Learning Optics and Electrodynamics as part of the Bachelor of Information Technology Security curriculum

Guillermo E. Sánchez Guerrero[a] and Perla M. Viera-González[a]

[a]Universidad Autónoma de Nuevo León, Facultad de Ciencias Físico Matemáticas, Av. Universidad SN Cd. Univeristaria, San Nicolás de los Garza, México

ABSTRACT

The bachelor program in Information Technology Security of the Universidad Autonoma de Nuevo Leon used to teach the students the use of hardware and software needed for their professional development; moreover, the constant evolution of technology and the imminent arrival of new technologies such as Quantum computers, 5G, 6G, and more lead to needing to include a solid base on Physics at the first semesters of the curriculum. Considering this, the recent updates in the academic program of the Bachelor of Information Technology Security include a subject called Transmission Signals, where fundamental electrodynamics and optics are the main topics covered, including the explanation of its application in Computer, Telecommunications, Cryptography, and Security in IT. The main objective of the subject is to prepare the students to understand how the technology works and the science behind it, which will lead to the opportunity for the student to easily understand future technologies from a solid foundation of knowledge in Electrodynamics and Optics. The subject of Transmission Signals has been taught since 2019, and the present work shows a summary of its content, the projects developed by the students, the impact of this subject in the curriculum, and the future work proposed to improve the integral development of the IT Security students.

Keywords: Transmission Signals, Learning Optics, Electrodynamics, Physics

1. INTRODUCTION

The Bachelor program in Information Technology Security was created in 2011, and it was one of the first programs in the Northeast of Mexico to offer professional formation in this field. The program is offered by the Physics and Math School (Facultad de Ciencias Físico Matemáticas - FCFM) of the Universidad Autónoma de Nuevo León (UANL) and, since its creation, has included a solid background in Math and Information Technology1.

In 2016, ABET and IEEE established a committee to create ABET program criteria for cybersecurity engineering programs. The criteria for accrediting Cybersecurity programs include subjects and content related to the security of the connections between physical and logical components, which leads to the need to understand how the systems, computers, telecommunications, and emerging technologies related to work from a Physics perspective2.

By 2017, the academic program began an update process, and a research project about the students, graduates, employers, and experts was conducted. Among the results, experts and employees mentioned that the technical skills of the graduates of this academic program were good. Still, some of them lacked the ability of problem-solving and critical thinking, and they were not prepared for the evolution of technology or the paradigm changes generated by the Fourth Industrial Revolution 3.

With the evolution of technology in the last decade and the arrival of the Fourth Industrial Revolution, it is necessary to prepare all the students to adapt to changes and understand emerging technologies easily. In addition, the skills developed to include STEM in the academic curricula are essential for preparing students for their professional paths. Moreover, understanding the technology at a physical level, where the laws and

Further author information: (Send correspondence to G.E.S.G)
G.E.S.G: E-mail: guillermo.sanchezgr@uanl.edu.mx
P.M.V.G: E-mail: perla.vieragn@uanl.edu.mx

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theorems of Physics can be observed and applied, prepare the student to quickly adapt to paradigm changes such as the one we are having with the quantum revolution. On that topic, we included as fundamental the learning of Electrodynamics and Optics to understand the new technologies and to be prepared to protect them (or vulnerate them) in the daily life activities of a professional in Cybersecurity4–17.

This work presents the curricular update of the Bachelor program in Information Technology Security of 2019, where a subject related to Electrodynamics and Optics was introduced. It presents the topics covered and academic activities, showing the first outcomes of this change.

2. METHODOLOGY

The first academic program of the Bachelor of Information Technology Security does not include any subject related to Physics, Optics, or similar fields; it only includes subjects related to Math, Programming, Telecommunications, and Cybersecurity. On this subject, for the update of the academic program, two new subjects related to Physics were included: Introductory Physics and Transmission Signals. Introductory Physics is a subject where Mechanics and general introduction vectors, and physics magnitudes are covered. This subject focuses on solving problems and developing critical thinking1.

