

# 可靠度資料分析

# **Reliability Data Analysis**

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**Lecture 1 - Introduction**

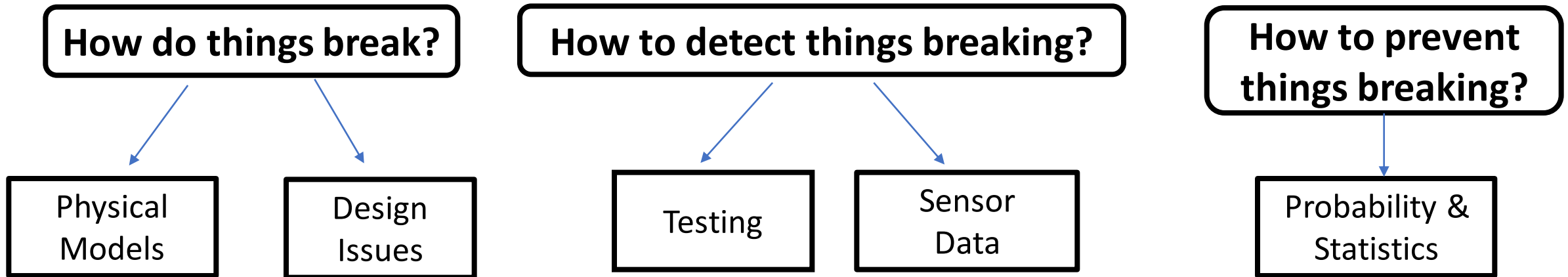
# Are you in the right place?

- This is CSIE 7637 (All English curriculum)



**ENGLISH  
ZONE**

## Reliability Data Analysis



# Treat this course as going abroad...

- Use this course to practice your English
- Feel free to ask questions or comments, either in Chinese or English



# Stay Healthy, Safe and Positive



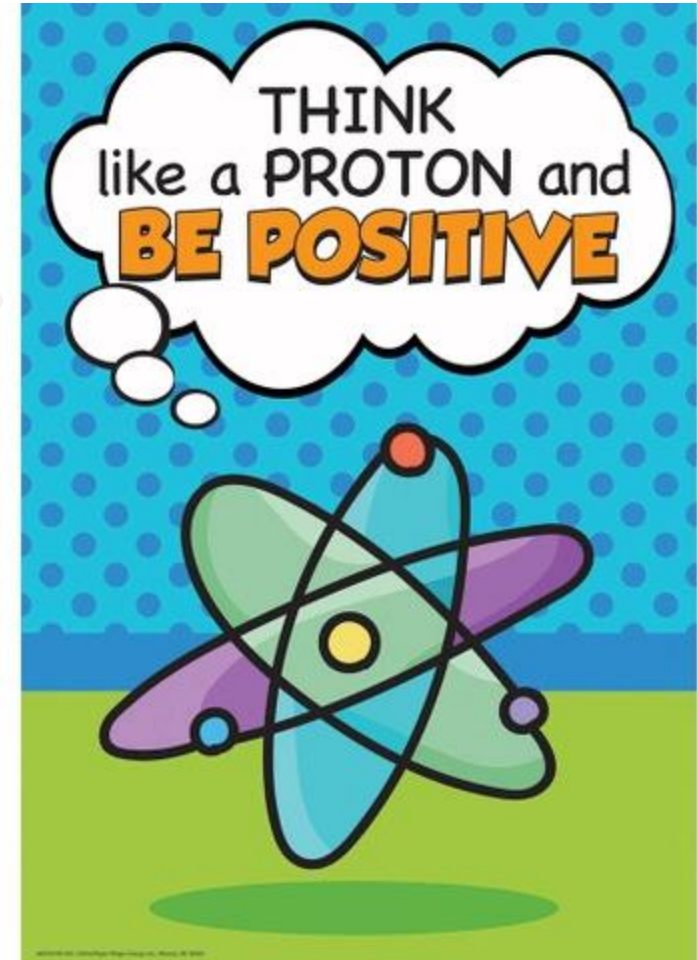
**Wear a Mask**



**Stay home  
if sick**



**Wash/disinfect  
regularly**



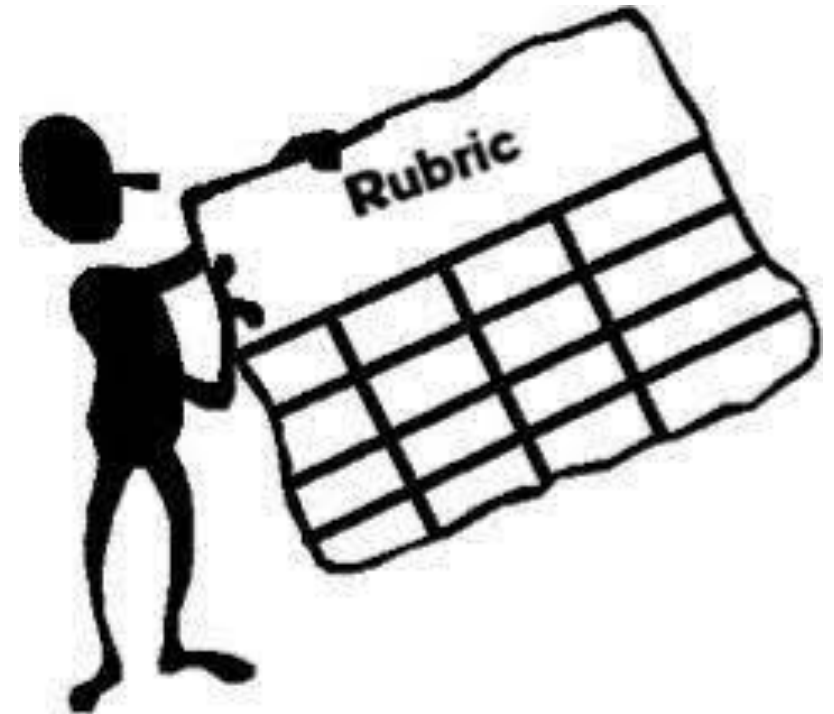
# Course Information

- In-person lectures, test & presentations
- Book: TBD
  - supply chain issues



# Grading

- Midterm Exam: 50%
  - Can bring one A4 double-sided paper with notes
  - Calculator (no internet capabilities)
- Presentation: 50%
  - Can be in either English or Chinese



