LaTeX Lectures for Mathematicians

Some Tips on TeX

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Sogang University

About me

- You can find a lecture note at my homepage (maths.sogang.ac.kr/willkwon).
- Major in Partial Differential Equation (advisor: Prof. Hyunseok Kim / Sogang University)
- I have used TEX for 6 years (since 2013)

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I have been worked as a TeXnician

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Figure 1: Seoul ICM 2014 LaTeX Technical editor: Proceeding, Abstract book, Program book

Graduate Student Seminar

2018.10.29 Mon. 5:00 R1418

Pak Tung Ho 교수 서강대학교 수학과

Eigenvalue in Riemannian Geometry

Abstract

I will first talk about the eigenvalues of a bounded domain in Euclidean space. Some properties and problems related to the eigenvalues will be mentioned. I will then explain about the concept of Riemannian manifolds, and talk about the eigenvalues of a Riemannian manifold.

This talk will be accessible to students who have learned multivariable calculus.

Everyone is welcome!
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1 복소수

학습 목표 복소수의 뜻을 알고 그 성질을 이해한다.
복소수의 사칙계산을 할 수 있다.

복소수

생각 열기

방정식 $x^2+1=0$의 해에 대하여 알아보자.

탐구 1 $x^2+1=0$을 만족시키는 실수 x가 있는지 말해보자.

탐구 2 탐구 1과 같이 답한 이유를 말해 보자.

제곱해서 음수가 되는 실수는 없으므로 방정식 $x^2+1=0$은 실수의 범위에서 해를 갖지 않는다.

방정식 $x^2+1=0$이 해를 갖도록 수의 범위를 확장해 보자.
제곱하여 -1이 되는 새로운 수를 생각하여 이것을

$$i$$

로 나타내고 허수단위라고 한다. 즉,

i는 허수단위를 뜻하는 imaginary unit의 첫 글자이다.

$$i^2=-1$$

이며, 제곱해서 -1이 된다는 뜻으로 $i=\sqrt{-1}$로 나타내기도 한다.

실수 a, b에 대하여

$$a+bi$$

의 꼴의 수를 복소수라고 한다. 이때 a를 $a+bi$의 실수부분, b를 $a+bi$의 허수부분이라고 한다.

복소수 $a+bi$에서 $a=0$일 때, $0+bi$는 간단히 bi로 나타내고, $0i=0$으로 정의한다.
또 $b=0$일 때, $a+0i$는 a이므로 실수도 복소수이다.
한편 $b\neq 0$일 때, $a+bi$는 실수가 아닌 복소수이다. 실수가 아닌 복소수를 허수라고 한다.

이상으로부터 복소수는 다음과 같이 분류할 수 있다.

$$\text{복소수 } a+bi \begin{cases} \text{실수 } a & (b=0) \\ \text{허수 } a+bi & (b\neq 0) \end{cases} \quad (a, b\text{는 실수})$$

오일러(Euler, L.; 1707~1783) 스위스의 수학자로 허수를 나타내기 위한 기호 i를 처음 사용하였다.

문제 1 다음 복소수 중에서 실수와 허수를 각각 찾아라.

(1) $2+3i$ (2) $5+0i$
(3) $\sqrt{(-7)^2}$ (4) $7i$

두 복소수에서 실수부분은 실수끼리, 허수부분은 허수부분끼리 서로 같을 때, 두 복소수는 서로 같다고 한다. 즉 두 복소수 $a+bi$, $c+di$(a, b, c, d는 실수)에 대하여

$$a=c,\ b=d\text{일 때, } a+bi=c+di$$

이다. 특히 $a=0, b=0$일 때 $a+bi=0$이다.

$3-4i=3+(-4)i$

보기 a, b가 실수일 때, $a+bi=3-4i$이면 $a=3, b=-4$이다.

문제 2 다음 등식이 성립하도록 실수 a, b의 값을 정하여라.

(1) $a+bi=1+2i$ (2) $a+bi=-3+i$
(3) $3+bi=a-4\sqrt{2}i$ (4) $a=5+bi$

복소수 $a+bi$ (a, b는 실수)에 대하여 허수부분의 부호를 바꾼 복소수 $a-bi$를 $a+bi$의 켤레복소수라고 하며, 이것을 기호로

$$\overline{a+bi}$$

와 같이 나타낸다. 즉

$$\overline{a+bi}=a-bi$$

이다. 또

$$\overline{a-bi}=a+bi$$

이므로 두 복소수 $a+bi$와 $a-bi$는 서로 켤레복소수이다.

보기 $\overline{2+i}=2-i$, $\overline{6}=6$, $\overline{-3-5i}=-3+5i$, $\overline{-3i}=3i$

문제 3 다음 복소수의 켤레복소수를 구하여라.

(1) $1-4i$ (2) $-3+2i$
(3) -5 (4) $-2\sqrt{5}i$

(4) 극한 $\lim_{h\to0}\frac{f(h)-f(0)}{h}=\lim_{h\to0}\frac{1}{h}\sin h$이 존재하지 않기 때문에 함수 f는 $x=0$에서 미분계수가 존재하지 않는다.

6. $f(x)$는 $x=0$에서만 미분 불가능이다.

7. (1) 도함수의 정의를 이용하면

$$\begin{aligned} f'(x) &= \lim_{h\to0}\frac{f(x+h)-f(x)}{h}=\lim_{h\to0}\frac{\sqrt{x+h}-\sqrt{x}}{h} \\ &= \lim_{h\to0}\frac{\sqrt{x+h}-\sqrt{x}}{h}\cdot\frac{\sqrt{x+h}+\sqrt{x}}{\sqrt{x+h}+\sqrt{x}} \\ &= \lim_{h\to0}\frac{1}{\sqrt{x+h}+\sqrt{x}}=\frac{1}{2\sqrt{x}} \end{aligned}$$

(2) 도함수의 정의를 이용하면

$$\begin{aligned} f'(x) &= \lim_{h\to0}\frac{f(x+h)-f(x)}{h}=\lim_{h\to0}\frac{\frac{1}{x+h}-\frac{1}{x}}{h} \\ &= \lim_{h\to0}\frac{-1}{x(x+h)}=-\frac{1}{x^2} \end{aligned}$$

1.2 미분법

1.1절에서 이미 언급한 바와 같이 주어진 함수 $f(x)$로부터 그의 도함수 $f'(x)$를 구하는 연산 방법을 미분법[2]이라고 한다. 도함수의 정의에 의해 매번 함수의 극한을 통하여 주어진 함수의 도함수를 얻는 것은 다소 복잡할 수 있다. 따라서 자주 쓰이는 함수에 대해서 정형화된 도함수 공식을 얻어 놓고, 이들을 필요로 하는 경우에 이를 이용하여 도함수를 찾는다면 보다 편리하게 주어진 함수의 도함수를 구할 수 있을 것이다. 이를 위해 먼저 이 절에서는 미분법과 관련한 도함수의 여러 공식들을 소개한다.

