frac{p}{2}\right)^2 - q}$$

Fun with quadratic binomials… ☺

Binomial formulas

$$(a+b)^2 = a^2 + 2ab + b^2$$

$$(a-b)^2 = a^2 - 2ab + b^2$$

$$(a+b)(a-b) = a^2 - b^2$$

Binomial theorem

$$(a+b)^n = \sum_{k=0}^{n} \binom{n}{k} a^{n-k} b^k$$

Binomial coefficient

Solving… the square

Algorithm:

1) Divide by quadratic‘s coefficient and move constant to RHS
2) Divide x‘s coefficient by 2, square it and add it to both sides of the equation
3) Factor LHS into $(a \pm b)^2$ and simplify RHS
4) Take square root of both sides
   → remember: Solution on RHS will be of sign $\pm$
5) Solve for x

Solving… the square

1) Divide by quadratic‘s coefficient and move constant to RHS
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5) Solve for x

$$4x^2 + 18x + 8 = 0 \,|\, \div 4$$

$$x^2 + \frac{18}{4}x + 2 = 0 \,|\, -2$$

$$x^2 + \frac{18}{4}x = -2 \,|\, + \left(\frac{\frac{18}{4}}{\frac{2}{1}}\right)^2$$

$$x^2 + \frac{18}{4}x + \left(\frac{18}{8}\right)^2 = -2 + \left(\frac{18}{8}\right)^2$$

$$(x + 2.25)^2 = 3.0625 \,|\sqrt{}$$

$$x + 2.25 = \pm 1.75 \,|\, -2.25$$

$$x_1 = -0.5$$

$$x_2 = -4$$

Solving... the square

$4x^2 + 18x + 8 = 0 \quad | :4$

$x^2 + \frac{18}{4}x + 2 = 0 \quad | -2$

$x^2 + \frac{18}{4}x = -2 \quad | + \left(\frac{\frac{18}{4}}{2}\right)^2 \rightarrow \left(\frac{18}{8}\right)^2 \rightarrow (2.25)^2 \rightarrow 5.0625$

refactor!

$x^2 + \frac{18}{4}x + \left(\frac{18}{8}\right)^2 = -2 + \left(\frac{18}{8}\right)^2 \quad |$

$(x + 2.25)^2 = 3.0625 \quad | \sqrt{\ }$

$x + 2.25 = \pm 1.75 \quad | -2.25$

$x_1 = -0.5$

$x_2 = -4$

it is often easy to refactor this expression into (a + b)^2, if you consider that it extends to a^2 + 2ab + b^2. If x takes on the value b, then the coefficient before x divided by 2, must be a!

and $\frac{18}{4} = 4.5$

$4.5 : 2 = 2.25$

so : $(x + 2.25)^2$

$= x^2 + 2 \cdot 2.25x + 2.25^2$

$= x^2 + 4.5x + 5.0625$

$= x^2 + \frac{18}{4}x + \left(\frac{18}{8}\right)^2$

Hands on – completing the square & quadratics

Task: Complete the square and apply the quadratic formula!

1) $x^2 - 3x + 2$

2) $x^2 + 10x + 16$

3) $x^2 + x \ - 12$

Hands on – completing the square & quadratics

- Solve the square for: $x^2 - 3x + 2$

$$1)\quad 1x^2 - 3x + 2 = 0 \qquad | -2$$

$$x^2 - 3x = (-2) \qquad | + \left(-\frac{3}{2}\right)^2 \rightarrow (-1.5)^2$$

$$x^2 - 3x + 2.25 = (-2) + 2.25$$

again: you arrive at the stand in for (a – b)^2, if you divide the coefficient before the x by 2

$$(x - 1.5)^2 = 0.25 \qquad | \sqrt{\ }$$

$$x - 1.5 = \pm 0.5 \qquad | + 1.5$$

$$x_1 = 2$$

$$x_2 = 1$$

//

1) Divide by quadratic‘s coefficient and move constant to RHS
2) Divide x‘s coefficient by 2, square it and add it to both sides of the equation
3) Factor LHS into $(a \pm b)^2$ and simplify RHS
4) Take square root of both sides
   → remember: Solution on RHS will be of sign $\pm$
5) Solve for x