# Tentative Schedule

Week 1	2023/2/19	Introduction
Week 2	2023/2/26	Review of Probability Concepts
Week 3	2023/3/4	Basic Reliability Concepts
Week 4	2023/3/11	Common Failure Distribution Models
Week 5	2023/3/18	Censoring
Week 6	2023/3/25	Accelerated Testing & Midterm Review
<b>Week 7</b>	<b>2023/4/1</b>	<b>Midterm Exam</b>
Week 8	2023/4/8	Class Presentation + Midterm Explanation
Week 9	2023/4/15	Class Presentation
Week 10	2023/4/22	Class Presentation
Week 11	2023/4/29	Class Presentation
Week 12	2023/5/6	Class Presentation
Week 13	2023/5/13	Class Presentation
Week 14	2023/5/20	Class Presentation
Week 15	2023/5/27	Class Presentation
Week 16	2023/6/3	Class Presentation
<b>Week 17</b>	<b>2023/6/10</b>	<b>Holiday: No class</b>
Week 18	2023/6/17	Final Week (Backup Week, tentative no class)

← Submit presentation topic

Current estimate:

- 60 students with 20 min presentation each

Note: Presenter needs to upload slides a week before presentation for audience to see

# Bonus Points!

- Tentative awarding policy to encourage interaction between presenter and audience
- After every presentation, there is a ~ 5min QA session
  - Audience can enter questions before, during or after the presentation on an online link
  - The best three questions will get 1 bonus point toward semester
    - Ex. If midterm is 80, presentation is 80, bonus point is 5, then final grade =  $(80+80+5)*0.5=82.5\%$  (will round up to 83%)
  - Person must be present asking the question to receive bonus points
  - A person can receive a bonus point no more than once for asking questions during the same presentation
- If any question asked after the first three questions is excellent, 1 bonus will be awarded too

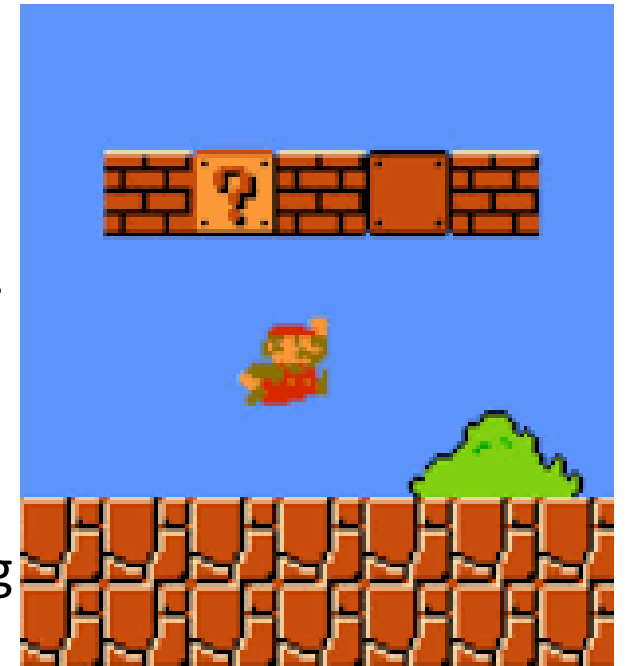


Image from <https://gamaverse.com/super-mario-bros-game/>



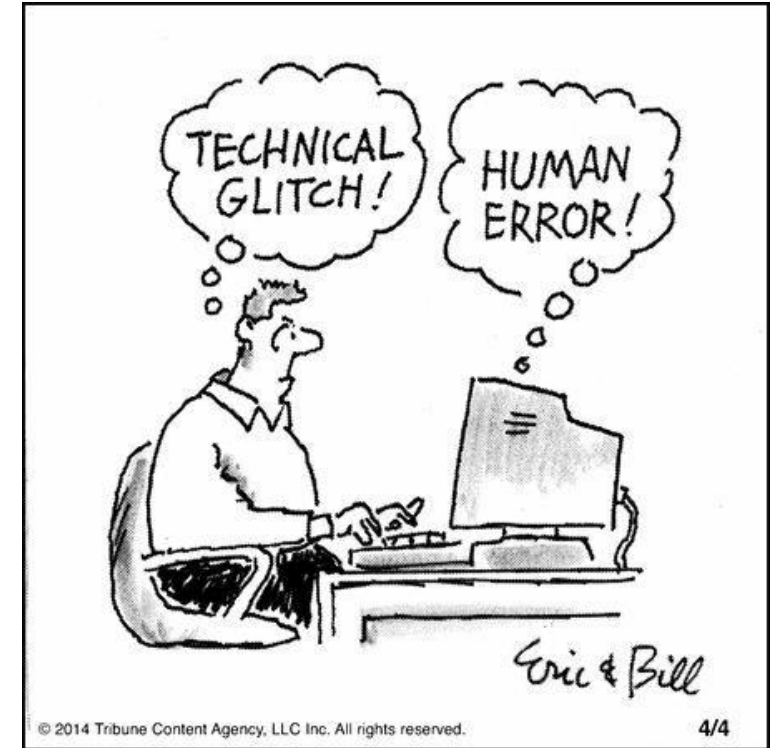
# Contact Information

- Professor Shu-han Hsu (許舒涵)
  - Email: [shhsu@gs.ncku.edu.tw](mailto:shhsu@gs.ncku.edu.tw)
  - Office hours: TBD, Email to schedule
- Teaching Assistant: 徐浩銘
  - Email: [p76111717@gs.ncku.edu.tw](mailto:p76111717@gs.ncku.edu.tw)
  - Office hours: TBD, Email to schedule