1.2.1 기초 미분법

가장 간단한 형태인 상수함수 $f(x)=c$의 도함수에 대해 알아보자. 이 함수의 그래프는 x축과 평행한 직선 $y=c$이므로 기울기가 0, 즉 $f'(x)=0$이어야 한다. 이는 도함수의 정의를 이용하여 다음과 같이 간단히 구할 수 있다.

$$f'(x)=\lim_{h\to0}\frac{f(x+h)-f(x)}{h}=\lim_{h\to0}\frac{c-c}{h}=\lim_{h\to0}0=0.$$

2) 미분법의 정의(7쪽 참조)

또한 항등함수 $f(x)=x$의 그래프는 기울기가 1인 직선 $y=x$이므로 그 도함수는 $f'(x)=1$임을 알 수 있다.

$$f'(x)=\lim_{h\to0}\frac{f(x+h)-f(x)}{h}=\lim_{h\to0}\frac{(x+h)-x}{h}=\lim_{h\to0}\frac{h}{h}=1.$$

다음 정리 1.6 에서는 일반적으로 거듭제곱함수 $f(x)=x^n$ (n은 양의 정수)에 대한 도함수를 소개하고, 그것이 도함수의 정의로부터 어떻게 얻어졌는지를 자세히 살펴본다.

정리 1.6

양의 정수 n에 대하여 $f(x)=x^n$의 도함수는 $f'(x)=nx^{n-1}$이다.

증명 $f(x)=x^n$ (n :양의 정수)일 때, 도함수의 정의와 이항정리[3]로부터

$$\begin{aligned} f'(x) &= \lim_{h\to0}\frac{f(x+h)-f(x)}{h}=\lim_{h\to0}\frac{(x+h)^n-x^n}{h} \\ &= \lim_{h\to0}\frac{\left(x^n+nx^{n-1}h+\frac{n(n-1)}{2!}x^{n-2}h^2+\cdots+nxh^{n-1}+h^n\right)-x^n}{h} \\ &= \lim_{h\to0}\left(nx^{n-1}+\frac{n(n-1)}{2!}x^{n-2}h+\cdots+nxh^{n-2}+h^{n-1}\right) \\ &= nx^{n-1} \end{aligned}$$

이 성립한다. □

하나의 함수에 상수배를 하거나, 두 함수를 더하고 빼고 곱하고 나누어서 얻어지는 새로운 함수에 대한 도함수를 살펴보자.

3) 양의 정수 n에 대하여 $(a+b)^n$을 전개하여 간단히 하면

$$(a+b)^n=\sum_{r=0}^{n}{}_nC_r a^{n-r}b^r \quad 또는 \quad (a+b)^n=\sum_{r=0}^{n}{}_nC_r a^r b^{n-r} \tag{1.11}$$

과 같이 나타낼 수 있다. 이때 식 (1.11)를 일컬어 이항정리(binomial theorem)라 한다. 여기서 ${}_nC_r$ $(n\geq r)$은 조합(combination)의 수로서

$${}_nC_r=\frac{n!}{r!(n-r)!},\quad {}_nC_r={}_nC_{n-r},\quad {}_nC_0=1\quad (n\geq r)$$

을 의미한다.

정리 1.7

두 함수 $f(x)$와 $g(x)$가 모두 미분가능하고, c는 상수라 하자.

(1) $(cf(x))' = cf'(x)$

(2) $(f(x) \pm g(x))' = f'(x) \pm g'(x)$ (복호동순)

(3) $(f(x)g(x))' = f'(x)g(x) + f(x)g'(x)$ (곱의 미분법)

(4) $\left(\dfrac{f(x)}{g(x)}\right)' = \dfrac{f'(x)g(x) - f(x)g'(x)}{(g(x))^2}$ 단, $g(x) \neq 0$ (몫의 미분법)

증명 (1) 도함수의 정의와 정리 **??**로부터 다음이 성립한다.

$$(cf(x))' = \lim_{h\to 0} \frac{cf(x+h) - cf(x)}{h} = c \lim_{h\to 0} \frac{f(x+h) - f(x)}{h} = cf'(x)$$

(2) 도함수의 정의와 정리 **??**로부터 다음이 성립한다.

$$\begin{aligned}(f(x) + g(x))' &= \lim_{h\to 0} \frac{(f(x+h) + g(x+h)) - (f(x) + g(x))}{h} \\ &= \lim_{h\to 0} \left(\frac{f(x+h) - f(x)}{h} + \frac{g(x+h) - g(x)}{h}\right) \\ &= \lim_{h\to 0} \frac{f(x+h) - f(x)}{h} + \lim_{h\to 0} \frac{g(x+h) - g(x)}{h} \\ &= f'(x) + g'(x)\end{aligned}$$

또한, (1)과 위 결과로부터 다음이 성립한다.

$$(f(x) - g(x))' = (f(x) + (-g(x)))' = f'(x) + (-g(x))' = f'(x) - g'(x).$$

(3) 도함수의 정의와 정리 **??**로부터 다음이 성립한다.

$$\begin{aligned}(f(x)g(x))' &= \lim_{h\to 0} \frac{f(x+h)g(x+h) - f(x)g(x)}{h} \\ &= \lim_{h\to 0} \frac{f(x+h)g(x+h) - f(x+h)g(x) + f(x+h)g(x) - f(x)g(x)}{h} \\ &= \lim_{h\to 0} \left(f(x+h)\frac{g(x+h) - g(x)}{h} + g(x)\frac{f(x+h) - f(x)}{h}\right) \\ &= \lim_{h\to 0} f(x+h) \cdot \lim_{h\to 0} \frac{g(x+h) - g(x)}{h} + \lim_{h\to 0} g(x) \cdot \lim_{h\to 0} \frac{f(x+h) - f(x)}{h} \\ &= f(x)g'(x) + g(x)f'(x)\end{aligned}$$

정리 1.4로부터 함수 $f(x)$가 연속이기 때문에 위 식의 마지막 등식이 성립한다.

(4) 도함수의 정의와 정리 **??**로부터 다음이 성립한다.

$$\begin{aligned}\left(\frac{f(x)}{g(x)}\right)' &= \lim_{h\to 0} \frac{\dfrac{f(x+h)}{g(x+h)} - \dfrac{f(x)}{g(x)}}{h} = \lim_{h\to 0} \frac{f(x+h)g(x) - f(x)g(x+h)}{hg(x+h)g(x)} \\ &= \lim_{h\to 0} \frac{f(x+h)g(x) - f(x)g(x) + f(x)g(x) - f(x)g(x+h)}{hg(x+h)g(x)} \\ &= \lim_{h\to 0} \frac{\dfrac{f(x+h) - f(x)}{h}g(x) - f(x)\dfrac{g(x+h) - g(x)}{h}}{g(x+h)g(x)} \\ &= \frac{\lim_{h\to 0} \dfrac{f(x+h) - f(x)}{h} \cdot \lim_{h\to 0} g(x) - \lim_{h\to 0} f(x) \cdot \lim_{h\to 0} \dfrac{g(x+h) - g(x)}{h}}{\lim_{h\to 0} g(x+h) \cdot \lim_{h\to 0} g(x)} \\ &= \frac{f'(x)g(x) - f(x)g'(x)}{(g(x))^2}\end{aligned}$$

정리 1.4로부터 함수 $g(x)$가 연속이기 때문에 위 식의 마지막 등식이 성립한다. □

예제 1.8 다음 함수의 도함수를 구하시오.

(1) $f(x) = 5x^3 + 4x^2 - 3x + 2$

(2) $f(x) = (2x+1)(x^2 - 2x + 3)$

(3) $f(x) = \dfrac{x^2 + 1}{x^4 + 3x}$

(4) $f(x) = \dfrac{3x^2 - 5x}{x}$

풀이 (1) 정리 1.7의 미분공식을 적용하면 $f'(x) = 15x^2 + 8x - 3$을 얻는다.

(2) 정리 1.7(3)의 미분공식을 적용하면

$$f'(x) = 2(x^2 - 2x + 3) + (2x+1)(2x-2) = 6x^2 - 6x + 4$$

을 얻는다.

