可靠度資料分析
Reliability Data Analysis

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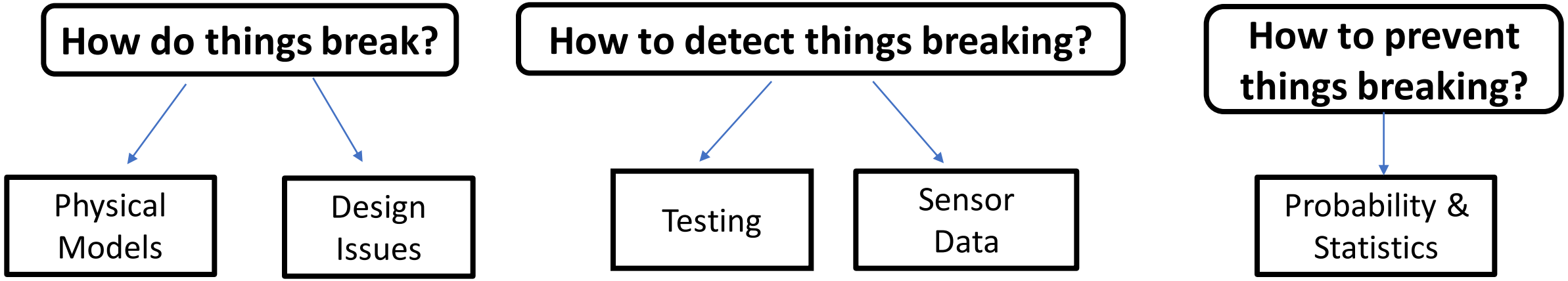
Lecture 1 - Introduction

Are you in the right place?

- This is CSIE 7637 (All English curriculum)

Reliability Data Analysis



Treat this course as going abroad…

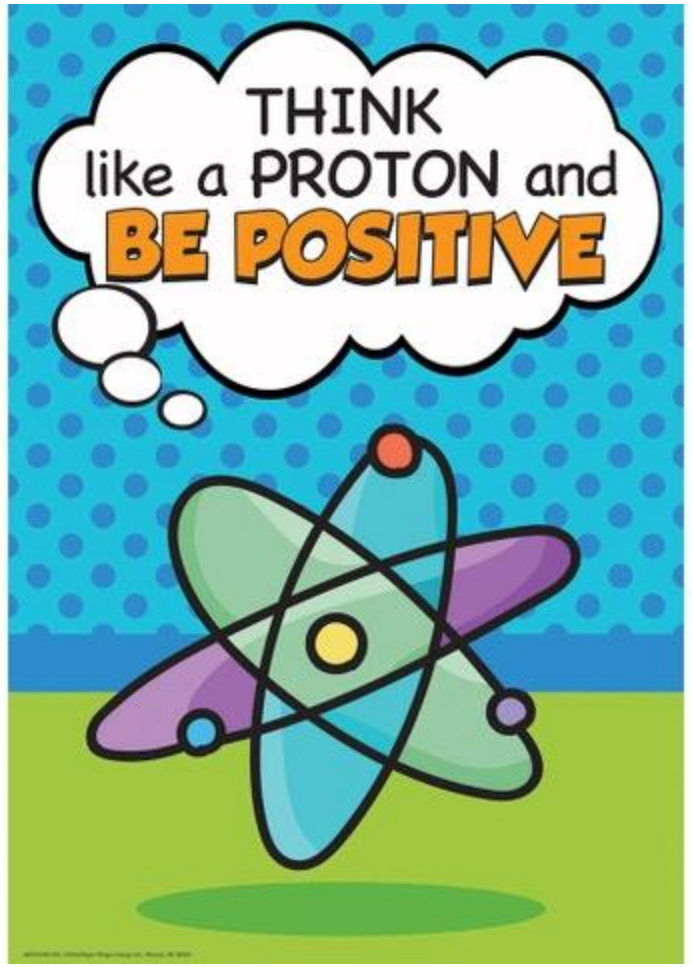
- Use this course to practice your English
- Feel free to ask questions or comments, either in Chinese or English

