THE PUBLIC IS MORE FAMILIAR WITH BAD DESIGN THAN GOOD DESIGN. IT IS, IN EFFECT, CONDITIONED TO PREFER BAD DESIGN, BECAUSE THAT IS WHAT IT LIVES WITH. THE NEW BECOMES THREATENING, THE OLD REASSURING.

PAUL RAND

A DESIGNER KNOWS THAT HE HAS ACHIEVED PERFECTION NOT WHEN THERE IS NOTHING LEFT TO ADD, BUT WHEN THERE IS NOTHING LEFT TO TAKE AWAY.

ANTOINE DE SAINT-EXUPÉRY

. . . THE DESIGNER OF A NEW SYSTEM MUST NOT ONLY BE THE IMPLEMENTOR AND THE FIRST LARGE-SCALE USER; THE DESIGNER SHOULD ALSO WRITE THE FIRST USER MANUAL. . . IF I HAD NOT PARTICIPATED FULLY IN ALL THESE ACTIVITIES, LITERALLY HUNDREDS OF IMPROVEMENTS WOULD NEVER HAVE BEEN MADE, BECAUSE I WOULD NEVER HAVE THOUGHT OF THEM OR PERCEIVED WHY THEY WERE IMPORTANT.

DONALD E. KNUTH

ANDRAS CSANYI

THE GUIDANCE, NAVIGATION AND CONTROL BOOK

ANDRAS CSANYI

PUBLISHED BY ANDRAS CSANYI

TUFTE-LATEX.GOOGLECODE.COM

First printing, June 2025

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Dedicated to those who appreciate LaTeX

and the work of Edward R. Tufte and Donald E. Knuth.

Despite the title this book is rather about my understanding about Guidance, Navigation and Control rather than the actual scientific field. I felt the need to 1, pull all the knowledge related to the field together with a single document and displaying the connections, and 2, explain it. The latter is the most cruical part of my learning process. If I can't explain it, I don't understand it. Yes, this idea was put into words by Feinmann. So as I learn, I explain and I learn more.

This book should be a website. The content is way more than a book ever discusses. But, at this point there is no tool to display information on the web with ease and beauty as latex can do. Latex is perfection. Web is imperfection. I am not going to waste my time on imperfection.

Mathematics, especially applied mathematics is the bottom line in GNC. As a result it will be discussed accordingly. I am going to go deep in Dynamic and Control theory as these are the two fields ruling the professional life of an GNC Engineer. The mathematics matter is split to Precalculus, Calculus, Dynamic theory, Control theory and GNC topics. The latter will be just examples and their solutions.

LaTeX is the other tool you are going to use frequently.

Physics will be discussed.

Programming is like breathing for a GNC engineer. This book won't teach you a particular language, rather will go through the foundations like algorhitms and data structures, and all the computation related details needed for scientific computing. The scientific calculations will be done by Python, Rust and MathPotato. The latter is my creation.

Part I

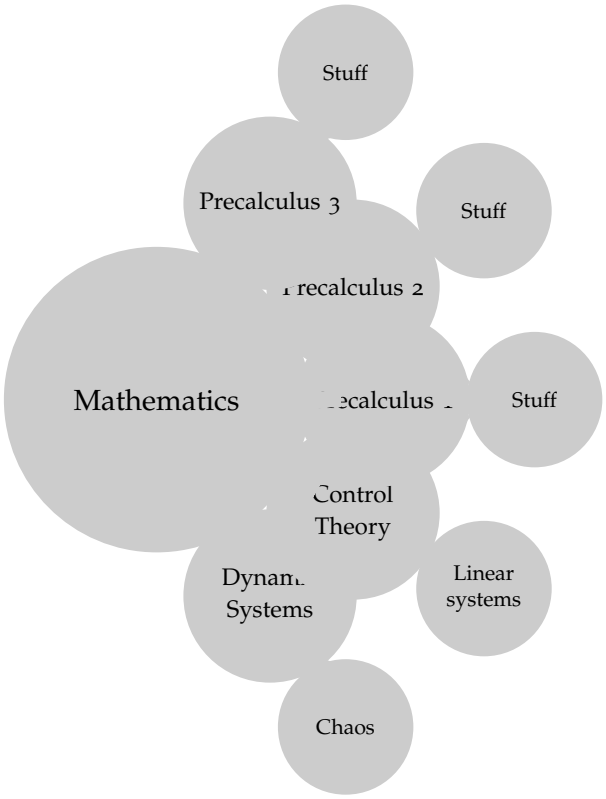
Mathematics

GNC is applied mathematics. Once you accept this the life will be easier. Once you made your life easier you can make the decision whether going into applied mathematics or not. Going into applied mathematics means accepting the friendship of mathematical rigour. I made this decision and accepted that mathematics is good and will be part of my life, and I write this book accordingly.

The mathematics chapter includes a landscape of what mathematics is needed for GNC in a graph form which is an information retrieval thesaurus. This help you to see what is the study material and when you feel lost helps you to find the "You are here!" point on this map.

The interesting part in mathematics comes after calculus. Everything before it is just dead boring. But, these boring things are the air in the clouds of Calculus, so that, you have to know these things.

The thesaurus of Mathematics



Fundamentals

Real Numbers

Real Numbers - Anki cards

Real Numbers overview card
What does the numbers set structure look like?
What are the Natural numbers and its notation?
What are the integers and its notation?
What are the rational numbers and its notation?
What are the irrational numbers and its notation?
What are the properties of real numbers? (Commutative, Associative, Distributive)
What are the rules of Addition and Subtraction?
What are the rules of Multiplication and Division?
What is the real line and its properties?
What are the sets and intervals, its properties, notation and operations?
What is absolute value and how it relates to distance?
What are the properties of absolute value?
Answers are on the subsequent cards in the topic

What does the numbers set structure look like?

What does the numbers set structure look like?

The numbers set structure looks like the following:

Real numbers set, notation: $\mathbb{R}$, includes:
Rational numbers, Notation: $\mathbb{Q}$; example: $\frac{4}{3}, 9.324$
Irrational numbers, Notation: $\mathbb{I}$; example: $\sqrt{2}\pi$

Rational numbers set includes:
Integers, Notation: $\mathbb{Z}$ example: $-1, 2, 3, \cdots$

Integers number set includes:
Natural numbers, Notation: $\mathbb{N}$, example: $1, 2, 3 \cdots$

What are the Natural numbers and its notation?

What are the Natural numbers and its notation?

Natural numbers, Notation: $\mathbb{N}$, example: $1, 2, 3 \cdots$

What are the Integers and its notation?

What are the integers and its notation?

Integers, Notation: $\mathbb{Z}$ example: $-1, 2, 3, \cdots$

What are the Rational numbers and its notation?

What are the rational numbers and its notation?

Rational numbers, Notation: $\mathbb{Q}$; example: $\frac{4}{3}, 9.324$

What are the Irrational numbers and its notation?

What are the irrational numbers and its notation?

Irrational numbers, Notation: $\mathbb{I}$; example: $\sqrt{2}, \pi$

What are the properties of Real Numbers?

