Tutors

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Treball Final de Grau

Forensic Engineering. Development of a proposal for a post degree course.

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Els bons costums, i no la força, són les columnes de les lleis; i el exercici de la justícia és el exercici de la llibertat.

Simón Bolivar

Per començar, donar les gràcies als meus pares Pilar i Adrián, al meu germà Gonzalo i als meus amics més pròxims pel seu suport incondicional, tant en els bons moments com en els pitjors, viscuts durant el grau. Per la seva dedicació i els seus grans consells que m'han ajudat en la meva fortalesa.

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Al meu tutor, Dr. Joan LLorens Llacuna, per la confiança mostrada a l'hora d'acceptar aquest treball.

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Gràcies

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SUMMARY

Forensic Engineering includes subjects of chemistry, physics, geology, biology and other natural sciences. Their professionals must be able to articulate principles and fundamental theories of science to find out the causes of incidents with legal implications.

Time moves in one direction by sweeping many of the details that could be important to clarify procedural cases. The details that are left behind make the data necessarily incomplete, sometimes strange and valued differently. Forensic Engineering tries, through scientific reasoning, to reconstruct the dark points of an account that leads to the causes of an incident.

The aim of the project is to develop a postgraduate course in Forensic Engineering. For this, a thorough bibliographical search will be made of books, articles and courses on Forensic Engineering worldwide. The information that will be collected, will be analyzed and studied in order to be able to design the best contents, depending on their applicability to make expert reports.

The need for the course comes from the fact that nowadays, a lot of people like lawyers, enterprises and private costumers are increasingly making contact with engineers in order to obtain forensic judgments.

On the other hand, due to its demand, it is observed that the Forensic Science is becoming a specialty in many universities around the world.

Keywords: Forensic Engineering, Forensic Science, Forensic post degree courses.

RESUM

L'Enginyeria Forense inclou temes de química, física, geologia, biologia i les altres ciències naturals. Els seus professionals han de poder articular els principis i teories fonamentals de la ciència per esbrinar les causes dels incidents amb implicacions judicials.

El temps es mou en una sola direcció arrasant molts dels detalls que podrien ser importants per esclarir casos processals. Els detalls que es queden enrere fa que les dades siguin necessàriament incompletes, de vegades vagues i valorades de forma diferent. L'Enginyeria Forense intenta mitjançant raonaments científics reconstruir els punts foscos d'un relat que porten a les causes d'un incident.

L'objectiu del projecte és elaborar un curs de postgrau d'Enginyeria Forense. Per això, es farà una cerca bibliogràfica exhaustiva de llibres, articles i cursos sobre Enginyeria Forense a nivell mundial. La informació que es recavarà s'analitzarà i s'estudiarà per tal de poder dissenyar els millors continguts, en funció de la seva aplicabilitat per fer informes pericials.

La necessitat dels curs prové del fet que cada dia són més freqüents els casos judicials en que es demana als enginyers fer dictàmens forenses.

Per altra banda, degut a la seva demanda, s'observa que la Ciència Forense va introduint-se com especialitat en moltes universitats del món.

Paraules clau: Enginyeria Forense, Ciència Forense i curs de Forense de post grau.

1. INTRODUCTION

The humans have very different behaviours, from these differences arise problems that sometimes have a more or less simple solutions. Depending on the seriousness of the problems, the justice of each country acts in one way or another. It is impossible for this justice to solve all cases on its own, for example, a judge cannot resolve on his own a case where a chemical production factory has been set on fire, since his knowledge of chemistry and fires is poor or null. It is at this moment where the expert must act and explain to the judge the scientific part of what happened, so that, he can already dictate or understand what has happened. Lawyers and their clients also hire them to better understand what happened and thus to prepare a more effective defense.

"Perito" comes from the Latin peritus and represents a judicial or forensic expert. It is a skilled and experienced person, understood in a science or art, that helps in some subjects to solve conflicts according to his knowledge.

Not all conflicts end up coming to trial, as both parties can end up understanding and reach an agreed solution. The lawyers or experts can get to understand to find a mutual agreement.

But if both parties finally get to trial, there are two types of experts, the judicial experts and the party experts. The first are appointed by the judge (officers) and the second by those involved (private), either the accusation or the defense (these must be accepted by the judge and the prosecutor). In no case some experts have more influence than others. The experts can be categorized in graduates and non-graduates, the graduated have obtained an official graduation, which allows them to report on the subject, and the latter has no the graduate.

These experts swear to the judge that they will tell the truth before presenting their higher education and knowledge. The expert does not give his opinion or make assumptions, always gives his foundations rigorously. The judge must attend to the information that is being given to him to dictate his verdict.

The procedure that should be followed in a case by the expert is simple. First of all, the judge will call by an ordinary citation to the expert, so that he accepts the order and the report.

There are other ways to quote the expert. Unless it is impossible, the experts are obliged to appear before the court at the indicated date and time.

Both parties (accusation and defense), once the experts have been notified by the Judicial Secretary, may challenge them for reasons of kinship, interest, friendship or enmity. Once the experts have been challenged, both parties can appoint private experts who will be approved by the judge. Once the oath is taken, the judge will state the purpose of the report. All the parties may attend to the expert diligence to make observations to the experts.

The judge can appoint more experts in case of contradictions.

The report must include three parts, the description of the person that is object of the same, detailed relation of all the operations practiced by the experts and of its result, conclusions according to the principles and rules of your science or art. Even so, it will be detailed later on how these reports are.

To understand where these experts can work, people must know which organizations or departments are the ones that contribute mostly experts to the processes. In Spain, there are forensic doctors, the National Institute of Toxicology and Forensic Sciences, the judicial police and others, which are included in the articles from 470 to 480 of the LOPJ (this articles can be consulted in the link that appear in the appendix 1).

An expert does not have to be an expert in the judicial field but he have to know some things, some minimums, such as the structure of the state, basic laws, the judicial organization and others that will be discussed later. The expert should only be an expert in his field.

In the Spanish constitution appears the structure of the state divided into 4 parts, Head of State, "Cortes Generales" or Legislative Power, Government or Executive Power and finally Courts of Justice or Judiciary.

In this case, the Judiciary is the one that interests, where the expert acts, this power serves the citizen so that a procedural system is guaranteed so that their values are defended before any action in the corresponding jurisdiction. The trial is the instrument and the infrastructure the courts of Justice. All this leads to a sentence that creates the right of the citizen.

The Constitution, the LOPJ, the LDPJ, the four laws that regulate the trials (Law of Civil Procedure, Law of Criminal Procedure, Law of Contentious Administrative Jurisdiction and Law of Labour Procedure) and international treaties are the main regulations of Procedural Law .

It is important to know briefly the judicial organization in Spain to understand where experts perform their functions. The judicial organization in Spain is complex since it is organized territorially in municipalities, parties, provinces and Autonomous Communities. The Supreme Court, "Audiencia Nacional, Superior Court of Justice, "Audiencias Provinciales and Jury Court", Criminal Courts, Courts of Contentious Administrative, Courts of the Social, Courts of Minors, Courts of Prision Surveillance, Courst of firts Instance and Instruction, Peace Courts and the Constitutional courts, form the Spanish Judcial Organization. The National Court and the Supreme Court have powers throughout the state.

So that, it's time to focus on Forensic Engineering.

The forensic engineer is an expert witness, specializing in a science or engineering subject, to resolve a conflict caused by an incident whether voluntary or involuntary. These problems have legal consequences, since they usually end up in the courts of justice. In addition, because of these incidents, new measures or regulations can be determined to improve the future and that the same events do not happen again.

Over the years it has been shown that experts have helped to prevent the same incidents from happening again, so it is possible to say that they have served as progress to science, technology, engineering and the legislative apparatus.

There are several examples of the issues that have to solve a forensic engineer, including fires (was caused? Who or what caused?), Explosions, spills, leaks, counterfeit money, checks, cards, problems derived from drugs , road accidents ... In each case, the engineer must know the subject of which he will treat as discussed above, to try to solve the problem effectively.

In order to carry out its work correctly, the expert must have a series of characteristics or aptitudes. The engineer must be competent, have to know well the working area to analyze the problem in a proper way and to discuss it with fundamentals. They always have to tell the truth because they has sworn to tell the truth, comply with the law, be neutral, have no kinship, be collegiate, in short, have professional ethics. The forensic expert should not know the law or be an expert in the judicial world, but should have a minimum. The expert must also know the specific vocabulary.

Whoever wants to exercise forensic engineering must also have a number of skills, for example, in written communication (for the drafting of the report) and oral communication, since its function is to teach or make understand what happened scientifically but in such a way that

lawyers, prosecutors and judges fully understand what happened, it has to be taken into account that these people are not experts in scientific issues which cannot be explained in a very technical or precise language, also must be very skilled in defending their opinion, the expert must defend it well , without hesitation and without falling into contradictions. It is also required to have an ability in the analysis of evidence, documents and witnesses, as well as to find new evidence.

In Spain an engineer has different career opportunities, for example, in departments of administration, entities of administration of justice, police departments, consultancies such as insurance companies or law firms and universities as teachers or researchers.

The process begins when an incident occurs and the client with the help of his lawyer contact the expert (people must not forget that a judge can also request the help of the forensic engineer). The expert begins to find evidence, and then, have to analyze it. After analyzing what happened from the evidence and drawing conclusions, the expert makes a first report. At this time, the lawyer can terminate the assignment or look for other reports to have more information and decide whether to end the forensic work or litigate. In the latter case, the expert must assist in the oral trial to defend his opinion and answer the pertinent questions to clarify some issues that do not end up being understood.

The report made by the forensic engineer has a series of guidelines but they do not have any strict model to follow. The 197001 standard includes different criteria of a general nature for the preparation of opinions and reports. The report should be clear, concise and precise, but above all they should be well-founded so that it turns out to be true and that the judge or the person who needs it should look favorably on it. In addition, this standard indicates how to make the identification and not just the structure to follow minimum standards.

As for the structure, most of the reports are very similar, they all start with a cover with identification of the expert, the case, a title and other information. Then all the reports have the objectives section, which expresses the purpose for which the opinion is being made, "the assignment". In the objective, it is common to add the scope of the expert performance. Another part is the background, brief information of who and to whom the incident occurred, a summary of the information received without being treated. The method of expertise would be the following section of the opinion, is to explain the techniques used in the expert opinion.

The most important part of the opinion is the analysis, where the expert must pay more attention and importance as it is the basis of the report. The facts are analyzed clearly and explained in an academic way for who are not experts in the subject to understand it. The most technical calculations should be summarized and everything that is done based on scientific fundamentals must be justified. All this analysis is reflected in the final conclusions, where in a brief sentence the final result is clearly stated. In it the final result is exposed (if there is one) the guilt or innocence is commented, the origin of the incident ...

Before reaching the annexes, it is possible to add a section of advice, where the expert informs of possible actions to be carried out so that it is not reproduced again or where it exposes possible future effects of the main incident.

Finally, the annexes, it serve as help in understanding the report, where photographs are added, more detailed calculations as well as tables and other types of aid.

This is the basic structure that the expert opinions usually have, but in the end it will depend on each expert or each case. Each report has a different way of identifying the case, the expert, the client, the date and the signature. (There is an example of an opinion in Appendix 1).

In addition there is another type of reports where the forensic expert only answers the questions that the judge asks, the format is very simple, question-answer.