(3) 정리 1.7(4)의 미분공식을 적용하면

$$\begin{aligned}f'(x) &= \frac{(x^4 + 3x)(x^2+1)' - (x^2+1)(x^4+3x)'}{(x^4+3x)^2} \\ &= \frac{(x^4+3x)(2x) - (x^2+1)(4x^3+3)}{(x^4+3x)^2} \\ &= \frac{-2x^5 - 4x^3 + 3x^2 - 3}{(x^4+3x)^2}\end{aligned}$$

을 얻는다.

(4) 정리 1.7(4)의 미분공식을 적용하면

$$f'(x) = \frac{x(3x^2-5x)' - (3x^2-5x)(x)'}{x^2}$$
$$= \frac{x(6x-5)-(3x^2-5x)}{x^2} = \frac{3x^2}{x^2} = 3$$

이다. 하지만 미분공식을 쓰기에 앞서, $f(x) = 3x - 5$와 같음을 알 수 있다. 따라서 $f'(x) = 3$임을 또한 쉽게 알 수 있다.

□

$f(x) = x^n$의 도함수에 대한 정리 1.6에서 n을 양의 정수로 제한하고 있지만, 이 후에 이를 확장시켜 n이 음의 정수인 경우, 유리수인 경우, 결국에는 임의의 실수인 경우에도 여전히 성립함을 보일 것이다.[4)]

예제 1.9 음의 정수 n에 대하여 $f(x) = x^n$의 도함수가 $f'(x) = nx^{n-1}$임을 증명하시오.

풀이 음의 정수 n을 $n = -m$ (m: 양의 정수)이라고 놓자. 그러면 $f(x) = x^n = x^{-m} = 1/x^m$이므로

$$f'(x) = \frac{(1)'x^m - 1\cdot(x^m)'}{(x^m)^2} = \frac{-mx^{m-1}}{x^{2m}} = -mx^{-m-1} = nx^{n-1}$$

이다. □

1.2.2 합성함수의 미분법

함수 $F(x) = \sqrt{x^4+1}$의 경우 앞에서 배운 미분공식으로는 도함수를 구하기가 어렵다. 하지만 $F(x)$는 두 함수 $g(u) = \sqrt{u}$ 와 $f(x) = x^4 + 1$의 합성함수, 즉 $F(x) = (g \circ f)(x)$임을 알 수 있다. 따라서 f와 g 의 미분을 이용하여 합성함수 $F = g \circ f$의 미분을 알 수 있다면 유용할 것이다.

두 함수 $y = g(u)$, $u = f(x)$가 각각 미분가능하고, 이들에 의한 합성함수 $y = (g \circ f)(x)$가 정의될 때, 이 합성함수의 도함수를 구하여 보자.

정리 1.10 연쇄법칙(chain rule)

함수 $y = f(x)$가 $x = a$에서 미분가능하고, 함수 $g(f(x))$가 $f(a)$에서 미분가능하면, 합성함수 $(g \circ f)(x)$도 $x = a$에서 미분가능하고,

$$(g \circ f)'(a) = g'(f(a))f'(a) \tag{1.12}$$

가 성립한다.

4) n이 음의 정수인 경우(14쪽, 예제 1.9), 유리수인 경우(16쪽, 예제 1.12와 20쪽, 예제 1.19), 실수인 경우(36쪽, 예제 1.38) 참조.

증명 극한과 관련한 정리 **??**의 (2)와 주어진 조건으로부터

$$(g \circ f)'(a) = \lim_{x\to a}\frac{(g\circ f)(x)-(g\circ f)(a)}{x-a}$$
$$= \lim_{x\to a}\left(\frac{(g\circ f)(x)-(g\circ f)(a)}{f(x)-f(a)}\cdot\frac{f(x)-f(a)}{x-a}\right)$$
$$= \left(\lim_{x\to a}\frac{(g\circ f)(x)-(g\circ f)(a)}{f(x)-f(a)}\right)\left(\lim_{x\to a}\frac{f(x)-f(a)}{x-a}\right)$$
$$= \left(\lim_{y\to f(a)}\frac{g(y)-g(f(a))}{y-f(a)}\right)\left(\lim_{x\to a}\frac{f(x)-f(a)}{x-a}\right)$$
$$= g'(f(a))f'(a)$$

을 얻는다. 즉, $(g \circ f)'(a) = g'(f(a))f'(a)$이다. □

정리 1.10의 연쇄법칙에 대응하는 도함수 공식은

$$(g \circ f)'(x) = g'(f(x))f'(x) \tag{1.13}$$

와 같이 나타낼 수 있다. 특히 $y = g(u)$, $u = f(x)$인 경우에 라이프니츠[5)] 기호를 사용하여 나타내면 다음과 같다.

$$\frac{dy}{dx} = \frac{dy}{du}\frac{du}{dx} \tag{1.14}$$

합성함수의 도함수를 얻기 위해서는 연쇄법칙을 마치 고리모양처럼 연속적으로 적용하게 되는데, 이와 같은 이유로 이 법칙을 연쇄법칙이라고 한다. 이를테면 미분가능한 함수 f, g, h에 대하여 $y = f(u)$, $u = g(v)$, $v = h(x)$라고 하자. 이때 x에 대한 y의 도함수를 얻기 위해 연쇄법칙을 거듭 적용하면

$$\frac{dy}{dx} = \frac{dy}{du}\frac{du}{dx} = \frac{dy}{du}\frac{du}{dv}\frac{dv}{dx} \tag{1.15}$$

을 얻는다.

예제 1.11 다음 함수의 도함수를 구하시오.

(1) $y = (x^3 - x + 1)^5$ (2) $y = \left(\dfrac{1}{x+1}\right)^2$

풀이 (1) $u = x^3 - x + 1$이라고 놓으면 $y = u^5$이다. 따라서 정리 1.10의 연쇄법칙을 적용하면

$$\frac{dy}{dx} = \frac{dy}{du}\frac{du}{dx} = 5u^4(3x^2-1) = 5(x^3-x+1)^4(3x^2-1)$$

이다.

5) 라이프니츠(Leibniz, 1646 ~ 1716) : 독일의 철학자 · 수학자

Advanced Calculus II

Continuous Functions

Continuity

Let E be a subset of $\mathbb{R}^n$ and let $\mathbf{f} : E \to \mathbb{R}^m$ be a function from E to $\mathbb{R}^m$. We say that $\mathbf{f}$ is *continuous* at a point $\mathbf{a}$ of E if for every $\varepsilon > 0$ there exists a $\delta > 0$ such that

$$\|\mathbf{f}(\mathbf{x}) - \mathbf{f}(\mathbf{a})\| < \varepsilon \quad \text{for all } \mathbf{x} \in E \text{ with } \|\mathbf{x} - \mathbf{a}\| < \delta$$

or equivalently

$$\mathbf{f}(\mathbf{x}) \in B_\varepsilon\left(\mathbf{f}(\mathbf{a})\right) \quad \text{for all } \mathbf{x} \in E \cap B_\delta(\mathbf{a}).$$

If $\mathbf{f}$ is not continuous at $\mathbf{a} \in E$, then $\mathbf{f}$ is said to be *discontinuous* at $\mathbf{a}$.

