ME303 Introduction to Mechanical Design

Lecture 16
Mechanical Design for Advanced Robotics

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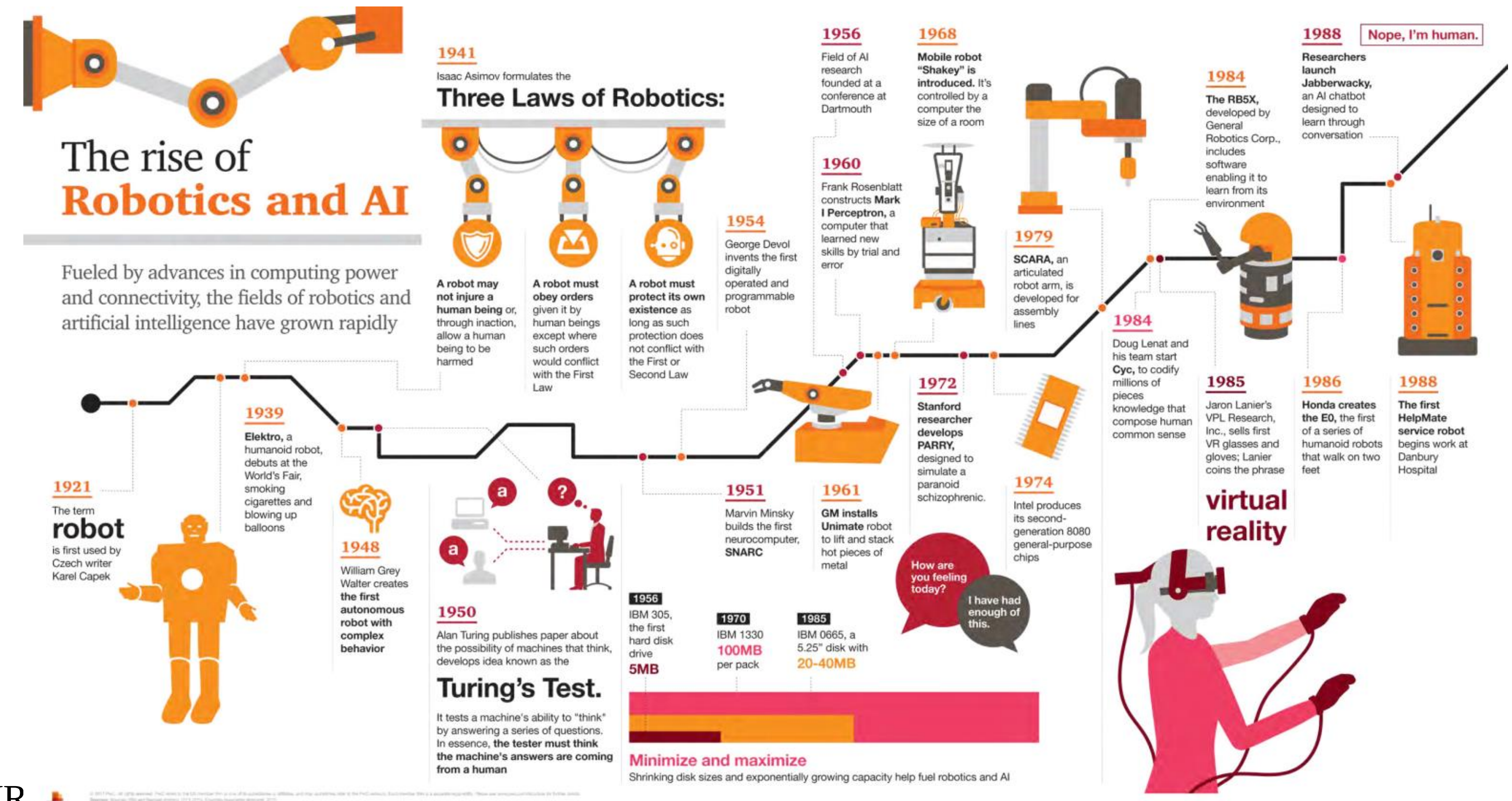
New Machines and Systems

New Demands for Mechanical Engineers

Driver of Design Intelligence → Mechanism → Machine → Robot → **Upgrading Need for Interaction**



