

ICME Fundamentals of Data Science: Introduction to Linear Algebra

Day 1: Fundamentals of vectors, matrices and their operations motivated by ranking and searching.

- Vectors: vector multiplication (inner product), cosine rule, vector norms
- Matrices: matrix-vector multiplication, matrix-vector systems, matrix-matrix multiplication, matrices as operators, orthogonal matrices, inverses and determinants, and a bit about eigenvalues and eigenvectors

Day 2: Diving deeper with as ultimate goal the SVD and linear regression.

- Matrices: Singular value decomposition, least squares, normal equations, QR decomposition

Approximate Schedule

Day 1


- 8 – 8:15
 - 8:15 – 9
 - 9 – 9:30
 - 9:30 – 9:45
 - 9:45 – 10:30
 - 10:30 – 11
- Introduction
 - New material
 - Practice
 - Break
 - New material
 - Practice

Day 2

- 8 – 9
 - 9 – 9:30
 - 9:30 – 9:45
 - 9:45 – 10:30
 - 10:30 – 10:50
 - 10:50 – 11
- New material
 - Practice
 - Break
 - New material
 - Practice
 - Closing

Slides after this are used
throughout the short course

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linear algebra, mathematical discipline that deals with vectors and matrices and, more generally, with vector spaces and linear transformations. Jun 29, 2023

 Britannica
https://www.britannica.com › Science › Mathematics


[Linear algebra | Matrices, Vectors & Equations - Britannica](#)

rules

Application $n \begin{bmatrix} a & b & c \\ d & e & f \end{bmatrix} = \begin{bmatrix} na & nb & nc \\ nd & ne & nf \end{bmatrix}$

Adition $\begin{bmatrix} a & b \\ c & d \\ e & f \end{bmatrix} + \begin{bmatrix} g & h \\ i & j \\ k & l \end{bmatrix} = \begin{bmatrix} a+g & b+h \\ c+i & d+j \\ e+k & f+l \end{bmatrix}$

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[Linear algebra](#)

Linear algebra is the branch of mathematics concerning linear equations such as: In three-dimensional Euclidean space, these three planes represent solutions to ...

Inverse elements of addition: For every v in V ,... Identity element of scalar multiplication: $1v$...

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[Linear Algebra](#)

Linear equation

In mathematics, a linear equation is an equation that may be put in the form $a_1x_1 + a_2x_2 + \dots + a_nx_n + b = 0$, where x_1, x_2, \dots, x_n are the variables, and b, a_1, a_2, \dots, a_n are the coefficients, which are often real numbers.

[Wikipedia](#)

Examples
Linear equations examples

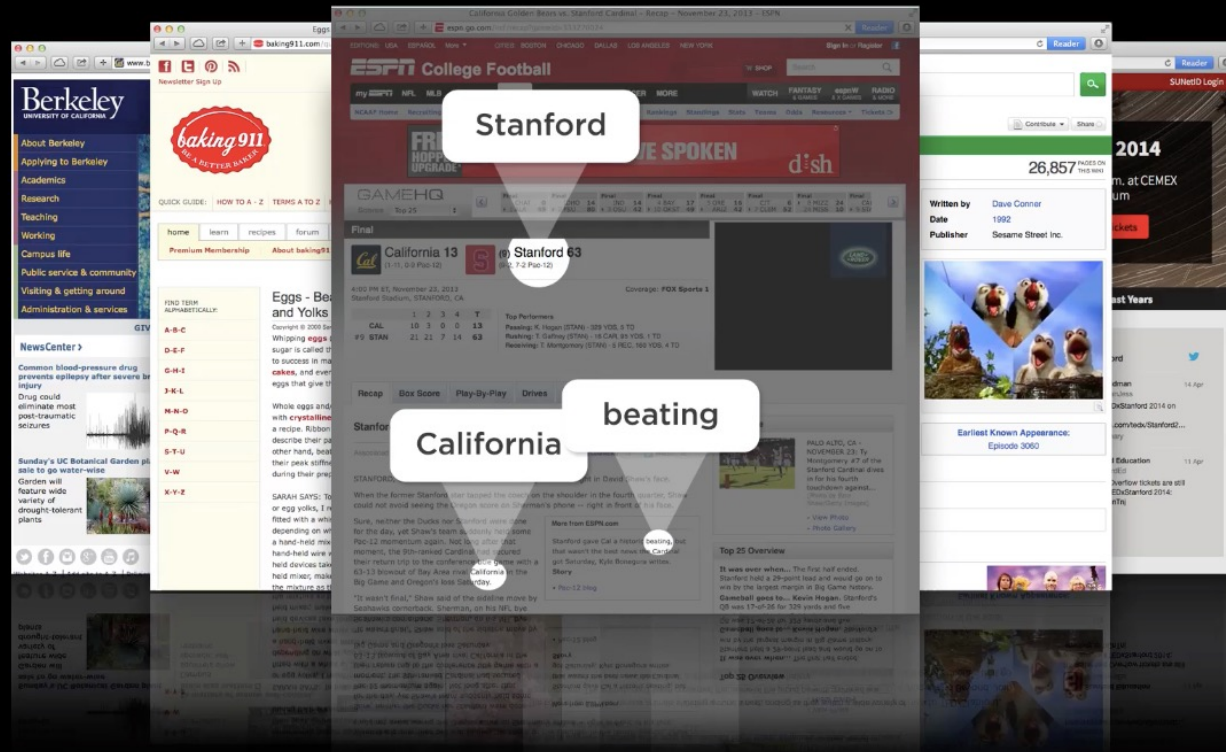
How to solve
How to solve linear equations

