Чичура І.І.

«Англійська мова професійного спрямування»

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Методичні вказівки до виконання лабораторних робіт з курсу „ Англійська мова професійного спрямування ”

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Відповідальний за випуск: доктор фіз.-мат. наук, зав. кафедрою приладобудування, проф. Іваницький В.П.

Рецензенти: канд. фіз.-мат. наук, доцент Цигика В.В.

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ЗМІСТ

ВСТУП

Дані методичні вказівки щодо виконання лабораторних занять з навчальної дисципліни «Англійська мова професійного спрямування» призначені для студентів денної форми навчання зі спеціальності 151 – «Автоматизація та комп'ютерно-інтегровані технології» за освітньо-професійною програмою «Автоматизація та комп'ютерно-інтегровані технології» рівня вищої освіти «Магістр». Мета вказівок – надати студентам допомогу у формуванні іншомовної комунікативної компетентності у сфері професійного спілкування, що обумовлюється метою викладання навчальної дисципліни «Англійська мова професійного спрямування» й основними завданнями вивчення цієї дисципліни, а саме: формування лексичного запасу з окреслених тематичними модулями тем; розвиток уміння висловлювати свою думку як усно, так і в письмовій формі; вести бесіду з професійних тем; презентувати результати своїх розробок; вільно

читати, розуміти й обговорювати тексти з визначеної тематики.

Вправи та завдання спрямовані на активізацію лексичного та граматичного матеріалу, розширення словникового запасу за тематикою змістових модулів.

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1 ПЕРЕЛІК ПРАКТИЧНИХ ЗАНЯТЬ

Практичні заняття № 1–3

Тема 1 Electronics Basics. Ing-form as a noun, after prepositions

Мета: ознайомити студентів з лексикою та теоретичними відомостями, закріпити знання студентів із зазначеної теми.

Короткі теоретичні відомості

Ing-form as a noun, after prepositions

We can use the **-ing form** of the verb as a noun. It can be the subject, object, or complement of a sentence. For example:

1. Managing the computer's resources is an important function of the operating system.

2. The operating system starts running the user interface as soon as the PC is switched on.

3. Another function of the operating system is executing and providing services for applications software.

The **-ing form** is also used after prepositions.

This includes **to** when it is a preposition and not part of the infinitive. For example:

4. Without the user being aware of the details, the operating system manages the computer's resources.

5. We begin by focusing on the interaction between a user and a PC operating system.

6. We look forward to having cheaper and faster computers.

Завдання до теми

1. **Read the text and name the basic components of electronic circuit.**

An electronic circuit is composed of various types of components. Some of these components are termed as active components because they take part in the transformation of the energy while other components, which only dissipate or store energy, are called as passive elements. The vacuum tubes, rectifier, transistors are some of-the common active while the resistances, which dissipate the power and energy storing elements such as capacitances and inductances are known as passive elements. The transformers may be regarded as a matching device. The success of any electronic circuit depends not only on proper selection of the active elements but on the passive and matching elements too. The proper function, of an active device is decided by the proper values of these passive elements. Hence the selection of these elements such as resistances, inductances, capacitance, and transformers not only require the proper attention, but also decide the proper function of the active devices as well as the circuit as a whole. Here we shall discuss about some important electronic components and their characteristics, particularly used in Biomedical instruments.

ELECTRONIC COMPONENTS: These can be classified into

Passive Components : Components like resistance, capacitance inductance, and fall in this class.

Active Components : They can be further classified as Semiconductor Devices : Semiconductor diode, zener diode, and varactor diode etc. Uni-junction transistor, Bipolar junction transistor (BJT), FET, silicon, Controlled rectifier etc. Vacuum Tube Devices : Vacuum tube diode, triode, Tetrode, Pentode, Hexode, Heptode etc. Gas Tube Devices : Gas diodes, Thyratons etc. Photo Sensitivity Devices : Gas photodiodes, photo multiplier tubes, photodiodes, light emitting diode, photosensitive transistor etc. Though there are devices, which are specific to particular frequency range and applications like microwave devices etc.

PASSIVE DEVICES:

RESISTANCES: Resistors can be made to control the flow of current, to work as Voltage dividers, to dissipate power and it can shape electrical waves when used in combination of other components. Basic unit is ohms, (Ω) .

RESISTIVE ELEMENTS: Metal alloys, carbon and graphite used with binders etc. are the, usual resistive materials. The alloys used as resistance wire usually have higher specific resistances than the base metals and have lower temperature coefficient of resistance. The three most common types of resistance wire used are nickel-copper, nickel. Chromium-aluminum and nickel-chromium. Carbon and graphite are used as the basic resistance materials when they are mixed and heated with proper variety of resin binders. These types of resistances are generally known as composition carbon type's resistors. The resistive element may be either in the form of a film or a solid slug, which consists of a number of conducting particles held together by resin. In the film type the base materials may be glass, ceramic and plastics. Resistors can be (i) fixed resistors with two ends, (ii) variable resistor or potentiometers. Resistors are specified by the value of resistance, in ohms maximum power dissipation in watts, and precision in %. Types: Resistors can be designed in many ways by usage, shape, physical construction tolerances, resistances are of the following three types i.e.

VARIABLE RESISTORS: The fixed resistances are those whose values cannot be changed. In case of semi variable types of resistances their values can be changed with help of a screwdriver. Semi variable types resistances are known as preset. In case of the variable resistances their values can be changed from zero to maximum with the help of a movable arm. Types include : Metal oxide, non inductive, carbon composition, carbon film, metal film, deposited film, ceramic, chip fixed, variable, trimmer, carmet, miniature, PC Board SPST combination, wire wound fixed and variable units, dual potentiometers, power resistors, precision, conductive plastic, hybrid and surface mount.

Resistances in series $R = R1 + R2 + R$

Resistances in parallel $1/R = 1/R1 + 1/R2 + 1/R3 +$ - Voltage drop $V = I.R$ I is current,

Power dissipation $P = I^2 .R = V^2 /R$

RHEOSTATE : A wire wound pot that can dissipate 5 and more watts is often referred to as a rheostat. The resistance wire is wound on an open ring of ceramic which is covered with vitreous enable, except for the track of the wiper arm. Rheostats are used to control motor speeds, x-ray tube voltages, ovens and many other high power applications.

THERMISTORS: A Thermistor is non-linear resistance made of semiconductor material that is extremely sensitive to change in temperature. For a small change in body temperature of a Thermistor, there is an appreciable change in its resistance, where as most conductors have a positive temperature coefficient, the thermistor can exhibits a positive or negative temperature coefficient, (NTC). The thermistor is mostly negative temperature coefficient resistances. The resistances of thermistor decreases rapidly for increased temperature. The thermistor are used in wide variety of applications. They can be used in measurement and control of temperatures, time delay, temperature compensation and liquid level indicators. The thermistor is available in the form of a disk, bead, or bolted assembly packages.

VARISTORS These are voltage dependent resistances. They also fall under the category of nonlinear resistors. According to the Ohm's Law the current is directly proportional to the impressed voltage but in case of varistors the current is proportional to the nth power of the impressed voltage i.e. I α Vn where I is the current in Amperes and V is the impressed voltage on the Varistors.

Application of the Varistor include voltage surge and protective circuits and the generation of non-sinusoidal waveform. The varrstors are made out of silicon carbide and is available in:the form of disk, rod or washers.They can withstand and d.c.voltage upto 10 kV or so. .

CAPACITORS:

It stores the charge across its two plates. Capacitor opposes the change of voltage across its plates; the electric field developed across the plate opposes the rapid change in voltages. It produces phase difference between voltage applied to it and the current, which passes through it. The current leads the voltage by 90o in the ideal capacitance with infinite resistance across the plates.

Design of capacitor is connected with relation of the proper electric material for particular type of application. The dielectric material used for capacitors may be grouped in the various classes.

The value of capacitor never remains constant except under certain fixed conditions. It changes with temperature, frequency and ageing. The capacitance value marked on the capacitor strictly applies only at specified room temperature and at low frequencies. The behavior of capacitor at various frequencies may be grouped into the following seven classes. Mica, glass, air, and low loss ceramic capacitors are used from few kHz to few hundreds MHz.

TRANSFORMERS :

The transformers used in electronic circuits may be classified into three classes depending on their application. Power transformers used with power supplies.

Audio transformers cover the input and output transformers and isolation transformers.

Pulse transformers used in various types of pulse circuits.

INDUCTORS: Like capacitors, inductors also store energy in one part of AC cycle and return it during the next part of the cycle.

Контрольні питання

1. What is resistance?
2. What is power dissipation?
3. What are differencies between a varistor and varactor?

Література: [2, с. 53–70; 3, с. 47–85].

Практичні заняття № 4–6

Тема 2 Diodes. Basic Types and Characteristics. Countable and Uncountable Nouns

Мета: ознайомити студентів з лексикою та теоретичними відомостями, закріпити знання студентів із зазначеної теми.

Короткі теоретичні відомості

Countable and uncountable nouns

Countable nouns are people or things that we can count. They have a singular and a plural form (e.g. file, program, system, application).

An icon is a small graphic. The icons on the toolbar are used to...

Uncountable nouns are things that we can't count. They have no plural form (e.g. software, music, robotics, multimedia, networking, storage).

A lot of software these days is open-source. Not: A lot of softwares these days *are open-source.*

Some words are countable in many languages but uncountable in English, and are used with a singular verb (e.g. advice, damage, equipment, furniture, research, news, progress, homework).

The advice he gave me was very useful.

Countable nouns must have a determiner (a, the, my, this, etc.) in the singular, although this is not necessary in the plural.

I deleted the file yesterday.

I lost more than 300 files when my computer crashed.

We use a before a consonant sound and an before a vowel. The definite article the means you know which one/ones I mean.

We don't use a/an with uncountable nouns.

Not: a robotics

We don't use the in generalizations with uncountable nouns or plural countable nouns.

I like music. Not: I like the music. Computer programs are expensive. Not: The computer programs are expensive.

Countable and uncountable nouns take different determiners.

Many, few, a few only go with countable nouns.

There are many versions of Windows Vista.

Much, little, a little, a great deal of only go with uncountable nouns.

I have a little time free this afternoon if you want to meet.

Завдання до теми

1. Read about diode and its characteristics. Learn new words and phrases.

Ideal Diodes

The key function of an ideal diode is to control the *direction* of current-flow. Current passing through a diode can only go in one direction, called the forward direction. Current trying to flow the reverse direction is blocked. They're like the one-way valve of electronics.

If the voltage across a diode is negative, no current can flow*, and the ideal diode looks like an open circuit. In such a situation, the diode is said to be *off* or reverse biased.

As long as the voltage across the diode isn't negative, it'll «turn on» and conduct current. Ideally* a diode would act like a short circuit (0V across it) if it was conducting current. When a diode is conducting current it's **forward biased** (electronics jargon for «on»).

The current-voltage relationship of an ideal diode. Any negative voltage produces zero current – an open circuit. As long as the voltage is non-negative the diode looks like a short circuit.

Circuit Symbol

Every diode has **two terminals** – connections on each end of the component – and those terminals are **polarized**, meaning the two terminals are distinctly different. It's important not to mix the connections on a diode up. The positive end of a diode is called the **anode**, and the negative end is called the **cathode**. Current can flow from the anode end to the cathode, but not the other direction. If you forget which way current flows through a diode, try to remember the mnemonic *ACID*: «anode current in diode» (also *anode cathode is diode*).

The **circuit symbol** of a standard diode is a triangle butting up against a line. There is a variety of diode types, but usually their circuit symbol will look something like this:

The terminal entering the flat edge of the triangle represents the anode. Current flows in the direction that the triangle/arrow is pointing, but it can't go the other way.

Above are a couple simple diode circuit examples. On the left, diode D1 is forward biased and allowing current to flow through the circuit. In essence it looks like a short circuit. On the right, diode D2 is reverse biased. Current cannot flow through the circuit, and it essentially looks like an open circuit.

Real Diode Characteristics

Ideally, diodes will block any and all current flowing the reverse direction, or just act like a short-circuit if current flow is forward. Unfortunately, actual diode behavior isn't quite ideal. Diodes do consume some amount of power when conducting forward current, and they won't block out all reverse current. Real-world diodes are a bit more complicated, and they all have unique characteristics which define how they actually operate.

Current-Voltage Relationship

The most important diode characteristic is its current-voltage (*i-v*) relationship. This defines what the current running through a component is, given what voltage is measured across it. Resistors, for example, have a simple, linear *i-v* relationship…Ohm's Law. The *i-v* curve of a diode, though, is entirely *non*-linear.

The current-voltage relationship of a diode.

Depending on the voltage applied across it, a diode will operate in one of three regions:

1. **Forward bias**: When the voltage across the diode is positive the diode is «on» and current can run through. The voltage should be greater than the forward voltage (V_F) in order for the current to be anything significant.
2. **Reverse bias**: This is the «off» mode of the diode, where the voltage is less than V_F but greater than $-V_{BR}$. In this mode current flow is (mostly) blocked, and the diode is off. A *very* small amount of current (on the order of nA) – called reverse saturation current – is able to flow in reverse through the diode.
3. **Breakdown**: When the voltage applied across the diode is very large and negative, lots of current will be able to flow in the reverse direction, from cathode to anode.

Forward Voltage

In order to «turn on» and conduct current in the forward direction, a diode requires a certain amount of positive voltage to be applied across it. The typical voltage required to turn the diode on is called the *forward voltage* (V_F). It might also be called either the *cut-in voltage* or *on-voltage*.

As we know from the *i-v* curve, the current through and voltage across a diode are interdependent. More current means more voltage, less voltage means less current. Once the voltage gets to about the forward voltage rating, though, large increases in current should still only mean a very small increase in voltage. If a diode is fully conducting, it can usually be assumed that the voltage across it is the forward voltage rating.

A specific diode's V_F depends on what semiconductor material it's made out of. Typically, a silicon diode will have a $V_F$around **0.6-1V**. A germanium-based diode might be lower, around 0.3V. The *type* of diode also has some importance in defining the forward voltage drop; light-emitting diodes can have a much larger V_F, while Schottky diodes are designed specifically to have a much lower-than-usual forward voltage.

Breakdown Voltage

If a large enough negative voltage is applied to the diode, it will give in and allow current to flow in the reverse direction. This large negative voltage is called the **breakdown voltage**. Some diodes are actually designed to operate in the breakdown region, but for most normal diodes it's not very healthy for them to be subjected to large negative voltages. For normal diodes this breakdown voltage is around -50V to -100V, or even more negative.

Diode Datasheets

All of the above characteristics should be detailed in the datasheet for every diode. For example, this datasheet for a 1N4148 diode lists the maximum forward voltage (1V) and the breakdown voltage (100V) (among a lot of other information):
A datasheet might even present you with a very familiar looking current-voltage graph, to further detail how the diode behaves. This graph from the diode's datasheet enlarges the curvy, forward-region part of the *i-v* curve.

That chart points out another important diode characteristic – the maximum forward current. Just like any component, diodes can only dissipate so much power before they blow. All diodes should list maximum current, reverse voltage, and power dissipation. If a diode is subject to more voltage or current than it can handle, expect it to heat up (or worse; melt, smoke,…).

Some diodes are well-suited to high currents – 1A or more – others like the 1N4148 small-signal diode shown above may only be suited for around 200mA.

That 1N4148 is just a tiny sampling of all the different kinds of diodes there are out there. Next we'll explore what an amazing variety of diodes there are and what purpose each type serves.

Контрольні питання

1. What is a diode?
2. Which are its main characteristics?
3. Which types of diode do you know?

Література: [2, с. 71–101; 3, с. 86–132].

Практичні заняття № 7–9

Тема 3 Transistors. Types and Basic Characteristics. The Passive

Мета: ознайомити студентів з лексикою та теоретичними відомостями, закріпити знання студентів із зазначеної теми.

Короткі теоретичні відомості

The Passive

An **active** sentence like **I drank two cups of coffee** has the subject first (the person or thing that does the verb), followed by the verb, and finally the object (the person or thing that the action happens to). So, in this example, the subject is 'I', the verb is 'drank' and the object is 'two cups of coffee'.

But, we don't always need to make sentences this way. We might want to put the object first, or perhaps we don't want to say who did something. This can happen for lots of reasons (see the explanation further down the page). In this case, we can use a passive, which puts the object first: Two cups of coffee were drunk (we can add 'by me' if we want, but it isn't necessary).

How to make the Passive in English

We make the passive by putting the verb 'to be' into whatever tense we need and then adding the ***past participle***. For regular verbs, we make the past participle by adding 'ed' to the infinitive. So **play** becomes **played**.

Tense	**Active**	**Passive**
present simple	I **make** a cake.	A cake **is made** (by me).
present continuous	I **am making** a cake.	A cake **is being made** (by me).
past simple	I **made** a cake.	A cake **was made** (by me).
past continuous	I **was making** a cake.	A cake **was being made**(by me).

present perfect	I **have made** a cake.	A cake **has been made** (by me).
pres. perf. continuous	I **have been making** a cake.	A cake **has been being made** (by me).
past perfect	I **had made** a cake.	A cake **had been made**(by me).
future simple	I **will make** a cake.	A cake **will be made** (by me).
future perfect	I **will have made**a cake.	A cake **will have been made** (by me).

Verbs with two objects

Some verbs that have two objects can make two different active sentences, and so two different passive sentences too:

Active: *He gave me the book / He gave the book to me.*

You can choose either of the two objects to be the subject of the passive sentence.

Passive: *I was given the book (by him)/ The book was given to me (by him).*

Other verbs like this are: ask, offer, teach, tell, lend, promise, sell, throw.

When should we use the Passive?

1. When we want to change the focus of the sentence:

The Mona Lisa was painted by Leonardo Da Vinci. (We are more interested in the painting than the artist in this sentence)

2. When who or what causes the action is unknown or unimportant or obvious or 'people in general':

He was arrested (obvious agent, the police).

My bike has been stolen (unknown agent).

The road is being repaired (unimportant agent).

The form can be obtained from the post office (people in general).

3. In factual or scientific writing:

The chemical is placed in a test tube and the data entered into the computer.

4. In formal writing instead of using someone/ people/ they (these can be used in speaking or informal writing):

The brochure will be finished next month.

5. In order to put the new information at the end of the sentence to improve style:

Three books are used regularly in the class. The books were written by Dr. Bell. ('Dr. Bell wrote the books' sound clumsy)

6. When the subject is very long:

I was surprised by how well the students did in the test. (More natural than: 'how well the students did in the test surprised me')

Завдання до теми

1. Read about transistors and learn new words and phrases.

Transistors make our electronics world go ‘round. They’re critical as a control source in just about every modern circuit. Sometimes you see them, but more-often-than-not they’re hidden deep within the die of an integrated circuit. In this tutorial we’ll introduce you to the basics of the most common transistor around: the bi-polar junction transistor (BJT).

