1ST EDITION

ENGLISH FOR

Mechatronics I

Pia Orešković | Ivana Grabar

Sveučilište Sjever

Varaždin

IMPRESUM

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English for Mechatronics I
Textbook

Varaždin, 2024

INTRODUCTION

English for Mechatronics I is the first book in a two-book series designed for students of the professional undergraduate study of Mechatronics at University North, as well as for all mechatronics engineers who want to expand their knowledge of the English language. In addition to authentic texts on the most modern technological achievements in the profession, the book also contains grammar units required for mastering the CEF level B1 of English.

The book is designed in such a way that the grammar and vocabulary related to the profession are studied through professional topics from the field of mechatronics, enabling students to communicate in real-life situations. The texts are accompanied by different types of tasks, which enable students to check their understanding of the English language in the mechatronics profession and upgrade the skills necessary for successful navigation in the labour market

The book is the result of many years of philological, methodical, and didactic experience of the authors, as well as extensive involvement in professional language courses.

Contents

1 Mechatronics engineering

1) Have a look at the following words. Which one(s) do you think are part of mechatronics engineering? Cross the other words out.

automation, controlling, raw material, supply chain, database, robotics, prototypes, design, test, quality management, ISO[1]

2) What is the Croatian term for each of the words in the box above?

automation	robotics
controlling	prototypes
raw material	design
supply chain	test
database	quality management

3) Have a look at the text below and add other key words to the box above.

Mechatronics is a high-tech field, and job applicants with a mechatronics engineering technology degree from an accredited program like the one offered at PennWest California are in demand. In fact, the Pennsylvania Department of Labor & Industry has identified mechatronics as a "high-priority" occupation with rapidly expanding job opportunities.

As more businesses advance their technologies and turn to sophisticated intelligent systems and robotics, mechatronics engineering will continue to grow in demand. Even manufacturing businesses considering a technology upgrade turn to mechatronics engineers in order to evaluate assembly line efficiency and costs.

4) The words provided in the box above are all nouns. Can these nouns be made plural?

[1] International Organization for Standardization

5) **Underline the nouns in the following text. Can you form their respective plural or singular form?**

Mechatronics Careers in Renewable Energy:

Pursue a career that makes civilization more sustainable. A bachelor's degree in mechatronics engineering technology from PennWest California will position you for high-impact jobs in solar power, wind energy, biofuel, hydropower and geothermal technologies. Renewable energy is a booming industry in which mechatronics graduates will find many opportunities to use their multi-disciplinary engineering skills to help make exciting innovations, test and improve components used in wind turbines and solar panels, and more. Job titles may include safety coordinator, materials engineer and energy systems technician, among others.

According to investinganswers.com, the median salary for a materials engineer in wind power is $83,190; in solar power, it is $86,380. The salary for a wind-turbine installer starts at $31,000 and increases to $104,000 with experience.

6) **Fill in the blanks with the verb provided, singular, plural or both if possible.**

Mechatronics Careers in Homeland Security and Defense:

The Department of Defense ____________ (predict) that 40% of military ground troops will be robotic in the near future; in turn, this will increase the need for robotic technicians with strong mechatronics engineering technology degrees. The PennWest California's mechatronics degree program ____________ (prepare) graduates to work for the U.S. government supporting the design, construction, alteration, testing and maintenance of new robotic and drone technologies. The United Nations _______________ (see) the future of mechatronic engineers in the creation of smart technologies used in surveillance, ground operations, border control, deployment logistics and more.

The committee at glassdoor.com ___________ (find) mechatronics engineering technician salaries at the U.S. Department of Defense to range from $85,040 to $91,042, whereas the BBC _____________ (state) the average salary for a U.S. Army Corps engineering technician to be at $53,329.

7) Fill in the following text with a noun provided below. Form their respective plural form, where necessary.

foundation; opportunity; field; reason; salary; position; equipment

Mechatronics Careers in Advanced Manufacturing and Robotics:

One of the top ________________ to get a mechatronics degree is the strong technical ________________ you'll gain in robotics. At PennWest California, you'll have ample ________________ to gain hands-on experience that will prepare you for an exciting career working with robotics in the medical and healthcare ________________, for the military, or in advanced manufacturing. In these ________________ you'll build robotic solutions that improve manufacturing quality, quantity and productivity; you'll manage, execute and troubleshoot electrical, robotic and automation ________________; and you'll ensure that all robotic appliances are compliant with industry standards.

The average ________________ for a robotics technician, according to recruiter.com, is $51,600 per year.

8) Fill in the gaps with a suitable verb provided beneath. Sometimes more than one word may be necessary in a blank. Use its singular or plural form.

are, can, enter, mimic, prepare

Mechatronics Careers in Biotechnology, Life Science and Medical Equipment Design

Among the most exciting fields that PennWest California mechatronics engineering technology graduates _______________ are biotechnology, life science and medical equipment design. A mechatronics engineering degree _______________ you for careers designing and building bio-inspired machines and medical devices that _______________ the behaviours of humans, animals and plants (this is called biomimetics). What you also may use knowledge of mechatronics engineering technology for _______________ to improve clinical equipment, surgical procedures, rehabilitation strategies, micro-implants, prostheses and more.

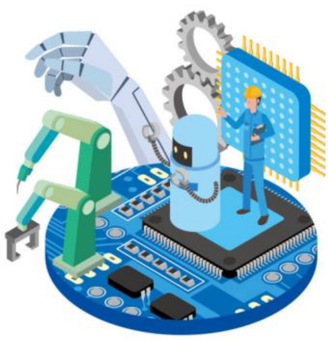
According to salary.com, biomedical engineering technicians _______________ an average of $62,282 per year.

9) Look at the text below. There are seven nouns with grammar mistakes. Can you find and correct them?

What's a mechatronics degree?

As you can perhaps guess from the names, mechatronics is a combination of "mechanisms" and "electronics." But a degree in mechatronics incorporates so much more. PennWest California's mechatronics engineering technology degree program gives you a broad range of knowledges and skills in:

- Manufacturing process.
- Industrial control principles, including instruments, circuits, component and control techniques.
- Statistics.
- Mechatronic control systems and programmable logic controllers.
- Practical physics, including dynamics and fluid power.
- The physical and chemical properties of material used in industry.
- Machine design elements and kinematics.
- Process control in plant automation.
- Computer-integrated manufacturing.



10) **Fill in the gaps with either a verb or a noun. Make changes to the inserted word, if necessary.**

Why should I earn a mechatronics degree at PennWest California?

PennWest California's mechatronics engineering technology degree program was designed around standards set by the Engineering Technology Accreditation Commission of the Accreditation Board for Engineering and Technology (ETAC of ABET). It is the only four-year bachelor's __________________ of its kind in Pennsylvania. It is also the first and only mechatronics bachelor's degree program in Pennsylvania's State System of Higher Education — your most affordable choice for higher __________________ in the state.

Furthermore, PennWest California's mechatronics engineering technology program is based on a rich history of providing students with relevant, hands-on activities. In fact, our on-campus labs are among the top __________________ students choose to pursue mechatronics at PennWest California.

PennWest California's mechatronics engineering technology degree program is advised by a __________________ of industry and academic __________________ and __________________ key partnerships with industry leaders:

- *Siemens AG*, a multinational powerhouse in electronics and electrical engineering.
- *FESTO*, a leading supplier of pneumatic and electrical automation technology.
- *Rockwell Automation*, a national provider of industrial automation and information products.
- *ANSYS*, a Pennsylvania-based developer of engineering simulation software.

11) Combine the sentence parts to form a coherent text.

What kind of careers can I pursue with a mechatronics degree?

1) The U.S. Department of Labor	a) may include: Automotive technician, Telecommunications technician, Robotics technician, Biomedical engineering technician, Wind-turbine installer.
2) The U.S. Department of Defense also	b) has deemed mechatronics an emerging growth area for new jobs, hoping the unemployment numbers will fall nationwide.
3) From advanced manufacturing and robotics to green energy and telecommunications, you'll	c) find mechatronics degree graduates working with smart technologies and complex machines in a variety of industries.
4) Job titles	d) has identified mechatronics as a "high-priority" occupation and has a variety of student loan benefits established.

12) In pairs, have a look at the texts on mechatronics in this unit. Answer the following questions using the texts and the internet, where necessary.

- Name at least 3 things mechatronics engineering technology includes. Explain them in your own words.

- Who are the 4 key partners for the degree program at PennWest? Can you guess what their field of work is? Have a look at their website, if necessary.

- Name two job titles for a graduate of this program. Describe the job. Use the internet, if necessary.

13) In pairs, write a summary on what careers a mechatronics degree enables you to pursue and in which field. Use the following four words (change them, if necessary) and write no more than 5 sentences.

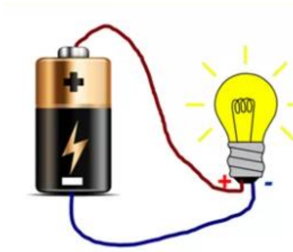
technology; industry; activity; property

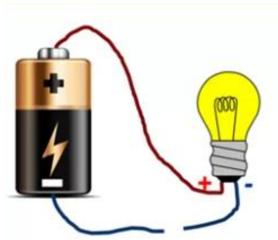
2 Electronics

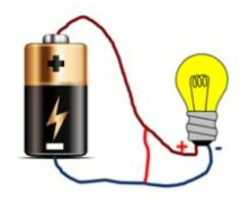
What are the following words referring to?

series *open* *short* *parallelclose*

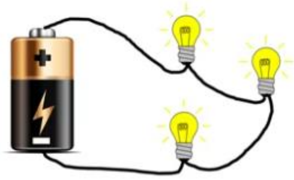
Match the words from above with the drawings below. Can you name their parts and describe how they work? Have a look at the description of a *Parallel Circuit* below for reference.

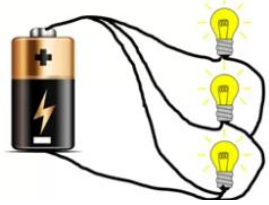
A. 

B. 

C. 

______________________ ______________________ ______________________

D. 

E. 

______________________ ______________________

When two or more loads (Bulb, CFL, LED, Fan etc) are connected to each other in parallel, then it is called Parallel Circuit. In this type of circuit, the voltage capacity of all loads must be equal to input supply. The power of the "load" can be different. In a parallel circuit, if one load or bulb gets fused, then the rest of the bulbs will still get power supply and will glow.

2.1 Types of EV batteries

1) Have a look at the text below and decide which paragraph describes one of the following batteries:

Nickel metal hydride batteries; Lead-acid batteries; Lithium-ion batteries

_________________ are used in all gasoline-powered vehicles to provide electricity in order to crank over the engine and get the car started. Invented in 1859, those batteries are the oldest form of rechargeable battery that is still on the market and are also called *wet cell batteries* because they use a mild solution of sulfuric acid. The name comes from the combination of lead electrodes and acid that is used to generate electricity. You'll find them used in EVs to power secondary features such as the infotainment system or driver-assist tech.

____________________ began to be used in the 1980s and are known for their high energy density. In other words, they pack a lot of power in a small package. Because they don't contain any toxic metals, they are easy to recycle. Here the positive electrode contains nickel oxide-hydroxide as an active material and the negative electrode is made of a hydrogen-absorbing alloy. They have a much longer life than lead-acid batteries and are widely used in hybrid and plug-in hybrid vehicles.

_____________________ first appeared in EVs in the 1990s. They have a very high energy density and hold their charge longer, making them excellent for powering electric vehicles. Energy density refers to the ratio between the storage capacity of the battery and its weight. By comparison, a lithium-ion battery offers ten times the density of a lead-acid battery. Those batteries produce high voltage, are easy to recharge, and are extremely durable, often lasting longer than the car itself.

2) Name at least one advantage for each battery. Can you think of any disadvantages?

Nickel-metal hydride batteries: ____

Lead-acid batteries: ____

Lithium-ion batteries: ____

3) What does a lithium-ion (Li-ion) battery consist of?

