Indian Institute of Technology Mandi

Scaling the Heights

An Engineering Career in a Fast-changing World

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Questions from a budding BTech in a fast-changing world

- Why an engineering career?
- What is engineering?
- How do I become an innovative engineer?
- My passion is ML, why study chemistry?
- Will AI/ML take over engineering?
- Which companies will hire me?

Questions from a budding BTech

- Why an engineering career?
- What is engineering?
- How do I become an innovative engineer?
- My
- Will
- Wh

Popular choices for
BTech graduates are
MBA, IAS, IT

Why an engineering career?

Why Engineering Career?

Chandrayaan 3:

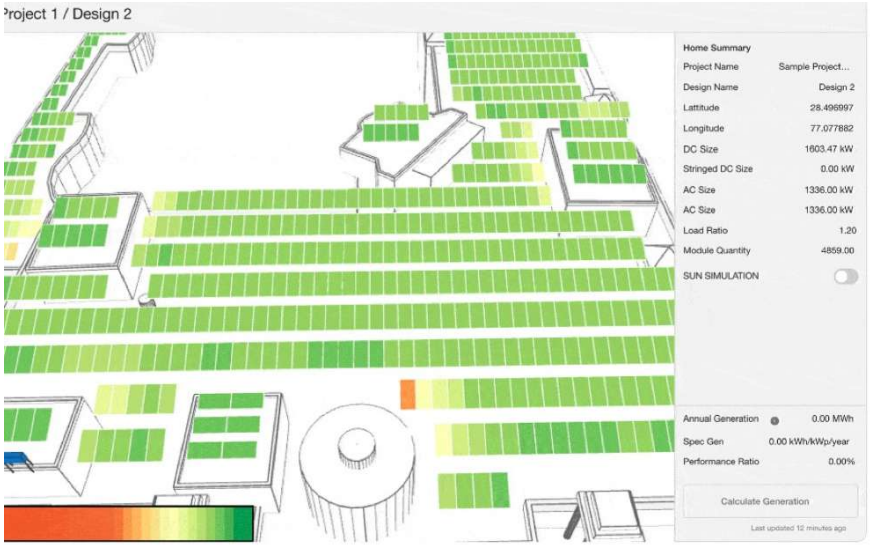
23rd Aug 2023 was the result of 60 years of engineering in ISRO and Indian industry

Chandrayaan3 launch, 14/7/23 (c) ISRO

Solar Power:

2017: Siddharth graduated from IIT Mandi, started The Solar Labs

2022: Siddharth sold TSL, got 20x salary



Rooftop solar installation planner

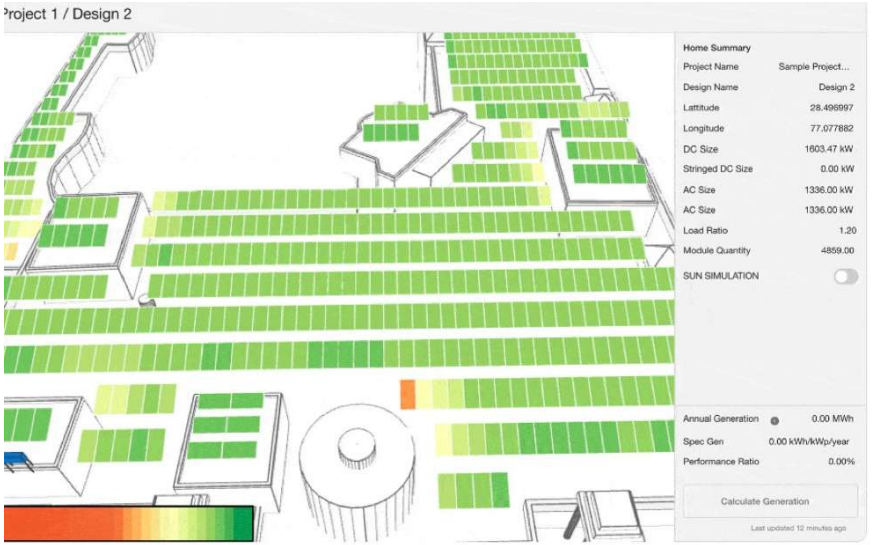
… Why Engineering Career?

Engineers serve society

Engineers win fame
-- Chandrayaan 3

Chandrayaan3 launch, 14/7/23 (c) ISRO

Engineers earn a fortune
-- The Solar Labs



Rooftop solar installation planner

Engineers can change the world for better

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What is “Engineering”?

1. Find something that bugs you
2. Think of 3 different solutions that involve technology
3. Choose the best solution and implement it

