



SCIENCE AND TECHNOLOGY CAREER PATHWAYS II

SEMESTER II

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Course Outline

Chapter 3

Civil Engineering, Hydraulic Engineering, and Public Works

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Career Opportunities for hydraulic Engineering Graduates

The roles of a hydraulic engineer specialist

Civil Engineering

- Civil Engineering is a branch of engineering concerned with the design, construction, and maintenance of infrastructure projects such as roads, bridges, buildings, dams, and other large-scale structures. Civil engineers apply scientific principles and technical knowledge to develop safe, efficient, and sustainable solutions for various civil engineering projects



Civil Engineering Materials

- Civil engineering materials cover a wide range of substances crucial for the construction and maintenance of infrastructure. These materials are carefully selected based on their properties and performance characteristics to ensure the structural integrity, safety, and longevity of various civil engineering projects. Examples include concrete, steel, asphalt, timber, brick, Aggregates and masonry, composite materials, glass, plastics, ceramics, and more. Each material serves a specific purpose and is utilized according to its unique properties to meet the diverse demands of civil engineering applications.

Civil Engineering Materials

- Concrete: is a composite material made up of cement, aggregates (such as sand and gravel or crushed stone), and water. When mixed together, these ingredients form a fluid mass that can be molded into various shapes and hardened to create durable and versatile construction materials. Concrete is widely used in construction for building foundations, roads, bridges, dams, and other structures due to its strength, durability, and versatility.
- Steel: Steel is a versatile material with high tensile strength and ductility, making it ideal for structural applications in buildings, bridges, and other infrastructures. It's used in columns, reinforcement bars, and other components.
- Asphalt: Asphalt is commonly used in road construction for its ability to provide a smooth, durable surface that can withstand heavy traffic loads. It's made from a mixture of aggregates and bitumen, a petroleum-based substance

Civil Engineering Materials

- **Timber:** Timber is a renewable resource that's used in construction for its lightweight, strength-to-weight ratio, and aesthetic appeal. It's used in building frames, bridges, and other structures.
- **Brick and Masonry:** Bricks are commonly used in construction for their durability, fire resistance, and thermal insulation properties. Masonry units made of bricks or concrete blocks are used in walls, partitions, and facades of buildings.
- **Aggregates:** Aggregates such as sand, gravel, and crushed stone are essential components of concrete and asphalt mixtures. They provide stability to the mixtures and contribute to the overall strength and durability of the construction material.
- **Etc..**

A Chronological Overview of Cement's Evolution

- Mortars and lime have been used for thousands of years in various construction projects around the world.
- Mortar, a mixture of sand, water, and either lime or cement, has been a fundamental building material since ancient times.
- It was commonly used by civilizations such as the Egyptians, Greeks, and Romans to bond stones or bricks together.
- In the 19th century, the popularity of mortars and lime decreased with the emergence of modern cement. Louis Vicat, a French engineer, played a significant role in this transition. In 1817, Vicat devised a method to evaluate hydraulic cements' quality, which can harden underwater.

Vicat's Bridge: Dordogne, France

- Louis Vicat achieved significant success by building Souillac bridge in the Dordogne region of France.
- This bridge, finalized in 1847, serves as evidence of Vicat's mastery in cement technology and engineering.



Public Works and Development

- Public works and development refer to the planning, construction, maintenance, and management of infrastructure and facilities that serve the public interest and benefit communities as a whole.
- Here are some key components of public works and development
 - The construction and maintenance of essential infrastructure such as roads, bridges, highways, railways, airports, ports, and water supply and sewage systems
 - Water storage facilities,
 - Works in maritime or river sites,
 - Agricultural engineering works.

Mission of a Civil Engineer

- The mission of a civil engineering engineer typically involves
 - Supervise project design within a team.
 - Serve as a leader during project execution.
 - Ensure safety standards for the well-being of workers and the public.
 - Managing construction site progress with contractor requirements.
 - Conduct site meetings.

