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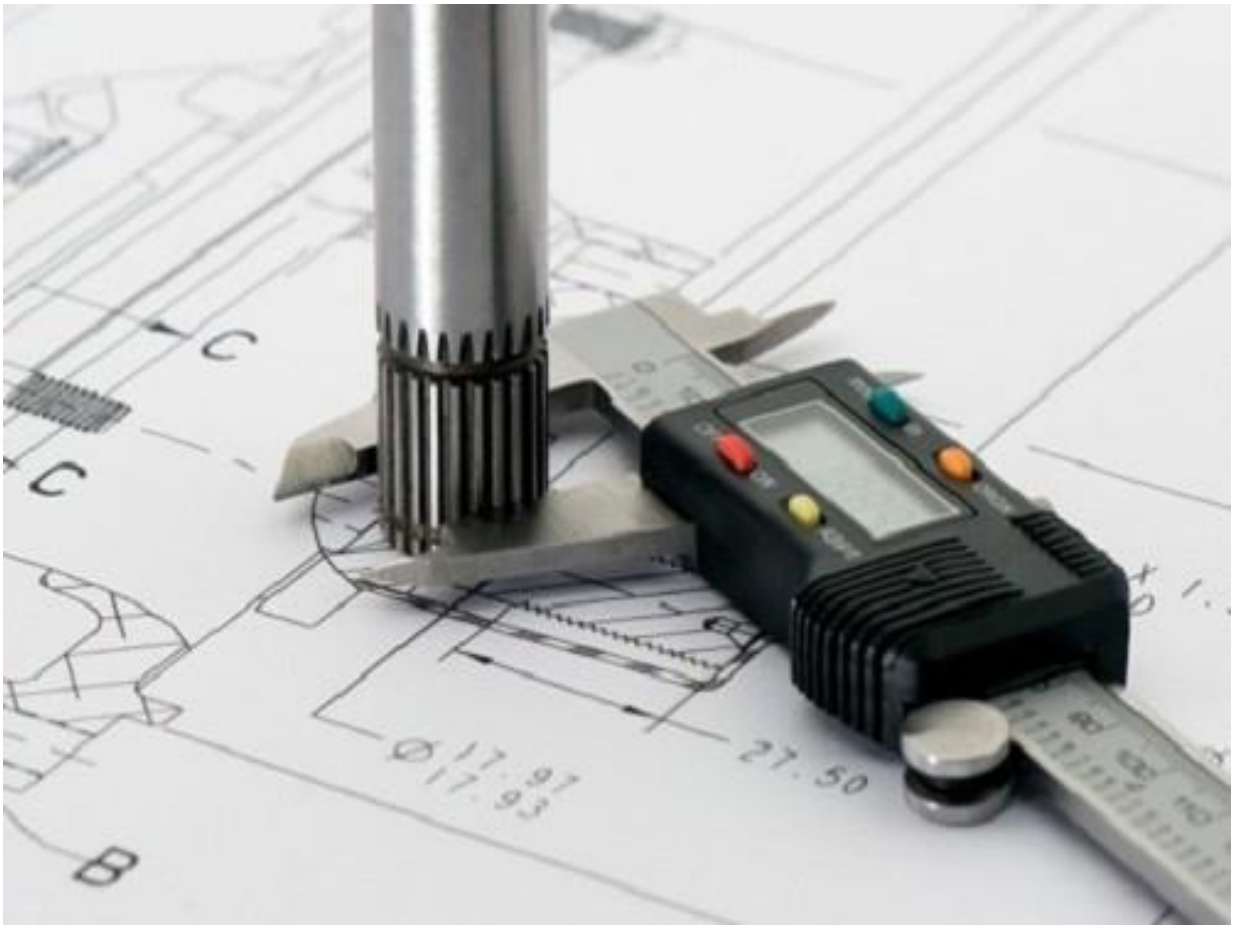
ENGLISH FOR SPECIFIC PURPOSES. METROLOGY AND MEASUREMENT TECHNIQUES



Міністерство освіти і науки України
Чернівецький національний університет імені Юрія Федьковича

ENGLISH FOR SPECIFIC PURPOSES.
METROLOGY AND MEASUREMENT TECHNIQUES

Навчальний посібник з англійської мови
для студентів інженерно-технічних спеціальностей
вищих навчальних закладів

Чернівці
2025

УДК 811.111'276.6:006.91](075.8)

М 52

Рекомендовано до друку: методичною комісією кафедри іноземних мов для природничих факультетів Чернівецького національного університету імені Юрія Федьковича
(протокол № 8 від 28.02.2025 року)
Вченою радою факультету іноземних мов
Чернівецького національного університету імені Юрія Федьковича
(протокол № 2 від 26 березня 2025 року)

Рецензенти:

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Олена ЯНКОВЕЦЬ, доктор філософії з філології, доцент кафедри іноземних мов факультету забезпечення оперативно-службової діяльності Національної академії прикордонної служби України мені Б. Хмельницького.

М 52 English for Specific Purposes. Metrology and Measurement Techniques. Навчальний посібник з англійської мови для студентів інженерно-технічних спеціальностей вищих навчальних закладів / Укл. Мельничук Р. І., Маковійчук Л.В. – Чернівці, 2025. – 198 с.

Навчальний посібник спрямований на розвиток та вдосконалення усної та письмової англійської мови за професійним спрямуванням. Призначений для студентів інженерно-технічних спеціальностей, а також усіх, хто вивчає метрологію та інформаційно-вимірювальну техніку, прагне удосконалити набуті знання та розширити словниковий запас англомовною фаховою термінологією. Посібник містить об'ємний текстово-інформаційний матеріал тематичного характеру із вправами для закріплення матеріалу та англійський словник професійних термінів для розвитку мовленнєвих навичок.

УДК 811.111'276.6:006.91](075.8)

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CONTENTS

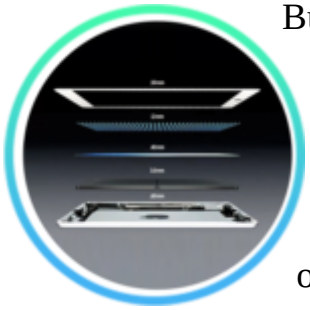
UNIT I

FUNDAMENTALS OF METROLOGY AND STANDARDIZATION

TEXT A

KEY CONCEPTS OF METROLOGY
WHAT IS METROLOGY?

1. a) Read and translate the text into Ukrainian using the dictionary. Pay attention to the underlined words and word combinations.



Metrology is the scientific study of measurement. It is defined by the International Bureau of Weights and Measures (BIPM) as "the science of measurement, embracing both experimental and theoretical determinations at any level of uncertainty in any field of science and technology". This discipline establishes a common understanding of units, crucial in linking human activities. Modern metrology has its roots in the French Revolution's political motivation to standardize units in France when a length standard taken from a natural source was proposed. This led to the creation of the decimal-based metric system in 1795, establishing a set of standards for other types of measurements.

Metrology is divided into three basic overlapping activities:

- The definition of units of measurement.
- The realization of these units of measurement in practice.
- Traceability – linking measurements made in practice to the reference standards.

These overlapping activities are used in varying degrees by the three basic sub-fields of metrology:

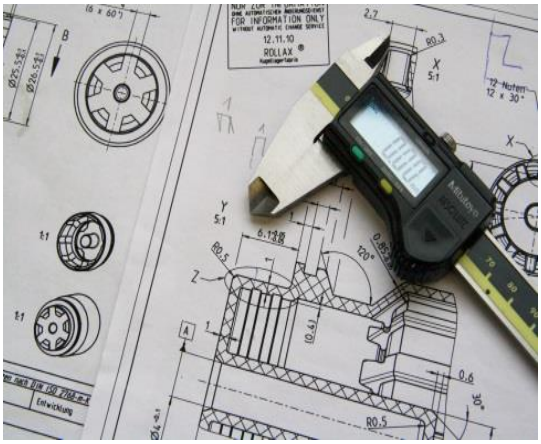
- Scientific or fundamental metrology, concerned with the establishment of units of measurement.
- Applied, technical or industrial metrology – the application of measurement to manufacturing and other processes in society.
- Legal metrology, covering the regulation and statutory requirements for measuring instruments and methods of measurement.

Scientific metrology *is concerned with the establishment of units of measurement, the development of new measurement methods, the realization of measurement standards, and the transfer of traceability from these standards to users in a society. This type of metrology is considered the top level of metrology which strives for the highest degree of accuracy. BIPM maintains a database of the metrological calibration and measurement capabilities of institutes around the world. These institutes, whose activities are peer-reviewed, provide the fundamental reference points for metrological traceability. In the area of measurement, BIPM has identified nine metrology areas, which are acoustics, electricity and magnetism, length, mass and related quantities, photometry and radiometry, ionizing radiation, time and frequency, thermometry, and chemistry.*

Scientific metrology plays an important role in this redefinition of the units as precise measurements of the physical constants is required to have accurate definitions of the base units.

Applied, technical or industrial metrology is concerned with the application of measurement to manufacturing and other processes and their use in society, ensuring the suitability of measurement instruments, their calibration and quality control. Producing good measurements is important in industry as it has an impact on the value and quality of the end product, and a 10–15% impact on production costs. Although the emphasis in this area of metrology is on the measurements themselves, traceability of the measuring-device calibration is necessary to ensure confidence in the measurement. Recognition of the metrological competence in industry can be achieved through mutual recognition agreements, accreditation, or peer review. Industrial metrology is important to a country's economic and industrial development, and the condition of a country's industrial-metrology program can indicate its economic status.

In manufacturing processes, **industrial metrology** is used to:



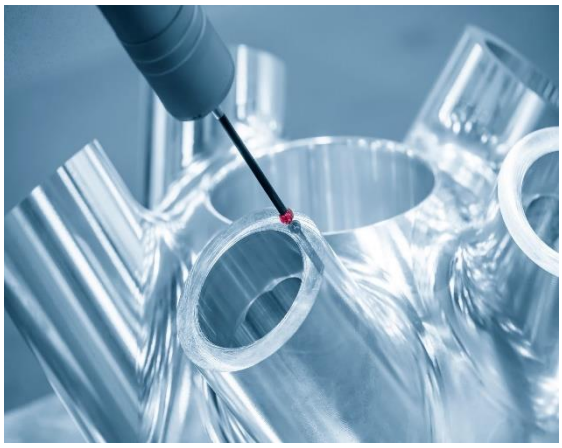
- Calibrate machinery and instruments for accuracy and adherence to quality control standards.
- Employ precise measurement tools in critical industries such as semiconductors, data storage, consumer electronics, photonics, aerospace, and automotive.
- Allow for consistent production of identical parts by ensuring manufacturing processes remain in control.
- Significantly influence production costs.

New and advanced measurement technology is continuing to be adopted by industry leaders as they continue to innovate and their ability to enhance design, simulation, and analysis processes, contributing to superior product development, control of their manufacturing processes, and quality assurance.

Legal metrology "concerns activities which result from statutory requirements and concern measurement, units of measurement, measuring instruments and methods of

measurement and which are performed by competent bodies". Such statutory requirements may arise from the need for protection of health, public safety, the environment, enabling taxation, protection of consumers and fair trade. The International Organization for Legal Metrology (OIML) was established to assist in harmonizing regulations across national boundaries to ensure that legal requirements do not inhibit trade. This harmonization ensures that certification of measuring devices in one country is compatible with another country's certification process, allowing the trade of the measuring devices and the products that rely on them. In the United States legal metrology is under the authority of the Office of Weights and Measures of National Institute of Standards and Technology (NIST), enforced by the individual states.

In a broader sense, metrology is crucial in many aspects of daily life and professional fields:



Industry – ensures product quality and reduces production errors.

Healthcare – guarantees accurate medical tests and equipment performance.

Science – provides reliable data for experiments and research.

Trade – protects consumers by ensuring fairness in weight and volume measurements (e.g., fuel pumps, grocery scales).

Environment – helps monitor pollution levels with precise measuring instruments.

Metrology permeates everyday life, influencing various aspects from household appliances to transportation and entertainment. Measurement instruments are everyday tools of metrology, using standardized units of measure to provide accurate readings for cooking, climate control, and construction. Here are some examples:

- Car speedometers
- Measuring cups
- Thermostats

- GPS
- Timers
- Scales

Metrology is essential for maintaining high standards in technology, production, healthcare, and research. Understanding its key concepts allows specialists to ensure reliable and trustworthy measurements.

b) Translate the italicized paragraph into Ukrainian (in writing).

c) Put 5 questions to the text.

2. Advanced Synonym Exercise: Metrology Terminology

a) Match the words with their synonyms.

1. Accuracy	A. Dependable
2. Standardized	B. Improve
3. Ensure	C. Precision
4. Measurement	D. Confirm
5. Establish	E. Essential
6. Reliable	F. Uniform
7. Regulate	G. Control
8. Traceability	H. Detection
9. Enhance	I. Determination
10. Fundamental	J. Set up

b) Find the most appropriate synonym.

Each sentence below contains a bolded word related to metrology. Choose the correct synonym that best replaces the bolded word without changing the meaning.

1. The **accuracy** of a measurement depends on the precision of the instruments used.
   A) Reliability
   B) Exactness
   C) Complexity
   D) Calibration
2. A **standardized** system of measurement is necessary for global consistency.
   A) Universal
   B) Approximate
   C) Inconsistent
   D) Arbitrary
3. Scientists must **ensure** that all measurements are traceable to international standards.
   A)Guarantee
   B)Compensate
   C)Predict
   D) Simplify
4. The **establishment** of measurement standards is crucial for scientific accuracy.
   A) Definition
   B) Expansion
   C) Elimination
   D) Validation
5. **Traceability** allows measurements to be linked to a reference standard.
   A) Verification
   B) Approximation
   C) Manipulation
   D) Disruption

c) Fill in the blanks with the correct synonym.

Use one of the given synonyms to complete each sentence. Make sure the sentence makes sense in the context of metrology.

precision, regulation, calibration, fundamental, reliability

1. The _____ of a measuring instrument must be performed regularly to maintain accuracy.
2. A _____ metrology principle is that every measurement must be linked to an internationally recognized standard.
3. Governments use _____ to ensure that measuring instruments used in trade are accurate.
4. In scientific experiments, the _____ of measurement results is essential to draw valid conclusions.
5. Engineers use high _____ tools to manufacture identical machine parts with minimal error.

3. Using the dictionary transcribe and translate the key words and words combinations:

Word	***Transcription***	***Translation***
Metrology		
Measurement		
Accuracy		
Precision		
Calibration		

Traceability		
Standardization		
Units of measurement		
International System of Units		
Fundamental metrology		
Industrial metrology		
Legal metrology		
Reference standard		
Measurement uncertainty		
Reliability		
Regulation		
Quality control		
Measuring instrument		
Repeatability		
Deviation		
Verification		

4. Match the words with their definitions.

a) Match each metrology-related term with its correct definition. Write the correct letter next to each number.

1. Metrology ___
2. Accuracy ___
3. Precision ___
4. Calibration ___
5. Traceability ___

6. Standardization ___
7. Measurement uncertainty ___
8. Legal metrology ___
9. Industrial metrology ___
10. Reference standard ___

A. The degree to which a measurement result is close to the true or accepted value.
B. The science of measurement, including its methods, applications, and principles.
C. The process of comparing a measuring instrument against a known reference to ensure accuracy.
D. The ability to repeat measurements with minimal variation, even if they are not necessarily accurate.
E. A set of procedures and rules to ensure consistency in measurements worldwide.
F. The connection of a measurement result to national or international measurement standards.
G. The estimation of possible errors in a measurement, recognizing that no measurement is perfectly exact.
H. The branch of metrology that ensures measuring instruments comply with laws and regulations.
I. The field of metrology that ensures accurate measurements in manufacturing and production.
J. A highly precise and internationally recognized unit or object used as a measurement benchmark.

b) Choose two terms and write your own sentences using them to reinforce understanding.

5. Give English equivalents to the meanings of the following words and word combinations.

Метрологія	
Вимірювання	
Точність	
Правильність	
Калібрування	
Відтворюваність	
Метрологічна простежуваність	
Одиниці вимірювання	
Міжнародна система одиниць (SI)	
Метрологічний стандарт	
Похибка вимірювання	
Юридична метрологія	
Фундаментальна метрологія	
Промислова метрологія	
Еталон	
Контроль якості	
Засіб вимірювальної техніки (ЗВТ)	
Сертифікація	
Нормування	
Достовірність вимірювань	
Валідація методики вимірювання	
Метрологічний контроль	
Атестація випробувального обладнання	
Єдність вимірювань	

6. Choose the correct answer.

1. What is metrology?

a) The science of materials

b) The science of energy

c) The science of measurement

d) The science of motion

2. Which organization defines metrology as "the science of measurement"?

a) ISO

b) BIPM

c) OIML

d) NIST

3. Which system of units was created during the French Revolution?

a) Imperial system

b) Metric system

c) CGS system

d) MKS system

4. What are the three main activities of metrology?

a) Definition of units, calibration, standardization

b) Definition of units, realization of units, traceability

c) Definition of units, certification, quality control

d) Definition of units, testing, analysis

5. What are the three basic subfields of metrology?

a) Fundamental, applied, legal

b) Fundamental, technical, industrial

c) Fundamental, scientific, medical

d) Fundamental, applied, environmental

6. What is the primary focus of scientific metrology?

a) Establishing units of measurement

b) Applying measurements in manufacturing

c) Regulating measuring instruments

d) Protecting consumers

7. Which organization assists in harmonizing regulations in legal metrology?
    a) ISO
    b) BIPM
    c) OIML
    d) NIST
8. What is the role of metrology in healthcare?
    a) Ensuring the accuracy of medical tests and equipment performance
    b) Ensuring the quality of food products
    c) Ensuring the accuracy of measurements in construction
    d) Ensuring the accuracy of measurements in trade
9. Which of the following are examples of measuring instruments in everyday life?
    a) Car speedometers, measuring cups, thermostats
    b) Measuring cups, thermostats, microscopes
    c) Car speedometers, microscopes, GPS
    d) Thermostats, GPS, microscopes
10. Which organization in the United States is responsible for legal metrology?
    a) ISO
    b) BIPM
    c) OIML
    d) NIST

7. Give the full version of the following acronyms:

BIPM - _____;

OIML - _____;

NIST - _____.

8. Translate the following sentences into Ukrainian.

1. Metrology is the scientific study of measurement, encompassing both experimental and theoretical determinations at any level of uncertainty.
2. Metrology establishes a common understanding of units, which is crucial for linking human activities across various fields of science and technology.
3. Scientific metrology focuses on the establishment of units of measurement, the development of new measurement methods, and the realization of measurement standards.
4. Applied metrology ensures the suitability of measurement instruments in manufacturing and other societal processes, impacting product quality and production costs.
5. Legal metrology involves statutory requirements for measuring instruments and methods, protecting consumers and ensuring fair trade practices.

9. Translate the following sentences into English.

1. Метрологія – це наукове дослідження вимірювань, яке охоплює як експериментальні, так і теоретичні визначення на будь-якому рівні невизначеності.
2. Наукова метрологія зосереджена на встановленні одиниць вимірювання, розробці нових методів та реалізації стандартів вимірювання.
3. Метрологія встановлює загальне розуміння одиниць вимірювання, що є важливим для зв'язку людської діяльності в різних галузях науки і техніки.
4. Прикладна метрологія забезпечує придатність вимірювальних приладів у виробництві та інших процесах суспільства, впливаючи на якість продукції та виробничі витрати.
5. Юридична метрологія охоплює нормативні вимоги до вимірювальних приладів і методів, захищаючи споживачів і забезпечуючи справедливу торгівлю.

10. Answer the questions to the text.

1. What is the definition of metrology according to the International Bureau of Weights and Measures (BIPM)?

2. What are the three basic overlapping activities in metrology?

3. What are the three basic subfields of metrology?

4. What is the primary focus of scientific metrology?

5. How does industrial metrology impact production costs in manufacturing?

6. What role does legal metrology play in consumer protection and fair trade?

7. Which organization assists in harmonizing regulations across national boundaries in legal metrology?

8. How does metrology contribute to the healthcare industry?

9. What are some examples of measurement instruments used in everyday life?

10. How does metrology help monitor pollution levels in the environment?

11. Write a short summary of the text «KEY CONCEPTS OF METROLOGY» (See the scheme below) and be ready to present it.

Information File - How to Write a Summary

1. Introduction	**Title**	Start with the title of the article, book, or document you are summarizing.
	Author	Mention the author's name.
	Purpose	Briefly state the purpose or main idea of the original text.
2. Main Body	**Key Points**	Identify and present the main points or arguments of the text. Focus on the most important elements that convey the overall message.
	Supporting Details	Include relevant supporting details that help explain the key points. Avoid unnecessary specifics or minor details.
	Logical Flow	Maintain a logical flow in your summary. Present the information in the same order as it appears in the original text to ensure coherence.

3. Conclusion	Restate Main Idea	Summarize the main idea or purpose of the text in a concise manner.
	Significance	Highlight the significance or implications of the text's main points. Explain why the text is important or relevant.
	Final Thoughts	If appropriate, include any final thoughts or reflections on the text. This can be a brief statement on the overall impact of the content.

Tips for Writing a Summary

1. **Read Thoroughly**: Carefully read the text you want to summarize to fully understand its main ideas and details.
2. **Identify Key Points**: Determine the main ideas and essential details that are crucial to the text. Focus on the who, what, when, where, why, and how.
3. **Use Your Own Words**: Rewrite the key points in your own words to avoid plagiarism and ensure you truly understand the content.
4. **Be Concise**: Keep your summary brief and to the point. Eliminate any unnecessary details or repetitive information.
5. **Maintain the Original Meaning**: Ensure your summary accurately reflects the original text's meaning and intent without adding your own opinions or interpretations.
6. **Organize Logically**: Present the information in a logical order, following the structure of the original text if possible.
7. **Check for Accuracy**: Review your summary to make sure it accurately represents the original text and includes all important points.
8. **Edit and Revise**: Edit your summary for clarity, coherence, and conciseness. Make sure it is free of grammatical errors and flows smoothly.

By following these tips, you can create a clear and effective summary that captures the essence of the original text!

Example Summary

Title: «WHAT IS METROLOGY?»

Author: Unknown

Purpose: The text provides an overview of various branches of metrology, highlighting key concepts and their significance in scientific research and real-world applications.

Summary: Metrology is the scientific study of measurement, defined by the International Bureau of Weights and Measures (BIPM) as the science of measurement at any level of uncertainty in any field of science and technology. It originated during the French Revolution with the creation of the metric system. Metrology is divided into three main activities: defining units of measurement, realizing these units in practice, and ensuring traceability to reference standards. The field has three subfields: scientific metrology, which focuses on establishing units and high accuracy; industrial metrology, which applies measurement to manufacturing and processes; and legal metrology, which involves statutory requirements for measurements to protect consumers and ensure fair trade. Metrology is essential in various aspects of daily life, including industry, healthcare, science, trade, and environmental monitoring.

12*. Creative Writing "The Secret Life of Measurements"

Imagine a world where measurements come to life and have personalities. Write a story from the perspective of different measurements, such as meters, kilograms, and seconds, as they navigate their daily lives. Explore their interactions with each other and with humans, their adventures in various industries, and the challenges they face in maintaining accuracy. Describe how they contribute to scientific discoveries, industrial processes, and everyday activities. Highlight the importance of their roles and the impact they have on the world around them.

SPEAKING

1. A Comprehensive Discussion & Guidelines

1. **Understanding Metrology:**

- Define metrology and its significance in science and technology.
- Discuss the historical development of metrology, particularly its roots in the French Revolution.

2. **Key Activities in Metrology:**

- Explain the three basic overlapping activities: definition of units, realization of units, and traceability.
- Explore how these activities contribute to accurate and reliable measurements.

3. **Subfields of Metrology:**

- Identify and describe the three subfields: scientific metrology, industrial metrology, and legal metrology.
- Discuss the primary focus and importance of each sub-field.

4. **Applications of Metrology:**

- Examine the role of metrology in various industries, including manufacturing, healthcare, science, trade, and environmental monitoring.
- Highlight specific examples of measurement instruments used in everyday life.

5. **Impact on Daily Life:**

- Discuss how metrology influences daily activities and ensures quality and safety in products and services.
- Explore the broader implications of accurate measurements in society.

2. Render the following text into English. Summarize its main idea in one sentence.

Метрологія – це наука про вимірювання, яка охоплює як експериментальні, так і теоретичні визначення на будь-якому рівні невизначеності в будь-якій галузі

науки і техніки. Вона встановлює загальне розуміння одиниць вимірювання, що є важливим для зв'язку людської діяльності в різних сферах.

Історія сучасної метрології бере свій початок з Французької революції, коли було запропоновано стандартизувати одиниці вимірювання у Франції, створивши метричну систему в 1795 році. Ця система стала основою для інших типів вимірювань.

Метрологія поділяється на три основні види діяльності:

1. Визначення одиниць вимірювання.
2. Реалізація цих одиниць на практиці.
3. Трасування – зв'язок вимірювань з еталонними стандартами.

Трьома основними підрозділами метрології є

1. Наукова метрологія, яка зосереджена на встановленні одиниць вимірювання, розробці нових методів вимірювання, реалізації стандартів вимірювання та передачі трасування від цих стандартів до користувачів.
2. Прикладна, технічна або промислова метрологія вивчає застосування вимірювань у виробництві та інших процесах, забезпечення придатності вимірювальних приладів, їх калібрування та контроль якості.
3. Юридична метрологія охоплює нормативні вимоги до вимірювальних приладів і методів вимірювання, захищаючи споживачів і забезпечуючи справедливу торгівлю.

Метрологія відіграє важливу роль у багатьох аспектах повсякденного життя та у таких професійних сферах як промисловість, охорона здоров'я, наука, торгівля та охорона навколишнього середовища. Вона забезпечує точність і надійність вимірювань, що є критично важливим для підтримання високих стандартів у технологіях, виробництві, медичних дослідженнях та інших галузях.

3*. Research and Presentation:

Prepare a presentation *«Metrology as a Science»* following the plan below:

→ Introduction to Metrology

→ Importance of Metrology

→ Measurement Systems and Standards

→ Fundamental Concepts in Metrology

→ Types of Measurement Errors

→ Practical Applications of Metrology

→ Conclusion

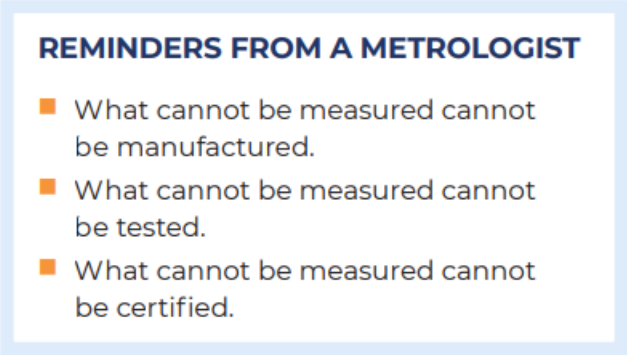
TEXT B

NATIONAL AND INTERNATIONAL STANDARDS & MEASUREMENT

1. a) Read and translate the text using the dictionary:

Today, metrology is much more advanced. It is used in major technological fields.

You have a tablet – a machine that seems so simple these days – but if you look inside, you will begin to understand the great part metrology plays in the design of this object. For such a sophisticated touch screen, thickness measurements are critical to the shape and function of the product. These are just examples. But if you look around you, you will see the essential part metrology plays in everything we do.



All industries depend on metrology for the quality of their work – in fact some of them have costs that are 50% dependent on metrology.