The purpose of courses and degrees in forensic engineering is to train engineers and science experts in the judicial world. Teach people, that they are presupposed a scientific knowledge, to elaborate opinions, specialize in the most typical cases like fires, spills, contaminations of all kinds ...

Courses tend to differ in different fields but in the end they all have the same objective and specific and similar guidelines. The normal thing is that the first subjects are introductory, explain the judicial system of the country and comment on the characteristics of the experts. All courses have specific areas in scientific fields, such as environment, fires, materials, machinery... To finish, the courses usually have case studies, elaboration of expert reports and a final work.

2. OBJECTIVES

The main purpose of the work is the development of a course in forensic engineering for subsequent application in the university. To establish the subjects to exercise with their corresponding percent of hours.

Another crucial objective of the work is to produce a bibliography on forensic engineering and forensic science, both nationally and globally. The objective is to analyze the contents that are exposed in each bibliographic and extract the most common and most necessary sections that are more related to what is taught in the degree of chemical engineering of the UB.

With all the information analyzed, the coure will be structured into subjects with their corresponding percentage depending on the difficulty and amount of content to be taught. From each subject is pretended to structure its content and explain the methodology of teaching and its evaluation,

Ensuring teaching in forensic science beyond medicine is crucial, since there are hardly any courses or degrees in other sciences, especially in forensic engineering. Most experts who have professional assignments in real cases are qualified professionals in the sciences related to the case but not graduates in forensic engineering, so this work aims to develop a course, to be able to get the qualification of experts in forensic engineering and those ones have greater recognition and validity.

3. BIBLIOGRAPHIC SEARCH

3.1. RESEARCH METHOD

To look for bibliography about forensic engineering several aspects have been considered.

Firstly, courses have been sought in relation to forensic engineering in various ways, fo example in online search engines such as *FindAMaster* and a search engine of colleges and universities of the *AAFS*. For this, the key words have been introduced to find the desired courses, the words that have been sought are forensic, forensic engineering, forensic science, engineering, science. In addition, to specify in the subject has been further detailed the search with keywords such as fires, accidents or leaks.

Another type of search is done through Google, this search engine has searched for information of all kinds, for example, other courses or books or to look up information to do the introduction.

The tutor has made available books that he has at his disposal, in addition, he has delivered a final master's degree which will be analyzed later on the most interesting parts of this proposal.

Finally, an optional subject that is carried out in the UB, which I have done myself, has been exposed.

The objective of all this bibliography is to observe the knowledge that is imparted in the worldwide to have them present to make the final proposal.

Next, the list will be exposed with all the bibliography compiled and that finally will be taken into account for the final proposal, it should be commented that much of the bibliography has been discarded due to its content as it is far from what is intended to analyze , for example courses with the name of forensic engineering where their contents are far from this scope.

3.2. BIBLIOGRAPCHIC LIST

In the list there are 4 differentiated groups of bibliography type, it is understood by the similarity of what they are, if tthese are degrees or masters, another type of courses or conferences and others.

The first group consists of degrees or masters found on the subject of forensic engineering or similar.

- Postgraduate degree at the University of Valencia.
- Master's degree in industrial engineering at the University of Seville.
- Master of Science at Cranfield University. Forensic explosive and explosion investigation.
- Forensic Engineering and Science Master at Cranfield University.
- International Master of Science in Fire Safety Engineering at the University of Edinburgh.

The second group consists of courses and / or conferences.

- Judicial technical surveying course. Forensic Engineering Official College of Industrial Engineers of Madrid.
- Conference of the NAFE. National Academy of Forensic Engineers.
- Course at the University of Barcelona: Forensic Science and Engineering.

The third group consists of three books. Two of them have been contributions from the tutor and the third has been contributed by the course held at the University of Barcelona previously commented.

- Chemistry and Criminal Investigation. Translation by Matthew E. Johll.
- Forensic Engineering Investigation written by Randall K. Noon.
- Forensic Engineering written by Kenneth L. Carper.

The last group is composed only of a Master's Final Project. Experimental in Chemical Engineering. The title is Forensic Science and Engineering. Proposal for a third cycle Master and a professional technical office.

In the next section of this project, the content of each of the previous points will be analyzed in more detail to finally elaborate the proposal.

4. ANALYSIS OF THE BIBLIOGRAPHY

The objective of this work is to develop a postgraduate course on Forensic Engineering. To achieve this goal, a bibliographic search has been developed on the subject in particular, books, courses at other universities, conferences, subjects of some courses and a final project of master's degree carried out in 2005 at the University of Barcelona. All this bibliography has been exposed previously. Once the search has been carried out, the objectives and structure of the courses will be analyzed to determine possible subjects. For the analysis, each subject of the courses with their objectives will be exposed. And, for the books, these will be analyzed their contents to conclude that possible subjects proposed in the course. So, each bibliography will be determined in order to select the most interesting sections to make the proposal.

This section is divided as can be seen in the previous section. A first part of analysis of courses related to degrees or masters, another group with courses and conferences, a section of books analysis and the last one with the master mentioned before.

4.1. QUALIFIED COURSES

In this section, all the bibliography found of qualified university courses on forensic engineering and related to this, will be analyzed.

4.1.1. University of Valencia

The first course to be analyzed is a postgraduate course at the University of Valencia, specifically a Master's Degree in Forensic Chemistry. It is added in this part of the project because it is one of the few similar courses on Forensic Engineering in the Spanish state, in addition, its program contains forensic engineering subjects. The program, which not only contains the subjects, contains the objectives of each subject. The programe of this course is the following (https://postgrado.adeituv.es, accessed April 8,2019):

Collection and conservation of evidence: Characteristics of the evidence and evidence. Search procedure. Footprints. Biological samples. Non-biological sample. Container. Conservation and protection. Pollution. Documentation. Case studies.

Development of fingerprints: Fingerprints and other types. Physical developers. Chemical developers. Specific stains. New developers. Case studies.

Legislation: Evidence in the civil process: concept, object, sources, means, probatory procedure, assessment, presumptions, material load. Means of proof: in particular, the opinion of experts. Measures of investigation and evidence in the criminal process: concept, evidence obtained with violation of fundamental rights, minimum probative activity, purpose, assessment, burden of proof and right to the presumption of innocence, evidentiary procedure, means of proof: in particular, the expert evidence. Study of cases.

Metrology: Calibration. Calibration / verification protocols. Quality assurance. Validation of procedures. Identification criteria. Criteria of accuracy and precision. Expression of results. Study of cases.

Fires and explosives: The chemistry of fire. Chemistry of explosives. Bombs and terrorism. Instrumental techniques: chromatography, mass spectrometry, neutron activation analysis, X ray fluorescence, ICP-MS, electron microscopy. Chemical sensors Study of cases.

Characterization of materials: glasses, soil, fibers, inks, paper, plastics, cosmetics: Molecular modeling. Differential properties. Identification and origin. Instrumental techniques: spectrophotometry, IR and Raman, NMR, X ray diffraction, mass spectrometry, electron microscopy, ICP-AES, ICP-MS. Study of cases.

Chemical analysis of materials: Destructive and non-destructive analysis. Microanalysis. Elemental, multielemental, molecular and multiresiduous analysis. Qualitative, screening and confirmation analysis. Categorization of instrumental techniques. Chromatography, capillary electrophoresis and coupled techniques. Computational molecular recognition. Study of cases

Chemical analysis of biomaterials: Analysis of vegetal organic matter. Analysis of animal organic matter. Analysis of fats and lipids in organisms. Analysis of proteins. Categorization of instrumental techniques. Immunoassay. Sensors and kits. Computational molecular recognition. Study of cases.

DNA studies: Concepts: function, structure, components. Analysis of repetitions in short tandems. Mitochondrial DNA and identification of samples. Characterization of DNA fragments by capillary electrophoresis and liquid chromatography-mass spectrometry. Study of cases.

Chemical analysis of drugs and poisons: Chemistry of drugs. Chemistry of addiction. Poisons Screening procedures for samples and compounds. Procedures for extracting the samples. Chromatography and coupled techniques. In situ tests. Confirmation studies. Measurements of stable isotope ratios. Study of cases

External practices: They will be carried out in collaboration with the National Police Force. Scientific police. The student will do the practical part of the subjects: Collection and preservation of evidence, Fingerprint development and Fires and explosives. It will include, obligatorily, a bibliographical revision and the presentation of a written memory.

Master's final project: Its objective is to enable the student to apply the knowledge acquired throughout the course to the realization of technical work or basic or applied research related to any of the fields studied. The preparation of the report will include, obligatorily, a summary in English, a bibliographic review and a critical analysis of the quality of the results. In addition, the student will have to analyze the relationship of practical activities with the knowledge, skills and attitudes achieved and learned during the studies and the way in which those skills will allow their professional practice. He should also offer suggestions about his future continuing education.

Regarding forensic engineering, it is important to highlight the fires section. The legislation is the same for all forensic sciences, this is more interesting because the course is in the same state. In other courses may also appear legislation, but being from another country cannot be taken into account, it will simply be concluded that this proposal will have this section but without the same contents. It is also worth mentioning the collection and conservation of evidence, in engineering it must also be taken into account, in spite of the fact, that other evidences than in science are obtained. Finally, the external internships and the final projectof the master are very interesting in this possible course, it will be taken into account to make this proposal.

The master's degree is held from October to June, that is, one year, with 4 hours a day from Monday to Thursday.

As for the realization of the course, they are expository classes with intervention of the students, in addition, the classes of problems and those of study of cases are distinguished. It is a face-to-face course.

As for group work, tutorials are organized, practical classes with assistance to work places. Seminars, works and activities are also carried out to finish acquiring the knowledge. The evaluation method is like most courses, through tests and exams.

The objectives of this master's degree are to create professionals in the expertise and professionals in criminal and forensic laboratories. Forensic chemistry, like forensic engineering, deals with legal issues through the application of chemistry. So, this master's course trains students to acquire the necessary skills to evaluate what happened, do their assessment and write the report to explain clearly to the competent authorities and / or clients with their scientific knowledge.

This master has requirements to be able to access it. Basically, the students have to be licensed in some areas of chemistry, for example, in Chemistry, Pharmacy, Food Science and Technology, Chemical Technology, Biochemistry, Environmental Sciences, Chemical Engineering and others Experimental sciences and related technologies

It should be noted that for some activities, students receive the collaboration of the Official College of Chemists of the Valencian Community, the National Police Force (Police Headquarters of the Valencian Community) and the Scientific Police.

4.1.2. University of Seville

The following case is not a specific course, it is a master's degree in industrial engineering at the University of Seville, which contains an optional subject in forensic engineering. The subject is called Forensic Engineering: Characterization of Materials and provides 5 ECTS credits of the total of the master.

The objectives of this course is to teach students the causes of failure of a piece, either by a component or its structure, to select the material and to design the piece, to know the service conditions of this and to know how to keep the piece until the end of its useful life and to replace it. These are all the points that are explained in this subject, there are no legal issues or related

to the expertise, so it is merely a subject of scientific content which could be included in this course proposal.

The subject is separated into two blocks, the first is based on the design and selection of material and the second consists in the analysis of failure in service, study, causes and possible solutions.

For the realization of this subject theoretical classes are taught with 40 hours and 85 own work. Teaching is based on theory and exercises. The course also develops team work.

