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ENGINEERING AN E-LEARNING PLATFORM FOR STREAMLINING FLUID MECHANICS AND HYDRAULIC MACHINERY LABORATORY FUNCTIONS

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Abstract
E-learning, an interactive instructional approach leveraging the web's vast resources, has reshaped learning environments. Within civil engineering curricula, the Fluid Mechanics and Hydraulic Machinery Laboratory holds pivotal significance. Recognizing these advantages, an attempt was made to create the "FM & HM E-Lab" website, using HTML, CSS and JavaScript. This website amalgamates innovative web development tools and pedagogical strategies. It encompasses sections like introduction, objectives, experiments list, target audience specifics, downloads, a lab calculator and dedicated pages for individual experiments. Emphasis is placed on two core sections, which include the lab calculator and individual experiment pages. The lab calculator ensures accuracy in calculations, while detailed experiment pages provide comprehensive insights. This e-learning initiative offers a robust platform, empowering students with comprehensive experiment information for autonomous execution. Automating calculations, offering downloadable resources in PDF format, and presenting detailed experiment insights, the website serves as an indispensable resource for fluid mechanics and hydraulic machinery students. The FM & HM E-Lab website emerges as an invaluable tool tailored to optimize the learning experience, fulfilling dynamic student requirements within the fluid mechanics and hydraulic machinery domain.

Key words: E-learning, Fluid Mechanics, Hydraulic Machinery, Website Development and Lab Experiments.

1. Introduction

In the educational landscape of India, the pursuit of knowledge among millions of young minds stands as a pivotal juncture for national progress, albeit challenged by varying standards in pedagogical delivery[1]. The emergence of E-learning presents a promising solution, representing a transformative shift in knowledge transmission via networks, computers, and the internet [2,3]. Leveraging modern communication tools, such as multimedia and the Internet, E-learning effectively disseminates educational materials, catering to diverse learning styles and increasing accessibility in higher education[4,5].

Recognizing technology's transformative potential, the Government of India has initiated key projects under the National Mission on Education through Information and Communication Technology (NMEICT)[6]. Initiatives like the National Video Server, National Programme on Technology Enhanced Learning (NPTEL), and Virtual Labs underline the commitment to democratizing education, providing valuable content and laboratory access across scientific disciplines[3,5].

While E-learning in India offers numerous advantages enhancing teacher effectiveness, providing flexibility, reducing costs, and accommodating diverse learning styles [1,2,4]. Meenakshi and Vasantha[7] used a casual model to examine how learner attributes affect satisfaction and how online learning elements' pros and cons affect efficacy. Mrinal Bhardwaj et al. [8] discussed resilience e-learning technologies development and implementation, their role in a modern and sustainable society, and the main barriers to stakeholders adopting them. Their work helps online educators create, implement, and move to resilient e-learning systems. Shailaj Kumar and Chandan[9] explored higher

education digitalization issues. Infrastructure, internet, digital equipment, a secure platform, and tech-savvy people are required. To strengthen competencies and align with industry capabilities, Indian higher education institutions utilize more Information and Communications Technology(ICT), cloud computing, Artificial Intelligence (AI), robotics, and virtual reality. Challenges persist in the Fluid Mechanics and Hydraulic Machinery Lab at Andhra University College of Engineering. Limited resources hinder students' practical learning experiences, necessitating the development of an e-learning platform.
The present study endeavours to bridge this gap by developing the "FM & HM E-Lab" website for the Fluid Mechanics and Hydraulic Machinery Lab. The aim is to create a centralized, accessible repository catering to students, teachers, and researchers interested in lab experiments. By offering online resources and an interactive lab calculator, the platform aims to enhance student learning experiences and facilitate error-free calculations [10].
The study objectives include analyzing user behaviour, designing an intuitive website, ensuring responsiveness across devices and evaluating its success in meeting user objectives. Through this comprehensive approach, the project seeks to optimize the educational journey for students pursuing fluid mechanics (FM) and hydraulic machinery (HM) courses at Andhra University College of Engineering, Visakhapatnam, Andhra Pradesh.

