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Укладач: Жукова Н. М., к. філол. н., доц.

Рецензент: Соболев Ю. О., к. філол. н., доц.

Відповідальний

за випуск: Жукова Н. М., к. філол. н., доц.

Комп'ютерна верстка: О. Л. Ляшова

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ЗМІСТ

ТЕМА 2. ЗНАРЯДДЯ ПРАЦІ ЕЛЕКТРИКА.	5
Electrical Tool Kit List: What You'll Need, and What You Won't.	5
ТЕМА 3. ЗНАРЯДДЯ ПРАЦІ ЕЛЕКТРИКА.	8
Cool Tools: Hand Tools 2015.	8
ТЕМА 4. ЗНАРЯДДЯ ПРАЦІ ЕЛЕКТРИКА.	10
The Changing Hand Tool Market.	10
ТЕМА 5. ЗНАРЯДДЯ ПРАЦІ ЕЛЕКТРИКА.	13
Hand Tool Safety For Electricians.	13
ТЕМА 10. МАТЕРІАЛИ В РОБОТІ ЕЛЕКТРИКА.	16
Is Perovskite the Future of Solar Cells?	16
ТЕМА 14. ТЕХНІКА БЕЗПЕКИ ПРИ РОБОТІ З ЕЛЕКТРИКОЮ.	17
21 Golden Safety Rules.	17
ТЕМА 15. ТЕХНІКА БЕЗПЕКИ ПРИ РОБОТІ З ЕЛЕКТРИКОЮ.	19
Block the Shock: Electrocutation and PPE.	19
ТЕМА 16. ЕНЕРГОЗБЕРЕЖЕННЯ.	22
Home Energy-Saving Devices.	22
ТЕМА 17. РОБОТА ЕЛЕКТРИКА.	24
Electrician Tasks.	24
Job Creation.	26
What is Solar Energy?	27
Photovoltaic Solar Panels.	29
Advantages of Solar Panels.	32
Disadvantages of Solar Energy.	33
ТЕМА 21. ОБЧИСЛЕННЯ.	35
The Importance of Precision Measurement.	35
Electrician Math: Life-Saving Skills.	36
ТЕМА 22. СИСТЕМИ МІР ТА ІНСТРУМЕНТИ ВІМІРЮВАННЯ.	39
International System of Units (SI).	39
New Technique for MEMS Power Measurement.	43
Comparative Measurements of Electric Current.	45
Measuring Instruments.	46

ТЕМА 23. ТЕРМІНИ В ЕЛЕКТРОТЕХНІЦІ.	48
Electrical Definitions: The Building Blocks of Learning.	48
ТЕМА 24. ТИПИ ДРОТІВ.	52
Electrical Wire Size.	52
Electrical Symbols.	54
ТЕМА 25. З'ЄДНУВАЧІ ДРОТІВ.	57
How to Use Electrical Wire Connectors.	57
How to Strip a Wire.	58
Список використаних джерел	60

ТЕМА 2. ЗНАРЯДІЯ ПРАЦІ ЕЛЕКТРИКА.

Task. Read the following text and answer the questions.

Electrical Tool Kit List: What You'll Need, and What You Won't

Assembling an electrical tool kit with the **proper** tools is your responsibility.

Becoming an electrician means learning a trade that specializes in fixing or installing stationary machinery, electrical wiring in buildings, and many other types of apparatus.

What To Carry In A New Electrical Tool Kit Is Important!

With the new electrical components, maintenance and repairs these days, making sure you have the right tools in your kit is the essential.

The electrician designs, installs and maintains electrical systems. Many first time rookie electricians feel that they need to buy top of the line tools, but as long as your tools are sturdy and in good working condition you don't have to spend a fortune. It is recommended to start with a basic electrical tool kit set up.

An apprentice still has a long way to go before becoming a certified electrician, but still needs the right tools without having to buy the extras he will eventually need down the road.

Perfect Electrical Tool Kit For New Electricians

Someone once said "It's always recommended that you treat your new electrical tool kit like a woman would treat her purse. Always know where it is and treasure its contents even when lending something." Apprentices, as well as some professionals can leave tools behind, and if they move from location to location, never get their tools back.

Your tool belt and pouch will keep the tools organized, easy to find, and enable you to reach the tool that you need. You should have another pouch on your belt that is for holding screws and other small parts. Try to have one with at least three pockets.

First Thing Is Choosing The Right Electrical Tool Kit

As mentioned above you don't necessarily need to buy the highest quality or most expensive hand tools. For a tool kit I would suggest investing in the higher quality brands. It is easy to lose small hand tools but it's pretty difficult to lose an entire tool pouch.

Here are my **top three favourite** tool kits to use in the field and, why I consider them as the best.

1. Veto Pro Pac – This one is probably the ultimate tool bag for electricians. I've seen this pouch fall from 40 feet and it sustained no damage!

- Very durable.
 - Almost 100% weatherproof, keeping your tools free of rust!
 - Heavy duty zippers to keep tools protected from dirt/debris and to prevent them from falling out if it was tipped over.
 - Lots of storage slots so your tools are organized and easily visible.
- This is especially good when you are under pressure on the job and need specific tools to get a viable piece of machinery up and running.

- Excellent warranty on this tool kit.

2. Klein Tool Belt, this belt is very comfortable to wear. Even when it is loaded with tools it does not become cumbersome around your waist.

This is a great setup when you are required to climb up and down ladders and scaffolding. Most of all, it is **safe** to use while climbing.

- Can hold pretty much the same amount of tools as a full carry-around tool kit.
- Quick and easy access to tools.
- For more even weight distribution there are built-in attachment points for suspenders.

3. Occidental Leather Pouch, this pouch is made with the highest quality leather.

- Long-lasting.
- Resilient to abuse.
- Nice open set up to easily grab the required tool.
- Sturdy/reinforced bottom, sits very flat so it doesn't tip over.
- Shoulder strap loops for added carrying comfort.
- Recommended for a maintenance electrician.

The tool kits listed above are by no means the only high quality brands. I've listed them because I personally have used them or know people in the field who have.

Now It's Time To Fill That Electrical Tool Kit

The most basic tools that you will need in your electrical tool kit are:

- *Lineman's Pliers*. Heavy duty pliers for general use in bending, cutting, crimping, pulling wire and twisting off tie wraps.

- *Side Cutters*. Used to cut smaller gauge wires or to cut off tie wraps.
- *Cable Cutters*. More powerful than regular pliers used to cut large conductors and smaller cable. Be sure to use these only on copper and aluminium. Also known as “eagle beaks”.
- *Crimping Pliers*. Used to install butt splices and Sta-kons. Be sure to get a pair that has the insulated and non -insulated option.
- *Needle Nose Pliers*. Used for gripping in tight spaces, I find these work best when the pliers are rough at the end.
- *Vise-Grips*. Comes in handy as an extra support, especially when working alone.
- *Wire Strippers*. Available in many different sizes, used to strip the insulation from the wire without damaging the wire as long as the proper size is selected.
- *Hex Keys Metric*. Used to tighten electrical termination lugs.
- *Electrician Scissors*. Used for cutting thick gauge wire.
- *Tape Measure*. Used for measuring strut, conduit and tray and many other things. A 25-foot tape measure should be sufficient for any task.
- *Electrician Hammer*. Hammer/Pry nails and to pound stuff.
- *Crescent Wrench*. Handy when nut size isn’t known, this specific wrench has a good set of jaws that won’t lock up.
- *Hack Saw*. Used to cut strut, conduit and cable.
- *Torpedo Level*. Magnetized for convenience and accurate readings.
- *Tri-Square*. Used to make accurate cut lines for a straight edge.
- *Tin Snips*. Used to cut straight edge in sheet metal.
- *Channellocks*. Used to tighten conduit, conduit fittings, gang boxes and connectors. Purchase three different sizes.
- *Wrench Set*. Speed wrenches are well worth it, most commonly used 7/16, 1/2, 9/16.
- *Nut Drivers*. Used where a wrench can’t, most common sizes 1/4, 5/16, 7/16, 1/2, and 9/16.
- *Variable Screwdriver*. Used for various types of screws and terminals.
- *Socket Set*. Most commonly used sizes are 3/8, 7/16, 1/2, and 9/16
- *Skinning Knife*. Used to strip cable and insulation.
- *Multimeter*. Can test volts AC/DC, Amps, and resistance.

1. Why are two pouches recommended?
2. What advantages of Vetro Pro Pac are mentioned?
3. Why is Klein Tool Belt considered a great set up?
4. What makes Occidental Leather Pouch necessary for a professional electrician?
5. What is another name for cable cutters?
6. When are Needle Nose Pliers used?
7. When is Crescent Wrench necessary?
8. What tool is magnetized for convenience and accurate readings?
9. What device can test volts AC/DC, Amps and resistance?

ТЕМА 3. ЗНАРЯДЦЯ ПРАЦІ ЕЛЕКТРИКА.

Task. Read the following text and answer the questions.

Cool Tools: Hand Tools 2015

Published: October 2015

By Jeff Griffin

The list of hand tools that are essential to electricians has mostly remained unchanged over the years. Cable cutters and strippers, linemen's pliers, screwdrivers, crimpers, and other basic tools always are on belts or in pouches or toolboxes. Many of these tools look much like they did 20 years ago. However, since toolmakers continually improve their products, it's fair to say today's models are superior in many ways.

Evolutionary improvements are ongoing, there are more multitask tools, and several companies best known in the industry for other products have added hand tools to their offerings (e.g., Milwaukee and Southwire).

"Today's hand-tool consumers are looking for products that deliver new, innovative ways to accomplish tasks more quickly and efficiently," said Charlotte Gooding, senior merchant, hand tools for The Home Depot. "Core tools (e.g., screwdrivers, pliers, etc.) stay true to their user-application requirements, but they reinvent themselves over time with the addition of new features that promote better ergonomics, quality enhancements and increased function."

Gooding said hand-tool users look for brands they know and tools they trust.

“A professional with a toolbox full of national brand tools has a relationship with the brand and expectations for products that carry its name,” she said. “The right brand, combined with tools that perform, and meaningful innovations definitely provides an edge over hand-toolmakers that have not kept their products fresh [and] current.”

Ryan DeArment, vice president of sales and marketing, Channellock, said that time is money in today’s working world.

“Anything that can be done to aid the professional user in getting the job done quickly and reliably is key,” he said. “Hand tools today are generally better designed to help the user access hard-to-reach areas while being more comfortable to use and more progressive in appearance. It’s what the end-user demands, and committed manufacturers are listening.”

For example, Channellock introduced a new line of American-made screwdrivers for professionals last year. The tools have four-sided, high-torque acetate handles, which provide more torque compared to standard, six-sided handles. The four-sided handles are impact-resistant, strong, and durable, and according to DeArment, they have exceptional solvent resistance.

“Channellock tools are designed to fit both the job and the technician,” he said. “The E Series line of pliers features several sizes of cutting, long nose and combination linemen’s pliers. Slimmer, sleeker design reaches into tighter spaces and our improved high-leverage design required 40 percent less force to make clean, accurate cuts compared to other high-leverage pliers.”