Stay Healthy, Safe and Positive

Wear a Mask

Stay home if sick

Wash/disinfect regularly

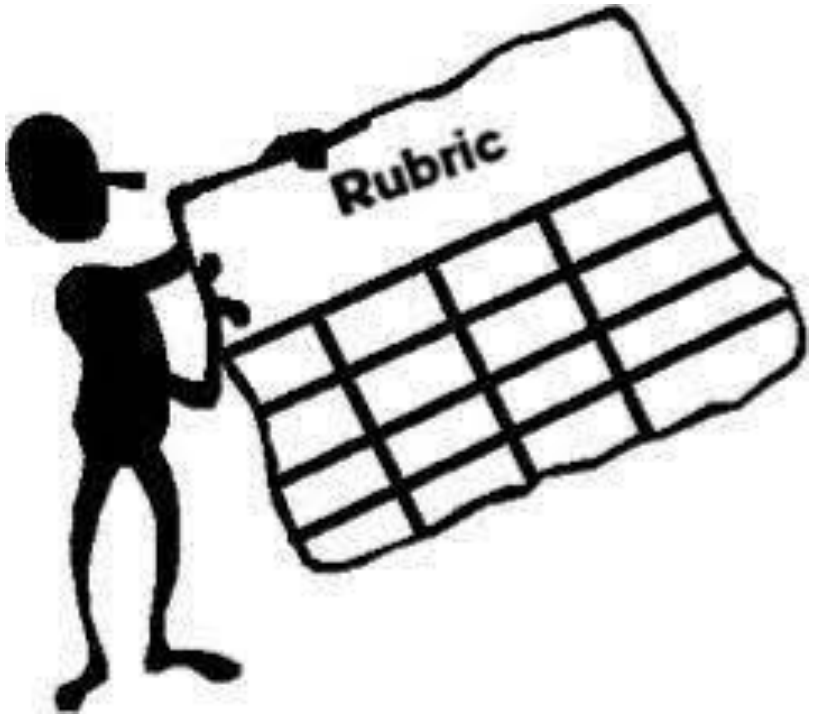


Course Information

- 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
Week 7	**2023/4/1**	**Midterm Exam**
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
Week 17	**2023/6/10**	**Holiday: No class**
Week 18	2023/6/17	Final Week (Backup Week, tentative no class)

