UCHWAŁA NR 43
RADY DYDAKTYCZNEJ WYDZIAŁU NAUK EKONOMICZNYCH
UNIWERSYTETU WARSZAWSKIEGO
z dnia 15 grudnia 2021 r.

w sprawie zmian w programie studiów drugiego stopnia na kierunku
Quantitative Finance

Na podstawie § 5 ust.1 pkt 3 Uchwały nr 441 Senatu Uniwersytetu Warszawskiego w sprawie uchwalenia Regulaminu Studiów na Uniwersytecie Warszawskim (Monitor UW z 2019 r. poz. 186), Rada Dydaktyczna Wydziału Nauk Ekonomicznych postanawia, co następuje:

§ 1

Zatwierdza się propozycje zmian w programie studiów stacjonarnych i niestacjonarnych drugiego stopnia na kierunku Quantitative Finance prowadzonych na Wydziale Nauk Ekonomicznych od roku akademickiego 2022/2023.

§ 2

Zmiany w programie studiów przedstawia załącznik do niniejszej uchwały.

§ 3

Uchwała wchodzi w życie z dniem podjęcia.

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Przewodnicząca Rady Dydaktycznej
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WNIOSEK O ZMIANY W PROGRAMIE STUDIÓW

kierunek: QUANTITATIVE FINANCE
(studia stacjonarne drugiego stopnia)

CZĘŚĆ I

	ZMIANY W PROGRAMIE STUDIÓW	
LP.	**DOTYCHCZASOWY ELEMENT PROGRAMU**	**PROPONOWANA ZMIANA**
1	Asset Allocation and Investment Strategies II	zastąpienie przedmiotem: Reproducible Research
2	Macroeconomics for Finance	zastąpienie przedmiotem: Machine Learning in Finance I i zmiana liczby punktów ECTS z 3 do 4
3	Advanced Microeconomics	zastąpienie przedmiotem: Machine Learning in Finance II
4	Mathematical Methods for Finance	zmiana liczby punktów ECTS z 7 do 6
5	Risk Analysis and Modelling II	zmiana liczby punktów ECTS z 5 do 4
6	Empirics of Financial Markets	zmiana liczby punktów ECTS z 5 do 4
7	C++ in Quantitative Finance II	zmiana liczby punktów ECTS z 5 do 4
8	Automatic Transactional Systems	zmiana liczby punktów ECTS z 5 do 4
9	Time Series Analysis	drobna korekta treści programowych
10	Automatic Transactional Systems	drobna korekta treści programowych
11	C++ in Quantitative Finance II	drobna korekta treści programowych
12	Preparation of the thesis for the diploma examination	zmiana liczby punktów ECTS

LP.	**UZASADNIENIE PROPONOWANYCH ZMIAN**
-	Wszystkie zmiany związane są z potrzebą uatrakcyjnienia kierunku studiów oraz dostosowania treści programowych do standardów uwzględniających zastosowania najnowszych metod uczenia maszynowego w finansach ilościowych. Zmiany mają także na celu pogłębienie wiedzy studentów z zakresu praktycznych finansów ilościowych, rozszerzenie ich umiejętności warsztatowych oraz ułatwienie im podjęcia pracy w szeroko rozumianym sektorze finansowym po zakończeniu studiów. W efekcie wprowadzenia zmian zmieniają się nieznacznie (2-3%) procentowe udziały poszczególnych dyscyplin. Przed zmianami: ekonomia i finanse 54%, matematyka 16%, informatyka 30%, po zmianach: ekonomia i finanse 52%, matematyka 15%, informatyka 33%
1	Usunięcie przedmiotu Asset Allocation and Investment Strategies II. Jego treści w znakomitej większości są realizowane dotychczasowej jego pierwszej części (Asset Allocation and Investment Strategies I). Przedmiot jest zastąpiony kursem Reproducible Research, który oferuje studentom

	poznanie nowoczesnych metod prowadzenia własnych badań oraz tworzenia raportów w sposób powtarzalny i z wykorzystaniem rozwiązań chmurowych.
2	Usunięcie przedmiotu Macroeconomics for Finance, którego treści nie są bezpośrednio związane z finansami ilościowymi i w części są realizowane na kursie Advanced Macroeconomics. Przedmiot jest zastąpiony kursem Machine Learning in Finance I, który oferuje studentom poznanie nowoczesnych metod uczenia maszynowego i data science oraz ich praktycznych zastosowań we współczesnych problemach w obszarze finansów ilościowych.
3	Usunięcie przedmiotu Advanced Microeconomics, którego treści nie są bezpośrednio związane z finansami ilościowymi i nie są istotne dla absolwenta kierunku Quantitative Finance. Przedmiot jest zastąpiony kursem Machine Learning in Finance II, który oferuje studentom poznanie nowoczesnych metod uczenia maszynowego i data science oraz ich praktycznych zastosowań we współczesnych problemach w obszarze finansów ilościowych.
4	zmiana punktacji wynikająca z przeszacowania czasu pracy niezbędnego do zaliczenia przedmiotu
5	zmiana punktacji wynikająca z przeszacowania czasu pracy niezbędnego do zaliczenia przedmiotu
6	zmiana punktacji wynikająca z przeszacowania czasu pracy niezbędnego do zaliczenia przedmiotu
7	zmiana punktacji wynikająca z przeszacowania czasu pracy niezbędnego do zaliczenia przedmiotu
8	zmiana punktacji wynikająca z przeszacowania czasu pracy niezbędnego do zaliczenia przedmiotu
9	Usunięcie metod dekompozycji szeregów czasowych, zwiększenie znaczenia wielowymiarowego modelowania zmienności (multivariate GARCH models)
10	Doprecyzowano treści dotyczące języka python.
11	Usunięto treści związane z wyceną opcji za pomocą drzew. Większy nacisk położono na integrację C++ z R oraz MS Excel.
12	Zmiana punktów wynikająca z przeszacowania czasu niezbędnego do przygotowania się do obrony pracy dyplomowej