4) Have a look at the picture. Can you describe the parts of a Li-ion battery using the terms below? Work in pairs. Use the words in italics.

carbon, metal oxide, lithium salt, separator

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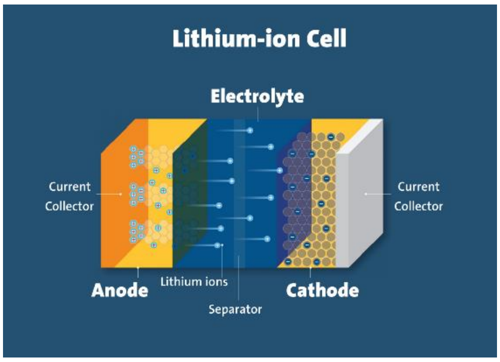


5) How does a lithium-ion cell work?

Have a look at the text and come up with the missing words. Then listen to the recording and check your answers.

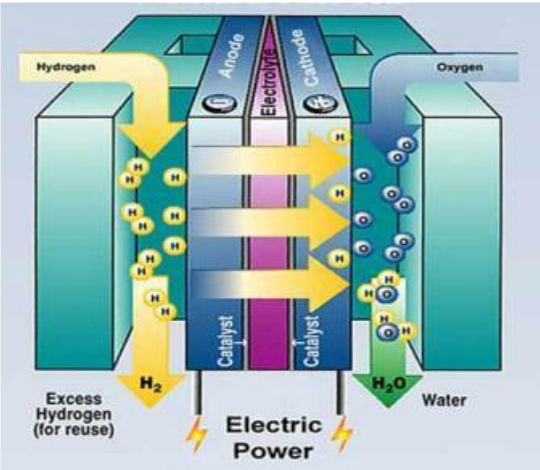
A lithium-ion battery consists of one or more lithium ion cells along with the protective circuit board.

In a lithium-ion cell, lithium ions (Li+) move between the electrodes of the cell internally, through a conductive electrolyte. Meanwhile, electrons move between electrodes in the ________________ direction through the external circuit. The movement of the lithium ions and the electrons provides a current that charges the device.

When the battery ____________________ energy to a device, lithium ions are released by the ____________ and ____________ by the cathode.

When the battery charges, the opposite occurs: the cathode releases lithium ions and the anode ______________ them. This is how a lithium-ion battery works.

6) Have a look at the following picture. What kind of battery is it? Discuss in pairs.



What do you know about it?

What does it consist of?

How does it work?

What are its advantages and disadvantages?

7) Listen to the extract of a seminar. Are these sentences true (T) or false (F)?

a) Fuel cells function using a chemical reaction. ________

b) Internal combustion engines have unlimited efficiency. ________

c) Even if a fuel cell is used, the car will need an electric motor to operate. ________

d) Electric motors are very flexible. ________

e) Making a small fuel cell has now become fairly simple. ________

8) If you were to engineer a car, what kind of battery would you choose and why? Use the handout for guidance.

____

____

____

____

____

____

2.2 Production Management

Read through the e-mail describing a technical problem. Underline the verbs.

> *Following our phone conversation this morning, I confirm that a forklift truck has hit our IPS15 unit. The impact has made a large hole in the main panel on the side of the machine. Liquid lubricant is leaking out from under the machine and the unit is crackling when you switch it on – presumably due to earthing/short-circuiting resulting from electrical damage.*
>
> *I confirm my request for intervention by your service team.*

Find at least one example for each of the following tenses in the text above:

Present simple: ____

Present continuous: ____

Present perfect: ____

VERB FORM

PRES. SIMPLE	PRES. CONTINUOUS
I/you/we/they work He/she/it work**s**	I am working you/we/they are working he/she it/ is working
I/you/we/they do not work (don't) He/she/it does not work (doesn't)	I am not ('m not) working You/we/they are not (aren't) working He/she/it is not (isn't) working Am I working?
Do I/you/we/they work? Does he/she/it work?	Are you/we/they working? Is he/she/it working?

TYPICAL TIME EXPRESSIONS

always, often, usually, sometimes, (n)ever, every day/week, on Friday, in the morning(s)/evening(s)	now, at the moment, at present, just, already, still

1) Fill in the blanks with the correct present tense.

Production management is concerned with planning and controlling industrial processes which ______________________ (produce) and ____________________ (distribute) products or services. Techniques of production management are also used in service industries, where they are called operations management. During production processes, inputs are converted into outputs. These processes _______________ (take) many forms: from basic agriculture to large-scale manufacturing. Much manufacturing _______________ (take place) in factories, where assembly lines _________________ (allow) a steady flow of raw materials (inputs) and finished products (outputs).

People in production ______________ (focus) on efficiency and effectiveness of processes in order to maximise productivity. To achieve overall success, it ________ (be) important to measure, analyse and evaluate these processes. However, other activities also _________________ (contribute) to success: purchasing, inventory control, quality control, storage, logistics.

2) Fill in the gaps with a suitable verb in the present tense.

We ____________________ (make) good progress with the new factory development. A new site close to the river has been acquired. Designers __________________ (work/currently) on the layout of the area and exact location of the factory building. Alan Shores Ltd. __________________ (carry out) all fixtures and fittings.

The present machinery __________________ (be) old and several breakdowns recently have caused production backlogs. We will continue to _______________ (maintain) and _______________ (repair) these machines until the new ones _______________ (arrive). I would ask you to __________________ (carry out) a full stock inventory as soon as possible. Any faulty goods should be removed from store and disposed of.

3 What are automated guided vehicles?

Read the text and fill in the gaps with a suitable verb in the present tense.

Sometimes called self-guided vehicles or autonomous guided vehicles, automated guided vehicles (AGVs) ________________ material handling systems or load carriers that ________________ autonomously throughout a warehouse, distribution center, or manufacturing facility, without an onboard operator or driver.

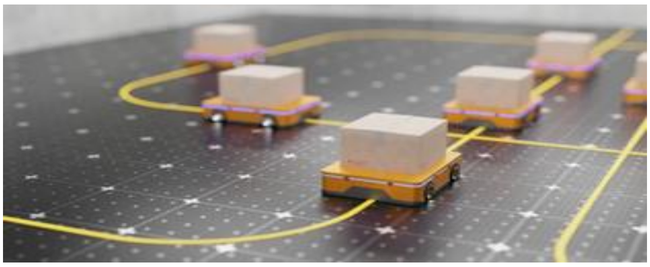
Applications for AGVs

Automated guided vehicle systems ________________ tasks that would typically be handled by forklifts, conveyor systems or manual carts, moving large volumes of material in a repetitive manner.

AGVs are used in a variety of applications. They often ________________ raw materials such as metal, plastic, rubber or paper. For example, AGVs can carry raw materials from receiving to the warehouse or ________________ materials directly to production lines. AGVs consistently and reliably ________________ raw materials needed without human intervention, ________________ that production lines always have the materials they need without interruption.

In addition to transporting raw materials, AGVs are used in work-in-process applications and with finished goods to support production or manufacturing lines. According to Investopedia, the term work-in-process describes “partially completed goods, which are typically turned from raw material to finished product in a short period of time,” such as manufactured goods. In work-in-process applications, AGVs move materials or parts from the warehouse to production lines or from one workstation to another, providing repetitive and efficient movement of materials throughout the manufacturing process. Without AGVs, manufacturing processes may come to a halt when processing lines ________________ of materials. Manufacturing is then delayed while a human worker retrieves the necessary materials from storage and transports them to the production line.

AGVs are also used in inbound and outbound handling for replenishment and for picking. For example, AGVs may be used to _________________ inventory from receiving to storage locations or from long-term storage locations to forward picking locations to replenish stock. _________________ inventory from long-term storage to forward picking locations ensures that adequate inventory is accessible to pickers, _________________ the order picking process more efficient. AGVs such as collaborative mobile robots assist in the picking process by _________________ warehouse associates through tasks and transporting picked orders to packaging and shipping workstations.



1) **Have a look at the text below and match the AGV navigation mechanism with its description.**

HOW AGVs WORK

AGVs are self-propelled vehicles with movement guided by software and sensors. Most AGVs move along defined pathways, but as mentioned, AMRs typically have more advanced technology with dynamic navigation capabilities. Here are some examples.

AGV NAVIGATION

AGV navigation may be guided using one or more of the following mechanisms:

1) Magnetic guide tape	A) With this method, reflective tape is mounted on objects such as walls, fixed machines and poles. AGVs are equipped with a laser transmitter and receiver. The lasers reflect off of the tape within the line of sight and are used to calculate the object's angle and distance from the AGV.
2) Wired navigation	B) Some AGVs follow wire paths embedded into the facility floor. The wire transmits a signal that AGVs detect via an antenna or sensor.
3) Laser target navigation	C) Like vision-guided AGVs, no infrastructure modifications are required for AGVs that use geoguidance. Geoguided AGVs recognize objects in their environment to establish their location in real-time to navigate throughout the facility.
4) Inertial navigation	D) No modification is required to the infrastructure for vision-guided AGVs. Cameras record the features along the route, and AGVs rely on these recorded features to navigate.
5) Vision guidance	E) This is a sophisticated navigation technology utilizing sensors that transmit laser pulses to measure the distance between the robot and objects in its environment. This data is compiled to create a 360-degree map of the environment, allowing robots to navigate the facility and avoid obstacles without the need for any additional infrastructure. 6 River Systems uses LiDAR navigation technology to enable their AGVs to navigate a warehouse without requiring changes to infrastructure as well as to adapt to new environments should the layout of a warehouse floor change.
6) Geoguidance	F) Some AGVs have magnetic sensors and follow a track using magnetic tape.
7) LiDAR	G) Some AGVs are controlled by a computer system with the aid of transponders embedded into the facility floor to verify that the AGV is on the proper course.



2) Discussion

a) What are some other parts of an AGV that can be controlled by automated mechanisms?

b) Can you think of any types of AGVs?

c) Why choose AGVs instead of conventional vehicles?

3.1 AGVs, AMRs and other types of automated vehicles

1) Skim through the following text. Highlight the topic sentences.
2) Write down a suitable heading for the text.
3) Using your topic sentences, tell the class what this text is about.

____

Automated Guided Vehicle (AGV) is the most common name for various types of automatic trolleys used for internal transport. It is often used alongside or even interchangeably with the name Automated Mobile Robot (AMR). There are also terms like Autonomous Intelligent Vehicle (AIV), Self-Guided Vehicle (SGV), and even Laser-Guided Vehicle (LGV). How to tell these machines apart? What design and functional differences are hidden in these terms and abbreviations?

An overabundance of names is often a result of a strong desire among manufacturers to distinguish their robots from the competition. However, regardless of the terms used, a rudimentary distinction can be made based on the level of autonomy of the machine.

Automated vs autonomous

The automation of internal transport is currently associated primarily with the concept of Industry 4.0, i.e. the Fourth Industrial Revolution. However, it is worth remembering that the first AGV trolley was introduced as early as the mid-twentieth century. The machine was deployed at the U.S. Barrett Electronics facility in Northbrook, Illinois. This historic robot was a kind of tug, adapted to pull trolleys and trucks without their own engines. It had very limited autonomy – it moved thanks to inductive guidance, that is, along a live wire embedded into the plant floor.

The key to the development of AGV robots was a navigation system capable of working inside warehouses and production facilities. The replacement of live wires embedded in the floor with adhesive tapes stuck to the surface of it was another milestone. Guides like these, made from ferromagnetic or light reflective material, did not require as much interference into the architecture of the work environment as inductive guidance, which greatly contributed to the popularisation of AGV robots. Machine vision and laser-based navigation were the next big breakthroughs. This is where the name Laser-Guided Vehicle (LGV) comes from. Using this technology, the robot scans the surroundings and possible routes during its first journey and creates a digital map of the area. Once implemented, the map is a reference guide for the robot. It compares the current state of the environment with the digital counterpart, which enables it to distinguish between permanent obstacles (storage shelves, pillars, walls, etc.) and temporary obstructions (e.g. an abandoned loaded pallet, etc.). Thanks to the use of laser scanners, AGV robots could be 'unleashed' – physical guidance systems became superfluous.