In small, discrete quantities, transistors can be used to create simple electronic switches, digital logic, and signal amplifying circuits. In quantities of thousands, millions, and even billions, transistors are interconnected and embedded into tiny chips to create computer memories, microprocessors, and other complex ICs.

There are two types of basic transistor out there: bi-polar junction (BJT) and metal-oxide field-effect (MOSFET). In this tutorial we’ll **focus on the BJT**, because it’s slightly easier to understand. Digging even deeper into transistor types, there are actually two versions of the BJT: **NPN** and **PNP**. We’ll turn our focus even sharper by limiting our early discussion to the NPN. By narrowing our focus down – getting a solid understanding of the NPN – it’ll be easier to understand the PNP (or MOSFETS, even) by comparing how it differs from the NPN.

Symbols, Pins, and Construction

Transistors are fundamentally three-terminal devices. On a bi-polar junction transistor (BJT), those pins are labeled**collector** (C), **base** (B), and **emitter** (E). The circuit symbols for both the NPN and PNP BJT are below:

The only difference between an NPN and PNP is the direction of the arrow on the emitter. The arrow on an NPN points out, and on the PNP it points in. A useful mnemonic for remembering which is which is: NPN: **N**ot **P**ointing i**N** Backwards logic, but it works!

Transistor Construction

Transistors rely on semiconductors to work their magic. A semiconductor is a material that's not quite a pure conductor (like copper wire) but also not an insulator (like air). The conductivity of a semiconductor – how easily it allows electrons to flow – depends on variables like temperature or the presence of more or less electrons. Let's look briefly under the hood of a transistor. Don't worry, we won't dig too deeply into quantum physics.

A Transistor as Two Diodes

Transistors are kind of like an extension of another semiconductor component: diodes. In a way transistors are just two diodes with their cathodes (or anodes) tied together:

The diode connecting base to emitter is the important one here; it matches the direction of the arrow on the schematic symbol, and shows you **which way current is intended to flow** through the transistor.

The diode representation is a good place to start, but it's far from accurate. Don't base your understanding of a transistor's operation on that model (and definitely don't try to replicate it on a breadboard, it won't work). There's a whole lot of weird quantum physics level stuff controlling the interactions between the three terminals.

Transistor Structure and Operation

Transistors are built by stacking three different layers of semiconductor material together. Some of those layers have extra electrons added to them (a process called «doping»), and others have electrons removed (doped with «holes» – the absence of electrons). A semiconductor material with *extra* electrons is called an **n-type** (*n* for negative because electrons have a negative charge) and a material with electrons removed is called a **p-type** (for positive). Transistors are created by either stacking an *n* on top of a *p* on top of an *n*, or *p* over *n* over *p*.

Simplified diagram of the structure of an NPN. Notice the origin of any acronyms?

With some hand waving, we can say **electrons can easily flow from *n* regions to *p* regions**, as long as they have a little force (voltage) to push them. But flowing from a *p* region to an *n* region is really hard (requires a *lot* of voltage). But the special thing about a transistor – the part that makes our two-diode model obsolete – is the fact that **electrons*can* easily flow from the p-type base to the n-type collector as long as the base-emitter junction is forward biased** (meaning the base is at a higher voltage than the emitter).

The NPN transistor is designed to pass electrons from the emitter to the collector (so conventional current flows from collector to emitter). The emitter «emits» electrons into the base, which controls the number of electrons the emitter emits. Most of the electrons emitted are «collected» by the collector, which sends them along to the next part of the circuit.

A PNP works in a same but opposite fashion. The base still controls current flow, but that current flows in the opposite direction – from emitter to collector. Instead of electrons, the emitter emits «holes» (a conceptual absence of electrons) which are collected by the collector.

The transistor is kind of like an **electron valve**. The base pin is like a handle you might adjust to allow more or less electrons to flow from emitter to collector. Let's investigate this analogy further…

Operation Modes

Unlike resistors, which enforce a linear relationship between voltage and current, transistors are non-linear devices. They have four distinct modes of operation, which describe the current flowing through them. (When we talk about current flow through a transistor, we usually mean **current flowing from collector to emitter of an NPN**.)

The four transistor operation modes are:

Saturation – The transistor acts like a **short circuit**. Current freely flows from collector to emitter.

Cut-off – The transistor acts like an **open circuit**. No current flows from collector to emitter.

Active – The current from collector to emitter is **proportional** to the current flowing into the base.

Reverse-Active – Like active mode, the current is proportional to the base current, but it flows in reverse. Current flows from emitter to collector (not, exactly, the purpose transistors were designed for).

To determine which mode a transistor is in, we need to look at the voltages on each of the three pins, and how they relate to each other. The voltages from base to emitter (V_{BE}), and the from base to collector (V_{BC}) set the transistor's mode:

The simplified quadrant graph above shows how positive and negative voltages at those terminals affect the mode. In reality it's a bit more complicated than that.

Let's look at all four transistor modes individually; we'll investigate how to put the device into that mode, and what effect it has on current flow.

Note: The majority of this page focuses on **NPN transistors**. To understand how a PNP transistor works, simply flip the polarity or > and < signs.

Saturation Mode

Saturation is the **on mode** of a transistor. A transistor in saturation mode acts like a short circuit between collector and emitter.

In saturation mode both of the «diodes» in the transistor are forward biased. That means V_{BE} must be greater than 0,*and* so must V_{BC}. In other words, V_B must be higher than both V_E and V_C.

$$V_B > V_C$$
$$V_B > V_E$$

Because the junction from base to emitter looks just like a diode, in reality, V_{BE} must be greater than a **threshold voltage** to enter saturation. There are many abbreviations for this voltage drop – V_{th}, V_γ, and V_d are a few – and the actual value varies between transistors (and even further by temperature). For a lot of transistors (at room temperature) we can estimate this drop to be about 0.6V.

Another reality bummer: there won't be perfect conduction between emitter and collector. A small voltage drop will form between those nodes. Transistor datasheets will define this voltage as **CE saturation voltage $V_{CE(sat)}$** – a voltage from collector to emitter required for saturation. This value is usually around 0.05-0.2V. This value means that V_C must be slightly greater than V_E (but both still less than V_B) to get the transistor in saturation mode.

Cutoff Mode

Cutoff mode is the opposite of saturation. A transistor in cutoff mode is **off** – there is no collector current, and therefore no emitter current. It almost looks like an open circuit.

To get a transistor into cutoff mode, the base voltage must be less than both the emitter and collector voltages. V_{BC} and V_{BE} must both be negative.

$$V_C > V_B$$
$$V_E > V_B$$

In reality, V_{BE} can be anywhere between 0V and V_{th} (~0.6V) to achieve cutoff mode.

Active Mode

To operate in active mode, a transistor's V_{BE} must be greater than zero and V_{BC} must be negative. Thus, the base voltage must be less than the collector, but greater than the emitter. That also means the collector must be greater than the emitter.

$V_C > V_B > V_E$ In reality, we need a non-zero **forward voltage drop** (abbreviated either V_{th}, V_γ, or V_d) from base to emitter (V_{BE}) to «turn on» the transistor. Usually this voltage is usually around 0.6V.

Amplifying in Active Mode

Active mode is the most powerful mode of the transistor because it turns the device into an **amplifier**. Current going into the base pin amplifies current going into the collector and out the emitter.

Our shorthand notation for the **gain** (amplification factor) of a transistor is β (you may also see it as β_F, or h_{FE}). β linearly relates the collector current (I_C) to the base current (I_B):

$$I_C = \beta I_B$$

The actual value of β varies by transistor. It's usually **around 100**, but can range from 50 to 200…even 2000, depending on which transistor you're using and how much current is running through it. If your transistor had a β of 100, for example, that'd mean an input current of 1mA into the base could produce 100mA current through the collector.

Active mode model. $V_{BE} = V_{th}$, *and* $I_C = \beta I_B$.

What about the emitter current, I_E? In active mode, the collector and base currents go *into* the device, and the $I_E$comes out. To relate the emitter current to collector current, we have another constant value: **α**. α is the common-base current gain, it relates those currents as such:

$$I_C = \alpha I_E$$

α is usually *very* close to, but less than, 1. That means ***I_C* is very close to, but less than *I_E*** in active mode.

You can use β to calculate α, or vice-versa:

$$\beta = \frac{\alpha}{(1-\alpha)}$$
$$\alpha = \frac{\beta}{\beta+1}$$

If β is 100, for example, that means α is 0.99. So, if I_C is 100mA, for example, then I_E is 101mA.

Reverse Active

Just as saturation is the opposite of cutoff, reverse active mode is the opposite of active mode. A transistor in reverse active mode conducts, even amplifies, but current flows in the opposite direction, from emitter to collector. The downside to reverse active mode is the β (β_R in this case) is *much* smaller.

To put a transistor in reverse active mode, the emitter voltage must be greater than the base, which must be greater than the collector ($V_{BE}<0$ and $V_{BC}>0$).

Reverse active mode isn't usually a state in which you want to drive a transistor. It's good to know it's there, but it's rarely designed into an application.

Relating to the PNP

After everything we've talked about on this page, we've still only covered half of the BJT spectrum. What about PNP transistors? PNP's work a lot like the NPN's – they have the same four modes – but everything is turned around. To find out which mode a PNP transistor is in, reverse all of the < and > signs.

For example, to put a PNP into saturation V_C and V_E must be higher than V_B. You pull the base low to turn the PNP on, and make it higher than the collector and emitter to turn it off. And, to put a PNP into active mode, V_E must be at a higher voltage than V_B, which must be higher than V_C.

Another opposing characteristic of the NPNs and PNPs is the direction of current flow. In active and saturation modes,**current in a PNP flows from emitter to collector**. This means the emitter must generally be at a higher voltage than the collector.

Контрольні питання

1. Which types of transistors do you know?
2. Which are their basic characteristics?

Література: [2, с. 102–175; 3, с. 87–187].

Практичні заняття № 10–12

Тема 4 BJTs. Basic Characteristics and Application. Relative Clauses with a Participle.

Мета: ознайомити студентів з лексикою та теоретичними відомостями, закріпити знання студентів з зазначеної теми.

Короткі теоретичні відомості

Relative clauses with a participle

Relative clauses with a participle are often used in technical descriptions. They allow you to provide a lot of information about a noun using as few words as possible.

Study these examples.

1 Computers equipped with wireless NICs.

2 A network printer connected to a wireless print server.

3 A modem providing access to the Internet.

4 A fixed LAN linking computers with cables.

We can use the passive participle as in examples 1 and 2.

Computers equipped with wireless NICs. = computers which are equipped.

A network printer connected to a wireless print server. = a network printer which is connected.

We can use an active participle as in examples 3 and 4.

A modem providing access to the Internet. = modem which provides access to the Internet.

A fixed LAN linking computers with cables. = A fixed LAN which links computers with cables.

Завдання до теми

1. Read the information on basic characteristics of BJTs and discuss their applications.

If we now join together two individual signal diodes back-to-back, this will give us two PN-junctions connected together in series that share a common P or N terminal. The fusion of these two diodes produces a three layer, two junction, three terminal device forming the basis of a **Bipolar Junction Transistor**, or **BJT** for short.

Transistors are three terminal active devices made from different semiconductor materials that can act as either an insulator or a conductor by the application of a small signal voltage. The transistor's ability to change between these two states enables it to have two basic functions: «switching» (digital electronics) or «amplification» (analogue electronics). Then bipolar transistors have the ability to operate within three different regions:

Active Region – the transistor operates as an amplifier and Ic = β.Ib

Saturation – the transistor is «Fully-ON» operating as a switch andIc = I(saturation)

Cut-off – the transistor is «Fully-OFF» operating as a switch and Ic = 0

A Typical Bipolar Transistor

The word Transistor is an acronym, and is a combination of the words Transfer Varistor used to describe their mode of operation way back in their early days of development. There are two basic types of bipolar transistor construction,PNP and NPN, which basically describes the physical arrangement of the P-type and N-type semiconductor materials from which they are made.

The **Bipolar Transistor** basic construction consists of two PN-junctions producing three connecting terminals with each terminal being given a name to identify it from the other two. These three terminals are known and labelled as the Emitter (E), the Base (B) and the Collector (C) respectively.

Bipolar Transistors are current regulating devices that control the amount of current flowing through them in proportion to the amount of biasing voltage applied to their base terminal acting like a current-controlled switch. The principle of operation of the two transistor types PNP and NPN, is exactly the same the only difference being in their biasing and the polarity of the power supply for each type.

Related Products: Darlington BJT | Digital BJT | GP BJT | RF BJT

A Darlington bipolar junction transistor (BJT) contains two BJT devices in a special configuration named after its inventor, Sidney Darlington. The two devices are connected in such a way that their gains are multiplied, creating a component with an effective gain much higher than could be achieved with a single device. A Darlington BJT can be created with two discrete transistors, but is available as a single component with two BJTs in a package. They are commonly used in circuits such as operational amplifiers where a very high gain is desired.

A digital bipolar junction transistor (BJT) is very similar to a general purpose BJT, except that it is intended for use specifically as a voltage or current controlled switch. Often, a digital BJT has biasing resistors built into the package for easy integration into a circuit providing a reduced component count. Digital BJTs are available as single NPN, PNP, or in combo packages with two or more devices in various configurations. Although metal oxide silicon field effect transistors (MOSFETs) are more commonly used in digital applications, a digital BJT may be preferred in some specialty circuits. For example, an application that is very sensitive to switching noise may be better suited to a digital BJT, which has an inherently slower switching rate.

A general purpose bipolar junction transistor (GP BJT) is a very versatile device that can be used as a current or voltage-controlled switch and also as an amplifier. It can be used to design a host of different types of circuits such as filters, receivers, transmitters, operational amplifiers, power supplies, and control circuits to name a few. A BJT is a three terminal device (base, emitter and collector) and is available in one of two complementary forms (NPN and PNP). When the terminal voltages are biased in the correct polarity, a current flows between the collector and emitter that are proportional to the current that is present between the base and emitter terminal. The ratio of the collector to the base current is called the gain or beta of the transistor.

The behavior of NPN and PNP types are almost identical, except that the bias voltages and controlling currents have opposite polarities. When selecting a BJT, many characteristics should be considered including absolute maximum ratings, thermal characteristics, and DC and AC electrical characteristics.

The RF BJT is a bipolar junction transistor that is designed to operate efficiently at higher RF frequencies in the 100s of MHz into the GHz range. A standard BJT would have unwanted losses in power transfer and may have bad characteristic transistor functionality at those same frequencies.

RF BJT components are used very frequently in power amplification applications. For high frequency signals, like RF, they are designed to have a very good linear response, meaning that the proportionality between input signal and output signal remains quite stable as long as the linear region ratings are followed and maintained. They can also be used as a switching transistor like a MOSFET, operation outside of the linear region and within its saturation mode. In this case, the signal must be translated into a pulse-width modulation and be passed and amplified through the BJT, where the signal is changed back to the original signal.

RF BJTs typically offer some superior characteristics as compared to RF MOSFETs. They maintain a higher linearity in their linear region and are much cheaper for the same functionality. They have much lower output impedances, and have much higher gain potential.

Bipolar Transistor Configurations

As the **Bipolar Transistor** is a three terminal device, there are basically three possible ways to connect it within an electronic circuit with one terminal being common to both the input and output. Each method of connection responding differently to its input signal within a circuit as the static characteristics of the transistor vary with each circuit arrangement.

Common Base Configuration – has Voltage Gain but no Current Gain.

Common Emitter Configuration – has both Current and Voltage Gain.

Common Collector Configuration – has Current Gain but no Voltage Gain.

The Common Base (CB) Configuration

As its name suggests, in the Common Base or grounded base configuration, the BASEconnection is common to both the input signal AND the output signal with the input signal being applied between the base and the emitter terminals. The corresponding output signal is taken from between the base and the collector terminals as shown with the base terminal grounded or connected to a fixed reference voltage point.

The input current flowing into the emitter is quite large as its the sum of both the base current and collector current respectively therefore, the collector current output is less than the emitter current input resulting in a current gain for this type of circuit of «1» (unity) or less, in other words the common base configuration «attenuates» the input signal.

The Common Base Transistor Circuit

This type of amplifier configuration is a non-inverting voltage amplifier circuit, in that the signal voltages Vin and Vout are »in-phase». This type of transistor arrangement is not very common due to its unusually high voltage gain characteristics. Its input characteristics represent that of a forward biased diode while the output characteristics represent that of an illuminated photo-diode.

Also this type of bipolar transistor configuration has a high ratio of output to input resistance or more importantly «load» resistance (RL) to «input» resistance (Rin) giving it a value of «Resistance Gain».

The common base circuit is generally only used in single stage amplifier circuits such as microphone pre-amplifier or radio frequency (Rf) amplifiers due to its very good high frequency response.

The Common Emitter (CE) Configuration

In the **Common Emitter** or grounded emitter configuration, the input signal is applied between the base and the emitter, while the output is taken from between the collector and the emitter as shown. This type of configuration is the most commonly used circuit for transistor based amplifiers and which represents the «normal» method of bipolar transistor connection.

The common emitter amplifier configuration produces the highest current and power gain of all the three bipolar transistor configurations. This is mainly because the input impedance is LOW as it is connected to a forward biased PN-junction, while the output impedance is HIGH as it is taken from a reverse biased PN-junction.

The Common Emitter Amplifier Circuit

In this type of configuration, the current flowing out of the transistor must be equal to the currents flowing into the transistor as the emitter current is given as Ie = Ic + Ib.

As the load resistance (RL) is connected in series with the collector, the current gain of the common emitter transistor configuration is quite large as it is the ratio of Ic/Ib. A transistors current gain is given the Greek symbol of Beta, (β).

As the emitter current for a common emitter configuration is defined as Ie = Ic + Ib, the ratio of Ic/Ie is called Alpha, given the Greek symbol of α. Note: that the value of Alpha will always be less than unity.

Since the electrical relationship between these three currents, Ib, Ic and Ie is determined by the physical construction of the transistor itself, any small change in the base current (Ib), will result in a much larger change in the collector current (Ic).

Then, small changes in current flowing in the base will thus control the current in the emitter-collector circuit. Typically, Beta has a value between 20 and 200 for most general purpose transistors. So if a transistor has a Beta value of say 100, then one electron will flow from the base terminal for every 100 electrons flowing between the emitter-collector terminal.

Where: «Ic» is the current flowing into the collector terminal, «Ib» is the current flowing into the base terminal and «Ie» is the current flowing out of the emitter terminal.

Then to summarise a little. This type of bipolar transistor configuration has a greater input impedance, current and power gain than that of the common base configuration but its voltage gain is much lower. The common emitter configuration is an inverting amplifier circuit. This means that the resulting output signal is 180^{o} »out-of-phase»with the input voltage signal.

The Common Collector (CC) Configuration

In the Common Collector or grounded collector configuration, the collector is now common through the supply. The input signal is connected directly to the base, while the output is taken from the emitter load as shown. This type of configuration is commonly known as a Voltage Follower or Emitter Follower circuit.

