SHAKE THE FUTURE.

CENTRALE NANTES

MASTER OF SCIENCE, TECHNOLOGY AND HEALTH

CIVIL ENGINEERING

MATERIALS AND STRUCTURES IN THEIR ENVIRONMENT

YEAR 2

PROGRAMME SUPERVISOR:
GIULIO SCIARRA

Établissement public sous tutelle du ministère de l'Enseignement supérieur, de la Recherche et de l'Innovation

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CIVIL ENGINEERING - MATERIALS AND STRUCTURES IN THEIR ENVIRONMENT

YEAR 2 - AUTUMN SEMESTER

CORE COURSES

Statistics of Materials and Structural Reliability

Numerical Analysis

Mechanics of Porous Media

Project

Cultural and Communication English

French Language

TRACK 1 COURSES

Homogenization Methods in Heterogeneous Media

Design and Behaviour of Modern Concrete

Durability and Structural Maintenance

TRACK 2 COURSES

Theory of Structures

Large Infrastructures of Energy and Transport

Earthquake Engineering

STATISTICS OF MATERIALS AND STRUCTURAL RELIABILITY

CIVIL ENGINEERING - MATERIALS AND STRUCTURES IN THEIR ENVIRONMENT
YEAR M2 - AUTUMN SEMESTER

LEAD PROFESSOR: Franck SCHOEFS / Giulio SCIARRA

Objectives

Accounting for uncertainties in civil engineering: risk and reliability.

Course contents

Part 1 - Introduction to probability and reliability in physical space.

- Introduction to random variables and stochastic fields.

Second order variables and iso-probabilistic transformations - Example of typical laws - Random fields properties: stationarity and ergodicity - Typical autocorrelation function and calculation technique - Maximum likelihood: identification of the parameters characterizing probability distributions and autocorrelation functions

- Probability of failure and reliability index of Rjanytzine-Cornell, the Hasofer-Lind extension.

Statement of a reliability problem starting from the concept of limit state: safety margin, limit state function - Evaluation of the probability of failure in the analytic case - Evaluation of the probability of failure in reference conditions and relation to the Rjanytzine-Cornell reliability index - Proof of the non-general character for a non-linear limit state function - Reliability of Hasofer-Lind

Part 2 - Evaluation of the reliability index in the physical space

- Method of the ellipsoid
- Approximate methods to estimate the probability of failure and errors: Monte-Carlo/ Importance Sampling/RSM

Part 3 - Practical cases with Matlab

- Numerical implementation and simulation of stochastic fields

Part 4 - Reliability index in the standard space

- Independent variables
- Correlated variables

Part 5 -Process of random degradation and reliability

- Introduction
- Basics of reinforced concrete:
- Overview of deterioration of reinforced concrete and corresponding legal issues
- Chloride-induced corrosion: mechanisms, models and parameters

- Corrosion propagation and cracking: mechanisms, models and parameters
- Fatigue of reinforced concrete: mechanisms, models and parameters
- Coupled mechanisms

Part 6 – Optimization

- Formulation of an optimization problem

Cost function - Optimization parameters - Optimization constraints - Example of optimization problems

- Fundamental optimization concepts

Global and local minima - Taylor polynomial expansion - Gradient Vector and Hessian matrix - Optimality conditions

- Linear optimization problems

Formulation of the linear programming problem - Simplex algorithm in linear programming

- Unconstrained nonlinear optimization

Study of the optimality condition on some functions - Mechanical Examples of unconstrained minimization

- Constrained nonlinear optimization problems

Equality constraints: Lagrange multipliers - Inequality constraints

Part 7 - Limit Analysis

- (Handout) Continuum mechanics: stress vector, stress tensor, Boundary conditions, stress eigen value and vectors, Bidimensional stress state, Mohr plane and Mohr circles, Normal stress and tangential stress, Local equilibrium equation
- (Handout) General concepts of plasticity: Notions of elastic limit, Partition to reversible and irreversible strains, bounding surface, Isotropic flow criteria, Anisotropic flow criteria, failure criterion, Loading and unloading criterion, Plastic flow law, Plastic potential, Work hardening modulus and plastic multiplier.
- Bars plasticity: Local equilibrium equation, Generalized behavior laws of beams, Failure state of beams
- Fundamental theorems in plasticity