Channellock invented the tongue-and-groove pliers in 1933, DeArment said, and it’s been a preferred tool ever since. Other milestones include the patented conical surface on the cam side of pliers when undercut in 1965, and the patent for the PermaLock fastener was added to the tongue-and-groove and slip-joint pliers in 1984.

“We don’t change tools just to make a change,” he said. “When we change something, we make sure it’s a needed change that will make tool users’ jobs easier.”

Nathan Buckert, product development manager, Ideal Industries, said: “Many additions and changes to hand tools in recent years are focused on working faster and more efficiently. Tool features can be added to an existing tool, which can take the place of an entirely other tool.

“Another trend is to make tools smaller and lighter while maintaining or even improving strength and performance.”

1. What are today's hand-tool consumers looking for?
2. What do new features of the core tools promote?
3. How is a new line of American-made screwdrivers by Channellock different from the standard ones?
4. What does the E Series line of pliers feature?
5. When were the tongue-and-groove pliers invented by Channellock?

ТЕМА 4. ЗНАРЯДЦЯ ПРАЦІ ЕЛЕКТРИКА.

Task. Read the following text and answer the questions.

The Changing Hand Tool Market

Published: October 2015

By Jeff Griffin

In 2010, power tool manufacturer Milwaukee introduced a line of manual hand tools for the electrical market, and the offerings of hand tools and testers has rapidly expanded. More recently, wire and cable manufacturer Southwire unveiled a line of hand tools for electricians.

Milwaukee has hundreds of products in its hand tool portfolio, said Tim Albrecht, senior vice president and general manager, hand tools.

“With a focus on key vertical trades, we set out to deliver innovative solutions that would make the user’s job easier regardless of if the tool had a motor or not,” he said. “Extending to hand tools made sense for us because our customer uses hand tools every day. With this focus on innovation rather than ‘me too’ products, we definitely are seeing the impact on long-established brands.

“With more competitors entering the marketplace, Milwaukee’s attention to innovation and user productivity set it apart from others. Sometimes it’s a matter of taking a tool that has been around for decades and really looking at how it’s used to make it better. Dedicated to delivering advanced solutions to increase productivity, this category will continue to grow and offer innovative products,” Albrecht said.

Citing the trend toward multifunction tools, Albrecht offered the example of Milwaukee’s popular 6-in-1 combination wire pliers, which

enable electricians to carry fewer tools to the job. He said more job sites than ever before are requiring insulated tools. He expects this trend to continue as an added safety measure.

Southwire introduced its line of professional-grade electricians hand tools in 2013, including pliers, strippers and screwdrivers as well as a wide array of electrical meters and testers. In 2014, more than 40 voice/data/video tools and test instruments were added to the hand tool product line. —J.G.

Alan Sipe, president, Knipex Tools, said: “Improvements in the ability of tools to perform their function faster and easier are the drivers of today’s best tool manufacturers.

“The basic use for many hand tools has not changed much since their invention, but there have been and continue to be major improvements in quality, ability to perform and user comfort. For instance, pliers started with bare handles and then improved when dipped. Plastisol-type handles were developed. Most quality pliers are available with single or dual-material comfort grip handles providing a firmer and more comfortable grip.

“Pump pliers with a simple arc joint have improved dramatically. The best jaws are now hexagonal-shaped, letting the user securely grip any shaped item. The best styles now are adjusted and set with a push button for a secure setting. These tools have 30 percent more capacity than similar ‘old-style’ tools.

“We are also seeing a huge demand for new, high-quality tools in miniature sizes. Industrial and commercial equipment is getting smaller and more efficient, and technicians need to have great tools to get into tight spaces and fix things. Another optional improvement over the years is the availability of insulated handles to help protect users from electric shock.

“We are seeing some companies make inroads with well-merchandised, Asian-imported tools, leveraging rebate opportunities to ‘big box’ stores. The price/value relationship between these products must be considered since these tools are purchased and privately labelled, so users don’t know who manufactured the tools, what their quality is, and how long the tool will last. Trade professionals are not fooled easily,” Sipe said.

Mark Klein, president, Klein Tools, said: “My great, great, great, grandfather founded Klein Tools in 1857 in Chicago. We have been making hand tools in America ever since, and we are known for our quality, craftsmanship and durability. We use a proprietary tool steel and do

our own forging and heat-treating in-house to ensure we meet our high standards. Klein Tools has more than 155 years of experience that won't be replicated by others any time soon. Professionals rely on our products to get their job done. It is my family's name on the product, so when tradespeople pick up a Klein tool, we don't want to let them down."

Technology advances, building code changes, updated safety laws, association or vendor requirements, new building material products, application improvements or multiuse products all contribute to the creation and advancement of new hand tools and accessories.

Klein Tools products are constantly reviewed to see how they can be made more efficient, comfortable or useful.

Examples of recent developments include fiberglass fishing tools with a proprietary protective coating to keep users' hands free from splinters when pulling wire; a foam wire-pulling lubricate alternative to gel and wax lubricants; development of a demolition screwdriver engineered for prying and chiseling as well as driving screws; all-purpose pliers that can strip, cut and loop 8–16 AWG solid and 10–18 AWG stranded wire, plus it has screw shearing holes; and cushion grip punchdown tools incorporating a two-step impact process that precisely inserts and then trims off excess wire and has a comfortable screwdriver shape design for accessing narrow, crowded blocks.

1. What set the Milwaukee apart from its competitors?
2. What drives today's best tool manufactures according to the president of Knipex Tools?
3. How have the pump pliers with a simple arc joint improved?
4. What are Klein Tools known for?
5. What contributes to the creation and advancement of new hand tools and accessories?
6. What are the examples of recent developments in Klein Tools products?

ТЕМА 5. ЗНАРЯДІЯ ПРАЦІ ЕЛЕКТРИКА.

Task. Read the following text and retell it summarizing the most important pieces of advice.

Hand Tool Safety For Electricians

Correct hand tool safety is vital for anyone who works with hand tools.

There are so many things that can harm you when working with these tools. You may think, they are small tools, how much damage can they really do? They can kill you. Especially electrical power tools.

An Accident is Always Possible

A hand saw or hammer may not do too much damage if the accident only involves you, but if that hammer comes crashing down on your head from three floors up, it will kill you.

That is why you should always wear a hardhat whenever there might be a chance of falling objects.

When working in high places, keep your work area clean and keep an eye on your tools. You don't want to be the one dropping that hammer on a fellow worker's head.

The best safety practice is to always put your tools back into your belt when not in use. It only takes a second, and it may very well save someone's life.

Power Tools

Power tools are the most dangerous hand tools. When you are using extension cords, you could get your feet tangled up or slip and fall. That is why cordless tools are better.

If you do work with extension cords, always ensure they are properly secured. Tape them to the floor or wall to get them out of your way.

Inspect your power tools before each use. Any signs of wear, frayed or exposed wire should be dealt with immediately. Do not use the tool.

Do not put off fixing the cord until the job is done. Fix it right away. An exposed wire could lead to electrocution. Maintenance is part of hand tool safety.

Never leave the power on. When you are finished with the tool, turn off the power before pulling the plug. The next time you go to use it you

may forget that you left the switch in the on position. This can cause a very serious accident.

Or, maybe someone else picks up the tool without realizing the switch is in the on position. You will be responsible for the injuries caused to that person.

Read the Tool Safety Guidelines

Tools come with hand tool safety guidelines. Ignoring these precautions can lead to serious injuries.

The manufacturer doesn't write up these guidelines so you will have something to read in your spare time. The guidelines and safe operating procedures are designed to teach you how to use the tool properly so that you won't get hurt.

Many experienced workers feel that safety guards and shields installed on power tools slow them down. These foolish individuals remove the guards and shields so that the job will go faster.

Never remove safety shields or guards. The shields are there for your protection. Removing them puts you at a higher risk of injury.

As an electrician you are usually required to work as quickly as possible. But, no matter how fast you have to complete the job, you should never put your health and safety at risk.

You won't get the job done any faster if you have to be rushed off to the hospital half way through.

On The Job Training

In my own working experience, I have found cut injuries to be the most frequent. In every single incident the individual was cutting towards themselves! ALWAYS cut AWAY from yourself! I've been in the trade for a long time and have never needed to cut towards myself. If you think about only cutting away then this is all you will do, and in turn you will eliminate your chance of cut injury by 99%.

When you are first starting out as an electrician apprentice, your master electrician will tell you all about hand tool safety. You will also learn about it in the classroom training portion of your apprenticeship. Plus, you will probably be told to read all of the safety guidelines and procedures that come with the tool.

This may sound like an overdose of safety training, but it's not. There is nothing more important than workplace safety. Thousands of workers every year are hurt or killed on the job.

Of course, once in a while you do have a freak accident, but in most cases, these injuries and deaths could have been avoided.

Most accidents happen when a worker is not paying close enough attention to the job at hand or handles his tools irresponsibly.

Use the Right Tool for the Job

Using the right tool for the job at hand is the first step in hand tool safety. Tools are designed to perform a specific task in a specific manner.

That's why you have screwdrivers in varying lengths and with different tips and pliers with different head shapes. When you use a tool improperly, you are asking for trouble.

You not only risk hurting yourself or maybe others around you, you may damage the tool. That may be a small consideration next to personal safety, but good electrician tools are expensive. Why take the chance of ruining your valuable tools?

Quality professional hand tools are designed to last for many years when properly cared for and used properly. Manufacturers design each tool for specific purpose. Using your screwdriver as a pry bar or chisel will make it useless when you need to actually use it as a screwdriver.

Use Insulated Tools

Working with electricity poses the threat of electrical shock. That is why there are tools specially designed for electricians. These are insulated to reduce the impact electricity may have on your body when you accidentally hit a live circuit.

You should never work on equipment until it is completely shut off. However, don't be complacent. You may come across a situation when you think the power is off, but there is actually a current still running through the machinery.

This could be from a computer or a medical device hooked up to the circuit that can not be shut down completely. Insulated tools will provide more protection than regular tools.

Don't make your job more dangerous than it already is. Always practice proper hand tool safety.

ТЕМА 10. МАТЕРІАЛИ В РОБОТІ ЕЛЕКТРИКА.

Task. Read the following text and answer the questions.

Is Perovskite the Future of Solar Cells?

IMT Staff posted on December 06, 2013

Are simpler, cheaper solar cells on the way? Work being done to improve solar cell efficiency using a mineral called perovskite at Oxford University raises interesting possibilities.

According to a summary at SciTechDaily, from about 2009 to now, solar cells made from materials called perovskites “have reached efficiencies that other technologies took decades to achieve, but until recently no one quite knew why.”

Perovskite is a calcium titanium oxide mineral species composed of calcium titanate. It can be found in the Urals and Switzerland, as well as in Arkansas and some chondritic meteorites. And it’s quite inexpensive.

As Inhabitat reported in August, the substance “is said to be very efficient at absorbing light and uses less material to capture the same amount of energy when compared to conventional solar absorbers,” meaning it could result in “dirt cheap solar power.”

Perovskite, according to SciTechDaily, was first used in 2009 to produce 3 percent efficient photovoltaic cells. Since then, scientists pushed the technology to achieve efficiencies beyond 15 percent, which overtakes other emerging solar technologies.