The common collector, or emitter follower configuration is very useful for impedance matching applications because of the very high input impedance, in the region of hundreds of thousands of Ohms while having a relatively low output impedance.

The Common Collector Transistor Circuit

The common emitter configuration has a current gain approximately equal to the βvalue of the transistor itself. In the common collector configuration the load resistance is situated in series with the emitter so its current is equal to that of the emitter current.

As the emitter current is the combination of the collector AND the base current combined, the load resistance in this type of transistor configuration also has both the collector current and the input current of the base flowing through it.

This type of bipolar transistor configuration is a non-inverting circuit in that the signal voltages of Vin and Vout are »in-phase». It has a voltage gain that is always less than «1» (unity). The load resistance of the common collector transistor receives both the base and collector currents giving a large current gain (as with the common emitter configuration) therefore, providing good current amplification with very little voltage gain.

We can now summarise the various relationships between the transistors individual DC currents flowing through each leg and its DC current gains given above in the following table.

Контрольні питання

1. Which types of BJTs are there in electronic engineering?
2. Which are their applications?

Література: [1, c. 86–150; 2, c. 381–420].

Практичні заняття № 13–15

Тема 5 MOSFETs. Basic Characteristics and Application. Questions

Мета: ознайомити студентів з лексикою та теоретичними відомостями, закріпити знання студентів із зазначеної теми.

Короткі теоретичні відомості

Questions can be a little difficult in English. The first thing to remember is that there are two main kinds, **'yes / no'** and **'wh'**:

The 'yes/no' kind need the answer 'yes' or 'no'.

For example:

Do you like chocolate?

Is he from India?

Have you been to Japan?

A 'wh' one needs more information in the answer. It uses a question word like 'where', 'why', 'how' etc.

Where do you live?

What did she do yesterday?

Where is the station?

They are made in three different ways in English grammar depending on the verb tense:

1:	**We change the position (or 'invert') the verb and the subject.** This is used for the present simple and the past simple of 'be' and for modal verbs
2:	**We add an extra word, like 'do / does' or 'did'.** This is used for the past simple and the present simple of all other English verbs (not 'be')
3:	**We change the position of the first auxiliary verb and the subject.** This is for all other tenses, for example the present perfect, the present continuous or the future perfect continuous

To make the 'wh' kind, just put the question word in front of any 'yes / no' question:

Is he coming ('yes / no') becomes **When is he coming?** ('wh')

Here is a summary of the tenses and their interrogative forms:

Yes / No:

Present simple 'be'	Are you hungry?
Present simple other verbs	Do you like ice cream?
Present continuous	Are you coming to the party?

Past simple 'be'	Were you at home yesterday?
Past simple other verbs	Did you go out last night?
Past continuous	Were you watching TV at 8 last night?
Present perfect	Have you eaten?
Present perfect continuous	Have you been working hard?
Past perfect	Had you slept?
Past perfect continuous	Had you been running?
Future simple	Will you come?
Future continuous	Will you be coming?
Future perfect	Will you have finished at 6?
Future perfect continuous	Will you have been working?
Modals	Can you swim?
Modals	Must you leave?

Wh:

Present simple 'be'	Who are you?
Present simple other verbs	Where do you play tennis?
Present continuous	When are you coming to the party?
Past simple 'be'	Where were you last night?
Past simple other verbs	How did you do it?
Past continuous	What were you doing when I called you?
Present perfect	What have you eaten?
Present perfect continuous	Where have you been working hard?
Past perfect	What had you eaten?
Past perfect continuous	Why had you been working hard?
Future simple	Who will you meet?
Future continuous	Why will you be sleeping?
Future perfect	When will you have finished?
Future perfect continuous	What will you have been doing?
Modals	Where can we swim?
Modals	Why must you leave?

Завдання до теми

As well as the Junction Field Effect Transistor (JFET), there is another type of Field Effect Transistor available whoseGate input is electrically insulated from the main current carrying channel and is therefore called an Insulated Gate Field Effect Transistor or IGFET. The most common type of insulated gate FET which is used in many different types of electronic circuits is called the Metal Oxide Semiconductor Field Effect Transistor or MOSFET for short.

The IGFET or MOSFET is a voltage controlled field effect transistor that differs from a JFET in that it has a «Metal Oxide» Gate electrode which is electrically insulated from the main semiconductor n-channel or p-channel by a very thin layer of insulating material usually silicon dioxide, commonly known as glass.

This ultra thin insulated metal gate electrode can be thought of as one plate of a capacitor. The isolation of the controlling Gate makes the input resistance of theMOSFET extremely high way up in the Mega-ohms (MΩ) region thereby making it almost infinite.

As the Gate terminal is isolated from the main current carrying channel «NO current flows into the gate» and just like the JFET, the MOSFET also acts like a voltage controlled resistor were the current flowing through the main channel between the Drain and Source is proportional to the input voltage. Also like the JFET, the MOSFETs very high input resistance can easily accumulate large amounts of static charge resulting in the MOSFET becoming easily damaged unless carefully handled or protected.

MOSFETs are three terminal devices with a Gate, Drain and Source and both P-channel (PMOS) and N-channel (NMOS) MOSFETs are available. The main difference this time is that MOSFETs are available in two basic forms:

Depletion Type – the transistor requires the Gate-Source voltage, (V_{GS}) to switch the device «OFF». The depletion mode MOSFET is equivalent to a «Normally Closed» switch.

Enhancement Type – the transistor requires a Gate-Source voltage, (V_{GS}) to switch the device «ON». The enhancement mode MOSFET is equivalent to a «Normally Open» switch.

The symbols and basic construction for both configurations of MOSFETs are shown below.

The four MOSFET symbols above show an additional terminal called the Substrate and is not normally used as either an input or an output connection but instead it is used for grounding the substrate. It connects to the main semiconductive channel through a diode junction to the body or metal tab of the MOSFET. Usually in discrete type MOSFETs, this substrate lead is connected internally to the source terminal. When this is the case, as in enhancement types it is omitted from the symbol for clarification.

Basic MOSFET Structure and Symbol

The construction of the Metal Oxide Semiconductor FET is very different to that of the Junction FET. Both the Depletion and Enhancement type MOSFETs use an electrical field produced by a gate voltage to alter the flow of charge carriers, electrons for n-channel or holes for P-channel, through the semiconductive drain-source channel.

The gate electrode is placed on top of a very thin insulating layer and there are a pair of small n-type regions just under the drain and source electrodes.

We saw, that the gate of a junction field effect transistor, JFET must be biased in such a way as to reverse-bias the pn-junction. With a insulated gate MOSFET device no such limitations apply so it is possible to bias the gate of a MOSFET in either polarity, positive (+ve) or negative (-ve). This makes the MOSFET device especially valuable as electronic switches or to make logic gates because with no bias they are normally non-conducting and this high gate input resistance means that very little or no control current is needed as MOSFETs are voltage controlled devices. Both the p-channel and the n-channel MOSFETs are available in two basic forms, the Enhancement type and the Depletion type.

Depletion-mode MOSFET

The Depletion-mode MOSFET, which is less common than the enhancement mode types is normally switched «ON» (conducting) without the application of a gate bias voltage. That is the channel conducts when $V_{GS} = 0$ making it a «normally-closed» device. The circuit symbol shown above for a depletion MOS transistor uses a solid channel line to signify a normally closed conductive channel.

For the n-channel depletion MOS transistor, a negative gate-source voltage, $-V_{GS}$ will deplete (hence its name) the conductive channel of its free electrons switching the transistor «OFF». Likewise for a p-channel depletion MOS transistor a positive gate-source voltage, $+V_{GS}$ will deplete the channel of its free holes turning it «OFF».

In other words, for an n-channel depletion mode MOSFET: $+V_{GS}$ means more electrons and more current. While a $-V_{GS}$ means less electrons and less current. The opposite is also true for the p-channel types. Then the depletion mode MOSFET is equivalent to a «normally-closed» switch.

Depletion-mode N-Channel MOSFET and circuit Symbols

The depletion-mode MOSFET is constructed in a similar way to their JFET transistor counterparts were the drain-source channel is inherently conductive with the electrons and holes already present within the n-type or p-type channel. This doping of the channel produces a conducting path of low resistance between the Drain and Sourcewith zero Gate bias.

Enhancement-mode MOSFET

The more common Enhancement-mode MOSFET or eMOSFET, is the reverse of the depletion-mode type. Here the conducting channel is lightly doped or even undoped making it non-conductive. This results in the device being normally «OFF» (non-conducting) when the gate bias voltage, V_{GS} is equal to zero. The circuit symbol shown above for an enhancement MOS transistor uses a broken channel line to signify a normally open non-conducting channel.

For the n-channel enhancement MOS transistor a drain current will only flow when a gate voltage (V_{GS}) is applied to the gate terminal greater than the threshold voltage (V_{TH}) level in which conductance takes place making it a transconductance device.

The application of a positive (+ve) gate voltage to a n-type eMOSFET attracts more electrons towards the oxide layer around the gate thereby increasing or enhancing (hence its name) the thickness of the channel allowing more current to flow. This is why this kind of transistor is called an enhancement mode device as the application of a gate voltage enhances the channel.

Increasing this positive gate voltage will cause the channel resistance to decrease further causing an increase in the drain current, I_D through the channel. In other words, for an n-channel enhancement mode MOSFET: $+V_{GS}$ turns the transistor «ON», while a zero or $-V_{GS}$ turns the transistor «OFF». Then, the enhancement-mode MOSFET is equivalent to a «normally-open» switch.

The reverse is true for the p-channel enhancement MOS transistor.

When V_{GS} = 0 the device is «OFF» and the channel is open. The application of a negative (-ve) gate voltage to the p-type eMOSFET enhances the channels conductivity turning it «ON». Then for an p-channel enhancement mode MOSFET: $+V_{GS}$ turns the transistor «OFF», while $-V_{GS}$turns the transistor «ON».

The MOSFET Amplifier

Just like the previous Junction Field Effect transistor, MOSFETs can be used to make single stage class «A» amplifier circuits with the enhancement mode n-channel MOSFET common source amplifier being the most popular circuit. The depletion mode MOSFET amplifiers are very similar to the JFET amplifiers, except that the MOSFET has a much higher input impedance.

This high input impedance is controlled by the gate biasing resistive network formed byR1 and R2. Also, the output signal for the enhancement mode common source MOSFET amplifier is inverted because when V_G is low the transistor is switched «OFF» and V_D(Vout) is high. When V_G is high the transistor is switched «ON» and V_D (Vout) is low as shown.

Metal Oxide Semiconductor Field Effect Transistors are three terminal active devices made from different semiconductor materials that can act as either an insulator or a conductor by the application of a small signal voltage. The MOSFETs ability to change between these two states enables it to have two basic functions: «switching» (digital electronics) or «amplification» (analogue electronics). Then MOSFETs have the ability to operate within three different regions:

1. Cut-off Region – with $V_{GS} < V_{threshold}$ the gate-source voltage is lower than the threshold voltage so the MOSFET transistor is switched «fully-OFF» andI_{DS} = 0, the transistor acts as an open circuit.

2. Linear (Ohmic) Region – with $V_{GS} > V_{threshold}$ and $V_{DS} < V_{GS}$ the transistor is in its constant resistance region and behaves as a voltage-controlled resistor whose resistive value is determined by the gate voltage, V_{GS}

3. Saturation Region – with $V_{GS} > V_{threshold}$ the transistor is in its constant current region and is switched «fully-ON». The current I_{DS} = maximum as the transistor acts as a closed circuit

MOSFET Summary

The Metal Oxide Semiconductor Field Effect Transistor, or MOSFET for short, has an extremely high input gate resistance with the current flowing through the channel between the source and drain being controlled by the gate voltage. Because of this high input impedance and gain, MOSFETs can be easily damaged by static electricity if not carefully protected or handled.

MOSFET's are ideal for use as electronic switches or as common-source amplifiers as their power consumption is very small. Typical applications for metal oxide semiconductor field effect transistors are in Microprocessors, Memories, Calculators and Logic CMOS Gates etc.

Контрольні питання

1. Which are basic MOSFET's characterestics?
2. Where are MOSFETs applied mostly?
3. Which types of MOSFET are there?

Література: [1, с. 151–195; 2, 421–470].

Практичні заняття № 16–18

Тема 6 Automatic Control Concept. Cause-and-Effect Sentences

Мета: ознайомити студентів з теоретичними відомостями, закріпити знання студентів із зазначеної теми.

Короткі теоретичні відомості

Cause and effect is a relationship between events or things, where one is the result of the other or others. This is a combination of action and reaction.

Consequently (adverb) and ***as a result*** (prepositional phrase) are **connectives** that transition the reader from the idea expressed in one clause to the idea expressed in the next clause. These connectives are followed by a clause expressing the **effect** of situation stated in the clause before it. A comma separates the adverb from the clause.

Because *(since, as, though)* and ***because of*** *(due to, on account of)* are **connective prepositions** that relate additional, nonessential information to the main clause. *Because* is complemented by a clause and *because of* is complemented by a noun phrase (NP) that states a reason (cause) for the effect stated in the main clause.

Both verbs, ***cause*** and ***result***, are used in the active form to relate an **effect**. The verb ***cause*** focuses on the source, while the verb+prep. ***result in*** focuses on the result. ***Result*** is always followed by a prepositional phrase (***in***).

Poor childhood education causes illiteracy. ***Poor childhood education results in illiteracy***.

Both verbs, ***cause*** and ***result,*** relate a cause. ***Cause*** may be used in the passive form with a ***by*** phrase. ***Result***does not take the passive. It is followed by a prepositional phrase (***from***).

Illiteracy is caused by poor childhood education.

Illiteracy results from poor childhood education.

Summary of Cause–Effect Words

SO + CLAUSE	SO/SUCH…THAT + CLAUSE	BECAUSE + CLAUSE	CONSEQUENTLY+ CLAUSE
So relates (is complemented by) a clause that expresses an effect (result) forthe situation expressed in the main clause. A comma usually separates the clause from the main clause.	***So*** and ***such*** are intensifiers that combine with othermodifiers to express a remarkable situation, which is followed by ***that + clause*** that expresses an effect. ***So****(Adv)* modifies an adjective or adverb in the cause-clause. ***Such****(Adv)* modifies an AdjP + NP in the cause-clause.	***Because, as, since, though***,and others are followed by an *djunct* clause expressing reason/cause. Thecause-clause maybe placed **before or after** the effect-clause.	***Consequently*** and ***For this reason*** express a relationship between two clauses. The word(s) transition the reader or listenerfrom the main idea in one clause to the ideain the next clause. The transition is a supplement to the sentence and is separated by a comma.
So is a *connective adverb,* also called a *coordinating conjunction* inother grammarsystems.	***So*** and ***such*** are *degree adverbs (intensifiers)* followed by ***that***, *a subordinator*, and acontent clause (alsocalled an *adverbialclause, subordinated clause, or that- clause).*	***Because*** and others are *adjunctprepositions*, also called an *adverbial*, a *subordinating conjunction*, or along with its clause is called an *adverbial clause*.	***Consequently*** isa *connective adverb* also called a *linking adverb, connective adjunct* or *a conjunctive adverb.* ***For thisreason*** is a supplemental *prepositional phrase*
He saw starving children, **so** *he helped them.*[effect/result] He helped, **for***he knew they could survive*. [cause/reason]	He raised **so** much money **that** *he couldopen a "food bank"*. He raised **such** a large amount of money **that** *he couldopen a "food bank"*. He raised **enough** money **that** *he*	The children survived **because** *they received help*. **Because** *they received help***,** thechildren survived.The children survived **because of** *the help*. (noun	People helped. **Consequently,** *the children survived*. People helped. **Forthis reason,** *the children survived*. People helped**; asa consequence,** *the*

	could open a "food bank".	phrase)	*children survived.*
CAUSE			
for (reason or cause) rarely used, very formal	so… (emphasis on cause) such… (emphasis oncause) enough…that sufficiently…that	because, since, now that, as, aslong as, inasmuch as, because of, dueto, owing to, onaccount of, despite, if only because	For this reason, Forall these reasons
EFFECT			
so (result)	…that (effect) …that (effect)	so that (purpose-result) in order (purpose-result)	Therefore, Consequently, As aconsequence, As a result, Thus

Завдання до теми

To understand automatic process control, you must first fix in your mind three important terms that are associated with any process: *controlled quantities*, *manipulated quantities*, and *disturbances*. The controlled quantities (or *controlled variables*) are those streams or conditions that the practitioner wishes to control or to maintain at some desired level. These may be flow rates, levels, pressures, temperatures, compositions, or other such process variables. For each of these controlled variables, the practitioner also establishes some *desired value*, also known as the *set point* or *reference input*.

For each controlled quantity, there is an associated manipulated quantity or *manipulated variable*. In process control this is usually a flowing stream, and in such cases the flow rate of the stream is often manipulated through the use of a control valve. Disturbances enter the process and tend to drive the controlled quantities or controlled variables away from their desired, reference, or set point conditions. The automatic control system must therefore adjust the manipulated quantities so that the set point value of the controlled quantity is maintained in spite of the effects of the disturbances. Also, the set point may be changed, in which case the manipulated variables will need to be changed to adjust the controlled quantity to its new desired value.

In such a system, the controlled variable is room temperature. (Your intent, of course, is to maintain creature comfort in the room, and you control “comfort” by controlling a variable that can be measured easily, such as temperature.) A number of disturbances cause room temperature to vary, for example, outside ambient temperature, the number of people in the room, the type of activity taking place in the room. The automatic control system is designed to manipulate the fuel flow to the furnace in order to maintain room temperature at its desired value or set point in spite of the various disturbances.

Typical Manual Control

Before studying automatic process control, it is helpful to spend a moment or two reviewing a typical manual operation. On the stream leaving the process, there is an indicator to provide the operator with information on the current actual value of the controlled variable. The operator is able to inspect this indicator visually and, as a result, to manipulate a flow into the process to achieve some desired value or setpoint of the controlled variable. The set point is, of course, in the operator's mind, and the operator makes all of the control decisions. The problems inherent in such a simple manual operation are obvious.

Feedback Control

The simplest way to automate the control of a process is through conventional feedback control. Sensors or measuring devices are installed to measure the actual values of the controlled variables. These actual values are then transmitted to feedback control hardware, and this hardware makes an automatic comparison between the set points (or desired values) of the controlled variables and the measured (or actual) values of these same variables.

Based on the differences ("errors") between the actual values and the desired values of the controlled variables, the feedback control hardware calculates signals that reflect the needed values of the manipulated variables. These are then transmitted automatically to adjusting devices (typically control valves) that manipulate inputs to the process.

The beauty of feedback control is that the designer does not need to know in advance exactly what disturbances will affect the process, and, in addition, the designer does not need to know the specific quantitative relationships between these disturbances or their ultimate effects on the controlled variables. To a very significant extent, this standard pattern exists regardless of the specific nature of the process or the controlled variable involved.

The particular hardware used in a loop and the particular matching of one hardware piece to another is an important responsibility for the designer, but the overall control strategy is always the same in feedback control.