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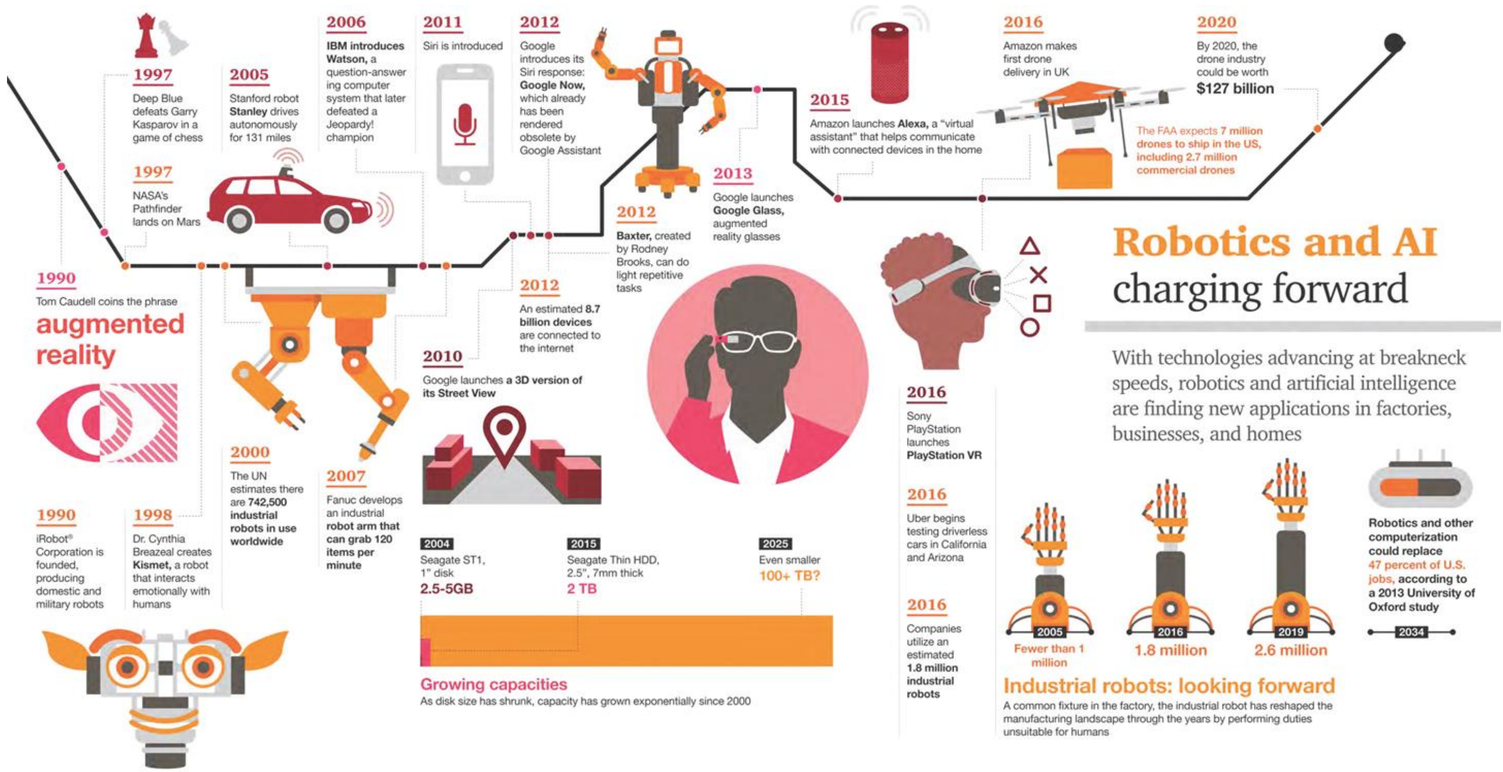

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Five ways robots are going mainstream

They're not restricted to structured environments.

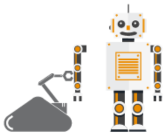
They can now handle dynamic, less predictable settings. In hospitals, robots can safely roam halls and deliver medications. In hotels, they can deliver towels, toiletries, and minibar items to guest rooms.

They can work with humans.

Thanks to sensors and smart technology, new-generation robots are much safer around humans.

They can learn.

The new robots can "learn" skills through trial and error, mimicking the way humans learn new tasks.



They are no longer single-task machines.

Robots are being designed with modularity in mind, beginning with a platform upon which a customized solution can be built.

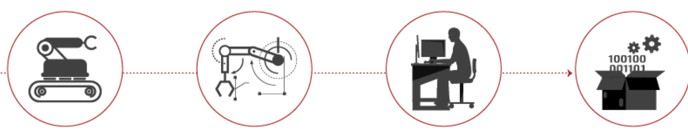
They're moving beyond the factory floor.

Robots are engaged in functions across the enterprise, including positions where they interact directly with customers and employees.

Benefits of robotics

Robots are not just for manufacturing anymore. No matter the industry, they can:

- Automate business operations
- Boost efficiency, quality, and repeatability
- Free up humans for higher-value tasks
- Replace or augment humans in jobs where there are labor shortages



Potential challenges

Lack of expertise and support — Your company may not have the knowledge or the resources to buy and maintain robots.

Fallout from job losses — Robots could displace workers, which could lower morale and create conflict with labor unions.

Regulatory compliance — Safety rules and monitoring and reporting requirements can create burdens, particularly for smaller companies.

Costs — Prices for robots are dropping, but the cost of engineering the system, installing it, and managing the change can be prohibitive.