Submit presentation topic

<u>Current estimate:</u>

- 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

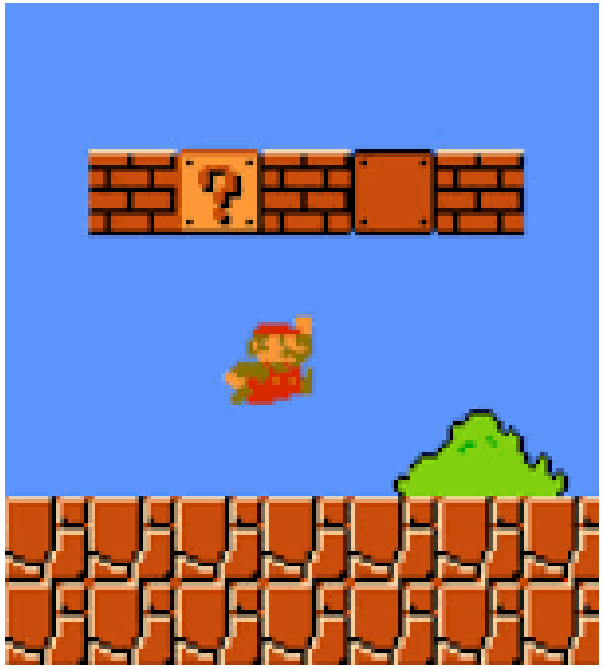


Image from https://gamaverse.com/super-mario-bros-game/

Contact Information

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

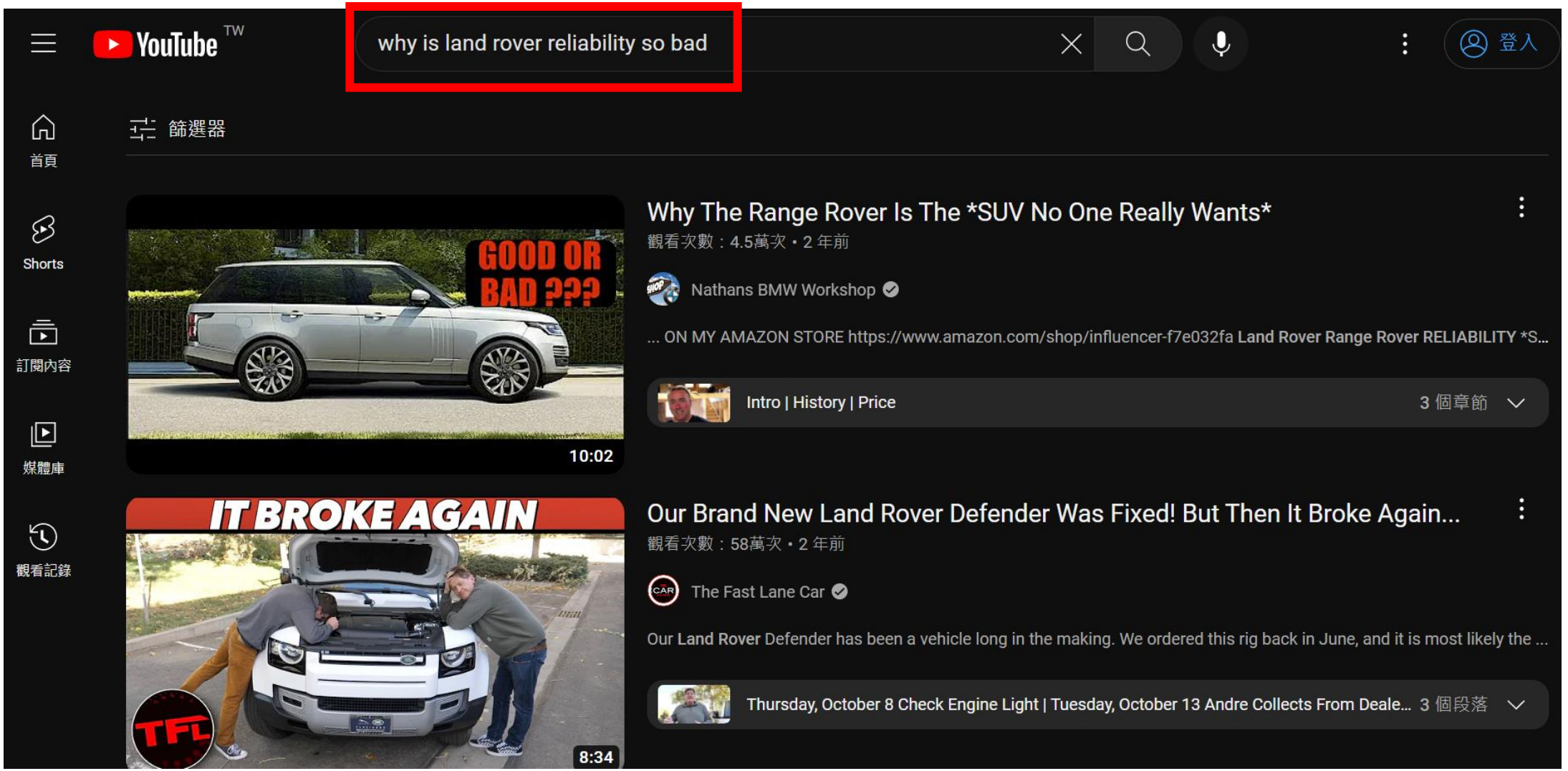
If failure can't be avoided, at least know when it is likely to occur so we can conduct preventative maintenance before the need for corrective maintenance arises