Such feedback control is the simplest automatic process control technique that can be used, and it represents the basis for the vast majority of industrial applications.

Manual Feedforward Control

Feedforward control is much different in conception from feedback control. As a disturbance enters the process the operator observes an indication of the nature of the disturbance, and based on that entering disturbance the operator adjusts the manipulated variable so as to prevent any ultimate change or variation in the controlled variable caused by the disturbance. The conceptual improvement offered by feedforward control

is apparent. Feedback control worked to eliminate errors, but feedforward control operates to prevent errors from occurring in the first place. The appeal of feedforward control is obvious.

Feedforward control does escalate tremendously the requirements of the practitioner, however. The practitioner must know in advance what disturbances will be entering the process, and he or she must make adequate provision to measure these disturbances. In addition, the control room operator must know specifically when and how to adjust the manipulated variable to compensate exactly for the effects of the disturbances. If the practitioner has these specific abilities and if they are perfectly available, then the controlled variable will never vary from its desired value or set point. If the operator makes some mistake or does not anticipate all of the disturbances that might affect the process, then the controlled variable will deviate from its desired value, and, in pure feedforward control, an uncorrected error will exist.

Automatic Feedforward Control

Disturbances are shown entering the process, and sensors are available to measure these disturbances. Based on these sensed or measured values of the disturbances, the feedforward controllers then calculate the needed values of the manipulated variables. Set points that represent the desired values of the controlled variables are provided to the feedforward controllers.

It is clear that the feedforward controllers must make very sophisticated calculations. These calculations must reflect an awareness and understanding of the exact effects that the disturbances will have on the controlled variables. With such an understanding, the feedforward controllers are able then to calculate the exact amount of manipulated quantities required to compensate for the disturbances.

These computations also imply a specific understanding of the exact effects that the manipulated variables will have on the controlled variables. If all of these mathematical relationships are readily available, then the feedforward controllers can automatically compute the variation in manipulated flows that is needed to compensate for variation in disturbances. The escalation in the theoretical understanding required is obvious. Feedforward control, while conceptually more appealing, significantly escalates the technical and engineering requirements of the designer and practitioner. As a result, feedforward control is usually reserved for only a very few of the most important loops within a plant. While the number of applications is small, their importance is quite significant.

Контрольні питання

1. Consider an electric oven in a typical modern kitchen. Identify the controlled variable, the manipulated variable, and the disturbances.

2. Consider an automatic gas-fired, home hot-water tank. Identify the controlled variable, the manipulated variable, and the disturbances.

3. Imagine you own a backyard swimming pool! Describe a manual control system to measure pH and to add an acidic solution to adjust pH. Define the controlled variable, the manipulated variable, and the disturbances.

4. Now automate the control of your swimming pool! Assume you have a tank of acid solution to pump into your pool to control pH; use feedback control.

5. The “Cruise Control” feature used to control speed in an automobile is a

good example of feedback control. Outline its operation in terms of feedback control.

Література: [8, с. 32–75; 9, с. 18–62].

Практичні заняття № 19–21

Тема 7 Automatic Control Systems. Comparing and contrasting

Мета: ознайомити студентів з лексикою та теоретичними відомостями, закріпити знання студентів із зазначеної теми.

Короткі теоретичні відомості

Comparing and contrasting

1. Comparing features which are similar:

- Both cameras have lenses.
- Like the conventional camera, the digital camera has a viewfinder.

2. Contrasting features which are different:

- The conventional camera requires chemical processing whereas the digital camera does not.
- The conventional camera uses film unlike the digital camera.
- With a digital camera you can transfer images directly to a PC but with a conventional camera you need to use a scanner.
- With digital cameras you can delete unsatisfactory images; however, with conventional cameras you cannot.

Types of Comparisons	
as ... (positive degree) ... as **not so as ... (positive degree) ... assuch a(n) ... as**	*His bands were as cold as ice.* *It is not so as cold as it was yesterday.* *This* is *not such an interesting book* as *his lastone.*
twice (three times etc., half) as …(positivedegree)... as **the same as**	*Their house* is *twice as big as ours. His carcost half as much as mine.* *Your jacket is the same as the one I bought lastmonth.*
look, sound, smell, taste + like	*She looks like an angel*
less (more) ... (positive degree)... than **the least (most) ... (positive degree)... of/in**	*The green sofa is less expensive than the blackone, but the blue one is the least expensive ofall.*
the + comparative ....the + comparative	*The sooner you start, the sooner you'll finish. The richer you are. the more friends you have.*
prefer + -ing form or noun + to + -ingform or noun (general preference)	*I prefer watching TV to going out. I prefer lemonade to cola.*

Завдання до теми

Control theory was developed to support the emergent activity of automatic control. It is therefore a useful motivation to turn our attention to automatic control.

Although automatic control is nowadays a complex discipline, no longer primarily concerned with the replacement of human operators, it is a useful starting point to consider what sort of skills are necessary to move from an existing, manually controlled situation to a new automatically controlled situation.

(1) A central idea of control theory is the control loop. All control loops have the same basic form, regardless of the particular application area. Thus, control theory uses an application-independent notation to convert all control problems into the same standard problem.We can consider that control theory concentrates on studying the universal situations that underlie all applications of quantitative control. In broadest form. The decisions govern actions that are taken. The effect of the actions is reported back by the information channel. Further decisions are taken and the loop operates continuously as described. A control loop provides an extraordinarily powerful means of control but, at the same time, the existence of the loop always brings the possibility of the potentially very destructive phenomenon of instability.

(2) All control loops are error driven, where error is defined as the difference between the behaviour that is desired and the behaviour that is measured.

(3) An important performance measure for a control system relates to rate of error reduction. Often, performance is quoted in terms of the highest frequency that the control system can follow, when required to do so.

(4) All control loops tend to become unstable as higher and higher performance is sought. A good understanding of the topic of stability is central to understanding control theory.

Requirements for an automatic control system

If it is possible to synthesise the best possible actions continuously by some sort of algorithm, then we have arrived at automatic control.

In the best known and simplest form of automatic control, the desired behavior is specified as a requirement that the measured system response (say y) should continuously and closely track a required system response (say *v*) that is input by the system user.

Of course, *v* may be constant or even always set equal to zero. In such cases, an automatic control system has the task of keeping a measured value of *y* always equal to the specified constant value of *v*, despite the presence of disturbing influences. These general requirements of an automatic control system are shown in Figure 2.4. Moving more towards the realisation of a practical system, Figure 2.5 results.

It is clear that the success of the scheme presented in Figure 2.5 depends on the disturbances *w* being measurable and on the existence of an accurate quantitative understanding of the system to be controlled, for otherwise the ‘generator of control actions’ cannot be accurately constructed. (Notice that no use is made of any measurement of the response.)

Контрольні питання

1. Which are requirements for ACS?
2. What is a realization of ACS?

Література: [8, c. 102–155; 9, c. 100–157].

Практичні заняття № 22–24

Тема 8 Feedback Control. Modals

Мета: ознайомити студентів з лексикою та теоретичними відомостями, закріпити знання студентів із зазначеної теми.

Короткі теоретичні відомості

Modals

Here's a list of the modal verbs in English:

can	could	may	might	will
would	must	shall	should	ought to

Modals are different from normal verbs:

1: They don't use an 's' for the third person singular.

2: They make questions by inversion ('she can go' becomes 'can she go?').

3: They are followed directly by the infinitive of another verb (without 'to').

Probability

First, they can be used when we want to say how sure we are that something happened / is happening / will happen. We often call these 'modals of deduction' or 'speculation' or 'certainty' or 'probability'.

For example:

It's snowing, so it **must be** very cold outside.

I don't know where John is. He **could have missed** the train.

This bill **can't be** right. £200 for two cups of coffee!

Ability

We use 'can' and 'could' to talk about a skill or ability.

For example:

She **can speak** six languages.

My grandfather **could play** golf very well.

I **can't drive.**

Obligation and Advice

We can use verbs such as 'must' or 'should' to say when something is necessary or unnecessary, or to give advice.

For example:

Children **must do** their homework.

We **have to wear** a uniform at work.

You **should stop** smoking.

Permission

We can use verbs such as 'can', 'could' and 'may' to ask for and give permission. We also use modal verbs to say something is not allowed.

For example:

Could I leave early today, please?

You **may not use** the car tonight.

Can we swim in the lake?

Habits

We can use 'will' and 'would' to talk about habits or things we usually do, or did in the past.

For example:

When I lived in Italy, we **would** often **eat** in the restaurant next to my flat.

John **will** always **be** late!

Завдання до теми

In automatic control, a device called a controller issues commands that are physically connected to a process with the intention to influence the behaviour of the process in a particular way. The commands that will be issued by the controller in a particular set of circumstances are completely determined by the designer of the controller. Thus, automatic control can be seen to be completely pre-determined at the design stage.

The controller may be driven by time alone or it may be driven in a more complex way by a combination of signals. In feedback control, the controller is error driven. That is, the controller receives a continuous measurement of the difference between required behaviour and actual behaviour and its output is some function of this error.

In this type of system, excellent results can be obtained in practice with very simple controllers indeed, even when operating under conditions where the system to be controlled is not well understood. Roughly speaking, we can imagine that the controller will keep on taking corrective action until the error is reduced to zero.

An alternative view of the arrangement is that users see an artificially enhanced system that has been synthesised to meet their wishes. If we represent the controller by an operator *D* and the system to be controlled by an operator *G*, we obtain:

The design task is to specify the controller D, connected to a given process G, such that a satisfactory overall performance is obtained. We can imagine that the controller modifies the process characteristics in ways chosen by the designer.

We next assume that there exists a desired hypothetical process *H*. By suitable connection of a controller *D* to the actual process, are we able to produce a configuration that behaves the same as *H*?

Here we assume that well-behaved operators can be found to operate on the sort of functions that exist in the control loop and possess those other properties of associativity and invertibility that are needed to make manipulation valid (i.e. we assume that the operators G, D, H are elements in a group).

Laplace transforms or other techniques can produce these operators for specific examples, but for the moment, it is sufficient to know that such operators exist.

We note and ask:

D contains G^{-1}, the inverse of the plant:

- This may be of high order.
- Is it (G) known?
- Does it (G) stay constant?
- If G changes by (say) 10%, will control become very poor?

(i) Can our requirements be adequately represented by an operator H?

(ii) How is H chosen?

(iii) Is it not disturbing that H is not in any way dependent on G? For instance, can we turn a low-performance aircraft (G) into a high-performance aircraft (H) simply with the aid of a clever algorithm? A simple question, but it leads to a valuable conclusion: high performance can rarely be obtained algorithmically but almost always requires expensive equipment such as big engines and high power-to-weight ratios.

(iv) Does D turn out to be a possible, buildable, robust, practical controller?

General conditions for the success of feedback control strategies

By the nature of feedback control, corrective action can only begin once an error has been detected. Therefore, close control will only be possible in those cases where the rate of corrective action can at least match the rate of disturbance generation. This idea, of course, soon leads to requests for high bandwidth of control loops to allow, in one way of looking at it, the control loop to successfully synthesize a signal equal and opposite to the disturbance signal.

In many cases, it is not possible to design a closed loop with a high enough bandwidth, and then feedback control has to be abandoned or relegated to a secondary role.

Контрольні питання

1. Which are fundamental concepts of feedback control?
2. List general conditions for the success of feedback control strategies

Література: [8, 156–201; 9, с. 158–211].

Практичні заняття № 25–27

Тема 9 Frequency Response Control. Linking Words

Мета: ознайомити студентів з лексикою та теоретичними відомостями, закріпити знання студентів із зазначеної теми.

Короткі теоретичні відомості

about, as far as … is concerned

1. Do not use *about* at the beginning of a sentence to introduce a topic.
2. A *s far as x is concerned* is used to introduce a new topic in which the dependent phrase has a subject that is different from the topic introduced in the previous phrase.
3. Avoid unnecessary or excessive use of *as far as x is concerned* . It can often be rewritten in a more concise form.

	YES	NO (1), NOT ADVISED (2,3)
1	We are writing to you **about** the paper we sent you in May. We would like to	**About** the paper we sent you in May, we would like to know whether …
	= Concerning / regarding / on the subject of / with regard to the paper we sent …	
2	**As far as the budget is concerned, we** would to ask you whether …	**As far as the budget is concerned, this** can be discussed at the next meeting.
	we is the subject of the second phrase	*budget* is the subject of both phrases
3	**The budget** can be discussed at the next meeting.	**As far as the budget is concerned, this** can be discussed at the next meeting.
3	**In terms of telephone production,** Nokia is Europe's biggest producer of mobile units.	**As far as telephones are concerned,** Nokia is Europe's biggest producer of mobile units.
	= Nokia is Europe's biggest producer of mobile telephones.	
3	**We can draw** a similar conclusion for the second phase as for the first phase.	**As far as the second phase is concerned** we can draw a similar conclusion as for the first phase.

also, in addition, as well, besides, moreover

1. *In addition* is used to add an additional positive or neutral comment. *also, further, furthermore* can be used in the same way.
2. *Moreover* generally adds an additional negative comment – this is not a rule, but seems to be a preference among native English-speaking authors.
3. *Besides* and *in addition to* (both + − *ing* form) are used at the beginning of a sentence which is made up of two parts, in which the second part contains an

additional feature or fact to the one given in the fi rst part. *besides* is not used at the beginning of sentence to add an additional idea to the one presented in a previous sentence.

4. *As well (as)* means the same as *also* . *as well as* can be used at the beginning of a phrase and takes the - *ing* form of the verb. *as well* , but not *also* , can be used at the end of the phrase.

	YES	NOT RECOMMENDED (1,2), NO (3,4)
1,2	This software program has several interesting features .... **In addition / Also / Furthermore**, the cost is low and it is quick to learn.	This software program has several interesting features .... **Moreover**, the cost is low and it is quick to learn.
1,2	This software program has very few useful features. **Moreover**, the cost is very high and it is quick to learn.	This software program has very few useful features. **Further / In addition**, the cost is very high and it is quick to learn.
3	**Besides / In addition to** having several interesting features, this program is also economical ...	This software program has several interesting features .... **Besides**, the cost is low and it is quick to learn.
3,4	**In addition to / Besides / As well as teaching** English, she **also** teaches French.	**In addition / Besides / As well to teach** English, she also teaches French.
4	She teaches French **as well**.	She teaches French **also**.
	She teaches French **as well as** English.	She teaches French **also** English.

also, as well, too, both, all:* use with *not

also , *as well as, too, both* and *all* are not generally found in negative sentences. So, in negative sentences:

1. Use *neither* / *nor* instead of *also, as well as, too.*

2. Use *either* instead of *both.*

3. Use *both* with a negative only for contrast.

4. Use *any* instead of *all.*

	YES	NO
	X did **not** function and **nor / neither** did Y.	X did **not** function and **also** Y.
1	Little is known about what truly matters in searching for information, **nor** what strategies users exploit.	Little is known about what truly matters in searching for information, **as well as** what strategies users exploit.
2	**Neither** of them **functioned** as required.	**Both** of them **did not function** as required.
3	We did **not** use **both** of them, just **one** of them.	We did **not** use **either** of them, just **one** of them.
4	There were no high scores in **any** of the tests.	There were no high scores in **all** the tests.

although, even though* versus *even if

1. *Even if* is only used for hypothetical situations, typically in second conditionals. Note: *also if* does not exist.

2. *Even though* and *although* have the same meaning. They are used to refer to real situations. They are generally found with present tenses. *though* means the same, but is not found at the beginning of a sentence in academic writing; *even though* is generally found at the beginning of a sentence rather than the middle.

	EVEN IF	EVEN THOUGH
1	**Even if** I was the President of the United States ...	**Even though** researchers don't earn much money, at least they get to travel a lot.
2	**Even if** the book were available in English (it is currently only in Spanish), nobody would read it.	**Even though / Although** the book is essentially for children, adults still love to read it.

and, along with

1. In a list of three items or more, put a comma before *and* – this signals to the reader that the *and* is introducing the last item.

2. When giving a list of items, use semi colons (or commas) to highlight what elements *and* joins together.

3. When you use *and* several times within the same phrase, consider either rephrasing the sentence. Alternatively, use *along with* or *together with* to make your meaning clear.

4. *Along with* is followed by a noun. It can be used at the beginning of sentence to mean *in addition to*. *Besides* has the same meaning and can be used with a noun or verb.

	YES	NO
1	These countries include Tajikistan, Uzbekistan, **and** Kyrgyzstan.	These countries include Tajikistan, Uzbekistan **and** Kyrgyzstan.
2	The following groups of countries will be involved in the project: Tunisia and Egypt; Vietnam and Laos; Peru and Chile; and Poland and Estonia.	
3	I could visit your lab in **January**. I could also come in **February and March** if my professor agrees.	I could visit your lab in **January and February and March** if my professor agrees.
3	A and B, **along with** C and D, are the most used solutions.	A **and** B **and** C **and** D are the most used solutions.
4	**Along with / Besides** Spanish and Chinese, English is the most spoken language in the world.	**Along with** speaking English, she also speaks Hindi and Arabic.

as* versus *as it

1. When *as* is used without a following pronoun or noun, it has a similar meaning to *like* and *how.*

2. When *as* is followed with a pronoun (often *it*) or a noun it means *because* or *since.*

	AS	AS IT
1,2	This is not true, **as is** evident from the figure.	This is not true, **as / because it is** impossible to prove that X = Y.
1,2	**As mentioned** above and **as can** be seen in the figure ...	These experiments were not performed **as / because it would** have required too much additional computing power.

as* versus *like (unlike)

1. *As* is used when the sense is that one thing is equal to another.

2. *Like* means 'similar to'.

3. *Unlike* is used when making a contrast. Note *differently from* does not exist in English, use *unlike* instead.

	AS	LIKE, UNLIKE
1,2	He works **as** a researcher in Paris.	She works **like** a slave for her boss.
	He is a researcher.	She is not a slave.
1,2	Diabetes acts **as** a significant risk factor for many physical diseases.	Xerostima: A symptom that **acts like** a disease.
	Diabetes is a risk factor.	Xerostima, i.e. dry mouth resulting from absent saliva flow, is not a disease but a symptom that can lead to a disease.
3,1	**As with copper and iron** techniques, lead substitution failed to demonstrate growth patterns in G. cirratum and C. altimus vertebrae.	Zinc, **unlike copper and iron**, fails to stimulate lipid peroxidation in vitro.
	Lead behaves in the same way as copper and iron.	Zinc does not behave in the same way as copper and iron.

as, because, due to, for, insofar as, owing to, since, why

1. *Because* indicates a consequence, *why* gives the reason or explanations.

2. Because can be used at the beginning of a sentence in order to explain a reason for doing something, but is usually replaced in formal English by *since, as, seeing as, given that, given the fact that* , *on account of the fact that* or *due to the fact that.* Another alternative is to use *in order to* or *so that.*

3. *Due to* and *owing to* mean the same as *because of* , and are followed by a noun. *owing to* tends only to be used at the beginning of a sentence.