A bit of history. In 1790, in the midst of the French Revolution, the French National Assembly asked the **French Academy of Sciences** to "deduce an **invariable standard for all measurements and weights**". The unit of length decided was the metre. This name was derived from the Greek word *metron*, meaning measure. The other units were to be derived from the unit of length. Thus, an evolved system in which the basic units of the system are linked to each other was born.

It was decided that the larger and smaller versions of each unit should be created by multiplying or dividing the base units by 10. Calculations in the metric system could therefore be performed simply by moving the decimal point. The metric system is a *decimal system*. The metric system was not initially accepted with much enthusiasm.

However, France made its use compulsory in 1840. Adoption by other States took place on a regular basis – the standardized metric characters and decimals were well suited to scientific work.

An **act of the United States Congress** in 1866 made it possible "to use the weights and measures of the metric system in all contracts, transactions or legal proceedings".

In 1875, the **Convention of the Metre** established well-defined metric standards for length and mass. A total of 17 States, including the United States, signed the Convention – the *Convention of the Metre*.

In 1900, a total of 35 States, the main countries of continental Europe and most of the states of South America, officially accepted the *metric system*.

The **Convention of the Metre** is the treaty that created the **Bureau International des Poids et Mesures** – *BIPM* – an intergovernmental organization under the direction and supervision of the **Comité International des Poids et Mesures** – *CIPM*. The first meeting was held in 1889 and continues once every four to six years.

The *CIPM*'s constant efforts to improve the metric system have resulted in the addition of new units of measurement: metre, kilogram, second, ampere, kelvin, mole and candela. The *International System of Units of Measurement* was born.

The modern version of the SI metric system has seven basic units from which all other units of measurement are derived.

- Scientists use the meter to measure length.
- They use the kilogram to measure mass.
- And the second to measure time.
- An ampere is the base unit to measure electric current.
- Kelvin is the unit for temperature.
- And the candela measures luminous intensity, or brightness.
- Last but not least, scientists use the mole to measure the amount of particles in a substance.

Thanks to SI Units, scientists from across the globe can understand each other, and successfully work together!

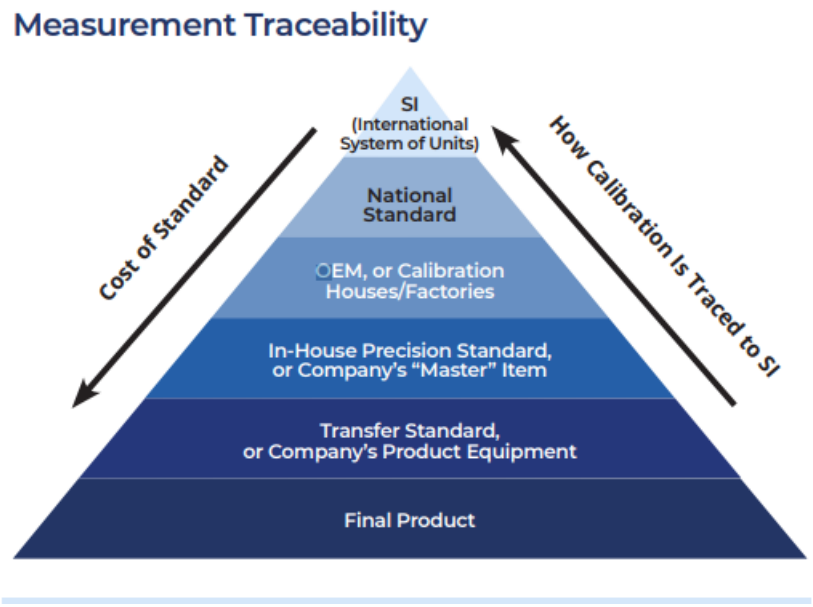
Today, only the kilogram remains a unit based on a physical artifact, the *standard kilogram*, kept near Paris. All other units are defined in terms of wavelength and time, which can be measured and reproduced with a high degree of accuracy.

The **measurement** is the set of operations whose purpose is to determine an experimental value – taking into account the environment – called *measurand* by comparing it directly or indirectly to a standard which is the material representation of the unit in which the *measurand* will be expressed.

A measurement standard (etalon/artifact) is a material measure, measuring instrument, reference material, or measuring system intended to define, realize, conserve, or reproduce a unit or one or more values of a quantity to serve as a reference.

Types of measurement standards. Within the field of metrology, experts rely on three main types of measurement standards. These include primary measurement standards, secondary measurement standards, and working measurement standards. A primary measurement standard is based on physical constants. These are widely acknowledged as having the highest metrological quantities, and their value is accepted without reference to other standards of the same quantity. A secondary measurement standard is valued in comparison with a primary standard of the same quantity. That is, they are calibrated upon the primary standard. A working measurement standard is used

routinely for the calibration of equipment and measuring instruments in general use, having less accuracy than secondary measurement standards.

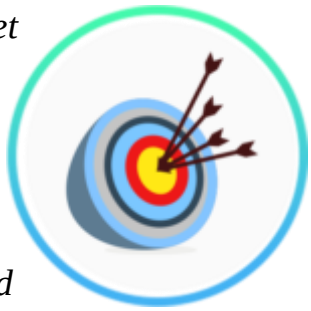


Traceability of measurement ensures that a measurement result or the value of the standard is related to references through an unbroken chain of comparisons. A calibration laboratory "establishes traceability of its own measurement standards and instruments to the SI by means of an unbroken chain of calibrations or comparisons linking them to relevant primary standards of the SI units of measurement."19 Linking calibration to SI units is done through national measurement standards, which may be primary standards. SI units are primary standards when tethered to fundamental physical constants. All test equipment requiring calibration should undergo an initial calibration before being put into service.

Calibration refers to the verifcation of instruments to ensure the precision and traceability of a measurement. Calibration involves determining the metrological characteristics of an instrument. This is achieved by a direct comparison to a higher accuracy know standard. A calibration certificate or test report is issued. Based on this information, a user can decide whether the instrument is fit for the application.

Errors inevitably occur in any measuring system:
– the measuring system is never perfect since it is generally more or less sensitive to the environment (temperature, pressure, humidity…).
– the standards used to calibrate the instrumentation are only an imperfect materialization of the definition of the unit that they are responsible for representing – the wrong definition of the quantity is itself a source of error.

We must therefore calibrate our measuring instrument – that is the art of metrology. Comparisons can be used to calibrate – to ensure that the values returned to us correlate with the values based on those of the standard. It is the repeatability of measurements that ensures a correct result.



*To explain, let's take the example of a **target**. The center of the target is the value of the standard, the value considered accurate – if, of course, our standard is not corrupted. Our measuring device, if it is out of adjustment, will give us points that are more or less close to the center of the target. Repeating these measurements over and over again, and adjusting the device, will gradually bring us closer to the center of the target. When the readings returned by our device are close enough to the center of our target, we consider that our device is calibrated – it hits in the bull's eye every time.*

*You have probably read this text via your smartphone or computer. Little quiz game: How is the design of your device decided? How is the fineness of your screen measured? Your battery voltage? How is the pixel density of your screen measured – fullHD we hope? The answer is **metrology**.*

b) Translate the italicized paragraphs into Ukrainian (in writing).

c) Translate the underlined words and word combinations into Ukrainian (in writing).

d) Put 5 questions to the text.

2. Synonym groups for metrological vocabulary.

a) Select five key terms from the text. For each term, create a list of 2 to 6 synonyms that capture the same or similar meanings within the context of metrology. Below are examples to guide you:

1. **Measurement** – Gauging – Quantification – Evaluation – Assessment.

2. **Calibration** – Adjustment – Standardization – Alignment – Tuning.

3. **Accuracy** – Precision – Exactness – Correctness – Fidelity.

4. **Traceability** – Verification – Validation – Authentication – Documentation.

5. **Standard** – Benchmark – Norm – Criterion – Reference.

6. **Instrument** – Device – Apparatus – Tool – Equipment.

7. **Unit** – Measure – Quantity – Dimension – Scale.

8. **Error** – Deviation – Discrepancy – Inaccuracy – Fault.

9. **Metrology** - Measurement science - Gauging science - Quantification science - Evaluation science.

10. **Verification** – Confirmation – Validation – Authentication – Certification.

b) Match the words with their synonyms.

1. Measurement	a) Fidelity
2. Calibration	b) Authentication
3. Accuracy	c) Quantification
4. Traceability	d) Adjustment
5. Standard	e) Criterion
6. Instrument	f) Tool
7. Unit	g) Dimension
8. Error	h) Discrepancy
9. Metrology	i) Evaluation science
10. Verification	j) Certification

c) Fill in the blanks with the correct synonym from the list provided.

1. The _____ of the measuring device is crucial for obtaining precise results. (Accuracy)

2. _____ ensures that measurements are linked to reference standards. (Traceability)
3. The _____ process involves adjusting instruments to ensure precision. (Calibration)
4. A _____ is used to define, realize, or reproduce a unit of measurement. (Standard)
5. _____ is the science of measurement. (Metrology)

d) Replace the underlined word with its synonym from the list provided.

1. The **measurement** of length is done using a meter.
2. **Calibration** of equipment is necessary for accurate results.
3. **Accuracy** is essential in scientific experiments.
4. **Traceability** ensures that measurements are reliable.
5. The **standard** kilogram is kept near Paris.

e) Multiple Choice. Choose the correct synonym for the underlined word.

1. The **instrument** used for measuring temperature is a thermometer.
    a) Device
    b) Criterion
    c) Dimension
    d) Discrepancy
2. **Verification** of measurements is important for quality control.
    a) Adjustment
    b) Authentication
    c) Quantification
    d) Fidelity
3. **Error** in measurements can lead to inaccurate results.
    a) Tool

b) Criterion

c) Discrepancy

d) Dimension

4. **Unit** of mass is the kilogram.

    a) Measure

    b) Tool

    c) Fidelity

    d) Authentication

5. **Metrology** is the science of measurement.

    a) Evaluation science

    b) Criterion

    c) Adjustment

    d) Quantification

f) Create your own sentences using the synonyms.

For example: The quantification of length is done using a meter.

1. Measurement – Quantification
2. Calibration – Adjustment
3. Accuracy – Precision
4. Traceability - Verification
5. Standard – Benchmark

3. Using the dictionary transcribe and translate the key words:

Word	Transcription	Translation
Measurement		
Calibration		
Accuracy		

Precision		
Traceability		
Unit		
Standard		
Instrument		
Error		
Metrology		
Verification		
Gauge		
Quantification		
Adjustment		
Benchmark		
Reference		
Certification		
Validation		
Deviation		
Artifact		

4. Match each word with its correct definition. Write the correct letter next to each number.

1. Measurement ___
2. Calibration ___
3. Accuracy___
4. Precision ___
5. Traceability ___
6. Standard ___
7. Instrument ___

8. Error ___

9. Verification ___

10. Artifact ___

a) The degree to which the result of a measurement conforms to the correct value.

b) The process of adjusting a measuring device to ensure its accuracy.

c) A material measure, measuring instrument, or reference material used as a reference.

d) The science of determining the size, quantity, or degree of something.

e) The ability to consistently reproduce a measurement.

f) The process of confirming that a measurement or instrument meets specified criteria.

g) A device used for measuring.

h) The relationship of a measurement to a reference standard.

i) A deviation from the correct value in a measurement.

j) A basis for comparison; a reference point against which other things can be evaluated.

5. Give English equivalents to the meanings of the following words and word combinations.

Наука про вимірювання	
Еталон	
Калібрування	
Точність	
Вимірювальний прилад	
Міжнародна система одиниць (SI)	
Стандарт	

Одиниця вимірювання	
Трасування	
Метрична система	
Конвенція метра	
Вимірювання	
Верифікація	
Сертифікат калібрування	
Метрологічні характеристики	
Помилка вимірювання	
Міжнародне бюро ваг і мір	
Десяткова система	
Міжнародний комітет ваг і мір	
Фізичні константи	

6. Choose the correct answer:

1. What role does metrology play in the design of modern technological devices like tablets?

    a) It ensures the aesthetic design of the device.

    b) It is crucial for thickness measurements and overall functionality.

    c) It provides entertainment features.

    d) It enhances battery life.

2. Which historical event led to the creation of the metric system?

    a) The Industrial Revolution

    b) The French Revolution

    c) The American Revolution

    d) The Scientific Revolution

3. What was the primary unit of length decided by the French Academy of Sciences in 1790?
    a) Inch
    b) Foot
    c) Meter
    d) Yard
4. How are larger and smaller versions of metric units created?
    a) By multiplying or dividing the base units by 100
    b) By multiplying or dividing the base units by 10
    c) By adding or subtracting fixed values
    d) By using fractions
5. Which organization was established by the Convention of the Metre in 1875?
    a) ISO
    b) BIPM
    c) OIML
    d) NIST
6. What are the seven basic units of the modern SI metric system?
    a) Meter, kilogram, second, ampere, kelvin, mole, candela
    b) Meter, gram, minute, volt, Celsius, mole, lumen
    c) Inch, pound, hour, watt, Fahrenheit, mole, lux
    d) Meter, kilogram, second, volt, Celsius, mole, lumen
7. Which unit remains based on a physical artifact?
    a) Meter
    b) Kilogram
    c) Second
    d) Ampere
8. What is the purpose of calibration in metrology?
    a) To enhance the aesthetic design of instruments

b) To verify the precision and traceability of measurements

c) To increase the speed of measurements

d) To reduce the cost of instruments

9. What is a primary measurement standard based on?

a) Physical constants

b) Secondary standards

c) Working standards

d) Environmental factors

10. What ensures the repeatability of measurements in metrology?

a) The aesthetic design of instruments

b) The calibration process

c) The use of advanced technology

d) The environmental conditions

7. Translate the following sentences into Ukrainian:

1. Measurement in metrology involves determining the size, quantity, or degree of something using standardized units.

2. Accurate measurements are essential in metrology to ensure the reliability and consistency of data across various fields.

3. Calibration is a crucial process in metrology that adjusts measuring instruments to maintain their precision.

4. Traceability in metrology ensures that measurements can be linked back to reference standards through an unbroken chain of comparisons.

5. Metrology plays a vital role in industries by providing accurate measurements that impact product quality and production costs.

8. Translate the following sentences into English:

1. Метрологічне супроводження вимірювальних систем забезпечує точність і надійність вимірювань у різних галузях.

2. Важливим аспектом метрологічного супроводження є регулярне калібрування вимірювальних приладів для підтримання їхньої точності.

3. Трасування вимірювань до еталонних стандартів є ключовим елементом метрологічного супроводження.

4. Метрологічне супроводження включає перевірку та сертифікацію вимірювальних систем для забезпечення відповідності нормативним вимогам.

5. Завдяки метрологічному супроводженню вимірювальні системи можуть забезпечувати високий рівень якості та точності даних.

9. Give the full version of the following acronyms:

CIPM -_____;

SI Units - _____;

NIST - _____;

APMP - _____;

EURAMET - _____;

AFRIMETS - _____.

10. Answer the questions to the text.

1. How does metrology contribute to the design and functionality of modern technological devices like tablets?

2. What historical event led to the creation of the metric system, and what was the primary unit of length decided?

3. How are larger and smaller versions of metric units created, and why is this system advantageous?

4. Which organization was established by the Convention of the Metre in 1875, and what is its role?

5. What are the seven basic units of the modern SI metric system, and what does each unit measure?
6. Why is the kilogram still based on a physical artifact, and where is it kept?
7. What is the purpose of calibration in metrology, and how does it ensure precision and traceability?
8. What are the three main types of measurement standards in metrology, and how do they differ?
9. How does traceability of measurement ensure the reliability of measurement results?
10. What role does metrology play in ensuring the repeatability of measurements, and why is this important?

10. Write a short summary of the text (See the scheme in the Information File – Ex. 11, P. 18) and be ready to present it.

11*. Creative Writing "A Day in the Life of a Measurement"

Imagine you are a measurement, such as a meter, kilogram, or second. Write a story from the perspective of this measurement as it travels through different environments and industries. Describe the challenges it faces, the importance of its accuracy, and the impact it has on the world around it. Explore how it interacts with various measuring instruments and the role it plays in scientific discoveries, industrial processes, and everyday life.

SPEAKING

1. A Comprehensive Discussion & Guidelines

1. **Define Key Concepts**:
    - Explain what metrology is and why it is important in science and technology.
    - Discuss the historical development of metrology, including the creation of the metric system.

2. **Identify and Explain Activities**:
    - Describe the three basic overlapping activities in metrology: definition of units, realization of units, and traceability.
    - Provide examples of how these activities are implemented in practice.
3. **Explore Subfields**:
    - Identify the three main sub-fields of metrology: scientific metrology, industrial metrology, and legal metrology.
    - Discuss the primary focus and significance of each subfield.
4. **Discuss Applications**:
    - Examine the role of metrology in various industries such as manufacturing, healthcare, science, trade, and environmental monitoring.
    - Provide specific examples of measurement instruments used in these industries.
5. **Analyze Impact on Daily Life**:
    - Discuss how metrology influences everyday activities and ensures quality and safety in products and services.
    - Explore the broader implications of accurate measurements in society.
6. **Evaluate Calibration and Standards**:
    - Explain the importance of calibration in metrology and how it ensures precision and traceability.
    - Discuss the different types of measurement standards (primary, secondary, and working standards) and their roles.
7. **Address Challenges and Solutions**:
    - Identify common challenges in metrology, such as measurement errors and environmental factors.
    - Discuss solutions to these challenges, including regular calibration and traceability.
8. **Encourage Critical Thinking**:

- Pose open-ended questions to stimulate deeper thinking and discussion. For example:
- How does metrology contribute to technological advancements?
- What are the potential consequences of inaccurate measurements in critical industries?

9. **Summarize Key Points**:
    - Periodically summarize the main points discussed to reinforce understanding.
    - Conclude with a summary that highlights the key takeaways from the discussion.
10. **Reflect and Follow Up**:
    - Reflect on the discussion and identify areas for further exploration.
    - Follow up with additional resources or questions to continue the conversation.

2. Translate the following text into English.

a) Express the main idea of the text in one sentence.

b) Write a short summary of the text in English.

Метрологічне супроводження вимірювальних систем є важливим аспектом забезпечення точності та надійності вимірювань у різних галузях. Воно включає в себе комплекс заходів, спрямованих на підтримання та покращення метрологічних характеристик вимірювальних приладів і систем.

Основними елементами метрологічного супроводження є:

1. **Калібрування** – це процес налаштування вимірювальних приладів для забезпечення їхньої точності. Калібрування включає порівняння показників приладу з еталонними значеннями та внесення необхідних коригувань.

2. **Трасування** забезпечує зв'язок вимірювань з національними або міжнародними еталонами через неперервний ланцюг порівнянь. Це дозволяє гарантувати, що результати вимірювань є достовірними та можуть бути відтворені в будь-якій точці світу.
3. **Перевірка та сертифікація** вимірювальних приладів підтверджує їхню відповідність встановленим стандартам.
4. **Моніторинг та контроль якості** – це постійний нагляд за станом вимірювальних систем та їхньою роботою. Сюди належать аналіз даних, виявлення та усунення можливих відхилень або несправностей.
5. **Навчання персоналу** охоплює підготовку та підвищення кваліфікації фахівців, які працюють з вимірювальними системами. Це забезпечує правильне використання приладів та дотримання метрологічних вимог.

Отже, метрологічне супроводження вимірювальних систем є критично важливим для забезпечення високої якості продукції, безпеки технологічних процесів та надійності наукових досліджень. Воно дозволяє мінімізувати похибки вимірювань, підвищити ефективність виробництва та забезпечити відповідність міжнародним стандартам.

3*. Research and Presentation:

Prepare a presentation *"Metrological Measurements" following the plan below:*

→ Introduction to Metrology

→ Types of Metrology

→ Basic Measurement Concepts

→ Measurement Standards

→ Measurement Errors and Uncertainty

→ Instruments and Calibration

→ Applications of Metrology

→ Conclusion

UNIT II

OPTICAL SYSTEM

TEXT A

Basics of optics: reflection, refraction, diffraction

1. a) Read and translate the text into Ukrainian using the dictionary. Pay attention to the underlined words and word combinations.

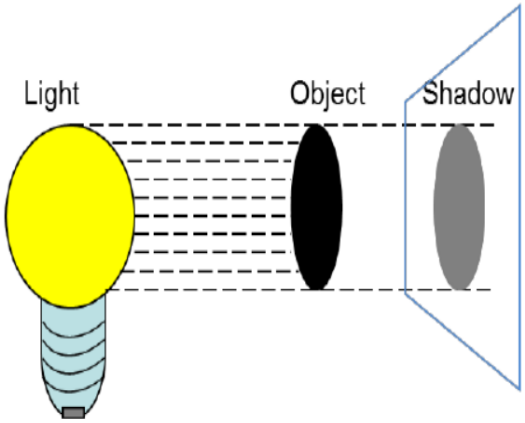
Optics is the scientific study of the behavior of light, and covers reflection, refraction, diffraction and interference, as well as polarization of light. Clinically, light is how we see. It transports visual impressions. Technically it is a form of radiant energy. It stimulates receptor cells on the retina, which in turn transmits impulses to the brain allowing us to see. In addition, light is essential for life on earth. Optics usually describes the behaviour of visible, ultraviolet, and infrared light. Light is a type of electromagnetic radiation, and other forms of electromagnetic radiation such as X-rays, microwaves, and radio waves exhibit similar properties.

Most optical phenomena can be accounted for by using the classical electromagnetic description of light, however complete electromagnetic descriptions of light are often difficult to apply in practice. Practical optics is usually done using simplified models. The most common of these, geometric optics, treats light as a collection of rays that travel in straight lines and bend when they pass through or reflect from surfaces. Physical optics is a more comprehensive model of light, which includes wave effects such as diffraction and interference that cannot be accounted for in geometric optics. Historically, the ray-based model of light was developed first, followed

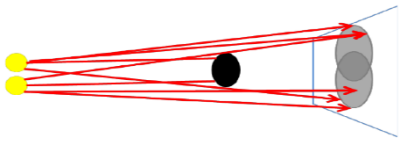
by the wave model of light. Progress in electromagnetic theory in the 19th century led to the discovery that light waves were in fact electromagnetic radiation.

Some phenomena depend on light having both wave-like and particle-like properties. Explanation of these effects requires quantum mechanics. When considering light's particle-like properties, the light is modelled as a collection of particles called "photons". Quantum optics deals with the application of quantum mechanics to optical systems. Optical science is relevant to and studied in many related disciplines including astronomy, various engineering fields, photography, and medicine (particulary ophthalmology and optometry, in which it is called physiological optics). Practical applications of optics are found in a variety of technologies and everyday objects, including mirrors, lenses, telescopes, microscopes, lasers, and fibre optics.

Originally introduced by Pythagoras and later elaborated on by Sir Isaac Newton, **the corpuscular theory of light** states that light consists of tiny particles or bundles of corpuscles, which are emitted by the light source and gathered in (absorbed) by the eye allowing for a visual experience. We use this theory to describe reflection. It also explains how light can be used to create electrical energy and to used to describe reflection, as well as rainbows. The Corpuscular Theory can explain shadows, in that the tiny particles of light will be stopped by an object and unobstructed particles will continue on, forming a shadow.



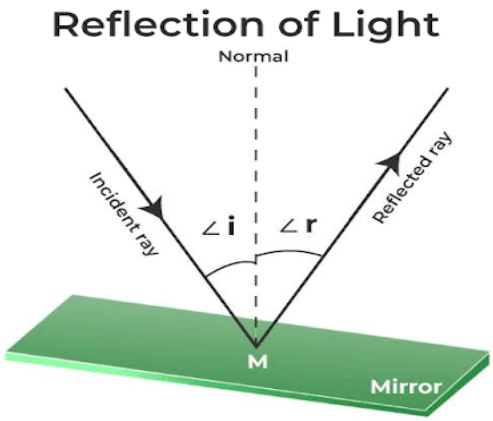
If light from two separate sources fall on the same object, two shadows overlap resulting in an indistinct shadow.



The Electromagnetic Wave Theory explains that light travels in a series of waves moving outward from a light source, how a rainbow is formed, how light is dispersed when it passes through a prism, and how a telescope works.

Begun as the Wave Theory of Light proposed by Huygens in 1678, this theory describes light as waves that move out/spread out from the source that generates light. Each color is a different wavelength. Supernumerary bows are explained by assuming that light is a wave. James Clark Maxwell elaborated on the Wave Theory and describes light as having electric and magnetic properties – electromagnetic waves. It is an improvement over the wave theory in that it explains how light is generated. Visible light is only one type of electromagnetic wave. This theory is very math intensive.

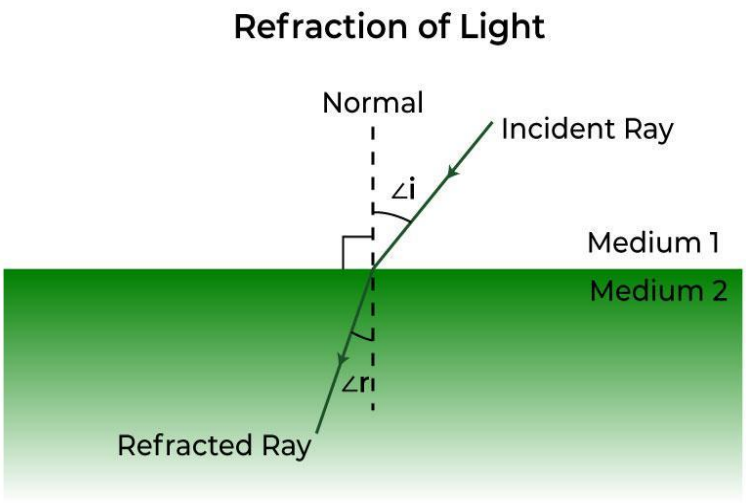
These three fundamental wave phenomena – reflection, refraction, and diffraction describe how waves (including light, sound, and water waves) interact with different media and obstacles. Understanding these concepts is crucial in physics, engineering, and optics.

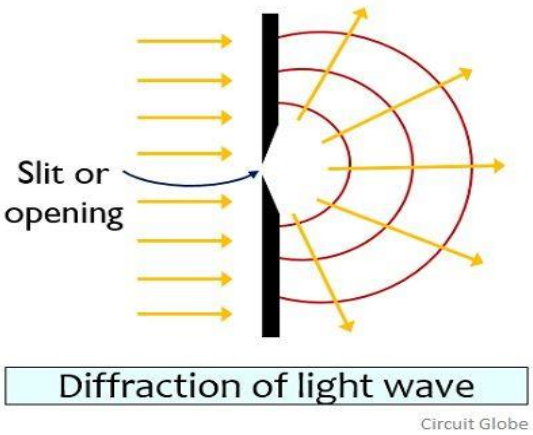


Reflection *is a property of wave which occurs when a travelling wave strikes a surface and it bounces back. The travelling wave is the incident wave while the one that bounces back is the reflected rain. In case of water waves generated in a ripple tank, if the waves were made to incident normally on a plane strip, the wave will be reflected back along their original course.*

If the waves are incident at a particular angle, it will be observed that the angle of incidence is equal to the angle of reflection in line with ***the laws of reflection****. The incident ray, the reflected ray and the normal, at point of incidence, all lie on the same plane. The angle of incidences is equal to the angle of reflection.*

Refraction is the change in the speed and direction of waves as it passes from one medium to another. When plane waves pass from deep to shallow water, their wavelength becomes shorter and thereby travels slowly. A change in the wavelength and speed produce a change in the direction of travel of waves when they cross the boundary. It is important to note that during refraction, the frequency remains constant.





