PHYSICAL FOUNDATIONS IN ARCHITECTURE

AREA: ACCOUNTING & MANAGEMENT CONTROL

GRADO EN ARQUITECTURA / BACHELOR IN ARCHITECTURE

Nº OF

Professor: **ANNA MESTRE SUÑÉ**

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BArch, Escola Tècnica Superior d'Arquitectura de Barcelona (ES) MA in Project Management in Building and Urban Planning, Colegio de Aparejadores y Arquitectos Técnicos de Barcelona (ES).

Professor Mestre interest in structures drove her to working as a scholar in the Structures Department at university. Since 2001 she is working in BOMA, a structures consultancy, first in the office in Barcelona, and since 2007, in the office in Madrid. This professional activity implies the proximity and participation in interesting projects such as Jean Nouvel's Agbar Tower in Barcelona, David Chipperfield and b720's redesigning of the staircase at the Óvalo promenade, in Teruel, Zaha Hadid's Spiralling Tower in Barcelona, or FOA's Legal Medicine Institute in Madrid. Anna Mestre is especially interested in the application of quality and management processes in the development of projects, as well as in their execution phase.

Professor: **JUAN TRAVESI CABETAS**

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Areas of research

- Energy simulation in buildings. Spanish contact person in the International Energy Agency in the following tasks:
  - Task 22 of the Solar Heating and Cooling program
  - Task 34 of the Solar Heating and Cooling program
  - Annex 43 of the Energy Conservation in Buildings and Community Systems program
- Fundación Rafael Escolá: Tutor of an investigation project within the I+D program at the Fundación. Design of a complete method for energy evaluation in buildings (2004) Academic background
- INDUSTRIAL ENGINEER by the UNIVERSIDAD POLITÉCNICA DE MADRID. Licence number in Madrid: Nº: 9.165

- A.S.H.R.A.E. MEMBER (American Society of Heating, Refrigerating & Air Conditioning Engineers) since December 1999. Today I am the responsible person of the technical and conferences committee at the Spain Chapter of ASHRAE
- ATECYR MEMBER since January 2002. Today member of the board of governors of Madrid Group.
- Member of the board of governors of AEDICI (Asociación Española de Ingenierías e Ingenieros Consultores de Instalaciones)
- NFPA MEMBER since September 2007.
- APICI (Asociación de Profesionales de Ingeniería de Protección Contra Incendios) MEMBER

Teaching experience

- Teacher at the Renewable Energy Masters (Masters de Energías Renovables) at the Universidad de Castilla La Mancha. Since 2005.
- Teacher of HVAC installations at the Energy Certification courses of FENERCOM. Since 2008.

Professional experience Since 1.995 working as a design engineer at A.C.H. S.L.. Today I am the main engineer an principal partner of the company since 2005.

This company has the next references, where the teacher has been the main designer and the project leader:

NEW BARAJAS AIRPORT. EDIFICIO SATÉLITE (T4S) Working for the UTE SATÉLITE, HVAC project, construction assistance and BMS design direction of these building of around 300.000 m2.

HOSPITAL UINIVERSITARIO CENTRAL DE ASTURIAS (HUCA). Working for Herráiz Arquitectura S.L.

HVAC project and construction assistance of this large hospital of more than 190.000 m2 and 1.100 beds. NEW SPANISH PARLAMENT BUILDING. Working for Gabinete de Ingeniería, technical assistance in mechanical installations for the new office building for the Spanish parlament.

OLIMPIC TENNIS COURTS. TENNIS INDOOR. Working for TYPSA, projecto of the mechanical installations of the Tennis Indoor, part of the Caja Mágica Complex, in Madrid.

ECONOMICAL CRIME PROSECUTION BUILDING. Working for the Architect Ignacio Mendaro project of the installations of this new office building in Madrid (4000 m2). This installation uses geothermal energy for cooling and heating the building.

ZARAGOZA AIRPORT. Working for DRAGADOS S.A. project of the installations for the new airport terminal in Zaragoza.