Internal and external variables - Internal and external generalized variables - Principle of virtual work - Theorem of maximal plastic work of Hill - Static approach: Lower bound theorem - Kinematic approach: Upper bound theorem

Course material

LANGUAGE OF INSTRUCTION	ECTS CREDITS	LECTURES	TUTORIALS	LABO	PROJECT	EXAM
English	4	22 hrs	8 hrs	0 hrs	0 hrs	2 hrs

NUMERICAL ANALYSIS

CIVIL ENGINEERING - MATERIALS AND STRUCTURES IN THEIR ENVIRONMENT
YEAR M2 - AUTUMN SEMESTER

LEAD PROFESSOR: Panagiotis KOTRONIS

Objectives

Introduction to numerical analysis and its application in civil engineering.

Course contents

- Finding the roots of an equation, interpolation, integration, derivatives
- Differential equations
- Solving linear/nonlinear systems
- Time integration schemes
- Least square method
- Eigen values
- Finite elements/Finite differences
- Integrating a constitutive law into a finite element code
- Introduction to an Enriched Finite Element method: main steps, Finite Element equation, solving process, application to a biphasic material
- Introduction to the discrete element method (DEM) (main steps, stability condition, constitutive elements (particles, contact laws...), possibilities for fluid/solid coupling

Acquired skill: choosing the adequate numerical method.

Course material

LANGUAGE OF INSTRUCTION	ECTS CREDITS	LECTURES	TUTORIALS	LABO	PROJECT	EXAM
English	4	22 hrs	8 hrs	0 hrs	0 hrs	2 hrs

MECHANICS OF POROUS MEDIA

CIVIL ENGINEERING - MATERIALS AND STRUCTURES IN THEIR ENVIRONMENT
YEAR M2 - AUTUMN SEMESTER

LEAD PROFESSOR: Giulio SCIARRA

Objectives

The lectures cover the characterization of constitutive laws of porous media addressing both the response of soils and concrete.
Thermodynamics is used to identify admissible constitutive laws so as to establish the framework of thermo-hydro-mechanical analysis of (partially) saturated porous media.
Some basic notions of micromechanics are provided.

- Identify the peculiar states which characterize the behaviour of soils (dilatancy, shear bands formation, liquefaction etc.)
- Use enhanced constitutive model of soils

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- Use enhanced constitutive model of soils

Course material

- O. Coussy Poromechanics 2004 Wiley
- O. Coussy Mechanics and Physics of Porous Solids 2010 Wiley
- L. Dormieux, E. Bourgeois Introduction à la micromécanique des milieux poreux 2002 Presses Ecole National des Ponts et Chaussées
- L. Dormieux, D. Kondo, F.J. Ulm Microporomechanics 2006 Wiley

LANGUAGE OF INSTRUCTION	ECTS CREDITS	LECTURES	TUTORIALS	LABO	PROJECT	EXAM
English	4	22 hrs	8 hrs	0 hrs	0 hrs	2 hrs

PROJECT

CIVIL ENGINEERING - MATERIALS AND STRUCTURES IN THEIR ENVIRONMENT
YEAR M2 - AUTUMN SEMESTER

LEAD PROFESSOR: Giulio SCIARRA

Objectives

The goal is to establish students' attitude to research.

Course contents

A research project is provided to each student during the first semester on the different topics addressed in the courses.

Course material

LANGUAGE OF INSTRUCTION	ECTS CREDITS	LECTURES	TUTORIALS	LABO	PROJECT	EXAM
English	2	hrs	hrs	0 hrs	0 hrs	hrs

CULTURAL AND COMMUNICATION ENGLISH

CIVIL ENGINEERING - MATERIALS AND STRUCTURES IN THEIR ENVIRONMENT
YEAR M2 - AUTUMN SEMESTER

LEAD PROFESSOR: Spencer HAWKRIDGE

Objectives

Team-building and Communicational English:

- Understand the general concepts of team-building
- Build a team-building project
- Understand and nurture the creative process
- Enhance self-belief and self-empowerment

Behavioral skills in an inter-cultural environment:

- Strengthen self-confidence and capacity for interaction
- Develop active listening and reformulation skills
- Develop networking skills

Course contents

Cultural and Communicational English: exercises to explore in practice the areas of culture and communication
Field-related or inter-cultural project (for example, construct content for inter-cultural teambuilding activities; example WIOBOX website etc).