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…



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

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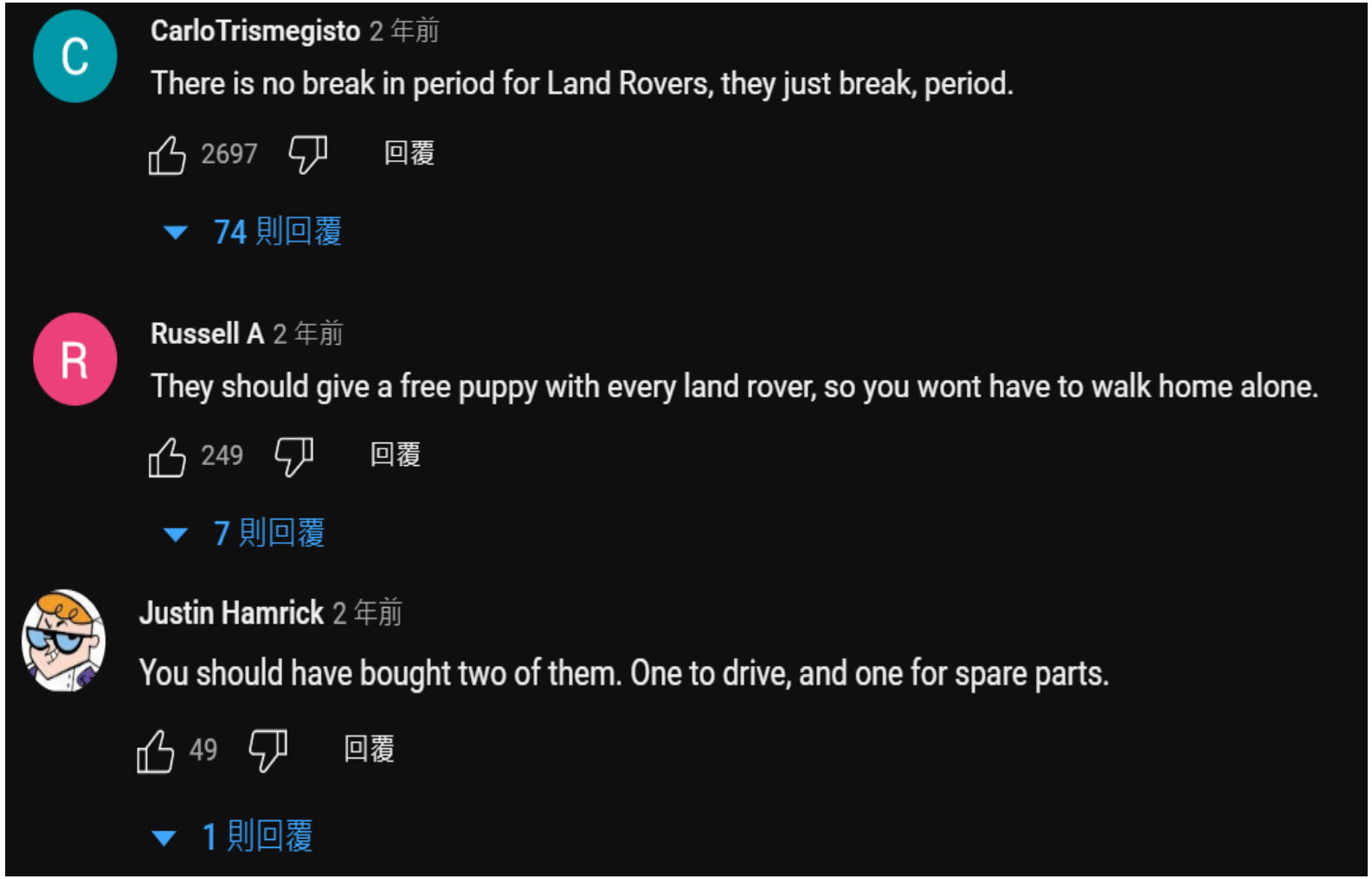
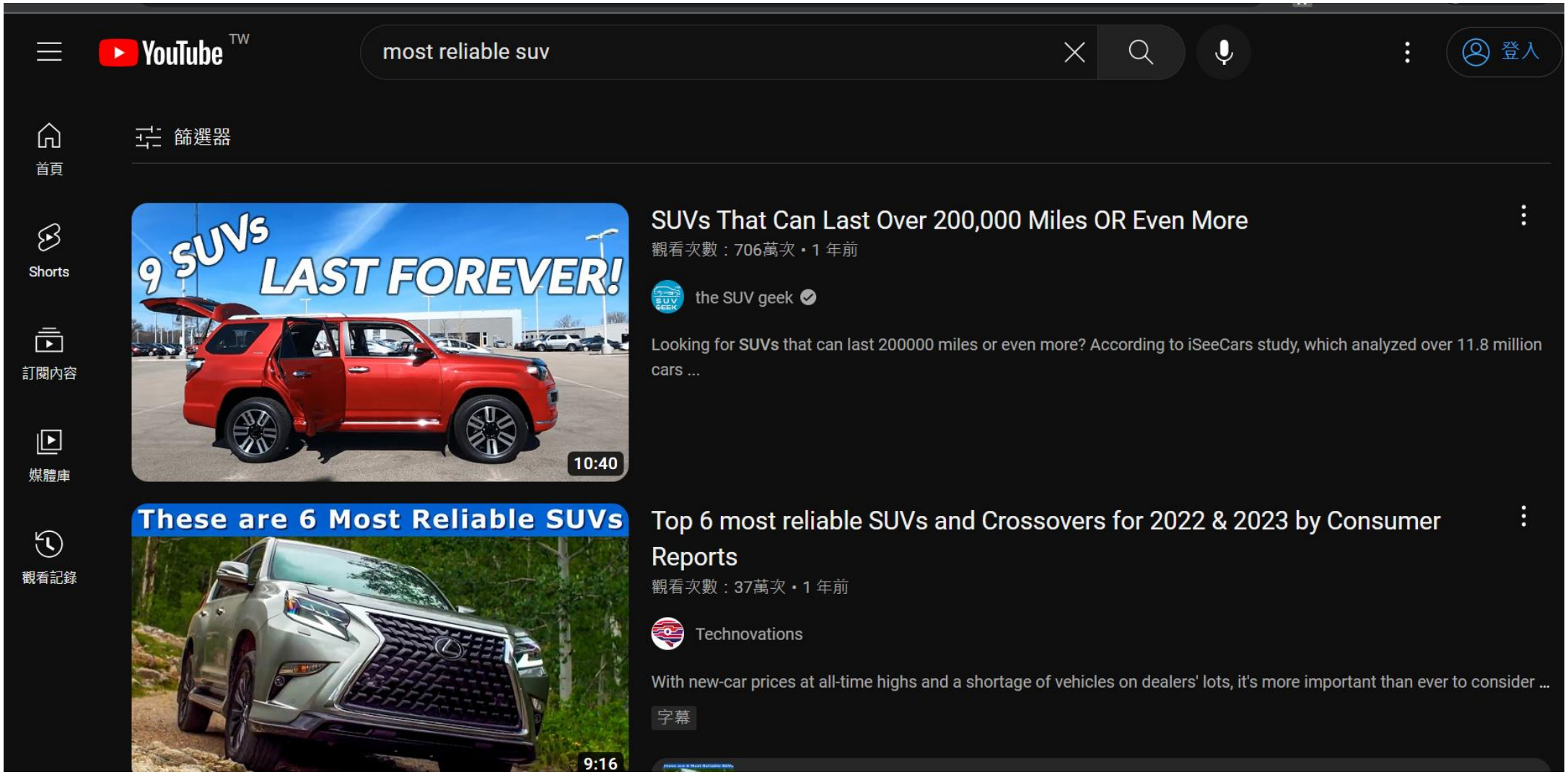


