




Use of Sage in Teaching Linear algebra

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Abstract



- We may review what we has done on teaching of Linear algebra with Sage.
- Issue : **Use of technology**
- Many of us is using PPT or PDF in our LA class
- It is natural and easy to show LA concepts and process on screen.
 ‘visualization and computation process’
- We found Sage is the most effective one to use in the class.

< My answer is the Sage >

Old Technology



산 가지
Counting Rods (Sanggi)
算子/算竹
算子



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+


Mobile Math

Textbook

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+

[Many different tries] Traditional LA textbook + Sage

Sage Contents + Sage Cell

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Area and Volume

Let $A(x_1, y_1), B(x_2, y_2), C(x_3, y_3)$ point are not collinear

and $A = \begin{pmatrix} x_1 & y_1 & 1 \\ x_2 & y_2 & 1 \\ x_3 & y_3 & 1 \end{pmatrix} = \begin{pmatrix} 1 & 1 & 1 \\ 1 & 0 & 1 \\ 0 & 2 & 1 \end{pmatrix}$

Area of Triangle $= \frac{1}{2} | \det A | = \frac{1}{2}$

A	(1, 0)	0.707106	-0.707106	0.0
B	(0, 2)	0.707106	0.707106	0.0
C	(1, 1)	0.0	0.0	2.0

행렬식의 부호가 + 이므로 오른쪽으로 회전

- Area of Triangle, Volume of Parallelepiped.
- Visualizations

Linear Transformation

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<http://math1.skku.ac.kr/pub>

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

Determinant: $\det(A) = 6$

Eigensystem
 $\{(3, [(1,0), 1]), (2, [(1, -1), 1])\}$

center pt. (1, 1)

pt1. (2, 1)

pt2. (1, 4)

pt3. (2, 7)

ratio 3

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

associated with $\lambda_1 = 3$

associated with $\lambda_2 = 2$

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<http://math3.skku.ac.kr/pub/2750/> <http://matrix.skku.ac.kr/2012-sage/>


```

i:=vector(00, [1, 0, 0]); # 벡터 생성
# 벡터 출력
(1, 0, 0)
g:=vector(00, [0, 1, 0]);
g
(0, 1, 0)
b:=vector(00, [0, 0, 1]);
b
(0, 0, 1)
c1:=1;
c2:=1;
c3:=1;
c:=c1+r+c2*g+c3*b;
c
(1, 1, 1)
c1:=1;
c2:=1;
c3:=1;
c:= 1/2*c1+r+c2*g+c3*b;
c
(1/2, 1, 1)
c1:=1;
c2:=1;
c3:=1;
c:= 1/3*c1+r+ 1/3*c2*g+ 1/3*c3*b;
c
(1/3, 1/3, 1/3)
        
```

SAGE CELL - NEW TECHNOLOGY BY JASON

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Wanted : New LA textbook with Sage




Wrote and had a classroom test over a year on (New book-Preprint)

Linear Algebra with Sage?

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Contemporary Linear Algebra with Sage

It will be published in this summer!



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Recorded Lecture

Students presentation

Several Sage Examples

3.1 행렬연산

Traditional + Sage Code

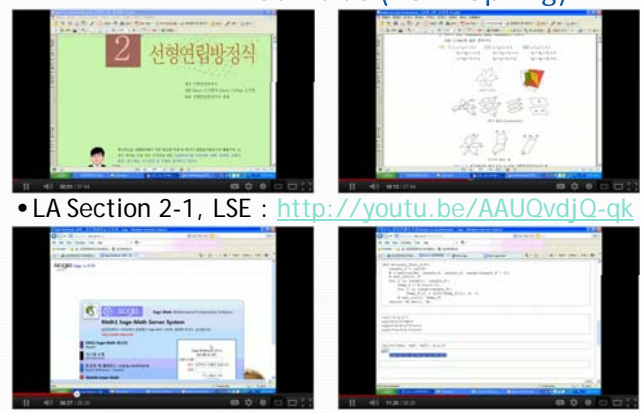
A=matrix(RDF, [[1, -1, 0], [-1, 0, -1], [0, -1, 0]])