4. *For* generally replaces *due to* and *because of* in phrases containing the word *'reason'.*

5. *Due to the fact that* and *owing to the fact* that are used before a subject + verb construction.

6. *Insofaras* and *inasmuchas* (also written *insofar as, in so far as, inasmuch as, in as*

much as) can be used to replace because or due to the fact that when these appear at the beginning of a sentence. But they are somewhat antiquated.

	USAGE	ALTERNATIVE
1	This battery may explode when used with a third-party power supply. This is **because** the battery is highly inflammable and this is **why** it should not be used in children's toys.	This battery may explode when used with a third-party power supply. This is **due to the fact that** the battery is highly inflammable and this is **the reason [why]** it should not be used in children's toys.
2	**Because** they wanted total control, the revolutionary party enacted a series of drastic reforms.	**As / Since / Given that / On account of the fact that** they wanted total control, the revolutionary party enacted a series of drastic reforms.
		In order to have total control ...
		So that they would have total control ...
3	This accident was **due to** an electrical fault.	**Owing to** an electrical fault there was an accident.
4	The evolution of the Internet did not occur homogeneously around the world, **for** obvious historical, economic and political **reasons**. Moreover, **for reasons** of space we can only mention the ...	
5,6	**Due to the fact / Owing to the fact** we only had a limited budget, it was decided to use the cheapest version.	**Inasmuch as** we only had a limited budget, it was decided to use the cheapest version.

both … and, either … or

These expressions are frequently confused, thus leading to ambiguity for the reader.

1. *Both ... and* is inclusive.
2. *Either ... or* is exclusive. You cannot use *either* in both parts.
3. *Both* is only used with *not* when used to contrast.
4. *Not ... either* .. . or indicates that none of the options are available.
5. The position of the preposition changes the meaning.

	YES	NO
1	We can go to **both** Iran **and** Jordon.	We can go **either** Iran **either** Jordon
	We will visit two places.	
2	We can go to **either** Iran **or** Jordon.	We can go **or** to Iran **or** Jordon.
	We can only visit one of the two alternatives.	
3	We **can't** go to **both** Iran and Jordon, but only to Iran.	
	We only have one choice.	
4	We **can't** go **either** to Iran **or** Jordon.	We **can't** go **neither** to Iran **nor** Jordon.
	We cannot visit these two places.	
5	We had fun **in both** the parks we visited and also the museums.	
	We visited two parks.	
	We had fun **both in** the parks and the museums.	
	We visited an undisclosed number of parks and museums.	

e.g.* versus *for example

1. Use a comma before *for example* and at the end of the example itself.

2. If you write *for example* after the example, rather than before, then it should be preceded and followed by commas. *for example* should not be placed at the end of the phrase.
3. In the middle of a sentence *e.g.* tends to be used for lists that are in brackets.
4. Don't use both *such as* and *for example* together. Use one or the other.
5. For instance and *like* are not normally used in research papers, prefer *for example.*

	YES	NO
1	Whenever you use your **PIN, for** example to get money from an **ATM,** do not let anyone see you.	Whenever you use your **PIN for** example to get money from an **ATM** do not let anyone see you.
2	Many governments are in crisis. In **Venezuela, for example, the** government is facing ...	Many governments are in crisis. In **Venezuela for example the** government is facing ...
		Many governments are in crisis. In Venezuela the government is facing big problems with the unions, **for example.**
3	When you use a PIN **(e.g.** to get money from an ATM, to pay for online purchases) ensure that ...	When you use a PIN **e.g.** to get money from an ATM, to pay for online purchases ensure that ...
4	We have collaborations with universities in many countries in Europe, **for example** France and Spain.	We have collaborations with universities in Europe, **such as for example** France and Spain.
5	We have given poster sessions at conferences in many countries in Europe, **for example** France and Spain.	We have given poster sessions at conferences in many countries in Europe, **like** France and Spain.

e.g., i.e., etc.

1. It is not necessary to put a comma immediately after *e.g.* and *i.e.*

2. *E.g.* and *i.e.* are also often written simply as *eg* and *ie* , but this may look confusing, particularly for non-native English readers.

3. *E.g.* introduces an example of what you have just said.
4. Use *i.e.* when what follows is a de fi nition or clari fi cation of what you have just said.

5. *E.g.* and *i.e.* are often confused. If you think your readers might not be familiar with the difference use *for example* and *that is to say*, respectively.

6. When you introduce a series of examples with *for example* , do not put *etc.* at the end.

7. If possible, think of something more meaningful than *etc.*

8. *Etc.* only requires one period (.) at the end of a sentence.

	YES	NO
1	Several authors, **e.g.** Schmidt, Si, and Hurria, have investigated this problem.	Several authors, **e.g.,** Schmidt, Si, and Hurria, have investigated this problem.
2	Several foods produce very strong allergies (**e.g.** eggs, nuts, wheat) …	Several foods produce very strong allergies (**eg** eggs, nuts, wheat **etc.**) …
3	This is true in at least ten countries, **e.g.** Spain, Japan and Togo.	This is true in at least ten countries, **i.e.** Spain, Japan and Togo.
4	The UK is made up of four countries, **i.e.** England, Scotland, Wales and N. Ireland.	The UK is made up of four countries, **e.g.** England, Scotland, Wales and N. Ireland.
5	The UK is made up of four countries, **that is to say** England, Scotland, Wales and N. Ireland.	
6	This is true in at least ten countries, **e.g.** Spain, Japan and Togo.	This is true in at least ten countries, **e.g.** Spain, Japan, Togo, **etc**.
7	This is true in many nations (Honduras **and other Central American countries**) and has very serious consequences.	This is true in many nations (Honduras **etc.**) and has very serious consequences.
8	This is true in at least ten European countries: France, Belgium, Sweden **etc.**	This is true in at least ten European countries: France, Belgium, Sweden **etc.**.

for this reason* versus *for this purpose, to this end

1. *For this reason* explains why something was done.

2. *For this purpose* and *to this end* can be used indifferently to describe how something just mentioned was achieved.

	FOR THIS REASON	FOR THIS PURPOSE, TO THIS END
1,2	They wish to improve their English. **For this reason**, they are studying ten hours a day.	Our aim was to achieve higher performance. **For this purpose** we built an ad hoc device to provide increased power.
1,2	The patient was suffering from amnesia, **for this reason** it was difficult to question him directly on the circumstances of the accident.	It is now considered expedient to purge bone marrow of tumor cells prior to returning it to the patient, and **to this end** a variety of techniques have been developed.

the former, the latter

1. Only use *the former* and *the latter* when it is 100% clear to the reader what *the former* and *the latter* refer *to.* It is not bad style to repeat the key word, particularly as this will make it easier for the reader to identify exactly what is being referred to.

2. It may not be clear which element *the former* and *the latter* refer to. For example, when there are three elements, it may not be clear if *the latter* refers to the third element alone, or the second and the third.

3. In long sentences the reader may have already forgotten which elements were mentioned earlier.

	YES	NOT 100% CLEAR
1	**Lagos** and Khartoum are the capital cities of Nigeria and Sudan. **Lagos** has a population of ...	**Lagos** and Khartoum are the capital cities of Nigeria and Sudan. **The former** has a population of ...
2	In this recipe we used potatoes, carrots and beans. This is common practice with this kind of cooking. **The beans** can, of course, be steamed.	In this recipe we used potatoes, carrots and beans. This is common practice with this kind of cooking. **The latter** can, of course, be steamed.
3	Such an unsolicited bandwidth request can be **incremental** or **aggregate**. If it is **aggregate**, the X indicates the whole connection backlog. Blah blah blah blah blah blah blah blah blah blah blah blah blah blah blah blah blah blah. On other hand, if it is **incremental**, the X indicates the difference between its current backlog and the one carried by its last bandwidth request.	Such an unsolicited bandwidth request can be incremental or aggregate. In **the latter** case, the X indicates the whole connection backlog. Blah blah blah blah blah blah blah blah blah blah blah blah blah blah blah blah blah blah. In **the former** case, the X indicates the difference between its current backlog and the one carried by its last bandwidth request.

however, although, but, yet, despite, nevertheless, nonetheless, notwithstanding

1. To qualify what you have just written, use *however* (or *but* , which is slightly less formal). *however* is used in preference to *but* at the beginning of a sentence. *however* can be used with or without a comma, and can be located mid phrase between two commas. *nonetheless* and *nevertheless* are synonyms and mean the same as *however.*

2. Yet means the same as *but* and *however* , but has a stronger note of surprise. *still* has a similar meaning.

3. Despite and *notwithstanding* cannot be used when immediately followed by a *noun + verb* construction. Instead they have to be accompanied *by the fact that* . Thus, given that they are more complex to use, it is probably best to use *but, however* and *although*.

	YES	ALTERNATIVE	NO
1	The system costs very little to implement, **but / however / nevertheless / although** it is very complicated to use.	**However / Nevertheless**, it is very complicated to use. It is, **however / nevertheless**, very complicated to use.	The system costs very little to implement, **despite / notwithstanding** it is very complicated to use.
2	Governments know this is a problem, **yet** they do nothing about it.	**Although** governments know this is a problem, they **still** do nothing about it.	Governments know this is a problem, **despite** they do nothing about it.
3	**Despite** being cheap, the system works well.	**Although** the system is cheap, it works well.	**Although / Notwith-standing** being cheap, the system works well
3	**Despite the fact / Not-withstanding the fact** that the system is cheap, it is very effective.	**Although** the system is cheap, it is very effective.	**Despite / Notwithstanding** the system is cheap, it is very effective.
3	**Despite / Notwith-standing** the cheap price, the system works well.	The system works well **despite** its low cost.	**Despite** the cost is cheap, the system is very effective.
3	The system works well, **nevertheless** it is rather complicated.	The system works well, **however** it is rather complicated.	The system works well, **notwithstanding** it is rather complicated.

however, although, but, yet, despite, nevertheless, nonetheless, notwithstanding (cont.)

4. Only *however* , *nevertheless* and *nonetheless* can be used at the end of a phrase.

5. *However* , and *nevertheless* / *nonetheless* can be used at the beginning of a

sentence, and be followed by a comma.

As highlighted by many of the examples, *although* can often be used to qualify a statement. However, it is not used (a) between commas, (b) directly before a verb, (c) at the end of a phrase

	YES	ALTERNATIVE	NO
4	The system took only two days develop, it works well **nonetheless**.	The system was designed and … it works well **however**.	The system was designed and … it works well **despite / although**.
5	The system is cheap. **However**, it is difficult to implement.	The system is cheap. **Nevertheless / Nonetheless**, it is difficult to implement.	The system is cheap. **Notwithstanding / Despite**, it is difficult to implement.

however* versus *nevertheless

1. There is a very subtle difference between *however* and *nevertheless*. *however* can be used to add an additional observation or piece of information. *nevertheless* makes a stronger back-reference to what was said earlier, rather than focusing on giving new information.

Essentially, if there is a causal relationship between two sentences, use *nevertheless* ; otherwise use *however.*

	HOWEVER	NEVERTHELESS
1	Fewer men now seem to see career success as a central life interest around which other life activities are subordinated, **however** for many women the opposite is often true.	Studies indicate that stress from working long hours causes high blood pressure, **nevertheless / despite this** companies still insist on their employees working up to 60 hours per week.
	There is no direct correlation between the fact that fewer men are obsessed by their career and the fact that women now are — *nevertheless* cannot be used here.	There is a direct correlation between the fact that long hours are detrimental to health, but people continue to work 60 hours in any case. *however* could also be used here but the contrast would be weaker.
1	We didn't discuss your paper. **However** we did mention the possibility of you working in their lab.	We didn't discuss your paper. **Nevertheless**, there will be many other opportunities to talk about it.

in contrast with* vs. *compared to, by comparison with

1. Use *in contrast with* when the difference you are referring to is striking or surprising.
2. Use *compared to / with* and *by comparison* in all other cases.

	IN CONTRAST TO	COMPARED TO
1	**In contrast to** what was previously observed by Heimlich [2], our results showed an opposite trend.	**Compared to** Smith's results, our results are somewhat disappointing.
		= Our results are somewhat disappointing **by comparison with** Smith's.
2	**In contrast to** Hill's top-down approach [Hill, 2015], we start from the bottom layer.	**Compared to** the old technology, the new technology offers several new features.

instead, on the other hand, whereas, on the contrary

1. Use *instead* at the beginning of a sentence to resolve a problem stated in the

previous sentence.

2. Do not use *instead* to introduce a new topic, even if the new topic is related in some way to the previous topic. Use *on the other hand.*

3. Use *on the other hand* to give an alternative or to add additional information about the thing mentioned previously – *whereas* is not used in such circumstances.

4. Both *on the other hand* and *whereas* can be used to make a contrast, but *whereas* gives the reader the idea that the contrast is quite strong. *whereas* is not normally used at the beginning of a sentence.

5. Do not use *on the other hand* simply to introduce new information without any sense of contrast.

6. *On the contrary* is only used to totally contradict what another author has stated.

	YES	NO
1/4	Do not join two independent clauses with a semicolon. **Instead**, make two simple separate sentences.	Do not join two independent clauses with a semicolon. **On the contrary**, make two simple separate sentences.
2	Italian and Spanish are similar languages, in fact they both derive from Latin. **On the other hand**, German is derived from …	Italian and Spanish are similar languages, in fact they both derive from Latin. **Instead**, German is derived from …
3	The conference may be held in Jordon, **on the other hand** it may be held in Egypt.	The conference may be held in Jordon, **whereas** it may be held in Egypt.
4	This year the conference is being held in Prague, **whereas** last year it was held on the other side of the globe in Sydney.	This year the conference is being held in Prague, **on the other hand** last year it was held on the other side of the globe in Sydney.
4	Italian and Spanish are similar languages, **whereas** German is completely different.	Italian and Spanish are similar languages. **Whereas** German is completely different.
4	We found that x = 1, **whereas [on the other hand]** Smith et al. reached a very different conclusion that x = 2.	
5	Much research has been carried out in the US on using sea animals as models for robots. **In addition / Furthermore**, new developments have been made in Japan with local species.	Much research has been carried out in the US on using sea animals as models for robots. **On the other hand**, new developments have been made in Japan with local species.
5	Italian and Spanish are similar languages, in fact they both derive from Latin. German, **on the other hand**, is derived from …	Italian and Spanish are similar languages, in fact they both derive from Latin. German, **instead / on the contrary**, is derived from …
6,4	Smith [2013] states that governments must intervene in such cases. We believe, **on the contrary**, that they absolutely must not intervene.	Smith [2013] states that governments must intervene in such cases. We believe, **whereas**, that they absolutely must not intervene.

thus, therefore, hence, consequently, so, thereby

1. *Thus, therefore, consequently, so* and *hence* all have the same meaning. They are used to indicate a consequence of what has just been said before. *so* is considered informal and is thus used less often.

2. *Hence* is generally reserved for mathematics.

3. *Thereby* means *in such a way* . It can only be used in the dependent phrase and is

followed by a verb.

	YES	ALTERNATIVE
1	Researchers do not have much time to read papers. **Consequently**, it makes sense to write papers in a way that they can understand quickly and easily.	Researchers do not have much time to read papers. **Therefore / Thus**, it makes sense to write papers in a way that they can understand quickly and easily.
1	**Thus** the best way to write a paper is to use short sentences.	The best way to write a paper is **thus** to use short sentences.
2	Note that the right-hand side of equation (2) equals r(p)v(x) + [3]. **Hence**, equation (2) reduces to equation (1) if ...	The square of the slope of the beam can be neglected in comparison with unity, **thus** equation (1) reduces to an ordinary linear equation.
3	Love promotes well-being **thereby** enabling people to live better lives.	Love promotes well-being **thus** enabling people to live better lives.

omission of words in sentences with *and, but, both* and *or*

You can omit certain words when used in conjunction with *and, but, both* and *or* . This helps to avoid unnecessary repetition

1. Nouns, pronouns, articles, possessive adjectives, *this, those* etc.
2. Verbs.
3. Prepositions.

	YES	YES
1	We measured and **[we]** calculated the values.	We extracted **[the fluid]** and then froze the fluid.
1	Give me your name and **[your]** address.	We need those books and **[those]** papers.
1	The sample can be introduced into the furnace using either a chromatographic **[pump]** or a peristaltic pump.	
	NB do not say: chromatographic **pump** or a peristaltic **one**.	
1,3	Is it a theoretical **[problem]** or **[a]** practical problem?	These can be found both in animals and **[in]** humans.
2	The flame was low but **[it was]** steady.	This is an expensive **[way]** but **[it is an]** effective way of reducing pollution.
3	This disease is predominantly found in the Sudan and **[in]** Chad.	These findings were true for adults and **[for]** children.

Завдання до теми

Design using frequency response methods: initial explanation

Control design in the frequency domain involves the following basic ideas:

(i) The performance of a system *H* that is to be synthesised may be approximately characterised by its bandwidth, i.e. by the range of frequencies to which it will respond.

(ii) The bandwidth of any process *G* that is to be controlled may be measuredexperimentally or calculated analytically by straightforward means.

(iii) The necessary frequency characteristics of a controller *D* may be determined graphically from information on G and H, such that the performance in (i) is obtained.

(iv) Sufficient stability of the resulting control loop is easily taken care of as part of the design method.

Frequency response of a linear system

A linear dynamic system consists mathematically of the following (repeated) operations: multiplication by a constant, differentiation, integration and summation.

By the *frequency response* of a system we mean a table or graph showing the output amplitude and phase difference as a function of frequency when a sinusoid of unit amplitude is applied to the system (it being assumed that all transient effects have died away before output measurements are taken).

The Bode diagram

The Bode diagram allows frequency response information to be displayed graphically. The diagram consists of two plots, magnitude and phase angle, both against frequency on the horizontal axis.

Frequency response and stability: an important idea

If, for some particular frequency ω, the block G has unity gain and $-180°$ phase shift, then the closed loop system will be in continuous oscillation at frequency ω.

Explanation: A sinusoid of frequency ω, once input to the block G, will be subjected to two phase shifts of $180°$ (one at G and one at the comparator (multiplication by -1 and phase-shifting by $180°$ having the same effect on a continuous sinusoid)) and will pass repeatedly around the loop without attenuation, since the loop gain at frequency ω is unity.

In practice, special log-linear axes are used for Bode diagrams with frequency on a logarithmic scale and magnitude not plotted directly but only after conversion to decibels (dB). Under these special circumstances, the Bode plots for magnitude for most simple transfer functions can be approximated by straight line segments.

In the logarithmic domain, products of transfer functions are replaced by summations of individual logarithmic approximations. Hence, the Bode diagram magnitude characteristic for a moderately complex transfer function can easily be produced by summing a few straight line approximations.

The Bode diagram's popularity derives from the ease with which it may be sketched, starting from a transfer function; the ease with which it may be obtained by plotting experimental results; and from its usefulness as a design tool.