Diffraction is the spreading out of a wave on passing through a narrow opening. If waves are directed towards a large gap compared with the wavelength of the waves, slightly bent or beam of waves are formed on passing through the gap. If the barriers are placed closer to leave a narrow gap waves forms spherical wave fronts on passing through a narrow shit. Diffraction occurs when the wavelength of the wave is longer than the width of the opening or the size of the obstacles.

Reflection, refraction, and diffraction are fundamental properties of wave behavior that explain various natural and technological phenomena. From the working of mirrors and lenses to fiber optics and sound propagation, these principles have wide-ranging applications in science and engineering.

b) Translate the italicized paragraph into Ukrainian (in writing).

c) Put 5 questions to the text.

2. Synonym in Optics Vocabulary:

a) Select five key terms from the text. For each term, create a list of 2 to 6 synonyms that capture the same or similar meanings within the context of optics. Below are examples to guide you:

→ Light – Radiant energy – Electromagnetic radiation – Visible radiation.

→ Travel – Move – Spread – Propagate.

→ Describe – Explain – Define.

→ Phenomenon – Event – Effect – Occurrence.

→ Bend – Refract – Curve – Deflect.

→ Scientific study – Research – Investigation – Exploration.

b) Fill in the Blanks with Synonyms. Choose the correct synonym to complete each sentence.

features, necessary, phenomenon, transmits, impacts

1. Light is _____ for life on Earth.

2. Optics _____ visual impressions to the eye.

3. Diffraction is a wave _____ that describes light spreading through small openings.

4. The study of optics _____ many areas, including physics and engineering.

5. Light _____ different materials in various ways, causing refraction and reflection.

c) Find the Odd One Out. In each group, one word does NOT belong. Find and underline it.

Behavior – Action – Function – Disappear.

Bounces – Reflects – Absorbs – Returns.

Light – Wave – Vision – Darkness.

Transmit – Block – Transfer – Send.

Frequency – Wavelength – Color – Temperature.

d) Rewrite the following sentences by replacing the underlined words with their synonyms.

- Light is a type of electromagnetic radiation.
- Reflection happens when light bounces off a surface.
- A prism splits white light into different colors.
- Refraction changes the speed and direction of light.
- Diffraction spreads out a wave when it passes through an opening.

e) Choose the correct synonym for the underlined word.

1. Light stimulates receptor cells on the retina.
   a) activates
   b) ignores
   c) removes
   d) prevents
2. Optics describes the behavior of light.
   a) prevents
   b) explains
   c) destroys
   d) confuses
3. Light travels as both a wave and a particle.
   a) moves
   b) stops
   c) blocks
   d) covers

4. Reflection occurs when light bounces off a surface.

a) absorbs

b) jumps

c) reflects

d) breaks

5. Diffraction causes light to spread out.

a) narrow

b) expand

c) shorten

d) darken

*f) Write a short paragraph (5-7 sentences) about optics using at least **five** synonyms for the following words: **light, wave, reflection, speed, energy.***

Example: "A beam of **radiant energy** moves through space at an incredible **velocity**. As it meets a mirror, it undergoes **bouncing** due to the law of **mirroring**. This **electromagnetic phenomenon** allows us to see objects around us. Scientists study these **oscillations** to understand the principles of physics."

3. Using the dictionary transcribe and translate the key words:

Word	Transcription	Translation
Electromagnetic radiation		
Electromagnetic spectrum		
Visible light		
Reflection		
Refraction		
Diffraction		
Interference		

Polarization		
Total internal reflection		
Wavelength		
Corpuscular theory of light		
Wave-particle duality		
Fiber optics		
Optical fiber		
Optometry		
Speed of light		
Amplitude		
Photon		
Infrared light		

4. Match each word with its correct definition. Write the correct letter next to each number.

1. Fiber optics ___
2. Prism ___
3. Reflection ___
4. Diffraction ___
5. Refraction ___
6. Interference ___
7. Laser ___
8. Polarization ___
9. Lens ___
10. Wavelength___

A. A technology that uses thin strands of glass or plastic to transmit light signals over long distances.

B. The spreading of waves when they pass through a narrow opening or around an obstacle.

C. A process in which light waves overlap, creating patterns of brightness and darkness.

D. The restriction of light waves to vibrate in a single direction.

E. The bouncing back of light from a surface.

F. A transparent optical element that refracts light to focus or disperse it.

G. A triangular optical element that disperses light into a spectrum of colors.

H. The distance between two successive crests or troughs of a wave.

I. A device that emits a narrow, intense beam of coherent light.

J. The bending of light as it passes from one medium to another.

5. Give English equivalents to the meanings of the following words and word combinations:

Відбиття	
Заломлення	
Дифракція	
Інтерференція	
Поляризація	
Електромагнітне випромінювання	
Хвильова теорія світла	
Корпускулярна теорія світла	
Квантова оптика	
Фотон	
Лінза	

Призма	
Оптичний спектр	
Світловий промінь	
Оптичні волокна	
Лазер	
Дзеркало	
Відбивний кут	
Кут заломлення	
Оптичні прилади	

6. Are the statements true or false?

1. Light is a form of electromagnetic radiation.
2. Reflection occurs when light changes its frequency.
3. Refraction happens when light alters its speed while passing through different mediums.
4. Diffraction describes the bending of light around obstacles or through narrow openings.
5. A photon represents the wave-like nature of light.
6. Polarization involves the alignment of light waves in a specific direction.
7. The corpuscular theory states that light behaves as particles.
8. Red light has a shorter wavelength than blue light.
9. A prism splits white light into its spectral colors.
10. Visible light is the only form of electromagnetic wave.

7. Choose the correct answer:

1. What property of light explains the formation of shadows?
   a) Reflection
   b) Refraction
   c) Diffraction

d) Corpuscular theory

2. What happens to light when it passes through a prism?

a) It reflects

b) It bends and forms a spectrum

c) It disappears

d) It gets scattered

3. What type of electromagnetic wave is visible to the human eye?

a) Infrared

b) Ultraviolet

c) Visible light

d) X-rays

4. Which term describes the bending of light as it enters a denser medium?

a) Reflection

b) Refraction

c) Diffraction

d) Interference

5. What is the smallest unit of light called?

a) Proton

b) Electron

c) Photon

d) Atom

6. Which theory explains light as both a wave and a particle?

a) Electromagnetic theory

b) Quantum mechanics

c) Corpuscular theory

d) Newton’s theory

7. What term is used to describe the spreading of light waves through a narrow opening?

a) Reflection

b) Refraction

c) Diffraction

d) Polarization

8. What phenomenon causes rainbows?

a) Reflection and refraction

b) Diffraction

c) Polarization

d) Interference

9. How do optical fibers transmit information?

a) By polarizing light

b) Through total internal reflection

c) By absorbing light waves

d) Through wave dispersion

10. Who first proposed the wave theory of light?

a) Isaac Newton

b) Christiaan Huygens

c) James Clerk Maxwell

d) Albert Einstein

8. Translate the following sentences into Ukrainian:

1. Optics represents a sophisticated branch of physics dedicated to analyzing the intricate behavior and multifaceted properties of light.

2. It delves deeply into phenomena such as the precise mechanisms of reflection, the bending of light during refraction, the spreading effects of diffraction, and the interaction patterns seen in interference.

3. The dual nature of light, encompassing both particle-like photons and wave-like characteristics, is elegantly described within the framework of quantum optics.

4. Practical implementations of optical science manifest in advanced technologies, including high-precision microscopes, state-of-the-art telescopes, and cutting-edge fiber optic communication systems.

5. The study of optics has catalyzed significant advancements across diverse fields, ranging from groundbreaking medical imaging techniques to revolutionary astronomical observations and innovative photographic technologies.

9. Translate the following sentences into English:

1. Оптика – галузь фізики, яка вивчає властивості та поведінку світла.

2. Світло має подвійну природу, проявляючи як хвильові, так і корпускулярні властивості.

3. Дифракція та інтерференція світла є ключовими явищами у фізичній оптиці.

4. Практичне застосування оптики включає розробку таких приладів, як телескопи, мікроскопи та оптоволоконні системи.

5. Знання оптики відіграють вирішальну роль у галузях медицини, астрономії та інженерії.

10. Answer the questions to the text.

1. What branch of science studies the behavior and properties of light?
2. How does geometric optics simplify the study of light?
3. What does the corpuscular theory of light propose about its nature?
4. How does the electromagnetic wave theory explain the formation of a rainbow?
5. What is the role of quantum mechanics in understanding light?
6. What are some everyday applications of optics mentioned in the text?
7. How does diffraction occur according to the description in the text?
8. What is the difference between physical optics and geometric optics?
9. Which scientist first proposed the wave theory of light?
10. What three fundamental wave phenomena are described in the text?

11. Write a short summary of the text (See the scheme in the Information File (Ex. 11, P. 18) and be ready to present it.

12*. Creative Writing "The Secret Lives of Light: An Adventure Through the World of Optics"

In this story, light is personified and embarks on a journey through various optical phenomena. From bending through prisms and creating rainbows to reflecting off mirrors and diving into the mysteries of fiber optics, light encounters different characters and challenges along the way. The narrative could explore how light interacts with different materials, the science behind these interactions, and the magical effects they produce.

SPEAKING

1. A Comprehensive Discussion & Guidelines

Choose one of the topics and be ready to present it.

→ Exploring the Fundamentals of Optics

1. Define optics and its importance in science and technology.
2. Explain the laws of reflection and its applications in everyday life.
3. Discuss the principles of refraction, Snell's law, and real-world examples like lenses and prisms.
4. Describe diffraction and its significance in optical instruments.
5. Explore the concept of polarization and its uses in sunglasses and photography.

→ Advanced Optical Technologies and Their Applications

1. Explain the working of fiber optic cables and their role in telecommunications.
2. Discuss the principles of lasers and their applications in medicine, industry, and entertainment.

3. Describe different types of optical sensors and their uses in environmental monitoring and security systems.
4. Explore the science behind holography and its potential future applications.

→ Optics in Nature and Everyday Life

1. Explain the formation of rainbows and mirages through optical principles.
2. Discuss how the human eye works and the role of corrective lenses.
3. Explore the use of optics in cameras and the art of photography.
4. Describe various optical illusions and the science behind them.

2. Translate the following text into English.

a) Express the main idea of the text in one sentence.

b) Write a short summary of the text in English.

Оптика – це розділ фізики, який вивчає властивості світла та його взаємодію з матеріалами. Світло може відбиватися, заломлюватися та поляризуватися, створюючи різноманітні оптичні явища.

Основні поняття оптики:

1. Відбиття: Світло відбивається від поверхні, змінюючи напрямок. Це явище використовується в дзеркалах.
2. Заломлення: Світло змінює напрямок при переході з одного середовища в інше. Прикладом є лінзи, які фокусують світло.
3. Дифракція: Світло розсіюється при проходженні через вузькі отвори або перешкоди, створюючи інтерференційні картини.
4. Поляризація: Світло може бути поляризованим, тобто його хвилі коливаються в одному напрямку. Це використовується в сонцезахисних окулярах.

Застосування оптики:

1. Фіброоптика: Використовується для передачі даних через оптичні волокна.

2. Лазери: Застосовуються в медицині, промисловості та розвагах.
3. Оптичні сенсори: Використовуються для моніторингу навколишнього середовища та систем безпеки.
4. Голографія: Створення тривимірних зображень за допомогою світла.

Оптика є важливою частиною нашого життя – від таких природних явищ як веселка до технологій, які ми використовуємо щодня. Вона допомагає нам краще розуміти світ навколо нас і розвивати нові технології для майбутнього.

3*. Research and Presentation:

Prepare a presentation «**The Wonders of Optics: From Basic Principles to Cutting-Edge Technologies**» *following the plan below:*

1. **Introduction to Optics**
    - Definition and importance of optics in science and technology.
    - Brief history of optical discoveries.
2. **Fundamental Principles of Optics**
    - Reflection: Laws of reflection and everyday applications.
    - Refraction: Snell's law, lenses, and prisms.
    - Diffraction: Understanding diffraction patterns and their significance.
    - Polarization: How polarization works and its practical uses.
3. **Optical Phenomena in Nature**
    - Rainbows: Formation and explanation.
    - Mirages: How they occur and the science behind them.
    - Optical Illusions: Examples and the principles that create them.
4. **Modern Optical Technologies**
    - Fiber Optics: How they work and their role in telecommunications.
    - Lasers: Principles, types, and applications in various fields.
    - Optical Sensors: Types and uses in environmental monitoring and security.

- Holography: The science behind holograms and future applications.

5. **Optics in Everyday Life**
    - Vision and Eyewear: How the human eye works and the role of corrective lenses.
    - Photography: The use of optics in cameras and the art of capturing images.
    - Sunglasses: How polarized lenses protect our eyes.
6. **Future of Optics**
    - Emerging technologies and potential advancements.
    - The impact of optics on future scientific research and everyday life.

Conclusion

TEXT B

LASER TECHNOLOGY APPLICATIONS

1. a) Read and translate the text into Ukrainian using the dictionary. Pay attention to the underlined words and word combinations.

In today's technological landscape, laser technology stands at the core of industrial development. This technology has a wide range of applications, from precision cutting to engraving. However, various applications of laser technology also present unique challenges, such as safety concerns and environmental impact.

Laser technology involves using light to perform various functions like cutting, engraving, measuring, and communication. The word "laser" stands for Light Amplification by Stimulated Emission of Radiation. Simply put, lasers produce highly focused beams of light that are coherent, monochromatic, and collimated.

Lasers are different from regular light sources so that they concentrate light into a powerful beam, enabling applications requiring precision and high energy density. This makes laser technology incredibly versatile across many industries. Laser-cutting equipment is commonly used in manufacturing processes with high precision and speed.

There are applications of laser in various fields and across a diverse range of industries. Lasers are used for a variety of applications in scientific, medical, industrial, and commercial fields. The output power and wavelength of a laser determines the kind of applications for which it is most appropriate.

Laser cutting is one of the most common uses of laser technology. It involves using a high-powered laser beam to cut through various materials, including metals, plastics, wood, and ceramics. Laser cutting machine is valued for its ability to create intricate designs.

Laser Technologies provides advanced tube Laser Cutting Machines that offer accuracy for industries needing high-quality, complex tube cuts. The Universal Tube Laser Cutting Machine R2 is an advanced machine for businesses looking to cut various tubes and profiles efficiently. Tiny Tube Laser Cutting Machine R1 is a more compact and specialized version for smaller tubes. R1 is a precision micro-cutting machine that is space-efficient, easy to maintain, and ideal for small workshops or operations with limited space.

Laser welding is a high-precision technique used in industries such as aerospace, automotive, and electronics. Lasers provide a focused, intense heat source, which enables highly accurate welding without affecting surrounding materials. Laser Welding is particularly useful in applications where a high-quality, clean weld is needed or where the components being joined are delicate.

Smartweld is a handheld, cost-effective welding system with faster writing speed, making it easy to operate and saving welders annually, resulting in smoother welding seams. This machine is suitable for basic applications of laser in industry to the most advanced applications of laser in manufacturing.

Laser engraving *and marking are used for permanent designs, logos, or text onto products. This is commonly used for industrial branding, product identification, and consumer personalization. The beauty of laser engraving is that it doesn't require physical contact, meaning there's no wear on the material surface during the process, and the designs are highly durable. Fiber Laser Marking Machines offer efficient, precise solutions for various materials, utilizing advanced fiber laser technology and beam control for high performance.*

Laser Technology Challenges. Despite its many laser technology applications, laser cutting machines in India do come with certain challenges. Some of the major laser technology challenges include:

1. High Initial Investment. Laser systems, especially industrial machines, can have a high upfront cost. This can make them prohibitive for small businesses or startups. However, the long-term benefits of improved precision and efficiency often outweigh the initial investment.

2. Material Limitations. While lasers are highly effective for cutting a range of materials, not all materials are suitable for laser cutting. Reflective materials like copper and brass can cause laser beams to scatter, reducing cutting efficiency. However, technological advancements are continually expanding the materials that can be processed with lasers.

3. Training and Expertise. Laser machines often require specialized knowledge to operate effectively. Operators need to be trained in how to handle the equipment, maintain it, and troubleshoot any issues that may arise. Companies must invest in training to ensure that their staff can utilize the full potential of laser technology.

4. Safety Concerns. Lasers emit powerful beams of light that can cause harm if not handled properly. Protective measures such as shields, and proper machine enclosures are necessary to ensure the safety of workers. Manufacturers must adhere to stringent safety standards to prevent accidents.

5. Maintenance and Calibration. Like all high-tech equipment, laser systems require regular maintenance and calibration to maintain their performance and precision. Although maintenance schedules can be planned, machine downtime can still be disruptive, particularly in high-demand operations.

Laser Technologies stands as a reliable partner for businesses looking to integrate laser-cutting solutions into their operations. With a focus on quality, innovation, and customer satisfaction, Laser Technologies provides products that address the needs of modern manufacturing industries.

Laser Technologies offers innovative machines such as the universal tube laser cutting machine R2 and the tiny tube laser cutting machine R1, both of which are designed to meet the demands of industries requiring high-precision cutting. These machines provide versatile, reliable, and efficient solutions for tube processing, ensuring that customers receive the best-in-class technology.

Superior After-Sales Support is committed to ensuring that customers get the most out of their laser machines. Their dedicated after-sales support team provides technical assistance, troubleshooting, and maintenance services to keep your machines running at peak performance. Whether it's machine installation, training, or regular servicing, Laser Technologies ensures that every customer gets the full value from their investment.

Laser Technologies understands that different industries have unique needs. They offer customizable laser-cutting solutions that can be tailored to specific requirements. Whether you're cutting small or large tubes or need specialized configurations, Laser Technologies works closely with customers to provide personalized solutions.

Laser technology has multiple industries, from precision cutting and applications. Laser-cutting machines like those offered by Laser Technologies provide businesses with the tools they need to stay ahead in the competitive manufacturing landscape. By choosing Laser Technologies the customers gain reliable support that ensures their machines perform at their best over the long term.

b) Translate the italicized paragraph into Ukrainian (in writing).

c) Put 5 questions to the text.

2. Advanced Synonym Exercise:

a) Match the words with their synonyms.

1. Precision	A. Use
2. Versatile	B. Limitation
3. Application	C. Restriction
4. Restriction	D. Diverse
5. Limitation	E. Accuracy
6. Advanced	F. Sophisticated
7. Efficient	G. Effective
8. Permanent	H. Lasting
9. Compact	I. Advancement
10. Innovation	J. Small-sized

b) Rewrite the following sentences, replacing the highlighted words with their synonyms.

1. Laser **technology** is widely used in manufacturing.
2. The **primary** challenge of laser cutting is its cost.
3. This machine provides **high-quality** results.
4. Laser engraving is a **permanent** method of marking materials.

5. The company offers **efficient** after-sales support.
6. Laser cutting allows for precise designs. (replace "precise")
7. The **development** of laser systems has revolutionized manufacturing.
8. The **compact** size of the Tiny Tube Laser Cutting Machine R1 makes it ideal for small workshops.
9. Laser welding provides a **strong** bond between materials.
10. The industry is looking for more **cost-effective** laser solutions.

c) Complete the sentences with the correct synonym of the word in brackets.

1. Laser cutting provides _____ (accuracy) for intricate designs.
2. The company offers _____ (customized) solutions for different industries.
3. One of the main _____ (challenges) of laser technology is high initial costs.
4. Laser welding is an _____ (effective) method for joining delicate components.
5. Smartweld is a _____ (portable) and user-friendly laser welding system.

d) Choose the synonym that best matches the word in bold.

1. **Precision** is a key factor in laser cutting.
    a) Efficiency
    b) Accuracy
    c) Strength
2. The company develops **advanced** laser machines.
    a) Outdated
    b) Sophisticated
    c) Simple
3. Laser welding provides a **focused** heat source.
    a) Diffused
    b) Concentrated
    c) Random

4. The use of lasers in medicine is **expanding.**

a) Growing

b) Shrinking

c) Stopping

5. The machine has **various** industrial applications.

a) Limited

b) Multiple

c) Single

3. Using the dictionary transcribe and translate the key words and words combinations:

Word	***Transcription***	***Translation***
Coherent light		
Laser technology		
Monochromatic light		
Collimated beam		
Laser cutting		
Engraving		
Marking		
Wavelength		
Output power		
Precision		
High energy density		
Tube laser cutting		
Fiber laser		
Micro-cutting		
Laser welding		

Beam control		
Calibration		
Reflective materials		
Safety standards		
Light Amplification		

4. Match the words with their definitions. Write the correct letter next to each number.

1. Laser cutting ___
2. Engraving ___
3. Marking ___
4. Wavelength ___
5. Precision ___
6. Collimated beam ___
7. Fiber laser ___
8. Calibration ___
9. Reflective materials ___
10. Safety standards ___

A. A technique that uses a laser to join materials by melting them together.

B. The process of removing material from a surface using a laser to create text, logos, or patterns.

C. The use of a focused laser beam to precisely cut materials like metal, plastic, or wood.

D. A measurement of the distance between two peaks in a wave of light, determining its color and energy.

E. The ability to achieve highly accurate and detailed results with minimal error.

F. A laser beam where the light rays travel parallel to each other without spreading out.

G. A type of laser that uses optical fibers to generate and transmit a powerful laser beam.

H. The process of adjusting and fine-tuning a laser system to ensure accurate performance.

I. Surfaces like copper or brass that can scatter or reflect a laser beam, making cutting more difficult.

J. Regulations and guidelines that ensure laser machines are used without causing harm to operators.

5. Give English equivalents to the meanings of the following words and word combinations.

стандарти безпеки	
калібрування	
відбиваючі матеріали	
керування променем	
мікрорізання	
лазерне зварювання	
лазерне різання труб	
волоконний лазер	
висока щільність енергії	
вихідна потужність	
точність	
довжина хвилі	
лазерна технологія	
підсилення світла	

когерентне світло	
монохроматичне світло	
коллімований промінь	
лазерне різання	
гравіювання	
маркування	

6. Choose the correct answer.

1. What does "laser" stand for?

a) Light Absorption by Simulated Emission of Radiation

b) Light Amplification by Stimulated Emission of Radiation

c) Light Application by Strong Energy Radiation

d) Light Acceleration by Systematic Emission of Rays

2. Which process uses a laser to cut materials with high precision?

a) Engraving

b) Marking

c) Welding

d) Laser cutting

3. What is the main advantage of laser engraving?

a) It requires physical contact with the surface

b) It is a temporary marking technique

c) It creates durable, precise designs without damaging the material

d) It works only on metal surfaces

4. Which type of laser is commonly used for high-precision cutting and marking?

a) Gas laser

b) Fiber laser

c) Fluorescent laser

d) Solar laser

5. What is a wavelength in laser technology?

a) The power output of a laser beam

b) The speed at which the laser moves

c) The distance between two peaks in a wave of light

d) The width of the laser beam

6. Why are reflective materials a challenge for laser cutting?

a) They absorb too much heat

b) They reflect the laser beam, reducing efficiency

c) They are too thin to be cut

d) They change color when exposed to a laser

7. Which industry commonly uses laser welding?

a) Fashion design

b) Aerospace

c) Agriculture

d) Baking

8. What is the main safety concern when using lasers?

a) Loud noise production

b) Weak structural design

c) High-energy beams that can damage eyes and skin

d) The need for frequent refueling

9. What is calibration in laser systems?

a) The process of heating up the laser

b) The adjustment of the laser for accuracy and performance

c) A method of cooling the laser machine

d) The installation of laser safety shields

10. What is one major disadvantage of laser technology?

a) Low precision

b) High initial cost

c) Slow processing speed

d) Requires constant manual operation

7. Write T (True) or F (False) for each statement.

1. ___ Lasers produce a highly focused, coherent, and monochromatic beam of light.

2. ___ Laser cutting can only be used on metal materials.

3. ___ One of the advantages of laser engraving is that it does not physically touch the material.

4. ___ Fiber lasers are less efficient than traditional gas lasers.

5. ___ Laser welding is commonly used in the aerospace and automotive industries.

6. ___ A collimated laser beam spreads out quickly as it moves away from the source.

7. ___ Calibration is necessary to maintain the accuracy and performance of laser machines.

8. ___ Reflective materials, such as copper and brass, can reduce laser cutting efficiency.

9. ___ Laser technology has no safety risks, making protective gear unnecessary.

10. ___ One of the main challenges of laser technology is its high initial investment cost.

8. Translate the following sentences into Ukrainian.

1. Laser technology is widely used in industries such as manufacturing, medicine, and telecommunications.

2. Laser cutting allows for precise and high-speed material processing, making it ideal for intricate designs.

3. Fiber lasers are energy-efficient and provide high-quality results in engraving and marking applications.

4. Laser welding is commonly used in the automotive and aerospace industries for strong and clean welds.

5. Despite its advantages, laser technology requires safety precautions to protect workers from high-energy beams.

9. Translate the following sentences into English.

1. Сучасні лазерні технології широко застосовуються в медицині, промисловості та науці.

2. Лазерне різання дозволяє виконувати точну та швидку обробку матеріалів без механічного контакту.

3. Волоконні лазери є енергоефективними та забезпечують високу якість гравіювання та маркування.

4. Лазерне зварювання використовується в авіаційній та автомобільній промисловості для створення міцних з'єднань.

5. Попри переваги, лазерне обладнання потребує регулярного калібрування та дотримання правил безпеки.

10. Answer the questions to the text.

1. What does the word LASER stand for?
2. What are the main applications of laser technology?
3. Why is laser cutting widely used in manufacturing?
4. What is the difference between laser engraving and laser marking?
5. How does laser welding benefit industries like aerospace and automotive?
6. Why can reflective materials be challenging for laser cutting?
7. What role does calibration play in laser systems?
8. What are some safety concerns associated with laser technology?
9. What is one of the biggest challenges in adopting laser technology?
10. How do fiber lasers differ from traditional gas lasers?

11. Write a short summary of the text (See the scheme in the Information File (Ex. 11, P. 18) and be ready to present it.

12*. Creative Writing *"The Future of Laser Technology: How Lasers Will Shape Our World in 2050"*

Prompt: Imagine you are living in the year 2050, where laser technology has advanced beyond today's limits. Write a futuristic story or an article exploring how lasers are transforming industries, from medicine and transportation to space exploration and daily life.

Ideas to consider:

- Laser-powered medical treatments that heal wounds instantly.
- Laser highways where vehicles move on beams of light.
- Space exploration using high-energy lasers to propel spacecraft.
- Holographic communication enhanced by laser projection.
- Potential dangers and ethical concerns of advanced laser technology.

SPEAKING

1. A Comprehensive Discussion & Guidelines

Discuss about laser technology, its applications, challenges, and future prospects. Provide detailed explanations, examples, and practical guidelines on its safe and effective use.

- *Define* laser technology and explain its significance.
- Briefly *mention* key applications and challenges.
- *Discuss* how lasers are used in industry, medicine, communication, and research.

- *Explain* the difficulties of high costs, safety risks, and material limitations.
- *Provide* recommendations on safety measures, proper training, and maintenance.
- *Predict* potential advancements and their impact on society.
- *Summarize* key points and express your opinion on the importance of further research in this field.

2. Translate the following text into English.

a) Express the main idea of the text in one sentence.

b) Write a short summary of the text in English.

Застосування лазерних технологій

Лазерні технології відіграють важливу роль у сучасному світі, охоплюючи широкий спектр галузей – від промисловості до медицини та науки. Завдяки своїй високій точності, швидкості та ефективності лазери відкрили нові можливості для технологічного прогресу.