Continuity

Let E be a subset of $\mathbb{R}^n$ and let $\mathbf{f}: E \to \mathbb{R}^m$ be a function from E to $\mathbb{R}^m$. We say that $\mathbf{f}$ is *continuous* at a point $\mathbf{a}$ of E if for every $\varepsilon > 0$ there exists a $\delta > 0$ such that

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or equivalently

$$\mathbf{f}(\mathbf{x}) \in B_\varepsilon(\mathbf{f}(\mathbf{a})) \quad \text{for all } \mathbf{x} \in E \cap B_\delta(\mathbf{a}).$$

If $\mathbf{f}$ is not continuous at $\mathbf{a} \in E$, then $\mathbf{f}$ is said to be *discontinuous* at $\mathbf{a}$. Note that f is continuous at every isolated point $\mathbf{a}$ of E since $E \cap B_\delta(\mathbf{a}) = \{\mathbf{a}\}$ for some $\delta > 0$. The function $\mathbf{f}$ is said to be *continuous on* E if it is continuous at every point of E.

Continuity

Example

The Euclidean norm $\|\cdot\|$ is continuous on $\mathbb{R}^n$. To show this, let $\mathbf{a} \in \mathbb{R}^n$ be given. By the triangle inequality, we have

$$|\|\mathbf{x}\| - \|\mathbf{a}\|| \leq \|\mathbf{x} - \mathbf{a}\| \quad \text{for all } \mathbf{x} \in \mathbb{R}^n.$$

Hence given $\varepsilon > 0$, we take $\delta = \varepsilon$. Then for all $\mathbf{x} \in B_\delta(\mathbf{a})$, we have

$$|\|\mathbf{x}\| - \|\mathbf{a}\|| \leq \|\mathbf{x} - \mathbf{a}\| < \delta = \varepsilon.$$

Some questions that I frequently received

Of course, we cannot do all of the previous slides....

- On Document
  - How to draw a picture in TEX?
  - It is hard to draw a picture that I wanted. What is a good format?
  - How to draw a picture in a paper or beamer?
  - How to modify the standard layout? How to change it easily? Efficient way to manage references and citations...
- On Beamer
  - How to write beamer slide more efficiently?
  - How to change beamer theme? I want to change picture, font, color, layout, etc...

Some questions that I frequently received

In this lecture series, I will answer the following:

- On Document
  - How to draw a picture in TeX?
  - It is hard to draw a picture that I wanted. What is a good format? (There is no loyal road...)
  - How to draw a picture in a paper or beamer?
  - How to modify the standard layout? How to change it easily?, Efficient way to manage references and citations...
- On Beamer (I will answer all of these)
  - How to write beamer slide more efficiently?
  - How to change beamer theme? I want to change picture, font, color, layout, etc...

Contents

More convinient way to writing

More convinient way to writing

You can see the formula right away when you type it:

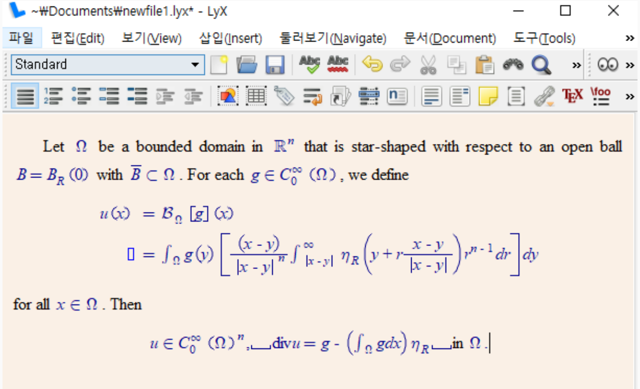

Figure 2: LyX

More convinient way to writing

Supplement program for typing formula: LaTeXiT (Only for Mac)

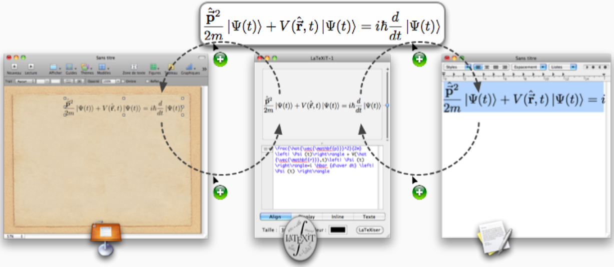

Figure 3: LaTeXiT

- One can use TeXShop (see edit-experiment)

How can I remeber a lot of commands?

```
In terminal or cmd,
> texdoc symbols-a4
```

http://detexify.kirelabs.org/classify.html

Beamer, such an annoying thing

Beamer, such an annoying thing

- Everytime, I have to write a command to make a frame....

Beamer, such an annoying thing

- Everytime, I have to write a command to make a frame....

One realistic way is to use ‘snippet’, usually ‘good editor’ must have.

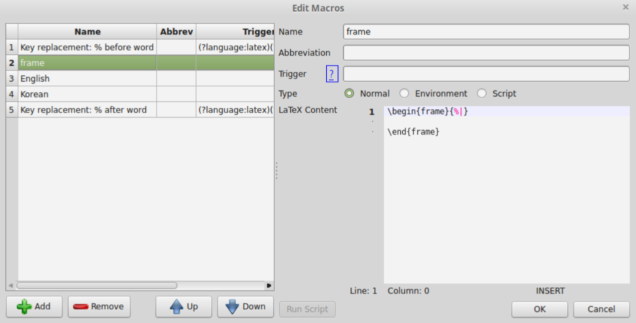

Figure 4: Macro: TEXStudio

Beamer, such an annoying thing

- everytime, I have to write a command to make a frame....

One realistic way is to use ‘snippet’, usually ‘good editor’ must have.

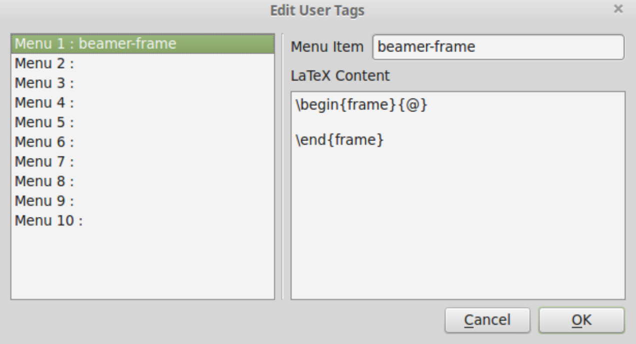

Figure 5: Macro: TEXmaker

Smart way to cite references

- It is not hard to cite something, but...
- it is quite annoying when we write ‘bibitem’..
- there is no ‘universal’ law for writing refrences... (Elsevier, Springer, AMS...)
- There is a difference between citing a book and paper. Do you really know how to write them appropriately?
- You are using computer but... writing references by your hand...?

