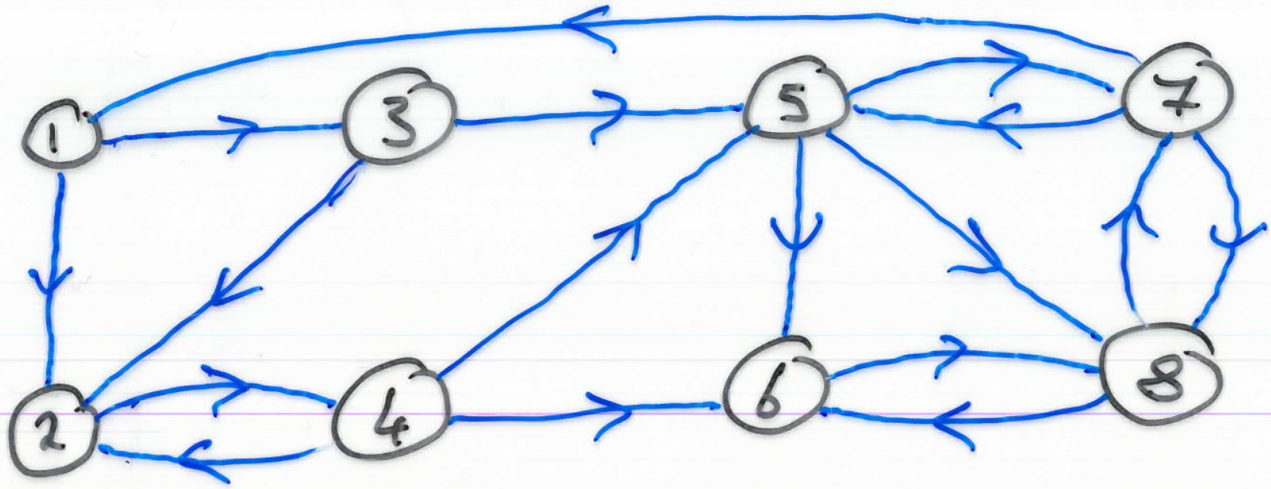
Google

A list of key words
rabbits, belly buttons, golden ratio
results in a few web pages
being listed as most likely
of interest.

The WWW pages containing
the key words can be
represented as a diagram
of nodes (one node for
each page) and arrows
(corresponding to a link
from one page to another)



When listing pages Google first assigns a number I_n to each page P_n.

I_n is the "importance" of the page P_n. Google lists the most important pages first.

$$I_1 = \frac{I_7}{3}$$

$$I_2 = \frac{I_1}{2} + \frac{I_3}{2} + \frac{I_4}{3}$$

$$I_3 = \frac{I_1}{2}$$

$$I_4 = I_2$$

$$I_5 = \frac{I_3}{2} + \frac{I_4}{3} + \frac{I_7}{3}$$

$$I_6 = \frac{I_4}{3} + \frac{I_5}{3} + \frac{I_8}{2}$$

$$I_7 = \frac{I_5}{3} + \frac{I_8}{2}$$

$$I_8 = \frac{I_5}{3} + I_6 + \frac{I_7}{3}$$

How do we determine the numbers I_n.

$$\underbrace{\begin{pmatrix} 0 & 0 & 0 & 0 & 0 & 0 & \frac{1}{3} & 0 \\ \frac{1}{2} & 0 & \frac{1}{2} & \frac{1}{3} & 0 & 0 & 0 & 0 \\ \frac{1}{2} & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & \frac{1}{2} & \frac{1}{3} & 0 & 0 & \frac{1}{3} & 0 \\ 0 & 0 & 0 & \frac{1}{3} & \frac{1}{3} & 0 & 0 & \frac{1}{2} \\ 0 & 0 & 0 & 0 & \frac{1}{3} & 0 & 0 & \frac{1}{2} \\ 0 & 0 & 0 & 0 & \frac{1}{3} & 1 & \frac{1}{3} & 0 \end{pmatrix}}_{A} \underbrace{\begin{pmatrix} I_1 \\ I_2 \\ I_3 \\ I_4 \\ I_5 \\ I_6 \\ I_7 \\ I_8 \end{pmatrix}}_{v} = \underbrace{\begin{pmatrix} I_1 \\ I_2 \\ I_3 \\ I_4 \\ I_5 \\ I_6 \\ I_7 \\ I_8 \end{pmatrix}}_{v}$$

Note: v is an eigenvector of A with corresponding eigenvalue $\lambda = 1$.

An eigenvector for A is:

$$v = \begin{pmatrix} 0.0600 \\ 0.0675 \\ 0.0300 \\ 0.0675 \\ 0.0975 \\ 0.2025 \\ 0.1800 \\ 0.2950 \end{pmatrix} \begin{matrix} \\ * \\ \\ * \\ \\ \\ \\ \\ \end{matrix}$$

Google lists the pages in the following order:

P_8

P_6

P_7

P_5

P_2

P_4

P_1

P_3

But:
How do we calculate eigenvectors for a square matrix A?

Let A be a 2×2 matrix.

Defn The polynomial

$$P_A(\lambda) = \det(A - \lambda I)$$

is called the characteristic polynomial of A.

