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Nuclear Power Engineering

Практикум
з англійської мови
професійного спрямування

для студентів
теплоенергетичного факультету
напряму підготовки 6.050603 «Атомна енергетика»

Рекомендовано Вченою радою факультету лінгвістики НТУУ «КПІ»

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Електронне видання

Nuclear Power Engineering

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для студентів
теплоенергетичного факультету
напряму підготовки 6.050603 «Атомна енергетика»

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Зміст

Передмова

Практикум укладено відповідно до робочої навчальної програми кредитного модуля «Англійська мова професійного спрямування», розробленої для студентів напряму підготовки 6.050603 «Атомна енергетика» на теплоенергетичному факультеті.

Розвиток вмінь читання автентичних матеріалів професійної тематики, використання лексико-граматичних структур в іншомовному мовленні, як діалогічному, так і монологічному, та формування навичок аудіювання і письма (реферування, написання есе тощо) забезпечується логічною і послідовною структурою видання.

Практикум складається з дев'яти розділів і додатку. Поділ на розділи зумовлений підбіркою сучасних автентичних матеріалів наступної професійної тематики: «Парові генератори», «Атомні електростанції», «Інженери-ядерники – завдання і обов'язки», «Атомні реактори і їх типи», «Тепло і температура», «Теплофізика», «Закони термодинаміки», «Відлуння атомної аварії в Японії». До текстів розроблено цілий комплекс вправ різних типів на засвоєння термінологічної лексики теплоенергетичної галузі, повторення основних граматичних структур, знання яких необхідне для розуміння англомовної науково-технічної літератури та спілкування в реальних ситуаціях професійного життя. Кожний розділ містить текст на переклад з української мови на англійську, завдання на розвиток вмінь говоріння і письма. Підібрані в практикумі матеріали познайомлять студентів із професійною діяльністю інженерів-ядерників, що сприятиме формуванню їх професійної компетенції.

В додаток увійшли рекомендації щодо написання есе та реферування текстів англійською мовою.

Інформаційно-насичений пізнавальний матеріал та виконання різноманітних лексичних завдань сприятимуть підвищенню мотивації студентів до вивчення англійської мови як під час практичних занять, так і в процесі підготовки домашніх завдань.

Unit 1 Steam generators

I. Give Ukrainian equivalents for the following words and phrases:

boiler; steam generator; heat energy; notable exception; steam-powered fireless locomotive; industrial installation; power station; separately-generated steam; prime mover; engine unit; furnace; saturated steam; suspended water content; combustion gases.

II. Give English equivalents for the following words and phrases:

паровий генератор; мобільний паровий двигун; транспортний засіб; стаціонарні парові машини; промислові установки; тягач; топка; насичений пар; питомий вміст води; температурний градієнт; вірогідність; газоподібні продукти, підігрівач, живильна вода.

III. Read the text about steam generators thoroughly, check your answers and be ready to answer the questions that follow.

A boiler or steam generator is a device used to create steam by applying heat energy to water. Although the definitions are somewhat flexible, it can be said that older steam generators were commonly termed boilers and worked at low to medium pressure (1–300 psi or 6.895–2,068.427 kPa) but, at pressures above this, it is more usual to speak of a steam generator.

A boiler or steam generator is used wherever a source of steam is required. The form and size depends on the application: mobile steam engines such as steam locomotives, portable engines and steam-powered road vehicles typically use a smaller boiler that forms an integral part of the vehicle; stationary steam engines, industrial installations and power stations will usually have a larger separate steam generating facility connected to the point-of-use by piping. A notable exception is the steam-powered fireless locomotive, where separately-generated steam is transferred to a receiver (tank) on the locomotive.

The steam generator or boiler is an integral component of a steam engine when considered as a prime mover. However, it needs to be treated separately, as to some extent a variety of generator types can be combined with a variety of engine units. A boiler incorporates a firebox or furnace in order to burn the fuel and generate heat. The generated heat is transferred to water to make steam, the process of boiling. This produces saturated steam at a rate which can vary according to the pressure above the boiling water. The higher the furnace temperature is, the faster the steam production becomes. The saturated steam thus produced can then either be used immediately to produce power via a turbine and alternator, or else may be further superheated to a higher temperature; this notably reduces suspended water content making a given volume of steam produce more work and creates a greater temperature gradient, which helps reduce the potential to form condensation. Any remaining heat in the combustion gases can then either be evacuated or made to pass through an economizer, the role of which is to warm the feed water before it reaches the boiler.

Adapted from: ebooklibrary.org

1) What is the difference between a steam generator and boiler?
2) When is a steam generator used?
3) What is the typical form and size of the steam generator?
4) How is the separate steam generating facility connected to the power station?
5) How does the fireless locomotive work?
6) What is the difference between a furnace and engine?
7) How does the furnace temperature influence the steam production?
8) What is an economizer used for?

IV. Complete these sentences with words from the box.

combustion, component, exception, furnace, generator, installations, integral part, piping, pressure, separated, size, source, steam, temperature, turbine

1) A boiler or steam . . . is a device used to create steam by applying heat energy to

water.

2) A boiler is used wherever a . . . of steam is required.

3) A medium . . . heat generator is called a boiler.

4) A smaller boiler typically forms an . . . of the steam-powered road vehicle.

5) Industrial . . . usually have a larger separate steam generating facility.

6) At the power station the boiler is connected to the point-of-use by . . . .

7) The steam-powered fireless locomotive is an . . . of typical locomotives.

8) Typically the . . . of mobile steam engines is smaller than power stations

9) The steam generator is an integral . . . of a steam engine as a prime mover.

10) The steam generator is . . . from the engine unit.

11) A boiler includes a . . . in order to burn the fuel and generate heat.

12) In the process of boiling the . . . is generated from water.

13) The higher the furnace . . . , the faster the steam production.

14) Using the saturated steam we can produce power via a . . . .

15) The exhaust gases after the . . . can either be evacuated or made to pass through an economizer.

V. Match words from box A to their synonyms from box B.

a) application, boiler, combustion, component, economizer, firebox, generate, heat, installation, integral, mover, turbine, unit, variety

b) alternator, block, built-in, burning, diversity, energy, engine, equipment, furnace, heat exchanger, part, produce, steam generator, use

VI. Match words from box A to their antonyms from box B.

a) applicable, boiling, engine, flexible, generator, heating, integral, rule, saturated, typical

b) alternator, condensation, consumer, cooling, exception, rigid, separate,

underheated, unique, useless

VII. In pairs, make questions using these prompts. Then practice asking and answering the questions.

1) What /a boiler?
2) Where /a boiler used?
3) Where / use smaller boilers?
4) Where /locate the stationary steam engine?
5) Where /the separately-generated steam transferred to?
6) What /a variety of generator types be combined with?
7) Why / a boiler incorporate a firebox or furnace?
8) What /the use of superheated steam create?
9) Why /the generated heat transferred to water?
10) What /the role of an economizer?

VIII. Render the following text into English.

Парова турбіна – паровий двигун безперервної дії, що перетворює теплову енергію в енергію обертання ротора. Він потрібен для перетворення теплової енергії водяної пари в механічну роботу. Парова турбіна використовує не потенціальну, а кінетичну енергію пари.

Парова турбіна виявилась дуже зручною для приводу обертових механізмів (генератори електричного струму, насоси) та корабельних гвинтів; вона виявилася дуже легкою, швидкохідною та економічною. Процес вдосконалення парової турбіни відбувався дуже швидко, як для поліпшення економічності та підвищення одиниці потужності, так і для створення спеціалізованих парових турбін різного застосування.

В залежності від характеру теплового процесу парові турбіни поділяють на 3 групи: суто конденсаційні, теплофікаційні та спеціального призначення.

Суто конденсаційні парові турбіни перетворюють максимально можливу частину теплоти пари в механічну роботу. Вони можуть бути стаціонарними або транспортними. Транспортні парові турбіни використовують як допоміжні двигуни на кораблях.

Теплофікаційні парові турбіни служать для одночасного отримання електричної та теплової енергії. Такі парові турбіни використовують у технологічних цілях (наприклад, для опалювання).

Теплові турбіни спеціального призначення зазвичай використовують на металургійних, машинобудівних і хімічних підприємствах.

На відміну від інших, теплові турбіни спеціального призначення не виробляють у великих кількостях, а лише за спеціальним замовленням.

IX. Summarize the text on pages 5 – 6 in 100 – 120 words. Follow the hints on how to write the Summary in Appendices A, B on pages 58 – 74.

Unit 2 Nuclear plants

I. Give Ukrainian equivalents for the following words and phrases:

earthquake; graphite reactor; a light bulb; usable electricity; to deteriorate; pellet; preventing from overheating; core; to pressurize steam; proliferation of nuclear weapons; to diminish or eliminate of risks; fusion reactor; passively safe; coal-burning power plant.

II. Give English equivalents for the following words and phrases:

живлення; активна зона; ядерне розщеплення; базове навантаження; гранули; паливний агрегат; вугільна електростанція; усувати ризики; стрижні; ядерний синтез.

III. Read the text about nuclear plants thoroughly, check your answers and be ready to answer the questions that follow.

Thanks to the earthquake and subsequent tsunami in Japan, the discussion and interest regarding nuclear power has exploded. Many have wondered if Fukushima Daiichi will turn into another Chernobyl or 3 Mile Island.

But what exactly is nuclear power, and how does it work? Is it as risky as the media portrays? When did the history of a new nuclear age start? And what is waiting for us in the future? Here you'll find the answers to all questions.

Electricity was generated by a nuclear reactor for the first time ever on September 3, 1948 at the X-10 Graphite Reactor in Oak Ridge, Tennessee in the United States, and was the first nuclear power plant to power a light bulb. The second, larger experiment occurred on December 20, 1951 at the EBR-I experimental station near Arco, Idaho in the United States. On June 27, 1954, the world's first nuclear power plant to generate electricity for a power grid started operations at the Soviet city of Obninsk. The world's first full scale power station, Calder Hall in England opened on October 17, 1956.

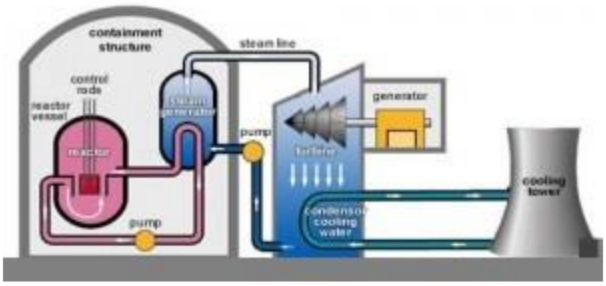
Today a nuclear power plant is understood as a thermal power station in which the heat source is a nuclear reactor. As it is typical in all conventional thermal power stations, the heat is used to generate steam which drives a steam turbine connected to a generator which produceselectricity. As of 21 April 2014, there are 435 nuclear power reactors in operation operating in 31 countries. Nuclear power plants are usually considered to be base load stations, since fuel is a small part of the cost of production.

Steam Power

At their heart, nuclear power plants are essentially steam power plants. Turbines, turned by intense steam pressure, generate usable electricity which is created from the heat resulting from nuclear fission reactions in the core. That same water used to power the turbines also serves as a coolant for the radioactive material, preventing it from overheating and melting down.

The Uranium Core

The core of a plant – the part that generates heat – contains 200 or so 12 foot long rods that are packed with uranium 235 pellets. These rods are then added to a fuel assembly. The fuel rods are then bombarded with neutrons which break apart the uranium 235 atoms. This process is known as nuclear fission.



Inside a nuclear power plant

The nuclear fission taking place in the rods creates large amounts of energy. This heat energy is used to pressurize steam to move the turbines which creates electricity.

Additional facts:

- Nuclear power plants actually give off less radiation than coal-burning power plants.
- Except for the Chernobyl plant in Ukraine, nuclear power plants have not caused a single known death.