Course material

Written and televised press, information and digital tools, general documents business environment and company strategies.
Internet conferences (Ted Talks, etc.), our own educational materials on Hippocampus (Moodle).

LANGUAGE OF INSTRUCTION	ECTS CREDITS	LECTURES	TUTORIALS	LABO	PROJECT	EXAM
English	4	0 hrs	32 hrs	0 hrs	0 hrs	hrs

FRENCH LANGUAGE

CIVIL ENGINEERING - MATERIALS AND STRUCTURES IN THEIR ENVIRONMENT
YEAR M2 - AUTUMN SEMESTER

LEAD PROFESSOR: Silvia ERTL

Objectives

The objective is to familiarize the learner with the French language and French culture through an entertaining task-based communicative language teaching, focused on speaking combined with:

- Phonetics
- Self-correcting exercises on our learning platform
- Learning Lab activities
- Project work
- Tutoring

Course objectives include the acquisition and reinforcement of vocabulary, syntax, and pronunciation by both traditional means and through the use of digital resources. Students will learn general French, develop language skills of oral and written comprehension and expression.

After completing this course (32 hours + personal work), the students will be able to communicate in spoken and written French, in a simple, but clear manner, on familiar topics in the context of study, hobbies etc. Another important goal of this course is to introduce the student to French culture.

At the end of the course (2 semesters), complete beginners can achieve an A1 level and some aspects of the A2 of The Common European Framework of Reference for Languages. More advanced students may aim for B1/B2 levels. Those who already completed the first year of the French course will be prepared for working in a French business environment.

Course contents

Two different tracks are proposed: track 1 for students newly arrived at Centrale Nantes and track 2 for students who have completed the first year of the French course.

Track 1:
Full range of practical communication language exercises: reading comprehension, listening comprehension, written expression, oral expression.
Learners will be able to use the foreign language in a simple way for the following purposes:

1. Giving and obtaining factual information:
- personal information (e.g. name, address, place of origin, date of birth, education, occupation)
- non-personal information (e.g. about places and how to get there, time of day, various facilities and services, rules and regulations, opening hours, where and what to eat, etc.)

2. Establishing and maintaining social and professional contacts, particularly:
- meeting people and making acquaintances
- extending invitations and reacting to being invited
- proposing/arranging a course of action

- exchanging information, views, feelings, wishes, concerning matters of common interest, particularly those relating to personal life and circumstances, living conditions and environment, educational/occupational activities and interests, leisure activities and social life

3. Carrying out certain transactions:
- making arrangements (planning, tickets, reservations, etc.) for travel, accommodation, appointments, leisure activities
- making purchases
- ordering food and drink

Track 2:
This track follows on directly from the first-year French course, developing and completing the concepts studied thus far. The main themes are: housing, health and work. These topics will help prepare students for their future work environment. For example, housing is explored in the form of a search for accommodation upon arrival in a new city.

Course material

Preparation manuals, our own tailor-made documents, written and televised press, internet, general civilization documents, digital tools, our own educational materials on Hippocampus (Moodle).

LANGUAGE OF INSTRUCTION	ECTS CREDITS	LECTURES	TUTORIALS	LABO	PROJECT	EXAM
French	**4**	**0 hrs**	**32 hrs**	**0 hrs**	**0 hrs**	**hrs**

HOMOGENIZATION METHODS IN HETEROGENEOUS MEDIA

CIVIL ENGINEERING - MATERIALS AND STRUCTURES IN THEIR ENVIRONMENT
YEAR M2 - AUTUMN SEMESTER

LEAD PROFESSOR: Giulio SCIARRA

Objectives

These lectures deal with characterising the behaviour of heterogeneous materials (in particular porous materials) by means of upscaling methods. Upscaling techniques calculate estimates of the behavior of the material parameters from the material behaviour of its constituents and their geometric distribution (the so-called micro-structure of the material).
The purpose of this course is to introduce students to upscaling techniques.

Course contents

The main elements covered in lectures are:

- Microstructural descriptors.

- n-Point Probability Functions. Ensemble averages. Ergodic hypothesis & statistical homogeneity. Scale separation. Representative Volume Element (RVE).