BARAJAS AIRPORT. TERMINALS T1-T2. Working for DRAGADOS S.A. project and construction assistance of the refurbishment of terminals T1-T2 in Barajas Airport.

ALMERÍA AIRPORT. Working for DRAGADOS S.A. project of the installations for the new airport terminal in Almería.

HOTEL MIRASIERRA SUITES IN MADRID. Working for GABINETE DE INGENIERÍA project of themechanical installations of these

LUXURY HOTEL of 20.000 m 2 placed in Madrid. This building has a tri- generation system to deliver electricity, heat and chilled water to de hotel.

ARCHBISHOPRIC LIBRARY. Working for the Architect Ángel García, project of the installations of the new archbishopric library in Madrid.

ISLAMIC UNIVERSITY IN RIYADH. Working for TYPSA, HVAC projects for 2 buildings larger that 50.000 m2 each in Saudi Arabia.

SUBJECT DESCRIPTION

Physics I

The objective of Physics I is to provide the student with tools for understanding the physical principles with which to analyse the stability and the statics of any structure or structural element.

The subject is designed to nurture an intuitive and integrated vision of the material, as an initial step before essential mathematical formalism.

The classes that students attend, in which the theoretic content is presented, are complemented with practical individual and group work, which are intended to give the student some cognitive and attitudinal skills that will be of great use to take on, with security, a professional career.

The course prepares the student for the subjects that will be encountered in later courses, such as structures, materials and construction, stimulating the interest in physics in architecture.

In broad terms, it consists of four blocks: the fundamental physics of the static, equilibrium in its environment, the physics of materials, and a final block that covers the effects of loads on beams. These blocks are nonetheless not arranged sequentially, but consist of chapters that are shared throughout the whole syllabus with the intention that students have to return continually to them in order to remember what they are about. In this way a student will find that over the semester he will have been reminded several times of the fundamentals of each block.

Physics II

The subject of Physics II aims to show the student the physics fundamentals necessary to design building installations, to evaluate building energy loads and to design according to acoustic considerations.

The way to introduce the student in the matter is through an intuitive and holistic vision before approaching the essential mathematical algorithms.

The formal learning is complemented with practices, visits, media tools, computer tools, case discussions and individual and group workshops, trying to provide the student with the knowledge and attitude to face a professional career.

Therefore, the objective of the course is not limited to prepare the student for further courses matters, such as structures, materials and construction. It is also organized to encourage students to follow the concepts, suggesting them how study must be undertaken and how to find information and face the workshops.

OBJECTIVES AND SKILLS

Objectives and General Competences (ORDEN ECI/3856/2007.BOE 312)

Conceptual Objectives/ Suitable knowledge apply to architecture and town planning.

- Principles of general mechanics, statics, mass geometrical properties, and vector and tensor space.
- Principles of thermodynamics, acoustics and optics.
- Principles of fluid dynamics, hydraulics, electricity and electromagnetics

Apprenticeships outcome

- According to topic 1: “To understand the principles of general mechanics, statics, mass geometrical properties, and vector and tensor space”. To aim the student to get, in the most suitable way, to demonstrate a generic knowledge on the fundamentals of general mechanics, statics, mass geometrical properties, and vector and tensor space, to be used in later structural analysis subjects.
- According to topic 2: “Thermodynamics, Acoustics and Optics Fundamentals”. The aim is to provide the student with a good ability to handle with the calculation algorithms based on the Thermodynamics, Acoustics and Optics Fundamental Laws, in order to apply them in further Conditioning subjects.
- According to topic 3: “Fluid Dynamics, Hydraulics, Electricity and Electromagnetism Fundamentals”. The aim is to provide the student with a good knowledge on Fluid Dynamics, Hydraulics, Electricity and Electromagnetism Fundamental Laws for further Installations subjects.

