Equations

March 6, 2018

1 Inline

1.1 Like normal text

The formula is $a^2 + b^2 = c^2$.

```
The formula is $a^2+b^2=c^2$.
```

1.2 Emphasized in normal text

The formula is

$$a^2 + b^2 = c^2.$$

```
The formula is $$a^2+b^2=c^2.$$
```

```
The formula is \[a^2+b^2=c^2.\]
```

2 Big equations

2.1 Without numbering

$$a^2 + b^2 = c^2$$

```
$$...$$
```

```
\begin{equation*}...\end{equation*}
```

```
\begin{align*}...\end{align*}
```

```
\[...\]
```

2.2 With numbering

$$a^2 + b^2 = c^2 \tag{1}$$

```
\begin{equation}...\end{equation}
```

```
\begin{align}...\end{align}
```

2.3 With more than one line

$$\begin{aligned} x &= \frac{p}{2} \pm \sqrt{\left(\frac{p}{2}\right)^2 - q} \\ &= -\frac{p}{2} \pm \sqrt{\left(\frac{p}{2}\right)^4 - q} \\ &= 4 \end{aligned}$$

```
\begin{align}...\end{align}
```

```
\begin{align*}...\end{align*}
```

```
x&=\frac{p}{2}\pm\sqrt{\left(\frac{p}{2}\right)^2-q}\\
 &=-\frac{p}{2}\pm\sqrt{\left(\frac{p}{2}\right)^4-q}\\
 &=4
```

3 Mathematical fonts

3.1 The fonts

- Normal: A, B, C, a, b, c, $1, 2, 3$
- `\mathnormal{...}`: $\mathnormal{A, B, C}$, $\mathnormal{a, b, c}$, $\mathnormal{1, 2, 3}$
- `\mathrm{...}`: $\mathrm{A, B, C}$, $\mathrm{a, b, c}$, $\mathrm{1, 2, 3}$
- `\mathit{...}`: $\mathit{A, B, C}$, $\mathit{a, b, c}$, $\mathit{1, 2, 3}$
- `\mathbf{...}`: $\mathbf{A, B, C}$, $\mathbf{a, b, c}$, $\mathbf{1, 2, 3}$
- `\mathsf{...}`: $\mathsf{A, B, C}$, $\mathsf{a, b, c}$, $\mathsf{1, 2, 3}$
- `\mathtt{...}`: $\mathtt{A, B, C}$, $\mathtt{a, b, c}$, $\mathtt{1, 2, 3}$
- `\mathfrak{...}`: $\mathfrak{A, B, C}$, $\mathfrak{a, b, c}$, $\mathfrak{1, 2, 3}$ (It requires the package `amsfonts`)
- `\mathbb{...}`: $\mathbb{A, B, C}$, $\mathbb{a, b, c}$, $\mathbb{1, 2, 3}$ (It requires the package `amsfonts`)
- `\mathcal{...}`: $\mathcal{A, B, C}$
- `\mathscr{...}`: $\mathscr{A, B, C}$ (It requires the package `mathrsfs`)

3.2 Font styling

- Make bold: $\boldsymbol{\beta} = (\beta_1, \beta_2, \ldots, \beta_n)$ (`\boldsymbol{...}`)
- Add color: $k = x{-}2$ (`{\color{red}...}, \mathbin{\color{blue{...}}}`)
- Bonus: Render text in math mode: text (`\text{text}`)

3.3 Accents

- `a'`, `a^{\prime}`: a'
- `a''`, `a^{\prime\prime}`: a''
- `\hat{a}`: $\hat{a}$
- `\bar{a}`: $\bar{a}$
- `\grave{a}`: $\grave{a}$
- `\acute{a}`: $\acute{a}$
- `\dot{a}`: $\dot{a}$
- `\ddot{a}`: $\ddot{a}$
- `\dddot{a}`: $\dddot{a}$
- `\overrightarrow{AB}`: $\overrightarrow{a}$
- `\overleftarrow{AB}`: $\overleftarrow{a}$
- `\overline{a}`: $\overline{a}$
- `\check{a}`: $\check{a}$
- `\breve{a}`: $\breve{a}$
- `\vec{a}`: $\vec{a}$
- `\not{a}`: $\not{a}$
- `\tilde{a}`: $\tilde{a}$
- `\underline{a}`: $\underline{a}$
- `\mathring{a}`: $\mathring{a}$
- `\widehat{AAA}`: $\widehat{AAA}$
- `\widetilde{AAA}`: $\widetilde{AAA}$
- `\stackrel\frown{AAA}`: $A\overset{\frown}{A}A$