Transmission Signals is the subsequent subject to Introductory Physics, and it is a requirement to approve it for taking the subsequent classes related to Telecommunications. This subject aims to understand the electromagnetic spectrum and waves, including Optics fundamentals, how the signals associated with Information Technology are processed, stored, and transmitted, and the security challenges and related solutions. It is also essential to prepare the student to adapt to new technologies once they graduate; this point was considered primarily for the evolution of Optics, Photonics, and Quantum technologies in the last years.

The topics covered on this subject include:

- Electromagnetism
- Waves
- Optics
- Communication systems
- Transmission of signals on guided mediums
- Antennas and wireless transmission
- Data processing in a Physical layer
- Cybersecurity over a physical layer

During the semester, the students coursing the Transmission Signals perform the next academic activities:

- Solution of physics problems related to Electromagnetism and Optics
- Essays about storage and transmission technologies
- Research project about the physical fundamentals of emerging technologies related to the storage or transmission of information, including an analysis of the security vulnerabilities associated with it

Due to a change in the Academic Model of our University, a new update of the Bachelor program was performed. Still, Transmission Signals and all related subjects are maintained as part of the curricula, as shown in 1.

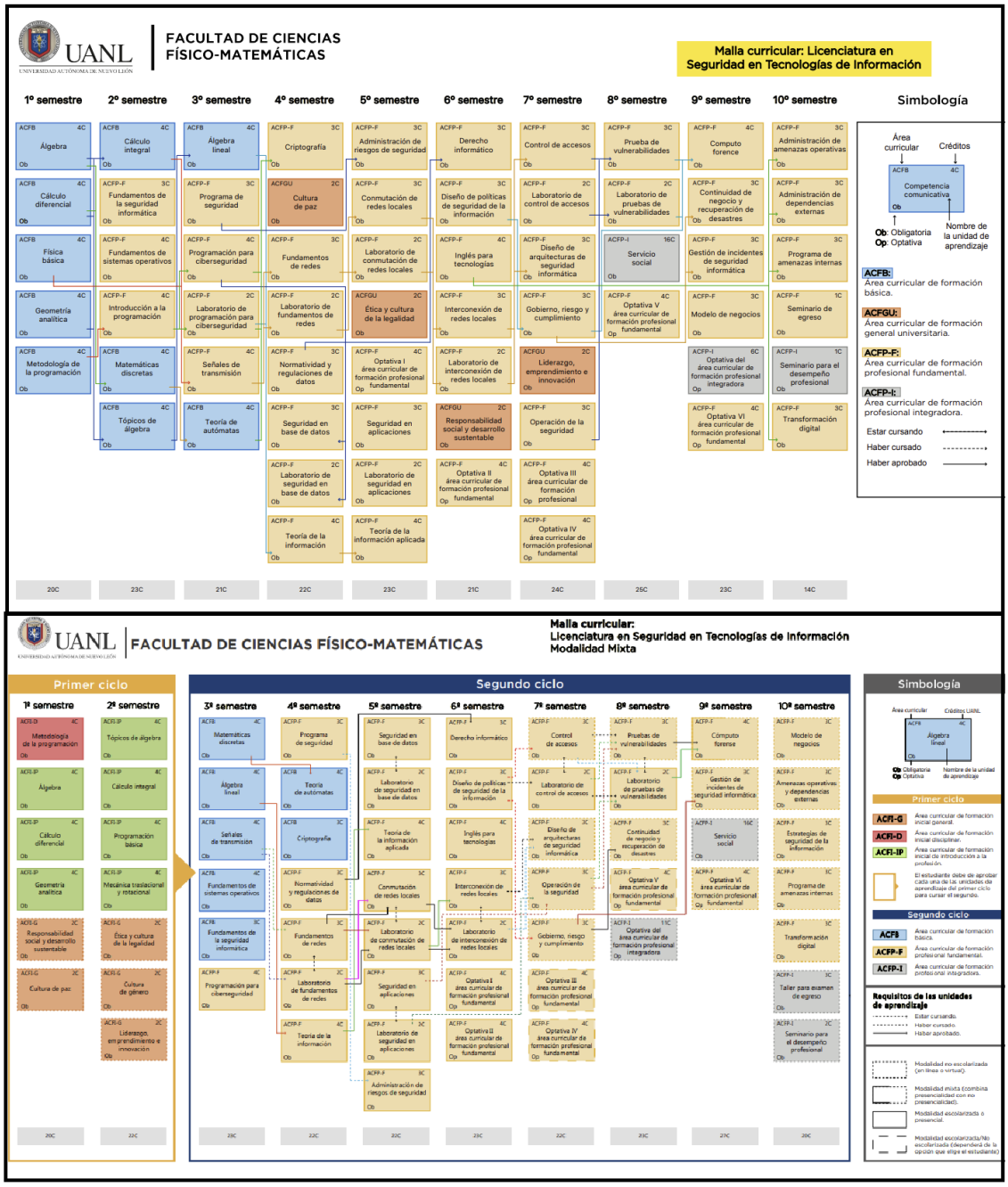

Figure 1. Curricula of the academic program in 2019 (top) and 2022 (bottom). It can be observed that the subject of Transmission Signals is conserved, and Introductory Physics changed to Rotational and Translational Mechanics.

3. RESULTS