The evaluation consists of two parts, a test of theory and problems and a group project with final written and oral presentation. The project consists of studying a piece or mechanism that has failed. With the knowledge acquired in the theory, students must apply their acquired knowledge to study the piece thoroughly.

The final conclusion of this subject is that it can be taken into account to add it to the scientific part of the course, adapting it to possible failures of components that cause accidents deriving to legal problems.

4.1.3. Cranfield University

4.1.3.1. Forensic Explosive and Explosion Investigation MSc

This course is a master's degree in science called Forensic explosive and explosion investigation. This course teaches students about the investigation of explosives and crime scenes related to chemistry, biology, radiology and nuclear radiation. Analyzing this, it is possible to affirm that it is a master's degree in Engineering and Forensic Science.

On the course website, the following introductory paragraph to the course that explains what it consists of is shown.

It considers both pre and post blast scenes, and associated scenes. The MSc also develops the student’s ability to apply Forensic Intelligence and exploitation techniques and blend it with Open Source Intelligence. The course offers students a wide range of different experiences with unique facilities available to no other university in the UK and is part of the MSc Forensic Programme which has been formally accredited by The Chartered Society of Forensic Sciences. Places on the MSc Forensic Explosive and Explosion Investigation are competitive.

Students come from a wide range of backgrounds, usually with a science or forensic science first degree. Many students come from abroad, especially Europe, Africa and North America. This course is designed to give a broad introduction to the subject, rapidly advancing into the understanding of cutting-edge research and the latest methodologies. The course is highly practical and hands-on, aiming to produce forensic experts capable of giving expert witness testimonies in a courtroom situation and elsewhere. (www.cranfield.ac.uk, accessed April 8, 2019).

A competitive course, unique in Europe. Scientific content about explosions is explained to face the legal world as an expert.

The structure of the course consists of eight compulsory subjects and three of free choice among many which each student must choose depending on their interests. At the end of the course a semester is added in which the final project is made, a project of free election or with subjects proposed by the teaching staff.

Below are all the subjects of the program and their objectives extracted from the website of the Cranfield Univeristy. (www.cranfield.ac.uk, accessed April 8, 2019).

- **Compulsory:**

Analytical Techniques: To provide an understanding of the principles and practical applications of the major analytical techniques used in materials based investigations.

Courtroom Skills: The module will provide an understanding of the role and responsibilities of expert witnesses in domestic and international criminal and civil cases and how they can present their evidence to the court effectively. You will also apply knowledge gained in previous modules to strengthen arguments presented in expert witness reports.

Fires, Explosions and their Investigation: The course covers fire dynamics and the characteristics of explosives, their effects on buildings and people and the physical effects that would be looked for in their investigation.

Forensic Investigation of Explosives and Explosive Devices: The aim of the FIEED course is to educate forensic scientists, police, military and relevant supporting disciplines in the process of investigating an explosive device, scene of explosion or suspected production facility

or hide. Students work up from scene processing and evidence recovery, through to selection of analytic techniques, production of witness statements and court hearings.

Investigation and Evidence Collection: The module provides an understanding of the core responsibilities of evidence recording and collection at the crime scene, both in general and specifically related to operational constraints of a UK investigative context. You will also understand the operation of forensic and police investigators within the context of a major investigation.

Reasoning for Forensic Science: To provide an understanding and experience of the disciplines underpinning critical evaluation of quantitative information applied within the Forensic Sciences.

Hazardous Forensics: To present the fundamental principles of hazardous investigations including CBRN and to introduce techniques and working practices that promote risk management during a methodical investigation.

Forensic Exploitation and Intelligence: To provide an understanding of the principles and practical applications of the major forensic analytical techniques used in forensic intelligence and exploitation.

Research Project: To undertake an independent and original investigation, normally experimentally or practically-based.

- **Elective:**

Introductory Studies: The aim of Introductory Studies is to prepare students for their subsequent programme of study on the assessed modules. It is optional and carries a formal credit rating of zero, although a student's understanding of the material covered may be tested as part of the assessments for the course modules. Students are advised to participate in Introductory Studies.

Fakes and Forgeries: The module will provide an understanding of the principles of forensic and scientific investigations into art objects.

Firearms Investigations: The module will provide an understanding of the principles of firearms design, forensic investigations involving firearms and the classification of firearms against the 1968 Firearms Act (as amended).

Introduction to Firearms Investigations and Forensic Ballistics: The module shall provide an introduction to the principles of forensic investigations involving firearms and forensic investigations of projectile ballistics.

Forensic Archaeology: Recovering Buried Remains: To introduce the role of the forensic archaeologist within the context of major crime investigation, specifically in the UK. The module aims to describe and discuss all aspects of this role, including project design, wide area search techniques, grave location techniques, excavation, evidence recognition and handling, grave and scatter scene interpretation and the production of specialist reports for court.

Fundamentals of Forensic Anthropology. Osteology: To provide a broad introduction to the subject, focusing on the role of the forensic anthropologist, human skeletal anatomy and the basic biological profile from human skeletal remains.

Mass Fatality Incidents: This course provides an introduction to mass fatality incidents (MFI); their definition, categorisation, mitigation and management. It has a strong focus on disaster victim identification (DVI) but also covers more general effects, challenges, lessons learnt, management developments and, the return to normality following an MFI. In particular, the course considers the roles and responsibilities of the personnel involved in the DVI process, practical application of Interpol guidelines and DVI forms, planning and evaluation of temporary mortuary facilities and, DVI humanitarian assistance aspects of mass fatality incident response.

The course may be of interest to a wide range of professionals including; emergency planners, emergency response personnel (police, fire and ambulance), family liaison officers, accident investigators, NGO workers, forensic scientists, medical doctors, lawyers, and those involved in the investigation of missing persons.)

Radiographic Investigations in Forensic Science: To provide an understanding of the principles and practical applications of radiographic imaging techniques used in forensic science.

Trace Evidence: The module will provide an understanding of the trace physical evidence and its associated forensic examination.

Digital Crime and Investigation: The aim of this module is to develop knowledge and understanding of the processes involved in the investigation of digital crime. These include the investigation of crime, the seizure of digital evidence, the examination of seized devices, the construction of reports and knowledge of relevant law.

Materials Engineering and Processing: The module provides an understanding of the structure and properties of materials, to understand how the processing and fabrication methods affect them, and to familiarise the student with the common faults that can arise during production.

Approach to Failure Investigation and Analysis: The module will introduce the failure investigation process, the importance of defining the objective(s) and planning the investigation, and the steps and common tools involved in failure analysis.

Failure Analysis of Components: The module will introduce the different causes of failure, and investigate the mechanisms and subsequent characteristic features of the different failure modes. This will enable the student to be able to evaluate and deduce the cause(s) of failure from the examination of failed engineered components.

Counter Improvised Explosive Devices Capability: The aim of the C-IED Capability course is to educate industry, military and civilian MoD C-IED staff in the Counter IED/Threat systems with emphasis on supporting capabilities and technology.

The organizers of the course intend to keep the course updated every year, that is, from one year to the next its content can be modified and be highly altered. It is due to the innovation they intend, these courses are adapted to business, industry and research. So these modifications are due to the development of the investigation, to the possible legislative change and for another reason. These modifications are also made to adapt better and better to the student and the staff that increases the degree of satisfaction of the course.

The duration of the course is eleven months on full time or up to three years if it is done in part-time. The evaluation consists of written and practical exams, it is continuous and the final project presented orally.

Analyzing this program, it can be clarified that the compulsory subjects focus on the science of fire and explosions, as well as subjects on legal issues and related to the expert itself. So, this course is quite useful to obtain subjects for this proposal. In subjects of free choice, it is observed that many areas of the scientific and technical world are treated, so this part serves to specialize students in some aspects. Of all these subjects of free choice some may appear in the final proposal.

4.1.3.2. Forensic Engineering and Science Master

There is another course in the same university on forensic engineering called Forensic Engineering and Science Master. For the title it is already observed that the content is about Forensic Engineering, so it is interesting to comment and take it into account for the proposal. Although the core of this course is not the explosions as in the previous case but it consists of failures in metal components as well as their analysis. As in the previous case, on the course website, the following introductory paragraph to the course that explains what it consists of is shown.

This course is designed to give a broad introduction to the application of engineering and physical sciences to forensic problems. Particular emphasis is given to understanding metallic component failures and the principles of failure analysis. The course offers students a wide range of different experiences with unique facilities available to no other university in the UK and is part of the MSc Forensic Programme which has been formally accredited by The Chartered Society for Forensic Sciences. Students come from a wide range of backgrounds, usually with a science, engineering or forensic science first degree. Many students come from abroad, especially Europe, Africa and North America. The course is highly practical and hands-on, aiming to produce forensic experts capable of giving an expert opinion in a courtroom situation and elsewhere. The course consists of a one-week period of introductory studies followed by academic instruction in modular form. Most modules are of five days' duration, interspersed with weeks devoted to private study. Students are required to take four core modules, four role specific modules and choose three elective modules based on their particular background, future requirements or interests. This is followed by a four-month research project and either a thesis or literature review and paper. (www.cranfield.ac.uk, accessed April 8, 2019).

The structure of the course consists of eight compulsory subjects and three of free choice among many which each student must choose depending on their interests. At the end of the course a semester is added in which the final project is made, a project of free election or with subjects proposed by the teaching staff.

Below are all the subjects of the program and their objectives extracted from the website of the Cranfield Universty. (www.cranfield.ac.uk, accessed April 8, 2019).

- **Compulsory:**

Analytical Techniques: To provide an understanding of the principles and practical applications of the major analytical techniques used in materials based investigations.

Approach to Failure Investigation and Analysis: The module will introduce the failure investigation process, the importance of defining the objective(s) and planning the investigation, and the steps and common tools involved in failure analysis.

Courtroom Skills: The module will provide an understanding of the role and responsibilities of expert witnesses in domestic and international criminal and civil cases and how they can present their evidence to the court effectively. You will also apply knowledge gained in previous modules to strengthen arguments presented in expert witness reports.

Failure Mechanisms of Materials: The module will introduce the different causes of failure, and investigate the mechanisms and subsequent characteristic features of the different failure modes. This will enable the student to be able to evaluate and deduce the cause(s) of failure from the examination of failed engineered components.

Fires, Explosions and their Investigation: The course covers fire dynamics and the characteristics of explosives, their effects on buildings and people and the physical effects that would be looked for in their investigation.

Investigation and Evidence Collection: The module provides an understanding of the core responsibilities of evidence recording and collection at the crime scene, both in general and specifically related to operational constraints of a UK investigative context. You will also understand the operation of forensic and police investigators within the context of a major investigation.

Reasoning for Forensic Science: To provide an understanding and experience of the disciplines underpinning critical evaluation of quantitative information applied within the Forensic Sciences.

Materials Engineering and Processing: The module provides an understanding of the structure and properties of materials, to understand how the processing and fabrication methods affect them, and to familiarise the student with the common faults that can arise during production.

Research Project: To undertake an independent and original investigation, normally experimentally or practically-based.

- **Elective:**

Introductory Studies: The aim of Introductory Studies is to prepare students for their subsequent programme of study on the assessed modules. It is optional and carries a formal credit rating of zero, although a student's understanding of the material covered may be tested as part of the assessments for the course modules. Students are advised to participate in Introductory Studies.