Objectives and specific competences

Physics I

Conceptual *objective*
The student has to acquire the capacity to:

- Understand the physical bases upon which the static rests
- Handle easily the essential mathematic tools for obtaining precise results in calculations
- Analyse the stability of architectonic structures

- Perceive structure as an organism
- Understand the circumstances in which problems can appear in structural elements
- Acquire the specific language used by architects and engineers when tackling structural problems
- Gain an integrated vision of the various themes that are going to be tackled

Professional skills
The student will be capable of:

- Carrying out work in an organised way
- Drawing up a priority list of activities
- Acquire the habit of constancy, avoiding accumulating an excess of work
- Organising work carried out in groups
- Applying knowledge gained from the practical work and not remaining only theoretical
- Solving complicated problems in a straightforward way
- Knowing how to handle and obtain information from diverse sources

Learning results
The student will have acquired:

- The ability to participate in an active manner during the sessions
- Ethical commitment
- Different ways of confronting and solving problems
- The ability to work in a team
- The capacity of self-criticism
- The capacity of being respectful towards the work of others
- The capacity of discussing the work of others
- Understanding that making mistakes is an essential way of learning and improving
- Understanding the context in which knowledge acquired was gained
- The circumstances in which during history new forms of structure appeared, giving the student a qualitative knowledge. Science will not be separated from the techniques of humanities, even in a scientific-technical subject such as this.

Physics II

Conceptual objectives
The student has to acquire the capacity:

- To know the physics principles on which architectural installations are based.
- To handle with mathematical tools essential to obtain exact results in the calculations.
- To analyze a building energetically and be able to retrofit its design.
- To take into account all the design parameters to accomplish with a good building design.
- To acquire the technical terms used by architects and engineers when dealing with installations.
- To understand the concept of energy and to use it properly when related to installations.

- To be able to learn how to use specific installations design software tools and building energy performance simulation tools.
- To acquire a holistic approach to all the physics matters related to a building, without losing the capacity to apply that knowledge in other fields.

Professional competences:
The student will be able to:

- To work neatly.
- To organize activities in accordance to their importance.
- To work constantly and to avoid work accumulation.
- To organize group activities and workshops.
- To apply the acquired knowledge to the practice and not to focus exclusively in the theory.
- To solve complicated problems in a simple way.
- To know how to research and obtain data from different sources.
- To use specific software.

Learning results
The student will acquire:

- To actively participate in the lectures.
- Different ways to face and to solve the problems.
- Capacity to team work.
- To admit errors as an essential way to learn and improve.
- Capacity to understand the context in which the acquired knowledge arose.
- Those circumstances give the student a rich and qualitative knowledge. For that reason technique will not be separated from humanities, even in a scientific and technological subject as physics is.
- Ethic commitment.
- Capacity of self-criticism.
- Capacity to be respectful with others, when criticizing their works.

METHODOLOGY AND WEIGHTING

GENERAL OBSERVATIONS

The subject is focused on the physics and mathematical principles on which structures and installations are based.

Each chapter turns upside down the usual approach. Traditional methodology consists basically on explaining the mathematical and physical principles at early stages so students are soon capable of solving problems of ideal situations, most of them separated from the reality. This new approach aims to start with a real case, to deal with its physics particularities and to learn how to use the proper mathematical tools to meet their resolution.

The learning will be supported by a varied range of activities. These are:

- Problems and practical examples to illustrate the concepts
- Accomplishment of creative practices that will be put under discussion
- Resolution of exercises and problems to illustrate the physical and mathematical principles on which the theory is based
- Graphical material, films, documentary, Internet connections, bibliography, etc, to help the student to clarify concepts and promote debate

THE STUDENT'S LEARNING METHOD/ECTS WEIGHTING

The Spanish university system is in the process of convergence to be integrated in the Espacio Europeo de Educación Superior (EEES). This process affects in particular the figure of the student and the role that the student will play in the new methodology. This calls for a new educational model based on the learning of the students and not on the teaching hours of the lecturer. In this way, the panorama needs an innovation in the design and organisation of University teaching.

Each credit is equivalent to a number of hours of the student's work which is in the region of 25, of which a percentage requires attendance and the rest is individual work. The workload refers to the theoretical time that it might be expected that a student would take to obtain the results of the course. This workload includes the time invested in attending classes, seminars, individual and group study, activities related to their education, preparation and performance in exams, etc.