# Why take this course?

- Nothing is perfect => Things fail
  - Engineering designs limited by technical, practical & economical factors
- Reliability is everywhere
  - Impact can range from minor inconveniences/costs to significant safety issues/economic losses
  - Practical knowledge for any engineering application
- Minimizing & preventing failures
  - Understand how, why and when failures occur



If failure can't be avoided, at least know when it is likely to occur so we can conduct preventative maintenance before the need for corrective maintenance arises

# Samsung Phone Explosion

- Galaxy Note 7 exploding batteries
- Product recall



<https://www.notebookcheck.net/Man-s-Samsung-Galaxy-S7-Edge-explodes-Samsung-replies.334234.0.html>

<https://sputniknews.com/20161015/samsung-note-7-fire-memes-1046366435.html>

# Also to avoid product issues like below...

The image is a screenshot of a YouTube search results page. At the top, the search bar contains the text "why is land rover reliability so bad", which is highlighted with a red rectangular box. The YouTube logo and "TW" are visible on the left side of the header. Below the header, the left sidebar shows navigation icons for Home, Shorts, Subscriptions, Library, and Watch History. The main content area displays two video results. The first video, titled "Why The Range Rover Is The \*SUV No One Really Wants\*", is by "Nathans BMW Workshop" and has 4.5 million views. Its thumbnail shows a silver Range Rover with the text "GOOD OR BAD ???". The second video, titled "Our Brand New Land Rover Defender Was Fixed! But Then It Broke Again...", is by "The Fast Lane Car" and has 58 million views. Its thumbnail shows two men working on the engine of a white Land Rover Defender with the text "IT BROKE AGAIN". Both videos have a duration of 10:02 and 8:34 respectively. The bottom of the page shows a "TFL" logo.

YouTube<sup>TW</sup>

why is land rover reliability so bad

篩選器

首頁

Shorts

訂閱內容

媒體庫

觀看記錄

**GOOD OR BAD ???**

**Why The Range Rover Is The \*SUV No One Really Wants\***

觀看次數：4.5萬次 · 2 年前

Nathans BMW Workshop

... ON MY AMAZON STORE <https://www.amazon.com/shop/influencer-f7e032fa> Land Rover Range Rover RELIABILITY \*S...

Intro | History | Price

3 個章節

**IT BROKE AGAIN**

**Our Brand New Land Rover Defender Was Fixed! But Then It Broke Again...**

觀看次數：58萬次 · 2 年前

The Fast Lane Car

Our Land Rover Defender has been a vehicle long in the making. We ordered this rig back in June, and it is most likely the ...

Thursday, October 8 Check Engine Light | Tuesday, October 13 Andre Collects From Deale... 3 個段落