Smart way to cite references

BibTeX

- save as ‘bib file’
- Separate ‘main text’ and ‘references part’
- You can ‘print’ references appropriately! (book, collections, arXiv, papers, Ph. D. thesis...)
- You can make your own ‘auto-compile rule’ for citations if you can make bst file (not easy)

Smart way to cite references

BibTeX

- save as ‘bib file’
- Separate ‘main text’ and ‘references part’
- You can ‘print’ references appropriately! (book, collections, arXiv, papers, Ph. D. thesis...)
- You can make your own ‘auto-compile rule’ for citations if you can make bst file (not easy)

My recommand:

MathSciNet (database) + BibTeX (engine) + JabRef (program) + natbib (package)

natbib (natbib-jabref.tex)

You can cite your references like [2-4,5,9].

```
\usepackage[numbers,sort&compress]{natbib}

\cite{key-1,key-5,key-3,key-4}
```

thebibilography

```
\begin{thebibliography}{longest one}
\bibitem{key-1} ....
\end{thebibliography}

If you have   131 bibliography items,
\begin{thebibliography}{101}
\bibitem{key-1} ....
\end{thebibliography}
```

DeclareMathOperator

`\DeclareMathOperator{\im}{Im}` or `\newcommand{\im}{\operatorname{Im}}`
`\DeclareMathOperator*{\esup}{ess.sup}`

$$\|f\|_{\infty;E} = \mathrm{ess.sup}_{x\in E}|f(x)|$$

When you used ‘mathrm’

$$\|f\|_{\infty;E} = \operatorname{ess.sup}_{x\in E}|f(x)|$$

When you used the command ‘DeclareMathOperator’ without *

$$\|f\|_{\infty;E} = \operatorname*{ess.sup}_{x\in E}|f(x)|$$

When you used the command ‘DeclareMathOperator’ with *

Use command! to be smart!

```
\newcommand{\norm}[1]{\Vert #1 \Vert} % #1 means a parameter of command
\[   \norm{e^{t\triangle } u_0}_{L^{q}_t L^{r}_x} \apprle \norm{u_0}_{2}
 ↪  \]
\[   \norm{\int_{t'<t} e^{(t-t')\triangle/2} F(t') ds} \apprle
 ↪  \norm{F}_{L^{\tilde{q}'}_t L^{\tilde{r}'}_{x}} \]
```

$$\|e^{t\triangle} u_0\|_{L^{q}_t L^{r}_x} \lesssim \|u_0\|_{2}$$

$$\|\int_{t'<t} e^{(t-t')\triangle/2} F(t') ds\| \lesssim \|F\|_{L^{\tilde{q}'}_t L^{\tilde{r}'}_{x}}$$

Use command! to be smart!

```
\makeatletter
\newcommand{\norm}{\@ifstar{\@normb}{\@normi}}
\newcommand{\@normb}[1]{\left\Vert{#1}\right\Vert}
\newcommand{\@normi}[1]{\Vert{#1}\Vert}
\makeatother
```

If you use the command norm*, @normb is activated. If you use the command 'norm' (without star), @normi is activated.

$$\left\Vert \int_{t'<t} e^{(t-t')\triangle/2} F(t')\, ds \right\Vert \lesssim \Vert F \Vert_{L_t^{\tilde{q}'} L_x^{\tilde{r}'}}$$

$$\Vert \int_{t'<t} e^{(t-t')\triangle/2} F(t')\, ds \Vert \lesssim \Vert F \Vert_{L_t^{\tilde{q}'} L_x^{\tilde{r}'}}$$

Aritcle

Don’t make a blank line between display maths

For $f \in L^p(\mathbb{R})$ $(1 < p < \infty)$, we define

$$Hf(x) = \mathrm{p.v.} \int_{\mathbb{R}} \frac{f(y)}{\pi(x-y)}\, dy$$

and call it the Hilbert transform.

```
For $f\in L^p(\mathbb{R}) $ $(1<p<\infty)$, we define
\[ Hf(x)=\mathrm{p.v.}\int_{\mathbb{R}} \frac{f(y)}{\pi (x-y)}dy\]
and call it the Hilbert transform.
```

Don’t make a blank line between display maths

For $f \in L^p(\mathbb{R})$ $(1 < p < \infty)$, we define

$$Hf(x) = \mathrm{p.v.} \int_{\mathbb{R}} \frac{f(y)}{\pi(x-y)} dy$$

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For $f\in L^p(\mathbb{R}) $ $(1<p<\infty)$, we define

\[ Hf(x)=\mathrm{p.v.}\int_{\mathbb{R}} \frac{f(y)}{\pi (x-y)}dy\]

and call it the Hilbert transform.
```

Don’t use eqnarray!

There are several reasons, anyway, don’t use it!

- Irregular spacing

$$\square \quad = \quad \boxed{\hspace{10em}} \tag{1}$$

versus

$$\square = \boxed{\hspace{10em}} \tag{2}$$

`http://www.tug.org/TUGboat/tb33-1/tb103madsen.pdf`

Don’t use eqnarray!

- Silence on labeling

$$\begin{array}{ccc} \square & = & \square \\ \square & = & \square \end{array} \tag{3}$$

From equation (4) we conclude

$$\square = 42. \tag{4}$$

```
\begin{eqnarray}
\framebox{} & = & \framebox{} \\
\framebox{} & = & \framebox{} \label{eq:my2} \nonumber
\end{eqnarray}
From equation (\ref{eq:my2}) we conclude
\begin{equation}
\framebox{}=42.
\end{equation}
```

Be careful when you define some commands

```
\newcommand{\Q}{\mathbb{Q}}
....

Let $\Q$ denote the field of rational numbers.
```

Don’t use single character when you want to define something.

Be careful when you define some commands

```
\newcommand{\Q}{\mathbb{Q}}
....

Let $\Q$ denote the field of rational numbers.
```

Don't use single character when you want to define something. As an example,

`\L, \H, \C,`

are used for Łaba / Erdős. / C was used when you are using XeLaTeX.

Use environment when you should use environment

Some people write

```
\newcommand{\beq}{\begin{equation}}
\newcommand{\eeq}{\end{equation}}
...
\beq
...
\eeq
```

instead of

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

To save your collaborator and editors, don't do that...

ref and eqref

`\eqref{...}` is much better than `(\ref{...})`

$$-\triangle u+\lambda u=f \tag{5}$$

Let $\lambda>0$. For every $f\in L^2(\mathbb{R}^n)$, there exists a unique $u\in W^{2,2}(\mathbb{R}^n)$ of (5).

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ref and eqref

`\eqref{...}` is much better than `(\ref{...})`

$$-\triangle u + \lambda u = f \tag{5}$$

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Let $\lambda > 0$. For every $f \in L^2(\mathbb{R}^n)$, there exists a unique $u \in W^{2,2}(\mathbb{R}^n)$ of (5).

How to write korean in LaTeX?

From TeXLive 2013, kotex is supported (MacTeX = TeXLive)

```
\usepackage{kotex}
```

How to write korean in LaTeX?

From TeXLive 2013, kotex is supported (MacTeX = TeXLive)

```
\usepackage{kotex}
```

If you use XeLaTeX or LuaLaTeX, then you can change font.

```
\usepackage{kotex}

\setmainfont{english serif}
\setsansfont{english sans-serif}
\setmainhangulfont{korean serif}
\setsanshangulfont{korean sans-serif}
```

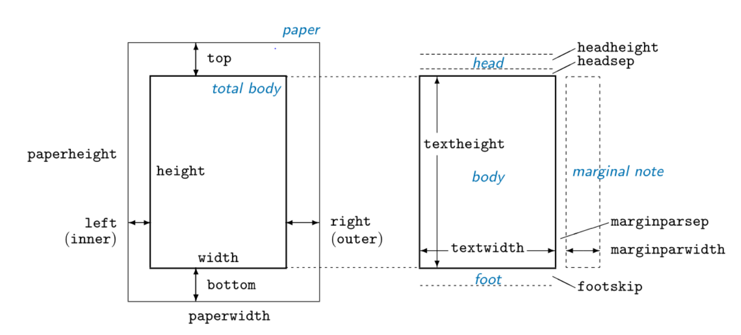
For more information, see

> *texdoc kotex, texdoc xetexko, texdoc luatexko*

Usually, if you want to write a korean article, it is better to use oblivoir class.

I want to change margin and linespacing

```
\usepackage{geometry} %if you use memoir or oblivoir, you should not use
↪  this package
\geometry{paperwidth=174mm,paperheight=248mm,inner=25mm,outer=25mm,
top=25mm,bottom=25mm}
```



I want to change margin and linespacing

```
\usepackage{setspace}

\setstretch{1.333} %appropriate linespacing for korean
...

\begin{spacing}{1.333}
...
\end{spacing}
```

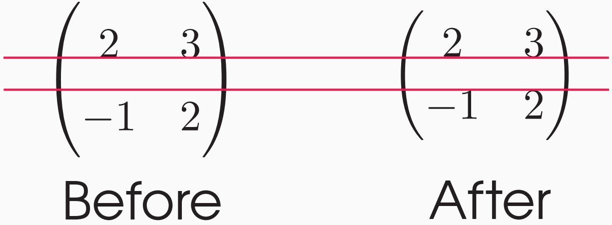
Formula for spacing

$$1 : 120 = x : 160$$

* It is different from oblivoir or memoir. See the manual.

I want to change margin and linespacing

If you change line spacing, some ugly phenomenon happens.



To fix it, write this in the preamble.