From the point of view of the student, the role of the teacher changes to that of a mentor who contributes not only the classic activities related directly to teaching classes but, complementarily, elaborates a detailed plan of activities, a monitoring of their education and a varied process of assessment. This obliges the lecturer to evaluate new aspects in education such as detecting the aims of teaching the subject that takes into account the needs of society, designing educational projects that are organic and coordinated with the other subjects (as much this particular course as later courses), adopting a methodology in which the student performs an active part of the process and to offer the student an itinerary and a guide on how to learn, providing him with instruments and competencies that will be of later benefit in his professional development.

The methodology of Physics is designed so that the student can play the role of the principal actor, instead of being a spectator in the formative process.

The distribution of the ECTS in the subject is now shown:

Subject with 3 credits ECTS						
(3 X 25 h./credit = 75 h. workload for the student)						
Activities	**Sessions**	**Hours of attendance**	**Factor**	**Hours of individual work**	**Total**	**ECTS**
Theoretical classes + media + debates	14	21.00	1.5	31.5	52.50	2.10
Practical exercises	5	7.50	1.5	11.25	18.75	0.75

Workshop	1	1.50	1.5	2.25	3.75	0.15
Total	20	3		39	75.0	3.00

RESOURCES

ELECTRONIC RESOURCES

This subject does not require the use of a laptop in class; nevertheless, if you want to bring your laptop, please contact your professor.

PROGRAM

SESSIONS 1 & 2

FIRST FOUR-MONTH PERIOD

PHYSICS I. STATIC

INTRODUCTION TO STATICS
Description of the content of the subject, of the objectives sought and the teaching methodology used; the form in which the knowledge of the student will be evaluated and recommendations on how to create an efficient method of working. Introduction to Mechanics. Fundamental quantities: Newton's Laws and their application to Statics. Mass and Weight. Units of measurement. Vector operations for scalar and vector quantities: addition, subtraction, multiplication. References to different coordinates and position vectors. Exercises Introduction to Statics of particles. Exercises.

SESSIONS 3 & 4

FORCE SYSTEMS
Forces and their characteristics. Resultant of concurrent forces. Resolution into components. Exercises.

SESSIONS 5 & 6

MOMENTS
Moments and their characteristics. Couples. Resolution of a force into a force and a couple. Simplification of a force system: resultants. Concept of the moment of a force applied to a body, mathematical fundamentals of momentum, vectorial representation. Moment of a force about a point, moment of a force about an axis. Exercises.

SESSION 7

CENTROID AND CENTER OF GRAVITY
Centre of gravity. Centroids. Concept of symmetry. Concept of gravity in a body of one two

and three dimensions. Calculations of gravity in symmetrical figures. Centre of gravity in compound figures.

SESSION 8

MOMENT OF INERTIA
Determination of moments of inertia manually. Analysis of catalogues. Radius of Gyration. Exercises.

SESSIONS 9 & 10

EQUILIBRIUM OF RIGID BODIES
Types of equilibrium. Free-body diagram. Supports and connections. Reactions. Equilibrium in two and three dimensions. Exercises. Structural equilibrium due to gravity. Concept of friction and compression. Compressed structural elements. Stress lines. Stability of walls. Introduction to arches.

SESSIONS 11 & 12

CHARACTERISTICS OF MATERIALS. ELASTICITY
Stress, strain, strength, yield point, Young's modulus, ductility.

SESSIONS 13 & 14

AXIALLY LOADED MEMBERS
Physical significance of axial forces (tension and compression). Effects produced by tension. Architectonic structural elements subjected to tension forces. Stress.

SESSIONS 15 & 16

BENDING MOMENTS
Bending moment. Deflection. Diagram of bending moments. Stress.

SESSIONS 17 & 18

SHEAR LOADS
Shear concept. Shear stress. Shear deformation. Modulus of rigidity. Shear and bending moments relationship.