There’s more exciting news. Researchers reported in Science that they have figured out the secret to perovskite’s success: It’s a property known as the diffusion length, and they also think they have a way to improve diffusion length by a factor of 10.

“The diffusion length gives us an indication of how thick the photovoltaic film can be,” Sam Stranks, who led the discovery with a group at Oxford University’s Department of Physics, wrote for Science. “If the diffusion length is too low, you can only use thin films so the cell can’t absorb much sunlight.”

1. What is Perovskite?
2. Where can it be found?
3. What are its physical properties?

4. When was Perovskite first used?
5. What is the secret of Perovskite's success?

ТЕМА 14. ТЕХНІКА БЕЗПЕКИ ПРИ РОБОТІ З ЕЛЕКТРИКОЮ.

Task. Read the following text and retell it.

21 Golden Safety Rules

A **safe work environment** is not always enough to control all potential electrical hazards. You must be **very cautious** and **work safely**. Safety rules help you control your and others risk of injury or death from workplace hazards.

If you are working on **electrical circuits** or with electrical tools and equipment, you need to use following **golden safety rules**:

1. **Avoid contact with energized electrical circuits.** Please don't make fun of this rule if you already know this (*and you probably already know if you are reading these lines*) and remember that if something bad occurs – you probably won't have second chance. That's not funny.

2. Treat all electrical devices as if they are live or energized. **You never know.**

3. Disconnect the power source before servicing or repairing electrical equipment. **The only way to be sure.**

4. Use only tools and equipment with non-conducting handles when working on electrical devices. **Easy to check.**

5. Never use metallic pencils or rulers, or wear rings or metal watchbands when working with electrical equipment. This rule is very easy to forget, especially when you are showing some electrical part pointing with metallic pencil. **Always be aware.**

6. When it is necessary to handle equipment that is plugged in, be sure hands are dry and, when possible, wear nonconductive gloves, protective clothes and shoes with insulated soles. **Remeber: gloves, clothes and shoes.**

7. If it is safe to do so, work with only one hand, keeping the other hand at your side or in your pocket, away from all conductive material.

This precaution reduces the likelihood of accidents that result in current passing through the chest cavity.

If you ever read about current passing through human body you will know, so remember – work with one hand only.

8. Minimize the use of electrical equipment in **cold rooms** or other areas where **condensation** is likely. If equipment must be used in such areas, mount the equipment on a wall or vertical panel.

9. If water or a chemical is spilled onto equipment, shut off power at the main switch or circuit breaker and unplug the equipment. **Very logical.** NEVER try to remove water or similar from equipment while energized. Afterall, it's stupid to do so.

10. If an individual comes in contact with a live electrical conductor, do not touch the equipment, cord or person. Disconnect the power source from the circuit breaker or pull out the plug using a leather belt.

Tricky situation, and you must be very calm in order not to make the situation even worse.

Like in previous rules – Always disconnect the power FIRST.

11. Equipment producing a “tingle” should be disconnected and reported promptly for repair.

12. Do not rely on grounding to mask a defective circuit nor attempt to correct a fault by insertion of another fuse or breaker, particularly one of larger capacity.

13. ***Drain capacitors*** before working near them and keep the short circuit on the terminals during the work to prevent electrical shock.

14. Never touch another person's equipment or electrical control devices unless instructed to do so.

Don't be too smart. Don't try your luck.

15. Enclose all electric contacts and conductors so that no one can accidentally come into contact with them.

If applicable do it always, if not be very careful.

16. Never handle electrical equipment when hands, feet, or body are wet or perspiring, or when standing on a wet floor.

Remember: Gloves and shoes

17. When it is necessary to touch electrical equipment (*for example, when checking for overheated motors*), use the back of the hand. Thus, if accidental shock were to cause muscular contraction, you would not “freeze” to the conductor.

18. Do not store ***highly flammable liquids*** near electrical equipment.

19. Be aware that interlocks on equipment disconnect the high voltage source when a cabinet door is open but power for control circuits may remain on.

Read the single line diagram and wiring schemes – know your switchboard.

20. De-energize open experimental circuits and equipment to be left unattended.

21. Do not wear loose clothing or ties near electrical equipment. ***Act like an electrical engineer, you are not on the beach.***

ТЕМА 15. ТЕХНІКА БЕЗПЕКИ ПРИ РОБОТІ З ЕЛЕКТРИКОЮ.

Task. Read the following text and answer the questions.

Block the Shock: Electrocution and PPE

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By Tom O'Connor

Contact with electrical current is one of the leading causes of occupational injuries and fatalities. Due to the nature of their jobs, wire and line workers carry an exponential risk for being involved in these types of incidents. Electrocution is one of the Occupational Safety and Health Administration's (OSHA) "Fatal Four," along with fall hazards, struck-by hazards and caught-in/in-between hazards. Fortunately, with the support of safety-training programs, most electrical incidents can be prevented by following relevant regulations. However, one of the most significant safeguards that employees and employers can take is the use of appropriate personal protective equipment (PPE).

Many forms of PPE protect workers from electrical hazards. According to OSHA's eTool on Electrical Power, "Depending on the job task to be performed, PPE for the electric power industry generally includes safety glasses, face shields, hard hats, safety shoes, insulating (rubber)

gloves with leather protectors, insulating sleeves, and flame-resistant (FR) clothing.”

Note that all equipment, such as glasses and face shields, should meet appropriate standards for electrical work to protect against arc flash. With the advances in protective clothing technology and the updated requirements in the National Fire Protection Association (NFPA) 70E, Standard for Electrical Safety in the Workplace, arc-rated clothing should replace FR clothing.

In addition, some may require the use of insulating protective equipment (IPE). Examples include line hoses, rubber hoods, rubber blankets and insulating live-line tools such as hotsticks, switchsticks or shotgun sticks. However, IPE is not PPE, because it is not worn. This is worth noting because it is an important employee protection.

When determining the necessary PPE for a job, employers must conduct a hazard assessment to evaluate specific safety needs. Once the needs have been identified, employees must be trained on equipment use and care. It should also be continually addressed during daily job briefings. PPE should be inspected or tested each time it is used as required by OSHA and the American Society for Testing and Materials (ASTM) standard. This process ensures the PPE is not damaged or defective and will work as intended.

When inspecting rubber gloves, sleeves and cover-ups, look for imbedded foreign objects, holes, punctures, cuts, tears, ozone cutting and checking, texture changes, hardening, stickiness, swelling, softening, inelasticity or any other defects that may affect PPE insulating properties. Any one of these conditions requires the PPE to be removed from service.

It is also important to test PPE. An air test is a common method to check equipment such as rubber gloves. Squeeze or roll gloves (or other rubber goods) while listening for air escaping through cuts, tears or holes. It can also be done with an inflator. If any air escapes the PPE, it must be removed from service. Some employers also require the water test, which involves filling a glove with water to help find holes.

Rubber gloves should be tested at least every six months, if the insulating value is suspect, after repair and after use without protectors. Rubber sleeves or rubber insulating blankets should be tested every 12 months, if the insulating value is suspect and after repair. IPE, such as insulating covers and line hoses, only need to be tested if suspect.

When not in use, rubber gloves and sleeves should be kept in a canvas bag or other approved container to prevent damage. Gloves should also be stored with cuffs facing downward to allow drainage and better circulation. This will also minimize the possibility of objects falling into the glove. Rubber protective gear should never be stored folded up, in direct sunlight, near or with petroleum products, near sharp objects, or with anything on top of them. These conditions can greatly compromise the PPE properties.

In addition to rubber goods, hard hats should be worn to prevent being struck by falling objects and being electrocuted. Three classifications of hard hats can be worn in this scenario: Class E (Electrical) hard hats can withstand up to 20,000 volts of electricity, Class G (General) hard hats are able to withstand 2,200 volts of electricity, and Class C (Conductive) hard hats offer no protection from electric shock.

Similarly, three general classifications of protective footwear can protect employees from electrical hazards. They include nonconductive footwear, antistatic footwear and conductive footwear. Antistatic footwear is designed for working in environments sensitive to static electricity. Nonconductive footwear is insulated to prevent electricity from getting to ground when you come into contact with live circuits or electrical equipment. Conductive footwear is intended to be worn in environments where the accumulation of static electricity on the body can be hazardous.

1. What do these abbreviations from the article stand for?

PPE

FR

OSHA

ASTM

NFPA

IPE

2. What does PPE usually include?
3. How can employers determine the necessary PPE for a job?
4. What is a common method to check equipment such as rubber gloves?
5. How often should rubber sleeves and rubber insulating blankets be tested?
6. How should gloves be stored?
7. What is the general classification of protective footwear?

ТЕМА 16. ЭНЕРГОЗБЕРЕЖЕНИЯ.

Task. Read the following text and answer the questions.

Home Energy-Saving Devices

Major home energy use comes from temperature-related operations such as heating and cooling your food, water and home. The rest of the usage is consumed by electric lighting and appliances.

You can conserve energy by practicing these energy-saving habits:

- Check for drafts throughout the home. Check windows, doors and any other places warm air can escape and cold air can move in.
- Have your home audited to determine which areas are wasting energy. Home energy monitors can also help with this by telling you how much energy an appliance is consuming.
- Some appliances draw energy even when not in use. Unplug these, if possible, to ensure they aren't wasting electricity.
- Turn off lights, radios and television sets you are actively using.
- Recycle whatever you can.
- Close the refrigerator door. Keeping it open when pouring a drink or separating food items wastes energy because the internal temperature rises, which must then be cooled down again, taking more energy than maintaining a steady temperature.

In addition to changing your habits, there are all sorts of gadgets and appliances that can help you reduce the amount of energy you consume. New technology has improved the efficiency of these appliances, so they work just as well as older models, but use less than half the amount of electricity.

Energy Saving Light Bulbs

Energy-efficient light bulbs provide the same amount of illumination as incandescent bulbs, but only consume between one fifth to one third as much electricity. These bulbs also last up to ten times longer than conventional bulbs.

These bulbs are available in a variety of shapes and sizes, and fit into conventional fixtures, so you can use them for all of your lighting needs.

Solar powered lights – these come in a variety of styles and be used indoors or outdoors. The outdoor versions are different than the indoor versions, but both types work great. A full day of sunlight charges these

lights up enough to run until morning. This means that even on cloudy days, the lights gather enough sun energy to light up your yard or home until at least midnight, which is usually more than enough for the average household. Some small lights, like night lights, can be powered by just about any light, so they don't have to be put out in the sun during the day.

Lighting Controls

There are two main types of energy-saving lighting controls. Each one uses a passive infrared (PIR) sensor for automatic operation. The Occupancy Sensor control turns the light off when a person leaves the room and on when someone enters. The Vacancy Sensor control turns the light off when the room is empty. Both types of controls save electricity by making sure lights aren't left on in rooms no one is using. If you can't get into the habit of turning off lights you aren't using, these controls can be big help. They are also very useful for rooms with the switch on the wrong end – you won't have to walk through a dark room to turn on the light, it will come on automatically as soon as you enter.

Energy Efficient Appliances

- Vacuum electric kettle – unique cross between a kettle and a thermos. Save energy by boiling water less often. Once the water boils, it stays hot for hours.

