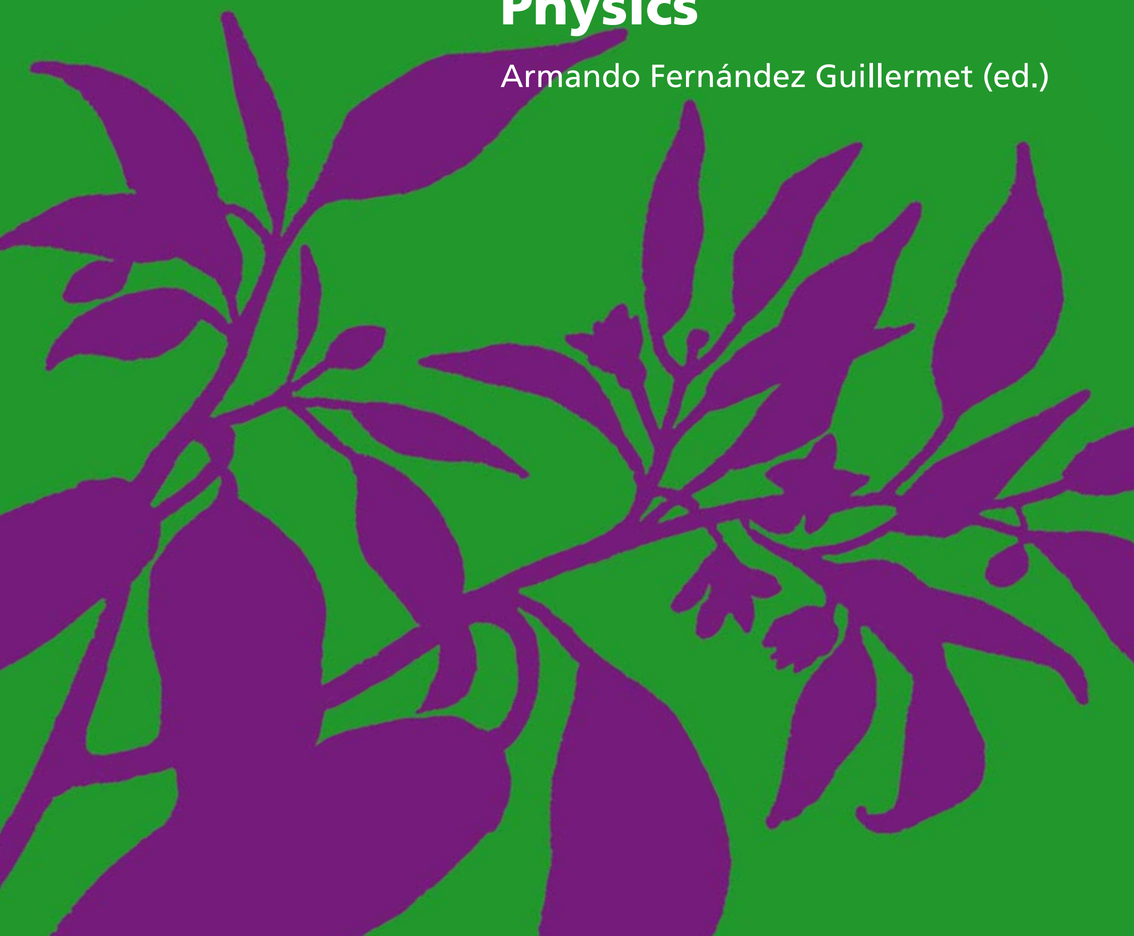
Tuning

Latin America

Higher Education in Latin America: reflections and perspectives on **Physics**

Armando Fernández Guillermet (ed.)



Higher Education in Latin America: reflections and perspectives on Physics

Tuning Latin America Project

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Tuning: past, present and future
An introduction

Major changes have taken place worldwide in higher education over the last 10 years, although this has been a period of intense reflection particularly for Latin America, insofar as the strengthening of existing bonds between nations has been promoted and the region has started to be considered as being increasingly close. These last 10 years also represent the transition time between Tuning starting out as an initiative that arose as a response to European needs and going on to become a worldwide proposal. Tuning Latin America marks the start of the Tuning internationalisation process. The concern with thinking how to progress towards a shared area for universities while respecting traditions and diversity ceased to be an exclusive concern for Europeans and has become a global need.

It is important to provide the reader of this work with some definitions of Tuning. Firstly, we can say that Tuning is **a network of learning communities**. Tuning may be understood as being a network of inter-connected academic and student communities that reflects on issues, engages in debate, designs instruments and compares results. They are experts that have been brought together around a discipline within a spirit of mutual trust. They work in international and intercultural groups and are totally respectful of independence on an institutional, national and regional level, exchanging knowledge and experiences. They develop a common language to problems in higher education to be understood and take part in designing a set of tools that are useful for their work, and which have been devised and produced by other academics. They are able to take part in a platform for reflection and action about higher education - a platform made up of hundreds of communities from different countries. They are responsible for developing reference points for disciplines that represent a system for designing top quality qualifications which are shared by many. They are open to the possibility of creating networks with many regions of the world within their own field and feel that they are responsible for this task.

Tuning is built on each person that forms part of that community and shares ideas, initiatives and doubts. It is global because it has pursued an approach based on worldwide standards while at the same time remaining both local and regional, respecting the specific features and demands of each context. The recent publication: *Communities of Learning: Networks and the Shaping of Intellectual Identity in Europe, 1100-1500* (Crossley Encanto, 2011) takes all the new ideas into consideration which are developed within a community context, whether of an academic, social or religious nature or simply as a network of friends. The challenge facing Tuning communities is to gain an impact on the development of higher education in its regions. Secondly, Tuning is a **methodology** with well-designed steps and a dynamic outlook that enables different contexts to be adapted. The methodology has a clear aim: to build qualifications which are compatible, comparable, are relevant to society and with top levels of both quality and excellence, while preserving the valuable diversity deriving from the traditions of each country involved. These requirements demand a collaborative methodology based on consensus which is developed by experts from different fields who are representatives of their disciplines, and who have the ability to understand local, national and regional situations.

This methodology has been developed around **three core themes**: the first is the **qualification profile**, the second is the **syllabus** and the third refers to the **trajectories of those who learn**.

The qualification profile enjoys a key position in Tuning. After a lengthy period of reflection and debate within Tuning projects in different regions (Latin America, Africa, Russia), the qualifications profile may be defined as being a combination of forces revolving around four core points:

- The region's needs (from local issues to the international context).

- The meta-profile of the area.

- The taking into consideration of future trends in the profession and society.

- The specific mission of the university.

The question of **social relevance** is essential for the design of profiles. Without doubt, any analysis of the relationship existing between university and society lies at the heart of the matter of relevance in higher education. Tuning's aim is to identify and meet the needs of the production sector, the economy, society as a whole and the needs of each student within a particular area of study – measured by specific social and cultural contexts. With a view to achieving a balance between these different needs, goals and aspirations, Tuning has consulted leading people, key local thinkers and experts from industry, both learned and civil society and working parties that include all those interested. An initial period of this phase of the methodology is linked to general competences. Each thematic area involves the preparation of a list of general competences deemed relevant from the standpoint of the region concerned. This task ends when the group has widely discussed and reached consensus about a selection of specific competences, and the task is also performed with specific competences. Once the means of consultation has been agreed and the process completed, the final stage in this practical exercise involving the search for social relevance refers to an analysis of results. This is done jointly by the group, and special care is taken not to lose any contributions from the different cultural perceptions that might illustrate understanding of the specific reality.

Once lists of the general and specific agreed, consulted and analysed competences had been obtained, a new phase got underway over these last two years that is related to the **development of meta-profiles for the area** under consideration. For Tuning methodology, meta-profiles represent the structures of the areas and combinations of competences (general and specific) that lend identity to the disciplinary area concerned. Meta-profiles are mental constructions that categorise competences in recognisable components and illustrate their inter-relations.

Furthermore, thinking about education means becoming involved in the present, while above all also looking towards the future – thinking about social needs, and anticipating political, economic and cultural changes. This means also taking into account and trying to foresee the challenges that those future professionals will have to face and the impact that certain profiles of qualifications is likely to have, as designing profiles is basically an exercise that involves looking to the future. Within the present context, designing degree courses takes time in order for them to be planned and developed and their approval obtained. Students need years to achieve results and mature in terms of their learning. Then, once they have finished their degree, they will need to serve, be prepared to act, innovate and transform future societies in which they will find new challenges. Qualification profiles will in turn need to look more to the future than the present. For this reason, it is important to take an element into consideration that should always be taken into account, which are future trends both in terms of the specific field and society in general. This is a sign of quality in design. Tuning Latin America embarked on a methodology so as to incorporate an **analysis of future trends into the design of profiles**. The first step therefore involved the search for a methodology to devise future scenarios following an analysis of the most relevant studies in education by focusing on the changing role of higher educational establishments and trends in educational policies. A methodology was chosen based on in-depth interviews with a dual focus: on the one hand, there were questions that led to the construction of future scenarios on a general society level, their changes and impact. This part needed to serve as a basis for the second part, which dealt specifically with the features of the area in itself, their transformation in general terms in addition to any possible changes in the degree courses themselves that might have tended to disappear, re-emerge or be transformed. The final part sought to anticipate the possible impact on competences based on present coordinates and the driving forces behind change.

There is a final element that has to be taken into account when constructing the profiles, which is linked to the **relationship with the university where the qualification is taught**. The mark and mission of the university must be reflected in the profile of the qualification that is being designed.

The second core theme of the methodology is linked to **syllabuses**, and this is where two very important Tuning components come into play: on the one hand, students' work volume, which has been reflected in an agreement to establish the Latin American Reference Credit (CLAR), and all studies are based on this and, on the other, the intense reflection process into how to learn, teach and assess competences. Both aspects have been covered in Tuning Latin America.

Lastly, an important area is opened up for future reflection about the **trajectories of those who learn** – a system that proposes focusing on the student leads one to consider how to position oneself from that standpoint so as to be able to interpret and improve the reality in which we find ourselves.

Finally, Tuning is a **project** and as such came into existence with a set of objectives and results and within a particular context. It arose from the needs of the Europe of 1999, and as a result of the challenge laid down by the 1999 Bologna Declaration. Since 2003, Tuning has become a project that goes beyond European borders, in so doing embarking on intense work in Latin America. Two very specific problems faced by the university as a global entity were pinpointed: on the one hand, the need to modernise, reformulate and make syllabuses more flexible in the light of new trends, society's requirements and changing results in a vertiginous world and, on the other, which is linked closely to the first problem, the importance of transcending limits imposed by staff in terms of learning, by providing training that would enable what has been learnt to be recognised beyond institutional local, national and regional borders. The Tuning Latin America project thus emerged which, in its first phase (2004-2007), sought to engage in a debate whose goal was to identify and exchange information and improve collaboration between higher educational establishments, with a view to developing the quality, effectiveness and transparency of qualifications and syllabuses.

This new phase of **Tuning Latin America (2011-2013)** started life on already-fertile terrain – the fruits of the previous phase and in view of the current demand on the part of Latin American universities and governments to facilitate the continuation of the process that had already been embarked on. The aim of the new Tuning phase in the region was to help build a Higher Education Area in Latin America. This challenge takes the form of four very specific central working themes: a deeper understanding of agreements involving **designing meta-profiles and profiles in the 15 thematic areas** included in the project (Administration, Agronomy, Architecture, Law, Education, Nursing, Physics, Geology, History, Information Technology, Civil Engineering, Mathematics, Medicine, Psychology and Chemistry); contributing to **reflections on future scenarios for new professions**; promoting the joint construction of **methodological strategies in order to develop and assess the training of competences**; and designing **a system of academic reference credits (CLAR-Latin American Reference Credit)** to facilitate recognition of studies in Latin America as a region that can be articulated with systems from other regions.

The Tuning door to the world was Latin America, although this internationalisation of the process wouldn't have gone far if it hadn't been for a group of prestigious academics (230 representatives of Latin American universities), who not only believed in the project, but also used their time and creativity to make it possible from north to south and west to east across the extensive, diverse continent that is Latin America. This was a group of experts in different thematic areas that would go on to study in depth and gain weight in terms of their scope and educational force, and in their commitment to a joint task that history had placed in their hands. Their ideas, experiences and determination paved the way and enabled the results which are embodied in this publication to be achieved.

Yet the Tuning Latin America project was also designed, coordinated and administered by Latin Americans from the region itself, via the committed work carried out by Maida Marty Maleta, Margarethe Macke and Paulina Sierra. This also established a type of *modus operandi*, conduct, appropriation of the idea and of deep respect for how this was going to take shape in the region. When other regions decided to join Tuning, there would henceforth be a local team that would be responsible for considering what to emphasize - specific features, the new elements that would need to be created to meet needs which, even though many of them might have common characteristics within a globalised world, involve dimensions specific to the region, are worthy of major respect and are, in many cases, of major scope and importance.

There is another pillar on this path which should be mentioned: the coordinators of the thematic areas (César Esquetini Cáceres-Coordinator of the Area of Administration; Jovita Antonieta Miranda Barrios-Coordinator of the Area of Agronomy; Samuel Ricardo Vélez González-Coordinator of the Area of Architecture; Loussia Musse Felix-Coordinator of the Area of Law; Ana María Montaño López-Coordinator of the Area of Education; Luz Angélica Muñoz González-Coordinator of the Area of Nursing; Armando Fernández Guillermet-Coordinator of the Area of Physics; Iván Soto-Coordinator of the

Area of Geology; Darío Campos Rodríguez-Coordinator of the Area of History; José Lino Contreras Véliz-Coordinator of the Area of Information Technology; Alba Maritza Guerrero Spínola-Coordinator of the Area of Civil Engineering; María José Arroyo Paniagua-Coordinator of the Area of Mathematics; Christel Hanne-Coordinator of the Area of Medicine; Diego Efrén Rodríguez Cárdenas-Coordinator of the Area of Psychology; and Gustavo Pedraza Aboytes-Coordinator of the Area of Chemistry). These academics, chosen according to the thematic groups to which they belonged, were the driving forces behind the building of bridges and strengthening of links between the project's Management Committee of which they formed a part and their thematic groups which they always held in high regard, respected and felt proud to represent. Likewise, they enabled there to be valuable articulation between the different areas, showing great ability to admire and listen to the specific elements attached to each discipline in order to incorporate, take on board, learn and develop each contribution – the bridges between the dream and the reality. Because they had to carve new paths in many cases to make the ideas possible, design new approaches in the actual language of the area and the considerations proposed, and to ensure that the group would think about them from the standpoint of the specific nature of each discipline. Following group construction, the process always requires a solid framework based on generosity and rigour. In this respect, the coordinators were able to ensure that the project would achieve specific successful results.

Apart from the contribution made by the 15 thematic areas, Tuning Latin America has also been accompanied by a further two transversal groups: the Social Innovation group (coordinated by Aurelio Villa) and the 18 National Tuning Centres. The former created new dimensions that enabled debates to be enriched and an area for future reflection on thematic areas to be opened up. Without doubt, this new area of work will give rise to innovative perspectives to enable those involved to continue thinking about top quality higher education that is connected to the social needs of any given context.

The second transversal group about which one should recognise the major role played comprises the National Tuning Centres – an area of representatives from the highest authorities of university policies from each of the 18 countries in the region. These centres accompanied the project right from the outset, supported and opened up the reality of their national contexts to the needs or possibilities developed by Tuning, understood them, engaged in dialogue with others, disseminated them and constituted reference points when seeking genuine anchors and possible goals. The National Centres have been a contribution from Latin America to the Tuning project, insofar as they have contextualised debates by assuming and adapting the results to local times and needs.

We find ourselves coming to the end of a phase of intense work. The results envisaged over the course of the project have succeeded all expectations. The fruits of this effort and commitment take the form of the reflections on the area of Physics that will be provided below. This process comes to an end in view of the challenge faced in continuing to make our educational structures more dynamic, encouraging mobility and meeting points within Latin America, while at the same time building the bridges required with other regions on the planet.

This is the challenge facing Tuning in Latin America.

July 2013

Pablo Beneitone, Julia González and *Robert Wagenaar*

1

Previous results obtained by the working group in the subject area of Physics

1.1. Backgrounds

The working group in the area of Physics was formed at the First General Meeting of the Tuning Latin America Project held in San José de Costa Rica between 22nd and 24th February 2006. The Group is made up of representatives from Argentina, Bolivia, Brazil, Chile, Colombia, Cuba, Ecuador, Guatemala, Honduras, Mexico, Peru and Venezuela.

The group began its activity with an analysis of the professional profiles and programmes for qualifications in Physics in the participant countries. The analysis showed considerable diversity in the names of programmes and qualifications. The key results of this analysis are summarised in Section 1.2.

The group went on to establish specific competences of the discipline (Section 1.3). The specific competences were finally systemised using a model that distinguishes three main categories and two subcategories (Section 1.4).

1.2. Undergraduate programmes and qualifications in Physics

There are both state and private universities in the region awarding qualifications in Physics. The academic units responsible for these programmes in universities also teach Physics as part of other programmes.

Although the qualifications obtained and the length of the programmes vary from country to country, on the whole, all the programmes are between 4 and 5 years in length and generally allow Physics graduates to opt for some of the following alternatives: a) to continue post-graduate studies; b) to work in fields involving the application of Physics; c) to become involved in teaching in secondary or higher education.

Taking these tendencies into account, the programmes were classified into three categories. Firstly, «traditional education in Physics» was used for the programmes whose aim is to develop a general or traditional Physicist. Secondly, «education in applied Physics» was used for those intended to prepare physicists to apply Physics to areas of science, technology and engineering. Thirdly, «education in educational Physics» was used for those that prepare students to teach Physics at an intermediate level.

Table 1

Types of training programmes in Physics existing in each country. Xa indicates programmes coordinated from other faculties, schools or departments and X[b] indicates programmes coordinated from Physics schools or departments

Country	Traditional Physics	Applied Physics	Educational Physics
Argentina	X	X	X[a]
Bolivia	X		X[a]
Brazil	X	X	X[b]
Chile	X	X	X[b]
Colombia	X	X	X[a]
Cuba	X	X	
Ecuador	X	X	X[a]
Guatemala	X		
Honduras	X		
Mexico	X	X	X[a]
Peru	X	X	
Venezuela	X	X	X[a]

Table 1, taken from Beneitone *et al*., 2007, summarises the situation according to country. The qualifications awarded in traditional Physics are called *Degree in Physics* (Argentina, Bolivia, Chile, Cuba, Guatemala, Honduras, Peru and Venezuela), *Physicist* (Colombia, Ecuador and Mexico) and *Bachelor in Physics* (Brazil).

1.3. Specific competences attached to the physicist in Latin America

The Group then conducted a study of specific competences. Programmes in traditional Physics were the main focus.

Programmes in traditional Physics aim to prepare professionals engaged in activities in society that respond to its demands through scientific research, technological development, participation in productive activity and services, and human resource development at university level. These programmes are designed so that students can pursue post-graduate studies in their field of specialisation - master's degrees and doctorates.

At the General Meeting held in Costa Rica, the Group drew up a list of 22 specific graduate competences for training in traditional Physics (Table 2). The proposal was subjected to a validation process by means of questionnaires aimed at academics, students, graduates and employers in the twelve participant countries. The results obtained are shown in (Beneitone *et al*., 2007).

Taking into account that the questionnaires attached a high degree of importance to the 22 specific competences, the Group decided to adopt them in order to characterise the training which is referred to in Chapter 2 of this publication as «the Latin American physicist».

Table 2
Specific competences for the graduate in traditional Physics («the physicist») in Latin America (Beneitone *et al.*, 2007)

V1 Considering, analysing and solving both theoretical and experimental physical problems by using analytical, experimental or numerical methods.
V2 Using or writing computer programmes or systems for processing information, numerical calculation, physical process simulation or control of experiments.
V3 Building simplified models that describe a complex situation, identifying its essential elements and using the necessary approaches.
V4 Verifying and assessing the adjustment of models to reality, identifying their domain of validity.
V5 Applying theoretical knowledge of Physics when conducting and interpreting experiments.
V6 Showing insight into the basic concepts and principles of both classical Physics and modern Physics.
V7 Describing and explaining natural phenomena and technological processes in terms of concepts, principles and physical theories.
V8 Developing valid arguments in the field of Physics, identifying hypotheses and conclusions.
V9 Synthesising specific solutions, extending them to more general principles, laws or theories.
V10 Perceiving analogies between seemingly different situations by using known solutions to solve new problems.
V11 Estimating the order of magnitude of measureable quantities to interpret different phenomena.
V12 Demonstrating experimental skills and the use of appropriate working methods in the laboratory.
V13 Participating in professional activities relating to top-level technologies, in both the laboratory and industry.
V14 Participating in the consultancy and preparation of proposals in science and technology with regard to nationwide issues that may have an economic or social impact.
V15 Acting with professional responsibility and ethics, showing social awareness of solidarity, justice and respect for the environment.
V16 Demonstrating the working habits required to develop the profession, such as teamwork, scientific rigour, self-learning and persistence.
V17 Searching for, interpreting and using scientific information.
V18 Communicating scientific concepts and results orally or in writing to their peers, and in teaching and disseminatory situations.
V19 Participating in the preparation and development of interdisciplinary projects or research projects into Physics.
V20 Showing willingness to take on new challenges in other fields by using their specific skills and expertise.
V21 Knowing and understanding the conceptual development of Physics in historical and epistemological terms.
V22 Knowing the relevant aspects of the teaching-learning process of Physics, showing willingness to collaborate in the training of scientists.

1.4. Systemisation of specific competences

Having completed the competence validation process, the possibility was explored of distributing them into a small group of non-exclusive categories, since all the identified competences are interdependent and their fulfilment involves an essential interrelationship for sound professional practices. The 22 specific competences were finally systemised by using a framework involving three main categories and two subcategories, as follows:

1. Cognitive competences: the competences characterising the graduate's disciplinary knowledge underlying the systemic competences.

2. Methodological competences: the competences characterising «Physics know-how», both theoretically and experimentally. These, in turn, could be distributed into two subcategories:

   - Instrumental competences: the competences that can be identified as a set of abilities and skills in the use of procedures applicable to scientific activity.
   - Systemic competences: the competences involving the interaction of cognitive elements and procedures, with high levels of complexity.

3. Labour and social competences: the competences integrating methodological competences and general competences apparent in professional conduct, interaction with the contexts in which the intervention is being performed, and under the influence of personal and community values.

Table 3 shows the distribution of the specific competences for the «Latin American physicist» into the above-mentioned categories.

Table 3
Systemisation of the specific competences for the graduate in Physics in Latin America (Beneitone *et al.,* 2007)

Category		Competences incorporated into the category
Cognitive competences		V6 Showing insight into the basic concepts and principles of both classical Physics and modern Physics. V7 Describing and explaining natural phenomena and technological processes in terms of concepts, principles and physical theories. V17. Searching for, interpreting and using scientific information. Knowing and understanding the conceptual development of Physics in historical and epistemological terms. V21 Knowing the relevant aspects of the teaching-learning process of Physics, showing willingness to collaborate in the training of scientists.
Methodological Competences	Systemic competences	V01. Considering, analysing and solving both theoretical and experimental physics problems by using analytical, experimental or numerical methods. Building simplified models that describe a complex situation, identifying its essential elements and using the necessary approaches. V3 Verifying and assessing the adjustment of models to reality, identifying their domain of validity. V4 Applying theoretical knowledge of Physics when conducting and interpreting experiments. V8 Developing valid arguments in the field of Physics, identifying hypotheses and conclusions. V9 Synthesising specific solutions, extending them to more general principles, laws or theories. V10 Perceiving analogies between seemingly different situations by using known solutions to solve new problems. V11 Estimating the order of magnitude of measureable quantities to interpret different phenomena.
	Instrumental competences	V02. Using or writing computer programmes or systems for processing information, numerical calculation, physical process simulation or experiment control. V12. Demonstrating experimental skills and the use of appropriate working methods in the laboratory.
Labour and social competences		V13. Participating in professional activities relating to top-level technologies, in both the laboratory and in industry. V14. Participating in the consultancy and preparation of proposals in science and technology with regard to nationwide issues that may have an economic or social impact. V15. Acting with professional responsibility and ethics, showing social awareness of solidarity, justice and respect for the environment. V16. Demonstrating the necessary working habits to develop the profession, such as teamwork, scientific rigour, self-learning and persistence. Communicating scientific concepts and results orally or in writing to their peers, and in teaching and disseminatory situations. V18 Participating in the preparation and development of interdisciplinary projects or research projects into Physics. V19 Showing willingness to take on new challenges in other fields by using their specific skills and expertise.

2

Formulating the meta-profile for the Latin American physicist

2.1. Basic principles

At the First General Meeting of the Tuning Latin America Project; Education and Social Innovation (hereafter, «Tuning-LA»), held in Bogota, Colombia between 18th and 20th May 2011, the Physics Group began to prepare the qualification meta-profile for the area. A working methodology based on the following premises and decisions was adopted for this purpose.

Firstly, the meta-profile was understood as being a graduate profile common to all Physics graduates in Latin America. In keeping with the work carried out in the 2004-2007 phase of the Tuning-LA Project (Beneitone et al., 2007), the Group concentrated on traditional Physics, i.e. the type of programme which prepares what is usually referred to as «a physicist».