SESSION 19

REVISION
Revision of all concepts acquired along the semester.

SESSION 20

Exam.
Final exam.

SESSION 21

SECOND FOUR-MONTH PERIOD

PHYSICS II. ENERGY

SESSION 1
PRESENTATION.
Description of the subject contents, objectives and methodology used. Evaluation and assessment explanation.
Exposition with examples of how the student can get the most of the knowledge to acquire and be able to develop an efficient work method.
Objectives: to understand the structure of the course, the methodology, and the tools available to face this matter throughout the architecture career.
Aspects: Procedures and right attitude learning.
Bibliography: 12 13 14

SESSION 22

HEAT

SESSION 2
CONSERVATION OF ENERGY AND HEAT TRANSFER
The building energy balance is discussed with the students. Analysis of heat sources and transmission mechanisms. Based on the previous cases.
Concepts: conservation of energy, energy loss and gain, energy balance, units. Ideal gas. Heat and internal energy. 1º Law of Thermodynamics. Conduction, convection and thermal radiation.
Objectives: to understand how a building works from an energy point of view and to meet the heat transfer mechanisms.
Requirements: High School Physics.
Aspects: conceptual learning, right attitude learning.
Bibliography: 1.2.6 7 8

SESSIONS 23, 24 & 25

HEAT CONDUCTION AND INSULATION.
Measurement of a particular case heat transfer capacity. Insulation influence in thermal balance.
Concepts: Heat capacity. Specific heat. Latent heat. Energy transfer. Heat transfer Coefficients.
Units. Steady-state and transient heat flow. Fourier´s equation, R-value. Thermal insulating materials..
Objectives: to handle specific software and meet different heat transfer parameters.

Requirements: High School Physics and Chemistry. User level computer skills.
Aspects: conceptual learning. Right attitude learning. Technological learning.
Bibliography: 1 2 6 7 8

SESSION 26

HEAT CONVECTION.
Concepts: Mass transfer. Flow causes. Film Coefficient. Boundary layer.
Objective: to understand the principles of the mechanism of heat transmission by convection.
Requirements: High School Physics.
Bibliography: 1 2 6 7 8

SESSIONS 27 & 28

HEAT TRANSFER. RADIATION.
Concepts: emission and absorption of a material. Coefficient of radiation. Stefan-Boltzmann´s Law. Wien´s law and Kirchoff´s law, black and grey bodies, shape factors.
Objective: to understand the principles of heat radiation mechanisms in buildings.
Requirements: High School Physics.
Bibliography: 1 2 6 7 8

SESSION 29

COMBINED TRANSMISSION. CONDUCTION, CONVECTION AND RADIATION. CASE COMBINED TRANSMISSION.

Different cases are discussed and practical methods of calculation are explained.
Concepts: Heat transmission combined coefficients.
Objectives: to understand the principles of combined heat transfer mechanisms.
Requirements: High School Physics and Mathematics.
Aspects: conceptual learning.

SESSION 30

THERMAL LOADS AND THERMAL INERTIA
Concepts: Thermal loads. Transmission and ventilation loads. Heating and cooling loads, Heat flow. Daily oscillation. Building thermal mass. Effective thermal inertia. Thermal stability. Diffusivity and effusivity. Thermal wave
Objectives: to understand the mechanisms to meet thermal comfort in a building.
Requirements: High School Physics and Mathematics. Preceding matters.
Aspects: conceptual learning.
Bibliography: 1 2 6 7 8 9

SESSION 31

FLUID DYNAMICS

SESSION 11
FLUID DYNAMICS I. FLUID PROPERTIES AND BASIC CONCEPTS.
Concepts: Static pressure density, viscosity, Bernoulli equation
Objectives: to understand the main properties in fluids and the most basic flow equations.
Requirements: High School Physics and Mathematics.
Aspects: conceptual learning.
Bibliography: 1.2.20