- 1.7L Eco kettle – boils water faster than standard kettles to save energy. Includes a removable water filter and safety shut off feature.

- Manual espresso coffee maker – doesn't use any electricity, except what is needed to boil water in your eco kettle. The manual pump provides the pressure.

- Solar kettle – boils water using the power of the sun. For best results, use in direct sunlight, but water will heat on cloudy days.

- Eco bread maker – fresh homemade bread in less than half the time of regular automatic bread making machines.

- Rechargeable batteries and solar powered recharger – rechargeable batteries save money and the environment, while a solar powered recharger saves energy by using solar power to recharge the batteries instead of electricity. Batteries are available in all sizes, so you can power all of your devices with rechargeable batteries. And solar powered chargers are available for every size of rechargeable battery.

- Usage monitor – this device measures how much electricity an appliance uses. By reducing the length of time you use high consumption devices, you use less energy. Trying to not use high consumption devices

or reducing the number of these devices in your home, will reduce energy usage even more.

1. What energy-saving habits are listed in the text?
2. Which of the mentioned energy-saving habits do you have?
3. What is the difference between energy-efficient and incandescent light bulbs?
4. What types of energy-saving lighting controls can you name?
5. What is the function of the Occupancy Sensor?
6. What is the purpose of the Vacancy Sensor?
7. What energy-efficient appliances do you know?
8. What device boils water using the power of the sun?
9. What device measures how much electricity an appliance uses?

ТЕМА 17. РОБОТА ЕЛЕКТРИКА.

Task. Read the following texts and answer the questions.

Electrician Tasks

Machinery is becoming more complex and employers are searching for professionals trained in working with these complexities.

This raises the requirements for an electrical tool kit. You must be able to:

- Install, test, assemble or maintain electrical equipment, wiring, appliances and fixtures using power and hand tools.
- Diagnose malfunctioning machinery, systems and components, find the cause and correct it with hand tools and test equipment.
- Be able to correct circuit breaker wires or transformers.
- Do inspections of equipment, components and other electrical systems to find hazards and defects in compliance with all codes. Advise management about the safety of their equipment.
- Be able to plan layout as well as installation of all electrical wiring, fixtures and equipment based on the job specifications and codes. Train or direct workers to maintain, install or do repairs on equipment, wiring and fixtures.

- Follow blueprints or prepare sketches that determine where the wiring and equipment is located to insure safety and building rules are being observed.

- Be able to use the variety of tools in their electrician tool kit, such as measuring devices, power construction equipment, and testing equipment.

- Install a ground lead and connect motor power cables.

- Have business management duties knowledge for preparing reports, maintaining records and equipment supplies.

- Know how to repair wiring, equipment and fixtures with power and hand tools.

- Work from scaffolds, roofs and ladders to repair, install, or maintain.

- Place piping or tubing inside partitions or walls and place wires or cables in complete circuits between boxes.

- Fabricate or construct parts to specifications using hand tools.

- Attach small plastic or metal boxes to the wall for home electrical outlets or switches.

- Be able to do physically demanding jobs such as trench digging to lay conduit wires as well as lifting and moving heavy objects. Safety on the job is critical and even simple ladder safety needs your attention.

- Provide assistance in emergencies by knowing how to operate generators and floodlights.

- Maintain an up-to-date electrician's license or ID card that meets government regulations.

Industries that rely on a domestic demand such as metal product manufacturing, high technology, transportation, electrical equipment and food as well as component and appliance manufacturing have many job opportunities.

By specializing in as many different areas as you can, you will have more options to move through the different fields and land the career you want.

As the needs of businesses that hire electricians change, so does the job growth in each market. When becoming an apprentice electrician, do some research that will head you in the right direction as you begin your training toward becoming a certified electrician.

1. What does the job of an electrician involve?
2. What kind of character should an electrician have?
3. What is the most significant knowledge an electrician should possess?
4. What are the vital skills for an electrician?

Job Creation

Producing and installing solar panels creates more jobs for electricians. This is a great advantage to individuals as well as the economy as a whole. From researching and developing new techniques and technologies, to the actual building of the products, hundreds of thousands of jobs have already been created. The more solar panels are put to use, the more jobs will be created. Currently, only about 4 % of the electricity consumed world wide is produced by solar power.

The price of fossil fuels continues to rise, whereas the price per watt to convert solar energy continues to drop. Within the past decade, the cost has already been cut in half. The cost to mine raw materials keeps rising as well, but the cost of solar radiation is now, and will always be free.

But, the worst part about conventional fuel sources is the destruction it causes. Whole forests and vast amounts of eco-systems are being wiped out with every mining project. From the destruction caused by extraction to irresponsible practices that cause bodily harm to workers, and even death, the cost is more than society can bear.

Major examples include the Niger Delta where excessive oil extraction has poisoned the water which provided the main source of food for the local villages. And Canada's tar sands which destroys large amounts of the Boreal Forest and creates large toxic ponds from the by-products. A more widely known example is the BP oil spill of 2010. Eleven people were killed and 780 thousand cubic meters of crude oil was spilled into the sea.

Solar power avoids all of these problems, and many more. Solar technology is rapidly advancing. What used to be expensive, inefficient and bulky, is becoming cheaper, more efficient and more accessible all the time.

1. What is bad about conventional fuel sources?
2. What examples of the negative effect that the use of fossil fuels has can you give?

What is Solar Energy?

Solar energy is energy from the sun. By harnessing the powerful light and heat provided by the sun, it is possible to use this energy for heating, photovoltaics, thermal electricity, architecture and artificial photosynthesis.

The Earth has always depended on energy from the sun. It heats the land, water and air, helps plants grow and provides light during the day. People have been relying on energy from the sun long before technologies were developed to harness this power.

Solar energy is used either passively or actively. One example of how it is used passively is through architecture. By designing a building to let in the most possible light and using materials with high thermal and light dispersing properties, light and air can circulate naturally. This greatly cuts down on heating and electricity consumption.

Active solar energy includes thermal collectors and photovoltaic panels that harness the power and convert it into usable energy. The energy collected from the sun can be stored in batteries to be used during the night or on cloudy days. Or, it can be used to heat water which can heat homes or provide hot water for laundry and bathing.

The Power of the Sun

An estimated 174 petawatts (PW) of solar radiation is constantly coming into the upper atmosphere. Of this, approximately 30 % is reflected back into outer space, while the remainder is absorbed by the oceans, clouds and masses of land, creating climate conditions and life all over the world.

When this power is harnessed by man using new technologies to take the fullest advantage, a renewable energy source is accessed that can never be depleted. Every hour the sun beams down onto the Earth, more than enough energy is made available than the entire world can use in one year – based on current energy consumption.

Harnessing Solar Energy

In 1897 a U.S. engineer, inventor and solar energy pioneer Frank Shuman, built a demo model of a solar powered steam engine. Using

square boxes filled with ether, which comes to a boil faster than water, and fitted on the inside with black pipes, the heat from the sun created steam, and the engine ran.

Shuman established the Sun Power Company in 1908, for the purpose of building larger solar power plants. Along with A.S.E. Achermann, his technical adviser, and Sir Charles Vernon Boys, a physicist, Shuman improved the system by reflecting the light with mirrors. This greatly increased the heating capacity so that water could be used in the collector boxes, instead of ether. This allowed him to build a full scale steam powered engine, which he was able to patent.

Between 1912 and 1913, Shuman build the first solar thermal power station in the world, in Maadi, Egypt. The station used U-shaped troughs to deliver power to a 60-70 h.p. (45-50 kilowatt) engine which pumped over 22,000 liters (approx. 6,000 gallons) of water per minute from the Nile River to nearby cotton fields.

The development of inexpensive ways of using oil to power engines in the 1930s discouraged further solar energy advancements. A new wave of interest in Shuman's basic design and vision for solar energy began during the 1970s.

Solar Energy in Use Today

Although one hour of sunlight produces enough energy to satisfy the needs of the entire world for a whole year, the technology is used for less than one tenth of one percent of the global demand.

Most people know about photovoltaic cells used on small calculators, rooftops, construction signs and some street lights. These cells are made of semiconductor materials like the ones used in computer chips. When the sun's rays hit the cells, electrons are separated from their atoms and flow through the cells, generating electricity.

On a much larger scale, power plants use a variety of techniques to harness the sun's power as a source for heat. Similar to Shuman's invention, the heat from the sun boils water to produce steam, which powers a turbine and generates electricity.

Another technique employs long, U-shaped troughs lined with mirrors that focus the rays on an oil filled pipe running through the center. The hot oil brings the water to the boiling point, and there by generating electricity. A different technique uses moveable mirrors to concentrate the rays onto a collector tower, which holds a receiver. The heat causes the molten salt inside to flow through the receiver, generating electrical power.

Solar energy is an inexhaustible source of fuel that doesn't produce any pollution and usually very little noise. The technology is also versatile and can be used in remote places, providing electricity where it may otherwise not be accessible. However, implementing this technology is still quite expensive, but by taking advantage of various tax incentives, a solar energy installation can pay for itself within about five to ten years.

3. Where can solar energy be used?
4. How is solar energy used passively?
5. How is solar energy used actively?
6. How much energy is reflected back into outer space?
7. What was F. Shuman's basic design and vision for solar energy?
8. How do power plants harness solar energy?
9. How do photovoltaic cells on small calculators work?

Photovoltaic Solar Panels

Individuals have been using solar power in various ways since the beginning of time. The power of the sun has been used to dry meats, fruits, vegetables and especially clothes.

Many people today still rely on the sun to dry their clothes in the summer. Plants and animals wouldn't survive without the sun.

During the 1980s, scientists began to harness the power of the sun on a larger scale. Located in California's Mojave Desert, the 354 megawatt SEGS is the largest solar power production plant in the world. Spain is home to two other large CSP plants – the Solnova (150 MW) and the Andasol (150 MW).

Some of the biggest power plants in the world that use photovoltaic solar panels, exist in India. The Gujarat Solar Park for example, generates 214 MW.

How do photovoltaic solar panels work?

Photovoltaic solar panels convert sunlight into electricity. They do this directly with photovoltaics (PV). Another way this is accomplished is indirectly with concentrated solar power (CSP).

With a concentrated solar power system, lenses or mirrors and sophisticated tracking systems are used to focus a large spectrum of

sunlight into one small beam. The photovoltaic method converts sunlight into electrical power using the photoelectric effect.

Solar power cells convert sunlight into electricity. An upgraded industrial system will use mirrors or lenses to take a large area of sunlight and concentrate the light into a small beam.

Once the light is focused, it can be used in various ways. The most developed methods include the parabolic trough, the solar tower, the Stirling dish and the concentrating linear Fresnel reflector.

How Do Electric Solar Panels Work With a Parabolic Trough?

The parabolic trough is a conic mirror usually made of polished aluminium or coated silver that has a Dewar tube at the focal point, along its full length.

The mirror reflects the sunlight and concentrates the heat on the Dewar tube. Normally the trough is aligned north to south and rotates in order to track the movement of the sun as it crosses the sky.

A fluid inside the tubes absorbs the concentrated sunlight. The fluid is heated up to about 400°C. The heat transfer fluid then heats the steam in a standard turbine generator. The generator then supplies the power.