What are the properties of Real Numbers?

Properties of Real Numbers

Commutative Properties

1[ex] $a + b = b + a$
$a \cdot b = b \cdot a$

Associative Properties

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

Distributive Properties

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

What are the properties of Addition and Subtraction?

What are the properties of Addition and Subtraction?

Properties of Addition and Subtraction

$(-1)a = -a$
$-(-a) = a$
$(-a)b = a(-b) = -(ab)$
$(-a)(-b) = ab$
$-(a + b) = -a - b$
$-(a - b) = b - a = -a + b$

What are the properties of Multiplication and Division?

What are the Rules of Multiplication and Division?

Properties of Multiplication and Division

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

2, $\frac{a}{b} \div \frac{c}{d} = \frac{a}{b} \cdot \frac{d}{c}$

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

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

5, $\frac{ac}{bc} = \frac{a}{b}$

6, If $\frac{a}{b} = \frac{c}{d}$, then $ad = bc$

What are the properties of the Real Line?

What are the the properties of the Real Line?

Properties of the Real Line	
Property	**Details**
Reference point, origin	Its value is 0
Positive numbers	Right side of the reference point
Negative numbers	Left side of the reference point
Order	the real numbers are ordered in the Real Line

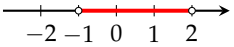
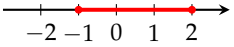
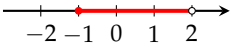
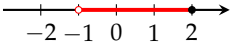
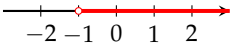
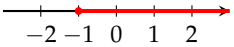
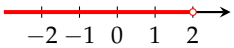
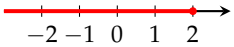
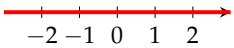
What are the notations of Sets and Intervals?

What are the notations of Sets and Intervals?

Notations of Sets and Intervals	
A **Set** is a collection of objects called **elements**	
S	sign of a Set
$a \in S$	a is element of S
$b \notin S$	b is not element of S
$S \cup T$	union of S and T sets
$S \cap T$	intersection of S and T sets
$\emptyset$	empty set
$A = \{1, 2, 3, 4, 5\}$	the listing elements notation of a Set
$A = \{x \mid x \text{ is an integer and } 0 < x < 8\}$	the builder notation

What are the notations of intervals?

What are the notations of intervals?

Notation	Set Description	Graph
(a,b)	$\{x \mid a < x < b\}$	
$[a,b]$	$\{x \mid a \leq x \leq b\}$	
$[a,b)$	$\{x \mid a \leq x < b\}$	
$(a,b]$	$\{x \mid a < x \leq b\}$	
(a,∞)	$\{x \mid a < \infty\}$	
$[a,\infty)$	$\{x \mid a \leq \infty\}$	
$(-\infty,a)$	$\{x \mid x < a\}$	
$(-\infty,a]$	$\{x \mid x \leq a\}$	
$(-\infty,\infty)$	$\mathbb{R}$set of real numbers	

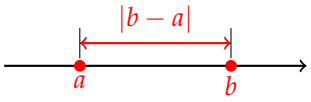
What are the rules of Absolute Value?

What are the rules of Absolute Value?

Rule	Description
$\lvert a\rvert = \begin{cases} a & \text{if } a \geq 0 \\ -a & \text{if } a < 0 \end{cases}$	when a is a real number
$\lvert a\rvert \geq 0$	The absolute value of a number is always positive or zero
$\lvert a\rvert = \lvert -a\rvert$	A number and its negative have the same absolute value
$\lvert ab\rvert = \lvert a\rvert\lvert b\rvert$	The absolute value of a product is the product of the absolute values
$\lvert \frac{a}{b}\rvert = \frac{\lvert a\rvert}{\lvert b\rvert}$	The absolute value of a quotient is the quotient of the absolute values
$\lvert a+b\rvert = \lvert a\rvert + \lvert b\rvert$	Triangle Inequality

Distance of two points on the Real Line

Distance of two points on the Real Line

Distance between two points
$d(a,b) = \lvert b-a \rvert$ 

Exponents and Radicals

Exponents and Radicals - Ankicards

Exponents and Radicals

What are the details of exponents and radicals?

What are the details of exponents and radicals?
What is the notation of exponentials?
What is the notation of zero and negative exponents?
What are the rules of exponents?
How to use the laws of Exponents to simplify expressions and expressions with negative exponents?
What is the scientific notation?
What are the radicals and what is the definition of n-th root?
What are the properties of the n-th root?
How to combine radicals and how not to?
What are the rational exponents and what is the definition?
How to rationalize the denominator?

Answers are on the subsequent cards in the topic

What are the details of exponents and radicals?

What are the integer exponents?

If a is any real number and n is a positive integer, then the n-th power or a is:

$$a^n = a \cdot a \cdot \cdots \cdot a$$

The number a is called the base, and n is called the exponent.

What are the details of exponents and radicals?

What is the notation of zero and negative exponents?

$a^0 = 1$ and $a^{-n} = \frac{1}{a^n}$

What are the rules of exponents?

What are the rules of exponents?

Laws of Exponents	
Rule	Explanation
$a^0 = 1$ and $a^{-n} = \frac{1}{a^n}$	If $a \neq 0$ is a real number and n is a positive integer
$a^m \cdot a^n = a^{m+n}$	
$\frac{a^m}{a^n} = a^{m-n}$	
$(a^m)^n = a^{m \cdot n}$	
$(ab)^n = a^n \cdot b^n$	
$\left(\frac{a}{b}\right)^n = \frac{a^n}{b^n}$	
$\left(\frac{a}{b}\right)^{-n} = \left(\frac{b}{a}\right)^n$	
$\frac{a^{-m}}{b^{-n}} = \frac{b^n}{a^m}$	

How to use exponents laws to simplify expressions?

How to use the laws of Exponents to simplify expressions and expressions with negative exponents?

$$\begin{aligned}\left(2a^3b^2\right)\left(3ab^4\right) &= \left(2a^3b^2\right)\left[3^3a^3\left(b^4\right)^3\right] \rightarrow \text{ Law 4 } : (ab)^n = a^n b^n \\ &= \left(2a^3b^2\right)\left(27a^3b^12\right) \rightarrow \text{ Law 3 } : (a^m)^n = a^{m \cdot n} \\ &= (2)(27)\,a^3a^3b^2b^{12} \rightarrow \text{ Group factors with the same base} \\ &= 54a^6b14 \rightarrow \text{ Law 1: } a^m \cdot a^n = a^{m+n}\end{aligned}$$

$$\begin{aligned}\frac{6st^{-4}}{2s^{-2}t^2} = \frac{6ss^2}{2t^2t^4} &\rightarrow \text{ Law 7} \\ &= \frac{3s^3}{t^6} \rightarrow \text{ Law 1}\end{aligned}$$

What are the details of scientific notation?

Details of Scientific Notation	
$x = a \times 10^n$	where $1 \leq a < 10$ and n is an integer

What are the radicals and what is the definition of n-th root?