2. Functions for automation of FM and HM labs

The laboratory functions in the Fluid Mechanics and Hydraulic Machinery lab encompass a wide array of experiments designed to delve into the behaviours of fluids and the operational dynamics of hydraulic machinery. These experiments cover a diverse range of concepts, from basic fluid properties to the intricate performance evaluations of hydraulic components. Following are various experiments and functions considered for automation for the intended E-Learning Platform.

2.1 Experiments Conducted in the Lab:

Fluid Flow Experiments:

- Small Orifice Experiment: Analyzing discharge through tanks using orifice.
- Mouthpiece Experiment: Measuring discharge through tanks with mouthpiece.
- Venturi Meter Experiment: Determining discharge through pipelines using venturi meter.
- Orifice Meter Experiment: Measuring pipeline discharge using orifice meter.
- Flow Nozzle Meter Experiment: Estimating pipeline discharge using nozzle meter.
- Triangular Notch Experiment: Gauging channel flow using triangular notches.
- Metacentric Height Experiment: Evaluating metacentric height of flat-bottomed pontoons.
- Hydraulic Machinery Experiments:
- Impact of Jets Experiment: Determining the impact coefficient of jets on vanes.
- Pipe Friction Experiment: Assessing Darcy-Weisbach’s friction factor for pipe flow.
- Francis Turbine Experiment: Studying the performance characteristics of Francis turbine.
- Centrifugal Pump Experiment: Analyzing the performance of centrifugal pump.
- Reciprocating Pump Experiment: Assessing the performance characteristics of reciprocating pump.
- Rugosity Coefficients Experiment: Determining rugosity coefficients for open channel flow.
- Hydraulic Jump Experiment: Studying the characteristics of hydraulic jumps in tilting flumes.

The development process of the "FM & HM E-Lab" website adhered to a structured methodology, as outlined by [11]. It commenced with the crucial phase of information gathering, where project objectives, user needs, and essential functionalities were delineated[12]. Subsequently, meticulous planning set milestones and scoped the project's parameters. The design phase visualized wireframes and prototypes, ensuring an intuitive and visually appealing interface. Content creation followed, detailing experiments and educational resources catering to diverse learning styles.
Each experiment within the E-Lab platform is meticulously designed to measure specific parameters

and coefficients crucial to understanding fluid behaviour, discharge rates, machinery efficiency, and various hydraulic principles[13]. These experiments involve a mix of methods, including constant head and variable head methods, measurements using manometers, collection of known volumes of fluid, and calculations based on established formulae. Understanding these fundamental concepts is integral to designing efficient hydraulic systems and comprehending fluid dynamics in practical applications.

3. Development options for automation

The pursuit of automation in modern industries and technological domains has sparked a profound exploration of various development options. These options encompass a spectrum of technologies, methodologies, and frameworks, each tailored to enhance efficiency, streamline processes, and optimize functionalities. Within the realm of automation, several key development avenues have been considered and evaluated for their applicability, feasibility, and impact across diverse domains.

3.1. Frontend Development Technologies

In the pursuit of crafting intuitive and interactive interfaces crucial for the fluid mechanics and hydraulic machinery labs, the development hinges on specific frontend technologies meticulously chosen for their impact on user interaction and experience. Key frontend technologies considered are:

(i) HTML (Hypertext Markup Language): Serving as the cornerstone of web content, HTML structures digital documents, ensuring semantic coherence and accessibility. The evolution into HTML5 enriches web experiences by enabling multimedia integration and bolstering accessibility features.

(ii) CSS (Cascading Style Sheets): Responsible for layout presentation, CSS offers aesthetic control, facilitating design uniformity, responsiveness, and cross-browser compatibility. Its modularity streamlines maintenance and adapts swiftly to design changes.

(iii) JavaScript: This dynamic scripting language fuels interactivity, real-time updates, and content manipulation. The continuous evolution and diverse libraries/frameworks (e.g., React, Angular, Vue.js) have revolutionized frontend interactivity, amplifying user engagement.

3.2. Considerations in Frontend Development

Each technology encapsulates distinct advantages pertinent to automation in FM and HM labs.

HTML's Structural Foundations: With a structured approach, HTML fosters semantic coherence, promoting accessibility and search engine optimization (SEO). HTML5's integration of multimedia elements and advanced form functionalities extends its capabilities.