```
\everydisplay\expandafter{\the\everydisplay\def
\baselinestretch{1.2}\selectfont}
```

I should write math formula very long, quite annoying!

As an example, when you write an estimates about 4 pages, what should I do?

`\allowdisplaybreaks`

I should write math formula very long, quite annoying!

```
\intertext{text}
\shortintertext{text}


\begin{align*}
 & =\int_{0}^{\infty}\left|\int_{0}^{1}\frac{g\left(x\left(1+y\right)\right)}
 {y^{1-\alpha}}dy\right|^{p}dx.
 \intertext{Now by the Minkowski's integral intequality, we get }
\int_{0}^{\infty}\left|\int_{0}^{1}\frac{g\left(x\left(1+y\right)\right)}
{y^{1-\alpha}}dy\right|^{p}dx &
....
\end{align*}
```

I should write math formula very long, quite annoying!

$$\begin{aligned}\int_0^\infty \left| \int_0^x \frac{g(x+t)}{|t|^{1-\alpha}} \, dt \right|^p x^{-\alpha p} \, dx &= \int_0^\infty \left| \int_0^1 \frac{g(x(1+y))}{(xy)^{1-\alpha}} x dy \right|^p x^{-\alpha p} \, dx \\ &= \int_0^\infty \left| \int_0^1 \frac{g(x(1+y))}{y^{1-\alpha}} \, dy \right|^p \, dx.\end{aligned}$$

Now by the Minkowski's integral intequality, we get

$$\begin{aligned}\int_0^\infty \left| \int_0^1 \frac{g(x(1+y))}{y^{1-\alpha}} \, dy \right|^p \, dx &\leq \left[\int_0^1 \left(\int_0^\infty \left[\frac{g(x(1+y))}{y^{1-\alpha}} \right]^p \, dx \right)^{\frac{1}{p}} \, dy \right]^p \\ &= \left[\int_0^1 \frac{1}{y^{1-\alpha}} \left(\int_0^\infty |g(x(1+y))|^p \, dx \right)^{\frac{1}{p}} \, dy \right]^p\end{aligned}$$

Shape of arrow of vector is too ugly!!!

Default one in TEX is quite ugly.

$$\vec{v} \quad \overrightarrow{AB}$$

```
\usepackage[option]{esvect}
```

option	a	b	c	d	e	f	g	h
flèche	$\rightarrow$	$\rightarrow$	$\rightarrow$	$\rightarrow$	$\rightarrow$	$\rightarrow$	$\rightarrow$	$\rightarrow$

$$\vec{v} \quad \overrightarrow{AB}$$

Position of ‘end of the proof’

When you use the package ‘amsthm’, if you write

```
...
\[  a=b \]
\end{proof}
```

then TEX prints

$$a = b$$

$\square$

Position of ‘end of the proof’

Use the command `\qedhere`.

```
...
\[  a=b \qedhere \]
\end{proof}
```

Proof.

$$a = b \qquad \square$$

I want to write 'nice matrix'

Don't use array!

```latex
\begin{equation}
R^2 =
\left({\begin{array}{cc} c & s
↪   \end{array}}\right)
\left(\begin{array}{cc} 1 & 0\\ 0 & 1
↪   \end{array}\right)
\left(\begin{array}{c} c \\ s
↪   \end{array}\right)
= c^2 + s^2
\end{equation}
```

```latex
\begin{equation}
R^2 =
\begin{pmatrix} c & s \end{pmatrix}
\begin{pmatrix} 1 & 0\\ 0 & 1
↪   \end{pmatrix}
\begin{pmatrix} c \\ s \end{pmatrix}
= c^2 + s^2
\end{equation}
```

$$R^2 = \left({\begin{array}{cc} c & s \end{array}}\right)\left(\begin{array}{cc} 1 & 0\\ 0 & 1 \end{array}\right)\left(\begin{array}{c} c \\ s \end{array}\right) = c^2 + s^2 \tag{6}$$

$$R^2 = \begin{pmatrix} c & s \end{pmatrix}\begin{pmatrix} 1 & 0\\ 0 & 1 \end{pmatrix}\begin{pmatrix} c \\ s \end{pmatrix} = c^2 + s^2 \tag{7}$$

- pmatrix, bmatrix, Bmatrix, vmatrix, Vmatrix

I want to write 'nice matrix'

Mathtools: an extension of amsmath

```
\usepackage{mathtools}

\[  \begin{pmatrix}  -2 & 3 \\ 3 & -2   \end{pmatrix}  \]
\[  \begin{pmatrix*}[r]  -2 & 3 \\ 3 & -2   \end{pmatrix*}  \]
```

$$\begin{pmatrix} -2 & 3 \\ 3 & -2 \end{pmatrix}$$

$$\begin{pmatrix*}[r] -2 & 3 \\ 3 & -2 \end{pmatrix*}$$

I want to write ‘nice matrix’

Mathtools: an extension of amsmath

```
\usepackage{mathtools}

\[
\begin{bsmallmatrix}
a & -b \\ -c & d \end{bsmallmatrix}
\begin{bsmallmatrix*}[r] a & -b \\ -c & d \end{bsmallmatrix*}
\]
```

$$\left[\begin{smallmatrix} a & -b \\ -c & d \end{smallmatrix}\right]\left[\begin{smallmatrix} a & -b \\ -c & d \end{smallmatrix}\right]$$

I want to write my equation more tidy!

$$\text{(NS)} \quad \begin{cases} \partial_t u - \triangle u + (u \cdot \nabla) u + \nabla p = 0 \\ \nabla \cdot u = 0 \end{cases} \tag{8}$$

I want to write my equation more tidy!

$$\text{(NS)} \quad \begin{cases} \partial_t u - \triangle u + (u \cdot \nabla) u + \nabla p = 0 \\ \nabla \cdot u = 0 \end{cases} \tag{8}$$

Some things...

- I want to make an alignmen with respect to t $=$.
- It seems that writing (NS) and (8) two times are not appropriate.

I want to write my equation more tidy!

$$\left\{ \begin{aligned} \partial_t u - \triangle u + (u\cdot\nabla)u + \nabla p &= 0 \\ \nabla\cdot u &= 0 \end{aligned} \right. \tag{NS}$$