Comments from:
https://www.youtube.com/watch?v=zBVZyvfiqKw

Goal: Reliable Products



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. 1st year masters, 1st 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

Electrical Reliability

Physical Hardware Reliability

Circuit Reliability

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

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

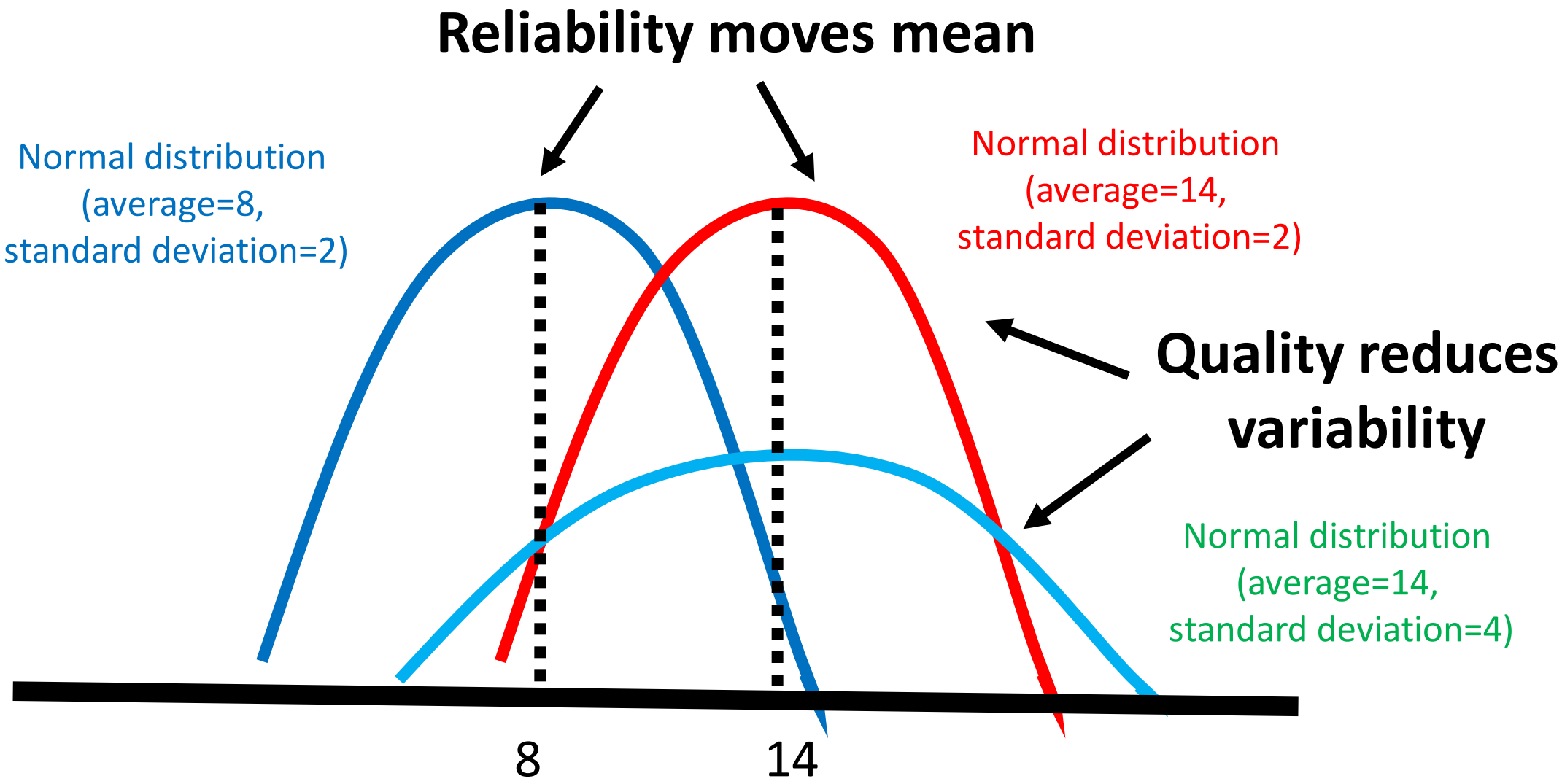
Mercedes-AMG Petronas F1
Material Science Reliability Engineer