CSS for Visual Cohesion: CSS's cascading nature ensures consistent styling, fortifying design uniformity across webpages. Its modular architecture simplifies maintenance and facilitates swift adaptability to evolving design trends.

JavaScript's Dynamic Capabilities: Beyond enabling interactivity, JavaScript empowers web applications with dynamic content updates, asynchronous data retrieval, and intricate functionalities, bolstering user engagement and interaction.

The meticulous selection and synergistic utilization of these frontend technologies converge towards an integrated and user-centric platform for automating and enhancing functions within fluid mechanics and hydraulic machinery laboratories..

3.3. Integration Strategies

Integration of these technologies often involves synergistic approaches:

External Style Sheets: Employing external CSS files ensures centralized styling, enabling uniform design across multiple web pages.

JavaScript's Interaction with HTML/CSS: Through DOM manipulation, JavaScript interacts with HTML and CSS, dynamically modifying webpage content and styles.

Frameworks for Enhanced Functionality: Utilizing frontend frameworks/libraries complements these core technologies, providing pre-designed functionalities and facilitating rapid development.

The consideration of these frontend technologies and their strategic integration forms a cornerstone in the quest for automation, offering avenues to create intuitive, visually appealing, and highly functional

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user interfaces. The careful selection and harmonious integration of these technologies align with the overarching goal of driving efficiency and delivering seamless user experiences in automated systems.

3.4. Development Platforms for Lab Automation and E-Platform Creation

The selection of Visual Studio Code (VS Code) and GitHub was meticulously aligned with the essential requisites of automating the functions within the Fluid Mechanics (FM) and Hydraulic Machinery (HM) labs while establishing a comprehensive e-platform for lab experiments.

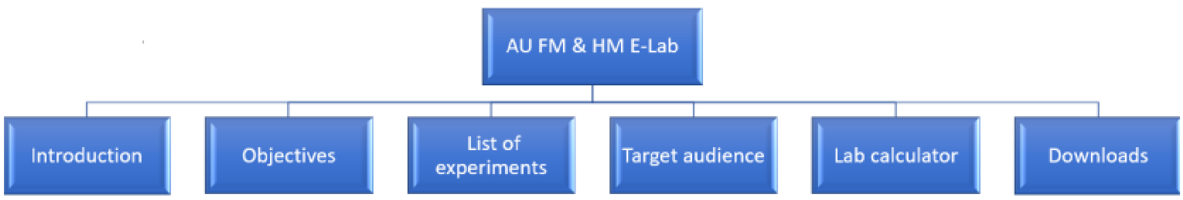
Visual Studio Code (VS Code): Opting for VS Code was a deliberate choice, driven by its lightweight yet powerful attributes, catering to the intricate needs of lab automation. Its versatile support for various programming languages and robust features like IntelliSense, debugging capabilities, and Live Share facilitated the swift development of an interactive e-platform. This choice was integral in enabling efficient coding, enhancing user experience, and ensuring seamless collaboration among developers working on the platform.

Git Hub: The strategic utilization of Git Hub stemmed from its pivotal role in streamlining the development process and fostering collaborative efforts essential for the e-platform's creation. Leveraging Git version control, Git Hub served as the cornerstone for version management and collaborative coding, pivotal for ensuring experimentally accurate code iterations and smooth integration of various lab functions into the e-platform. Its collaboration tools, including issue tracking and pull requests, synergized with the project's requirements, facilitating effective team coordination and meticulous code management throughout the platform's development lifecycle.