Aircraft Accident Investigation and Response: The process of accident investigation will be considered as a whole from notification and disaster response through evidence collection and analysis to the preparation of a final report and recommendations for change. Different approaches will be considered including 'no-blame', criminal and coronial investigations with particular emphasis on the role that human factors practitioners can play in the investigation and in dealing with the consequences of an accident and its associated recommendations.

Digital Crime and Investigation: The aim of this module is to develop knowledge and understanding of the processes involved in the investigation of digital crime. These include the investigation of crime, the seizure of digital evidence, the examination of seized devices, the construction of reports and knowledge of relevant law.

Fakes and Forgeries: The module will provide an understanding of the principles of forensic and scientific investigations into art objects

Firearms Investigations: The module will provide an understanding of the principles of firearms design, forensic investigations involving firearms and the classification of firearms against the 1968 Firearms Act (as amended).

Forensic Archaeology: Recovering Buried Remains: To introduce the role of the forensic archaeologist within the context of major crime investigation, specifically in the UK. The module aims to describe and discuss all aspects of this role, including project design, wide area search techniques, grave location techniques, excavation, evidence recognition and handling, grave and scatter scene interpretation and the production of specialist reports for court.

Forensic Ballistic Investigations: To provide an understanding of the principles of internal, intermediate, external, terminal and wound ballistics and how they are used in forensic investigations.

Forensic Exploitation and Intelligence: To provide an understanding of the principles and practical applications of the major forensic analytical techniques used in forensic intelligence and exploitation.

Forensic Investigation of Explosives and Explosive Devices: The aim of the FIEED course is to educate forensic scientists, police, military and relevant supporting disciplines in the process of investigating an explosive device, scene of explosion or suspected production facility or hide. Students work up from scene processing and evidence recovery, through to selection of analytic techniques, production of witness statements and court hearings.

Fundamentals of Forensic Anthropology. Osteology: To provide a broad introduction to the subject, focusing on the role of the forensic anthropologist, human skeletal anatomy and the basic biological profile from human skeletal remains.

Hazardous Forensics: To present the fundamental principles of hazardous investigations including CBRN and to introduce techniques and working practices that promote risk management during a methodical investigation.

Introduction to Firearms Investigations and Forensic Ballistics: The module shall provide an introduction to the principles of forensic investigations involving firearms and forensic investigations of projectile ballistics.

Mass Fatality Incidents: This course provides an introduction to mass fatality incidents (MFI); their definition, categorisation, mitigation and management. It has a strong focus on disaster victim identification (DVI) but also covers more general effects, challenges, lessons learnt, management developments and, the return to normality following an MFI. In particular, the course considers the roles and responsibilities of the personnel involved in the DVI process, practical application of Interpol guidelines and DVI forms, planning and evaluation of temporary mortuary facilities and, DVI humanitarian assistance aspects of mass fatality incident response.

The course may be of interest to a wide range of professionals including; emergency planners, emergency response personnel (police, fire and ambulance), family liaison officers, accident investigators, NGO workers, forensic scientists, medical doctors, lawyers, and those involved in the investigation of missing persons.

Radiographic Investigations in Forensic Science: To provide an understanding of the principles and practical applications of radiographic imaging techniques used in forensic science

Trace Evidence: The module will provide an understanding of the trace physical evidence and its associated forensic examination

Counter Improvised Explosive Devices Capability: The aim of the C-IED Capability course is to educate industry, military and civilian MoD C-IED staff in the Counter IED/Threat systems with emphasis on supporting capabilities and technology.

The organizers of the course intend to keep the course updated every year, that is, from one year to the next its content can be modified and be highly altered. It is due to the innovation they intend, these courses are adapted to business, industry and research. So these modifications are due to the development of the investigation, to the possible legislative change and for another reason. These modifications are also made to adapt better and better to the student and the staff that increases the degree of satisfaction of the course.

The duration of the course is eleven months on full time or up to three years if it is done in part-time. The evaluation consists of written and practical exams, it is continuous and the final project presented orally.

Analyzing this program it can be observed that it is very similar to the previous one, what some compulsory subjects before were optional and vice versa. The main focus is on materials, as well as subjects on legal issues and related to the expert itself, with a lot of focus also on explosions and fire. With which this course is quite useful to obtain subjects for this proposal. In subjects of free choice, it is observed that many areas of the scientific and technical world are treated, so this part serves to specialize students in some aspects. Of all these subjects of free choice, some may appear in the final proposal.

4.1.4. University of Edinburgh

This course is an International Master of Science in Fire Safety Engineering.

This is a master in which the student could do an erasmus.It lasts 4 semesters and it is possible to do each in a different city, each semester has a total of 30 ECTS credits. The cities in which is possible to do the erasmus are Edinburgh, Ghent and Lund. In addition, students

have the opportunity to do the thesis in three other cities such as Queensland, Zurich and Maryland. The current program is as follows (www.findamaster.com, accessed May 15, 2019):

Year 1

Semester 1

Students choose to study at either Ghent or Edinburgh.

Ghent University (Belgium):

- Fire Dynamics
- Basics of Structural Engineering
- Thermodynamics, Heat and Mass Transfer
- Explosions and Industrial Fire Safety

And 9 ECTS credits from the following elective courses (subject to approval by the faculty):

- FSE Based Firefighting (3 credits)
- Modelling of Turbulence and Combustion (3 credits)
- Introduction to Entrepreneurship (3 credits)
- Turbomachines (6 credits)
- Computational Fluid Dynamics (3 credits)

The University of Edinburgh (Scotland):

- Fire Science and Fire Dynamics
- Fire Safety, Engineering and Society
- Fire Safety Engineering
- Structural Mathematics

Semester 2

Lund University (Sweden):

- Risk Assessment
- Advanced Fire Dynamics
- Human Behaviour in Fire
- Simulation of Fires in Enclosures

Between Year 1 and Year 2 you can opt to do an industrial internship.

Year 2

Semester 3

Students choose to study at either Ghent or Edinburgh.

Ghent University (Belgium):

- Passive Fire Protection
- Active Fire Protection I: Detection and Suppression
- Active Fire Protection II: Smoke and Heat Control
- Fire Safety and Legislation
- Performance-Based Design

And 6 ECTS credits from the following elective courses (subject to approval by the faculty):

- FSE Based Firefighting (3 credits)
- Modelling of Turbulence and Combustion (3 credits)
- Introduction to Entrepreneurship (3 credits)
- Turbomachines (6 credits)
- Computational Fluid Dynamics (3 credits)

The University of Edinburgh (Scotland):

- Fire Science Laboratory
- Fire Investigation and Failure Analysis
- Finite Element Analysis for Solids
- Structural Design for Fire

Semester 4

The Master thesis research is supervised in either Ghent, Lund or Edinburgh (full partners), in an associated partner (ETH Zürich - Switzerland, The University of Queensland - Australia, The University of Maryland - USA) or an industrial company.

This master is a clear example of all the courses that exist that focus on specific topics, topics in scientific or engineering, in this case focuses on the fires. Of this course some sections could be extracted to explain in the proposal in a hypothetical subject on fires. However, this course does not teach anything about the judicial system or the work of the experts, so it can be concluded that it is a purely scientific course and that it does not focus on the forensic.

4.2. OTHER COURSES AND CONFERENCES

4.2.1. Judicial technical surveying course. Forensic Engineering

This course has been formed by the college of industrial engineers of Madrid. The objective of the course is to teach industrial engineers the expert techniques to include them in judgments and show their importance. It is carried out through practical cases, the assistants observe recorded tapes of judgments where industrial engineers acts in the litigation and their effects. Some of the cases shown correspond to cases in which the director of the same course has intervened. These cases have occurred in all jurisdictions, Civil, Criminal, Administrative Contentious and Social.

It is also the objective of the course to teach the participants to prepare expert reports. The writing of the report, the acceptance, the ratification on the Court and the collection of the fees.

The contents of the course are for those technical professionals, who can be claimed by law at any time as an aid to Justice and also to professionals of the same Justice.

The program of the course is the following (http:portal.coiim.es, accessed April 3, 2019):

- Law 1/2000 of Civil Procedure regarding the expert evidence.

  Designation of experts.

  Conditions of the experts.

  Recusations and flaws.

- The Penal Code regarding the expert evidence.

  Designation of experts.

  Conditions of the experts.

  Recusations and flaws.

- Content of the expert report.
    - Structure.
    - Objectivity requirements.
- Expert activity.
    - General Obligations
    - Specific obligations.
- The expert as a means of proof and help of the judge.
- Legitimization of the expert.
- Responsibility of the expert.
- Ratification and clarifications to the expert.
- Fee collection process.
- Obligations and advantages of the collegiate visa.
- Public Defender.
- Rights of the experts.
- Practical cases with sentences.
- Conclusions.

This course can be used for subjects that are not related to engineering or science, so, possible subjects to be dealt with by the legal system and the expert's work, as well as the preparation of the report. It is important to highlight the importance given to practical cases, which will be interesting to include in the work proposal. In this course, a lot of contents will be extracted for the judicial and expert subjects. In this proposal there will be subjects of these subjects, so this course is very useful for it.

4.2.2. The National Academy of Forensic Engineers

NAFE, the National Academy of Forensic Engineers. This academy was created to bring together qualified professional engineers with experience in forensic engineering to improve or increase their education and promote standards of professional ethics and excellence in practice. The academy seeks to advance the cause in forensic engineering, the members of this entity must be registered as professional engineers and also they must be a member of the NSPE.

The NAFE's Mission are the following:

- Serving the public by advancing the ethical and professional practice of forensic engineering;
- Serving the jurisprudential system by certifying individuals having achieved expertise in forensic engineering;
- Serving Academy members and furthering the development of forensic engineers through education and the publication of peer-reviewed technical literature.

This academy offers courses on forensic engineering, specifically conferences of short duration, for example, this year (2019) will take place from July 26 to 28. The program of this conference is not purely educational, it has parts where they only relate to each other to improve communication among all. There are also meetings of the directors and other agents, but the topics that are interesting for this proposal are the following (htpps://nafe.memberclicks.net, accessed May 13, 2019):

- Engineering Analysis of a Failed Roll-Over Protective Structure
- FE Analysis of a Crash Caused by Swingout of an Articulated Booster on a Semi-Trailer
- FE Analysis of Communication Systems for Drive-Through Restaurants in a Business Dispute over Quality Specifications and Design Process
- FE Analysis of a Wheel Spindle Failure due to Pre-Load and Fatigue
- FE Analysis of a Fatal Overhead Crane Accident
- The Application of Matchmoving for Forensic Video Analysis of a Fatal Sprint Car Accident
- Forensic Engineering Investigation of a Self-Unloading Boom Collapse on a Great Lakes Freighter
- Ergonomic Considerations in Forensic Engineering
- Forensic Evaluation of Ground Vibrations & Noise in an Urban Drainage Project
- Causes of Failures in Confined Masonry Reinforced Walls during an Earthquake in Guatemala
- A Forensic Investigation of Concrete Runway Degradation

- Forensic Investigation of Electric Shock Drowning: Speculation vs. Reality
- Forensic Engineering Analysis of Weapons Incidents
- Friction or Fiction: The Changing World of Slip-and-Fall Analysis
- Expert Mistakes you can Avoid
- Impact of Climate Change and the Evolving Standard of Care Issue on Forensic Engineering
- Fire Investigation (esta parte ocupa mucho tiempo y tiene un programa el cual será expuesto al final del actual)
- How Recreational Marijuana can cause Construction Defects
- Advanced vehicle damage analysis techniques

The fire research program is as follows:

- Fire investigation technology and Fire analysis
- Fire science and Thermodynamics
- Fire chemistry, Thermometry and Fire
- Explosion dynamics
- Fire protection systems and Hazardous materials
- Electricity and electrical systems
- Evidence documentation, collection, preservation
- Failure analysis

From the program, it can be concluded that many aspects of engineering are dealt with through real cases, analysis topics and evaluations. Finally, the most interesting part is the fire, where there is more content and where some expert work is also discussed, such as documentation of evidence, collection and preservation.