A number of new designs for nuclear power generation, collectively known as the Generation IV reactors, are the subject of active research and may be used for practical power generation in the future. Many of these new designs specifically attempt to make fission reactors cleaner, safer and/or less of a risk to the proliferation of nuclear weapons. Passively safe plants (such as the ESBWR) are available to be built and other designs that are believed to be nearly fool-proof are being pursued. Fusion reactors, which may be viable in the future, diminish or eliminate many of the risks associated with nuclear fission.

Adapted from: wpedia.goo.ne.jp

1. When was electricity generated the first time by a nuclear reactor?
2. What is a uranium core?
3. What is preventing the radioactive material from the overheating and melting down?
4. How many are there nuclear power reactors in the world?
5. What is the heat source of a thermal power station?
6. Which process is known as nuclear fission?

IV. Match words from box A to their synonyms from box B.

a) area, to support, energy, device, waste, construction, production, inactively, actively, reduce, increase.

b) power, territory, maintain, mechanism, refuse, design, manufacturing, passively, energetically, decrease, enhance.

V. Match words from box A to their antonyms from box B.

a) increase, refuse, passive, homogeneous, new, more, safely, heat, typical, ponderable.

b) active, accept, reduce, unusual, old, less, dangerously, cold, insignificant, varied.

VI. Fill in the gaps with propositions/pronouns.

The core … a plant – the part … generates heat-contains 200 or so 12 foot roods … are packed … uranium 235 pellets.

Today a nuclear power plant is understood as a thermal power station … which the heat source … a nuclear reactor. As it is typical … all conventional thermal power stations, the heat is used … generate steam … drives a steam turbine connected … a generation … produce electricity.

At their heart, nuclear power plants are essentially steam power plants. Turbines, turned …intense steam pressure, generate usable electricity … … created from the heat resulting from nuclear fission reactions … … core.

VII. Render the following text into English.

Радіоактивні відходи

Одним із небагатьох недоліків ядерної енергетики є радіоактивні відходи використаного палива. Загалом – їх кількість незначна в порівнянні з відходами при спалювані вугілля на ТЕС, але і така кількість створює проблеми. Ці відходи повинні бути ізольовані від нашої екосистеми, адже перш ніж вони розпадуться через свою радіоактивність на більш безпечні хімічні елементи можуть пройти тисячі років.

Використане паливо перед захороненням поміщають в басейн з водою для зняття залишкового тепловиділення, тому що через радіоактивність, воно залишається гарячим впродовж 20 – 40 років. Після охолодження паливо підлягає тривалому зберіганню. Ці відходи потім захоронюють на сотні метрів під землю в бетонні бункери для стримування радіоактивності і для подальшої ізоляції від навколишнього середовища.

«Безпечно зберігатись під землею протягом 100 000 років» – звучить ризиковано, значною мірою тому, що людство ніколи не підписувало такі довготермінові контракти. Проте, є приклади того, як радіоактивне стримування відбувалося на Землі. Ядерні реактори, які утворювалися природно глибоко в земній корі, діяли протягом 1,7 млрд. років.

VIII. In pairs, make sentences using words and phrases below. Using your sentences discuss how steam is generated and process of fission, then present your ideas to the rest of the class.

1) Core of a plant, generate, nuclear reactor, power plant, steam, turned to, spend, turbine, fuel, boil.

2) Occur, station, temperature, fuel, since, reaction, increase, fission, efficiency, pellet, risky, burn, superheat.

IX. Summarize the text on pages 10 – 12 in 100 – 120 words. Follow the hints on how to write the Summary in Appendices A, B on pages 58 – 74.

Unit 3 Nuclear engineers: tasks and duties

I. List some of the jobs in engineering. Combine and discuss your list with others in your group.

II. Give Ukrainian equivalents for the following words and phrases:

atomic nuclei; radioactive waste disposal; positron emission tomography; nuclear accident; to benefit; interaction; construction process; radiation shielding; nuclear power plant; corrective actions; government-based research; development facilities; weaponry; employment setting; to gain more knowledge.

III. Give English equivalents for the following words and phrases:

космічний корабель; радіоактивні відходи; співпрацювати з іншими спеціалістами; докторська ступінь; радіаційний захист; технічне обслуговування; в той час як; проводити дослідження; контролювати роботу станції.

IV. Read the text about nuclear engineers thoroughly, check your answers and be ready to answer the questions that follow.

Nuclear engineering is the branch of engineering concerned with the application of the breakdown (fission) as well as the fusion of atomic nuclei and the application of other subatomic physics, based on the principles of nuclear physics. In the sub-field of nuclear fission, it particularly includes the interaction and maintenance of systems and components like nuclear reactors, nuclear power plants, and nuclear weapons. The field also includes the study of medical and other applications of (generally ionizing) radiation, nuclear safety, heat/thermodynamics transport, nuclear fuel or other related technology (e.g. radioactive waste disposal), and the problems of nuclear proliferations.

So, what do nuclear engineers do? Nuclear engineers are at the forefront of researching and developing, the processes used to obtain benefits from nuclear energy and radiation. Engineers in this subfield combine their knowledge of nuclear energy and expertise in nuclear reactions for design, research, development, and construction processes.

Nuclear engineers work to find industrial uses for nuclear material for the development of spacecraft, ships, and agricultural equipment. Nuclear engineers also work to develop uses of radioactive materials for medical imaging devices, such as positron emission tomography (PET) scanners. Some also specialize in designing cyclotrons, which provide high energy beams to treat cancerous tumors in the medical field.

Their duties are:

- develop and design nuclear equipment, including radiation shielding, nuclear reactors, and associated instrumentation;
- monitor various nuclear facility operations to ensure all practices for design and construction comply with safety regulations and government laws;
- evaluate nuclear accidents and collect data that can be used to prevent a similar event from recurring;
- create clear operational instructions for nuclear plant operation, as well as proper procedures for handling and disposing radioactive waste;
- supervise operations and maintenance activities at nuclear power plants;
- conduct studies to determine whether various methods of using nuclear material, reclaiming nuclear energy, or disposing of waste are appropriate and safe;
- perform necessary corrective actions to improve plant functioning for the safety of both the workers and public;
- respond to emergency situations by ordering nuclear plants to shut down.

Nuclear engineers often work in private or government-based research and development facilities. Others educate nuclear engineering students at colleges and universities, while some are also employed at nuclear power plants and factories that specialize in manufacturing nuclear equipment or weaponry.

Depending on the employment setting, a nuclear engineer job description will typically specialize in designing, researching, or developing nuclear equipment in a range of industries. Although a bachelor's degree can lead to entry-level positions in nuclear engineering, most nuclear engineers possess an advanced master's or doctoral degree.

Nuclear engineers must have strong analysis and problem solving skills, as well as communication skills to work well as part of a team. On-site nuclear engineers working on or supervising construction projects collaborate with other specialists and engineers. Some may supervise technicians that are utilizing radiation technology in manufacturing. Nuclear engineers often work closely with scientists to help them gain more knowledge about the structure and dynamics of matter or energy, as well as to come across new ways of using nuclear energy to benefit the world.

Adapted from: www.access 2 knowledge.org

1. What does sub-field of nuclear fission include?
2. What do you know about radioactive waste disposal?
3. What is the benefit from nuclear energy and radiation?
4. Are nuclear technologies safe?
5. What skills must engineers have?
6. Should nuclear engineers have a master's or doctoral degree?

V. Match words from box A to their synonyms from box B.

a) breakdown, design, machine, core, experimentalist, skills, position, experienced, safety, job, device, benefit

b) accident, build, mechanism, midpoint, researcher, ability, location, skilled,

safeness, work, mechanism, interest

VI. Match words from box A to their antonyms from box B.

a) safe, destroy, light, helpful, heat up, thick, load, failure, simply, synthesis

b) dangerous, build, dark, harmful, cool, rare, unload, luck, difficult, analysis

VII. Fill in the blanks with prepositions and adverbs.

So, what do nuclear engineers do? Nuclear engineers are at the forefront of researching and developing, the processes used to obtain benefits … nuclear energy and radiation. Engineers … this subfield combine their knowledge of nuclear energy and expertise in nuclear reactions … design, research, development, and construction processes.

Nuclear engineers work … find industrial uses for nuclear material for the development … spacecraft, ships, and agricultural equipment. Nuclear engineers also work to develop uses … radioactive materials for medical imaging devices, such as positron emission tomography (PET) scanners. Some also specialize … designing cyclotrons, which provide high energy beams to treat cancerous tumors … the medical field.

VIII. Choose the correct word and fill in the blanks.

(to) work work(s) working

1. A nuclear engineer … to find industrial uses for nuclear material for the development of spacecraft, ships, and agricultural equipment.
2. Nuclear engineers often … in private or government-based research and development facilities.
3. Nuclear engineers … on or supervising construction projects collaborate with other specialists and engineers.

(to) use   use(s)   used

4. Nuclear engineers work to develop … of radioactive materials for medical imaging devices, such as positron emission tomography scanners.
5. Nuclear engineers are at the forefront of researching and developing, the processes … to obtain benefits from nuclear energy and radiation.
6. The evaluation of nuclear accidents and collecting data can be … to prevent a similar event from recurring.

IX. Render the following text into English.

Ядерна фізика – розділ фізики, який вивчає структуру і властивості атомних ядер та механізми ядерних реакцій (в тому числі радіоактивний розпад).

Задачі, що виникають в ядерній фізиці, – це типовий приклад задач декількох тіл. Ядра складаються з нуклонів (протонів і нейтронів). В типових ядрах містяться десятки і сотні нуклонів. Це число дуже велике, щоб точно вирішувати задачі, але все-таки дуже мале, щоб можна було використати методи статистичної фізики. Це і призвело до великої різноманітності різних моделей атомних ядер.

Вивчення будови ядра та його складових елементів можливе лише за допомогою вивчення ядерних реакцій. Для проведення ядерних реакцій необхідні засоби прискорення й детектування частинок. Тому невід’ємними підрозділами ядерної фізики є фізика прискорювачів і фізика детекторів.

Радіаційна фізика та радіаційне матеріалознавство є міждисциплінарними підрозділами фізики, які вивчають вплив ядерного випромінювання на властивості опромінених речовин і методи модифікації властивостей матеріалів за допомогою опромінення.

Ядерна фізика має принципове значення для багатьох розділів астрофізики (первинний нуклеосинтез, термоядерні реакції в зорях як під час життя на головній послідовності, так і при сході з неї), і, безпосередньо, для ядерної енергетики.

X. Summarize the text on pages 15 – 17 in 100 – 120 words. Follow the hints on how to write the Summary in Appendices A, B on pages 58 – 74.

Unit 4 Nuclear power reactors

I. A. Listen to a lecture on a nuclear reactor and decide whether these sentences are true or false. Correct the false ones.

1. Nuclear reactors are the up-to-date devices extensively used for power generation.
2. A nuclear reactor consists of two crucial components: moderator and control rods.
3. Moderators are capable of slowing down the speed of high-energy neutrons.
4. By controlling the number of spare neutrons, the rate of the nuclear fusion chain reaction can be controlled.
5. Water is flown in and out of the nuclear reactor using the heat exchanger.

B. Read this extract from the tapescript and fill in each gap with an appropriate word.

The **1** … of a moderator is to slow down the energy neutrons in a nuclear reactor which are produced during the nuclear fission process by the fuel elements. Thermal neutrons, which are neutrons with energy of about **2** … electron volts, are capable of producing fission reaction with 235 92 U. During the **3** … reaction process, new neutrons are **4** … out which have energies of about 1 MeV. These neutrons of typically escape from participating in another fission process as they are **5** … by enormous energy release. In fact, the probability of these neutrons produce another fission reaction is **6** … times less than as compared to that of a thermal neutron. This is where moderator is extremely useful. Moderator has the capability to slow down, or in other words moderate, the speed of these high-energy neutrons, so that they can 7 … be used for a chain reaction to **8** … multiple fission reactions of other 235 92U nucleus.

Commonly, **9** … or heavy water is used as moderator in nuclear reactors because of the deuterons present in them which are **10** … of slowing the neutron speed. Water molecules in the moderator are useful in slowing down the high-energy neutrons which leave the fuel-element after nuclear fission. These high-energy neutrons **11** … with water molecules thereby losing out on some energy with every collision and therefore slow down **12** … . A new fission reaction can now be triggered using this slow neutron by striking it with the fuel element.