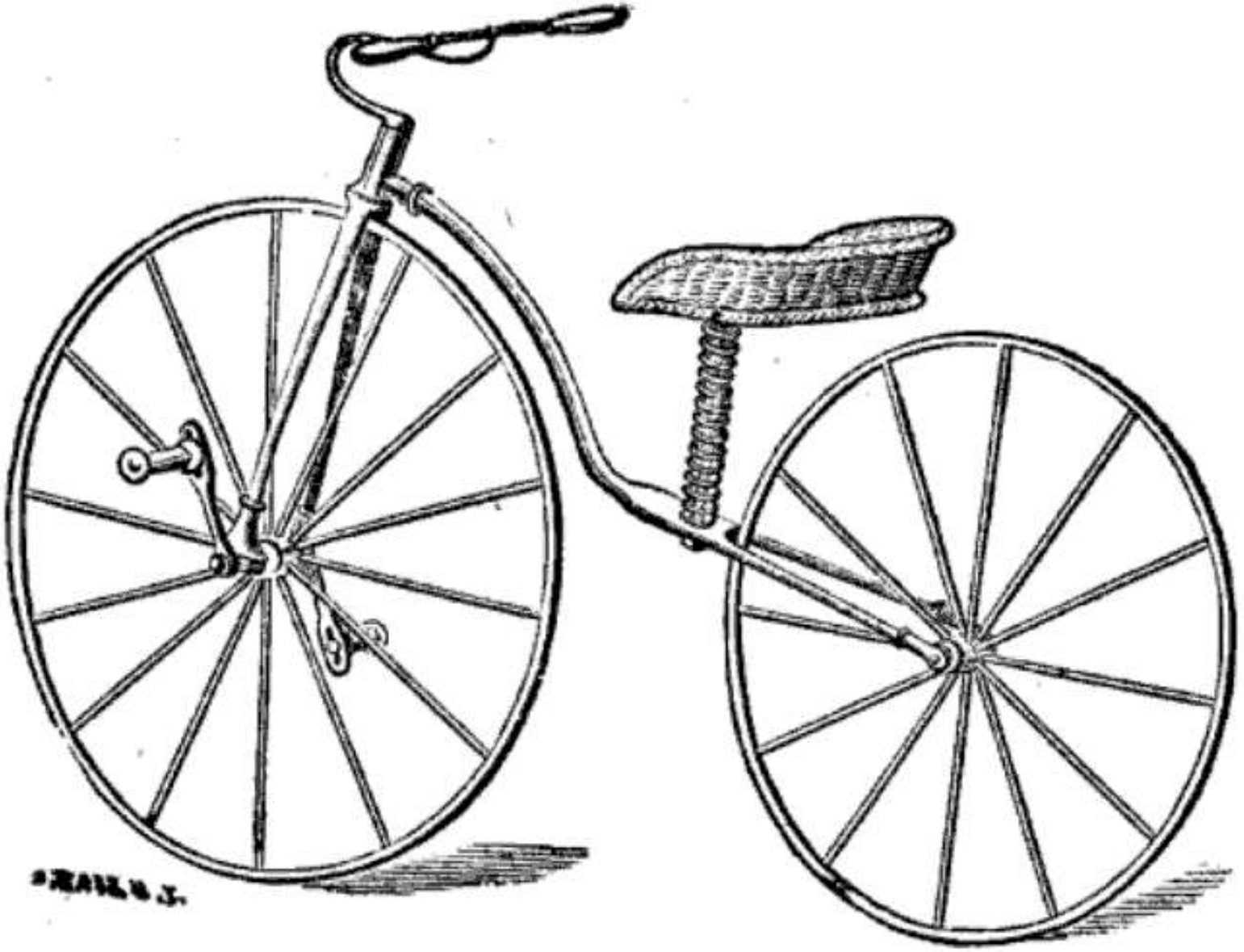
This is engineering!

Example: transport in cities

- Horses were used for many centuries
- Horses need hay, produce dung
  - 500 tonnes of dung removed from London daily
- Ok in the countryside
- Major problems in the city
- What is an alternative?

London bicycle, Early 1800s

Velocipede for ladies



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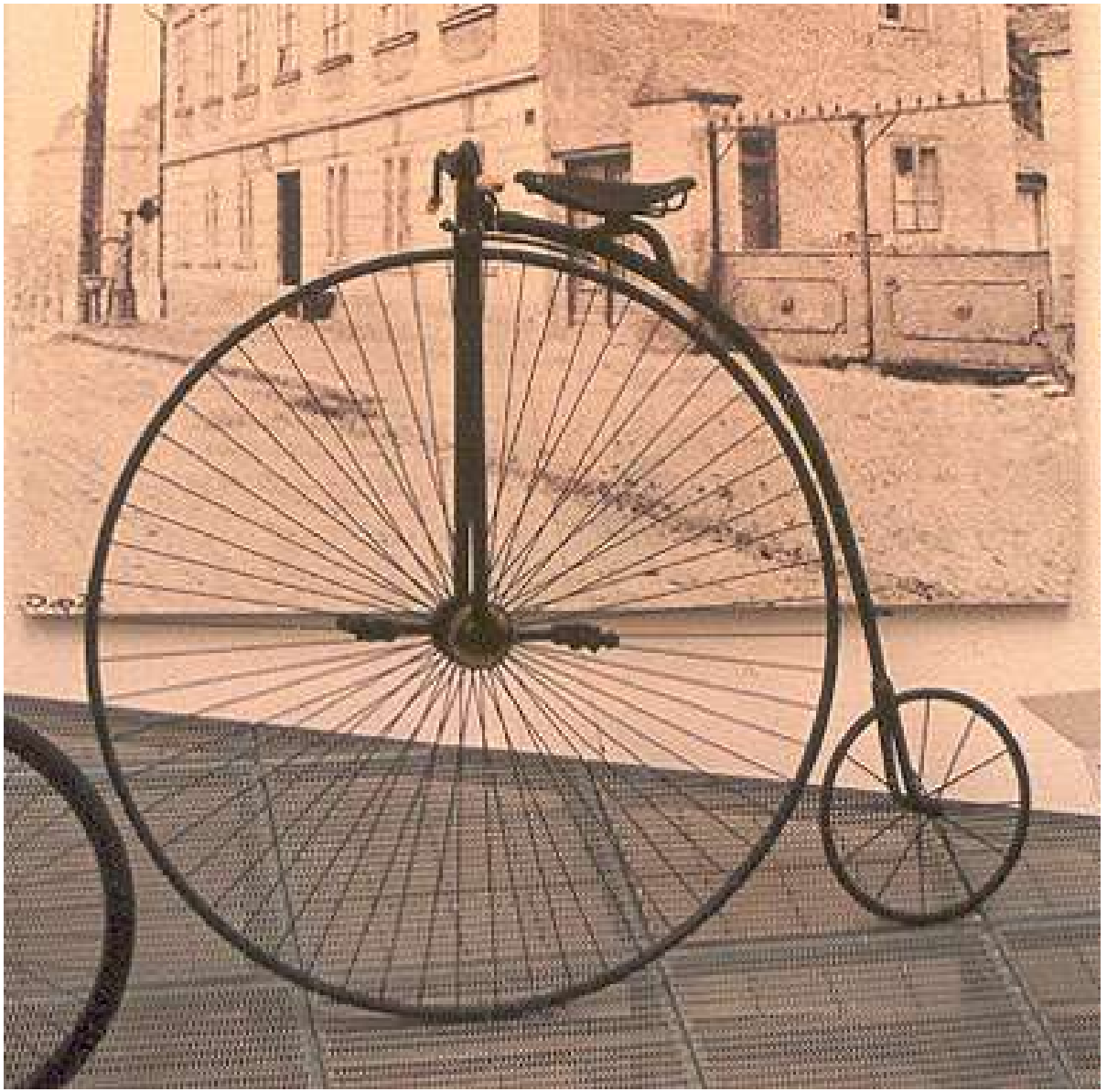
Penny-Farthing