Implication: For stability of the closed loop system shown in Figure 5.3, at that frequency where the phase shift produced by G is –180°, the loop gain must be less than unity. Notice that the stability of the complete closed loop is being inferred from frequency response information referring to the block G alone.

General idea of control design using frequency response methods

Control design in the frequency domain is quite a specialist subject, requiring considerable experience and detailed knowledge. However, in principle, what is involved is, in addition to the original process, a *compensator D* and, as before, a gain C, to be chosen.

Obtaining the frequency response of a system experimentally

A frequency response analyser makes the work easy since this device generates the necessary sinusoids, measures the responses and produces digital displays and plots of amplitudes and phase angles.

Even the very simplest of systems can prove surprisingly difficult to identify in practice. That is just one of several reasons for the much-discussed gap between the promises of theory and the achievements of practice – if a meaningful model can't be obtained, a meaningful control design is necessarily difficult to produce.

Some of the difficulties frequently encountered in practice are as follows:

● It often proves quite a challenge to connect the sinusoidal stimulus signal $u(t)$ from the analyser to the system to be identified. Few real processes have a pair of convenient terminals that allow this; many industrial interfaces use mark space chopping of power to avoid the cost of continuously variable power amplifiers; unwieldy devices need to be rigged up to produce linearly reciprocating sine waves to excite some types of mechanical systems.

● Industrial processes are often already operating in 'some sort of closed loop arrangement' and it is not possible to isolate such processes for testing.

● The product is often a key part of the process that is to be tested. Industrial processes, in many cases, cannot be considered to exist separately from the product being produced – managers may not take kindly to sinusoidal variations being induced into the products.

● Testing takes a very long time if low frequencies are involved. This applies particularly to large processes that tend to operate in the low-frequency end of the spectrum.

● Electromechanical systems tend to move in a series of jerks when confronted with very low frequency signals. They tend to move erratically, giving inconsistent results, for high frequencies. Both effects can be attributed to the presence of non-linearities. Usually stiction is the cause of the low-frequency jerking phenomenon, whereas backlash in mechanisms is the source of most high-frequency erratic behaviour. (At high frequencies, attenuation is severe, drive signals are of small amplitude and backlash becomes significant.)

● Systems whose output has a non-zero mean level (especially a mean level that follows a long-term large amplitude ramp) are very difficult to deal with.

Контрольні питання

1. Which are fundamental concepts of frequency response control?
2. Which techniques are applied for frequency response control?

Література: [8, 156–201; 9, с. 158–211].

Практичні заняття № 28–30

Тема 10 Non-Linear Systems. Numbers

Мета: ознайомити студентів з лексикою та теоретичними відомостями, закріпити знання студентів із зазначеної теми.

Короткі теоретичні відомості

words versus numerals: basic rules

1. If a number has to appear at the beginning of a sentence use the word (e.g. *eleven*) rather than the numeral (e.g. 11).
2. If necessary, rearrange the sentence so that the number does not appear at the beginning.

3. If it is not possible to apply Rule 2, use words instead.

	YES	NO
1	**Two hundred** samples were examined.	**200** samples were examined.
2	This feature is not used by **50%** of users.	**50%** of users do not use this feature.
2	**An amount of 1.85 mL** of distilled water was added to the mixture.	**1.85 mL** of distilled water was added to the mixture.
3	**Seventy per cent** of managers believe that praising employees makes no difference to performance.	**70%** of managers believe that praising employees makes no difference to performance.

words versus numerals: additional rules

1. When you use numbers from one to eleven within a written text, write them as words (e.g. *nine*) rather than numerals (e.g. *9*). The reason for this is visual: it is harder to see a digit in a text than a word, e.g. *1* is harder to see than *one* .

2. Consider using words for numbers above ten if this will facilitate reading.

3. Do not mix words and digits to refer to the same number, unless this number is a million or more.

4. Do not mix words and digits within the same context.

5. Times of day are written as numerals; use the 24 hour clock to avoid having to use *a.m.* (before midday) or *p.m.* (after midday).

	YES	NO
1	For the color measurements, **three** fruits of each cultivar were analyzed.	For the color measurements, **3** fruits of each cultivar were analyzed.
2	Of the 270 examined faecal samples, 46 were positive for Trichuridae eggs: **six** (2.2%) were positive for *E. boehmi* (Fig. 1a), **twelve** (4.4%) *E. aerophilus* (Fig. 1b) and **thirty-three** (12.2%) for *T. vulpis* (Fig. 1c).	Of the 270 examined faecal samples, 46 were positive for Trichuridae eggs: **6** (2.2%) were positive for *E. boehmi* (Fig. 1a), **12** (4.4%) *E. aerophilus* (Fig. 1b) and **33** (12.2%) for *T. vulpis* (Fig. 1c).
2	In **Tables 1 and 2, twenty** samples with ...	In Tables **1 and 2, 20** samples with ...
3	There were **200,000** people at the conference.	There were **200 thousand** people at the conference.
	There were **two hundred thousand** people at the conference.	
3	More than half of the Earth's **7.4 billion** inhabitants live in the tropics and subtropics.	More than half of the Earth's **7,400,000,000** inhabitants live in the tropics and subtropics.
4	There were **two- to three**-fold increases.	There were **two- to 3-fold** increases.
5	Rats were fed at **09.00** and **17.00** every day.	Rats were fed at **9 o'clock** in the morning and at **5 p.m.** every day.

when 1–10 can be used as digits rather than words

1. Use digits not words when numbers are in association with percentages, abbreviations for measurements, tables, and figures etc.

You can optionally use digits rather than words when:

2. The second number in a range of numbers is higher than eleven; alternatively write both numbers as words.

3. There is a series of numbers, or in ratios and proportions.

4. Numbers act as adjectives. Note the use of hyphens

	YES	ALSO POSSIBLE
1	As shown in **Table 3**, the patient was only **1.20 m** tall and weighed **9 kg**. Her percentage body fat was **9.9%**.	
2	The process usually takes between **4 and 12** days.	The process usually takes between **four and twelve** days.
3	In the last three years the numbers have risen by **11, 6 and 7**, respectively.	In the last three years the numbers have risen by **eleven, six and seven**, respectively.
3	Multiple mating by females occurred in only **5 out of 34** species.	Multiple mating by females occurred in only **five out of thirty-four** species.
4	a **3-point** turn, a **4-day** week, a **size 7** component, a **6-year-old** child	a **six-year-old** child

making numbers plural

1. Whole numbers do not require an *-s* to indicate the plural and no preposition is used between the number and the noun.

2. An exception to Rule 1 is in expressions such as *tens, dozens, hundreds, thousands*, i.e. to indicate large generic numbers. In such cases *of* follows the number.

3. Fractions require an *-s* plural.

4. For reasons for readability, make single digits plural using *' s*. However, for other numbers (including dates) simply add an *s*.

5. A noun which follows a number is used in the singular form when acting as an adjective (technically these are called 'numerical modifiers'). Note the use of hyphens

	YES	NO
1	**Four thousand experiments** have been conducted so far.	**Four thousands of** experiments have been conducted so far.
2	**Hundreds of** people were at the conference.	**Hundred of** people were at the conference.
3	One and a half **hours** (= an hour and a half), three **quarters** of an hour, four **fifths** of a liter, nine **tenths** of a second.	One and a half **hour**, three **quarter** of an hour, four **fifth** of a liter, nine **tenth** of a second.
4	The table contains only **0's** and **1's**.	The table contains only **0s** and **1s**.
4	In the **1990s**, many airlines flew Boeing **747s**.	In the **1990's**, many airlines flew Boeing **747's**.
5	A **51-year-old** patient	a 51 **years** old patient
	i.e. a patient who is 51 years old	
	multi-**megabyte** memory	multi **megabytes** memory

singular or plural with numbers

1. Numbers and quantities require the verb that follows to be in the singular form. This is because they are seen as a mass rather than individual items.

2. The use of *there is / was* and *there are / were* depends on whether the noun that follows is in the singular or plural, respectively.

3. Use *another* , not *other* , before a number.

4. *None* is followed by a verb in the plural.

	YES	NO
1	Two weeks **is** not enough.	Two weeks **are** too few.
1	Three hundred kilometers **is** not too far.	Three hundred kilometers **are** not too far.
1	Clearly, $1,000,000 **is** a lot of money.	Clearly, $1,000,000 **are** a lot of money.
2	In this diagram there **is** a rectangle and two squares. = In this diagram there are **two** rectangles and a square.	In this diagram there **are** a rectangle and a square.
3	We need to do **another three** tests.	We need to do **other three** tests.
	= We need to do **three other** tests.	
4	None of the tests **give** optimum results.	None of the tests **gives** optimum results.

abbreviations, symbols, percentages, fractions, and ordinals

1. Always use numerals with abbreviations or symbols. Do not combine spelled forms of numbers with symbols.

2. P*ercentage* is one word, both *percent* (one word) and *per cent* (two words) are correct; do not use *%age.*

3. In ranges of percentages, either put the percentage symbol tends after the second number or after both numbers.

4. Fractions and ordinal numbers should not appear as digits (e.g. *1 / 4, 2nd*) at the beginnings of sentences or between other words.

5. Decimals are not written as words.

6. Decimals are written with a point (.) rather than a comma (,).

7. Commas tend to be used in whole numbers above 999 (but not in dates or horsepower).

	YES	NO
1	$2,000 / two thousand dollars	$two thousand
1	68c / sixty-eight cents	sixty-eight c
1,2	45% / forty-five per cent	forty-five%
1,2	The percentage of students who …	The %ge of students who …
3	The disease is fatal in **2–3%** of cases.	The disease is fatal in **2%–3** of cases.
	The disease is fatal in **2%–3%** of cases.	
4	**Two thirds** of those interviewed said that **one fifth** of their income was spent on fuel.	2/3 of those interviewed said that 1/5 of their income was spent on fuel.
4	The **first** and the **second** experiments proved the most successful.	The **1st** and **2nd** experiments proved the most successful.
5	The student scored **2.4** and **2.6** in the first two tests.	The student scored **two point four** and **two point six** in the first two tests.
6	The student scored **0.4** and **1.6** in the first two tests.	The student scored **0,4** and **1,6** in the first two tests.
7	The faculty has a total of **24,563** students.	The faculty has a total of **24563** students.

ranges of values and use of hyphens

You can introduce a range of values in three different ways:

*There should be **11 – 20** participants.*

*There should be **from 11 to 20** participants.*

*There should be **between 11 and 20** participants.*

Use a hyphen:

1. To indicate a range of values with numerals. But to indicate a range of values with words, use *to*.

2. With fractions that are made up of two words (e.g. *three- fifths, seven-ninths*).

3. With ages and periods of time. Note that there is no plural *s* on the time period.

	YES	NO
1	The courses last **15–20** weeks.	The courses last **fifteen–twenty weeks.**
1	The course will last **three to four** weeks.	The course will last **three–four** weeks.
2	**Three-quarters** of the employees in this institute come to work by car.	**Three quarters** of the employees in this institute come to work by car.
3	**Four-week** holidays can only be taken by **40-year-old** employees.	**Four weeks** holidays can only be taken by **40 years old** employees.

definite article (*the*) and zero article with numbers and measurements

Use the zero article:

1. With percentages and fractions.

2. Before the following words (and similar words) when they are followed by a number: *figure, appendix, table, schedule* etc.; *step, phase, stage* etc.; *question, issue, task* etc., *case, example, sample* etc.

3. With weights, distances etc.

4. In the expression *on average.*

Use the definite article:

5. Measurements that begin with *by.*

6. A number that has already been mentioned.

	YES	NO
1	Almost **80%** of scientific papers are published in English.	Almost **the 80%** of scientific papers are published in English.
1	More than **half** of the patients were infected with HIV.	More than **the half** of the patients were infected with HIV.
2	See the table in **Section** 2.	See the table in **the Section** 2.
2	We weighed **Sample 1** and **Sample 2** (see **Figure** 3).	We weighed **the Sample 1** and **the Sample 2** (see **the Figure** 3).
2	Details can be found in **Schedule** 2.	Details can be found in **the Schedule** 2.
3	The sample weighed **3 kg / three kilos**.	The sample weighed **the 3 kg / the three kilos**.
4	**On average**, debt rises by about $400 a month.	**On the average**, debt rises by about $400 a month.
5	Gold is sold by **the ounce** while coal sells by **the ton**.	Gold is sold by **ounce** while coal sells by **ton**.
6	Values must not go over a 90% threshold. This means that any values that go over **the 90%** threshold are not considered.	

definite article (*the*) and zero article with months, years, decades and centuries

1. Use the zero article before months (e.g. *July, August*) and years (e.g. 1992, 2013, 2024).

2. Use the definite article to refer to decades and centuries.

	YES	NO
1	Work began in **July** and is only expected to end in **2030**.	Work began in **the July** and is only expected to end in **the 2030**.
2	Research on this topic started **in the late 1990s**.	Research on this topic started **in late 1990s**.
2	**The twenty-first century / The 21st century** will witness the end of many minerals.	**Twenty-first century / 21st century** will witness the end of many minerals.
2	From **the 15th to the mid 16th century**, important changes were made to the techniques used in Chinese painting.	From **15th to mid 16th century**, important changes were made to the techniques used in Chinese painting.

once, twice* versus *one time, two times

1. *O nce* = one time, *twice* = two times. *once* and *twice* are more commonly found than *one time* and *two times* – avoid mixing the two forms in the same phrase. *thrice* (three times) is archaic and should not be used.

2. O nce and *twice* cannot be used after expressions such as a *minimum / maximum of.*

	YES	NO
1	The tests should be repeated at least **two or three times**.	The tests should be repeated at least **twice or three times**.
2	The test should repeated a **minimum of two times**.	The test should repeated a **minimum of twice**.

ordinal numbers, abbreviations and Roman numerals

There are three forms of writing ordinal numbers:

Form (A) word e.g. fi rst, second, third, fourth.

Form (B) abbreviation e.g. *1st, 2nd, 3rd, 4th.*

Form (C) Roman numeral e.g. *I, II, III, IV.*

1. Use Form A within the main text of a manuscript.

2. Use Form B with centuries, millenniums, dynasties etc.

3. Form B can also be used (e.g. July 4th) but usage with the cardinal form is equally acceptable and avoids possible errors with **-** *st, -rd,* and *-th.*

4. Some conference names use Form A, others Form B, and others Form C – there appears to be no rationale for deciding which form to use.

Note: do not mix the forms (e.g. *IIIrd*).

5. Use Form C with the names of people.

6. Arabic numerals (1, 2, 3) are used much more frequently than Roman numerals (I, II, III) for section numbering in papers.

	YES	NO (1–5), LESS COMMON (6)
1	This is the **first** time that ... During the **third** experiment we ...	This is the **1st** time that ... During the **3rd** experiment we ...
2	They can be dated to a time-span ranging from the **7th century** BC to the **2nd century** AD.	They can be dated to a time-span ranging from the **VII century** BC to the **II century** AD.
3	The Second Conference on Jugular Architecture will be held on **3 April 2026**.	The Second Conference on Jugular Architecture will be held on **3th** April 2026.
4	A summary of this paper was presented at the **Fourth / 4th / IV** Euroanalysis Conference, Helsinki.	A summary of this paper was presented at the **IVth** Euroanalysis Conference, Helsinki.
5	John Paul Getty **III**, King William **IV** and Pope John Paul **II** never met all together, but if they had ...	John Paul Getty **3rd**, King William **4th** and Pope John Paul **2nd** never met all together, but if they had ...
6	This is dealt with in more detail in **Sections 3 and 4**.	This is dealt with in more detail in **Sections III and IV**.

dates

1. Write centuries with Arabic numerals not Latin numerals. Note: nonreligious alternatives to BC (before Christ) and AD (anno domini – year of our Lord) are BCE (before common era) and CE (common era), and also BPE (before present era) and PE (present era). However these acronyms are not, as yet, very common.

2. Write decades in their full numerical form (1980s) rather than abbreviated form ('80s) as otherwise there could be confusion between centuries. Also use the plural *s* without an apostrophe.

3. Write the first decade of each century in words not numerals. Note that 2000s could refer to the period from 2000-2009, or 2000-2099.

4. The world has three principal systems for writing dates:

Form A: (dmy) 10 March 2020 = 10.03.2020.

Form B: (mdy) March 10, 2020 = 03.10.2020.

Form C: (ymd) 2020 March 10 = 2020-10-03.

The first form (number month year) is perhaps the clearest. To avoid confusion, always write the date with the month as a word.

	YES	NO
1	They can be dated to a time-span ranging from the **7th century** BCE to the **2nd century** CE.	They can be dated to a time-span ranging from the **VII century** BCE to the **II century** CE.
2	This paper presents an analysis of the techno-rhythms of the music of the **1990s**.	This paper presents an analysis of the music of the **'90s / 1990's**.
3	Little progress was made in the **first decade of the 21st century**, but considerable progress has been made in the **second decade / in the 2010s**.	Little progress was made in **2000s**, but considerable progress has been made in the **2010s**.
4	Smith et al. calculate that the world will end on **10 March 2030**.	They calculate that the world will end on **03.10.2030**.
		In the US, this would be interpreted as 10 October not 10 March.

Завдання до теми

What is meant by non-linearity

In the linear world, the relation between cause and effect is constant and the relation is quite independent of magnitude. For instance, if a force of 1 N, applied to a mass *m*, causes the mass to accelerate at a rate *a*, then according to a linear model, a force of 100 N, applied to the same mass, will produce an acceleration of 100*a*.

Strictly, a linear function *f* must satisfy the following two conditions, where it is assumed that the function operates on inputs $u_1(t)$, $u_2(t)$, $u_1(t) + u_2(t)$, $\alpha u(t)$, where α is a scalar multiplier.

Any system whose input/output characteristic does not satisfy the above conditions is classified as a non-linear system.

Thus, there is no unifying feature present in non-linear systems except the absence of linearity. Non-linear systems sometimes may not be capable of analytic description; they may be sometimes discontinuous or they may contain well-understood smooth mathematical functions.

The following statements are broadly true for non-linear systems:

(i) Matrix and vector methods, transform methods, block-diagram algebra, frequency response methods, poles and zeros and root loci are all inapplicable.

(ii) Available methods of analysis are concerned almost entirely with providing limited stability information.

(iii) System design/synthesis methods scarcely exist.

(iv) Numerical simulation of non-linear systems may yield results that are misleading or at least difficult to interpret.

Thus, the same system may be locally stable, unstable, heavily damped or oscillatory, according to the operating region in which it is tested. For a linear system, local and global behaviour are identical within a scaling factor – they are topologically the same. For a non-linear system, it is generally meaningless to speak of global behaviour.

Very loosely, we can organise our thinking about non-linearity in real-world systems. We comment as follows:

(a) very few real-world systems are strictly linear;

(b) a large class of systems can be regarded as approximately linear;

(c) a strongly non-linear class exists, but such systems may often be linearised;

(d) a class whose non-linearity is its most important characteristic exists and needs special consideration.