AGV robots, if equipped with the appropriate software, can independently make decisions about the best route to take, but also assess whether a given obstacle is temporary (e.g. a forklift operated by a person) and passage will be possible shortly, or whether it is better to choose a new route to the collection and delivery point. If the AGV truly possesses such capabilities, then it fully deserves to be called an AMR. An example of Autonomous Mobile Robots, transport trolleys with actual autonomy, are the VERSABOT 500 and VERSABOT 1000.

Unit load vehicles, tugs and forklifts

Apart from a division based on intelligence and autonomy, AMRs also represent several different functional classes. As mentioned above, the first AGV trolley was a tug, representing the category of towing vehicles. These types of trolleys or trucks are designed to move loads on mobile platforms. An interesting class of AGV robots are the so-called fork vehicles, i.e. autonomous forklifts, that enable horizontal transport, but also collection and delivery of loads to the higher shelves of storage racks.

The aforementioned VERSABOT 500 and VERSABOT 1000 belong to the currently most popular class of AGVs in the industry – unit load vehicles. They are very easy to spot – low platforms equipped with a load collection mechanism. The items to be transported are either on a pallet or a specially adapted cart on wheels – the robot moves under the cart, attaches to it from below, and begins the delivery.

AMRs are the future

To sum up this analysis, it can be assumed that Automated Guided Vehicle (AGV) is the broadest category that encompasses all automated trolleys (mobile robots) used for internal transport in warehouses and production facilities. Autonomous Mobile Robots (AMRs), also called Autonomous Intelligent Vehicles (AIVs) or Self-Guided Vehicles (SGVs), are the most important subcategory of AGVs. Mobile robots that use inductive or reflective guidance systems are still present in warehouses and factories. However, at present, the market is dominated by robots that navigate using digital maps of the premises.

The choice of a specific AMR model should be based on an analysis of implementation possibilities in a given work environment. When it comes to the design of the machines themselves, their navigation systems or lift capacity, there are very few differences between what the AMR manufacturers have to offer. The key issue is the efficient management of the robot fleet. The actual advantages of using AMRs depend on the system's capabilities, including its optimisation potential.

3) Fill in the blanks with the appropriate words from the text:

1) The ____________ of AGV robots was a navigation system capable of working inside warehouses and production facilities.
2) The AGV trolley at the U.S. Barrett Electronics facility had ____________ autonomy as it moved along a live wire.
3) The ____________ of AGV robots led to the popularization of adhesive tapes as guides.
4) Laser scanners enabled AGV robots to navigate without the need for ____________ guidance systems.
5) AGV robots can make decisions about the best route to take and assess whether an obstacle is ____________ or permanent.

4) Choose the correct synonym or antonym for some of the words from the text above:

Overabundance

a) Excess
b) Scarcity
c) Shortage
d) Deficiency

Autonomy

a) Dependence
b) Liberty
c) Sovereignty
d) Reliance

Optimisation

a) Enhancement
b) Deterioration
c) Decline
d) Disruption

Implementation

a) Execution
b) Abandonment
c) Termination
d) Withdrawal

Distinguish

a) Differentiate
b) Associate
c) Identify
d) Merge

4 Static electricity

How do identical materials behave after having been rubbed? What is static electricity?

Which forces are produced during the process of rubbing?

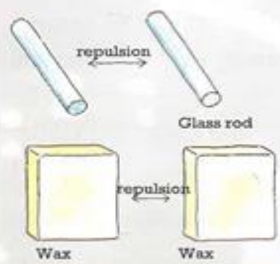
1) **Read the text and put it in the right order. Then check your answers from the questions above.**

Some experimenters speculated that invisible "fluids" were being transferred from one object to another during the process of rubbing, and that these "fluids" were able to create and influence a physical force over a distance. Charles Dufay was one of these early experimenters who demonstrated that there were definitely two different types of changes resulting from rubbing certain pairs of objects together. The fact that there was more than one type of change in these materials was evident because there were two types of forces produced: **attraction** and **repulsion**. The hypothetical fluid transfer became known as a **charge**.

The result of an imbalance of this "fluid" (electrons) between objects is called **static electricity**. It is called "static" because the displaced electrons tend to remain stationary after being moved from one material to another. Further experimentation with wax and wool led to the discovery that electrons in the wool were actually transferred to the atoms in the wax. Consequently, an object whose atoms have received a surplus of electrons is said to be **negatively** charged, while an object whose atoms are lacking electrons is said to be **positively** charged.

Glass and silk are not the only materials that are known to behave in this way. Anyone who has ever brushed up against a latex balloon only to find that it tries to stick to them has experienced this same phenomenon. Another pair of materials early experimenters recognized as possessing visible attractive forces after being rubbed together is paraffin wax and wool cloth.

This phenomenon became even more interesting when it was discovered that identical materials, after having been rubbed with their respective cloths, always repelled each other:



Centuries ago it was discovered that certain types of materials mysteriously attracted one another after being rubbed together. For example: after rubbing a piece of silk against a piece of glass, the silk and glass would tend to stick together. Not only that, but an attractive force could be seen even when the two materials were separated:

Much later, it was discovered that this "fluid" was actually composed of extremely small bits of matter called **electrons**, named in honor of the ancient Greek word for amber - another material that exhibits **charge** when rubbed with cloth. Experimentation has since revealed that all objects are made up of extremely small "building-blocks" known as **atoms**, and that these atoms are in turn composed of smaller components known as **particles**. The three fundamental particles in atoms are called **protons**, **neutrons**, and **electrons**.

Furthermore, it was found that any material manifesting properties of attraction or repulsion after being rubbed could be classed into one of two distinct categories: attracted to glass and repelled by wax, or repelled by glass and attracted to wax. It was either one or the other: there were no materials found that would be attracted to or repelled by both glass and wax, or that reacted to one without reacting to the other.

This led to more attention being directed toward the pieces of cloth used to do the rubbing. It was discovered that after rubbing two pieces of glass with two pieces of silk cloth, not only did the glass pieces repel each other, but so did the cloths. The same phenomenon held true for pieces of wool used to rub wax.

Now, this was really strange to witness. After all, none of these objects were visibly changed by the rubbing, but they still definitely behaved differently than before they were rubbed. Whatever change took place to make these materials attract or repel one another was invisible.

4.1 Static build-up in manufacturing

Static build-up is the phenomenon wherein electric charges are exchanged between the surfaces of two objects that come into contact with each other. In this process, one object takes on a positive charge and the other a negative charge. It is because of this that static electricity builds up on the surface of objects.

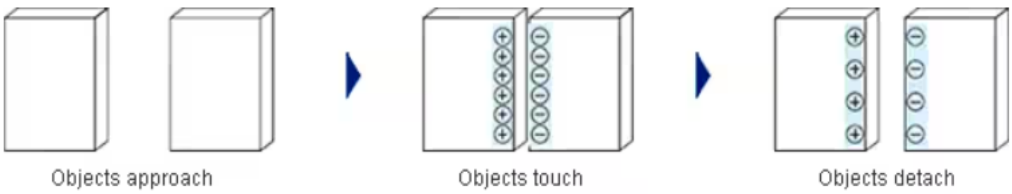
2) There are three major types of static build-up. Read the texts below and decide what the term for each type of build-up is. Choose from the following:

Frictional Static Build-up; Contact Static Build-up; Detachment Static Build-up

| ____________________ |

This is the static buildup that occurs when two objects come into contact with each other and electrons are transferred from one object to the other.

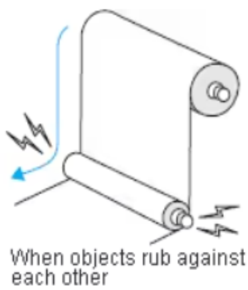
The transition of this charge is almost complete the instant contact is made.
Contact static buildup is the main cause of static electricity generated by contact and detachment.



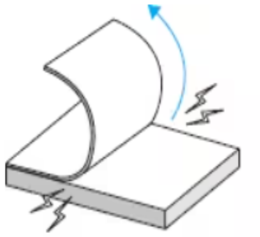
| ____________________ |

This is the static buildup created when friction occurs between two objects.
The principle behind this occurrence of static electricity is the same as that for contact static buildup. However, as the area of contact is larger, the amount of static electricity generated is greater than the amount produced by contact static build up.

Additionally, because the contact surface area increases as more force is applied, the amount of static electricity tends to increase.



This is the static buildup that occurs when items like adhesive tape and protective film are removed.
As with frictional static buildup, the principle behind this kind of static electricity is the same as that for contact static buildup.
The tape or film is in very close contact with the object so the effective contact surface is large. The amount of static electricity generated is overwhelmingly greater than that of contact static buildup.



When an attached material is removed

3) Static Electricity in Manufacturing

- **What are the causes of static electricity in manufacturing?**
- **Try to come up with 2 different examples. Work in small groups. Here are some ideas to get you started:**

Rapid heat change; Induction

5 Nanotechnology

1) Read the text and underline the verbs.

The American physicist Richard Feynman lectured, "There's Plenty of Room at the Bottom," at an American Physical Society meeting at Caltech on December 29, 1959, which is often held to have provided inspiration for the field of nanotechnology. Feynman had described a process by which the ability to manipulate individual atoms and molecules might be developed, using one set of precise tools to build and operate another proportionally smaller set, so on down to the needed scale. In the course of this, he noted, scaling issues would arise from the changing magnitude of various physical phenomena: gravity would become less important, surface tension and Van der Waals attraction would become more important.

There are **four past tense forms** in English:

Past simple	I worked
Past continuous	I was working
Past perfect	I had worked
Past perfect continuous	I had been working

VERB FORM

PAST SIMPLE (regular v.)

I/you/we/they worked
He/she/it worked

I/you/we/they did not work (didn't)
He/she/it did not work (didn't)

Did I/you/we/they work?
Did he/she/it work?

PAST CONTINUOUS

I was working
you/we/they were working
he/she it/ was working

I was not (wasn't) working
You/we/they were not (weren't) working
He/she/it was not (wasn't) working

Was I working?
Were you/we/they working?
Was he/she/it working?

TYPICAL TIME EXPRESSIONS

yesterday, this morning/evening, last week/year, a week/month ago, that day/afternoon, the other day/week, at eleven o'clock, on Tuesday, in 2006, once, then next, etc.

2) **Read the following text on nanotechnology and put the verb into the correct past tense form.**

Nanotechnology has revolutionized various fields of science and technology. In the past, scientists ____________________ (conduct) extensive research to understand the potential applications of nanotechnology. They ____________________ (discover) that by manipulating matter at the atomic and molecular level, they could create materials and devices with unique properties.

In the early days of nanotechnology, researchers ____________________ (focus) on developing new methods and tools. They ____________________ (work) tirelessly in laboratories, conducting experiments and analyzing data. Scientists across the globe ____________________ (collaborate) on groundbreaking projects, sharing their findings and pushing the boundaries of knowledge.

During that time, nanomaterials ____________________ (begin) to gain recognition. Scientists ____________________ (synthesize) nanoparticles and nanocomposites with remarkable properties. These materials ____________________ (show) great promise in areas such as electronics, medicine, and energy storage. Researchers ____________________ (work) meticulously, studying the behaviour of these materials under different conditions.

While scientists ____________________ (explore) the potential of nanotechnology, industries ____________________ (start) to show interest. Companies ____________________ (invest) heavily in research and development to harness the benefits of nanomaterials. They ____________________ (employ) skilled engineers and scientists to further advance nanotechnology applications.

3) **Now continue with the second half of the text. Use the past continuous tense.**

In 2010, researchers ____________________ (investigate) the potential use of nanomaterials in solar cells. They ____________________ (explore) ways to enhance the efficiency of solar energy conversion. Scientists ____________________ (experiment) with different nanoscale materials, testing their conductivity and absorption properties.

Meanwhile, in the field of medicine, scientists ___________________ (develop) drug delivery systems using nanoparticles. They ___________________ (conduct) trials to understand how these nanoparticles interacted with the human body. Researchers __________________________ (carefully monitor) the release of drugs from the nanoparticles and studying their effectiveness in treating various diseases.

In conclusion, nanotechnology has come a long way since its inception. Scientists and industries have made significant strides in utilizing nanomaterials for various applications.