So it is interesting to highlight for the proposal the use of cases for the teaching of many subjects, since it can help to visualize what is being explained. It is also fair to take into account some scientific topics, especially fires.

4.2.3. Course at the University of Barcelona: Forensic Science and Engineering

This course is carried out as an optional subject in the degree of chemical engineering at the University of Barcelona, this course gives 3 ECTS credits. This course lasts one semester with two hours a week. It consists of theoretical classes with a final exam that corresponds to 100% of the grade. In this course it is recommended to use the CHEMISTRY AND CRIMINAL INVESTIGATION book which will be commented in the later section.

The objective of the course is to train the student (future scientist or engineer) and to learn about being a forensic expert in order to develop their profession in a legal environment in the future. The course is divided into two chapters, the first is introductory to the general concepts to familiarize with the forensic expert and the second consists of the explanation of real cases, these cases are result of the experience of the teacher, Dr. Jose Costa López professor emeritus of the UB.

Then, the structure of each chapter is presented as a table and will be analyzed later.

Table 1.Index of chapter 1. (Costa,J., 2018)

CHAPTER 1: INTRODUCTION	
Section Number	**Title of the Section**
1	Definition
2	Situation of Forensic Science and Engineering in the world
3	Situation of Forensic Science and Engineering at the University of Barcelona
4	The Organization of Coexistence and the Spanish Procedural System
5	Aptitude, Responsibilities and Opportunities of the Forensic Science and Engineering Expert
6	Typical professional order
7	Methodology
8	Drafting and Format of the opinion
9	International and Spanish forensic organizations. Schools professionals in Spain. The labour market
10	Fees
11	Forensic Science and Engineering Publications

The table above indicates the sections of the first chapter that deals with the course. This chapter, as can be seen, is quite orientative, conceptualizes the work of the forensic engineer. First of all it defines forensic engineering and exposes the current situation of engineering in the world and at the University of Barcelona. It also explains the Spanish judicial system to document the expert on the subject that a priori does not know, it is necessary because the expert have to know the typical vocabulary of the legal field and the severity of some issues.

The remaining topics are related, since they focus on the figure of the expert; in the skills, in the assignment, so, in the analysis of the case and the drafting of the opinion, in the organizations that accredit the experts and in their fees. Finally, the forensic science and engineering publications, as well as magazines and other entities that publish content, are exposed.

Table 2. Index of chapter 2. (Costa,J., 2018)

CHAPTER 2: STUDY OF CASES	
Section Number	**Title of the Section**
1	Fires, Explosions
2	Spills and environmental emissions
3	Accidents: Materials, Leaks, Vehicles, Motorcycles, Vehicle and boat lighting and slippery floors
4	Electric-short circuits
5	Defective machinery
6	Raw materials / Defective products
7	Drugs
8	Patents ("know-how")
9	Computing
10	Documents (falsification, ...)
11	Damage caused by lightning, hail, rain (storms) or by drought
12	Damage caused by vibrations (blasting, heavy machinery)
13	Damages due to water leaks (breakage due to freezing, etc.)

This table indicates the contents of the second chapter. This chapter explains different past real cases, exposes the scientific knowledge, reproduces how happened the case and the opinion that was elaborated is taught.

This course is very useful for the realization of the proposal. It has all kinds of subjects, subjects in the legal field, the work of the expert and scientific subjects. The first subjects have an extra value, it is because the course takes place in the same country in which the proposal is intended to be implemented, so the legal subjects will have a quite similar implant. Regarding the subjects of science or engineering, the use of real cases should be highlighted, for the proposal it will be very important to combine scientific foundations with real cases.

4.3. BOOKS

4.3.1. Chemistry and Criminal Investigation

Before entering the analysis of this book, two things must be commented on. First of all it is to emphasize its paper in the course of the University of Barcelona on science and forensic engineering commented previously and the second is that this book is original in English and this is a translation of the original work. The publisher Reverté is the one who has made the publication in Spanish translated by Dr. Jose Costa Lopez of the original work of Matthew E. Johll entitled "Investigation Chemistry, A Forensic Science Perspective".

This book was made for those curious or science students with concerns in forensic science and especially in crimes related to forensics. It was developed because of the greater demand in this area and for readers to acquire a basic level in chemistry. This increase in demand can be seen in the rise of criminal novels, detective stories, murders and the large audience of the crime resolution series.

The objective of this book is to provide a knowledge of chemistry in a fun, clear and understandable way to students of liberal arts and relate them to forensic science.

As far as the organization is concerned, the book consists of 14 main blocks where each chapter or block begins with the presentation of a real case and ends with its resolution. In

between, the fundamentals in chemistry or science appear, necessary for the solution of the case. It also provides a series of exercises to check if you have learned the explained.

Next, a table with the contents of the 14 chapters is added.

Table 3. Index of the book. (Costa,J., 2008).

CHEMISTRY AND CRIMINAL INVETIGATION	
Section Number	**Title of the Section**
1	Introduction to forensic chemistry
2	Collection and storage of evidence
3	Atomic tracks
4	Chemical tests
5	Properties of solutions 1: Aqueous solutions
6	Properties of solutions 2: Intermolecular forces and colligative properties
7	Chemistry of drugs
8	Chemistry of addiction
9	Investigation of arson
10	Explosion chemistry
11	Estimate the moment of death
12	Dirty bombs and nuclear terrorism
13	Poisons
14	Identification of victims: DNA analysis

Observing the totality of the content, there are two topics that refer explicitly to forensic engineering, chapters 9 and 10, fires and explosions, even so, the other topics also have to be taken into account, since they are topics that cover chemistry that a forensic engineer should also know and also some of the chapters can also be taken into account as an optional subject.

Chapter 9 contains the following sections.

Table 4. Index of the chapter 9. (Costa,J., 2008).

CHAPTER 9: INVESTIGATION OF ARSON	
Section Number	**Title of the Section**
Real Case	Cause of a domestic fire
1	The chemistry of fire
2	Combustion reactions
3	Redox reactions
4	The thermodynamics of fire
5	Heat capacity and phase changes
6	Mathematics of heat capacity
7	The first law of thermodynamics and calorimetry
8	The mathematics of calorimetry
9	Oil refining
10	End of the case in study

Chapter 10 contains the following sections.

Table 5. Index of the chapter 10. (Costa,J., 2008).

CHAPTER 10: CHEMISTRY OF EXPLOSIONS	
Section Number	**Title of the Section**
Real Case	Trace Explosives
1	Explosives
2	Redox chemistry of explosives
3	Molecular kinetic theory of gases
4	The laws of gases
5	The mathematics of the laws of gases
6	The law of combined gases and the law of ideal gases
7	The mathematics of the law of combined gases and the law of ideal gases
8	Detect explosives: Dalton's law of partial pressures
9	End of the case in study

Analyzing these tables and reading the book, it can be concluded that it is an introductory syllabus, so for the level that is requested in the proposal, it is a basic book. However, it can be a determinative book to do the proposal, for example, the use of cases can be taken into account to document, specify and clarify the scientific foundations taught in each section of the proposal, so, if in the proposal appears a fire subject, it is possible to add several real cases of fires to add information that helps to understand the subject and also put the student in the environment of expertise.

The scientific sections of these two chapters are introductory, in fact, the student is presupposed that this knowledge has already been acquired in case of carrying out the course proposed.

4.3.2. Forensic Engineering

Next, the book titled Forensic Engineering written by Kenneth L. Carper will be analyzed.

The preface is the first part that will be discussed. The preface shows that the book has the collaboration of experts from all branches of science, it is interesting to take it into account to see what kind of teachers or experts could give the course of the proposal.

Preface: The activities of forensic experts in engineering are explained in this book, activities that are common in many disciplines of engineering, this is explained in the general chapters. In this book there are experts in particular who have made some specific chapters, each one is a specialist in their field. Each chapter includes a description and the experiences of each expert but from the point of view of the author and not the collaborators.

These experts have included in their part the following information:

- Typical clients, and scope and purpose of investigations
- Techniques, procedures, and tools used in investigation and analysis
- Interface with forensic specialists from other disciplines
- Impact of forensic activity on improved practices, products, or planning to
- reduce the frequency and severity of failures
- Case study examples from the contributors' experiences
- Reference lists for further reading

Each contributor has made reference in different aspects such as the organization in the investigation, theories in the analysis or in the practice of forensic engineering.

Despite being a second edition (since both have passed time and new points of view have emerged for the realization of this second edition), the focus in their disciplines has been the same, a view of forensic activities and research in engineering accidents. This book is widely used and recommended for forensic experts practicing in all engineering disciplines, design and construction professionals, lawyers, product manufacturers, insurance, professionals and engineering students. In different universities, they use this book as a textbook, whether in university or postgraduate courses.

As it has been commented this book has been updated in this second version so the specialized chapters have been reviewed by each contributor, new cases have been added as discussions of judicial decisions in the field of forensic engineering.

The Collaborators are the following:

Glenn R. Bell, who is an expert in structural distress and failure research and in the design of peculiar structures.

Kenneth L. Carper, who is an architect.

Ron Hendry, who is a professional engineer.

Joel T. Hicks who is a partner of a company that has developed a computer tool for the solution in the reconstruction of accidents and related technical investigations. He has experience in engineering management, product and process development, security and product review and forensic investigations.

William G. Hyzer, who is an expert in photography with leading instrumentation at the time and especially technology to apply in scientific research.

Rudolf Kapustin who is an expert in the world of aviation, security, accident investigation ...

Lindley Manning, mechanical engineer. Forensic Engineer specializing in litigation for product liability, vehicle accident analysis, industrial safety and machinery failures or accidents.

M. D. Morris works for the government in terms of communication of important industries and professional offices.

Paul E. Pritzker retired president of a forensic engineering firm.

Robert A. Rubin who is an engineer specialized in construction problems, especially in the resolution of complex problems as well as client representative in these disputes and mediator.

Fred H. Taylor who is an engineer and president of a mechanical engineering company. Related to forensic services.

Dana Wordes who is a geotechnical engineer and civil engineer.

Now the content of the book will be exposed to observe the syllabus to be able to add some part to the final proposal.

The book is divided into 13 sections, an introductory first, then 8 sections related to the most scientific part, then has 3 sections related to the less scientific part, that is, the most judicial part related to the forensic expert and to finalize a final section of conclusions.

First, the introductory part contains 5 points and are the following:

1. What is forensic engineering?

Definitions.

This section begins by defining who is a forensic engineer, who is an engineer who should try to solve legal problems with knowledge in engineering. The determination of accident causes of failures in the machinery or buildings, making the opinion, understanding the causes of a fire, assisting as an expert in oral proceedings are many of the activities or functions that have a forensic engineer. In this chapter, other definitions of other professionals are also exposed.