As seen in Figure 2, the average grade increased by 4.2 points on a scale of 100, and the standard deviation decreased by 1.43 points on a scale of 100. On average, it takes them fewer opportunities to pass the subject. The courses in this study are four telecommunications courses, including laboratory courses where students practice with physical components.

The final projects of this course are an opportunity for the students to explore new technology from a

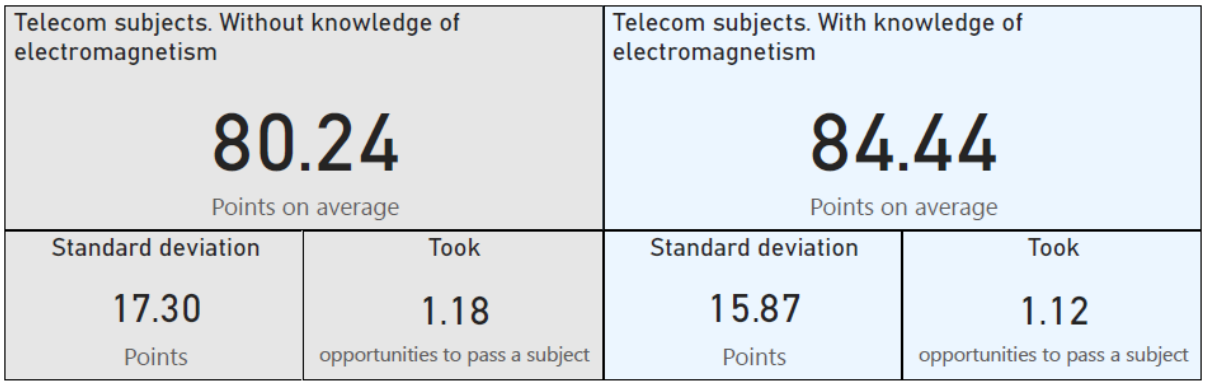

Figure 2. The students show better results in telecommunications when studying electromagnetism topics, including optics. In the degree, students have six opportunities to pass a subject; on average, it takes fewer opportunities to pass a telecommunications subject.

physics and IT perspective. They present topics such as Bluetooth, Wi-Fi, 5G communications, fiber optic, and vulnerabilities in the physical layer. The projects will demonstrate how physics and IT can collaborate to create innovative solutions for various challenges and domains.

4. CONCLUSIONS

Students who include optics and physics in their training can better understand the concepts of modulation, line coding, and signaling concepts that apply to this OSI model layer. Thus, they can delve into the rest of the layers of the communication model and understand how the virtual links between the nodes are established. Some students have taken a particular interest in vulnerabilities in the physical layer and have created clubs to investigate the hardware used in this layer.

Students who have taken physics subjects have shown better performance in telecommunications-related subjects. According to our results, these students have obtained higher scores and have failed fewer times than those who have not taken physics.

Finally, students understand optical phenomena that will serve them in new technological challenges. For example, fiber optic topics are included in this curriculum. These topics were not covered in the previous curriculum and are essential for developing telecommunications and other applications.

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