- Quantitative definition of the RVE size.
- Averaging operations and applications to the balance laws.
- Concentration & Homogenization.

- Uniform stress (strain) boundary conditions. Hill Lemma. Reuss and Voigt bounds.
- Classical homogenization schemes: micro-elasticity & micro-poroelasticity.

- Double-scale expansion & periodic homogenization.

- Asymptotic expansions. Incompressible Newtonian fluid flow through a rigid porous medium: the Darcy law. Quasi-statics of saturated deformable porous media.

- Random homogenization.
- Numerical homogenization methods.

Course material

- J.L. Auriault et al. Homogenization of Coupled Phenomena in Heterogenous Media. (2009) Wiley
- L. Dormieux, E. Bourgeois Introduction à la micromécanique des milieux poreux. (2002) Presses Ecole National des Ponts et Chaussées
- L. Dormieux, D. Kondo, F.J. Ulm Microporomechanics. (2006) Wiley
- T. Kanit et al. Determination of the size of the representative volume element for random composites: statistical and numerical approach. Int. J. Solids Structures 40 (2003) 3647- 3679
- S. Torquato Random Heterogeneous Materials (2002) Autumner

LANGUAGE OF INSTRUCTION	ECTS CREDITS	LECTURES	TUTORIALS	LABO	PROJECT	EXAM
English	4	22 hrs	8 hrs	0 hrs	0 hrs	2 hrs

DESIGN AND BEHAVIOUR OF MODERN CONCRETE

CIVIL ENGINEERING - MATERIALS AND STRUCTURES IN THEIR ENVIRONMENT
YEAR M2 - AUTUMN SEMESTER

LEAD PROFESSOR: Ahmed LOUKILI

Objectives

The aim of the course is to provide knowledge of the physical, chemical and mechanical properties of materials used in the composition of concrete and teach standard practices for its formulation for a better mechanical behavior.

Skill: Choose the concrete formulation in order to have the best mechanical behavior.

Course contents

- Cement hydration in the presence of mineral additives.
- Cement hydration.
- Physical consequences of cement hydration.
- Microstructure of the cement paste.
- Deferred concrete behavior: shrinkage and creep.
- Theoretical basis for the formulation of concrete.
- Basics of formulation of modern concretes and for a reliable environmental impact.

Course material

LANGUAGE OF INSTRUCTION	ECTS CREDITS	LECTURES	TUTORIALS	LABO	PROJECT	EXAM
English	4	22 hrs	8 hrs	0 hrs	0 hrs	2 hrs

DURABILITY AND STRUCTURAL MAINTENANCE

CIVIL ENGINEERING - MATERIALS AND STRUCTURES IN THEIR ENVIRONMENT
YEAR M2 - AUTUMN SEMESTER

LEAD PROFESSOR: Abdelhafid KHELIDJ / Giulio SCIARRA

Objectives

The goal of the course is, on the one hand, the identification of the nature of a problem of durability, and on the other, the optimal choice of composition and type of concrete.

Course contents

Part 1 – Durability

- Reminders: Presentation of concrete - Hydration reactions and various compounds
- General approach to concrete durability: Corrosion -Sulphate attack - Alkali aggregate reaction - Frost
- Permeability: Darcy Law - Poiseuille law - How to measure permeability - Klinkenberg effect - Forsheimer law - Effect of damage - Effect of crack - Effect of temperature - Effect of saturation
- Chloride Diffusion: Fick's laws (1st and second) - Bind and free chloride - How to measure chloride diffusion? (Steady state / Unsteady state) - Migration and Nernst-Planck law - Effect of temperature - Effect of crack
- Carbonation: When and where? - The condition for carbonation in concrete - How to measure the depth of carbonation?