II. Give Ukrainian equivalents for the following words and phrases:

chain reaction; fission of heavy nuclei; moderator; radiopharmaceuticals; focal point of a reactor; metal sheath; molten sodium; control rod; vessel; heat-transfer fluid.

III. Give English equivalents for the following words and phrases:

постійний потік; конструктивні особливості; механічна енергія; рушійний генератор; стримувальні структури; електростанція; дослідницький реактор; енергетичний реактор; металева оболонка; рідкий теплоносій; гермооболонка; стрижні управління.

IV. Read the text about nuclear power reactors thoroughly, check your answers and be ready to answer the questions that follow.

All nuclear reactors are devices designed to maintain a chain reaction producing a steady flow of neutrons generated by the fission of heavy nuclei. They are, however, differentiated either by their purpose or by their design features. In terms of purpose, they are either research reactors or power reactors.

Research reactors are designed at universities and research centers in many countries, including some ones where no nuclear power reactors are operated. These reactors generate neutrons for multiple purposes, including producing radiopharmaceuticals for medical diagnosis and therapy, testing materials and conducting basic research.

Power reactors are usually found in nuclear power plants. Dedicated to generating heat mainly for electricity production, they are operated in more than 30 countries.

There are many different types of power reactors. What is common to them all is that they produce thermal energy that can be used for its own sake or converted into mechanical energy and ultimately, in the vast majority of cases, into electrical energy.

In these reactors, the fission of heavy atomic nuclei, the most common of which is uranium-235, produces heat that is transferred to a fluid which acts as a coolant.

Main components of a nuclear reactor

Core. It is the focal point of the reactor, where fuel is contained and nuclear fission reactions take place.

Fuel. Generally, fuel is made of small enriched uranium oxide rods, stacked so as to form cylinders, approx. 4 meters long and with a diameter of about one centimeter. These rods are wrapped in metal sheathes (steel or zirconium alloy), which allow heat to pass through while blocking the radioactive elements produced by fission.

Moderator. This is a material placed in the reactor to slow down the neutrons produced by fission, in order to reach the most suitable speed allowing the chain reaction to continue. Depending on reactor models, the moderator may consist of graphite, water or heavy water (water where hydrogen is present as its heavier isotope, deuterium).

Heat-transfer fluid (or coolant). This fluid (liquid or gas) cools the core and carries outside the heat that is produced there. The most common used fluid is water, but some types of reactors use heavy water, molten sodium, carbon dioxide, helium and other fluids.

Control rods. These are rods used in specific materials (silver, indium, cadmium or boron carbide) to control fission inside the core. Since they absorb neutrons, they are capable of controlling the chain reaction which – depending on how deep down rods are inserted into the core – can be accelerated, slowed down or even stopped, thus changing the capacity of the reactor. Indeed, if necessary, the reactor can be immediately stopped when they are fully inserted.

Vessel. The large steel recipient containing the core, control rods and heat-transfer fluid.

All components of the reactor are contained in a solid concrete structure that guarantees further isolation from external environment. This structure is made of concrete that is one-meter thick, covered with steel. The most recent reactors sometimes contain two containment structures and are designed to withstand all types of accidental events, even the impact of an aircraft.

Adapted from: www.enel.com

1. What is a nuclear reactor?
2. What kinds of reactors do you know?
3. Where are research reactors designed?
4. Where are power reactors operated?
5. What is common to all reactors?
6. What are the main components of the nuclear reactor?

V. Match words from box A to their synonyms from box B.

a) difference, do, move, predicament, wrong, stop, bent, perilous, perceive, make, exhibit, use

b) hazardous, to catty out, perform, pickle, expend, discontinue, hooked, incompatibility, watch, scurry, expose, improper

VI. Match words from box A to their antonyms from box B.

a) kind, same, common, flood, natural, general, exact, break, continue, increase

b) decrease, interrupt, rare, particular, artificial, different, approximate, repair, drought

VII. Fill in the blanks with prepositions.

There are many different types of power reactors. What is common ... them all is that they produce thermal energy that can be used for its own sake or converted into mechanical energy and ultimately, ... the vast majority of cases, into electrical energy.

... these reactors, the fission of heavy atomic nuclei, the most common ... which is uranium-235, produces heat that is transferred ... a fluid which acts as a coolant. During the fission process, bond energy is released and this first becomes noticeable as the kinetic energy of the fission products generated and that ... the neutrons being released. Since these particles undergo intense deceleration in the solid nuclear fuel, the kinetic energy turns into heat energy.

... the case of reactors designed to generate electricity, the heated fluid can be gas, water or a liquid metal. The heat stored ... the fluid is then used either directly (in the case of gas) or indirectly (in the case of water and liquid metals) to generate steam. The heated gas or the steam is then fed into a turbine driving an alternator.

VIII. In pairs, make sentences using words and phrases below. Using your sentences discuss operation of nuclear power reactors and plants, then present your ideas to the rest of the class.

1) Research centers, nuclear power reactors, research reactors, neutrons radiopharmaceuticals, medical diagnosis and therapy;
2) Nuclear power plants, dedicated, heat, electricity production, power reactors.

IX. Render the following text into English.

Під час процесу поділу важких ядер енергія зв’язку вивільняється у вигляді генерованої кінетичної енергії продуктів поділу. Енергія розподіляється між уламками ділення та нейтронами. Оскільки нейтрони піддаються інтенсивному уповільненню в твердому ядерному паливі, кінетична енергія перетворюється в теплову енергію.

У разі використання реактору для вироблення електроенергії, теплоносієм може бути газ, вода або рідкий метал. Тепло, накопичене рідиною, потім використовується або безпосередньо (у випадку газу), або побічно (у разі води і рідких металів) для генерації пари. Нагрітий газ або пара потім подається на турбіну з електричним генератором змінного струму.

Так, відповідно до законів природи, тепло не може бути повністю перетворене в іншу форму енергії, частина тепла є залишковою і викидається в навколишнє середовище. Випуск є, або прямим – наприклад, в річку, або непрямим – в атмосферу через градирні. Така практика є спільною для всіх теплових станцій, і в жодному разі не виключає ядерні реактори, котрі є одним з різновидів теплових електростанцій.

X. Summarize the text on pages 22 – 24 in 100 – 120 words. Follow the hints on how to write the Summary in Appendices A, B on pages 58 – 74.

Unit 5 Types of nuclear power reactors

I. Give Ukrainian equivalents for the following words and phrases:

moderation; reactor pressure vessel; simultaneously; to sustain the chain reaction; primary circuit; heat exchanger; reinforced building; turbine-alternator set; pressurized water reactor; boiling water reactor; pressurized heavy water reactor; gas-cooled reactor; light water graphite reactor; the Commonwealth of Independent States (CIS).

II. Give English equivalents for the following words and phrases:

збагачений уран, достатньо стійкий, підтримувати ланцюгову реакцію, виділення пари, поглинати тепло, реактор з водою під тиском, реактор з киплячою водою, об'єкт активної зони реактора.

III. Read the text about types of nuclear power reactors thoroughly, check your answers and be ready to answer the questions that follow.

Nuclear power reactors can be classified according to the type of fuel they use to generate heat.

Uranium–fuelled reactors. The only natural element currently used for nuclear fission in reactors is uranium. Natural uranium is a highly energetic substance: one kilogram of it can generate as much energy as 10 tons of oil. Naturally occurring uranium comprises, almost entirely, two isotopes: U238 (99.283%) and U235 (0.711%). The former is not fissionable while the latter can be fissioned by thermal (i.e. slow) neutrons. As the neutrons emitted in a fission reaction are fast, reactors using U235 as fuel must have a means of slowing down these neutrons before they escape from the fuel. This function is performed by what is called a moderator, which, in the case of certain reactors (see table of reactor types below) simultaneously acts as a coolant. It is common practice to classify power reactors according to the nature of the coolant and the moderator plus, as the need may arise, other design characteristics.

Reactor Type	Coolant	Moderator	Fuel	Comment
Pressurised water reactors (PWR, VVER)	Light water	Light water	Enriched uranium	Steam generated in secondary loop
Boiling water reactors (BWR)	Light water	Light water	Enriched uranium	Steam from boiling water fed to turbine
Pressurised heavy water reactor (PHWR)	Heavy water	Heavy water	Natural uranium	
Gas-cooled reactors (Magnox, AGR, UNGG)	CO2	Graphite	Natural or enriched uranium	
Light water graphite reactors (RBMK)	Press-urised boiling water	Graphite	Enriched uranium	Soviet design

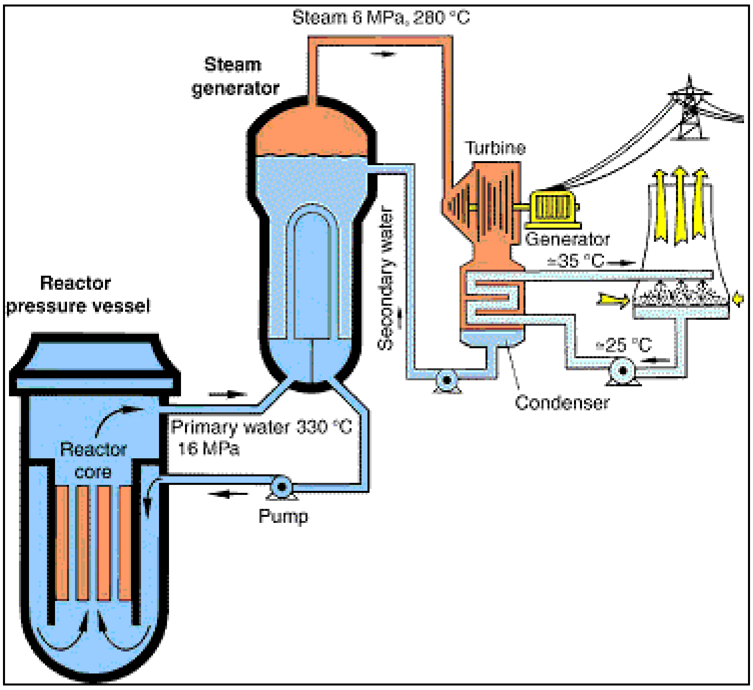
PWRs and BWRs are the most commonly operated reactors in Commonwealth of Independent States (CIS). VVERs, designed in the former Soviet Union, are based on the same principles as PWRs. They use “light water”, i.e. regular water (H2O) as opposed to “heavy water” (deuterium oxide D2O). Moderation provided by light water is not sufficiently effective to permit the use of natural uranium. The fuel must be slightly enriched in U235 to make up for the losses of neutrons occurring during the chain reaction. On the other hand, heavy water is such an effective moderator that the chain reaction can be sustained without having to enrich the uranium. This combination of natural uranium and heavy water is used in PHWRs, which are found in a number of countries, including Canada, Korea, Romania and India.

Graphite-moderated, gas-cooled reactors, formerly operated in France and still operated in Great Britain, are not built any more in spite of some advantages.

RBMK-reactors (pressure-tube boiling-water reactors), which are cooled with light water and moderated with graphite, are now less commonly operated in some former Soviet Union bloc countries. Following the Chernobyl accident (26 April 1986) the construction of this reactor type ceased. The operating period of those units still in operation will be shortened.

Plutonium-fuelled reactors. Plutonium (Pu) is an artificial element produced in uranium-fuelled reactors as a by-product of the chain reaction. It is one hundred times more energetic than natural uranium; one gram of Pu can generate as much energy as one ton of oil. As it needs fast neutrons for fission, moderating materials must be avoided to sustain the chain reaction in the best conditions. The current Plutonium-fuelled reactors, also called "fast" reactors, use liquid sodium which displays excellent thermal properties without adversely affecting the chain reaction. These types of reactors are in operation in France, Japan and CIS.