https://www.youtube.com/watch?v=j_xotv7npsQ&list=PLbJwtTv097-8lvVTR3nPXIXaMMiTCruvK&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



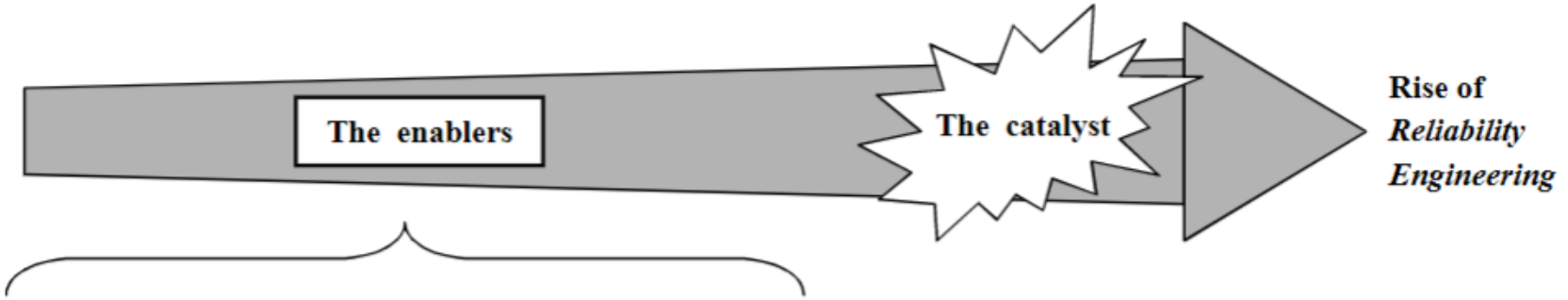
Quality vs. Reliability

- 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



(gaming & gambling)

(5x replacement compared to other equipment)

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 1st Reliability & Quality Control Society.
- 1960: US Naval Post-Graduate School becomes 1st intuition to teach reliability engineering courses in the US.
- 1962: 1st Annual Reliability and Maintainability (RAM) Conference held in US.
- 1963: University of Arizona, with support from National Science Foundation, became the 1st national research university to establish a Reliability Engineering program in the US.