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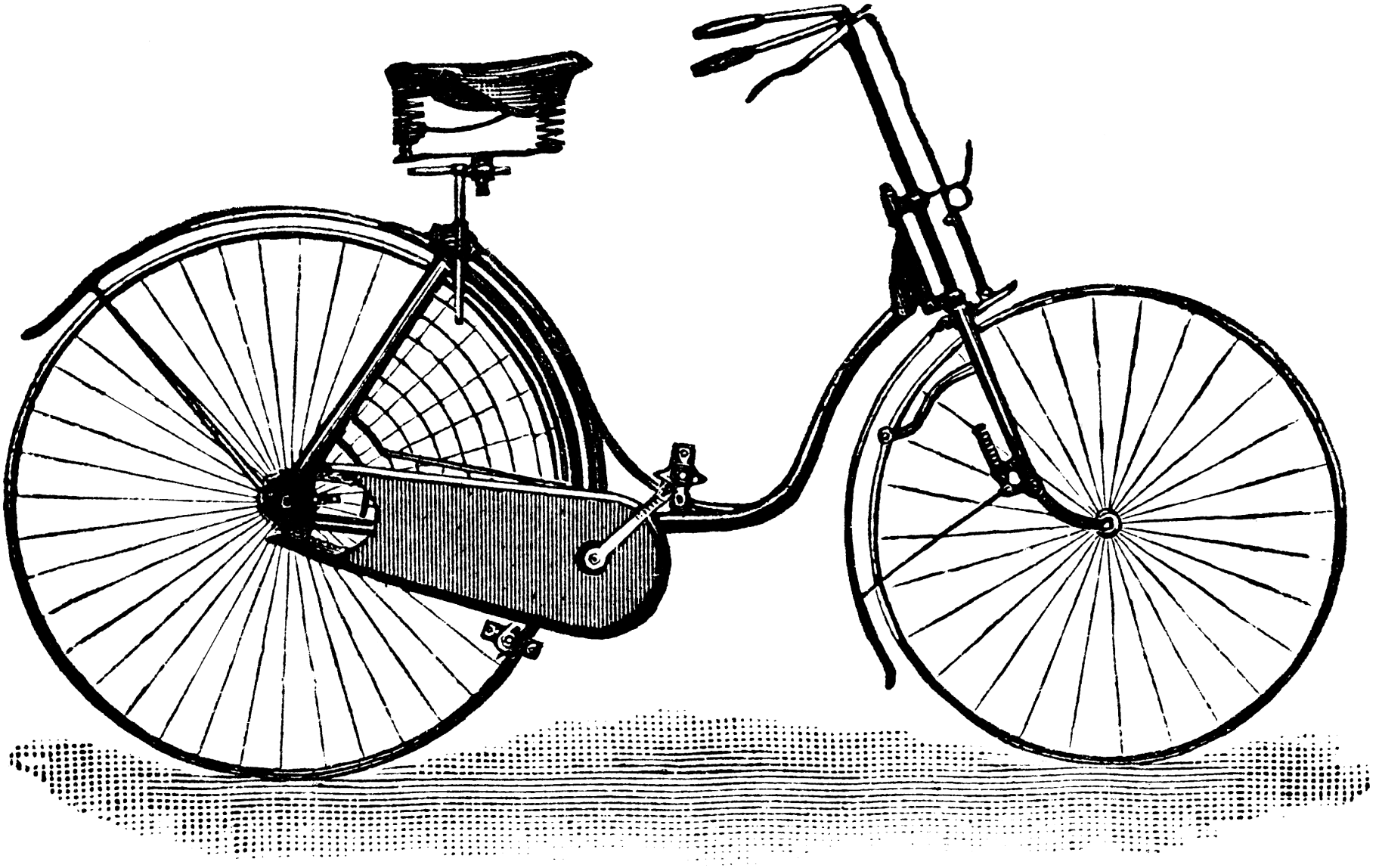
“Modern” cycle, 1885



Modern cycle with gears

Funky folding cycle

Land + water bicycle

What is “Engineering”?

Engineering is using technology and science to solve problems of society

- Must serve a Need
- Must be Acceptable
  - Cost
  - Usability
  - Sustainability
  - Maintainability

Engineering is occasionally disruptive

- Changes the way society lives/works/behaves

Is usually incremental

- Builds on previous engineering

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What is “Innovation”?