TFL



# Ford Bronco vs. Land Rover Defender Price



**Price: \$30,800 to \$68,500 US**

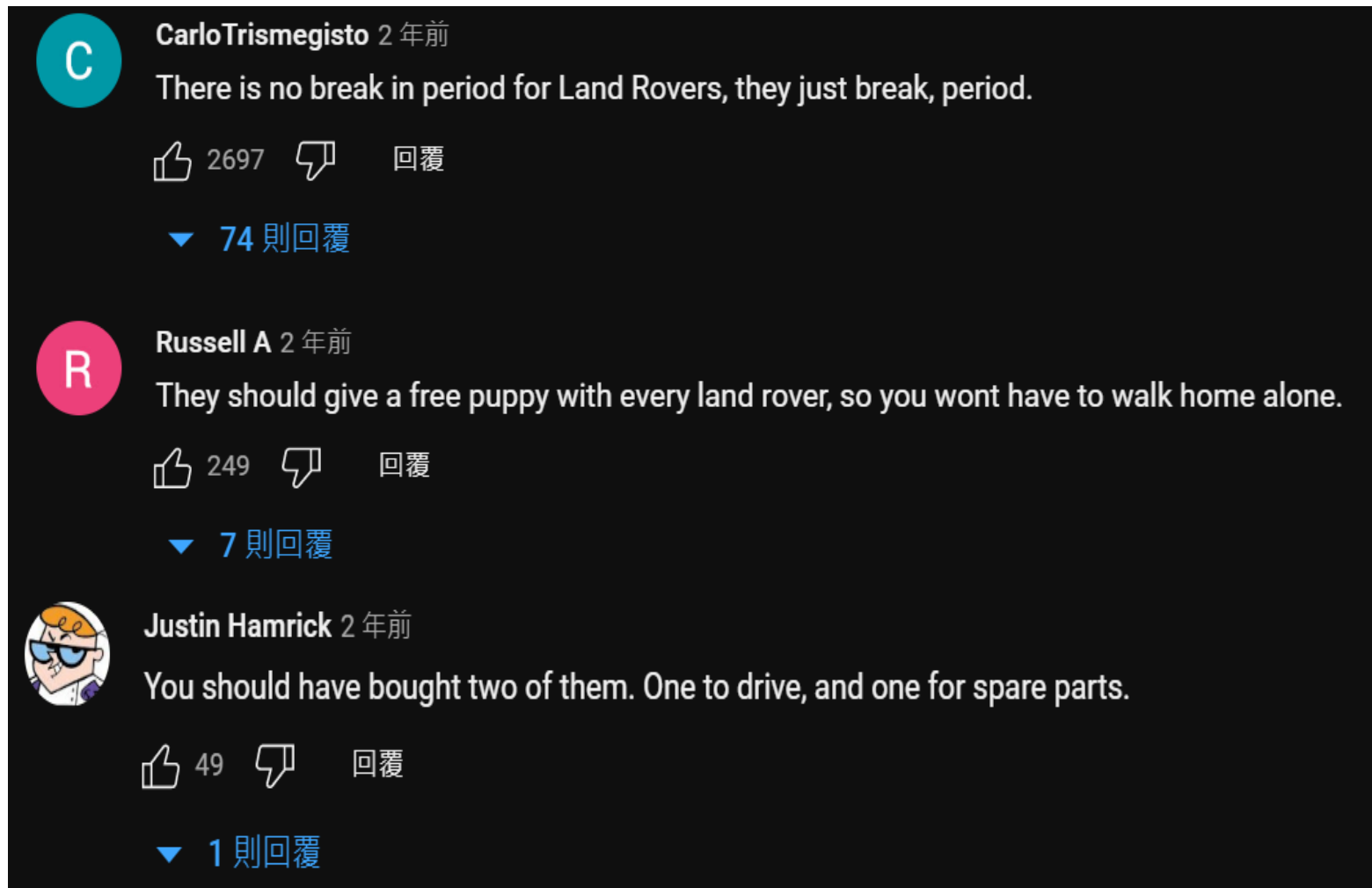


**Price: \$53,500 to \$118,400 US**

Reference:

1. <https://www.jdpower.com/cars/shopping-guides/2022-ford-bronco-vs-2023-land-rover-defender-comparison>
2. <https://www.landroverusa.com/vehicles/defender/index.html>

# Also to avoid product issues like below...



Comments from:  
<https://www.youtube.com/watch?v=zBVZyvfiqKw>

# Goal: Reliable Products

The image is a screenshot of a YouTube search results page. At the top, the YouTube logo is on the left, and the search bar contains the text "most reliable suv". To the right of the search bar are icons for a close button, a search icon, a microphone, and a user profile icon with the text "登入". On the left side of the page is a vertical navigation menu with icons and labels: a home icon labeled "首頁", a shorts icon labeled "Shorts", a video icon labeled "訂閱內容", a media icon labeled "媒體庫", and a clock icon labeled "觀看記錄". Below the navigation menu, there are two video thumbnails. The first thumbnail shows a red SUV with its rear door open, with the text "9 SUVs LAST FOREVER!" overlaid. Below the thumbnail is a duration of "10:40". The second thumbnail shows a silver Lexus SUV driving on a dirt road, with the text "These are 6 Most Reliable SUVs" overlaid. Below the thumbnail is a duration of "9:16". To the right of the first thumbnail, the video title is "SUVs That Can Last Over 200,000 Miles OR Even More", followed by the view count "觀看次數：706萬次" and the upload time "1 年前". The channel name "the SUV geek" is shown with a verified badge. Below the title is a short description: "Looking for SUVs that can last 200000 miles or even more? According to iSeeCars study, which analyzed over 11.8 million cars ...". To the right of the second thumbnail, the video title is "Top 6 most reliable SUVs and Crossovers for 2022 & 2023 by Consumer Reports", followed by the view count "觀看次數：37萬次" and the upload time "1 年前". The channel name "Technovations" is shown with a verified badge. Below the title is a short description: "With new-car prices at all-time highs and a shortage of vehicles on dealers' lots, it's more important than ever to consider ...". At the bottom of the second video's description, there is a button labeled "字幕".

YouTube

most reliable suv

登入

首頁

Shorts

訂閱內容

媒體庫

觀看記錄

篩選器

9 SUVs LAST FOREVER!

10:40

SUVs That Can Last Over 200,000 Miles OR Even More

觀看次數：706萬次 · 1 年前

the SUV geek

Looking for SUVs that can last 200000 miles or even more? According to iSeeCars study, which analyzed over 11.8 million cars ...

These are 6 Most Reliable SUVs

9:16

Top 6 most reliable SUVs and Crossovers for 2022 & 2023 by Consumer Reports

觀看次數：37萬次 · 1 年前

Technovations

With new-car prices at all-time highs and a shortage of vehicles on dealers' lots, it's more important than ever to consider ...

字幕

# Learning Outcomes

- Interpret accelerated life testing results to estimate time to failure under normal operating conditions
- Predict product reliability based on failure mechanisms and associated stresses
- Recommend design changes to improve overall reliability
- Evaluate designs to control failure propagation and mitigate hazardous operation



# Course Objectives

- Utilize knowledge of statistics as a tool to evaluate product reliability
- Critical Thinking:
  - Identify and characterize failure mechanisms to evaluate
- Solution Seeking:
  - Analyze failure effects on system performance
- Disciplinary Knowledge and Practice:
  - Utilize acquired knowledge to complete a project on evaluating a specific issue and associated recommendations to address reliability

# Introduce Yourself

- Name
- Research Interests
- Advisor (if applicable)
- What year in study: ex. 1<sup>st</sup> year masters, 1<sup>st</sup> year PhD
- Anything else you want others to know...