Одна з найпоширеніших сфер використання лазерів – *промислове виробництво*. Лазерне різання застосовується для обробки металів, пластику, скла та інших матеріалів. Воно дозволяє створювати складні деталі з високою точністю, що особливо важливо в автомобільній, авіаційній та електронній промисловості. Крім того, лазерне зварювання забезпечує міцні та чисті шви без зайвого перегріву матеріалу.

У *медицині* лазери використовуються для операцій, діагностики та терапії. Лазерна хірургія дозволяє виконувати безкровні операції, наприклад, корекцію зору чи видалення пухлин. Лазерна косметологія допомагає в лікуванні шкірних захворювань, видаленні татуювань та омолодженні шкіри. Лазерні технології також активно застосовуються в стоматології для лікування карієсу та відбілювання зубів.

Наукові лабораторії широко використовують лазерні технології для *досліджень у фізиці, хімії та біології*. Лазерна спектроскопія дозволяє вивчати

склад речовин, а потужні лазерні установки допомагають моделювати екстремальні умови, що існують у космосі.

Сучасні оптичні волоконні мережі працюють на основі лазерного випромінювання, що забезпечує швидку та стабільну передачу інформації. Волоконні лазери використовуються для передачі сигналів у глобальних мережах зв'язку, що дозволяє отримувати доступ до високошвидкісного інтернету та мобільного зв'язку.

У *військовій галузі* лазери застосовуються для систем наведення, далекомірів, зв'язку та навіть зброї. Лазерні системи дозволяють точно визначати відстань до цілі, а також використовуються в оборонних технологіях, зокрема для створення протиракетних систем.

Отже, лазерні технології мають величезний потенціал і продовжують розвиватися. Їх застосування покращує точність виробничих процесів, сприяє розвитку медицини, науки та комунікацій. Незважаючи на певні виклики, такі як висока вартість обладнання та необхідність дотримання правил безпеки, лазерні технології залишаються ключовим елементом сучасного технічного прогресу.

3*. Research and Presentation:

Conduct research on **laser technology**, focusing on its **applications, challenges, and future developments**. Prepare a well-structured **presentation** to share your findings with the class.

Instructions:

1. **Research Phase:**
    - Define **laser technology** and explain how it works.
    - Explore **key applications** of lasers in industries such as **manufacturing, medicine, telecommunications, and space exploration**.

- Identify **challenges** in laser technology, such as **safety concerns, material limitations, and high costs**.
- Discuss future advancements and how lasers could evolve in the next decades.

2. **Presentation Structure:**
   - **Slide 1:** Title Slide (Topic, Your Name, Date)
   - **Slide 2-3:** Introduction to Laser Technology (Definition, Principles, Types)
   - **Slide 4-6:** Applications (Provide examples with images or diagrams)
   - **Slide 7-8:** Challenges and Solutions
   - **Slide 9-10:** Future Prospects and Innovations
   - **Slide 11:** Conclusion (Key Takeaways)
   - **Slide 12:** References (Sources used in research)
3. **Presentation Requirements:**

✓ **10-12 slides** using Power Point, Google Slides, or another visual tool.

✓ Use **clear headings, bullet points, and visuals** to support your points.

✓ Keep text **concise** and focus on **key facts.**

✓ Be ready to **present for 5-7 minutes** and answer questions.

UNIT III

LASER TECHNOLOGIES AND MICROTECHNOLOGIES

TEXT A

WHAT IS AN INDUSTRIAL LASER AND HOW DOES IT WORK?

1. a) Read and translate the text into Ukrainian using the dictionary. Pay attention to the underlined words and word combinations.

For a lot of people, lasers are small boxes that shoot red dots, which drive cats crazy. But in fact, laser systems are used in many manufacturing processes.

Industrial lasers are used to cut metals and fabrics, mark tracking codes for industrial traceability, weld metals with high precision, clean metal surfaces, change the surface roughness, and measure part dimensions. They are widely used in several industries such as the EV and primary metals industries.

There are numerous industrial applications that could benefit from the use of a laser, which is found in many industries. But before you can decide if a laser machine would be useful for one of your applications, it might be helpful to have an understanding of the components of a laser and how they work. Lasers come at different power levels, colors and beam sizes, but they all rely on the same principles. Here's what an industrial laser is and how it works.

For now, let's just imagine that a laser is a magic black box with light coming out of it.

Here are **the three properties** of that light:

1. *Monochromatic*

2. *Single Direction*
3. *Coherent*

Laser light is monochromatic, meaning that the color of the beam has a single specific color. The color of the light is defined by the wavelength of the electromagnetic waves that it is composed of. The beam can be either visible, infrared or ultraviolet. For example, a normal incandescent light appears yellowish, but actually emits a mixture of green, yellow, red, blue and even infrared light. Its wavelength ranges between 400 and 800 nanometers.

On the other hand, a standard industrial red laser (helium-neon, for example) has a wavelength that ranges between 632.800 to 632.802 nanometers. Common incandescent light is polychromatic and a helium-neon laser is monochromatic. Monochromaticity is what makes laser light unique and allows for some of its special applications.

Lasers come at different **power levels, colors** and **beam**

The laser beam has a single direction. Its direction is fixed and its beam diameter is small and almost constant over large distances. This concentration of light is what allows lasers to have very high power output. High-energy pulsed lasers, with power in the megawatts, are strong enough to cut through metal.

The beam is also said to be *coherent*, meaning that all the light rays in the beam are synchronized. They have the same phase and the same polarity. This coherence also helps the beam reach its high powers.

Three Components. Here are the three things you need in your laser cavity (the magic black box) to have a working laser:

1. *Gain Medium*
2. *Energy Source*
3. *Two Mirrors*

The gain medium is the material you put in your laser cavity. It can be a solid (a ruby crystal), a liquid (a dye solution) or a gas (a helium-neon mixture). The important feature is that it emits light in the desired wavelength when excited.

In fiber lasers, the gain medium is an optical fiber doped with a rare-earth element. Ytterbium-doped fiber lasers, for example, emit a wavelength that is ideal for laser processing metals.

The energy source is what causes the gain medium to emit light in the laser cavity. Very often, the energy source is a set of diode lasers which transform electricity into light.

In CO2 lasers however, simple electrical discharges can cause the carbon dioxide gas to emit light. This happens because by exciting the molecules (using a discharge) the electrons in the gas reach a higher energy state. However, electrons prefer being in their lower energy state (the ground state). So, some electrons will spontaneously go back to that ground state by emitting light to spend their excess energy. In this case, light is randomly emitted in every direction though spontaneous emissions of light are rare. Both of these factors are problems for creating lasers. These problems can be solved by using the third component, the two mirrors.

Laser is an acronym for **L**ight **A**mplification by **S**timulated **E**mission of **R**adiation

The mirrors are put on both sides of the laser cavity with critical parallel alignment. The mirrors will bounce the light endlessly creating perfectly perpendicular light rays. The accumulation of light along the axis of the laser cavity eventually creates a high-power laser beam. This solves the first problem of creating a coherent laser beam out of randomly emitted light.

The second problem, the rarity of spontaneous emissions, is solved by provoking stimulated emissions. When light waves pass near excited electrons, these electrons are stimulated and have a higher probability of going to their ground state thereby emitting light at the same wavelength, direction and polarization as the one that passed near it.

So now, we have a cavity filled with a gain medium that, when excited by an energy source, emits light. Two mirrors enable the selection of a specific direction, provoke the

accumulation of light and stimulate the emission of even more light. So how does the light come out of the cavity? Well, actually, one of the mirrors isn't perfectly reflective. It let some of the light through and that's how the laser beam is created. That beam has special characteristics that can be used for laser marking, cleaning, cutting or even welding.

You now know the basic principles behind creating lasers. Modern industrial lasers are optimized using more elaborate techniques to increase their power, precision, and robustness, but the principles remain the same.

b) Translate the italicized paragraph into Ukrainian (in writing).

c) Put 5 questions to the text.

2. Advanced Synonym Exercise:

a) Match the words with their synonyms.

1. Light	A. Optical radiation
2. Power	B. Gain medium
3. Emit	C. Output intensity
4. Beam	D. Coherent wavefront
5. Energy	E. Specular return
6. Reflection	F. Induce
7. Material	G. Manufacturing application
8. Precision	H. Micron-level accuracy
9. Generate	I. Radiate
10. Process	J. Excitation source

b) Fill in the blanks with the correct synonym for the word in parentheses.

1. The _____ (light) emitted by the laser is highly monochromatic and coherent.
2. High _____ (power) lasers can penetrate thick metal sheets.

3. The beam remains _____ (focused) over long distances due to its coherence.
4. Industrial lasers use optical fibers to _____ (transmit) light efficiently.
5. Laser welding provides extreme _____ (precision) in joining materials.
6. The surface of the material can _____ (absorb) laser energy for processing.
7. The laser's _____ (intensity) determines the depth of engraving.
8. Engineers use lasers for _____ (measurement) of complex geometries.
9. The laser system must be properly aligned to avoid excessive _____ (reflection).
10. CO_2 lasers are commonly used to _____ (cut) through non-metallic materials.

c) Select the most appropriate synonym for the underlined word.

1. The beam is concentrated and does not disperse easily.
    a) Pulse
    b) Wave
    c) Coherent wavefront
    d) Glow
2. The laser processes the material by heating it.
    a) Alters
    b) Transforms
    c) Engraves
    d) Ablates
3. High-energy lasers can penetrate metal surfaces.
    a) Pierce
    b) Absorb
    c) Scatter
    d) Refine
4. The laser's mirror must be aligned properly for efficiency.
    a) Reflective surface

b) Optical filter

c) Lens

d) Glass

5. Laser systems require extreme accuracy to ensure quality results.

a) Focus

b) Precision

c) Power

d) Speed

3. Using the dictionary transcribe and translate the key words and words combinations:

Word	***Transcription***	***Translation***
Laser system		
Welding		
Surface cleaning		
Manufacturing processes		
Coherence		
Light reflection		
Optical cavity		
Gain medium		
Industrial lasers		
Emission power		
Metal cutting		
Directed beam		
Engraving		
Precision		
Industrial application		

Energy source		
Molecular excitation		
High-energy pulse		
Wavelength		
Optical fiber		

4. Give English equivalents to the meanings of the following words and word combinations.

Лазерна система	
Високоенергетичний імпульс	
Промислове застосування	
Підсилююче середовище	
Потужність випромінювання	
Оптична порожнина	
Відбиття світла	
Оптичне волокно	
Збудження молекул	
Виробничі процеси	
Джерело енергії	
Довжина хвилі	
Направлений промінь	
Коагерентність	
Точність	
Очищення поверхонь	
Промислові лазери	

Розрізання металу	
Зварювання	
Гравіювання	

5. Match the words with their definitions.

1. Laser system	A. The process of removing contaminants or coatings from a surface using laser energy.
2. Manufacturing processes	B. The accuracy and consistency of a laser beam in industrial processes.
3. Industrial lasers	C. A complete setup that generates, directs, and controls laser beams for industrial use.
4. Metal cutting	D. A fine-tuned manufacturing method that removes material from a surface to create markings or designs.
5. Welding	E. The ability of a laser to emit light waves that are synchronized in phase and direction.
6. Surface cleaning	F. A laser beam that maintains a single trajectory without dispersing.
7. Engraving	G. A category of lasers designed specifically for heavy-duty material processing and manufacturing.
8. Precision	H. The process of cutting materials like steel, aluminum, or titanium using a high-powered laser.
9. Coherence	I. A controlled process that joins materials by melting them together with laser energy.
10. Directed beam	J. The set of procedures and techniques used in producing goods, often involving automation.

6. Choose the correct answer.

1. What makes laser light different from regular light?

    a) It consists of multiple wavelengths.

    b) It is polychromatic and incoherent.

    c) It is monochromatic, directional, and coherent.

    d) It scatters in all directions.

2. Which component of a laser provides energy to excite the gain medium?

    a) Optical fiber

    b) Energy source

    c) Beam expander

    d) Reflection mirror

3. What is the function of the gain medium in a laser system?

    a) It amplifies light by stimulated emission.

    b) It reflects the laser beam.

    c) It cools down the laser system.

    d) It absorbs light instead of emitting it.

4. Which type of laser is commonly used for cutting metals in industrial applications?

    a) CO_2 laser

    b) Excimer laser

    c) Ultraviolet laser

    d) Dye laser

5. What happens when a laser beam is directed at a metal surface with high energy?

    a) The metal absorbs the energy and melts or vaporizes.

    b) The metal reflects all the light, preventing any effect.

    c) The laser beam passes through without interaction.

    d) The metal changes color permanently but does not heat up.

6. What does “wavelength” determine in a laser?

    a) The amount of power the laser emits

    d) The color and type of laser light

c) The speed at which the laser beam moves

d) The ability of the laser to reflect surfaces

7. What property of laser light ensures that the beam stays narrow over long distances?

a) Divergence

b) Coherence

c) Dispersion

d) Absorption

8. Which laser characteristic is responsible for high precision in industrial applications?

a) Random emission of light

b) Low energy output

c) Directionality and coherence

d) Large beam divergence

9. Why do CO_2 lasers work well for cutting non-metal materials like plastics and wood?

a) Their wavelength is well absorbed by these materials.

b) They emit ultraviolet light that reacts with the materials.

c) They have low power and cannot cut metals.

d) Their beam is highly divergent.

10. In laser welding, what is the primary advantage of using a laser compared to traditional welding methods?

a) Lasers generate less heat and are safer.

b) Laser welding is slower but more stable.

c) Lasers provide precise, deep penetration with minimal distortion.

d) Laser welding works only on thin materials.

7. Write T (True) or F (False) for each statement.

1. ___ Lasers emit light that is polychromatic and incoherent.

2. ___ The gain medium in a laser system is responsible for amplifying light.

3. ___ Laser cutting is only used for metals and cannot be applied to non-metal materials.

4. ___ Coherence ensures that laser waves are synchronized in phase and direction.

5. ___ Optical fibers are used to transmit laser beams over long distances with minimal energy loss.

6. ___ All industrial lasers use gas as a gain medium.

7. ___ High-energy pulsed lasers can be used for cleaning surfaces and removing coatings.

8. ___ Reflection does not affect laser systems and has no role in their operation.

9. ___ Wavelength determines the color and absorption properties of laser light.

10. ___ Laser welding is less precise than traditional welding methods.

8. Translate the following sentences into Ukrainian.

1. Industrial lasers are widely used in various manufacturing industries for cutting, welding, engraving, and marking materials with extremely high precision and efficiency.

2. The gain medium inside a laser system, which can be a gas, solid, or liquid, plays a crucial role in amplifying light by emitting photons through the process of stimulated emission when excited by an external energy source.

3. Coherent laser beams, unlike regular light sources, maintain their phase, direction, and focus over long distances, which makes them highly effective for industrial applications such as laser cutting, medical surgeries, and optical communication.

4. Optical fibers, made of flexible and transparent glass or plastic, are specifically designed to transmit laser light over long distances with minimal energy loss, ensuring efficient power delivery in telecommunications, medical treatments, and laser machining.

5. High-energy pulsed lasers, which generate short but extremely intense bursts of light, are commonly used in industrial cleaning processes to remove rust, paint, and contaminants from metal surfaces without causing any damage to the underlying material.

9. Translate the following sentences into English.

1. Промислові лазери широко використовуються у виробництві для різання, зварювання, гравіювання та маркування матеріалів з надзвичайною точністю та ефективністю.

2. Підсилювальне середовище всередині лазерної системи, яке може бути газоподібним, твердим або рідким, відіграє ключову роль у посиленні світла шляхом випромінювання фотонів під дією стимульованого випромінювання.

3. Когерентні лазерні промені, на відміну від звичайних джерел світла, зберігають свою фазу, напрямок і фокусування на великих відстанях, що робить їх ідеальними для промислових застосувань, таких як лазерне різання, медичні операції та оптичний зв'язок.

4. Оптичні волокна, виготовлені з гнучкого та прозорого скла або пластику, спеціально розроблені для передачі лазерного світла на великі відстані з мінімальними втратами енергії, забезпечуючи ефективну передачу потужності у телекомунікаціях, медичних процедурах і лазерній обробці.

5. Високоенергетичні імпульсні лазери, які створюють короткі, але надзвичайно інтенсивні спалахи світла, широко застосовуються у промисловому очищенні для видалення іржі, фарби та забруднень з металевих поверхонь без пошкодження основного матеріалу.

10. Answer the questions to the text.

1. What are some industrial applications of laser systems?
2. What are the three key properties of laser light?
3. How does the wavelength of a laser affect its color and application?
4. What role do mirrors play inside a laser system?
5. What is the function of the gain medium in a laser?
6. How does the energy source contribute to laser operation?
7. What is the difference between polychromatic and monochromatic light?
8. Why is coherence an important property of laser light?

9. How do high-energy pulsed lasers achieve metal cutting?

10. What makes fiber lasers different from CO_2 lasers?

11. Write a short summary of the text (See the scheme in the Information File (Ex. 11, P. 18) and be ready to present it.

12*. Creative Writing «The Secret Life of a Laser Beam»

Imagine that you are a laser beam, created inside a high-tech industrial machine. From the moment you are emitted through the tiny opening of the optical cavity, your journey begins. You travel at the speed of light, slicing through metal, engraving intricate designs, or welding pieces together with incredible precision.

But what if lasers had thoughts? What if they had emotions? What would it feel like to be the sharpest, most precise tool in the factory? Would you enjoy cutting through steel, or would you long for a different purpose, like creating stunning light shows?

Write a story from the perspective of a laser beam as it moves through different industrial applications.

SPEAKING

1. A Comprehensive Discussion & Guidelines

Hold a debate on «Industrial applications of lasers». Work in small groups.

1. The Role of Lasers in Modern Manufacturing

- How have industrial lasers changed the manufacturing industry?
- What are the advantages of laser cutting compared to traditional cutting methods?
- What industries benefit the most from laser technology?

2. The Science Behind Laser Technology

- How does the coherence of laser light make it different from regular light?
- Why is monochromatic light important in laser applications?

- How do different types of lasers (CO_2, fiber, solid-state) compare in terms of efficiency?

3. Future Innovations in Laser Technology

- How could lasers improve medical treatments and surgeries in the future?
- Could lasers replace traditional energy sources for industrial applications?
- What are the potential risks and ethical concerns of using high-powered lasers?

4. Lasers and Environmental Sustainability

- Are lasers more energy-efficient than traditional industrial tools?
- How can laser technology contribute to sustainable manufacturing?
- Could laser-based recycling systems help reduce industrial waste?

5. The Ethical and Safety Considerations of Laser Use

- What safety measures should be taken when working with industrial lasers?
- Should there be stricter regulations on laser technology to prevent misuse?
- How can laser technology be used responsibly in defense and military applications?

2. Translate the following text into English.

a) Express the main idea of the text in one sentence.

b) Write a short summary of the text in English.

Індустріальне застосування лазерів

Сучасні промислові лазери відіграють ключову роль у виробничих процесах, забезпечуючи високу точність, ефективність та швидкість обробки матеріалів. Завдяки своїм унікальним властивостям – монохроматичності, когерентності та направленості – лазерне випромінювання широко застосовується в різних галузях промисловості.

1. Лазерне різання та гравіювання. Однією з найпоширеніших сфер використання лазерів є різання металів, пластику, скла та інших матеріалів. Лазерні різальні установки дозволяють отримати високоточні розрізи з мінімальними

відходами, що робить їх незамінними в автомобільній, авіаційній та електронній промисловості. Лазерне гравіювання, у свою чергу, використовується для нанесення серійних номерів, логотипів та інших позначень на продукцію.

2. Лазерне зварювання. Лазерне зварювання забезпечує глибоке проникнення тепла та мінімальну деформацію матеріалів, що особливо важливо для авіаційної та медичної техніки. Використання лазерів дозволяє створювати міцні та акуратні зварні шви навіть у важкодоступних місцях.

3. Очищення поверхонь лазером. Лазерні системи використовуються для видалення іржі, фарби, оксидних шарів та інших забруднень з металевих поверхонь. Такий метод є екологічно чистим, оскільки не потребує використання хімічних реагентів або абразивних матеріалів.

4. Вимірювання та контроль якості. Лазерні сенсори та оптичні системи активно застосовуються для контролю якості продукції, вимірювання розмірів деталей та виявлення дефектів. Лазерна інтерферометрія дозволяє проводити вимірювання з нанометричною точністю, що є критично важливим у мікроелектроніці та прецизійній інженерії.

5. Використання лазерів у 3D-друку. Лазери використовуються у технологіях 3D-друку, таких як селективне лазерне плавлення та селективне лазерне спікання. Ці методи дозволяють створювати деталі з металів та полімерів із високою точністю, що активно застосовується в авіабудуванні, медицині та виробництві складних механізмів.

Отже, лазерні технології відкривають нові можливості для промисловості, дозволяючи автоматизувати процеси, підвищувати якість продукції та зменшувати виробничі витрати. Завдяки постійному розвитку лазерних систем їхнє застосування у промисловості продовжує зростати, роблячи виробничі процеси більш ефективними та екологічно безпечними.

3*. Research and Presentation «Industrial Laser Applications»

Conduct research on the use of industrial lasers in modern manufacturing and present your findings in a well-structured presentation.

Instructions:

1. Choose a Specific Area of Laser Application
    - Laser cutting (metals, plastics, or other materials)
    - Laser welding in the automotive or aerospace industry
    - Laser engraving and marking for industrial traceability
    - Laser cleaning for surface preparation and rust removal
    - Laser-based measurement and quality control
2. Conduct Research
    - Use reliable sources such as academic articles, industry reports, and manufacturer websites.
    - Identify key advantages, challenges, and real-world applications of the chosen laser technology.
    - Find examples of companies or industries using this technology.
3. Prepare a Presentation (8-10 Slides)
    - Slide 1: Title and your name
    - Slide 2: Introduction to industrial lasers
    - Slide 3-5: Explanation of the chosen laser application, including technical details
    - Slide 6: Advantages and limitations of the technology
    - Slide 7: Real-world examples (companies, industries, case studies)
    - Slide 8: Conclusion and future trends
    - Slide 9 (optional): References
4. Present Your Findings
    - Prepare to present for 5-7 minutes.
    - Use visuals, diagrams, or short videos to support your points.
    - Be ready to answer questions from your audience.

TEXT B

PHOTON ENGINEERING IN MEDICAL EQUIPMENT

1. a) Read and translate the text into Ukrainian using the dictionary. Pay attention to the underlined words and word combinations.

Photon engineering plays a key role in modern medical technology. It involves the study and application of light and electromagnetic waves to create advanced medical devices. These technologies help doctors diagnose diseases, perform surgeries, and develop new treatments.

Photon

Composition	Elementary particle
Statistics	Bosonic
Family	Gauge boson
Interactions	Electromagnetic, weak (and gravity)
Symbol	γ
Theorized	Albert Einstein (1905) The name "photon" is generally attributed to Gilbert N. Lewis (1926)
Mass	0 (theoretical value) $< 1 \times 10^{-18}$ eV/c^2 (experimental limit)[1]
Mean lifetime	Stable[1]
Electric charge	0 $< 1 \times 10^{-35}$ e[1]
Color charge	No
Spin	1 $\hbar$
Spin states	+1 $\hbar$, −1 $\hbar$
Parity	−1[1]
C parity	−1[1]
Condensed	$I(J^{PC})$=0,1(1^{--})[1]

Photons are particles of light that move at high speed. They can be absorbed, reflected, or transmitted through different materials. Engineers use these properties to design medical devices that interact with the human body in non-invasive and precise ways.

A photon (*from Ancient Greek φῶς, φωτός (phôs, phōtós)* '*light*') is an elementary particle that is a quantum of the electromagnetic field, including electromagnetic radiation such as light and radio waves, and the force carrier for the electromagnetic force. Photons are massless particles that can move no faster than the speed of light measured in vacuum. The photon belongs to the class of boson particles.

The photon has no electric charge, it is generally considered to have zero rest mass and is a stable particle. In a vacuum, a photon has two possible polarization states. The

photon is the gauge boson for electromagnetism, and therefore all other quantum numbers of the photon (such as lepton number, baryon number, and flavour quantum numbers) are zero.

Photons are fundamental subatomic particles that carry the electromagnetic force – or, in simpler terms, they are light particles (and so much more). The photon is also the "quantum," or fundamental unit, of electromagnetic radiation. Everyone is surrounded by photons: The light coming from the screen you're viewing is composed of photons, the X-rays doctor use to see bones are made of photons, the radio in a car receives its signal from photons, and the magnets on a fridge use photons to hold themselves up.

Like all other subatomic particles, photons exhibit wave-particle duality, meaning that sometimes they behave as tiny particles and sometimes they act as waves. Photons are massless, allowing them to travel at the speed of light in a vacuum (299,792,458 meters per second) and can travel an infinite distance.

Although physicists have studied the nature of light for centuries, arguments went back and forth as to whether light was made of tiny particles or was wave-like in nature. In the late 1800s, however, the pioneering work of German physicist Max Planck changed the entire picture.

Planck was studying something called blackbody radiation, or light from a special device that emitted light at all frequencies as efficiently as possible. Until Planck, nobody could explain the spectrum of light coming from these devices, so Planck added a "fix" to the equations. By assuming that light could be emitted only in discrete chunks of energy, known as quanta, he was able to develop a formula that perfectly explained the blackbody spectra, according to Hyper Physics.

Photons are emitted in many natural processes. For example, when a charge is accelerated it emits synchrotron radiation. During a molecular, atomic or nuclear transition to a lower energy level, photons of various energy will be emitted, ranging from radio waves to gamma rays. Photons can also be emitted when a particle and its corresponding antiparticle are annihilated (for example, electron–positron annihilation)

There are different types of photons based on their energy levels.

Infrared photons are used in thermal imaging and medical lasers, visible light photons – in endoscopy and microscopy, ultraviolet photons are used for sterilization and skin treatments, X-ray and gamma-ray photons – for imaging and cancer treatment.

Medical Imaging Technologies. Photon-based imaging helps doctors see inside the body without surgery. Some common imaging devices include:

- *X-ray Machines* send high-energy photons through the body to create images of bones and organs.
- *Computed Tomography (CT scans)* takes multiple X-ray images and combines them into a 3D model of the body.
- *Magnetic Resonance Imaging (MRI)* uses electromagnetic radiation to produce detailed images of soft tissues and the brain.
- *Optical Coherence Tomography (OCT)* is a laser-based imaging technique used in ophthalmology to examine the retina.

Laser Technologies in Medicine. Lasers generate focused beams of photons. They are used in various medical applications:

- *Laser surgery* helps in precise cutting of tissues, reducing damage and improving healing.
- *LASIK eye surgery* – A laser reshapes the cornea to correct vision problems.
- *Laser skin treatments* is used for removing scars, wrinkles, and tattoos.
- *Photodynamic Therapy (PDT)* uses laser light and special drugs to destroy cancer cells.

Therapeutic and Diagnostic Applications. Photon engineering is also used in non-invasive therapies and diagnostic tools:

- *Endoscopy* – A flexible tube with a light and camera is inserted into the body to examine internal organs.
- *Infrared Thermography* detects temperature differences in the body to identify inflammation or circulation problems.

- *Radiotherapy* uses high-energy photons (gamma rays or X-rays) to destroy cancer cells.