Career Opportunities for Civil Engineering Graduates

- Civil engineering graduates can pursue careers in a wide range of fields, including
 - Major construction companies,
 - Civil engineering consulting firms,
 - Inspection offices,
 - Real estate developers, industrialists, individuals, local authorities,
 - Architectural firms,
 - Etc

Required Qualities of a Civil Engineer

- The required qualities of civil engineers typically include:
 - Strong technical knowledge and skills in civil engineering principles and practices.
 - Excellent problem-solving abilities to address various challenges encountered in construction projects.
 - Ability to speak publicly
 - Effective communication skills to collaborate with team members and clients
 - Leadership skills to oversee and manage teams of workers and contractors.
 - Adaptability and flexibility to adjust to changing project requirements and unexpected situations.
 - Rigor (especially regarding standards)

The roles of a civil engineer specialist

- Designing and planning infrastructure projects such as roads, bridges, buildings, and water supply systems.
- Conducting site investigations and surveys to gather data for project planning.
- Analyzing and interpreting data to ensure compliance with regulatory standards and safety requirements.
- Managing construction projects and overseeing construction activities to ensure quality and adherence to project specifications.
- Collaborating with architects, contractors, and other stakeholders to coordinate project activities and resolve any issues that may arise.
- Monitoring project progress and budget to ensure timely completion and cost-effectiveness.
- Providing technical expertise and guidance to project teams and junior engineers.
- Etc..

Hydraulic

- The word "hydraulic" originates from the Greek word "hydraulikos," which is derived from "hydōr," meaning "water," and "aulos," meaning "pipe" or "channel". Thus, "hydraulikos" refers to something related to water or conveyed by water. In a broader sense, it can refer to the science and technology of using fluid properties to perform mechanical tasks, such as generating power or controlling machinery.



Chronological Development of Hydraulic Engineering

- ✓ Ancient Civilizations: The history of hydraulics can be traced back to ancient civilizations like the Egyptians, Greeks, and Romans, who used hydraulic principles for various purposes such as irrigation, water supply systems, etc.
- ✓ Ancient China: The Chinese invented the waterwheel, a device that harnessed water power for various applications, including grinding grain and pumping water.
- ✓ Middle Ages: In the Middle Ages, hydraulic engineering continued to develop, with advancements in water mills, water clocks, and various irrigation systems.
- ✓ Renaissance: During the Renaissance, there were significant advancements in hydraulic engineering, particularly in Europe. Engineers like Leonardo da Vinci made important contributions to the understanding of fluid mechanics and hydraulic machinery.
- ✓ Industrial Revolution: The Industrial Revolution marked a period of rapid technological advancement, including in hydraulics. Hydraulic power became increasingly important for industrial machinery, leading to the development of hydraulic presses, cranes, and other equipment.
- ✓ Modern Era: In the modern era, hydraulics has become an integral part of various industries, including construction, manufacturing, aerospace, and transportation. Hydraulic systems are used in applications ranging from heavy machinery and equipment to aircraft and automobiles.

Different forms of energy used in hydraulics

- The different forms of energy used in hydraulics are:
 - Potential energy (due to gravity), such as in a water tower.
 - Kinetic energy (due to velocity), such as in a hydroelectric turbine.
 - Energy by pressure. This form of energy is used in industrial and mobile hydraulic systems.
- In industrial systems, hydraulics refers to the transmission and control of forces using a liquid medium, typically hydraulic oil.
- This means that hydraulic systems utilize hydraulic fluid, often oil, to transmit power from one point to another and to control the operation of various components such as cylinders, motors, and valves

Definitions and Quantities: Hydrostatic Pressure and Hydrodynamic Flow

- Hydrostatic pressure refers to the pressure exerted by a fluid at rest or in equilibrium. It is the force exerted by the fluid per unit area and is measured in pascals (Pa). Pressure plays a crucial role in hydraulic systems as it determines the force applied by the fluid, which is essential for generating movement or transmitting power.
- Hydrodynamic flow rate refers to the volume of fluid that flows through a specific point in a fluid system per unit time (L/s). It is a measure of the rate at which fluid moves and is influenced by factors such as fluid velocity, cross-sectional area, and viscosity. Hydrodynamic flow rates are crucial in fluid dynamics, where they help in analyzing fluid motion in pipes, channels, rivers, and other fluid transport systems.