Reconstruction of accidents

This chapter emphasizes the importance of accident reconstruction. The chapter emphasizes that it does not always appear in the litigation but it is important for the experts to reconstruct the facts to determine the cause of the accident and also to avoid its reproduction in the future. A competent forensic engineer who makes a good expertise and a good reconstruction is able to prevent the trial from being reached as it makes any doubt impossible, both parties agree and the case is finalized.

Typical clients and projects

The usual clients are both parties involved in the accident, defense and accusation. So, lawyers representing the parties that can be individuals, companies or government agencies. In addition, it indicates other ways of working, so, to work for agencies to cooperate or for example to work for the press depending on the case.

Influence on Improved Practices

As in other areas of the sciences, forensic investigation has served for the development of science. In this chapter, the importance of forensic engineers is also commented, in recommending in some processes, improvements to be made in the deficiencies investigated.

2. Qualifications of the Forensic Engineer

In the following sections the author comments on the skills of a forensic engineer, whether personal or professional. In the next chapter, the author describes the technical skills and the knowledge of legal procedures. Other characteristics that stand out in the section of written and oral communication, which has also been discussed in the introduction of this work, it is very important to know how to defend the opinion in the litigation as well as writing it in an understandable but with fundamentals that they are what make the report itself credible. Finally, it teaches personal characteristics, for example, the ethics of each one.

3. Ethicals and Professional Responsabilities

In this section, the author affirms the need to create a professional ethics guide, such as the NAFE, an American academy, which has developed the standards of professional ethics. This is due to the increase in the number of engineers who have approached the forensic world just for the money it brings. There are many other organizations that have also established these guides.

4. Resources and Professional Organizations

This section is perhaps the least relevant of this first introductory point, because it refers to all types of resources and organizations created, especially in North America, for the proper development of forensic engineering. It is not relevant because it is only applicable in that state and not in the Spanish state. In the case of implementing this in a hypothetical textbook or course, it should be exposed organizations working in this field at the national level, it should also include publications that are made as well as magazines or articles.

5. Opportunities in Forensic Engineering Practice

In this section, the author comments on the opportunities that an engineer has based on his ethics and integrity, in the sense that he can contribute in different cases, as a representation for the public or for oral judgment.

From section two to nine, the topics, that the author has believed most important terms to explain of the scientific knowledge that must be acquired in order to work in as many cases as possible, are exposed. The autor made an in-depth study of each topic, with the help of cases, research, scientific explanations of all kinds, historical context, antecedents ... (In the appendix 2, the index of this book will be included to observe all the exposed sections) . Even so, the main topics are the following (Carper,K., 2001):

- Learning from Failures
- Fire Investigtion
- Industrial Accidents
- Product Liability
- Traffic Accident Reconstruction
- Transportion Disaster Investigation
- Civil Engineering Investigation
- Environmental Systems Failures

The tenth chapter deals with the expert opinion. As in all the chapters, this one is also divided into different sections, a first introductory one where it explains the objectives globally, and a little bit above how it should be done. The following section discusses the reasons why these reports are made or written, whether to inform, instruct, influence, control, criticize and save the efforts made by the expert. Then, the audience is informed it means who will read that report, since it is vital to know who will read the report, who will sign it and to whom it should be delivered. In short, along with other sections, it can be concluded that this chapter shows the importance of making the report and a guide for the procedure of this.

The following chapter tells the importance of the photographs in the cases and the testimony that these photographs provide. Also introduce the techniques used throughout all the

cases that have occurred as well as their instruments. At the end of this chapter, the role of photography experts is also discussed, as well as a guide to make these photographs effective.

Before the conclusions, in the chapter twelve appears the chapter called "The Engineer as an Expert Witness". That is, how the work of the forensic engineer is reflected in the legal field. So as in the other chapters, start with an introduction, explain the ethics that all expert witness should have, then try to comment on how the lawyer works with this expert and when a lawyer can contact or request the work of this expert. Next, it is explained the process before the trial where both parties obtain information from the case, finally before the trial the lawyer and the expert prepare the testimony of the expert in the same trial. Below are other chapters in which it is reported that aspects should be taken into account by the expert to introduce evidence in the trial, how to make the trial and other aspects that follow the trend of this chapter in narrating the procedure of the forensic engineer, since clients give the case until it is completely closed.

The book ends with some conclusions about the context of forensic engineering, with some recommendations and an appendix. (In the appendix 2, the index of this book will be included to observe all the sections).

4.3.3. Forensic Engineering Investigation

The next book to be analyzed is titled "Forensic Engineering Investigation" and is written by Randall K, Noon.

Like the previous book, this book begins with the preface, where forensic engineering is defined. "Forensic engineering is the application of engineering principles, knowledge, skills, and methods to answer questions of fact that may have legal ramifications". In short, a forensic engineer is useful when an expert must analyze car accidents, building collapses, fires, explosions, industrial accidents and other problems, this engineer must answer the question, "What caused this to happen?". Finally, this preface explains what a forensic engineer is and what his work consists of.

Next, a table with the contents of the introductory chapter of the book will be presented and then its content will be briefly summarized to know which aspects it speaks about.

Table 6. Index of the introductory chapter. (Noon,R., 2001)

INTRODUCTORY CHAPTER	
Section Number	**Title of the Section**
1	Definition of Forensic Engineering
2	Investigation Pyramid
3	Eyewitness Information
4	Role in the Legal System
5	The Scientific Method
6	Applying the scientific Method to Forensic Engineering
7	The Scientific Method and the legal System
8	A Priori Biases
9	The Engineer as Expert Witness
10	Reporting the Results of a Forensic Engineering Investigation

This first chapter introduces the forensic engineer, provides definitions about this engineering and information about it. It also develops the role that the expert has, how a case is produced and the steps to follow, from when an information is given until it is concluded. It shows the detective characteristics of the expert, indicates the role he has within the legal system, explains how to develop the scientific method for the application in this field of work and in the legal field. The last points are about the forensic engineer as an expert and explain what their research and purpose are.

It can be said that this first introductory chapter tries to comment on some basic aspects of the forensic engineer within the legal system and the purpose of their work.

Next, a table with the title of all the remaining chapters will be exposed and a small conclusion will be made. (In the appendix 3, the index of this book will be included to observe all the sections)

Table 7. Index of the main sections of the book. (Noon,R., 2001)

Section Number	Title of the Section
1	Introduction
2	Wind Damage to Residential Structures
3	Lightning Damage to Well Pumps
4	Evaluating Blasting Damage
5	Building Collapse Due to Roof Leakage
6	Putting Machines and People Together
7	Determining the Point of Origin of a Fire
8	Electrical Shorting
9	Explosions
10	Determining the Point of Ignition of an Explosion
11	Arson and Incendiary Fires
12	Simple Skids
13	Simple Vehicular Falls
14	Vehicle Performance
15	Momentum Methods
16	Energy Methods
17	Curves and Turns
18	Visual Perception and Motorcycle Accidents
19	Interpreting Lamp Filament Damages
20	Automotive Fires
21	Hail Damage
22	Blaming Brick Freeze-Thaw Deterioration on Hail
23	Management's Role in Accidents and Catastrophic Events

It is appreciated that in these chapters there is nothing about the judicial system or the work of the experts. However, it deals with the sciences that an engineer must know or that the

author considers it. Compared with the other book, it can be said that this is the technical part and the other explains the expert's work. So, from both books, possible subjects are extracted to do the course in question. From the first, the subjects of the procedural system and the characteristics of the expert, but modified to the Spanish state, can be obtained. On the other hand, since science is the same everywhere, it could be applied in the same way, expanding knowledge and modifying some that have become obsolete.

4.4. PROPOSAL FOR A MASTER

Finally, the last part to analyze is a master's final project in Forensic Science and Engineering.

This is a master's project carried out in 2005 at the University of Barcelona. The objective of this project was similar to the proposal but with other additions that are not interesting. The objective was to know the status of Forensic Science and Engineering in the world and Spain and to carry out a market study in Spain. On the other hand, it was also an objective to develop a work methodology of the forensic engineer to implement an expert company. Finally, to establish a Forensic Engineering course. This last part is the most remarkable for the realization of this proposal because it is the common goal.

On the next page, the table with the content of the course of the proposal made in this master project will be presented. Then, the table will be analyzed in order to conclude and extract the most important subjects to make this new proposal.

The proposal of that project is the following:

Table 8. Subjects of the first proposal. (Martinez,D., 2005)

Title	Theorical credits	Practical credits	Trimester
Introduction to Forensic Engineering	3.0	–	1
Study of practical cases	1.5	1.5	1
Fundaments of Science and Engineering of Materials	2.5	2.0	1
Fundamentals of Environmental Engineering	1.5	–	1
Methods of Work in Forensic Engineering	4.5	–	1
Fundamentals of Law	3.0	–	1
The Human Factor. Risk and Reliability	3.0	–	2
Fundamentals of Safety and Hygiene	4.5	–	2
Fundamentals of Toxicology	2.5	2.0	2
Fundamentals of Ergonomics	3.0	–	2
Simulation and Calculation Tools	2.5	2.0	2
Analytical Techniques in Forensic Engineering	2.5	2.0	2
Professional Ethics and Deontology	3.0	–	3
Forensic Engineering Project	–	12.0	3
Total	40	21.5	–

The duration of the master is 1 year and is divided into three trimesters. The first two trimesters consist of various theoretical subjects with their corresponding credits and the last trimester has the project and a theoretical subject. The subjects of engineering character are those that receive a greater number of credits. However, the project involves the most practical credits.

The structure of that course wii be taken into account to make the proposal, tha case studies appears once again, so it sure appears in this new proposal. The project also appears

again, so it will definitely be in this new proposal. Regarding the subjects, these of the legal field are repeated. In addition, for the final proposal, other subjects such as the basics in environmental engineering and the tools of simulation and calculation will be taken into account.

There is another proposal in that same project, there are no subjects, but it shows the blocks of the course. The blocks are the following:

Table 9. Subjects of the second proposal. (Martinez,D., 2005)

Title	Credits
Fundamentals and Complements	15
Legal System	15
Scientific-Technical Knowledge	30
Professionals Aspects	30
Development of a Project	30
Total	120

As can be seen, these blocks are similar to those in the first table, where there is a first introduction, a section of the legal system, another more scientific or technical part, another that focuses on the professional part of the expert and the last the final project. The second table could perfectly be a summary of the first. This table can be the summary of this new proposal.

Both tables will be very useful for the elaboration of this proposal.

5. THE PROPOSAL

Now that the bibliography has been analyzed, the proposal will be elaborated. The compulsory subjects will be detailed. In the technical or scientific section, the subjects of forensic engineering will be the main ones and those of forensic science the secondary ones.

The course will last one year and will be divided into two semesters. In addition, the final project will be carried out in another additional semester. This project can be done in two ways, one of them would be to focus on one of the scientific subjects and perform some practice in relation to the subject and the second would consist of the most legal aspect of the course, make an opinion properly, make some litigation ... Anyway, it would be free to choose but with consultation to the tutor. The project includes an oral defense.

To complete this course, it will be obligatory to have previous studies in chemistry and / or chemical engineering. The first semester of the course will focus on the work of the professional, that is, the way of working, characteristics, the legal system in which the expert will work (in this case the Spanish system). Although there is also a scientific subject. The second part of the course will be studied more engineering aspects and the elaboration of opinions.

The following tables show the organization and program of the course:

Table 10. Compulsory subjects.