Future of Photon Engineering in Medicine. Photonics continues to revolutionize medicine. Future advancements may include:

- *Advanced laser therapies* – More precise and less invasive treatments for cancer and other diseases.
- *Biophotonics* is the study of how light interacts with biological tissues, leading to better diagnostic tools.
- *Nanophotonics* is using tiny optical devices to detect diseases at an early stage.

As technology improves, photon engineering will help create safer, faster, and more efficient medical equipment. Engineers working in this field need knowledge of physics, optics, and biomedical engineering to design the next generation of medical technologies.

b) Translate the italicized paragraph into Ukrainian (in writing).

c) Put 5 questions to the text.

2. Advanced Synonym Exercise:

a) Match the words with their synonyms.

1. Innovate	A) Essential
2. Significant	B) Exact
3. Illustrate	C) Modify
4. Adapt	D) Show
5. Crucial	E) Improve
6. Enhance	F) Discover
7. Accurate	G) Important
8. Conduct	H) Carry out
9. Determine	I) Develop
10. Identify	J) Establish

b) Rewrite each sentence using a synonym for the bold word.

1. The project was **successful** due to teamwork.
   → The project was _____ due to teamwork.
2. The new machine is **efficient** and saves energy.
   → The new machine is _____ and saves energy.
3. The professor **explained** the concept clearly.
   → The professor _____ the concept clearly.
4. The results were **unexpected** but useful.
   → The results were _____ but useful.
5. Scientists must **analyze** the data carefully.
   → Scientists must _____ the data carefully.
6. The research had a **profound** impact on medical technology.
   → The research had a _____ impact on medical technology.
7. Engineers must **adhere to** safety regulations.
   → Engineers must _____ safety regulations.
8. The scientist made a **precise** calculation.
   → The scientist made an _____ calculation.
9. The experiment **demonstrated** the effectiveness of the new treatment.
   → The experiment _____ the effectiveness of the new treatment.
10. The company aims to **develop** innovative medical devices.
    → The company aims to _____ innovative medical devices.

c) Choose the synonym that best matches the word in bold.

1. The scientist made a **precise** measurement.

a) Rough

b) Accurate

c) Estimated

2. The new technology will **enhance** patient recovery.

a) Improve

b) Delay

c) Reduce

3. Engineers must **adhere to** safety protocols.

a) Follow

b) Ignore

c) Oppose

4. The research had a **profound** effect on medicine.

a) Weak

b) Significant

c) Minor

5. The professor **illustrated** the concept with examples.

a) Explained

b) Confused

c) Removed

6. The results were **unexpected** but useful.

a) Predictable

b) Surprising

c) Obvious

7. The company aims to **develop** new medical devices.

a) Destroy

b) Improve

c) Create

8. The scientist needed to **analyze** the data carefully.

a) Examine

b) Ignore

c) Forget

9. The experiment **demonstrated** the effectiveness of the drug.

a) Proved

b) Questioned

c) Denied

10. The team **conducted** several tests before publishing the results.

a) Performed

b) Avoided

c) Stopped

3. Using the dictionary transcribe and translate the key words and words combinations:

Word	***Transcription***	***Translation***
Innovation		
Implementation		
Optimization		
Evaluation		
Validation		
Hypothesis		
Simulation		
Algorithm		
Data acquisition		
Experimental design		
Feasibility study		
Computational analysis		
Error margin		
Correlation coefficient		
Statistical significance		

Conceptual framework		
Theoretical model		
Biomedical engineering		
Photon interaction		
Quantum mechanics		

4. Match the words with their definitions.

1. Quantum mechanics –	the application of engineering principles to medicine
2. Photon interaction –	a system of ideas that helps structure research
3. Theoretical model –	a statistical measure that describes the relationship between two variables
4. Biomedical engineering –	the process of collecting and measuring information
5. Conceptual framework –	the branch of physics that studies subatomic particles
6. Correlation coefficient –	how light particles interact with different materials
7. Error margin –	the plan for conducting a scientific study
8. Computational analysis –	a simplified version of reality used to explain complex systems
9. Experimental design –	an assessment of how practical or possible a project is
10. Feasibility study –	using computers to process and analyze data
11. Data acquisition –	the amount of uncertainty in a measurement or result
12. Algorithm –	a step-by-step procedure for solving a problem
13. Simulation –	improving something to make it as effective as possible
14. Hypothesis –	assessing or analyzing the quality or performance of something
15. Validation –	putting a plan or system into action
16. Evaluation –	a model or experiment that replicates real-world conditions

17. Optimization –	a proposed explanation that can be tested through research
18. Implementation –	the process of creating new ideas or technologies
19. Innovation –	confirming that something meets the required standards
20. Statistical significance –	the probability that a result is not due to chance

5. Give English equivalents to the meanings of the following words and word combinations.

Фотон	
Електромагнітне поле	
Оптична когерентна томографія	
Лазерна хірургія	
Рентгенівське випромінювання	
Комп’ютерна томографія	
Магнітно-резонансна томографія	
Гамма-промені	
Інфрачервоне випромінювання	
Фотодинамічна терапія	
Оптичні волокна	
Ендоскопія	
Лазерна абляція	
Когерентне випромінювання	
Спектроскопія	
Фотонна детекція	
Термографія	
Біофотоніка	
Квантова оптика	

Радіотерапія	

6. Choose the correct answer.

1. What type of photons are used in X-ray imaging?
    a) Infrared photons
    b) Visible light photons
    c) X-ray photons
2. Which technology uses a strong magnetic field to create images of the body?
    a) CT scan
    b) MRI
    c) X-ray
3. What is the main function of laser surgery?
    a) To generate heat for thermal imaging
    b) To precisely cut or remove tissues
    c) To capture images of internal organs
4. What is the primary benefit of endoscopy?
    a) It uses radiation to scan the body
    b) It allows non-invasive internal examination
    c) It provides high-energy treatment for cancer
5. What is photodynamic therapy (PDT) used for?
    a) Destroying cancer cells using light-sensitive drugs and lasers
    b) Generating high-energy X-rays
    c) Producing 3D images of organs
6. What type of radiation is used in radiotherapy to treat cancer?
    a) Microwaves
    b) Gamma rays
    c) Ultraviolet rays
7. Which of the following is not a characteristic of a photon?

a) It has no mass

b) It carries electromagnetic energy

c) It moves slower than the speed of light

8. What is the main use of infrared thermography?

a) To measure temperature differences in the body

b) To produce high-resolution 3D images

c) To detect fractures in bones

9. Which of these is a non-invasive medical imaging technique?

a) Laser surgery

b) MRI

c) Photodynamic therapy

10. Which of the following best describes photon engineering?

a) The study of electrical circuits in medical devices

b) The application of light and electromagnetic waves in medical technology

c) The development of mechanical prosthetics

7. Translate the following sentences into Ukrainian.

1. Photon engineering plays a crucial role in modern medical equipment, as it enables the development of advanced imaging and treatment technologies that help doctors accurately diagnose and effectively treat various diseases.

2. X-ray machines use high-energy photons that can pass through soft tissues but are absorbed by denser materials like bones, allowing doctors to create detailed images of the skeletal system and detect fractures or internal abnormalities.

3. Laser surgery, which is based on photon technology, allows doctors to perform highly precise and minimally invasive medical procedures, reducing damage to surrounding tissues and leading to faster recovery times for patients.

4. Optical coherence tomography (OCT) is a laser-based imaging technique that uses low-coherence light to create detailed cross-sectional images of biological tissues,

particularly in ophthalmology, where it helps doctors examine the retina and diagnose eye diseases.

5. In radiotherapy, high-energy photons, such as gamma rays or X-rays, are directed at cancerous cells to destroy them while minimizing harm to surrounding healthy tissues, making it one of the most effective treatments for various types of cancer.

8. Write T (True) or F (False) for each statement.

1.___ Photon engineering is only used in medical imaging and not in treatments.

2.___ X-ray machines use high-energy photons to create images of bones and organs.

3.___ Lasers in medicine are only used for cutting tissues and cannot be used for other treatments.

4.___ Optical coherence tomography (OCT) is a laser-based imaging technique commonly used in ophthalmology.

5.___ Radiotherapy uses high-energy photons, such as gamma rays, to destroy cancer cells.

6.___ Infrared thermography is a technique used to detect temperature differences in the body.

7.___ Photons travel slower than sound waves in air.

8.___ MRI (Magnetic Resonance Imaging) works by using electromagnetic waves instead of X-rays.

9.___ Photodynamic therapy (PDT) uses light-sensitive drugs and laser light to treat cancer.

10.___ Endoscopy uses visible light and optical fibers to examine internal organs without surgery.

9. Translate the following sentences into English.

1. Фотонна інженерія відіграє важливу роль у сучасному медичному обладнанні, забезпечуючи точну діагностику та ефективне лікування захворювань.

2. Рентгенівські апарати використовують високоенергетичні фотони, які проникають через м'які тканини, але поглинаються кістками, що дозволяє отримати детальні зображення скелета.

3. Лазерна хірургія, заснована на технології фотонів, дає змогу виконувати операції з високою точністю та мінімальним пошкодженням навколишніх тканин, що сприяє швидкому загоєнню.

4. Оптична когерентна томографія (ОКТ) є передовим методом візуалізації, який використовує лазерне світло для створення детальних зображень внутрішніх структур ока.

5. Променева терапія застосовує високоенергетичні фотони, такі як гамма-промені або рентгенівське випромінювання для знищення ракових клітин, мінімізуючи при цьому пошкодження здорових тканин.

10. Answer the questions to the text.

1. What is photon engineering, and why is it important in medical equipment?

2. How do X-ray machines use photons to create medical images?

3. What is the role of lasers in medical treatments such as surgery and vision correction?

4. How does Optical Coherence Tomography (OCT) help in ophthalmology?

5. What types of photons are used in medical imaging and treatments?

6. How does radiotherapy use high-energy photons to treat cancer?

7. What are the advantages of using laser technology in medical procedures?

8. What is the difference between MRI and CT scans in terms of photon usage?

9. How does photodynamic therapy (PDT) work in treating cancer?

10. Why is photon engineering expected to play a bigger role in the future of medicine?

11. Write a short summary of the text (See the scheme in the Information File (Ex. 11, P. 18) and be ready to present it.

12*. Creative Writing "A Doctor from the Future: Healing with Light"

Imagine you wake up 2150, where medicine has advanced beyond what we know today. Doctors no longer use scalpels or traditional medicines, they heal people using pure light energy.

In this future, hospitals are equipped with photon-based technology that can scan a patient instantly, repair damaged tissues with laser precision, and even regrow organs using biophotonic regeneration. Instead of painful treatments, diseases are cured by adjusting the body's light frequency.

Write a story about a young doctor who is training to use this new technology. One day, they face a mysterious disease that no known photon treatment can cure. How will they solve this problem? Will they need to invent a new technology or discover an ancient secret about light and healing?

Let your imagination guide you – describe futuristic hospitals, the feeling of using healing light, and the emotions of a doctor trying to save a life in this high-tech world!

SPEAKING

1. A Comprehensive Discussion & Guidelines

Hold a debate on the following discussion points. Work in small groups.

1. Introduction to Photon Engineering in Medicine

- Definition and importance of photon engineering
- How light and electromagnetic waves are used in medical devices
- The role of photons in diagnostics and treatment

2. Medical Imaging Technologies

- X-ray imaging: principles, advantages, and risks

- CT (Computed Tomography) scans and their applications
- MRI (Magnetic Resonance Imaging) and how it differs from X-ray technology
- Optical Coherence Tomography (OCT) in ophthalmology
- Infrared thermography for detecting temperature changes in the body

3. Laser Applications in Medicine

- Laser surgery: benefits and common procedures (e.g., LASIK, tumor removal)
- Photodynamic therapy (PDT) for cancer treatment
- Laser skin treatments (scar removal, tattoo removal)
- The safety and precision of medical lasers

4. Radiotherapy and Cancer Treatment

- How gamma rays and X-rays destroy cancer cells
- The balance between killing cancer cells and protecting healthy tissue
- Innovations in radiotherapy for better accuracy and fewer side effects

5. Emerging Technologies in Photon Engineering

- Biophotonics: using light to study and manipulate biological tissues
- Nanophotonics: ultra-small optical devices for early disease detection
- Future advancements in non-invasive photon-based treatments

6. Ethical and Safety Considerations

- Risks of radiation exposure and how to minimize them
- The importance of regulations in medical photon technology
- Ethical concerns in laser treatments and patient consent

7. Practical Guidelines for Professionals

- Best practices in handling photon-based medical equipment
- Safety protocols for using X-ray, MRI, and laser technology
- Training requirements for medical engineers and doctors in photon-based medicine

8. Conclusion and Future Perspectives

- The growing role of photon engineering in medicine
- How new research may change medical treatments in the next decade

- Challenges and potential breakthroughs in the field

2. Translate the following text into English.

a) Express the main idea of the text in one sentence.

b) Write a short summary of the text in English.

Значення фотонної інженерії в медицині

Фотонна інженерія є важливою галуззю сучасної медицини, що використовує властивості світла та електромагнітного випромінювання для діагностики, лікування та досліджень. Завдяки цій технології лікарі отримують доступ до високоточних методів візуалізації внутрішніх органів, безконтактного хірургічного втручання та інноваційних терапевтичних процедур.

Одним із найпоширеніших застосувань фотонної інженерії є **медична візуалізація**. Рентгенівські знімки, комп'ютерна томографія (КТ) та магнітно-резонансна томографія (МРТ) дозволяють лікарям отримувати детальні зображення органів і тканин без потреби у відкритих хірургічних втручаннях. Оптична когерентна томографія (ОКТ) широко використовується в офтальмології для діагностики захворювань сітківки, а інфрачервона термографія допомагає виявляти порушення кровообігу та запальні процеси.

Також фотонна інженерія відіграє важливу роль у **хірургії та терапії**. Лазерна хірургія забезпечує високу точність при проведенні операцій на очах, шкірі та внутрішніх органах, зменшуючи крововтрати та скорочуючи період відновлення пацієнтів. У фотодинамічній терапії (ФДТ) фотонне випромінювання використовується для активації спеціальних препаратів, що знищують ракові клітини.

Ще однією важливою сферою є **променева терапія**, яка використовує високоенергетичні фотони для боротьби зі злоякісними пухлинами. Завдяки

сучасним технологіям радіотерапія стала більш точною, що дозволяє мінімізувати пошкодження здорових тканин та підвищити ефективність лікування раку.

Майбутнє фотонної інженерії в медицині пов'язане з розвитком **біофотоніки** та **нанофотоніки**, які дозволяють розробляти нові методи діагностики та лікування на молекулярному рівні. Очікується, що ці технології допоможуть виявляти хвороби на ранніх стадіях, покращать можливості персоналізованої медицини та зроблять лікування ще більш безпечним і ефективним.

Таким чином, фотонна інженерія є невід'ємною частиною сучасної медицини, що сприяє розвитку безпечних, точних і малотравматичних методів діагностики та лікування, покращуючи якість життя пацієнтів.

3*. Research and Presentation «The Role of Photon Engineering in Medical Imaging»

Create a comparison chart of different medical imaging techniques, showing how they use photons differently. Follow the key points below.

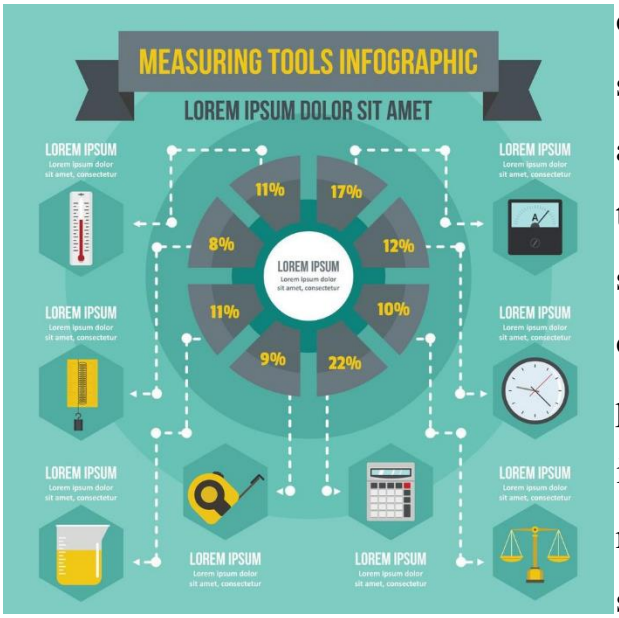
- How X-rays, CT scans, and MRI work.
- Differences between imaging technologies.
- Advantages and risks of photon-based imaging.
- Future advancements in medical imaging.

UNIT IV

INFORMATION-MEASURING SYSTEMS

Text A

1. a) Read and translate the text into Ukrainian using the dictionary. Pay attention to the underlined words and word combinations.



Architecture and Structure of Measuring Devices. Measuring devices form the cornerstone of any information-measuring system, serving as vital tools for acquiring accurate data in scientific, industrial, and technological applications. The architecture of such devices encompasses several key components, including sensors, signal processing units, data acquisition modules, and interfaces for user interaction. Sensors are responsible for detecting physical parameters such as temperature, pressure, or light intensity, and converting these into measurable signals. The signal processing unit enhances the quality of these signals by filtering noise, amplifying weak inputs, and preparing data for further analysis.

The structural design of measuring devices depends largely on their intended application. For instance, compact portable devices prioritize mobility and ease of use, while stationary systems focus on durability and precision. In recent years, advancements in microelectronics and materials science have revolutionized measuring devices,

enabling higher accuracy, faster response times, and enhanced integration with digital systems.

Adjustment and Calibration of Optical Systems. Optical systems, widely used in measurement technology, require precise adjustment and calibration to deliver reliable results. Adjustment refers to the alignment of optical components, such as lenses, mirrors, and prisms, to optimize performance. Factors like focal length, aperture size, and beam alignment are meticulously fine-tuned to ensure accurate measurements. Modern techniques, including computer-aided alignment and laser-guided positioning, have significantly improved the efficiency of this process.

Calibration is the next critical step, ensuring that the optical system provides measurements consistent with standard references. This process involves comparing the instrument's readings with those from a certified standard under controlled conditions. For example, in spectrometers or interferometers, calibration ensures wavelength accuracy and intensity uniformity. Regular calibration not only maintains the system's accuracy but also compensates for factors like wear and environmental changes, which can affect optical components over time.

Automation of Production Processes. *In contemporary industrial environments, automation is an indispensable aspect of production processes, heavily relying on information-measuring systems. Automated systems integrate sensors and measurement tools to monitor parameters such as temperature, flow rate, and dimensional accuracy in real time. The data collected by*

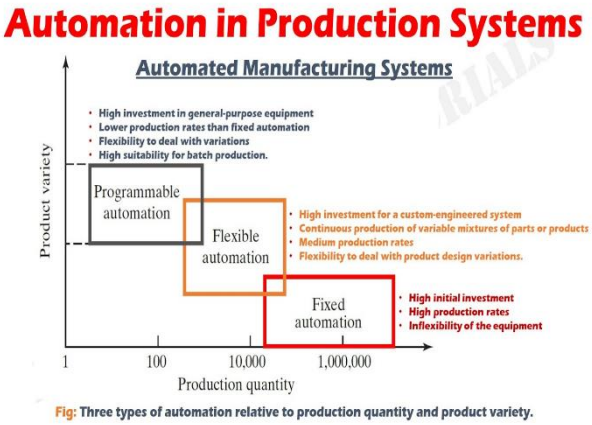


Fig: Three types of automation relative to production quantity and product variety.

these systems is analyzed and used to control machinery, ensuring consistent quality and efficient operation.

The implementation of feedback loops is a hallmark of automated production systems. Measurements are continuously fed back into control algorithms, which adjust operating conditions to maintain optimal performance. Furthermore, modern advancements in artificial intelligence and machine learning enable predictive maintenance, identifying potential faults before they result in downtime. This reduces costs and enhances productivity across industries.

Automation has also facilitated the development of smart factories, where interconnected devices and systems exchange information seamlessly. This concept, often referred to as the Industrial Internet of Things (IIoT), allows for the dynamic adaptation of production lines to changing demands, fostering flexibility and innovation.

b) Translate the italicized paragraph into Ukrainian (in writing).

c) Put 5 questions to the text.

2. Advanced Synonym Exercise:

a) Match the words with their synonyms.

Word	Synonym
1. Calibration	A. Adjustment
2. Measurement	B. Quantification
3. Precision	C. Accuracy
4. Automation	D. Mechanization
5. Sensor	E. Detector
6. Validation	F. Verification

7. Data	G. Information
8. Structure	H. Configuration
9. Alignment	I. Positioning
10. Reliability	J. Dependability

b) Find the most appropriate synonym.

Each sentence below contains a **bolded word** related to metrology. Choose the correct synonym that best replaces the bolded word without changing the meaning.

1. The **calibration** of instruments ensures measurement consistency.
   A) Adjustment
   B) Evaluation
   C) Prediction
   D) Reduction
2. Optical systems require precise **alignment** for optimal performance.
   A) Detection
   B) Positioning
   C) Complexity
   D) Stabilization
3. Advanced metrology tools offer enhanced **reliability** in industrial automation.
   A) Verification
   B) Dependability
   C) Approximation
   D) Standardization
4. The system's **structure** includes sensors, processors, and interfaces for data exchange.
   A) Design
   B) Accuracy

C) Complexity

D) Variation

5. Automation improves efficiency through accurate **data** collection and analysis.

A) Quantification

B) Information

C) Validation

D) Disruption

c) Fill in the blanks with the correct synonym.

Use one of the given synonyms to complete each sentence. Make sure the sentence makes sense in the context of metrology.

alignment, integration, feedback, adaptation, maintenance

1. The _____ of optical components is critical to ensure the accuracy of measurements in advanced systems.
2. The seamless _____ of sensors and data processing units improves the efficiency of automation systems.
3. In automated production, _____ loops allow systems to adjust operations in real time based on collected data.
4. The _____ of machines to changing conditions is a key feature of modern smart factories.
5. Regular _____ of equipment ensures consistent performance and minimizes system downtime.

3. Using the dictionary transcribe and translate the key words and words combinations:

Word	Transcription	Translation
Sensor		
Automation		
Alignment		
Calibration		
Reliability		
Precision		
Integration		
Traceability		
Maintenance		
Feedback		
Configuration		
Optimization		
Determination		
Detection		
Quantification		

4. Match the words with their definitions. Write the correct letter next to each number.

1. Integration ___
2. Alignment ___
3. Automation ___
4. Feedback ___
5. Maintenance ___
6. Optimization ___
7. Configuration ___
8. Detection ___

9. Reliability ___

10. Adaptation ___

Definitions:

A. The ongoing process of keeping equipment functional and in good working condition.

B. The process of identifying and recognizing specific signals or features in a system.

C. Modifications or adjustments made to suit changing conditions or requirements.

D. Information returned to a system to adjust or improve its operations.

E. The ability of a system or tool to perform consistently and dependably over time.

F. The process of ensuring proper positioning of components for optimal performance.

G. The use of strategies to enhance the efficiency and performance of a process.

H. The seamless combination of multiple systems or components into a unified operation.

I. The use of machinery and systems to carry out tasks with minimal human intervention.

J. The systematic arrangement of elements or parts within a system.

b) Choose two terms and write your own sentences using them to reinforce understanding.

5. Give English equivalents to the meanings of the following words and word combinations:

1. Вирівнювання / Налаштування
2. Інтеграція
3. Автоматизація
4. Зворотний зв'язок
5. Обслуговування
6. Оптимізація

7. Конфігурація

8. Виявлення

9. Надійність

10. Адаптація

11. Обробка сигналів

12. Датчики

13. Збирання даних

14. Інтерфейси

15. Калібрування

16. Точність

17. Вимірювальні прилади

18. Розумні фабрики

19. Прогнозне обслуговування

20. Моніторинг у режимі реального часу

6. Choose the correct answer:

1. What is the primary function of sensors in information-measuring systems?

a) Generating data visualizations

b) Detecting and converting physical parameters into measurable signals

c) Storing data for future use

d) Enhancing the durability of measuring devices

2. Why is calibration necessary in optical systems?

a) To increase the lifespan of the system

b) To ensure accurate measurements aligned with standard references

c) To improve the physical design of the system

d) To simplify the system's operation

3. What does alignment of optical components primarily involve?

a) Adjusting settings for automated systems

b) Ensuring lenses and mirrors are correctly positioned

c) Reducing the system's weight

d) Installing additional components for performance improvement

4. What feature characterizes automated production systems?

a) Elimination of sensors

b) Use of feedback loops to adjust operations

c) Independent operation without data analysis

d) Manual monitoring of all processes

5. What is the purpose of predictive maintenance in industrial automation?

a) To repair equipment after significant downtime

b) To identify potential faults before they occur

c) To eliminate regular inspections

d) To reduce the efficiency of automated systems

6. How does integration benefit information-measuring systems?

a) By isolating each system component

b) By combining multiple systems for unified operation

c) By minimizing the number of sensors used

d) By enhancing the complexity of processes

7. What is the main advantage of using smart factories in industrial automation?

a) Manual adjustments to production lines

b) Independent operation without external communication

c) Dynamic adaptation to changing production demands

d) Replacement of all measuring devices with basic tools

8. Which of the following best describes feedback in automated systems?

a) Input data generated by external users

b) Information returned to adjust or improve operations

c) Static measurements that remain unchanged

d) Irrelevant data discarded during processing

9. Find the Correct Sentence Translation - *Regular maintenance ensures that measurement instruments continue to provide accurate and reliable data*.

a) Регулярне обслуговування забезпечує точність та надійність вимірювань.

b) Постійні експерименти з приладами гарантують отримання нових даних.

c) Тестування вимірювальних систем завжди дає найточніші результати.

d) Технічне обслуговування приладів не впливає на їх точність.

10. Find the Correct Sentence Translation - Feedback loops in automation systems allow for real-time adjustments to ensure consistent performance.

a) Зворотні зв’язки в автоматизованих системах допомагають уникати несправностей.

b) Петлі зворотного зв’язку в автоматизованих системах дозволяють коригувати процеси в реальному часі.

c) Автоматизація забезпечує зворотний зв'язок лише для періодичного коригування.

d) У реальному часі зворотній зв'язок не впливає на автоматизацію.

7. Give the full version of the following acronyms:

IIoT – _____

AI – _____

8. Translate the following sentences into Ukrainian.

1. Advanced measuring devices rely on integrated sensors and data acquisition modules to enhance system performance.
2. The precise alignment of optical components is vital for achieving accurate results in complex measurement systems.
3. Automation in production processes uses real-time data analysis to optimize efficiency and reduce operational costs.
4. Feedback mechanisms in automated systems ensure that any deviations in performance are promptly corrected.
5. Smart factories utilize interconnected devices to dynamically adjust production workflows based on changing demands.

9. Translate the following sentences into English.

1. Measuring devices integrate advanced signal processing units to filter out noise and ensure precise data acquisition.
2. Calibration procedures are essential for maintaining the accuracy of optical measurement systems over time.
3. The feedback loop in automated systems plays a critical role in maintaining consistent operational efficiency.
4. The adaptation of measurement systems to environmental changes ensures long-term reliability in industrial applications.
5. Integration of smart sensors and real-time monitoring tools has revolutionized modern production processes.

10. Answer the questions to the text.

1. What are the main components of modern measuring devices?
2. Why is signal processing essential in information-measuring systems?
3. How does the structural design of measuring devices differ based on their application?

