

A Talk  
on

# Math Beyond Grades and What Industry Wants

by

Neel Joshi  
Consultant  
Analytics & AI

# Little About Me

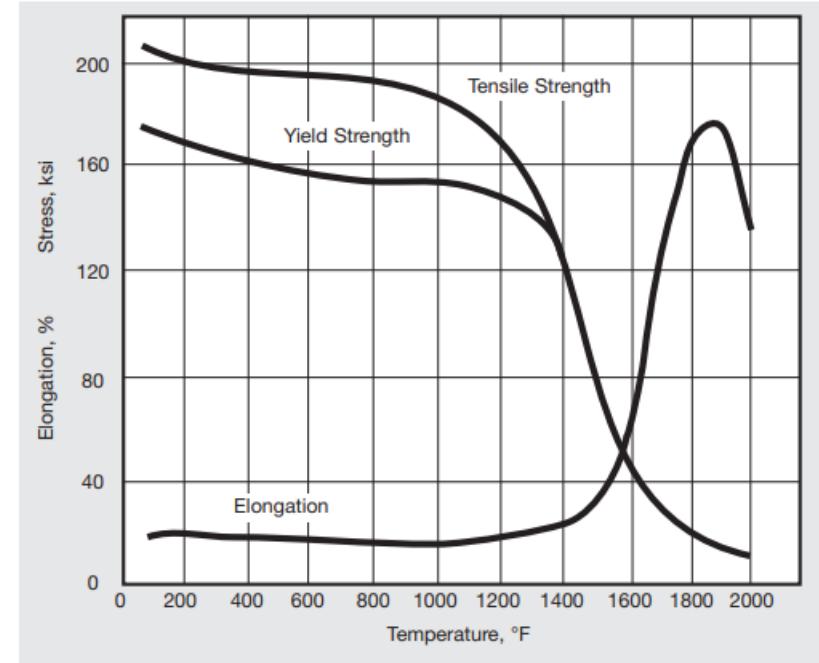
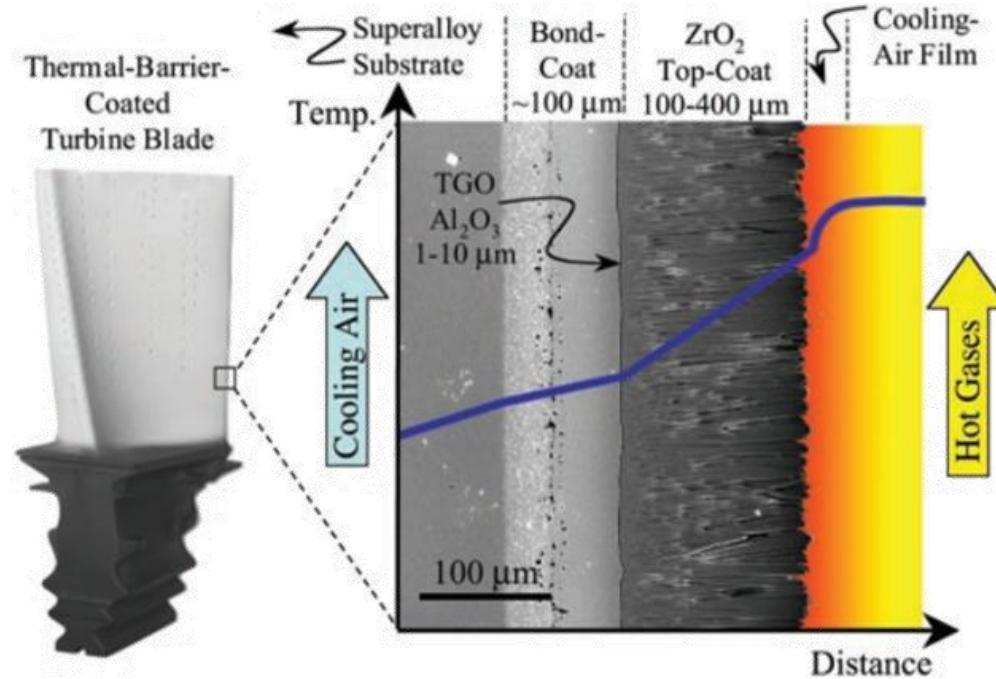
## Experience

Consultant (Present)	Self-Employed
Mechanical Engineer I	Jefferson Lab
Graduate Research Assistant	Musculoskeletal Biomechanics Lab, Carnegie Mellon University
Intern	Metal Forming Lab, IIT Bombay

## Education

M.S. in Mechanical Engineering	Carnegie Mellon University
B.Tech. in Mechanical Engineering	Manipal Academy of Higher Education

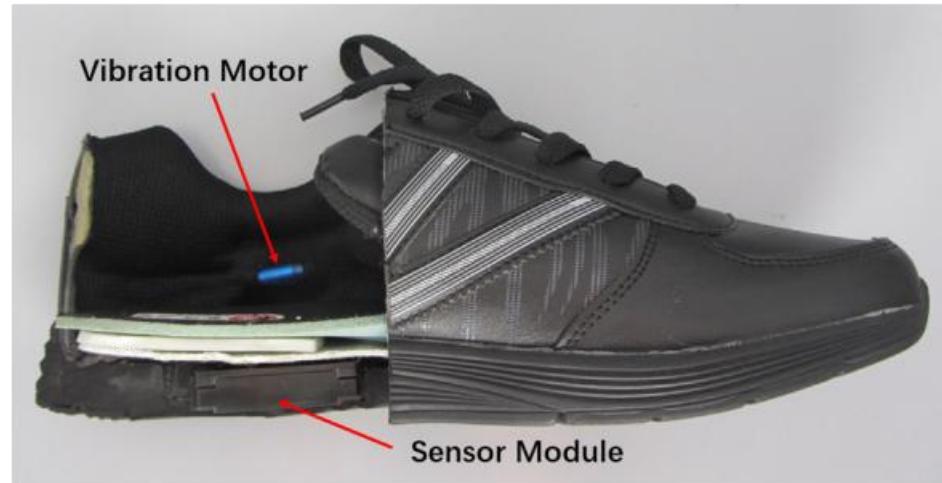
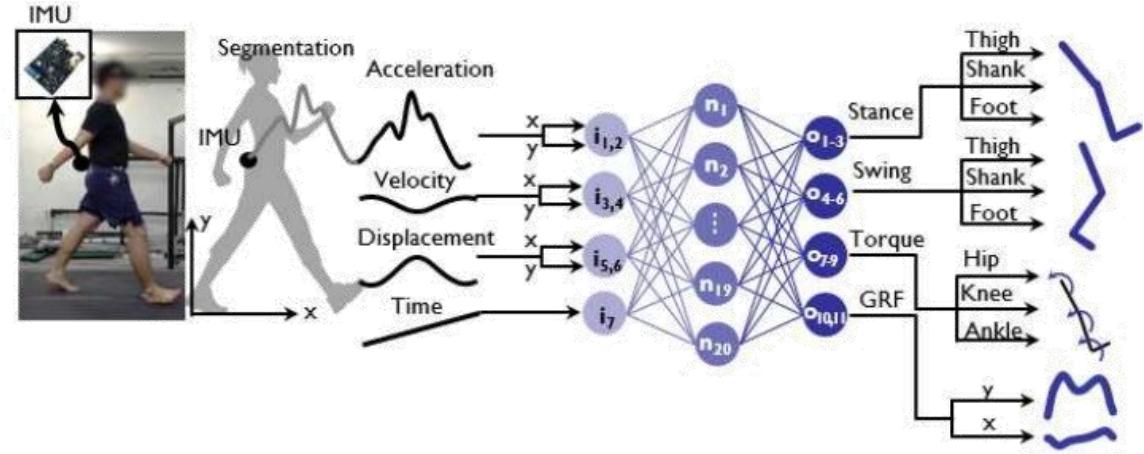
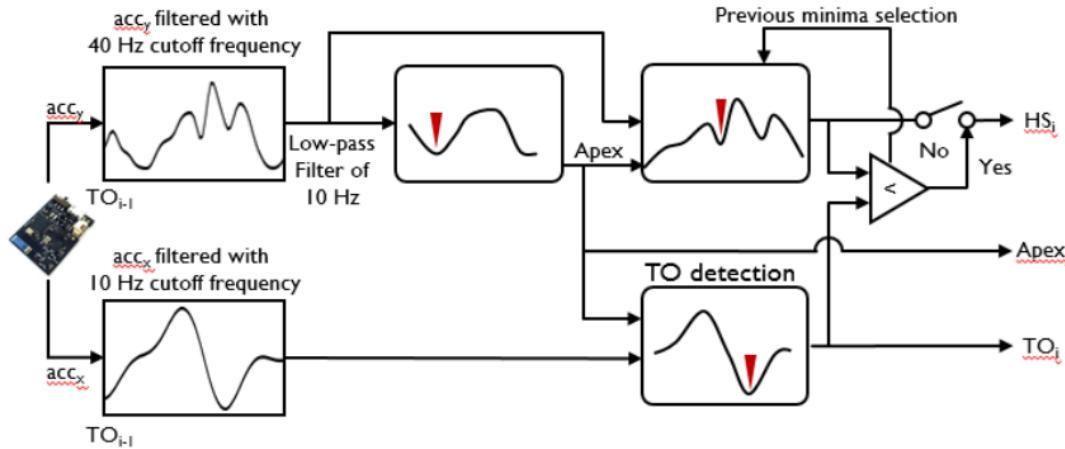
# Recent Projects



Publication Number SMC-045  
Copyright © Special Metals Corporation, 2007 (Sept 07)

Padture, N.P., Gell, M. and Jordan, E.H., 2002. Thermal barrier coatings for gas-turbine engine applications. Science, 296(5566), pp.280-284.