3.4 Dots

- `\dots`: $\dots$
- `\ldots`: $\ldots$
- `\cdots`: $\cdots$
- `\vdots`: $\vdots$
- `\ddots`: $\ddots$
- `\iddots`: $\iddots$ (It requires the package `mathdots`)

Code	Output	Description
`A_1,A_2,\dotsc,`	$A_1, A_2, \dotsc,$	for "dots with commas"
`A_1+\dotsb+A_N`	$A_1 + \dotsb + A_N$	for "dots with binary operators/relations"
`A_1 \dotsm A_N`	$A_1 \dotsm A_N$	for "multiplication dots"
`\int_a^b \dotsi`	$\int_a^b \dotsi$	for "dots with integrals"
`A_1\dotso A_N`	$A_1 \dotso A_N$	for "other dots" (none of the above)

3.5 Symbols

Code	Symbol	Code	Symbol	Code	Symbol
`<`	$<$	`>`	$>$	`=`	$=$
`\leq`	$\leq$	`\geq`	$\geq$	`\doteq`	$\doteq$
`\ll`	$\ll$	`\gg`	$\gg$	`\equiv`	$\equiv$
`\subset`	$\subset$	`\supset`	$\supset$	`\approx`	$\approx$
`\subseteq`	$\subseteq$	`\supseteq`	$\supseteq$	`\cong`	$\cong$
`\not\subseteq`	$\not\subseteq$	`\not\supseteq`	$\not\supseteq$	`\simeq`	$\simeq$
`\sqsubset`	$\sqsubset$	`\sqsupset`	$\sqsupset$	`\sim`	$\sim$
`\sqsubseteq`	$\sqsubseteq$	`\sqsupseteq`	$\sqsupseteq$	`\propto`	$\propto$
`\preceq`	$\preceq$	`\succeq`	$\succeq$	`\neq`	$\neq$

Code	Symbol	Code	Symbol	Code	Symbol
`\parallel`	$\parallel$	`\not\parallel`	$\nparallel$	`\pm`	$\pm$
`\asymp`	$\asymp$	`\bowtie`	$\bowtie$	`\mp`	$\mp$
`\vdash`	$\vdash$	`\dashv`	$\dashv$	`\times`	$\times$
`\in`	$\in$	`\ni`	$\ni$	`\div`	$\div$
`\smile`	$\smile$	`\frown`	$\frown$	`\ast`	$\ast$
`\models`	$\models$	`\notin`	$\notin$	`\star`	$\star$
`\perp`	$\perp$	`\mid`	$\mid$	`\dagger`	$\dagger$
`\prec`	$\prec$	`\succ`	$\succ$	`\ddagger`	$\ddagger$

Code	Symbol	Code	Symbol	Code	Symbol
\cap	$\cap$	\diamond	$\diamond$	\oplus	$\oplus$
\cup	$\cup$	\bigtriangleup	$\bigtriangleup$	\ominus	$\ominus$
\uplus	$\uplus$	\bigtriangledown	$\bigtriangledown$	\otimes	$\otimes$
\sqcap	$\sqcap$	\triangleleft	$\triangleleft$	\oslash	$\oslash$
\sqcup	$\sqcup$	\triangleright	$\triangleright$	\odot	$\odot$
\vee	$\vee$	\bigcirc	$\bigcirc$	\circ	$\circ$
\wedge	$\wedge$	\bullet	$\bullet$	\setminus	$\setminus$
\cdot	$\cdot$	\wr	$\wr$	\amalg	$\amalg$

Code	Symbol	Code	Symbol
\exists	$\exists$	\rightarrow, \to	$\rightarrow$
\not\exists	$\nexists$	\leftarrow, \gets	$\leftarrow$
\forall	$\forall$	\mapsto	$\mapsto$
\neg	$\neg$	\implies	$\implies$
\subset	$\subset$	\Rightarrow	$\Rightarrow$
\supset	$\supset$	\leftrightarrow	$\leftrightarrow$
\in	$\in$	\iff	$\iff$
\not\in	$\notin$	\Leftrightarrow	$\Leftrightarrow$
\ni	$\ni$	\top	$\top$
\not\ni	$\not\ni$	\bot	$\bot$
\land	$\land$	\emptyset	$\emptyset$
\lor	$\lor$		