4. What is the purpose of calibrating optical systems?

5. How do feedback loops contribute to automated production processes?

6. What role does data acquisition play in measuring systems?

7. Why is the alignment of optical components critical for accurate measurements?

8. How has the integration of smart sensors improved automation systems?

9. What advantages do smart factories provide in the context of industrial automation?

10. What benefits does predictive maintenance offer in reducing operational costs?

11. Write a short summary of the text (See the scheme p. 18, ex. 11) and be ready to present it.

12*. Creative Writing

1. Imagine and Innovate:

Write a short story or descriptive essay (150-200 words) imagining a futuristic "smart factory." Describe how information-measuring systems, sensors, and automation work together to create an efficient production environment. Highlight the role of real-time monitoring and predictive maintenance.

2. Metrology in Action:

Compose a journal entry as if you are a metrology engineer in a high-tech manufacturing facility. Write about your daily tasks, such as calibrating devices, ensuring alignment of optical systems, and managing automated processes. Include creative descriptions of challenges you face and how you solve them.

3. The Missing Link:

Invent a scenario where a critical failure occurs in an automated production line. Write how the failure was identified through information-measuring systems, and describe the innovative solution implemented to restore the system's efficiency. Focus on teamwork and technology.

4. The Future of Measurement:

Write a visionary essay (200-250 words) predicting how information-measuring systems and automation will evolve in the next 50 years. Use your imagination but incorporate existing technologies such as IIoT (Industrial Internet of Things), AI, and smart factories.

SPEAKING

A Comprehensive Discussion & Guidelines:

1. Advancements in Measuring Device Architecture

- Highlight examples of advancements, such as faster response times or enhanced integration with digital systems.
- Compare traditional systems with modern high-precision devices.
- Suggest future trends or innovations in measuring device design.

2. The Role of Calibration and Alignment in Measurement Systems

- Provide examples of calibration practices in industrial and laboratory settings.
- Include modern technologies such as laser-guided alignment or automated calibration tools.
- Discuss the importance of standard references in calibration and their global impact.

3. Automation and Its Integration into Information-Measuring Systems

- Explain key concepts such as the Industrial Internet of Things (IIoT) and smart factories.
- Provide examples of industries where automation has significantly improved production.
- Highlight the role of sensors and data acquisition in enabling automation.

4. Smart Factories and the Future of Industrial Metrology

- Discuss real-life applications of smart factories and the benefits they bring.
- Address challenges such as cost, complexity, and cybersecurity in implementing smart systems.
- Suggest how students can prepare to work with advanced systems in the future.

Discussion Points

1. Advancements in Measuring Device Architecture

- What are the essential components of modern measuring devices, and how do they contribute to performance?
- Discuss the impact of microelectronics and material science on the evolution of measuring devices.
- How do portable and stationary devices differ in their structural design and intended applications?

2. The Role of Calibration and Alignment in Measurement Systems

- Why is calibration critical to maintaining accurate and consistent measurements?
- Explain the process of alignment in optical systems and its significance.
- What are the challenges and methods of ensuring alignment and calibration over time?

3. Automation and Its Integration into Information-Measuring Systems

- Explore the benefits of automation in production processes, focusing on efficiency and consistency.
- How does real-time data analysis contribute to automated systems?
- Discuss the significance of feedback loops and predictive maintenance in industrial automation.

4. Smart Factories and the Future of Industrial Metrology

- What are the defining features of smart factories, and how do they integrate with metrology systems?
- How does adaptability in production processes benefit industries?
- Discuss the potential of interconnected devices and real-time monitoring in shaping the future of industrial automation.

2. Render the following text into English. Summarize its main idea in one sentence.

Інформаційно-вимірювальні системи відіграють ключову роль у сучасних технологіях, забезпечуючи точність і ефективність у різних галузях промисловості та науки. Основними компонентами таких систем є датчики, що перетворюють фізичні параметри, як-от температура чи тиск, у вимірювані сигнали, а також модулі обробки сигналів, які підвищують якість цих даних. Завдяки розвитку мікроелектроніки сучасні вимірювальні пристрої стали більш компактними, швидкими та інтегрованими з цифровими системами, що полегшує їх використання в складних виробничих умовах.

Одним із важливих аспектів функціонування інформаційно-вимірювальних систем є калібрування та юстування. Калібрування дозволяє встановити відповідність вимірювальних приладів міжнародним стандартам, забезпечуючи стабільність та точність їх роботи. Юстування, зі свого боку, фокусується на налаштуванні компонентів, таких як оптичні елементи, для досягнення оптимальної продуктивності. Сучасні технології, як-от лазерна юстировка чи автоматизоване калібрування, значно спрощують ці процеси.

У сфері автоматизації виробничих процесів інформаційно-вимірювальні системи сприяють покращенню продуктивності, зменшенню витрат та забезпеченню стабільної якості продукції. Використання зворотних зв'язків дозволяє автоматизованим системам адаптувати роботу до змін у реальному часі,

забезпечуючи високу надійність і безперебійність процесів. Інтеграція таких систем із концепцією "розумних фабрик" створює нові можливості для гнучкої адаптації виробничих ліній до попиту, підвищуючи ефективність на глобальному рівні.

Таким чином, сучасні інформаційно-вимірювальні системи не лише забезпечують точність вимірювань, але й стають невід'ємною частиною процесів автоматизації, формуючи основу для подальшого технічного прогресу. Вони є ключовим елементом у переході до Індустрії 4.0, де інноваційні технології змінюють підхід до виробництва та управління.

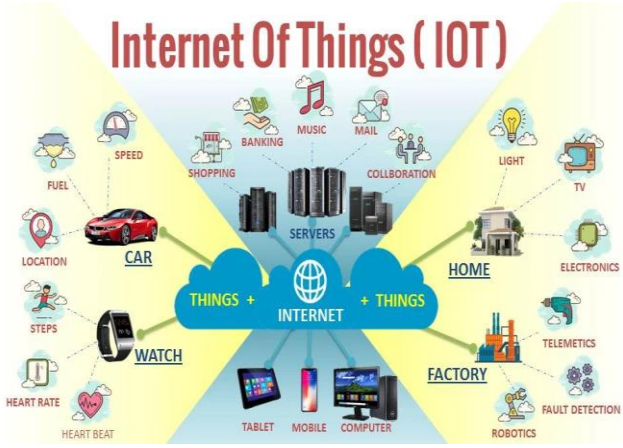
Text B

Intelligent Control and Self-Diagnostic Systems in Information-Measuring Technology

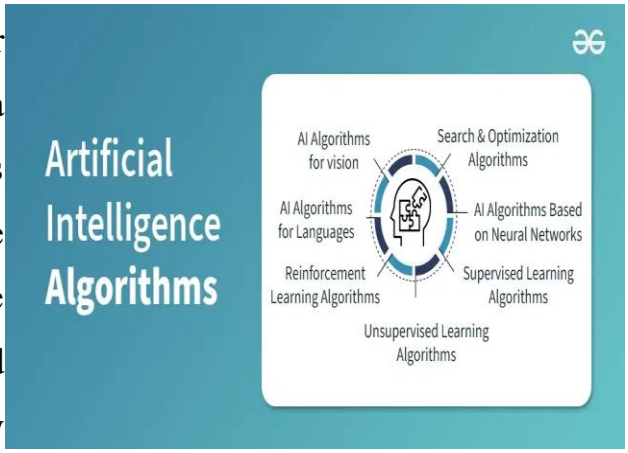
1. a) Read and translate the text into Ukrainian using the dictionary. Pay attention to the underlined words and word combinations.

The integration of intelligent systems into information-measuring technologies represents a transformative leap in industrial processes. These systems, powered by artificial intelligence (AI) and predictive analytics, enhance the reliability, accuracy, and efficiency of measurement devices. By continuously monitoring the performance of instruments, intelligent systems not only identify potential faults in real time but also ensure uninterrupted operation of production lines, thus reducing downtime and costs.

One of the key features of intelligent control systems is their ability to incorporate self-diagnostics. This capability allows measuring devices to autonomously evaluate their own functionality and detect inconsistencies or errors. For instance, optical systems equipped with self-diagnostic modules can identify misalignment or calibration drift without external intervention. This level of automation minimizes human error and ensures the consistency of measurements. Coupled with IoT (Internet of Things) technology, these self-diagnostic systems can communicate their findings to centralized platforms, enabling engineers to take immediate corrective actions.



Another critical aspect is the role of predictive maintenance in these systems. By analyzing historical data and real-time sensor inputs, AI algorithms can predict when a device is likely to fail or when recalibration is necessary. Unlike traditional reactive maintenance approaches, predictive maintenance prevents unexpected breakdowns by addressing issues before they escalate. For example, in a high-precision manufacturing environment, predictive algorithms can notify technicians of slight temperature fluctuations that might compromise the accuracy of measurements, allowing them to act promptly. Intelligent control systems also play a pivotal role in adapting production processes to dynamic environments. These systems utilize real-time feedback loops to optimize workflows, making on-the-fly adjustments to align with changing operational requirements. For example, in smart factories, interconnected devices monitor every stage of production, from data acquisition to final inspections. If a deviation occurs, such as material inconsistencies, these systems automatically adapt the process to maintain product quality.



Moreover, the integration of intelligent technologies with standard metrological practices strengthens traceability in measurement systems. By linking each measurement to a recognized reference standard, intelligent systems ensure compliance with national and international regulations. This is particularly important in industries such as pharmaceuticals and aerospace, where even minimal deviations can have significant consequences.

In the context of Industry 4.0, the implementation of intelligent control and self-diagnostic systems is not merely an option but a necessity for companies aiming to remain competitive. These systems enhance the overall productivity of industrial environments by creating seamless communication between devices, ensuring operational efficiency, and maintaining the highest standards of measurement accuracy. The combination of

predictive analytics, IoT, and self-diagnostics sets a foundation for the future of metrology and automation.

In conclusion, intelligent control and self-diagnostic systems have become an integral component of modern information-measuring technologies. They represent a harmonious blend of innovation and practicality, addressing the demands of precision, efficiency, and adaptability. As industries continue to evolve, the application of such systems will expand, paving the way for more advanced and interconnected production ecosystems. The future lies in the ability to predict, adapt, and ensure reliability in every aspect of industrial measurement and automation.

b) Translate the italicized paragraph into Ukrainian (in writing).

c) Put 5 questions to the text.

2. Advanced Synonym Exercise:

a) Match the words with their synonyms

Word	**Synonym**
1. Integration	a) Adaptability
2. Monitoring	b) Innovation
3. Diagnostics	c) Efficiency
4. Prediction	d) Consistency
5. Efficiency	e) Prediction
6. Optimization	f) Maintenance
7. Maintenance	g) Diagnostics
8. Adaptability	h) Monitoring
9. Innovation	i) Optimization
10. Consistency	j) Integration

b) Find the most appropriate synonym

Each sentence below contains a **bolded word** related to metrology. Choose the correct synonym that best replaces the bolded word without changing the meaning.

1. The **integration** of self-diagnostic modules enhances the functionality of modern measurement systems.

A) Configuration

B) Combination

C) Separation

D) Alignment

2. Real-time **monitoring** ensures that any deviations in system performance are detected promptly.

A) Observation

B) Validation

C) Manipulation

D) Calibration

3. The system's ability to make **adaptations** during production increases overall reliability and efficiency.

A) Modifications

B) Maintenance

C) Detections

D) Mechanization

4. Predictive maintenance depends on the **accuracy** of the data collected by sensors.

A) Verification

B) Exactness

C) Adjustment

D) Consistency

5. The efficiency of production lines relies heavily on the **optimization** of workflows and resources.

A) Innovation

B) Improvement

C) Simplification

D) Integration

c) Fill in the blanks with the correct synonym

Use one of the given synonyms to complete each sentence. Make sure the sentence makes sense in the context of intelligent control systems.

alignment, integration, feedback, adaptation, maintenance

1. The self-diagnostic system improves the _____ of the production process by ensuring minimal delays.

2. Advanced sensors allow for real-time _____ of industrial equipment to detect any deviations.

3. Effective _____ of various subsystems ensures smooth operation within automated factories.

4. Predictive maintenance relies heavily on accurate system _____ to identify potential faults.

5. The ability of smart factories to demonstrate _____ to changes in production demands increases their competitiveness.

3. Match the words with their definitions:

a) Match each term with its correct definition. Write the correct letter next to each number

1. Integration ___
2. Monitoring ___
3. Adaptability ___
4. Predictive maintenance ___
5. Optimization ___
6. Feedback ___
7. Diagnostics ___
8. Efficiency ___
9. Self-diagnostics ___
10. Innovation ___

Definitions:

A. The process of analyzing system performance to identify and correct malfunctions.

B. Continuous observation and assessment of processes or equipment.

C. Information returned to improve processes or performance in automated systems.

D. The seamless combination of multiple components into a unified operation.

E. A process that anticipates potential system failures and addresses them before they occur.

F. The ability to perform tasks or processes with minimal waste of resources.

G. The introduction of new ideas or methods to improve existing systems.

H. A system's ability to detect and correct its own errors autonomously.

I. The use of strategies to enhance system functionality and performance.

J. The ability to adjust to new conditions or changes in an environment.

b) Choose two terms and write your own sentences using them to reinforce understanding

4. Give English equivalents to the meanings of the following words and word combinations:

1. Інтеграція
2. Моніторинг
3. Адаптивність
4. Передбачуване обслуговування
5. Оптимізація
6. Зворотний зв’язок
7. Діагностика
8. Ефективність
9. Самодіагностика
10. Впровадження інновацій
11. Виявлення несправностей
12. Точність
13. Надійність
14. Калібрування
15. Обробка даних
16. Конфігурація
17. Автоматизовані процеси
18. Виробничі системи
19. Інтелектуальне управління
20. Спостереження в реальному часі

5. Choose the correct answer:

1. What is the role of self-diagnostic systems in measuring devices?

a) Increase device weight

b) Detect and correct errors autonomously

c) Replace manual calibration

d) Eliminate the need for sensors

2. What technology enables predictive maintenance in automated systems?

a) Manual observation

b) Artificial intelligence

c) Complex wiring systems

d) Optical misalignment

3. Why is integration important in modern production systems?

a) To isolate each system component

b) To enhance smooth operation and collaboration between devices

c) To reduce the use of advanced technology

c) To maintain outdated practices

4. Which of the following best describes adaptability in smart factories?

a) Resistance to change

b) The ability to adjust to varying production demands

c) Reliance on manual processes

d) Disconnection from real-time data

5. What is the main purpose of real-time monitoring in production systems?

a) To predict changes in weather conditions

b) To observe and assess equipment performance continuously

c) To disconnect machinery from networks

d) To delay system feedback

6. How does optimization contribute to the functionality of production systems?

a) By increasing operational inefficiency

b) By improving workflows and resource usage

c) By introducing unnecessary processes

d) By reducing system functionality

7. What advantage does feedback provide in automated systems?

a) It increases manual intervention

b) It offers data to enhance system performance

c) It eliminates real-time communication

d) It disrupts system functionality

8. Which statement accurately reflects the purpose of innovation in industrial automation?

a) To maintain outdated methods

b) To introduce new ideas for improving systems and processes

c) To remove technological advancements

d) To reduce system accuracy

9. Find the Correct Sentence Translation - *Predictive maintenance improves system reliability by addressing potential faults before they occur.*

a) Передбачуване обслуговування підвищує надійність системи, усуваючи можливі збої завчасно.

b) Оптимізація дозволяє системі працювати без будь-яких збоїв.

c) Моніторинг забезпечує зворотний зв'язок під час несправності.

d) Технічне обслуговування не впливає на роботу пристроїв.

10. Find the Correct Sentence Translation - *Real-time monitoring ensures the immediate detection of any deviations in equipment performance*.

a) Спостереження в реальному часі гарантує швидке виявлення будь-яких відхилень у роботі обладнання.

b) Автоматизація сприяє стабільній роботі системи.

c) Точність вимірювань не залежить від часу.

d) Моніторинг забезпечує лише періодичну перевірку відхилень.

6. Translate the following sentences into Ukrainian:

1. Self-diagnostic systems enable devices to autonomously identify performance issues, ensuring uninterrupted operation.

2. The integration of AI in predictive maintenance allows for early detection of potential failures, reducing downtime significantly.

3. Real-time monitoring enhances production efficiency by providing immediate feedback on equipment performance.

4. Intelligent control systems in smart factories adapt dynamically to changing production demands, optimizing resource allocation.

5. The use of IoT in measuring systems facilitates seamless data exchange between devices, creating a connected network for analysis.

7. Translate the following sentences into English:

1. Інтелектуальні системи дозволяють виявляти несправності в режимі реального часу, забезпечуючи безперебійність виробничих процесів.

2. Інтеграція штучного інтелекту в автоматизовані системи значно підвищує ефективність прогнозування можливих збоїв.

3. Моніторинг в реальному часі сприяє оперативному виявленню відхилень у роботі обладнання.

4. Зворотні зв'язки допомагають оптимізувати виробничі лінії, адаптуючи їх до мінливих умов.

5. Використання Інтернету речей у вимірювальних системах сприяє обміну даними між пристроями, створюючи єдину мережу для аналізу.

8. Answer the questions to the text:

1. What is the primary purpose of self-diagnostic systems in measurement devices?

2. How does predictive maintenance improve the reliability of automated processes?

3. In what ways does real-time monitoring enhance production efficiency?

4. Why is adaptability important in intelligent control systems within smart factories?

5. How does IoT facilitate data exchange in modern measurement systems?

6. What role does artificial intelligence play in predictive maintenance strategies?

7. How do feedback loops contribute to the optimization of production workflows?

8. What benefits do intelligent control systems bring to automated manufacturing environments?

9. How does the integration of self-diagnostic systems reduce downtime in production processes?

10. Why is resource allocation optimization essential for efficient production systems?

9. Write a short summary of the text (See the scheme p. 18, ex.11) and be ready to present it.

10*. Creative Writing

1. A Day in the Life of a Smart Factory

Write a journal entry as if you are a self-diagnostic system in a high-tech manufacturing facility. Describe your daily tasks, how you detect issues, and how you communicate solutions to other systems. Be creative and personify the system to make it more engaging.

2. The Future of Automation

Imagine it is the year 2050, and intelligent control systems have evolved significantly. Write a short story or an essay describing how these systems influence daily life, industries, and human interaction. Include examples of new technologies and challenges.

3. Predictive Maintenance Saves the Day

Create a fictional scenario where predictive maintenance prevents a major system failure in a critical industry (e.g., aerospace, healthcare, or energy). Describe the steps taken by the system, the technology involved, and the impact of solving the issue in time.

4. Designing the Ultimate Intelligent System

Write a proposal for an advanced intelligent control system. Include details about its features, benefits, and potential applications. Be imaginative but tie your ideas to the principles outlined in the topic (e.g., real-time monitoring, self-diagnostics, and adaptability).

5. The Ethical Dilemma of Automation

Explore a creative dialogue between a factory manager and an intelligent system. Discuss the benefits and drawbacks of automation, touching on topics like job displacement, system reliability, and ethical considerations. Make the conversation engaging and thought-provoking.

SPEAKING

A Comprehensive Discussion & Guidelines:

1. The Role of Self-Diagnostic Systems in Modern Automation

- Provide examples of self-diagnostic mechanisms, such as in optical systems or sensors.

- Highlight benefits such as reduced downtime, higher accuracy, and cost-effectiveness.
- Discuss challenges in implementing self-diagnostics, such as integration complexity or cost.

2. Predictive Maintenance and Its Impact on Industrial Efficiency

- Explain key concepts, such as data analysis, real-time monitoring, and forecasting.

- Include industries where predictive maintenance is essential (e.g., manufacturing, aviation).

- Address potential limitations, such as reliance on high-quality data and training AI systems.

3. Integration of IoT in Intelligent Control Systems

- Discuss the use of IoT for interconnected networks in smart factories.

- Provide examples of how IoT contributes to efficiency and adaptability in production.

- Highlight possible solutions for addressing cybersecurity risks.

4. The Future of Intelligent Control in Industry 4.0

- Emphasize technologies such as AI, machine learning, and big data in the context of Industry 4.0.

- Predict how advancements in intelligent systems will transform productivity and efficiency.

- Encourage exploring the ethical and economic implications of widespread automation.

Discussion Points

1. The Role of Self-Diagnostic Systems in Modern Automation

- How do self-diagnostic systems improve the reliability of production processes?

- What are the key technologies enabling autonomous fault detection and correction?

- Discuss real-world applications of self-diagnostics in industrial systems.

2. Predictive Maintenance and Its Impact on Industrial Efficiency

- What is predictive maintenance, and how is it different from traditional maintenance approaches?
- How does artificial intelligence enhance the effectiveness of predictive maintenance?
- Discuss the potential cost savings and productivity improvements it offers.

3. Integration of IoT in Intelligent Control Systems

- How does IoT enable seamless communication between measurement devices?
- What role does IoT play in real-time monitoring and data exchange?
- Explore the security challenges related to IoT integration in industrial settings.

4. The Future of Intelligent Control in Industry 4.0

- How do intelligent control systems align with the principles of Industry 4.0?
- What are the future trends in adaptive and autonomous systems for industrial automation?
- Discuss the role of innovation in shaping the next generation of measurement technologies.

2. Render the following text into English. Summarize its main idea in one sentence.

Інтелектуальні системи управління та самодіагностики є основою сучасної автоматизації виробничих процесів. Завдяки впровадженню технологій штучного інтелекту та Інтернету речей (IoT), ці системи здатні виявляти несправності, проводити аналіз даних у реальному часі та пропонувати оптимальні рішення для забезпечення безперебійної роботи обладнання. Це дозволяє не лише підвищити ефективність роботи виробничих ліній, але й мінімізувати втрати часу та ресурсів.

Однією з ключових функцій таких систем є передбачуване обслуговування. Використовуючи історичні дані та алгоритми прогнозування, системи можуть виявляти потенційні ризики перед їх фактичним виникненням. Наприклад, у разі

зносу критичних компонентів обладнання система автоматично попереджає інженерів, надаючи можливість провести ремонтні роботи заздалегідь. Це не тільки знижує ризик поломок, але й допомагає уникнути дорогих простоїв у виробництві.

Водночас, інтеграція IoT дозволяє створити мережу взаємопов'язаних пристроїв, які обмінюються даними та забезпечують повну прозорість виробничих процесів. Це створює умови для гнучкого управління ресурсами та швидкої адаптації до змін у виробничому середовищі. Завдяки зворотному зв'язку системи можуть вносити коригування в реальному часі, забезпечуючи стабільність якості продукції.

У майбутньому інтелектуальні системи управління матимуть ще ширші можливості, сприяючи переходу до повністю автоматизованих та адаптивних виробничих середовищ. Їх впровадження є важливим кроком у розвитку Індустрії 4.0, де інноваційні рішення стають рушійною силою прогресу.

UNIT V

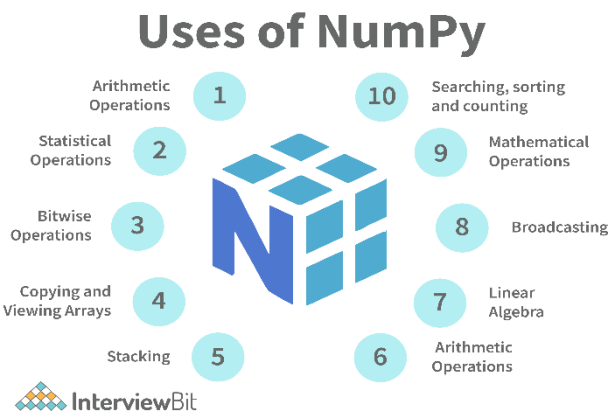
PROGRAMMING, ALGORITHMS AND HARDWARE INTEGRATION

Text A

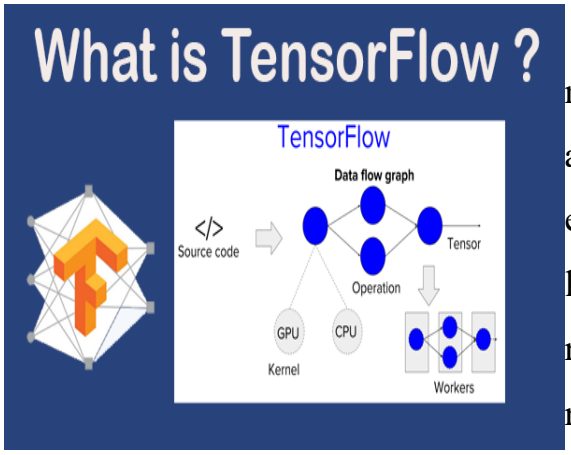
Algorithmic Programming and Coding Languages

1. a) Read and translate the text into Ukrainian using the dictionary. Pay attention to the underlined words and word combinations.

The field of algorithmic programming plays a pivotal role in modern automation and system development. It provides the foundation for creating efficient and precise algorithms that drive the functionality of various automated systems. Among the most widely used algorithmic languages are Python and Flash, both of which are renowned for their versatility and applicability in diverse industrial contexts.



Basics of Programming Using Python and Flash. Python is celebrated for its simplicity and readability, making it an ideal choice for beginners and professionals alike. Its extensive libraries, such as NumPy and pandas, provide tools for mathematical computations, data manipulation, and automation, while frameworks like TensorFlow support advanced tasks such as machine learning integration. Python's structured syntax ensures that developers can easily write and maintain efficient code for complex systems. Its adaptability in areas ranging from web development to robotics highlights its indispensable role in algorithmic programming.



On the other hand, Flash, though historically more associated with multimedia applications, has also been a powerful tool for creating interactive elements in automated systems. Its ActionScript language allows the development of dynamic and responsive algorithms, particularly in systems that require engaging user interfaces or multimedia integration. Flash's versatility in creating animations and simulations provides valuable insights in prototyping automated workflows.

Developing Algorithms for Automated Systems. The development of algorithms for automated systems demands a comprehensive understanding of problem-solving strategies and a structured approach to coding. In automated environments, algorithms function as the "brain" behind system operations, dictating how a machine processes input, reacts to changes, and achieves predefined goals. For instance, in an industrial assembly line, an algorithm may control the precise timing and sequence of robotic actions to optimize efficiency.

Python and Flash both contribute significantly to this process. Python, with its advanced libraries and support for real-time data processing, enables engineers to craft algorithms that adapt to dynamic conditions, ensuring reliability and efficiency. Flash's ability to visually represent workflows or simulate processes allows developers to test and refine algorithms before full implementation.

Additionally, the integration of algorithms with sensors, microprocessors, and communication systems enhances the intelligence of automated setups. Predictive logic, error handling, and adaptability are key components of these algorithms, ensuring robust and scalable operations in modern industries.

In conclusion, mastering algorithmic programming in languages like Python and Flash equips professionals with the tools to design and optimize the core functionality of automated systems. As industries increasingly rely on automation, a strong foundation in these programming languages and algorithm development is essential for staying at the forefront of technological innovation.

b) Translate the italicized paragraph into Ukrainian (in writing):

c) Put 5 questions to the text

2. Advanced Synonym Exercise:

a) Match the words with their synonyms

Word	Synonym
1.Algorithm	A. Combination
2. Efficiency	B. Flexibility
3. Simulation	C. Calculation
4. Automation	D. Program
5. Optimization	E. Improvement
6. Processing	F. Workflow
7. Microprocessor	G. Autonomy
8. Integration	H. Performance
9. Real-time	I. Emulation
10. Adaptability	J. Instantaneous

b) Find the most appropriate synonym

Each sentence below contains a **bolded word**. Choose the correct synonym that best replaces the bolded word without changing the meaning.

