Lingnan University

Course Syllabus

Course Title	:	Web 3D Technology
Course Code	:	CDS4103
Recommended Study Year	:	Year 4
No. of Credits	:	3
Mode of Tuition	:	Sectional Approach
Class Contact Hours	:	3 hours per week
Category	:	Major Elective
Discipline	:	Nil
Prerequisite(s)	:	CDS2101 C++ Programming
Co-requisite(s)	:	Nil
Exclusion(s)	:	Nil
Exemption Requirement(s)	:	Nil

Brief Course Description:

As interactive and immersive experiences become central to modern web applications, Web 3D technologies are transforming how users engage with digital content. This course introduces students to the principles, tools, and frameworks for creating and deploying 3D graphics on the web. Students will learn the fundamentals of 3D rendering, scene composition, and animation using web-based technologies such as WebGL, Three.js, and related libraries. The course covers essential topics including 3D geometry, lighting, shading, textures, and camera controls, as well as performance optimization for real-time rendering in browsers. Students will also explore interactive techniques, integrating user input and dynamic behaviours to create engaging 3D experiences. Emphasis is placed on practical implementation, enabling students to build visually compelling and interactive web applications. Through hands-on projects, students will design and develop 3D scenes and animations that run seamlessly in modern web environments.

Aims:

This course aims to:

1. Introduce the fundamental concepts and principles of Web 3D technologies.
2. Enable students to apply WebGL-based techniques using modern tools such as Three.js and WebStorm.

3. Develop students' ability to design and implement interactive Web 3D scenes for web-based visualization.
4. Enhance students' creative, analytical, and collaborative skills through integrated design and development projects.

Learning Outcomes (LOs)

Upon successful completion of this course, students will be able to:

1. Explain the core concepts and fundamental principles underlying Web 3D technologies and web-based 3D graphics systems. (PILO1)
2. Apply WebGL-based techniques using development tools such as Three.js and WebStorm to build interactive 3D web applications. (PILO2, PILO5)
3. Design and implement Web-based 3D scenes and visualization solutions that support interactive digital and design-oriented applications. (PILO3, PILO5)
4. Optimize the performance of Web 3D applications by improving rendering efficiency and accelerating web-based 3D visualization. (PILO2)
5. Collaborate effectively in the analysis, design, and development of Web 3D projects, demonstrating creativity and problem-solving skills. (PILO6)

Indicative Contents:

Introduction to Web 3D Technologies

Overview of the development of Web 3D technologies, definitions and core components of Web 3D systems, application domains of Web-based 3D graphics.

Web 3D Interactive Devices and Systems

Visual reality systems, motion capture systems, rapid modelling devices, three-dimensional tracking devices, and their roles in interactive 3D environments.

Virtual 3D Scene Construction and Navigation

HTML page structure for Web 3D applications, rendering and displaying 3D objects, scene composition using geometries and mesh objects, camera setup and navigation, animation techniques for extending virtual scenes.

Lighting and Materials in 3D Virtual Scenes

Ambient, point, spot, and directional lighting, advanced lighting techniques, material properties, mesh and advanced materials, line and geometry materials for visual effects.

Geometry Modelling and Boolean Operations

Built-in geometries in Three.js, convex and lathe geometries, geometry creation through extrusion and transformation, text-based geometry definitions, boolean operations on 3D objects.

Particle Systems and Visual Effects

Fundamentals of particles and particle systems, particle rendering using HTML5 canvas and textures, particle systems generated from complex geometries.

Advanced Rendering and Texture Techniques

Texture loading and mapping, bump mapping and normal mapping, light maps for shadow effects, environment mapping for reflection effects, advanced texture applications for enhanced realism.