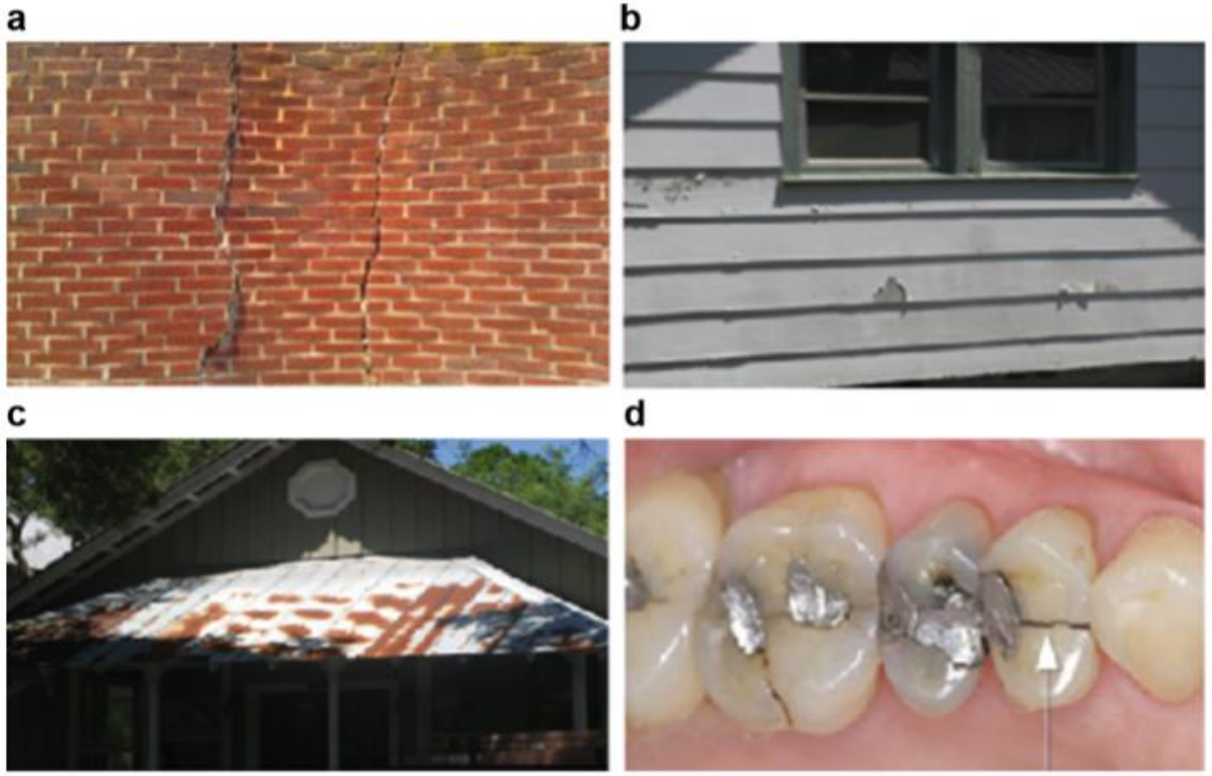
(Reference: Dimitri Kececioglu, Reliability Engineering Handbook, Vol. 1, PTR Prentice Hall, 1991.)