Definition of n-th Root

If n is any positive integer, then the principal n-th root of a is defined as follows:

$\sqrt[n]{a}$ means $b^n = a$

If n is even, then we must have $a \geq 0$ and $b \geq 0$

What are the Laws of Roots?

Laws of Roots

$\sqrt[n]{ab} = \sqrt[n]{a} \cdot \sqrt[n]{b}$
$\sqrt[n]{\frac{a}{b}} = \frac{\sqrt[n]{a}}{\sqrt[n]{a}}$
$\sqrt[n]{\sqrt[m]{a}} = \sqrt[n \cdot m]{a}$
$\sqrt[n]{a^n} = a$, if n odd
$\sqrt[n]{a^n} = \lvert a \rvert$, if n is even
$a^{\frac{1}{n}} = \sqrt[n]{a}$
$a^{\frac{m}{n}} = \sqrt[n]{a^m}$

How to combine radicals and how not to?

Positive case

$$\sqrt{32} + \sqrt{200} = \sqrt{16 \cdot 2} + \sqrt{100 \cdot 2}$$
$$= \sqrt{16}\sqrt{2} + \sqrt{100}\sqrt{2}$$
$$= 4\sqrt{2} + 10\sqrt{2}$$
$$= 14\sqrt{2}$$

Negative case

WRONG!!! $\sqrt{a+b} = \sqrt{a} + \sqrt{b}$ WRONG!!!

What are the rational exponents and what is the definition?

$$a^{\frac{1}{n}} = \sqrt[n]{a}$$

For any rational exponent m/n in lowest terms,
where m and n are integers and $n > 0$, we define:
$a^{m/n} = \left(\sqrt[n]{a}\right)^m$ or equivalently $a^{m/n} = \sqrt[n]{a^m}$
If n is even, then we require that $a \geq 0$.

What are the details of exponents and radicals?

How to rationalize the denominator?

$$\frac{2}{\sqrt{3}} = \frac{2}{\sqrt{3}} \cdot \frac{\sqrt{3}}{\sqrt{3}}$$

Algebraic Expressions

Algebraic Expressions - Anki cards

What are the details of Algebraic Expressions?
What is the definition and properties of polynomials?
Addings and substracting polynomials
What are the rules of multiplying algebraic expressions?
What does expanding and factoring a polynomial mean?
What are the special factoring formulas?
Answers are in the subsequent cards in the topic
What is the definition and properties of polynomials?

Polynomials	
$a_n x^n + a_{n-1} x^{n-1} + \cdots + a_1 x + a_0$	where $a_n, a_{n-1}, \cdots, a_0$ are real numbers, and n is a nonnegative integer. If $a_n \neq 0$, then n is called the **degree** of the polynomial. The monomials $a_k x^k$ that make up the polynomial are called the **terms** of the polynomial.
$2x^2 - 3x + 4$	is a **trinomial** with degree 2.
$x^8 + 3x$	is a **binomial** with degree 8.
$5x^3$	is a **monomial** with degree 3.
5	is a **monomial** with degree 0.

Addings and substracting polynomials

Addings and substracting polynomials

$$\begin{aligned}
&\left(x^3 - 6x^2 + 2x + 4\right) + \left(x^3 + 5x^2 - 7x\right) \\
&= \left(x^3 + x^3\right) + \left(-6x^2 + 5x^2\right) + (2x - 7x) + 4 \rightarrow \text{ Group like terms} \\
&= 2x^3 - x^2 - 5x + 4 \rightarrow \text{ Combine like terms}
\end{aligned}$$

What are the Laws of Binomial Expansion?

What are the Laws of Binomial Expansions?	
Laws of Binomial Expansion	
$(a+b)(a-b) = a^2 - b^2$	Sum and difference of the same terms
$(a+b)^2 = a^2 + 2ab + b^2$	Square of a sum
$(a-b)^2 = a^2 - 2ab + b^2$	Square of a difference
$(a+b)^3 = a^3 + 3a^2b + 3ab^2 + b^3$	Cube of a sum
$(a-b)^3 = a^3 - 3a^2b + 3ab^2 - b^3$	Cube of a difference

What does factoring or expanding mean?

What does factoring or expanding mean?
$\rightarrow$ **Expanding** $\rightarrow$
$(x-2)(x+3) = x^2 + x - 6$
$\leftarrow$ **Factoring** $\leftarrow$

What are the Laws of Binomial Expansion?

What are the special factoring formulas?	
Laws of Binomial Expansion	
Formula	**Name**
$a^2 - b^2 = (a+b)(a-b)$	Difference of squares
$\left(a^2 + b^2\right) = a^2 + 2ab + b^2$	Perfect square
$\left(a^2 - b^2\right) = a^2 - 2ab + b^2$	Perfect square
$a^3 - b^3 = (a-b)\left(a^2 + ab + b^2\right)$	Difference of cubes
$a^3 + b^3 = (a+b)\left(a^2 - ab + b^2\right)$	Difference of cubes

Rational expressions

Rational expressions - Anki cards

What are the details of Rational Expressions?

What are the details of Rational Expressions?
What is the domain of an algebraic expression?
How to find the domain of an algebraic expression?
What are the rules of simplyfing algebraic expressions?

Answers are in the subsequent cards in the topic

What are the domains of rational expressions?

What is the domain of an algebraic expression?	
Domains of Rational Expressions	
Expression	Domain
$\frac{1}{x}$	$\{x \mid x \neq 0\}$
$\sqrt{x}$	$\{x \mid x \geq 0\}$
$\frac{1}{\sqrt{x}}$	$\{x \mid x > 0\}$

How to find the domain of an algebraic expression?

How to find the domain of an algebraic expression?
The domain cannot contain values which makes the algebraic expression invalid or zero in vague terms.
The denominator cannot be zero.
Square root and roots cannot be negative number.

What are the rules of operations with Rational Expressions?

What are the rules of operations with Rational Expressions?
Rules working with rational expressions
$\frac{ab}{bc} = \frac{a}{b}$
$\frac{a}{b} \cdot \frac{c}{d} = \frac{ac}{bd}$
$\frac{a}{b} \div \frac{c}{d} = \frac{a}{b} \cdot \frac{d}{c}$
$\frac{a}{c} + \frac{b}{c} = \frac{a+b}{c}$

Equations

Equations - Anki cards

What are the details of equations?

What are the details of equations?
What is an equation?
What are the properties of equality?
What are the linear equations?
What are the rules of solving a quadratic equation by factoring?
What is the completing the square method?
What is the quadratic formula?
What is the discriminant of the quadratic formula?
Answers are in the subsequent cards in the topic

What is an equation?

What is an equation?
An equation is a statement that two mathematical expressions are equal. The values of the unknown are the **solutions** or **roots** of the equation.

What are the properties of equality?

What are the properties of equality?	
Properties of Equality	
Property	**Description**
$A = B \iff A + C = B + C$	Adding the same quantity to both sides of an equation gives and equivalent equation.
$A = B \iff CA = CB (C \neq 0)$	Multiplying both sides of an equation by the same nonzero quantity gives and equivalent equation.