Teaching Methods:

This course adopts a practice-oriented and studio-based teaching approach that integrates lectures, laboratory sessions, and project-based learning. Lectures introduce the core concepts, principles, and technical foundations of Web 3D technologies, while laboratory sessions provide hands-on experience with WebGL-based tools such as Three.js and WebStorm. A series of structured assignments aligned with key course topics guide students to progressively apply theoretical knowledge to the construction of interactive web-based 3D scenes. Individual and group projects further reinforce learning through design, implementation, experimentation, and performance optimization in realistic development contexts. Peer discussion, critique, and presentation activities are incorporated throughout the course to support collaborative learning and reflective practice, enabling students to develop technical competence, creativity, and problem-solving skills in Web 3D application development.

Measurement of Learning Outcomes:

Assessment / **LOs**	Class Attendance and Participation	Assignments	Individual Design Project	Group Project and Presentation
	(10%)	(30%)	(30%)	(30%)
LO1	✓			
LO2		✓	✓	✓
LO3		✓	✓	✓
LO4			✓	✓

LO5	✓			✓

1. Class attendance and participation assess students' engagement in learning activities and their understanding of fundamental Web 3D concepts introduced in lectures (LO1), as well as their collaborative learning attitude in studio-based discussions and activities (LO5).
2. Assignments are designed to progressively assess students' ability to apply Web 3D concepts and techniques introduced in key chapters, including scene construction, lighting and materials, geometry operations, and advanced rendering effects (LO2, LO3).
3. The Individual Design Project evaluates students' independent ability to design, implement, and optimize a Web-based 3D application, with particular emphasis on technical implementation, interactivity, and performance awareness (LO2, LO3, LO4).
4. The Group Project and Presentation assess students' capability to collaboratively apply WebGL-based techniques, design and implement a more complex Web 3D system, integrate multiple modules, consider performance optimization, and clearly communicate design and technical decisions through presentations and demonstrations (LO2, LO3, LO4, LO5).

Assessment:

Class Attendance and Participation	10%
Assignments	30%
Individual Design Project	30%
Group Project and Presentation	30%
Total	100%

Required/Essential Readings:

1. Dirksen, J. (2023). Learn Three.js : program 3D animations and visualizations for the web with JavaScript and WebGL (Fourth edition.).
2. Parisi, T. (2012). WebGL : up and running. O'Reilly Media.

Recommended/Supplementary Readings:

1. Matsuda, K., & Lea, R. (2013). WebGL programming guide : interactive 3D graphics programming with WebGL. Addison-Wesley.

2. Dirksen, J. (2015). Three.js cookbook : over 80 shortcuts, solutions, and recipes that allow you to create the most stunning visualizations and 3D scenes using the Three.js library. Packt Publishing.
3. Cantor, D., & Jones, B. (2012). WebGL Beginner's Guide. Packt Publishing.

Important Notes:

(1) Students are expected to spend a total of 9 hours (i.e. 3 hours of class contact and 6 hours of personal study) per week to achieve the course learning outcomes.
(2) Students shall be aware of the University regulations about dishonest practice in course work, tests and examinations, and the possible consequences as stipulated in the Regulations Governing University Examinations and Course Work. In particular, plagiarism, being a kind of dishonest practice, is "the presentation of another person's work without proper acknowledgement of the source, including exact phrases, or summarised ideas, or even footnotes/citations, whether protected by copyright or not, as the student's own work". Students are required to strictly follow university regulations governing academic integrity and honesty.
(3) Students are required to submit writing assignment(s) using Turnitin.
(4) To enhance students' understanding of plagiarism, a mini-course "Online Tutorial on Plagiarism Awareness" is available on http://pla.ln.edu.hk/.
(5) Students must adhere to the University's guidelines and practices when using Generative Artificial Intelligence (GAI) tools. The official documents "Guidelines for Using GAI Tools at Lingnan University" and "Best Practices for Ethical and Responsible Use of GAI Tools in Course Assessments" can be found here: https://www.ln.edu.hk/tlc/generative-artificial-intelligence/gai-guidelines-best-practices.