Compulsory Subjects		
Subject	% Hours	Semester
Introduction to Forensic Engineering	5	1
Basic law	30	1
The Expert Witness	20	1
Fires	30	1
Explosions	15	2
Environmental Engineering	20	2
Opinion and Defense	20	2
Failure Mechanisms of Materials	15	2
Final Project	100	3

This table shows the compulsory subjects in the course, in the first semester there is a 15% corresponding to a elective subject to be chosen in the next tables. In the second semester, 30% is missing, corresponding to two electives. The final project is 100% of the third semester, the latter in case the student has not approved a maximum of two subjects, the student can combine the project with these two subjects or less. (In the appendix 4, the tables corresponding to each subject are shownin order, with their index, objectives, evaluation and methodology). The tables, with the content of each subject have been elaborated according to the importance that has been given in the previous bibliography.

Next, there is a table that shows the elective subjects:

Table 11. Elective subjects.

Elective Subjects		
Subjects	% Hours	Semester
Automobile Accidents	15	1 2
Collapse of buildings	15	1 2
Simulation and Calculation tools	15	1 2
Drugs	15	2
DNA Studies	15	2
Fakes and Forgeries	15	2
ForensicToxicology	15	2

The first three are typical of Forensic Engineering, the student must do at least one of them, in case of doing only one, it must be in the first semester, if two, one in each semester. The other 4 subjects will be done in the second semester, one or two will be done depending on whether the student has chosen to do 1 or 2 in the previous three.

The elaboration of the proposal has been carried out contrasting all the bibliography previously exposed. For example, in all the courses, in all the books and in the project, there is a section on fires. The NAFE's conferences and the post degree course at the University of Edinburgh have served to show the big importance of fires in Forensic Engineering

The books have served to complete the contents of the scientific subjects. The Spanish Universities of the bibliography section have served to document all courses realted to Forensic Science and Engineering of the state and to help the decision to select some subjects to the proposal.

The others subjectes have been elected as a result of the repetition of these subjects in all the bibliographies

6. CONCLUSIONS

The implantation of this course in Spain, would suppose a great advance of the forensic sciences in this state. Currently there is only one post degree on Forensic Science and none in Forensic Engineering. In Spain there are only elective subjects in some degrees or independent courses that talk about Science or Forensic Engineering that they only intend to inform.

Worldwide, it is different, there are many courses of all kinds, especially in Forensic Science, while Forensic Engineering is scarce. Most courses in Engineering are not complete, but are complemented by science courses.

In each educational center subjects related to the legal field and to the professional are taught. The legal section is dependent on the country or region in which the educational center is located, since it is not the same judicial system for Spain as for the United States of America. So an expert in Spanish law should be responsible for teaching this subject. Each educational center chooses the subjects of scientific scope that it is going to teach, this implies that in each center some subjects or others are given. However, it can be concluded that there are some subjects that are often repeated and that are taught in a similar way. The most common are subjects of fires, explosions, materials and environmental contamination.

Also, the case studies should be highlighted, these are carried out in all the educational centers where these courses are taught. The cases are a great help to experience the student in the work of the forensic expert. As with the case studies, the final project is also repeated in all Forensic Science and Engineering courses.

As a final conclusion, Forensic Science and Engineering in Spain is in the process of being developed, there are currently few courses and bibliography. In addition there are no entities that look after the interests of this union. On the other hand, in other countries, especially in the United States, there are more courses, bibliographies and organizations of all kinds that seek the development of this science.

Finally, the objectives have been carried out, the bibliography search has been done and the proposal for a post degree course in forensic engineering has been developed,

REFERENCES AND NOTES

1. BOE. https://www.boe.es/buscar/act.php?id=BOE-A-1985-12666&tn=1&p=20190115 (accessed May 5, 2019).
2. Carper,K., *Forensic Engineering*, CRC Press LLC: Boca Raton, United States of America, 2001.
3. Colegio Oficial de Ingenieros Industriales de Madrid. Curso de Peritaciones Técnicas Judiciales. Ingeniería Forense. http://portal.coiim.es/servicios/formacion/curso-de-peritaciones-tecnicas-judiciales-ingenieria-forense-1-314 (accessed April 3, 2019)
4. Costa, J., *Química e Investigación Criminal*, 1th ed.; Reverté: Basauri, España, 2008.
5. Costa,J., Forensic Science and Engineering. University of Barcelona. Private notes.
6. Forensic Engineering and Science MSC. University of Cranfield. https://www.cranfield.ac.uk/courses/taught/forensic-engineering-and-science (accessed April 8, 2019).
7. Forensic Explosive and Explosion Investigation MSc. University of Cranfield. https://www.cranfield.ac.uk/courses/taught/forensic-explosive-and-explosion-investigation (accessed April 8, 2019)
8. International Post degree Master of Science in Fire Safety Engineering. University of Edinburgh. https://www.findamasters.com/masters-degrees/course/international-master-of-science-in-fire-safety-engineering-msc/?i300d1312c43009 (accessed May 15,2019).
9. Martinez, D., Master's Final Project. Experimental in Chemical Engineering. Forensic Science and Engineering. Proposal for a third cycle Master and a professional technical office. University of Barcelona. Chemical Engineering and Metallurgy department, 2005.
10. National Academy of Forensic Engineers. Conference Scheduling. https://nafe.memberclicks.net/july-2019-conference-in-denver-colorado (accessed May 13, 2019).
11. Noon, R., *Forensic Engineering Investigation*; CRC Press LLC: Boca Raton, United States of America, 2001.
12. Post degree in Forensic Chemistry. University of Valencia. https://postgrado.adeituv.es/es/cursos/area_de_ciencias_y_tecnologia-8/quimica-forense/programa.htm?option=2 (accessed April 8, 2019)

ACRONYMS

LOPJ	Ley Orgánica de Poder Judicial
LDPJ	Ley de Demarcación y de Planta Judicial
DNA	Deoxyribonucleic acid
IR	Infrared Radiation
NMR	Nuclear Magnetic Resonance
ICP-AES	Inductively coupled plasma atomic emission spectroscopy
ICP-MS	Inductively coupled plasma mass spectrometry
MSc	Master of Science
CBRN	Chemical, biological, radiological and nuclear
FIIED	Forensic Investigation of Explosives and Explosive Devices
DVI	Disaster Victims Identification
MFI	Mass Fatality Incidents
NGO	Non-Governmental Organization
C-IED	Counter Improvised Explosive Devices
MoD	Ministry of Defence
IED	Improvised Explosive Devices
UB	University of Barcelona
ECTS	European Credit Transfer System
NAFE	National Academy of Forensic Engineers
NSPE	National Society Professional Engineers
FSE	Fire Safety Engineering

APPENDICES

APPENDIX 1: APPENDIX OF THE INTRODUCTION

The link below shows the article 470 to 480 of the LOPJ. These articles show the organizations or departments where the experts can work.

https://www.boe.es/buscar/act.php?id=BOE-A-1985-12666&tn=1&p=20190115

Example of an expert opinion:

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JOSÉ COSTA LÓPEZ, CATEDRÁTICO Y PROFESOR EMÉRITO DE INGENIERÍA QUÍMICA Y DECANO DEL ILUSTRE COLEGIO OFICIAL DE QUÍMICOS DE CATALUÑA, EN SU CALIDAD DE PERITO PROPUESTO POR LA PARTE ACUSADA EN LAS D.P. XXXX DEL JUZGADO DE INSTRUCCIÓN Nº XXX DE BARCELONA, EMITE EL SIGUIENTE

DICTAMEN

Sobre los siguientes extremos:

1.- Análisis de las sustancias.

En un atestado obrante en la causa los MMEE establecían que hallaron al Sr. XXX un bote de pequeñas dimensiones con un pequeño bote de cristal que podría ser sustancia explosiva. Dicha sustancia fue analizada por la Unidad Central de Laboratori Químic de la policía científica del cuerpo de MMEE en informe de XX de XXXX de XXXX. En dicho informe se establece que la sustancia pesa en total **2,56 gramos de una mezcla de sacarosa (2/3 partes) y clorato sódico (1/3 parte).**

La **sacarosa** es un compuesto químico orgánico, del grupo denominado hidratos de carbono o sacáridos (azúcares) de formula global $C_{12}H_{22}O_{11}$ y de peso molecular 342. Es el azúcar común utilizado en alimentación. Es pues un edulcorante.

El **clorato sódico** es un compuesto químico inorgánico de fórmula $NaClO_3$ y peso molecular 106,5. Es la sal correspondiente al ácido clórico y la base hidróxido sódico. Es un compuesto **oxidante.** Sus aplicaciones en química derivan de esta característica de sustancia oxidante que reacciona con las sustancias reductoras. Se ha utilizado como herbicida, generador de dióxido de cloro para blanqueo de pasta de celulosa, etc. Es una sustancia que puede reaccionar como oxidante con compuestos orgánicos, por ejemplo azúcar, de forma explosiva deflagrante.

La sal **potásica (clorato potásico)** es totalmente similar y se ha utilizado más en pirotecnia, … dadas su posible reacción explosiva con determinadas sustancias. Dado su poder oxidante se ha utilizado también en aplicaciones farmacéuticas como antiséptico oral.

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2.- Análisis de si estamos ante sustancias explosivas.

Explosiones y fuegos. Introducción histórica

El interés por los procesos de combustión se remonta a los albores de la Humanidad. Se sitúa en un periodo de 6 x 10^5 a 4 x 10^6 años atrás la adquisición -atribuida a Prometeo en la Mitología griega- de la libertad que le supone al hombre el disponer del fuego como fuente de calor al haber aprendido a obtenerlo por sus propios medios. Haciendo abstracción de los procesos químicos de índole culinaria, la primera aplicación del calor procedente de la combustión como agente energético "industrial" fue en la cocción de la cerámica y data de unos 8.000 años. En la Metalurgia empezó a utilizarse hace unos 5.500 años.

Si se consideran la concepción aristotélica, anteriormente esbozada por la escuela de Mileto, del fuego como uno de los elementos del universo; las múltiples elucubraciones de la Alquimia, y las teorías del flogisto, del fluido calórico y del calor latente, queda esbozada la historia del interés científico del hombre por la combustión hasta insertarla en la Ciencia moderna.

Nombres tan ilustres como Boyle, Lavoisier, Priestley, Cavendish, Faraday, Hess, Haber y otros muchos, marcan el camino seguido por la investigación sobre las reacciones de combustión como uno de los temas básicos de la Química durante el nacimiento y desarrollo de esta Ciencia.

En el siglo pasado continuó el gran interés por este tema tan antiguo y a la vez tan actual. Dixon, Coward, Hinshelwood, Penner van Tiggelen, Hirschfelder, Kistiakowsky, Kondratiev y Semenov, entre otros muchos son figuras importantes en este campo. El último, concretamente, recibió el Premio Nobel en 1956, precisamente por su valiosa contribución al estudio de los procesos de combustión y de las reacciones en cadena relacionadas con los mismos. Una buena revisión bibliográfica del tema y de las vías que se siguen en la investigación teórica, experimental y técnica puede encontrarse en el libro: "Some problems in chemical kinetics and reactivity", de N.N. Semenov, , Princeton Univ. Press, Princeton, N. Jersey (1959).