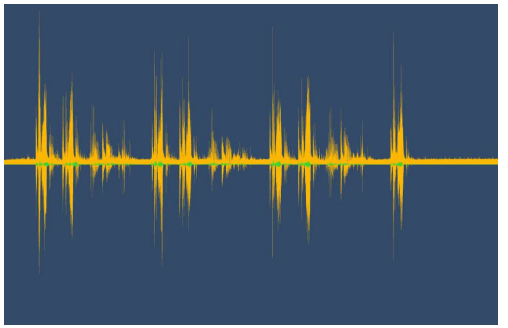
Error! —bug-fix→ *Wrong format, try again*

Bug-fix is routine engineering

- Useful but does not change the world

Keyboard control

—innovation→



Speech control

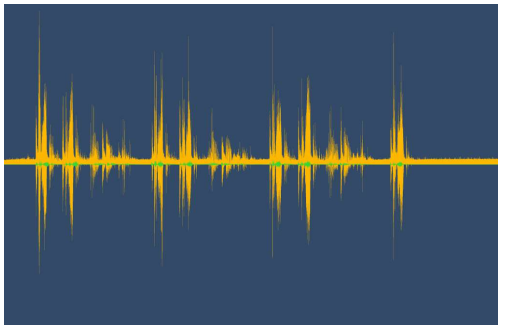
Innovative engineering

- Known concepts, existing components used in novel ways
- Changes the world

https://commons.wikimedia.org/wiki/File:Keyboard_Close_Up.jpg
https://commons.wikimedia.org/wiki/File:Andrea_Electronics_PureAudio_Speech_Development_Kit_(39763899664).png

How to be Innovative?

innovation →



1)Identify a need
- Problem for many people

2)Design a solution
- Think out-of-the-box
- Feasible, affordable, usable, ...

3)Implement the design
- Minimum viable product

4)Deliver the product to users
- Feedback → improve

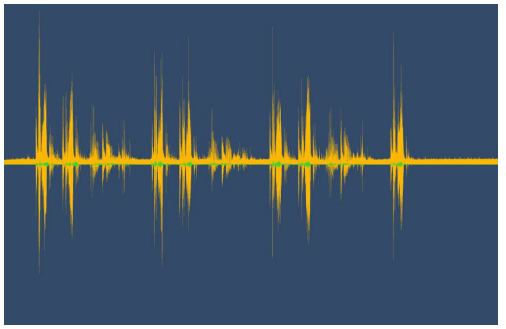
Engineering requires science, technology & common sense

Learn by doing

Develop common sense by experience

How to be Innovative?

innovation →



Problem:

Take a real video of Chandrayaan 4 landing on the moon

1. Brainstorm: think of several designs without worrying about details
2. Select: evaluate various designs and select one