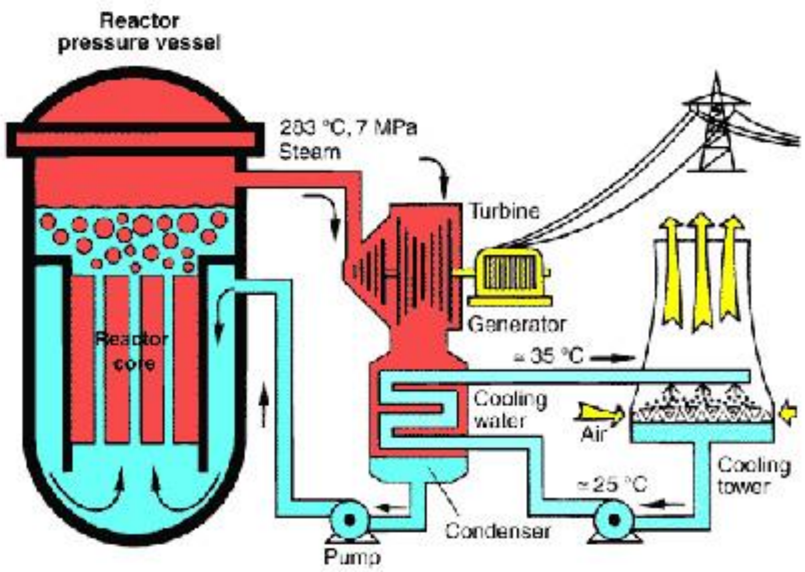
Pressurized water reactors. The fission zone (fuel elements) is contained in a reactor under a pressure of 150 to 160 bar (15 to 16 MPa). The primary circuit connects the reactor pressure vessel to heat exchangers. The secondary side of these heat exchangers is at a pressure of about 60 bar (6 MPa) – low enough to allow the secondary water to boil. The heat exchangers are, therefore, actually steam generators. Via the secondary circuit, the steam is routed to a turbine driving an alternator. The steam coming out of the turbine is converted back into water by a condenser after having delivered a large amount of its energy to the turbine. It then returns to the steam generator. As the water driving the turbine (secondary circuit) is physically separated from the water used as reactor coolant (primary circuit), the turbine-alternator set can be housed in a turbine hall outside the reactor building.



Nuclear power plant with pressurized water reactor

Boiling water reactors. The fission zone is contained in a reactor pressure vessel, at a pressure of about 70 bar (7 MPa). When the temperature reaches approximately 290°C, the water starts boiling and the resulting steam is produced directly in the reactor pressure vessel. After the separation of steam and water in the upper part of the reactor pressure vessel, the steam is routed directly to a turbine driving an alternator.

The steam coming out of the turbine is converted back into water by a condenser after having delivered a large amount of its energy to the turbine. It is then fed back into the primary cooling circuit where it absorbs new heat in the fission zone. Since the steam produced in the fission zone is slightly radioactive, mainly due to short-lived activation products, the turbine is housed in the same reinforced building as the reactor.



Principle of operation of a nuclear power plant with boiling water reactor

Adapted from: ncert-notes.blogspot.com

1. What natural element is currently used in reactors?
2. What does «heavy water» mean?
3. What is moderation provided by light water not sufficiently effective for?
4. What fuel does a «fast» reactor use?
5. What moderator is used in the fast reactor?
6. Why will the operating period of RBMC be shortened?
7. What does a turbine turn?
8. What connects the primary circuit?
9. What function do exchangers perform?

IV. Match words from box A to their synonyms from box B.

a) activate, separation, liquid, metrics, cooling, moderator, accelerant, reaction, circuit, pipe, heat, vacuum, shell

b) enable, membrane, dividing, refrigeration, stats, fluid, rarefaction, warm, tube, booster, backlash, retardant, contour

V. Match words from box A to their antonyms from box B.

a) boil, core, steam, pressure, heat, moderator, emit, condenser, fission, enriched, high

b) depleted, low, freeze, ice, shell, cool, discharge, steam generator, joining, absorb, accelerator

VI. Fill in the blanks with articles or prepositions.

1) The former is not fissionable while ... latter can be fissioned … thermal (i.e. slow) neutrons.

2) This function is performed … what is called a moderator, … in the case … certain reactors simultaneously acts … a coolant.

3) Moderation provided … light water is not sufficiently effective to permit the use … natural uranium.

4) These types … reactors are in operation in France, Japan and …Commonwealth … Independent States (CIS).

5) … the water driving the turbine (secondary circuit) is physically separated … the water used … reactor coolant (primary circuit), the turbine-alternator set can be housed in a turbine hall outside … reactor building.

VII. Render the following text into English.

Реактори на легкій воді

Даний тип реакторів ділиться на такі типи: реактори з водою під тиском (ПВР та ВВЕР) і реактори з киплячою водою (БВР). Обидва ці типи використовують легку воду і збагачений уран як паливо. Легка вода, яку вони використовують, є одночасно теплоносієм і сповільнювачем. Потоки води проходять через активну зону реактора, яка містить блок паливних стрижнів, де теплоносій забирає тепло, що виділяється внаслідок поділу урану-235 в паливних стрижнях. Після теплообмінника пар потрапляє до парової турбіни, а відпрацьований пар конденсується і направляється назад до активної зони реактора. Таким чином, замикається цикл першого контуру. Для передачі високого потенціалу теплової енергії на турбіну необхідно досягти температури близько 300 градусів. ПВР і БВР відрізняються тиском теплоносія, що проходить через активну зону реактора. В БВР, тиск охолоджувальної рідини істотно нижче, ніж в ПВР, що запобігає її кипінню. Пар, в результаті цього процесу, подається в турбіну.

Принципова різниця між нагріванням під тиском і випаровуванням під час кипіння зумовлює багато конструктивних характеристик двох типів реакторів на легкій воді. Незважаючи на відмінності в конструкціях, слід зазначити, що в двох типах реакторів забезпечується еквівалентний рівень безпеки.

VIII. In pairs, make sentences using words and phrases below. Using your sentences discuss functions of the primary cooling circuit and heat exchangers, then present your ideas to the rest of the class.

1) the turbine, back into water, a large amount, the primary cooling circuit, the fission zone, steam, a condenser, energy**.**

2) the primary circuit, reactor pressure vessel, secondary side, a pressure, secondary water, heat exchangers, steam generators, to boil.

IX. Summarize the text on pages 27 – 30 in 120 – 140 words. Follow the hints on how to write the Summary in Appendices A, B on pages 58 – 74.

Unit 6 Heat and temperature

I. A. Listen to a lecture on heat and temperature and decide whether these sentences are true or false. Correct the false ones.

1. Temperature is a measure of the average potential energy in a substance.
2. As temperature increases, molecular motion increases, kinetic energy of particles increases.
3. Absolute 0 (0 K) is the lowest possible temperature.
4. Energy is related to temperature and heat.
5. 1 calorie is the amount of energy needed to raise the temperature of 1g of water, 1 Celsius degree.

B. Listen to a lecture again and complete the student's notes.

Kinetic energy	*Potential energy*
1. Energy in motion e.g. ________________________ *2. ________________________* *3. Associated with ____________* *4. The faster the movement of particles, ________________________* *5. ________________________, the faster the particles move.*	*1. Energy ________________ gasoline in a tank, water behind a dam and a roller coaster at the top of a hill.* *2. Capacity to do work.* *3. Related to ________________.* *The more chemical bonds, ________________________.*

II. Give Ukrainian equivalents for the following words and phrases:

hand in hand; metric unit; remarkable coincidence; the freezing point of water; to cuddle up; convenient unit of measurement; in the context of a food's nutritional content; specific heat.

III. Give English equivalents for the following words and phrases:

суттєва відмінність, взаємозв'язок, розміщення, розсіювати, теплоємність, простий збіг, зіштовхнутись з проблемою, довільно обрана точка, хімічні зв'язки, речовина.

IV. Read the text about heat and temperature thoroughly, check your answers and be ready to answer the questions that follow.

In everyday speech, heat and temperature go hand in hand: the hotter something is, the greater its temperature. However, there is a subtle difference in the way we use the two words in everyday speech, and this subtle difference becomes crucial when studying physics.

Temperature. Temperature is a property of a material, and thus depends on the material, whereas heat is a form of energy existing on its own**.** While temperature is related to thermal energy, there is no absolute correlation between the amount of thermal energy (heat) of an object and its temperature. Temperature measures the concentration of thermal energy in an object in much the same way that density measures the concentration of matter in an object. As a result, a large object will have a much lower temperature than a small object with the same amount of thermal energy. As we shall see shortly, different materials respond to changes in thermal energy with more or less dramatic changes in temperature.

Degrees Celsius. In the United States, temperature is measured in degrees Fahrenheit (ºF). However, Fahrenheit is not a metric unit, so it will not show up on SAT II Physics. Physicists and non-Americans usually talk about temperature in terms of degrees **Celsius**, a.k.a. centigrade (ºC). Water freezes at exactly 0ºC and boils at 100ºC. This is not a remarkable coincidence – it is the way the Celsius scale is defined.

SAT II Physics will not ask you to convert between Fahrenheit and Celsius, but if you have a hard time thinking in terms of degrees Celsius, it may help to know how to switch back and forth between the two. The freezing point of water is 0ºC and 32ºF. A change in temperature of nine degrees Fahrenheit corresponds to a change of five degrees Celsius, so that, for instance, 41ºF is equivalent to 5ºC. In general, we can relate any temperature of *y*ºF to any temperature of *x*ºC with the following equation:

$$y^\circ\mathrm{F} = \frac{9}{5}x^\circ\mathrm{C} + 32$$

Kelvins. In many situations we are only interested in changes of temperature, so it does not really matter where the freezing point of water is arbitrarily chosen to be. But in other cases, as we shall see when we study gases, we will want to do things like "double the temperature," which is meaningless if the zero point of the scale is arbitrary, as with the Celsius scale.

The **Kelvin** scale (K) is a measure of absolute temperature, defined so that temperatures expressed in Kelvins are always positive. **Absolute zero**, 0 K, which is equivalent to – 273ºC, is the lowest theoretical temperature a material can have. Other than the placement of the zero point, the Kelvin and Celsius scales are the same, so water freezes at 273 K and boils at 373 K.

Calories. Like work, heat can be measured in terms of joules, but it is frequently measured in terms of **calories** (cal). Unlike joules, calories relate heat to changes in temperature, making them a more convenient unit of measurement for the kinds of thermal physics problems you will encounter on SAT II Physics. Be forewarned, however, that a question on thermal physics on SAT II Physics may be expressed either in terms of calories or joules.

A calorie is defined as the amount of heat needed to raise the temperature of one gram of water by one degree Celsius. One calorie is equivalent to 4.19 J.

$$1\ \text{cal} = 1\ \text{g}/^{\circ}\text{C} = 4.19\ \text{J}$$

You are probably most familiar with the word *calorie* in the context of a food's nutritional content. However, food calories are not quite the same as what we are discussing here: they are actually Calories, with a capital "C," where 1 Calorie = 1000 calories. Also, these Calories are not a measure of thermal energy, but rather a measure of the energy stored in the chemical bonds of food.

Specific Heat. Though heat and temperature are not the same thing, there is a correlation between the two, captured in a quantity called **specific heat**, *c*. Specific heat measures how much heat is required to raise the temperature of a certain mass of a given substance. Specific heat is measured in units of J/kg · ºC or cal/g · ºC. Every substance has a different specific heat, but specific heat is a constant for that substance.

Adapted from: 123 doc.org

1. What is the difference between heat and temperature?
2. Is the correlation between the amount of thermal energy (heat) of an object and its temperature absolute?
3. In which units is the temperature measured in the U.S.?
4. How can we relate any temperature of yºF to any temperature of xºC?
5. What is the difference between calories and Calories?
6. What does specific heat measure?

V. Complete these sentences with words from the box.

melting point, centigrade, steam generator, measurable, conduction, generally speaking, agitated, the calorie, thermal equilibrium, designed, molecules, equal, intensive property, heat, be detected

1. Nuclear power reactors can be classified according to the type of fuel they use to generate ….

2. Heat capacity, or thermal capacity, is the … physical quantity of heat energy

required to change the temperature of an object by a given amount.