Al igual que la aplicación del calor a la Metalurgia determinó la existencia de la Edad de los Metales, la utilización de una nueva forma de combustión, la explosión detonante, como forma de obtener súbitamente energía mecánica (artillería, voladuras, etc.) determinó el principio de la Edad Moderna. Posteriormente, cuando se consiguió controlar el proceso de transformación energía química-calor-energía

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mecánica al inventar Watt la máquina de vapor, la combustión jugó un papel importante en el principio de la Era Industrial. Finalmente, el control de la reacción explosiva en los motores de Otto, de Diesel, de turbina y de reacción, ha contribuido notablemente al progreso tecnológico actual.

Las reacciones explosivas. Deflagración, detonación e ignición.

Habida cuenta de la variedad existente en la terminología utilizada en este campo por diferentes autores, se fijarán a continuación los términos que se usarán en el presente informe. Se han elegido los de uso más frecuente con las acepciones que parecen más razonables.

Explosión: todo fenómeno de combustión que se propaga por sí mismo.

- **Deflagración:** explosión que se propaga isobáricamente y a velocidad subsónica. Algunos autores aplican este término al caso de que se produzca en sólidos, utilizando el de "inflamación" cuando tenga lugar en fase líquida o gaseosa.

- **Detonación**: explosión de naturaleza no isobárica que se propaga a velocidad supersónica.

Ambos tipos de explosión suelen ir acompañados del desprendimiento de energía luminosa, fenómeno que recibe el nombre de **llama**.

Ejemplos de explosiones deflagrantes:

- Las mezclas explosivas de gas natural y aire en condiciones normales
- La descomposición de nitrato de celulosa (un compuesto inestable usado en propulsores)
- Pólvora negra
- Polvo de granos

Ejemplos de explosiones detonantes:

- Dinamita
- Nitroglicerina
- Fulminato de mercurio
- Trinitrotolueno
- Nitrato de amonio

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El hecho experimental de que, en la mayor parte de los casos, una misma mezcla explosiva sea capaz de deflagrar o detonar indistintamente, así como las teorías de vigencia actual sobre las explosiones térmicas y las reacciones en cadena demuestran el que sean condiciones exteriores, completamente ajenas a la naturaleza de la mezcla explosiva de partida, las que imponen una y otra forma de explosión, De esta forma, cualquier intento de comprender la naturaleza de estos fenómenos, e igualmente los trabajos de investigación en este campo, han de tener en cuenta la influencia de factores externos. Tales factores son: presión, temperatura, forma y dimensiones del recipiente o reactor, naturaleza y estado de las paredes del mismo, dilución de la mezcla con gases inertes, presencia de substancias activantes o desactivantes ajenas a la mezcla, forma de iniciar la explosión, etc.

La explosión detonante suele nacer de una deflagrante autoacelerada, determinando esta última un periodo de inducción o predetonación. Precisamente esta etapa deflagrante es, mas que la detonación supersónica, la que esta influenciada por los factores, ajenos a la naturaleza de la mezcla, que se han mencionado antes.

La combustión deflagrante puede iniciarse de muy diferentes maneras (calentamiento de toda la masa gaseosa, calentamiento local mediante llamas, chispas, superficies calientes, etc., choque acústico, etc.) dependiendo de los factores repetidamente citados el que se convierta en detonación o que siga su curso subsónico, El fenómeno del paso de deflagración a detonación es lo que se denomina **ignición.** Algunos autores lo denominan **autoinflamación** pero aquí se utilizara el término anterior.

Consideraciones energéticas

La cantidad de energía liberada por una explosión está directamente relacionada con el tipo de mezcla explosiva, la **cantidad** y **proporción** comburente (oxidante)/combustible (reductor) y el espacio donde esta encerrado. En general, las explosiones disipan energía de las siguientes maneras:

1. Acústica: el sonido de la explosión

2. Cinética: desplazando objetos que se encontraban en el punto de origen de la explosión.

3. Calor i energía expansiva hacia los alrededores.

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En el caso que nos ocupa como se ha dicho en el extremo anterior el **clorato sódico** es un potente oxidante que puede reaccionar explosivamente (deflagración) con compuestos orgánicos (reductores), como por ejemplo **sacarosa**. Ahora bien, el impacto dependerá de la cantidad y la proporción entre los componentes de la mezcla.

3.- Análisis del impacto que dicha cantidad tendría al ser objeto de deflagración. Posible comparación con petardos de ámbito comercial.

Como se acaba de mencionar en el apartado anterior, el impacto de la posible deflagración depende fuertemente de la **cantidad de mezcla explosiva** y también de las **proporciones** entre oxidante y reductor. En general un exceso de uno de los dos (sobre todo del reductor) "apagaría" en términos químicos la reacción. La proporción adecuada está normalmente alrededor de lo que en Química se denomina **estequiometria** (proporciones entre reactantes) **de la reacción.**

En el caso que nos ocupa la cantidad total es 2,56 gramos y es una cantidad muy pequeña inferior incluso a las que se utilizan en algunos petardos pirotécnicos y por tanto el impacto de una posible explosión sería despreciable. Daría lugar a una pequeña deflagración (llamarada) isobárica es decir sin onda expansiva en una situación de no confinación.

Por otro lado, la proporción está muy lejos de la estequiometria de la reacción entre el clorato sódico y la sacarosa. Hay claramente un exceso de este último lo que significa que la deflagración no se extendería a toda la mezcla (se apagaría antes).

Por tanto, impacto muy pequeño -inferior a los que se buscan en las aplicaciones pirotécnicas de las mezclas explosivas en las que se emplean como se ha dicho antes cantidades superiores de mezcla explosiva-.

Barcelona 2 de marzo de 2015

APPENDIX 2: INDEX OF THE BOOK "FORENSIC ENGINEERING"

APPENDIX 3: INDEX OF THE BOOK "FORENSIC ENGINEERING INVESTIGATION"

APPENDIX 4: CONTENT TABLES OF THE COMPULSORY SUBJECTS

Introduction to Forensic Engineering

Index

- Definition.
- Conceptualizaction.
- Introduction to previous cases.
- Influence of accidents.

Objectives

- To establish a first contact with forensic engineering. To define the forensic engineering is and to contrast experts examples in order to establish a first contact whit it.
- To make the student aware of the current situation of forensic engineering and introduce them.
- To observe how the forensic engineer's investigation in real cases has served for the development of science.
- To Introduce the world of forensic engineering and to stand out the importance for society.

Evaluation

- The evaluation consists of two multiple choice exam. One will be done in the middle of the semester and the other at the end. The first represents 40% of the grade and the second 60%.

Methodology

- Theoretical classes with compulsory attendance.

Basic Law

Index

- The Organization of the Coexistence and the Constitution
- Procedural System
- Judicial System
- The Courts of Justice
- Typical Vocabulary of the Legal scope.

Objectives

- To understand the structure of the state to facilitate understanding with legal professionals.
- To know basic aspects of the constitution.
- To know the structure and characteristics of the Spanish Judicial and Procedural Systems.
- To know the typical vocabulary of the legal field, both for communication with clients, and in oral proceedings.

Evaluation

- The evaluation consists on a theoretical exam that represents the 30% of the grade and a final exam that represents the 60%.
- The rest of activities represents the 10%. Small online test, activities in class....

Methodology

- Theoretical classes with compulsory attendance, 90%.
- Classes based on activities, 10%.

The Expert Witness

Index

- Law 1/200 of Civil Procedure regarding the Expert Evidence.
- The Penal Code regarding the Expert Evidence.
- Content of the Expert Report.
- Expert Activity.
- The Expert as a means of proof and help of the Judge.
- Legitimization of the Expert.
- Responsibility of the Expert.
- Ratifications and Clarifications to the Expert.
- Fee Collection Process.
- Obligations and Advantages of the Collegiate Visa.
- Public Defender.
- Rights of the Expert
- Case Study

Objectives

- The first objective is to show the importance of the forensic engineer as an expert witness.
- To teach the expert's work process, from the beginning of the case until it ends.
- To learn the characteristics of the expert.
- To carry out a case study where the guidelines to be followed in a case will be drawn up.

Evaluation

- The evaluation consists on a theoretical exam that represents the 20% of the grade and a final exam that represents the 50%.
- The case study that represent the 30%.

Methodology

- Theoretical classes with compulsory attendance, 70%.
- Classes of the case study at the end of the semester, 30%.

Fires

Index

- General
- Burning Velocity
- Flame Spread Ratings of Materials
- A Little Heat Transfer Theory: Conduction and Convection
- Radiation
- Initial Reconnoiter of the Fire Scene
- Method of Fire Determination
- Arsonist Profile
- Typical Characteristics of an Arson or Incendiary Fire
- Liquid Accelerant Pour Patterns
- Detecting Accelerants after a Fire
- Case Study

Objectives

- To know the science of fire, point of ignition, propagation, heat transfer ...
- To determine the profile of the arsonist
- To find and analyze the evidence.

Evaluation

- The evaluation consists on a theoretical exam that represents the 30% of the grade and a final exam that represents the 50%.
- The case study represents the 20%.

Methodology

- Theoretical classes with compulsory attendance, 80%.
- Classes of the case study at the end of the semester, 20%.

Explosions

Index

- General
- Diffusion and Fick's Law
- Flame Fornts and Fire Vectors
- Pressure Vectors
- The Epicenter
- Energy Considerations

Objectives

- To learn the science of explosions.

Evaluation

- The evaluation consists on a theoretical exam that represents the 40% of the grade and a final exam that represents the 60%.

Methodology

- Theoretical classes with compulsory attendance.

Environmental Engineering

Index

- Enviromental chemistry.
- Water pollution.
- Air pollution.
- Land pollution.
- Solid waste treatment.
- Environmental impact assessment
- Environmental legislation. Rules and regulations
- Study Case

Objectives

- To give the basic knowledge about pollution to the forensic engineer in order to do a proper use in the expert report.

Evaluation

- The evaluation consists of two exams, the first one is in the middle of the semester and represents the 30% of the grade, and the other one in the end of the course and represents the 50% of the grade.
- The study case represents the 20% of the grade.

Methodology

- Theoretical classes with compulsory attendance, 80%.
- Case study classes at the end of the semester, 20%.

Opinion and Defense

Index

- Examples of Opinions
- Structure of the Opinios
- Preparation of Opinions
- Preparation of a Hypothetical Oral Defense

Objectives

- To teach the students to prepare the opinions and to know how to defend them in the litigation.

Evaluation

- Final exam that represents the 30% of the grade.
- Preparation of three opinions from three different cases that represents the 40% of the grade.
- Oral presentation where an oral trial will be simulated that represents the 30% of the grade.

Methodology

- Assistance to real trials.
- First of all, the teacher of the subject will explain in theoretical classes how to make the opinions, then the student will have to prepare three different opinions in practical classes. Finally, the students will make an oral presentation to defend their opinions.

Failure Mechanisms of Materials

Index

- Failure modes-ductile, brittle, fatigue, excessive deflection, creep rupture, corrosion, instability etc, loading type, material properties, environmental factors and structural properties governing onset of failure
- Experimental analysis of failed components-surface inspection, crack inspection techniques, deformation measurement, and residual stress management.

Objectives

- The aim of this course is to examine modes of failure in engineering components and to develop the ability to deduce causes of failure from post-failure component examination.

Evaluation

- The evaluation consists on a final exam that represents the 70% of the grade.
- The experimental part that represents the 30% of the grade.

Methodology

- Theoretical classes with compulsory attendance, 70%.
- Classes in the laboratory with compulsory attendance, 30%..