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Laser Technology and Medical Applications

BIOS4YOU
AR 2.0

BIO-INSPIRED STEM TOPICS FOR ENGAGING YOUNG GENERATIONS THANKS TO THE USE OF AUGMENTED REALITY

Project Number: 2023-1-DE03-KA220-SCH-000126516

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Introduction

This document describes the Augmented Reality (AR) exercise titled Laser Technology and Medical Applications, designed for students aged 17–19 within the European project BioS4You 2.0 (Work Package 3: AR Exercises).

The aim of this exercise is to help students understand how laser light is generated through stimulated emission and how it is applied in medical treatments, connecting physics (quantum mechanics, atomic energy levels), chemistry (material properties), and medicine (clinical laser applications).

This document follows the standard BioS4You AR Exercise template and is organized into the following sections:

General Information: title, authors, target group, duration, keywords, and topics

Pedagogical Specifications: learning objectives, methodology, integration with curriculum

Technical Specifications: hardware, software, AR experience design

The exercise has been developed using the 3E approach (Explore – Execute – Enhance), encouraging students to explore laser mechanisms step-by-step through interactive AR scenes showing atomic excitation, stimulated emission, optical cavities, and medical applications.

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	General Information
Name of the exercise:	**Laser Technology and Medical Applications** From atomic excitation to medical light: understanding stimulated emission and clinical lasers The title reflects both the physical principles and practical applications of laser technology. "Laser Technology and Medical Applications" emphasizes the dual focus on fundamental physics and clinical use, while the subtitle "From atomic excitation to medical light" highlights the journey from quantum mechanics (atomic energy levels) to practical healthcare applications through stimulated emission and coherent light generation.
Description of the exercises:	Laser Technology and Medical Applications is designed for students aged 17–19 to explore the fundamental principles of laser generation and medical applications through Augmented Reality. The main objective is to help students understand how coherent light is produced through stimulated emission and how different laser types (CO2, Argon, Nd:YAG) are used in clinical treatments. Students will: • Understand three-level atomic systems and population inversion • Visualize stimulated emission and photon amplification • Explore optical cavity design with mirrors • Learn about medical laser applications (surgery, dermatology, ophthalmology) The AR experience uses Delightex Studio – Spaces (Marker) with 5 sequential scenes and 6 integrated quizzes.
Participants:	The exercise is suitable for both individual students and small groups of 3–5 members. Working in groups is recommended to stimulate discussion about atomic transitions, compare observations of stimulated emission processes, and develop collaborative problem-solving skills when analyzing medical laser applications.
Participants' age range:	Students should have basic understanding of physics and chemistry, in particular the concepts of energy, electromagnetic radiation, atomic structure, and light-matter interaction. Prior knowledge of quantum mechanics basics (energy levels,

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	photons) is recommended but not mandatory.
STEM subject and specific topic:	STEM Subject: Physics, Chemistry, Medicine, Engineering Specific Topic: Laser physics, stimulated emission, three-level atomic systems, optical cavities, coherent light, medical laser applications Main challenge of the topic: Students often struggle to understand how stimulated emission differs from spontaneous emission, why population inversion is necessary, and how coherent light enables precise medical procedures. AR visualization helps bridge these abstract concepts with tangible medical applications.
Gamification process:	The gamification strategy follows BioS4YOU WP2 guidelines, focusing on challenge-based learning and immediate feedback with Delightex Studio. Challenge-based learning: Students follow the journey from atomic excitation to medical applications. Each scene presents a quiz that must be answered correctly to proceed to the next stage, creating a progressive learning pathway. Immediate feedback: Delightex provides instant visual feedback when students answer quiz questions. Correct answers unlock the NEXT button and advance the storyline, while incorrect answers prompt students to reconsider the physical principles involved. Achievement unlocking: Scene 5 requires completing all three medical application quizzes to receive the final congratulations message, providing a sense of accomplishment and mastery.
Written or graphic description of Augmented info:	The AR experience is developed in Delightex Studio – Spaces (Marker) and includes: Scene 1: Title and introduction Title "Laser Technology and Medical Applications" with START button