A look at *robots ready for work*

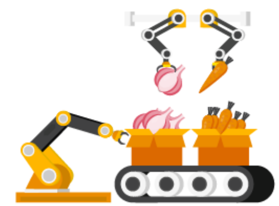
At a glance

Robots once were viewed as expensive, limited in their abilities, and applicable only in manufacturing. Now, THEY are more capable, easier to use, and less COSTLY, making the technology more desirable and accessible. But competing operating systems, form factors, and interfaces make for a fragmented robotics marketplace. We believe widespread adoption will accelerate when dominant vendors and platforms begin to emerge.

Potential new applications

Collaboration

Robots can replace or work as "cobots," in tandem with humans.



Handling more complex tasks

Robots can be instrumental in warehousing and fulfillment by fetching, monitoring inventory, moving pallets, picking, packing, screening, and inspecting. They can also greet, direct, and assist customers.

Mitigating labor shortages

Robots can be used to automate tasks too difficult and expensive for human manual labor. For example, robots won't just plant and harvest crops; they'll also monitor their health, size, and maturity, and target-spray fertilizer, herbicides, and fungicides where most needed.

Source: PwC, 2017

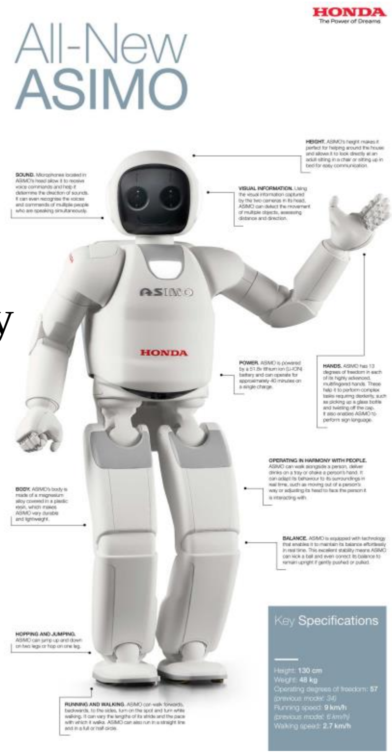
pwc.com/NextinTech

Design Iterations

HONDA's ASIMO

Advanced **S**tep in **I**nnovative **MO**bility

Mechanical Design for Advanced Robotics usually takes an iterative process that requires a great amount of **time**, **money**, **technology** and **public acceptance**.