3. Heat capacity is an … of matter, meaning it is proportional to the size of the system.

4. Solids are rigid because their … do not have enough kinetic energy to go anywhere – they just vibrate in place.

5. Changes in heat can usually … as changes in temperature.

6. Because energy is conserved, the heat that flows out of the hotter object will be … to the heat that flows into the colder object.

7. A boiler or … is a device used to create steam by applying heat energy to water.

8. All nuclear reactors are devices … to maintain a chain reaction producing a steady flow of neutrons generated by the fission of heavy nuclei.

9. Celsius, also known as …, is a scale and unit of measurement for temperature.

10. Thermal physics, …, is the study of the statistical nature of physical systems from an energetic perspective.

11. When the thermal changes have stopped, we say that the two objects (physicists define them more rigorously as systems) are in ….

12. If a solid is heated through its …, it will melt and turn to liquid.

13. … is the transfer of heat by intermolecular collisions.

14. Molecules are always …, to some extent – and therefore the absolute zero of temperature remains a theoretical concept.

15. Commonly used units for measuring heat are ... and the British thermal unit, or Btu.

VI. Match words from box A to their synonyms from box B.

a) equivalent, temperature, crucial, disperse, between, constant, usually, average, absolute, change, to support, measure, correlation, theoretical.

b) heat, dissipate, amid, permanent, commonly, alter, medium, unmitigated, to back up, interrelation, degree, decisive, ideal, tantamount.

VII. Match words from box A to their antonyms from box B.

a) warm, increase, boiling point, solid, positive, dense, constant, accumulate, expand, disadvantage.

b) negative, cool, soft, thin, advantage, variable, freezing point, dissipate, compress, decrease.

VIII. In pairs, make questions using these prompts. Then practice asking and answering the questions.

1. What / temperature?
2. What / temperature measure?
3. How / relate any temperature of yºF to any temperature of xºC?
4. Why / use the Kelvin scale in the study of gases?
5. How / a calorie defined?
6. What / the difference between calories and Calories?
7. What / the measure of specific heat?

IX. Render the following text into English.

Визначення температури

Температура матеріалу є мірою середньої кінетичної енергії молекул, з яких складається цей матеріал. Абсолютний нуль визначається як температура, при якій молекули мають нульову кінетичну енергію.

Тверді тіла є жорсткими, тому що їх молекули не мають достатньої кінетичної енергії, щоб рухатись куди завгодно – вони просто вібрують у вузлах кришталевої гратки. Молекули в рідині мають достатньо енергії для руху один до одного – і саме тому рідини текучі, але не достатньо, щоб молекули уникнули одна одну. У молекул газу настільки багато кінетичної енергії, що вони розтікаються і газ розширюється, щоб заповнити ємність, в якій він знаходиться.

Теплова енергія. Вона передається від більш гарячого тіла до більш холодного згідно з другим законом термодинаміки. У той час як і робота, і висока температура може бути виміряна, вони не є мірою енергії, ці параметри є мірою передачі енергії. Грілка має певну кількість теплової енергії; коли ви прикладаєте пляшку гарячої води, вона віддає певну кількість тепла вашому тілу.

X. Summarize the text on pages 35 – 37 in 100 – 120 words. Follow the hints on how to write the Summary in Appendices A, B on pages 58 – 74.

Unit 7 The notions of thermal physics

I. Give Ukrainian equivalents for the following words and phrases:

energy is conserved; phase changes; block of ice; melting point; boiling point; condense into a liquid; steady heat; most likely; qualitative understanding; intermolecular collisions; water molecules; transferring heat; electromagnetic waves; energizing the molecules.

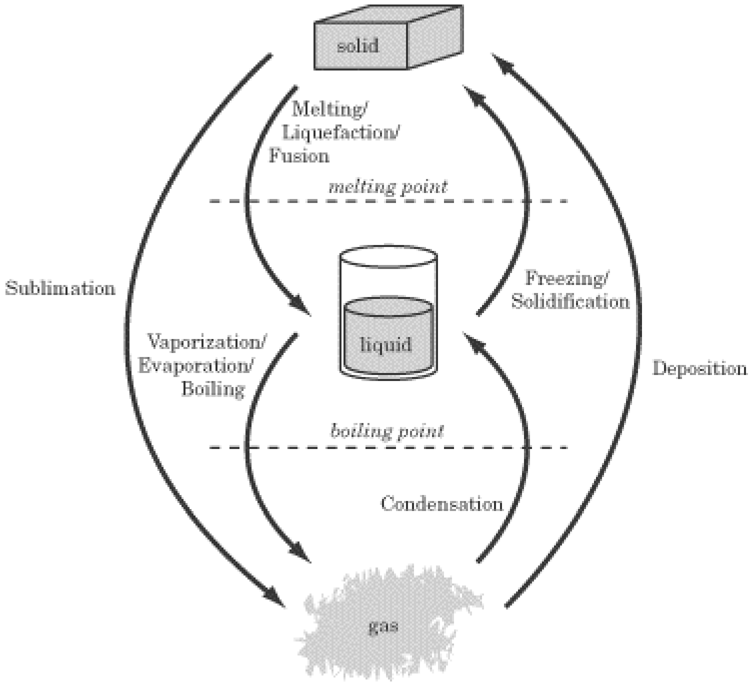
II. Give English equivalents for the following words and phrases:

загальна істина, передача теплоти, зберігати енергію, теплова рівновага, може бути перетворений, міжмолекулярне зіткнення, теплопровідність, кінетична енергія, тверде тіло, рідина, активізація молекул, сонячні промені.

III. Read the text about the notions of thermal physics thoroughly, check your answers and be ready to answer the questions that follow.

Phase changes. As you know, if you heat a block of ice, it will not simply get warmer. It will also melt and become liquid. If you heat it even further, it will boil and become a gas. When a substance changes between being a solid, liquid, or gas, we say it has undergone a phase change.

Melting point and boiling point. If a solid is heated through its melting point, it will melt and turn to liquid. Some substances – for example, dry ice (solid carbon dioxide) – cannot exist as a liquid at certain pressures and will sublimate instead, turning directly into gas. If a liquid is heated through its boiling point, it will vaporize and turn to gas. If a liquid is cooled through its melting point, it will freeze. If a gas is cooled through its boiling point, it will condense into a liquid, or sometimes deposit into a solid, as in the case of carbon dioxide. These phase changes are summarized in the figure below.



A substance requires a certain amount of heat to undergo a phase change. If you were to apply steady heat to a block of ice, its temperature would rise steadily until it reached 0ºC. Then the temperature would remain constant as the block of ice slowly melted into water. Only when all the ice had become water would the temperature continue to rise.

Methods of heat transfer. There are three different ways heat can be transferred from one substance to another or from one place to another. This material is most likely to come up on SAT II Physics as a question on what kind of heat transfer is involved in a certain process. You need only have a qualitative understanding of the three different kinds of heat transfer.

Conduction. Conduction is the transfer of heat by intermolecular collisions. For example, when you boil water on a stove, you only heat the bottom of the pot. The water molecules at the bottom transfer their kinetic energy to the molecules above them through collisions, and this process continues until all of the water is at thermal equilibrium. Conduction is the most common way of transferring heat between two solids or liquids, or within a single solid or liquid. Conduction is also a common way of transferring heat through gases.

Convection. While conduction involves molecules passing their kinetic energy to other molecules, convection involves the molecules themselves moving from one place to another. For example, a fan works by displacing hot air with cold air. Convection usually takes place with gases traveling from one place to another.

Radiation. Molecules can also transform heat into electromagnetic waves, so that heat is transferred not by molecules but by the waves themselves. A familiar example is the microwave oven, which sends microwave radiation into the food, energizing the molecules in the food without those molecules ever making contact with other, hotter molecules. Radiation takes place when the source of heat is some form of an electromagnetic wave, such as microwave or sunlight.

Adapted from: indahnyafizik.blogspot.com

1. How is heat transferred between hotter and cooler body?
2. How is the state when both of the bodies have the same temperature called?
3. What happens with a solid if it is heated through its melting point?
4. What is the difference between convection and conduction?
5. What is the difference between convection and radiation?
6. What happens with a liquid if it is heated through its boiling point?

IV. Complete these sentences with words from the box.

hotter object, melt, colder object, phase change, freeze, vaporize, condense, conduction, transferred, kinetic energy, convection, thermal equilibrium, electromagnetic waves

1. Heat flows spontaneously from a … object to a … object, but never from a … object to a … object.
2. If you heat a block of ice, it will not simply get warmer. It will also … and become liquid.
3. When a substance changes between being a solid, liquid, or gas, we say it has undergone a … .
4. If a liquid is heated through its boiling point, it will … and turn to gas.

5. If a liquid is cooled through its melting point, it will … .
6. If a gas is cooled through its boiling point, it will … into a liquid.
7. There are three different ways heat can be … from one substance to another or from one place to another.
8. … is the transfer of heat by intermolecular collisions.
9. The water molecules at the bottom transfer their … to the molecules above them through collisions, and this process continues until all of the water is at … .
10. While conduction involves molecules passing their kinetic energy to other molecules, … involves the molecules themselves moving from one place to another
11. Molecules can also transform heat into …, so that heat is transferred not by molecules but by the waves themselves.

V. Match words from box A to their synonyms from box B.

a) warmer, cooler, energy, solid, liquid, melt, transfer, between, constant, usually

b) freezer, power, fluent, fuse, convert, amid, firm, permanent, commonly, hotter

VI. Match words from box A to their antonyms from box B.

a) solid, rise, single, melting, equilibrium, hot, boil, flow

b) liquid, cool, stand, drop, condense, boiling, collision, multiple

VII. Render the following text into English.

Теплова рівновага

Візьміть гарячу кружку какао в руку, і ваша рука буде нагріватися, в процесі кружка стає холоднішою. Можливо, ви помітили, що інакше не відбувається: ви не можете зробити свою руку холоднішою і кухоль тепліше, поклавши руку на кружку. Те, що ви помітили це – загальна істина в світі: тепло не тече спонтанно з більш гарячого об’єкта до більш холодного об’єкта, але ніколи від більш холодного об’єкта до більш гарячого об’єкта. Це один із способів доказу другого закону термодинаміки.

Всякий раз, коли два об’єкти з різними температурами контактують, тепло надходитиме від теплішого з двох об’єктів, до холоднішого, поки вони обидва будуть мати однакову температуру. Коли вони досягають цього стану, ми говоримо, що вони перебувають у тепловій рівновазі.

Оскільки енергія зберігається, тепло, яке витікає з гарячого об’єкта дорівнюватиме теплоті, яка тече до холодного об’єкта. Маючи це на увазі, можна обчислити температуру обох об’єктів, коли вони перебувають в тепловій рівновазі.

VIII. In pairs, make sentences using words and phrases below. Using your sentences discuss such notions of thermal physics as conduction, convection, radiation, then present your ideas to the rest of the class.

1) Conduction, convection, kinetic energy, molecules, one place to another. Convection, gases, traveling.

2) Molecules, electromagnetic waves, waves, radiation, the source of heat, microwave, sunlight.

IX. Summarize the text on pages 41 – 43 in 100 – 120 words. Follow the hints on how to write the Summary in Appendices A, B on pages 58 – 74.

Unit 8 The laws of thermodynamics

I. Give Ukrainian equivalents for the following words and phrases:

to accelerate; as long as; to do any calculating; thermal equilibrium; matter of logic; a significant consequence; to be placed in contact with one another; an isolated system; internal energy; potential energy; conservation of energy; equivalent forms; heat engines.

II. Give English equivalents for the following words and phrases:

впорядкований від нуля до трьох, теплова рівновага, термодинамічна система, однакова температура, значний наслідок, рівняння, впливати на внутрішню енергію, об'єм роботи, рівнодійна сила, інтуїтивне формулювання, абсолютний нуль, третій закон термодинаміки.

III. Read the text about the laws of thermodynamics thoroughly, check your answers and be ready to answer the questions that follow.