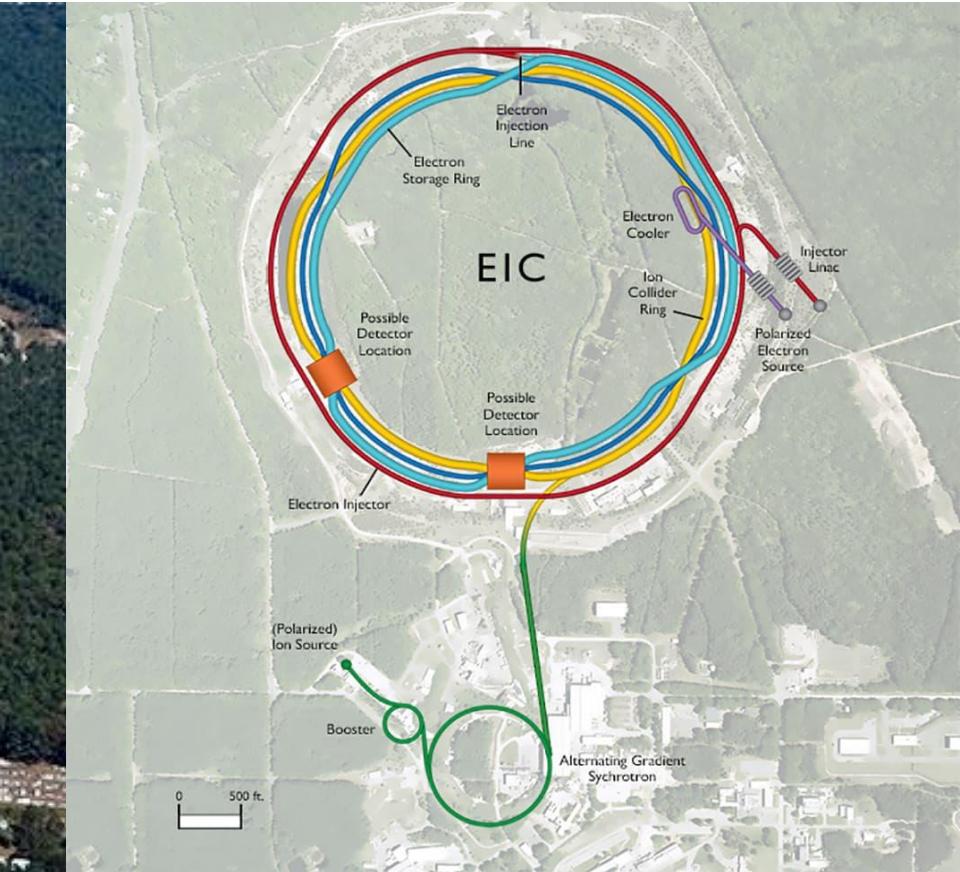
# Recent Projects



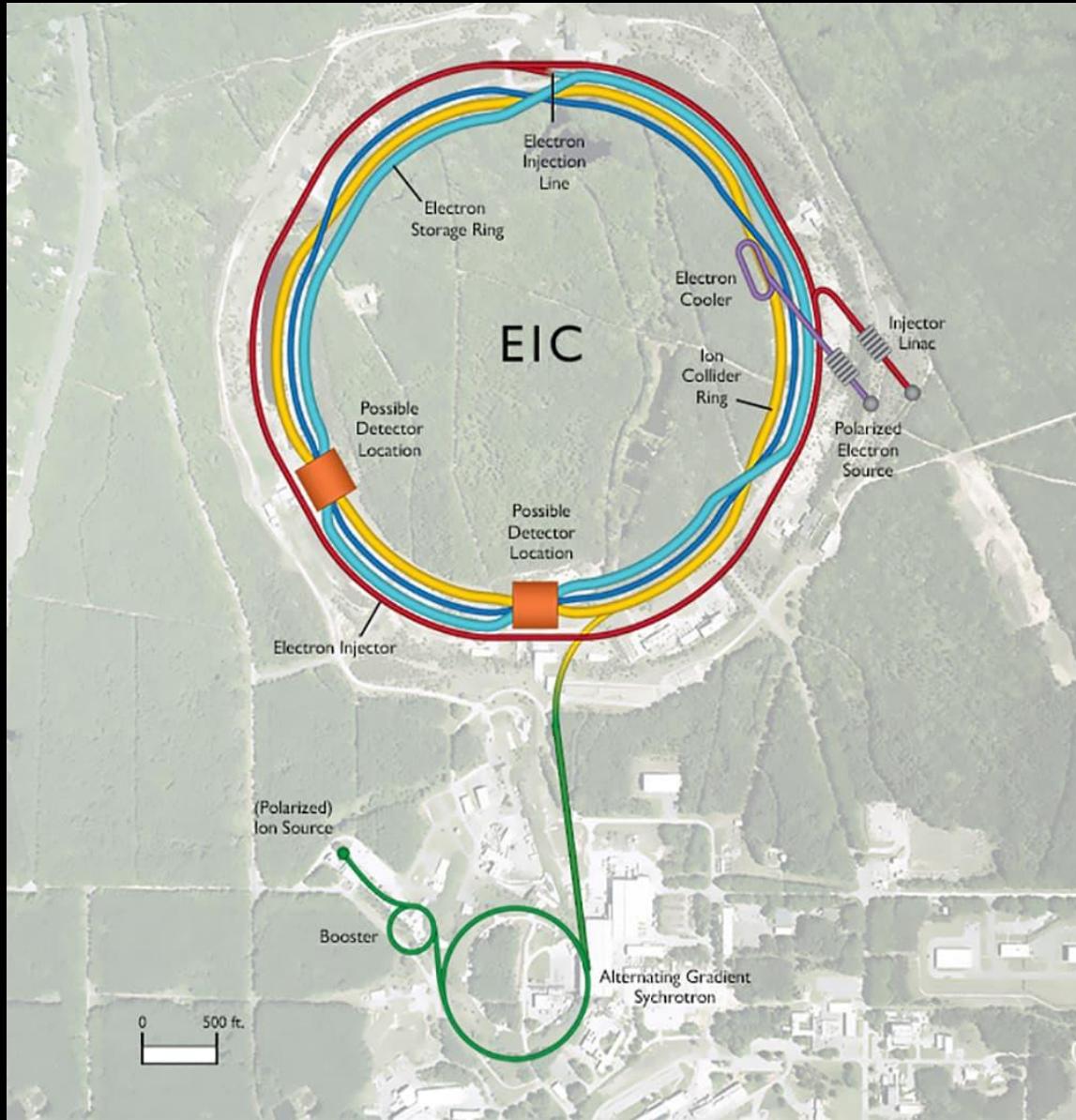
Lim, H., Kim, B. and Park, S., 2019. Prediction of lower limb kinetics and kinematics during walking by a single IMU on the lower back using machine learning. *Sensors*, 20(1), p.130.

Xia, H., Charlton, J.M., Shull, P.B. and Hunt, M.A., 2020. Portable, automated foot progression angle gait modification via a proof-of-concept haptic feedback-sensorized shoe. *Journal of biomechanics*, 107, p.109789.