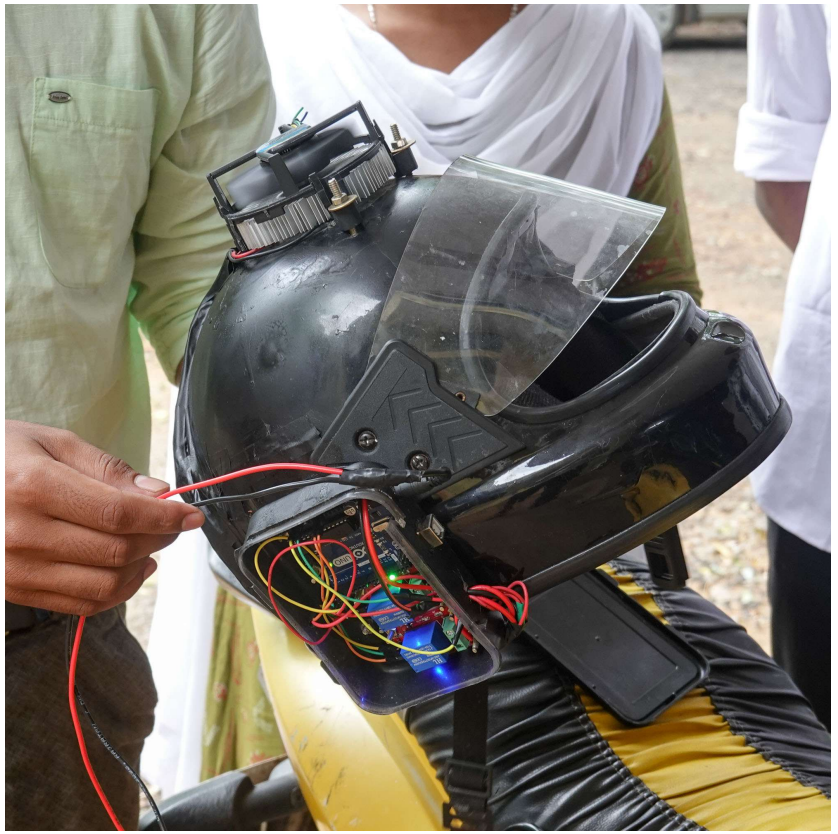
Learn by doing

Develop common sense by experience

LEAP: 2nd /3rd BTech

Robotic Feeder
GEC, Idukki

Air-cooled bike helmet
GCE, Tirunelveli



LEAP
Learning Engg by Activity with Products
www.leap.respark.iitm.ac.in

Questions from a budding BTech

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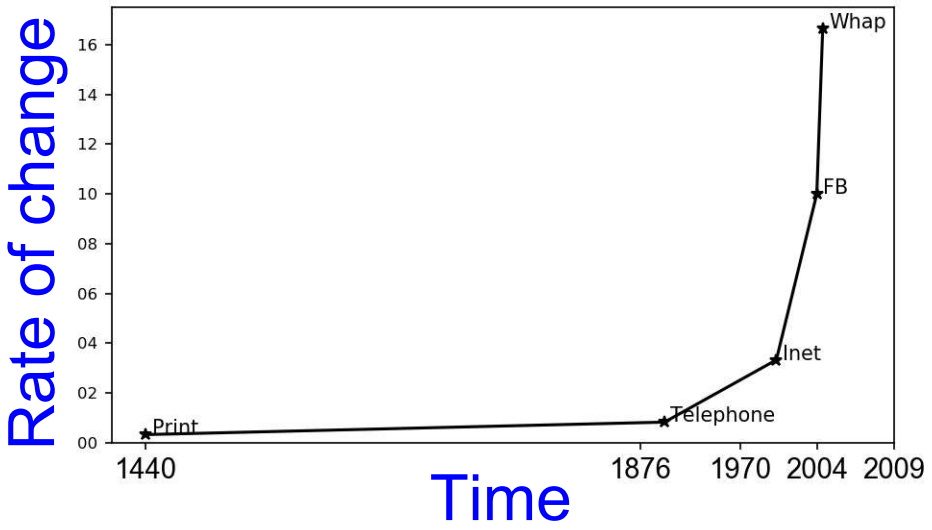
Why “irrelevant” subjects?

- Rate of change of technology is increasing
- ML is a hot career today



- Until 2000 AD, only a few geeks got jobs in ML
- By 2028/2035/2045 there may be no jobs in ML, Chemistry may be the hot topic at that time!
- Most important:
  - Build strong fundamentals
  - Learn how to learn

Questions from a budding BTech

- Why an engineering career?
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Human Learning

- Real world → Observations → Model → Outcome
- Model of water tap:
  - Knob → rotate to increase flow of water
- General model:
  - Knob → rotate to increase quantity
  - Volume of loudspeaker,
    Brightness of light, …

AI/Machine Learning

- Build a model using training data
  - More training data --> better model (usually)
- Select one of many models (regression, ANN, deep learning, SVM, ...)
- Apply the model to testing data to gain insights

Eg. Clustering in Python

- Scikit-learn module: `sklearn.cluster`
- Data: `X.shape` (`n_samples`, `n_features`)
  rows columns

```
from sklearn.cluster import KMeans
```

```
cModel = KMeans(n_clusters = 5, n_init=1,
        init='k-means++')              # Create the model
X = pd.read_csv("data.csv")
cModel.fit(X)                          # Train the model
cModel.predict(Z)                      # Use model to classify
cModel.print()
```

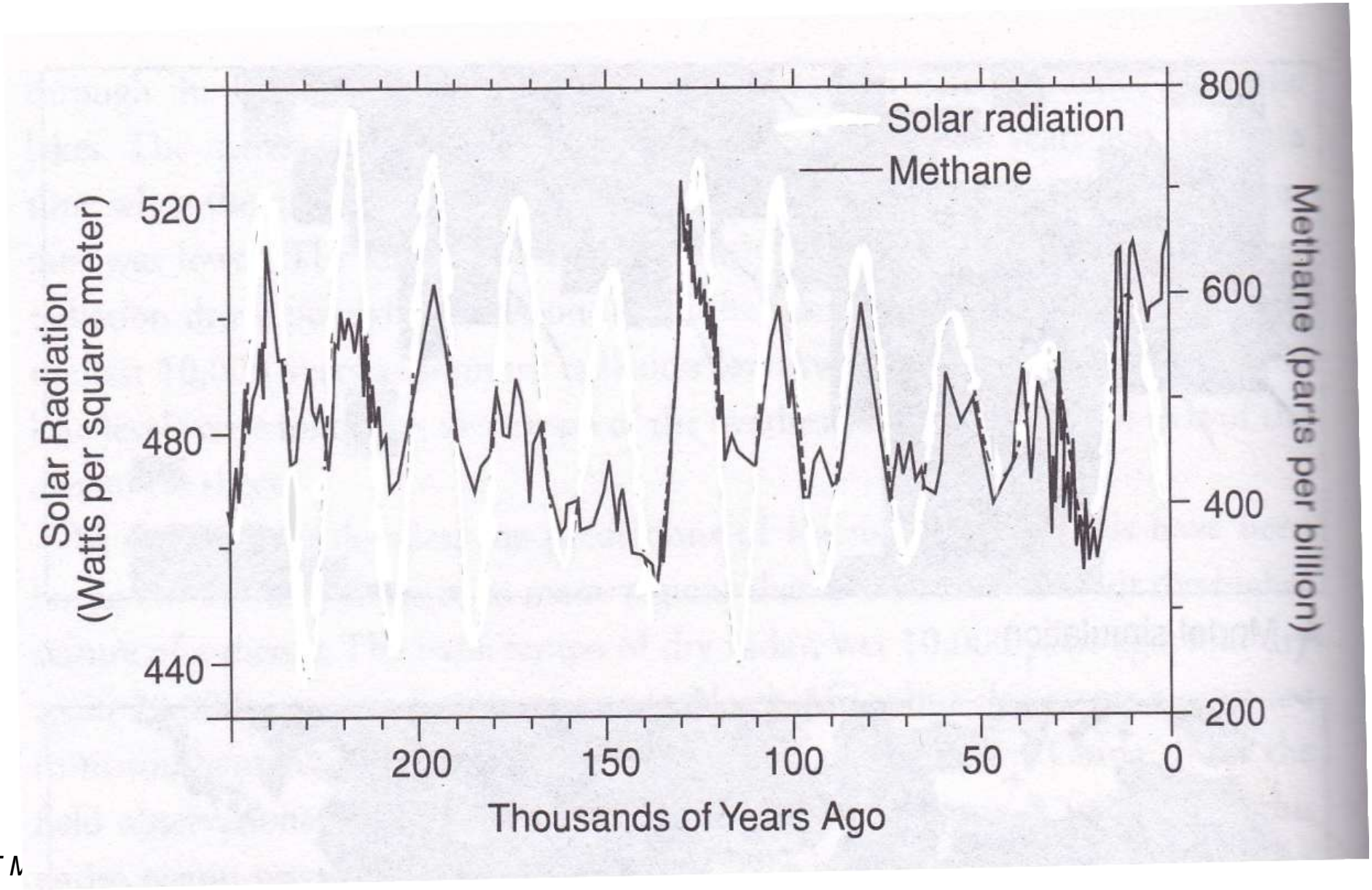
- Large number of engineers can write these few lines of Python
  - Considered ML experts