Part 2 - Experimental aspects and Macroscopic modelling of chloride transfer in cementitious materials

- Mechanisms involved during chloride ingress (chloride binding, electrostatic interaction, Electrical Double Layer (EDL), activity of pore solution
- Approaches to modelling chloride transfer in saturated concrete: Mono specie Approach (Modified Fick's Law) - Multi species Approach based on Nernst-Planck equation - Multi species approach with consideration of EDL Approaches of modelling of chloride transfer in saturated concrete
- Initiation to chloride transfer in unsaturated concrete

Part 3 - Structural maintenance

- Context on NDT: Specificity of NDT, Employment situations and requirements - Implementation of NDT versus management cases - French associations promoting NDT quality
- Generality on NDT: Non-Destructive Testing aims – Vocabulary - Inverse problem
- Basics of ultrasonic methods: Basics of wave propagation (elastic homogeneous linear isotropic) - Geometry characterization - Material properties characterization
- Classical US techniques (transmission, refraction, ultrasonic pulse echo, impact echo): principle and experimental set-up - signal processing - example of results
- Advanced US methods (tomography, surface wave, coda wave): principle and experimental set-up - signal processing - example of results
- Ground Penetrating Radar technique: Physical Principle - Data processing - Civil engineering applications

- Electromagnetic NDT techniques: Low frequency technique - Infra-red technique - Gammagraphy

Part 4 - Performance-based specifications

- Context of durability and why performance-based specifications are needed: Examples - Delayed ettringite formation - Shrinkage-induced cracking
- Deemed-to-satisfy provisions: Standards - Minimum cover - Exposure classes
- Performance-based approach of durability: Carbonation – Chlorides – Leaching - External sulphate attacks

Course material

LANGUAGE OF INSTRUCTION	ECTS CREDITS	LECTURES	TUTORIALS	LABO	PROJECT	EXAM
English	4	22 hrs	8 hrs	0 hrs	0 hrs	2 hrs

THEORY OF STRUCTURES

CIVIL ENGINEERING - MATERIALS AND STRUCTURES IN THEIR ENVIRONMENT
YEAR M2 - AUTUMN SEMESTER

LEAD PROFESSOR: Panagiotis KOTRONIS

Objectives

The lectures deal with the theory of structures typically found in civil engineering, say beam-like (1D), shell-like (2D) and masonry (3D) structures. The more general approach of micromorphic continua is also discussed showing how the previous theories can be regarded as special cases of this more general framework. The finite element for beam and plate structures is also presented.

The objective of the lectures is on the one hand that of presenting typical engineering models of structures characteristic of civil engineering (using a quite sophisticated theoretical framework), and on the other, to introduce master students to non-standard or enhanced theories of continua.

Course contents

- Beam-like structures:

- Beam-like domain: one-dimensional modelling
- Static of beams
- Structures formed of curvilinear elements
- Finite element method

- Shell-like structures:

- Shell like domains: two-dimensional modelling
- Surfaces and curves, first and second fundamental forms, curvature. Integration along the thickness. Differential operators in curvilinear coordinates.
- Kinematics
- The Kirchhoff-Love hypothesis, examples: plate, cylindrical & spherical shell.
- State of stress
- Stress characteristics, examples: plate, cylindrical & spherical shell.
- Balance laws given in terms of forces and couples
- Finite element method

- Masonry structures

- Equivalent 3D continua and homogenization.

- Micromorphic & Cosserat continua

Course material

- J. Salençon Milieux curvilignes. (1988) Ellipses
- P. Podio-Guidugli Lezioni sulla teoria lineare dei gusci elastici sottili. (1991) Masson
- R. Masiani, P. Trovalusci Cosserat and Cauchy Materials as Continuum Models of Brick Masonry. Meccanica 31: 421-432 (1996).
- I. Vardoulakis Cosserat Continuum Mechanics. English Edition by E. Gerolymatou, J. Sulem, I. Stefanou and M. Veveakis. (2018) Autumner

LANGUAGE OF INSTRUCTION	ECTS CREDITS	LECTURES	TUTORIALS	LABO	PROJECT	EXAM
English	4	22 hrs	8 hrs	0 hrs	0 hrs	2 hrs

LARGE INFRASTRUCTURES OF ENERGY AND TRANSPORT

CIVIL ENGINEERING - MATERIALS AND STRUCTURES IN THEIR ENVIRONMENT
YEAR M2 - AUTUMN SEMESTER

LEAD PROFESSOR: Giulio SCIARRA

Objectives

The lectures cover the main pathologies of hydraulic earth structures and concrete structures dedicated to energy production or the transport and some impact on the environment.