4) Underline the correct alternative.

Nanotechnology has had a significant impact on the field of medicine. Researchers (1) **were developing/were developed** innovative techniques to improve patient care. One area of focus (2) **was/was being** the development of nanoscale drug delivery systems.

In the past, scientists (3) **conducted/were conducting** extensive research to understand the potential applications of nanotechnology. They (4) **synthesized/were synthesizing** nanoparticles with unique properties. Meanwhile, doctors (5) **tested/were testing** these nanoparticles for targeted drug delivery.

During the testing phase, the researchers (6) **analyzed/were analyzing** the effectiveness of the drug delivery system. They (7) **measured/were measuring** the release of drugs from the nanoparticles and (8) **monitored/were monitoring** their behavior in the body. At the same time, patients (9) **received/were receiving** treatment with these nanoscale drug delivery systems.

In recent years, advancements in nanotechnology (10) **led/were leading** to improved treatments. Scientists (11) **developed/were developing** new nanosensors for disease detection. These nanosensors (12) **detected/were detecting** early signs of diseases, enabling prompt intervention.

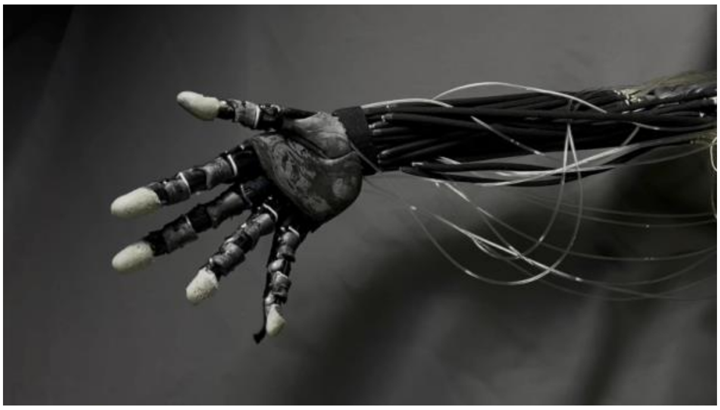
In conclusion, nanotechnology (13) **revolutionized/was revolutionizing** the field of medicine. Researchers (14) **made/were making** significant progress in developing nanoscale drug delivery systems and nanosensors. The use of nanotechnology in medicine (15) **improved/was improving** patient outcomes and (16) **opened/was opening** new possibilities for disease detection and treatment.

5) Now look back at this unit and try to answer the following questions.

A. What initial focus did researchers have in the early days of nanotechnology?

B. How did industries react to the advancements in nanotechnology?

C. What were researchers investigating in 2010 regarding solar cells?



6 Artificial muscles

Artificial muscle systems represent a crucial area of innovation in mechatronics, offering biomimetic solutions for motion and force generation. As research progresses and technology advances, these systems hold the promise of revolutionizing robotics and prosthetics, paving the way for a future where machines more closely resemble their biological counterparts.

1) Think about the following questions regarding artificial muscles.

- As artificial muscle muscles become more advanced, what ethical considerations arise in terms of their use in enhancing human capabilities or replacing human labor?
- Can you think of any environmental impacts of developing and using artificial muscle systems? How can engineers design these systems to be more sustainable?
- What are some advancements artificial muscles might bring along? Compare a world with and without artificial muscle systems.

VERB FORM

PRESENT PERFECT	PAST PERFECT	FUTURE PERFECT
I/you/we/they have worked He/she/it has worked	I had worked you/we/they had worked he/she it/ had worked	I will[2] have worked you/we/they will have worked he/she it/ will have worked
I/you/we/they have not (haven't)worked He/she/it has not (hasn't) worked	I had not (hadn't) worked You/we/they had not (hadn't) worked He/she/it had not (hadn't) worked	I will not have (won't) worked You/we/they will not have (won't) worked He/she/it will not have (won't) worked
Have I/you/we/they worked? Has he/she/it worked?	Had I/ you/we/they worked? Had he/she/it worked?	Will I/ you/we/they have worked? Will he/she/it have worked?

TYPICAL TIME EXPRESSIONS

since, yet, never, always, so far, many times, lately, recently, already, by (the time), before, etc.

[2] 'will' and 'going to' can be used interchangeably with only a minor difference in meaning.

2) **Read the text on artificial muscles and fill in the blanks using the Present Perfect tense.**

Artificial muscles developed through nanotechnology ________________ (revolutionise) the field of robotics and prosthetics. Scientists ________________ (make) significant progress in creating highly functional and flexible materials. They ________________ (work) tirelessly to harness the potential of nanomaterials for constructing artificial muscles.

Researchers ________________ (utilise) nanofibers and nanocomposites to fabricate artificial muscles with exceptional strength and resilience. These materials ________________ (demonstrate) the ability to contract and expand in response to electrical stimulation, mimicking natural muscle movements.

The development of artificial muscles ________________ (be) an ongoing process. Scientists ________________ (conduct) numerous experiments to optimize the performance of these materials. They ________________ (explore) different combinations of nanomaterials and studied their mechanical properties.

In recent years, researchers ________________ (achieve) breakthroughs in enhancing the controllability and response time of artificial muscles. They ________________ (employ) advanced manufacturing techniques and incorporated nanoscale sensors to provide real-time feedback for precise control.

The advancements in artificial muscle technology ________________ (pave) the way for innovative applications. Prosthetic limbs equipped with nanotechnology-based artificial muscles offer improved mobility and functionality for individuals with limb loss. Additionally, robotic systems integrated with these artificial muscles ________________ (become) more agile and capable of performing intricate tasks.

3) **Fill in the blanks with the appropriate form of the Past Perfect tense of the verbs given in brackets**.

1) The researchers ________ (conduct) extensive experiments before they published their findings.
2) By the time the team arrived at the conference, other scientists ________ (already/ present) their research.
3) Before the breakthrough, the engineers ________ (work) on artificial muscle prototypes for several months.

4) The scientists _________ (discover) that nanomaterials had been used in previous studies on artificial muscles.

5) By the end of the year, the researchers _________ (achieve) remarkable progress in enhancing the performance of artificial muscles.

4) Rewrite the sentences using the Past Perfect tense.

a) The scientists published their findings after they conducted extensive experiments.

____

b) The team arrived at the conference. Other scientists had already presented their research.

____

c) The engineers had worked on artificial muscle prototypes for several months before the breakthrough.

____

d) The researchers found that nanomaterials had been used in previous studies on artificial muscles.

____

e) The researchers achieved remarkable progress in enhancing the performance of artificial muscles by the end of the year.

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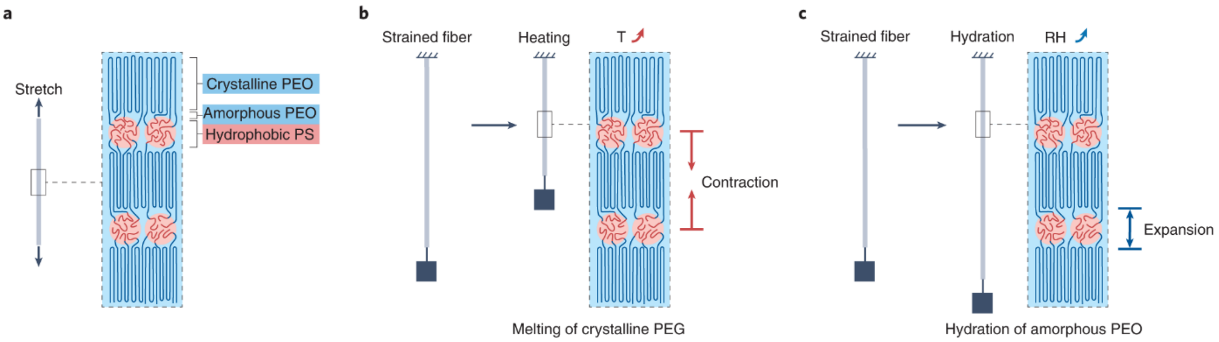

7 Codes and Standards in Engineering

1) Read the text on standards and fill in the blanks with the right tense.

What (1) ________________ (be) the first concern of any engineer? At one time, perhaps, the answer to this question (2) ________________ (be): to solve a problem or to improve an existing machine, or even to make more money. Nowadays, however, the answer (3) ________________ (be) simple. The first concern (4) ________________ (be) safety. This concern (5) ________________ (lead) to the introduction of worldwide codes and standards for the manufacture and maintenance of machines.

Machinery of all kinds (6) ________________ (certainly/ make) the world a more dangerous place. Hundreds of people are at risk from the crash of a jumbo jet, or the explosion of a power station. At one time, of course, engineers (7) ________________ (not/ know) how to make a chine safe. But a they (8) ________________ (begin) to understand the science behind the behaviour of metals and other materials, engineers (9) ________________ (start) to construct codes of manufacturing and standards to which machines (10) ________________ (must) be built.

The steam engine (11) ________________ (be) one of the first machines which (12) ________________ (arise) interest in safety standards. The danger of steam under pressure was recognized very early in the history of the machine. Denis Papin, a French mathematician, (13) ________________ (design) the first safety valve for boilers in 1679. But safety valves sometimes (14) ____________________ (fail) and explosions (15) ________________ (be) quite common.

The steam engine (16) ________________ (work) on a very simple scientific principle. When you (17) ________________ (heat) water in a vessel, the molecules (18) ________________ (expand), until, at a certain temperature, the liquid (19) ________________ (turn) into a gas. This gas (20) ________________ (need) a greater space than the same volume of liquid. If the Bessel is sealed, the gas (21) ________________ (not/ can) occupy a greater volume, so the pressure (22) ________________ (increase).

At first, engineers (23) ________________ (try) to avoid the problem by only working with low-pressure steam. The first practical low-pressure engine was built in 1712 by Thomas Newcomen, an English inventor. It was used to pump water out of a coal mine. The invention (24) ________________ (help) to spark the Industrial Revolution, the time of fast progress in mechanization of agriculture and the textile industry.

James Watt (25) ________________ (improve) the efficiency of the engine. His first patent, in 1769, (26) ________________ (include) oil lubrication, and insulation of the cylinder to maintain the high temperature needed for efficient operation. Further improvements were made in the 1830s by a man called Jacob Perkins. His boiler (27) ________________ (can) produce 1,400 pounds per square inch (psi). The normal pressure of the air around us, atmospheric pressure, is 14,7 psi.

However, as the boilers (28) ________________ (use) higher temperatures and developed higher pressures, the dangers (29) ________________ (rise). In 1854, an explosion in England (30) ________________ (kill) ten people. ON 30th July, 1870, the boiler of the Staten Island ferry in New York City (31) ________________ (explode), killing 62 people. It (32) ________________ (be) time for mechanical engineers to act.

In 1882, a new law on boiler safety was passed in the UK. As a result, the number of deaths from boiler accidents (33) ________________ (fall) from 35 in 1883 to 14 in 1905. However, there (34) ________________ (be) no similar legislation in the United States and 383 people (35) ________________ (die) in the same period. Finally, in 1914, the American Society of Mechanical Engineers (ASME) (36) ________________ (produce) the Boiler Safety Code.

The boiler code (37) ________________ (be) only the start. Over the next 80 years, the ASME (38) ________________ (produce) codes in all areas of mechanical engineering, including safety standards for cranes, industrial ladders, elevators, machinery shafts, liquid fuels and incinerators for hazardous medical waste.

Codes and standards in engineering (39) ________________ (be) often unknown to the general public. However, they (40) ________________ (be) fundamental to the safety of manufactured products and they (41) ________________ (lead) to a safer world.

2) Read the text again and try to answer the following questions.

1. What do you understand by the term *codes and standards*?
2. Think of good research questions before you re-read the text. Have those questions been answered in the text?
3. Highlight the topic sentences for each paragraph. What will you find in the rest of the paragraph?

3) Write a short summary (<u>150 words</u>) of the text on Codes and Standards. Pay attention to the verb tense. Work in pairs, if necessary.