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	Scene 2: Three-level atom system Diagram showing E1, E2 (metastable), E3 levels with pumping radiation and population inversion Quiz: Function of metastable level E2 Scene 3: Stimulated emission Before/During/After sequence showing photon triggering identical photons (same frequency, phase, direction) Quiz: What makes laser light coherent Scene 4: Laser cavity Optical cavity with total reflector, active medium, partial reflector (output coupler), pump source Quiz: Why two mirrors are needed Scene 5: Medical applications Three quizzes on: - Tissue penetration depth (CO2, Argon, Nd:YAG) - CO2 laser applications - Photodynamic therapy (PDT) Final congratulations message after completing all quizzes.
External (or extra) tools required	• Devices: Smartphones or tablets with Delightex app installed (iOS or Android) • AR markers: Required; Delightex Studio – Spaces (Marker) uses marker-based AR. Students scan the provided marker to launch the AR experience • Printed worksheets: Optional for note-taking during AR exploration • Internet connection: Required for initial app download and AR content loading
Links (video, images, text online and so on).	**QUIZ** The quizzes are integrated natively in Delightex Studio (scenes 2-5) and do not require external links. Students answer directly within the AR experience with automatic feedback.

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Pedagogical specifications

Here we will collect information on how to use the exercise in the learning session and the results and benefits of using it, from a pedagogical perspective.

How can this augmented information be used to address a STEAM topic in a more interesting way for students?

The AR exercise transforms abstract quantum mechanics concepts into visual, interactive experiences that students can explore in real time. By visualizing electrons transitioning between energy levels, witnessing photon multiplication during stimulated emission, observing coherent light propagation inside optical cavities, and making direct connections to real medical devices, students bridge the gap between theoretical physics and clinical applications. The immersive nature of AR allows learners to manipulate and observe invisible quantum processes, making laser physics tangible and engaging while demonstrating the interdisciplinary connections between physics, chemistry, and medicine.

Which pedagogical objectives are addressed through this scenario?

The exercise addresses multiple pedagogical objectives across different learning domains. Students develop understanding of three-level atomic systems, metastable states, and the fundamental difference between stimulated and spontaneous emission. They learn to describe optical cavity function and identify medical laser types with their clinical applications. Through AR visualization, students connect atomic-scale physics to macroscopic medical devices, analyze cause-effect relationships in laser generation, and evaluate appropriate laser choices for different medical procedures. At the competence level, the exercise develops scientific reasoning about light-matter interaction and critical thinking about medical laser safety and efficacy in healthcare settings.

Which results are expected to be reached with its use?

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Students are expected to explain why population inversion is necessary for laser operation, describe the role of metastable states in three-level systems, understand how stimulated emission produces coherent light, and match different laser types (CO_2, Argon, Nd:YAG) to appropriate medical applications based on wavelength and tissue penetration properties. Assessment of these learning outcomes includes successful completion of all six quizzes during the AR experience, demonstrated ability to draw and label three-level energy diagrams, correct explanation of the stimulated emission process, and appropriate selection of laser types for specific clinical scenarios.

Which benefits are expected to be reached with its use?

The exercise provides enhanced visualization of quantum phenomena that cannot be directly observed, increasing student engagement through interactive AR technology while delivering immediate feedback that supports self-paced learning. Gamification elements maintain motivation throughout the experience. From an interdisciplinary perspective, the exercise integrates physics (quantum mechanics), chemistry (materials), and medicine (applications), providing real-world context that demonstrates STEM relevance in healthcare and bridges theoretical science with clinical practice. Long-term benefits include establishing a foundation for advanced studies in photonics, medical physics, or biomedical engineering, developing understanding of safe laser use in various professional contexts, and fostering critical thinking about technology selection based on physical properties.

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Technical specifications

In this part it is necessary to specify whether the exercise was designed to be implemented with AR technology. This part is fundamental for the translation process. Please include text, audio text and all the necessary materials.