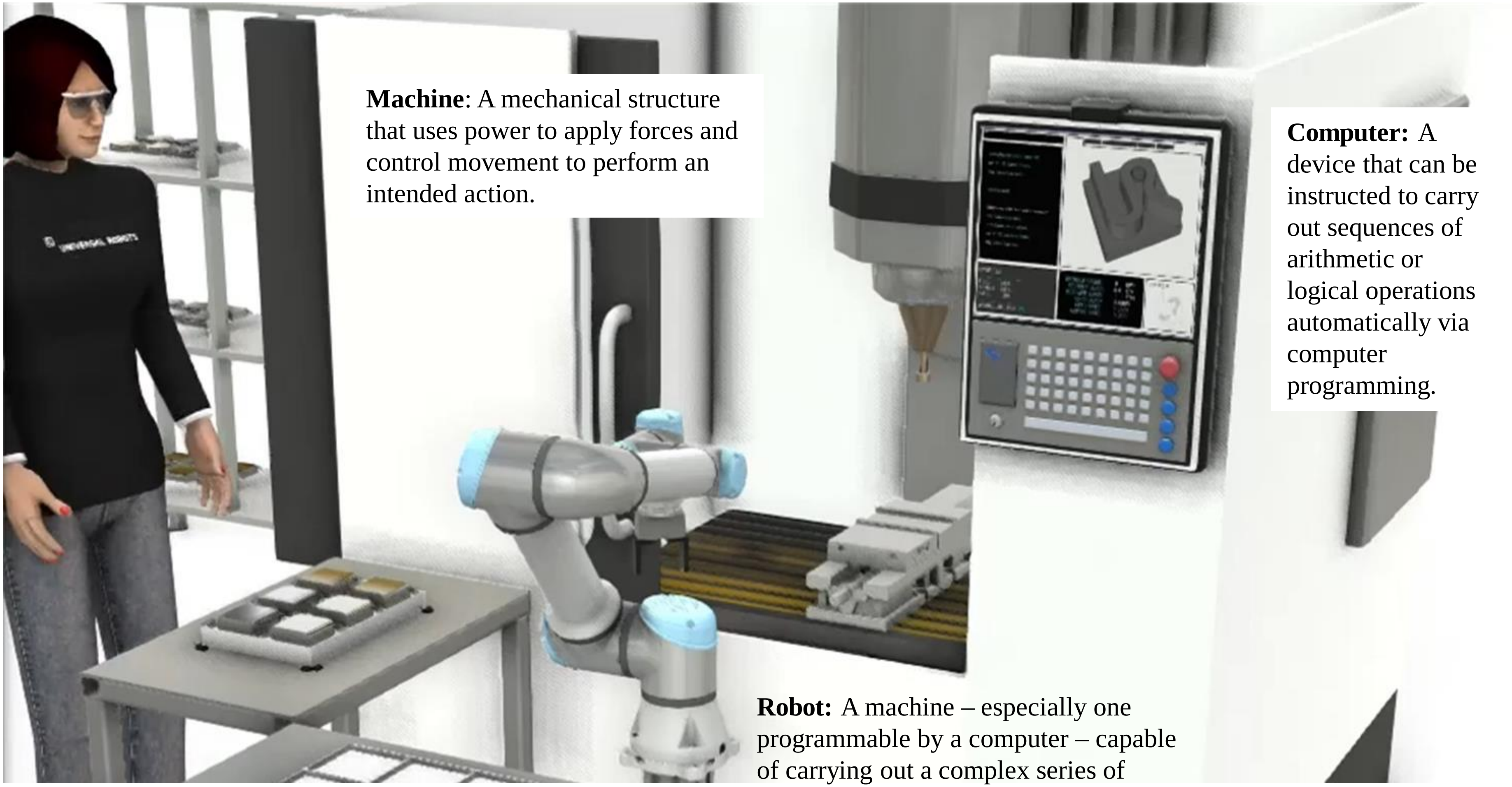


Honda Robotics

Universal Robot

Some Differentiations

Devices designed by human for different level of interactions



Machine: A mechanical structure that uses power to apply forces and control movement to perform an intended action.

Computer: A device that can be instructed to carry out sequences of arithmetic or logical operations automatically via computer programming.

Robot: A machine – especially one programmable by a computer – capable of carrying out a complex series of actions automatically.