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Course Rubrics

Rubric for Attendance and Participation (10%)

Criterion	Excellent (90-100)	Good (70-89)	Pass (50-69)	Fail (0-49)
Class Attendance (50%)	Attends over 90% of all scheduled classes, including lectures and other sessions.	Attends at least 70% but less than 90% of all scheduled classes.	Attends at least 50% but less than 70% of all scheduled classes.	Attends less than 50% of all scheduled classes.
Class Participation (50%)	Actively and consistently participates in class activities, discussions, and in-class exercises; demonstrates strong engagement, preparedness, and constructive contribution.	Participates regularly in class activities and discussions; demonstrates adequate preparation and engagement.	Participates occasionally in class activities with limited engagement or preparation.	Rarely or never participates in class activities; shows minimal engagement or preparation.

Rubric for Assignments (30%)

Criterion	Excellent (80-100)	Good (65-79)	Pass (50-64)	Fail (0-49)
Functional Completeness and Correctness (40%)	All required features for the assignments are fully implemented and function correctly; demos run reliably and clearly demonstrate the intended effects.	Most required features are implemented and functional; minor bugs or incomplete features are present.	Minimum functional requirements are met, but demos contain frequent errors, instability, or missing components.	Assignments are largely incomplete, incorrect, or fail to run.
3D Scene Structure and Output Clarity (30%)	Implements well-structured and coherent 3D scenes that clearly and effectively present the required visual and interactive elements.	Implements functional 3D scenes that generally present required elements, though with limited visual or structural refinement.	Implements basic 3D scenes that minimally demonstrate required elements.	Fails to implement a coherent or meaningful 3D scene or output.
Progressive Development Across Assignments (20%)	Shows clear progression across assignments, effectively building upon earlier techniques and integrating	Shows some evidence of progression and partial integration of techniques across assignments.	Limited evidence of progression; assignments appear largely isolated.	No evidence of progression or cumulative development across assignments.

	them into later, more complex implementatio ns.			
Code Organization and Technical Clarity (10%)	Code is well-organized, readable, and logically structured, with clear naming and modular design that supports understanding and evaluation.	Code is generally readable with acceptable structure, though minor organization issues are present.	Code structure is weak or inconsistent, making understanding difficult.	Code is poorly organized, unreadable, or lacks clear structure.

Rubric for Individual Design Project (30%)

Criterion	Excellent (80-100)	Good (65-79)	Pass (50-64)	Fail (0-49)
Technical Implementation and Functional Completeness (25%)	Fully implements a functional and stable Web 3D application that meets all baseline requirements; features are correctly integrated and run reliably.	Implements a functional application that meets most baseline requirements; minor technical issues or omissions are present.	Meets minimum baseline requirements, but implementation contains frequent errors, instability, or incomplete features.	Fails to meet baseline requirements or application is largely non-functional.
Integration of Web 3D Techniques (20%)	Demonstrates effective integration of multiple Web 3D techniques, including scene construction, lighting, materials, geometry, animation, and selected advanced techniques where appropriate.	Demonstrates adequate integration of core Web 3D techniques, with limited use of advanced features.	Demonstrates basic use of core techniques with minimal integration.	Demonstrates little or no meaningful integration of required Web 3D techniques.
3D Scene Design and Interactive	Designs a coherent and well-	Designs a functional 3D scene	Designs a basic 3D scene with	Fails to design a coherent or

Capability (20%)	structured 3D scene with intuitive and meaningful interactions that enhance user experience.	with working interactions, though with limited refinement or clarity.	simple interactions that minimally support usability.	interactive 3D scene.
Animation and Dynamic Behaviour (10%)	Implements effective and purposeful animation that enhances visual presentation or interaction within the 3D scene.	Implements basic animation that functions correctly but lacks refinement or depth.	Implements minimal animation with limited contribution to the overall scene.	No meaningful animation is implemented.
Performance Awareness and Basic Optimization (15%)	Demonstrates clear awareness of performance considerations; reports basic performance observations and applies at least two appropriate optimization strategies.	Demonstrates basic awareness of performance issues and applies limited or partially effective optimization strategies.	Demonstrates minimal awareness of performance considerations, with little evidence of optimization.	Shows no awareness of performance issues or optimization.
Technical Documentation and Reflection (10%)	Provides clear and well-structured documentation explaining design	Provides generally clear documentation with basic	Documentation is minimal or largely descriptive,	Documentation is missing, unclear, or does not support

	objectives, key implementations, performance considerations, and reflections on challenges and improvements.	explanation and limited reflection.	with limited reflection.	understanding of the project.