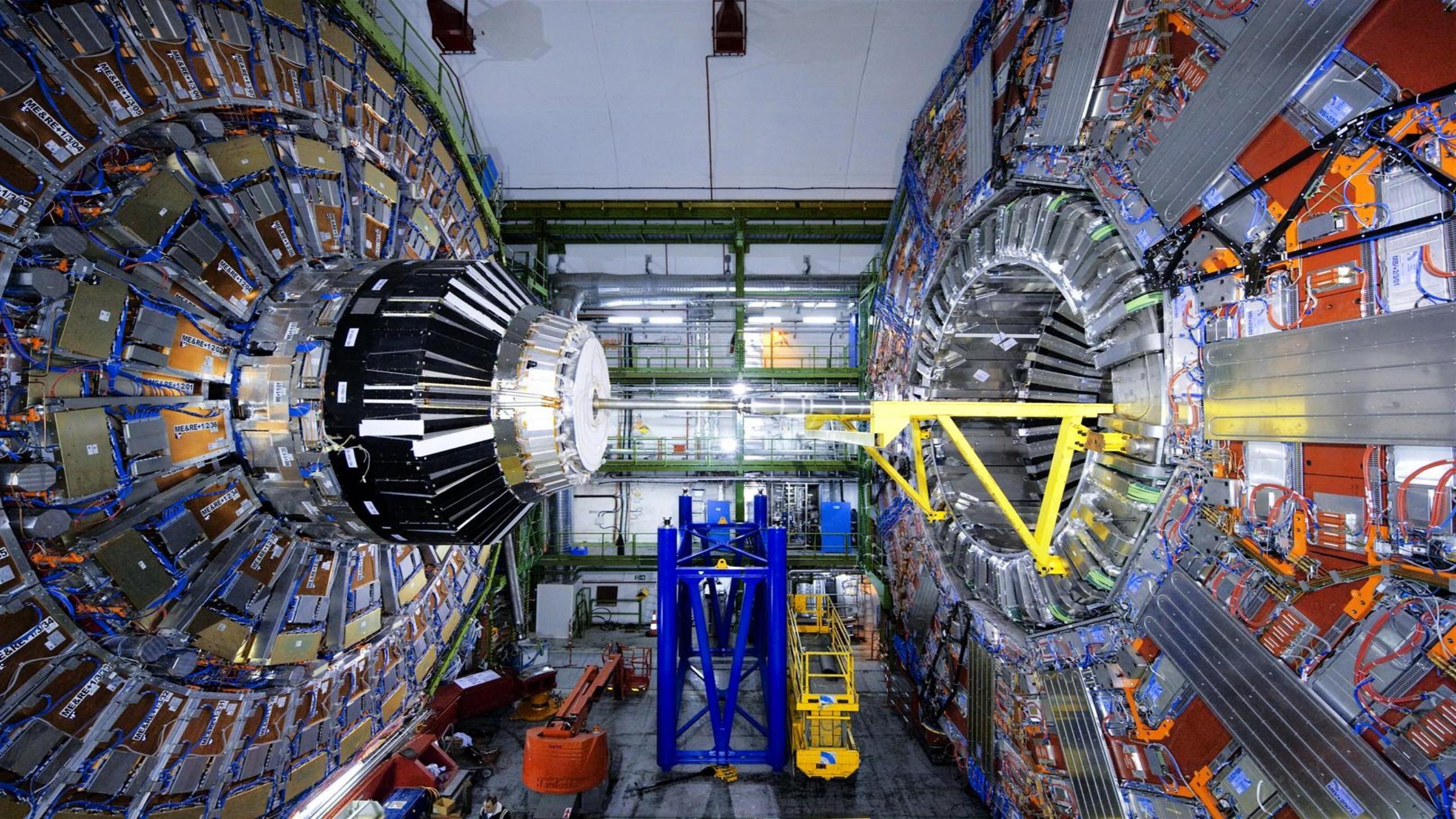
# Recent Projects



Courtesy: Brookhaven National Laboratory, Upton, New York

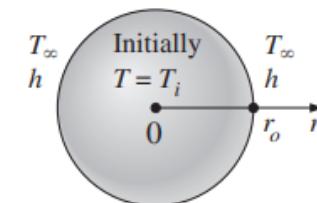
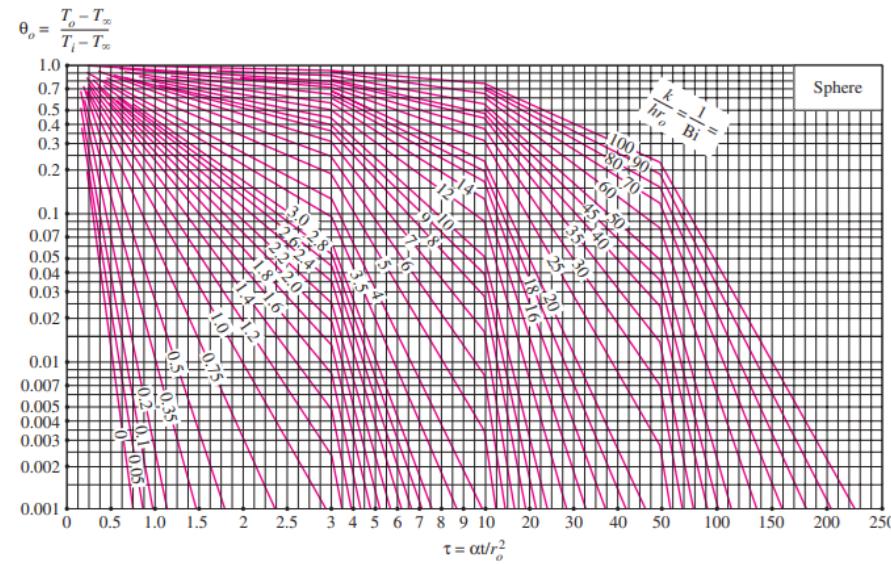
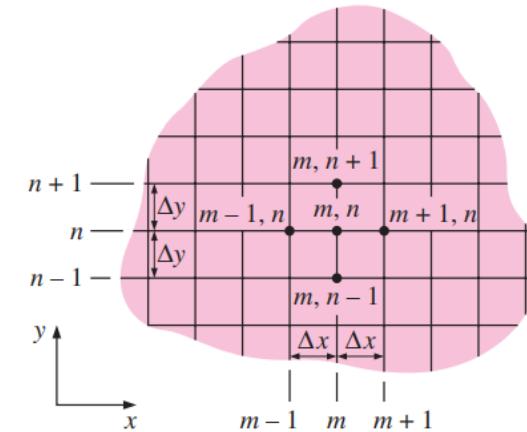
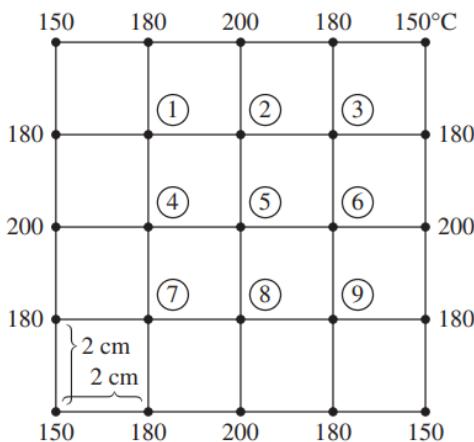


Courtesy: Brookhaven National Laboratory, Upton, New York



# Recent Projects

- Thermal Engineering
- Algorithms
  - Faster
  - More accurate
  - More reliable
  - Specialised for tasks
- Interdisciplinary collaboration
  - Mechanical + Thermal
  - Electrical + Thermal
  - Nuclear + Mechanical + ...



Cengel, Y.A., 1998. Heat transfer: a practical approach.

'Challenges in The Industry' by Neel Joshi ©

# Highlights

1. Qualifications of candidates and job descriptions
2. Doing interesting things with math (in two parts)
3. Artificial Intelligence
  1. Scope
  2. Limitations
4. FinTech
  1. Scope
  2. Game theory
  3. Graph theory
  4. Blockchain
  5. Cyber security
5. Working at the job (pun intended)

# Let's Talk About (\*Your) Background

Bachelor

Set the basics straight

Master

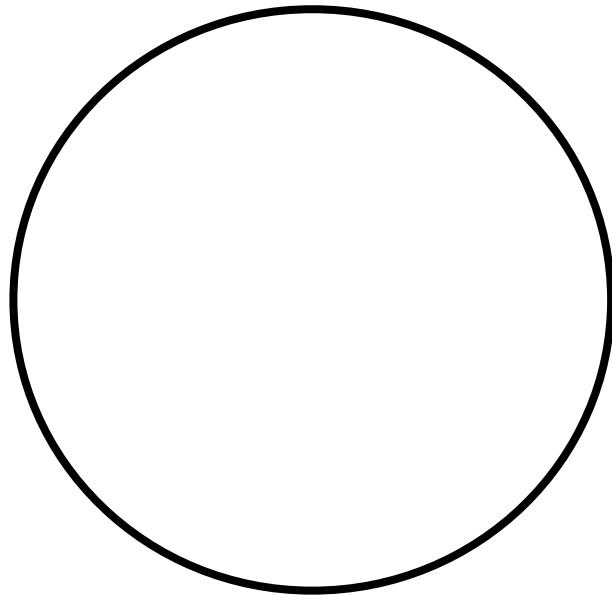
Meant for selecting an area of expertise and delving deeper often by way of researching

PhD

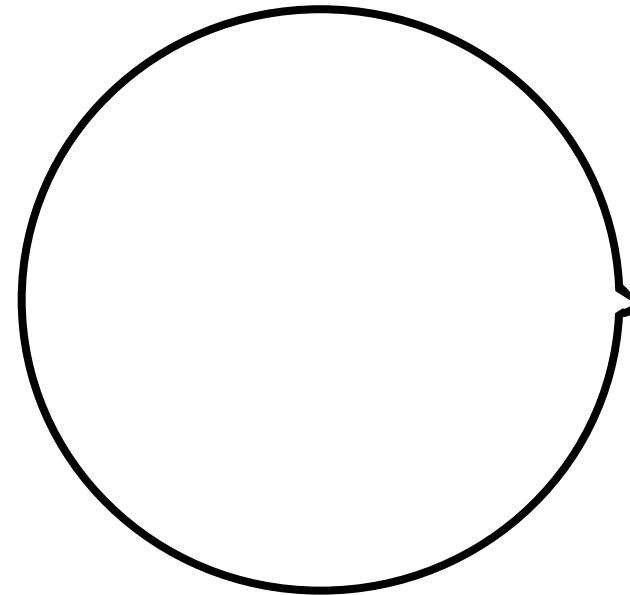
Less of taking lessons in class and more of contributing to a field

# Research: Contribute Something Meaningful

Honesty and integrity in everything you do ... and consequences for not maintaining so