A

QR Code

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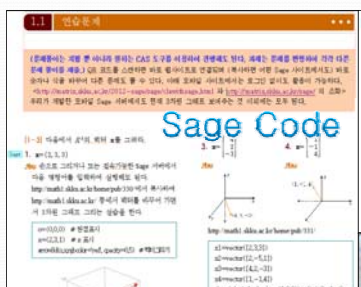
Examples of Linear Algebra Lec. in You-Tube (2012 Spring)




- LA Section 2-1, LSE : <http://youtu.be/AAUQvdjQ-kg>
- LA: Introduction of CAS : <http://youtu.be/0SQpiNe2LU8>

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Traditional + Several Sage Examples

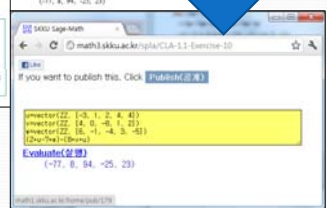


Sage Code



QR Code



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<http://matrix.skku.ac.kr/sglee/photo.html>

Developed Materials for LA

- [2012-Visual Math with Sage \(LA & Calculus\)](#)
- [SKKU Sage Cell](#) <http://sage.skku.edu/> Sage Cell Examples <http://matrix.skku.ac.kr/cal-lab/cal-2-2-1-14-8-7.html>, [0-3-1-1-3-5](http://matrix.skku.ac.kr/cal-lab/cal-2-2-1-14-8-7.html), [1-4-7-2-1-3](http://matrix.skku.ac.kr/cal-lab/cal-2-2-1-14-8-7.html)
- [2012-CLA with Sage \(all commands\)](#), [2012-Visual LA with Sage web book](#)
- [2011-CLA with Mobile Sage](#), [2011-Visualization of LA with Sage](#), [2011-S-Matrix Theory - Appl \(Web version\)](#)
- [\(New\) 2011-Mobile Math with Sage](#), [2011-Mobile Linear Algebra with Sage](#)
- [\(SAGE\) How to do LU -Decomposition with Sage](#), [\(SAGE\) 2011-How to use Sage](#), [2011-how to use Sage 2](#)
- [2010-12-Sage-Qreference](#), [Sage-Reference](#), [SKKU-Sage-Math](#)
- <http://matrix.skku.ac.kr/2012-Sage/sage-la/> (test)
- <http://matrix.skku.ac.kr/sage/> 와 <http://matrix.skku.ac.kr/2011-sage/sage/clawithsage.html>
- [4. How to Solve Linear Algebra Chapter 7-1, 7-2, 7-3, 7-4 problems](#), <http://www.youtube.com/watch?v=BHfiAZiyAdQ&feature=related>, by Prof. Sang-Gu Lee
- [3. How to Solve Linear Algebra 1st HW problems](#), <http://www.youtube.com/watch?v=07q1zQC5Gs>,
- [2. How to use Sage for Linear Algebra](#), <http://www.youtube.com/watch?v=XiD5WizZoTk>,
- [1. Visualization of LA\(Linear Algebra\) with Sage](#), <http://www.youtube.com/watch?v=e5MDq8wNWmw>,
- [2012-CLA with Sage Chapter 1](#), [2012-CLA with Sage Preview.html](#)

Developed Materials 2 for LA

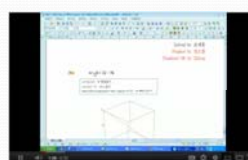
Sage (embedded)