Code	Symbol	Code	Symbol
\mid	$\mid$	\\|	$\|$
\{	$\{$	\}	$\}$
\uparrow	$\uparrow$	\Uparrow	$\Uparrow$
\downarrow	$\downarrow$	\Downarrow	$\Downarrow$
/	$/$	\backslash	$\backslash$
\langle	$\langle$	\rangle	$\rangle$
\lceil	$\lceil$	\rceil	$\rceil$
\not\in	$\notin$	\rfloor	$\rfloor$

Code	Symbol	Code	Symbol	Code	Symbol
A,\alpha	A, α	I,\iota	I, ι	P,\rho	P, ρ
B,\beta	B, β	K,\kappa	K, κ	\Sigma,\sigma	Σ, σ
\Gamma,\gamma	Γ, γ	\Lambda,\lambda	Λ, λ	T,\tau	T, τ
\Delta,\delta	Δ, δ	M,\mu	M, μ	\Upsilon,\upsilon	Υ, υ
E,\epsilon	E, ϵ	N,\nu	N, ν	\Phi,\phi	Φ, ϕ
Z,\zeta	Z, ζ	\Xi,\xi	Ξ, ξ	X,\chi	X, χ
H,\eta	H, η	O,o	O, o	\Psi,\psi	Ψ, ψ
\Theta,\theta	Θ, θ	\Pi,\pi	Π, π	\Omega,\omega	Ω, ω

Code	Symbol	Code	Symbol
`\partial`	∂	`\imath`	$\imath$
`\eth`	eth	`\jmath`	$\jmath$
`\hbar`	$\hbar$	`\ell`	ℓ
`\Re`	$\Re$	`\nabla`	∇
`\Im`	$\Im$	`\Box`	$\Box$
`\wp`	cosh	`\infty`	∞
`\aleph`	$\aleph$		

Code	Symbol	Code	Symbol
`\sin`	sin	`\arcsin`	arcsin
`\cos`	cos	`\arccos`	arccos
`\tan`	tan	`\arctan`	arctan
`\cot`	cot	`\csc`	csc
`\sinh`	sinh	`\sec`	sec
`\cosh`	cosh		
`\tanh`	tanh		
`\coth`	coth		

4 Matrices

Name	Delimiter
`matrix`	$\begin{matrix} a & b \\ c & d \end{matrix}$
`pmatrix`	$\begin{pmatrix} a & b \\ c & d \end{pmatrix}$
`bmatrix`	$\begin{bmatrix} a & b \\ c & d \end{bmatrix}$
`Bmatrix`	$\begin{Bmatrix} a & b \\ c & d \end{Bmatrix}$
`vmatrix`	$\begin{vmatrix} a & b \\ c & d \end{vmatrix}$
`Vmatrix`	$\begin{Vmatrix} a & b \\ c & d \end{Vmatrix}$

```
\begin{matrix}
        a & b \\
        c & d
\end{matrix}
```

A matrix in text must be set smaller: $\left(\begin{smallmatrix} a & b \\ c & d \end{smallmatrix}\right)$ to not increase leading in a portion of text.

5 Examples

5.1 Solve a formula

$$\begin{aligned} x &= \frac{p}{2} \pm \sqrt{\left(\frac{p}{2}\right)^2 - q} \\ &= -\frac{p}{2} \pm \sqrt{\left(\frac{p}{2}\right)^4 - q} \\ &= 4 \end{aligned}$$

5.2 Different cases

$$f(n) = \begin{cases} n/2 & \text{if } n \text{ is even} \\ -(n+1)/2 & \text{if } n \text{ is odd} \end{cases}$$