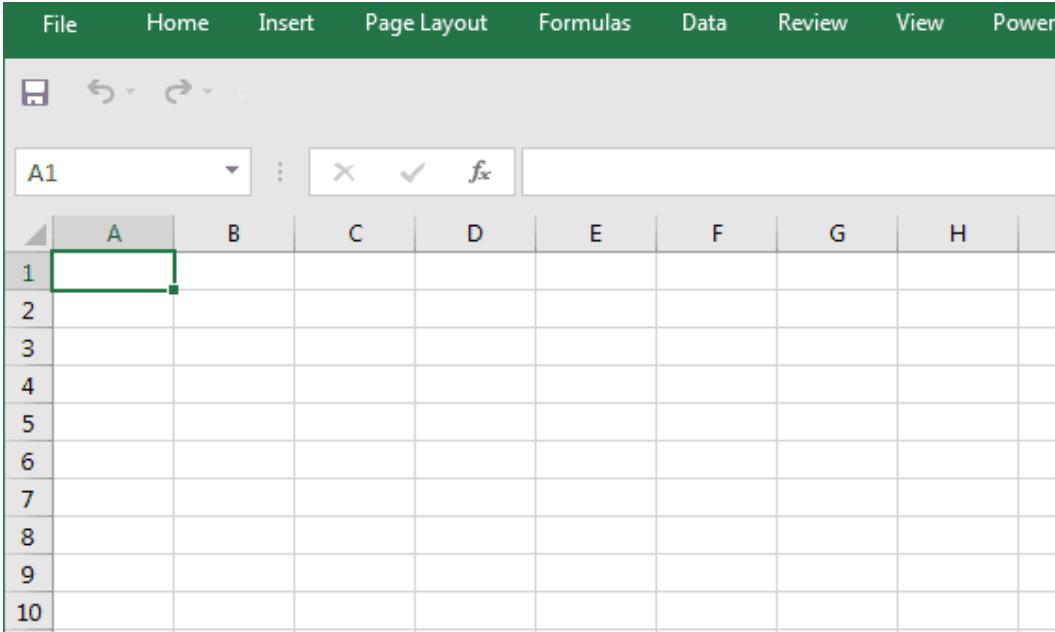


Existing boundary



Extending the existing boundary

# College vs Job



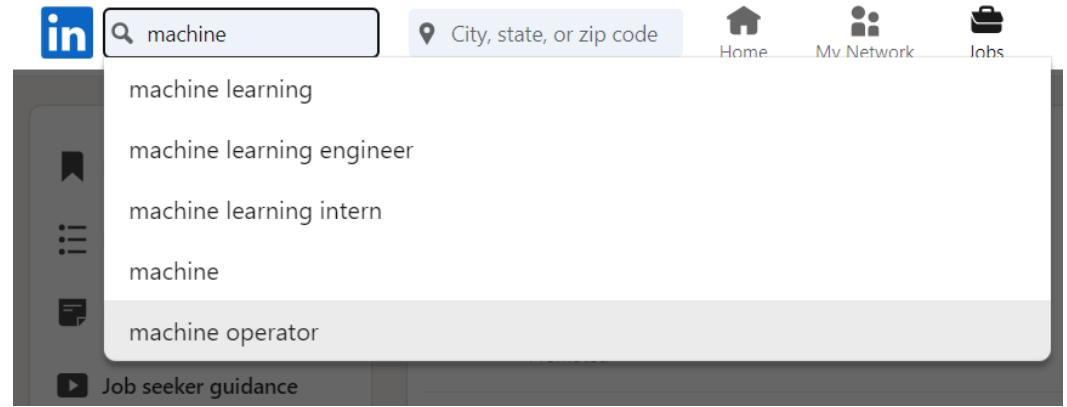
[Source: Hindustan Times](#)

- Easy to use
- Low cost
- Extensions
- Easily Available

# College vs Job



\*Any job search platform of your choice



# Data Analyst

Apply

## **Data Analyst :**

### **RESPONSIBILITIES**

1. Building templates, dashboards in Excel /Google Sheet / PowerBI for operational and management reporting
2. Statistical and Analytical Models and methods for data analysis related to customer initiatives & growth hacks including issue diagnosis, problem dissection and tracking of results
3. Running and maintaining the reporting system
4. Data extraction as per business request for Ad hoc analysis
5. Assisting the team in data analysis and mining
6. Business analysis and understanding to highlight key lead indicators

### **SKILLS**

- Strong database concepts and experience in **SQL** – can convert any business requirement into a SQL statement
- Expertise in **Excel, PowerBI**

**Working experience in R, Python, Tableau, Qlikview, Datastudio is a good to have Experience of working in a customer growth/customer analytics role is a plus**

- Quick learner and ability to work in dynamic work environment
- Team player and comfortable interacting with people from multiple disciplines

### **QUALIFICATIONS**

- Bachelors in Engineering, Computer Science, Math, Statistics, or related discipline from a reputed institute or an MBA from a reputed institute
- 2+ years of experience in working on reporting / business intelligence systems

## Dimensionality Reduction

Vibration Modes in  
Structural  
Simulations



Matrix Series  
Convergence

Corner Detection in  
Computer Vision

Image Compression

## Dimensionality Reduction

Vibration Modes in  
Structural  
Simulations

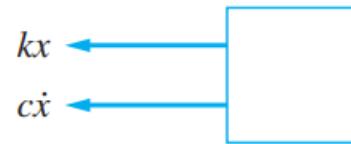
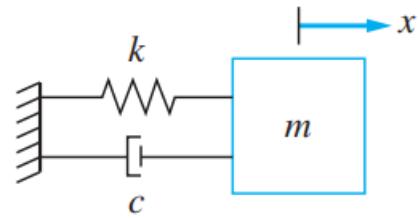


Matrix Series  
Convergence

Corner Detection in  
Computer Vision

Image Compression

$$A\mathbf{x} = \lambda\mathbf{x}$$



$$m\ddot{x} + c\dot{x} + kx = f$$

Assuming damping free oscillations,  $c = 0$ , and no external forces,  $f = 0$

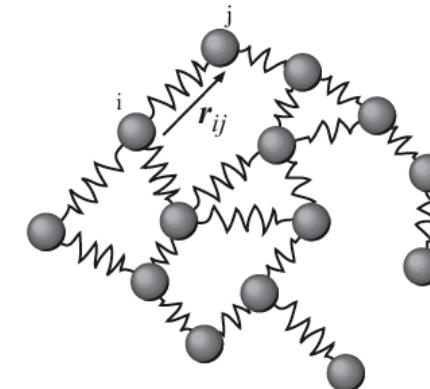
$$m\ddot{x} + kx = 0$$

Plugging in general solution of the form  $x_o \sin(\omega t)$

$$-m\omega^2 x_o \sin(\omega t) + kx_o \sin(\omega t) = 0$$

$$\omega = \sqrt{k/m}$$

$$\omega = GM(k, m^{-1})$$



$$\mathbf{M}\ddot{\mathbf{x}} + \mathbf{C}_{\text{eq}}\dot{\mathbf{x}} + \mathbf{K}_{\text{eq}}\mathbf{x} = \mathbf{F}$$

$$-\omega^2 \mathbf{M}\mathbf{x}_o \sin(\omega t) + \mathbf{K}_{\text{eq}}\mathbf{x}_o \sin(\omega t) = \mathbf{0}$$

$$-\omega^2 \mathbf{M}\mathbf{x}_o + \mathbf{K}_{\text{eq}}\mathbf{x}_o = \mathbf{0}$$

$$\mathbf{K}_{\text{eq}}\mathbf{x}_o = \omega^2 \mathbf{M}\mathbf{x}_o$$

$$(\mathbf{M}^{-1}\mathbf{K}_{\text{eq}} - \omega^2 \mathbf{I})\mathbf{x}_o = \mathbf{0}$$

$$\mathbf{A} = \mathbf{U}\Sigma\mathbf{V}^T$$

# Let's start with programming

Signal Denoising

Quantum Algorithms

Image Filtering

Analysis of Control  
Systems

Solving Math  
Problems



Signal Denoising

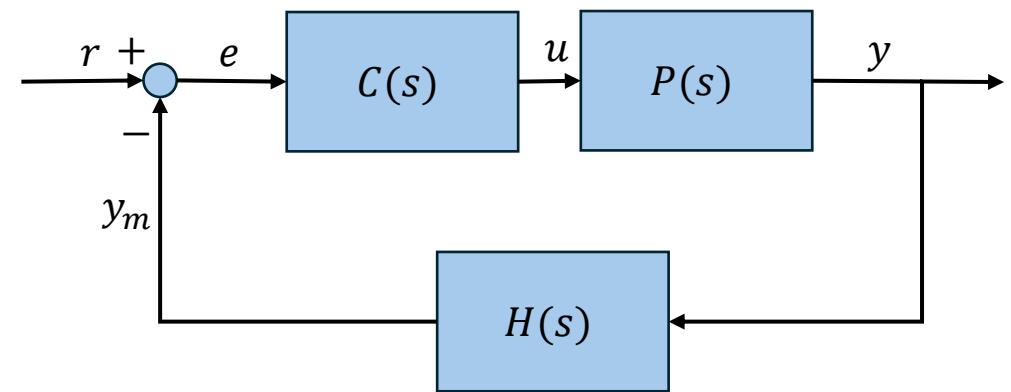
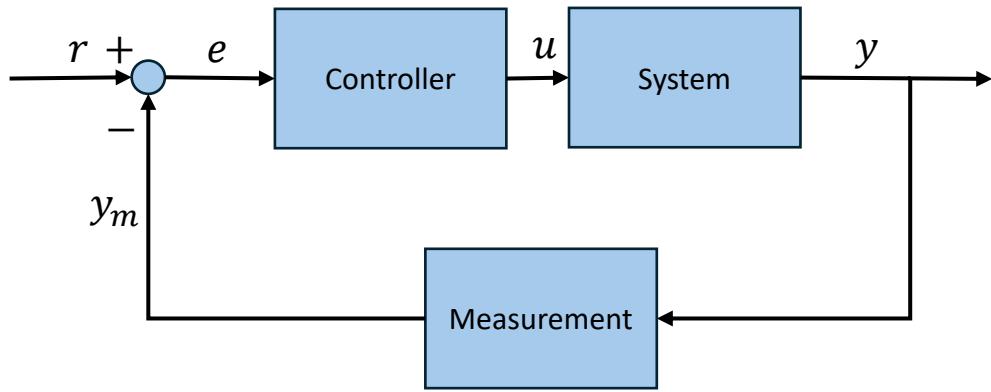
Quantum Algorithms