1. The **libraries** in Python allow programmers to simplify complex coding tasks.

A) Tools

B) Frameworks

C) Devices

D) Languages

2. Flash enables developers to create interactive **simulations** of automated workflows.

A) Designs

B) Experiments

C) Models

D) Interpretations

3. Optimization ensures that the algorithms perform efficiently under all conditions.

A) Development

B) Refinement

C) Reduction

D) Expansion

4. Writing structured **algorithms** is essential for managing automated systems.

A) Instructions

B) Processes

C) Configurations

D) Blueprints

c) Fill in the blanks with the correct synonym.

Use one of the given synonyms to complete each sentence. Make sure the sentence makes sense.

algorithm, automation, optimization, real-time, libraries

1. Python's extensive _____ simplify the process of implementing machine learning models.
2. Developing an efficient _____ is crucial for solving a complex coding problem.
3. The _____ of production processes minimizes the need for manual intervention.
4. _____ data processing helps ensure that systems respond instantly to input changes.
5. Code _____ improves performance and reduces execution time in automated systems.

3. Using the dictionary transcribe and translate the key words and words combinations:

Word	**Transcription**	**Translation**
Algorithm		
Automation		
Libraries		
Optimization		
Real-time processing		
Simulation		
Workflow		

Microprocessor

Code readability

Debugging

4. Match the words with their definitions:

a) Match each term with its correct definition. Write the correct letter next to each number

1. Debugging ___
2. Syntax ___
3. Variable ___
4. Algorithm ___
5. Runtime ___
6. Compilation ___
7. Integration ___
8. Framework ___
9. Execute ___
10. Optimization ___

Definitions

A. A set of rules that defines the structure of statements in a programming language.

B. The process of finding and fixing errors in a computer program.

C. A structural platform that provides foundational tools and components for development.

D. To carry out a specific instruction or set of instructions in a program.

E. The seamless combination of multiple systems or components into a unified operation.

F. A storage location identified by a name that can hold different values during program execution.

G. The period during which a program is actively being executed.

H. The act of improving a system or process to achieve maximum performance and efficiency.

I. A step-by-step procedure or formula for solving a specific problem.

J. The process of translating source code into machine code so that it can be run by a computer.

b) Choose two terms and write your own sentences using them to reinforce understanding.

5. Give English equivalents to the meanings of the following words and word combinations:

1. Алгоритм
2. Автоматизація
3. Оптимізація коду
4. Обробка в реальному часі
5. Розробка алгоритмів
6. Бібліотеки Python
7. Симуляція
8. Інтеграція компонентів
9. Виконувати
10. Простота програмування
11. Ефективність
12. Читабельність коду

13. Компіляція

14. Адаптивний

15. Налагодження програми

6. Choose the correct answer

1. What is a key advantage of Python in algorithmic programming?

A) It is primarily used for animations.

B) It has a complex syntax.

C) It offers extensive libraries for simplifying coding tasks.

D) It cannot handle real-time data processing.

2. What makes Flash suitable for developing interactive systems?

A) Its readability for beginners.

B) Its capability to create dynamic multimedia simulations.

C) Its advanced libraries for machine learning.

D) Its focus on mathematical computations.

3. What does real-time processing enable in automated systems?

A) Delayed responses to new data.

B) Immediate reactions to changes in input data.

C) The execution of only pre-recorded instructions.

D) The need for manual adjustments.

4. Why is optimization important in automated systems?

A) It reduces system performance.

B) It minimizes efficiency and code readability.

C) It improves performance and reduces execution time.

D) It ensures the manual operation of algorithms.

5. What is the primary function of an algorithm in automated systems?

A) To perform complex animations.

B) To provide a step-by-step solution to a problem.

C) To store values during execution.

D) To serve as a standalone component without external systems.

6. What is one of Python's strengths in programming automated systems?

A) It is limited to web development only.

B) Its syntax is difficult to read and write.

C) It supports adaptability in changing conditions.

D) It lacks frameworks for advanced tasks.

7. How does Flash contribute to automated workflows?

A) By enhancing efficiency with machine learning frameworks.

B) By creating dynamic visual simulations for testing processes.

C) By performing numerical calculations for real-time data.

D) By offering syntax similar to Python's.

8. What role do Python libraries play in algorithm development?

A) They offer predefined tools for complex computations.

B) They complicate the coding process.

C) They restrict real-time data processing.

D) They are used only in multimedia applications.

9. Find the Correct Sentence Translation - *Optimization ensures that algorithms perform efficiently and reduce resource consumption.*

A) Оптимізація забезпечує ефективність алгоритмів та знижує використання ресурсів.

B) Розробка алгоритмів ускладнює роботу програмного забезпечення.

C) Впровадження алгоритмів підвищує складність автоматизації.

D) Ефективність систем не залежить від оптимізації.

10. Find the Correct Sentence Translation - *Flash simulations allow developers to test and refine automated workflows visually.*

A) Симуляції у Flash дозволяють розробникам візуально тестувати та вдосконалювати робочі процеси автоматизації.

B) Flash не використовується для роботи з автоматизованими системами.

C) Візуальні симуляції у Flash значно ускладнюють процес автоматизації.

D) Симуляції у Flash використовуються виключно для розваг.

7. Translate the following sentences into Ukrainian:

1. Python's extensive libraries provide developers with powerful tools for real-time data processing and algorithm development.
2. Flash enables the creation of interactive simulations, offering a visual approach to testing automated workflows.
3. Code optimization ensures that automated systems operate efficiently while consuming minimal resources.
4. Integration of Python with microprocessors enhances the adaptability and functionality of modern automated systems.
5. Developing algorithms tailored to dynamic conditions is essential for ensuring reliability in automated environments.

8. Translate the following sentences into English:

1. Бібліотеки Python забезпечують розробникам потужні інструменти для обробки даних у реальному часі та створення алгоритмів.
2. Симуляції у Flash допомагають візуально тестувати та вдосконалювати автоматизовані робочі процеси.
3. Оптимізація коду гарантує ефективну роботу автоматизованих систем із мінімальним використанням ресурсів.
4. Інтеграція Python із мікропроцесорами розширює функціональність і адаптивність сучасних автоматизованих систем.

5. Розробка алгоритмів, що враховують динамічні умови, є ключем до забезпечення надійності в автоматизованих середовищах.

9. Answer the questions to the text.

1. What are the key advantages of Python as an algorithmic programming language?
2. How does Flash contribute to the development of interactive simulations?
3. Why is real-time processing important in automated systems?
4. In what ways does code optimization improve the performance of automated systems?
5. How do algorithms function as the "brain" behind automated systems?
6. What features of Python make it suitable for dynamic and adaptive programming tasks?
7. Why is component integration critical for the seamless operation of automated processes?
8. How can Flash simulations assist developers in testing and refining workflows?
9. What role do Python libraries play in simplifying complex programming tasks?
10. What are the essential elements of algorithm development in ensuring the reliability of automated systems?

10. Write a short summary of the text (See the scheme p. 18, ex. 11) and be ready to present it.

11*. Creative Writing

1. Imagine a Coding Challenge. Write a short story about a programmer solving a critical issue in an automated system using Python. Include details about how they utilized libraries or implemented real-time data processing.

2. Design an Ideal Algorithm. Create a concept for an algorithm that could improve efficiency in smart factories. Describe its function, how it processes data, and how Python or Flash could be used to implement it.

SPEAKING

A Comprehensive Discussion & Guidelines

1. The Importance of Algorithmic Programming in Modern Automation

- Highlight the versatility of Python in various industries, from web development to robotics.
- Emphasize the role of Flash in creating interactive and dynamic simulations.
- Encourage learners to discuss how properly designed algorithms influence the efficiency and reliability of automated processes.

2. Real-Time Data Processing: Benefits and Applications

- Provide case studies or examples where real-time processing prevents system failures.
- Explore the challenges of implementing real-time processing and how they can be addressed.
- Encourage participants to brainstorm potential use cases in their own fields.

3. Code Optimization and Its Role in Efficiency

- Focus on real-world benefits, such as reduced system downtime or improved energy efficiency.
- Discuss tools and techniques for optimizing code, such as debugging and refining algorithms.

- Encourage participants to share examples of how they have improved code performance in their own projects.

4. The Contribution of Flash to Workflow Simulations

- Provide examples of scenarios where simulations reduce development time and costs.
- Emphasize the creative applications of Flash in prototyping workflows.
- Explore new technologies that could enhance or replace Flash in simulation development.

5. Challenges in Algorithm Development for Dynamic Systems

- Highlight the adaptability of Python in dynamic environments through its extensive libraries.
- Explore strategies to enhance algorithm flexibility and adaptability.
- Encourage brainstorming about the future of algorithm development in handling complex systems.

Discussion Points

1. The Importance of Algorithmic Programming in Modern Automation

- Why are algorithms considered the foundation of automated systems?
- How do Python and Flash serve as key tools for algorithm development?
- Discuss the significance of structured syntax and readability in programming.

2. Real-Time Data Processing: Benefits and Applications

- What is real-time data processing, and why is it critical for automation?
- How does Python's ability to handle real-time tasks make it suitable for automated environments?
- Discuss examples of real-time processing in industries such as manufacturing or healthcare.

3. Code Optimization and Its Role in Efficiency

- What are the key methods for optimizing code in algorithmic programming?
- Why is optimization essential for reducing resource consumption in automated systems?
- How does optimized code contribute to the scalability of a system?

4. The Contribution of Flash to Workflow Simulations

- How do Flash simulations support the development and refinement of automated workflows?
- Why are visual simulations important for testing and troubleshooting algorithms?
- Discuss the limitations of Flash and potential alternatives for creating simulations.

5. Challenges in Algorithm Development for Dynamic Systems

- What are the key challenges when developing algorithms for dynamic and unpredictable conditions?
- How can Python and Flash assist in creating adaptable algorithms?
- Discuss the role of libraries and frameworks in overcoming these challenges.

2. Render the following text into English. Summarize its main idea in one sentence.

Алгоритмічне програмування є ключовою складовою сучасних автоматизованих систем. Воно надає можливість створювати чітко структуровані алгоритми, які забезпечують ефективність та надійність роботи різноманітних процесів. Python та Flash є популярними мовами програмування, які допомагають реалізувати ці алгоритми завдяки їхнім унікальним особливостям.

Python виділяється простотою синтаксису, читабельністю коду та наявністю широких бібліотек, таких як NumPy та pandas, що робить його універсальним для вирішення складних завдань. Ця мова використовується для обробки даних у

реальному часі, розробки алгоритмів, інтеграції з мікропроцесорами та навіть для навчання штучного інтелекту. Завдяки цьому Python стає незамінним інструментом у багатьох галузях, від робототехніки до веб-розробки.

Flash, хоча його здебільшого асоціюють із мультимедійними додатками, також має значний потенціал у створенні інтерактивних симуляцій. Його здатність моделювати процеси допомагає розробникам тестувати алгоритми та вдосконалювати робочі процеси до їхнього впровадження. Симуляції у Flash є зручним інструментом для візуалізації, що дозволяє швидше виявляти та виправляти помилки.

Загалом, ефективне використання алгоритмічних мов програмування, таких як Python і Flash, є важливим кроком у розробці інноваційних автоматизованих систем. Вони допомагають реалізувати сучасні рішення, що відповідають вимогам Індустрії 4.0, сприяючи підвищенню ефективності, адаптивності та інтеграції систем.

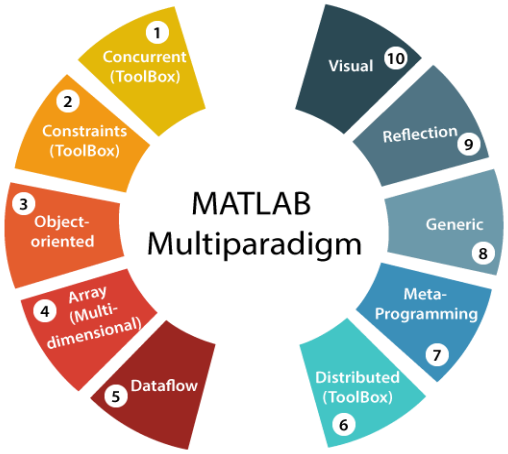
Text B

Specialized Software and Hardware Integration

1. a) Read and translate the text into Ukrainian using the dictionary. Pay attention to the underlined words and word combinations:

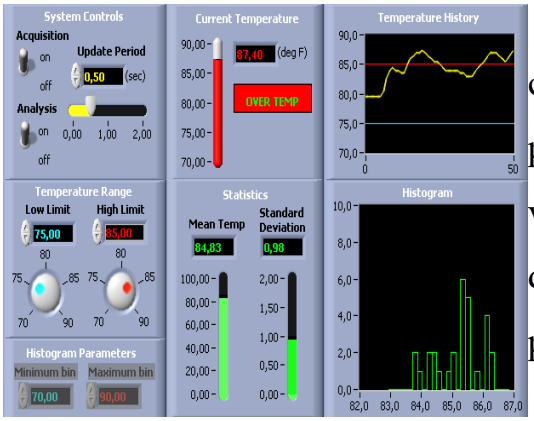
In modern engineering and automation, specialized software and hardware integration have become crucial for developing efficient and adaptable systems. This chapter focuses on the use of advanced tools and techniques, including specialized software, microprocessor technologies, and their seamless integration to enhance functionality and performance in various industries.

Using Specialized Software (MATLAB, AutoCAD, LabVIEW). Specialized software plays an integral role in solving engineering challenges and enhancing the design, analysis, and automation of complex systems. MATLAB, with its extensive libraries and toolboxes, is a go-to platform for numerical computations, control systems, and data visualization. Its ability to simulate real-world systems before implementation minimizes risks and saves time in the engineering process. For instance, it enables users to test algorithms for control systems or analyze signal processing tasks in a virtual environment.

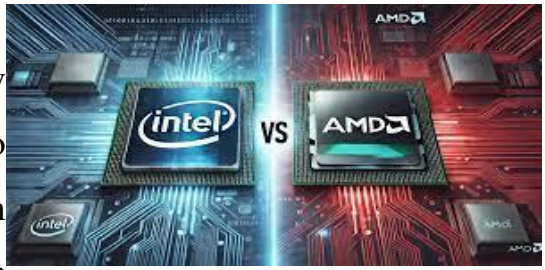


AutoCAD is another invaluable tool, particularly in fields that require precision in technical drawings and 3D modeling. Architects and engineers rely on its robust features to design everything from buildings to machine components with meticulous accuracy. Its compatibility with other

software also makes it a versatile choice for collaborative projects. Additionally, its 3D

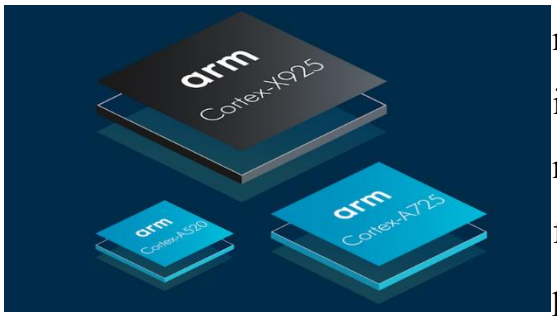


modeling capabilities allow professionals to visualize projects in detail before physical construction begins.



LabVIEW, on the other hand, is unparalleled in its ability to handle automated testing and measurement systems. Its graphical programming interface simplifies the process of designing virtual instruments, making it easier for engineers to acquire and analyze data in real-time. LabVIEW is widely used in laboratories and industries to create complex testing setups, enabling users to monitor processes, generate reports, and identify issues quickly. Working with Microprocessors from Modern Manufacturers. Microprocessors are the core components of intelligent systems, enabling devices to perform complex tasks and calculations efficiently. Manufacturers like Intel, AMD, and ARM have revolutionized the industry by producing processors tailored to different applications, from consumer electronics to industrial automation and high-performance computing. These microprocessors are designed to handle massive amounts of data, perform calculations at lightning speed, and manage multiple processes simultaneously.

For engineers, understanding the architecture and functionality of modern



microprocessors is critical. Skills in programming instruction sets, managing memory, and interfacing microprocessors with peripheral devices are essential for creating efficient systems. For example, ARM processors are widely used in embedded systems due to their low power consumption and adaptability, while Intel's high-performance processors are preferred for tasks requiring significant computational power. Familiarity

with these technologies enables professionals to select the right hardware for specific applications, ensuring the optimal performance of automated systems.

Integration also plays a vital role in enhancing system reliability and scalability. It allows for the development of modular systems where microprocessors and software can be updated or replaced independently without disrupting the entire setup. This flexibility is crucial in modern industries that demand adaptable and future-proof solutions.

In conclusion, the combination of specialized software tools with advanced microprocessors opens up endless possibilities for innovation in engineering and automation. Proficiency in these areas enables professionals to design cutting-edge solutions and stay at the forefront of technological advancement.

b) Translate the italicized paragraph into Ukrainian (in writing).

c) Put 5 questions to the text.

2. Advanced Synonym Exercise:

a) Match the words with their synonyms

Word	Synonyms
1. Simulation	A. Expandability
2. Integration	B. Procedure
3. Workflow	C. Expertise
4. Acquisition	D. Framework
5. Scalability	E. Calculation
6. Architecture	F. Process
7. Computation	G. Emulation
8. Deployment	H. Collection

Word	Synonyms
9. Algorithm	I. Implementation
10. Proficiency	J. Unification

b) **Find the most appropriate synonym**

Each sentence below contains a bolded word related to metrology. Choose the correct synonym that best replaces the bolded word without changing the meaning.

1. The **integration** of microprocessors with software enables efficient system performance.
   A) Fusion
   B) Separation
   C) Disconnection
   D) Isolation
2. Engineers rely on accurate **simulation** to test workflows before implementation.
   A) Observation
   B) Visualization
   C) Emulation
   D) Execution
3. Proper **deployment** of algorithms ensures seamless functionality in automated systems.
   A) Removal
   B) Testing
   C) Implementation
   D) Creation
4. The **scalability** of modern processors allows systems to adapt to increasing demands.
   A) Expandability

B) Limitation

C) Size

D) Restriction

5. Software like LabVIEW facilitates efficient **acquisition** of real-time data.

A) Processing

B) Collection

C) Generation

D) Loss

c) Fill in the blanks with the correct synonym

Use one of the given synonyms to complete each sentence. Make sure the sentence makes sense in the context of metrology.

integration, simulation, scalability, deployment, acquisition

1. The seamless _____ of microprocessors and software enhances system functionality in modern engineering.
2. Accurate _____ helps developers test workflows before final implementation.
3. The _____ of algorithms is crucial to ensure the reliable operation of automated systems.
4. The _____ of real-time data allows engineers to make precise decisions in dynamic environments.
5. The _____ of processors ensures that systems can handle increasing computational demands efficiently.

3. Using the dictionary transcribe and translate the key words and words combinations:

Word	Transcription	Translation
Integration		
Simulation		
Microprocessor		
Acquisition		
Automation		
Deployment		
Efficiency		
Scalability		
Computation		
Performance		
Enhance		
Streamline		
Adapt		
Optimize		
Reliability		

4. Match the words with their definitions:

a) Match each term with its correct definition. Write the correct letter next to each number

1. Simulation ___

2. Microprocessor ___

3. Deployment ___

4. Scalability ___

5. Acquisition ___

6. Computation ___

7. Visualization ___

8. Enhancement ___

9. Adaptability ___

10. Architecture ___

Definitions

A. The act of improving or refining system performance or functionality.

B. The ability of a system to adjust and function in changing environments.

C. A structural design or framework used to organize components in a system.

D. A method of imitating or modeling real-world processes for testing purposes.

E. The collection or gathering of data for analysis or application.

F. A small electronic chip that performs computations and controls system operations.

G. The execution or implementation of software, tools, or systems for real-world use.

H. The ability of a system to expand and handle increased workloads effectively.

I. The process of solving problems through mathematical or logical calculations.

J. The graphical representation or illustration of data, systems, or workflows.

b) Choose two terms and write your own sentences using them to reinforce understanding.

5. Give English equivalents to the meanings of the following words and word combinations:

1. Інтерфейс користувача
2. Розгортання алгоритмів
3. Графічна візуалізація
4. Збір даних
5. Програмна архітектура
6. Виконання завдань

7. Обчислювальна потужність

8. Моделювання процесів

9. Інженерні інструменти

10. Масштабованість системи

11. Тестування програмного забезпечення

12. Інтеграція обладнання

13. Автоматизовані рішення

14. Налаштування системи

15. Реальний час

16. Вбудовані системи

17. Контрольні алгоритми

18. Технічне моделювання

19. Віртуальні інструменти

20. Підтримка обчислень

6. Choose the correct answer:

1. Which software is widely used for control systems, signal processing, and simulations?

A) AutoCAD

B) MATLAB

C) LabVIEW

D) ARM

2. What is the primary advantage of AutoCAD in engineering?

A) Data acquisition

B) Numerical computations

C) Creating precise technical drawings and 3D models

D) Algorithm deployment

3. Which tool is known for simplifying the design of automated testing systems?

A) MATLAB

B) LabVIEW

C) Microprocessor

D) Intel Processor

4. Why is scalability important in modern processors?

A) To consume less power

B) To allow systems to handle increasing computational demands

C) To create more complex algorithms

D) To improve graphical representation

5. What does the integration of microprocessors with software primarily ensure?

A) Manual adjustments

B) Minimal performance

C) Seamless system functionality

D) Limited scalability

6. How does LabVIEW enhance engineering workflows?

A) By providing precise 3D modeling capabilities

B) By offering visual programming for data acquisition and real-time analysis

C) By simulating physical processes with emulation algorithms

D) By automating microprocessor architecture updates

7. What is a key feature of microprocessors produced by ARM?

A) High power consumption

B) Advanced graphical interfaces

C) Low power consumption and adaptability

D) Exclusive use in industrial environments

8. What is the main purpose of simulation in engineering?

A) To observe real-world events without predictive analysis

B) To replace physical systems with virtual frameworks

C) To test and refine workflows in a virtual environment before deployment

D) To collect data passively without interaction

9. Find the Correct Sentence Translation - *Seamless integration of microprocessors with software enables efficient system performance*.

A) Безшовна інтеграція мікропроцесорів із програмним забезпеченням забезпечує ефективну роботу системи.

B) Інтеграція апаратного забезпечення ускладнює автоматизацію.

C) Розгортання мікропроцесорів не впливає на функціонування системи.

D) Тестування програмного забезпечення дозволяє уникати інтеграції.

10. Find the Correct Sentence Translation - *LabVIEW simplifies automated testing and real-time data analysis for engineers*.

A) LabVIEW ускладнює аналіз даних у реальному часі для інженерів.

B) LabVIEW полегшує автоматизоване тестування та аналіз даних у реальному часі для інженерів.

C) LabVIEW використовується лише для тестування апаратного забезпечення.

D) LabVIEW застосовується для створення технічних малюнків у 3D.

7. Give the full version of the following acronyms:

MATLAB – _____

AutoCAD – _____

LabVIEW - _____

ARM - _____

8. Translate the following sentences into Ukrainian.

1. Engineers utilize MATLAB to simulate and analyze dynamic systems, ensuring reliability before real-world implementation.
2. AutoCAD's precision in creating technical drawings makes it an indispensable tool for designing complex engineering projects.
3. LabVIEW streamlines data acquisition by allowing users to build intuitive workflows for automated testing processes.
4. Modern microprocessors, such as those by ARM, are designed for low power consumption and exceptional adaptability in embedded systems.
5. Seamless integration of software and hardware components enhances the flexibility and scalability of automated workflows.

9. Translate the following sentences into English.

1. MATLAB дозволяє інженерам проводити моделювання динамічних систем, зменшуючи ризики перед впровадженням у реальних умовах.
2. AutoCAD незамінний у створенні точних технічних креслень і тривимірних моделей для складних інженерних проектів.
3. LabVIEW полегшує автоматизований збір даних і забезпечує ефективний аналіз у реальному часі.
4. Сучасні мікропроцесори, такі як ARM, вирізняються низьким енергоспоживанням і високою адаптивністю для вбудованих систем.
5. Інтеграція програмного забезпечення та апаратних компонентів підвищує масштабованість і ефективність автоматизованих робочих процесів.

10. Answer the questions to the text.

1. What are the primary applications of MATLAB in engineering?
2. How does AutoCAD contribute to the design of complex technical projects?
3. Why is LabVIEW considered an effective tool for real-time data analysis?
4. What are the advantages of ARM microprocessors in embedded systems?

5. How does the integration of microprocessors with software enhance system performance?
6. In what ways does simulation reduce risks during the development of automated systems?
7. Why is scalability important for modern processors in engineering projects?
8. How does LabVIEW streamline the development of automated testing processes?
9. What makes AutoCAD essential for creating precise technical drawings and 3D models?
10. How do modern microprocessors improve the adaptability of automated workflows?

11. Write a short summary of the text (See the scheme p. 18, ex. 11) and be ready to present it.

12*. Creative Writing

Design the Future:

A World Transformed by Specialized Software and Hardware Integration

Instructions: Imagine a world where the seamless integration of advanced software and hardware has revolutionized every aspect of life—healthcare, education, transportation, industry, or even daily routines. Write a short story, an article, or a journal entry describing this futuristic world.

Your writing should address the following:

1. How do systems like MATLAB, AutoCAD, or LabVIEW play a role in shaping this future?
2. What innovative applications of microprocessors and automated workflows can be imagined?
3. How does this technological advancement improve the lives of individuals and society as a whole?

4. Are there any challenges or ethical considerations introduced by these advancements?

Optional Elements to Include:

1. A day in the life of someone living in this world.

2. A dramatic event where software and hardware integration solves a critical problem.

3. Personal reflections of an engineer or scientist who played a key role in designing such systems.

Make your writing imaginative and vivid. Use descriptive language to paint a picture of this exciting future!

SPEAKING

A Comprehensive Discussion & Guidelines

1. A Comprehensive Discussion

The Role of Specialized Software and Hardware in Modern Engineering

Instructions: Work individually or in pairs to discuss the following topics. Use examples from the real world, or imagine innovative possibilities to elaborate on your points. Be sure to share your personal insights and engage deeply with the questions.

Discussion Questions:

1. Why is the integration of software like MATLAB, AutoCAD, or LabVIEW essential in engineering and automation today?
2. How do modern microprocessors improve the efficiency and adaptability of automated systems?
3. Can you think of a scenario where simulation and visualization software might prevent critical errors in engineering projects?

4. What are the potential challenges engineers face while integrating software and hardware in complex systems?
5. How can scalability in hardware systems contribute to long-term technological advancement?
6. Imagine you're designing a smart factory. Which specialized tools or software would you choose and why?
7. What ethical considerations might arise with the rapid development of automation and intelligent systems?
8. In your opinion, how will the future of specialized software and hardware integration impact industries like healthcare, education, or transportation?

Extension Task: Present your thoughts to the group and support your ideas with examples or analogies. You may also debate contrasting viewpoints and reflect on the pros and cons of advanced technology in daily life.

2. Collaborating on Advanced Engineering Concepts

Exploring the Impact of Specialized Software and Hardware Integration

Guidelines:

1. **Form Groups or Pairs**: Work in small groups or pairs to ensure an active exchange of ideas and balanced participation.
2. **Preparation**: Each participant should think of at least one example of how specialized software (like MATLAB, AutoCAD, or LabVIEW) and hardware (such as microprocessors) are used in real-world applications. Prepare to share your example with the group.
3. **Discussion Topics**:

   - How has the integration of software and hardware transformed specific industries (e.g., healthcare, manufacturing, or transportation)?

- In what ways can automation improve efficiency, and are there any potential risks involved?
- Imagine a future innovation made possible through the seamless integration of advanced software and hardware. Describe it.
- Discuss the role of adaptability and scalability in modern systems. Why are these characteristics vital for long-term success?