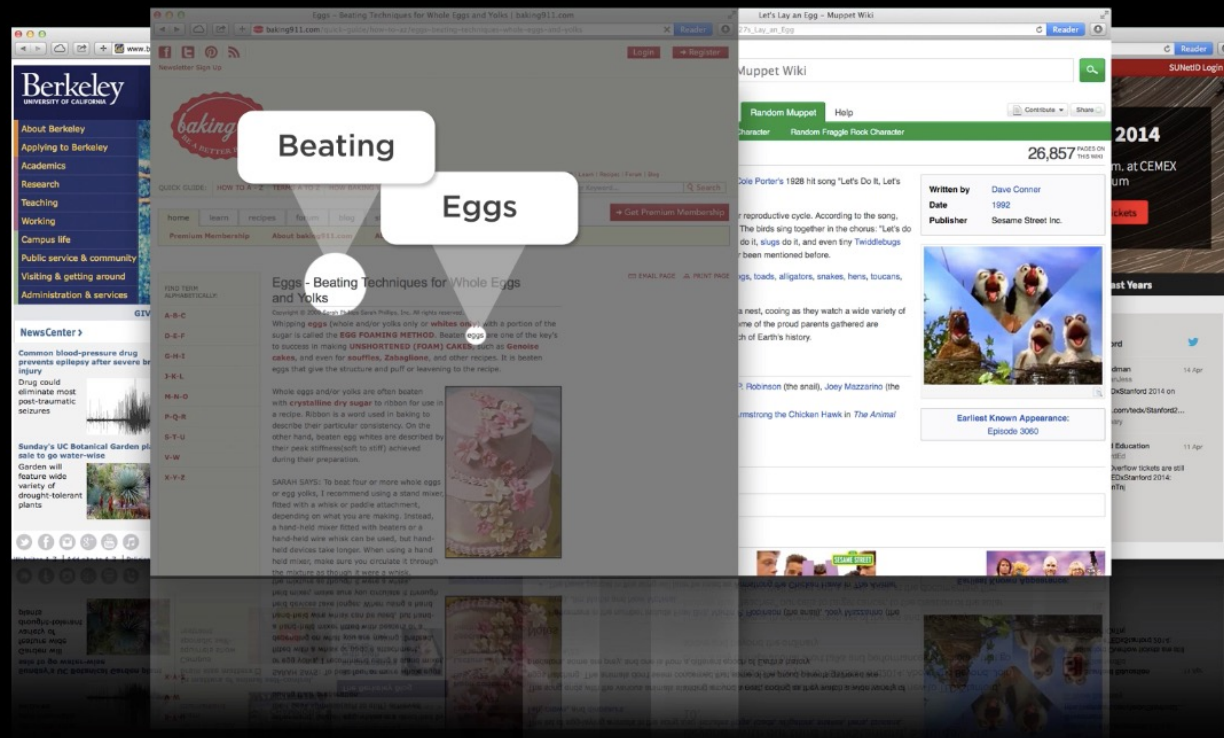
Equation
Linear equation equation

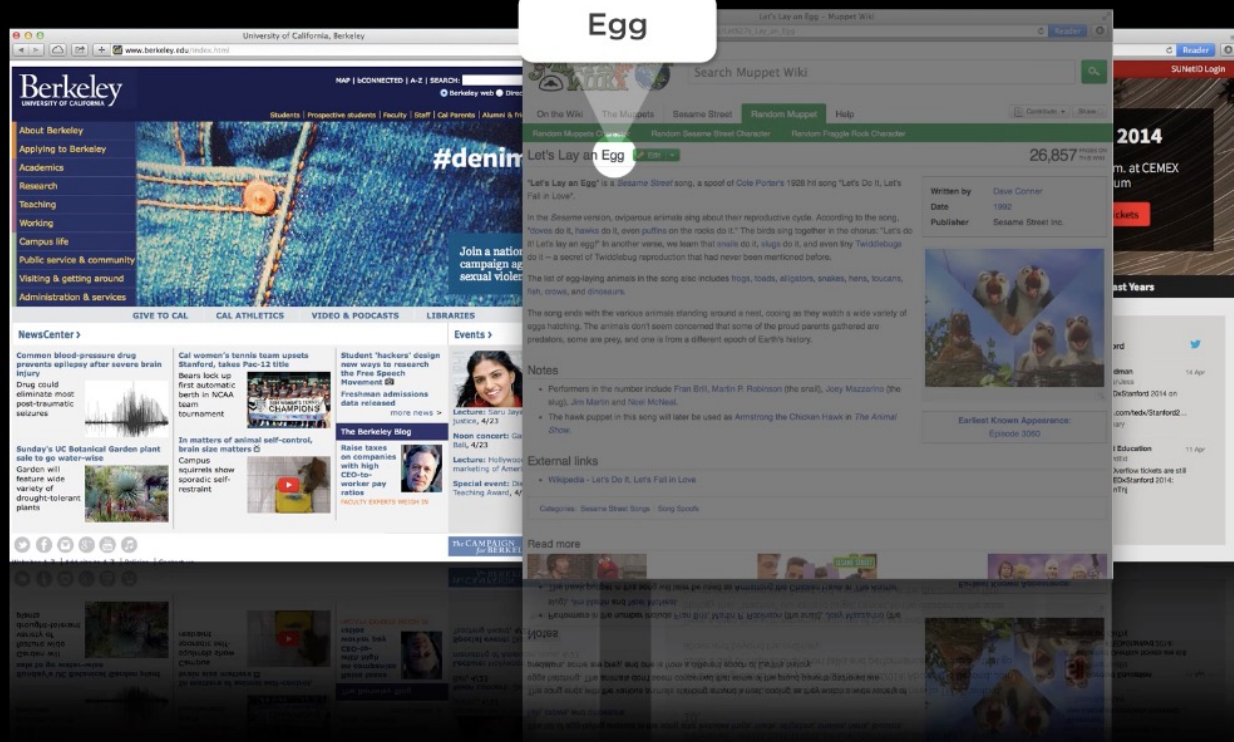
List
List of linear equations

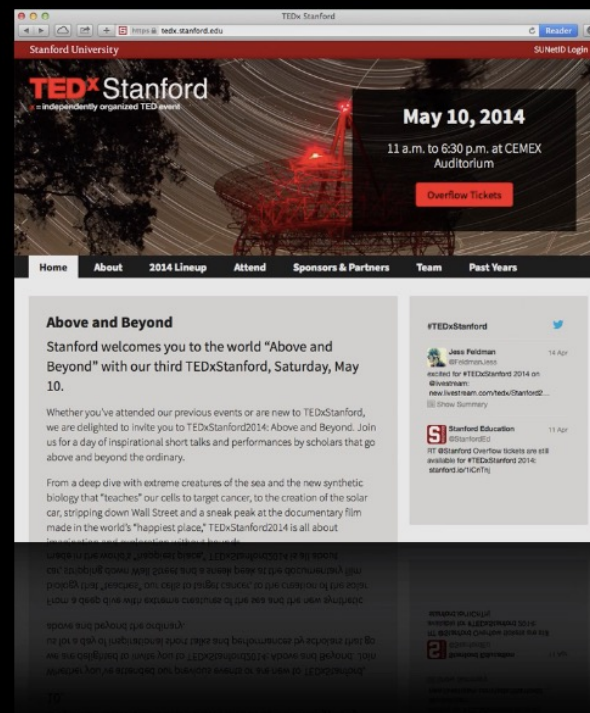