What are the linear equations?

What are the linear equations?

A **linear equation** in one variable is an equation equivalent to one of the form:

$$ax + b = 0$$

where a anf b are real numbers and x is the variable.

What are the rules of solving a quadratic equation by factoring?

What are the rules of solving a quadratic equation by factoring?

A **quadratic equation** is an equation of the form:

$$ax^2 + bx + c = 0$$

where a, b and c are real numbers with $a \neq 0$

Zero Product property:

$AB = 0$ if and only if $A = 0$ or $B = 0$

Solving a simple quadratic equation

The solution of equation $x^2 = c$ are $x = \sqrt{c}$ and $x = -\sqrt{c}$

What is the completing the square method?

What is the completing the square method?

To make $x^2 + bx$ a perfect square, add $\left(\frac{b}{2}\right)^2$, the square of half the coefficient of x. This gives the perfect square.

$$x^2 + bx + \left(\frac{b}{2}\right)^2 = \left(x + \frac{b}{2}\right)^2$$

What is the quadratic formula?

What is the quadratic formula?

The solution of the general quadratic equation: $ax^2 + bx + c = 0$, where $a \neq 0$, are:

$x = \frac{-b \pm \sqrt{b^2 - 4ac}}{2a}$

What is the discriminant?

What is the discriminant?

The **discriminant** of the general quadratic equation: $ax^2 + bx + c = 0$ is $D = b^2 - 4ac$.

If $D > 0$, then the equation has two real solutions.

If $D = 0$, then the equation has one real solution.

If $D < 0$, then the equation has no complex solutions.

Complex Numbers

Complex Numbers - Anki cards

What are the complex numbers?

What are the complex numbers?
What is the definition of complex numbers?
What are the rules of arithmetic operations with complex numbers?
What are the conjugates of complex numbers?
What are the square roots of complex numbers?
Answers are in the subsequent cards in the topic

What is the definition of complex numbers?

What is the definition of complex numbers?
A **complex number** is an expression of the form $a + bi$ where a and b are real numbers and $i^2 = -1$. The **real part** of this complex number is a, and the **imaginary part** is b. Two complex numbers are **equal** if an only if their real parts are equal and their imaginary parts are equal.
$3 + 4i \rightarrow$ Real part: 3, imaginary part: 4 $\frac{1}{2} - \frac{2}{3}i \rightarrow$ Real part: $\frac{1}{2}$, imaginary part: $-\frac{2}{3}$ $6i \rightarrow$ Real part: 0, imaginary part: 6 $-7 \rightarrow$ Real part -7, imaginary part: 0

What are the rules of arithmetic operations with complex numbers?

What are the rules of arithmetic operations with complex numbers?

Definition	Descritpion
Addition $(a+bi)+(c+di)=(a+c)+(b+d)\,i$	To add complex numbers, add the real parts and the imaginary parts.
Subtraction $(a+bi)-(c+di)=(a-c)+(b-d)\,i$	To subtract complex numbers, subtract the real parts and the imaginary parts.
Multiplication $(a+bi)\cdot(c+di) = (ac-bd)+(ad-bc)\,i$	Multiply complex numbers like binomials, using $i^2=-1$.

What are the conjugates of complex numbers?

What are the conjugates of complex numbers?

Dividing complex numbers
To simplify the quotient $\frac{a+bi}{c+di}$, multiply the numerator and the denominator by the complex conjugate of the denominator:

$$\frac{a+bi}{c+di}=\left(\frac{a+bi}{c+di}\right)\left(\frac{c-di}{c-di}\right)$$

$$=\frac{(ac+bd)+(bc=ad)\,i}{c^2+d^2}$$

Complex conjugates
$3+2i\to 3-2i$
$1-i\to 1+i$
$4i\to -4i$
$5\to 5$

What is the square root of negative numbers?

What is the square root of negative numbers?

Square roots of negative numbers
If -1 is negative, then the **principal square root** of $-r$ is
$\sqrt{-r}=-i\sqrt{r}$
The two sqare roots of $-r$ are $\sqrt{ri}$ and $-\sqrt{ri}$

Modeling with Equations

Modeling with Equations - Anki Cards

What are the details of modeling with equations?

What are the details of modeling with equations?
Explain the basic guidelines working with equations.j
Explain the "Interest rate" problem space in terms of equations and modeling.
Explain the "Area or Length" problem space in terms of equations and modeling.
Explain the "Mixtures" problem space in terms of equations and modeling
Explain the "Time needed to do a job" problem space in terms of equations and modeling.
Explain the "Distance, Rate and Time" problem space in terms of equations and modeling.
What are the details of modeling with equations?

What are the details of modeling with equations?

What are the details of modeling with equations?
Identify the variable. Identify the quantity that the problmen asks yo to find. This quantity can usually be determined by a careful reading of the question that is posed at the end of the problem. Then **introduce notation** for the variable (carr it x or some other letter).
Translate from Words to Algebra. Read each sentenxe in the problem again, and express all the quantities mentioned in the problem in terms of the variable you defined int Step 1. To organize this information, it is sometimes helpful to **draw a diagram or make a table**.
Set up the model. Find the crucial fact in the problem that gives a relationship between the expressions you listed in Step 2. **Set up an equation** or a model that expresses this relationship.
Solve the equation and check your answer. Solve the equation, check you answer, and **state your answer** as a sentence.

Explain the "Interest rate" problem space in terms of equations and modeling.

Explain the "Interest rate" problem space in terms of equations and modeling.

The fee what is paid over the borrowed money is the **interest**. The most basic type of the **simple interest** meaning annual interest. The amount of loan called **principal**. The annual percentage paid for the use of the money is the **interest rate**.
$I = Prt$
Where I is the interest, P is the principal amount, r is the interest rate in percentage (4%) and the t is time, usually in years.

Explain the "Area or Length" problem space in terms of equations and modeling.

Explain the "Area or Length" problem space in terms of equations and modeling.

Expect to use basic formulas from algebra, like area or perimeter.

Explain the "Mixtures" problem space in terms of equations and modeling

Explain the "Mixtures" problem space in terms of equations and modeling

Substances where different materials are mixed together.
$C = \frac{x}{V}$
Where C is the concentration of the substance, x is the amount dissolved in a solution with V volume.

Explain the "Time needed to do a job" problem space in terms of equations and modeling.

Explain the "Time needed to do a job" problem space in terms of equations and modeling.

A good example for this is the "how long time does it take to lover the water level by 1 meters in the reservoir when the water spillways are opened by 1 feet."

Explain the "Distance, Rate and Time" problem space in terms of equations and modeling.

Explain the "Distance, Rate and Time" problem space in terms of equations and modeling.

The formula we use to deal with distance, rate (speed) and time is the following:
distance $=$ rate $\times$ time

Inequalities

Anki Cards

What are the details of inequalities?

Introduce inequalities
What are the rules of inequalities?
how to solve linear inequalities?
how to solve nonlinear inequalities?
What are the guidelines to solve nonlinear inequalities?
What are the absolute value inequalities?
How to use inequalities in modeling?
Answers in the subsequent cards.