CZĘŚĆ II

ZMIENIONY PROGRAM STUDIÓW

nazwa kierunku studiów	**Quantitative Finance**
nazwa kierunku studiów w języku angielskim / w języku wykładowym	**Quantitative Finance**
język wykładowy	angielski
poziom kształcenia	studia II stopnia
poziom PRK	VII poziom Polskiej Ramy Kwalifikacji
profil studiów	Profil ogólnoakademicki
liczba semestrów	**4**
liczba punktów ECTS konieczna do ukończenia studiów	**120 ECTS**
forma studiów	stacjonarne
tytuł zawodowy nadawany absolwentom (nazwa kwalifikacji w oryginalnym brzmieniu, poziom PRK)	magister
liczba punktów ECTS, jaką student musi uzyskać w ramach zajęć prowadzonych z bezpośrednim udziałem nauczycieli akademickich lub innych osób prowadzących zajęcia	**115 ECTS** (co stanowi 96% łącznej liczby punktów ECTS)
liczba punktów ECTS w ramach zajęć z dziedziny nauk humanistycznych lub nauk społecznych (nie mniej niż 5 ECTS)	**6 ECTS** w ramach przedmiotów ogólnouniwersyteckich (co stanowi 5% łącznej liczby punktów ECTS)

Studia przygotowują do zawodu nauczyciela			
pierwszego przedmiotu:	nie	w szkole:	nie
drugiego przedmiotu:	nie	w szkole:	nie

Przyporządkowanie kierunku studiów do dziedzin nauki i dyscyplin naukowych, w których prowadzony jest kierunek studiów

Dziedzina nauki	Dyscyplina naukowa	Procentowy udział dyscyplin	Dyscyplina wiodąca (ponad połowa efektów uczenia się)
Dziedzina nauk społecznych	Ekonomia i finanse	52%	Ekonomia i finanse
Dziedzina nauk ścisłych i przyrodniczych	Matematyka	15%	Matematyka
Dziedzina nauk ścisłych i przyrodniczych	Informatyka	33%	Informatyka
Razem:	-	100%	-

Efekty uczenia się zdefiniowane dla programu studiów odniesione do charakterystyk drugiego stopnia Polskiej Ramy Kwalifikacji dla kwalifikacji na poziomach 6-7 uzyskiwanych w ramach systemu szkolnictwa wyższego i nauki po uzyskaniu kwalifikacji pełnej na poziomie 4

Symbol efektów uczenia się dla programu studiów	Efekty uczenia się	Odniesienie do charakterystyk drugiego stopnia PRK
Wiedza: absolwent zna i rozumie		
K_W01	Zna w pogłębionym stopniu teorię finansów, a także zaawansowane metody ilościowe, w szczególności znajdujące zastosowanie w wycenie instrumentów pochodnych, zarządzaniu ryzykiem portfela inwestycyjnego, procesie alokacji aktywów oraz prognozowania finansowych szeregów czasowych.	P7S_WG
K_W02	Zna i rozumie zjawiska finansowe, poszerzone o podstawy ekonomiczne oraz posiada umiejętność ich rygorystycznego analizowania i prognozowania.	P7S_WG
K_W03	Zna i rozumie cele, kontekst oraz znaczenie standardów etycznych i regulacji prawnych na rynkach finansowych.	P7S_WK
K_W04	Zna zasady ochrony własności intelektualnej i porządku prawnego.	P7S_WK
K_W05	Zna najnowsze osiągnięcia analityczne i trendy w światowej literaturze finansowej.	P7S_WG, P7S_WK
K_W06	Zna najnowsze narzędzia analityczne, informatyczne i programistyczne pozwalające na obróbkę danych empirycznych oraz praktyczną implementację modeli stosowanych w rozmaitych zagadnieniach z obszaru finansów ilościowych, w tym m. in. w wycenie instrumentów pochodnych, procesie alokacji aktywów, zarządzaniu ryzykiem portfela inwestycyjnego, tworzenia automatycznych strategii inwestycyjnych czy też prognozowania finansowych szeregów czasowych.	PS7_WG
K_W07	Zna i rozumie od strony matematycznej zasadę działania modeli analitycznych stosowanych w zagadnieniach z obszaru finansów ilościowych, w tym wyceny instrumentów pochodnych, modelowania zmienności, zarządzania ryzykiem portfela inwestycyjnego, procesów stochastycznych, symulacji Monte-Carlo i podobnych.	PS7_WG
Umiejętności: absolwent potrafi		
K_U01	Posiada umiejętność praktycznego zastosowania, implementacji i oprogramowania modeli statystycznych, ekonometrycznych i matematycznych adresujących problemy z obszaru finansów, w tym modelowania ekonometrycznego, prognozowania szeregów czasowych, modelowania zmienności, wyceny instrumentów pochodnych, zarządzania ryzykiem portfela inwestycyjnego z wykorzystaniem narzędzi analityczno-informatycznych i języków programowania, w tym R, C++, Python i/lub VBA.	PS7_UW
K_U02	Posiada umiejętność opracowania i optymalizowania systemu inwestycyjnego bazującego na sygnałach generowanych automatycznie. Umiejętność wdrożenia takiego systemu w praktyce, właściwej jego oceny i sprawnego zarządzania ryzykiem z nim związanym.	PS7_UW