Hands on – completing the square & quadratics

2) $x^2 + 10x + 16 = 0 \quad | -16$

$x^2 + 10x = -16 \quad | + \left(\frac{10}{2}\right)^2 = 5^2 = 25$

$x^2 + 10x + 25 = (-16) + 25$

$(x+5)^2 = 9 \quad | \sqrt{\ }$

$x + 5 = \pm 3 \quad | -5$

$x_1 = -8$

$x_2 = -2$ //

3) $x^2 + x - 12 = 0 \quad | +12$

$x^2 + x = 12 \quad | + \left(\frac{1}{2}\right)^2 = 0.5^2 = 0.25$

$x^2 + x + 0.25 = 12 + 0.25$

$(x + 0.5)^2 = 12.25 \quad | \sqrt{\ }$

$x + 0.5 = \sqrt{12.25}$

$x + 0.5 = \pm 3.5 \quad | -0.5$

$x_1 = -4$

$x_2 = 3$ /

Hands on – completing the square & quadratics

Solution:

1) $x^2 - 3x + 2$
$\rightarrow x = 2 \; or \; x = 1$

2) $x^2 + 10x + 16$
$\rightarrow x = (-8) \; or \; x = (-2)$

3) $x^2 + x \; - 12$
$\rightarrow x = 3 \; or \; x = (-4)$

Hands on – Factoring and fractions

Task:

1) $\frac{9}{x+4} = 7$

2) $\frac{x-5}{x-2} = 1 - \frac{x+1}{x-2}$

3) Factor: $2x + 4$

4) Factor: $5x + 10xy$

Hands on – Factoring and fractions

Solution:

1) $\frac{9}{x+4} = 7$

2) $\frac{x-5}{x-2} = 1 - \frac{x+1}{x-2}$

$$\frac{9}{x+4} = 7 \mid \cdot (x+4)$$

$$9 = 7 \cdot (x+4)$$

$$9 = 7x + 28 \mid -28$$

$$-19 = 7x$$

$$x = -\frac{19}{7}$$

$$\frac{x-5}{x-2} = 1 - \frac{x+1}{x-2} \mid \cdot (x-2)$$

$$x - 5 = x - 2 - (x+1)$$

$$x - 5 = x - 2 - x - 1$$

$$x - 5 = -3 \mid +5$$

$$x = 2 \rightarrow \emptyset$$

Hands on – Factoring and fractions

Solution:

3) Factor: $2x + 4$

→$2(x + 2)$

→$4(0.5x + 1)$

…

4) Factor: $5x + 10xy$

→$5(x + 2xy)$

→$5\mathrm{x}(1 + 2\mathrm{y})$

→$\mathrm{x}(5 + 10\mathrm{y})$

…

Solving…

Equations

1) Focus on variable of interest
2) Combine like terms
3) Check your answer
4) Make use of identities
5) Note: Equivalent transformation!!
   → execute same operation on each side

$$2x - 6 = 4 \mid +6$$
$$2x = 10 \mid \div 2$$
$$x = 5$$

Inequalities

←do the same thing…

But whenever you multiply or divide by a negative number – flip the inequality symbol!

$$2x - 6 > 4 \mid +6$$
$$2x > 10 \mid \div 2$$
$$x > 5$$

$$-2x - 6 > 4 \mid +6$$
$$-2x > 10 \mid \div (-2)$$
$$x < -5$$

Modulo – Division with Remainder

Idea: Sometimes, we are **not interested** in a **fractions/decimal** numbers as a **result of division**

Solution: Inspect the **remainder** after division!

We use modulo to find this remainder after division:

- **4 mod 3 = 4 % 3 = 1** → if we divide 4 by 3, 3 fits into 4 one time, with a **single 1** being left over… this is the **remainder**!

What does congruence mean?

- two numbers a and b are congruent mod n, if they have the same remainder when divided by n!
- $a \equiv b \ (mod\ n) \rightarrow 5 \equiv 9 \ (mod\ 4)$

Real World Applications - Modulo

- **Hash functions** in algorithms, e.g. sorting
  - set array of fixed size 10 and sort elements from 'bucket' into it
  - for each element key, calculate index = key % 10
  - → if slot empty, place element key there or handle collisions
- **Shuffling algorithms** to e.g. systematically shift numbers
- **Cryptography**

- **Time series data** and **Cyclical data**
  - use modulo operations to **identify** the **date of the week**
  - 0 = Sunday, 1 = Monday, ..., 6 = Saturday:
  - set **reference date** like October 27th 2024 ← Sunday
  - for **new date** i: day-difference % 7 = |27 – i| % 7 = day of the week
  - considering today: |27 – 31| % 7 = 4 mod 7 = 4 → Thursday!

Boolean Arithmatic

Input: Boolean Values

- True (1) and False (0)

Basic Boolean Operators:

- AND ∧: Returns True only if both inputs are True!
  →1 AND 1 = 1, any other input combination yields 0
- OR ∨: Returns True if at least one input is True → 1 OR 1 = 1, 1 OR 0 = 1, 0 OR 1 = 1, and only 0 OR 0 = 0
- NOT ¬ : Inverts the value:
  NOT 1 = 0 and NOT 0 = 1.