AI/Machine Learning

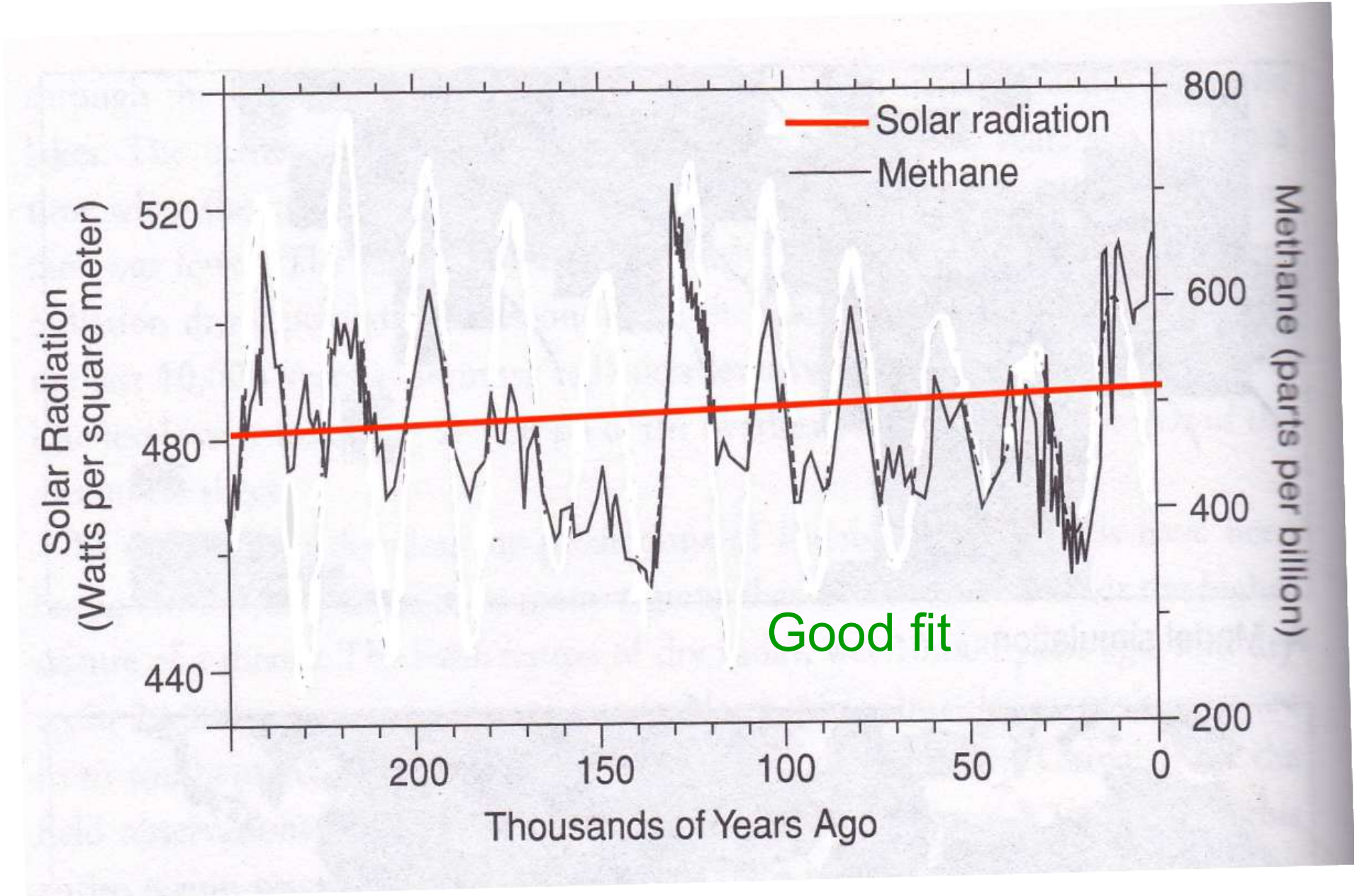
- Issues
  - Errors in data – garbage-in garbage-out (GIGO)
  - Learning bias
  - Insufficient training data from irregular, occasional events (earthquakes, moon landing, climate change)
  - Useful AI is 10% ML and 90% domain expertise