K_U03	Potrafi tworzyć raporty i komunikatywnie prezentować wyniki samodzielnych analiz w języku angielskim.	PS7_UK, PS7_UW
K_U04	Potrafi prawidłowo zaplanować badanie empiryczne, skutecznie kierować pracą zespołu i dostarczyć poprawne rozwiązanie problemu w określonych ramach czasowych.	PS7_UW, PS7_UK, PS7_UO
K_U05	Potrafi posługiwać się językiem angielskim na poziomie B2+ z użyciem terminologii specjalistycznej potrzebnej do pracy i prowadzenia badań w obszarze finansów ilościowych (*Quantitative Finance*)	PS7_UK
K_U06	Potrafi zoptymalizować działanie modeli statystycznych, ekonometrycznych i matematycznych, dokonać wyboru ich właściwych parametrów i wykorzystać te modele do rozwiązania problemu i/lub wykonania prognozy.	PS7_UW
Kompetencje społeczne: absolwent jest gotów do		
K_S01	Jest gotów do krytycznej oceny dorobku, teorii i najnowszych koncepcji finansów ilościowych.	PS7_KK
K_S02	Jest przygotowany do objęcia stanowisk analitycznych i wykonawczych w sektorze finansowym w kraju i zagranicą.	PS7_KO, PS7_KR
K_S03	Jest przygotowany do realizacji samodzielnych i zespołowych projektów badawczych i analitycznych.	PS7_KO, PS7_KR

OBJAŚNIENIA

Symbol efektu uczenia się dla programu studiów tworzą:

− litera K – dla wyróżnienia, że chodzi o efekty uczenia się dla programu studiów,

− znak _ (podkreślnik),

− jedna z liter W, U lub K – dla oznaczenia kategorii efektów (W – wiedza, U – umiejętności, K – kompetencje społeczne),

− numer efektu w obrębie danej kategorii, zapisany w postaci dwóch cyfr (numery 1-9 należy poprzedzić cyfrą 0).

Efekty uczenia się zdefiniowane dla specjalności z odniesieniem do efektów uczenia się zdefiniowanych dla kierunku studiów

(należy wypełnić, jeżeli na kierunku studiów prowadzona jest specjalność; w przypadku kilku specjalności dla każdej z nich należy wypełnić odrębną tabelę)

Na kierunku Quantitative Finance nie są prowadzone specjalności.

Zajęcia lub grupy zajęć przypisane do danego etapu studiów

(tabelę należy przygotować dla każdego semestru studiów odrębnie)

Rok studiów: pierwszy

Semestr: pierwszy

Nazwa przedmiotu	Forma zajęć – liczba godzin								Razem: liczba godzin zajęć	Razem: punkty ECTS	Symbole efektów uczenia się dla programu studiów	Dyscyplina / dyscypliny, do których odnosi się przedmiot
	Wykład	Konwersatorium	Seminarium	Ćwiczenia	Laboratorium	Warsztaty	Projekt	Inne				
Statistics & Econometrics	30								30	1	K_W07, K_U01, K_S03	ekonomia i finanse, matematyka
Treści programowe	*The lecture gives a theoretical basis for basic statistics analysis and econometrics modelling. Participants will acquire theoretical knowledge about basic concepts and tools used in statistics and econometrics. Every topic discussed during the lecture will be illustrated with case study examples and exercises to be solved by students. The course is obligatory for students of Quantitative Finance.* *1. Introduction & organizational tasks* *2. Evaluation Exam* *3. Introduction to statistics* *a. Descriptive statistics,* *i. Population versus sample,* *ii. Measures of central tendency, variation & position,* *b. Probability, Random Variable & Probability distributions,* *i. Discrete and continuous variables,* *ii. Central Limit Theorem,* *iii. Main discrete and continuous probabilistic distributions: normal, lognormal, geometric, binomial, Poisson, Student's t, F, chi-square, gamma, normal multivariate distribution.* *4. Basics of statistical inference* *a. Essential concepts of statistical inference,* *b. Point estimation and confidence intervals,*

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	c. Statistical tests about parameters, *d. Tests about frequencies,* *e. Testing hypotheses of independence, normality, and symmetry for returns,* *f. Nonparametric tests of goodness-of-fit, independence, two-sample comparison,* *g. One-factor and multiple ANOVA,* *h. Nonparametric ANOVA,* *i. Covariance, correlation.* *5. Introduction to Econometrics* *a. What is Econometrics?* *b. Econometrics model & estimation of parameters,* *c. Regression analysis: estimation, OLS, Likelihood functions, Tests of fit,* *d. Elementary stochastic processes,* *e. Simple Monte-Carlo simulations.* *Students will learn how to perform the main procedures of statistical inference, such as point estimation, interval estimation, parametric and nonparametric statistical tests, and to give a statistically correct interpretation of the results. Additionally, they will learn how to prepare basic econometric models using basic approaches (such as OLS).*												
Sposoby weryfikacji efektów uczenia się	egzamin pisemny											
Introduction to Quantitative Finance	30								30	3	K_W01, K_W02, K_W03, K_W04, K_W05, K_S01, K_S03	ekonomia i finanse
Treści programowe	*The aim of this course is to familiarize students with the key topics in modern finance. The first part of the course introduces key "underlying" instruments – stocks, bonds, FX etc. – and discusses the main theories developed for thinking about the relationship between risk and return, and the pricing of assets more generally. The second part of the course develops tools and techniques used for the valuation of financial derivatives, i.e. claims that promise some payment contingent on the behavior of a given underlying instrument. Finally, the third part of the course investigates theoretical and empirical arguments for market efficiency and behavioral finance.* *The detailed contents of the course:* *• Preliminaries: basic financial arithmetic* *• No arbitrage axiom: the bedrock of modern finance* *• Risk and return principles: the Markowitz framework* *• Capital Asset Pricing Model: theory and applications* *• Derivatives: more sophisticated instruments call for more sophisticated tools* *• Replication and risk neutrality: binomial trees* *• Martingales and the fundamental theorem of finance* *• From binomial trees to continuous-time limit: the Black-Scholes formula* *The student after completion of this course should:*											