4. **Engage Actively**: Use follow-up questions to dive deeper into each idea. For example:
   - "Can you explain how LabVIEW contributes to this process?"
   - "Do you think automation will fully replace human roles in this field?
   - "What challenges might engineers face with scalability in their systems?"
5. **Feedback Loop**: Provide constructive feedback to each other. Highlight creative ideas and ask clarifying questions to enrich the discussion.
6. **Presentation**: Conclude the activity by having each group/pair present their insights and innovations to the rest of the class or group. Encourage others to ask questions about the presentation.
7. **Key Points**: Focus on clear communication, using specialized vocabulary and practical examples wherever possible. Avoid overcomplicating explanations—keep it engaging and collaborative!

2. Render the following text into English. Summarize its main idea in one sentence.

Інтеграція програмного забезпечення
та апаратного забезпечення: майбутнє інженерії

Безшовна інтеграція спеціалізованого програмного забезпечення та сучасного апаратного забезпечення змінює ландшафт інженерії та автоматизації. Інструменти, такі як MATLAB, AutoCAD та LabVIEW, стали незамінними завдяки своїм потужним можливостям для проектування, моделювання та оптимізації складних

систем. MATLAB зі своїми широкими обчислювальними функціями дозволяє інженерам розробляти алгоритми керування та аналізувати динамічні процеси з високою точністю. Тим часом AutoCAD забезпечує створення детальних технічних креслень і 3D-моделей, що є важливим етапом візуалізації під час проєктування. LabVIEW ще більше вдосконалює робочі процеси, спрощуючи збір даних і аналіз у реальному часі та оптимізуючи розробку автоматизованих систем тестування.

Мікропроцесори відіграють ключову роль у забезпеченні роботи інтелектуальних та адаптивних систем. Сучасні виробники, такі як ARM та Intel, випускають високопродуктивні процесори, які поєднують низьке енергоспоживання з високою обчислювальною потужністю, що робить їх ідеальними для вбудованих систем та промислової автоматизації. Ці сучасні мікропроцесори забезпечують масштабованість, дозволяючи системам обробляти зростаючі навантаження та адаптуватися до змінних вимог. Інженери використовують цю адаптивність для створення інноваційних рішень, які є надійними та ефективними, гарантуючи довговічність автоматизованих систем у швидко змінюваних галузях.

Синергія між інтеграцією програмного забезпечення та апаратного забезпечення відкриває двері для революційних проривів у багатьох сферах, включно з охороною здоров’я, виробництвом і транспортом. Моделювання, створене за допомогою інструментів, таких як MATLAB, допомагає інженерам тестувати та вдосконалювати робочі процеси у віртуальному середовищі, знижуючи ризики перед впровадженням. Масштабованість сучасних систем забезпечує довгострокову стійкість, а точність таких інструментів, як AutoCAD, підтримує створення оптимальних проєктів. Завдяки цьому поєднанню технологій підвищується продуктивність та стимулюється інноваційний підхід до вирішення реальних викликів.

Загалом, поєднання спеціалізованого програмного забезпечення із сучасним апаратним забезпеченням визначає майбутнє інженерії. Ця інтеграція надає

інженерам змогу розширювати межі можливого, забезпечуючи більш розумні, швидкі та ефективні рішення, які відповідають вимогам все складнішого й автоматизованого світу. Завдяки постійному розвитку потенціал для інновацій залишається безмежним.

TEST YOURSELF

Choose the correct answer.

1. What is metrology?
    a) The science of materials
    b) The science of energy
    c) The science of measurement
    d) The science of motion
2. Which organization defines metrology as "the science of measurement"?
    a) ISO
    b) BIPM
    c) OIML
    d) NIST
3. Which system of units was created during the French Revolution?
    a) Imperial system
    b) Metric system
    c) CGS system
    d) MKS system
4. What are the three main activities of metrology?
    a) Definition of units, calibration, standardization
    b) Definition of units, realization of units, traceability
    c) Definition of units, certification, quality control
    d) Definition of units, testing, analysis
5. What are the three basic subfields of metrology?
    a) Fundamental, applied, legal
    b) Fundamental, technical, industrial
    c) Fundamental, scientific, medical
    d) Fundamental, applied, environmental
6. Which organization was established by the Convention of the Metre in 1875?

a) ISO

b) BIPM

c) OIML

d) NIST

7. What are the seven basic units of the modern SI metric system?

a) Meter, kilogram, second, ampere, kelvin, mole, candela

b) Meter, gram, minute, volt, Celsius, mole, lumen

c) Inch, pound, hour, watt, Fahrenheit, mole, lux

d) Meter, kilogram, second, volt, Celsius, mole, lumen

8. Which unit remains based on a physical artifact?

a) Meter

b) Kilogram

c) Second

d) Ampere

9. What is the purpose of calibration in metrology?

a) To enhance the aesthetic design of instruments

b) To verify the precision and traceability of measurements

c) To increase the speed of measurements

d) To reduce the cost of instruments

10. What is a primary measurement standard based on?

a) Physical constants

b) Secondary standards

c) Working standards

d) Environmental factors

11. What ensures the repeatability of measurements in metrology?

a) The aesthetic design of instruments

b) The calibration process

c) The use of advanced technology

d) The environmental conditions

d) X-rays

12. Which term describes the bending of light as it enters a denser medium?

a) Reflection

b) Refraction

c) Diffraction

d) Interference

13. What is the smallest unit of light called?

a) Proton

b) Electron

c) Photon

d) Atom

14. Which theory explains light as both a wave and a particle?

a) Electromagnetic theory

b) Quantum mechanics

c) Corpuscular theory

d) Newton’s theory

15. What term is used to describe the spreading of light waves through a narrow opening?

a) Reflection

b) Refraction

c) Diffraction

d) Polarization

16. What phenomenon causes rainbows?

a) Reflection and refraction

b) Diffraction

c) Polarization

d) Interference

17. How do optical fibers transmit information?

    a) By polarizing light

    b) Through total internal reflection

    c) By absorbing light waves

    d) Through wave dispersion

18. What does "laser" stand for?

    a) Light Absorption by Simulated Emission of Radiation

    b) Light Amplification by Stimulated Emission of Radiation

    c) Light Application by Strong Energy Radiation

    d) Light Acceleration by Systematic Emission of Rays

19. Which process uses a laser to cut materials with high precision?

    a) Engraving

    b) Marking

    c) Welding

    d) Laser cutting

20. What is the main advantage of laser engraving?

    a) It requires physical contact with the surface

    b) It is a temporary marking technique

    c) It creates durable, precise designs without damaging the material

    d) It works only on metal surfaces

21. Which type of laser is commonly used for high-precision cutting and marking?

    a) Gas laser

    b) Fiber laser

    c) Fluorescent laser

    d) Solar laser

22. What is a wavelength in laser technology?

    a) The power output of a laser beam

    b) The speed at which the laser moves

c) The distance between two peaks in a wave of light

d) The width of the laser beam

23. What is calibration in laser systems?

a) The process of heating up the laser

b) The adjustment of the laser for accuracy and performance

c) A method of cooling the laser machine

d) The installation of laser safety shields

24. What is one major disadvantage of laser technology?

a) Low precision

b) High initial cost

c) Slow processing speed

d) Requires constant manual operation

25. What is the function of the gain medium in a laser system?

a) It amplifies light by stimulated emission.

d) It reflects the laser beam.

c) It cools down the laser system.

d It absorbs light instead of emitting it.

26. Which type of laser is commonly used for cutting metals in industrial applications?

a) CO_2 laser

b) Excimer laser

c) Ultraviolet laser

d) Dye laser

27. What happens when a laser beam is directed at a metal surface with high energy?

a) The metal absorbs the energy and melts or vaporizes.

b) The metal reflects all the light, preventing any effect.

c) The laser beam passes through without interaction.

d) The metal changes color permanently but does not heat up.

28. What does “wavelength” determine in a laser?

a) The amount of power the laser emits

d) The color and type of laser light

c) The speed at which the laser beam moves

d) The ability of the laser to reflect surfaces

29. What property of laser light ensures that the beam stays narrow over long distances?

a) Divergence

b) Coherence

c) Dispersion

d) Absorption

30. Which laser characteristic is responsible for high precision in industrial applications?

a) Random emission of light

b) Low energy output

c) Directionality and coherence

d) Large beam divergence

31. What is the main function of laser surgery?

a) To generate heat for thermal imaging

b) To precisely cut or remove tissues

c) To capture images of internal organs

32. What is the primary benefit of endoscopy?

a) It uses radiation to scan the body

b) It allows non-invasive internal examination

c) It provides high-energy treatment for cancer

33. What is photodynamic therapy (PDT) used for?

a) Destroying cancer cells using light-sensitive drugs and lasers

b) Generating high-energy X-rays

c) Producing 3D images of organs

34. What type of radiation is used in radiotherapy to treat cancer?

a) Microwaves

b) Gamma rays

c) Ultraviolet rays

35. Which of the following is not a characteristic of a photon?

a) It has no mass

b) It carries electromagnetic energy

c) It moves slower than the speed of light

36. What is the main use of infrared thermography?

a) To measure temperature differences in the body

b) To produce high-resolution 3D images

c) To detect fractures in bones

37. What is the purpose of predictive maintenance in industrial automation?

a) To repair equipment after significant downtime

b) To identify potential faults before they occur

c) To eliminate regular inspections

d) To reduce the efficiency of automated systems

38. How does integration benefit information-measuring systems?

a) By isolating each system component

b) By combining multiple systems for unified operation

c) By minimizing the number of sensors used

d) By enhancing the complexity of processes

39. What is the main advantage of using smart factories in industrial automation?

a) Manual adjustments to production lines

b) Independent operation without external communication

c) Dynamic adaptation to changing production demands

d) Replacement of all measuring devices with basic tools

40. Which of the following best describes feedback in automated systems?

a) Input data generated by external users

b) Information returned to adjust or improve operations

c) Static measurements that remain unchanged

d) Irrelevant data discarded during processing

41. Find the Correct Sentence Translation - *Regular maintenance ensures that measurement instruments continue to provide accurate and reliable data*.

a) Регулярне обслуговування забезпечує точність та надійність вимірювань.

b) Постійні експерименти з приладами гарантують отримання нових даних.

c) Тестування вимірювальних систем завжди дає найточніші результати.

d) Технічне обслуговування приладів не впливає на їх точність.

42. Find the Correct Sentence Translation - *Feedback loops in automation systems allow for real-time adjustments to ensure consistent performance*.

a) Зворотні зв’язки в автоматизованих системах допомагають уникати несправностей.

b) Петлі зворотного зв’язку в автоматизованих системах дозволяють коригувати процеси в реальному часі.

c) Автоматизація забезпечує зворотний зв'язок лише для періодичного коригування.

d) У реальному часі зворотній зв'язок не впливає на автоматизацію.

43. What is the main purpose of real-time monitoring in production systems?

a) To predict changes in weather conditions

b) To observe and assess equipment performance continuously

c) To disconnect machinery from networks

d) To delay system feedback

44. How does optimization contribute to the functionality of production systems?

a) By increasing operational inefficiency

b) By improving workflows and resource usage

c) By introducing unnecessary processes

d) By reducing system functionality

45. What advantage does feedback provide in automated systems?

a) It increases manual intervention

b) It offers data to enhance system performance

c) It eliminates real-time communication

d) It disrupts system functionality

46. Which statement accurately reflects the purpose of innovation in industrial automation?

a) To maintain outdated methods

b) To introduce new ideas for improving systems and processes

c) To remove technological advancements

d) To reduce system accuracy

47. Find the Correct Sentence Translation - *Predictive maintenance improves system reliability by addressing potential faults before they occur.*

a) Передбачуване обслуговування підвищує надійність системи, усуваючи можливі збої завчасно.

b) Оптимізація дозволяє системі працювати без будь-яких збоїв.

c) Моніторинг забезпечує зворотний зв'язок під час несправності.

d) Технічне обслуговування не впливає на роботу пристроїв.

48. Find the Correct Sentence Translation - *Real-time monitoring ensures the immediate detection of any deviations in equipment performance*.

a) Спостереження в реальному часі гарантує швидке виявлення будь-яких відхилень у роботі обладнання.

b) Автоматизація сприяє стабільній роботі системи.

c) Точність вимірювань не залежить від часу.

d) Моніторинг забезпечує лише періодичну перевірку відхилень.

49. Find the Correct Sentence Translation - *Optimization ensures that algorithms perform efficiently and reduce resource consumption.*

a) Оптимізація забезпечує ефективність алгоритмів та знижує використання ресурсів.

b) Розробка алгоритмів ускладнює роботу програмного забезпечення.

c) Впровадження алгоритмів підвищує складність автоматизації.

d) Ефективність систем не залежить від оптимізації.

50. Find the Correct Sentence Translation - *Flash simulations allow developers to test and refine automated workflows visually.*

a) Симуляції у Flash дозволяють розробникам візуально тестувати та вдосконалювати робочі процеси автоматизації.

b) Flash не використовується для роботи з автоматизованими системами.

c) Візуальні симуляції у Flash значно ускладнюють процес автоматизації.

d) Симуляції у Flash використовуються виключно для розваг.

ABBREVIATIONS

BIPM	the International Bureau of Weights and Measures
OIML	The International Organization for Legal Metrology
NIST	National Institute of Standards and Technology
CIPM	the Comité International des Poids et Mesures
SI	The International System of Units
APMP	Asia Pacifc Metrology Program
EURAMET	European Association of National Metrology Institutes
AFRIMETS	Intra-Africa Metrology System
LASER	Light Amplification by Stimulated Emission of Radiation
LMP	Laser Material Processing
MRI	Magnetic Resonance Imaging
OCT	Optical Coherence Tomography
CT	Computed Tomography
PDT	Photodynamic Therapy
CMM	Coordinate Measuring Machine
FAI	First Article Inspection
Gage R&R	Gage Repeatability and Reproducibility
SRS	Spatial Reference System
MATLAB	Matrix Laboratory
AutoCAD	Automatic Computer-Aided Design
LabVIEW	Laboratory Virtual Instrument Engineering Workbench
ARM	Advanced RISC Machine
Intel	Integrated Electronics (name of a well-known microprocessor manufacturer)

RISC	Reduced Instruction Set Computing
IIoT	Industrial Internet of Things
AI	Artificial Intelligence

GLOSSARY OF METROLOGICAL TERMS

A

Accuracy

The closeness of a measured quantity to the actual quantity that was measured, the measurand. Sometimes thought of as a tolerance range on a measurement's value. Often used colloquially as a synonym for uncertainty of measurement.

Alignment

The state or orientation of an object or feature with respect to the act of putting an object or feature into a desired state or orientation. Example alignments include: setting several bearings supporting a shaft in a line (or not quite a line); mounting aircraft sensors in a specific direction with respect to an aircraft's navigation system; bore-sighting weapons mounted on aircraft; best-fitting point cloud data to a set of surfaces.

As-built

Or the As-built condition. Refers to the actual dimensions of a part or assembly as it was manufactured. Also sometimes called "As-found". In reverse engineering, as-built models or drawings do not try to divine design intent. They try to exactly portray a part exactly as it is, including defects.

B

Ball-bar

A precision fixture that can be used as a standard of length. Ball-bars are often built with precision nests to accept Sphere Mounted Reflectors or precision ball bearings to aid in checking or calibrating laser trackers and CMMs.

Boresighting

This term refers to an old method for setting sights on a firearm, in which the bolt or part of the action was removed and a target point was viewed alternately through the bore and through the sights while adjustments were made until the sights pointed at the target point.

The term Boresighting today has been expanded to include determining the primary axis of a directional antenna, and aircraft weapons harmonization. Many techniques now exist including the use bore mounted lasers or laser trackers.

C

Calibration

"Calibration is the operation that, under specified conditions, establishes a relationship between the quantity values with measurement uncertainties provided by measurement standards and corresponding indications with measurement uncertainties." (VIM) Thus, calibration involves measurements and comparisons, not an actual adjustment. For metrology, the formal comparison is of measuring equipment against a standard of higher level (a national standard defined in the U.S. by NIST) under controlled and specified conditions to document the accuracy of the instrument being compared.

CMM

This acronym stands for Coordinate Measuring Machine. These machines measure parts through the acquisition of points.
Many types of CMMs exist, traditional 3 axis contact probing machines, articulated arm CMMs, and laser trackers are a few examples. Laser scanners or "white light" scanners are other examples that don't require contact with the measured part. CMMs are often run with software that can compute features such as planes, cylinders, and lines from the measured points.

D

Datum

In metrology, a datum is simply an idealized reference feature from which another features' orientation, position, or other characteristic is defined. Datums can be many types of features, planes, cylinders, points, centerlines, constructions or offsets from other features, anything that can be measured or established for use in locating other features.

Although the plural form of datum is really data, many people, including the author, uses datums as the plural in this application.

Datum Feature

A datum feature is the measured or contacted feature which establishes a datum. It is an actual point, line or surface on the part being measured.

Dimensional Inspection

The process of characterizing an object's size and shape through measurements of points, lengths, and volumes. Usually such an inspection results in a report comparing the measured object to another object, an idealized object, or a previous state of the object.

Dimensional Metrology

The study or practice of high precision measurements to quantify physical sizes, orientations, and distances of objects and shapes.

Discrimination Threshold

"The largest change in a value of a quantity being measured that causes no detectable change in the corresponding indication. NOTE: Discrimination threshold may depend on, e.g. noise (internal or external) or friction. It can also depend on the value of the quantity being measured and how the change is applied." (VIM)

Dimensional inspection

A method that involves measuring a part's dimensions by way of a 3D laser tracker or scanner. There are several types of dimensional inspection services depending on the type of measurements that a project requires. Services offered by ECM: First Article Inspection, In-Line and In-Process Testing, As-Built Inspection as well as Calibration and Certification of machines, tooling and fixtures.

E

Error

The difference between the measured value and the actual value.

Expanded Uncertainty

A broader uncertainty range obtained by applying a coverage factor.

Extensometer

An instrument used to measure strain in materials.

Extraneous Influence

Any external factor that affects measurement accuracy.

Eutectic Point

The lowest melting temperature of a specific alloy.

F

First Article Inspection (FAI)

As the name implies, first article inspection is usually performed on one or more of the first parts in production. The inspection is usually exhaustive, covering every dimension on the drawing, and provides a final verification of the manufacturing process. After the first article is proved out, subsequent parts are often inspected less exhaustively to save time and money.

Free-Form Shapes

In metrology, this refers to surfaces with unconventional or continuously varying shapes like bones, customized molds, boat hulls, or the sculptures of Henry Moore.

G

Gantry CMM

A gantry CMM has the measurement head mounted on a beam that overhangs and spans the measurement table. The head can move both vertically and side to side along the beam, providing two axes of motion. The third axis can be generated by moving either the towers that support the beam along a fixed table, or moving the measurement table between the towers.

Gage R&R (Gage Repeatability and Reproducibility)

A set of repeated measurements used to determine the fitness of a gage or other measuring

instrument for a specific function. The test tries to account for the effects of equipment, method, and operator in an estimate of precision and uncertainty by having a number of operators use the equipment to measure a reference standard or part.

GD&T

Geometric dimensioning and tolerancing is a system and symbolic language for describing the permissible limits, or tolerances, in a part's physical dimensions and measured values. In the United States the standard describing GD&T is ASME Y14.5. In Europe ISO has a series of standards that cover the same material. The ASME and ISO standards use the same symbols, but interpretations are slightly different in some cases.

I

Influence Quantity

A quantity that, in a direct measurement, does not affect the quantity that is actually measured, but affects the relation between the indication and the measurement result. An example in laser tracker work would be air temperature and humidity.

Instrumental Drift

Drift Change in a measured value, "related neither to a change in the quantity being measured nor to a change of any recognized influence quantity." (VIM)

Instrumental Uncertainty

A component of measurement uncertainty arising from the measuring instrument or measuring system in use, and obtained by its calibration.

L

Laser Scanning

Using laser measurement systems to digitally capture the geometry of a product or part without contact between a probe and the part surface. The laser scanner will measure and record thousands or even millions of data points from a part's surface or a large area. Laser scanning is done on objects ranging in size from several inches to over 100

feet. These points, often called a point cloud, can then be used for comparison to customers' CAD models or to reverse engineer 3D models.

Laser Tracker

One form of portable CMM, a laser tracker can measure large objects or spaces with a relatively high degree of accuracy. The typical laser tracker uses two rotary encoders and a laser ranging system to make measurements at the center of an SMR which is placed on the project or at the point of interest. Measurements are therefore limited by line of sight between tracker and SMR, and the tracker's range. Depending on the tracker and measurement conditions measurements can be made 100 yards or more from the tracker head.

A 3d laser tracker can be used in measuring, aligning and even calibrating automated measurement systems, large and small parts, complex surfaces and even immobile manufacturing machinery.

M

Maximum Permissible Error

There are a few synonyms for this term but all pertain to measurements and limits of error. The "extreme value of measurement error, with respect to a known reference quantity value, permitted by specifications or regulations for a given measurement, measuring instrument, or measuring system.

Measurement Result

Any quantities attributed to a measurand from a measurement together with other relevant information. Environmental conditions or measurement uncertainty are two examples of other relevant information.

Measurement Traceability

Also known as "metrological traceability." This is simply how metrologists connect to the standard by which they measure. That standard in the U.S. is set and defined by NIST. Picture links in a chain. Each link represents a comparison that pertains to an instrument

or tool's measurements to a NIST defined standard or requirement. Because ECM calibrates to a NIST traceable standard, ECM can determine the precision and accuracy of a tool or instrument.

Measurement Uncertainty

An estimate of the uncertainty of a measurement. Usually comprised of instrumental uncertainty, and a number of other factors such as procedural uncertainty, and environmental uncertainty.

Measuring System

A set of one or more measuring instruments and often other devices, including any reagent and supply, assembled and adapted to give information used to generate measured quantity values within specified intervals for quantities of specified kinds.

Metrology

The science of measurement and how measurements are used. Used to measure and verify an objects dimensional quality.

Measurand

Any quantity being measured. The term applies to any type of measurement, mass, force, luminosity, etc. in dimensional metrology, one could also call an object or a feature of an object being measured a measurand and be understood.

Mesh

1. A type of model consisting of small usually triangular planar surface patches that approximate an object's shape. It is much like an STL model. This type of model is often produced from scanned data and may be used as an intermediate step to a Nurbs surface model.

2. Occasionally used to describe Nurbs surfaces because the mathematical model of a surface can be thought of as a series of intersecting curves that lie in the surface.

Micron or Micrometer (µm)

A unit in the metric system equal to one millionth of a meter or approximately 0.00003937

inches. It is commonly used to describe the uncertainty of precision measuring machines.

N

Noise

At ECM, we use "Noise" to refer to incorrect data within a point cloud generated during a laser scanning. Reflections from dust in the air, errant reflections from corners, surface texture, or highly reflective surfaces are sources of noise.

Nominal Dimensions

In dimensional metrology Nominal Dimensions are the dimension values given on a drawing or in a computer model. Measured values are compared to nominal to determine whether a part conforms to its design.

Non-Contact Measurement

This is simply the practices of taking an object's measurements without making physical contact with it. Often called scanning. Non-contact measurements can be used to measure an object with a delicate surface or weak structure that could not otherwise stand up to contact measuring.

Non-Parametric Model

Also known as a "dumb model", this is a 3D CAD model whose shape cannot usually be edited as easily as a parametric model. Commonly available file formats for porting files between CAD programs like IGES or STEP typically produce dumb models.

NURBS

With a full name of Non Uniform Rational B-Spline, this refers to NURBS curves and surfaces. The name comes from the mathematical technique used to model the curve or surface. It is one of the more common ways to model freeform geometry.

O

Outlier

A point which lies outside the expected range of variation for data. In scan data outliers

are usually removed during post-processing of the point cloud using statistical algorithms. Sometimes the scanning instrument and software remove them during the point cloud acquisition. In data generated by CMM or laser trackers, outliers are considered for removal on a case by case basis, because the data is often too sparse for statistical methods and because the operator can usually tell by visual observation or confirming measurements if an outlier accurately represents the part or was acquired incorrectly, perhaps by probing debris on the surface instead of the surface itself.

P

Parametric Model

A parametric model is a CAD model that, can be edited and changes will propagate through the model automatically preserving the relationships between features. Typically these models can only be edited in the CAD program that created them.

Photogrammetry

Non-contact imagery that takes 3D coordinate measurements (XYZ) through photographs.

Point Cloud

A type of data consisting of many points in 3D space. The number of points may run from hundreds or thousands in the case of a CMM or laser tracker, to hundreds of millions, or even more points in the case of a laser scanner. Point cloud data can be compared to a CAD model or used to reverse engineer an object.

Polygonal Modeling

A CAD model using small planar surfaces to approximate the shape of a surface. The surfaces are usually triangular and the model is quite similar to an STL model.

Precision

How close one measurement result will be to another result or set of results. Precision should not be mistaken for accuracy. A precise instrument could give a consistently

erroneous result. The term precision is often used as a synonym for an instrument's repeatability.

Probe

A device attached to a CMM that is used in taking measurements. Typical CMMs have contact probes (called touch probes) but a probe can be non-contact like a portable CMM laser scanner.

R

Reference Model

Typically a CAD model, but occasionally a physical master, against which data on a measured part is compared.

Repeatability

A measurement system's precision under a set of measurement conditions, the repeatability condition.

Reproducibility

Measurement precision under the Reproducibility Condition of Measurement.

Repeatability Condition

In contrast to the Repeatability Condition of Measurement, the Reproducibility Condition specifies different measuring systems, locations, operators, and environmental conditions for measurement.

Resolution

1. (of a measuring instrument or system) Smallest change in a quantity being measured that causes a perceptible change in the corresponding indication. Resolution can be affected by internal or external factors like noise, friction, or temperature. The value of the measurand may also affect resolution. Not to be confused with definition 2. 2. (of a displaying device) Smallest difference between indications that can be meaningfully distinguished or the number of digits in a digital display.

Reverse Engineering

This process involves producing a drawing or 3D digital representation of a pre-existing, tangible object usually via CAD, CAE or CAM type software. At ECM, the object is measured with a 3D laser scanner, the generated point cloud data is transferred into a NURBS surface or triangular mesh or a number of other options. From this point, the 3D digital CAD model is reconstructed to look like the original object that was laser scanned.

S

Scan Density

Laser scan density refers to the proximity between 3D coordinates in a given data point cloud.

Scan Speed

This refers to a laser scanner's speed regarding the collection of 3D coordinates. The speed is measured in points per second or even millions of points per second.

Spatial Reference System (SRS)

This is another name for a coordinate reference systems (CRS) that captures geo-location entities. This would be considered a civil engineering term or a term used in the utility field more so than in dimensional metrology.

T

Temperature Compensation

This is something to consider when using a CMM. If using a CMM in less than ideal weather or within extreme temperatures, the CMM will swell or contract. To prevent in accuracy, this behavior needs to be considered when taking a 3D measurement unless the measurement system was built to prevent this and is highly accurate.

Tooling Ball

A close tolerance sphere, usually on a precision shouldered shank used in aligning or locating parts or assemblies.

U

Uncertainty

See Measurement Uncertainty.

V

Validation

Demonstration by test or analysis that an instrument, system, or procedure is fit for a certain task.

Verification

The proof, by means of objective evidence, that an item meets its specification requirements. In dimensional inspection the object's dimensions would be measured and compared to the drawing or CAD model of the object.

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Навчальний посібник з англійської мови для студентів інженерно-технічних спеціальностей вищих навчальних закладів

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