Image Filtering

Transform

Analysis of Control  
Systems

Solving Math  
Problems



$$y = f_{System}((f_{Controller}(e)))$$

$$e = r - y_m$$

$$Y(s) = P(s)C(s)E(s)$$

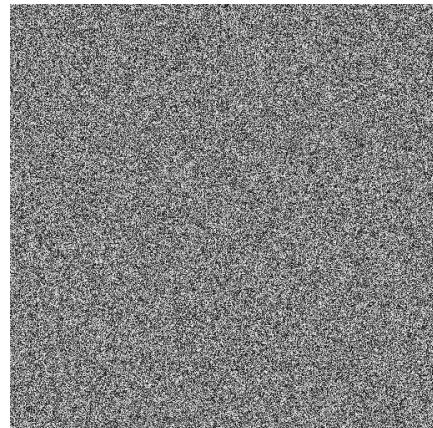
$$E(s) = R(s) - H(s)Y(s)$$

# back to programming

# Image Details Created Layer-by-Layer



# Artificial Intelligence

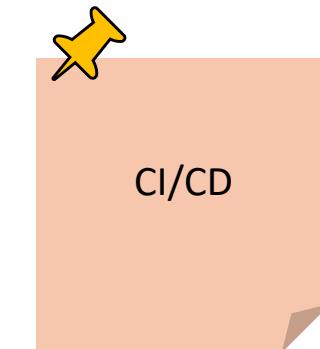
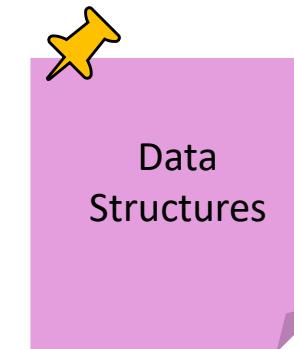
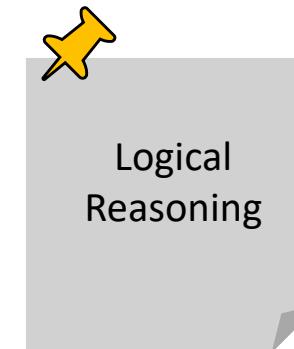
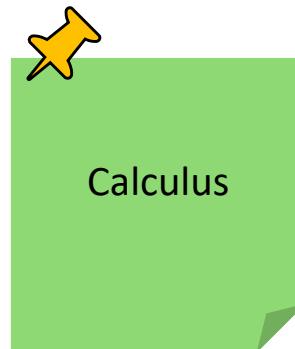
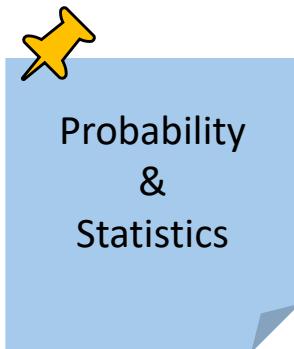
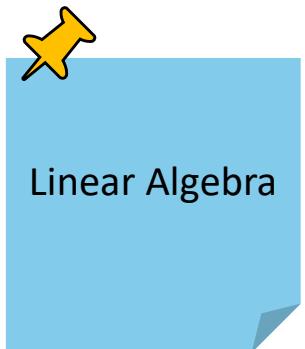
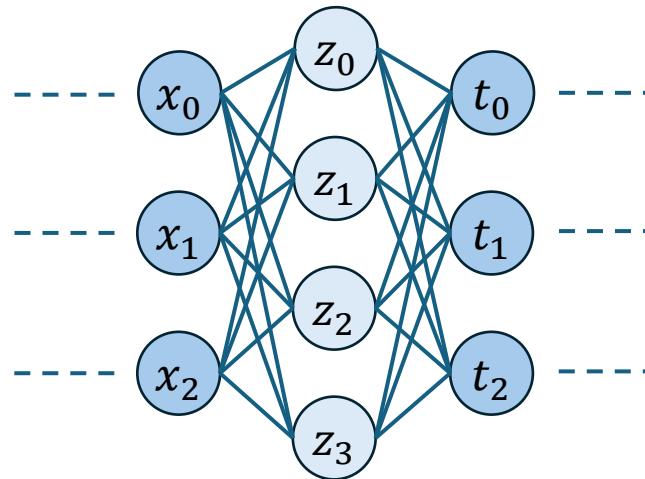


'denoising'

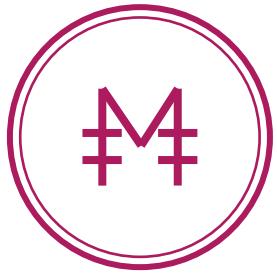


$noise \sim P(\mu, \sigma)$

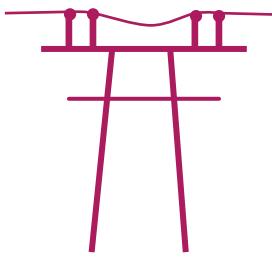
# Artificial Intelligence



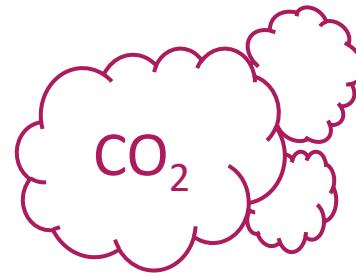
# Realistic Limitations



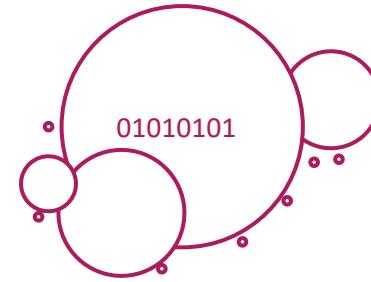
Budget



Energy



Pollution



Tech Bubbles

## Budget

## Energy

## Pollution

## Tech Bubbles

Instance name	On-Demand hourly rate	vCPU	Memory	Storage	Network performance
t4g.nano	\$0.0042	2	0.5 GiB	EBS Only	Up to 5 Gigabit
t4g.micro	\$0.0084	2	1 GiB	EBS Only	Up to 5 Gigabit
t4g.small	\$0.0168	2	2 GiB	EBS Only	Up to 5 Gigabit
t4g.medium	\$0.0336	2	4 GiB	EBS Only	Up to 5 Gigabit
t4g.large	\$0.0672	2	8 GiB	EBS Only	Up to 5 Gigabit
t4g.xlarge	\$0.1344	4	16 GiB	EBS Only	Up to 5 Gigabit
t4g.2xlarge	\$0.2688	8	32 GiB	EBS Only	Up to 5 Gigabit
t3.nano	\$0.0052	2	0.5 GiB	EBS Only	Up to 5 Gigabit
t3.micro	\$0.0104	2	1 GiB	EBS Only	Up to 5 Gigabit
t3.small	\$0.0208	2	2 GiB	EBS Only	Up to 5 Gigabit
t3.medium	\$0.0416	2	4 GiB	EBS Only	Up to 5 Gigabit
t3.large	\$0.0832	2	8 GiB	EBS Only	Up to 5 Gigabit
t3.xlarge	\$0.1664	4	16 GiB	EBS Only	Up to 5 Gigabit
t3.2xlarge	\$0.3328	8	32 GiB	EBS Only	Up to 5 Gigabit
t3a.nano	\$0.0047	2	0.5 GiB	EBS Only	Up to 5 Gigabit
t3a.micro	\$0.0094	2	1 GiB	EBS Only	Up to 5 Gigabit
t3a.small	\$0.0188	2	2 GiB	EBS Only	Up to 5 Gigabit
t3a.medium	\$0.0376	2	4 GiB	EBS Only	Up to 5 Gigabit
t3a.large	\$0.0752	2	8 GiB	EBS Only	Up to 5 Gigabit

\*Please visit AWS official website for latest information

The Batch > Hardware > Article

# GPU Data Centers Strain Grid Power

AI's electricity demands spur an expansion of power sources.

Hardware AI & Society Graphics Processing Unit (GPU)

Data Centers Climate Change Energy Renewable Energy

Published

Feb 14, 2024

Reading time

2 min read



<https://www.deeplearning.ai/the-batch/ai-electricity-demands-spur-an-expansion-of-power-sources/>

## Energy and Policy Considerations for Deep Learning in NLP

**Emma Strubell    Ananya Ganesh    Andrew McCallum**

College of Information and Computer Sciences

University of Massachusetts Amherst

{strubell, aganesh, mccallum}@cs.umass.edu

### Abstract

Recent progress in hardware and methodology for training neural networks has ushered in a new generation of large networks trained on abundant data. These models have obtained notable gains in accuracy across many NLP tasks. However, these accuracy improvements depend on the availability of exceptionally large computational resources that necessitate similarly substantial energy consumption. As a result these models are costly to train and develop, both financially, due to the cost of hardware and electricity or cloud compute time, and environmentally, due to the carbon footprint required to fuel modern tensor

Consumption	CO <sub>2</sub> e (lbs)
Air travel, 1 passenger, NY↔SF	1984
Human life, avg, 1 year	11,023
American life, avg, 1 year	36,156
Car, avg incl. fuel, 1 lifetime	126,000

### Training one model (GPU)

NLP pipeline (parsing, SRL)	39
w/ tuning & experimentation	78,468
Transformer (big)	192
w/ neural architecture search	626,155

Table 1: Estimated CO<sub>2</sub> emissions from training common NLP models, compared to familiar consumption.<sup>1</sup>

Strubell, E., Ganesh, A. and McCallum, A., 2020, April. Energy and policy considerations for modern deep learning research. In *Proceedings of the AAAI conference on artificial intelligence* (Vol. 34, No. 09, pp. 13693-13696).

- Happen when a new technology gets hyped
- '.com' bubble in 1990s
- Telecom bubble in 2000s
- Bitcoin bubbles
- Hoarding

Often followed by

- Recession
- Disruption in industry
- Bank failures

'ai' bubble in 2020s (?)