5.3 Unsorted

$$\binom{n}{r} = \frac{n!}{r!(n-r)!}$$

$$\left(\frac{x^2}{y^3}\right)$$

$$P\left(A = 2 \middle| \frac{A^2}{B} > 4\right)$$

$$\left\{\frac{x^2}{y^3}\right\}$$

$$\frac{\mathrm{d}}{\mathrm{d}x}\big(kg(x)\big)$$

$$\begin{matrix} a & b & c \\ d & e & f \\ g & h & i \end{matrix}$$

$$\begin{matrix} -1 & 3 \\ 2 & -4 \end{matrix} = \begin{matrix} -1 & 3 \\ 2 & -4 \end{matrix}$$

$$\begin{array}{c|c} 1 & 2 \\ \hline 3 & 4 \end{array}$$

$$M = \begin{bmatrix} \frac{5}{6} & \frac{1}{6} & 0 \\ \frac{5}{6} & 0 & \frac{1}{6} \\ 0 & \frac{5}{6} & \frac{1}{6} \end{bmatrix}$$

$$M = \begin{array}{c} \\ A \\ B \end{array} \begin{array}{c} \begin{array}{cc} x & y \end{array} \\ \begin{pmatrix} 1 & 0 \\ 0 & 1 \end{pmatrix} \end{array}$$

$$\chi^2 = \sum \frac{(O-E)^2}{E} = \frac{(22-24)^2}{24} + \frac{(26-24)^2}{24} = \frac{1}{3}$$

$$\chi^2 = \sum \frac{(O-E)^2}{E} = \frac{(24-31.1)^2}{31.1} + \frac{(22-14.9)^2}{14.9} + \frac{(76-68.9)^2}{68.9} + \frac{(26-33.1)^2}{33.1} = 7.22$$

$$P(x) = \frac{N!}{x!(N-x)!}\pi^x(1-\pi)^{N-x}$$

$$f(x;\mu,\sigma^2) = \frac{1}{\sigma\sqrt{2\pi}}e^{-\frac{1}{2}(\frac{x-\mu}{\sigma})^2}$$

$$\bar{x} = \frac{(\sum x)}{n}$$

$$\bar{x} = \frac{(\sum x)}{n}$$

$$\text{skew} = \sum \frac{(X-\mu)^3}{\sigma^3}$$

$$\text{sum of squared errors (SS)} = \sum (x_i - x_{\text{mean}})^2 = 7366.625\text{kg}^2$$

$$\text{variance of the sample (SS/N)} = \frac{\sum (x_i - x_{\text{mean}})^2}{N} = 736.66\text{kg}^2$$

$$\sigma = \sqrt{\frac{\sum (x_i - \bar{x})^2}{N-1}}$$

$$s^2 = \frac{\sum (x_i - \bar{x})^2}{N}$$

$$t = \frac{|\bar{x}_{\text{sample}} - \bar{x}_{\text{population}}|}{s_{\bar{x}}} = \frac{4}{4.92} = 0.81$$

$$s = \sqrt{\frac{(N_1 - 1)s_1^2 + (N_2 - 1)s_2^2}{n_1 + n_2 - 2}}$$

$$\text{SS}(T) = \sum \left(x - \frac{\sum x}{N}\right)^2 = \sum x^2 - \frac{\left(\sum x\right)^2}{N}$$

$$F = \frac{\text{betweenGroup variance}}{\text{withinGroup variance}} = \frac{\text{treatment variance} + \text{error variance}}{\text{withinGroup variance}} = \frac{\sigma^2_{\text{between}}}{\sigma^2_{\text{within}}} = \frac{s^2_{\text{between}}}{s^2_{\text{within}}}$$

$$\text{SS}_{\text{between}} = \sum \left[\frac{\left(\sum x_j\right)^2}{n_j}\right] - \frac{\left(\sum x_{ij}\right)^2}{N}$$

$$\eta^2 = \frac{\text{SS}_{\text{between}}}{\text{SS}_{\text{total}}}$$

$$f = \sqrt{\frac{\eta^2}{1 - \eta^2}}$$

$$\int_a^b x^2 dx$$

$$sum_{n=1}^{\infty} 2^{-n} = 1$$

$$\prod_{i=a}^{b} f(i)$$

$$\lim_{x \to \infty} f(x)$$

$$\binom{n}{k} = \frac{n!}{k!(n-k)!}$$

$$\frac{1 + \frac{a}{b}}{1 + \frac{1}{1 + \frac{1}{a}}}$$

$$a_0 + \cfrac{1}{a_1 + \cfrac{1}{a_2 + \cfrac{1}{a_3 + \cdots}}}$$

$$\begin{aligned} A &= \frac{\pi r^2}{2} \\ &= \frac{1}{2}\pi r^2 \end{aligned}$$