SESSION 32

SESSION 12
FLUID DYNAMICS I. FLOW ANALYSIS.
Concepts: Conduit friction, transition losses, flow measurement, cavitation, noise in fluid flow.
Objectives: To get familiarized with fluid dynamics in buildings and understand typical problems.
Requirements: High School Physics and Mathematics.
Aspects: conceptual learning. Technological learning.
Bibliography: 10 11 12

SESSIONS 33, 34 & 35

MOIST AIR AND VENTILATION

SESSION 13, 14 & 15
THERMAL COMFORT AND PSYCHROMETRICS.
Concepts: absolute and relative humidity. Wet-bulb temperature. Capillarity. Condensation. Dew point. Psychrometrics, main processes, PMV, PPD, etc.
Objective: to understand the behavior and processes of moist air and its influence in the humidity sensation in the atmosphere. Processes of humidity formation.
Requirements: High School Physics and Mathematics.
Aspects: conceptual learning.
Bibliography 1 2 4 5 15

SESSIONS 36, 37 & 38

LIGHT AND ILLUMINATION

SESSION 16, 17 &18. NATURAL LIGHT AND ILLUMINATION.
Concepts: Radiation. Nature of light. Behavior through different materials. Light intensity. Buildings orientation. Seasonal influence. To learn about the nature and the behavior of the light, Sun paths, principles of light, color index, glare index.
Requirements: High School Physics and Mathematics.
Aspects: conceptual learning. Practical learning.
Bibliography: 1 2 9

SESSION 39

ACOUSTICS

SESSION 19
SOUND CONCEPTS AND ACOUSTICAL DESIGN
Concepts: Harmonic motion. Propagation. Speed of propagation. Wavelength. Frequency. Equation of the wave. Superposition of waves. Frequency. Types of wave. Sound speed (paths). Sound pressure. Sound intensity. Sound power. The decibel, sound transmission paths, absorbents. Techniques of absorption
Objectives: to understand sound transmission from sources and to quantify it.
Requirements: High School Physics and Mathematics.
Aspects: conceptual learning.
Bibliography: 10 11 12

SESSION 40

ELECTRICITY

SESSION 20
BASIC CONCEPTS. FROM THE POWER PLANT TO THE PLUGING IN THE BUILDING.

Electrical energy as an input to the building and its transformations. Media.
Concepts: Electric field. DC and AC. Basic magnitudes: Intensity, tension, resistance and energy. Ohm´s law.
Objective: to learn the physics principles that are behind the transport of electrical energy to our building and necessary means to carry it.
Requirements: High School Physics.
Aspects: conceptual learning.
Bibliography 1 3 19

EVALUATION SYSTEM

GENERAL OBSERVATIONS

Ordinary Examination (1st exam session):

Aspect: **concepts**, consisting of intermediate and final examinations. A minimum qualification of 5.0 must be obtained, in order to include it in the final assessment.

Aspect: **accomplishment of works or handing in of exercise**s, the minimum qualification to include it in the final assessment is 5.0.

Aspect: **presentation of works**, the minimum qualification to include it in the final assessment is 5.0.

Aspect: **attendance and participation**, the minimum qualification to include it in the final assessment is 8.0.

For all students who fulfill the university's attendance requirements (which is a minimum of a 70%), final assessment will be the weighted average of the aspects related above, If the obtained qualification is not equal or superior to 5.0, the student will have to do the extraordinary examination (2nd exam session). Students with a percentage of class attendance inferior to 70% will be assessed directly on the 3rd and 4th exam sessions.

In order to assess the whole subject, the mean of the results of the two four period evaluations will be done. At least a **5.0** must be obtained to pass. Nevertheless a minimum mark of 4.0 in any of the four-month qualification will be required to do the mean. So if in one of the period a 6.0 has been gotten and a 4.0 in the other, the mean 5.0, will be the final mark. But if the mark in any of the four-period is under 4.0, no mean with the other part is allowed and the student must attend the ordinary examination of this part.

Extraordinary Examination (2nd exam session):

The student will have to attend a full examination of the part (Physics I or Physics II) of the subject that has been failed. The resulting mark of the part of the subject that has been passed by the student will be kept. Students can attend the extraordinary examination only if all exercises have been submitted.