# Forbes

## Bubbles: From "tronics" to "dot com"

Jan 14, 1999, 04:25pm EST

[Home](#) / [World News](#) / Year after Silicon Valley Bank crisis, a struggle over what needs to change

### Year after Silicon Valley Bank crisis, a struggle over what needs to change

*Regulators say they are now paying closer attention to midsize banks, recognizing that problems can quickly spread between banks with diverse geographic footprints and customer bases*

### Echoes of dotcom bubble haunt AI-driven US stock market

By Lewis Krauskopf

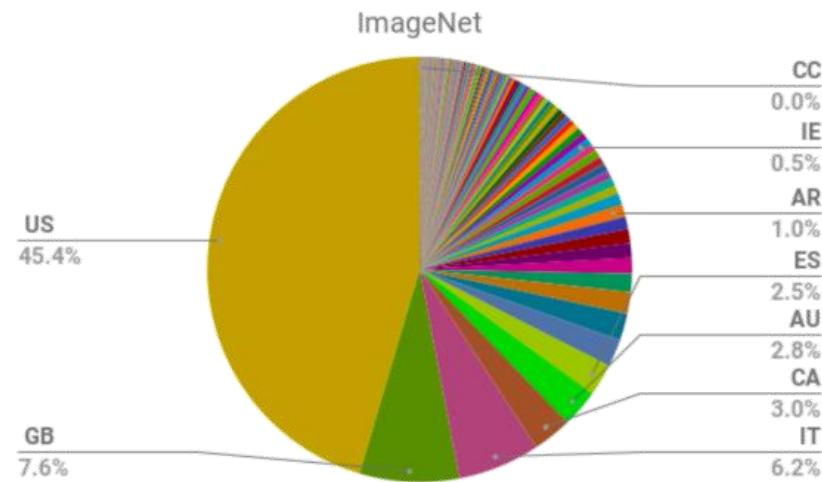
July 2, 2024 1:03 AM EDT · Updated 2 months ago



<https://www.reuters.com/markets/echoes-dotcom-bubble-haunt-ai-driven-us-stock-market-2024-07-02/>

[https://www.business-standard.com/world-news/year-after-silicon-valley-bank-crisis-a-struggle-over-what-needs-to-change-124031000694\\_1.html](https://www.business-standard.com/world-news/year-after-silicon-valley-bank-crisis-a-struggle-over-what-needs-to-change-124031000694_1.html)

# 'Responsible AI'



## Biases

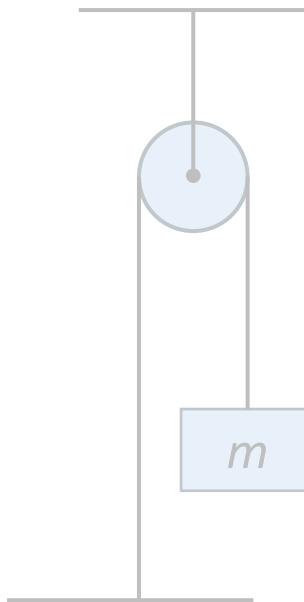
- Algorithmic
  - Historical
  - Measurement
  - Ranking
- ... to name a few

## Privacy

- LLMs scrape data from the open internet
- Possible to recover hidden data
- Personal information can be tracked with ease

Mehrabi, N., Morstatter, F., Saxena, N., Lerman, K. and Galstyan, A., 2021. A survey on bias and fairness in machine learning. ACM computing surveys (CSUR), 54(6), pp.1-35.

# Don't Use AI for Everything...



$$m\ddot{x} + c\dot{x} + kx = f$$

Perfectly described by closed-form solutions

- AI is inherently probabilistic
- Consumes a lot of resources while setting up

Which means

- Repetitive tasks can be automated up to a certain tolerance
- AI *might* help better analyse stochastic phenomena (where there are no laws available to perfectly describe them)

Which also implies

- Jobs with repetitive elements *may* cease to exist
- AI can still make mistakes

# FinTech

## We are Engineering

**Marc-Anthony Hurr: How engineering mathematics gave me the perfect skill set for fintech**

Posted on 05/10/2021



*Marc-Anthony Hurr tells us how his engineering mathematics course at the University of Bristol led him to co-found a global business.*

**Categories**

- [Aerospace Engineering](#)
- [Civil Engineering](#)
- [Computer Science](#)
- [Electrical Engineering](#)
- [Engineering Design](#)
- [Engineering Management](#)
- [Engineering Maths](#)
- [Engineers in Action](#)
- [Health and Society](#)
- [Mechanical Engineering](#)
- [Outreach](#)
- [Robotics](#)
- [Student Stories](#)
- [Sustainability](#)
- [Tech](#)
- [Year in Industry](#)

**Research themes**

- [Advanced Computation and Quantum](#)
- [AI and Data Science](#)
- [Energy and Environment](#)
- [Health and Living](#)
- [Manufacturing](#)

<https://engineering.blogs.bristol.ac.uk/engineering-mathematics-skills-for-fintech/>

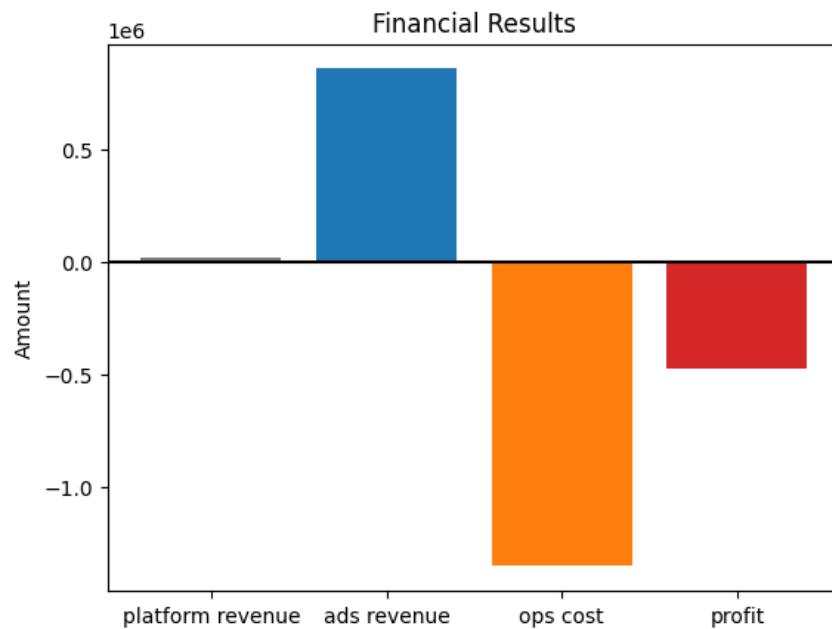
10/25/2025

'Challenges in The Industry' by Neel Joshi ©

35

# FinTech

- Converting problem to financial model
- Converting financial model to program
  - Website, UX/UI
  - Optimisation, real time ops
- ...
- Understanding statistics and data
  - Right kind of talent
  - Especially experts in field
  - Continuously updating knowledge base



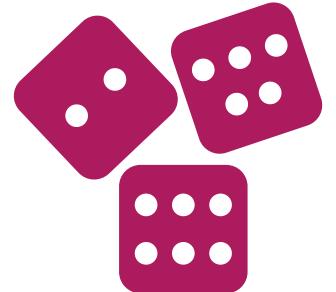
# Game Theory

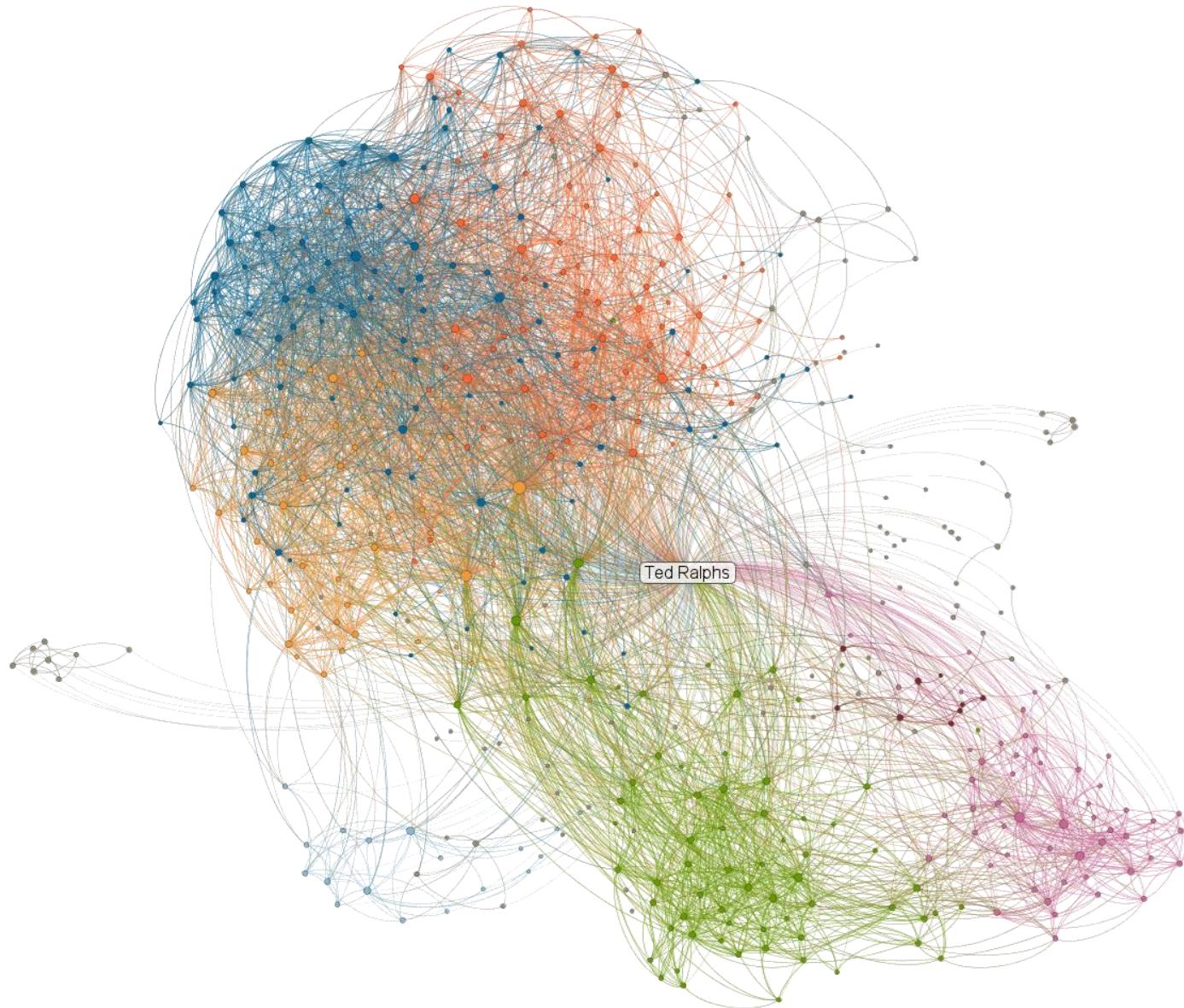
- Everyone make a choice sometime or other
- People at responsible positions have to make difficult choices, they are expected to defend their choices and own up the results
- Nash Equilibrium
- Ex.