Solar Tower

The solar power tower uses movable, flat mirrors (called heliostats) to concentrate the light from the sun onto a collector tower. Early designs used the concentrated sunlight to heat water, which in turn would heat steam to power a turbine, just like the parabolic trough.

New designs now use liquid sodium. These fluids have a high heat capacity, which can be used to store the energy before using it to boil water to drive the turbine generators.

With this design power can be generated even on cloudy days.

How Do Electric Solar Panels Work With a Stirling Dish?

In the Stirling dish system the solar concentrator is in the form of a dish, where the mirrors are made of curved glass.

The parabolic dish rotates with the movement of the sun throughout the day. The sunlight is concentrated and the heat is absorbed by the internal liquid, which is then transformed into grid-quality electricity.

The internal liquid is usually hydrogen or helium, which is recycled through the engine. As with the other concentrated solar systems, the fluid is heated and pressurized by the solar receiver.

But, instead of using turbines, this system uses the Stirling engine, which was first developed in 1812.

The photovoltaic system is comprised of one or more solar panels. The panels collect the sunlight which is then converted into energy by a controller or a power converter.

There are several interconnections and mounting hubs for the other components. One small photovoltaic system is enough to provide power to a single device like a garden lamp or Christmas lights.

Large PV systems connected to a grid can provide enough energy for an entire neighbourhood.

The photovoltaic system is the most user-friendly, especially on a small scale. You have probably seen many of these on calculators for decades. More recently, you will have seen them pop up all over the neighbourhood, lighting backyards and front walkways.

Installing a sophisticated system that will power your entire house is much more complicated. The idea and technology is the same, only on a much larger scale.

How Do Photovoltaic Solar Panels Work Out For Smaller Dwellings?

Smaller systems are ideal at the cottage where you don't have any other source of electricity. All you need are a few solar panels, a converter and some large batteries, like car batteries.

To use the power, you will also need some type of mount, like an eliminator. Eliminators are also capable of storing power, so it can double as an extra battery.

The photovoltaic solar panels collect the power from the sun, which is then converted into usable power by the converter. This power is stored in the batteries, so that you will have power on cloudy days and throughout the night.

Most eliminators have several different outlets. You can use any type of device that needs 110V power.

The average person can probably set up a small system on a cottage, but for a full-size house, you should call a professional.

As an electrician, you will be the professional people call. Solar power might not fall into the regular definition of the electrical trade, but as more people go green, the more the need will increase for electricians to move into the field of solar power.

The sun may be expected to last forever, but the lifespan of these solar systems is not quite that long. As technologies advance, they will last

longer, but presently the average lifespan of any solar power system is only about 5 years.

This means not only a lot of installation work, but a lot of maintenance, as well.

Harnessing the power of the sun is still in its infant stages. How do photovoltaic solar panels work? We still have a lot of learning and experimenting ahead of us to truly answer that question.

1. How do photovoltaic solar panels work?
2. What are the biggest Concentrated Solar Power Plants?
3. What are the most developed methods of using solar power?
4. What is the working principle of a parabolic trough?
5. How does a solar tower operate?
6. How do electric solar panels with a stirling dish operate?

Advantages of Solar Panels.

A solar panel is a group of solar photovoltaic (PV) cells connected together electronically, packaged in a module and mounted to a supporting structure. The cells collect energy from the sun which can then be converted into a useable source of power. The system generally includes a set of solar panels and an inverter, and some systems also include storage batteries or solar trackers.

The inverter is what converts the DC solar energy into usable AC electricity, which can then be used immediately or stored in batteries for later use. The solar tracker follows the movement of the sun throughout the day in order to collect as much energy as possible.

There are many advantages of solar panels, the biggest is that they don't produce any green house gases. You get all of the electricity you need, without increasing your carbon footprint on the earth. The process of producing solar energy doesn't create any smoke, gas or any other type of chemical by-product.

Free Supply of Energy

Another huge advantage of using solar power is the free supply of energy. Aside from the initial cost of equipment and installation, and maintaining the equipment, there are no other costs involved. Solar energy doesn't need a continuous supply of raw materials like coal or oil. Operational costs are much lower as well, because raw materials don't have

to be extracted from the earth, refined or transported. The only material needed is the radiation from the sun, which is supplied in large quantities, and completely free of charge.

The life expectancy of solar panels varies from one manufacturer to another, but in general, they are expected to last for up to 40 years. Most panels carry a warranty between 25-30 years.

Power Sources Available Anywhere

Anywhere there is sunlight, you have a power source for your solar panels. Power sources used to produce conventional electricity, like gas, coal and oil, have to be transported great distances before they reach your home. This means additional costs, labor, fuel for trucks or ships, wear and tear on the roads, plus the cost to the environment because of the pollution created by the transportation methods.

Going Off the Grid

One of the main reasons people choose to go solar is to get off the grid. Saving the Earth is a big factor, as well, but the concept of producing free energy from a renewable resource is the goal for many. No more monthly bills or brown-outs to worry about. With good solar panels and an adequate storage system, you never have to rely on conventional energy.

This is particularly advantageous to people living in rural areas who experience frequent power outages, and where the cost to install power lines can be extremely high, or not possible at all.

1. Why are solar panels useful?

Disadvantages of Solar Energy.

The sun provides free energy that can be used in a variety of ways. The most obvious is the light and heat it provides during the day. We can see outside, and with a properly designed house, much of the light we need indoors can be provided, as well. The sun can also be used to dry laundry and warm up the water in swimming pools. More importantly, the sun helps food grow and influences the weather.

Using the power of the sun in these ways is free, and doesn't have any drawbacks. However, when harnessing the sun to create solar energy there are some disadvantages. The most obvious drawback is that isn't available during the night, and it is much less powerful on cloudy days. In order for solar panels to collect the most energy possible, they have to face

the sun directly. This is why large “solar farms” place the panels on rotating towers that track the sun’s movement throughout the day.

The problem is that even the most efficient solar cells can only convert a little more than 20% of the solar rays into electricity. Advances in solar cell technology are likely to increase the efficiency in the near future, but for now, that is all they can do.

High Cost of Equipment

Using solar energy is completely free, however the equipment used to harness, convert and store the power is quite expensive. Although government tax incentives help to off-set some of these costs, it is still an expensive project. It can take up to ten years for the system to pay for itself. This time can be reduced if the homeowner is able to sell excess electricity back to the grid.

Requires a Large Surface Area

Even a small, single family home requires a large surface area of solar panels for the system to be efficient enough to provide a reliable source of electricity. This can be a huge problem when space is limited. Most homeowners install the panels on the roof of the house because the space is usually large enough, and the panels have the greatest exposure to the sun.

Lots of Sunlight is Needed

In order for the system to work efficiently, the panels need lots of sunlight. The solar panels must be installed in a sunny area and in such a way as to receive the most sunshine as possible. For most homeowners, placing the panels on rotating towers isn’t an option, so they have to find an area on the roof with the most direct sunlight, and not in the shade of trees or other buildings.

Pollution

Where in the world you live can also be a disadvantage of using solar panels. For example, high levels of pollution can reduce the efficiency of photovoltaic cells. Like heavy cloud cover, pollution can restrict the amount of solar energy the cells receive. This problem is being resolved with new designs that incorporate technologies to fight these effects. However, these technologies are still in the experimental stage and not yet ready for wide spread use.

Doesn’t Work at Night

Most residential solar energy systems are only useful on sunny days. To produce electricity at night or on cloudy days, some systems use

batteries to store the energy, and draw on the batteries when sunlight isn't available. The biggest disadvantage of this is that you need a lot of high capacity batteries to store enough energy for even a minimum amount of use. For example, you probably won't be able to store enough energy for a load of laundry, but you may be able to use some lights and maybe a television for a few hours. And once the batteries are drained, it can take a full day or more of direct sunlight to recharge them. If you have several days in a row without enough sunlight to fully charge the batteries, you could be in big trouble.

Industrial solar power stations that use molten salt to power a generator are able to produce electricity throughout the night because the salt retains enough heat to keep the generator running.

Currently, these are the main disadvantages of changing over to a solar energy system to generate electricity for your home. As technology advances, more and more of these disadvantages will be overcome. The costs of purchasing and installing the systems will come down and new, better ways of storing the energy will be created. But even now, the advantages of using solar energy far outweigh the disadvantages.

1. What are the disadvantages of solar energy?
2. Which disadvantage is the most significant in your opinion?
3. Why are the panels of the "solar farms" placed on rotating towers?

ТЕМА 21. ОБЧИСЛЕННЯ.

Task. Read the following texts and answer the questions.

The Importance of Precision Measurement

Life in the 21st century relies heavily on precision measurement. Often we are not even aware of it:

- Satellite navigation systems depend on ultra-stable clocks, as any small error in timing can throw navigation a long way off course.
- Electrical components ordered from different suppliers will work together in your personal electrical goods.

- Food producers know the optimal temperature for preparing biscuits perfectly, so that they do not waste any unnecessary energy.

Precision measurement is at the heart of each of these experiences, and many more that we often take for granted.

When it all goes wrong: even simple measurement mistakes can be very costly!

- The Great Kersten Blunder. Software controlling the Vigor space probe, on course for Venus, used 24.5 instead of 25.4 to convert millimetres to inches. The error meant that the probe missed Venus completely, and \$2 billion worth of technology was lost. The eponymous Kersten was the programmer who made the error.

- NASA's Mars Climate Orbiter. Programming teams in Europe and the USA used two different measurement systems, imperial and metric, to calculate the trajectory of the spacecraft. The probe consequently entered the Martian atmosphere at the wrong angle, and promptly disintegrated.

- The 'Gimli Glider'. An Air Canada Boeing 767-233 jet was refuelled in Montreal using 22 300 pounds of fuel instead of 22 300 kilograms. The pilot calculated how much fuel he needed thinking he was getting his fuel in pounds per litre. When the plane ran out of fuel mid-flight, the pilot had to make an emergency 'gliding' landing at Gimli Canadian Air Force Base.

1. What measurement mistakes are mentioned in the text? Can you add anything to the list?

2. Do you know any examples when precision measurement was vital?

Electrician Math: Life-Saving Skills.

Electrician math is vital to your career, maybe even your life.

When you construct a building that will last, you have to start with a strong foundation. No one sees the foundation when the building is finished, but it is an essential part of the structure. Electrical formulas and concepts are the foundation you need to be a successful electrician.

Many people don't even realize how important math is in their lives. You use it in just about everything you do. From measuring the coffee grounds and water for your coffee in the morning to counting your money at the grocery store – everything involves math in some shape or form.

This is especially true for an electrician. You are constantly calculating measurements and voltages. You will always be using basic arithmetic (mostly fractions) to calculate many of these measurements.

You will need to know basic right angle trigonometry when bending conduit, in order to find the correct angle and the necessary distance between bending points. Just about every job you do will involve some type of math.

Changing a Fraction to a Decimal

To change a fraction into a decimal, divide the top number (numerator) by the bottom number (denominator).

For example: $1/6 = 1$ divided by $6 = 0.166$

Percentages

Values are often displayed as percentages. One hundred percent is equal to the entire value, 50 percent is half, and 25 percent is a quarter of the total value.

Multiplying or dividing a percentage is easier when you first convert the value into a decimal and use the new number in your calculation.