ML to predict solar radiation

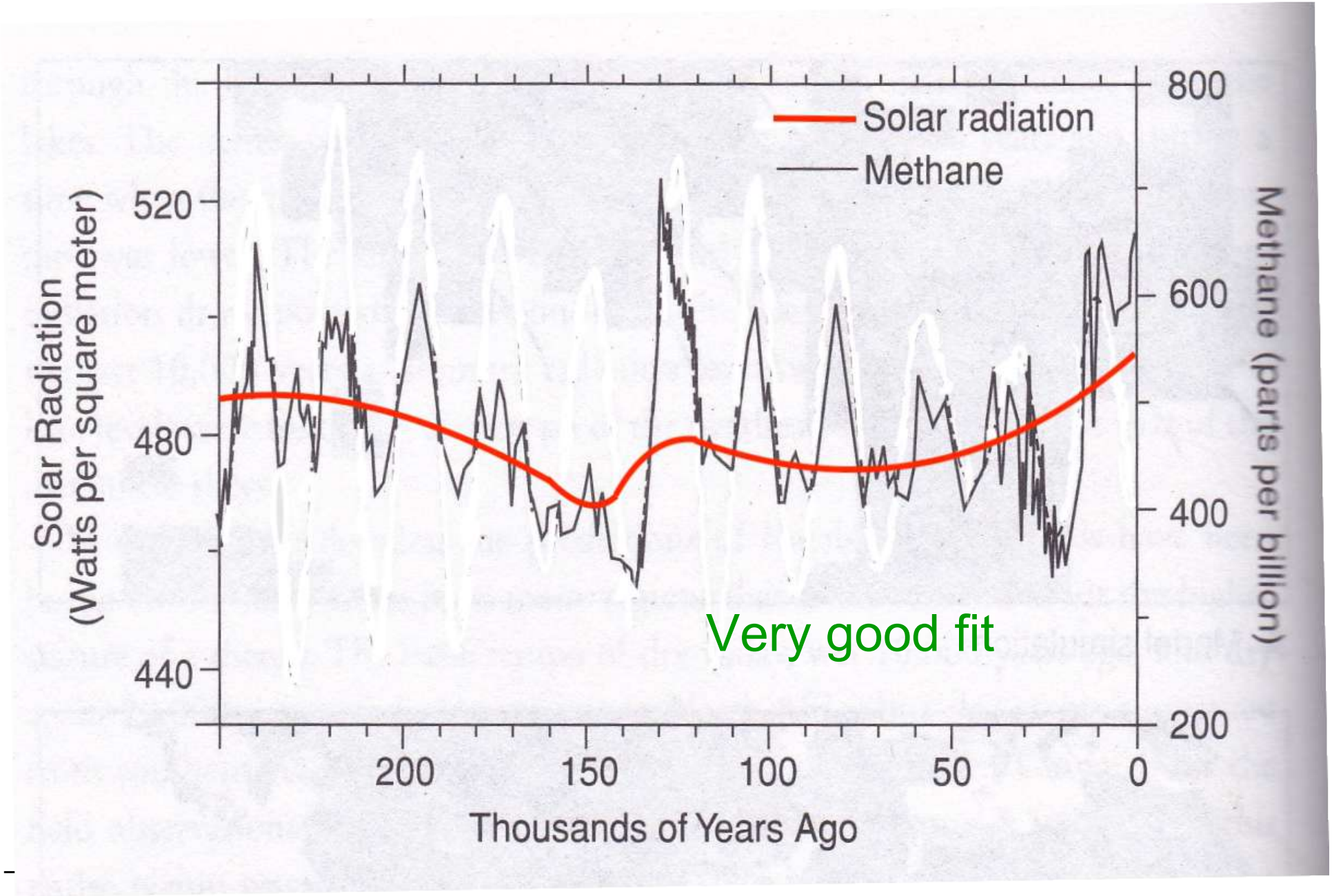
Use methane measurements to predict solar radiation