# What is Reliability?

- **Probability** that a product, system, or service will perform properly for a specified period of time under intended operating conditions without failure.
- Time-dependent characteristic
  - Can only be determined after an elapsed time, but can be predicted at any time



# Reliability is Everywhere...



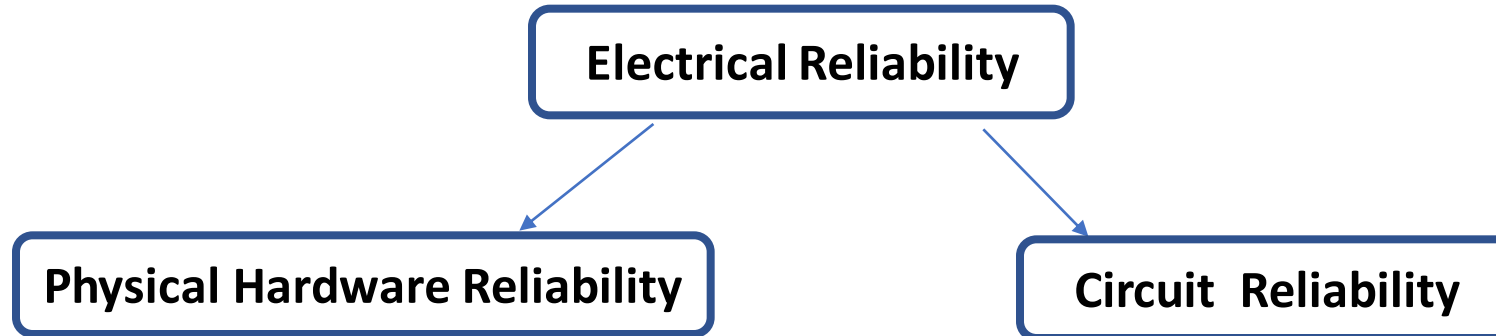
**Food Safety**



**Reliable Internet Connection**

<https://www.youtube.com/watch?v=90-cQTARgyk>

# Example Jobs for Specific Application Areas



**Amazon126 Reliability Research Scientist**



<https://www.youtube.com/watch?v=b5vCNZYnwfm>

**Optiver (trading firm) FPGA Engineer**



<https://www.youtube.com/watch?v=xWDH-tgysr8>

# Example Jobs for Specific Application Areas

## Software Reliability

### Pinterest Site Reliability Engineer



[https://www.youtube.com/watch?v=aLtn\\_nV5rHA](https://www.youtube.com/watch?v=aLtn_nV5rHA)

### **Note:**

There are many other software roles that use reliability concepts, but may not necessarily have the name “reliability” in the job role, such as “software development”.

# Example Jobs for Specific Application Areas

## Mechanical Reliability

**Mercedes-AMG Petronas F1  
Senior Reliability Engineer**



<https://www.youtube.com/watch?v=AVbnck-i4p4>

## Materials Reliability

**Mercedes-AMG Petronas F1  
Material Science Reliability Engineer**



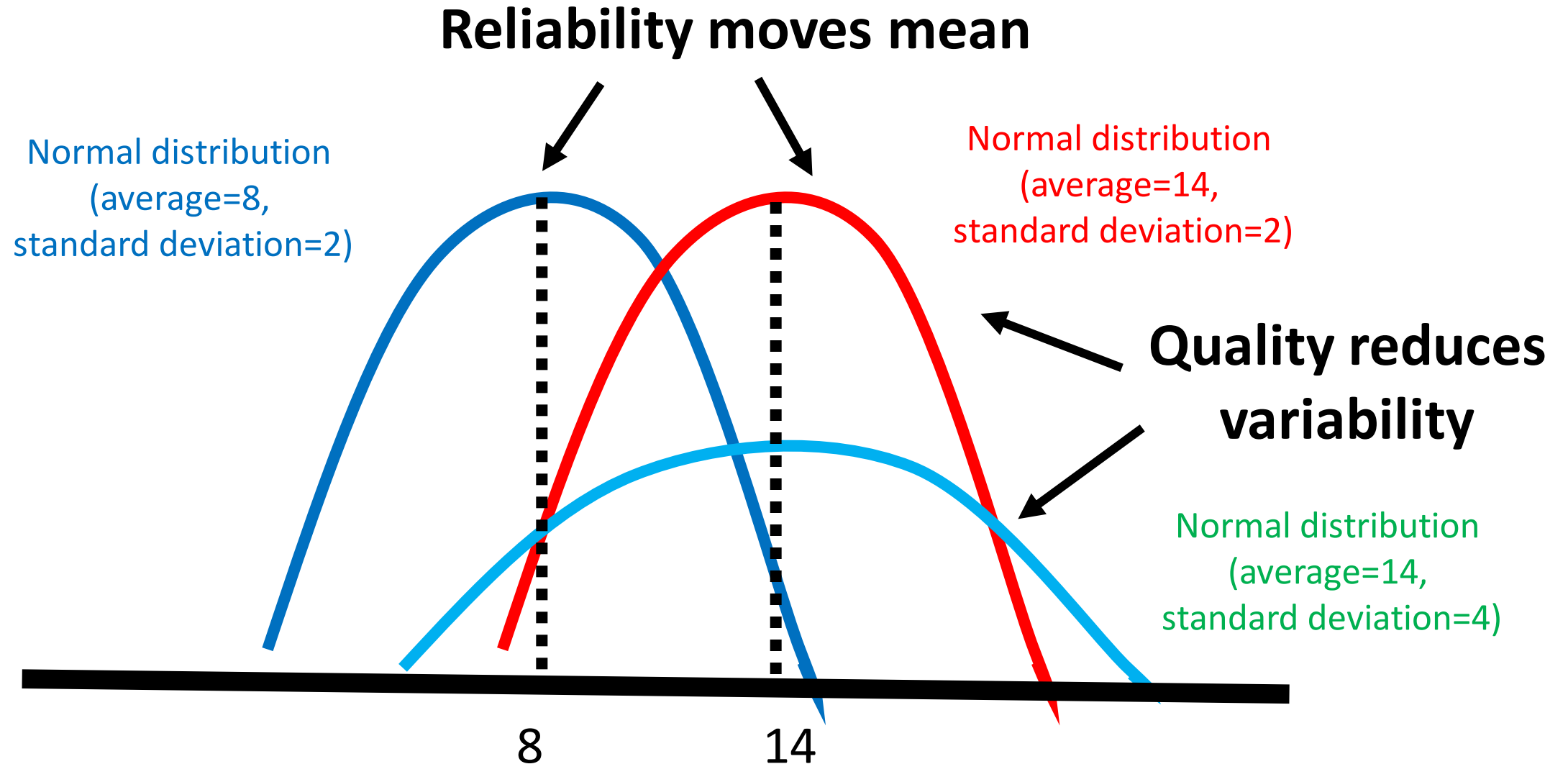
[https://www.youtube.com/watch?v=j\\_xotv7npsQ&list=P LbJwTV097-8lvVTR3nPXIXaMMiTCruvK&index=11&t=3s](https://www.youtube.com/watch?v=j_xotv7npsQ&list=P LbJwTV097-8lvVTR3nPXIXaMMiTCruvK&index=11&t=3s)