To change a percentage to a decimal, drop the % and move the decimal 2 place to the left.

For example:

$$45.2\% = 0.452$$

Multiplier

If you need to change a number by multiplying it by a percentage, the percentage is called the multiplier.

First you must convert the percentage into a decimal, and then multiply the number by the converted decimal value.

For example:

An over current protection device, such as a fuse or a circuit breaker, must be sized no less than 125% of the continuous load.

For a load that is 80A, the over current protection device can not be sized less than 100A.

To get this answer, we convert 125% to 1.25 and multiply $80 \times 1.25 = 100A$

The maximum continuous load on a circuit breaker is limited to 80% of the device rating.

For a device rated at 50A, what would be the maximum continuous load permitted? 40A.

Why?

$$80\% = 0.80$$

$$\text{Multiply } 0.80 \times 50\text{A} = 40\text{A}$$

These are just a few examples of the types of calculations you will encounter in electrician math.

You will also learn all types of formulas involving ohms and watts. For example, you may need to know how much power is consumed in watts by a 12 AWG conductor, 200 feet long with a total resistance of 0.40 ohms, if the current in the circuit is 16A.

The formula for this problem is $\text{Power} = I^2 \times R$

$$P = I^2 \times R$$

$$I = 16\text{A}$$

$$R = 0.40 \text{ ohms}$$

$$P = 16\text{A}^2 \times 0.40 \text{ ohms}$$

$$P = 16\text{A} \times 16\text{A} \times 0.40 \text{ ohms}$$

$$P = 102.40\text{W}$$

Answers can be rounded to the nearest 50, so the correct answer is 100W.

Build a strong foundation and your life as an electrician will be much easier. Keep in mind that a strong foundation begins with a solid understanding of electrician math.

1. Do you realize how important math is in your life?
2. Why is it necessary to know the basic right angle trigonometry?
3. What is a numerator?
4. What is a denominator?
5. What is a multiplier?

ТЕМА 22. СИСТЕМИ МІР ТА ІНСТРУМЕНТИ ВІМІРЮВАННЯ.

Task. Read the following texts and answer the questions.

International System of Units (SI)

The International System of Units has the abbreviation SI from the French ‘Le Système International d’Unités’. The SI is at the centre of all modern science and technology and is used worldwide to ensure measurements can be standardised everywhere. There are tremendous benefits to using SI units and countries routinely compare their SI measurement standards. This keeps measurements made in different countries compatible with one another.

Base SI units

There are seven base units of the SI, in terms of which all physical quantities can be expressed.

SI		
Quantity	SI Unit	Symbol
Length	metre	m
Mass	kilogram	kg
Time	second	s
Electric current	ampere	A
Temperature	Kelvin or degree Celsius	K or °C
Luminous intensity	candela	cd
Amount of substance	mole	mol

The first letters of the names of the units are in lower case, e.g. four kilograms or eight seconds. The one exception is the Celsius, which is capitalised because its full version is ‘degrees Celsius’ with a small ‘d’.

For clarity, it is normal practice to put a single space between a number and its unit symbol, e.g. 4 mm rather than 4mm.

Derived SI units

All measurements can be expressed using combinations of the seven base units (and angle if needed). These combinations are called *derived units*.

Derived units – examples		
<i>Quantity</i>	<i>Unit</i>	<i>Symbol</i>
Energy	joule	J
Power	watt	W
Quantity of electricity	coulomb	C
Electromotive force	volt	V
Electric field strength	volt per metre	
Electric resistance	ohm	Ω
Electric conductance	siemens	S
Capacitance	farad	F
Magnetic flux	weber	Wb
Magnetic flux density	tesla	T
Inductance	henry	H
Magnetic field strength	ampere per metre	
Magnetomotive force	ampere	A

A full list of derived units can be found at www.kayelaby.npl.co.uk

A shorthand system of prefixes was agreed as part of the SI. All prefixes are related to each other by powers of 10, making them very easy to use.

SI prefixes			
Prefix	Symbol	Decimal	Power of 10
yotta	Y	1 000 000 000 000 000 000 000 000	10^{24}
zetta	Z	1 000 000 000 000 000 000 000	10^{21}
exa	E	1 000 000 000 000 000 000	10^{18}
peta	P	1 000 000 000 000 000	10^{15}
tera	T	1 000 000 000 000	10^{12}
giga	G	1 000 000 000	10^9
mega	M	1 000 000	10^6
kilo	k	1 000	10^3
hecto	h	100	10^2
deca	da	10	10^1
deci	d	0.1	10^{-1}
centi	c	0.01	10^{-2}
milli	m	0.001	10^{-3}
micro	μ	0.000 001	10^{-6}
nano	n	0.000 000 001	10^{-9}
pico	p	0.000 000 000 001	10^{-12}
femto	f	0.000 000 000 000 001	10^{-15}
atto	a	0.000 000 000 000 000 001	10^{-18}
zepto	z	0.000 000 000 000 000 000 001	10^{-21}
yocto	y	0.000 000 000 000 000 000 000 001	10^{-24}

The highlighted section above indicates the range that electrical measurement routinely covers.

It might seem that some of these prefixes are somewhat extreme, but they can be useful. For example:

- The Sun delivers 5.6 YJ (yottajoules) of energy to the Earth

every year

- A proton is 1.6 fm (femtometres) in diameter

There is one exception to the system of prefixes. For historical reasons we do not apply the prefixes to the kilogram, but instead to the gram. This is to avoid the need to refer to a gram as a millikilogram!

There are a small number of agreed SI exceptions which you will be familiar with and are shown in the table below.

Internationally agreed SI exceptions			
Name	Symbol	Quantity	Equivalent SI unit
minute	min	time	1 min = 60 s
hour	h	time	1 h = 3600 s
day	d	time	1 d = 86400 s
degree of arc	°	angle	1° = ($\pi/180$) rad
minute of arc	′	angle	1′ = ($\pi/10800$) rad
second of arc	″	angle	1″ = ($\pi/648000$) rad
hectare	ha	area	1 ha = 10000 m ²
litre	l or L	volume	1 l = 0.001 m ³
tonne	t	mass	1 t = 1000 kg

The definitions of the SI units allow scientists to create unit amounts of the SI base quantities.

Six of the SI definitions are the procedures needed to 'realise' – literally, to make real – the standard or a close approximation of it. This applies to the second, metre, Kelvin, ampere, candela and mole.

The seventh base unit – the kilogram – is not based on a procedure, but instead on a single physical artefact: a cylinder made up of platinum and iridium metals, which is kept in a safe in the International Bureau of Weights and Measures (BIPM) on the outskirts of Paris, France.

The beauty of the SI system is that if every measuring instrument were destroyed tomorrow, six of the seven base units could be

reconstructed using their definitions. It also means that these base units are truly international.

The current scientific measurement challenge is to develop a way to 'realise' a kilogram so that it can follow the other six units and no longer rely upon a single physical object.

The realisation of SI units requires expensive equipment and highly trained measurement scientists, and is extremely time-consuming. Therefore, it is done at specialised National Measurement Institutes such as NPL. The realised units, their multiples and sub-multiples are then disseminated for trade, industry, science and health and safety. This dissemination process is known as 'traceability'.

1. What are the benefits of using SI units?
2. What are the base units of the SI?
3. How are the names of the units spelled?
4. What are derived units? Name them.
5. How are SI prefixes related to each other?
6. What exception is there to the system of SI prefixes?
7. Are there any exceptions to the SI?
8. What is 'traceability'?
9. What is the standard kilogram?
10. In what way is the definition of the kilogram different from the other six base SI units?

New Technique for MEMS Power Measurement

Researchers developed a new technique to accurately measure the power requirements of micro-electro-mechanical systems (MEMS), delivering a competitive edge to EU companies and supporting large-scale manufacturing excellence.

MEMS are very small devices that can be used both as remotely powered sensors to measure variations in the physical environment such as changes in force, light or motion, and as actuators that convert changes in energy back into motion. They are made up of components that interact with the outside environment such as micro sensors, and a central unit that processes data allows MEMS to make decisions based on the information they receive. Current applications for the devices include use in

accelerometers in airbag deployment systems, inkjet printer heads and rotation measurement systems for smartphone displays.

A lack of understanding of the potential power requirements and outputs of the devices held back developments, since mechanical components were often embedded in protective packaging, making them hard to access and consequently hindering developers and customers from understanding how best to use the devices.

A new experimental set-up was developed to find the mechanical values and properties of any MEMS device through electrical measurement. A current was applied across the device with a varying frequency allowing users to analyse the harmonic content of the output voltage of the component parts and to electrically determine all the mechanical characteristics of the MEMS device, including the damping factor (a negative impact on the amplitude of oscillations), and the frequency that determines the maximum electrical power generation from mechanical vibrations of MEMS transducers.

Several MEMS devices were tested using the technique at Laboratoire national de métrologie et d'essais (LNE) in Paris, and their mechanical resonant frequencies were measured with only a tiny uncertainty. The researchers believe the technique can be used to provide feedback on production methods that will allow manufacturers to design MEMS to the needs of each particular system they operate in. More accurate knowledge of the product output and energy requirements will also affect the choice of device from potential consumers who will now be able to select only those with optimised performance for their particular sector. The technique should help improve performance, functionality and reliability of MEMS around the world.

1. What does the abbreviation MEMS stand for?
2. What constitutes MEMS?
3. What are current applications for these devices?
4. How are the mechanical values and properties of any MEMS device found?
5. What are the benefits of the new technique for MEMS power measurements?

Comparative Measurements of Electric Current

Researchers developed an electric current instrument to create a primary standard of resistance, enabling innovation.

Accurately measuring electric current is vitally important for a range of applications, from billing people for electricity use and ensuring a stable electricity market, to calculating the right current input for controlling doses of ionising radiation in cancer treatment.

Ionising radiation is measured in picoamps, while undersea cables, for example, carry hundreds of amps. Furthermore, some industries measure resistance or voltage rather than current itself and these all need to be related back to the ampere, the SI unit of current.

Researchers developed a new electric current instrument that provided the world's most accurate ratio of current. Together with the Quantum Hall effect – a phenomenon whereby electrical properties in 2D materials can be determined based on fundamental constants of nature - the Cryogenic Current Comparator (CCC) allows resistance to be measured to very high accuracy, creating a primary standard of resistance.

It measures in milliamps or ohms, and the CCC related this back to primary standards more simply and more accurately than ever before. It sits in a liquid helium dewar – a thermos flask that holds very cold liquids – keeping it at four Kelvin and allowing superconductivity, delivering accuracy and sensitivity.

The CCC is accurate to better than 1 part in 10^{-9} . Using the optically isolated current sources, the resistance bridge can make comparisons between resistors with an accuracy and repeatability of better than 10^{-8} .

The CCC was a significant accuracy upgrade on any previous system and has, for example, provided the most accurate measurements of the electrical impedance of the quantised Hall effect in graphene, which is a key to understanding this material's properties. It is the first digitally driven CCC, meaning set up and measurements are stored on the computer, reducing the chance of error.

This CCC also has another important advantage over previous systems – the dewar uses less liquid helium than other systems. Cryogenics such as liquid helium are expensive and must be fed in continuously, so reductions offer a significant financial advantage to scientists.