- **Combination of Operators:**
  - combine operators to form complex expressions, which are evaluated in a specific order

- **Implication A → B :**
  - meaning "If A, then B“
  - our implication is false only if A is true and B is false; otherwise, it’s true
  - we do not care about anything else happening next to B!
    → but based on the implication, if A happens, B must follow suit!

Boolean Arithmatic

Task: You are a social scientist and want to analyse voting behaviour in a group of lawmakers on a recent policy vote on climate change. Lawmakers' support might depend on two main conditions:

- **A**: The lawmaker aligns with the ruling party's position on climate change
- **B**: The lawmaker's constituents (main group of voters) support the climate change policy

How do these influence, whether the lawmaker votes ‘Yes’ on the policy?

Based on your observations, the following **rule of voting V** holds: A lawmaker votes in favour of the climate change policy if they align with the ruling party or if their constituents support the policy, unless neither condition is met.

Create a truth table and fill in all possible outcomes!

Boolean Arithmatic

Hints:

1. Formulate an implication
2. Setup your truth table
3. Fill it in!

A: Support Party	B: Support Voters	V: Votes Yes
1	1	
1	0	
0	1	
0	0	

Boolean Arithmatic

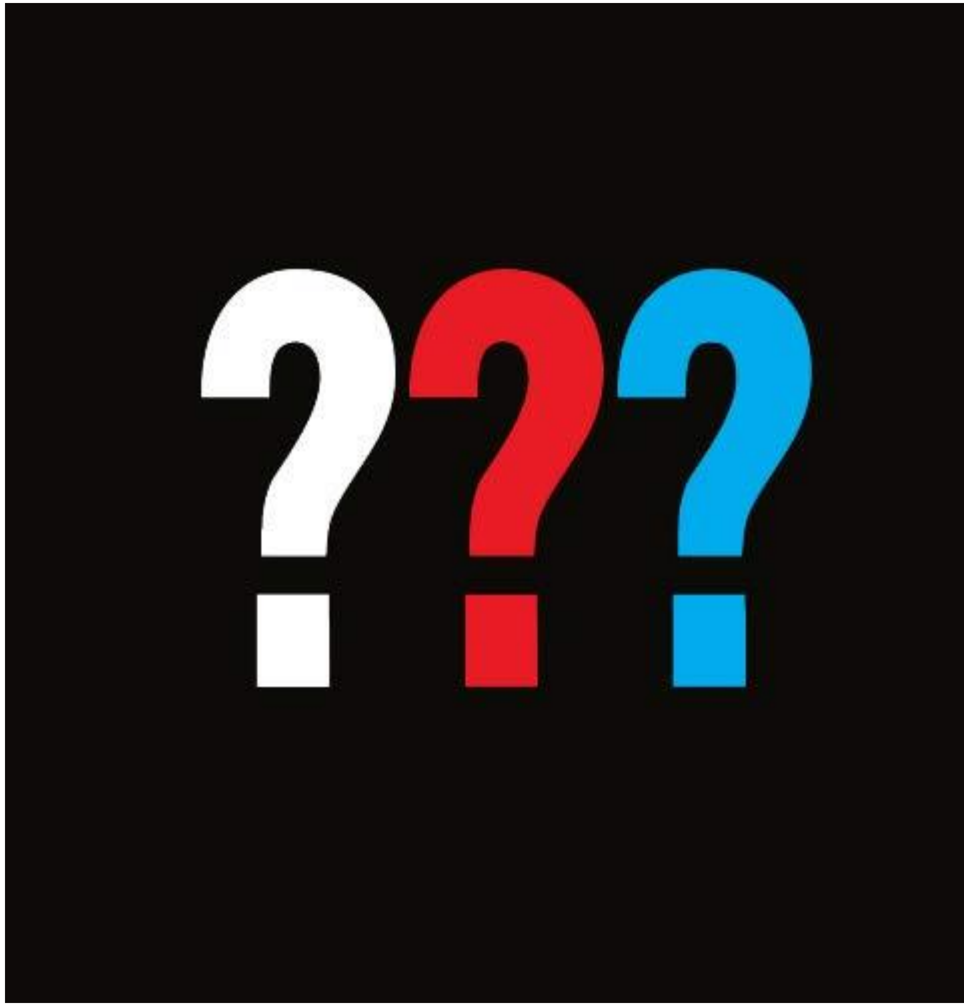
Hints:

1. Formulate an implication: Our implication is A V B → V
2. Setup your truth table
3. Fill it in!

A: Support Party	B: Support Voters	V: Votes Yes
1	1	1
1	0	1
0	1	1
0	0	0

Time for your questions

- Any questions during the week?
  - → joerdis.strack@uni-konstanz.de



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