THE EFFECT OF LUMEN OUTPUT AND ELECTROMAGNETIC RADIATION IN AN INDOOR ENVIRONMENT

FABIOLA T. ORTIZ CASTILLO, JONCY PASTOR CARATTINI
WILFREDO TORRES VELEZ, PE
ELECTRICAL & COMPUTER ENGINEERING AND COMPUTER SCIENCE DEPARTMENT
POLYTECHNIC UNIVERSITY OF PUERTO RICO - SAN JUAN
UNDERGRADUATE RESEARCH PROGRAM FOR HONOR AND OUTSTANDING STUDENTS 2025-2026

POLYTECHNIC UNIVERSITY OF PUERTO RICO
A MULTIFACETED APPROACH TO STUDENT CENTERED STEM EDUCATION
P031C210139

Abstract

This study evaluates illuminance, electromagnetic radiation, and flicker characteristics of lighting systems across several indoor spaces at the Polytechnic University of Puerto Rico, including classrooms P-315, L-301, CTE-5, a library cubicle, and the gymnasium. Results indicate significant variability: some spaces had insufficient or nonuniform illumination, others exceed recommended lumen levels, and most exhibit acceptable flicker ranges, with a few showing moderate flicker linked to LED driver instability. Based on these findings, recommendations include luminaire repositioning, lamp and filter replacement, and periodic maintenance. This first-phase study contributes to improving lighting quality, visual comfort, energy efficiency, and photobiological safety in educational environments.

Introduction

Artificial lighting technologies—incandescent, fluorescent, and LED—vary significantly in spectral output, emitting different combinations of visible and non-visible radiation that can affect circadian rhythm and visual comfort. As people spend more time indoors, understanding this exposure becomes increasingly important for health and productivity. This study analyzes the lumen output and spectral properties of common electric lamps to clarify their implications for indoor environments and support informed lighting decisions.

Objectives

- Measure the luminance and illuminance levels produced by different types of electric lamps in an indoor environment.
- Measure the electromagnetic radiation emitted by each lamp, including ultraviolet (UV) and infrared (IR) components.
- Compare the lumen output and electromagnetic radiation characteristics among various lamp types.
- Determine the power consumption of each lamp and evaluate its relationship with luminous efficiency.
- Examine how differences in lighting characteristics, particularly electromagnetic radiation and light intensity, may impact human health and comfort in indoor environments.

Methodology

Measurement Instruments:


Visible Light Meter

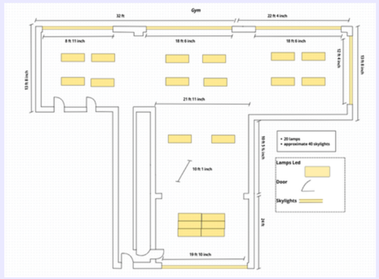

UV Light Meter


Infrared Light Meter


Blue Light Meter


Magnetic Field Meter

Measurement Location Diagrams:

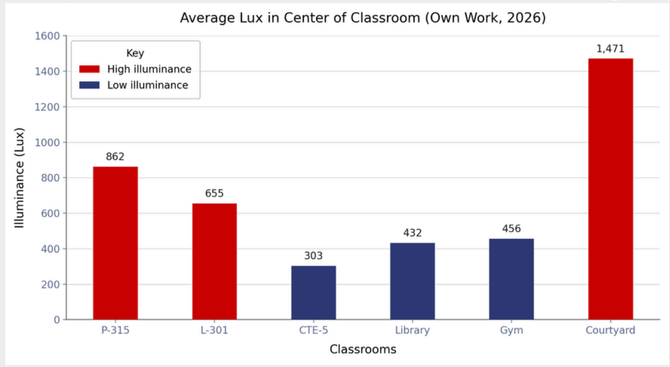


Average Measurement Range Table:

Type	Safety	Measured
EMF	500 mT	0.009–0.19 μT
Blue Light	2.5 mW/cm²	0–1.0 mW/cm²
Infrared	1000 W/m²	0–10 W/m²
Ultraviolet	0.4 μW/cm²	0 μW/cm²

Analysis and Results

Most indoor spaces met or approached the 300–500 lux classroom recommendation, but lighting distribution was uneven. Some areas exceeded 500 lux at the center while corners had insufficient illumination, indicating that fixture placement is the main issue. Indoor LED measurements showed no detectable UV or IR radiation. Blue-light irradiance remained below the 2.5 mW/cm² ACGIH limit. Outdoor sunlight produced substantially higher UV, IR, and blue-light levels than indoor lighting. EMF measurements ranged from 0.01–0.19 μT, far below the 500 mT ICNIRP guideline. Most locations exhibited low flicker, although some points showed moderate flicker, which could contribute to visual discomfort over prolonged exposure.



Conclusions and Recommendations

Phase 1 of this investigation assessed lighting quality across six indoor and outdoor spaces at the Polytechnic University of Puerto Rico, revealing inconsistent illumination that ranged from insufficient light levels in the Library Cubicle and CTE-5 to excessive illumination in L-301. Common contributing factors included degraded or opaque filters, malfunctioning fixtures, and uneven lamp distribution.

As a general recommendation, fixes are room-specific: the Library Cubicle needs lamp repositioning for better corner lighting; CTE-5 needs new filters and lamps (positions unchanged due to computers); L-301 needs darker curtains to offset excess sunlight; the gymnasium needs upgraded lamps and cleaned/replaced filters; and P-315 needs its rear lamp repaired, a filter replaced, and one lamp repositioned. Sites with moderate flicker should get IEEE 1789–compliant drivers and standardized DC dimming, with annual inspections going forward.

References

- Atchison, D. (2023). Optics of the Human Eye (2nd ed.). CRC Press.
- Bullough, J. D. (2000). The blue-light hazard: A review. J. Illum. Eng. Soc., 29(2).
- He, J. (2024). Indoor lighting standards. Indoor Lighting Manufacturer.

Acknowledgements

- We would like to thank Eng. Wilfredo Torres Vélez for his guidance and mentorship throughout this investigation. We also extend our gratitude to Emmanuel Medina, Dian Otero, Amanda Cabrera, Jeremías Flores, and Alejandro Ayala for their assistance in conducting the experiment and research alongside us. Finally, we would like to acknowledge the Undergraduate Research Program for its support.