Darcy's Law

- Darcy's Law is a fundamental principle in hydrogeology and fluid mechanics that describes the flow of fluids through porous materials such as soil, sand, or rock. It states that the rate of flow (Q) of a fluid through a porous medium is directly proportional to the product of the hydraulic conductivity (K), the hydraulic gradient (dh/dl), which is the change in hydraulic head (h) per unit distance (l) along the flow path, and the cross-sectional area (A) through which the fluid is flowing.
- Mathematically, Darcy's Law can be expressed as: $Q = -KA \frac{\Delta h}{l}$ Where:
 - Q is the volumetric flow rate of the fluid (volume per unit time),
 - K is the hydraulic conductivity of the porous medium (a measure of how easily water can flow through the material),
 - A is the cross-sectional area through which the fluid is flowing,
 - $\Delta h/l$ is the hydraulic gradient, representing the change in hydraulic head per unit distance.

The hydraulic conductivity or permeability coefficient

- The hydraulic conductivity or permeability coefficient (K) is a measure of a porous material's ability to transmit fluid through it under the influence of a hydraulic gradient. The formula for K is given by Darcy's Law:

$$K = k \cdot \frac{\rho \cdot g}{\mu}$$

Where:

- K is the hydraulic conductivity,
- k is the intrinsic permeability of the porous medium,
- ρ is the fluid density,
- g is the acceleration due to gravity, and
- μ is the dynamic viscosity of the fluid.

The application areas of hydraulics

- The application areas of hydraulics include:
 - **Water supply:** store, treat, and distribute drinking water to populations.
 - **Public works machinery:** excavator, grader, bulldozer, loader, ...
 - **Agricultural machinery:** tractor, harvester, ...
 - **Agricultural irrigation:** Water is pumped and transported via hydraulic systems to irrigate agricultural crops, increasing yields and productivity.
 - **Hydraulic power:** Hydroelectric power plants use the energy of moving water to produce electricity cleanly and renewably.
 - **Maritime and river transport:** the design and management of ports, canals, and waterways to facilitate maritime and river transport of goods and passengers.
 - **Sanitation networks**
 - **Etc..**

Advantages and limitations of a Hydraulic systems

- Hydraulic systems offer several advantages and limitations:

- ✓ Advantages of hydraulic systems

- **High Power Density:** Hydraulic systems can deliver high power in a compact size.
- **Precise Control:** Hydraulic systems allow for precise control over speed, force, and position, making them ideal for applications requiring accurate motion control.
- **High Efficiency:** transmission of power over long distances with minimal energy loss.
- **Flexibility:** A great flexibility of use in many areas
- **Durability:** Hydraulic components are often durable and resistant to harsh environmental conditions, ensuring long service life in demanding applications.

Advantages and limitations of a Hydraulic systems

✓ Limitations of hydraulic systems

- **Potential Fluid Leakage:** Hydraulic systems may experience fluid leakage, which can lead to environmental contamination and loss of efficiency.
- **Maintenance Requirements:** Hydraulic systems require regular maintenance to ensure proper functioning, including fluid replacement, filter changes, ...
- **Temperature Sensitivity:** sensitive to extreme temperatures.
- **Complexity:** complex to design, install, and maintain, requiring specialized knowledge and skills.
- **Cost:** Hydraulic systems may have higher initial costs compared to other power transmission methods

Career opportunities for hydraulic engineering graduates

- Hydraulic Engineer
- Water Resources Engineer
- Hydrologist (Studying the distribution and movement of water in the environment.)
- Researcher
- Consultant
- Project Manager
- Public service (water agencies, etc.)
- Etc..

The required qualities of a hydraulic engineer

- The required qualities of a hydraulic engineer include:
 - Strong technical knowledge in fluid mechanics, hydraulics, and related engineering principles.
 - Knowledge in civil, mechanics, electromechanics, electricity, electronics engineering...
 - Analytical skills to solve complex hydraulic problems and optimize system performance.
 - Collaboration skills to work effectively in multidisciplinary teams.
 - Problem-solving abilities to address unforeseen issues during hydraulic projects.

The roles of a hydraulic engineer specialist

- The roles of a hydraulic engineer specialist may include:
 - Designing hydraulic systems for various applications such as dams, irrigation networks, ...
 - Ensures the operation and maintenance of hydraulic installations
 - Providing technical expertise and support to project teams during the implementation and maintenance of hydraulic infrastructure.
 - Collaborating with architects, civil engineers, and other professionals to integrate hydraulic components into overall project designs.
 - Ensuring compliance with regulatory standards and safety requirements.
 - Etc..