		Player 2	
		1	2
Player 1	1	1	-1
	2	-1	1

		Player 2		
		1	2	3
Player 1	1	-3	-2	6
	2	2	0	2
	3	5	2	-4

Where is it used?

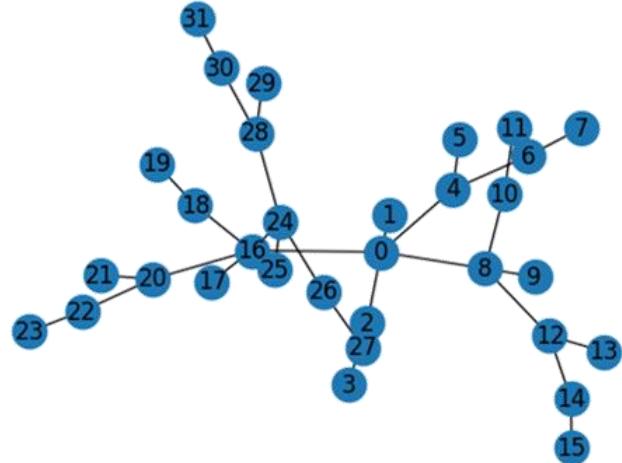
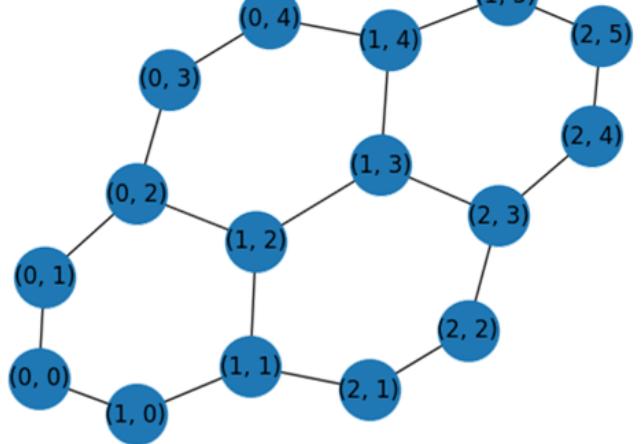




This Photo by Unknown Author is licensed under CC BY-SA

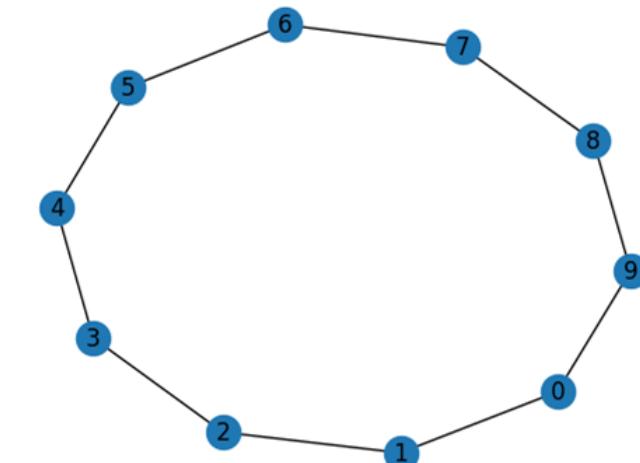
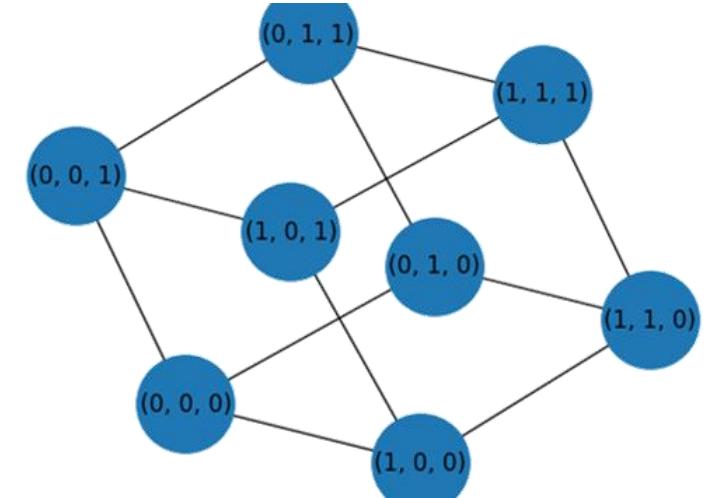
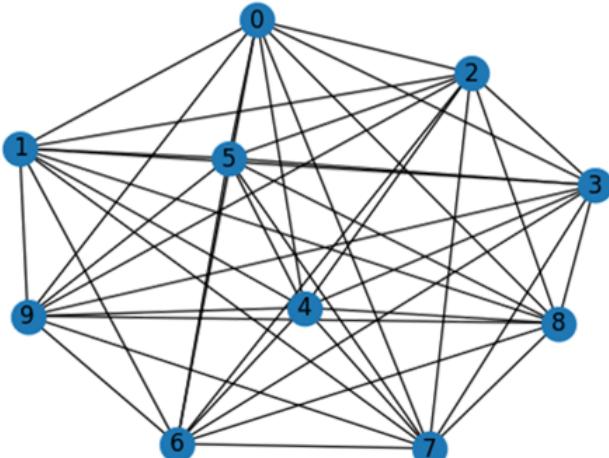
©2011 LinkedIn - Get your network map at [inmaps.linkedinlabs.com](http://inmaps.linkedinlabs.com)