Rubric for Group Project and Presentation (30%)

1. **Group Project Component (20%)**

Criterion	Excellent (80-100)	Good (65-79)	Pass (50-64)	Fail (0-49)
System Functionality and Stability (30%)	The Web 3D system is fully functional, stable, and reliable; all core features operate correctly and consistently.	The system is functional with minor issues; most core features operate as intended.	The system meets minimum functional requirements but contains frequent errors or unstable behaviour.	The system is largely incomplete, unstable, or fails to run.
Web 3D Technology Integration and Modularity (20%)	Demonstrates effective integration of multiple Web 3D techniques and modules; system architecture is clear and logically structured.	Demonstrates adequate integration of core techniques with generally clear modular structure.	Demonstrates limited integration; modules are loosely connected or poorly structured.	Demonstrates little or no meaningful integration of Web 3D techniques or modules.
Scene Complexity and Overall Design Quality (20%)	Implements a well-designed and coherent 3D environment with a level of complexity clearly exceeding the individual	Implements a functional 3D environment with moderate complexity and generally	Implements a basic 3D environment with limited complexity or weak design coherence.	Fails to implement a coherent or sufficiently complex 3D environment.

	project; interactions and visuals support system objectives.	appropriate design.		
Performance Awareness and System-Level Optimization (20%)	Clearly identifies performance considerations and applies at least two effective optimization strategies at the system level.	Demonstrates basic awareness of performance issues with limited or partially effective optimization.	Demonstrates minimal awareness of performance considerations, with little evidence of optimization.	Shows no awareness of performance issues or optimization strategies.
Technical Documentation and System Explanation (10%)	Provides clear and well-structured documentation explaining system architecture, key implementations, performance considerations, and team roles.	Documentation is generally clear with basic explanation and limited detail.	Documentation is minimal or largely descriptive, with limited technical clarity.	Documentation is missing, unclear, or insufficient to support evaluation.

2. Individual Presentation and Individual Contribution Component (10%)

Criterion	Excellent (80-100)	Good (65-79)	Pass (50-64)	Fail (0-49)
Presentation Organization and Delivery (50%)	Presentation is well-structured, coherent, and professionally delivered; key points are communicated clearly and confidently within the allotted time.	Presentation is generally clear and understandable, though organization or delivery may lack consistency or polish.	Presentation conveys basic information but lacks clear structure, fluency, or confident delivery.	Presentation is unclear, poorly organized, or incomplete.
Engagement and Responsiveness in Discussion (10%)	Responds to questions accurately and confidently, demonstrating thoughtful engagement with technical and design aspects of the project.	Responds to most questions appropriately, with minor uncertainty or lack of depth.	Responses are limited, vague, or show minimal engagement.	Unable to respond meaningfully to questions or engage in discussion.
Individual Contribution to the Team and Collaboration (40%)	Demonstrates substantial and well-defined individual contributions that are essential to the group project	Makes clear and meaningful contributions to assigned tasks with generally good quality	Shows some contribution to the project, but work is limited in scope,	Shows little or no reliable evidence of meaningful contribution; frequently misses responsibiliti

	(e.g., ownership of key modules/features, consistent high-quality deliverables); collaborates proactively and reliably, communicates clearly, supports integration and problem-solving, and provides verifiable evidence of contribution (e.g., commit history, task logs, documented role, and peer feedback).	and timeliness; collaborates effectively in most team activities and supports integration, though the scope/impact of contributions or evidence of role ownership may be less consistent or less visible than Excellent.	inconsistent, or requires significant support from teammates; collaboration is uneven (e.g., late responses, limited coordination), and individual contribution is not clearly articulated or evidenced.	es or deadlines, demonstrates poor collaboration or disengagement, and/or contribution cannot be verified through project outputs, documentation, or peer evaluation.