	• *know the concept of mean-variance portfolio efficiency;* • *distinguish between idiosyncratic and systematic risk factors and understand why investors are only rewarded for taking systematic risk;* • *understand that the expected value of something is not a good guide to its price;* • *understand the difference between risk-neutral and real-world probability measure;* • *be able to derive the Black-Scholes option pricing formula and explain the idea behind it.*										
Sposoby weryfikacji efektów uczenia się	egzamin pisemny, projekt										
Machine Learning in Finance I	15				15				30	4	K_W01, K_W02, K_W05, K_U01, K_U03, K_U04, K_U05, K_U06, K_S03	ekonomia i finanse, informatyka, matematyka
Treści programowe	*1. Python - lightning fast course: preparation of the environment, variables, data type, operators and control structure, functions, modules, data science toolkit: numpy, pandas, matplotlib, scikit-learn* *2. Introduction to Machine Learning: Types of Machine Learning, Introduction to Supervised Statistical Learning, Types of predictions, types of models, types of tabular data structures, Notations and general concepts - loss function, cost function, gradient descent, Simple Supervised Learning models - linear regression and logistic regression* *3. Assessing model accuracy, machine learning diagnostics: Evaluation metrics- regression and classification, Learning curves, Training, validation and testing sets, Cross-validation technique, The concept of bias and variance and their trade-off, Possible remedies of underfitting or overfitting* *4. Basic Supervised Learning models: K-nearest neighbours, Support Vector Machines, Decision trees and Random Forest (bagging idea)* *5. Important machine learning techniques: Dataset preparation steps, Initial feature selection methods, Feature engineering, Regularization, Rebalancing, Explainable Artificial Intelligence** *6. Elements of a practical case study: construction of the first classification machine learning end-to-end pipeline, solving the problem of unbalanced data set, Testing multiple machine learning models, comparing the results of the models in the business context,* *After completing the course, the student will have reliable, structured knowledge on a wide range of supervised learning algorithms for regression and classification problems, such as linear and logistic regression, linear discriminant analysis, kNN, ridge regression, LASSO, Support Vector Machine, decision trees, and random forest. They will know the theoretical foundations of these algorithms, as well as have programming skills allowing their application in finance. They will be able to select predictive modelling algorithms that are best suited to the specific research problem, perform reliable validation of models, select and transform variables, and perform an independent research project using the methods learned.*										
Sposoby weryfikacji efektów uczenia się	egzamin pisemny, projekt										
Mathematical Methods for Finance	30			30					60	6	K_W07, K_U06, K_S03	ekonomia i finanse, matematyka

Treści programowe	1.The purpose of this course is to help students develop advanced skills for formulating and analyzing mathematical models in economics and finance. Rigorous mathematical analysis of theoretical models can lead to a better understanding of economic problems. 2. Basic content: nonlinear programming, differential and difference equations, optimal control, dynamic programming, stochastic differential equations, partial differential equations. Detailed content: I. Nonlinear programming Constrained optimization. Equality constraints and the theorem of Lagrange. The constraint qualification. The Lagrangean multipliers. Inequality constraints and the theorem of Kuhn and Tucker. The constraint qualification. The Kuhn-Tucker multipliers. II. Differential and difference equations. Constant coefficient linear differential equation (ODE) systems. Jordan canonical form of ODE systems. Fundamental matrix. Qualitative solution: phase portrait diagrams. Nonlinear systems. Fixed points. Linearization of the dynamic system in the plane. Linearization theory in higher dimensions. Hyperbolic points. Theorem of Hartman and Grobman. Phase diagrams of nonlinear dynamical systems. Review of difference equations. Linear difference equations. Non-linear difference equations and phase diagrams. First order difference equations systems. Jordan canonical form. Discrete time version of linearization theory. III. Optimal control Pontryagin's maximum principle. Transversality conditions. Transversality conditions in infinite horizon problem. Second variations and sufficient conditions. IV. Dynamic programming Dynamic programming problems. The Principle of Optimality. The value function. Bellman equation. Euler equations. V. Stochastic differential equations and partial differential equations Probability spaces, random variables and stochastic processes. Brownian motion. Construction of the Ito integral. The Ito integral. Properties of the Ito integral. 1-dimensional Ito processes. 1-dimensional Ito formula. The martingale representation theorem. Stochastic differential equations - examples and some solution methods. Existence and uniqueness theorem for stochastic differential equations. Weak and strong solutions. Partial differential equations. A student should be able to: - solve constrained optimization problems, - solve simple differential and difference equations, - analyze nonlinear differential and difference equations and systems of equations, - solve and analyze optimal control problems, solve basic stochastic differential equations, - calculate Ito integrals, - solve basic linear parabolic partial differential equations, - use the above techniques in economic modeling and finance.												
Sposoby weryfikacji efektów uczenia się	egzamin pisemny, prace domowe												
Asset Allocation and Investment Strategies		30							30	3	K_W01, K_W02, K_U01, K_U02, K_U03, K_S01	ekonomia i finanse