```
\begin{equation}\label{eq:Chemotaxis-2}\tag{NS}
\left\{
\begin{alignedat}{2}
 \partial_{t} u  -\triangle u +(u\cdot \nabla)u +\nabla p &=0 \\
 \nabla \cdot  u &= 0
\end{alignedat}
\right.
\end{equation}
```

I want to write my equation more tidy!

$$
\left\{
\begin{alignedat}{2}
\partial_{t} u -\triangle u +(u\cdot \nabla)u +\nabla p &=0 &&\quad \text{in } \Omega \times (0,T)\\
\nabla \cdot u &= 0 &&\quad \text{in } \Omega \times (0,T) \\
u&=0 && \quad \text{on } \partial\Omega \times (0,T)\\
u&=u_0 &&\quad \text{on } \Omega \times \{t=0\}
\end{alignedat}
\right. \tag{NS}
$$

```
\begin{equation}\label{eq:Chemotaxis-2}\tag{NS}
\left\{
\begin{alignedat}{2}
 \partial_{t} u  -\triangle u +(u\cdot \nabla)u +\nabla p &=0 &&\quad \text{in }
 ↪  \Omega \times (0,T)\\
 \nabla \cdot  u &= 0   &&\quad \text{in } \Omega \times (0,T) \\
 u&=0 && \quad \text{on } \partial\Omega \times  (0,T)\\
 u&=u_0 &&\quad \text{on } \Omega \times \{t=0\}
\end{alignedat}
\right.
\end{equation}
```

I want to write my equation more tidy!

$$\text{(NS)} \qquad \begin{cases} \partial_t u - \triangle u + (u \cdot \nabla) u + \nabla p = 0 & \text{in } \Omega \times (0, T) \\ \nabla \cdot u = 0 & \text{in } \Omega \times (0, T) \\ u = 0 & \text{on } \partial\Omega \times (0, T) \\ u = u_0 & \text{on } \Omega \times \{t = 0\} \end{cases}$$

```
\usepackage[leqno]{mathtools}

\makeatletter
\newcommand{\leqnomode}{\tagsleft@true\let\veqno\@@leqno}
\newcommand{\reqnomode}{\tagsleft@false\let\veqno\@@eqno}
\makeatother
...
\leqnomode
\begin{equation}\label{eq:Chemotaxis-2}\tag{NS}
....
\end{equation}
\reqnomode
```

I want to write my equation more tidy!

```
\begin{equation}\tag{MKG}
\begin{aligned}
        \partial^{\mu} F_{\nu \mu} =& \im(\phi \overline{\mathbf{D}_{\nu} \phi})  \\
        \Box_{A} \phi =& 0,
\end{aligned}
\end{equation}
```

$$\begin{aligned} \partial^{\mu} F_{\nu \mu} =& \operatorname{Im}(\phi \overline{\mathbf{D}_{\nu} \phi}) \\ \Box_{A} \phi =& 0, \end{aligned} \tag{MKG}$$

I want to write my equation more tidy!

- The Chicago Manual of Style
    - If displayed expressions are centered, runover lines are aligned on the relation signs, which should be followed by thick spaces

$$\begin{aligned} h(x) &= (x-\alpha)(x-\beta)(x-\gamma) \\ &= x^3 - (\alpha+\beta+\gamma)x^2 + (\alpha\beta+\alpha\gamma+\beta\gamma)x - \alpha\beta\gamma \end{aligned}$$

- If a runover line begins with an operation sign, the operation sign should be lined up with the first character to the right of the relation sign in the line above it, followed by a medium space.

$$\begin{aligned} \frac{\pi}{4} &= \frac{1}{2} - \frac{1}{3\times 2^3} + \cdots \\ &\quad + \frac{1}{3} - \frac{1}{3\times 3^3} + \cdots \end{aligned}$$

I want to write my equation more tidy!

Suggestion given in LaTeX Companion, 2nd Edition (LC2, p.474)

```
\begin{equation}\tag{MKG}
\left\{\begin{aligned}
        \partial^{\mu} F_{\nu \mu} &= \im(\phi \overline{\mathbf{D}_{\nu}
        ↪  \phi})  \\
        \Box_{A} \phi &= 0,
\end{aligned}\right.
\end{equation}
```

$$\left\{\begin{aligned} \partial^{\mu} F_{\nu \mu} &= \mathrm{Im}(\phi \overline{\mathbf{D}_{\nu} \phi}) \\ \Box_{A} \phi &= 0, \end{aligned}\right. \tag{MKG}$$

When you write equations..

We split L_2 and make use of the fact that $v_{\lambda,h}(z) = v_h(z)$ for all $z \in E_\lambda \cap K_{4\rho}^{\alpha}(\mathfrak{z})$.

$$
\begin{array}{ll}
L_2 & = \iint_{K_{4\rho}^{\alpha}(\mathfrak{z})\cap E_{\lambda}} \left\langle [A(x,t,\nabla u) - A(x,t,\nabla w)]_h \nabla v_{\lambda,h}\right\rangle \zeta_{\varepsilon}\ dz \\
& \qquad + \iint_{K_{4\rho}^{\alpha}(\mathfrak{z})\setminus E_{\lambda}} \left\langle [A(x,t,\nabla u) - A(x,t,\nabla w)]_h \nabla v_{\lambda,h}\right\rangle \zeta_{\varepsilon}\ dz
\end{array}
$$

```
\begin{equation*}
\begin{array}{ll}
L_2 & = \iint_{{K_{4\rho}^{\alpha}(\mathfrak{z})}\cap E_{\lambda}}
↪  \left<{[A(x,t,\nabla u) - A(x,t,\nabla w)]_h}{\nabla
↪  v_{\lambda,h}}\right> \zeta_{\varepsilon}\ dz  \\
& \qquad + \iint_{{K_{4\rho}^{\alpha}(\mathfrak{z})}\setminus
↪  E_{\lambda}} \left<{[A(x,t,\nabla u) - A(x,t,\nabla w)]_h}{\nabla
↪  v_{\lambda,h}}\right> \zeta_{\varepsilon}\ dz
\end{array}
\end{equation*}
```

When you write equations..

Suggestion given in LaTeX Companion, 2nd Edition (LC2, p.474)

```
\newcommand\relphantom[1]{\mathrel{\phantom{#1}}}

\begin{align*}
L_2 & = .....
& \relphantom{=}{} + ...
\end{align*}
```

We split L_2 and make use of the fact that $v_{\lambda,h}(z) = v_h(z)$ for all $z \in E_\lambda \cap K^\alpha_{4\rho}(\mathfrak{z})$.

$$\begin{aligned} L_2 = & \iint\limits_{K^\alpha_{4\rho}(\mathfrak{z})\cap E_\lambda} \langle [A(x,t,\nabla u) - A(x,t,\nabla w)]_h \nabla v_{\lambda,h}\rangle\, \zeta_\varepsilon \ dz \\ & + \iint\limits_{K^\alpha_{4\rho}(\mathfrak{z})\setminus E_\lambda} \langle [A(x,t,\nabla u) - A(x,t,\nabla w)]_h \nabla v_{\lambda,h}\rangle\, \zeta_\varepsilon \ dz \end{aligned}$$

*You can use allowdisplaybreaks effect when you are using “align environment”.

It is hard to use float environment

LaTeX is not a wordpress! Let it be!

See several manuals on ‘float environment latex’.

* Actually, I can put pictures anywhere I wanted. (use capt-of package + TikZ etc.)

I want to use symbol $\mathcal{T}$ in Topology written by Munkres

A topology, denoted by $\mathcal{T}$

- You should buy the package MathTime Professional 2.

For more information on mathematics font in LaTeX, see

- S. G. Hartke, *A Survey of Free Math Fonts for TeXand LaTeX*, The PracTeX Journal, 2006.

Beamer

A typical example of beamer slide

In this presentation we study the regularizing effect of the gain part of the collision operator of the relativistic Boltzmann equation:

$$\partial_t f + \hat{p} \cdot \nabla_x f = Q(f, f), \tag{1}$$

The collision operator Q is given by

$$Q(f,h)(p) = Q^{+}(f,h)(p) - Q^{-}(f,h)(p). \tag{2}$$

The relativistic Boltzmann collision kernel $\sigma(g,\theta)$ is a non-negative function which depends only on the relative velocity g and the scattering angle θ. We assume that σ satisfies

$$\sigma(g,\theta) \lesssim g^{a}\sigma_0(\theta), \qquad (a > -3) \tag{3}$$

Theorem

1. (*Hard potentials*) *Assume that the scattering kernel σ satisfies* (3) *with $a \geq 0$. Also, suppose that $f \in L^m_{\frac{m}{2}(a-1)}$ and $h \in L^n_{\frac{n}{2}(a-1)}$ with $\frac{1}{m} + \frac{1}{n} = \frac{3}{2}$. Then the gain term Q^+ has the following regularizing property:*

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I want to remove the navigation bar