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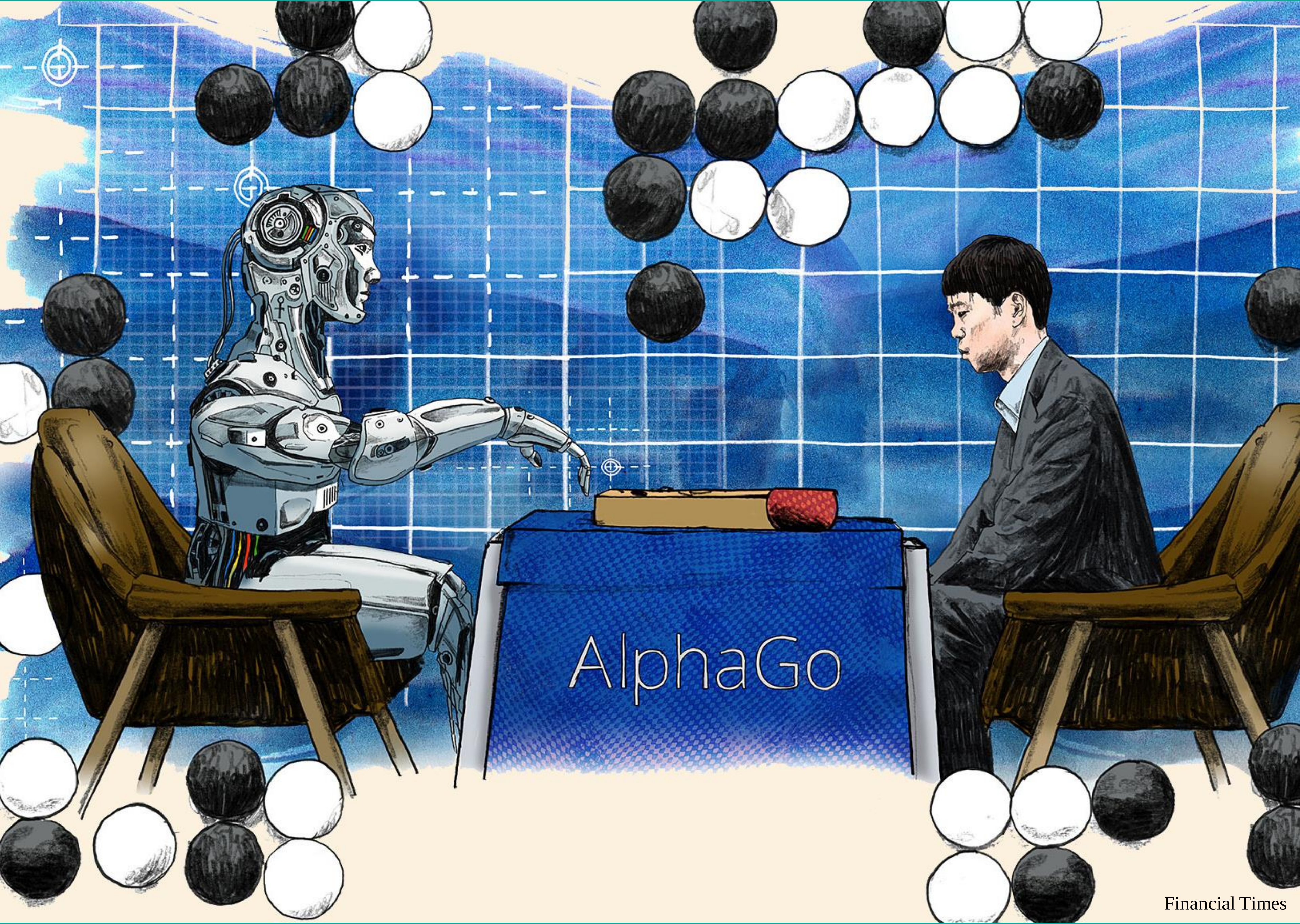
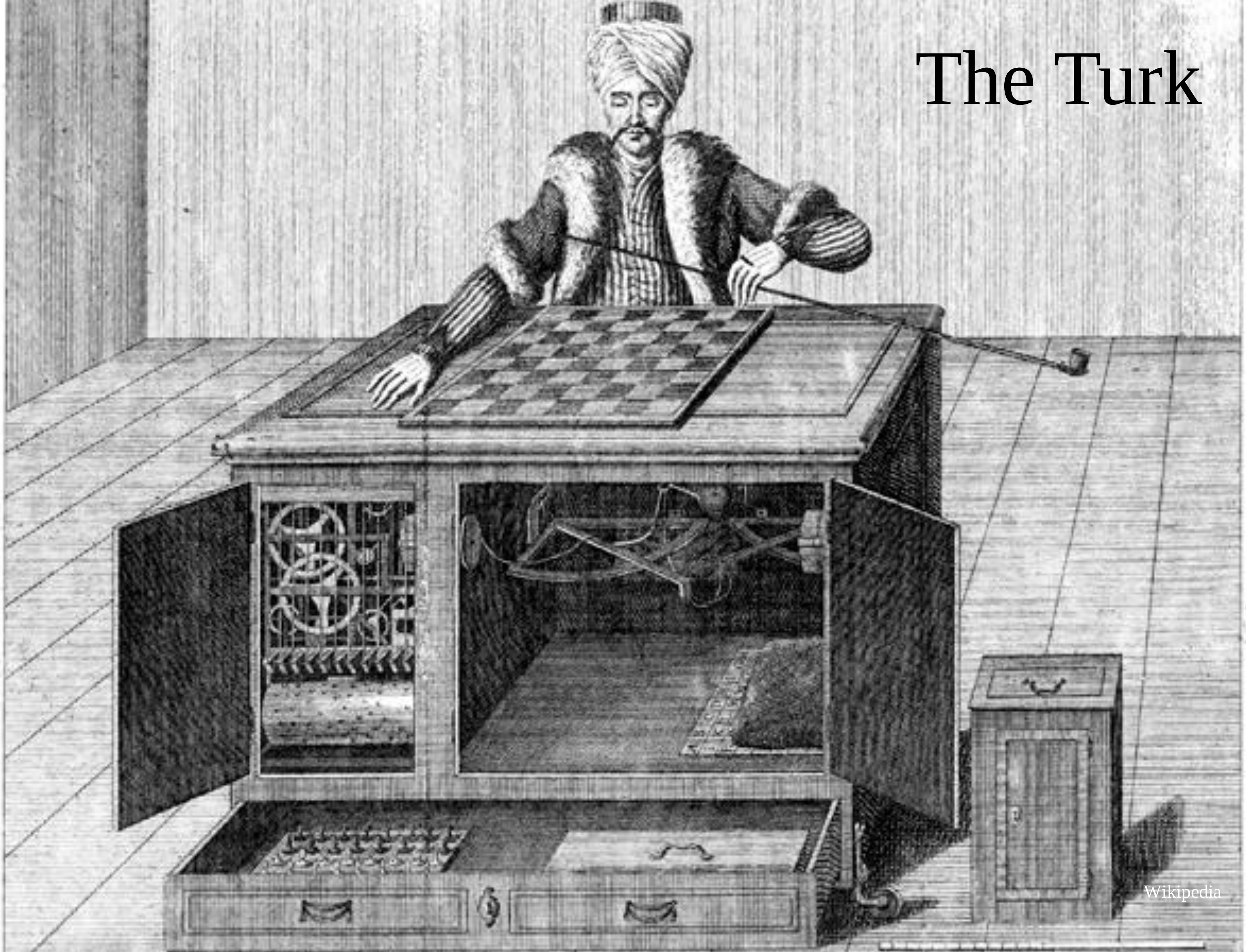