Example $A = \begin{pmatrix} 2 & 1 \\ 1 & 2 \end{pmatrix}$

$$P_A(\lambda) = \det\left(\begin{pmatrix} 2 & 1 \\ 1 & 2 \end{pmatrix} - \lambda \begin{pmatrix} 1 & 0 \\ 0 & 1 \end{pmatrix}\right)$$

$$= \det\begin{pmatrix} 2-\lambda & 1 \\ 1 & 2-\lambda \end{pmatrix}$$

$$= (2-\lambda)(2-\lambda) - 1.1$$

$$= \lambda^2 - 4\lambda + 4 - 1$$

$$= \lambda^2 - 4\lambda + 3.$$

$$P_A(\lambda) = \lambda^2 - 4\lambda + 3$$

$$P_A(2) = 2^2 - 4.2 + 3 = -1$$

$$P_A(A) = A^2 - 4A + 3I$$

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

$$= \begin{pmatrix} 5 & 4 \\ 4 & 5 \end{pmatrix} - \begin{pmatrix} 8 & 4 \\ 4 & 8 \end{pmatrix} + \begin{pmatrix} 3 & 0 \\ 0 & 3 \end{pmatrix}$$

$$= \begin{pmatrix} 0 & 0 \\ 0 & 0 \end{pmatrix}.$$

Cayley - Hamilton Theorem

For any 2×2 (or n×n) matrix A we have

$$P_A(A) = 0I$$

Name	MA180	MA185	MA190
DYLAN BUCKLEY	✓		
Lise wall	✓		
Rachel Kelly	✓		
Jemima òfarrell	✓		
Ana Devaney	✓		
Shannen Kilkenny	✓		
Liam Lingolon-Shuton	✓		
Ciarán kenny		✓	
Ryan Maguire			✓
Liam English			
Ryan o malley	✓		
Eoin Quirke	✓		
Anton Sohn	✓		

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Fiachra Healy	18365186			✓
Lauren omalley	18309423	✓		
Jackie Wang	18696969		✓	
Jonas Frelich	18452216	✓		
Cian Forde	18424894	✓		
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Aibhlín Crangle	✓		
Sam Hudson	✓		
Eleanor Fitzpatrick		✓	
Marie McDonagh		✓	
Jordan McCartney.	✓		
Karl Gordon			✓
Claire Moloney	✓		
Cathal Byrne	✓		
Jared Mullin			✓
Josh Stoney	✓		
Jan Konrad Kruszynski		✓	
Rory O'Halloran		✓	
Sinead Bannon	✓		
Cian Doheny	✓		

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Cormac Deighan	18373681	X		
Seán Duggan	18419154	X		
Brendan O' Donoghue	1833 5916		X	
Stephen Malone	18717531		X	
Cian Griffin	18410086		X	
Dillon Hughes	18373013	X		
Sophie Plunkett	18491924	X		
Matthew van der Walt	18418966	X		
Seán Tynan	18341103	X		
Megan McGlinchey	18902362	X		

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Sinéad St. John (18400884)			✓
Diarmuid Donnellan	✓		
Colm Óg Conneely	✓		
Alan Henson	✓		
Darragh Flannery	✓		
James Foley	✓		
Brad Reid	✓		
Feargal Kelly	✓		
Seosamh Ó Roibín	✓		✓
Cian Gibbons			✓
Cammie Dundas		✓	
Jonathan Hester	✓		
Padraig Lafferty	✓		
Ciára Galvin			✓
Emer Forde	✓		

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Mairtin O Flatharta	18314986			✗
Rory Sweeney	18342673			✗
Patrycja Szczypkowski	18740211			✗
Megan Reilly	18326546	✗		
Stephen MacDonnacha	18314981			✗
Robert Feely		✗		
Oisin Ganley		✗		
John Tierney		✓		
Aidan O'Hora		✓		
Dara Carr		✓		
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Lydia Costello	✓		
Emma Waters	✓		
Eoin Mulvihill	✓		
Daniel Moran	✓		
Alen Mazarek	✓		
Luke Mullee		✓	
Ruairi Dennehy	✓		
Brian M^cGuiness	✓		
~~Tommy~~ Thomas Conroy	✓		
Phaoi Tyng See		✓	

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Marie Murphy		✓	
Lloyd BOULGER	✓		
Ruth Kelly	✓		
Stephen Quinlan	✓		
Ciara Wall	✓		
Orla O'Neill	✓		
James Spillane		✓	
Luke Flynn	✓		
DAVID CORMICAN	✓		
Ciara Hamilton		✓	
Caoimhe Reidy	✓		
Jack Gavin	✓		
Chloe Reilly			✓
Amy O'Grady	✓		

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Shane Maher	18376381	✓		
Ciaron Maher	18445062	✓		
John Kavanagh	18410284	✓		
Evan Fahy	18391616			✓
Orlaith Ní Chonaire	18384931		✓	
MIHAILO SRECKOVIC	18738401	✓		
Anna Mc Nena	18359021	✓		
Siobhan Beatty	18331526	✓		
Ellen O'Toole	18323523	✓		
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David Flanagan	✓		
Julia Inglés Cerrillo	✓		
Evan O'Riordan			✓
Cathal O'Callaghan			✓
Eoin McArdle			✓
Patrick Ryder	✓		
Xilian Yang			✓
Katie Feeney		✓	
Casey Cowan		✓	
Paul Costello	✓		
Cathal Boyce	✓		

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Ryan Kidd 18384966	✓		
Shain Sutton 18331093			✓
Darren Brown 18385273			✓
Mark Ryder 18390276	✓		

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Marie Brockschmidt	✓		
Evelyn Gitchel	✓		
JACK CREAGH	✓		
Ryan McElhattan	✓		
Lee Mc Sharry	✓		
Ruth Manning	✓		
Paul O'Loughlin		✓	
Remus Ariton	✓		
Nicolas Amaya Aguilar	✓		