```
\setbeamertemplate{navigation symbols}{}
```

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I want to change my math font like papers

```latex
\usefonttheme{professionalfonts}
\usefonttheme[onlymath]{serif}
```

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I want to change fonts

```
%lualatex
\usepackage[no-math]{fontspec}
\setmainfont{TeX Gyre Termes}
\setsansfont{TeX Gyre Heros}
```

or

```
\usepackage{kotex}

\setmainfont{English Serif}
\setsansfont{English Sans-Serif}
\setmainhangulfont{Korean Serif}
\setsanshangulfont{Korean Sans-Serif}
```

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I want to change margins

```
\setbeamersize{text margin left=0.75cm}
\setbeamersize{text margin right=0.75cm}
```

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Change the aspect ratio of the slide

```
\documentclass[aspectratio={169}]{beamer}
```

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I want to make a theorem box

```
\usecolortheme{orchid}
```

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The box is too rigid!

```
\useinnertheme[shadow=true]{rounded}
```

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Circle number is not cool

```
\useinnertheme[shadow=true]{rounded}
\useinnertheme{rectangles}
```

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I want to put my name, title, and the affiliation at the bottom

```
\useoutertheme{infolines}
```

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I want to change the color

```
\definecolor{lapis}{cmyk}{1,0.78,0.18,0.04}

\setbeamercolor{structure}{fg=lapis}
\setbeamercolor*{palette primary}{use=structure,fg=white,
bg=structure.fg}
\setbeamercolor*{palette secondary}{use=structure,fg=white,
bg=structure.fg!70!black}
\setbeamercolor*{palette tertiary}{use=structure,fg=white,
bg=structure.fg!15!black}
\setbeamercolor*{palette quaternary}{fg=white,bg=black}


\setbeamercolor*{block body}{bg=lapis!10}
\setbeamercolor*{block title}{fg=white,bg=lapis}
```

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I want to change more...

Don’t do that...

- Beamer theme gallery `http://deic.uab.es/~iblanes/beamer_gallery/`
- Metropolis theme `\usetheme{Metropolis}`

If you ‘really’ want to study more, see

- 권현우, 비머 테마 만들기, 2017 한국텍학회 학술대회 (`http://wiki.ktug.org/wiki/wiki.php/KTSConference/2017`) / Korean

Some useful tips (overlay)

Maybe most of people know `\pause`...

```
\begin{enumerate}
\item<1-> from the first slide
\item<3> only third slide
\item<2-> from the second slide
\item<4->  from the fourth slide
\item<5> last one
\end{enumerate}
```

1. from the first slide

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```

1. from the first slide

3. from the second slide

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```

1. from the first slide
2. only third slide
3. from the second slide

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```

1. from the first slide

3. from the second slide
4. from the fourth slide

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```

1. from the first slide

3. from the second slide
4. from the fourth slide
5. last one

Some useful tips (overlay)

```
\uncover<2->{so far invisible, but now I can see!} or <2>
```

Some useful tips (overlay)

```
\uncover<2->{so far invisible, but now I can see!} or <2>
```

so far invisible, but now I can see!

```
Let $\Omega$ be a bounded Lipschitz domain in $\mathbb{R}^n$.
\only<1>{First assertion}%
\only<2>{Second assertion}
```

Let Ω be a bounded Lipschitz domain in $\mathbb{R}^n$.

Some useful tips (overlay)

```
\uncover<2->{so far invisible, but now I can see!} or <2>
```

so far invisible, but now I can see!

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```
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so far invisible, but now I can see!

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\only<1>{First assertion}%
\only<2>{Second assertion}
```

Let Ω be a bounded Lipschitz domain in $\mathbb{R}^n$. Second assertion

A practial example

Theorem

Under the same condition,

- *first one*

```
\begin{theorem}
Under the same condition,
\begin{itemize}
\only<1>{\item first one}
\only<2>{\item second one}
\end{itemize}
\end{theorem}
```

A practial example

Theorem

Under the same condition,

- *second one*

```latex
\begin{theorem}
Under the same condition,
\begin{itemize}
\only<1>{\item first one}
\only<2>{\item second one}
\end{itemize}
\end{theorem}
```

I want to show the tableofcontents when I move to the next section

```
\AtBeginSection[]
{

\begin{frame}{Contents}

\tableofcontents[currentsection]

\end{frame}

}
```

I want to divide my slide automatically

`\begin{frame}[allowframebreaks]{title}` bla bla bla `\end{frame}`

lipsum i

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.

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I want to remove the roman counter

```
\setbeamertemplate{frametitle continuation}{}
```

If you want to print from the second one,

```
\setbeamertemplate{frametitle continuation}{%
    \ifnum\insertcontinuationcount>1
    \insertcontinuationcount
    \fi}
```

화면전환도 됩니다! (Adobe reader, evince는 됩니다)

`\transblindshorizontal`	Horizontal blinds pulled away
`\transblindsvertical`	Vertical blinds pulled away
`\transboxin`	Move to center from all sides
`\transboxout`	Move to all sides from center
`\transdissolve`	Slowly dissolve what was shown before
`\transglitter`	Glitter sweeps in specified direction
`\transslipverticalin`	Sweeps two vertical lines in
`\transslipverticalout`	Sweeps two vertical lines out
`\transhorizontalin`	Sweeps two horizontal lines in
`\transhorizontalout`	Sweeps two horizontal lines out
`\transwipe`	Sweeps single line in specified direction
`\transduration {2}`	Show slide specified number of seconds

e.g.

```
\begin{frame}{title}
\transblindshorizontal

\end{frame}
```

I want to input the talking balloon in the beamer slide

I cannot understand why you want it...

```
\usepackage{tikz}
\usetikzlibrary{shapes.callouts}
\begin{tikzpicture}[overlay]
\node[fill=red!50, rectangle callout, callout relative pointer={(-2,-1)}] at (12,1)
{Nonlinear Schr\"odinger equation};
\node[fill=red!50, rectangle callout, callout relative pointer={(-2,1)}] at (12,-3)
{Hartree equation};
\end{tikzpicture}
```

Nonlinear Schrödinger equation

$$i\partial_t u + \triangle u = |u|^{p-1}u$$

$$i\partial_t u + \triangle u = V(u)u$$

Hartree equation

where $V(u) = |x|^{-n} * |u|^2$.

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