Ordinary and Extraordinary Examinations (3rd and 4th exam sessions):

For those students that are on the 3rd and 4th exam sessions, the evaluation system will follow the same criteria. Taking into account the fact that they might not be able to attend the sessions regularly, they will be provided with the course material via e-mail or on the on-line campus. The 10% percentage weight, corresponding to attendance and participation, will not proceed; thus, the percentage of the examination will be increased up to a 65%.

EVALUATION AND WEIGHTING CRITERIA

In accordance with the spirit of the EEES, the assessment will be continuous. The teacher will evaluate certain aspects set down in the table below and their corresponding weight in order to grade the student.

Physics I:

Activity	Criteria	Means	Weight
Attendance and participation	Attendance and active participation in class activities	Observation and professors notes	10%
Completion of exercises, assignments and workshop	Submission of tutorials with problems addressed satisfactorily. Participation in group assignment and submission of acceptable work	Exercises completed and submitted on time Results of workshop submitted on time	20% 15%
Examination of	Demonstrate adequate	Written exams	55%

lecture material	understanding of the structural principles dealt with in classes		

Physics II:

Activity	Criteria	Means	Weight
Attendance and participation	Attendance and active participation in class activities	Observation and professors notes	10%
Completion of exercises, assignments and workshop	Submission of tutorials with problems addressed satisfactorily. Participation in group assignment and submission of acceptable work	Exercises completed and submitted on time	20%
Examination of lecture material	Demonstrate adequate understanding of the structural principles dealt with in classes	Written exams	70%

BIBLIOGRAPHY

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Many thanks to all those who participated in the workshop Foundations for Innovation in Cyber-Physical Systems held March 13-14, 2012 in Rosemont, Illinois. The presentations and discussions that took place at the workshop provided the foundation for this report. A complete list of attendees is provided in Appendix A. Special thanks are extended to the members of the workshop steering committee and plenary speakers, listed below. 3.40 Foundation Architecture. Generic building blocks, their inter-relationships with other building blocks, combined with the principles and guidelines that provide a foundation on which more specific architectures can be built. 3.41 Framework. A structure for content or process that can be used as a tool to structure thinking, ensuring consistency and completeness. 3.42 Gap. A statement of difference between two states. Used in the context of gap analysis, where the difference between the Baseline and Target Architecture is identified. Note: Gap analysis is described in Part III, 23.Â Physical elements in an Enterprise Architecture may still be considerably abstracted from Solution Architecture, design, or implementation views. 3.58 Principle. See 3.16 Architecture Principle . 1. 5C architecture for implementation of Cyber-Physical System. J. Lee et al. / Manufacturing Letters 3 (2015) 18â€“23 19. 2.3. Cyber.Â Workshop report on. foundations for innovation in cyber-physical systems, January 2013. Fig. 4. The ï¬‚ow of data and information in a CPS enabled factory with machine tools in production line based on 5C CPS architecture. 22 J. Lee et al. / Manufacturing Letters 3 (2015) 18â€“23.Â The term cyber-physical systems was coined by Helen Gill of the National Science Foundation in 2006 (Gunes et al., 2014). CPS is a technology for managing interconnected systems of physical assets, computational capabilities and networking processes to provide customer solutions (Khaitan & McCalley, 2015;Lee et al., 2015;Wiesner et al., 2017). The architecture of San Vitale, evoking this relation of the death and resurrection of the titular saint to the death and resurrection of Christ, is a significant tribute to the Christâ€like dignity of St. Vitalis." Otto von Simson. coffer.Â specific form of buttressing most strongly associated with Gothic church architecture. The purpose of any buttress is to resist the lateral forces pushing a wall outwards (which may arise from stone vaulted ceilings or from wind-loading on roofs) by redirecting them to the ground. stained glass.Â - housing type - origins in Ancient Rome - developed in Renaissance - physical expression of dwelling and rule. villa (second definition). in Roman architecture, the landowner's residence or farmstead on his country estate in Renaissance architecture, a country house.