Linear methods will normally be applied to class (b) without any discussion.

Systems in class (c) will often be linearised to allow certain types of controller synthesis to be carried out. Checks by numerical simulation of the complete unapproximated system plus controller will then be used to determine whether the designs (based on linearised approximation) will be sufficiently valid in practice over a choice of envisaged operating conditions.

Systems in class (d) have their behaviour dominated by non-linearity. Such systems include:

(i) *Stable oscillators*: Governed by continuous non-linear differential equations such as the van der Pol equation. This type of equation exhibits, for the right choice of parameters, limit cycle behaviour. This stable oscillatory behaviour, essentially non-linear in its origins, is very interesting and has been much studied.

(ii) *Relay and switched systems*: The systems appear deceptively simple, but, because of the discontinuous non-linearity, special techniques of analysis are required. Because switched systems are both cheap and high performing, they are frequently applied in industry, even in situations for which they are not too well suited.

(iii) *A variety of systems exhibiting jump resonance, stick-slip motion, backlash and* *hysteresis*: All of these phenomena can be present as insidious and persistent degraders of performance of control loops.

Approaches to the analysis of non-linear systems

As discussed in (ii) above, available methods of analysis are concerned almost entirely with providing stability information.

Architecture of Industrial Automation Systems

The Functional Elements of Industrial Automation

An Industrial Automation System consists of numerous elements that perform a variety of functions related to Instrumentation, Control, Supervision and Operations Management related to the industrial process. These elements may also communicate with one another to exchange information necessary for overall coordination and optimized operation of the plant/factory/process. Below, we classify the major functional elements typically found in IA systems and also describe the nature of technologies that are employed to realize the functions.

Sensing and Actuation Elements

These elements interface directly and physically to the process equipment and machines. The sensing elements translate the physical process signals such as temperature, pressure or displacement to convenient electrical or pneumatic forms of information, so that these signals can be used for analysis, decisions and finally, computation of control inputs. These computed control inputs, which again are in convenient electrical or pneumatic forms of information, need to be converted to physical process inputs such as, heat, force or flow-rate, before they can be applied to effect the desired changes in the process outputs. Such physical control inputs are provided by the actuation elements.

Industrial Sensors and Instrument Systems

Scientific and engineering sensors and instrument systems of a spectacular variety of size, weight, cost, complexity and technology are used in the modern industry. However, a close look would reveal that all of them are composed of a set of typical functional elements connected in a specified way to provide signal in a form necessary. The various tasks involved in the automation systems.

Industrial Actuator Systems

Actuation systems convert the input signals computed by the control systems into forms that can be applied to the actual process and would produce the desired variations in the process physical variables. In the same way as in sensors but in a reverse sense, these systems convert the controller output, which is essentially information without the power, and in the form of electrical voltages (or at times pneumatic pressure) in two ways. Firstly it converts the form of the variable into the appropriate physical variable, such as torque, heat or flow. Secondly it amplifies the energy level of the signal manifold to be able to causes changes in the process variables. Thus, while both sensors and actuators cause variable conversions, actuators are high power devices while sensors are not. It turns out that in most cases, actuators are devices that first produce motion from electrical signal, which is then further converted to other forms. Based on the above requirement of energy and variable conversion most actuation systems are structured.

A. ***The electronic signal-processing element*** accepts the command from the control system in electrical form. The command is processed in various ways. For example it may be filtered to avoid applying input signals of certain frequencies that may cause resonance. Many actuators are themselves closed feedback controlled units for precision of the actuation operation. Therefore the electronic signal-processing unit often contains the control system for the actuator itself.

B. ***The electronic power amplification element*** sometimes contains linear power amplification stages called servo-amplifiers. In other cases, it may comprise power electronic drive circuits such as for motor driven actuators.

Контрольні питання

1. What is non-linearity?
2. Describe a structure of an actuation system.

Література: [8, 156–201; 9, с. 158–211].

Практичні заняття № 30–32

Тема 11 Computer System Architecture. Present Simple and Present Progressive

Мета: ознайомити студентів з лексикою та теоретичними відомостями, закріпити знання студентів із зазначеної теми.

Короткі теоретичні відомості

Present Simple and Present Progressive

Uses of the simple present tense:

✓ Permanent truths. We use the simple present for statements that are always true.

✓ The present period. We use the simple present to refer to events actions or situations which are true in the present period of time and which for all we know may continue indefinitely What we are saying in effect, is 'this is the situation as it stands at present

✓ Habitual actions. The simple present can be used with or without an adverb of time to describe habitual actions, things that happen repeatedly. We can be more precise about habitual actions by using the simple present with adverbs of indefinite frequency (always never, etc.) or with adverbial phrases such as every day / sometimes.

✓ We commonly use the simple present to ask and answer questions which begin with How often.

✓ Future reference. This use is often related to timetables and programmes or to events in the calendar.

✓ Observations and declarations. We commonly use the simple present with stative and other verbs to make observations and declarations in the course of conversation e.g. hope/assume/suppose/promise.

Uses of the present progressive tense:

✓ Actions in progress at the moment of speaking. We use the present progressive to describe actions or events which are in progress at the moment of speaking. To emphasize this, we often use adverbials like now, at the moment, just, etc.

✓ Temporary situations. The present progressive can be used to describe actions and situations which may not have been happening long or which are thought of as being in progress for a limited period. We also use the present progressive to describe current trends.

✓ Planned actions: future reference. We use the present progressive to refer to activities and events planned for the future. We generally need an adverbial unless the meaning is clear from the context. This use of the present progressive is also commonly associated with future arrival and departure and occurs with verbs like arrive, come, go, leave, etc. to describe travel arrangements.

✓ Repeated actions. The adverbs always (in the sense of 'frequently'), constantly, continually, forever, perpetually and repeatedly can be used with progressive forms to describe continually-repeated actions. Sometimes there can be implied complaint in this use of the progressive when it refers to something that happens too often.

Завдання до теми

1. Read the text and then explain Fig. 1 in your own words.

A computer is an electronic machine which can accept data in a certain form, process the data, and give the results of the processing in a specified format as information.

First, data is fed into the computer's memory. Then, when the program is run, the computer performs a set of instructions and processes the data. Finally, we can see the results (the output) on the screen or in printed form (see Fig. 1 below).

A computer system consists of two parts: hardware and software. **Hardware** is any electronic or mechanical part you can see or touch. **Software** is a set of instructions, called a program, which tells the computer what to do. There are three basic hardware sections: the **central processing unit (CPU), main memory** and **peripherals**

Perhaps the most influential component is the central processing unit. Its function is to execute program instructions and coordinate the activities of all the other units. In a way, it is the'brain'of the computer. The main memory (a collection of RAM chips) holds the instructions and data which are being processed by the CPU. Peripherals are the physical units attached to the computer. They include storage devices and input/ output devices.

Storage devices (hard drives, DVD drives or flash drives) provide a permanent

1. software 2. peripherals 3. main memory 4. hard drive (also known as hard disk) 5. hardware 6. input 7. ports 8. output 9. central processing unit CPU)	a) the brain of the computer; b) physical parts that make up a computersystem; c) programs which can be used on a particular computer system; d) the information which is presented to thecomputer; e) results produced by a computer; f) input devices attached to the CPU; g) section that holds programs and datawhile they are executed or processed; h) magnetic device used to store information; i) sockets into which an external device maybe connected

storage of both data and programs. **Disk drives** are used to read and write data on disks. **Input devices** enable data to go into the computer's memory.The most common input devices are the **mouse** and the **keyboard. Output devices** enable us to extract the finished product from the system. For example, the computer shows the output on the **monitor** or prints the results onto paper by means of a **printer**

On the rear panel of the computer there are several **ports** into which we can plug a wide range of peripherals - a modem, a digital camera, a scanner, etc. They allow communication between the computer and the devices. Modern desktop PCs have USB ports and memory card readers on the front panel.

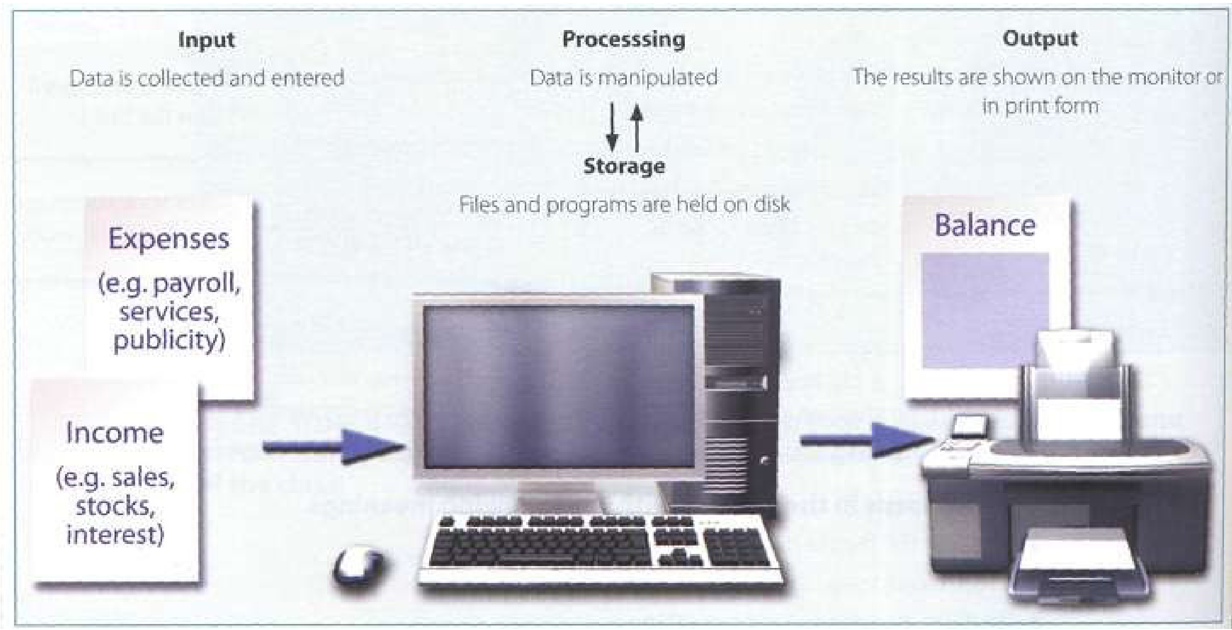


Fig. 1

2. Match the words (1-9) with correct meanings (a-i).

3. Now study the text below to find the information:

1. What is the memory size of this PC?
2. What storage devices are supplied?
3. What size is the display screen?
4. How fast is the processor?
5. What is the capacity of the hard drive?
6. Which operating system does it use?
7. What multimedia features does the computer have?

Match each item in Column A with its function in Column B. Then describeits function.

A item	B function
1. RAM	a) controls the cursor
2. processor	b) inputs data through keys like a typewriter
3. mouse	c) displays the output from a computer on a screen
4. clock	d) reads DVD-ROMs
5. flash memory key	e) reads and writes to electronic chips on a card
6. monitor	f) holds instructions which are needed to start up the computer
7. keyboard	g) holds data read or written to it by the processor
8. DVD-ROM drive	h) provides extremely fast access for sections of a program and its data
9. cache	i) controls the timing of signals in the computer
10. ROM	j) controls all the operations in a computer

Контрольні питання:

Mark the following as True or False:

8. Cache memory is faster than RAM.
9. The processor looks for data in the main memory first.

10. Write-through cache is faster than write-back cache.
11. Write-back cache requires a more intelligent cache controller.
12. Most programs use instructions that are stored in sequence in memory.
13. Most cache controllers transfer one item of data at a time.
14. Hardware and software disk caches work in much the same way.

Література: [2, с. 28–42; 3, с. 12–46].

Практичні заняття № 34–36

Тема 12 Operating System Concept. Past Simple and Present Perfect

Мета: ознайомити студентів з лексикою та теоретичними відомостями, закріпити знання студентів із зазначеної теми.

Короткі теоретичні відомості

Past Simple and Present Perfect

Study these examples of the Present Perfect from the recording of the artist.

1. I've scanned in about a third of these photographs.
2. I've organised the paintings into themes.
3. I've added a sound track.

Why doesn't the speaker use the Past Simple?

4. I scanned in about a third of these photographs.
5. I organised the paintings into themes.
6. I added a sound track.

We use the Present Perfect to describe past actions with present relevance.

The artist uses the Present Perfect because he is describing a CD he has just made and what he is going to do with it in the near future.

We use the Past Simple to describe completed actions in the past. It is often used with time expressions such as *last year, before PCs were introduced, in 1998.*

Note these examples from the recording:

7. I made one for Mary's birthday last week.
8. We tried it out last term.

Завдання до теми

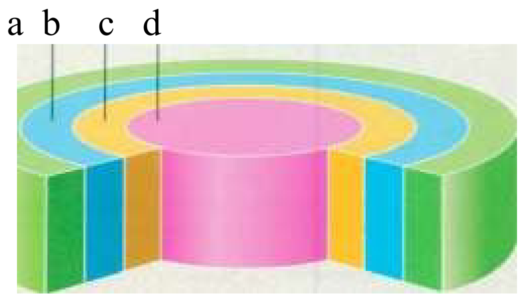
1. Match the labels to the four layers of this diagram with the help of the diagram caption.

1. Applications programs; 2. User; 3. Hardware; 4. Operating system.

Closest to the user are applications programs – software that helps a user compute a payroll or play a game or calculate the trajectory of a rocket.

The operating system is the set of programs between the applications programs and the hardware.

Conceptual diagram of an operating system



2. Now read this text to check your answer and to find the answers to these questions:

1. What difference is there between applications software and operating systems?

2. Why is the supervisor program the most important operating system program?

3. What is the difference between resident and non-resident programs?

4. What are the main functions of an operating system?

When a brand new computer comes off the factory assembly line, it can do nothing. The hardware needs software to make it work. Are we talking about applications software such as wordprocessing or spreadsheet software? Partly. But an applications software package does not communicate directly with the hardware. Between the applications software and the hardware is a software interface - an operating system. An operating system is a set of programs that lies between applications software and the computer hardware.

The most important program in the operating system, the program that manages the operating system, is the supervisor program, most of which remains in memory and is thus referred to as resident. The supervisor controls the entire operating system and loads into memory other operating system programs (called non-resident) from disk storage only as needed.

An operating system has three main functions: (1) manage the computer's resources, such as the central processing unit, memory, disk drives, and printers, (2) establish a user interface, and (3) execute and provide services for applications software. Keep in mind, however, that much of the work of an operating system is hidden from the user. In particular, the first listed function, managing the computer's resources, is taken care of without the user being aware of the details. Furthermore, all input and output operations, although invoked by an applications program, are actually carried out by the operating system.

3. Complete the gaps in this summary of the text on operating systems using these linking words and phrases: although, in addition, because, such as, but, therefore.

The user is aware of the effects of different applications programs operating systems are invisible to most users. They lie between applications programs, ______ wordprocessing, and the hardware. The supervisor program is the most important. It remains in memory,______it is referred to as resident. Others are called non-resident__they are loaded into memory only when needed. Operating systems manage the computer's resources,____the central processing unit.____they establish a user interface, and execute and provide services for applications software. ______ input and output operations are invoked by applications programs, they are carried out by the operating system.

Контрольні питання

1. What difference is there between applications software and operating systems?
2. Why is the supervisor program the most important operating system program?
3. What is the difference between resident and non-resident programs?
4. What are the main functions of an operating system?

Література: [2, с. 23–52; 3, с. 12–46].

Практичні заняття № 37–39

Тема 13 Computer Network Concept and Architecture. Enabling Words

Мета: ознайомити студентів з лексикою та теоретичними відомостями, закріпити знання студентів із зазначеної теми.

Короткі теоретичні відомості

Enabling words

New developments in computing are often designed to make something easier.These verbs are often used to describe such developments: ***allow, let, enable, permit, help.***

Study these examples:

1. A GUI lets you point to icons and click a mouse button to execute a task.

2. A GUI allows you to use a computer without knowing any operating system commands.

3. The X Window System enables Unix-based computers to have a graphical look and feel.

4. Voice recognition software helps disabled users (to) access computers.

Allow, enable and ***permit*** are used with this structure:

verb + object + to-infinitive

Let is used with this structure:

verb + object + infinitive

Help can be used with either structure

Завдання до теми

1. Read the text about Computer Networks.

A computer network or data network is a telecommunications network which allows computers to exchange data. In computer networks, networked computing devices exchange data with each other along network links (data connections). The connections between nodes are established using either cable media or wireless media. The best-known computer network is the Internet.

Network computer devices that originate, route and terminate the data are called network nodes. Nodes can include hosts such as personal computers, phones, servers as well as networking hardware. Two such devices can be said to be networked together when one device is able to exchange information with the other device, whether or not they have a direct connection to each other.

Computer networks differ in the transmission media used to carry their signals, the communications protocols to organize network traffic, the network's size, topology and organizational intent. In most cases, communications protocols are layered on (i.e. work using) other more specific or more general communications protocols, except for the *physical layer* that directly deals with the transmission media.

Computer networks support applications such as access to the World Wide Web, shared use of application and storage servers,printers, and fax machines, and use of email and instant messaging applications.

Wired technologies

Fiber optic cables are used to transmit light from one computer/network node to another. The orders of the following wired technologies are, roughly, from slowest to fastest transmission speed.

Coaxial cable is widely used for cable television systems, office buildings, and other work-sites for local area networks. The cables consist of copper or aluminum wire surrounded by an insulating layer (typically a flexible material with a high dielectric constant), which itself is surrounded by a conductive layer. The insulation helps minimize interference and distortion. Transmission speed ranges from 200 million bits per second to more than 500 million bits per second.

ITU-T G.hn technology uses existing home wiring (coaxial cable, phone lines and power lines) to create a high-speed (up to 1 Gigabit/s) local area network.

Twisted pair wire is the most widely used medium for all telecommunication. Twisted-pair cabling consist of copper wires that are twisted into pairs. Ordinary telephone wires consist of two insulated copper wires twisted into pairs. Computer network cabling (wired Ethernet as defined byIEEE 802.3) consists of 4 pairs of copper cabling that can be utilized for both voice and data transmission. The use of two wires twisted together helps to reduce crosstalk and electromagnetic induction. The transmission speed ranges from 2 million bits per second to 10 billion bits per second. Twisted pair cabling comes in two forms: unshielded twisted pair (UTP) and shielded twisted-pair (STP). Each form comes in several category ratings, designed for use in various scenarios.

An *optical fiber* is a glass fiber. It carries pulses of light that represent data. Some advantages of optical fibers over metal wires are very low transmission loss and immunity from electrical interference. Optical fibers can simultaneously carry multiple wavelengths of light, which greatly increases the rate that data can be sent, and helps enable data rates of up to trillions of bits per second. Optic fibers can be used for long runs of cable carrying very high data rates, and are used for undersea cables to interconnect continents.