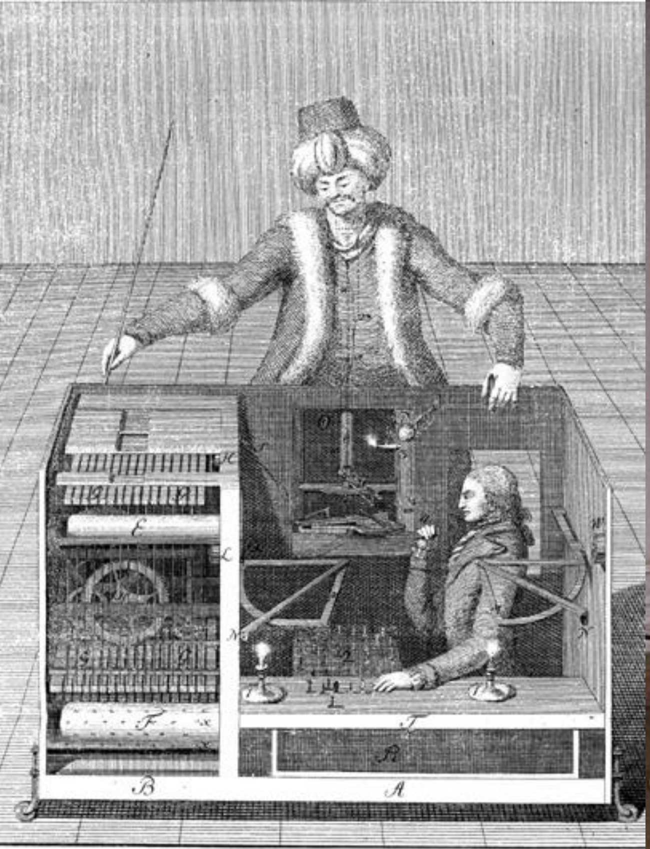
Financial Times

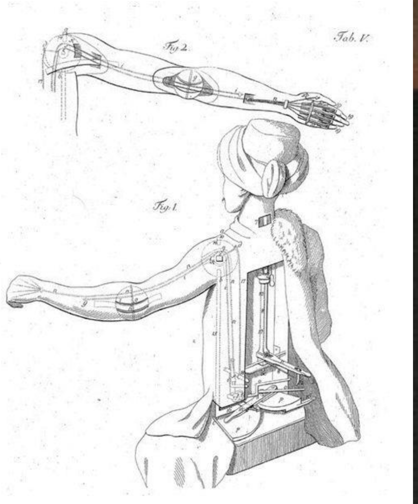
Ars Technica

The Turk



Wikipedia





The Fake Chess Player

Wikipedia

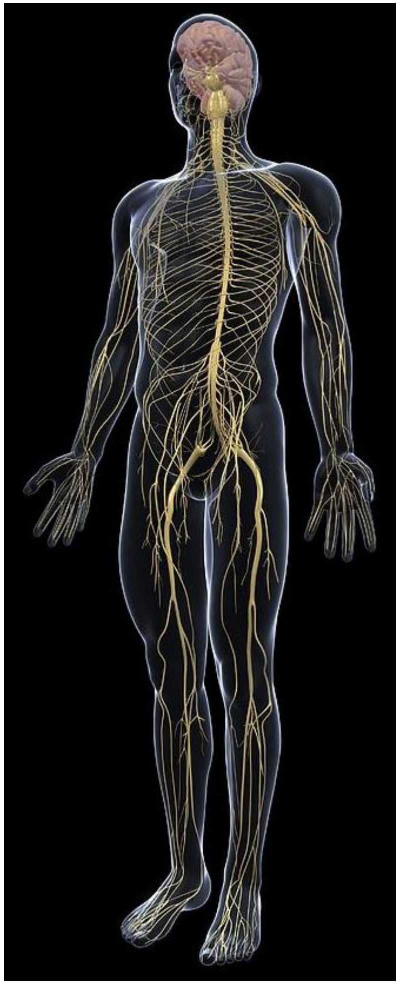
Defining Moment of A Robot

Physical Interactions in A Real-World Environment

Anki

The Role of Mechanical Design in Advanced Robotics

An Over-Simplification of the Engineering Roles



Mechanical Engineers

The Body: in charge of the physical system that makes up the robot, including pieces of the robots (like motors and actuators) and how the robotic will function in a production setting. The safety measures and physical operating protocols fall under this branch of engineering.

Electrical Engineers

The Nervous System: gives the electronic foundation of the robot, including the embedded systems, low-level circuit programming, electrical resistance, and control theory.

Computer Engineers

The Brain: focuses on the software and programming language rather than the hardware, encompassing such topics as artificial intelligence (AI) and machine learning.

Design Engineers

The Balance: focuses on the integration of the overall hardware and software that enables the robot to operate in a structured/unstructured environment with programmable interaction to fulfill designated tasks. All engineering roles must coordinate with the design of the robot to perform in a robust and reliable manner.