<ul style="list-style-type: none"> 1. http://mathi.skku.ac.kr/home/pub/534 ; SKKU-LA-1-1- (Vector) 2. http://mathi.skku.ac.kr/home/pub/535 ; SKKU-LA-1-1- (Vector) 3. http://mathi.skku.ac.kr/home/pub/583 ; LA-2-1- (Linear Equations) 4. http://mathi.skku.ac.kr/home/matrix/348 ; SKKU-LA-3-2- (inverse) 5. http://mathi.skku.ac.kr/home/pub/730/ ; SKKU-LA-4-4- volume (Det) 6. http://mathi.skku.ac.kr/home/pub/597 ; LA-4-4-Curve Fitting (Det) 7. http://mathi.skku.ac.kr/home/pub/540 ; LA-4-4- Equations (Det) 8. http://mathi.skku.ac.kr/home/pub/732 ; SKKU-LA-4-5- (Eigensystem) 9. http://mathi.skku.ac.kr/home/pub/733 ; SKKU-LA-5-2- Crypto 	<ul style="list-style-type: none"> 11. http://mathi.skku.ac.kr/home/pub/639 ; SKKU-LA-6-2- Flag (Rotation) 12. http://mathi.skku.ac.kr/home/pub/508 ; SKKU-LA-6-2- (Linear Transformation) 13. http://mathi.skku.ac.kr/home/pub/506 ; SKKU-LA-6-2- (Linear Transformation) 14. http://mathi.skku.ac.kr/home/pub/582 ; SKKU-LA-6-2- (Linear Transformation) 15. http://mathi.skku.ac.kr/home/pub/580 ; SKKU-LA-6-5- (Dilation) 16. http://mathi.skku.ac.kr/home/pub/729/ ; SKKU-LA-6-5-Tri (Dilation) 17. http://mathi.skku.ac.kr/home/pub/708 ; SKKU-LA-6-5- (Linear Transformation) 18. http://mathi.skku.ac.kr/home/pub/539 ; SKKU-LA-7-5- (Projection)
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Student's Activities in You-Tube

(2012 Spring Linear Algebra Class)






Search in Youtube : SKKU CLA SGLee

- **LA Section 1-3, Vector equations :**
- <http://youtu.be/fbCMYh-iDCQ>

- **LA Section 10-2, Jordan Canonical Forms :**
- http://youtu.be/vx_6rTJq5jk



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QR Code

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Combination: Smartphone Apps

Inner product and projection

Cover	Vector operations
<p>Linear Algebra with Sage</p>	<p>Contemporary Linear Algebra with Sage</p> <ul style="list-style-type: none"> · LSE · L. T. · Matrix · Diagonalization

Sage-Math Tutorial

All could download this free Android Smartphone App in <https://market.android.com/>
Search : **SKKU matrix** or 'LA with Sage'

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We have added new functions in the book.

(Web, Java, Sage, Movie, Code, Sage Contents, Sage Cell, QR-code, **Students-Storytelling(BBS)**, Finalize, Presentation, History, etc)

- New HW (small and large size problems as well)
- New style Midterm and Final Exam
- **Mobile** (Sage-publish, Web address, QR-code, Smartphone, Mobile computation, ...)
- **Student's Motivation, confidence, ability soars~~~~.**
- **Student's Satisfaction fly high again~~**

Some of our Android APP can be downloaded from **Google Play** <https://play.google.com/> by typing **SKKU matrix** or **Matrix Theory**

Recently, we made one App for **i-phone** and **i-pad**. **<All Free>**

Now we are making **E-book** of Lab Manual for Calculus with Sage And High school Calculus book

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<http://matrix.skku.ac.kr/2012-sage/>

7.2 Trigonometric Integrals

CAS 1. $\int \cos^3 x dx$

CAS 2. $\int \sin^2 x \cos^4 x dx$

CAS 3. $\int \sin^2(4x) dx$

CAS 4. $\int \sin^2 x \cos^{-4} x dx$

<SKKU : Sage-Math : 수학 도구>

Integral(sin(x)^5*cos(x)^4,x)

Session d99afb13-4b8e-472d-bdc0-c4991f21877a

Session d99afb13-4b8e-472d-bdc0-c4991f21877a done

SESSION 03

Conclusion

Conclusion

In this series of talks, we introduced how and what we have developed on Sage for teaching of Linear Algebra. We have used them in our class and the output comes out as a TEXTBOOK.

We believe we now have an affordable and inspiring CAS tool for Linear Algebra as well as other Math courses.

We may expect all new era of University Math Education in Korea as well as producing new math teachers with CAS capability with no cost and time to learn programming language.

Welcome to

July 8-15, 2012
Seoul, KOREA
<http://icme12.org/>

2014

THANK YOU

Q. to Sang-Gu Lee
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SUNGKYUNKWAN UNIVERSITY Unique Origin Unique Future

ICME-12
The 12th International Congress on Mathematical Education
July 8-15, 2012, COEX, Seoul, Korea