Course contents

Part 1: earth structures:

- Earth dams and dikes: types and main instabilities
- Bank sliding process
- External and internal erosion processes
- From the specimen to the structure, by considering:

- spatial scale effect on physical parameter - spatial variabilities - sieving process influence

- Simulation of piping process
- Risk analysis
- Environmental impact

Part 2: concrete structures:

- Reinforced Concrete Structures (quay, bridges and Offshore Floating Wind Turbines OFWT) in the marine environment: main instabilities
- Maintenance: Inspection on site and laboratory measurements
- Prediction
- Repair
- Examples: quay of GPNSN, bridge

Part 3: technical visit of earth structures and concrete structures

Course material

- Bonelli S. Editor, (2013). Erosion in geomechanics applied to dams and levees. ISTE – Wiley
- Guide technique IFSTTAR, "Recommandations pour la prévention des désordres dus à la réaction sulfatique interne", Oct 2017
- Ouvrage Scientifique IFSTTAR, "Le béton recyclé", Nov 2018
- Bonnet S., Breysse D., "L'évaluation de la durée de vie des ouvrages", chapitre de l'ouvrage de synthèse publié par l'AFGC et la COFREND: "La méthodologie d'évaluation non destructive de l'état d'altération des ouvrages en béton armé", pp. 117-144, 2006

LANGUAGE OF INSTRUCTION	ECTS CREDITS	LECTURES	TUTORIALS	LABO	PROJECT	EXAM
English	4	22 hrs	8 hrs	0 hrs	0 hrs	2 hrs

EARTHQUAKE ENGINEERING

CIVIL ENGINEERING - MATERIALS AND STRUCTURES IN THEIR ENVIRONMENT
YEAR M2 - AUTUMN SEMESTER

LEAD PROFESSOR: Panagiotis KOTRONIS

Objectives

Seismic risk, analysis of the dynamic behaviour of a structure, soil dynamics, nonlinear calculations and design of earthquake-resistant structures.

Course contents

Part I - Dynamics of structures

- Seismic risk, seismic hazard
- Dynamic equation of a simple oscillator, solving the equation
- Dynamic equation of a multi-degree-of-freedom structure, solving the equation
- Modal analysis, modal superposition technique, spectrum analysis
- Earthquake-resistant structure design according to EC8, capacity design
- Nonlinear calculations, multifiber beams, macro element for Soil Structure Interaction

Part 2 - Soil dynamics and geotechnical earthquake engineering

- Dynamic soil properties
- Ground motion parameters
- Wave propagation
- Ground response analysis
- Soil liquefaction
- Seismic slope stability
- Seismic design of foundations

Acquired skill: Calculating a structure submitted to earthquake loading.

Course material

LANGUAGE OF INSTRUCTION	ECTS CREDITS	LECTURES	TUTORIALS	LABO	PROJECT	EXAM
English	4	22 hrs	8 hrs	0 hrs	0 hrs	2 hrs

YEAR 2 - SPRING SEMESTER

Master Thesis / Internship

MASTER THESIS / INTERNSHIP

CIVIL ENGINEERING - MATERIALS AND STRUCTURES IN THEIR ENVIRONMENT
YEAR 2 - SPRING SEMESTER

LEAD PROFESSOR: Giulio SCIARRA

Objectives

- Be exposed to and adapt to an industrial or research environment
- Put in practice the scientific and technical skills acquired in the previous semesters
- Strengthen interpersonal and communication skills
- Be part of or manage a project
- Organize tasks, analyze results and build deliverables

Course contents

Students should be pro-active and career-oriented in the search for their thesis/internship. The topics are validated by the program supervisor to ensure an adequate Master level. The thesis/internship is evaluated through the submission of a written report and an oral defense.

Course material

- Turabian Kate Larimore, Booth Wayne Clayton, Colomb Gregory G., Williams Joseph M., & University of Chicago press. (2013). A manual for writers of research papers, theses, and dissertations: Chicago style for students and researchers (8th edition.). Chicago (Ill.) London: University of Chicago Press.
- Bui Yvonne N. How to Write a Master's Thesis. 2nd ed. Thousand Oaks, Calif: Sage, 2014.
- Evans David G., Gruba Paul, et Zobel Justin. How to Write a Better Thesis. 3rd edition. Carlton South, Vic: Melbourne University Press, 2011.

LANGUAGE OF INSTRUCTION	ECTS CREDITS	LECTURES	TUTORIALS	LABO	PROJECT	EXAM
English	30	0 hrs	0 hrs	0 hrs	0 hrs	0 hrs