# Quality vs Reliability

- Quality
  - How well a product performs
  - Initial assessment by customer
  - Minimize variability
- Reliability
  - How well product maintains quality
  - Definable under various use conditions
  - “how quality changes over time”



# Quality vs. Reliability



# Quality vs. Reliability

- The difference between quality and reliability is that quality shows how well an object performs its proper function, while reliability shows how well this object maintains its original level of quality over time, through various conditions.
- For example, a quality vehicle that is safe, fuel efficient, and easy to operate may be considered high quality. If this car continues to meet this criterion for several years, and performs well and remains safe even when driven in inclement weather, it may be considered reliable.
- Asking a few key questions can help one determine the difference between both quality and reliability:
  - Quality = Does the object perform its intended function? If so, how well does it perform its intended function?
  - Reliability = To what level has said object maintained this level of quality over time?

# Brief History

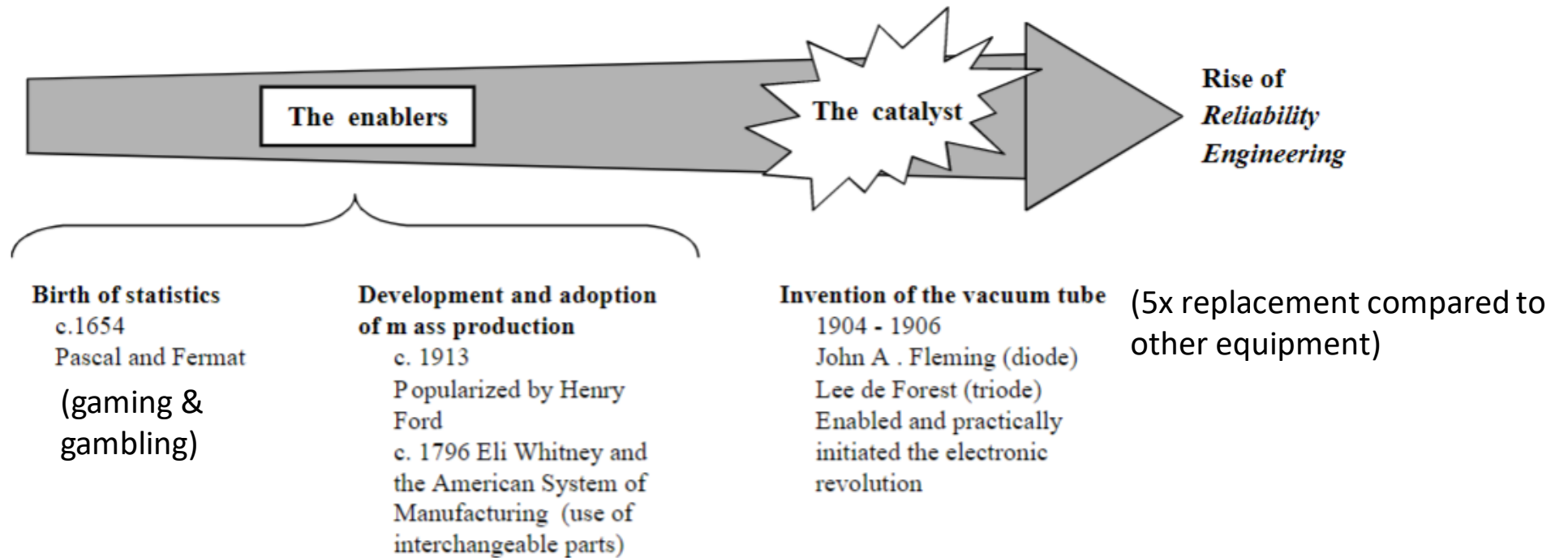


Fig. 1. Enablers and the catalyst of reliability engineering: statistics, mass production, and the vacuum tube.

Saleh, Joseph H., and Ken Marais. "Highlights from the early (and pre-) history of reliability engineering." Reliability engineering & system safety 91.2 (2006): 249-256.

# Brief History

- 1941: Robert Lusser, who led German V-1 missile test program, first recognized the need for a separate discipline as Reliability Engineering.
- 1950: US Department of Defense (DoD) established the Ad Hoc Group on Reliability.
- 1951: Secretary of Defense, General George C. Marshall, ordered all DoD agencies to increase emphasis on reliability of military electronic equipment.
- 1955: Institute of Electrical and Electronics Engineers (IEEE) initiated the world's 1<sup>st</sup> Reliability & Quality Control Society.
- 1960: US Naval Post-Graduate School becomes 1<sup>st</sup> institution to teach reliability engineering courses in the US.
- 1962: 1<sup>st</sup> Annual Reliability and Maintainability (RAM) Conference held in US.
- 1963: University of Arizona, with support from National Science Foundation, became the 1<sup>st</sup> national research university to establish a Reliability Engineering program in the US.