Treści programowe	*The course presents state-of-the-art methods of asset management as well as techniques of analysis and design of investment strategies in the equity, forex, option and derivatives markets used by major institutional investors and hedge funds through the discussion of current research papers. Major areas covered include: active and passive asset management, investment performance attribution and analysis, empirical and practical analysis of investment portfolios, practical applications of quantitative methods in the design of market strategies and new investment products. The target audience of the course are students interested in asset management.* *1. Basic investment models and characteristics of financial time series* *2. Basic methods of security analysis and their investment applications* *3. Multifactor models and their practical applications* *4. Microstructure of financial markets and its role in strategy execution* *5. Active and passive asset management. Performance attribution and analysis* *6. Momentum strategies and their implementation* *7. Event driven and merger arbitrage strategies* *8. Carry trade strategies and portfolios* *9. Long-short strategies in the equity markets* *10. Analysis of option investments* *Students are expected to become familiar at an advanced level with: 1. fundamental investments models, characteristics of financial data and microstructure of financial markets from the perspective of asset management, 2. methods of construction and implementation of major classes of investment strategies used by actively managed funds, 3. risk and cost analysis of investment strategies, 4. performance attribution and analysis.*
Sposoby weryfikacji efektów uczenia się	projekt, prezentacja

Financial Statement Analysis	30			15					45	6	K_W02, K_W03, K_W04, K_U03, K_S01, K_S03	ekonomia i finanse

Treści programowe	*The purpose of the course is to familiarize students with general principles of the financial reporting system, underscoring the critical role of analysis of financial reports in investment decision making, including the principal financial statements (the income statement, balance sheet, cash flow statement and statement of changes in owners' equity) which allows a financial analyst to evaluate trends in performance of different companies over the same period. In addition, specific categories of assets and liabilities that are particularly susceptible to the impact of alternative accounting policies and estimates will be discussed.* *1. Financial reporting mechanics: Describing the three groups into which business activities are classified for financial reporting purposes. Introduction of the linkages among the financial statements. Consequences of timing differences between the elements of a transaction. An overview of how information flows through a business's analysis.* *2. Financial statement analysis: Scope of financial statement analysis, sources of information used in financial statement analysis, including the primary financial statements (income statement, balance sheet and cash flow statement), a framework for guiding the process of financial statement analysis.* *3. Financial reporting standards: The objective of financial statements and the importance of financial standards. Describing trends toward convergence of global financial reporting standards and characteristics of an effective financial reporting framework. Presentation of International Financial Reporting Standards (IFRS) framework. Comparison of IFRS with alternative reporting systems.* *4. Balance sheet: Structure and components of the balance sheet, measurement bases for assets and liabilities, components of equity.*

	5. Income statement: Description and analysis of income statement components, basic principles and selected applications related to the recognition of revenue and expenses, calculation of earnings per share. *6. Cash flow statement: Components and format of the cash flow statement, classification of cash flows under IFRS and U.S. GAAP, linkages of the cash flow statement with the income statement and balance sheet, direct and indirect methods of cash flow statement preparation.* *7. Statement of changes in shareholders' equity and Additional information* *Structure and components of these statements and its usefulness in financial statement analysis.* *8. Financial analysis techniques: Description of analytical tools and techniques, calculating, analyzing and interpreting financial data.* *9. Financial statement analysis: application, Description of the use of financial statement analysis to evaluate a company's past financial performance and basic approaches to projecting a company's future financial performance.* *10. Inventories: Definition, classification and scope of inventories, initial valuation, valuation at the balance sheet date, the rules of measurement of inventories during an accounting period, impairment of inventories and its reversal.* *11. Long-term assets: Accounting for the acquisition and disposal of long-term tangible and intangible assets, allocation of those assets over their useful lives, impairment and revaluation.* *12. Long-term liabilities and leases: Accounting for long-term bonds and leases, description of the debt treatment with equity features.* *13. Conclusion and examination.* *Students will be provided with intermediate knowledge of financial accounting procedures and the rules that govern disclosure.* *Students should be able to record business transactions in books of accounts, prepare the following financial statements:* *- balance sheet,* *- income statement,* *- cash flow.* *They will be provided with knowledge of depreciation of tangible assets, impairment of inventory and financial investment, deferred taxes and on- and off - balance sheet debt techniques, application and International Standards convergence.* *The student has knowledge of the financial reporting and differences between Polish and international financial reporting standards. The student has knowledge of basic categories on financial statements (balance sheet, profit and loss account, cash flow statement, account of changes in equity and notes to financial statements), which may have a significant impact on the information presented in the reports and therefore decisions made by stakeholders on the basis of these reports. The student has knowledge of the preparation of financial statement analysis using indicators of profitability, efficiency, debt, market value and liquidity.*
Sposoby weryfikacji efektów uczenia się	egzamin pisemny