The CCC can now be used by National Measurement Institutes (NMIs) and laboratories around the world to provide a more accurate

standard for current ratio and ensure that current measurement is not a limiting factor in innovation.

1. What is the Quantum Hall effect?
2. What is the Cryogenic Current Comparator (CCC)?
3. Where is the CCC located?
4. What are the advantages of the CCC over previous systems?

Measuring Instruments.

For the last few decades both analogue and digital measuring instruments have existed alongside one another.

The former are devices in which the information is associated with physical quantities that are continuously variable whereas in digital instruments (that emerged later in the 1970s and 1980s with the arrival of electronics and IT) the quantities have discrete values (as in the word ‘digit’).

These instruments consist of an A/D transducer-converter system for transforming any non electric input quantity into an outlet analogue electric quantity (generally voltage) and subsequently converting into digital form, and of a counter system for providing information on the number of pulses.

Analogue instruments

These instruments exploit phenomena for which the interaction of electric or magnetic quantities gives rise to mechanical force or torque. These instruments consist of a movable part that has an initial rest position, on which a driving torque acts in function of the electric or magnetic quantities on which the associated phenomenon depends. The driving torque is opposed by restoring, normally elastic, torque, which, depending on the movement, tends to return the movable part to the initial position when the action produced by the driving torque ceases.

From the balance of the two torques an angular deviation is obtained that is proportional to the quantity to be measured.

An index fixed to the movable part rotates along a scale. In general, the manufacturer places on the dial of the instrument certain conventional symbols that characterise not only the unit of measurement but also the operating principle, the connection network (direct or alternating), the accuracy rating, operating position (horizontal, vertical) and safety prescriptions (test voltage).

Digital instruments

The operating principle of digital instruments is based on analogue-digital conversion techniques; decoding and display devices are always associated with them, as are very often sample frequency oscillators and decimal count circuits. The digital instruments are essentially voltmeters for direct currents; nevertheless, using usual conversion systems from VAC to VDC (especially thermocouple conversion systems) and introducing direct-current sources, they can become universal instruments for also measuring high-frequency voltage up to a few hundred kHz and resistances.

If these measuring instruments are in place they can be used to store and subsequently call up measuring values, and process them and control them remotely, as they can be interfaced with microprocessor systems until automatic measuring structures of great functional versatility are obtained.

Two particular aspects must be borne in mind when constructing and using digital instruments in order not to compromise operation and safety:

- electromagnetic inference;
- earth sockets.

The manufacturer of the instrument protects it directly against electromagnetic interference by providing the instrument with an electrostatic screen (a non-ferrous magnetic metal) that is also effective against high-frequency electromagnetic fields. This screen can be connected to one of the measuring terminals or it can constitute a third terminal in its own right.

In the first case so-called ‘unbalanced’ measurements are obtained as one of the two terminals has to be connected to the measurement earth, so that only two voltage measurements are possible that refer to the earth potential.

On the other hand, in instruments with three terminals, two are dedicated to measuring and one that is dedicated to shielding is earthed. In this case potential differences can be measured also between the two points that are both outside earth and the type of measurement is known as ‘balanced’.

Earth connections are defined as a point the potential of which remains constant and which is assumed to be a reference potential; this is obtained through an earth connection with very low impedance.

In electronic/digital instruments it may be necessary to have several reference points to which distinct parts of the circuits of the instrument

belong; these points are known as mass connections and are ohmically isolated from one another (the capacitive coupling must also be minimised).

1. What are analogue measurement instruments?
2. What are digital measurement instruments?
3. When did digital instruments emerge?
4. What do analogue instruments consist of?
5. What is the operating principle of analogue instruments?
6. What is the operating principle of digital instruments?
7. How is a digital instrument protected against electromagnetic inference?
8. What kind of measurement is known as 'balanced'?
9. What are earth connectors?
10. What are mass connectors?

ТЕМА 23. ТЕРМІНИ В ЕЛЕКТРОТЕХНІЦІ.

Task. Read the text and solve the crossword puzzle.

Electrical Definitions: The Building Blocks of Learning

Here is a glossary of electrical definitions you will hear quite often during your career as an electrician.

AC. AC is short for alternating current. Electricity is created when electrons move through a conductor. When these electrons constantly move in alternating directions, it is referred to as an alternating current.

Amps. Units of measurement are necessary in order for others to know what you are talking about. Length is measured in meters. Time is measured in minutes or seconds. An electrical current is measured in amps.

Ammeter. This is a device that measures (in amps) the amount of electricity passing through the meter to which it is connected.

Calories per centimetre squared (Cal/cm²). This is referred to the amount of energy that can result from an electric arc flash. It is measured in cal/cm².

Circuit. Electricity works by entering an appliance, passing through and coming out again. It needs to have a continuous flow without any

breaks. This continuous flow is called a circuit. If there is any break in the circuit, the appliance won't work because it won't get the "juice" it needs to function.

Current. The current is the electrons moving through a conductor. The more electrons flowing through the conductor and the faster they move, the more power the current will have. The larger the electric current, the more powerful and dangerous it becomes.

DC. DC is short for direct current. When electrons are all moving through the conductor in the same direction, it is called a direct current.

Earth. In a residential wiring system, EARTH is the safety wire. In case something goes wrong with the unit you are working on, the earth will send the electricity to the ground instead of allowing it to pass through you. The earth wire is normally coated in a yellow with green stripe plastic cover. However, sometimes it does not have any type of coating, so be careful!

Electricity. Electricity is electrons moving through a conductor – in most cases a metal conductor. Electrons are the tiny particles spinning around the center (nucleus) of atoms.

Energy. Defined as the ability to do work. A unit of energy is referred to a joule and the symbol is J.

Fuse. Fuses are designed to prevent too much electricity from passing through the wires. Homes have a fuse for just about every electrical outlet and light socket. Some appliances, such as your stove, have their own set of fuses inside. One large fuse prevents too much electricity from entering the house and a circuit breaker cuts the power when an outlet is overloaded to prevent the fuse from burning out.

Generator. A generator can produce large amounts of electricity. They are used as backup systems in case of a power failure and in areas where electricity isn't available.

Hydro-electric. Flowing water used to power a generator is called hydro-electric power.

Insulation. There are all types of materials through which electricity can pass – these are known as conductors. To prevent the electricity from passing through these materials, they are coated with insulation. Plastic is commonly used to insulate wires.

Joule. Joule is the unit of measurement used to measure energy.

Kilowatt. One thousand watts is one kilowatt.

Live. The live wire carries the electricity into a house and to everything in the house that uses electricity. To distinguish the live from the other wires it is coated in blown plastic. Older wiring systems might have the live covered with red plastic. The live wire is the most dangerous.

Neutral. The neutral wire completes the circuit and carries the power back to the station. The neutral wire in modern wiring configurations is covered with blue plastic, while in older systems it is usually black.

Ohm's Law. The Law describes how voltage, current and resistance in a circuit interact with each other. Current in a circuit is directly proportional to the voltage applied, and is inversely proportional to the resistance.

Parallel. Some electrical objects, like batteries, have terminals (+ red and – black). When all of the + terminals of more than one object are connected and all – terminals are connected, the objects are joined in parallel. The electricity passing in the circuit is split and part passes through each object.

Power. The rate of doing work. In electrical work the force is referred to as voltage, and the motion is the movement of electrons. Power is represented by the letter P and is measured in watts.

Resistor. The resistor is the part of the electrical circuit designed to reduce current flow.

Resistance. Resistance is any opposition posed by a circuit, substance or component to the flow of current.

Series. A series is several objects joined together in a loop, end to end. Electricity flows through the objects until it has completed the circuit.

Transformer. The transformer changes, or transforms a low voltage into a high voltage, or the other way around – transforming a high voltage into a low one.

Transistor. Invented in the 1950s, the transistor largely replaced the thermionic valve because it is much smaller, less expensive to produce and lasts a lot longer than the thermionic valve. Transistors are used in many electronic devices such as radios, televisions and computers.

Thermionic valve. This device increases electrical currents. It is used mostly in amplifiers to increase the volume.

Triode. This is a special type of thermionic valve with three active electrodes.

Unit. Electricity used in the home is measured in units. Your utility bill is calculated by the number of units that have been used during a billing

cycle. One unit is consumed when one kilowatt of electricity is in use for one hour.

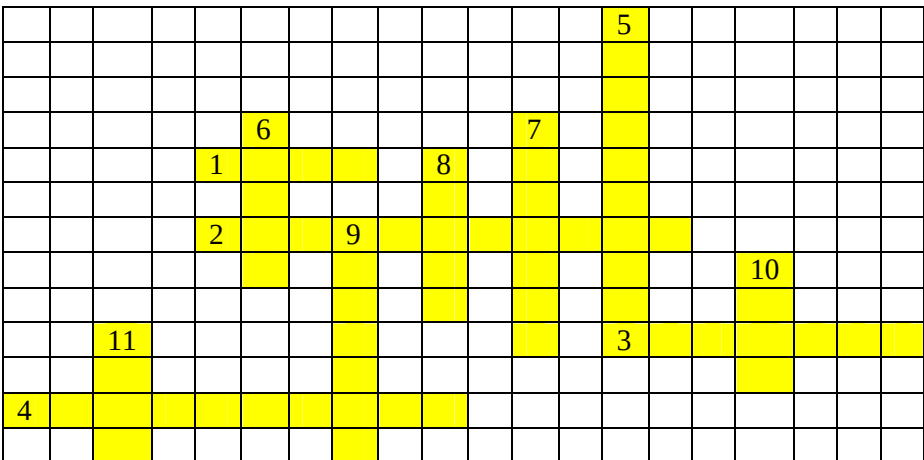
Voltage. Voltage is a unit for measuring electricity. It measures the force of the electricity moving through the wires – the more voltage, the larger the force. This is what makes high voltage so dangerous.

Voltmeter. The voltmeter measures the force applied or the voltage used to move the electricity through a circuit. The voltage is measured in volts.

Volt. This is the unit of measurement used to measure voltage.

Watt. This is the unit of measurement used to measure power.

From time to time you may hear and use other electrical definitions, but the electrical definitions above are the most common ones.



1. The unit of measurement used to measure voltage.
2. Electrons moving through a conductor.
3. The wire which completes the circuit and carries the power back to the station.
4. Any opposition posed by a circuit, substance or component to the flow of current.
5. The coating preventing the electricity from passing through conductors.
6. The unit of measurement used to measure energy.
7. The continuous flow of electricity.

8. The safety wire.
9. The electrons moving through a conductor.
10. The unit of measurement used to measure power.
11. A device designed to prevent too much electricity from passing through the wires.

ТЕМА 24. ТИПИ ДРОТІВ.

Task. Read the following texts and answer the questions.

Electrical Wire Size

Knowing the correct electrical wire size is one of the most important aspects when installing wires and electrical cables. The proper size of the wire to be fixed or installed depends on the amount of load current the wire must carry.

Not using the correct wire size could lead to damage to the appliance, or worse, a house fire. Usually, the gauge will be marked on the wire, or packaging.

Once in a while, though, you may have to find the size yourself.