Secondly, the 27 generic competences corresponding to all university qualifications and the 22 competences specific to the subject area of Physics proposed and validated in the 2004-2007 phase of the Tuning-LA Project (Beneitone et al., 2007) were used as a starting point. As stated in Chapter 1 of this publication, these specific competences were grouped into three main categories and two subcategories, as follows:

1. Cognitive competences: the competences characterising «Physics know-how».

2. Methodological Competences: the competences characterising both theoretical and experimental «Physics know-how». These, in turn, are distributed into two subcategories:

   - Instrumental competences.
   - Systemic competences.

3. Labour and social competences: the competences characterising «knowing how to act as a physicist».

The categories of importance («A», «B», «C» y «D») previously used by the Group when analysing the questionnaires on specific competences were also used.

Thirdly, the interrelationships between the generic and specific competences for Physics were studied and the coincidences between them identified (Section 2.2).

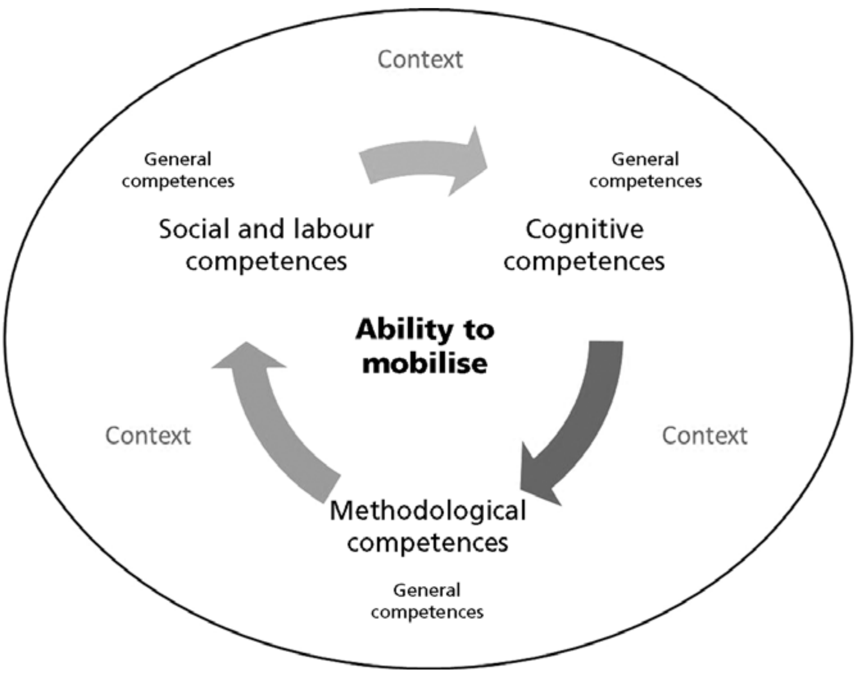

Figure 1
Basic conceptual principles of the meta-profile for physicists in Latin America

Fourth, a conceptual framework was developed for the meta-profile for Physicists focusing on the ability to mobilise the generic competences and the competences specific to Physics previously identified as being most important in the conceptual, methodological and labour and social domains of professional performance within a given context, and when faced with a specific problem-situation. Fig. 1 outlines the conceptual relationships between the generic competences and specific competences that form the basis of the meta-profile developed.

Lastly, degree programmes at a range of universities in Latin America were analysed in order to identify the generic and specific competences involved, and this result was compared with the competences chosen when formulating the meta-profile (Section 2.4).

2.2. Study of the inter-relations between generic and specific competences

In order to study the interrelationship between the specific and generic competences, a comparative matrix was developed involving the 27 generic competences and 22 validated specific competences, and the coincidences between them determined (Fig. 2). The last column («F») of this matrix shows the total coincidence for each generic competence (specific). The initials «C», «SM», «IM» and «LS» show the cognitive competences, systemic methodological, instrumental methodological, and labour and social, respectively. «A», «B», «C» and «D» are the categories of importance (from greater to lesser) previously used by the Physics group to classify the specific competences (Beneitone et al., 2007).

First of all, the use of a comparative matrix revealed three generic competences which most coincided with the specific competences:

[2] Ability to apply knowledge in practice.
[4] Knowledge of the area of study and profession.
[15] Ability to identify, consider and deal with problems.

These 3 generic competences were considered as being among the most important in the surveys conducted within the framework of Tuning-LA (Beneitone et al., 2007).

General																							F
27																							**0**
26															X								**1**
25												X		X									**2**
24																X							**1**
23													X										**2**
22															X	X							**2**
21															X						X		**2**
20															X								**1**
19																X						X	**2**
18																						X	**1**
17																X						X	**2**
16																			X			X	**2**
15	X								X	X													**3**
14			X																				**1**
13																				X			**1**
12																X							**1**
11																	X						**1**
10																X						X	**2**
9																			X				**1**
8																							**1**
7																		X					**1**
6																		X					**1**
5															X							X	**2**
4			X	X	X	X	X	X	X	X											X		**9**
3												X							X				**2**
2			X	X	X	X	X	X	X	X	X	X	X										**11**
1	X																						**1**
Specific	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	**F**
Classification	A	B	A	B	A	A	B	C	C	C	C	C	C	D	A	A	B	B	B	C	D	D	
Classification	SM	IM	SM	SM	SM	C	C	SM	SM	SM	SM	IM	LS	LS	LS	LS	C	LS	LS	LS	C	C	
F	**2**	**1**	**3**	**2**	**2**	**2**	**2**	**2**	**3**	**3**	**1**	**3**	**2**	**1**	**5**	**6**	**1**	**2**	**4**	**1**	**2**	**6**	

Figure 2
Coincidence between the generic and specific competences for Physics

Secondly, by means of the comparative matrix, the most important specific competences were identified (namely, those belonging to level

«A») in each of the categories and subcategories used («C», «MS», «MI» y «LS») which most coincide with the generic competences. Table 1 shows the result.

Table 1
Coincidence between the Tuning-LA generic competences and the most important specific competences (category «A») for degree programmes in Physics

Category	Most important specific competences	Related generic competences
Cognitive	Showing insight into the basic concepts and principles of both classical physics and modern physics [V06].	[2], [4]
Methodological	Considering, analysing and dealing with both theoretical and experimental physical problems by using analytical, experimental or numerical methods [V01].	[1], [15]
	Building simplified models describing a complex situation, identifying its essential elements and using the approaches required [V03].	[2], [4], [14]
	Applying theoretical knowledge of Physics when conducting and interpreting experiments [V05].	[2], [4]
Labour and Social	Acting with professional responsibility and ethics, showing social awareness of solidarity, justice and respect for the environment [V15].	[5], [20], [21], [22], [26]
	Demonstrating the necessary working habits to develop the profession, such as teamwork, scientific rigour, self-learning and persistence [V16].	[10], [12], [17], [19], [22], [24]

2.3. Formulating the meta-profile for the Latin American physicist

Taking into account the conceptual outline shown in Fig. 1 and the most important coincidences between the generic and specific competences (Fig. 2 and Table I), the following formulation of the graduate meta-profile in Physics in Latin America was developed:

> Latin American physicists are professionals who combine insight into the basic concepts and principles of Physics and the ability to apply them practically to natural phenomena and technological processes. They possess the abilities and skills to consider, analyse and deal with both theoretical and experimental problems by using analytical, experimental or numerical methods, and build models describing a complex situation, identifying its essential elements and using the approaches required. In their social and work performance, they act with creativity, responsibility, professional ethics and scientific rigour, showing solidarity, respect towards the environment and the capacity for self-learning and teamwork in their disciplinary and multidisciplinary environments. Their conceptual and methodological preparation, in addition to the interpersonal skills acquired, enables them to operate in a variety of working contexts such as scientific research and technological development, teaching, technical advice, scientific-technical services, and science outreach and communication. It will also enable them to participate in the search for solutions to problems of regional importance in areas of economic and social impact, such as health, energy, natural resources, education, climate and the environment.

2.4. Comparing the proposal for the meta-profile

In order to check the meta-profile, the Physics Group adopted the following work methodology. Each national representative reviewed programmes in their countries so as to identify the (explicit or implicit) presence of the 22 specific competences and 27 generic competences that form the basis of the proposal, and produced an overview report with the following information: University or Universities, Degree(s) and Graduate Qualifications, Degree Objectives, Graduate Profile (aspects covering identity, functions to be fulfilled and the graduate's operational scope).

The competences involved in each degree course were also specified in the reports. The information gathered, some of which is shown in Annex I of this publication, was analysed as follows.

First of all, the specific competences identified in each country were tabulated and the coincidences between countries quantified, taking the number of these coincidences as a measurement of each specific competence's «representativeness» in the preparation of physicists in Latin America.

Similarly, the generic competences relating to each country's specific competences were tabulated and the coincidences found quantified, taking the number of these coincidences as a measurement of each generic competence's «representativeness».

And lastly, the «representativeness» of each specific and generic competence was compared with its «degree of importance» according to the surveys conducted in the 2004-2007 phase of Tuning-LA.

Fig. 3 compares the «representativeness» the specific competences (in descending order) with the degree of importance determined for each one in the Tuning-LA surveys. This figure shows that, overall, there is a reasonable correlation between the degree of importance of the specific competences and the «representativeness» measurement established in this study. In particular, 4 of the 6 most important specific competences used to formulate the meta-profile (i.e. the cognitive competence [V06] and methodological competences [V01], [V03] and [V05]) are in the top positions of «representativeness».

Fig. 3 also shows that there are some discrepancies between importance and «representativeness». In particular, the «representativeness» of labour and social competences [V15] and [V16] fails to tally with their perceived importance.

Fig. 4 shows the Tuning-LA generic competences in descending order of «representativeness». This figure suggests that there is also a reasonable correlation between the degree of importance (determined by the Tuning-LA surveys) and «representativeness» established in this study for the generic competences. In particular, competences [02], [04]

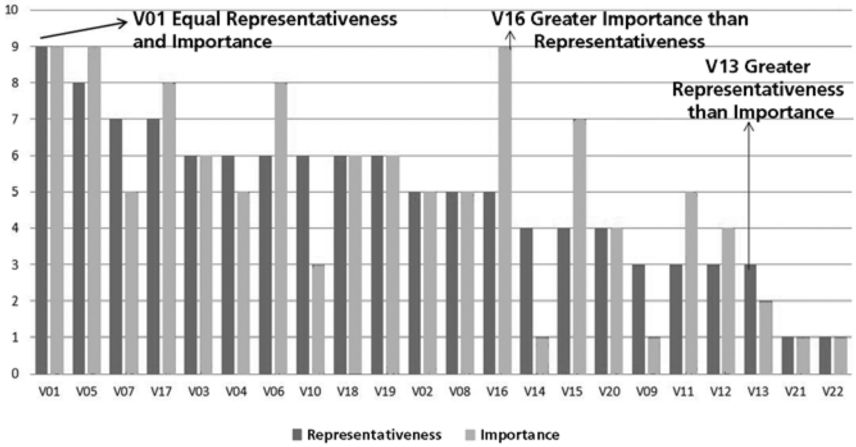

Figure 3
Comparison of the «representativeness» and degree of importance of the specific competences determined by the Tuning-LA surveys in descending order of «representativeness»

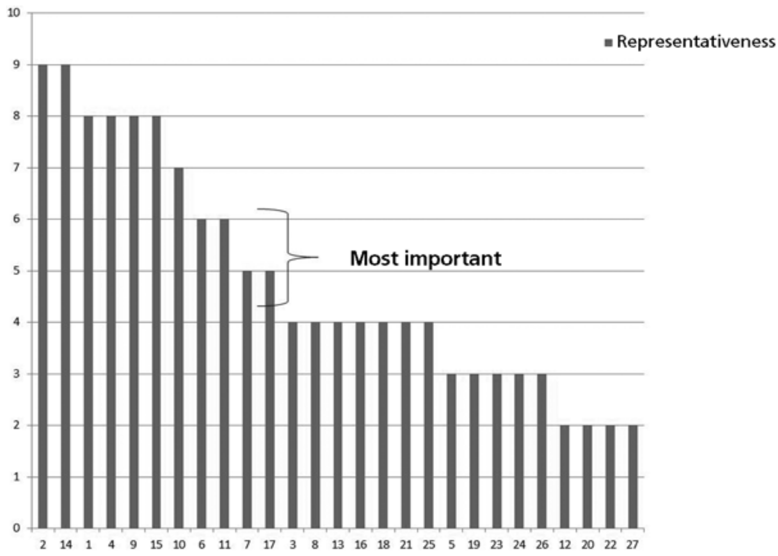

Fig. 4
The Tuning-LA generic competences in descending order of «representativeness»

and [15], which are among the most important in the Tuning-LA surveys (Beneitone et al., 2007), appear in the top positions of «representativeness» in the programmes analysed.

This result is consistent with the fact that these generic competences most correlate with the specific competences for Physics according to the comparative matrix (Fig. 1). Other generic competences ranking in the top positions of «representativeness», in particular [01], [09], and [15] and [10], also rank at the top of the degree of importance lists stemming from the Tuning-LA surveys (Beneitone et al., 2007).

2.5. Summary and conclusions

The purpose of this chapter has been to describe the development of the professional meta-profile for Latin American physicists, this being understood as the graduate profile common to Physics graduates in Latin America.

In accordance with the work carried out in the 2004-2007 phase of Tuning-LA, the Working Group concentrated on the education of what is traditionally called «a physicist».

This meta-profile is based on the specific competences for Physics graduates that were considered most important in the surveys conducted within the framework of the Tuning-LA Project, and the generic competences displaying the most coincidences with the specific competences.

The meta-profile put forward by the Group was compared with the specific and generic competences explicitly or implicitly involved in the programmes of different Physics degrees in Latin America. An analysis was conducted according to the degree programme and country and then coincidences were determined between countries, which were taken as a measurement of the «representativeness» of each competence in the area analysed. Comparisons were finally made of the degree of importance determined by the Tuning-LA surveys for the specific and generic competences involved and the respective measurements of their «representativeness». The results obtained show that there is a reasonable correlation between importance and «representativeness». It is also found that the specific and generic competences occupying the top positions of «representativeness» belong to those considered most important in the above-mentioned surveys.

It can therefore be concluded that the educational objectives of the programmes for Physics analysed in this work are compatible with the graduate profile (or meta-profile) for Latin American physicists this work puts forward.

3

Future Scenarios

3.1. Description of the study carried out

At the Third General Meeting of the Project, held in Santiago de Chile between 2nd and 4th May 2012, the Physics Group addressed the study of future scenarios for professions. A procedure based on conducting in-depth interviews was adopted, using the questionnaires agreed at the General Meeting.

In order to fulfil the proposed objectives, prominent academics working in teaching or research or who hold or have held positions of responsibility in academic management were interviewed.

Attempts were made to keep a balance of respondents between professionals at the beginning of their career and those who have gained greater experience and recognition.

The interviewees' areas of work were extremely diverse, covering, among other fields: astrophysics, condensed matter, high energy, optics, medical imaging technology, statistical physics, complex systems, electronics, medical physics, earth sciences and biophysics.

Table 1 summarises information about the interviewees according to country. The specific subject matter on each interview conducted by each representative is shown in Annex II of this publication. The conclusions of the study are summarised below.

Table 1
Interviewees according to the country and specific subject matter concerning each interview shown in Annex II

<table>
<tr><th rowspan="2">Country</th><th rowspan="2">Interviewee details</th><th colspan="2">Subject matter incorporated into Annex II</th></tr>
<tr><th>Full interview</th><th>Analysis and summary</th></tr>
<tr><td rowspan="4">Brazil</td><td>Dr Eduardo de Campos Valadares</td><td>X</td><td rowspan="4"></td></tr>
<tr><td>Dr Cláudio Lenz Cesar</td><td>X</td></tr>
<tr><td>Dr Hans Jürgen Herrmann</td><td>X</td></tr>
<tr><td>Dr Vanderlei Salvador Bagnato</td><td>X</td></tr>
<tr><td rowspan="2">Colombia</td><td>Prof. Rubén Antonio Vargas Zapata</td><td>X</td><td rowspan="2">X</td></tr>
<tr><td>Prof. Germán Antonio Pérez Alcázar</td><td>X</td></tr>
<tr><td rowspan="3">Cuba</td><td>Professor and Head of the Department of Theoretical Physics, Faculty of Physics, Universidad de La Habana.</td><td>X</td><td rowspan="3">X</td></tr>
<tr><td>Professor at the Faculty of Physics, Universidad de La Habana.</td><td>X</td></tr>
<tr><td>Senior Research Fellow at the Genetic Engineering and Biotechnology Centre, Professor at the Universidad de La Habana.</td><td>X</td></tr>
<tr><td rowspan="2">Ecuador</td><td>Dr Jenny Orbe</td><td>X</td><td rowspan="2">X</td></tr>
<tr><td>Dr Dennis Cazar</td><td>X</td></tr>
<tr><td rowspan="3">Guatemala</td><td>Dr Eduardo Rubio</td><td>X</td><td rowspan="3"></td></tr>
<tr><td>Mr Carlos Esquit (Engineer)</td><td>X</td></tr>
<tr><td>Mr Carlos Rolz (Engineer)</td><td>X</td></tr>
<tr><td rowspan="2">Honduras</td><td>Prof. Edwin Romell Galo Roldán</td><td>X</td><td rowspan="2">X</td></tr>
<tr><td>Prof. Carlos Alberto Tenorio Moncada</td><td>X</td></tr>
<tr><td>Mexico</td><td>Dr Alejandro Ayala Mercado</td><td>X</td><td></td></tr>
<tr><td>Venezuela</td><td>Prof. Gustavo Gutiérrez</td><td>X</td><td></td></tr>
</table>

3.2. Conclusions

According to the views expressed in the interviews, the future scenarios display the following characteristics:

a) High interconnection and complexity.

b) Ubiquity of information technologies.

c) Energy crisis.

d) Water and food shortage.

e) Environmental degradation and likelihood of natural disasters.

f) Social and economic rise of Latin America in the world.

g) Increasing life expectancy.

h) Heavy demands on the education and health systems.

An increase in the importance of interdisciplinary professions relating to Physics is envisaged in these scenarios, in particular: Biophysics, Medical Physics, Econophysics, Engineering Physics, Earth Sciences, Materials Science, and Physics of the Environment and Natural Resources.

Lastly, and with regard to the competences needed to undertake these professions in the scenarios put forward, it is worth mentioning the following:

a) Flexible, interdisciplinary education.

b) Training in teaching and dissemination.

c) Communicative ability.

d) Global vision of processes.

e) Broad cultural education.

f) Human and social commitment.

g) Motivation to be scientifically creative.

h) Ability to consider and solve complex problems.

i) Ability to address and offer solutions to regional issues.

j) Capacity for self-learning.

k) Capacity for research and development.

l) Capacity for teamwork.

m) Commitment to conservation of the environment.

4

Teaching, learning and assessment strategies for competences

4.1. Description of the study carried out

At the Third General Meeting of the Tuning-LA Project held in Santiago de Chile between 2nd and 4th May 2012, the Physics Group began the study of the teaching, learning and assessment strategies for competences in the subject area. A working methodology based on the following premises and decisions was used for such purpose.

First of all, the Group decided to concentrate on the generic competences [01] and [15] and the specific competence [V01] for Physics, which are described as follows:

[01] Capacity for abstraction, analysis and synthesis.
[15] Ability to identify, address and deal with problems.
[V01] Considering, analysing and solving both theoretical and experimental problems in physics by using numerical, analytical or experimental methods.

Secondly, each Group member selected two or three subjects from the curriculum of a degree programme at their University. The chosen subjects were classified, according to their position in the curriculum, into basic, intermediate and advanced.

Thirdly, taking into account that the three competences are closely related in Physics degree courses, it was agreed that a distinction should be made between three levels of development for each one: high, medium or low. In order to do so, the proposed learning results for the subject, conceptual difficulty, level of numerical, analytical or experimental methods used and amount of student working time devoted to attaining the competence were taken into account.

Lastly, the learning results and teaching and assessment strategies were identified for each subject. The information obtained, shown in Annex III of this publication, was analysed so as to determine the overall characteristics of the teaching, learning and assessment strategies applied to Physics degree courses in Latin America. The conclusions of the study are detailed below.

4.2. Conclusions

4.2.1. *Regarding teaching and learning strategies*

Firstly, it should be noted that the relevance of the chosen competences turn them into indicators of the way Physics is taught at our universities.

The information obtained indicates that although traditional methods persist - in particular, master classes being dictated and problems raised and solved by lecturers - there are significant attempts to shift towards methods that focus on student activity. Among such methodologies, there is student-centred problem solving, which can be regarded as a Physicist's main teaching and learning method. It can also be seen that the use of new information and communications technologies plays an important role in improving teaching and learning strategies in Physics.

4.2.2. *Regarding assessment strategies*

The information analysed also indicates that the assessment activities and players involved in educating physicists have diversified, in particular, the use of seminars for analysis and discussion, written reports, forums for discussion, computer simulations, demonstrations and small research projects, all of which are carried out periodically and continuously.

The underlying idea behind this diversification is that assessment is also a learning experience.

4.3. Perspectives and challenges

Improving competence oriented teaching, learning and assessment poses several challenges for educational establishments and teaching staff. In particular, institutional support and the implementation of measures are needed that encourage attitudes towards innovation on the part of lecturers. First of all, it is vitally important for teaching staff to know their students and the structure of their community.

Lastly, with regard to teaching methodology, the key challenges are to: a) design and establish new learning environments where students can develop activities in order to encourage attitudes that are conducive to learning and contribute to competence development; b) apply continuous and periodic forms of assessment; and, c) use new information and communications technologies appropriately.

4.4. References

BENEITONE *et al.* (2007): «Reflections and perspectives on Higher Education in Latin America». Pablo BENEITONE, César ESQUETINI, Julia GONZÁLEZ, Maida MARTY MALETÁ, Gabriela SIUFI and Robert WAGENAAR, Editors. University of Deusto Publications, Bilbao, 2007.

5

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Annex I

Physics graduate profiles in different Latin American universities

Country University	Graduate profile	
	Qualification and aspects giving the degree identity	**Degree objectives:** **«*to train a professional able to...*»** **+** **Identified competences**
ARGENTINA UBA	Qualification: Graduate in Physical Sciences Graduates in Physical Sciences are professionals qualified to intervene scientifically in all affairs relating to matter and its changes.	Acquiring scientific knowledge of matter, its modifications and behaviours. General: 1, 2, 4, 9, 11, 14, 15 Specific: (V01); (V03); (V04), (V05) Predicting the properties of matter qualitatively and/or quantitatively from general theories and experimental laws. General: 1, 4, 9, 14, 15 Specific: (V01); (V03); (V04) Using acquired knowledge to find solutions to specific problems. General: 2, 15 Specific: (V01); (V03); (V04); (V07); (V10); (V17) Understanding the constant need for perfection and thematic updating. General: 10
BOLIVIA UMSA UATF UMSS	Qualifications: Physicist or Graduate in Physics Physicists are scientific professionals with sound knowledge in the area of their speciality. Owing to the thoroughness of their academic, theoretical and practical training, they have the intellectual versatility to solve a range of problems, and even venture into areas of different specialities. Physicists are scientific researchers who are able to internalise new knowledge in the different areas of science and technology and contribute to expanding such knowledge in a critical, ethical and serious way.	Acquiring knowledge of physical phenomena, the theories and laws governing them and models explaining them. General: 1, 2, 4, 9,11, 14, 15 Specific: (V01); (V03); (V04), (V05) Acquiring a thorough understanding of nature of physics research and the ways in which it is carried out, and how physics research is applicable to many other fields; the ability to design experimental and/or theoretical procedures to solve common problems in academic or industrial research and improve existing results (basic and applied research skills). General: 1, 4, 9, 14, 15 Specific: (V01); (V03); (V04) Applying acquired scientific knowledge explicitly to solving problems of particular interest. General: 2, 15 Specific: (V01); (V03); (V04); (V07); (V10); (V17)

Graduate profile	
Qualification functions and scope **+** **Identified competences**	**Field of employment** **+** **Identified competences**
Carrying out studies and research concerning the properties of bodies, their make-up, the interactions forming them, their modifications, and the methods and techniques to measure, use and produce them. Designing, building, testing and modifying components, instruments and systems designed to measure the properties of bodies, their make-up, the interactions forming them, their modifications in state, and the radiations produced in such modifications. Designing, producing, codifying and modifying models of the properties of physical systems. Organising, leading, carrying out and assessing activities taking place in the area of laboratories, factories or companies where tests, trials, analyses and measurements regarding the properties of bodies and their make-up are carried out. Determining the equipment requirements and operational conditions, and specifying the required health and safety conditions. Consultancy services for third parties. Determining the metrological standards to measure the properties of bodies, their make-up, the interactions forming them, their modifications in state, and the radiations produced in such modifications. Carrying out arbitration work and technical surveys in their field of expertise.	Graduates in Physical Sciences can pursue their profession in both the public and private sectors. Teaching is prominent at university level, as it is in secondary education. Research is mainly carried out in faculties and science institutes nationwide and, to lesser extent, in private industry.
Graduates in Physics are professionals qualified, through appropriate curricular training, to perform the following main functions in their productive process: Basic and applied scientific research. University teaching. Scientific consultancy and advisory services in areas of the application of Physics. Technological adaptation towards unforeseen applications by interpreting phenomena or solving problems relating to their field and related fields.	Professional physicists have the expertise, skills and abilities to join the productive world. They can carry out their activities in different types of institutions: Science and technology research institutions. Institutions devoted to alternative energies, such as non-governmental organisations, agricultural and municipal agencies, prefectures and specialised laboratories. Medical institutions such as hospitals, health centres with specialised radiology and nuclear magnetic resonance equipment, and so on. Higher and secondary education establishments via the provision of services.