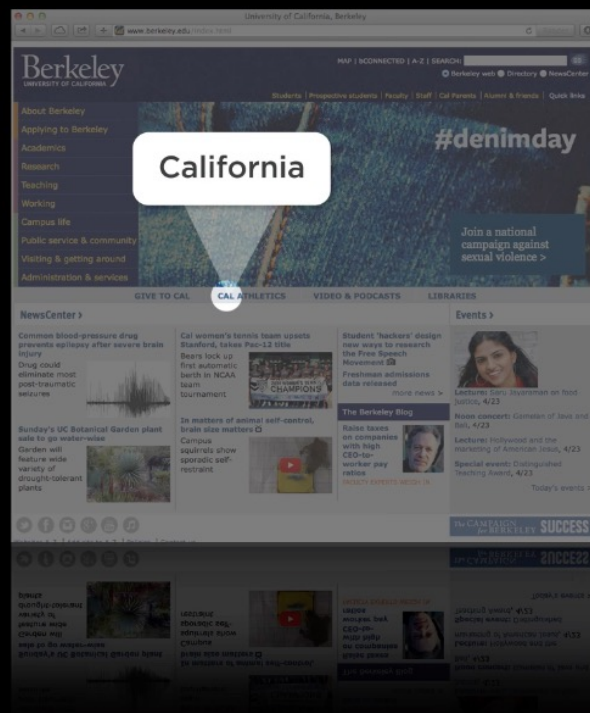
Function
Linear equation function

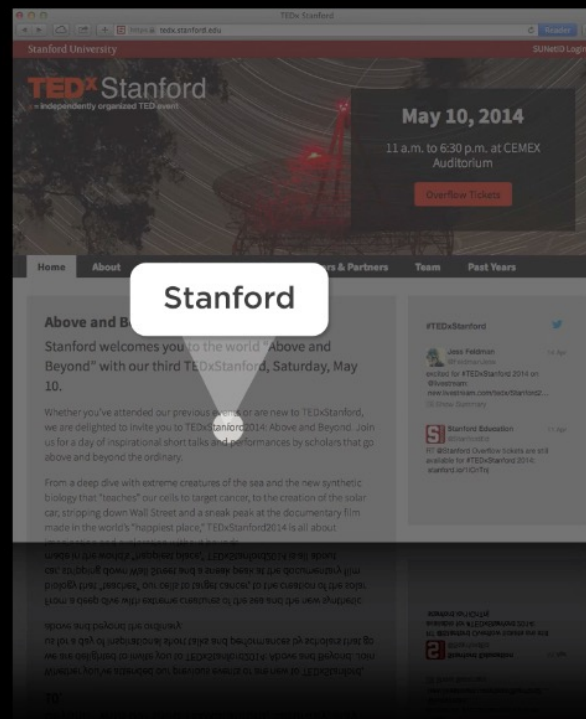
- Google returns exact and related matches
- The resulting pages are ranked in some order











words \ website	Page 1	Page 2	Page 3	Page 4	Page 5
stanford	1	1	0	0	0
Beating	1	0	0	1	0
CAL	1	0	1	0	0
Eggs	0	0	0	1	1