Ethical Standards and Financial Law	30								30	3	K_W02, K_W03, K_W04, K_U03, K_S01, K_S03	ekonomia i finanse
Treści programowe	*The main course objective is a presentation of backgrounds and significance of ethical and professional standards and legal regulations in the financial market. The basic expected result of instruction is getting knowledge of existing regulations and standards and ability to apply them to factual situations. The course is focused both on regulations and standards of international scope as well as those applicable in Poland. The course is conducted as a lecture in English and it is intended for first-year students of II degree studies, major: Quantitative Finance. The final grade is based on the written exam.*											

	The lecture focus is to show students significance of ethical and professional standards and legal regulations in the financial market and present their backgrounds and consequences. The course introduces an overview of main existing regulations and standards, both applicable in Poland and of international scope, as well as it shows how to apply them to factual situations. The following topics will be covered: *- The course content in a big picture - its economic, social and philosophical context.* *- Significance of formal and informal norms in economy - an institutional approach.* *- Morality and speculations - a historical preview.* *- Historical backgrounds of ethical standards and legal regulations regarding financial markets. Financial frauds versus financial crises. Reputational capital and the role of trust. Review, aims and significance of professional standards regulating behaviors of financial market's actors.* *- Professionalism: knowledge of the law, independence and objectivity, honesty. Case studies and standard application.* *- Nonpublic information and market manipulation. Case studies and standard application.* *- Duties to clients, employees and employers. Case studies and standard application.* *- Investment analyses, investment recommendations and financial statements. Case studies and standard application.* *- Conflicts of interest. Case studies and standard application.* *- International ethical and professional standards, e.g. Global Investment Performance Standards.* *- Polish ethical standards applying to investment advisors (DI) and stock brokers (MPW).* *- Corporate governance.* *- Compliance and internal corporate ethical standards and code of conduct.* *- Corporate social responsibility.* *- Legal basis of the financial market in Poland. Financial law institutions. Basics of legal regulations related to financial system supervision.* *- Protection of financial institutions' clients, e.g. MiFID. Complementarity of legal regulations and ethical and professional standards.* *- Ethical and professional standards, laws and regulations in the financial market - trends and perspectives.* *After the course, students will understand aims, context and significance of ethical standards and legal regulations in the financial market. They will have a general knowledge of ethical standards and will be able apply them to business situations. They will get to know the basic codes of conduct regarding management of conflicts of interest. They will gain knowledge of basic issues regarding corporate governance. They will get an orientation of legal basis applicable to the Polish financial market, including regulations regarding protection of financial institutions' clients. They will understand the implications of violating regulations of financial law and applicable standards.*											

Sposoby weryfikacji efektów uczenia się	egzamin pisemny										

Intellectual Property Protection								6	6	0,5	K_W04	-

| **Treści programowe** | *The aim of the course is to familiarize students with the basic information in the field of copyright and certain general aspects of industrial property rights. Course participants will acquire knowledge about the sources of law and fundamental concepts relating to intellectual property rights and will be able to apply them at a basic level. Students will be aware of protection of intellectual property rights (in particular in the field of copyright) and the complexity of these issues.*
The course is designed to familiarize students with the basic information on copyright and indicate some issues of industrial property protection. Special attention will be paid to copyright protection in the context of studying at university and research. Course participants will acquire knowledge about the sources of law and fundamental concepts relating to intellectual property rights and will be able to apply them at a basic level. Students will be aware of protection of intellectual property rights (in particular in the field of copyright) and the complexity of these issues. |

	The following topics will be covered: *1) National (Polish) legal acts of intellectual property rights protection* *2) The general concepts of intellectual property rights - the scheme of intellectual property rights* *3) Some aspects of industrial property rights (patents, trademarks, /industrial/ designs)* *4) Right-holder, subject and content of the copyright - moral and economic rights, the idea of neighboring rights, specific rules for computer software* *5) The practical aspects of copyright law - how to use the third parties works (e.g. copying, bibliographical references), use of third parties research results and databases, the concept of plagiarism, how to protect own works - copyright issues in scientific papers and dissertations.* *6) The copyright protection and the Internet* *Student has knowledge about the sources of law, the general concepts and issues in the field of legal protection of intellectual property* *Participants know the basic rules and the consequences of the use of copyright protection (in particular in terms of functioning at university) and the elements of industrial property protection.* *Student has the ability to use in everyday life general concepts relating to the protection of intellectual property* *Participants know at a basic level how to apply the provisions of copyright protection, in particular concerning the use of third parties works in terms of studies and research work, taking into account specific issues of copyright protection on the Internet.* *Students have a general awareness of protection of intellectual property rights (in particular in the field of copyright) and the complexity of these issues.* *Students recognize the importance of intellectual property protection in various aspects of society.* *Participant is aware of their actions in relation to the subject of intellectual property rights (in particular in the subject of copyright) and rights in relation to the works of his own authorship.*
Sposoby weryfikacji efektów uczenia się	egzamin pisemny

Occupational Safety and Health (OSH)									4	4	0,5	K_U05	

Treści programowe	*The subject of the course is the acquisition of basic knowledge in the field of occupational safety and health, elements of labor law, fire protection as first aid in the event of an emergency.* *Occupational health and safety are all legal norms and means of research aimed at creating an employee's working conditions so that they can work in a productive way without exposing themselves to unjustified risk of accident or occupational disease and excessive physical and mental strain. The specificity of the higher education institution requires the provision of safe and hygienic working conditions not only to the employees employed by the university, but also to the trainees.* *The condition of completing the occupational health and safety training is:* *1) get acquainted with materials placed on the platform,* *2) get the right number of points from the selection test.*
Sposoby weryfikacji efektów uczenia się	egzamin pisemny