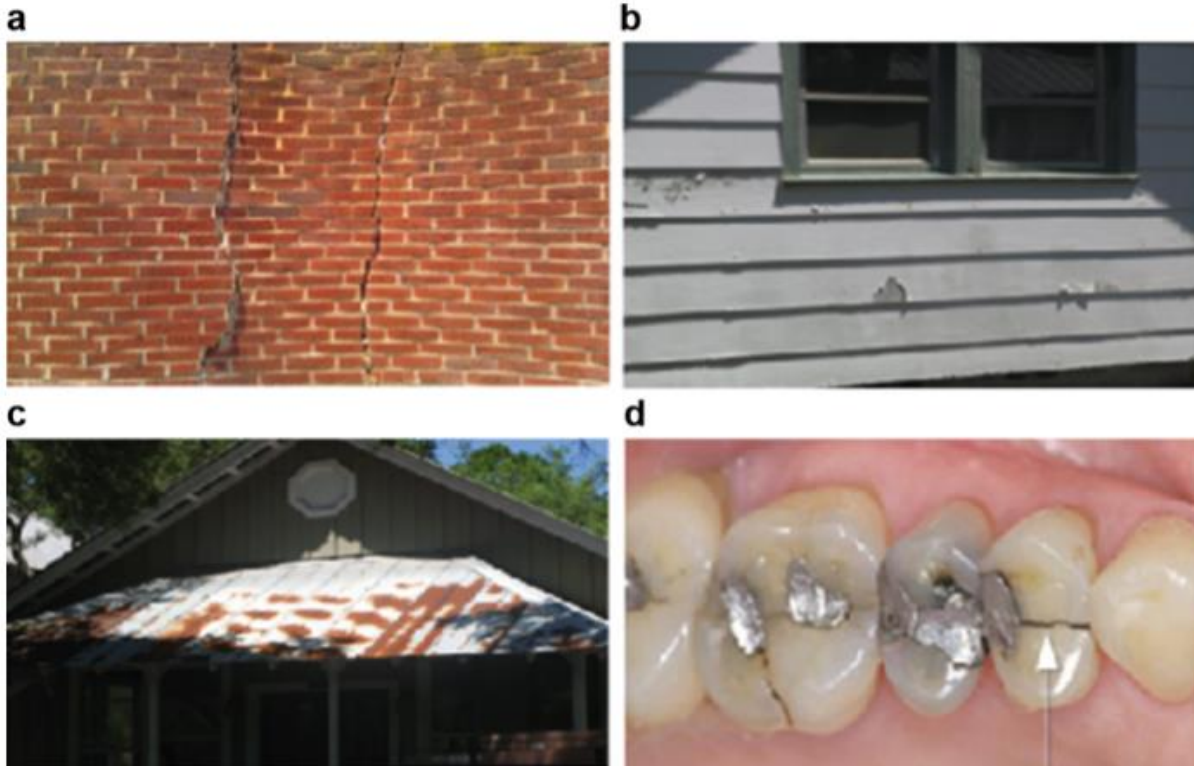
(Reference: Dimitri Kececioglu, Reliability Engineering Handbook, Vol. 1, PTR Prentice Hall, 1991.)

# Uncertainties of Failure

- In theory, if we were able to comprehend and understand the mechanisms of failure processes, then we would be able to predict failures with certainty.
- In practice, we have limited knowledge of the physical state of the system, a lack of understanding of the physical processes and chemical reactions that cause failure, and the randomness of external events.
- Thus, failures appear to be random. However, this randomness may exhibit some pattern that can be modeled by some probability distribution. We can, therefore, predict failures statistically.