Determining the Gauge

The gauge of the wire is determined by heating the wire and then drawing it through a hole which is smaller than the wire. How many draws it takes, determines the gauge.

The drawing operations for different cables are different. Very fine wire, which has a gauge of approximately 30, will pass more times through the drawing dies than that of gauge 0.

The variable that will be used to determine the size should be carefully examined. It is usually correctly determined by the reduction ratio of the draws based on the number of draws that were made from the size of the rod.

The number of amps determines the amount or strength of the electricity that can pass through a cable. The ampere rating of a conductor is determined by the gauge. The bigger the wire gauge, the smaller the amps and vice versa.

The amps are necessary when determining the correct set of conductors to use to connect to a device. Information about the correct option in relation to the feed is extremely useful. It ensures the safety of the device and the surrounding area.

When chosen correctly, it will handle the amount of current running through it without getting too hot and cause the wire insulation to break down. Electrical fires sometimes occur as a result of the wire conductor not being able to withstand the high voltage.

Understanding the wire characteristics in the National Electric code (NEC) table is useful in determining the electrical wire size to be used. Using the chart simplifies the process of determining the proper size by listing the right amps you need for aluminum and copper wires.

Before choosing the correct conductor for a particular situation, first determine the load that the wire will be carrying. The load determines the amperage that the conductor will be handling.

Different devices require different amounts of electricity.

The load can be on non-continuous duty, continuous duty or both continuous and non-continuous duty loads. A continuous load refers to a device where the current is not disrupted and can conduct electricity for more than three hours nonstop.

Non-continuous on the other hand, conducts electricity continuously for a short duration. This is normally less than three hours.

Save Money

Knowing the correct electrical wire size can save costs. If the wrong ones are chosen, they will overheat and eventually the insulation will break down.

This may spoil the appliance and, in some cases, it may create potential fire hazards. You should always check to make sure that appliances comply with municipal codes and the guidelines set out in the appliance's manual.

1. What does the proper size of the wire depend on?
2. How is the gauge of the wire determined?
3. What does the gauge determine?
4. How is the correct conductor chosen?

Electrical Symbols.

When installing a new wiring system or repairing an existing one, you will probably use a schematic, which is a detailed drawing of how the system should look.

Every line and circle in the schematic is symbol. These symbols tell you whether the wires are connected or not, where to put in a toggle or push button switch, where to connect a ground, and everything else you need to know in order to install the system correctly.

Electrical Blueprints

Reading blueprints and knowing the meaning of every schematic symbol used is a basic part of your electrician training.

In most cases the electrical symbols used are standard; however, some schematic drawings might use slight variations. It is up to the electrician to properly read and understand all symbols and possible variations used.

When working on an electrical system, the power must be shut off. However, you can use switches and disconnects to turn off the current to certain parts of the system, and keep it on in other sections, which might be necessary when performing various tasks.

The current powers a variety of mechanisms throughout the system, such as motors and controllers. All of this activity has to be clearly outlined on the schematic.

The schematic drawing uses electrical symbols to represent all of the different components within the system.

The Electrical Circuit

The circuit is represented on the schematic drawing. The most basic component in any electrical circuit is the conductor, which is usually a wire.

In a schematic drawing, the standard symbol for a wire is a straight line. When there are two lines crossing over each other without any other symbol, it means the wires are not connected.

If the wires are connected, there will be a dot on the intersection, also called a node. The dot indicates the presence of a connection, and means that at this point current is passing through both wires.

Some schematics will use a semi-circle bridge where the wires intersect, to indicate that the wires are not connected. This is done to make

it very clear that the wires are not connected, so there is no chance of confusion.

On average, an electrical schematic depicting a complex system could have as many as sixty standard electrical symbols or more. Each symbol is a representation of a different component within the system.

When there is a component in the system that doesn't have a corresponding standard schematic symbol, a different symbol may be used. In this case, a key will be included on the drawing to explain the unknown symbol.

When working on a new building, the blueprints will include other electrical symbols as well.

All of the lights, switches and outlets have their own distinct symbol, so that you know exactly what type of fixture will go where. For example, ceiling lights, recessed ceiling lights and surface fluorescent lights all have a different symbol.

You will also find different symbols showing where to install the thermostat, smoke detectors and doorbell chimes.

Colored Schematics.

Colored schematics give you a great advantage over black and white ones when working on complicated wiring systems.

The color of every wire you use is color coded to represent its function.

- **Black wires always mean hot wires, which means they have current.** This type of wire will be used to feed an outlet or light switch and many other devices. You would never use a black wire as a neutral or to ground a device in any type of connection.

- **Red wires also mean hot wires.** This type is used to feed switch legs (a ceiling fan for example), and as the second hot wire in a 220-volt installation. Red wires are also useful for interconnecting two smoke detectors in a hardwired system.

- **Blue and yellow coated wires are also used as hot wires, and are the ones that are normally pulled in conduit.** It is common for blue wires to be used as travellers in three-way switch connections, as well as in switch legs to appliances such as fans and lights. Yellow wires are also commonly used for switch legs. You would install these to control devices such as switched outlets, fans and lights.

- **Green coated and bare copper wires act as the ground – only!** To avoid confusion, you would never use these in any other

applications. These wires bond devices to ground, and must be properly bonded to appliance connections and junction boxes to ensure safety.

Colour codes have been known to change over the years, as well are different in some countries, so it is important to always have the most up-to-date information.

It is also important to know the old codes, in case you are working on older wiring systems that may be using old colour codes.

Exceptions to the Wire Colour Rule

In certain situations, wire colours can be used in applications that don't fall under these general connection rules.

An example of this is a 240-volt outlet or appliance, where a white wire may be used as the second hot wire in a two-conductor cable.

Another application where you could use a white wire would be in a switch leg for running a three-way switch, or in some lighting applications. However, this white wire must be marked properly to show that it has been connected to serve another purpose, other than as a neutral.

You can do this easily by simply putting black or red electrical tape on the wire. This shows anyone else who may work on the device in the future what the wire is being used for. Also, keep in mind that when you come across a white wire with black or red tape on the end, it is not a neutral.

When you understand electrical symbols and wire colours used on a schematic, and you have a detailed and accurate blueprint, you can make sense of even the most complicated wiring system.

1. What is the most basic component in an electrical circuit?
2. How can you indicate that the wires are not connected?
3. What do the wire colours mean?
4. What exceptions to the wire colour rule can you name?

ТЕМА 25. З'ЄДНУВАЧІ ДРОТІВ.

Task. Read the following texts and answer the questions.

How to Use Electrical Wire Connectors

What you'll need: wire stripper, wire cutter, electrical wire connector.

Electrical wire connectors are a common and easy way to splice two current carrying electrical wires together. Unlike many electrical wiring projects, installing an electrical wire connector is easy enough for a non-professional to do and requires very few tools. It is important to note though that there are many different types of wire connectors. Some crimp on, while others simply slide on. The steps below, will explain how to use the most common type: the twist-on wire connector.

Step 1 – Turn Off the Power

To avoid dangerous electrical shocks always turn off the power before working on any wiring project.

Step 2 – Choose the Right Size Wire Connector

Almost as important as turning off the power, choosing the right size wire connect for the job can prevent electrical failure and prevent electrical fires. The reason for this is that when a switch or device is turned on, it causes an electrical current to flow through to wires and into the wire connector. Once the current reaches the connector, it encounters a mild resistance in its flow. The resistance causes the wires themselves to heat up slightly which, in turn, causes them to expand. Once the switch is turned off again and the current has been stopped, the wires will cool and contract once again to their normal size. If the wrong size wire connector has been applied, it may pop off when the wire expands or simply fall off when the wire contracts. Either way, the conductors of the wires will be left exposed, which can potentially cause all kinds of problems. To choose the right size wire connector, look on the side of the connector box and make sure that the connector being used is rated for the size of the wire it is being connected to and also for the number of conductors that are in the wire.

Step 3 – Strip the Wires that are Being Connected

Using a wire stripper, remove the coating around the ends of the two wires that need to be connected. No more than 3/8 inch of the coating needs to be removed.

Step 4 – Place the Two Stripped Ends Together

Line up the two wires so that they are parallel with each other. Some electricians will twist the wires together before placing the connector on them. There is no harm in doing this; however, in order to be UL-listed (which means it was approved by a safety testing board) a connector must make a firm connection without twisting the wires, so applying the connector without twisting the wires will also work. In fact, twisting the wires together before installing the connector may make future repairs on that splice more difficult as the two wires will be more difficult to separate.

Step 5 – Place the Connector Over the Ends of the Wires

Whether the wires are twisted or simply lined up parallel with each other, place the cap portion of the wire connector over the exposed conductors of the two wires. Check to make sure that none of the exposed conductor material is protruding from the bottom of the connector. If some of the exposed wire does protrude, remove the cap and clip off a little of the end with a wire cutter and try again.

Step 6 – Twist the Connector On

Once the connector covers the entirety of the exposed wires, twist the connector clockwise until it feels very tight. Finally, test the quality and strength of the splice by holding the connector and trying to firmly pull each wire free. Remember, if the wire connector isn't as tight as possible, the cap may slip off as described in step 2 and cause problems.

1. What are electrical wire connectors?
2. What may happen if the wrong size wire connector has been applied?
3. Where should the cap portion of the wire connector be placed?
4. How can you test the quality and strength of the splice?

How to Strip a Wire

Safe, durable electrical connections begin with clean, accurate wire stripping. Removing the outer layer of plastic without nicking the wires

underneath is critical. If a wire does get nicked, the connection may break or an electrical short may occur.

A simple manual wire stripper is a pair of opposing blades much like scissors. There are several notches of varying size. This allows the user to match the notch size to the wire size, which is very important for not damaging the wires.

Warning: Many wire strippers found at the hardware store do not strip small gauge wire (22 to 30). When getting into prototyping, be sure to get a tool that is capable of stripping 22 AWG and smaller. Being able to strip very small 30 AWG wire (also known as wire wrap wire) is a plus.

Although a knife would also strip the wires, it may also damage the wire by nicking the metal or cutting into it. Using a knife to strip wire is also really dangerous! The knife can easily slip and cause wicked injuries.

By simply squeezing the handles about 1/4" from the end of the wire or the desired length, using the correct notch on the tool, and then twisting it slightly, the insulation will be cut free.

Then by pulling the wire strippers towards the end of the wire, the insulation should slide right off of the wire.

Tips, Tricks, and Hints

It is important to match the size of wire to the correct notch in the stripper. If the notch is too large, the wire will not get stripped. If the notch is too small, there is a risk of damaging the wire. Using an undersized notch means the strippers will close too far, digging into the wire underneath. With stranded wire, the tool will cut off the outer ring of wires, decreasing the total diameter of wire and reduce the strength of the wire. A nick in solid core wire will severely reduce the strength and flexibility of the wire. The likelihood of the wire breaking upon being bent increases significantly.

If a wire does accidentally get a nick in it, the best plan of action is to cut the damaged part of the wire off and try again.

1. What may happen if a wire doesn't get nicked?
2. What is a wire wrap wire?
3. Why is a knife unsuitable for stripping a wire?
4. How is a wire stripped?
5. Why is it important to match the size of the wire to the correct notch in the stripper?

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