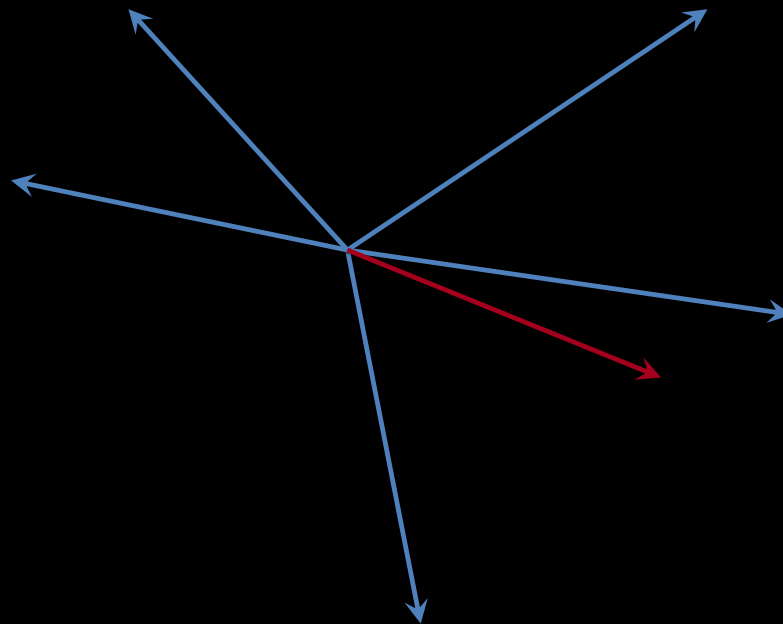
How to search for the phrase "Stanford eggs"

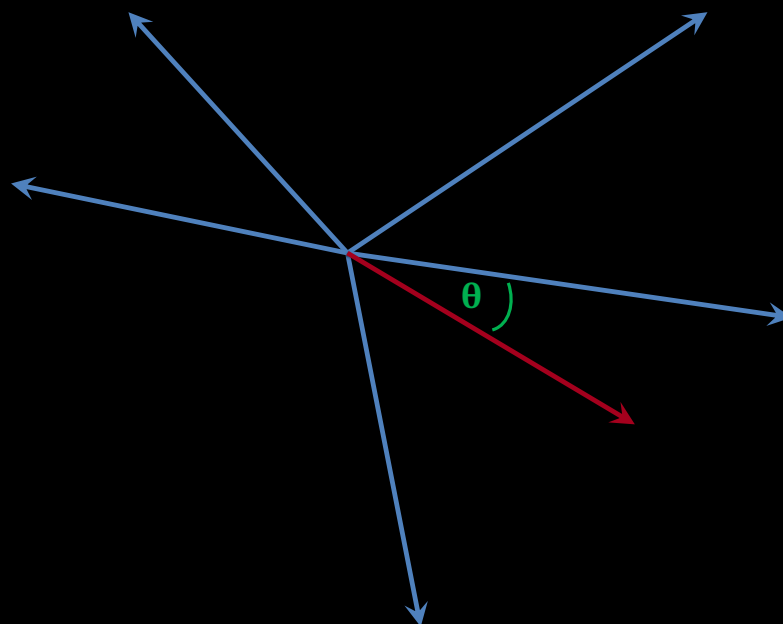
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Eggs	0	0	0	1	1



1
0
0
1

How would you determine which of the page vectors are closest?

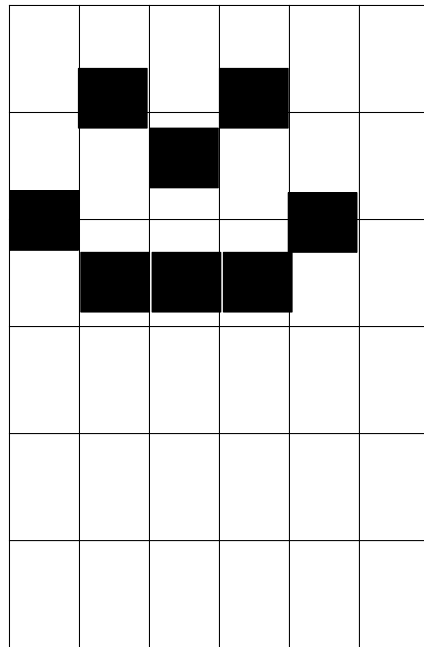




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1	1	0	0	0
1	0	0	1	0
1	0	1	0	0
0	0	0	1	1