Dynamics is the study of why things move the way they do. The prefix *thermo* denotes heat, so thermodynamics is the study of what compels heat to move in the way that it does. The Laws of Thermodynamics give us the whats and whys of heat flow.

The laws of thermodynamics are a bit strange. There are four of them, but they are ordered zero to three, and not one to four. They were not discovered in the order in which they are numbered, and some – particularly the Second Law – have many different formulations, which seem to have nothing to do with one another.

There will almost certainly be a question on the Second Law on SAT II Physics, and quite possibly something on the First Law. The Zeroth Law and Third Law are unlikely to come up, but we include them here for the sake of completion. Questions on the Laws of Thermodynamics will probably be qualitative: as long as you understand what these laws mean, you probably will not have to do any calculating.

The Zeroth Law

If system *A* is at thermal equilibrium with system *B*, and *B* is at thermal equilibrium with system *C*, then *A* is at thermal equilibrium with *C*. This is more a matter of logic than of physics. Two systems are at thermal equilibrium if they have the same temperature. If *A* and *B* have the same temperature, and *B* and *C* have the same temperature, then *A* and *C* have the same temperature.

The significant consequence of the Zeroth Law is that, when a hotter object and a colder object are placed in contact with one another, heat will flow from the hotter object to the colder object until they are in thermal equilibrium.

The First Law

Consider an isolated system – that is, one where heat and energy neither enter nor leave the system. Such a system is doing no work, but we associate with it a certain internal energy, *U*, which is related to the kinetic energy of the molecules in the system, and therefore to the system's temperature. Internal energy is similar to potential energy in that it is a property of a system that is doing no work, but has the potential to do work.

The First Law tells us that the internal energy of a system increases if heat is added to the system or if work is done on the system and decreases if the system gives off heat or does work. We can express this law as an equation:

$$\Delta U = \Delta Q + \Delta W$$

where *U* signifies internal energy, *Q* signifies heat, and *W* signifies work.

The First Law is just another way of stating the law of conservation of energy. Both heat and work are forms of energy, so any heat or work that goes into or out of a system must affect the internal energy of that system.

The Second Law

There are a number of equivalent forms of the Second Law, each of which sounds quite different from the others. Questions about the Second Law on SAT II Physics will invariably be qualitative. They will usually ask that you identify a certain formulation of the Second Law as an expression of the Second Law.

The Second Law in Terms of Heat Flow

Perhaps the most intuitive formulation of the Second Law is that heat flows spontaneously from a hotter object to a colder one, but not in the opposite direction. If you leave a hot dinner on a table at room temperature, it will slowly cool down, and if you leave a bowl of ice cream on a table at room temperature, it will warm up and melt. You may have noticed that hot dinners do not spontaneously get hotter and ice cream does not spontaneously get colder when we leave them out.

The Second Law in Terms of Heat Engines

One consequence of this law, which we will explore a bit more in the section on heat engines, is that no machine can work at 100% efficiency: all machines generate some heat, and some of that heat is always lost to the machine's surroundings.

The Third Law

It is impossible to cool a substance to absolute zero. This law is irrelevant as far as SAT II Physics is concerned, but we have included it for the sake of completeness.

Adapted from: www. sparknotes.com

1. What do the laws of thermodynamics define?
2. What is the definition of the Zeroth Law?
3. What is a thermal equilibrium?
4. What is the significant consequence of the Zeroth Law of thermodynamics?
5. What does the First Law of thermodynamics tell us?
6. Does the Second Law of thermodynamics have equivalent forms?

7. How does the formulation of the Second Law of thermodynamics sound in terms of Heat Flow?

IV. Match words from box A to their synonyms from box B.

a) to study, to accelerate, to compel, heat, equilibrium, flow, internal, container, formulation

b) to learn, to precipitate, balance, stream, warmth, package, enunciation, inside, to cause.

V. Match words from box A to their synonyms from box B.

a) equilibrium, hotter, spontaneously, positive, add, hot, equal, order, together.

b) purposely, negative, unbalance, cool, different, separately, colder, remove, disorder.

VI. Choose the correct word and fill in the blanks:

sake study equilibrium ordered

1) Dynamics is the ……… of why things move the way they do.

2) There are four of them, but they are ……..zero to three, and not one to four.

3) The Zeroth Law and Third Law are unlikely to come up, but we include them here for the ……..of completion.

4) If system *A* is at thermal ………..with system *B*, and *B* is at thermal equilibrium with system *C*, then *A* is at thermal equilibrium with *C*.

work hotter flow heat similar

1) The significant consequence of the Zeroth Law is that, when a …… object and a colder object are placed in contact with one another, heat will ……. from the hotter object to the colder object until they are in thermal equilibrium.

2) Internal energy is ……..to potential energy in that it is a property of a system that is doing no work, but has the potential to do……… .

3) The First Law tells us that the energy of a system increases if …… is added to the system or if work is done on the system and decreases if the system gives off heat or does work.

key cool conservation force work

1) The First Law is just another way of stating the law of ………..of energy.

2) The ……….. to answering this question is to note that the temperature of the container remains constant.

3) The amount of ………done by the system on the piston is the product of the …….. exerted on the piston and the distance the piston is moved.

4) It is impossible to ………….. a substance to absolute zero.

VII. A. Listen to a lecture on entropy and decide whether these sentences are true or false. Correct the false ones.

1. 1865 the term entropy was coined by a German physicist Rudolph Clausius.
2. According to the online etymology dictionary the word entropy means ‘in a turning’.
3. The Second Law of Thermodynamics says the entropy of the universe tends towards a maximum.
4. Entropy is an emergent property that arises when the whole is less than the sum of its parts.
5. The entropy of perfectly isolated stuff must always decrease.

B. Work in pairs, A and B. Listen again and explain your partner such physical phenomenon as entropy. Before you start, work out with your partner useful questions to obtain as much information as possible.

VIII. Render the following text into English.

Другий закон з точки зору ентропії

Найвідомішим формулюванням Другого Закону є формулювання з точки зору ентропії. Поняття «ентропія» було введено в 19-му столітті як технічний термін для позначення невпорядкованості системи. Той же самий принцип, який говорить нам, що тепловий потік переміщується від гарячого до холодного тіла, але не по зустрічному напрямку говорить нам, що головні, впорядковані системи, схильні до того, щоб ставати невпорядкованими, але невпорядковані системи не схильні до того, щоб ставати впорядкованими.

Уявіть, що засипаєте столову ложку солі і потім столову ложку перцю в банку. Спочатку, будуть дві окремі купи: одна з солі і одна з перцю. Але якщо Ви тряхнете суміш, то частинки солі і перцю змішаються. І ніякі струшування тоді не допоможуть Вам розділити суміш назад в дві відмінні купи. Дві окремі купи солі і перцю представляють більш упорядковану систему, ніж їх суміш.
Потім, уявіть, що Ви впускаєте банку на підлогу. Скло б'ється і частинки солі, і перцю розсипаються на підлозі. Ви можете терпляче чекати, але Ви виявите, що в той час як скло може розбитися і частинки можуть розсіятися, ніяка дія, настільки ж проста, як розбиття банки не змусить скло з'єднатися назад, щоб знову зібрати себе, або сіль і перець. Ваша система солі і перцю в банці більш впорядкована, ніж система розбитої банки і розсипаних приправ.

IX. In pairs, make sentences using words and phrases below. Using your sentences discuss the laws of thermodynamics, and then present your ideas to the rest of the class.

thermodynamics, to explain, definition, thermodynamic systems, the laws of thermodynamics, heat, cool, hot, different formulations, physics, temperature, heat flow, internal energy, thermal equilibrium, absolute zero, entropy, work, equation.

X. Summarize the text on pages 46 – 48 in 100 – 120 words. Follow the hints on how to write the Summary in Appendices A, B on pages 58 – 74.

Unit 9 Inside the Fukushima Daiichi reactors:
the echo of Japan disaster

I. Give Ukrainian equivalents for the following words and phrases:

thermal power; heat removal; heat exchanger; primary containment; to house; external stack; fire pump; to vent; wet well; noble gases; to accompany; rupture interpretation; to solidify; debris; defueled; reactor pressure vessel (RPV); IAEA; NISA.

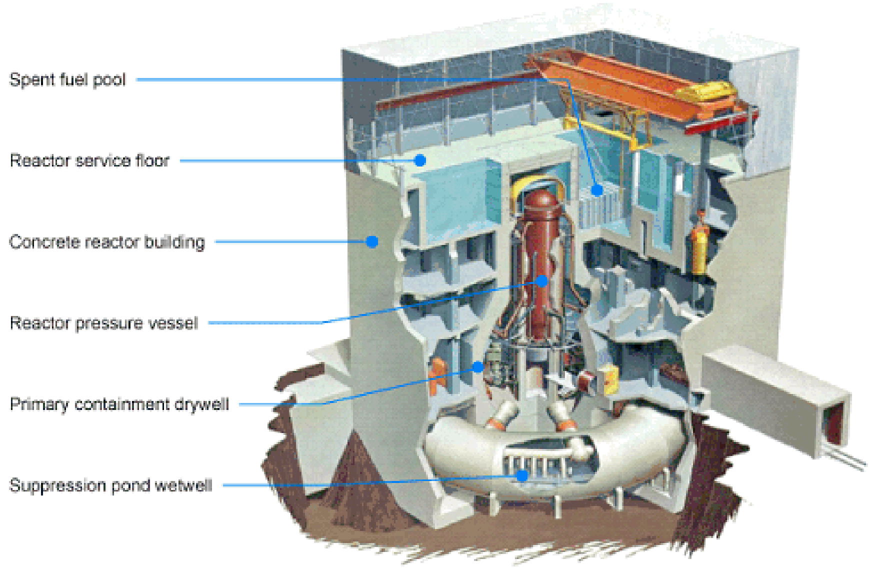
II. Give English equivalents for the following words and phrases:

проектування, експлуатація, запобіжна оболонка, внутрішній тиск, ослабити, система аварійного охолодження серцевини, неухильно, насосна станція, дренажний колодязь, камера стримування, Організація з регулювання ядерної енергетики, витік цезію, повернення потоку, радіоактивний викид, легке розпилення у повітрі, герметичний корпус.

III. Read the text about the Japan disaster inside the Fukushima Daiichi reactors thoroughly, check your answers and be ready to answer the questions that follow.

The Fukushima Daiichi reactors are GE boiling water reactors (BWR) of an early (1960s) design supplied by GE, Toshiba and Hitachi, with what is known as a Mark I containment. Reactors 1-3 came into commercial operation 1971-75. Reactor power is 460 MWe for unit 1, 784 MWe for units 2-5, and 1100 MWe for unit 6.

When the power failed at 3.42 pm, about one hour after shutdown of the fission reactions, the reactor cores would still be producing about 1.5% of their nominal thermal power, from fission product decay – about 22 MW in unit 1 and 33 MW in units 2 & 3. Without heat removal by circulation to an outside heat exchanger, this produced a lot of steam in the reactor pressure vessels housing the cores, and this was released into the dry primary containment (PCV) through safety valves. Later this was accompanied by hydrogen, produced by the interaction of the fuel's very hot zirconium cladding with steam after the water level dropped.



As pressure started to rise here, the steam was directed into the suppression chamber under the reactor, within the containment, but the internal temperature and pressure nevertheless rose quite rapidly. Water injection commenced, using the various systems provide for this and finally the Emergency Core Cooling System (ECCS). These systems progressively failed over three days, so from early Saturday water injection to the reactor pressure vessel (RPV) was with fire pumps, but this required the internal pressures to be relieved initially by venting into the suppression chamber/ wet well.

Inside **unit 1**, as pressure rose, attempts were made to vent the containment, and when external power and compressed air sources were harnessed this was successful, by about 2.30 pm Saturday, though some manual venting was apparently achieved at about 10.17 am. The venting was designed to be through an external stack, but in the absence of power much of it back flowed to the service floor at the top of the reactor building, representing a serious failure of this system. The vented steam, noble gases and aerosols were accompanied by hydrogen. At 3.36 pm on Saturday 12th, there was a hydrogen explosion on the service floor of the building above unit 1 reactor containment, blowing off the roof and cladding on the top part of the building, after the hydrogen mixed with air and ignited. (Oxidation of the zirconium cladding at high temperatures in the presence of steam produces hydrogen exothermically, with this exacerbating the fuel decay heat problem.)