AR INFORMATION	
Technology	https://edu.delightex.com/YKC-KUE YKC KUE Delightex Studio – Spaces (Marker) The exercise is designed to be implemented entirely with Augmented Reality. It uses marker-based AR, since Delightex Studio – Spaces (Marker) requires students to scan a printed marker to launch the AR experience and view the laser physics scenes on their device screen.
If it's needed a marker, description of the marker	A specific marker is required for Delightex Studio – Spaces (Marker). The marker is a printed image or pattern that students scan with their smartphone or tablet camera to launch the AR experience. The marker can be a custom-designed image related to laser technology (such as a laser beam symbol or atom diagram) or a standard QR-style pattern provided by Delightex.
Hardware and software needed:	- Hardware: Smartphones or tablets with camera and internet connection. Gyroscope and accelerometer are required (standard in most modern devices)

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	- Software: Delightex app (free, available on Android and iOS). Teachers need a Delightex educational account to access and share the AR project - Other: Printed marker for each student or group
Type of Augmented data	The AR experience integrates different types of content: - 3D text (title "Laser Technology and Medical Applications", scene labels, quiz questions) - Images (three-level energy diagram, stimulated emission sequence, optical cavity diagram) - Interactive buttons (START, NEXT, QUIZ buttons) - Text overlays (explanatory messages about pumping, emission, cavities) - Quiz interface (multiple-choice questions with automatic feedback)
Written description of the AR data	When students open the exercise with Delightex app and scan the marker, they begin with Scene 1 displaying the title "Laser Technology and Medical Applications" as 3D text. Tapping START leads to Scene 2 showing the three-level atom system diagram with energy levels E1, E2 (metastable), and E3. Students see pumping radiation (yellow arrows) exciting electrons from E1 to E3, followed by rapid decay to metastable E2, creating population inversion. A quiz asks about E2's function before enabling NEXT. Scene 3 displays the stimulated emission process in three stages: Before (electron in E2, incident photon arriving), During (electron transition E2→E1), After (two identical photons emitted with same frequency and direction). Quiz covers coherence and directionality. Scene 4 shows the optical cavity with total reflector mirror, active laser medium, partial reflector (output coupler), and pump source. Students visualize photons bouncing between mirrors, amplifying stimulated emission until coherent beam exits through partial reflector. Quiz addresses mirror function. Scene 5 presents three consecutive quizzes about medical laser applications: tissue penetration depth comparison (CO_2, Argon, Nd:YAG), CO_2 laser uses (surface treatment), and photodynamic therapy (Argon + photosensitizing drug). Completing all three

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	reveals congratulations message.
If Image	If the AR data are Images, the formats needed are .jpg and .png (better size < 2Mb). The exercise uses multiple images: - Scene 2: Three-level energy diagram (YouTube source) showing E1, E2, E3 levels with pumping and decay arrows - Scene 3: Before/During/After stimulated emission diagram (Mathwizurd source) with photon multiplication - Scene 4: Optical cavity diagram (MEETOPTICS source) with mirrors, active medium, pump source, and laser beam output
If Text	Short explanatory messages are displayed as text overlays inside Delightex Studio. Scene 1: Title and subtitle Scene 2: "Pumping radiation excites electrons to E3. They rapidly decay to metastable E2, creating population inversion" Scene 3: "Stimulated emission: photons trigger identical photons with same frequency, phase, and direction - this is amplification!" Scene 4: "Mirrors create resonant cavity. Photons bounce back, amplifying stimulated emission until coherent beam exits" Quiz questions: - What is the function of level E2 in a three-level laser? - What makes laser light coherent and directional? - Why does the laser cavity need two mirrors? - Which laser penetrates deepest into tissues? - CO2 lasers are primarily used for: - Photodynamic Therapy (PDT) uses: Final message: "Congratulations! You've successfully completed the Laser Light exploration! You now understand how atoms generate coherent light for medical applications.

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If video	-
If audio	-
If 3D model	3D models in Delightex Studio can be used in formats compatible with the platform (.glb, .obj). The exercise primarily uses 3D text elements for titles and labels. Optional enhancement could include importing 3D models of laser devices or medical equipment from libraries compatible with Delightex.

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