____

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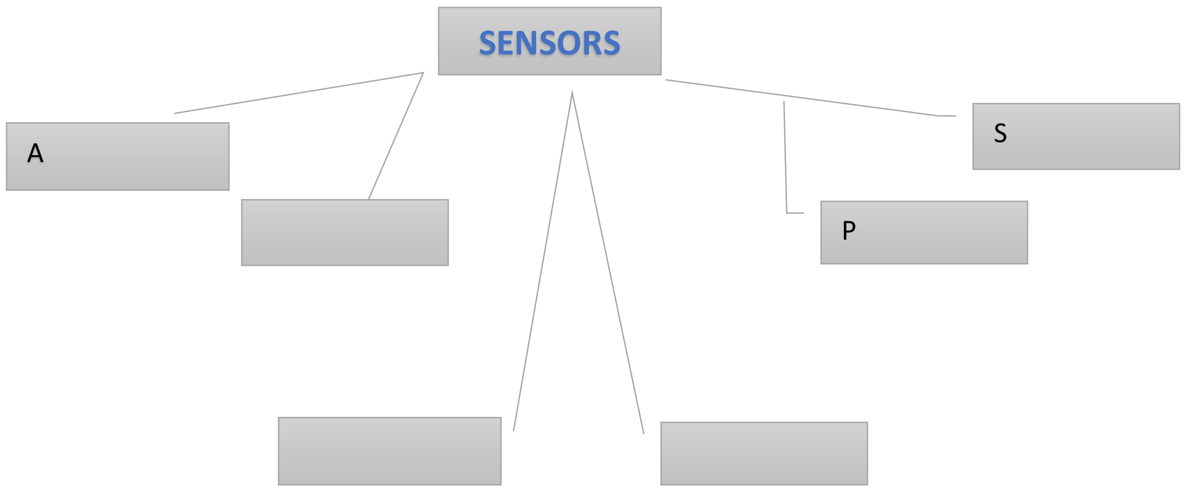
8 Sensors in Mechatronics

1) How do you classify sensors in Mechatronics? Can you think of the different types? The first letter to some of those is already given.



2) Check your diagram with another student. Then, listen to the short extract of a lecture on sensors. (Note, the lecturer is a foreign speaker)

3) Now listen again and try to answer the following questions:

a. According to the video, what is the significance of UC activation?

b. What is mentioned about the location of job placement?

c. What does the video suggest about the role of producers and directors?

4) Complete the following sentences using the present continuous tense to talk about future plans and arrangements. Do not repeat verbs.

conduct; explore; have; showcase; organize

a) The engineering team ________________ a workshop on sensor calibration next week.

b) Our company ________________ a new sensor prototype at the upcoming tech exhibition.

c) Currently, the technicians ________________ the latest advancements in sensor technology.

d) I ________________ a conference call with sensor suppliers tomorrow morning.

e) The research and development department ________________ a series of experiments with different sensors this month.

5) Use the present simple tense to fill in the blanks with scheduled events. Do not repeat verbs.

arrive; complete; happen; occur; take place

a) The seminar on "Introduction to Sensors" ___________________ on August 15th.

b) The factory tour ___________________ every Friday at 3 PM.

c) The guest speaker from XYZ Sensors Inc. ___________________ next week.

d) Our team ___________________ the final sensor testing phase on September 10th.

e) The annual conference on mechatronics ___________________ in October.

6) Fill in the gaps with the verbs in brackets. Use the correct present tense.

Advancing Encoders in Mechatronics: A Glimpse into the Future

In the world of mechatronics, encoders play a crucial role in converting mechanical motion into electrical signals. As technology continues to advance rapidly, the future of encoders _______________ (become) even more promising, with significant developments and applications on the horizon.

Currently, engineers and researchers _______________ (explore) innovative ways to enhance encoder technology. They _______________ (develop) encoders with higher precision and accuracy to meet the ever-increasing demands of industries like robotics, automation, and manufacturing. As we _______________ (speak), several companies _______________ (invest) in research and development projects focused on improving encoder resolution and reducing signal noise.

Moreover, the ongoing collaboration between mechatronics experts and software developers _______________ (lead) to the creation of smart encoders. These encoders will be equipped with built-in processors and advanced algorithms, allowing them to process data in real-time. This development _______________ (open up) new possibilities for real-time motion control and predictive maintenance in mechatronic systems. In the near future, we will see smart encoders being integrated into various applications, from precision manufacturing machines to autonomous vehicles.

Additionally, the application of encoders _______________ (expand) beyond traditional industries. With the rise of wearable devices and the Internet of Things (IoT), encoders are being utilized in novel ways. Researchers _______________ (work/currently) on miniature encoders that can provide accurate motion tracking for wearable health devices and virtual reality applications.

Looking ahead, the demand for encoders will continue to soar, driven by the increasing automation and digitalization of industries. Companies _______________ (schedule) workshops and conferences to discuss and explore the latest advancements in encoder technology and its potential applications. Engineers _______________ (participate/ actively) in these events to stay up-to-date with the latest trends and to develop innovative solutions for future challenges.

8.1 BionicANTs

7) Fill in the gaps with the words in brackets to express future using *will*.

a) The research team __________________ (integrate) artificial intelligence into BionicANTs to enhance their autonomous capabilities.

b) In the coming months, scientists __________________ (study) swarm behaviour in BionicANTs to optimize their collective decision-making processes.

c) To increase their versatility, BionicANTs __________________ (feature) modular components that can be easily replaced and upgraded.

d) The company __________________ (invest) in extensive field-testing to validate the reliability of BionicANTs in real-world scenarios.

e) By the end of the decade, BionicANTs __________________ (play) a crucial role in tasks such as search and rescue operations.

f) Engineers __________________ (work) on miniaturizing components to reduce the overall weight and size of BionicANTs.

g) The team __________________ (focus) on improving the communication protocols among BionicANTs for better coordination.

h) Researchers __________________ (explore) biomimicry further to enhance BionicANTs' adaptability to different terrains.

8) Now fill in the gaps again, but this time to express future using *be going to*.

a) The research team has identified key areas for improvement, and they ______________ (implement) changes in BionicANTs' design.
b) By 2025, engineers ______________ (conduct) field tests in challenging conditions to evaluate the performance of BionicANTs.
c) The company ______________ (collaborate) with industry partners to accelerate the adoption of BionicANTs in practical applications.
d) In the near future, BionicANTs ______________ (revolutionize) the monitoring of industrial facilities for maintenance and safety purposes.
e) Scientists ______________ (study) the behaviour of real ants in depth to further enhance the swarm intelligence of BionicANTs.
f) By the end of the project, BionicANTs ______________ (be capable) of seamlessly interacting with other robotic systems in complex operations.
g) Next year, BionicANTs ______________ (be commercially available) for various industries, ranging from construction to environmental monitoring.
h) The company ______________ (actively promote) the educational aspects of BionicANTs to inspire future generations of engineers and researchers.

9) Fill in the gaps in the following text. Each paragraph has a specific future tense. Decide which verb and tense to use.

***verbs**: integrate, enable, play*

Researchers believe that BionicANTs ____________ a pivotal role in multiple domains. By 2030, engineers ____________ artificial intelligence, allowing BionicANTs to make autonomous decisions and adapt to dynamic environments efficiently. The swarm intelligence algorithms ____________ them to communicate seamlessly, enhancing their collaborative efforts in tasks like environmental monitoring and search and rescue operations.

***verbs**: collaborate, harness, focus*

In the near future, scientists ____________ on optimizing the energy efficiency of BionicANTs. By 2025, they ____________ solar energy to power the robots, reducing their reliance on traditional batteries and extending their operational duration significantly. Moreover, the research team ____________ with various industries, intending to deploy BionicANTs in logistics and precision agriculture applications.

***verbs**: refine/continuously, develop, conduct/also*

The company's commitment to innovation is evident in its ongoing efforts. In the coming months, engineers ________________________ more compact and lightweight components for BionicANTs. They ________________________ extensive field tests to evaluate the robots' performance in extreme weather conditions and challenging terrains. Throughout this process, the team ______________________ the robots' capabilities.

***verbs**: undergo, perfect, integrate, achieve, study*

By 2035, BionicANTs ____________________ remarkable transformations. Researchers ______________________ real ants' behaviors and _____________________ these insights into the swarm intelligence algorithms, making BionicANTs more adaptable and responsive. Engineers _____________________ their construction materials and ____________________ a high level of durability and resilience, ensuring their efficiency in demanding operations.

9 Grammar reference

9.1 Nouns

The English language has countable and uncountable nouns. Compare:

Countable (*things we **can** count)*	Uncountable (*things we **cannot** count)*
I eat **a banana** every day. I like **bananas**. We don't have enough **cups**. ***How many*** bananas do you have?	I eat **rice** every day. I like **rice.** We don't have enough **water**. ***How much*** rice is there?

9.1.1 Countable nouns

Countable nouns refer to things, concepts or living creatures we can count. Thus, those nouns may have a singular or a plural form. In order to form a **plural** noun, you will have to follow these rules:

1) with regular nouns just add -s to the end
    a. *member -> members; room -> rooms; street -> streets*
2) should the singular noun end in **–s, –ss, –sh, –ch, –x,** or **–z**, add **-es** to the end
    a. *bus -> bus**es**; lunch -> lunch**es**; tax -> tax**es***
3) some nouns ending in **-s** or **-z** may require doubling that consonant before adding **-es**.
    a. *quiz -> qui**zzes**; gas -> ga**sses***
4) nouns ending with *-f* or *-fe* change these letters to *-ve* before adding the *-s.*
    a. *wife -> wi**ves**; wolf -> wol**ves***
    b. EXCEPTIONS: roofs, beliefs, chefs, chiefs
5) with singular nouns that end in consonant + *y*, the *-y* changes to *-ie* before adding the *-s*
    a. *battery -> batter**ies***
6) if the noun ends in a vowel + *y*, simply add the *-s*
    a. *boy -> bo**ys***
7) if the noun ends in *-o*, add *-es* to form plural nouns
    a. *potato -> potat**oes***
    b. EXCEPTION: photos, pianos, halos,
8) if the singular ends in *-us*, the plural ending is usually *-i*
    a. *focus ->foc**i***
9) if the noun ends in *-is*, the plural ending is frequently *-es*
    a. *analysis -> analys**es***
10) if the noun ends in *-on*, the plural ending is *-a*
    a. *criterion -> criteri**a***
11) some nouns do not change when they are pluralized!
    a. *sheep, species, deer.*
12) IRREGULAR NOUNS follow no specific rules.
    a. *child -> children; tooth -> teeth; mouse -> mice*

Some nouns end in **-ics** but are not usually plural. For example: athletics, mathematics, mechatronics, physics, electronics, economics.

*Mechatronics **is** a high-tech field.*

News is not plural.

*What time **is** the news on television?*

Some words ending in **-s** can be singular or plural. Compare:

a **means** of transportation	many **means** of transport
a television **series**	two television **series**
a **species** of bird	200 **species** of bird

We think of a sum of money, a period of time, a distance etc. as one thing. Therefore, we use a singular verb:

***Twenty thousand pounds** (=it) was stolen in the robbery.*
***Three years** is a long time to be without a job.*
***Six miles** is a long way to walk every day.*

9.1.2 Uncountable nouns

Uncountable nouns are usually nouns that refer to an idea, a concept or any sort of system that we cannot necessarily divide into elements without changing its meaning. Note that in some languages those nouns may be countable. For example:

news; advice; information

music; art; love; happiness;

furniture; luggage

rice; sugar; butter; water

electricity; gas; power

money; currency

Uncountable nouns can be divided into **abstract**, **concrete** or **collective** nouns. Have a look:

- **abstract noun**: The **advice** Greg received from his father helped him tremendously.
- **concrete noun**: The price of **oil** continues to increase.
- **collective noun**: When will the **food** be ready?

Look at the following sentences and the nouns in bold. Which ones are abstract nouns, which ones are concrete nouns and which ones are collective nouns?

a) Could you please fill the shaker with **salt**?
b) The **air** felt thick after the thunderstorm.
c) Mary listed all of the key facts of the **investigation**.
d) Betty felt that **love** was in the air.
e) Help yourself to the **food** in the refrigerator.
f) Sarah enjoys eating **fruit** for breakfast.
g) After a dry summer, there is less **water** in the pond.
h) They all thought Alex was a true **patriot**.
i) The **government** declared today was a national holiday.