$$\begin{aligned} 2x - 5y &= 8 \\ 3x + 9y &= -12 \end{aligned}$$

$$\begin{aligned} x &= y & w &= z & a &= b + c \\ 2x &= -y & 3w &= \frac{1}{2}z & a &= b \\ -4 + 5x &= 2 + y & w + 2 &= -1 + w & ab &= cb \end{aligned}$$

$$\begin{aligned} 2x - 5y &= 8 \\ 3x^2 + 9y &= 3a + c \end{aligned}$$

$$
\begin{aligned}
f(x) =& x^2 + 3x + 2 \\
f(x) =& x^2 + 3x + 2 \\
f(x) =& x^2 + 3x + 2 \\
f(x) =& x^2 + 3x + 2 \\
f(x) =& x^2 + 3x + 2 \\
f(x) =& x^2 + 3x + 2 \\
f(x) =& x^2 + 3x + 2 \\
f(x) =& x^2 + 3x + 2
\end{aligned}
$$

$$
\Rightarrow \begin{pmatrix} a_{1,1} & a_{1,2} & a_{1,3} \\ a_{2,1} & a_{2,2} & a_{2,3} \\ a_{3,1} & a_{3,2} & a_{3,3} \end{pmatrix} \begin{pmatrix} b_{1,1} \\ b_{2,1} \\ b_{3,1} \end{pmatrix} = \begin{pmatrix} c_{1,1} = \begin{pmatrix} a_{1,1} & a_{1,2} & a_{1,3} \end{pmatrix} \begin{pmatrix} b_{1,1} \\ b_{2,1} \\ b_{3,1} \end{pmatrix} = a_{1,1}b_{1,1} + a_{1,2}b_{2,1} + a_{1,3}b_{3,1} \\ c_{2,1} = a_{2,1}b_{1,1} + a_{2,2}b_{2,1} + a_{2,3}b_{3,1} \\ c_{3,1} = a_{3,1}b_{1,1} + a_{3,2}b_{2,1} + a_{3,3}b_{3,1} \end{pmatrix}
$$

$$
\begin{aligned}
A_{m \times n} * B_{n \times p} =& C_{m \times p} \\
A_{3 \times 3} * B_{3 \times 1} =& C_{3 \times 1}
\end{aligned}
$$

$$
\begin{pmatrix} 1 & 0 & 3 \\ 0 & 1 & 4 \\ 0 & 0 & 1 \end{pmatrix} \begin{pmatrix} 2 & 0 & 0 \\ 0 & 1 & 0 \\ 0 & 0 & 1 \end{pmatrix} = \begin{pmatrix} 1*2+0*0+3*0 & 1*0+0*1+3*0 & 1*0+0*0+3*1 \\ 0*2+1*0+4*0 & 0*0+1*1+4*0 & 0*0+1*0+4*1 \\ 0*2+0*0+1*0 & 0*0+0*1+1*0 & 0*0+0*0+1*1 \end{pmatrix}
$$

$$
= \begin{pmatrix} 2 & 0 & 3 \\ 0 & 1 & 4 \\ 0 & 0 & 1 \end{pmatrix}
$$

$$
\Rightarrow \begin{pmatrix} 2 & 0 & 3 \\ 0 & 1 & 4 \\ 0 & 0 & 1 \end{pmatrix} \begin{pmatrix} 0 \\ 0 \\ 1 \end{pmatrix}_h = \begin{pmatrix} 2*0+0*0+3*1) \\ 0*0+1*0+4*1 \\ 0*0+0*0+1*1 \end{pmatrix}_h = \begin{pmatrix} 3 \\ 4 \\ 1 \end{pmatrix}_h = \begin{pmatrix} 3 \\ 4 \end{pmatrix} \Leftrightarrow \begin{pmatrix} 3 \\ 4 \end{pmatrix} + \begin{pmatrix} 0 \\ 0 \end{pmatrix}
$$

$$
\begin{pmatrix} 1 & 0 & 0 \\ sh_y & 1 & 0 \\ 0 & 0 & 1 \end{pmatrix} \begin{pmatrix} x \\ y \\ 1 \end{pmatrix}_h = \begin{pmatrix} x \\ sh_y * x + y \\ 1 \end{pmatrix}_h
$$

1	2	3
4	5	6
7	8	9

1	2	3
4	5	6
7	8	9

1	2	3
4	5	6
7	8	9