Introduce inequalities

Introduce inequalities
Some problems lead to inequalities instead of equalities. An inequality looks like an equality, but it represents that the solution is greater (greater or equal) or less (less or equal) than a certain value. Based on this we can say that the solution of an inequality is not an exact number, but an interval.

What are the rules of inequalities?

What are the rules of inequalities?

Rules of inequalities	
Rule	**Description**
$A \leq B \iff A + C \leq B + C$	**Adding** the same quantity to each side of an inequality gives the equivalent inequality.
$A \leq B \iff A - C \leq B - C$	**Subtracting** the same quantity from each side of an inequality gives an equivalent inequality.
If $C > 0$, then $a \leq B \iff CA \leq CB$	**Multiplying** each side of an inequality by the same positive quantity gives an equivalent inequality.
If $C < 0$, then $a \leq B \iff CA \geq CB$	**Multiplying** each side of an inequality by the same negative quantity gives an equivalent inequality.
If $A > 0$ and $B > 0$ then $A \leq B \iff \frac{1}{A} \geq \frac{1}{B}$	**Taking reciprocals** of each side on an inequality involving positive quantities reverses the direction of the inequality.
if $A \leq B$ and $C \leq D$, then $A + C \leq B + D$	Inequalities can be added.
If $A \leq B$ and $B \leq C$, then $A \leq C$	Inequality is transitive

how to solve linear inequalities?

how to solve linear inequalities?
And inequality is linear when each term is constant or multiple of the variable, and it doesn't include exponentials.
$2x < 8x + 4$ Isolate x on one side.

how to solve nonlinear inequalities?

how to solve nonlinear inequalities?

Signs of product or quotient:
if a product or a quotient has an **even** number of **negative** factors, then its valie is **positive**.
if a product or a quotient has an **odd** number of **negative** factors, then its value is **negative**.

Guidelines for solving nonlinear inequalities
Moce all terms to one side
If necessary, rewrite the inequality so that all nonzero terms appear on one side of the inequality sign. If the nonzero side of the inequality involves quotients, bring them to a common denominator.
Factor Factor the nonzero side of the inequality.
Find the intervals
Determine the values for qhich each faxtor is zero. These numbers divide the real line into intervals. Llist the intervals that are determined by these numbers.
Make a table or a diagram Use **test values** to make a table or diagram of the signs of each factor on each interval. Inteh last row of the table determine the sign of the product (or quotient) of these factors.
Solve Use the sign table to find the intervals on which the inequality is satisfied. Check whether the endpoints of these intervals satisfy the inequality. (This may happen if the inequaltiy involves $\geq$ or $\leq$)

Important The factoring technique that is described in the guidelines works only if all non-zero terms appear on one side of the inequality symbol.

What are the absolute value inequalities?

What are the absolute value inequalities?

When absolute value is involved in inequalities it includes both the positive and negative numbers.

How to use inequalities in modeling?

How to use inequalities in modeling?

The method is similar to what we seen in equalities.

Part II

Physics

Part III

GNC

Part IV

Programming

Part V

LaTeX

The Design of Tufte's Books

The pages of a book are usually divided into three major sections: the front matter (also called preliminary matter or prelim), the main matter (the core text of the book), and the back matter (or end matter).

The front matter of a book refers to all of the material that comes before the main text. The following table from shows a list of material that appears in the front matter of *The Visual Display of Quantitative Information*, *Envisioning Information*, *Visual Explanations*, and *Beautiful Evidence* along with its page number. Page numbers that appear in parentheses refer to folios that do not have a printed page number (but they are still counted in the page number sequence).

	Books			
Page content	*VDQI*	*EI*	*VE*	*BE*
Blank half title page	(1)	(1)	(1)	(1)
Frontispiece[1]	(2)	(2)	(2)	(2)
Full title page	(3)	(3)	(3)	(3)
Copyright page	(4)	(4)	(4)	(4)
Contents	(5)	(5)	(5)	(5)
Dedication	(6)	(7)	(7)	7
Epigraph	–	–	(8)	–
Introduction	(7)	(9)	(9)	9

[1] The contents of this page vary from book to book. In *VDQI* this page is blank; in *EI* and *VE* this page holds a frontispiece; and in *BE* this page contains three epigraphs.

The design of the front matter in Tufte's books varies slightly from the traditional design of front matter. First, the pages in front matter are traditionally numbered with lowercase roman numerals (*e.g.*, i, ii, iii, iv, ...). Second, the front matter page numbering sequence is usually separate from the main matter page numbering. That is, the page numbers restart at 1 when the main matter begins. In contrast, Tufte has enumerated his pages with arabic numerals that share the same page counting sequence as the main matter.

There are also some variations in design across Tufte's four books. The page opposite the full title page (labeled "frontispiece" in the above table) has different content in each of the books. In *The Visual Display of Quantitative Information*, this page is blank; in *Envisioning Information* and *Visual Explanations*, this page holds a frontispiece; and in *Beautiful Evidence*, this page contains three epigraphs.

The dedication appears on page 6 in *VDQI* (opposite the introduction), and is placed on its own spread in the other books. In *VE*, an epigraph shares the spread with the opening page of the introduction.

None of the page numbers (folios) of the front matter are expressed except in *BE*, where the folios start to appear on the dedication page.

THE FULL TITLE PAGE of each of the books varies slightly in design. In all the books, the author's name appears at the top of the page, the title it set just above the center line, and the publisher is printed along the bottom margin. Some of the differences are outlined in the following table.

Feature	*VDQI*	*EI*	*VE*	*BE*
Author				
Typeface	serif	serif	serif	sans serif
Style	italics	italics	italics	upright, caps
Size	24 pt	20 pt	20 pt	20 pt
Title				
Typeface	serif	serif	serif	sans serif
Style	upright	italics	upright	upright, caps
Size	36 pt	48 pt	48 pt	36 pt
Subtitle				
Typeface	–	–	serif	–
Style	–	–	upright	–
Size	–	–	20 pt	–
Edition				
Typeface	sans serif	–	–	–
Style	upright, caps	–	–	–
Size	14 pt	–	–	–
Publisher				
Typeface	serif	serif	serif	sans serif
Style	italics	italics	italics	upright, caps
Size	14 pt	14 pt	14 pt	14 pt

THE TABLES OF CONTENTS in Tufte's books give us our first glimpse of the structure of the main matter. *The Visual Display of Quantitative Information* is split into two parts, each containing some number of chapters. His other three books only contain chapters—they're not broken into parts.

Typefaces

Tufte's books primarily use two typefaces: Bembo and Gill Sans. Bembo is used for the headings and body text, while Gill Sans is used for the title page and opening epigraphs in *Beautiful Evidence*.

Since neither Bembo nor Gill Sans are available in default LaTeX installations, the Tufte-LaTeX document classes default to using Palatino and Helvetica, respectively. In addition, the Bera Mono typeface is used for `monospaced` type.