Note that collective uncountable nouns can refer to either the group as a whole, or the individuals within the group. Thus, we use either a singular or a plural verb depending on where the focus is.

*The **council** has/have postponed a decision on the new road.*

However, there are cases where we have to use a singular or a plural form of the verb:

The committee usually **raise** their hands to vote 'Yes'. (~~raises~~)	The action is conducted by individuals rather than the group (committee) as a whole.
The school **is** to close next year (~~are~~)	The subject is the school as a building or institution, not the individuals in the school.

Many nouns can be used as both, countable and uncountable nouns, sometimes with a change in meaning.

Compare and jot down the difference in meaning.

Countable	*Uncountable*
There is **some juice** on the table. ____________________	There are **some juices** on the table. ____________________
I had **a good time** at the party. ____________________	I don't have **time** to do the work. ____________________
The nation's fuel **supplies** will not last forever. ____________________	The government will boost **the supply** of sustainable alternatives. ____________________
Industries exploit the technologies developed by **universities.** ____________________	It's very common to go to **university** after secondary school. ____________________

9.1.3 Agreement between subject and verb

A singular subject is followed by a singular verb, and a plural subject is followed by a plural verb.

Mechatronics *<u>is</u> a high-tech field.*
*As **more businesses** <u>advance</u> their technologies, mechatronics engineering will continue to grow in demand.*

If the subject is a noun phrase, the verb agrees with the main noun in the subject.

*Even **manufacturing <u>businesses</u> considering a technology upgrade** <u>turn</u> to mechatronics engineers in order to evaluate assembly line efficiency and costs.*

The only <u>assistance</u> required in mechatronics *<u>is</u> the design of robotic and intelligent equipment.*

If the subject is a clause, we usually use a singular verb:

Having overall responsibility for the course <u>means</u> that I have a lot of meetings.

However, if we use a **what-**clause as a subject, the verb agrees with the following main noun. Compare:

What a mechatronics degree from PennWest California will prepare you for *<u>is</u> a **career** as a mechatronics engineering technologist in a vast array of industries.*
What is needed *<u>are</u> additional **resources**. (*or more colloquially *is)*

9.2 Perfect tenses

The English Perfect tenses are all used to make connections in time for actions that are completed. Here are examples of verbs in the perfect tense.

- The Present Perfect Tense

  *The researchers **have made** a great discovery.*

- The Past Perfect Tense

  *The company was sure that competing researchers **had made** a great discovery.*

- The Future Perfect Tense

  *By the time this discovery goes public, the company **will have made** their own breakthrough.*

To form a perfect tense, we use the auxiliary verb *to have* and the past participle of the verb.

9.3 Past tenses

The past tense in English is used:

- to talk about the past
- to talk about hypotheses (when we imagine something)
- for politeness

When talking about the past, we use the past tense to talk about:

- something that happened once in the past:

*I **met** my wife in 2002.*

*The scientists **created** a new type of solar panel.*

*The scientists **discovered** a novel method to extract energy from waste materials, revolutionizing the field of renewable energy.*

- something that happened several times in the past:

*When I **was** a boy, I walked a mile to school every day.*

*The production line **underwent** regular inspections to ensure consistent quality standards were maintained.*

*The software developers **conducted** multiple software updates to address known issues and enhance the system's performance.*

- something that was true for some time in the past:

*I **lived** abroad for ten years.*

*During the testing phase, the prototype **exhibited** intermittent functionality issues that were later resolved through iterative improvements.*

*In the earlier stages of production, the manufacturing plant **experienced** occasional fluctuations in output due to equipment malfunctions.*

- we often use expressions with ago with the past simple:

*They **discovered** penicillin a long time ago.*

9.4 Future tenses

When we **know about the future** we usually use the present tense:

- **Present simple** for something scheduled:

The meeting starts at 4pm.

- **Present continuous** for plans and arrangements:

*They **are having** a meeting later tonight to discuss the issues on the project.*
*The client **is leaving** first thing in the morning.*

- We use ***will***:
  - when we express beliefs about the future:

*The project **will be** a success.*
*I think the two-step method **will disperse** nanoparticles.*

  - to mean *want to* or *be willing to*:

*I hope the high costs **won't discourage** our client.*
*George says they **will join** our research team.*

  - to make offers and promises:

*I'**ll see** you tomorrow.*
*We'**ll send** you an email.*

  - to talk about offers and promises:

*Tim **will be** at the meeting.*
*They **will help** with data processing.*

- We use ***be going to***:
  - to talk about plans or intentions:

*I'**m going to drive** to work today.*
*They **are going to move** the Research Center on-site.*

  - to make predictions based on evidence we can see:

Be careful! You are going to fall. (= I can see that you might fall.)
Look at those black clouds. I think it's going to rain. (= I can see that it will rain.)

10 Glossary

Word		Pronunciation	Definition	Example sentence
absorption	n	/əbˈzɔːpʃn/	the process of a liquid, gas or other substance being taken in	*Vitamin D is necessary to aid the **absorption** of calcium from food.*
accelerate	v	/əkˈseləreɪt/	to happen faster or earlier; to make something happen faster or earlier	*Inflation continues to **accelerate**.*
accessible	adj	/əkˈsesəbl/	that can be reached, entered, used, seen, etc.	*These documents are not **accessible** to the public*
accreditation	n	/əˌkredɪˈteɪʃn/	official approval given by an organization stating that somebody/something has achieved a required standard	*Industry-driven **accreditation** serves the interests of industry and may not ensure unbiased or comprehensive regulation.*
accuracy	n	/ˈækjərəsi/	the state of being exact or correct; the ability to do something with skill and without making mistakes	*They questioned the **accuracy** of the information in the file*
acid	n	/ˈæsɪd/	a chemical, usually a liquid, that contains hydrogen and has a pH of less than seven	*The **acid** burned a hole in her coat.*
acquire	v	/əˈkwaɪə/	to gain something by your own efforts, ability or behaviour, to buy something	*She has **acquired** a good knowledge of English.*
adapt	v	/əˈdæpt/	to change something in order to make it suitable for a new use or situation	*We need technology that can be **adapted** to suit the needs of the future.*
adhesive	n	/ədˈhiːsɪv/	a substance that you use to make things stick together	*Use a good waterproof **adhesive** in addition to the screws.*
advance	n	/ədˈvɑːns/	progress or a development in a particular activity or area of understanding	*Recent **advances** in technology have made the procedure safe.*
alloy	n	/ˈælɔɪ/	a metal that is formed by mixing two types of metal together, or by mixing metal with another substance	*Brass is an **alloy** of copper and zinc.*
alteration	n	/ˌɔːltəˈreɪʃn/	a change to something that makes it different	*They are making some **alterations** to the house.*
ample	adj	/ˈæmpl/	enough or more than enough	*There was **ample** time to get to the airport.*
anode	n	/ˈænəʊd/	the electrode in an electrical device where oxidation occurs; the positive electrode in an electrolytic cell and the negative electrode in a battery	*This figure shows the beam divergence angle along the **anode** radius.*
appliance	n	/əˈplaɪəns/	a machine that is designed to do a particular thing in the home, such as preparing food, heating or cleaning	*Always switch off **appliances** that are not in use.*
application	n	/ˌæplɪˈkeɪʃn/	the practical use of something, especially a theory, discovery, etc.	*The invention would have a wide range of **applications** in industry.*
			an act of putting or spreading something, such as paint or medical creams, onto something else	*It took three **applications** of paint to cover the graffiti.*
array	n	/əˈreɪ/	a group or collection of things or people, often one that is large or impressive	*They sat before an **array** of microphones and cameras.*
assess	v	/əˈses/	to make a judgement about the nature or quality of somebody/something	*It's difficult to **assess** the effects of these changes.*
atmospheric	adj	/ˌætməsˈferɪk/	related to the earth's atmosphere	*Plants are the main source of **atmospheric** oxygen.*
atomic	adj	/əˈtɒmɪk/	relating to atoms or an atom	*Electrons and protons are **atomic** particles.*
			relating to the energy that is produced when atoms are split; related to weapons that use this energy	*At the nuclear reprocessing plant they extract plutonium from spent **atomic** fuel rods.*
automate	v	/ˈɔːtəmeɪt/	to use machines and computers instead of people to do a job or task	*The factory is now fully **automated**.*
autonomous	adj	/ɔːˈtɒnəməs/	that has the technology to drive itself without a person in control	*The company bought new **autonomous** vehicles.*
backlog	n	/ˈbæklɒg/	a quantity of work that should have been done already, but has not yet been done	*We are faced with a **backlog** of orders we can't deal with.*
battery	n	/ˈbætri/	a device that is placed inside a car engine, clock, radio, etc. and that produces the electricity that makes it work	*The bicycle even has a built-in **battery** charger for a mobile phone.*
biofuel	n	/ˈbaɪ.əʊˌfjuː.əl/	a fuel that is made from living things or their waste	*We must take care to maintain the balance between the development of*

				***biofuels** and food security, especially in these critical times.*
biomedical	adj	/ˌbaɪəʊˈmedɪkl/	relating to how biology affects medicine	*She is studying for a doctorate in **biomedical** sciences.*
biomimicry	n	/ˌbaɪ.əʊˈmɪm.ɪ.kri/	the practice of making technological and industrial design copy natural processes:	*The idea behind biomimicry is that nature has already solved the challenges that we are trying to solve.*
biotechnology	n	/ˌbaɪ.əʊ.tekˈnɒl.ə.dʒi/	the use of living things, especially cells and bacteria, in industrial processes:	*They are active in the field of **biotechnology**.*
boiler	n	/ˈbɔɪlə/	a container in which water is heated to provide hot water and heating in a building or to produce steam in an engine	*There was a gas **boiler** mounted on the far wall.*
build-up	n	/ˈbɪld ʌp/	an increase in the amount of something over a period of time	*The leak led to a slow **build-up** of carbon dioxide.*
calibrate	v	/ˈkælɪbreɪt/	to mark units of measurement on an instrument such as a thermometer so that it can be used for measuring something accurately	*Our radar was **calibrated** for 100,000 yards.*
capacity	n	/kəˈpæsəti/	the number of things or people that a container or space can hold	*The generators each have a capacity of (= can produce) 1,000 kilowatts.*
carbon	n	/ˈkɑːbən/	a chemical element	*The substance was identified as **carbon**.*
cart	n	/kɑːt/	a small vehicle with wheels that can be pushed or pulled along and is used for carrying things	*The **cart** would advance by 3 feet and then repeat the above processing.*
cathode	n	/ˈkæθəʊd/	the electrode in an electrical device where reduction occurs; the negative electrode in an electrolytic cell and the positive electrode in a battery	*The positive space charge of the ion layer near the **cathode** will shield the electric field.*
charge	n	/tʃɑːdʒ/	the amount of electricity that is put into a battery or carried by a substance	*The electron has a negative **charge**.*
circuit	n	/ˈsɜːkɪt/	the complete path of wires and equipment along which an electric current flows	*A defect was found in the electrical **circuit**.*
combustion	n	/kəmˈbʌstʃən/	the process of burning	*Poisonous gases are produced during fossil fuel **combustion**.*
compliant	adj	/kəmˈplaɪənt/	in agreement with a set of rules	*This site is HTML **compliant**.*
component	n	/kəmˈpəʊnənt/	one of several parts of which something is made	*Nitrogen is the main **component** of air.*
conduct	v	/kənˈdʌkt/	to allow heat or electricity to pass along or through it	*Copper **conducts** electricity well.*
conductivity	n	/ˌkɒndʌkˈtɪvəti/	the quality of being able to conduct electricity, heat, etc.	*Aluminium has good heat **conductivity**.*
controller	n	/kənˈtrəʊlə/	a device that controls or regulates a machine or part of a machine	*The assisted braking **controller** is integrated into the dash.*
conversion	n	/kənˈvɜːʃn/	the act or process of changing something from one form, use or system to another	*No **conversion** from analogue to digital data is needed.*
conveyor	n	/kənˈveɪə/	a continuous moving band used for transporting goods	*The products are labelled as they pass by on the **conveyor**.*
counterpart	n	/ˈkaʊntəpɑːt/	a person or thing that has the same position or function as somebody/something else in a different place or situation	*European environmentalists have their **counterparts** in the US.*
criterion	n	/kraɪˈtɪəriən/	a standard or principle by which something is judged, or with the help of which a decision is made	*She failed to meet the strict selection **criteria**.*
current	n	/ˈkʌrənt/	the flow of electricity through a wire, etc.	*Check all your wiring before switching on the **current**.*
cylinder	n	/ˈsɪlɪndə/	the hollow tube in an engine, like a cylinder in shape, inside which the piston moves	*The engine isn't firing on all its **cylinders**.*
database	n	/ˈdeɪtəbeɪs/	an organized set of data that is stored in a computer and can be looked at and used in various ways	*We're trying to create our own computerized **database**.*
detachment	n	/dɪˈtætʃmənt/	the state of not being involved in something in an emotional or personal way	*She felt a sense of **detachment** from what was going on.*
disperse	v	/dɪˈspɜːs/	to move apart and go away in different directions; to make somebody/something do this	*The crowd **dispersed** quickly.*
dispose of	v	/dɪˈspəʊz/	to get rid of somebody/something that you do not want or cannot keep	*Radioactive waste must be **disposed of** safely.*
distinguish	v	/dɪˈstɪŋgwɪʃ/	to recognize the difference between two people or things	*English law clearly **distinguishes** between murder and manslaughter.*
distribute	v	/dɪˈstrɪbjuːt/	to give things to a large number of people	*Viruses are often **distributed** via email.*