$$A = \begin{bmatrix} 1 & 1 & 0 & 0 & 0 \\ 1 & 0 & 0 & 1 & 0 \\ 1 & 0 & 1 & 0 & 0 \\ 0 & 0 & 0 & 1 & 1 \end{bmatrix}$$



$$\begin{bmatrix} 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 1 & 0 & 1 & 0 & 0 \\ 0 & 0 & 1 & 0 & 0 & 0 \\ 1 & 0 & 0 & 0 & 1 & 0 \\ 0 & 1 & 1 & 1 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 \end{bmatrix}$$

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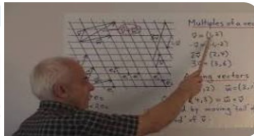
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Linear equation equation

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List of linear equations

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Linear equation function

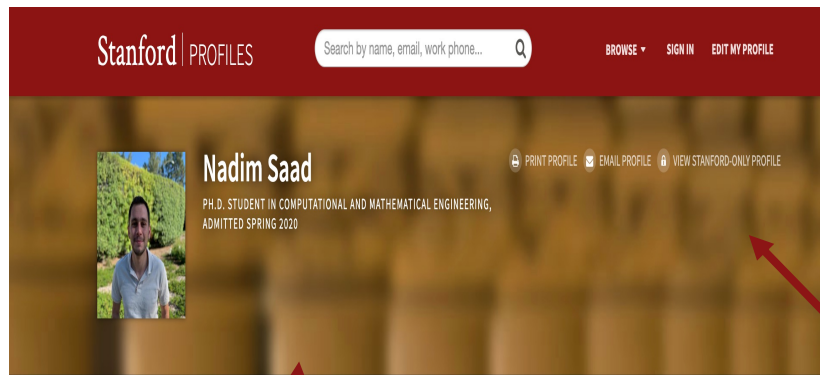
- The web pages are ranked in some order, how would you do it?

Ranking depends on many factors

- Traditional page rank algorithm (measure of importance of a page)
- Number of visits
- Age
- Recent edits
- ...

Initial PageRank Algorithm

Lawrence Page, Sergey Brin, Rajeev Motwani, Terry Winograd "The PageRank Citation Ranking: Bringing Order to the Web" Technical Report, Stanford InfoLab, 1999



Linear Algebra Workshop

ICME

Wednesday, July 26 (8:00 AM - 11:00 AM PDT) & Thursday, July 27, 2023 (8:00 AM - 11:00 AM PDT)

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Lecturer: Nadim Saad
(nsaad31@stanford.edu)

Teaching Assistant: Marie Jose Azzi
(mjazzi@stanford.edu)

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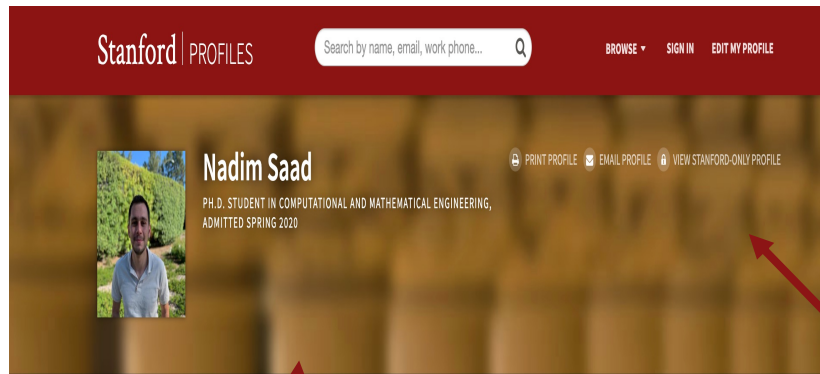
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Linear Algebra Workshop

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A screenshot of the Stanford Institute for Computational & Mathematical Engineering (ICME) homepage. The header is dark red with the Stanford logo and 'Institute for Computational & Mathematical Engineering'. A search bar is present. Below the header, there's a navigation menu with links: 'Academics & Admission', 'Research & Impact', 'People', 'Events', 'Culture', 'Corporate Programs', and 'Get Involved'. The main content area features a large image of people looking at a screen displaying a map and mathematical equations. The text 'Ask Big Questions, Solve Big Problems' is prominent, followed by 'Computational mathematics is at the heart of many engineering and science disciplines'. There's a link 'Learn about ICME PhD & MS Programs and How to Apply' and a button 'Academics & Admission'.