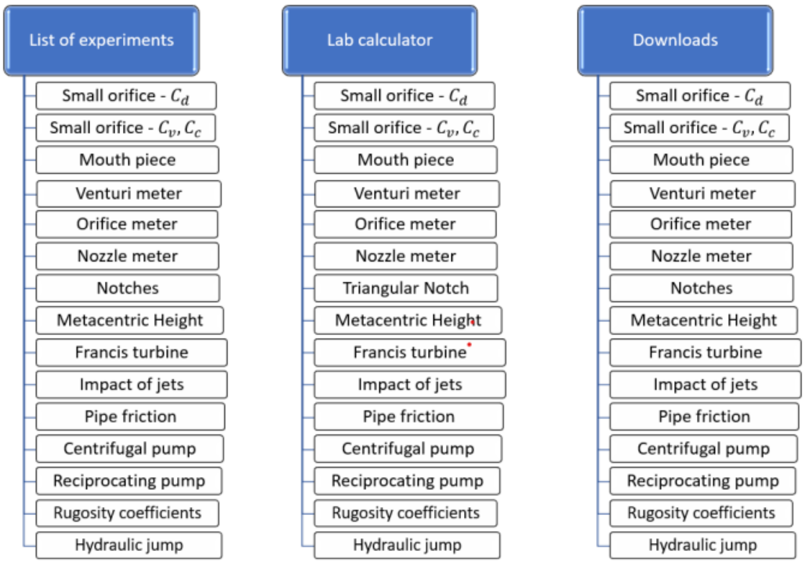
4. Design and development methodology

The development process of the "FM & HM E-Lab" website adhered to a structured methodology, as outlined by [11]. It commenced with the crucial phase of information gathering, where project objectives, user needs, and essential functionalities were delineated[12] . Subsequently, meticulous planning set milestones and scoped the project's parameters. The design phase visualized wireframes and prototypes, ensuring an intuitive and visually appealing interface. Content creation followed, detailing experiments and educational resources catering to diverse learning styles. Coding implemented these designs and content into a functional website using HTML, CSS, JavaScript and frameworks. The final phase encompassed rigorous testing, review, and refinements based on stakeholder feedback before the official launch, ensuring functionality, usability, and performance were optimized for the educational journey of fluid mechanics and hydraulic machinery lab students at Andhra University College of Engineering.

In the planning phase of the website development, key elements are crafted to provide users with a preview of the website's appearance. This includes crucial components like the sitemap, wireframe, and technology stack for the FM & HM E-Lab website. The sitemap, a diagram or list of accessible pages, showcases the hierarchical structure of the site's content, aiding navigation for users and search engines. It outlines main pages and their relationships, offering metadata like modification dates and priority levels. This phase forms the foundation for the site's structure and organization based on gathered information.



(a)



(b)

Figure1: Site map (a) Level 1, and (b) Level 2

4.1. Website Methodology Overview

The development of the AU FM & HM E-Lab, an e-learning platform for the Fluid Mechanics and Hydraulic Machinery lab at Andhra University College of Engineering, emphasized the importance of methodology in ensuring user satisfaction, consistency, and efficiency throughout the project lifecycle. Evaluating various website methodologies highlighted the Agile methodology as the optimal choice due to its iterative nature and adaptability to evolving project requirements.

4.2. Agile Methodology Adoption

The Agile methodology, chosen for its adaptability and customer-centric approach, aligned seamlessly with the project's characteristics. Its iterative nature allowed for ongoing client engagement, accommodating frequent changes, and ensuring continuous feedback and delivery. Phases were meticulously followed, starting from information gathering about the website's purpose, goals, and intended audience to detailed planning, design, and content creation.

4.3. Development Phases

Each development phase was intricately managed to ensure alignment with project objectives. Designing layouts focused on usability and engagement, evolving through continuous review and refinement. Content creation involved developing concise yet comprehensive materials for lab experiments, meticulously reviewed by subject matter experts. The coding phase brought the platform to life using HTML, CSS, and JavaScript, following rigorous coding standards for maintainability.

4.4. Testing and Review

Extensive testing encompassed functional, performance, compatibility, and security checks, ensuring the platform's robustness. The continuous review ensured user-friendliness, engagement, and alignment with project goals. Git Hub served as the deployment platform, harnessing its hosting and publication capabilities.

4.5. Agile Methodology Benefits

Throughout these phases, adherence to the Agile methodology facilitated iterative development, customer collaboration, and continuous improvement, ensuring the AU FM & HM E-Lab's alignment with user needs and educational objectives. The comprehensive approach, adaptability, and rigorous testing assured an efficient and user-centric educational experience.

4.6. Modules Designed for AU FM & HM E-Lab

(i) Experiment Exposition Module

This module serves to present detailed information about lab experiments, encompassing objectives, procedures, and safety considerations **[Figure 4].** It provides a structured display of experiment-related data, facilitating an in-depth understanding for students.