The following font sizes are defined by the Tufte-LaTeX classes:

LaTeX size	Font size	Leading	Used for
`\tiny`	5	6	sidenote numbers
`\scriptsize`	7	8	–
`\footnotesize`	8	10	sidenotes, captions
`\small`	9	12	quote, quotation, and verse environments
`\normalsize`	10	14	body text
`\large`	11	15	B-heads
`\Large`	12	16	A-heads, TOC entries, author, date
`\LARGE`	14	18	handout title
`\huge`	20	30	chapter heads
`\Huge`	24	36	part titles

Table 1: A list of LaTeX font sizes as defined by the Tufte-LaTeX document classes.

Headings

Tufte's books include the following heading levels: parts, chapters,[2] sections, subsections, and paragraphs. Not defined by default are: sub-subsections and subparagraphs.

[2] Parts and chapters are defined for the `tufte-book` class only.

Heading	Style	Size
Part	roman	24/36×40 pc
Chapter	italic	20/30×40 pc
Section	italic	12/16×26 pc
Subsection	italic	11/15×26 pc
Paragraph	italic	10/14

Table 2: Heading styles used in *Beautiful Evidence*.

Paragraph Paragraph headings (as shown here) are introduced by italicized text and separated from the main paragraph by a bit of space.

Environments

The following characteristics define the various environments:

Environment	Font size	Notes
Body text	10/14×26 pc	
Block quote	9/12×24 pc	Block indent (left and right) by 1 pc
Sidenotes	8/10×12 pc	Sidenote number is set inline, followed by word space
Captions	8/10×12 pc	

Table 3: Environment styles used in *Beautiful Evidence*.

On the Use of the `tufte-book` Document Class

The Tufte-LaTeX document classes define a style similar to the style Edward Tufte uses in his books and handouts. Tufte's style is known for its extensive use of sidenotes, tight integration of graphics with text, and well-set typography. This document aims to be at once a demonstration of the features of the Tufte-LaTeX document classes and a style guide to their use.

Page Layout

Headings

This style provides A- and B-heads (that is, `\section` and `\subsection`), demonstrated above.

Sidenotes

One of the most prominent and distinctive features of this style is the extensive use of sidenotes. There is a wide margin to provide ample room for sidenotes and small figures. Any `\footnotes` will automatically be converted to sidenotes.[3] If you'd like to place ancillary information in the margin without the sidenote mark (the superscript number), you can use the `\marginnote` command.

The specification of the `\sidenote` command is:

`\sidenote[`⟨*number*⟩`][`⟨*offset*⟩`]{`*Sidenote text.*`}`

Both the ⟨*number*⟩ and ⟨*offset*⟩ arguments are optional. If you provide a ⟨*number*⟩ argument, then that number will be used as the sidenote number. It will change of the number of the current sidenote only and will not affect the numbering sequence of subsequent sidenotes.

Sometimes a sidenote may run over the top of other text or graphics in the margin space. If this happens, you can adjust the vertical position of the sidenote by providing a dimension in the ⟨*offset*⟩ argument. Some examples of valid dimensions are:

```
1.0in    2.54cm    254mm    6\baselineskip
```

[3] This is a sidenote that was entered using the `\footnote` command.

This is a margin note. Notice that there isn't a number preceding the note, and there is no number in the main text where this note was written.

If the dimension is positive it will push the sidenote down the page; if the dimension is negative, it will move the sidenote up the page.

While both the ⟨*number*⟩ and ⟨*offset*⟩ arguments are optional, they must be provided in order. To adjust the vertical position of the sidenote while leaving the sidenote number alone, use the following syntax:

```
\sidenote[][⟨offset⟩]{Sidenote text.}
```

The empty brackets tell the `\sidenote` command to use the default sidenote number.

If you *only* want to change the sidenote number, however, you may completely omit the ⟨*offset*⟩ argument:

```
\sidenote[⟨number⟩]{Sidenote text.}
```

The `\marginnote` command has a similar *offset* argument:

```
\marginnote[⟨offset⟩]{Margin note text.}
```

References

References are placed alongside their citations as sidenotes, as well. This can be accomplished using the normal `\cite` command.[4]

[4] The first paragraph of this document includes a citation.

The complete list of references may also be printed automatically by using the `\bibliography` command. (See the end of this document for an example.) If you do not want to print a bibliography at the end of your document, use the `\nobibliography` command in its place.

Figures and Tables

Images and graphics play an integral role in Tufte's work. In addition to the standard `figure` and `tabular` environments, this style provides special figure and table environments for full-width floats.

```
\begin{marginfigure}
   \includegraphics{helix}
   \caption{This is a margin figure.}
   \label{fig:marginfig}
\end{marginfigure}
```

The `marginfigure` and `margintable` environments accept an optional parameter ⟨*offset*⟩ that adjusts the vertical position of the figure or table. See the "Sidenotes" section above for examples. The specifications are:

```
\begin{marginfigure}[⟨offset⟩]
   ...
\end{marginfigure}
```

```
\begin{margintable}[⟨offset⟩]
   ...
\end{margintable}
```

`figure` environment.

As with sidenotes and marginnotes, a caption may sometimes require vertical adjustment. The `\caption` command now takes a second optional argument that enables you to do this by providing a dimension ⟨*offset*⟩. You may specify the caption in any one of the following forms:

```
\caption{long caption}
\caption[short caption]{long caption}
\caption[][⟨offset⟩]{long caption}
\caption[short caption][⟨offset⟩]{long caption}

\caption[Hilbert curves...][6pt]{Hilbert curves...}
```

Table 4 shows table created with the `booktabs` package. Notice the lack of vertical rules—they serve only to clutter the table's data.

Margin	Length
Paper width	8 1/2 inches
Paper height	11 inches
Textblock width	6 1/2 inches
Textblock/sidenote gutter	3/8 inches
Sidenote width	2 inches

Table 4: Here are the dimensions of the various margins used in the Tufte-handout class.

Occasionally LaTeX will generate an error message:

```
Error:  Too many unprocessed floats
```

LaTeX tries to place floats in the best position on the page. Until it's finished composing the page, however, it won't know where those positions are. If you have a lot of floats on a page (including sidenotes, margin notes, figures, tables, etc.), LaTeX may run out of "slots" to keep track of them and will generate the above error.

LaTeX initially allocates 18 slots for storing floats. To work around this limitation, the Tufte-LaTeX document classes provide a `\morefloats` command that will reserve more slots.

The first time `\morefloats` is called, it allocates an additional 34 slots. The second time `\morefloats` is called, it allocates another 26 slots.

The `\morefloats` command may only be used two times. Calling it a third time will generate an error message. (This is because we can't safely allocate many more floats or LaTeX will run out of memory.)

If, after using the `\morefloats` command twice, you continue to get the `Too many unprocessed floats` error, there are a couple things you can do.

The `\FloatBarrier` command will immediately process all the floats before typesetting more material. Since `\FloatBarrier` will start a new paragraph, you should place this command at the beginning or end of a paragraph.

The `\clearpage` command will also process the floats before continuing, but instead of starting a new paragraph, it will start a new page.

You can also try moving your floats around a bit: move a figure or table to the next page or reduce the number of sidenotes. (Each sidenote actually uses *two* slots.)