Events & Seminars

News

Workshops

April 10, 2023

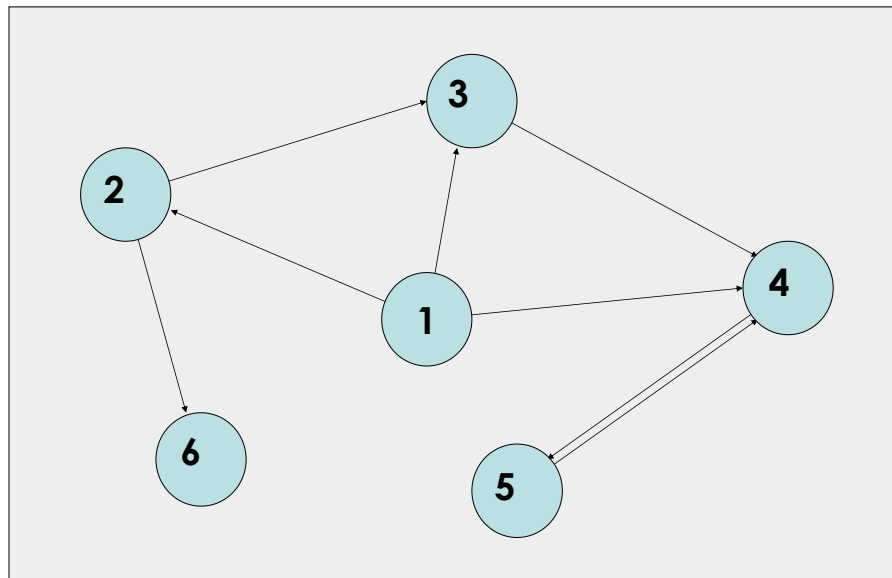
Links coming in from an import page have more weight

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RANK PROPAGATION

Rank of page j denoted by x_j

$$x_1 = 0$$



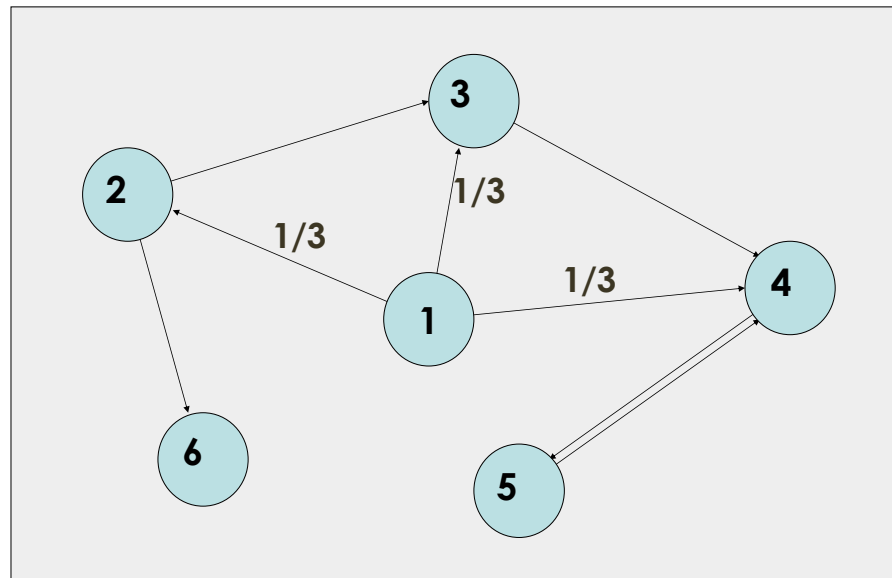
A very small internet "graph"

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Rank of page j denoted by x_j

$$x_1 = 0$$

$$x_2 = \frac{1}{3} x_1$$



A very small internet "graph"