Elective course (OGUN)	30									30	3	K_U03, K_U05	

Treści programowe	*Elective course (OGUN) (humanistic profile)*
Sposoby weryfikacji efektów uczenia się	różne formy: egzamin ustny, egzamin pisemny, test, esej, projekt

Łączna liczba punktów ECTS (w semestrze): 30
Łączna liczba godzin zajęć (w semestrze): 295
Łączna liczba godzin zajęć określona w programie studiów dla danego kierunku, poziomu i profilu (dla całego cyklu): 1000

Rok studiów: pierwszy

Semestr: drugi

Nazwa przedmiotu	Forma zajęć – liczba godzin								Razem: liczba godzin zajęć	Razem: punkty ECTS	Symbole efektów uczenia się dla programu studiów	Dyscyplina / dyscypliny, do których odnosi się przedmiot
	Wykład	Konwersatorium	Seminarium	Ćwiczenia	Laboratorium	Warsztaty	Projekt	Inne				
Time Series Analysis	30			30					60	6	K_W01, K_W02, K_W05, K_U01, K_U03, K_U04, K_U05, K_U06, K_S03	ekonomia i finanse, informatyka, matematyka
Treści programowe	*The lecture gives a theoretical basis for time series modeling. Participants will acquire theoretical knowledge about concepts and tools used in time series analysis and forecasting. The role of practical sections is to practice econometric analysis of time series: preparing the data, estimation and post estimation procedures, model verification and diagnostics, forecasts building and evaluation. Every topic discussed during the lecture will be illustrated with case study examples and exercises to be solved by students. R software will be used - its previous knowledge is not required.* *1. Univariate time series – modeling and forecasting* *- stochastic process, deterministic process and time series – definitions,* *- weak and strong stationarity of time series,* *- random walk (with/without drift), white noise,* *- stationarity testing, unit root tests: DF/ADF, KPSS* *- autocorrelation and partial autocorrelation functions, correlograms,* *- autoregressive process AR(p) and its features,* *- moving average process MA(q) and its characteristics,* *- ARMA(p,q) models, stationarity conditions, Box-Jenkins procedure, information criteria AIC, SBC (BIC), parameter estimation and model diagnostics,* *- Portmanteau test, Box-Pierce and Ljung-Box tests,* *- integrated series, integration level, differentiation of series,* *- ARIMA models for integrated series,* *- forecasting in ARMA/ARIMA models, ex-ante forecast error, confidence intervals for the forecast, ex-post measures of forecast quality (absolute and percentage)* *- seasonal SARIMA models – estimation and forecasting,* *- univariate smoothing methods*											

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	3. Modeling volatility *- stylized facts in financial time series, leptokurtic series, "fat tails", leverage effect,* *- homoscedasticity vs. heteroskedasticity,* *- conditional vs. unconditional variance,* *- ARCH(q) process and its features, testing for conditional heteroskedasticity,* *- estimation of ARCH models,* *- generalized ARCH models (GARCH), estimation methods,* *- GARCH extensions: IGARCH, GARCH-M, GARCH-t, asymmetric GARCH models: EGARCH, GJR-GARCH, TGARCH* *- multivariate volatility models: multivariate smoothing with EWMA, Diagonal-VEC model, BEKK model, CCC-GARCH model, Cholesky decomposition, DCC-GARCH model* *4. Multivariate time series models* *- long-term relationships in financial time series* *- cointegration – definition and testing, estimation of cointegrating vector, Johansen test, error correction mechanism models (ECM),* *- Granger causality testing,* *- vector autoregression models (VAR),* *- impulse response functions,* *- variance decomposition,* *- vector error correction mechanism models (VECM),* *5. Switching models* *- Markov switching models* *- Threshold autoregressive models* *Students will be able to identify features of time series and select the best modeling method. They will know how to decompose time series into its components, identify, estimate and interpret models in univariate and multivariate time series framework (for macroeconomic and financial data), produce and evaluate forecasts and verify research hypotheses. In addition, students will know how to apply a wide range of models, including modeling non-stationary time series and long-run relationships between economic variables.*												

Sposoby weryfikacji efektów uczenia się	egzamin pisemny, projekt											

Equity and Fixed Income	30			15					45	5	K_W01, K_W02, K_U01, K_U02, K_U03, K_S01	ekonomia i finanse

Treści programowe	*Main objective of the course is to discuss problems of equity/corporate value and fixed income securities from a practical perspective: construction, valuation and application in the field of financial markets. Course is comprised of two main building-blocks (preceded by one introductory lecture):* *1) corporate valuation,* *2) overview of fixed income securities, its valuation and application.* *1. Revision of basic concepts: time value of money, incorporation of risk into the model.* *PART I Corporate Valuation* *2. Introduction to Company Valuation*											