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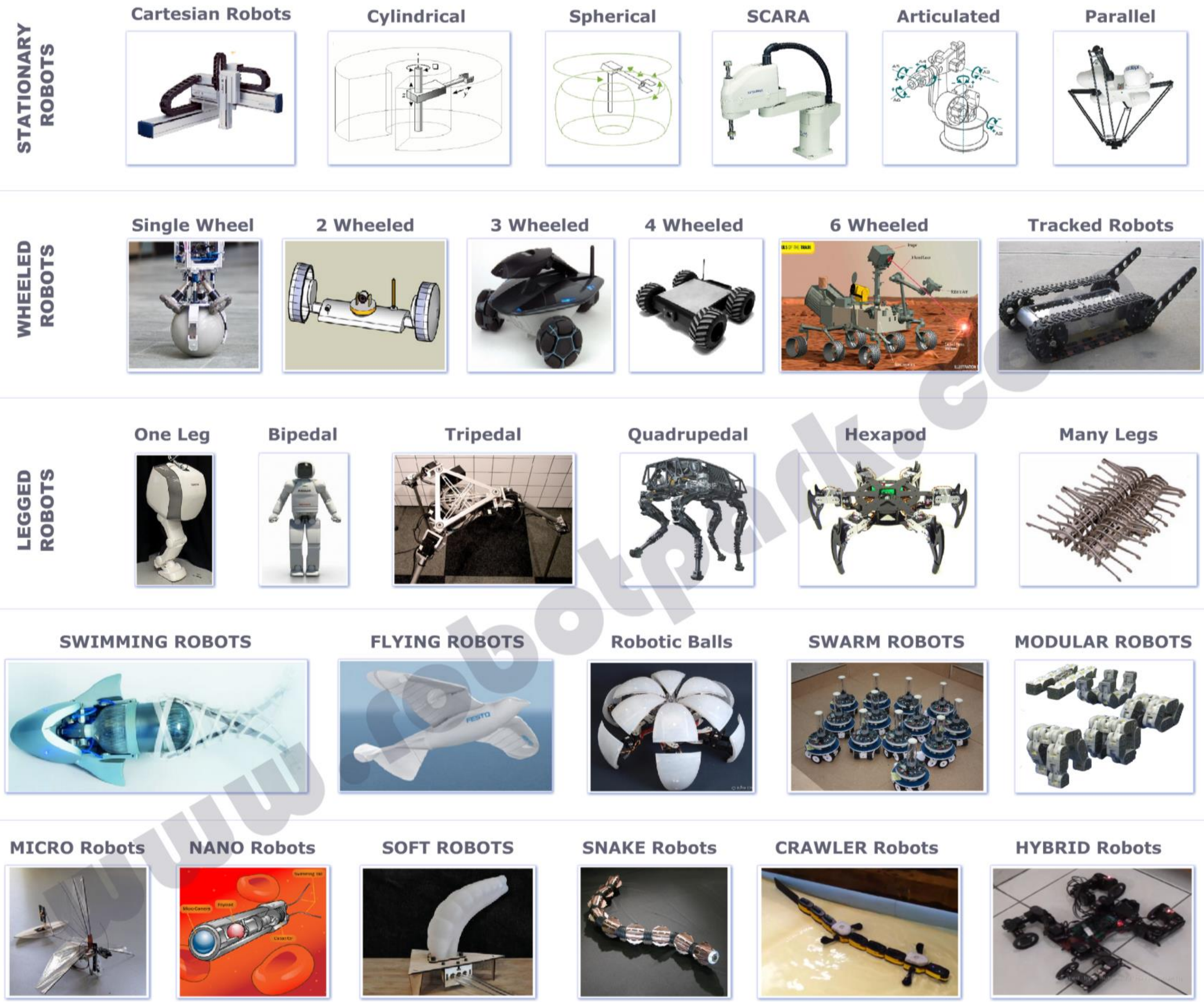
Robot Design Process

1. Kinematic topology
2. Geometric dimensioning
3. Structural dimensioning for static loading
4. Structural dimensioning for dynamic loading
5. Elastodynamic dimensioning of the overall structural
6. Actuator and transmission selections

Mechanical Design Considerations

For Advanced Robotics

- Materials
- Function
- Safety
- Efficiency
- Cost-Effectiveness
- Modularity
- Inspiration
- Aesthetics
- User Interface
- Ethics
- …