(ii) Lab Calculator Module

Designed to enable automated lab calculations, this module hosts an interactive calculator for students to perform essential calculations related to the experiments **[Figure 6].** It enhances the learning experience by automating complex calculations.

(iii) Downloadable Resources Module

Facilitating access to crucial experiment-related files, this module allows users to download resources pivotal to their learning process **[Figure 7].** It provides easy accessibility to supplementary materials aiding comprehensive learning.

(iv) User Progress Tracking Module

Incorporating a tracking system, this module monitors and displays users' progress in exploring experiments within the platform **[Figure 8].** It serves as a tool for students to track their advancement through various experiments.

These modules were meticulously devised and implemented to augment user engagement, offer vital learning resources, and facilitate interactive learning experiences within the AU FM & HM E-Lab platform.

5. Results and discussion

The designed FM & HM E-Lab website is a comprehensive platform that encapsulates various pages catering to specific aspects of the fluid mechanics and hydraulic machinery laboratory curriculum. The following pages, accessible through the website interface, provide a structured and interactive experience for users [12].

The website design and its individual sections collectively aim to create an interactive, informative, and user-centric platform tailored to enhance the learning experience of students enrolled in fluid mechanics and hydraulic machinery laboratory courses.

5.1. Introduction/Home Page

The introduction/home page shown in Figure 2 serves as the gateway to the FM & HM E-Lab website. It welcomes users and provides an initial overview of the platform’s purpose, showcasing its functionalities and guiding users on navigation. This section aims to create an engaging starting point, capturing users’ attention and encouraging further exploration.

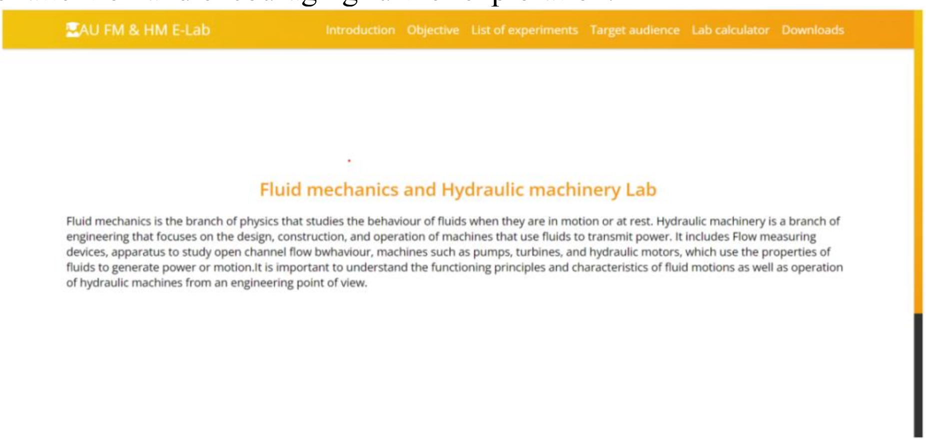


Figure 2Home page of FM & HM E-Lab website

5.2. Objectives Page

The objectives page in Figure 3 outlines the specific goals and aims of the e-learning platform. It details the educational objectives, learning outcomes, and the broader mission of the platform. This section aims to align user expectations with the website's objectives, setting the tone for a focused and productive learning experience.