Country University	Graduate profile	
	Qualification and aspects giving the degree identity	**Degree objectives:** **«*to train a professional able to...*»** **+** **Identified competences**
BRAZIL Univ. Federal do Paraná-UFPR Curitiba-Paraná Região Sul do Brasil	Physicist	4.5 years
Centro Universitário Franciscano-UNIFRA Sul do Brasil	Physicist qualified in Medical Physics	4.5 years, with 3,264 working hours
Universidade Estadual de Campinas-UNICAMP Campinas-São Paulo (Região sudeste)	Four qualifications: BSc in Physics; BSc in Applied Physics; BSc in Biomedical Physics; BSc in Medical Physics	BSc in Physics 4 years (3,255 h) BSc in Applied Physics: 4 years (3,780 h) BSc in Biomedical Physics: 4 years (3,495 h) BSc in Medical Physics: 4 years (4,245 h)
Universidade Federal do Ceará-UFC Fortaleza-Ceará Rigião Nordeste	BSc in Physics	4 years (3,008 h) The UFC does not work with credit system.
Universidade Federal do Rio Grande do Norte-UFRN Natal-Rio Grande do Norte Região Nordeste	BSc in Physics	4 years (2,400 h = 160 credits)
CHILE UFRO	Qualification: Graduate in Applied Physics Graduates in Applied Physics have a broad view of physics, and are qualified to work in institutions and companies in the area of health, education, the environment, geophysics services and industrial applications. They can also participate in teaching and research at universities.	Acquiring and integrating knowledge of physics and mathematics, and developing critical reasoning and creativity capabilities. General: 1, 2, 4, 15 Specific: (V06), (V01) Developing innovative solutions that are appropriate and suited to the needs, problems and requirements of the area covered b y the discipline. General: 1, 2, 4, 14, 15 Specific: (V01), (V03) Developing the capacity for self-learning, enabling participation in applied research projects. General: 2, 4, Specific: (V05) Pursuing post-graduate studies in Physics or areas related to the discipline. General: 2, 4. Specific: (V06)

Graduate profile	
Qualification functions and scope + Identified competences	**Field of employment + Identified competences**
Offer training, both comprehensive and flexible, to develop the skills and knowledge required to meet current expectations and the capacity to adapt to different prospective actions in the future.	Cognitive: V06. V07, V17, V21 Systemic: V01, V04, Occupational & Social: V15, V18 Instrumental: V02, V12
Train physics graduates who are responsible and competent individuals committed to the social context and suited to professional practice in the diagnosis and treatment of illnesses involving basic knowledge of physics and its application in this field.	Cognitive: V06, V07, V22 Systemic: V01, V10 Occupational & Social: V19, V20
	Systemic: V01 Occupational & Social: V14, V18, V19, V20
Train professionals to work in Physics research and teaching at graduate level.	Cognitive: V06, V07, V21 Systemic: V01, V03 Instrumental: V02, V12 Occupational & Social: V15, V18
Provide training for students with emphasis on the specific areas of mathematics, computing and fundamental theoretical physics and integrate the student as quickly as possible into an area of post-graduate research, encouraging more career-focussed teaching.	Cognitive: V06, V21, V22 Systemic: V04, V05, Instrumental: V02, V12 Occupational & Social: V15, V18
Participating in research and development projects at universities and public and private institutions. Physics teaching. Forming part of consultancy teams for businesses and industries involved in Physics-based productive processes. Pursuing post-graduate studies in Physics.	Universities and public and private institutions. Businesses devoted to the sale of scientific equipment or Physics laboratory support services. Physics teaching. Consultancy for businesses and industries involved in productive processes.

Country University	Graduate profile	
	Qualification and aspects giving the degree identity	Degree objectives: «*to train a professional able to...*» + Identified competences
COLOMBIA UPTC	Qualification: Physicist The Physics syllabus, through the consolidation of its academic community, fully trains students to access universal knowledge, with the basic principles of the theories and overall expertise of Physics disciplines, enabling professionals to address different issues with an innovative and critical attitude in order to foster science and technology research development of national and international impact and regional identity, and with a broad sense of humanism and service to the community.	Training competent internationally recognised professionals in Physics as the basis for the scientific, technological and social development of the region and country. General: 1, 2, 21, 23 Specific: (V14), (V15) Training physicists capable of laying the theoretical and experimental foundations needed to put forward, create and develop research and technological application projects. General: 1, 2, 9, 14, 25 Specific: (V01); (V05); (V17), (V19) Training Physics professionals to be able to access academic processes that contribute to their training and equip them according to the needs and possibilities of new labour markets. General: 10 Contributing to the dissemination and socialisation of scientific knowledge and advances in Physics. General: 6 Specific: (V18)
CUBA U La Habana U Las Villas U Oriente	Qualification: Graduate in Physics Training wide-profile physicists to work in universities, research, production and service provision centres, with solid scientific and professional training, and qualified in scientific work, the use of technology and multidisciplinary work through basic and/or applied research, as well as scientific-technical services. Their comprehensive training allows them to develop fully as human beings so that they can contribute efficiently to the sustainable development and progress of our nation and humanity.	Instilling in future professionals a scientific conception of the world based on dialectic materialism and rigorous, high-quality scientific study of physical phenomena and the laws governing them. General: 4 Specific: (V06) Fostering love for Physics, work, study, research and scientific, technical and cultural self-training in future professionals; in addition to the rigour, creativity, modesty, scientific honesty, dedication, spirit of sacrifice and collectivism needed to perform their professional activity. General: 14, 17, 18, 26 Specific: (V15); (V16)

<table>
<tr><th colspan="2">Graduate profile</th></tr>
<tr><th>Qualification functions and scope
+
Identified competences</th><th>Field of employment
+
Identified competences</th></tr>
<tr><td>The aim is comprehensive professional training with sound knowledge of theoretical and experimental Physics geared towards applications encouraging scientific and technological development.
General: 2

Future professionals will acquire skills designed for the use of research methods, data processing and interdisciplinary work, with a sense of ethics and broad general knowledge, which will enable them to interpret the socio-economic reality of the environment appropriately, so that they can contribute to solving problems regarding the environment in which they are to operate as professionals.
General: 1, 2, 21, 23
Specific: (V14), (V15)

Identifying, tackling and proposing solutions to problems concerning their social and natural environment using their scientific knowledge.
General: 2, 15
Specific: (V20)

Producing, adapting and disseminating scientific knowledge at all levels.
General: 2
Specific: (V18)

Participating and leading academic research processes with high social and scientific impact at a disciplinary and interdisciplinary level.
General: 5, 25
Specific: (V14), (V19)</td><td>Designing and adapting technologies in order to deal with problems relating to their discipline.
General: 8, 14
Specific: (V02)

Proposing, coordinating, advising on, developing and innovating physical applications processes in industry.

Participating in interdisciplinary research groups.

Collaborating with institutions and industry in the conservation of the environment.
General: 20</td></tr>
<tr><td>Taking part in basic or applied, theoretical or experimental research projects and the development of Physics problems, in interdisciplinary areas or areas concerning the application of Physics and its methods.

Participating in Physics teaching in Higher Education.

Participating in the provision of scientific-technical services relating to the application of physical methods of analysis, assessment and diagnosis.

Taking part in quality control inspections, studies of technological processes and the introduction of new technologies, equipment construction and measuring systems, and the development of software for problems relating to Physics, technology, its methods and applications.</td><td>Production areas in a wide range of industries (electronics, mining, metallurgy, building, etc.), where physicists have demonstrated the fruitful work they perform in areas of development, quality control and technology.

Research and service areas in the field of health, forming part of multidisciplinary teams dealing with biomedicine, biophysics, medical instrumentation and so on.

University teaching.

Areas of research and scientific-technical services and technological innovation related to meteorology, geophysics, electronics and computing, communications, equipment construction, mining, metallurgy and so on.

Other spheres of research, production and services.</td></tr>
</table>

Country University	Graduate profile	
	Qualification and aspects giving the degree identity	Degree objectives: «*to train a professional able to...*» + Identified competences
CUBA (continued)		Raising economic awareness in students and, in particular, the role of Physics in our society, in accordance with the scientific policy of the Cuban State and the need to link their scientific work to the line of economic and social development prioritised by the State. General: 2, 21 Specific: none Contributing to the comprehensive training of future professionals, and inwardly developing a suitable understanding of what sustainable development is, as well as sensitivity, skills and interest in different forms of physical, artistic, literary and scientific-technical culture, encouraging participation in sporting and artistic activities and other related cultural activities. Moreover, training physicists to know how to popularise and publicise their science within the framework of our society. General: 5, 6, 18 Specific: (V18) Linking students' overall aesthetic training to the development of appropriate language usage and scientific terminology, accuracy of oral and written expression, rejection of all shows of shoddiness, inaccuracy or lack of workmanship, but also the ability to appreciate the beauty of Physics and its working methods. Teaching and developing the ethical values embedded in a science degree, and which characterise future science graduates and professionals. General: 26, 27 Specific: none Analysing the scientific bibliography in Spanish and English for a specific assignment and drawing a distinction between the aspects already solved, methods used, problems pending solution and possible ways of tackling them. General: 7, 10, 11 Specific: (V17) Designing, calculating, building, adjusting, calibrating and fine-tuning equipment and systems to measure and record physical parameters under controlled conditions. General: none Specific: (V01); (V11); (V12);(V13) Processing and systemising data from experiments and productive experiences, and formulating the corresponding empirical regularities. General: none Specific: (V05)

Graduate profile	
Qualification functions and scope + Identified competences	Field of employment + Identified competences

Country University	Graduate profile	
	Qualification and aspects giving the degree identity	Degree objectives: «*to train a professional able to...*» + Identified competences
CUBA (continued)		Interpreting and explaining experimental results on the basis of models and physical laws. General: 8, 9 Specific: (V04); (V05) Carrying out theoretical studies of real systems by formulating physical models, calculation of the values characterising them, analysis of the theoretical and experimental results, and the formulation of the laws governing them. Developing the mathematical and theoretical methods of the systems being studied. General: 15 Specific: (V01); (V02); (V03); (V07); (V08) Producing algorithms and computer programmes for data processing, numerical calculation, the assimilation of physical processes and control of experiments. General: 8 Specific: (V02) Presenting the results, conclusions and recommendations of their scientific-technical and diploma work through reports, scientific articles and oral presentations. General: none Specific: (V18) Encouraging university extension activities as part of the students' teaching practice and as a public exercise of their activity for lecturers. General: none Specific: (V14); V15) Participating with other specialists in order to introduce and make recommendations on the scientific–technical achievements of research results in production, services and social practice, and ensuring their legal protection. General: 2, 17 Specific: (V13); (V14); (V16); (V19)

Graduate profile	
Qualification functions and scope + **Identified competences**	**Field of employment** + **Identified competences**

Country **University**	**Graduate profile**	
	Qualification and aspects giving the degree identity	**Degree objectives:** **«*to train a professional able to...*»** **+** **Identified competences**
ECUADOR ESPOCH	Qualification: Biophysicist Graduates in Biophysics will be able to pursue post-graduate studies at speciality, master's degree or doctorate level in the areas of Medical Physics, Molecular Biophysics, Cellular Biophysics, Biophysics of Complex Systems, Biomechanics, Biomedicine, Nanosystems and so on, in universities with a high scientific profile.	Upholding the solution to specific problems relating to ecology, biology, medicine and so on. General: 1, 2, 4, 15 Specific: (V06); (V01); (V12); (V13) Taking decisions and contributing to the development of the scientific and technological sectors, in the relevant field. General: 16, 4, 9 Specific: (V05); (V12); (V13); (V20) Designing and administering science and technology development projects in the relevant field. General: 9,15, 25 Specific: V14, V19, V16 Implementing new technologies that enable our society's most pressing problems to be solved. General: 8, 13, 23 Specific (V05); (V13); (V16); (V04)
	Qualification: Physicist To train professionals, covering all the basic principles of these sciences, with solid overall foundations.	Showing a command of scientific conception to solve problems in the productive field. General: 2, 23. Specific:(V06); (V17); (V01); (V13) Steering their individual interests according to human and social needs in line with socio-cultural traditions and values. General: 27, 21 Specific:(V15); (V14) Updating their knowledge constantly, allowing them to acquire new competences that specialise in solving current problems. General: 4, 10, 15 Specific: (V16); (V20) Showing readiness and skill when carrying out their activities. General: 8, 6 Specific: (V20); (V12) Using basic IT and mathematical tools to carry out their activities more efficiently. General: 8, 11, 15 Specific: (V02); (V20) Feeding and feeding back their expertise, providing it with all kinds of scientific and technological information. General: 1, 4, 10 Specific: (V18); (V19); (V05)

Graduate profile	
Qualification functions and scope + Identified competences	**Field of employment + Identified competences**
Establishing radiation levels of natural and artificial isotopic sources, and recommending the corresponding regulations. Researching the properties of biological structures and their interactions. Establishing new medical diagnosis methods based on physical principles. Conducting research into the field of biophysics in order to apply and validate new methods and techniques, and generate resources. Being thoroughly familiar with the established laws and principles explaining our physical universe, and the latest trends in new theories that aim to explain the unknown. Having and applying in-depth knowledge of physics with ease in order to solve problems relating to natural sciences. Improving the instrumentation needed to understand hypotheses and/or theories concerning natural phenomena experimentally by suitable measurement and treatment of the appropriate physical magnitudes.	Biophysicists are qualified to work in organisations such as the CEEA (Ecuadorian Atomic Energy Commission), INE (National Institute of Energy), SOLCA (Society for the Fight Against Cancer), hospitals, government ministries, IESS (Ecuadorian Institute of Social Security), foundations and NGOs, etc.
Identifying, formulating and solving small, medium and large problems related to physics in the field of production. Performing actions in keeping with their work location that allow the rational use of natural resources to guarantee production in order to satisfy the population involved. Applying advanced research techniques in order to solve problems arising in day-to-day professional practice. Understanding the impact of solutions put forward. Applying and integrating knowledge acquired in order to solve production and service problems. Designing and conducting experiments, as well as analysing and implementing data and results. Participating and contributing effectively as a member or leader of mutildisciplinary teams. Using information technology as a practical tool for design, analysis, research and communication. Giving support at all levels with their expertise, if need be.	Regarding prospects, physicists are qualified to work in organisations such as the INAMHI (National Institute of Meteorology and Hydrology), INOCAR (National Oceanographic Institute of the Armada), CEEA (Ecuadorian Atomic Energy Commission), SOLCA (Society for the Fight Against Cancer), hospitals, government ministries, IESS, foundations and NGOs, etc., as well as working in businesses devoted to agroindustry, agriculture, livestock farming and others.

Country University	Graduate profile	
	Qualification and aspects giving the degree identity	**Degree objectives: «*to train a professional able to...*» + Identified competences**
GUATEMALA UVG	Qualification: Graduate in Physics Graduates in Physics from the Universidad del Valle de Guatemala are professionals who are able to model and solve complex problems relating to their profession analytically and technologically. They also use their skills to conduct research that generates and transfers knowledge in their area of interest. They are qualified to pursue post-graduate studies in pure and applied sciences at any university worldwide.	Ability to analyse, model and solve complex problems relating to their profession both analytically and numerically. General: 1, 2, 4, 8, 9, 15, 16 Specific: (V01); (V02); (V03); (V04); (V06);(V08); (V09); (V10); (V17) Working in multidisciplinary teams in the search for global solutions to many-sided situations involving energy, sustainable development and the mathematical modelling or mechanical modelling of systems. General 5, 9, 15, 16, 17, 18, 20, 21 Specific: (V14); (V15); (V16); (V19) Conducting research into their field. General: 9, 13, 14, 15 Specific: (V01); (V02); (V03); (V04);(V07); (V09); (V10); (V17); (V18); (V19); (V20) Exercising leadership. General: 12, 13, 16, 17, 19, 25, 26 Specific: (V13); (V14); (V15); (V16); (V18);(V19); (V20) Constant updating. General: 10, 24 Specific: (V16) Putting forward models that describe the reality surrounding them. General: 1,2, 3, 4, 8, 11, 14, 15, 18, 24 Specific: (V03); (V05) Using critical judgement and putting forward their criteria rationally, systematically and respectfully with regard to other professionals. General: 5, 6, 7, 12, 16, 17, 18, 26 Specific: (V13); (V15); (V16); (V18); (V19)

Graduate profile	
Qualification functions and scope + Identified competences	**Field of employment + Identified competences**
Training professionals who have: 1. Solid theoretical and practical foundations that enable them to understand interactions of matter and energy in the universe, at different scales. 2. The ability and willingness to contribute to finding solutions to the problems of their environment. General: 1, 2, 4, 5, 8, 9, 10, 12, 13, 14, 15, 16, 17, 18, 19, 20, 21, 24, 25, 26. Specific: (V01); (V02); (V03); (V04); (V05) (V06); (V07); (V08); (V9); (V10); (V13); (V14); (V15); (V16); (V17); (V18); (V19); (V20) Core curricular themes: 1. Research. 2. Critical and creative thinking. 3. Responsibility in relations with the natural and socio-cultural environment. 4. Social responsibility and civic awareness. 5. Entrepreneurship. 6. Training in values: Excellence; Ethics; Respect; Responsibility; Freedom Areas of excellence: 1. Research 2. Theoretical and experimental work in Physics. 3. Consideration and assessment of: Models describing reality from different perspectives. Multiple solutions to complex problems. Work in interdisciplinary teams.	Post-graduate courses at Universities. Teaching at Universities. Pure and applied research at Universities, Institutes and Research Centres Project development. Industry and other areas.

Country University	Graduate profile	
	Qualification and aspects giving the degree identity	**Degree objectives: «*to train a professional able to...*» + Identified competences**
MEXICO U de Sonora	Qualification: Graduate in Physics Graduates in Physics are knowledgeable in four fundamental areas of Physics: Classical Mechanics, Classical Electrodynamics, Quantum Mechanics and Statistical Physics. Their training includes a technical and experimental aspect so as to be able to operate in three areas, which are not necessarily inclusive: teaching, research and consultancy in the dissemination of scientific subjects.	Graduates in Physics are knowledgeable in four fundamental areas of Physics: Classical Mechanics, Classical Electrodynamics, Quantum Mechanics and Statistical Physics. General: 1, 15, 24. Specific: (V01); (V05); (V06). Using mathematics in the modelling of physical phenomena, and their training to solve specific scientific problems by means of analytical, experimental or computational techniques. General: 1, 2, 4, 8, 9, 14, 15. Specific: (V01); (V02); (V03); (V04); (V05); (V08). They should be able to complete post-graduate studies successfully within recognised international standards. General: 1, 3, 4, 6, 7, 9, 10, 11, 13, 14, 15, 17, 24. Specific: (V01); (V02); (V03); (V04); (V06); (V07); (V09); (V10); (V11); (V16); (V17); (V18); (V19). Unidentified competences General: 3, 8, 12, 16, 18, 19, 22, 23, 25, 26, 27. Specific: (V20); (V21).
PERU UNI	Qualification: Graduate in Physical Sciences Physics professionals must have wide-ranging knowledge of the different fields of Physics, mainly Theoretical Physics, Solid-state Physics, Nuclear Physics and Applied Physics, as well as the Mathematics needed to formulate and develop postulates, principles, laws and theories in Physics.	Willingness to carry out scientific work. General: 3, 4, 9, 11, 14, 15, 16, 17. Specific: (V16); (V20). Ability to write and present reports on work being carried out. General: 6, 7, Specific: (V07); (V18); (V19). Patience, tenacity and perseverance in study and laboratory work. General: 3, 9, 11, 17, 24. Specific: (V01); (V05); (V12). Willingness to learn languages. General: 7 Specific: (V18). Skill in scientific programming. General: 8, 10 Specific: (V01); (V02); (V20). Ability to observe and discover different aspects and factors intervening in the behaviour of simple physical systems. General: 1, 2, 9, 11, 13, 14, 15. Specific: (V01); (V03); (V04); (V05); (V06); (V07); (V08); (V09); (V10); (V11).

Graduate profile	
Qualification functions and scope **+** **Identified competences**	**Field of employment** **+** **Identified competences**
The experience acquired by Physics graduates to use mathematics in the modelling of physical phenomena, as well as training in order to solve specific scientific problems by means of analytical, experimental or computational techniques, prepares them to aim their area of interest in different directions that may include disciplines other than Physics. In this sense, the Physics degree could be understood as the initial phase of a process whereby students prepare themselves to pursue their training through post-graduate studies, a doctorate being the final stage of such training. In addition to educational establishments, businesses can also make use of Physics graduates, given the ease with which they receive training. Daily training with a view to solving academic problems leads to the fact that students, to differing degrees of development, tend towards independent thinking and creativity as part of their professional activity.	In the area of teaching, Physics graduates can work at levels ranging from secondary education (the 6 years prior to university studies) up to degree courses. In the field of research, they can work as assistants on specific tasks in work being carried out by a research fellow in Physics. As for outreach, they are qualified to participate in interdisciplinary groups developing science outreach activities.
Conducting research on the physical aspects of materials both to increase scientific knowledge about them and produce materials with specific characteristics for certain applications. General: 9, 11, 14, 15, 18 Specific: (V01); (V03); (V05). (V10); (V12); (V13). (V17); (V19); (V20). Using mathematics and scientific computation to express and analyse their observations on the behaviour of physical systems and drawing the corresponding conclusions. General: 2, 8, 10, 11, 15 Specific: (V01); (V02); (V03); (V10); (V16). Designing and building modules and prototypes to teach Physics at different levels of education. General: 8, 10, 11, 14 Specific: (V06); (V07); (V08). (V18); (V21); (V22).	Physics teaching at university level. General: 8, 10, 11, 14 Specific: (V06); (V07); (V08); (V18); (V21); (V22) Applications of spectroscopic techniques in the analysis of materials. General: 9, 11, 14, 15, 18 Specific: (V01); (V03) (V05); (V10); (V12); (V13); (V17); (V19); (V20) Theoretical and practical analysis of physical systems in general. General: 1, 2, 9, 10, 11, 14, 18 Specific: (V01); (V02); (V03); (V10); (V16) Applications of nuclear physics. General: 9, 10, 11, 24 Specific: (V06); (V12); (V17).

Country University	Graduate profile	
	Qualification and aspects giving the degree identity	**Degree objectives: «*to train a professional able to...*» + Identified competences**
VENEZUELA USB	Qualification: Graduate in Physics Physics degree course graduates at the Universidad Simón Bolívar are trained to participate in basic and applied research aimed at formulating models and obtaining experimental data, enabling them to corroborate, modify and/or put forward new theories looking for greater understanding of the environment around us and the development of high technology in multidisciplinary areas, such as: Quality Control, Instrumentation, Materials Sciences, Biophysics, Computing, Technological Processes, Electronics and the Environment and so on.	Training professionals qualified to operate in the different areas of theoretical, experimental and computational Physics. General: 1, 2, 4, 10, 15 Specific: (V01); (V02); (V06); (V07); (V12) Contributing to the development of national scientific activity with the aim of attaining scientific and technological autonomy. General: 5, 6, 13, 14, 16, 17, 18, 19, 20, 21, 22, 25 Specific: (V07); (V13); (V14); (V15); (V18); (V22) Training professionals who can naturally join research teams and international-standard post-graduate courses. General: 1, 3, 4, 6, 7, 9, 10, 13, 14, 17, 23 Specific: (V01); (V08); (V10); (V16); (V17); (V18); (V19); (V20)

Graduate profile	
Qualification functions and scope **+** **Identified competences**	**Field of employment** **+** **Identified competences**
Using the basic concepts and principles of classical and Physics and modern Physics with ease. General: 1,4,15 Specific: (V01); (V05); (V06); (V07) Describing and explaining natural phenomena and technological processes, in terms of concepts and principles of Physics. General: 1, 2, 4, 8, 9, 11, 15 Specific: (V01); (V02); (V04); (V05); (V07); (V10); (V13); (V20). Demonstrating the working habits needed to develop the profession, such as: teamwork, scientific rigour, self-learning and persistence. General: 3, 6, 10, 12, 17, 18, 26, 27 Specific: (V16) Producing and using computer programmes for systems simulation, data processing or experiment control. General: 2, 4, 8, 14 Specific: (V02); (V03); (V04) Communicating concepts and scientific results in oral or written language to their peers and in teaching and outreach situations. General: 4, 6, 7, 18, 21 Specific: (V06); (V08); (V18); (V22)	A physicist, trained with analytical criteria and a creative attitude will be able to practise their profession at research centres and centres for industrial and technological development. Moreover, they will be able to use their skills and expertise in teaching, planning and service development activities.

Annex II

Interviews regarding future scenarios according to country

BRAZIL

Interview with Prof. Eduardo de Campos Valadares

Interviewee profile

Holds a PhD in physics from the Brazilian Center for Research in Physics (*Centro Brasileiro de Pesquisas Físicas*) and has conducted postdoctoral research at USP and at Nottingham University, in the United Kingdom. He is currently Associate Professor in the Physics Department of the Universidade Federal de Minas Gerais (UFMG), where he coordinates the "Science, fun and beyond" project, the "Innovation Project" and the "Innovating School" project. He has written more than 60 articles, covering a wide range of topics, from Condensed Matter Physics, teaching Maths and Physics and popularizing science. He has translated the work of German poet Stefan George ("Twilight", bilingual edition, Iluminuras) and has had several books published, namely "Physics, fun and beyond" (Publisher: UFMG), translated into English, German, Basque and Spanish, "Newton: The Earth's Orbit in a Glass of Water" (Publisher: Odysseus) and is co-author of "The Application of Quantum Physics: From the Transistor to Nanotechnology" (Publisher: Livraria da Física) and "Aerodiscoveries: Exploring new possibilities" (Fundação Ciência Jovem). He is a member of the Brazilian Society of Physics, the Institute of Physics, the European Optical Society and the American Association of Physics Teachers. In 2001 he was awarded the Francisco Assis Magalhães Gomes prize for his work to promote popular access to science and in 2006 he received the Brazilian Denatran Prize in the category of individuals providing guidance to university students.