durable	adj	/ˈdjʊərəbl/	likely to last for a long time without breaking or getting weaker	*Painted steel is likely to be less **durable** than other kinds.*
effective	adj	/ɪˈfektɪv/	producing the result that is wanted or intended; producing a successful result	*The system has proved less **effective** than hoped.*
efficient	adj	/ɪˈfɪʃnt/	doing something in a good, careful and complete way with no waste of time, money or energy	*Which software is the most **efficient** at processing the data?*
electrode	n	/ɪˈlektrəʊd/	either of two points (or terminals) by which an electric current enters or leaves a battery or other electrical device	*Thus, elemental carbon was released from the **electrodes** during arcing.*
electrolyte	n	/ɪˈlektrəlaɪt/	a liquid that an electric current can pass through, especially in an electric cell or battery	*Solid-state cells differ from conventional lithium-ion batteries in their use of a glass or ceramic **electrolyte**, instead of a liquid composed of lithium salts.*
electronics	n	/ɪˌlekˈtrɒnɪks/	the use of electronic technology, especially in developing new equipment	*Their company merged with a Japanese **electronics** giant.*
electron	n	/ɪˈlektrɒn/	a very small piece of matter (= a substance) with a negative electric charge, found in all atoms	*If the free **electron** remains free after the collision, we speak of a free-free collision.*
employ	v	/ɪmˈplɔɪ/	to use something such as a skill, method, etc. for a particular purpose	*He criticized the repressive methods **employed** by the country's government.*
enhance	v	/ɪnˈhɑːns/	to increase or further improve the good quality, value or status of somebody/something	*The new initiative will **enhance** our ability to respond to threats abroad.*
extract	v	/ɪkˈstrækt/	to remove or obtain a substance from something, for example by using an industrial or a chemical process	*The Egyptians used a primitive form of distillation to **extract** the essential oils from plants.*
			to obtain information, money, etc., often by taking it from somebody who is unwilling to give it	*Journalists managed to **extract** all kinds of information about her private life.*
fabricate	v	/ˈfæbrɪkeɪt/	to make or produce goods, equipment, etc. from various different materials	*These specialized chips will be **fabricated** by Mykrokorp Inc.*
facility	n	/fəˈsɪləti/	buildings, services, equipment, etc. that are provided for a particular purpose	*Recycling **facilities** are provided.*
faulty	adj	/ˈfɔːlti/	not perfect; not working or made correctly	*The accident was caused by a **faulty** signal.*
ferromagnetic	adj	/ˌferəʊmægˈnetɪk/	having the kind of magnetism that iron has	*We mention that in **ferromagnetic** materials the permeability depends on the magnetic induction.*
fleet	n	/fliːt/	a group of planes, buses, taxis, etc. travelling together or owned by the same organization	*There were plans to modernize the tram and bus **fleet**.*
flow	n	/fləʊ/	the steady and continuous movement of something/somebody in one direction	*The whole operation depends on a steady **flow** of electricity.*
fluctuation	n	/ˌflʌktʃuˈeɪʃn/	one of several changes in size, amount, quality, etc. that happen frequently, especially from one extreme to another; the act of changing frequently like this	*Scientists have concluded that temperature **fluctuations** may increase the spread of infectious diseases.*
fluid	n	/ˈfluːɪd/	a liquid; a substance that can flow	*Retaining excess **fluid** could be a problem.*
force	n	/fɔːs/	physical strength, especially as shown when something hits something else	*You have to apply some **force** to move the lever.*
forklift	n	/ˈfɔrkˌlift/	a vehicle with two bars in the front for moving and lifting heavy goods	*He put himself through college by operating a **forklift** at night.*
fuel	n	/ˈfjuːəl/	any material that produces heat or power, usually when it is burnt	*Most of the houses are heated with solid **fuel.***
fuse	n	/fjuːz/	a small wire or device inside a piece of electrical equipment that breaks and stops the current if the flow of electricity is too strong	*Check whether a **fuse** has blown.*
gain	v	/geɪn/	to obtain an advantage or benefit from something or from doing something	*The industry will **gain** enormously from the new proposals.*
generate	v	/ˈdʒenəreɪt/	to produce energy, especially electricity	*Living cells **generate** energy from food.*
geothermal	adj	/ˌdʒiːəʊˈθɜːml/	connected with the natural heat of rock deep in the ground	*As the authors point out, **geothermal** energy is, at best, a semi-renewable resource, akin to 'mining' heat from the ground.*
guidance	n	/ˈgaɪdns/	the process of controlling the direction of a rocket, etc., using electronic equipment	*Almost all missiles contain some form of **guidance** and control mechanism and are therefore often referred to as guided missiles.*
harness	v	/ˈhɑːnɪs/	to control and use the force or strength of something to produce power or to achieve something	*How can this energy be **harnessed** effectively for the good of humankind?*

hazardous	adj	/ˈhæzədəs/	involving risk or danger, especially to somebody's health or safety	*They endured a **hazardous** journey through thickening fog.*
hybrid	adj	/ˈhaɪbrɪd/	using two different types of power, especially petrol or diesel and electricity	*The **hybrid** aircraft can fly like a plane and take off and land like a helicopter.*
hydrogen	n	/ˈhaɪdrədʒən/	a gas that is the lightest of all the elements. It combines with oxygen to form water.	*Alternatives such as wind, solar, **hydrogen** and new nuclear are years away.*
hydropower	n	/ˈhaɪdrəʊpaʊə/	electricity produced using the power of water	*The technologies have included solar, wind, biomass and small **hydropower**.*
hydroxide	n	/haɪˈdrɒksaɪd/	a chemical consisting of a metal and a combination of oxygen and hydrogen	*Diluted solutions of zinc and copper chloride and sodium **hydroxide** were used.*
incinerator	n	/ɪnˈsɪnəreɪtə(r)/	a container that is closed on all sides for burning waste at high temperatures	*Veolia executives say burning e-cigarettes' lithium batteries can damage their **incinerators**.*
induction	n	/ɪnˈdʌkʃn/	the process by which electricity or magnetism passes from one object to another without them touching	*Then a high-frequency current is run through a copper coil around the quartz tube, which heats the graphite crucible through **induction**.*
inductive	adj	/ɪnˈdʌktɪv/	connected with the induction of electricity	*In their analysis of decarbonization methods, DC-MUSE researchers identified pathways including resistive, microwave, and **inductive** heating strategies.*
input	n	/ˈɪnpʊt/	a place or means for electricity, data, etc. to enter a machine or system	*Where is the audio **input** on the computer?*
inspect	v	/ɪnˈspekt/	to look closely at something/somebody, especially to check that everything is as it should be	*Make sure you **inspect** the goods before signing for them.*
inspections	v	/ɪnˈspekʃn/	the act of looking closely at something/somebody, especially to check that everything is as it should be	*Engineers carried out a thorough **inspection** of the track.*
insulation	n	/ˌɪnsjuˈleɪʃn/	the act of protecting something with a material that prevents heat, sound, electricity, etc. from passing through; the materials used for this	*Better **insulation** of your home will help to reduce heating bills.*
interference	n	/ˌɪntəˈfɪərəns/	interruption of a radio signal by another signal on a similar wavelength, causing extra noise that is not wanted	*It was hard to hear the radio program because of all the **interference**.*
intermittent	adj	/ˌɪntəˈmɪtənt/	stopping and starting often over a period of time, but not regularly	*A day of **intermittent** rainstorms followed.*
intricate	adj	/ˈɪntrɪkət/	having a lot of different parts and small details that fit together	*The building has **intricate** geometric designs on several of the walls.*
ion	n	/ˈaɪən/	an atom or a molecule with a positive or negative electric charge caused by its losing or gaining one or more electrons	*Chloride **ions** can corrode vehicles and infrastructure.*
kinematics	n	/ˌkɪnəˈmætɪk/	a branch of dynamics that deals with aspects of motion apart from considerations of mass and force	*Seatmakers call this **kinematics** the parts that move.*
bill of lading	n	/ˌbɪl əv ˈleɪdɪŋ/	a list giving details of the goods that a ship, etc. is carrying	*The report, which is more than 200 pages long, includes copies of contracts between North Korean and Syrian companies as well as **bills of lading** indicating the types of materials shipped.*
lead	n	/led/	a chemical element (Pb)	***Lead** is a heavy, soft grey metal, used especially in the past for water pipes or to cover roofs.*
leak	v	/liːk/	to allow liquid or gas to get in or out through a small hole	*A pipe was **leaking** in her hotel room.*
leverage	v	/ˈliːvərɪdʒ/	to get as much advantage or profit as possible from something that you have	*This system will help you to **leverage** your time so that you get more done.*
lithium	n	/ˈlɪθiəm/	a chemical element	***Lithium** is a soft, very light, silver-white metal used in batteries and alloys.*
load	n	/ləʊd/	something that is being carried (usually in large amounts) by a person, vehicle, etc.	*The trucks waited at the warehouse to pick up their **loads**.*
	v	/ləʊd/	to put a large quantity of things or people onto or into something	*Can you help me **load** the dishwasher?*