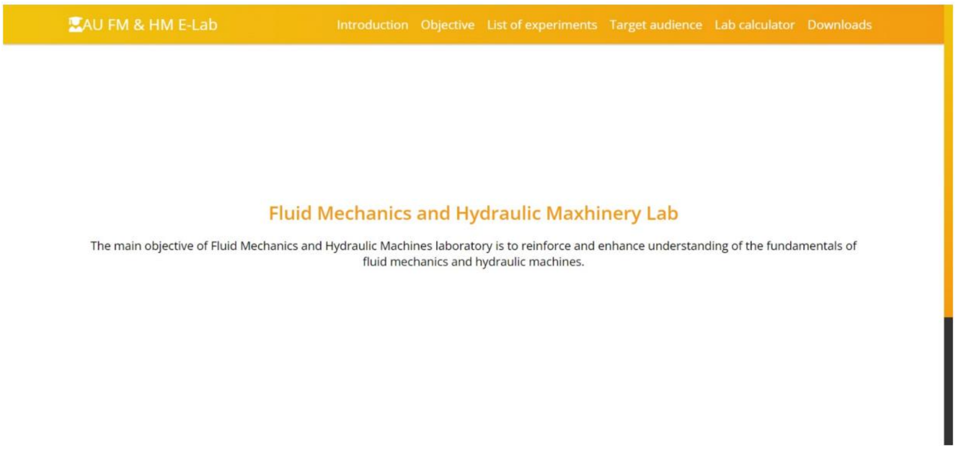


Figure 3 Objectives page

5.3. List of Experiment

Figure 4 provides an organized list of experiments available on the platform. Each experiment is likely accompanied by a brief description or overview, offering users a comprehensive view of the experiments covered. The list format aids users in navigating through the available experiments, allowing them to select and explore based on their preferences or academic requirements.

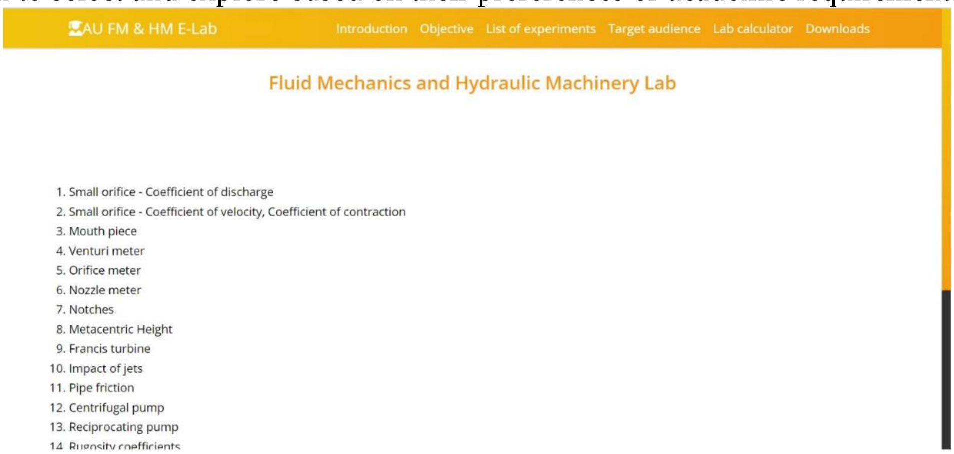


Figure 4 List of experiments page

5.4. Target Audience

The target audience page in Figure 5 delineates the specific academic disciplines and courses that benefit from the content available on the website. It offers insights into the relevance and applicability of the platform's materials to various academic programs, guiding the appropriate user base towards utilizing the provided resources effectively.

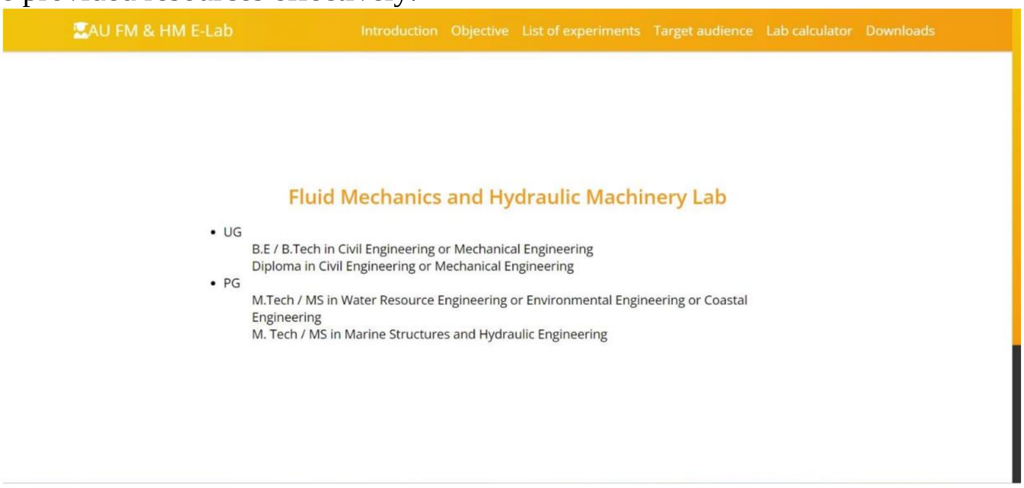


Figure 5 Target audience page

5.5. Lab Calculator

The lab calculator page in Figure 6 provides interactive tools or modules that enable users to perform calculations relevant to fluid mechanics and hydraulic machinery experiments. Section 1 and Section 2 of this page likely present distinct functionalities or calculations, allowing students to engage in practical calculations or simulations related to laboratory experiments.