In 2004 he co-founded the Fundação Ciência Jovem (Youth Science Foundation), of which he is currently Director and Chairman.

Principal Publications: Physics, fun and beyond (Publisher: UFMG, 2002); Newton: The Earth's Orbit in a Glass of Water (Publisher: Odysseus, 2003); The Application of Quantum Physics: from the Transistor to Nanotechnology (Publisher: Livraria da Física, 2005).

Lattes curriculum vitae: http://buscatextual.cnpq.br/buscatextual/visualizacv. do?id=K4783022H4

What changes do you think society will undergo in the near future (the next 20 years or so)?

With almost unrestricted access to information and with new user-friendly tools developed in information technology and in virtual and physical prototyping, a significant number of children and adolescents will now be able to come up with innovative solutions to scientific, technological and social problems. Communities which are, at present, isolated (Indians, low income populations, riverside populations in the interior of the Amazon, populations in Central America, Asia and Africa, etc.) will be able to unite and generate solutions to counter the most immediate challenges facing them with the support of tutors from all parts of the world connected through a new, more accessible and user-friendly global network. Young people from more economically developed countries, and those from emerging and emerged economies will be able to join in and act as tutors and interlocutors in processes involving authentic challenges, generating a new stage of inclusive globalization and a greater ethical and social conscience.

You identified changes in future society; could you point out some possible scenarios that may arise?

Even if no global disaster occurs (asteroid collision or nuclear war), there may still be serious social issues related to persistently weak public investment in education and inadequate schooling, the global ageing population and drastic environmental pollution, a more noticeable increase in desertification and land erosion with scant drinking water and food supplies, the emergence of chronic illnesses and rising crime rates.

Another possible scenario is the socio-economic emergence of South America and of Africa, the spread of new technologies and a revolution in traditional education, with an emphasis on innovation and with a more integrated approach to fostering scientific and technical knowledge, which will allow new generations to learn to innovate by being exposed to real problems and to new ways of thinking and implementing their ideas.

What would the implications be for your professional area in each of the scenarios described?

Speaking as a university professor, I do not feel that academia is ready to act in any meaningful way in either of the scenarios I have described. The same can be said of our educational system as a whole, which insists on ignoring progress achieved beyond the confines of academia and the challenges facing the world today. On the other hand, there is a growing awareness of the need for change. It is possible to foresee the emergence of new and more efficient ways of learning which could bypass the traditional school and university settings. In both cases, the role of educators needs to be fundamentally reappraised. The same applies to the health system and the notion of formal employment, with the emergence of an entrepreneurial mindset that is more comprehensive and responsive.

What professions and/or professional approaches in your area do you envisage in each scenario?

Organizers, inventors and facilitators who are capable of creating and working in innovative environments.

What competences will these professions require?

Creativity, lateral thought and forward vision, fluent communication, ability to work in a team and to explore new possibilities, openness to challenges, an ethical sense and a social and environmental conscience, enthusiasm and a capacity to implement new ideas involving multi-disciplinary support networks.

What, in your opinion, would be a possible but highly unlikely scenario?

The complete social irrelevance of schools and universities if they do not get ready for the challenges that the future will bring, which implies a need for greater freedom of thought and the coalition of various fields of human knowledge and elimination of the artificial barriers which separate them, starting by tackling relevant, multi-disciplinary issues, and producing constructive and inclusive solutions for society.

What professions and competences would be important for your area in this unlikely scenario?

Competent and creative educators, who are tuned in to the immediate challenges and to other, less obvious ones, and who are able to act as leaders and facilitators in a new extra-scholastic environment.

Interview with Prof. Cláudio Lenz Cesar

Interviewee profile

Physics Graduate from the Universidade Federal do Ceará (1985), with a Master's Degree in Physics from the Universidade Federal de Pernambuco (1988) and a PhD in Physics from the Massachusetts Institute of Technology (1995). He is currently a full Professor at the Universidade Federal do Rio de Janeiro.

He has practical experience in Physics, with particular emphasis on Atomic and Molecular Physics. Works mainly in the following fields: Atom Trapping, High Resolution Spectroscopy, Spin-polarized Hydrogen. Conducts research at the cold atom and spectroscopy laboratory, part of the Physics Institute of the Universidade Federal do Rio de Janeiro (UFRJ) on a new magnetic trap for Hydrogen, Lithium, and light atoms and molecules; new lasers; optical sensors and techniques; Research on Antihydrogen in collaboration with ALPHA, which aims to produce and study antihydrogen as part of the CERN (European Nuclear Research Organisation) ALPHA/AD-5 experiment. He has had 55 articles published in international journals and a total of 1190 citations.

Lattes curriculum vitae: http://buscatextual.cnpq.br/buscatextual/visualizacv. do?id=K4781410Y2

What changes do you think society will undergo in the near future (the next 20 years or so)?

Society will achieve great technological progress and increased life expectancy will lead to significant demographic changes (age distribution). The demand for energy, healthcare for the elderly and work/employment will create constant pressure requiring scientific and technological developments (for energy and healthcare) and new ways of organizing society and family to tackle the employment issue. Society may benefit from information technology to achieve more direct and relevant participation in politics. Drug-related problems and associated violence may increase. Society will continue to strive for better quality of life with regard to transport and urban living; there is likely to be more remote working and distance learning.

You identified changes in future society; could you point out some possible scenarios that may arise?

The use of information technology in politics: more direct participation, by means of plebiscites, and less representation of society on its issues. The use of communication technologies may lead to people travelling less to work or school on a daily basis and, instead, conducting a substantial part of their work or education remotely. Also, people will have to work more in service industries with growing unemployment in other areas. Issues concerning social security will have to be reviewed to find a satisfactory way to tackle the aging population. People will continue working for longer. Demand for medical and health care services, mainly for the elderly, will increase substantially. At the same time, drug-related problems will diversify and will continue to put pressure on society through related violence and family problems. With regard to human relationships, although we may see new kinds of family units, we will never stray very far from our biological needs, specifically our emotional, sexual and social needs. However, I do believe that there will tend to be more singletons in society.

What would the implications be for your professional area in each of the scenarios described?

As a teacher and researcher, I would say that:

With the continuing deconstruction of family life, primary and secondary education will become more and more important in the upbringing of children and adolescents. Consequently, it is vital that we have a school system that teaches students to think, observe, analyse and experiment. It is crucial that schools turn out people who are able to think and not just accumulate knowledge, and that they foster good citizenship and involvement with their communities. To have such schools, it is fundamental that Universities take on the role of training new teachers for a new school system. At the same time, society will see a growing demand for scientific and technological research. The basic survival issues — food, health, energy, the global climate and global disasters — in addition to issues concerning quality of life, both from the perspective of transport and technologies used on a day-to-day basis, will always be highly valued by society.

What professions and/or professional approaches in your area do you envisage in each scenario?

In the field of education I think that we need to have more experimentation— different educational models — in order to create a school system that attracts students and can train their minds to think for themselves and be independent. Starting with models and ideas, we need to experiment with different models and see what works, where it works, and identify the main elements (positive and negative). From there, we need to be ready to abandon models that do not work — regardless of the attractive ideologies behind them — and adopt models that do work, always leaving some margin for experimentation, adaptation and development. In the sciences, I don't see that many changes in relation to how things are done today, except that fields dealing with more complex systems will have to learn to cope with their multivariables in a more complex way. In Physics, for centuries we had to be reductionist in order to understand the principles. Until recently, the nonlinearities, the noise, the undesirable effects were minimized or disregarded. Now, in Medicine and in Biology, systems are complex from the outset and a reductionist approach is virtually impossible; we will need to have experimental tools and theories to tackle the huge quantity of data and causes and effects, as in the field of multivariable systems.

What competences will these professions require?

The main competence required is to have learned to think and to tackle new problems. This involves learning, observing and experimenting. Mathematics and experimentation (in Physics/Chemistry/Biology) remain the basis for this process. The humanities are the natural complement to this subject group. In addition to studying the classics, humanities teaching could also incorporate experimentation. It would be of huge value to place students in social projects – involving them in, and resolving, issues in local communities – and in politics.

What, in your opinion, would be a possible but highly unlikely scenario?

a) That society becomes a slave to drugs and violence.

b) That society frees itself of drugs and violence.

c) That we are devastated by large-scale natural disasters.

What professions and competences would be important for your area in this unlikely scenario?

a) Well-trained and interesting teachers and well-resourced schools would be fundamental. And, society should attach more value to the nuclear family and its interaction with others.

b) Well-trained and interesting teachers and well-resourced schools would provide the starting point for a new era of prosperity, peace and humanity.

c) Researchers, doctors and engineers would be fundamental for reconstruction.

Interview with Prof. Dr Hans Jürgen Herrmann

Interviewee profile

E-mail: hjherrmann@ethz.ch

Graduated in Physics in 1978. He was a Researcher at Cologne University where he gained his PhD in 1981. From 1981 to 1982 he held a postdoctoral Fellowship at the University of Athens. He was a Lecturer at the École Supérieure de Physique et de Chimie Industrielles of the Université Paris Descartes-Paris V, where he was also Academic Chair of Particle Physics. He worked at the CTE nuclear power station and at the CNRS research centre in Saclay. He was Director of the multiparticle group of the Centre for High Performance Computing (Höchstleistungsrechenzentrum-HLRZ) in Jülich, Germany. He was a professor at the University of Stuttgart and was Director of the Institute of Computational Physics. Since 2006 he has been professor of Computational Physics of Materials Engineering and Director of the Zurich Federal Institute of Technology (ETH). He is a visiting professor at the Physics Department of the Universidade Federal do Ceará, in Fortaleza, Brazil. He is currently working mainly on dunes and Apollonian packings. He is also researching density waves, fragmentation, stratification, segregation, compactification, sedimentation, dissipative gases, the shape of sand piles, the non-linear elasticity of packings and shear bands, which he also studies micro-mechanically.

He has been awarded various prizes and honorary titles, including:

- ABIF Prize —Associação Brasileira da Indústria Farmacêutica—, 1971.
- ABIFARMA Prize —Associação Brasileira da Indústria Farmacêutica—, 1977.
- ABIFARMA Prize —Associação Brasileira de Indústrias Farmacêuticas—, 1978.
- Farmasa Prize for Gastroenterology —FARMASA—, 1994.
- Max-Planck Prize, Jan/2002.
- Gentner-Kastler Prize, Jan/2004.

- IBM Faculty Prize, Jan/2009.
- Honorary titles: WF James Professor of Pure and Applied Sciences —Universidade de St. Francis Xavier—, 1994.
- He has had 482 articles published in international journals, in addition to 4 books.

Lattes curriculum vitae: http://buscatextual.cnpq.br/buscatextual/visualizacv. do?id=K4716617H4

What changes do you think society will undergo in the near future (the next 20 years or so)?

I see two trends: One is that society is becoming progressively older and there are increasingly fewer people to ensure the continuing survival of humankind. The second is that I see a trend of an increasing use of audio-visual methods which diminishes the population's capacity to read and, also, to perform calculations. What I fear may happen is that new generations will become accustomed to images and to using a microphone to communicate and, consequently, will lose many skills and techniques which, for those of us involved in Physics - an exact science rooted in theorems which are very much based on mathematical calculations - will mean that the profession will suffer because the new generations will have less affinity with the language of science created by the great scientists of the past, such as Newton, Einstein, etc.

You identified changes in future society; could you point out some possible scenarios that may arise?

In my opinion, we will need to change teaching techniques and methods of passing on information and knowledge among people. We will have to try to develop more audio visual descriptions of Mathematics, as opposed to written ones, and we will have to motivate new generations more as, with fewer young people than there were in the past, they will have a greater burden in terms of supporting society. We have to motivate them to make an effort to study with books again, and with formulas. We will first have to develop ways of motivating them and then find ways of passing on that motivation.

What would the implications be for your professional area in each of the scenarios described?

We will have to put more effort into teaching new generations and, above all, into creating new techniques such as, for example, using computer games to learn Physics or develop ways of teaching a class over the Internet or of teaching a class using audio-visual means, which is the preferred language of new generations and, on the other hand, we will have to weed out our acquired knowledge and distil it so that we retain the important parts that we will need to maintain society's technological standards and continue making technological progress.

What professions and/or professional approaches in your area do you envisage in each scenario?

I think that in the future we will have to work more with information technology and with people who understand the media and ways of transmitting information through visual media, via the Internet and through audio-visual methods. I think that we will need to develop new ways of presenting and communicating the laws of Physics, not just with formulas or with texts, and we will have to learn to communicate with new generations in a more entertaining way, above all by introducing virtual worlds than can be compared against the real world to learn, for example, the Law of Gravity. The Law of Gravity varies according to 1/distance, let's imagine that instead of using 1/distance, we used 1/(distance)2. What would change in this virtual world so that someone who is used to thinking in an audio visual way could better understand the meaning of 1/distance?

What competences will these professions require?

We need to have a better understanding of the psychology of communication. We would need to have a better feel for games played in the virtual world. I believe that new generations (and I see this in my own children) think in a different way from us. They think in images, virtual worlds. I believe that we have to know how to play their games in order to sustain communication with them. Then the new generations will automatically produce the competences that are needed.

What, in your opinion, would be a possible but highly unlikely scenario?

This question has many possible answers. One of them is the appearance of a giant meteorite. This has already happened in the past and we know that it had catastrophic consequences for nature. Such a disaster would undoubtedly confront humanity with unimagined challenges and would place demands on our profession to quickly develop new techniques for human survival.

What professions and competences would be important for your area in this unlikely scenario?

Physicists will have to help to develop new techniques for survival. For example, in the case of the meteorite, one can imagine that the earth would become very cold as a result of dust clouds entering the atmosphere and so we would have problems with energy and with agriculture. We would have to develop techniques to warm our homes and we would have to adapt to the new climate; obviously, this would mean that physicists would have to carry out research and work to develop new instruments, new machines and new possibilities.

Interview with Professor Vanderlei Salvador Bagnato

Interviewee profile

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Graduated in Physics from the Universidade de São Paulo, USP, Brazil and in Materials Engineering from the Universidade Federal de São Carlos, UFSCAR, Brazil. He has a PhD in Physics from Massachusetts Institute of Technology, awarded in 1987. He became a Lecturer at the Universidade de São Paulo, USP, Brazil in 1990 and was awarded full Professorship by USP in 1992. He is a Fellow of the Brazilian National Council for Scientific and Technological Development

(*Conselho Nacional de Desenvolvimento Científico e Tecnológico – CNPq*). He is a Full Member of the Academia Brasileira de Ciências (the Brazilian Academy of Sciences). He is collaborating on various national and international research projects, among them: Research and Development of New Techniques for the Application of Preheated Dental Resin; Research on Cold Atoms in Classical and Quantum Regimes and Development of Biophotonic Techniques; Development of an instrument and procedure for thermo-mechanical therapy (ultrasound + heat therapy) in the treatment of osteoarthritis; Atomic references of time and frequency; Investigation into atomic superfluids; Diagnosis and treatment of skin cancer using photodynamic therapy; Science for All: Disseminating and Popularizing Science through Television, public exhibitions, school visits and activities with the Brazilian Academy of Sciences (*Academia Brasileira de Ciências*); DOxR - Digital Odontological X-rays.

He is currently a full Professor at the Universidade de São Paulo and is Coordinator of the FAPESP-supported Optics and Photonics Research Center (*Centro de Pesquisa em Óptica e Fotônica - CEPOF*), at the Physics and Science Department of the Instituto de Física de São Carlos, at USP. He was elected Fellow of The Academy of Sciences for the Developing World (TWAS) on 20/10/2009. He has published 368 articles in specialist journals and has presented 1062 papers in scientific events. He has written 5 books and has had 18 chapters published in co-authored books. He has supervised 34 M.Sc. dissertations and has co-supervised a further 2; in addition, he has supervised 25 doctoral theses in Physics, Odontology and Medicine. He has been the recipient of 6 prizes and/or tributes. He works in Physics with emphasis on Atomic Physics and the Application of Optics in Health Sciences.

Lattes curriculum vitae: http://buscatextual.cnpq.br/buscatextual/visualizacv. do?id=K4783134Y5

What changes do you think society will undergo in the near future (the next 20 years or so)?

I think that in the decades to come, society will undergo huge transformations. We will continue to increase life expectancy and that will bring with it a huge list of needs ranging from laser applications, through to education and health. The solutions to these problems will require new technologies. At this point, we will have to ensure that the scientific developments and innovations taking place in the academic environment are handled with greater social responsibility. As scientists we have to be alert to such needs. If we do not ensure that technology works for society we will create a huge gulf between markets and social wellbeing.

You identified changes in future society; could you point out some possible scenarios that may arise?

As a professor and a scientist, I have noticed that higher education is increasingly becoming just another stage of life in young people's preparation for a career. These days we have to offer education at university level to people who will take very diverse paths through life. Just to have a shop and be an ordinary sales person one needs knowledge. This is happening more and more often. We have to face up to the fact that higher education will cease to be a specialist undertaking and will become a necessity in a globalized world. Universities will have to confront this challenge: how to educate more people without spending more... This is the most likely scenario. Everyone will need to have access to technology. This also presents the challenge of producing technology within the economic reach of the people.

A second possible scenario would be a desolate one, in which we only try to train specialists and we end up with a massive population of unemployed people.

What would the implications be for your professional area in each of the scenarios described?

As a university professor, I have to try to create graduate and post-graduate programmes which can satisfy this potential new demand. Masters theses, PhDs, specialist courses should aim to assist people in their general preparation for a career. We cannot continue to offer a high degree of specialization in our courses. This will remove young people from the job market instead of introducing them into it. We have to promote good, solid training for students to enable them to enter the job market in any field or to confront the challenges of the job market in with the qualifications that they have.

What professions and/or professional approaches in your area do you envisage in each scenario?

Obviously, as we are dealing with scientific and technological fields, I am envisaging the training of professional engineers, physicians, chemists, doctors, etc. But I think that all disciplines will suffer the same fate. It is also important to say, as part of this challenge to provide a generalist training, that we need people coming from a background of exact sciences to have more exposure to humanities subjects in their education and for people from humanities to learn more about the general concepts of Mathematics, Physics and Chemistry. In general, citizens will be increasingly exposed to situations where they will require certain scientific knowledge to progress in their careers.

What competences will these professions require?

As I said, basic training must be broad and flexible. Naturally, specialist options will remain at post-graduate level. This should also be open to all those who are interested, as these are the people who will work as professionals in society in the future. It is more and more difficult to be a doctor without more specific scientific training; the same applies to engineering, etc. The pace of evolution is so fast that what we learn in school, specifically, is very quickly superseded.

What, in your opinion, would be a possible but highly unlikely scenario?

That Latin America sees how to prepare its young people so that they can create a more humane and developed Latin America.

What professions and competences would be important for your area in this unlikely scenario?

I have not specified any areas; I have been as general as possible. The success of Latin America depends on a concerted effort. We have to create skills centres that can help everyone. We must have centres for tropical diseases located in the tropics and not in the northern hemisphere. We must reach a consensus as a continent. We have the opportunity to be a part of the world that does not suffer so badly from the decisions of others.

COLOMBIA

Interview with Dr. Rubén Antonio Vargas Zapata

Interviewee profile

Physicist qualified in Mathematics and Physics, M.Sc., Ph.D. in Physics, Senior Lecturer at the Universidad del Valle since 1965. Honoured with different awards: Distinguished Professor-Universidad del Valle (1985), Encouragement for Researchers-COLCIENCIAS (1997), Overall Work of a Scientist-Colombian Academy of Exact, Physical and Natural Sciences (1997), Honorary Professor-Universidad del Valle (1997), National Physics Award-Colombian Society of Physics (2001), University Lecturer-Universidad del Valle (2005). He directs the Phase Transitions in Non-Metallic Systems Working Group, A1 classification of COLCIENCIAS. Many of his projects have been financed by COLCIENCIAS, and others have been the subject of international cooperation with Sweden and Brazil. His areas of research are: The physics of phase transitions and critical phenomena in condensed matter, materials composed of polymers and ceramic nanoparticles, the development of materials for solid-state electro-chemical applications. He has published some 80 articles in international journals, has been an arbitrator in over 10 international science journals and directed some 65 theses, including undergraduate and master's degree studies, and 15 doctoral theses.

Characterisation of future scenarios

Society will face a food shortage. Future society may therefore turn into an agricultural society and the provider of commodities within a knowledge-based, industrial society. This new society will need to achieve economic independence and develop new technologies enabling such independence, i.e. a society that produces its own goods and services.

Professions envisaged in each scenario

Some interdisciplinary areas are envisaged: Physics-Biology, Physics-Engineering of materials, Physics-Geology, Physics-Health Sciences, Physics-Nanotechnology, and so on.

Competences required for these professions

a) Ability to work in a team.

b) Ability to take part in interdisciplinary research projects.

c) Showing readiness to tackle new problems in other fields, using their skills and specific expertise.

d) Commitment to environmental conservation.

e) Ability to work within international contexts.

Other comments relevant to the future

In all the future scenarios, the interdisciplinary relations between current professions are envisaged that will give rise to future professions and research projects. Moreover, greater commitment to the environment will be needed.

Interview with Dr Germán Antonio Pérez Alcázar

Interviewee profile

Physicist, M.Sc., Ph.D. in Physics. Senior Lecturer at the Universidad del Valle. Distinguished Professor-Universidad del Valle (1993), Corresponding Member of the Colombian Academy of Exact, Physical and Natural Sciences (2002), ranked as the fourteenth most internationally active scientist in Mössbauer Spectroscopy (1997), the Colombian Physics Society Award (2009), and Professor Emeritus-Universidad del Valle (2010). Member of the Mössbauer Effect Reference and Data Journal's International Academic Committee (2004), member of the International Board on the Mössbauer-IBAME Effect (1997), associate editor of the Journal of Metastable and Nanocrystalline Materials (2002). He leads the Physical Metallurgy and Phase Transitions research team, Category A of COLCIENCIAS. His lines of research are magnetism, nanoparticles, physical metallurgy, phase transitions and statistical models in metallic systems, nuclear techniques and nanomagnetism. He has published over 80 articles in highly prestigious international journals. He has developed three technological applications in his research area and has directed 65 theses, of which 32 are doctorates.

Characterisation of future scenarios

The degradation of the environment will lead to the future depletion of drinking water due to pollution. The struggle will be for drinking water, and this involves the development of seawater desalination and ocean cleaning processes, which will lead to the development of Hydrology, Earth Physics, Environmental Physics and Geophysics.

Professions envisaged in each scenario

The development of new areas or professions based on interdisciplinary relations between biologists, physicists, geologists, chemists and systems engineers is envisaged in this scenario.

Competences required for these professions

Of the different competences, the interviewee mainly highlighted:

a) Ability to search for, process and analyse information from different sources.

b) Ability to act in new situations.

c) Capacity for teamwork.

d) Commitment to environmental conservation.

e) Ability to work with international contexts.

f) Ability to work on interdisciplinary projects.

Other comments relevant to the future

The new professions will force degree programmes to be redesigned as interdisciplinary courses.

CUBA

Brief description of the interviewees

Interviewee 1 is Senior Lecturer and Head of the Department of Theoretical Physics at the Universidad de La Habana's Physics Faculty. He is a prominent lecturer and conducts important research projects in the area of Statistical Physics. He has received important national awards and has published important, internationally recognised work.

Interviewee 2 is Senior Lecturer at the Universidad de La Habana's Physics Faculty who is highly experienced in research into teaching and research. He is a specialist in Optics, Semiconductor Physics and Solar Cells. He has received the Academy of Sciences of Cuba's award on more than one occasion and is an acknowledged professional in Cuban Physics.

Interviewee 3 is Senior Research Fellow at the Centre of Genetic Engineering and Biotechnology, Senior Lecturer at the Universidad de la Habana, Visiting Professor at the Universidad Nacional de La Plata, Argentina, 2010 National Physics Award, Academic of Merit at the Academy of Sciences of Cuba and Member of the IUPAP. He specialises in medical imaging equipment.

Characterisation of considered future scenarios

Common themes: i) awareness will be raised of the importance of looking after the environment; ii) the role of Information and Communications Technology will increase; iii) increased globalisation; iii) improvement in education.

Professions envisaged in each scenario

Professionals with broad, flexible training, biophysicists, Theranostics, Electronics and Computing.

Competences required for these professions

Qualification; dedication; training for teaching; motivation for scientific creation; global and overall vision of processes; sound basic training and broad cultural education; devotion to the truth and objectivity; power to analyse critically; ethics; human and social commitment.

CUBA Interview 1

What changes do you think society will undergo in the near future (the next 20 years or so)?

Population density in cities will increase even more. Latin America will exploit its mineral resources even more intensively. The use of information technologies will increase. Society will become increasingly aware of the importance of the environment. China will play a more significant role in the region's economic and political dynamics.

You identified changes in future society; could you point out some possible scenarios that may arise?

These changes, depending on whether suitable policies are marked out or not, will have a direct impact on environmental pollution. It will be important to respond to the new reliance our countries will be subjected to with advances made in new information technologies and the increasing importance of services in our economies.

What would the implications be for your professional area in each of the scenarios described?

In general, there will continue to be a brain drain to more developed countries outside our region, but also to the countries with the most resources within the region, which will accentuate the existing asymmetries, as well as creating new ones.