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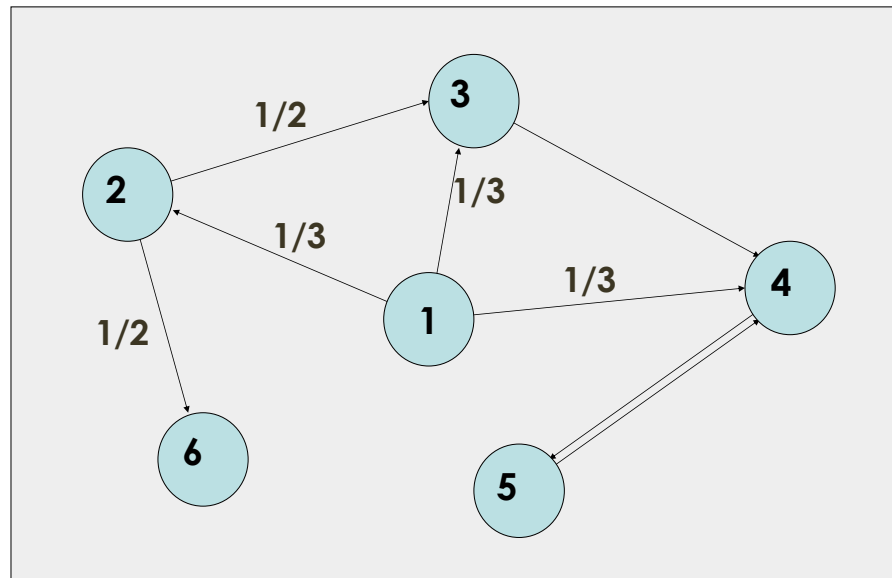
$$x_2 = \frac{1}{3}x_1$$

$$x_3 = \frac{1}{3}x_1 + \frac{1}{2}x_2$$

$$x_4 = \frac{1}{3}x_1 + x_3 + x_5$$

$$x_5 = x_4$$

$$x_6 = \frac{1}{2}x_2$$



A very small internet "graph"

$$x_1 = 0$$

**A COUPLED AND LINEAR
SYSTEM OF EQUATIONS**

$$x_2 = \frac{1}{3} x_1$$

$$x_3 = \frac{1}{3} x_1 + \frac{1}{2} x_2$$

$$x_4 = \frac{1}{3} x_1 + x_3 + x_5$$

$$x_5 = x_4$$

$$x_6 = \frac{1}{2} x_2$$

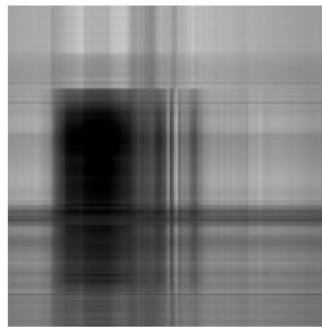
IN MATRIX-VECTOR NOTATION

$$\begin{bmatrix} x_1 \\ x_2 \\ x_3 \\ x_4 \\ x_5 \\ x_6 \end{bmatrix} = \begin{bmatrix} 0 & 0 & 0 & 0 & 0 & 0 \\ 1/3 & 0 & 0 & 0 & 0 & 0 \\ 1/3 & 1/2 & 0 & 0 & 0 & 0 \\ 1/3 & 0 & 1 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 & 0 & 0 \\ 0 & 1/2 & 0 & 0 & 0 & 0 \end{bmatrix} \begin{bmatrix} x_1 \\ x_2 \\ x_3 \\ x_4 \\ x_5 \\ x_6 \end{bmatrix} \quad \text{or} \quad \begin{matrix} x = Px \\ Px = x \end{matrix}$$

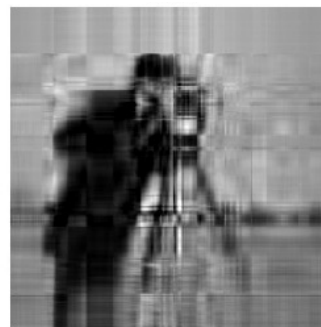
SVD FOR COMPRESSION ON MORE THAN A 5x5 MATRIX



256x256



keep 2 terms



keep 8 terms



keep 32 terms