Mechanical Design reflects the physical embodiment of the robots

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GM
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Velodyne
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MDV
Red Bull
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Primary GPS
Camera System
IMU
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MIT
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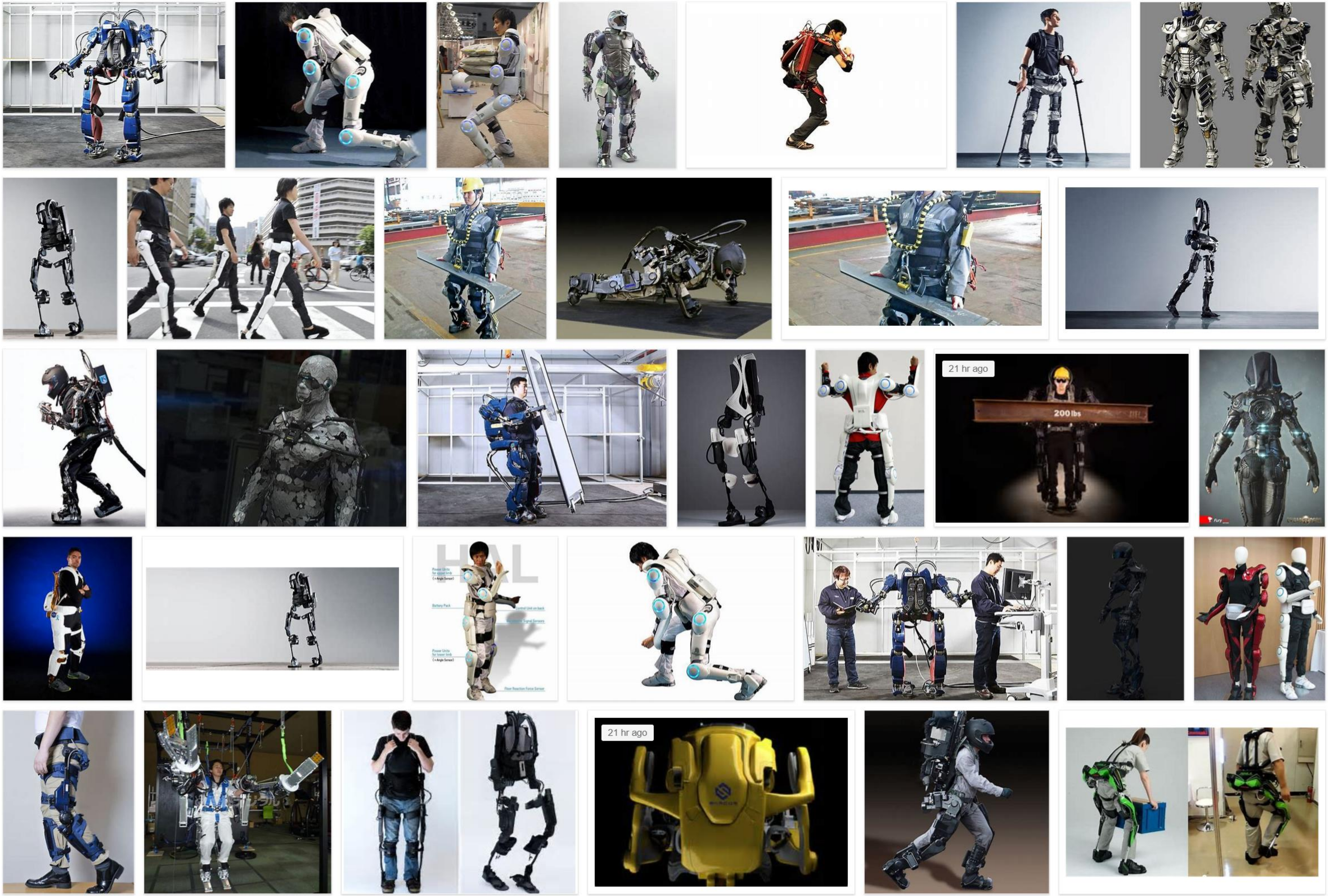

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Class Arrangements

The Final Weeks

- This Friday: Design Consultation
- Next Wednesday: Final Report
  - Before class starts (link at course webpage)
    - Submit online before Next Wednesday Noon (1200 @ 25 Dec)
    - 5 min video presentation
    - A 20-page engineering report
  - During the class
    - Cross evaluation based on Video Presentation
    - All students must show up, otherwise zero points for the whole team
- Next Friday: In-class Demonstration
  - During the class
    - Cross evaluation based on Live Demonstration
    - All students must show up, otherwise zero points for the whole team

Next Wednesday

Cross Evaluation

- Each student is assigned with 100 credits
  - *Evaluation based on Video presentation only*
- Submit online before 1530 during the class
  - *bring your laptop would be convenient*
- Each student must spend all 100 credits
  - *Any unused credits will be deducted against your team's credits*
- Each student can only give credits to team other than yours
  - *Any credit to your own team will be deducted against your team*
- Each team will have a second chance in Friday's class
  - *Teams with the most & least total credits will receive a prize*

Next class

- **Lab for Group 2**: Design Consultation
- Friday 0800-1000, Dec 20
- Room 412, 5 Wisdom Valley

- **Discussion for Group 1**: Design Consultation
- Friday 0800-1000, Dec 20
- Room 202, 1 Lychee Park

Thank you & Good Luck!

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