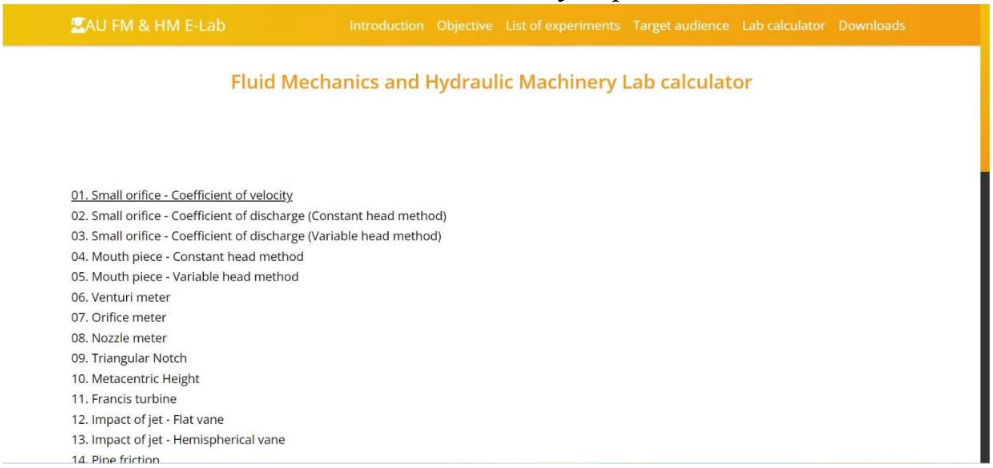


Figure 6 Lab calculator page (section 1)

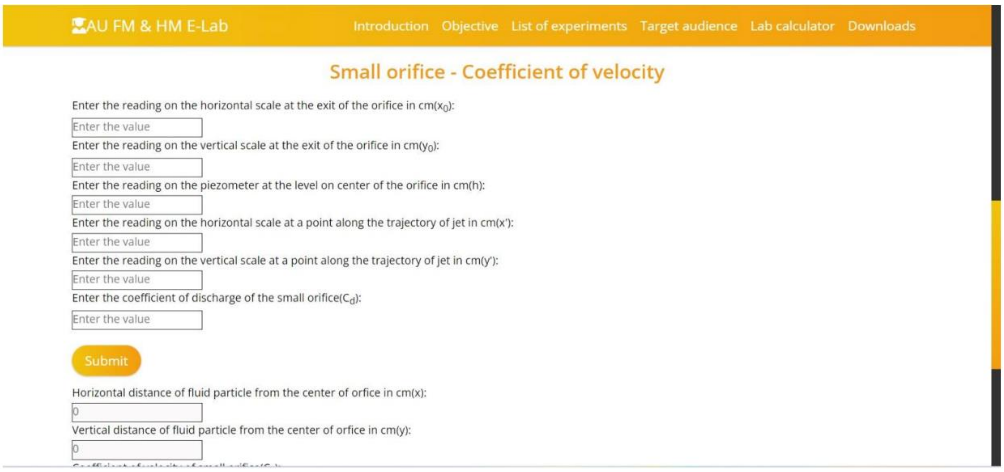


Figure6 Lab calculator Page (section2)

5.6. Downloads

The downloads page shown in Figure 7 offers users access to downloadable resources, such as PDFs, documents, or supplementary materials associated with the experiments. It acts as a repository for additional reference materials or guidelines that complement the experimental content provided on the website.