# Why do things fail?

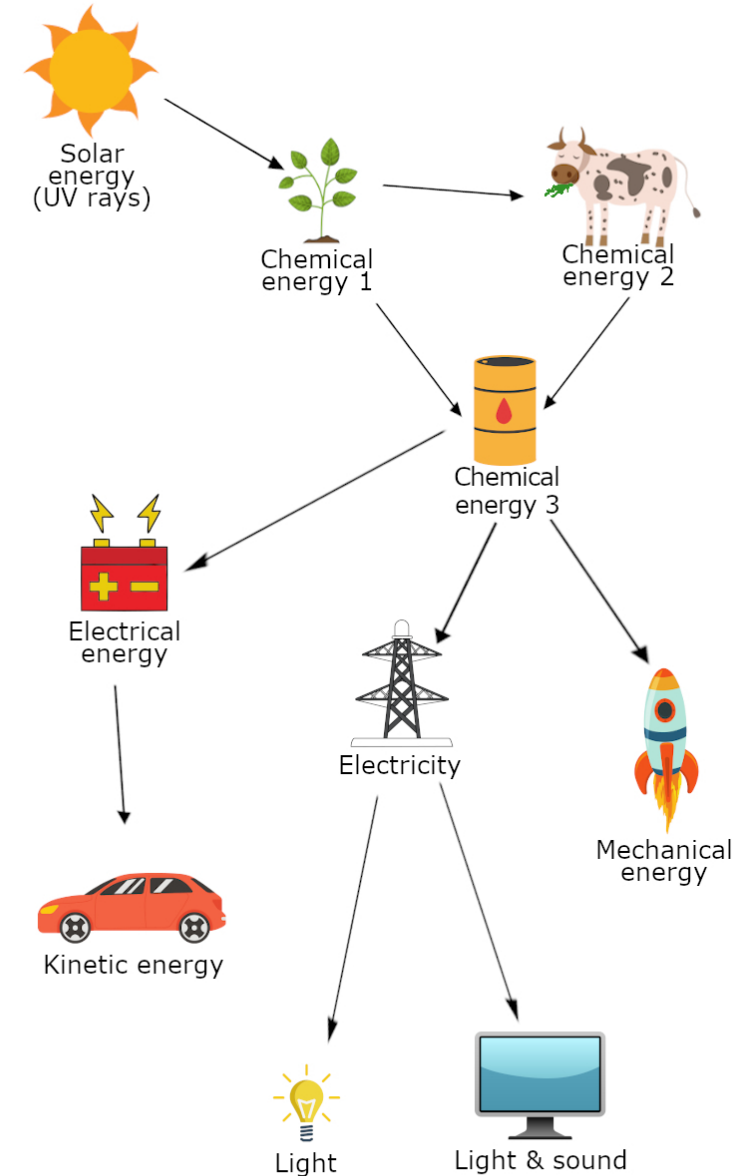
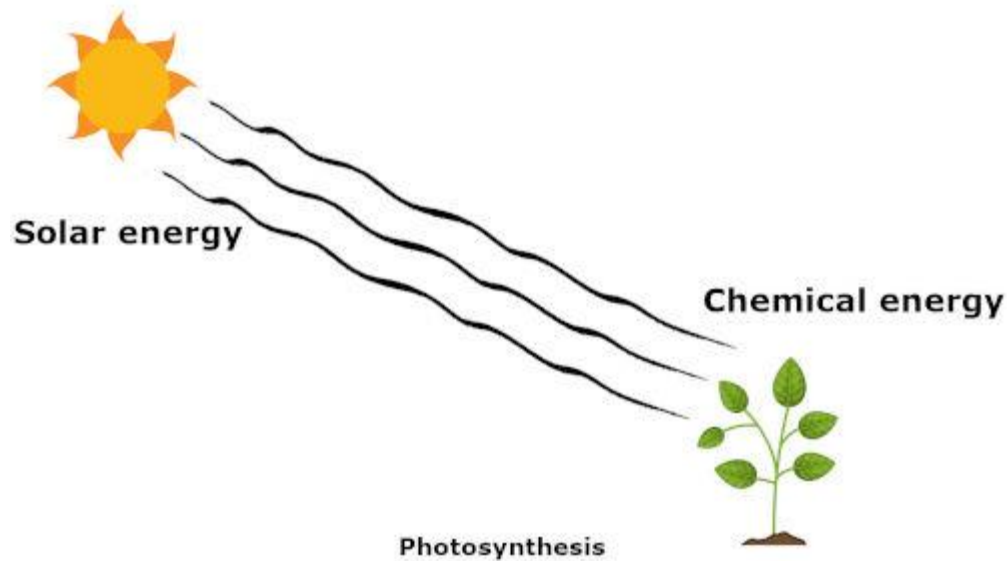
- Degradation: regardless of how carefully crafted a device is at time zero, the materials in the device will degrade with time



- (a) Cracks tend to develop in brick walls as the foundation degrades.
- (b) Paint will eventually crack and peel.
- (c) Bright shiny metal roofs will oxidize/corrode.
- (d) Human beings are not immune to degradation—note the tooth decay, fillings, and cracking

# First law of thermodynamics

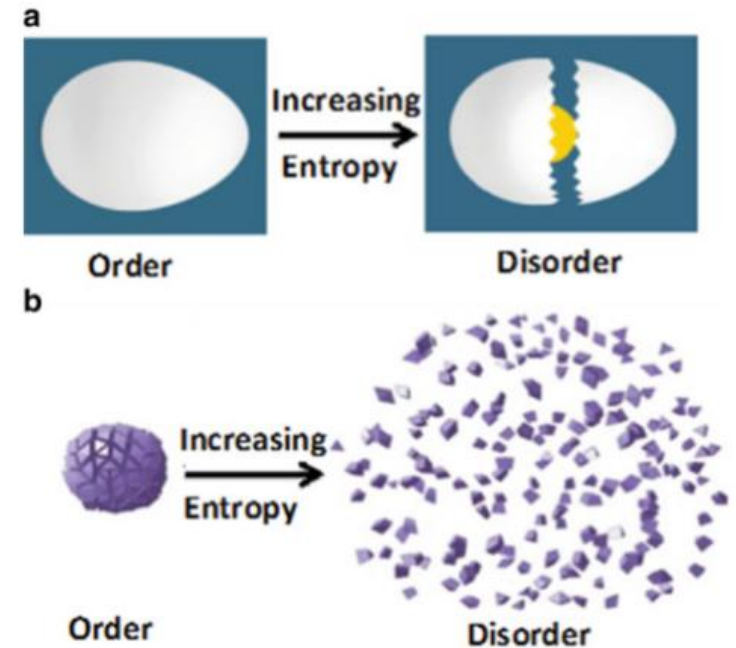
- Energy can change forms, but is neither created or destroyed (conservation of energy).



# What causes degradation?

- **Second law of thermodynamics:**  
Entropy of an isolated system always increases.
  - for an isolated system (a system for which no energy or mass can be transferred), order tends to degrade with time
    - a.k.a. the entropy (chaos) of the system will tend to increase spontaneously with time
- Impact on reliability: Second Law means that even the most carefully prepared material/device will tend to degrade with time.

Examples of increased entropy



(a) Egg tends to split when cracked. (b) Object breaks into many pieces when dropped



# Summary

- Reliability is everywhere
- Reliability vs. Quality:
  - Quality shows how well an object performs its proper function
    - Minimize variability
  - Reliability shows how well object maintains its original level of quality over time, through various conditions
- Degradation (from Second Law of Thermodynamics) causes failure