Much of the fuel in units 2 & 3 also apparently melted to some degree, but to a lesser extent than in unit 1, and a day or two later. In mid-May 2011 the unit 1 core would still be producing 1.8 MW of heat, and units 2 & 3 would be producing about 3.0 MW each.

In mid-2013 the Nuclear Regulation Authority (NRA) confirmed that the earthquake itself had caused no damage to unit 1.

In **unit 2**, water injection using the steam-driven back-up water injection system failed on Monday 14th, and it was about six hours before a fire pump started injecting seawater into the RPV. Early on Tuesday 15th, the pressure suppression chamber under the actual reactor seemed to rupture, possibly due to a hydrogen explosion there, and the drywell containment pressure inside dropped. However, subsequent inspection of the suppression chamber did not support the rupture interpretation. Later analysis suggested that a leak of the primary containment developed on Tuesday 15th. Most of the radioactive releases from the site appeared to come from unit 2.

In **Unit 3**, the main back-up water injection system failed at 11 am on Saturday 12th and early on Sunday 13th, water injection using the high pressure system failed also and water levels dropped dramatically. RPV pressure was reduced by venting steam into the wet well, allowing injection of seawater using a fire pump from just before noon. Early on Monday 14th PCV venting was repeated, and this evidently backflowed to the service floor of the building, so that at 11 am a very large hydrogen explosion here above unit 3 reactor containment blew off much of the roof and walls and demolished the top part of the building. This explosion created a lot of debris, and some of that on the ground near unit 3 was very radioactive.

In defueled **unit 4**, at about 6 am on Tuesday 15 March, there was an explosion which destroyed the top of the building and damaged unit 3's superstructure further.

This was apparently from hydrogen arising in unit 3 and reaching unit 4 by backflow in shared ducts when vented from unit 3.

There was a peak of radioactive release on 15th, apparently mostly from unit 2, but the precise source remains uncertain. Due to volatile and easily-airborne fission products being carried with the hydrogen and steam, the venting and hydrogen explosions discharged a lot of radioactive material into the atmosphere, notably iodine and caesium. NISA said in June that it estimated that 800-1000 kg of hydrogen had been produced in each of the units.

Through 2011 injection into the RPVs of water circulated through the new water treatment plant achieved relatively effective cooling, and temperatures at the bottom of the RPVs were stable in the range 60-76°C at the end of October, and 27-54°C in mid-January. RPV pressures ranged from atmospheric to slightly above (102-109 kPa) in January, due to water and nitrogen injection. However, since they are leaking, the normal definition of "cold shutdown" does not apply, and Tepco waited to bring radioactive releases under control before declaring "cold shutdown condition" in mid-December, with NISA's approval. This, with the prime minister's announcement of it, formally brought to a close the 'accident' phase of events.

The AC electricity supply from external source was connected to all units by 22 March. Power was restored to instrumentation in all units except unit 3 by 25 March. However, radiation levels inside the plant were so high that normal access was impossible until June.

Adapted from: wegotnuked.giorginline.com

1. When did reactors 1 – 3 come into commercial operation?
2. What happened in Japan on Saturday 12th 2011?
3. What did the Nuclear Regulation Authority (NRA) confirm in mid-2013?
4. What happened in defueled unit 4, at about 6 am on Tuesday 15 March?
5. When was a peak of radioactive release?
6. How many kilograms of hydrogen had been produced in each of the units?

IV. Match words from box A to their synonyms from box B.

a) extract, via, release, provide, authority, design, gain, attempt, house, suppression,vent, melt, fail, decay, leak, avoid

b) prevent, pull out, supply, discharge, power, through, seep, rot, let out, crash, project, obtain, containment, solve, effort, contain

V. Match words from box A to their antonyms from box B.

a) increase, rapidly, external, fueled, appear, high, above, charge, approval, successfully, melt, fail

b) solidify, unsuccessfully, below, decrease, discharge, slowly, internal, disappear, defueled, low, succeed, disapproval

VI. Fill in the blanks with prepositions.

1. The producers … Fukushima Daiichi reactors are GE, … design supplied … GE, Toshiba and Hitachi. Such reactors came … commercial operation in 1971 – 75.
2. When the power failed … 3.42 pm, … heat removal … circulation … an outside heat exchanger, this produced a lot of steam … the reactor pressure vessels housing the cores.
3. … pressure started … rise, the steam was directed … the suppression chamber … the reactor, … the containment, but the internal temperature and pressure nevertheless rose quite rapidly.
4. As pressure rose, attempts were made to vent the containment, and when external power and compressed air sources were harnessed this was successful, cooling was provided … external sources, using treated recycled water, … a stable heat removal path … the actual reactors … external heat sinks.
5. Temperatures … the bottom … the reactor pressure vessels have decreased … well below boiling point and was stable.

6. Access has been gained … all three reactor buildings, … dose rates remain high inside. Nitrogen was being injected into all three containment vessels and pressure vessels.

7. Tepco declared "cold shutdown condition" … mid-December when radioactive releases had reduced … minimal levels.

VII. Render the following text into English.

На ранньому етапі на всіх трьох бл оках відбулося значне руйнування палива, хоча, фактично, паливо залишилось. Все це не стосувалося деяких вибухонебезпечних продуктів поділу, які були викинуті в оточуюче середовище раніше, і деяких розчинних речовин, які витікали з водою, особливо з блоку 2, де герметичність, очевидно, була порушена. Охолодження забезпечується за рахунок зовнішніх джерел, використовуючи оброблену циркуляційну воду, зі стабільним відведенням тепла від самих реакторів на зовнішні теплообмінники. Температура в нижній частині корпусу реактора знизилася до значно нижчої за точку кипіння і стала постійною. Доступ був отриманий до всіх трьох реакторів, але рівень потужності тепловиділення всередині залишився високим. Азот в даний час вводиться в усі три резервуари стримування і резервуари високого тиску. Компанія «Терсо» оголосила «стан холодного вимикання» в середині грудня, коли радіоактивні викиди скоротили до мінімального рівня.

VIII. In pairs, make sentences using words and phrases below. Using your sentences discuss the the Fukushima Daiichi nuclear disaster, then present your ideas to the rest of the class.

1) The Fukushima Daiichi, a meltdown, catastrophic failure, Fukushima I Nuclear Power Plant, on 11 March 2011, nuclear disaster, by the tsunami, the Tohoku earthquake, in august 2013, pressing problems, radioactive, affecting, the cleanup process, contaminated water.

2) To lower the leaks, plant workers, chemical underground walls, financial compensation, evacuated, short term radiation exposure fatalities, temporary housing, evacuation conditions, evacuation-related deaths.

IX. Summarize the text on pages 53 – 56 in 120 – 140 words. Follow the hints on how to write the Summary in Appendices A, B on pages 58 – 74.

APPENDIX A

How to Write a Summary

Preparing to write. To write a good summary it is important to thoroughly understand the material you are working with. Here are some preliminary steps in writing a summary.

1. Skim the text, noting in your mind the subheadings. If there are no subheadings, try to divide the text into sections. Consider why you have been assigned the text. Try to determine what type of text you are dealing with. This can help you identify important information.
2. Read the text, highlighting important information and taking notes.
3. In your own words, write down the main points of each section.
4. Write down the key support points for the main topic, but do not include minor detail.
5. Go through the process again, making changes as appropriate.

For example:

Global Implications of Patent Law Variation

A patent is an exclusive right to use an invention for a certain period of time, which is given to an inventor as compensation for disclosure of an invention. Although it would be beneficial for the world economy to have uniform patent laws, each country has its own laws designed to protect domestic inventions and safeguard technology. Despite widespread variation, patent laws generally fall under one of two principles: the first-to-file and first-to-invent. The first-to-file principle awards a patent to the person or

This first sentence is a general definition. It may be safe to assume that your audience is already familiar with patents; thus you do not have to include it in your summary.

This is the main idea.

The classification of the two principles is important.

Ignore specific details about the different principles. The institution that applies for a patent first, while the first-to- invent principle grants the patent to the person or institution that was first to invent - and can prove it. Most countries have adopted the first-to-file system. However, the United States maintains a first-to-invent system, despite obvious shortcomings. A result of countries employing different patent law principles is inconsistency of patent ownership.

Patent ownership is not recognized globally. On the contrary, ownership may change depending on the country. It is not uncommon for an invention to have two patent owners - one in the United States and one in the rest of the world. This unclear ownership often has economic consequences. If a company is interested in using a patented invention, it may be unable to receive permission from both patent owners, which in turn may prevent manufacture of a particular product. Even if permission is received from both owners, pay royalties to both may be quite costly. In this case, if the invention is useful enough, a company may proceed and pass on the added cost to consumers.

International economic tension has

terms are self-explanatory.

It is important to point out that most of the world follows one system and the United States another.

Include a description of the problem surrounding variation in patent laws.

Provide some support/explanation for the problem, but not all the details also been increasing as a result of differing policies. Many foreign individuals and companies believe that they are at a serious disadvantage in the United States with regard to patent ownership because of the logistical difficulties in establishing first-to- invent status. Further, failure of the United States to recognize patent ownership in other countries is in violation of the Paris Conventions on Industrial Properties, which requires all member nations to treat all patents equally. The conflict surrounding patents has prompted the World Intellectual Properties Organization (WIPO) to lobby for universality in patent laws. WIPO maintains that the first necessary step involves compelling the United States to reexamine its patent principle, taking into account the reality of a global economy. This push may indeed result in more global economic cooperation.

Describe this other problem associated with differing patent principles.

Provide some explanation, but not all the details.

Describe the action taken to solve the problem.

When writing the summary there are three main requirements:

1. The summary should cover the original as a whole.
2. The material should be presented in a neutral fashion.
3. The summary should be a condensed version of the material, presented in your own words.

* * **Also** do not include anything that does not appear in the original. (Do not include

your own comments or evaluation.) and Be sure to identify your source.

An example of a summary:

In his paper "Global Implications of Patent Law Variation," Koji Suzuki (1991) states that lack of consistency in the world's patent laws is a serious problem. In most of the world, patent ownership is given to the inventor that is first to file for a patent. However, the United States maintains a first-to-invent policy. In view of this, patent ownership can change depending on the country. Multiple patent ownership can result in economic problems; however, most striking is the international tension it causes. The fact that the United States does not recognize patent ownership in other countries, in violation of the Paris Convention on Industrial Properties, has prompted the World Intellectual Properties Organization (WIPO) to push the United States to review its existing patent law principles.

APPENDIX B

Useful phrases for summary writing

The Summary is a short version of the paper. The lists below offer general phrases that can be used in many kinds of research papers. For mastering the terminology and phraseology specific to a field, regular reading of the relevant literature is necessary. Some hints on how to start the Summary follow:

Introductory sentences

The paper/article

discusses/deals with/analyses/considers/explains/describes/establishes/

introduces…..

develops/presents/provides/studies/represents/features/contains/

concentrates on…..

covers/suggests/proposes/shows…..

demonstrates the feasibility of…..

opens up a new field/issue…..

gives/aims to give a comprehensive account of…..

offers a solution to…..

serves as an introduction to…..

The main objective/goal/purpose of the paper/article is…..

Common mistakes:

Wrong:	Right:
In this paper there/it is presented a novel method of…..	This paper presents a novel method of In this paper, a novel method of… is presented.

1. Sections of the paper

1.1. Introduction

In most cases, **the Introduction** section is treated as a whole and is not divided into subsections. The subheadings below should only help you organize the information.

1.1.1. Problem background

…..plays an important/vital role in…..

…..is an important issue for…..

…..is extensively/widely used in…..

…..is a very effective method for…..

In the last few years there has been a growing interest in…..

Quite recently, considerable attention has been paid to…..