# Graph Theory

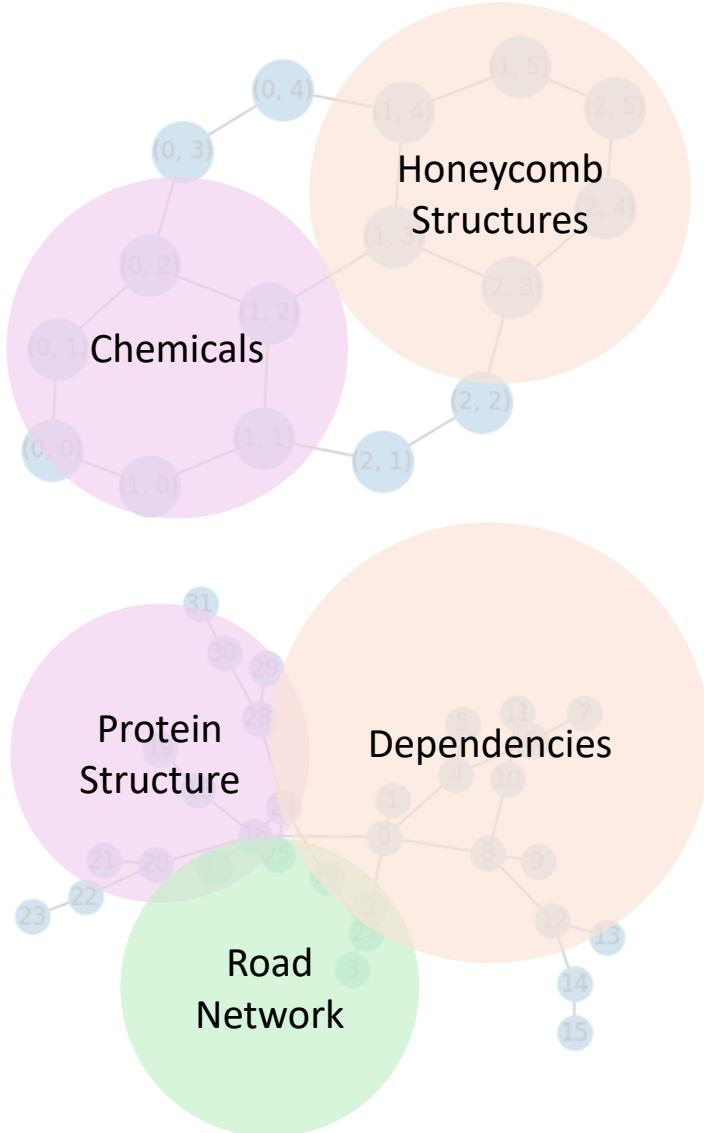


$$G = (E, V)$$

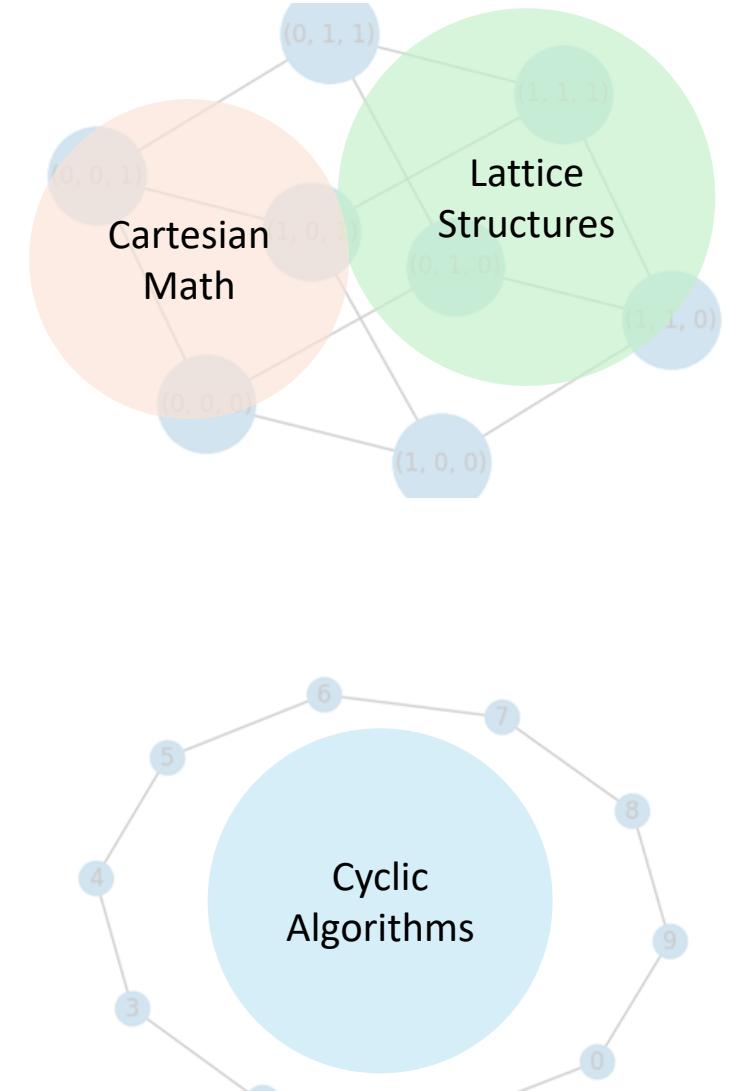
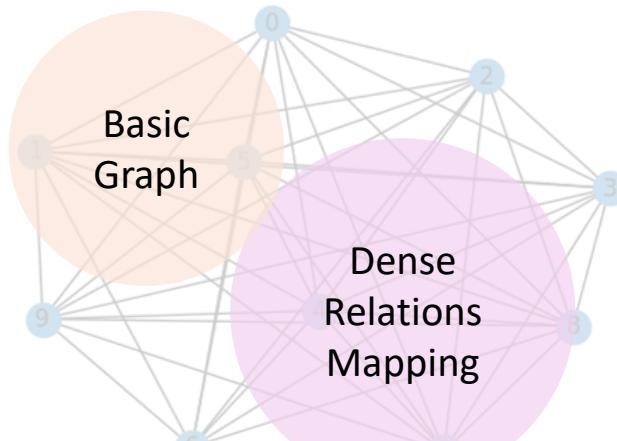
E: set of edges  
V: set of vertices



# Graph Theory Use Cases

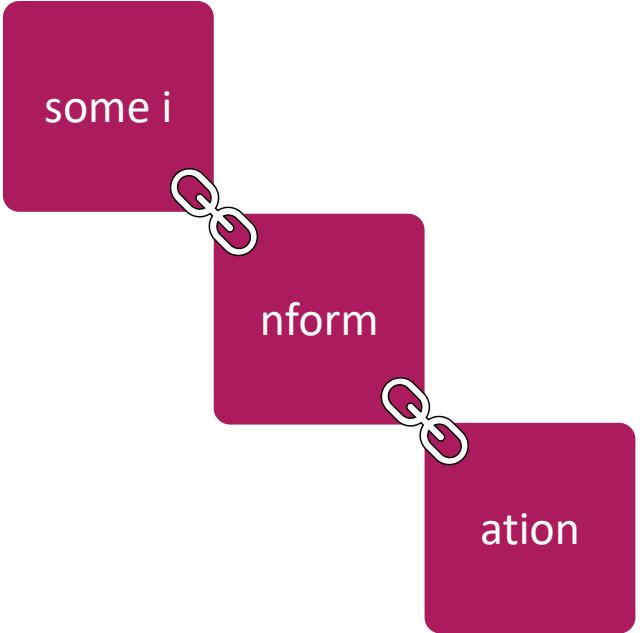


$G = (E, V)$   
E: set of edges  
V: set of vertices



# Blockchain

- Ledger
- Runs on consensus protocol (everybody decide/modify algorithms with consensus)
- Each block created with its timestamp
  - e.g. **1725444605.001** is the timestamp for **2024-09-04 10:10:05.001000**
- Chained by cryptographic algorithms
- Regulatory concerns
- Only as strong as the cryptography algorithms used to create the hash
- Multiple Bitcoin crashes in recent past



# back to programming

# Cyber Security

The most stringent laws about personal information (PI) data protection

## California Consumer Privacy Act (CCPA)

- Responsibility of the company
  - Locating all customer data
  - Protecting all collected data
  - Alerting consumers that their data has been collected
  - Establishing and announcing a company privacy policy etc.
- Penalties for noncompliance
  - USD 2,500 (unintentional) and USD 7,500 (intentional) data breach **per person**

## General Data Protection Regulation (GDPR)

- Applicable to data collected from **all** EU citizens anywhere in the **world**
- Penalties for noncompliance
  - Up to 20 Million in Euros or 4% of company's prior financial year **worldwide annual revenue**

<https://oag.ca.gov/privacy/ccpa>

<https://gdpr.eu/what-is-gdpr/>

# Cyber Security

Back when I was planning to come here, on the airlines website ...

## 1) What is our legal basis for processing your Personal Information? ^

will only process your Personal Information where we have a legal basis to do so (in accordance with Article 6 of the GDPR and other privacy laws). This will depend on the purposes for which collects and uses your Personal Information. Under EU GDPR and under the Indian IT Act, in almost all cases the legal basis will be the following:

## 10) Transfer of Personal Information Overseas ^

We may need to transfer your Personal Information to countries other than your own, such as where some of our service providers are based. To do so, we rely on your consent, where applicable under the law. We will make such transfer only if the same level of protection is adhered to by the service providers as that of , or if the country of our service providers is subject to Adequacy Decision by the European Commission.

If you reside in the EU, our transfers of Personal Information outside the European Economic Area are supported by appropriate cross-border transfer mechanisms as provided under GDPR.

If you reside in India, our transfer of Personal Information outside India will be allowed only if it is necessary for the performance of a lawful contract.

<https://oag.ca.gov/privacy/ccpa>

<https://gdpr.eu/what-is-gdpr/>

[airline\\_data\\_privacy](#)

# Cyber Security

## Bot-net

Remotely controlled compromised network

## Criminal Groups

Usually working for money

## Insiders

Advertently or inadvertently provide access to critical data

## Nations

Nation-state actors

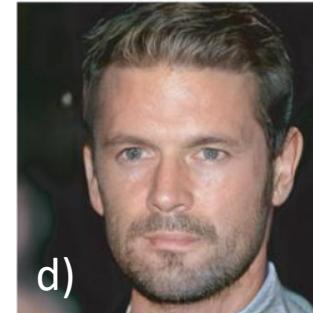
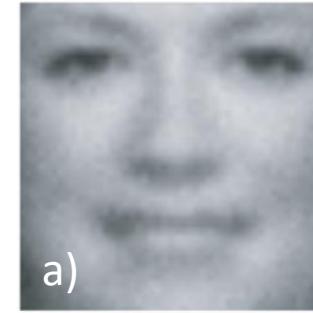
## Phishers

Try to get money etc. by way of impersonation

## Terrorists

Use critical data to cause panic and use it for meeting their demands

- Better **algorithms** and **data** (guess what you get in your antivirus updates?)
- Threat actors *might* use AI in the future to generate automatic attacks. It can also help conceal them better. Generative adversarial networks generate flawless fake images. Deepfakes have already become a source for malicious activities, misinformation.
- IT and networks (communications) domain knowledge essential for understanding cybersecurity landscape.



Output of Generative Adversarial Networks from years a) 2014, b) 2015, c) 2016, d) 2017.

Goodfellow, I., Pouget-Abadie, J., Mirza, M., Xu, B., Warde-Farley, D., Ozair, S., Courville, A. and Bengio, Y., 2020. Generative adversarial networks. Communications of the ACM, 63(11), pp.139-144.

# Working at The Job

## Getting Along with Colleagues

- People from different cultures, continents, diverse backgrounds
- Ambitions, competition, conflicts, etc.
- Compliance programs

## Workforce of The Future

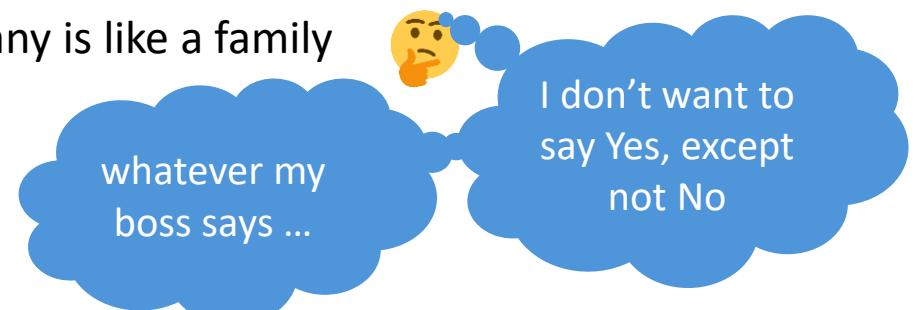
- Increasingly automated, computer oriented
- Interdisciplinary
- Behavioural traits >>> work savviness

## Managing Teams

- Ambitions, competition, conflicts, etc.
- Strengths & weaknesses, delegating work
- You are responsible for your team!

## Work – Life Balance

- Figure out what you like to do for a living
- Taking breaks away from work regularly
- Company is like a family



# Q&A