After the floats have placed, LaTeX will mark those slots as unused so they are available for the next page to be composed.

Captions

You may notice that the captions are sometimes misaligned. Due to the way LaTeX's float mechanism works, we can't know for sure where it decided to put a float. Therefore, the Tufte-LaTeX document classes provide commands to override the caption position.

Vertical alignment To override the vertical alignment, use the `\setfloatalignment` command inside the float environment. For example:

```
\begin{figure}[btp]
    \includegraphics{sinewave}
    \caption{This is an example of a sine wave.}
    \label{fig:sinewave}
    \setfloatalignment{b}% forces caption to be bottom-aligned
\end{figure}
```

The syntax of the `\setfloatalignment` command is:

```
\setfloatalignment{⟨pos⟩}
```

where ⟨*pos*⟩ can be either `b` for bottom-aligned captions, or `t` for top-aligned captions.

Horizontal alignment To override the horizontal alignment, use either the `\forceversofloat` or the `\forcerectofloat` command inside of the float environment. For example:

```
\begin{figure}[btp]
    \includegraphics{sinewave}
    \caption{This is an example of a sine wave.}
    \label{fig:sinewave}
    \forceversofloat% forces caption to be set to the left of the float
\end{figure}
```

The `\forceversofloat` command causes the algorithm to assume the float has been placed on a verso page—that is, a page on the left side of a two-page spread. Conversely, the `\forcerectofloat` command causes the algorithm to assume the float has been placed on a recto page—that is, a page on the right side of a two-page spread.

Full-width text blocks

In addition to the new float types, there is a `fullwidth` environment that stretches across the main text block and the sidenotes area.

```
\begin{fullwidth}
Lorem ipsum dolor sit amet...
\end{fullwidth}
```

Lorem ipsum dolor sit amet, consectetuer adipiscing elit. Ut purus elit, vestibulum ut, placerat ac, adipiscing vitae, felis. Curabitur dictum gravida mauris. Nam arcu libero, nonummy eget, consectetuer id, vulputate a, magna. Donec vehicula augue eu neque. Pellentesque habitant morbi tristique senectus et netus et malesuada fames ac turpis egestas. Mauris ut leo. Cras viverra metus rhoncus sem. Nulla et lectus vestibulum urna fringilla ultrices. Phasellus eu tellus sit amet tortor gravida placerat. Integer sapien est, iaculis in, pretium quis, viverra ac, nunc. Praesent eget sem vel leo ultrices bibendum. Aenean faucibus. Morbi dolor nulla, malesuada eu, pulvinar at, mollis ac, nulla. Curabitur auctor semper nulla. Donec varius orci eget risus. Duis nibh mi, congue eu, accumsan eleifend, sagittis quis, diam. Duis eget orci sit amet orci dignissim rutrum.

Typography

Typefaces

If the Palatino, Helvetica, and `Bera Mono` typefaces are installed, this style will use them automatically. Otherwise, we'll fall back on the Computer Modern typefaces.

Letterspacing

This document class includes two new commands and some improvements on existing commands for letterspacing.

The `\textsc` command has also been redefined to include letterspacing. The case of the `\textsc` argument is left as is, however. This allows one to use both uppercase and lowercase letters: The Initial Letters Of The Words In This Sentence Are Capitalized.

Document Class Options

The `tufte-book` class is based on the LaTeX `book` document class. Therefore, you can pass any of the typical book options. There are

a few options that are specific to the `tufte-book` document class, however.

The `a4paper` option will set the paper size to A4 instead of the default US letter size.

The `sfsidenotes` option will set the sidenotes and title block in a sans serif typeface instead of the default roman.

The `twoside` option will modify the running heads so that the page number is printed on the outside edge (as opposed to always printing the page number on the right-side edge in `oneside` mode).

The `symmetric` option typesets the sidenotes on the outside edge of the page. This is how books are traditionally printed, but is contrary to Tufte's book design which sets the sidenotes on the right side of the page. This option implicitly sets the `twoside` option.

The `justified` option sets all the text fully justified (flush left and right). The default is to set the text ragged right. The body text of Tufte's books are set ragged right. This prevents needless hyphenation and makes it easier to read the text in the slightly narrower column.

The `bidi` option loads the `bidi` package which is used with XeLaTeX to typeset bi-directional text. Since the `bidi` package needs to be loaded before the sidenotes and cite commands are defined, it can't be loaded in the document preamble.

The `debug` option causes the Tufte-LaTeX classes to output debug information to the log file which is useful in troubleshooting bugs. It will also cause the graphics to be replaced by outlines.

The `nofonts` option prevents the Tufte-LaTeX classes from automatically loading the Palatino and Helvetica typefaces. You should use this option if you wish to load your own fonts. If you're using XeLaTeX, this option is implied (*i.e.*, the Palatino and Helvetica fonts aren't loaded if you use XeLaTeX).

The `nols` option inhibits the letterspacing code. The Tufte-LaTeX classes try to load the appropriate letterspacing package (either pdfTeX's `letterspace` package or the `soul` package). If you're using XeLaTeX with `fontenc`, however, you should configure your own letterspacing.

The `notitlepage` option causes `\maketitle` to generate a title block instead of a title page. The `book` class defaults to a title page and the `handout` class defaults to the title block. There is an analogous `titlepage` option that forces `\maketitle` to generate a full title page instead of the title block.

The `notoc` option suppresses Tufte-LaTeX's custom table of contents (TOC) design. The current TOC design only shows unnumbered chapter titles; it doesn't show sections or subsections. The `notoc` option will revert to LaTeX's TOC design.

The nohyper option prevents the hyperref package from being loaded. The default is to load the hyperref package and use the \title and \author contents as metadata for the generated PDF.

Customizing Tufte-LaTeX

The Tufte-LaTeX document classes are designed to closely emulate Tufte's book design by default. However, each document is different and you may encounter situations where the default settings are insufficient. This chapter explores many of the ways you can adjust the Tufte-LaTeX document classes to better fit your needs.

File Hooks

If you create many documents using the Tufte-LaTeX classes, it's easier to store your customizations in a separate file instead of copying them into the preamble of each document. The Tufte-LaTeX classes provide three file hooks: `tufte-common-local.tex`, `tufte-book-local.tex`, and `tufte-handout-local.tex`.

`tufte-common-local.tex` If this file exists, it will be loaded by all of the Tufte-LaTeX document classes just prior to any document-class-specific code. If your customizations or code should be included in both the book and handout classes, use this file hook.

`tufte-book-local.tex` If this file exists, it will be loaded after all of the common and book-specific code has been read. If your customizations apply only to the book class, use this file hook.

`tufte-common-handout.tex` If this file exists, it will be loaded after all of the common and handout-specific code has been read. If your customizations apply only to the handout class, use this file hook.