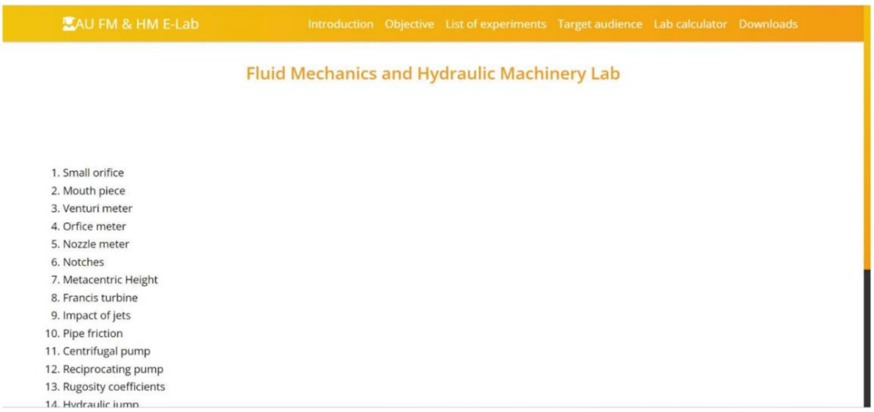


Figure 7 Downloads Page

5.7. Individual Experiments

Figure 8 demonstrates the layout and content structure of an individual experiment page, here specifically showcasing the small orifice experiment. These pages likely offer detailed procedures, diagrams, calculations, and safety considerations related to each experiment, providing comprehensive information for students' understanding and practical application.

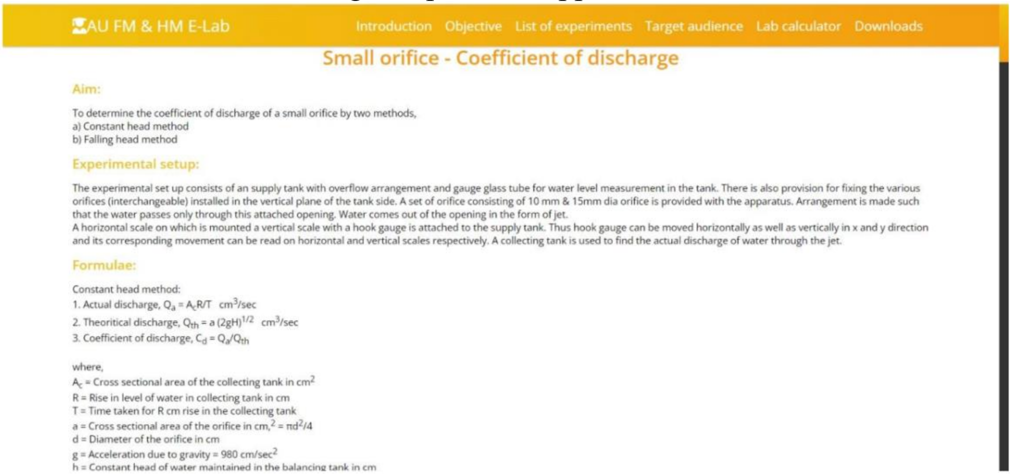


Figure 8 Small orifice experiment Page

These pages collectively create an engaging and informative platform tailored to enhance the learning experience for students in fluid mechanics and hydraulic machinery laboratory courses.

The AU FM & HM E-Lab website is a modest effort aimed at fulfilling the requirements of the project. Extensive use of user-friendly code was implemented. This website will serve as a prominent resource for fulfilling all the requirements of the fluid mechanics and hydraulic machinery lab. Here is the link generated from the current study: Link: https://aufmhmlab.github.io.

6. Conclusions

The FM & HM E-Lab website signifies a culmination of dedicated efforts aimed at fulfilling project needs. Its user-friendly coding and comprehensive design are poised to significantly impact fluid mechanics and hydraulic machinery education. By visiting the provided URL FM & HM E-Lab Website, users encounter an engaging homepage that embodies the collaborative endeavor behind this platform. This study addressed objectives encompassing contextualizing the project, understanding existing learning systems, identifying areas for improvement, and crafting a user-centric website. Benefits include enriched student experiences, automated experiment calculations, independent learning resources, and efficient content accessibility for revision. Learning outcomes span technical, laboratory, design, communication, and project management skills. Looking forward, the website holds vast potential for growth, with prospects for multimedia-rich content, personalized learning, mobile optimization, and collaborative educational environments. Essentially, this expansive scope of the platform ensures its adaptability and alignment with evolving educational needs in fluid mechanics and hydraulic machinery studies.

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