maintain	v	/meɪn'teɪn/	to keep a building, a machine, etc. in good condition by checking or repairing it regularly	*The house is large and difficult to* ***maintain****.*
maintenance	n	/'meɪntənəns/	the act of keeping something in good condition by checking or repairing it regularly	*The school pays for heating and the* ***maintenance*** *of the buildings.*
malfunction	v	/ˌmæl'fʌŋkʃn/	to fail to work correctly	*He was killed when his parachute* ***malfunctioned****.*
	n	/ˌmæl'fʌŋkʃn/	failure of a machine, etc. to work correctly	*There was no evidence of technical* ***malfunction****.*
manufacture	v	/ˌmænju'fæktʃə(r)/	to make goods in large quantities, using machines	*This company* ***manufactures*** *the equipment used to make contact lenses.*
	n	/ˌmænju'fæktʃə(r)/	the process of producing goods in large quantities	*The amount of recycled glass used in* ***manufacture*** *doubled in five years.*
mass	n	/mæs/	the quantity of material that something contains	*As a black hole gives off particles and radiation, it will lose* ***mass****.*
matter	n	/'mætə(r)/	a substance or things of a particular sort	*Add plenty of organic* ***matter*** *to improve the soil.*
meticulously	adv	/mə'tɪkjələsli/	in a way that pays careful attention to every detail	*She checked the painting* ***meticulously*** *for any damage.*
mimetic	adj	/mɪ'metɪk/	copying the behaviour or appearance of somebody/something else	*Art is a* ***mimetic*** *representation of reality.*
mimic	v	/'mɪmɪk/	to look or behave like something else	*The robot was programmed to* ***mimic*** *a series of human movements.*
monitor	v	/'mɒnɪtə(r)/	to watch and check something over a period of time in order to see how it develops, so that you can make any necessary changes	*The authorities will continue to* ***monitor*** *the situation.*
nanocomposite	n	/ˌnanəʊkɒm'pəzɪt/	a composite material with features measured in nanometers	*Other* ***nanocomposites****—materials put together molecule by molecule—could be used to coat implants so that the body doesn't react to them.*
nanofibre	n	/'nanə(ʊ)ˌfʌɪbə/	one-dimensional nanomaterial of fiber shape with a diameter in the range of tens to hundreds of nanometers	*To circumvent this problem fast degrading* ***nanofibers*** *can be combined with slow degrading fibers.*
nanomaterial	n	/'nænəʊməˌtɪərɪəl/	any material that has an average particle size of between 1 and 100 nanometres	*General safety aspects of handling* ***nanomaterials*** *have been briefly addressed.*
nanoparticle	n	/'nænəʊpɑːtɪkl/	a piece of matter less than 100 nanometres long	*The* ***nanoparticle*** *has a unique size dependent magnetic, optical, and electrical property, which makes it a suitable candidate in the field of material science.*
nanoscale	adj	/'nænəʊskeɪl/	of a size that can be measured in nanometres	*Their technique takes advantage of the bonds that form between atoms in a* ***nanoscale*** *channel of the new transistor.*
nanosensor	n	/'nænəʊsensə/	sensitive material used to transmit chemical, physical, or biological information about nanomaterials and recognition molecules	***Nanosensors*** *in agriculture are used to detect the humidity of soil, pesticide residue, nutrient requirements, and crop pest identification.*
nanotechnology	n	/ˌnænəʊtek'nɒlədʒi/	the branch of technology that deals with structures that are less than 100 nanometres long	***Nanotechnology*** *is the blanket term used to describe the precision manufacture of materials and structures of molecular dimensions.*
obstacle	n	/'ɒbstəkl/	something that blocks you so that movement, going forward, or action is prevented or made more difficult	*The biggest* ***obstacle*** *in our way was a tree trunk in the road.*
obstructions	n	/əb'strʌkʃn/	something that blocks a road, an entrance, etc.	*It is my job to make sure that all pathways are clear of* ***obstructions****.*
occupation	n	/ˌɒkju'peɪʃn/	a job or profession	*Please state your name, age and* ***occupation*** *below.*
operate	v	/'ɒpəreɪt/	to work in a particular way	*Most domestic freezers* ***operate*** *at below −18°C.*
			to use or control a machine or make it work	*The doors can be manually* ***operated*** *in the event of fire.*
overabundance	n	/ˌəʊvərə'bʌndəns/	a supply or amount that is greater than required	*Due to the* ***overabundance*** *of casualties, the hospitals were overwhelmed.*
oxide	n	/'ɒksaɪd/	a compound of oxygen and another chemical element	*Most patients were intubated and anesthetized with nitrous* ***oxide*** *and oxygen during catheterization.*

pallet	n	/ˈpælət/	a flat wooden or metal platform on which goods are stored so that they can be lifted and moved using a forklift truck	*The warehouse will hold more than 90,000 **pallets** storing 30 million Easter eggs.*
panel	n	/ˈpænl/	a square or rectangular piece of wood, glass or metal that forms part of a larger surface such as a door or wall	*One of the glass **panels** in the front door was cracked.*
patent	n	/ˈpætnt/ /ˈpeɪtnt/	an official right to be the only person to make, use or sell a product or an invention; a document that proves this	*The device was protected by **patent**.*
pathway	n	/ˈpɑːθweɪ/	a track that serves as a path	*They came out of the woods and onto a **pathway**.*
pivotal	adj	/ˈpɪvətl/	of great importance because other things depend on it	*She played a **pivotal** role in the civil rights movement.*
plant	n	/plɑːnt/	a factory in which a particular product is made or power is produced	*Two more car-assembly **plants** were closed by the strike.*
plug-in	adj	/ˈplʌg ɪn/	able to be connected to an electricity supply using a plug	*Component makers are excited by the development of **plug-in** electric cars.*
pneumatic	adj	/njuːˈmætɪk/	operated by air pressure	*Our car has **pneumatic** brakes.*
premises	n	/ˈpremɪsɪz/	the building and land near to it that a business owns or uses	*These **premises** are regularly checked by security guards.*
principle	n	/ˈprɪnsəpl/	a basic idea or rule that explains or controls how something happens or works	*The machine works according to the **principle** of electromagnetic conduction.*
processor	n	/ˈprəʊsesə(r)/	a part of a computer that controls all the other parts of the system	*Therefore, to plan the elementary motions it is possible to use a multi **processor** system.*
prompt	adj	/prɒmpt/	done without delay	***Prompt** action was required as the fire spread.*
	n	/prɒmpt/	an instruction given to an artificial intelligence by a human using natural language rather than computer language	*AI **prompts** are essentially commands that the AI model can understand.*
prosthetic	adj	/prɒsˈθetɪk/	relating to an artificial body part, such as an arm, foot, or tooth, that replaces a missing part	*People have learned to ski, kayak, and run marathons with their **prosthetic** limbs.*
protocol	n	/ˈprəʊtəkɒl/	a set of rules that control the way data is sent between computers	*It should be noticed that the remote system uses the communication **protocol** that the hand controller uses as well.*
prototype	n	/ˈprəʊtətaɪp/	the first design of something from which other forms are copied or developed	*Scientists have developed a working **prototype** for the machine.*
ratio	n	/ˈreɪʃiəʊ/	the relationship between two groups of people or things that is represented by two numbers showing how much larger one group is than the other	*What is the **ratio** of men to women in the department?*
recharge	v	/ˌriːˈtʃɑːdʒ/	to fill a battery with electrical power; to be filled with electrical power	*The drill takes about three hours to **recharge**.*
refine	v	/rɪˈfaɪn/	to improve something by making small changes to it	*She has **refined** her playing technique over the years.*
reject	v	/rɪˈdʒekt/	to refuse to accept or consider something	*The proposal was firmly **rejected**.*
reliability	n	/rɪˌlaɪəˈbɪləti/	the quality of being likely to be correct or true	*The **reliability** of these results has been questioned.*
reliance	n	/rɪˈlaɪəns/	the state of needing somebody/something in order to survive, be successful, etc.; the fact of being able to rely on somebody/something	*Such learning methods encourage too great a **reliance** upon the teacher.*
repetitive	adj	/rɪˈpetətɪv/	repeated many times	*Through **repetitive** training, the controller obtains knowledge about the system and the tracking length is elongated gradually.*
replenishment	n	/rɪˈplenɪʃmənt/	the act of making something full again by replacing what has been used	*Computerization has enabled the automatic **replenishment** of stock.*
resilience	n	/rɪˈzɪliəns/	the ability of a substance to return to its original shape after it has been bent, stretched or pressed	*The plant fibre has incredible strength and **resilience**.*
responsive	adj	/rɪˈspɒnsɪv/	saying or doing something as a reaction to something or someone, especially in a quick or positive way	*The car's transmission is much smoother and more **responsive** than previous models.*
retrieve	v	/rɪˈtriːv/	to bring or get something back, especially from a place where it should not be	*She bent to **retrieve** her comb from the floor.*
robotics	n	/rəʊˈbɒtɪks/	the science of designing and operating robots	*The field of **robotics** has seen many exciting developments in the last decade.*

large-scale	adj	/ˌlɑːdʒ ˈskeɪl/	involving many people or things, especially over a wide area	*Large areas of the forest will be cleared for ranching as part of a **large-scale** development plan.*
separator	n	/ˈsepəreɪtə(r)/	a machine for separating things	*For the negative electrode, magnesium is used, while the electrolyte is composed of magnesium acetate, and cellulose is used for the **separator**.*
shaft	n	/ʃɑːft/	a metal bar that joins parts of a machine or an engine together, enabling power and movement to be passed from one part to another	*A propeller **shaft** for a small yacht is made of a solid steel bar 100mm in diameter.*
slopes	n	/sləʊp/	a surface that lies at an angle to the horizontal so that some points on it are higher than others	*The roof is at a **slope** (= at an angle to a horizontal surface) of 30°.*
soar	v	/sɔː(r)/	if the value, amount or level of something soars, it rises very quickly	*Air pollution will soon **soar** above safety levels.*
solar	adj	/ˈsəʊlə(r)/	of or from the sun, or using the energy from the sun to produce electric power	*They are searching for intelligent life forms in other **solar** systems.*
spark	v	/spɑːk/	to cause something to start or develop, especially suddenly	*Winds brought down power lines, **sparking** a fire.*
static electricity	n	/ˌstætɪk ɪˌlekˈtrɪsəti/	electricity that gathers on or in an object that is not a conductor of electricity	*Nylon brushes are not recommended because they are likely to create **static electricity**.*
sulphuric (AE sulfuric) acid	n	/sʌlˌfjʊərɪk ˈæsɪd/	a strong acid with no color	*A concentrated solution of ammonium thiocyanate was mixed with 50 % **sulfuric acid** and kept on ice.*
supplier	n	/səˈplaɪə(r)/	a person or company that supplies goods	*You will need to be able to deal with both customers and **suppliers**.*
surveillance	n	/sɜːˈveɪləns/	supervision or inspection	*The vehicle was said to be fitted with advanced **surveillance** equipment.*
terrain	n	/təˈreɪn/	used to refer to an area of land when you are mentioning its natural features, for example, if it is rough, flat, etc.	*The car handles particularly well on rough **terrain**.*
tow	v	/təʊ/	to pull a car, boat, etc. behind another vehicle, using a rope or chain	*Our car was **towed** away by the police.*
track	v	/træk/	to follow the movements of somebody/something, especially by using special electronic equipment	*Media consultants can **track** the eye movements of people who are watching TV commercials.*
trolley	n	/ˈtrɒli/	affordable piece of equipment for many assembly, manufacturing, and warehouse environments as it can be used to transport a wide variety of products and materials	*Using **trolleys** increases warehouse safety and efficiency by allowing employees to move items with ease through the warehouse space.*
troubleshoot	v	/ˈtrʌblʃuːt/	to discover why something does not work effectively and help to improve it	*A top German engineer has been appointed to troubleshoot the cause of the accident.*
tug	n	/tʌg/	a type of industrial equipment used to move large, heavy loads	*On the other hand, an electric **tug** is designed to push, pull, steer and position heavy-wheeled loads.*
utilise	v	/ˈjuːtəlaɪz/	to use something, especially for a practical purpose	*Vitamin C helps the body **utilize** the iron present in your body.*
validate	v	/ˈvælɪdeɪt/	to state officially that something is useful and of an acceptable standard	*The data is **validated** automatically by the computer after it has been entered.*
valve	n	/vælv/	a device for controlling the flow of a liquid or gas, letting it move in one direction only	*The plumber will fit some new safety **valves**.*
vast	adj	/vɑːst/	extremely large in area, size, amount, etc.	*They sell a **vast** array of products.*
versatility	n	/ˌvɜːsəˈtɪləti/	the quality of having many different uses	*Printers offer surprising **versatility** for the money.*
vessel	n	/ˈvesl/	a container used for holding liquids, such as a bowl, cup, etc.	*We used bowls, pots, bottles, pitchers – any **vessels** we could find.*
voltage	n	/ˈvəʊltɪdʒ/	electrical force measured in volts	*The increase of **voltage** resulted in a sharp increase of the radiation power.*
warehouse	n	/ˈweəhaʊs/	a building where large quantities of goods are stored, especially before they are sent to shops to be sold	*He's a **warehouse** manager for an import company.*
weld	v	/weld/	to join pieces of metal together by heating their edges and pressing them together	*All the parts of the sculpture have to be **welded** together.*
workstation	n	/ˈwɜːksteɪʃn/	an intelligent terminal or personal computer usually connected to a computer network	*In the first level, only one **workstation** is needed and all three components are assembled there.*

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