Numbered Section Headings

While Tufte dispenses with numbered headings in his books, if you require them, they can be anabled by changing the value of the `secnumdepth` counter. From the table below, select the heading level at which numbering should stop and set the `secnumdepth` counter to that value. For example, if you want parts and chapters numbered,

but don't want numbering for sections or subsections, use the command:

```
\setcounter{secnumdepth}{0}
```

The default `secnumdepth` for the Tufte-LaTeX document classes is −1.

Heading level	Value
Part (in `tufte-book`)	−1
Part (in `tufte-handout`)	0
Chapter (only in `tufte-book`)	0
Section	1
Subsection	2
Subsubsection	3
Paragraph	4
Subparagraph	5

Table 5: Heading levels used with the `secnumdepth` counter.

Changing the Paper Size

The Tufte-LaTeX classes currently only provide three paper sizes: A4, B5, and US letter. To specify a different paper size (and/or margins), use the `\geometrysetup` command in the preamble of your document (or one of the file hooks). The full documentation of the `\geometrysetup` command may be found in the `geometry` package documentation.

Customizing Marginal Material

Marginal material includes sidenotes, citations, margin notes, and captions. Normally, the justification of the marginal material follows the justification of the body text. If you specify the `justified` document class option, all of the margin material will be fully justified as well. If you don't specify the `justified` option, then the marginal material will be set ragged right.

You can set the justification of the marginal material separately from the body text using the following document class options: `sidenote`, `marginnote`, `caption`, `citation`, and `marginals`. Each option refers to its obviously corresponding marginal material type. The `marginals` option simultaneously sets the justification on all four marginal material types.

Each of the document class options takes one of five justification types:

`justified` Fully justifies the text (sets it flush left and right).

raggedleft Sets the text ragged left, regardless of which page it falls on.

raggedright Sets the text ragged right, regardless of which page it falls on.

raggedouter Sets the text ragged left if it falls on the left-hand (verso) page of the spread and otherwise sets it ragged right. This is useful in conjunction with the `symmetric` document class option.

auto If the `justified` document class option was specified, then set the text fully justified; otherwise the text is set ragged right. This is the default justification option if one is not explicitly specified.

For example,

```
\documentclass[symmetric,justified,marginals=raggedouter]{tufte-book}
```

will set the body text of the document to be fully justified and all of the margin material (sidenotes, margin notes, captions, and citations) to be flush against the body text with ragged outer edges.

THE FONT AND STYLE of the marginal material may also be modified using the following commands:

```
\setsidenotefont{⟨font commands⟩}
\setcaptionfont{⟨font commands⟩}
\setmarginnotefont{⟨font commands⟩}
\setcitationfont{⟨font commands⟩}
```

The `\setsidenotefont` sets the font and style for sidenotes, the `\setcaptionfont` for captions, the `\setmarginnotefont` for margin notes, and the `\setcitationfont` for citations. The ⟨*font commands*⟩ can contain font size changes (e.g., `\footnotesize`, `\Huge`, etc.), font style changes (e.g., `\sffamily`, `\ttfamily`, `\itshape`, etc.), color changes (e.g., `\color{blue}`), and many other adjustments.

If, for example, you wanted the captions to be set in italic sans serif, you could use:

```
\setcaptionfont{\itshape\sffamily}
```

Compatibility Issues

When switching an existing document from one document class to a Tufte-LaTeX document class, a few changes to the document may have to be made.

Converting from `article` to `tufte-handout`

The following `article` class options are unsupported: `10pt`, `11pt`, `12pt`, `a5paper`, `b5paper`, `executivepaper`, `legalpaper`, `landscape`, `onecolumn`, and `twocolumn`.

The following headings are not supported: `\subsubsection` and `\subparagraph`.

Converting from `book` to `tufte-book`

The following `report` class options are unsupported: `10pt`, `11pt`, `12pt`, `a5paper`, `b5paper`, `executivepaper`, `legalpaper`, `landscape`, `onecolumn`, and `twocolumn`.

The following headings are not supported: `\subsubsection` and `\subparagraph`.

Troubleshooting and Support

Tufte-LaTeX Website

The website for the Tufte-LaTeX packages is located at `http://code.google.com/p/tufte-latex/`. On our website, you'll find links to our SVN repository, mailing lists, bug tracker, and documentation.

Tufte-LaTeX Mailing Lists

There are two mailing lists for the Tufte-LaTeX project:

Discussion list The `tufte-latex` discussion list is for asking questions, getting assistance with problems, and help with troubleshooting. Release announcements are also posted to this list. You can subscribe to the `tufte-latex` discussion list at `http://groups.google.com/group/tufte-latex`.

Commits list The `tufte-latex-commits` list is a read-only mailing list. A message is sent to the list any time the Tufte-LaTeX code has been updated. If you'd like to keep up with the latest code developments, you may subscribe to this list. You can subscribe to the `tufte-latex-commits` mailing list at `http://groups.google.com/group/tufte-latex-commits`.

Getting Help

If you've encountered a problem with one of the Tufte-LaTeX document classes, have a question, or would like to report a bug, please send an email to our mailing list or visit our website.

To help us troubleshoot the problem more quickly, please try to compile your document using the `debug` class option and send the generated `.log` file to the mailing list with a brief description of the problem.

Errors, Warnings, and Informational Messages

The following is a list of all of the errors, warnings, and other messages generated by the Tufte-LaTeX classes and a brief description of their meanings.

```
Error:  \subparagraph is undefined by this class.
```

The `\subparagraph` command is not defined in the Tufte-LaTeX document classes. If you'd like to use the `\subparagraph` command, you'll need to redefine it yourself. See the "Headings" section on page 53 for a description of the heading styles availaboe in the Tufte-LaTeX document classes.

```
Error:  \subsubsection is undefined by this class.
```

The `\subsubsection` command is not defined in the Tufte-LaTeX document classes. If you'd like to use the `\subsubsection` command, you'll need to redefine it yourself. See the "Headings" section on page 53 for a description of the heading styles availaboe in the Tufte-LaTeX document classes.

```
Error:  You may only call \morefloats twice.  See the
        Tufte-LaTeX documentation for other workarounds.
```

LaTeX allocates 18 slots for storing floats. The first time `\morefloats` is called, it allocates an additional 34 slots. The second time `\morefloats` is called, it allocates another 26 slots.

The `\morefloats` command may only be called two times. Calling it a third time will generate this error message. See page 55 for more information.

```
Warning:  Option '⟨class option⟩' is not supported -- ignoring option.
```

This warning appears when you've tried to use ⟨*class option*⟩ with a Tufte-LaTeX document class, but ⟨*class option*⟩ isn't supported by the Tufte-LaTeX document class. In this situation, ⟨*class option*⟩ is ignored.

Package Dependencies

The following is a list of packages that the Tufte-LaTeX document classes rely upon. Packages marked with an asterisk are optional.

- xifthen
- ifxetex*
- ifpdf*
- hyperref

- geometry
- ragged2e
- chngpage *or* changepage
- paralist
- textcase
- soul*
- letterspace*
- setspace
- natbib *and* bibentry
- optparams
- placeins
- mathpazo*
- helvet*
- fontenc
- beramono*
- fancyhdr
- xcolor
- textcomp
- titlesec
- titletoc

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