…..have/has been gaining importance in recent years

…..have/has been utilized in many applications such as…..

1.1.2. Literature review/Summary of previous research

Referring to the sources in general

Current research on…..is focused on…..

Previous studies indicate that…..

The literature on…..shows a variety of approaches to…..

Much research on ….. has been done.

The focus of recent research has been on

…..has/have been widely researched/investigated.

In recent years, research on/into…..has become very popular.

In the last decade…..has attracted much attention from research teams

For several years great effort has been devoted to the study of …..

Several publications have appeared in recent years documenting …..

Previous research has documented/shown/demonstrated that …..

To solve this problem/issue, many researchers have proposed various methods of (+-ing) …..

In the literature, several theories have been proposed to explain…..

Referring to individual authors

…..and…..are discussed in [3] and [6].

X [4] and Y [3] indicate that…..

X et al. [1] argue that…..

One of the first examples of…..is presented in [2].

Another/The latest solution is described in [3].

The results obtained/offered by X in [5] suggest that…..

Recently, several authors [4], [5], [7] have proposed (a new theory)

X [2] and X [5] have demonstrated that…..

A/The most interesting approach to this issue has been proposed by [2].

X [6] has also found that….. . However, our researchers have arrived at the conclusion/have concluded that…..

…..was experimentally measured by [7].

X et al. [7] studied…..and showed that …..

X [11] developed a novel sensor using …..

In this work and in related references it was observed that …..

In [8] it was shown that …..

As reported by X [2], …..

In a recent paper by X [9], …..

Saying that little research has been done in a particular field

However, to the author's/authors' best knowledge, very few publications can be found/are available in the literature that discuss/address the issue of …..

To the author's/authors' knowledge, ….. has/have been scarcely investigated from the point of view of ….. /from the theoretical point of view.

Pointing out limitations of previous research

A key limitation of this research is that (it does not address the problem of …..)

The major drawback of this approach is …..

However, most of the previous studies do not take into account …..

This approach may not be practical/orthodox/conventional in all situations.

Reference [3] analyses and compares various aspects of…... Nevertheless, there are still some interesting and relevant problems to be addressed.

However, studies on ….. are still lacking.

The problem with this approach is in that it…..

Although several studies have indicated that ….., little attention has been paid/given to…..

1.1.3. Problem statement, purpose/main objective of the paper

- **Problem statement and description of the objective of the paper** are very specific parts of the paper and the phrases used depend on the nature of the problem. Examples showing how closely this part is related to the literature review and previous research are given below.

(A….. theory of …..) has recently been presented in […..]. However, several practical questions arise when dealing with….. : 1) It is important to (identify…..). 2) It is key to (predict…..). 3) It is crucial to (establish when…..). To answer all these questions, we present an original approach which……

Even though (the efficiency of …..) has been improved in recent years, most improvements have been achieved by (minimizing the amount of energy lost in …..). Nonetheless, it is possible to further improve (the efficiency by …..). With this goal, this work (explores, seeks to…..).

Based on the approach presented in [3], the purpose of this paper is to …..

In this paper, while we refer to our earlier work [2], [3], and [4], the focus is different.

Like most authors, we…..

The objective/aim of this paper/study is to propose…..

The paper presents/proposes a new approach to…..

This article introduces a new type of…..

In this paper, we/the authors offer…..

In this paper, we explore the possibility of…..

In this study, a new technique that improves…..is suggested.

1.1.4. Framework of the paper (usually the last part of the Introduction)

The remainder of the paper is organized as follows/into…..sections:

Section II describes/outlines…..

Section III discusses/analyses…..

(Experimental results) are presented in Section IV.

Section V concludes the paper.

In Section II…..will be discussed.

Section III is devoted to…..

Section IV presents (the experimental results).

The conclusion is reported in Section V.

The proposed (design) is discussed in Section II.

(The implementation of the proposed design) is presented in Section III.

Section IV shows (the experimental results of…..).

Finally, Section V concludes with a summary.

In Section II we explain…..

In Section III we introduce our…..

The measurements are presented in Section IV.

Section V summarizes the results of this work and draws conclusions.

1.2. Body/Core of the paper

General information

The Body of the paper is very specific in its content. For this reason, the number of generally applicable phrases is smaller than in the other parts. Examples of some of these phrases are given below.

There are, however, linguistic means common to all kinds of research papers, i.e. words and phrases expressing *cause, results, addition, similarity, etc.*

1.2.1. Materials and Methods/Methods of Approach

Describing what was done and how it was done

We started by investigating…..

We designed a new technique for…..

We used a new approach.

These experiments were carried out to find out…..

In order to verify the validity of the…..method, we carried out several experiments.

All the tests/measurements were carried out at room temperature.

The (signals) were measured before and after…..

To illustrate ….., a simulation was performed.

The…..analysis was performed in order to…..

We checked for the presence of …..

(The chemical structure of…..) was examined by (the…..technique).

A gradual change (in temperature) was observed.

The increase in…..was not caused by/was not due to a decrease in…..

The (optimized condition) was obtained from…..

Describing numerical methods

The equation that describes….. is as follows:

Equation (2) represents/defines/expresses…..

The equation can be written as….., where…..

Thus, the following equation is obtained:

…..can be computed by the following equation:

Equations (5) and (6) approximate (the original formulas).

…..satisfies equation (3).

Equations (2) and (3) demonstrate that…..

(3) implies that…..

….. is described by (5).

The function of….. is given/defined by…..

Let ……. be given/defined by…..

To simplify (3) we can…..

For simplicity we ignore the dependence of…..on…..

It follows from (3) that…..

Substituting/inserting (4) and (6a) in (to) (6b), we obtain…..

Substitution/Insertion of (4) in(to) (5) yields…..

Now we can derive…..according to (2)

We can now proceed analogously to…..

This is true for…../This holds for…..

Similarly, (5) is also valid/true for the following relation.

Assume/Let us assume that (3) holds for…..

(6) holds under the condition that…..

We will make the following assumptions:…..

From now on we assume that…..

Let us define the following dependence/relation by/as…..

Let (3) satisfy the following relation…..

Equality holds in (10) if and only if…..

The inequality is satisfied if and only if…..

We shall write the above expression as…..

In this way we obtain…..

According to (5) we have/obtain…..

…..is obtained as…../can be obtained as…..

…..is denoted (M) and defined as…..

…..takes the form …../…..can be written in the form…..

As is clear from (5,) …..

We first prove that…../Let us first prove that…..

It remains to prove that…..

It is clear/evident/obvious that…..

From this we conclude/see/deduce that…..

Referring to/Describing figures, graphs, tables, diagrams

Fig. 2 shows/presents/depicts/outlines/illustrates/represents…..

Fig. 3 gives an example of…..

Such cases are depicted in the following figures.

This is illustrated in Fig. 5.

….. is/are shown/given in Figs. 3 and 4.

….. can be found in Fig. 8.

Consider Fig. 2, which plots …..versus/against…..

As can be seen from Figs. 5 and 3, …..

As shown in Fig. 1, …..

As follows from the figures shown above, …..

From this figure it can be seen that …..

For the resulting plot, see Fig. 2.

For visual representation of the dependence the reader is referred to Tables V and VI.

Table II summarizes …..

The graph/diagram suggests/indicates that…..

Common mistake

Wrong	Right
As shown in the Fig. 1	*As shown in Fig.1*
The Fig. 2 presents	*Fig. 2 presents*

1.2.2. Results

Some of the phrases listed under **Materials and Methods** may also be suitable for the **Results** section, e.g. summarizing what was done, referring to diagrams, graphs, etc.

It has been found that…..

The results show that…..

The results thus obtained are compatible with…..

The overall measurement results are summarized in Table II.

As mentioned earlier/above, …..

The previous sections have shown that…..

This method is based on…..

The method was tested on…..

The method is an effective way to improve…..

The analysis and simulation indicate that

The…..analysis plays a crucial role in

As may be seen below, …..

We have introduced a new approach to…..

A similar approach is used for…..

This approach may fail if/due to…..

One of the big advantages of (this approach/method) ….. is that…..

To verify this method, ….. is compared with…..

The only disadvantage/drawback of such…..is…..

There is no evident relationship between…...and…..

…..are in good agreement/correspond with

There is a good match between …..and…...

To illustrate the result, a simulation of…..was performed.

The simulation results match the calculations.

The differences in (temperature) result in significant differences in…..

The decrease/increase in…..can be contributed to…..

To overcome/avoid this problem/difficulty, it is necessary to adopt a…..

One possible solution to this problem is to (use) …..

This solution requires …..

1.2.3. Discussion

For more phrases see also Introduction and Conclusion(s).

Stating the main objective

In this paper we propose/examine/study…..

This paper proposes/has proposed…..

The purpose of the paper/study is to…..

The paper presents/has presented several solutions to…..

This paper is a modest contribution to the ongoing discussions about/on…..

It was the main purpose of the paper to draw attention to…..

The main concern of the paper was to…..

In our paper, the focus of attention was/is on…..

This study shows/has shown that…..

This experiment/technique/demonstrates that…..

Specifying the objective

Particular attention is paid to.....

The author's attention was focused/concentrated not only on…..but also on…..

We have addressed not only…..but also…..

We have also considered the consequences of…..

Pointing out the originality of the solution

Our paper presents an innovative/a novel view of…..

The originality of our solution lies in the fact that…..

This is a novel solution to…..

Our results describe for the first time the…..

To our knowledge, this is the first study to deal with/examine/investigate…..

Only one other study, to our knowledge, has come up with…..

This paper presents a pilot study to find the answer.

Our observations that…..are not new, but…..

Interpreting the facts

The data obtained is/are broadly consistent with the major trends.

These results agree/concur/are consistent/are in good agreement with other studies which have shown that…..

In contrast to some reports in the literature, there were…..

An important implication of these findings is that…..

The finding was quite unexpected/surprising and suggests that…..

The most likely explanation of the negative result is…..

The findings have a number of possible limitations, namely…..

So far, the significance of this finding is not clear.

Stating the limitations of the research

The main limitation of the experimental result is…..

One question still unanswered is whether…..

The analysis does not enable us to determine…..

These results are not conclusive.

Suggesting possible applications (possible applications are commonly found in the Conclusion(s) section; they may, however, be mentioned in this section, too. For useful phrases see **Conclusion(s).**

1.2.4. Conclusion(s)

The Conclusion(s) section usually starts with

Stating the objective

The objective presented in the Conclusion(s) section should agree with the objective stated in the Introduction. For suitable phrases see **Introduction** and **Discussion**.

Drawing conclusions

From the research that has been carried out/ done/ conducted/ performed/ undertaken, it is possible to conclude that…..

Based on the results, it can be concluded that the research into…..has been very successful.

From the outcome of our investigation it is possible to conclude that…..

The findings of our research are quite convincing, and thus the following conclusions can be drawn:…..

Summing up the results, it can be concluded that…..

In conclusion, it is evident that this study has shown…..

This paper has clearly shown that…..

It has been demonstrated/shown/found that…..

The results/data obtained indicate/have indicated/suggest/show that…..

The existence of (these effects) implies that…..

Suggesting possible application(s)

The proposed method can be readily used in practice.

The technique/approach/result is applicable to…..

…..can be successfully used for a number of ….. applications.

The/our…..has great potential for other applications such as…..

This research was concerned with…..; however, the results should be applicable also to…..

The findings suggest that this approach could also be useful for…..

The findings are of direct practical relevance.

Suggesting further research

In our future research we intend to concentrate on…..

Future work will involve…..

On the basis of the promising findings presented in this paper, work on the remaining issues is continuing and will be presented in future papers.

The next stage of our research will be (experimental confirmation of our theory).

Further study of the issue would be of interest.

Clearly, further research will be needed/required to prove/validate…..

Several other questions remain to be addressed/resolved.

More research into…..is still necessary before obtaining a definitive answer to…..

Further study of the issue is still required.

Further research on/into…..is desirable/necessary (to extend our knowledge of…..).

Continuing/continued research on/into…..appears fully justified because…..

More tests/experiments/calculations will be needed to verify whether…..

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