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

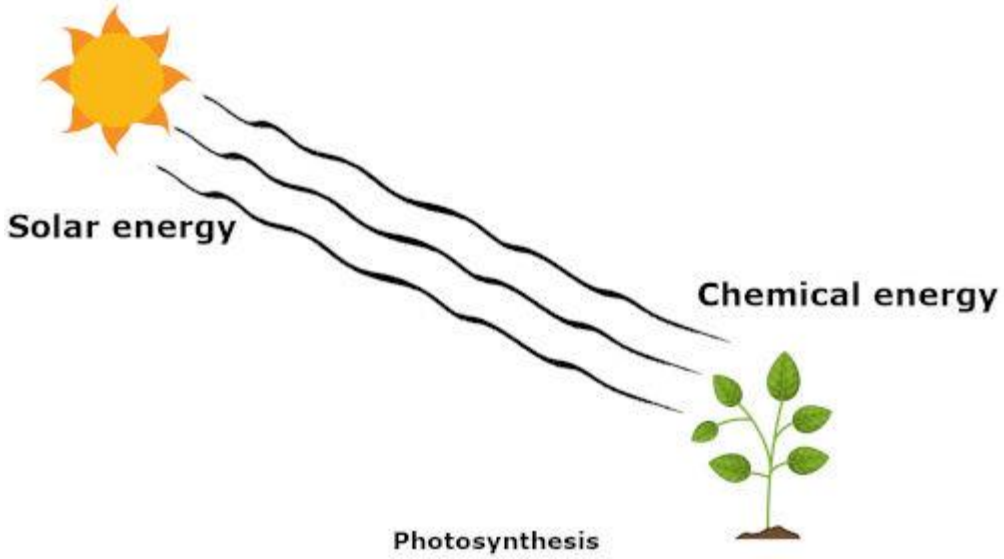


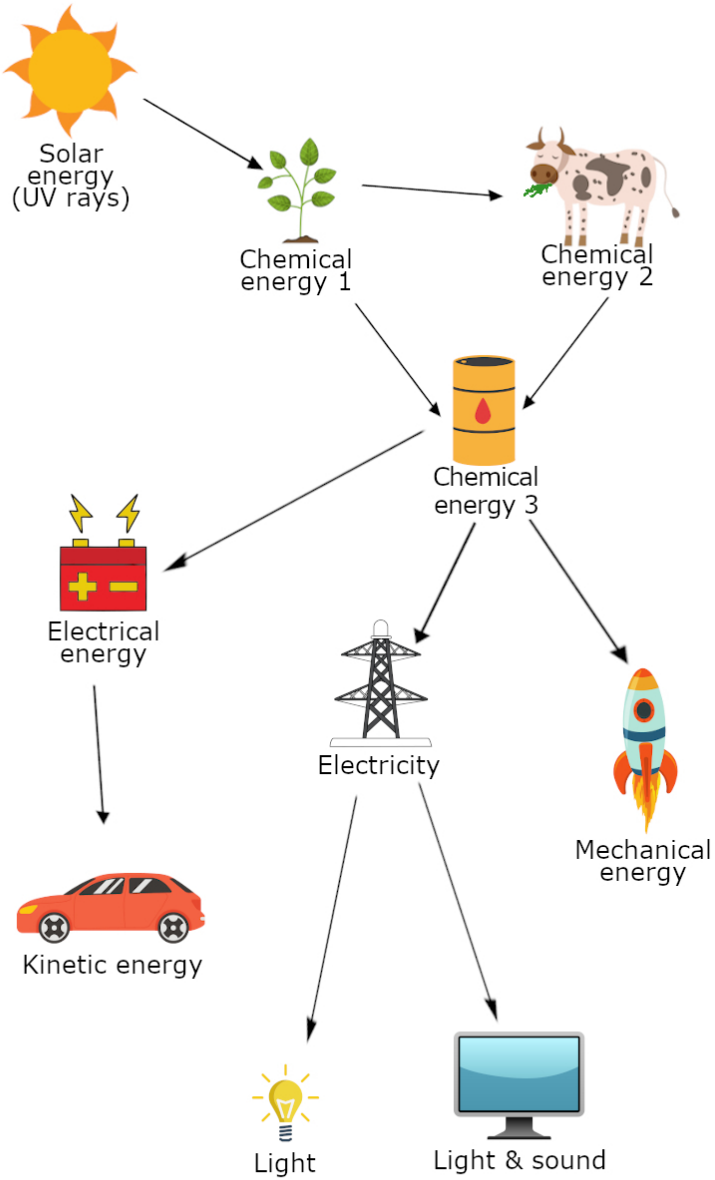
(a) Cracks tend to develop in brick walls as the foundation degrades.
(b) Paint will eventually crack and peel.
(c) Bright shiny metal roofs will oxidize/corrode.
(d) Human beings are not immune to degradation—note the tooth decay, fillings, and cracking

McPherson, Joe W. Reliability physics and engineering: time-to-failure modeling. Springer, 2019.

First law of thermodynamics

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



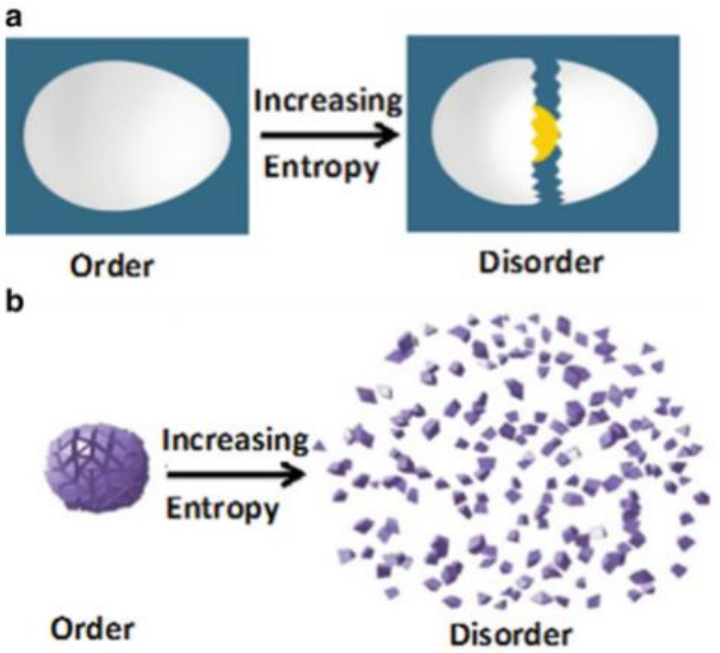


https://lawofthermodynamicsinfo.com/first-law-of-thermodynamics-in-photosynthesis/

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

McPherson, Joe W. Reliability physics and engineering: time-to-failure modeling. Springer, 2019.

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