What professions and/or professional approaches in your area do you envisage in each scenario?

We need professionals with comprehensive training in problems concerning the environment, but also with flexible training that allows them to join different sectors of our countries' economies - from biophysics to data analysis. On the whole, we should invest in sound training enabling, especially in the less developed countries, the creation of a community with scientific training that helps the political administration to take far-sighted, rational decisions.

What competences will these professions require?

We need professionals with comprehensive training in problems concerning the environment, but also with flexible training that allows them to join different sectors of our countries' economies - from biophysics to data analysis. On the whole, we should invest in solid training that enables, especially in the less developed countries, the creation of a community with scientific training that helps the political administration to take far-sighted, rational decisions.

What, in your opinion, would be a possible but highly unlikely scenario?

New, direct invasions by the United States of America.

What professions and competences would be important for your area in this unlikely scenario?

Very few, but solid training in Computing and Electronics would be useful.

CUBA Interview 2

What changes do you think society will undergo in the near future (the next 20 years or so)?

Technology will keep on evolving and will allow closer interconnection between the nations of the world, thanks to advances in communications and transport. Future challenges will therefore be global and will need to be dealt with by all of us, including: energy production and saving; maintaining aquifers for safe water supplies and food production for the disturbing rise in population; environmental conservation in such a way as to strike a balance between nature and human activity; a steady rise in education and cultural standards, which will not only enable science and technology to be applied but will also allow shifts in the consumption paradigms of today's most economically developed societies; eradicating poverty, war and terrorism; developing a more participatory democracy with various models that take each nation's peculiarities into account. Regional blocs will get stronger - the Asian, Latin American, European, African and North American ones - in order to boost science and technology and so increase production and trade.

You identified changes in future society; could you point out some possible scenarios that may arise?

I don't think the current situation will change much in the next 20 years; war, famine and environmental degradation will carry on; nations will consume all the energy they can. Nonetheless, renewable energy sources will continue to be developed by those countries owning the technology; the speculative economy will continue to prevail and important countries will lose their sovereignty. However, emerging countries will appear, such as BRICS and the Latin American countries, which will constitute a driving force behind development.

What would the implications be for your professional area in each of the scenarios described?

Physics has always been the powerhouse of science and now, in the 21st century, it will continue to be the driving force. There is no major challenge currently facing humanity in which Physics fails to play a decisive role: energy production, water and environmental conservation, curing disease, eradicating poverty, and so on.

What professions and/or professional approaches in your area do you envisage in each scenario?

Two large areas face Physics. Developing new theories that enable cosmological explanations to be provided which, as yet, have not been achieved, including the clarification of concepts of dark energy and matter and explaining what happened before the Big Bang. The more we know about the world around us, the easier it will be to find solutions to major challenges. Moreover, Physics needs to spearhead research into nanoscience, which will lead to a vital shift in this century's technology.

What competences will these professions require?

As always, research and education, which require high professional qualification and dedication, would be the required competences, where Physics, once again, should take the lead. In order to do so, countries need to invest a significant part of their GDP.

What, in your opinion, would be a possible but highly unlikely scenario?

Total degradation of the habitat - whether it be because of nuclear war, a cosmic event or total environmental breakdown caused by human activity.

What professions and competences would be important for your area in this unlikely scenario?

Whatever the scenario may be, Physics should be at the forefront of science in order to show the way forward, and the competences are the same; research, education and dedication to the enlightened progress of humanity.

CUBA Interview 3

What changes do you think society will undergo in the near future (the next 20 years or so)?

20 years is an appropriate period of time, it is perhaps a quarter of a person's lifetime, and it is also a period long enough to mature in a professional profile or for a person to go from their primary school education to their doctorate.

The easiest way to conceive and imagine the future is to think that everything «good» from the past and present remains, and everything «bad» transforms or disappears. It's an outlook that is too simplistic and idealistic, but even so, it could at least be a starting point.

Nevertheless, there are drawbacks to imagining the future even when it is relatively near. I can think of two reasons. The first is the intense momentum and acceleration (the second derivative) of events in all areas of current society and all spheres of knowledge. The second reason is that the course of events is not only governed by society's laws but also by the interests of circles of power, especially in the most important nations. They make the rules, even when they are plainly designed to increase their power and fly in the face of rationality and common sense, people and their environment - for instance, wars for spoils, which bring death, and the destruction of works built by man, nature and its resources. Having made these essential clarifications, I will go on to outline my opinion on some of the distinctive features surmised in the next 20 years:

a) An increase in the struggle for the sovereignty of countries, especially in Latin America and the Caribbean. This can be seen now, and should be consolidated and expanded.

b) This process, along with greater equity between human beings and nations, will create the conditions for science and technology to play a more significant role in economic, social and human development in the three quarters of the world that is underdeveloped.

c) The existing awareness of the danger to the world's habitat will grow and shift from a contemplative, diagnostic plane to more vital, concrete actions to protect and restore the environment, and repair the damage.

d) Current distances and journey times will get even shorter due to the development of information and communications technologies and astronautics - one of the premises of a globalised world.

e) Globalisation, as a phenomenon, will not only include the closeness of nations, their leading politicians, scientists and artists, but will also continue to influence integration between the different branches of scientific expertise and technological development. The boundaries between different fields of knowledge will become less defined, visions of systems will become more important and hopefully the methodology and scientific ways of thinking will have greater specific weight in political decisions and the course of human civilisation.

f) Interactions between the approaches and results of studying the cosmological mega-world, the world (including the social outlook) and the micro-world will be more clearly articulated, apparent and useful.

g) Education, especially higher education, will be more widespread, of a high standard and rigorous, giving rise to new methods with more inclusive perspectives and ethical instruction that protects and believes in essential human values, which is a premise for the sustainability of civilisations.

You identified changes in future society; could you point out some possible scenarios that may arise?

A Latin America and the Caribbean with a prominent degree of social and economic integration. With intense artistic-cultural and scientific-cultural exchange, including shared long-term science and technology projects that narrow the gaps between our countries and developed countries and have a decisive impact on the vast majority of the population's way of life, thinking and acting.

What would the implications be for your professional area in each of the scenarios described?

As a physicist devoted to Biophysics and Medical Physics, in particular molecular imaging, I would say that the systemic vision of the biological world will reach a highly prominent and useful position. Molecular and cellular information and information concerning tissues and organs will be described increasingly analytically, quantitatively and systemically, enabling early, personalised diagnoses and therapies that are minimally invasive and available to the entire population. There will be processes producing new drugs in formulations that are intelligent and externally governable, with new implantable nanodevices for curing disease, and for correcting anomalies in an organism's different structures and functions. They will gain momentum and have an impact far beyond human biology, into veterinary and plant biology.

What professions and/or professional approaches in your area do you envisage in each scenario?

Going back to what I said earlier, Theranostics forms part of the contemporary scientist's day-to-day business, and mine in particular. It is the formulation of structures on a nano scale that simultaneously contain elements which guarantee a diagnosis (particularly through imaging), combined therapy (various medicines or physical-chemical actions at the same time), and elements ensuring their suitable and selective bio-distribution and control. Examples of nanoformulations already exist. Nonetheless, many scientific and legal issues have yet to be resolved for these events in the new field of science to have any real impact on each individual's quality of life. They will only be possible with a strategy that combines Physics, Chemistry, Biology, Medicine, the Pharmaceutical sector, and Molecular and Quantum Electronics. There is also an urgent need for health systems, the scientific sector and the medical-pharmaceutical industry to join forces more effectively so that new products are truly targeted against the most common diseases and the time and cost from research to production reduced.

What competences will these professions require?

Although other characteristics might be worth a mention, I will only refer to the following to make my point clear. In contemporary society, thanks to automation and computerisation, many processes —even scientific and research processes— will tend to get easier. Such a favourable situation, despite being beneficial as a whole due to its high productivity of social processes, including science, has detrimental aspects. Everything is easier - you don't always need to understand how technology works, or the essence of its composition, or the nature of its output, to make use of it. The most important competences, from my point of view, should be:

a) Motivation, and also humanism, for scientific creation.

b) Overall, global vision of processes.

c) Solid, basic training and broad cultural education.

d) Devotion to the truth and objectivity.

e) Power of critical analysis.

f) Ethics, human and social commitment.

What, in your opinion, would be a possible but highly unlikely scenario?

That Man and humanity self-destruct.

What professions and competences would be important for your area in this unlikely scenario?

All professions! The most important competence in this highly unlikely scenario would be human and social commitment. When we stop to think about it, we realise that human beings are just a miniscule and fragile part of the universe, and what we have done for science is at best tenuous compared with what remains to be done in our America. Scientists like me represent no more than 0.1% of the world population. The authority of science and scientists does not, however, depend on this figure. We should make our presence felt much more, rise to this social challenge. At least two prerequisites can be derived from this context:

a) We must defend the human race, life, nature and the planet even more; rid ourselves of wars for spoils, the squandering of resources, irrationality, inequalities and injustice.

b) We have to constantly look for more efficient ways for science to have greater impact on our people's wellbeing, favouring genuine sovereignty, development and equity in our America.

Schools can do a great deal to achieve this.

ECUADOR

Interviewee profiles

They are qualified physicists from the ESPOCH School of Physics who have specialised in the United States and Europe respectively. Dr Jenny Orbe is currently Director of the School of Physics and Mathematics at ESPOCH's Faculty of Sciences, and is also working on several research projects. Dr Dennis Cazar is a researcher into nanotechnology and is leading and taking part in several projects, with broad experience in the labour market. He worked in Europe for over 15 years, where he obtained his PhD and returned to work at the School of Physics at EPOCH's Faculty of Sciences.

Characterisation of future scenarios

Widespread proliferation of data sources; globalisation; collaboration between different investigative groups or social curiosities; rapid social changes; fast communication; easier exchange of experiences between working groups; changes in people's lifestyle and education; the issue of energy generation, distribution and use; more intensive use of renewable energy; significant advances in technology, biotechnology and science.

Professions envisaged in each scenario

Professionals in Environmental Sciences, Electronics, Communications; for professional physicists who are studying: Solid State Physics, Materials, Biological Systems, pollution issues, recovering polluted areas; biological systems that can examine molecular dynamics, computational simulations to make models explaining the functioning of multi-particle systems with complicated interactions and nanotechnology; studies of materials at a nanoscopic scale to be able to study the properties and modify them so that they can be used for a specific application.

Competences required for these professions

The competences envisaged for physicists basically relate to having a good command of the principles governing them and the essential tools such as Mathematics, Computing and so on, as well as professional conduct and ethics, the effective communication these professionals should have, commitment to their on-going training and to knowing about the local and national environments related to their profession.

Other comments regarding the future

It is also thought that the problems involved in implementing technology in production processes will make the gap between rich and poor wider for both people and countries; problems adapting to radical changes, and in the case of energy, we need a change. Society must become aware of the need to save energy; physicists are the people who need to set the standards and present innovative ideas and new ways of looking at things that make people think about how there are ways of evolving quickly using the capabilities we possess; we should also give physicists the chance to come up with «the crazy idea» that I can provide solutions to local problems by studying the basic principles in order to give guidance on what can be done.

Interview with Dr Jenny Orbe (Director of the School of Physics and Mathematics at ESPOCH)

Dr Jenny Orbe, Director of the School of Physics and Mathematics, and a professional in the area of Physics, graduated from the United States. The Tuning Project would like to ask you a few questions to get an idea of your opinion on future scenarios that may arise in different professions, and the characteristics these professional should have. In order to do so, we have prepared a set of questions to be considered.

Dr Orbe, what changes do you think society will undergo in the near future?

Changes can be classified from different points of view, and so from different sources. When someone talks about changes and thinks about 2030 or 2032, the first thing you think about is climate change, which is what we are experiencing and feeling now; the second thing you imagine are changes in energy production. I suppose clean and natural energies will be used in the future. The significant and rapid progress of science and technology will also involve changes in people's lifestyles, since we now know that knowledge is the most valuable thing that today's society possesses and so extremely radical changes will come about in education, as will many interesting challenges in future society.

What will be the implications of these changes, and this scenario you have mentioned, particularly for the area of Physics?

The scenario I imagine is a globalised, interconnected world, a more humane world, a world where people have longer life expectancy, where the aging population increases while the young population decreases, meaning that the economically active population, especially in developed countries, will be close to 75 years of age. The fact that we would only rely on elderly people to take charge of the industrial institutions in different countries around the world would therefore be a social issue.

How could the development of Physics contribute in this scenario?

I imagine a society where houses are energy efficient; people eating genetically modified food; Electronics; we will also be engaging Communications and Systems experts. These high priority areas can be envisaged in future society.

What competences do you think these professionals should have in order to tackle these challenges?

In today's society, or in the next 20 years, I think competences are classified in the following way: competences that are specific to each profession's degree qualification and competences that are common to professions. I do believe that we ought to place emphasis on common competences, especially those to do with professional conduct and ethics, the effective communication these professionals should have, commitment to their on-going training and to knowing about the local and national environments relating to their profession.

Another of the Tuning Project ideas is to find possible but highly unlikely scenarios that can be specified. Which of these possible scenarios that may arise in the future do you think, due to either political or economic circumstances or practical application, would not, in fact, take place in the future?

When you think about society in 20 years' time, you also think about the problems involved in implementing technology in production processes; it will mean an increasing reduction in the workforce. Companies in industries will have no need for so many workers and so unemployment will rise; this has the implication that the gap between rich and poor will gradually widen over the years. Inequality will gradually increase primarily between countries and then between people with opportunities and those we would call poor, living in the same country.

How do you think people should be trained in Physics in order to contribute to overcoming this problem, which may arise?

In society of 2030, I imagine scientific research will play a major role and we, as physicists, as Ecuadorian university lecturers in Latin America, must get involved in research in order to bring on the changes we believe future society will undergo. When we carry out research, when we think of the information society, the knowledge society, I am convinced that brilliant minds and state-of-the-art laboratories around the world are what will build future society.

In this case, given it is unlikely that these scenarios will arise in the future, but you feel it is necessary to create professions that are trained to this end, what competences should these professionals have, were such professions to be created?

In these scenarios, we can see that Robotics and Electronics are envisaged immediately but when responding to the case you were asking me about, referring to what the most unlikely scenario would be, my opinion is that the gap between the rich and poor will close. In other words, technology would be within everyone's reach and information would reach everyone, and with that information universal education, i.e. reaching the knowledge society, which, until now, has been nothing but a utopia when we talk of achieving such a knowledge society. Hence, the major role to be played by educators of all professions and teachers; it is the educators who would take the leading role. As for competences, I would keep on stressing that, with the passing of time, we shouldn't abandon the idea of a humanistic society with professionals displaying moral and ethical conduct, good practice and who are, above all, committed to their training.

Interview with Dr Dennis Cazar
(Researcher at the ESPOCH School of Physics and Mathematics)

A Doctor in Physics graduating from the EPOCH, he took his post-graduate studies in Italy. He has worked in Europe for several years and, once again, we find him working in collaboration with the School of Physics and Mathematics. We are going to interview him so that he can give us his opinion on future scenarios, particularly in the area of Physics. Dennis, many thanks for this interview.

What is your opinion on the changes that may arise in the near future?

Society in the coming years, as has been seen in the nineties, when the sweeping boom of computers began, will be the globalisation of information, given the ease with which you can get information on any argument anywhere in the world. The Internet has opened up a wealth of possibilities. Therefore, I think that in 20 years' time, this reliance will be much heavier, not only on information but also on the possible collaboration between different research teams, or just social curiosities or social changes because interaction is much easier now, much quicker, because of the means of communication we have now. We have means of communication that enable us to interact, and I believe this trend will be much more pronounced in 20 years' time. We will have electronic devices that will allow us to be in constant touch, in whatever working group, anywhere in the world. We will be able to exchange our experiences more easily and I hope we will be able to focus on key issues in order to design a plan of action. For instance, the energy issue is a problem that will come to the forefront in the next 20 years because we are still tending to use an increasing amount of energy to process information for distribution. We are increasingly becoming a society that needs more commodities, which requires vast amounts of energy. Therefore, strategies to produce and save energy to make it sustainable I see as being one of the most pressing problems to solve in the coming years.

What would the implications be, particularly for the area of Physics, in these scenarios you pointed out?

A period of far more applicative and detailed study for the specific area of Physics, where physicists will have to develop theories that provide practical results. Still on the subject of energy, for instance, in Physics, we have to address the fact that renewable sources of energy with the same or greater efficiency than traditional generation systems need to be produced.

It is an open field: renewable energy systems still have efficiency issues and attempts must be made to find new materials to boost efficiency, new ways of generating energy, or perhaps actual new sources of energy. That's why I think the study of nanotechnology, which is currently very much in vogue, on the increase, will help us develop new materials for both generating and consuming energy. We will be able to consume less energy and do the same job as traditional methods do now.

What professions or professional approaches should be assigned to physicists in order to deal with these scenarios and implications?

For physicists to deal with these scenarios, it is essential that Solid State Physics and Materials are studied; the relevant area of Biological Systems could also be studied, for instance, issues of pollution, recovering polluted areas, which, for example, in the case of our school, could be studied through molecular dynamics or computational simulations in order to generate models explaining the functioning of multi-particle systems, complicated interactions and, as I said, the study of nanotechnology, and materials at nanoscopic scale to be able to study their properties and modify them so that they can be used for a specific application.

What competences do you feel these professionals should have in order to achieve these objectives?

In the case of molecular dynamics, which is what I have been working on recently, physicists must have very good grounding in Electromagnetics, Statistical Physics, Analytical Mechanics and, for more advanced applications, Quantum Mechanics as a basis and mathematical methods for generating models, simulations, Montecarlo simulations and everything relating to mathematical models as support materials. They must also have grounding in Computational Physics; mathematical models applied to basic problems in Physics. Sadly, and luckily, physicists can't be far from computers, so they have to learn to programme them, and not just computers. We are moving towards high-performance computers, which have fortunately come down in price, like computer clusters or computers working in parallel. I don't feel it is necessary to have this type of processing knowledge - physicists don't need to go into programming like electronics or systems engineers do, but must understand how this process works so as to be able to interact, offer suggestions and improve such processes.

In this respect, do you envisage any scenarios that are possible but, for some reason or other, will not arise?

More than anything, social issues can cause anything to happen. There are certain societies that are somewhat reluctant to make radical change and in the present age, as we mentioned, in the case of energy, we need a radical change, not only in the way of conceiving how we generate and distribute energy, but also more in the way we use energy. Society needs to become aware of the fact that a radical change must be made in order to maintain current standards of living. We can't maintain it with the energy systems currently in place. We are going to overload the distribution networks completely, we are going to deplete all existing energy sources and this is going to pose an extremely serious problem for the planet itself. So, as I see it, resistance to change is the most challenging thing, becoming aware of the need to save energy, to save natural resources, the way we do things needs to change. We are so used to doing the same things and we don't want to change. I see that here in Ecuador and in many parts of South America - people still aren't aware of the importance of recycling, producing efficient, loss-free energy capture and supply systems, making investments in infrastructures that are not envisaged like other types of work. It's easier to design a beautiful building than design an efficient building, which may be much more costly, much more difficult to do but, in the end, it will give me a different way of seeing things. That is what society needs to realise. That is the point, not to think that a change must be made for the planet but to act now. Social inertia resists certain changes.

In this scenario, do you believe that physicists can somehow collaborate to overpower this resistance, maybe through training in the professional profile or competences needed to be able to contribute to such changes?

In this respect, physicists feel that they are the people most be called upon to make society aware of these changes since, due to our training and the type of career Physics instils in us, we are essentially curious people who wonder how things work, why such-and-such a process exists in nature, and how can I interact or modify it so that it gives the results I'm looking for. Physicists are at the root of all the types of engineering that apply principles developed in Physics. Physicists are the ones who have to set the standards and, up to a certain extent, from a spectacular point of view - for instance, when I was working in Italy at the Carlo Rubbia University, who is a physicist that worked at the CEAIE; A Nobel Prize laureate, after having won the award, he spent much of his time working not so much as a physicist but as a politician, engaged in certain decision-making spheres of society, presenting innovative ideas and new ways of seeing things that made people think about ways of being able to evolve quickly with the capabilities we possess. Let's also give physicists the chance to pursue the crazy idea they can capture energy. For instance, in our country, geothermic energy could be interesting, but we don't have the type of professional that could tell us how to capture heat from the earth. This is a field of energy where physicists could, to a certain extent, participate by studying the basic principles and decide, from there, whether it could be done.

GUATEMALA

Interview with Dr Eduardo Rubio (Doctor in Astrophysics)

What changes do you think society will undergo in the near future (the next 20 years or so)?

I hope the changes to come are positive changes that involve and improve various aspects that I deem essential in our society. I think that if these social aspects fail to change, our society will be doomed to stagnation and dependence, and will fail to achieve self-sustainability. I would particularly focus the changes I expect on these aspects: a) education; b) implementing technology; and, c) aspects relating to the use of natural resources. Each is described below.

a) Changes in education: I feel that the most important changes that should be implemented in society in the near future are those referring to education. Education must be of the highest possible standard, free and secular, and accessible to all our Republic's citizens. It is paramount that the Government ensures that its citizens have access to first-class education at primary, secondary, higher and university levels. The measures we take now will be the measures enabling such changes. Failing to do so would simply lead to a broadening in the gap between those with access to private education and those with access to state education which, in turn, would lead to huge social division. Education would give individuals in our society the chance to become aware of their capabilities and life options and clearly enables everyone to improve their situation.

b) Implementing technology at all levels of society: technology needs to be implemented to make our society one that is safer, more effective and transparent. Implementing technology can improve practically all aspects of our society, from aspects concerning health and safety to transparency and corruption. The administration of the state and its resources can be made more transparent through technology and this is an important aspect with regard to improving people's quality of life in Guatemala.

c) Substantial improvements with regard to the administration and use of natural resources: Guatemala is a unique country when it comes to natural resources. If we do not know how to administer and create ecological awareness so that resources are used sustainably, Guatemala will become overpopulated and likely doomed to suffer the consequences of deforestation, water shortage and the depletion of its natural resources. Moreover, the appropriate use of these natural resources could potentially turn Guatemala into a highly suitable place to exploit as a tourist destination.

You identified changes in future society; could you point out some possible scenarios that may arise?

a) Positive scenario: Through education we are managing to curb the hunger for power and wealth of generations of Guatemalans (10 years) with the aim of showing them that it is possible to build a participative, safe and economically productive society where each, individual citizen is educated and well aware of their rights and obligations.

   Part of this would also involve curbing social decay, taking all types of education to all corners of society and implementing actions to rethink the problem of drug trafficking and eradicate it from society. If these changes were ever to take place, we would undoubtedly start to pass these values on to future generations. And we would undoubtedly build a society that is more open to dialogue, transparent and socially aware - a truly integrated society.

b) Negative scenario: The problems of drug trafficking and social breakdown spiral out of the government's control and we enter a state of anarchy (a somewhat worse situation than now exists in our society). As I am an optimist, I wouldn't want to go into this scenario more than I have done already, and I hope we never come to such a situation.

What would the implications be for your professional area in each of the scenarios described?

In my particular case, I am an astrophysicist and one of my plans is to try and develop an astrophysics group at a higher education establishment in Guatemala, as well as developing educational projects connected with astronomy. In order to do so, I need to be able to rely on the support of different sectors of society, the private sector on the one hand and public sector on the other. In order to finance this, I have to create conditions of credibility between both sectors by applying policies of total transparency. It is also necessary to increase both sectors' interest in natural sciences and change the mentality and show that it is possible to train top-level professionals in our country. That is why what I want to do is to promote education at all levels, with the aim of having sufficiently motivated and responsible students who take up the offers higher education establishments may put to them, and ensure that these new generations continue this tradition and pass it on to following generations.

What professions and/or professional approaches in your area do you envisage in each scenario?

I see many applications of what I have learnt to do that can help to improve Guatemalan society in many ways.

We need the professionals who train us to be able to tackle the specific issues that may arise in a place like Guatemala. For example, an astrophysicist is trained to be able to make mathematical models describing real situations, which means they can take part in more everyday problems like solving systems to describe traffic or climate patterns using mathematical models.

What competences will these professions require?

Professionals will need to be created with the capacity to deal with and solve national issues and contribute towards solutions. In order to rise to this challenge, the public and private sectors will need to stimulate fund-raising for scholarships for talented students who deserve to pursue their university studies and so be trained to face the challenges national issues will pose. These professionals should be highly trained and should aim for full university education: degrees, master's degrees, doctorates and fellowships. The policies implemented should also, in part, highlight the importance of having our own scientists and personnel who are qualified to solve problems. A policy of excellence and pride needs to be implemented by the Guatemalans of something «made in Guatemala».

Interview with Carlos Esquit (Electronics engineer and physicist)

In the context of Electronics Engineering, what changes do you think society will undergo in the near future (the next 20 years or so)?

On a global scale, a possible polarisation of the approach or application of Engineering is perceived. The exponential development of the role of electronic devices has fuelled a highly competitive, worldwide, billion-dollar industry, and the semiconductor industry, which, in turn, has stimulated the creation of a lot of large and small companies devoted to electronic design around the world. Polarisation might occur due to the fact that, on the one hand, countries, universities and syllabuses could focus on a more «integrated» approach to Engineering than on pure design; many companies produce electronic devices and equipment that can then be used by Engineering students and engineers to carry out what is called «integration», whereby engineers only use the devices and equipment to implement an application that solves the problem, meaning that they are more users than engineers. On the other hand, these devices and equipment have been designed and produced by the other group in our polarised scenario - the engineers working for companies that actually carry out engineering design, who definitely must have been academically trained so as to be able to respond to the competences needed for pure design, i.e. with a more scientific and rigorous approach.