2. With the help of this diagram, try to describe the function of these components of a typical network system:

1. a file server; 2. bridge; 3. a router; 4. a backbone; 5. a LAN; 6. a gateway; 7. a modem

Now read these definitions to check your answers.

A bridge is a hardware and software combination used to connect the same type of networks. Bridges can also partition a large network into two smaller ones and connect two LANs that are nearby each other.

A router is a special computer that directs communicating messages when several networks are connected together. High-speed routers can serve as part of the Internet backbone.

A gateway is an interface that enables dissimilar networks to communicate, such as two LANs based on different topologies or network operating systems.

A backbone is the main transmission path, handling the major data traffic, connecting different LANs together.

A LAN is a network contained within a small area, for example a company department.

A modem is a device for converting digital signals to analogue signals and vice versa to enable a computer to transmit and receive data using an ordinary telephone line.

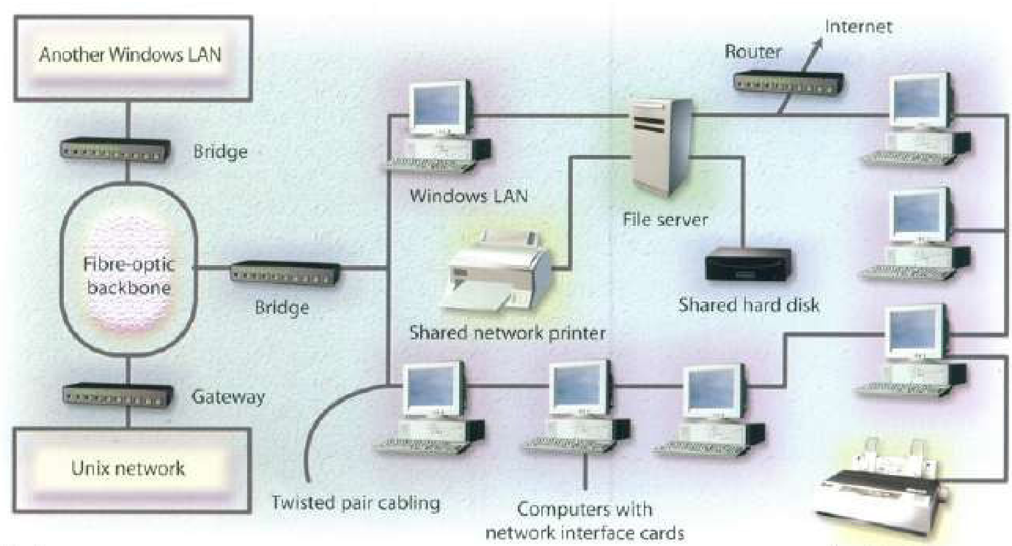


Fig 1
Components of a typical LAN

2. Complete the gap in each sentence with the correct form of the verb in brackets.

1. The Help facility enables users______(get) advice on most problems.
2. Adding more memory lets your computer______(work) faster.
3. Windows allows you________(display) two different folders at the same time.
4. The Shift key allows you_______(type) in upper case.
5. The MouseKeys feature enables you______(use) the numeric keypad to move the mouse pointer.
6. ALT+TAB allows you______(switch) between programs.
7. The StickyKeys feature helps disabled people________(operate) two keys simultaneously.
8. ALT+PRINT SCREEN lets you________(copy) an image of an active window to the Clipboard.

3. Complete the sentences with the words in the box.

allow	provide	enable

1. Process scheduling is an essential part of a Multiprogramming operating system. Such operating systems________more than one process to be loaded into the executable memory at a time and loaded process shares the CPU using time multiplexing.

2. An operating System is an intermediary between users and computer hardware.

It_______users an environment in which a user can execute programs conveniently and efficiently.

3. Time sharing is a technique which______many people, located at various terminals, to use a particular computer system at the same time.

4. Network Operating System runs on a server and_______server the capability to manage data, users, groups, security, applications, and other networking functions.

5. Threads ______ a suitable foundation for parallel execution of applications on shared memory multiprocessors.

6. Virtual memory is the separation of user logical memory from physical memory. This separation _____ an extremely large virtual memory to be provided for programmers when only a smaller physical memory is available.

Контрольні питання

1. What is a LAN?

2. What is a WLAN?

3. What are differencies, benefits and lacks of LAN and WLAN?

Література: [1, с. 53–85; 2, с. 345–380].

Практичні заняття № 40–42

Тема 14 Database Organization. Objective, facilitate

Мета: ознайомити студентів з лексикою та теоретичними відомостями, закріпити знання студентів із зазначеної теми.

Короткі теоретичні відомості

Objective [countable] – *something that you are trying hard to achieve, especially in business or politics [= goal]*

COLLOCATIONS

achieve/meet an objective

accomplish an objective (=achieve an objective)

have an objective

set an objective (=decide what your objective is)

main/primary/principal objective clear/specific objective career

objectives business objectives

1. He vowed to achieve certain objectives before the end of his presidency.

2. the best way to accomplish your objectives

3. The degree program has two main objectives.

4. Managers should set specific performance objectives for their teams.

5. The main objective was to improve children's knowledge of geography.

6. A clear objective was set and adhered to.

7. One of your first business objectives should be to get your own office.

8. State your business objectives clearly.

9. The objective of this computer game is to design a city.

10. The company's main objective is to keep recyclable material out of landfills.

Facilitate *– to make it easier for a process or activity to happen:*

1. Computers can be used to facilitate language learning
2. Both centers are electronically linked to facilitate communication.
3. Dividing students into small groups usually helps facilitate discussion.
4. Legislation is urgently needed to facilitate police counterterrorist operations.
5. Bodybuilders use mental imaging to facilitate their physical development.
6. The managers research, collect, and maintain special education materials and facilitate their distribution within a region.

Завдання до теми

1. Read the text and make questions to each paragraph.

What is a database?

A database is a tool for collecting and organizing information. Databases can store information about people, products, orders, or anything else. Many databases start as a list in a word-processing program or spreadsheet. As the list grows bigger, redundancies and inconsistencies begin to appear in the data. The data becomes hard to understand in list form, and there are limited ways of searching or pulling subsets of data out for review. Once these problems start to appear, it's a good idea to transfer the data to a database created by a database management system (DBMS).

A computerized database is a container of objects. One database can contain more than one table. For example, an inventory tracking system that uses three tables is not three databases, but one database that contains three tables. Unless it has been specifically designed to use data or code from another source, an Access database stores its tables in a single file, along with other objects, such as forms, reports, macros, and modules. Databases created in the Access 2007 format have the file extension .accdb, and databases created in earlier Access formats have the file extension .mdb. You can use Access 2007 to create files in earlier file formats (for example, Access 2000 and Access 2002-2003).

Using Access, you can:

Add new data to a database, such as a new item in an inventory

Edit existing data in the database, such as changing the current location of an item

Delete information, perhaps if an item is sold

Organize and view the data in different ways

Share the data with others via reports, e-mail messages, an intranet, or the Internet.

2. Read about the parts of an Access database and answer the questions:

1. What does a table look like?
2. What is normalization?
3. What is a row?
4. What do forms provide?
5. What are real workhoses in a database?
6. What do we use to add functionality to our database?

Tables

A database table is similar in appearance to a spreadsheet, in that data is stored in rows and columns. As a result, it is usually quite easy to import a spreadsheet into a database table. The main difference between storing your data in a spreadsheet and storing it in a database is in how the data is organized.

To get the most flexibility out of a database, the data needs to be organized into tables so that redundancies don't occur. For example, if you're storing information about employees, each employee should only need to be entered once in a table. Data about products will be stored in its own table, and data about branch offices will be stored in another table. This process is called normalization.

Each row in a table is referred to as a record. Records are where the individual pieces of information are stored. Each record consists of one or more fields. Fields correspond to the columns in the table. For example, you might have a table named "Employees" where each record (row) contains information about a different employee, and each field (column) contains a different type of information, such as first name, last name, address, and so on. Fields must be designated as a certain data type, whether it's text, date or time, number, or some other type.

Another way to describe records and fields is to visualize a library's old-style card catalog. Each card in the cabinet corresponds to a record in the database. Each piece of information on an individual card (author, title, and so on) corresponds to a field in the database.

Forms

Forms are sometimes referred to as "data entry screens." They are the interfaces you use to work with your data, and they often contain command buttons that perform various commands. You can create a database without using forms by simply editing your data in the table datasheets. However, most database users prefer to use forms for viewing, entering, and editing data in the tables.

Forms provide an easy-to-use format for working with the data, and you can also add functional elements, such as command buttons, to them. You can program the buttons to determine which data appears on the form, open other forms or reports, or perform a variety of other tasks. For example, you might have a form named "Customer Form" in which you work with customer data. The customer form might have a button which opens an order form where you can enter a new order for that customer.

Forms also allow you to control how other users interact with the data in the database. For example, you can create a form that shows only certain fields and allows only certain operations to be performed. This helps protect data and to ensure that the data is entered properly.

Reports

Reports are what you use to summarize and present data in the tables. A report usually answers a specific question, such as "How much money did we receive from each customer this year?" or "What cities are our customers located in?" Each report can be formatted to present the information in the most readable way possible.

A report can be run at any time, and will always reflect the current data in the database. Reports are generally formatted to be printed out, but they can also be viewed on the screen, exported to another program, or sent as e-mail message.

Queries

Queries are the real workhorses in a database, and can perform many different functions. Their most common function is to retrieve specific data from the tables. The data you want to see is usually spread across several tables, and queries allow you to view it in a single datasheet. Also, since you usually don't want to see all the records at once, queries let you add criteria to "filter" the data down to just the records you want. Queries often serve as the record source for forms and reports.

Certain queries are "updateable," meaning you can edit the data in the underlying tables via the query datasheet. If you are working in an updateable query, remember that your changes are actually being made in the tables, not just in the query datasheet.

Queries come in two basic varieties: select queries and action queries. A select query simply retrieves the data and makes it available for use. You can view the results of the query on the screen, print it out, or copy it to the clipboard. Or, you can use the output of the query as the record source for a form or report. An action query, as the name implies, performs a task with the data. Action queries can be used to create new tables, add data to existing tables, update data, or delete data.

Macros

Macros in Access can be thought of as a simplified programming language which you can use to add functionality to your database. For example, you can attach a macro to a command button on a form so that the macro runs whenever the button is clicked. Macros contain actions that perform tasks, such as opening a report, running a query, or closing the database. Most database operations that you do manually can be automated by using macros, so they can be great time-saving devices.

Modules

Modules, like macros, are objects you can use to add functionality to your database. Whereas you create macros in Access by choosing from a list of macro actions, you write modules in the Visual Basic for Applications (VBA) programming language. A module is a collection of declarations, statements, and procedures that are stored together as a unit. A module can be either a class module or a standard module. Class modules are attached to forms or reports, and usually contain procedures that are specific to the form or report they're attached to. Standard modules contain general procedures that aren't associated with any other object. Standard modules are listed under Modules in the Navigation Pane, whereas class modules are not.

An alternative concept in database design is known as *Hypertext*. In a Hypertext database, any object, whether it be a piece of text, a picture, or a film, can be linked to any other object. Hypertext databases are particularly useful for organizing large amounts of disparate information, but they are not designed for numerical analysis.

Контрольні питання

1. What does a table look like?
2. What is normalization?
3. What is a row?
4. What do forms provide?
5. What are real workhoses in a database?
6. What do we use to add functionality to our database?
7. Which characteristics of a database are more important?

Література: [7, с. 76–101; 8, с. 63–98].

Практичні заняття № 43–45

Тема 15 Database Design. Time Clauses

Мета: ознайомити студентів з лексикою та теоретичними відомостями, закріпити знання студентів із зазначеної теми.

Короткі теоретичні відомості

Time Clauses

What is the relationship between each of these pairs of actions?

a You click on a URL.
b Your browser sends it to a DNS server.

a The packets are passed from router to router.
b They reach the Web server.

a The packets may travel by different routes.
b They reach the Web server.

a The individual packets reach the Web server.
b They are put back together again.
Each pair of actions is linked in time. *We can show how actions are linked in time by using time clauses. For example:*

We can use ***when*** *to show that one action happens immediately after another action:*

1. When you click on a URL, your browser sends it to a DNS server.

We can use ***once*** *in place of when to emphasise the completion of the first action. It often occurs with the Present perfect. For example:*

2. Once the DNS server has found the IP address, it sends the address back to the browser.

We can use ***until*** *to link an action and the limit of that action:*

3. The packets are passed from router to router until they reach the Web server.

We can use ***before*** *to show that one action precedes another:*

4.The packets may travel by different routes before they reach the Web server.

If the subjects are the same in both actions, we can use a participle:

5. The packets may travel by different routes before reaching the Web server.

We can use ***as*** *to link two connected actions happening at the same time:*

1. As the individual packets reach the Web server, they are put back together again

Завдання до теми

1. Read the text and ask questions.

Database management systems are generally categorized as transaction processing systems, decision support systems and/or knowledge-based systems. During their development each of these types of DBMS introduces different problems and challenges. Traditionally, SDLC models designed for developing DBMS followed the design-first-implement-later approach because of the DBMS were mainly of the transaction processing type. The authors believe, as we will explain later, that the design-first-implement-later approach does not work for the databases underlying data mining or knowledge-base systems or for that matter for any system where the requirements change very frequently.

Some of the traditional SDLCs models used for software development are: waterfall, prototypes, spiral and rapid application development (RAD). These life cycles models are defined broadly in terms of what each individual phase accomplish, the input and output documents it produces or requires, and the processes that are necessary in completing each phase. In general, the output deliverables from the previous phase serve as an input to the next phase. However, in these models it can be observed also that usually there is no interaction between two consecutive phases; therefore, no feedback between these phases exists. When creating a database system the feedback between some of the life cycle phases is very critical and necessary to produce a functionally complete database management system.

When choosing or defining a lifecycle model for database systems we need to take into account properties such as scope restriction, progressive enhancement, incremental planning and pre-defined structure. In addition, it is essential that the requirements and goals should be documented using a requirements traceability matrix (RTM) that will help in limiting the project to its envisioned scope. The database development life cycle should allow the incorporation of new user's requirements at a later phase due to the interactive nature that should exist between the user and the developers. This would make the enhancement of a product easier and would not increase the cost significantly. For this reason incremental planning is important for database system development. Apart from the initial planning phase, individual planning is required for the design and the requirements revision phases as they highly influence the overall implementation and the evaluation of the entire system. A life cycle model lacking any of aforementioned properties (scope restriction, progressive enhancement, incremental planning and pre-defined structure) would increase the cost, time and effort to develop a DBMS.

2. Read about Traditional Lifecycle Models and compare them.

This section discusses the traditional lifecycle models and shows that, at least one of the properties required for database system development (scope restriction, progressive enhancement, incremental planning and pre-defined structure), is missing from each of these lifecycles. For this reason, these life cycle models are not completely suitable for developing database systems. In the remaining of this section we briefly describe some of the most popular software models and point out their deficiencies for developing DBMSs.

Waterfall model: This is the most common of all software models. The phases in the waterfall cycle are: project planning, requirements definition, design, development, testing, and installation and acceptance (See Figure 1). Each of these phases receives an input and produces an output (that serves as the input for next phase) in the form of deliverables.

On the other hand, the waterfall model lacks the progressive enhancement and incremental planning property. In this model, the requirements are finalized early in the cycle. In consequence, it is difficult to introduce new requirements or features at later phases of the development process. This waterfall model, which was derived from the «hardware world», views the software development from a manufacturing perception where items are produced once and reproduced many times. A software development process does not work this way because the software evolves as the details of the problem are understood and discussed with the end user.

Prototype model: In this life cycle model, the developers create a prototype of the application based on a limited version of the user requirements. The prototype consists mainly of a «hallow graphics» which shows some basic and simple functionality. However, this may create a problem because the user may view the prototype as it were the final product overlooking some of the requirements specified in the SRS which may not be met fully by this «final product».

The prototype model limits the pre-defined structure property of a lifecycle. When a prototype is designed, the developer uses minimal code to show some requirements. During this process no integration with other tools is shown. This leads to uncertainty about the final product. The prototype may have to be re-designed in order to provide a finalized product and thus it may not look the same as the one shown to the user initially.

This lifecycle model does support the progressive enhancement property. However, since the user is only shown a prototype there may be features that the user would like to incorporate but which may too costly or time consuming to incorporate later in the project.

In the prototype model, the requirements are finalized early in lifecycle. The iterations are focused on design, prototyping, customer evaluation and review phases. This model lacks the incremental planning property as there is no planning after the initial planning phase.

Spiral model: This model is a combination of the prototyping and waterfall model. Starting with the requirements and a development plan, the system prototypes and the risks involved in their developments are analyzed through an iterative process. During each iteration alternative prototypes are considered based upon the documented constraints and risks of the previous iteration. With each subsequent prototype the risks or constraints are minimized or eliminated. After an operational prototype has been finalized (with minimal or no risks), the detailed design document is created.

The spiral model supports the scope restriction property of a lifecycle. The requirements are designed in a hierarchical pattern; any additional requirements are build on the first set of requirements implemented. In this model, the problem to be solved is well defined from the start. In consequence, the scope of the project is also restricted.

To control risk, the spiral model combines the development activities with a risk management process. This latter process requires expertise in the area of risk evaluation which makes the activities that need to be carried out very complex and difficult. The risk evaluation process imposes the consideration of constraints such as cost, time and effort for the entire project.

Figure 3 shows the activities and phases of the spiral model and its iterative nature. However, notice that the incremental planning property is still missing from this lifecycle. The initial iterations are focused on alternatives and risks involved in the prototype selected. However, none of these iterations focus on updating the SRS by discussing it with the end user. As a result of this the requirements may not be updated; this may lead to having missing or misunderstood requirements. Due to its iterative nature this model may work well for developing requirements that are well understood from the beginning of the project. However, it is not a good model for developing database systems where new requirements may arise during the later phases of the project. The spiral model also assumes that software is developed in discrete phases; for this reason it does not satisfy the property of incremental planning.

Rapid application development model (RAD): The basic approach of this model is to let the user try the application before it is finally delivered. The users provide feedback based upon their hands-on experience with the system.

The foremost problem with this model is that it is very easy to get caught in an unending and uncontrollable cycle of enhancements. This will lead to violations of the progressive enhancement and scope restriction property.

As the name of this model implies a prototype is created and installed as soon as possible at the user's site for their review. This model lacks the predefined structure because, in general, the rapid prototype phase is completed without strictly adhering to the guideline documents and the processes already defined to complete this phase.

As the incremental planning property of a lifecycle is missing in this model too. After the prototype is completed and evaluated by the end user the requirements may or may not change. If there are no changes in the requirements, then development of the system will continue as initially envisioned. However, if significant requirement changes are necessary, then it is imperative that a timeline for the remaining of the project be established but this is not generally done.

Контрольні питання

1. Which database design models do you know?
2. Which model is better for your database development?
3. Which steps of database design did you perform?

Література: [7, с. 202–295; 8, с. 212–295].

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