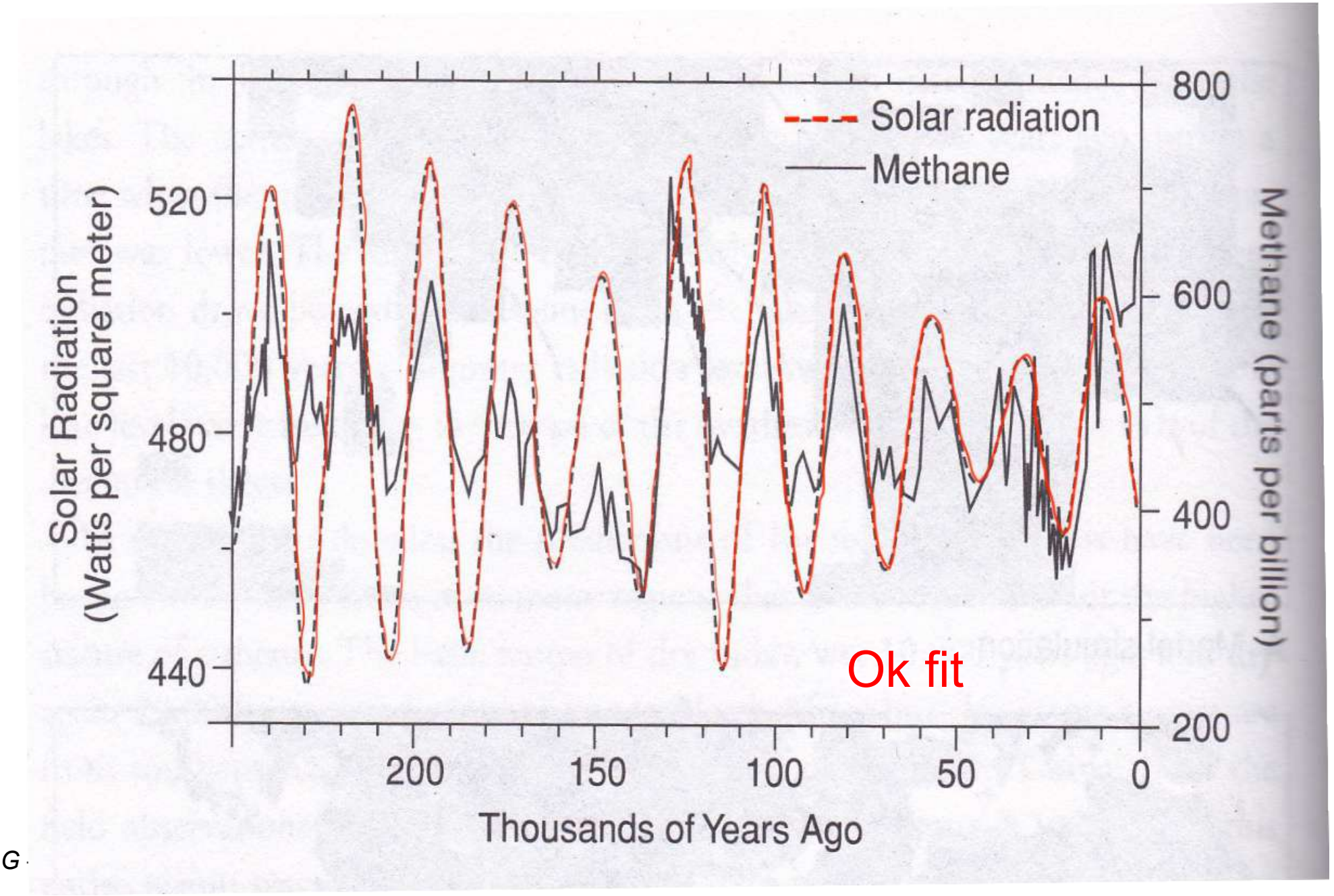
ML Model 1: Linear



ML Model 2: Polynomial



ML Model 3: Sinusoid



AI/Machine Learning

- ML chooses Model 1 or Model 2 as they have good statistical fit
- Astronomers know that there is a solar cycle of 22,000 years due to elliptical orbit of earth

==> Domain expert chooses Sinusoidal Model 3 as best

- Useful AI is 10% ML and 90% domain expertise
- Spend time becoming expert in some domains, you can easily pick up ML coding
- You'll become a sought after expert

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Jobs for Innovative Engineers

- Engineering jobs in India:
  - Private companies, PSUs
    - Products, services, infrastructure
  - Govt engineering services, railways, etc
  - A few in NGOs, research organisations
  - You will
    - Have well-defined roles
      - small cog in a big wheel
      - May be innovative or routine
    - Move steadily up the hierarchy for greater impact after many years

Jobs for Innovative Engineers

- A new option: Start-ups
  - Most innovative engineering in India is in startups
    - The Solar Labs – solar installation planning
    - Agnikul – 3D-printed rocket engines
  - You will
    - Have many responsibilities at a young age
    - Learn all aspects of a tech company
    - Make impact quickly
  - Your own startup – if you have a good idea, trusted partners and an appetite for risk

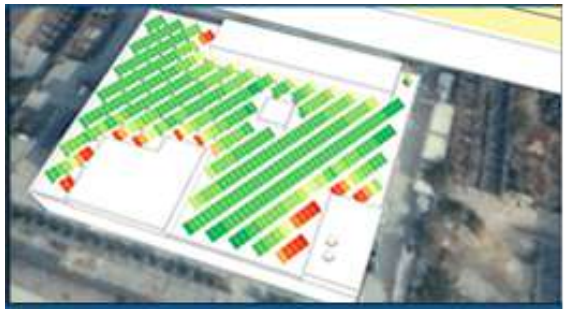
The Solar Labs

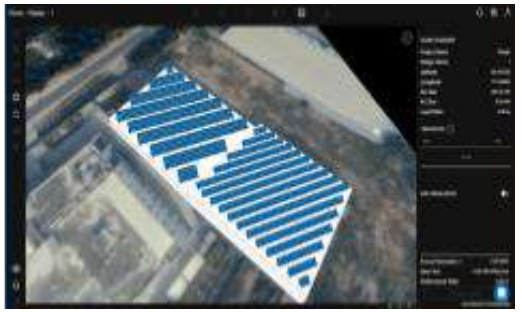
https://thesolarlabs.com/

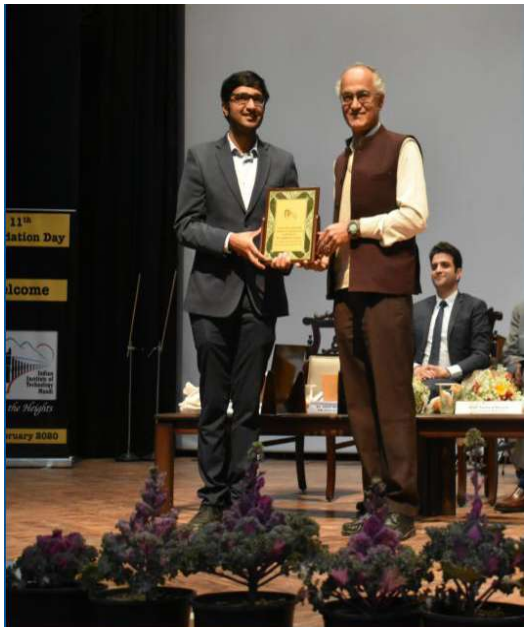
1st Startup of IIT Mandi Catalyst

- Enabling solar vendors through image technology for surveys and capacity analysis
- ==> faster, better, and less costly solar installation
- Optimized PV system design with 3D visualizations

Siddharth Gangal
BTech 2017







Employees: 25 **Funding:** ~1.14Cr **Revenue**: 2.1 Cr/year

Clients: Tata Power, Amplus, Adani + ~400 solar businesses

Awards/recognition:

- 3rd Prize-Schneider Electric APAC 2018 Pitches: Top Ideas in Energy in APAC
- 2nd Prize: ESRI Geo innovation 2018: Top GIS startups in India
- Winner of Smart City Category under Government of Maharashtra - NITI Aayog AI Innovation Challenge

Acquired by ARKA Energy in 2022

Conclusions

- Engineers serve needs of society using technology
- Innovative engineers can change the world, earn fame and fortune
- Learn by doing, starting from 1st year in college
- Learn how to learn, so you can adapt to the fast changing world

Questions?

Links

- W. Brian Arthur, *The Nature of Technology: What it is and how it evolves*, 2009
- Eugene S. Ferguson, *Engineering and the Mind's Eye*, MIT Press, 1992
- Johnson, S., *Where Good Ideas Come From: the natural history of innovation, Penguin*, 2010
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