Such polarisation is already becoming apparent. Were it to take hold and prevail in the near future, it would be critically significant, with negative implications for developing countries, as it would «condemn» these countries to staying on that track. They would fail to achieve their objective of development due to the fact their engineers would be integrators rather than designers, and so science and technology would keep on being imported.

There should always be professionals at both extremes, as some need to do research and development, and others applications. However, it is not considered right that a country only adopts core area of application (integration).

The fact that there is a current move towards professionals with degree training combining different fields (for example, Electronics and Mechanics, Computer Science and Administration, etc.) is very interesting. This phenomenon encourages polarisation towards integration, and in no way helps polarisation towards design as there is no doubt that professionals will have fewer expert design competences if they take on several fields at the same time because they do not go so deeply into each one (useful characteristics for integration engineers but useless for design engineers).

You identified changes in future society; could you point out some possible scenarios that may arise?

One scenario relates to the academic field: universities focusing on training pure Engineers (more research and design) and other universities focusing on training integration engineers (more application/use).

Another scenario relates to the field of employment: integration engineers would work chiefly in their countries of origin, while design engineers would look for and/or find more opportunities abroad (with reference to developing countries).

Another scenario relates to the economic field: the dynamics of this scenario would be more difficult for me to explain as I am no expert on the subject, but polarisation on a national scale would surely have implications in terms of the country's economy, helping the economies at the design core to strengthen, while it would not be conducive to the economies at the integrating core.

What would the implications be for your professional area in each of the scenarios described?

The academic scenario involves the Government and university authorities having to take policy and strategy decisions in order to respond to this possible polarisation. Syllabuses must be designed to cover both approaches separately so that the competences needed for each core theme can be developed in professionals. In this way, the country isn't confined to just one core theme.

In the employment and economic scenarios, the implications could be very negative if there are no professionals trained in both extremes, since being polarised on the integration side, there would be negative self-feedback effects, increasingly reducing the chances of development.

What professions and/or professional approaches in your area do you envisage in each scenario?

The two approaches I mentioned earlier, the first being that of integration engineers - who basically use devices, equipment and software to implement solutions - are engineers with a more practical approach that does not involve research or in-depth analysis. The second professional approach would be that of design engineers - I mean, engineers more focused on research and development. In this second approach, all engineering specialities would play a crucial role in a country's development.

It is important to point out that the multidisciplinary education I mentioned in response to the first question is obviously a professional approach, which is not regarded as favourable to scientific and technological development but is sadly suited to a developing country's requirements, where many employment scenarios need a professional to be «multi-purpose».

What competences will these professions require?

The most interesting professions are regarded as being those with a design approach because they provide the conditions (technical conditions) needed for solid development. In this case, the following are included in the macro-competences: a) analytical thinking; b) self-learning; c) command and interpretation of mathematical and physical tools; d) command of state-of-the-art hardware and software tools; e) capacity for research and development; f) teamwork; and, g) oral and written communication. Analytical thinking and self-learning are regarded as the most important competences for present-day Engineering and Engineering in the near future.

Interview with Carlos Rolz
(Chemical Engineer. National Medal of Research.
Former Dean of the Research Institute)

What changes do you think society will undergo in the near future (the next 20 years or so)?

I think society will: a) implement a policy to recycle renewable materials used as raw materials in fuels and chemical products in biological biorefineries; b) apply biotechnologies widely in agriculture and the production of pharmaceutical drugs; c) develop better materials that will enable full virtual communication; d) come up with measures to curb human growth; and, e) devise mechanisms to solve social and economic inequalities.

You identified changes in future society; could you point out some possible scenarios that may arise?

a) Municipal and industrial sewage treatment plants will become energy-producing companies.

b) No solid waste will go without use.

c) There will be combined production of energy and food.

d) Genetically modified crops will become widespread.

e) There will be a wide range of affordably priced transgenic pharmaceutical drugs such as vaccinations and monoclonal antibiotics.

f) The large digital information storage hubs will become more efficient in their energy use.

g) Genetic therapy will be widely used and will influence human reproduction.

What would the implications be for your professional area in each of the scenarios described?

Multidisciplinary teams will have to participate in all these scenarios, and we, the engineers, will have to learn about medical, nutritional, physical and chemical issues. Conversely, molecular biologists, chemists and biophysicists will have to gain insight into mathematics applied to solving real problems and understand the principles of all the Engineering sciences.

What professions and/or professional approaches in your area do you envisage in each scenario?

Engineering in Life Sciences or Biological Engineering applied to all the scenarios.

What competences will these professions require?

a) Biophysics.

b) Biochemistry.

c) Data Mining.

d) Molecular Biology.

e) Bioinformatics.

HONDURAS

Brief description of the interviewees

Edwin Romell Galo Roldán is a professional Physicist who has held a variety of different positions in the academic world of Honduran universities. He graduated in Meteorology from the University of Costa Rica. He then joined the National Autonomous University of Honduras as Physics Professor, where he was also appointed Head of the Physics Department. He later went on to work in the private university sector. He has been Professor of Physics and academic administrator at UNITEC, San Pedro Sula Private University and currently works as Professor of Physics, carrying out a variety of academic administrative duties at the Technology University of Honduras. He is also a graduate from the University of Barcelona with a Master's degree in the Management of Teaching Centres.

Carlos Alberto Tenorio Moncada holds a BSc in Physics from the National Autonomous University of Honduras and a Master's degree in Seismology from Bergen University in Norway. He has devoted his career to research into the field of seismology. He is currently Senior Lecturer of Physics at the National Autonomous University of Honduras. He has been Academic Coordinator of the Physics Degree Course at the UNAH.

Characteristics of the future scenarios considered

At least 3 changes in future society were identified:

a) One relates to energy, the region and country's future energy demands.

b) There will be demands on the service industry.

c) The region's vulnerability will be a problem demanding a great deal of attention by the scientific community.

d) The foreseeable breakdown of the national education system with growing movement towards the privatisation of education.

e) Widespread expansion in the use of information technologies.

Professions envisaged in each scenario

a) Physicists devoted to education but with thorough technological training.

b) Professionals trained to offer technical backup in the field of the prevention of natural disasters (meteorologists, astrophysicists, seismologists, and so on).

c) Physicists trained to address the area of alternative energy.

d) Professionals in the field of Medical Physics.

Competences needed for these professions

a) Command of new information and communications technologies.

b) Training in programming (Computational Physics); using different versions of commercial and free software.

c) Ability to conduct outreach activities for scientific ideas.

d) Solid training in mathematics.

Other relevant comments on the future

a) The breakdown of the formal education system envisaged can be attributed to government policies in the area.

b) The scenario involving natural disasters in the region seems rather gloomy.

c) Four possible scenarios are highlighted: the energy scenario, the services scenario, the health scenario and the scenario involving environmental vulnerability.

Interview with Carlos Alberto Tenorio Moncada

Carlos Alberto Tenorio Moncada holds a BSc in Physics from the National Autonomous University of Honduras and a Master's degree in Seismology from Bergen University in Norway. He is currently Senior Lecturer at the National Autonomous University of Honduras, where he has worked for the past 18 years. He has held the position of Physics Degree Course Coordinator, but has developed his career more in the area of teaching and research in the field of seismology.

Carlos, we have chosen you for this interview, acknowledging that you are a young and highly experienced professional and researcher in the academic field. A questionnaire has been prepared for this interview with 7 main questions, which I am going to ask you and will then be used in an analysis being conducted by the Tuning Project for Latin America. As a general guideline to this interview, please feel free to express your point of view openly; afterwards, the information will be transcribed and compiled in a database with the opinions of other experts from the region.

The first question: I would like to know your opinion on the following: what changes do you think society will undergo in the near future (the next 20 years or so)? I would be most grateful if you could focus your analysis on Honduran society in particular, and then on Latin American society as a whole. What changes do you think our society will undergo in the Central American region?

Well, I can't envisage many radical, qualitative changes but more a continuation of the same trends we have seen in the past 20 or 30 years. If anything, the changes will be in the number of aspects we have been seeing. I could mention a few aspects: the economic aspect, we will continue to see the effects of instability, possibly economic in the developed countries. Crises in economies that go through brief periods of growth and then financial crashes take place, as we saw in 2008, which affect us by causing economic turndowns that have repercussions for our economies. On the other hand, with regard to the social aspect, as a result of these economic difficulties, we will continue to see the deterioration of social conditions. Perhaps the social instability stemming from conflicts relating to delinquency, drug trafficking and social decay we have seen over the past 30 years will continue to increase. On a political note, we will undoubtedly continue to see the debilitation of state institutions. Seeing it from perhaps a very pessimistic point of view, the signs of the breakdown of the State as a regulating body can already begin to be seen in our country, such as proposals to build model cities and services normally belonging to the State beginning to be privatised. As far as science and technology is concerned, perhaps, on the one hand, scientific advances in the fields of communications and health might, of course, lead to an improvement in the standard of living and living conditions, but only for a small proportion of the population because of limited access to resources.

Following on from this question, Carlos: if you had to point out 2 or 3 changes that might emerge in Honduran or Central American society in the future, what, in your opinion, would those 2 or 3 changes be that might take place in the next 20 years?

One of them would be the breakdown of traditional education systems due to social conflict or the economic situation. It can be seen that the State is increasingly incapable of providing satisfactory nationwide education, so a crisis in education may well erupt. In the next 20 years, there would be a breakdown of education systems, which would be incapable of guaranteeing education - the same as in the health and social security systems, on the one hand. On the other, the population's vulnerability to natural disasters and seismic and meteorological catastrophes would increase as a result of overpopulation and the shortage of State resources to find solutions to such situations. Another scenario I can see is, paradoxically, the technology aspect - the widespread expansion of information technologies. Despite the fact that these technologies are highly advanced and cutting-edge, the cost of such resources has, paradoxically, come down. This is perhaps, therefore, the only aspect of technology that is widely accessible to the population.

Anyone can have a mobile phone, anyone can have an Internet connection, but not everyone can have a vehicle, which is traditional technology. In this case, despite the lack of resources, it is often easier for someone to get an Internet connection or mobile phone than it is to get access to medical services or traditional education, which are increasingly difficult to get.

You identified two aspects (let's see if I remember them both): the breakdown of the education system and the rise of information technologies - also, vulnerability to natural disasters. So, there are 3 aspects. You have identified at least 3 changes in future society: one concerning the breakdown of the education system, and another concerning information technology and a third to do with natural disasters. Carlos, can you highlight *some possible scenarios that may arise here in Honduras, or in the surrounding region, related to these 3 changes you have pointed out? Possible scenarios involving the breakdown of the education system, information technologies, and our vulnerability to natural disasters? One or two possible scenarios for Honduras and the region?*

The breakdown of the traditional State-funded education system is due to the fact that the State is lacking in financial resources and has major political issues that prevent the smooth functioning of the education system. So, unfortunately, a scenario that I can foresee is the privatisation of education: education shifting towards private commercial interests.

At all levels or only in higher education?

At all levels, basically, especially at the level that matters most: the basic level, primary level. A negative consequence would be the other scenario since large sections of the population will be neglected, they will have no access to quality education; the traditional systems will be full of conflict involving the teachers' unions and the quality of education very poor. As a matter of fact, another scenario connected with this one is, in fact, that something needs to be done, and in this respect, introducing cutting-edge information technologies could be the answer, given that their cost is low compared to the traditional system. A boost in these technologies funded perhaps by international organisations or through aid programmes could help correct this deficiency. This has already begun, for example, at the INFOP, the Institute of Professional Training, which now offers online resources and e-learning completely free of charge, and which helps to improve the situation we were talking about.

So, Carlos, you have already touched on the subject of information technologies, only you did so from the angle of the breakdown of the education system. But on the whole, regarding what has come to be called information technology, what do you see as being the possible scenario or scenarios for this country?

First of all, the aim must be for these technologies to be used positively, to expand the use of low-cost devices in schools and colleges, and somehow set up the education programme online in the area of science and technology and all the branches of human knowledge to make up for the disadvantages of a system that has collapsed due to the traditional system's policies and lack of resources. Then the younger generations can gain unconstrained, widespread access to information.

On the subject of vulnerability, how do you imagine the scenarios, if vulnerability to natural disasters does emerge in the next 20 years? What are the possible scenarios facing the country?

Shambolic urban growth, not necessarily just in large cities but also in every single municipality, in every village. There is urban growth and people have no information on the geological conditions; the areas where homes are built are often prone to flooding or landslides, for instance which, in the end, incurs a lot of cost when the hurricane season arrives or there is an earthquake, or simply due to the natural instability of the ground, which gets waterlogged in a heavy downpour. All of this could be prevented, but there are no professional personnel to advise people on geology; there are no engineers in geotechnics associated to some town council. Each town needs a geologist who is familiar with the local geology and can draw maps showing the seismic micro-zoning of the neighbouring regions.

In the previous two cases – the breakdown of the education system and information technology – you suggested, as it were, the scenario of disaster building, but you also suggested an alternative scenario that could emerge as a solution; in the case of vulnerability, you have already highlighted the scenario of disaster, I mean, if we carry on growing shambolically, without the help of enough scientific and technological information, we can hardly expect things to go well. What would be the positive, «proactive» scenario, as it were, that you might envisage? (Real)

Everything depends on the State policy-making agencies' readiness to train professionals and fund studies that can, at least, provide people with information, which is what is needed right now. People don't know what the threat is in a certain place. All of this has to be built up gradually and involves a huge amount of research work: desktop studies on impact models of flooding and earthquakes, discovering land deceleration in the case of seismic events. All of this should be done via State support and by looking for external financing.

Of the three things you pointed out that might happen in the future, in the first two – the breakdown of the national education system and the emergence of information technology – you assigned an important role to private enterprise, and in this third one, to the State, with the help of international cooperation or international funding. In each of these scenarios, what would the implications be for your specific professional area? What would be the implications for future professionals specialising in Physics?

To start with, in the case of technology, there are two things. Firstly, physicists geared towards teaching must be qualified in the use of technology, not only in programme design and courses in themselves, as I believe I mentioned earlier, with the support of people trained in graphic design and such like, but they must also be capable of socialising and promoting low-cost operating systems for the IT development of such platforms; also free software, which can be distributed without the high cost of licences, and the use of devices and equipment that are not as costly as traditional desktop computers. They could be low-cost tablets with user-friendly operating systems, which are not that expensive, and they could be easily accessible to people in need of such resources. Thus, in the professional area, people devoted to teaching Physics need to have technical training in the use not only of computers, mobile phones or tablets but also free software applications that are accessible to the population at large, which is their purpose. Turning to the case of natural disasters, we also need professionals in the area of sciences, in the area of Meteorology, to supply backup to local authorities and municipalities in order to prevent such disasters.

In these three scenarios you describe I can see direct implications in the training of present-day physicists, that is to say, do these 3 scenarios need to be taken into account when reviewing the curriculum we are working on?

Yes, considering the situation we are in. We are not a developed country and we have no resources. It is difficult to imagine scenarios where research into cutting-edge Theoretical Physics is developed. Here, in Honduras, it is hardly likely that things like that will happen because of the brain drain. There are outstanding students who have to leave the country in order to pursue their activities - it is extremely difficult to succeed here. Yes, there is indeed a need for teacher training in Physics and instruction in the use of information technologies, devices, operating systems, free software, graphic design, web page design, online course design, and educational applications development. The training of physicists who are going to teach Physics should no longer be typical, blackboard training, but rather training that gives them the skills to programme, design interfaces and courses, and make videos and recordings for the public at large; and the commitment would be to all those people who no longer have access to a secondary school classroom, perhaps at university level, distance learning. This would therefore be an integral part, not just in terms of Physics content, but also training in programming and technology.

You have been coordinator of the Physics degree course, and are familiar with the syllabus and current curriculum for training Physics Graduates. Do you feel that new areas related to the scenarios you described will inevitably need to be included when this curriculum undergoes thorough review? What would your priorities be?

Some need to be modified, but essentially I feel that the spirit of the Physics degree should be upheld. We can't subordinate everything we do. We can't subordinate it 100% to the environment, to the problems we have, to social, political and economic issues. These factors should not have complete control over what we do. We mustn't lose sight of traditional science, although a component addressing teaching is needed, especially addressing the dissemination of ideas that are complex and only normally studied at Master's degree level, such as concepts of Modern Physics, Quantum Mechanics and Field Theory. It is a question of gradually shifting them to higher, undergraduate education or even socialising these concepts at secondary schools and the fundamental ideas of Modern Physics. In this case, pedagogic training is needed with an element of technology and design, and online education issues for those professionals who eventually find ourselves in education - and we need to keep up to date.

What would the implications be for professionals in the field of Physics? We have talked about training; so now, if I have a group of professionals in the field of Physics and these three scenarios arise, what role should physicists play in a system that has collapsed? What role should physicists play in relation to the boom of information technologies and the increase in problems with vulnerability?

Physicists trained in geosciences such as meteorologists, astrophysicists and seismologists are obviously in a position to do something. At least they can study the environmental conditions and try to spread the information among the population that need it, with institutional support, of course, because the instruments are very costly and studies can't be conducted from behind desks. On the other hand, it is the responsibility of physicists with theoretical training to spread their knowledge in a society where there is practically no way that young people in secondary education or in their first years at university can get nationwide access to this information. There is no chance for them to learn Physics, which is one of the basic sciences. It is the responsibility of physicists to convey the work they do, spreading the knowledge they have either through videos, web pages or programmes designed to be distributed via easy-access, low-cost mobile devices, perhaps with the support of state programmes to popularise the fundamental ideas of Physics - because we can't afford to have a scientifically illiterate population. We can allow the population to tend towards basically being users of technology, who don't produce science, but it would be truly pitiful to see an entire nation of people who use technology but have no general knowledge in this respect.

Now, Professor Tenorio, I would like to ask you, in each of the possible scenarios that you have described in this interview, in our professional area, your professional area, what professions, within the professional area of Physics, and within the field of Physics, and what professional approaches in your area can you envisage? For example, in the field of vulnerability?

The strictly professional approach would involve training in geophysical exploration; in Geotechnical Engineering, the use of traditional geophysical techniques to detect subterranean structures, the reception of seismic waves, setting up seismological networks to be able to get an idea of a region or country's seismicity, monitoring ground movement via GPS.

You said that new physicists, with regard to information technologies, will need to be able to use free software competently, which will enable them to use tablets, mobile phones and other devices that allow communication with society and the public as a whole, and this could break the traditional circle of exclusive communication among professionals, characterised by its strictly technical language. That is my brief recap.

You have pointed out three possible scenarios, and the professional approaches you envisage in those scenarios. Now, you have already responded to a certain extent, but I'll press my point: what are the most important competences these new professions will need? You already mentioned the ability to programme, the ability to use instrumentation in the case of vulnerability, but I would like you to tell me exactly, I insist, what are the basic competences you would identify? For example, to address the breakdown of the education system?

For the breakdown of the education system, supposing you find yourself in a position to collaborate on a project, we would need training in the use of different programmes; calculation programmes, programmes whereby you can make physical calculations, such as Mathematica or Matlab, as well as alternative, free software such as Máxima. In addition to traditional, paying operating systems like Windows, you will need to be familiar with Linux, Android and other operating systems that have emerged, and have some programming and application skills, be able to use programmes to develop online courses, or at least have an idea of how to develop a pedagogical video on Physics, how to develop a presentation that is not too over-elaborate and is suitably designed to be included as a subject in an online course. As far as the scenario regarding vulnerability is concerned, slightly more technological training is needed in Geophysics and practical applications of Geophysics, especially supporting the exploration, design or identification of areas of vulnerability. Another aspect we are missing is the drafting of documents and verbal and written communication skills. This also needs to be improved, besides the question of technology.

What —in your opinion, Carlos— would be a possible scenario in Honduras or in the Central American region that you would consider highly unlikely? Choose one of the three ideas you have been elaborating on, but it must be highly unlikely.

A possible but highly unlikely scenario, of course everything is possible if there is a will, is that we actually manage to save the State institutions, they get stronger and the trend we are seeing whereby the State is increasing losing its role in the face of the power exercised by multinational companies and organised crime is reversed and actually starts going the other way. There needs to be a turning point at which the State strengthens its institutions and is capable of providing quality education.

So, this is a possible scenario, but just because the trend is the opposite, is it highly unlikely?

But we hope that this trend can be reversed, and in the future we will once again see State support for research projects, the creation of research institutes and not simply fight fires or catastrophes, and we can resume the tradition of western civilisation of becoming involved in science simply for science's sake.

So, this unlikely scenario requires the basic premise that the State regains its identity and capacity for management leadership. Supposing that this unlikely scenario arose, Carlos, what professions or competences would be important for our area of science? If investment was made and professionals trained in this area, how should this resource be used if we were given the privilege? If physicists were told that we were going to work on these three topics, how should this resource be used suitably?

Well, in that case, the approach changes from strictly attempting to solve a completely chaotic situation to other matters which are slightly more applicable to pure Physics, to research. We could start thinking about developing other branches of science that have been neglected here, that is if I understood the question correctly, as the State would have the resources to award scholarships, I mean, for other things apart from natural disasters.

In your opinion, would we have to train resources?

The breakdown of the education system has now become an emergency situation, and obviously the most important thing for the country is that it does not die, that the flame of knowledge and love for science doesn't go out, that the embers keep on smouldering amongst the population. If the trend of crises were to be reversed and progress was seen, we could think about creating research institutes like in Brazil and other Latin American countries that have crossed that barrier and, in spite of having their own major social issues, their own misery and poverty like us, they can afford not to neglect Theoretical Physics, Particle Physics, Materials Physics, and other things that keep up with the pace of research demanded by the world.

There is a subject we haven't touched on that is having a lot of impact on the national economy: the energy issue. Even though you haven't mentioned it, I would like to know your response. If this were one of the possible scenarios —the energy issue— what would you recommend if the country decided to invest in the field of energy? What would you recommend to physicists?

It is definitely a subject we haven't mentioned, but it is obviously extremely important. In this respect, there is a void in training related to alternative forms of clean energy, which, to a certain extent, may be costly because the country doesn't have the technology to produce equipment that harnesses solar, wind or water energy. As for engineering, what is most needed here is a branch of Physics, but I see it more as being an area of Engineering.

Carlos, we are coming to the end of the interview and your development of the three key ideas you have put forward is clear to see. Is there anything you'd like to add, since we are reaching the end of the interview? Is there anything that you feel you have missed and would like to stress now, just to finish off?

Well, it is probably quite difficult to know what is going to happen in the coming 20 years. The only idea you have is of what has already happened and is based on current trends. You can perhaps envisage the same scenarios in the future, and in this respect, we are concerned about the role we, as physicists, can play, not only in the country's development but also in the field of education, the field where we are responsible for the conservation of knowledge. Even though we don't have the conditions to develop new research expertise, perhaps the time is not right, we *do* have the responsibility to ensure that what we know does not just stay in books, but that the people coming after us have access to the same ideas - the same ideas inspiring us, ideas which make people aspire to noble occupations that are of beneficial use to society, that are not simply personally enriching but have society's development as a whole in mind.

Well, we are most grateful to Professor Carlos Alberto Tenorio Moncada, Senior Lecturer at UNAH, for kindly accepting this invitation to take part as one of the people being interviewed to contribute to the Tuning Project currently underway.

Interview with Edwin Romell Galo Roldán

Edwin Romell Galo Roldán is a qualified physicist in the area of Meteorology (University of Costa Rica). He also holds a master's degree from the University of Barcelona in Management of Teaching Centres. He is a university lecturer and has taught at the National Autonomous University of Honduras and several universities nationwide. He graduated at the University of Costa Rica and has held positions at different public and private universities around the country. He has been Head of the Physics Department at the UNAH and went on to hold management positions at the San Pedro Sula Private University and the Technological University of Honduras (UTH), where he currently holds an academic position, and at the UNITEC, Technological University of Central America. He has many years' experience.

Mr Romell, we have chosen you for this interview, because of your experience in the academic field and the fact you have also employed personnel in the field of Physics, so that you can help us develop a questionnaire on 7 key questions which will be used for an analysis being conducted by the Tuning Project for Ibero-America and Latin America. We have already talked to you about what the overall guidelines for this interview are. What changes do you think society will undergo in the near future (the next 20 years or so)? I would be most grateful if you could focus your analysis on Honduran and Central American society.

Well, good afternoon, Dr Euceda. First of all, I would like to thank you for this interview. It is a rather complicated question to answer with certainty. Nonetheless, it is no secret that the Central American region and society as a whole is lagging a long way behind the rest of the world's regions when it comes to research, as shown by certain public indexes: in North America, around 37% of GDP goes to research; in Europe, 35%; in Asia, 26%; in Latin America, it barely reaches 2%, and that 2% is basically being absorbed by 2 countries, Brazil and Argentina, leaving us, in Honduras as a country, somewhat lagging behind in this area, still living in the second industrial revolution. So, what I envisage in the next 20 years is that the same world has to keep on acting as a model by showing the need for this country to gear its objectives towards situations linked to the country's own technological development.

And if, in this same question, I could invite you to highlight 2 or 3 changes in future Honduran or Central American society, what, in your opinion, would those 2 or 3 changes be?

Well, we here, as physicists, have basically devoted ourselves to teaching, and some of us, due to the actual way in which we were trained, have had to join the academic administration. Nonetheless, I do feel there is a very important, latent opportunity with regard to energy sources. In this country's situation, with a high budget in fuel costs and the budget cost itself, we must draw our attention to non-conventional energy sources, in other words, wind energy, which is less reliant on hydrocarbons. The other area I envisage is the area of services, in the sense that more attention needs to be given to selling services - call it the sale of services, if you like. In the area of Electronics, for instance, where countries like Costa Rica are already doing so, and with great success.

Good, you have pointed out and identified at least 2 changes in this future society. One is to do with energy, the energy demands the region will require, and the fact the country will need to look at new forms of energy, energy other than hydrocarbons; and the other change you highlighted is to do with the service industry. Now, you identified changes in society. Can you highlight some possible scenarios that may arise, possible scenarios for Honduras, for the region, relating to the 2 changes you pointed out?

Well, with regard to services, I think the most important role should be played by private enterprise, and we need to understand that we have to take that quantitative and qualitative leap forward. And regarding energy, I feel that the government has an important role to play because it should act as a model in terms of the need for and incorporation of professionals in these areas in order to develop them. These are the scenarios I consider most relevant.

So, you pointed out that in the energy scenario, the government will continue to play a leading role and in the services scenario, private enterprise will play a significant role. Now, in each of the possible scenarios of the two you described, what would the implications be for your professional area, the implications for future professionals in the field of Physics?

This would be decisive, first of all, in order to avoid a brain drain, which is very normal in the region, the lack of incentive that exists due to the meagre support, virtually no support, for research; the importance it could be given and the incorporation of these frameworks into these scenarios may stop our professionals from leaving the country, they might return to our country or our own universities might even grow aware of the need to strengthen the training of physicists with an employment profile that actually foresees these areas we have mentioned.

So, what you are saying is that in these two scenarios you mention, in the scenario concerning the country and region's energy issues, there are direct implications for the training of physicists.

You have been involved in administrating the curriculum. What would it specifically imply for the professional area, in concrete terms? I mean: well, the country has a visible scenario, which is a scenario regarding the energy issue. How should physicists, the profession of physicist, approach the solution, address this issue?

I think it is the chance to put the curricula and post-graduate courses in Physics under thorough review. Unfortunately, Physics is an extremely open science and it is difficult to create highly specialised employment profiles in degree courses, as they have to cover 4 main areas: Classical Mechanics, Electrodynamics, Quantum Mechanics and Statistical Physics. However, at post-graduate level, you can steer employability considerably so as to strengthen the area of energy, giving rise to a kind of specialist employability, without missing the basics contained in a Master's degree, logically, but tending towards profiles in these areas and the area of services.

That of course reminds me there are several hydroelectric projects underway in the country at the moment, for instance, which are being built and, from what I hear, the Physics curriculum needs to be reoriented in order to exploit the possibility of graduating professionals in the field of Physics who are interested in the energy issue. Now, let's turn to the other scenario you mentioned, the scenario concerning services. Obviously, the service scenario is extremely wide-ranging and you pointed out that private enterprise needs to play a highly significant role in this scenario. What would the implications be for professionals in the area of Physics if the government —for instance, universities— put the service industry or service assignments on the agenda as one of the possible scenarios? How would physicists fit in as professionals?

Well, because of the nature of the area, at degree level training, we must always consider the fact physicists have solid theoretical and experimental training. Then, perhaps within the experimental training, contact with the outside world could be developed slightly more - I mean, with private enterprise or public institutions by going out to solve purely technical problems. Thus, we can make full use of the degree course curriculum, reinforce this aspect and offer a service, this component.

At the beginning of the interview you also mentioned, when you were referring to services, the electronics industry, to what is happening in the world of the electronics industry, in the world, I would also add, of telecommunications. How could these professionals be suitably assigned to tasks in the service industry? Following your reasoning, what would the implications be in the professional area if physicists joined the world of professional services in the field you described, the field of electronics? What are all the implications it entails?

I believe that one of major weaknesses of this generation - my generation - is the lack of focus the syllabus had relating to the area of programming. The area of programming now plays a key role and physicists who don't know how to programme definitely won't be able to join this field. So a great deal of emphasis must be placed on the fact that there should be a very important component in the area of programming so that they can incorporate it into this medium - it is almost an inescapable fact.

In each of the possible scenarios you describe in our, your, professional area, what professions within this profession, or professional approaches in your area can you envisage, for example, in the field of energy?

Well, there are two elements to be exploited here, owing to our country's geographical conditions: one is hydroelectric power, we all know that this is one of the countries, together with Costa Rica, where it most rains and with the fastest flowing rivers, so we should harness this type of energy in order to generate the highest percentage of this form of power. There are a lot of mountainous areas where wind power projects could also be implemented, and with these two components, I believe we could replace the use of thermal energy by almost 95%. So I see physicists in the future as being trained in these two areas, plus an area I would call, and excuse me for encroaching on your field, Computational Physics, which I believe is the field that is going to determine whether physicists logically continue to retain their hegemony, or at least maintain it, because they don't have it in the field of industry, where there is already credibility.

Now, we are missing the other scenario, the scenario concerning services. What professions or professional approaches in our area of Physics do you envisage in the field of services? You talked about energy, now provide us with an example of services.

I referred to the field of programming - this is a determining factor, I mean, physicists are not going to replace computational or electrical engineers, or electronics engineers or chemical engineers, but they can generate all the ideas needed within the same industry to improve development in each of these areas.

Good, you have described 2 possible scenarios, and the professional approaches you envisage in those scenarios. What competences will these professionals need? You already mentioned one: the ability to programme. What others do you think these new professionals will need?

It is very important that we always maintain the imprint we have attempted to leave on our students that distinguishes them from other professions. We normally define physicists as being responsible, critical people who deal with experimental aspects despite not being related to their field of work, but who understand that they *do* need to be developed, such as in the case of Medical Physics and Biophysics. I think that Medical Physics is also going to be an important field. Therefore, it is also important that, in addition to knowing a lot about programming so that they can acquire all these generic competences I have described, the curriculum has a strong mathematical component because knowledge of mathematics is the most important tool for physicists to be able to carry out their work. So, mathematics, programming, and also experimentation will, to my mind, be the basic three components for the development of physicists over the coming 10 or 20 years.

With these competences in mind, I am now going to change the framework of the questions. What, in your opinion, would be a possible but highly unlikely scenario in Honduras or the Central American region?

As I said at the beginning of the interview, the proportions of GDP investment in different regions around the world are immense. Nonetheless, it is not strange for us, nor is it a dream, to think that one day we will carry out true research in our country - scientific research, which you and I know is key to a country's technological development, and, to my mind, this is a possible scenario. Not only governments but also private enterprise would be fully aware of the need to invest in research. Investment in research logically can't be seen in the short term. It's an investment that is seen over time, after many years, but it is the only way to overcome barriers and turn from a developing country into a developed country.

So, what would the unlikely scenario be? What would a possible but highly unlikely scenario be? In short, it is what you just said; I want to be sure I have understood.

Having an important research component.

But it is unlikely investment will be made.

That's what I believe.

What professions and competences would be important for our area if this unlikely scenario arose? I mean, if the region, the country, invested in research and development, what profession or competences in our area would be important? That is, if the money were provided, how would we use this resource you are referring to? In what areas? What professions would have the privilege?

One of the determining factors on this country is the area of health. I believe heavy investment needs to be made in this area.

We are dealing with Physics, so you are referring to Biophysics. It is a new profession, which we didn't talk about earlier, and so we should add a third scenario that wasn't mentioned when we talked about possible scenarios: the energy scenario, services scenario and the health scenario.

Unfortunately this scenario is extremely costly, and that's why I feel it is unlikely despite being part of the big picture.

So one of the professions you mention that I can identify is training physicists in the area of Medical Physics. What competences should professionals have in this area?

Here, we just know how a cobalt pump works, but a medical physicist has to go a lot further than that; they must be people with comprehensive knowledge of Radiation Physics and its consequences, and the treatment of very common diseases in the region.

Well, we are coming to the end of the interview, Mr Romell, and you quite naturally added a new scenario in the closing stages which we hadn't discussed: the scenario concerning the development of Medical Physics, Physics applied to Health Sciences, which you see as being a future scenario. If this scenario regarding Medical Physics were to be cultivated, what implications would it have for physicists if the decision were taken that Medical Physics should be a privileged area?

Well, the country has been making attempts to promote this area for the past 35 years in the belief that it is a fundamental area to support development and health.

Even so, there are 2 or 3 professions (in this field)

Yes, I would say of very little weight. I mean their specific influence within the country's limited area of Physics is very low.

Is there anything you would like to add? We are coming to the end of the interview. Is there anything you feel you have missed or wish to stress?

I feel that we have to be extremely careful. We are the ones who have been called upon at this time to take on the responsibility of conducting a detailed review of the syllabus, not only at undergraduate level but also post-graduate level so that this syllabus, as you rightly said earlier, responds to the needs this country will have in 20 years' time. Otherwise, the brain drain will therefore continue and we will be reduced to just being teachers, which is by no means a bad thing, but it is nothing more than an essential component of the area we form part of, and in some cases, like yours and mine, to being academic administrators.

Thank you Mr Romell. University Professor Edwin Romell Galo Roldán has kindly allowed this interview to be contributed to the Tuning Project.

MEXICO

Interview with Dr Alejandro Ayala Mercado

Dr Alejandro Ayala Mercado is Senior Research Fellow at the National Autonomous University of Mexico's Institute of Nuclear Sciences. He is an eminent researcher in the area of High Energy Physics (elementary particles). He is currently studying the extreme states of matter in quark and gluon plasma. He is a member of the National System of Researchers (at the highest level). He also actively participates in university life at the Institute and has held the position of Vice-President and President of the Mexican Society of Physics' Particles and Fields Division.

What changes do you think society will undergo in the near future (the next 20 years or so)?

I can see that the changes are moving towards greater economic integration, meaning greater interdependence and wider use of all types of technologies.

You identified changes in future society; could you point out some possible scenarios that may arise?

In the economic field, I can see how the imbalances in economies will have an increasing impact on distant geographical areas but which, at the same time, are connected by the global flow of goods. In the technological field, I can see that the societies adopting and developing different types of technology in order to carry out increasingly everyday jobs will have the advantage.

What would the implications be for your professional area in each of the scenarios described?

With regard to Physics, I feel there will be the need to train coming generations to address this scenario. At the moment, Physics teaching follows traditional patterns with little adaptive capacity to constant change and scant use of technology. This situation must change as soon as possible.

What professions and/or professional approaches in your area do you envisage in each scenario?

I envisage an interdisciplinary approach, less geared towards encyclopaedic knowledge and more towards agility in solving problems.

What competences will these professions require?

Greater command of information technologies - for instance, GRID technology; early initiation in the subjects involved in the specific area chosen by future professionals.

What, in your opinion, would be a possible but highly unlikely scenario?

It could be foreseen that the «status quo» will simply remain, but I believe that if this is the case, it will just be an illusion in the immediate surroundings, as it is increasingly apparent that the global surroundings tend to reward versatility over immobility ever more rapidly.

What professions and competences would be important for your area in this unlikely scenario?

Traditional professions and normal competences that value encyclopaedic knowledge and high-level specialisation over versatility.

VENEZUELA

Interview with Prof. Gustavo Gutiérrez

Department of Physics, USB; pioneer in Venezuela in the area of Complex Systems.

What changes do you think society will undergo in the near future (the next 20 years or so)?

For better or for worse, the extremely high connectivity between people will increase. Computers or their derivatives will be the instruments that determine our relationships and decisions, to a great extent. We will become more collective. Limits on the availability of resources could play a predominant role in town planning and the structure of society.

You identified changes in future society; could you point out some possible scenarios that may arise?

Important changes in the notion of individuality and privacy; greater emphasis on collectivity; availability of large amounts of information.

What would the implications be for your professional area in each of the scenarios described?

Complex Systems and networks will have a significant impact on issues considered important. Interdisciplinarity will become increasingly important. The content of syllabuses urgently needs to be changed in order to incorporate the conceptual changes that have taken place in the past sixty years (fractal geometry, chaotic dynamical systems, recurrence relationships, cellular automata, topology, non-linear equations, solitons, and so on).

What professions and/or professional approaches in your area do you envisage in each scenario?

Computational Physics will gain in importance, and Non-Linear Systems Physics will form part of syllabuses. Imaging will become part of the language and the written word will undergo significant changes. The study of nature based on the understanding of the Physics of Pattern Formation will be much more highly developed. Syllabus content will need to be changed in order to introduce subjects of an interdisciplinary nature.

What competences will these professions require?

Computational tools and interdisciplinary culture; greater creativity should be constantly stimulated; information search techniques that taking the impact of networks into account; competence in the use and understanding of networks and the mathematics involved.

What, in your opinion, would be a possible but highly unlikely scenario?

The disappearance of the human race from planet Earth, or a large part of the population, for failing to take into account the impact of its own activity; worldwide conflagration; contamination caused by a large volcanic eruption or meteorite; an extreme situation caused by a combination of these events.

What professions and competences would be important for your area in this unlikely scenario?

Technological competences enabling us to escape from Earth. This would entail greater emphasis on instrumentation and its applications. Greater emphasis on the conquest of space; low-gravity architectural design; use of instruments to make full use of resources in interstellar space; efficient energy use and waste recovery (recycling materials, recycling energy, and so on); survival techniques in a hostile world. This would involve speeding up knowledge of our climatic environment. The tools offered by research into Complex Systems may be of great use for this. In the case of subterranean and sub-oceanic town planning, Physics could contribute its tools for this although greater exchange of ideas, techniques and strategies between the different disciplines is needed. There should be greater freedom for students to take courses in different disciplines. A coherent way must be devised to open up these possibilities.

Annex III

Teaching, learning and assessment strategies for the development of competences in subjects covered in Physics degree courses suggested by different Latin American universities

Level	Subject	University (country)	Degree of competence development		
			[01]	[15]	[V01]
Basic	Mechanics	Universidad de la Frontera (Chile)	Medium	Medium	Medium

Learning results	Teaching strategies	Assessment strategies
1. Defines a conceptual and methodological framework of vector mechanics to propose, analyse and solve problems of particle dynamics, particle systems and rigid solid. 2. Identifies the concepts, laws and principles of vector mechanics needed to solve problems of particle movement. 3. Solves problems of particle movement, applying concepts and laws of vector mechanics and energy conservation, linear momentum and angular momentum theorems. 4. Expands concepts and laws of Mechanics and theorems from particle conservation to the movement of a particle system and a rigid solid. 5. Proposes and solves problems of particle system movement and solid rigid by applying concepts and laws of Mechanics and conservation theorems. 6. Analyses qualitatively and quantitatively the results of problems of particle movement, particle systems and rigid solid by discussing solutions and solution methods.	1. This subject consists of 3 hours of lectures and 3 hours of workshop per week, with the following chapter content: — Particle dynamics. — Work and energy. — Impulse and momentum. — Oscillations. — Particle systems and rigid solid. 2. In order to achieve learning results, each student is given a weekly Activity Guide, which specifies the out-of-class activities to be carried out by each student before each lecture, and the in-class activities to be performed during the lecture. 3. A Weekly Handout is also given to each student with the content, examples and problems to be dealt with in the lectures and workshops during the week. The purpose of these activities and materials is to foster meaningful learning of Mechanics through teaching conceived as a mediation facilitating the assimilation and exchange of conceptual and methodological meanings between the lecturer and students. 4. Concepts and laws of Mechanics are developed and formulated in the theory lectures with the support of educational materials, such as PPT, note reading, videos, Internet portals and others. 5. Learning activities on methods in Mechanics to address problems are performed in the workshops. Problems are put forward and solved, with emphasis on analytical discussion of the results and methods used. 6. The course materials (guides, notes, PPT presentations, videos etc.) are provided via a platform (Moodle or other).	1. Problem solving: At the end of each chapter the lecturer puts forward assessment problems which students must solve and report on using the content taught and learnt in the lectures and workshops as a conceptual and methodological reference. The lecturer gives guidance to students whenever necessary. This assessment activity is a competence performance criterion: generic (15) identifying, specific (V01) using numerical and analytical methods to propose and analyse theoretical physical problems in the field of Mechanics. 2. Presenting and reporting on results: Having solved the problems, students must prepare a written report and give a presentation of results to their peers, informing them of solutions to problems and the basic theories and methodologies used. Analysis and discussion of the results obtained must also be included in the report and presentation. This activity is a performance criterion for the generic competence: capacity for abstraction, analysis and synthesis (01). 3. Final exam: At the end of the course, a written exam is set which will assess the achievement levels of all learning results in the subject of Mechanics. The definition of achievement levels will be determined on the basis of the key assignment definitions, operational conditions and performance standards.

Level	Subject	University (country)	Degree of competence development		
			[01]	[15]	[V01]
Basic	Programming and Fortran	Universidad de Sonora (Mexico)	Medium	Low	Low
Intermediate	Mechanics	Escuela Superior Politécnica de Chimborazo (Ecuador)	Medium	Medium	Medium

Learning results	Teaching strategies	Assessment strategies
a) Knows the basic elements of a computer and Linux, enabling the development of the activities planned in the course. b) Recognises the importance of using programming as a backup tool to solve problems in Physics. c) Knows the basic elements of programming and different components of a FORTRAN programme. d) Applies programming concepts to solve simple problems by generating clear, trustworthy and structured programmes that are easily maintained.	a) At the beginning of the semester, the subjects to be discussed are distributed, and the activities to be performed throughout the course. b) The course is scheduled with 5 contact hours per week, two of which are devoted to laboratory work. The three remaining hours are divided into two sessions. In the first, the lecturer teaches the basic concepts of the week. In the second, a programming workshop is organised where the students work on solving problems via programmes. c) Throughout the course, emphasis is placed on practical work and application.	Two main tasks are performed to assess this course: Written exams, which account for a maximum of 20% of the course grade. The exams are partial in that they are taken in the subject covered up to that point in the course, although all students always have exams in ALL subjects. The final exam is therefore global. To assess the remaining 80% of the grade, students must prepare a portfolio showing work performed during the course. This portfolio is prepared and assessed throughout the course (on at least three different occasions) in order to make observations for its improvement.
a) Applies expertise in order to understand the function of different systems. b) Recognises different types of problems in different scenarios. c) Summarises phenomena observed. d) Abstracts physical phenomena observed. e) Formulates identified problems mathematically. f) Uses the principles of Physics to analyse, identify, consider and deal with problems. g) Applies expertise in Mechanics in order to understand the function of different systems. h) Recognises different types of problems in different scenarios. i) Formulates identified problems mathematically. j) Uses the principles of Physics to analyse, identify, consider and deal with problems of Mechanics, and apply them in different systems.	METHODOLOGICAL AND TECHNICAL STRATEGIES The main methods to be applied are expected to be: presentation, master classes, experimental, virtual and problem solving. Techniques: verbal presentation of expertise, visual explanation of phenomena, online classes. Students will present work periodically that has been developed in class and at home, whether it be individual or group work, which should be posted onto the virtual classroom or submitted in writing. Each end-of-subject assignment will be assessed according to the work carried out throughout the course. Workshops will be held and laboratory practice arranged. USE OF TECHNOLOGIES The virtual classroom in Moodle will be used as a support base for the course, which is on the Polytechnic's website, as well as computer tools such as INTERNET, INTRANET, WEB 2.0, etc., and other visual and writing tools, along with simulations and objective laboratory experiments.	ACTIVITIES TO BE ASSESSED Exams. Lessons. Individual assignments. Reports. Observation sheets. Teamwork. Research work. Portfolios. Virtual classroom. Others.

Level	Subject	University (country)	Degree of competence development		
			[01]	[15]	[V01]
Intermediate	Electromagnetics	Escuela Superior Politécnica de Chimborazo (Ecuador)			
Intermediate	Electromagnetism I and II	Universidad Federal do Ceará (Brazil)	Low	Medium	Medium

Learning results	Teaching strategies	Assessment strategies
a) Applies expertise in order to understand the function of different systems. b) Recognises different types of problems in different scenarios. c) Summarises phenomena phenomena. d) Abstracts physical phenomena observed. e) Formulates identified problems mathematically. f) Uses the principles of Physics to analyse, identify, consider and deal with problems. Applies expertise in Electromagnetism in order to understand its function in different systems. g) Recognises different electromagnetic problems in different scenarios. h) Formulates identified problems mathematically. i) Uses the principles of Physics to analyse, identify, consider and deal with problems of Electromagnetism, and apply them to different systems.	METHODOLOGICAL AND TECHNICAL STRATEGIES The main methods to be applied are expected to be: presentation, master classes, experimental, virtual and analytical. The techniques: verbal presentation of expertise, visual explanation of phenomena, online classes. Students will present work periodically that has been developed in class and at home, whether it be individual or group work, which should be posted onto the virtual classroom or presented in writing. Each end-of-subject assignment will be assessed according to the work carried out throughout the course. Workshops will be held and laboratory practice arranged. USE OF TECHNOLOGIES The virtual classroom in Moodle will be used as a support base for the course, which is on the Polytechnic's website, as well as computer tools such as INTERNET, INTRANET, WEB 2.0, etc., and other visual and writing tools, along with simulations and objective laboratory experiments.	ACTIVITIES TO BE ASSESSED Exams. Lessons. Individual assignments. Reports. Observation sheets. Teamwork. Research work. Portfolios. Virtual classroom. Others.
a) Knows the electrostatic field in a vacuum and dielectric medium. b) Is able to solve Laplace and Poisson's equations and their applications in dealing with contour problems. c) Is able to determine the magnetic field produced by currents in stationary, non-magnetic medium. d) Knows Faraday's Laws and is able to determine induced electric and magnetic fields. e) Is able to determine a magnetic field caused by a magnetised material. f) Knows and is able to determine the energy and the density of electric and magnetic energy.	The subject of Electromagnetism (I and II) consists of 6 hours of lectures per week. It is completely theoretical. Lectures consist of presentations through dialogue with discussion of texts, individual or group work, and the use of digital technologies. Some didactic resources are used, for example, educational sites, learning objects, simulations, basic books on the subject and scientific articles. Lecturers can use up to 20% of the virtual activities in their subjects, at their discretion.	Assessment of academic performance always includes attendance and efficiency, both of which are given grades. Continuous assessments are performed throughout the entire semester, a minimum of 2 assessments. They can be in the form of lists of exercises, written work, trials, seminars and written tests. To control efficiency in each subject, students with an average grade in the continuous assessments of higher or equal to 0.7 (seven) automatically pass, and do not need to take the final exam. Students with an average lower than 0.7 (seven) and higher or equal to 0.4 (four) will have to take the final exam. In this case, students will pass when a

Level	Subject	University (country)	Degree of competence development		
			[01]	[15]	[V01]
Intermediate ***(continued)***	Electromagnetism I and II	Universidad Federal do Ceará (Brazil)	Low	Medium	Medium
Intermediate	Introduction to Modern Physics	Universidad Federal do Ceará (Brazil)	High	High	Medium

Learning results	Teaching strategies	Assessment strategies
g) Recognises the importance of Faraday's Laws in the technological development of humanity. h) Knows Maxwell's equations. i) Is able to analyse and deal with problems related to the propagation and emission of electromagnetic radiation. j) Knows the applications of Maxwell's equations in waveguides. k) Knows cavity resonators, reflection and refraction. l) Understands the relationship of Electromagnetism with Optics.		final average higher or equal to five (0.5) is obtained, calculated as follows: FA = (FAG + ∑CAG/N) / 2 Where: Final average: FA Final Assessment Grade: FAG Continuous Assessment Grade: CAG Number of Continuous Assessments: N Regarding the verification of attendance, students must attend at least 75% (seventy-five per cent) or more of the subject workload in order to attain a pass. Lecturers using virtual contributions in their subject should use a maximum of 40% of virtual activities in the assessment method. The experimental element of Introduction to Modern Physics is assessed by means of detailed reports on the experimental practice carried out.
a) Knows the Theory of Special Relativity. b) Recognises and applies the Principle of Relativity. c) Is able to describe space-time through events and recognises the concepts of time itself and length itself. d) Is able to solve problems concerning time dilation and length contraction. e) Describes the kinematics and dynamics of objects moving at relativistic speeds. f) Is able to apply Lorentz Transformations. g) Knows and applies concepts of relativistic mass, mass and energy. h) Describes thermal radiation and the origin of Quantum Theory and black body radiation. i) Is able to describe the interaction between electromagnetic radiation and matter (the photoelectric effect, quantum theory of light, Compton scattering and X-rays). j) Knows the Rutherford and Bohr atomic models.	Introduction to Modern Physics covers theoretical and experimental elements. There are 6 hours of theory lectures and 3 hours of laboratory work per week. Lectures consist of presentations through dialogue with discussion of texts, individual or group work, and the use of digital technologies. Some didactic resources are used, for example, educational sites, learning objects, simulations, basic books on the subject and scientific articles. Lecturers can use up to 20% of the virtual activities in their subjects, at their discretion.	Assessment of academic performance always includes attendance and efficiency, both of which are given grades. Continuous assessments are performed throughout the entire semester, a minimum of 2 assessments. They can be in the form of lists of exercises, written work, trials, seminars and written tests. To control efficiency in each subject, students with an average grade in the continuous assessments of higher or equal to 0.7 (seven) automatically pass, and do not need to take the final exam. Students with an average lower than 0.7 (seven) and higher or equal to 0.4 (four) will have to take the final exam. In this case, students will pass when a final average higher or equal to five (0.5) is obtained, calculated as follows: FA = (FAG + ∑CAG/N) / 2 Where: Final average: FA Final Assessment Grade: FAG Continuous Assessment Grade: CAG Number of Continuous Assessments: N

Level	Subject	University (country)	Degree of competence development		
			[01]	[15]	[V01]
Intermediate ***(continued)***	Introduction to Modern Physics	Universidad Federal do Ceará (Brazil)	High	High	Medium
Intermediate	Introduction to Modern Physics I	Universidad de Sonora (Mexico)	Medium	Medium	Low

Learning results	Teaching strategies	Assessment strategies
k) Understands wave-particle duality and the Uncertainty Principle. l) Knows the Schrödinger theory and is able to solve the Schrödinger equation for one-dimensional problems.		Regarding the verification of attendance, students must attend at least 75% (seventy-five per cent) or more of the subject workload in order to attain a pass. Lecturers using virtual contributions in theory subject should use a maximum of 40% of virtual activities in the assessment method. The experimental element of Introduction to Modern Physics is assessed by means of detailed reports on the experimental practice carried out. The reports make up 25% of the subject assessment total.
a) Describes space-time through events. b) Calculates the distance between events in space-time. c) Recognises and applies the Principle of Relativity. d) Describes the kinematics and dynamics of objects moving at high speeds: a) Calculates time and distance. b) Calculates the four moments of a vector and a system's total mass. e) Describes the interaction between light particles (light pressure, energy-mass photon energy equivalence). f) Describes the interaction between electromagnetic radiation and massive particles (photoelectric effect, Compton scattering and X-ray production).	The course consists of 5 contact hours per week for students. One of these hours is used in the laboratory with the intention of repeating at least 5 of Modern Physics' original experiments, such as photoelectric effect, black body radiation or X-ray dispersion, among others. Subjects relating to modern Physics are taught in the remaining hours, mainly by the lecturer, but some sessions are expected to be led by students.	Two main tasks were performed to assess this course: Written exams, which account for a maximum of 20% of the course grade. The exams are partial in that they are taken on the subject covered up to that point in the course, but all students always have exams in ALL subjects. The final exam is therefore global. To assess the remaining 80% of the qualification, students must prepare a portfolio showing work performed during the course. This portfolio is prepared and assessed throughout the course (on at least three different occasions) to make observations for its improvement.

Level	Subject	University (country)	Degree of competence development		
			[01]	[15]	[V01]
Intermediate	Modern Physics	Universidad de La Habana	High	High	High

Learning results	Teaching strategies	Assessment strategies
a) Explaining and applying the laws of Black Body Radiation to solve problems, critically analysing classical predictions and its comparison to Planck's law. b) Calculating atomic magnitudes and parameters using semi-classical atomic models, and traditional and contemporary quantum physics. c) Solving the Schrödinger equation for simple cases such as free particles, particle movement in infinite and finite one- and two-dimensional potential wells, particle movement in the presence of potential barriers, and electron atoms. d) Applying the concept of wave function and quantum numbers to calculate magnitudes and parameters characterising the hydrogen atom and other simple atomic systems, and their interactions with external fields. e) Calculating magnitudes that characterise the origin and distinguishing elements of molecular spectrums of rotation, vibration and electron excitation. f) Calculating the Miller Indices of high-symmetry crystallographic planes. Calculating directions in crystallographic lattices. Obtaining the elements belonging to the same family of crystallographic planes and directions. g) Using Bragg's law when determining diffraction directions, interplanar distances and lattice constants in the case of cubic structures. h) Calculating dispersion relationships in linear mono and biatomic lattices using harmonic and nearest neighbour approximation. i) Calculating the electric and thermal conductivities of metals and the contribution of lattices and electrons to specific heat. j) Solving the Kronig-Penney problem and interpreting its results. k) Using computers, the most common professional programmes and the programming language used to solve increasingly difficult problems requiring these techniques at the corresponding level to complete this subject.	The subject is called General Physics V and is taught in the 5th semester of the degree course, 6 hours per week, 2 of which are devoted to problem solving. In the same semester, students go to a Physics laboratory that is closely related to the course. Students are given a polished physical picture of the world by being taught the laws and theories that form part of the present moment in time. These should clearly prove the impossibility of explaining the regularities and phenomena of the microworld within the framework of classical physics. They should be an initial approach to the content and application of Quantum Mechanics, highlighting its principles and postulates, as well as its operability, to explain structures and processes self-consistently in the subatomic world, but without turning into an abbreviated course on this theory. Within the discipline of General Physics, this subject constitutes the best framework to introduce concepts of nanophysics and nanotechnology, basically through examples. When the wave-particle duality is debated, scanning tunnelling microscopy images can be shown, quantum corral, etc. In the introduction to Quantum Mechanics, when potential wells are solved, examples can be shown of heterostructures, two-dimensional wells, degeneration, and so on. These subjects should be approached from the phenomenological point of view, stressing the experimental aspects although, in fact, current trends and theories at a micro and macroscopic scale will need to be shown, starting from the actual unity of the world and the different forms of matter that exist.	Students are assessed by means of seminars on topics relating to the subject that lend themselves to discussion and the presentation of new problems or new advances. There is also a written test (1hr), a twice-yearly written test (2hr) and a final exam (4hr).

Level	Subject	University (country)	Degree of competence development		
			[01]	[15]	[V01]
Intermediate	Quantum Mechanics	Universidad Nacional de Ingeniería (Peru)	High	High	High

Learning results	Teaching strategies	Assessment strategies
a) As it is a new physical approach different to Classical Mechanics, the capacity for abstraction, analysis and synthesis is heavily identified. b) As it aims to compare the experimental results giving rise to Quantum Mechanics, the ability to propose, analyse and deal with both theoretical and experimental physical problems becomes more apparent. c) The mathematical tools involved, both analytical and numerical, are necessary in order to tackle problems such as Dispersion, Perturbation Methods, and others.	1. The course consists of 6 hours of master classes per week taught by the lecturer, with the following content: — Postulates of Quantum Mechanics (principles and Schrödinger equation). — One-dimensional problems (potential well, potential barrier). — Three-dimensional problems (hydrogen atom). — Perturbation Method (respective or irrespective of time). — Dispersion (Bohr's Method and Partial Waves). 2. A four-hour weekly assessment is taken in the classroom (there are 12 assessments per semester). 3. Two exams are taken, one partial and the other, final.	As it is a subject with a wide range of content, additional topics are provided for each student to develop that are not included in the bibliography. Hence, the competences (01) capacity for abstraction, analysis and synthesis, (15) ability to identify, consider and deal with problems, and the ability to consider, analyse and deal with theoretical physical problems by using numerical and analytical methods (V01) are assessed. All of these activities take up the entire semester and are supervised by the lecturer or assistant lecturer. This assessment is conducted by means of a final presentation before a panel of experts. Conclusions It can now be seen that the leading role in learning is played by the student. Assigning an original undertaking that is not included in the bibliography makes each student display the capacities to be assessed: (01), (15) and (V01). In this case, the lecturer fulfils the role of supervisor and advisor. Periodic presentations previewing topics are needed in order to improve monitoring. It would be advisable to place more emphasis on this type of assessment rather than traditional assessment.

Level	Subject	University (country)	Degree of competence development		
			[01]	[15]	[V01]
Intermediate	Electromagnetism	Universidad Nacional de Ingeniería (Peru)	High	High	High

Learning results	Teaching strategies	Assessment strategies
a) Understanding real electromagnetic problems through the use of advanced mathematical tools makes the capacity for abstraction, analysis and synthesis heavily identified. b) Solving contour problems in different geometries makes the use of numerical and/or analytical methods necessary and these, in turn, will be compared with experimental data. c) Both the analytical and numerical mathematical tools are necessary in order to tackle problems such as radiation and retarded potentials, among others.	1. The course consists of 6 hours of master classes per week taught by the lecturer, with the following content: — Boundary-value problems in Electrostatics, Green's function method, Method of Images. — Dielectrics, conductors, Polarisation. — Electromagnetic energy fields. — Magnetostatics. — Magnetism in materials — Maxwell's equations. — Radiation. 4. A four-hour weekly assessment is taken in the classroom (there are 12 assessments per semester). 5. Two exams are taken, one partial and the other, final.	As it is subject matter with a broad range of content, additional topics are provided not included in the bibliography for each student to develop. Hence, the competences (01) capacity for abstraction, analysis and synthesis, (15) ability to identify, consider and deal with problems, and the ability to propose, analyse and deal with theoretical physical problems by using numerical and analytical methods (V01). All of these activities will take the entire semester and will be supervised by the lecturer or assistant lecturer. This assessment will be conducted by means of a final presentation before a panel of experts. Conclusions It can now be seen that the leading role in learning is played by the student. Assigning an original undertaking that is not included in the bibliography makes each student display the capacities to be assessed: (01), (15) and (V01). In this case, the lecturer fulfils the role of supervisor and advisor. Periodic presentations previewing topics are needed in order to improve monitoring. It would be advisable to place more emphasis on this type of assessment rather than traditional assessment.

Level	Subject	University (country)	Degree of competence development		
			[01]	[15]	[V01]
Intermediate	Electromagnetic Theory	Universidad de la Frontera (Chile)	High	High	High

Learning results	Teaching strategies	Assessment strategies
1. Defines a conceptual and methodological framework of classical electromagnetic theory to consider, analyse and deal with problems of phenomena relating to electromagnetic fields. 2. Applies the classical model in the description of electric interactions and static magnetic fields and the technical applications 3. Applies the field model in the description of electric and time-dependent magnetic interactions and the technical applications. 4. Applies and transfers expertise and methods in classical electromagnetic theory in order to consider and tackle problems in other branches of sciences. 5. Analyses the results of problems concerning electromagnetism qualitatively and quantitatively, discussing their solutions.	1. This subject consists of 4 hours of lectures and 2 hours of workshops per week, with the following chapter content: — Electrostatic field. — Special methods for electrostatic problems. — Electrostatics in dielectric medium. — Magnetic field of stationary currents. — Electromagnetic induction. — Magnetic fields in matter. — Maxwell's equations. 2. In order to achieve learning results, each student is given a weekly Activity Guide, which specifies the out-of-class activities to be carried out by each student before each lecture, and the in-class activities to be performed during the lecture. 3. Each student is also given a handout with content, examples and problems relating to topics to be addressed in the lectures and workshop during the week. The purpose of these activities and materials is to foster meaningful learning of classical electromagnetic theory through teaching designed as mediation, enabling the assimilation and exchange of theoretical meanings and methodologies between the lecturer and students. 4. This theory is presented and developed in the theory lectures using Maxwell's formalism, with the help of educational materials such as PPT, note reading, videos, Internet portals, and so on. 5. Learning activities concerning methods in electromagnetic theory in order to tackle problems are performed in the workshops. Problems are considered and solved, with emphasis on the discussion of results analysis and methods used. 6. Course material (guides, notes, PPT presentations, videos, etc.) will be distributed via a platform (Moodle or other).	1. Problem solving: At the end of each chapter, the lecturer puts forward assessment problems that students have to solve and inform on, using the content taught and learnt in lectures and workshops as a conceptual and methodological reference. The lecturer may guide students if need be. This assessment activity is a competence performance criterion: generic (15) identifying, considering and deal with problems, specific (V01) using numerical and analytical methods to consider, analyse and solve theoretical physical problems in the field of mechanics. 2. Presenting and reporting on results: Having solved the problems, students must prepare a written report and give a presentation of results to their peers, informing of solutions to problems and the basic theories and methodologies used. Analysis and discussion of the results obtained must also be included in the report and presentation. This activity is a performance criterion for the generic competence: capacity for abstraction, analysis and synthesis (01). 3. Final exam: At the end of the course, a written exam is set which will assess the achievement levels of all learning results in the subject of Mechanics. Achievement levels will be defined on the basis of the key assignment definitions, operational conditions and performance standards.

Level	Subject	University (country)	Degree of competence development		
			[01]	[15]	[V01]
Advanced	Modern Physics Laboratory III	Universidad del Valle (Colombia)	High	High	High

Learning results	Teaching strategies	Assessment strategies
a) Learns the basics principles, procedures and basic methods in Experimental Physics at an advanced level. b) Gains sufficient confidence in their ability to observe, measure and design experiments to determine physical bodies and properties and establish relationships between them. c) Is familiar with research equipment and the most basic techniques in the fields of Nuclear Physics, Atomic and Molecular Physics and Laser Physics d) Acquires the skills needed to present and defend their ideas and work, convincing people of the importance of carrying the work out and their ability to carry it out suitably.	The course is theoretical-practical. The methodology has a 6-week preparatory component, where the theory and basic principles are reviewed, and a second part consisting of experimental work for the rest of the semester. Students are divided into pairs. Each pair is given a specific topic to which they devote the entire semester; the topics are: 1. General properties and applications of electromagnetic radiation. 2. Application of X-ray diffraction to the study of crystallographic structure. 3. Applications of nuclear radiations and spectroscopy (α, β y γ). 4. Laser operation (CO_2). 5. Emission of radiation by discharge plasmas in molecular gases. 6. Applications of diffraction and coherent light scattering. 7. Optical properties of thin, metallic films. Students develop the theory component by conducting a theory review of the assigned topic and, in the fourth week, they present the topic they intend to develop and the experiment design. The experimental element consists of the design, set-up and development of the experiment. There should be an oral presentation of the design and then another informing of progress in the work's development. The results of the experiment will be reported in an article. At the end of the course, each pair gives an oral presentation on the work performed and its results in front of other lecturers from the Physics Department.	The lecturer ensures that students are able to abstract, analyse and summarise the information found in the search for the theoretical base, which is assessed, by means of oral presentations, in the fourth week of the semester (01). In order to develop the experimental component, students must first design the experiment. This implies that students must go to the laboratory to consider and deal with the problems arising in the experiment design (15). The lecturer assesses this competence when requesting the oral presentation of the design. This allows students to correct or change the design. Once the design is completed, students go on to the set-up and development of the experiment, analysing and dealing with the problems proposed by using experimental methods. (V01). The final results of the experiment are reported in an article, and finally presented to a group of lecturers, who will assess it. 70% of the assessment will consist of experimental work (regular attendance at the laboratory, initiative and ability to solve development problems arising in the laboratory), and the assessment of presentations. 30% of the grade corresponds to the article. Conclusions The overall conclusions on the competence-based assessment, teaching and learning process were: — Constant assistance by the lecturer is vitally important when teaching the competences students need to acquire.

Level	Subject	University (country)	Degree of competence development		
			[01]	[15]	[V01]
Advanced ***(continued)***	Modern Physics Laboratory III	Universidad del Valle (Colombia)	High	High	High
Advanced	Modern Physics	Universidad de Sonora (Mexico)	High	High	Medium
Advanced	Statistical Physics I	Universidad Experimental Simón Bolívar	High	High	High

Learning results	Teaching strategies	Assessment strategies
		— With this constant assistance and supervision of work developed by students, the impact of learning results is gradually assured. — Periodic assessment by the lecturer helps to visualise progress in the learning process and shows whether the expected results have been achieved. — The competence-based teaching, assessment and learning process demands more working time from lecturers as they now have to offer support to students at each stage of learning and carry out periodic assessments in order to obtain expected learning results.
a) Understands General and Special Relativity and some of its simplest implications. b) Applies the quantisation of fields to the description, at an introductory level, of the interactions of elementary particles. c) Describes Solid-State band theory band through Quantum Mechanics.	The proposed topics are presented in 5 sessions per week. Some of the sessions are devoted to students solving example problems.	Three or four partial exams are taken to assess course content.
a) Appreciates the difference between a mechanical description (equations of movement for each particle) versus a statistical description of multibody systems. b) Uses basic notions of statistics: averages, fluctuations, probability, distributions, etc. c) Appreciates the usefulness of the Macro State concept. d) Uses different thermodynamic potentials and the principles of equilibrium and stability of thermodynamic systems. Uses the concept of entropy. e) Operates using the Splitting Function.	Simple models are used in which students learn to use basic concepts and connect them with specific experimental situations. In this respect, identification problems relating to experiments are identified and conceptualised through simple models, later enabling them to be solved analytically or numerically. Examples: — The random walk problem: assemblies probabilities, correlations, Gaussian and Poisson distribution and diffusion. This is a simple problem with many of the elements needed for the whole course.	Homework assignments and written exams. Important topics are emphasised through the assignments, which are taken up again in the exams.

Level	Subject	University (country)	Degree of competence development		
			[01]	[15]	[V01]
Advanced *(continued)*	Statistical Physics I	Universidad Experimental Simón Bolívar	High	High	High
Advanced	Computational Physics	Universidad Experimental Simón Bolívar	High	High	High
Advanced	Solid State Physics	Universidad del Valle (Colombia)	High	High	High

Learning results	Teaching strategies	Assessment strategies
f) Uses the concepts and tools learnt to tackle basic, practical problems.	— Van der Waals equation: interactions between molecules, modifications to ideal gas. It will enable calculations to be made in relatively complex situations. — Spin systems: they illustrate the concept of microstates and macrostates. Firstly, with no interaction between spins, explicitly enabling the calculation of the partition function. They prepare the ground for discussion of the Ising model and phase transitions, which come up in the following term of the course. — Joule-Thompson effect (throttling): illustrates the use of Enthalpy and different manipulations of thermodynamic amounts. It illustrates the consequences of interactions between molecules and how to take them into account; it relates to an important industrial process — The Einstein solid for oscillations of a solid: notions of quantum mechanics are used. It enables analytical calculations to be made; despite its simplicity, it explains the behaviour of the specific heat of solids at low temperatures qualitatively.	
a) Understands the interaction between theory, experiments and numerical simulations. b) Uses basic programming elements in C (programming language). c) Programmes basic numerical models and schemas enabling data to be obtained that is charted and analysed.	The course is regarded as a laboratory, with emphasis on practical tasks in programming.	Assignments every two weeks. The ground is prepared in the lectures for the assignments, working on some of the aspects students will encounter when attempting to solve them.
a) Understands the basic concepts, theories and models of Solid State Physics. b) Uses the concepts, theories and models to formulate quantitative explanations of simple phenomena related to the crystallographic structure of solids.	The lecturer teaches 4 hours of master classes weekly during the course, with the following content: — Crystallographic structure of solids. — Crystallographic lattice dynamics and thermal properties. — Free electron gas model.	At the end of each chapter, the lecturer assigns a set of problems that students must develop with the help of the theory presented by the lecturer and guiding text. The lecturer advises students on their development, and students finally submit their work to the lecturer for assessment.

Level	Subject	University (country)	Degree of competence development		
			[01]	[15]	[V01]
Advanced *(continued)*	Solid State Physics	Universidad del Valle (Colombia)	High	High	High
Advanced	Electromagnetic Theory	Universidad del Valle de Guatemala	High	High	High

Learning results	Teaching strategies	Assessment strategies
c) Understands simple models explaining the microscopic origin of phenomenological characteristics such as electric conductivity, specific heat, the dielectric constant, absorption or dispersion of collective excitations, etc.	— Electrons in a periodic potential. — Electric and magnetic properties of crystallographic solids. 2. Students develop and submit a set of problems at the end of each chapter for assessment; the lecturer gives advice regarding its development. 3. Students give a presentation on topics specific to solids previously assigned by the lecturer, who offers advice by giving guidelines on bibliography, presentation length and verifying the suitability of the subject matter consulted. 4. Students take an end-of-course exam.	This comprises the lecturer's supervision and support in learning to identify, consider and deal with problems (G15), based on the theory and lecturer's guidance. Thus, students learn to use numerical and analytical methods to consider, analyse and deal with theoretical, physical problems they are presented with throughout the course (V01). Towards the end of the course, students are assigned a special topic from the course to present in front of the group of students. The lecturer gives advice on bibliography, presentation length and verifying the level of the topic consulted. This ensures the development of abstraction, analysis and synthesis skills (G1), so as to be able to give presentations in public. At the end of the course, the lecturer sets a final exam on all the subjects seen throughout the whole course to ensure that learning has been successful, i.e. that students are able to abstract, analyse and synthesise what they have learnt throughout the course, and able to identify, consider and deal with problems regarding Solid State Physics.
a) Understands the basic concepts, theories and models of Electromagnetic Theory and its applications. b) Uses the concepts, theories and models to formulate quantitative explanations of simple phenomena related to Electromagnetic Theory. c) Uses models that apply the basic equations governing Electromagnetic Theory.	1. The course lecturer gives 3 hours of contact lectures per week covering the following subjects: Maxwell's equations and their applications to phenomena related to Electromagnetic Theory. 2. Students develop and submit the assigned problems for assessment, and the lecturer advises them on their development. 3. Students conduct research and give presentations on specific subjects assigned by the lecturer. 4. Students take exams on the course subjects.	Assessment as a continuous process includes: problem solving, research, presentations and simulations. All of this supervision and assistance in learning by lecturers enables students to identify, consider and deal with problems (15), based on the theory and lecturer's guidance. Thus, students learn to use numerical and analytical methods to consider, analyse and deal with the theoretical physical problems presented throughout the course. (V01).

Level	Subject	University (country)	Degree of competence development		
			[01]	[15]	[V01]
Advanced	Optics	Universidad del Valle de Guatemala	High	High	High
Advanced	Materials Science	Universidad del Valle de Guatemala	High	High	High
Intermediate	Modern Physics	Universidad Nacional Autónoma de Honduras (UNAH).	Medium	Medium	Low

Learning results	Teaching strategies	Assessment strategies
a) Understands the basic concepts, theories and models of Optics and its applications. b) Uses the concepts, theories and models to formulate quantitative explanations of phenomena related to Optics. c) Applies the concepts of wave propagation, geometric optics, polarisation, interference, diffraction, Fourier optics, Coherence and Topics in modern Optics. d) Learns the basic principles, procedures and basic methods of Optics at advanced level. e) Gains confidence in the ability to observe, measure and design experiments to determine physical bodies and properties, and establish relationships between them.	1. The course lecturer teaches 3 contact hours of lectures per week and 3 laboratory hours per week covering topics in Optics and its applications. 2. Students develop and submit their assigned problems for assessment, and the lecturer advises on their development. 3. Students carry out research and give presentations on specific subjects assigned by the lecturer. 4. Students take exams on the course subjects. 5. Students perform laboratory practice where they conduct experiments related to Optics and its applications.	The process of continuous assessment includes: problem solving, research, presentations, simulations and laboratory experiments. All of this supervision and assistance in learning by the lecturer enables students to identify, consider and deal with problems (15), based on the theory and lecturer's guidance. Thus, students learn to use numerical and analytical methods to consider, analyse and deal with the theoretical physical problems presented throughout the course. (V01).
a) Understands the basic concepts, theories and models of Materials Science and its applications. b) Uses the concepts, theories and models to formulate quantitative explanations of phenomena related to Materials Science. c) Applies the concepts of Physics to understand the design and functioning of different types of materials and their applications.	1. Course lecturers teach 3 contact hours per week covering topics in Materials Science and its applications. 2. Students develop and submit their assigned problems for assessment, and the lecturer advises on their development 3. Students carry out research and give presentations on specific subjects assigned by the lecturer. 4. Students take exams on the course subjects.	The process of continuous assessment includes: problem solving, research, presentations, simulations and laboratory experiments. All of this supervision and assistance in learning by the lecturer enables students to identify, consider and deal with problems (15), based on the theory and lecturer's guidance. Thus, students learn to use numerical and analytical methods to consider, analyse and deal with the theoretical physical problems presented throughout the course. (V01).
a) Interpreting the need for the creation of a new theory in Physics. b) Recognising and using the units and dimensions commonly used in Modern Physics; estimating orders of magnitude of amounts that are measured in the study of Modern Physics, from subatomic phenomena to cosmological phenomena. c) Analysing and interpreting the results of classical experiments on which Modern Physics is based.	This course holds a value of 4 credits or Value Units (4 U.V.), which is equivalent to 60 contact hours of work (15 hr./U.V.) plus 120 hours of independent work by students (30 hr./U.V.), to make up a total of 180 hours throughout the entire *academic period*. Students are given the study *plan* of the topics included in the subject curriculum.	Assessment is continuous. Assessments are performed online and in person. — The *assignments, reading tests, research and practical activities* (including the use of new information technologies ICTs) have a ***50-point*** accumulative value of the subject's value. — Students must take part in two (2) virtual forums on subjects relating to Modern Physics (a total of 8 points).

Level	Subject	University (country)	Degree of competence development		
			[01]	[15]	[V01]
Intermediate ***(continued)***	Modern Physics	Universidad Nacional Autónoma de Honduras (UNAH).	Medium	Medium	Low

Learning results	Teaching strategies	Assessment strategies
d) Understanding the basic concepts of the special theory of relativity: concepts of time and space, kinematics and relativistic dynamics. e) Understanding the concepts and basic principles of Quantum Physics: wave-particle duality, atomic models, Schrödinger equation and the Pauli Exclusion Principle. f) Solving classical problems of Physics using the mathematical tools needed at this level of university study.	The course is taught through b-learning using the Moodle Platform. The following are used: *Reading checklists* of parts of the material selected from the text. a) *Exercise guides* that will be assessed using micro-assessments. b) *PowerPoint Presentations, PDF or Videos* as a backup to the material being studied. c) Consulting *documents on the Internet*. d) Working in collaborative groups (including at least two virtual laboratory sessions), presenting assignments and reports, analysing classical experiments, presentations with multimedia support (videos, wikis, thematic forums, preparing glossaries, blogs, etc.). e) *Online use of didactic materials* [Use of Web-Based Multimedia Learning Modules: PhET Interactive Simulations, pages supporting physics texts; others]. f) *Educational techniques:* Talks by experts, peer instruction, guided notes and professorship experiments (*on-site or virtual*)	— Students are arranged into *learning groups* with the aim of conducting two *phenomena simulation virtual laboratories* (a total of ***12 points***). — Three *partial exams* are set (a total of ***30 points***).

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