	3. Discounted Cash Flows Method in detail *4. Weighted Average Cost of Capital* *5. DCF in practice* *PART II Fixed Income Securities* *6. Overview of Fixed Income Securities and Bond Valuation: basic fixed income securities: bonds and their features, fixed income derivatives: futures, options, swaps, swaptions, bond valuation methods.* *7. Theory of Interest Rates: yield curve (possible shapes, theories of yield curve), kinds of interest rates: spot rates, forward rates, simple and compounded interest (incl. logarithmic rates), short rates* *8. Risk associated with investing in bonds and its measurement: kinds of risks (incl. interest rate risk, reinvestment risk, liquidity risk, credit risk), duration, convexity and other methods in quantifying interest rate risk.* *9. Forward Rate Agreements* *10. Interest Rate Swaps* *11. Modeling Option-like Fixed Income Securities: Binomial Trees, Black's Model* *12. Caplets, Floorlets/Caps, Floors* *13. Swaptions* *14. Bonds with Embedded Derivatives* *Students with given credit for this course can demonstrate knowledge at intermediate level concerning company valuation and fixed income securities and have acquired practical skills related to the subject of pricing and application of securities in question. The course encompasses concepts that are required for (and in some cases goes beyond) CFA examination (related to the Fixed Income Analysis), nevertheless should not be treated as a preparatory course for CFA examination.*										

Sposoby weryfikacji efektów uczenia się	egzamin pisemny										

Derivatives Markets	30			15						45	4	K_W01, K_W02, K_W07, K_U01, K_U03, K_S01	ekonomia i finanse, informatyka

Treści programowe	*The course aims at profound understanding of the specifics of derivative markets.* *Vast scope of real derivative instruments traded on world exchanges will be described: starting with plain futures/forwards, through swaps, vanilla options, exotic instruments, ending with advanced financial derivatives like CDS. Both theoretical (pricing) and practical (trading, risk management) aspects are going to be addressed with reference to various asset classes: stocks, commodities, currencies. Derivatives markets will be analyzed also in the context of recent macroeconomic developments and growing role of speculation in pricing the assets. The lecture will be conducted mainly via multimedia slideshows. Upon starting the course students are expected to have micro- and macroeconomic background as well as intermediate skills in mathematics and probability/statistics.* *The lecture starts with an overview of main classes of tradable assets, such as stocks, indices, bonds, commodities (with subsectors), currency pairs and some alternative assets. These assets serve as underlying for derivative instruments. Leading stock and/or derivative exchanges will be introduced and described: NYSE, Euronext/Liffe, NYMEX, COMEX, CBOE, NYBOT, ICE and most liquid local exchanges. Highlighting their brief history and developments, consolidation processes. Detailed description of various types of derivatives: plain futures/forwards; vanilla options; swaps, exotic options. Vital practical issues will be tackled: pricing, real trade, commercial usage for risk management, arbitrage or speculation. In case of options practical aspects of Greek analysis will be presented. Discussing the volatility, nonlinearities and term structures. The contents of the lecture will be successively enriched with case studies and rooted in*

	current market development context (monetary politics, boom-bust cycles, dominant role of speculation, etc.). Students will learn the empirics of derivatives markets, studying specific behaviors of respective underlying segments (e.g. agricultural commodities, emerging markets currencies. The course in general is intended to cast a multicolor light on derivatives world but with no in-depth analysis of formal regulations and juridical solutions. *Students will acquire profound knowledge about derivative instruments, including: specifics of futures, various classes of options, swaps and alternative derivatives. The course's main aim is to popularize the specifics of derivatives with their broad practical usage possibilities (hedging, diversification, speculation). Theoretical aspects as pricing are to be confronted with real market trade. On finishing the course students possess versatile knowledge encompassing theoretical and practical aspects of derivatives markets. They also gain up-to-date multi-aspect familiarity coupled with current macroeconomic background. Classes perform a complementary role of enhancing practical aspects.*										
Sposoby weryfikacji efektów uczenia się	egzamin pisemny, projekt										
Corporate Finance	30			15					45	4	K_W01, K_W02, K_U01, K_U02, K_U03, K_S01	ekonomia i finanse, informatyka

Treści programowe	*Attendants to this course will get acquainted with theory and practice of financial management in a modern corporation. They will learn where a company can get financing and which financial instruments it should use. They will know instruments that are helpful in making key financial decisions on strategic and operational level. This course will be held as a lecture with classes. It is expected that students have intermediate knowledge in finance and accounting and some mathematical background. Credit will be given after three written exams - one from the lecture and two from classes.* *To fully participate in this lecture basic knowledge in finance is necessary. Mathematical analysis and some accounting intuitions will also be helpful.* *1. Goals and governance of the firm: basic principles of functioning of a listed company (board, management, shareowners, limited liability)* *role of financial manager, incentive and agency problems, different conflicts of interest and ways of managing them* *2. Investment decisions: popular investment criteria (NPV, IRR, MIRR and other), their advantages, disadvantages* *NPV rule in different applications, practical problems in capital budgeting, risk in capital budgeting and methods of its evaluation* *3. Risk and cost of equity capital: choosing a risk model, risk-free rate, general risk premium, country risk premium, estimating betas, estimating lambdas.* *4. Overview of corporate financing. Equity and debt as a source of capital: equity issuance step by step procedure, underwriting, private placement, IPOs, capital dilution and privileged subscription, bonds issuance step by step, bank credit as an alternative source of long term financing* *5. Lessons of market efficiency: Efficient Market: theory and evidence, Six lessons for financial managers* *6. Dividend policy: types of dividends, reasons to pay dividends, taxation and dividends, optimal dividend model* *7. Optimal capital structure: traditional approach, Modigliani-Miller theorems, tradeoff theory, pecking order theory* *8. Calculating cost of capital of the firm: value of corporate debt, foreign capital cost and yield spread, WACC, financing and valuation - APV* *9. Mergers: reasons to merge and types of mergers, cost and gains of a merger, mergers financing and tactics, corporate restructuring* *10. Working capital management: cash management, inventory management, managing liquidity of assets and liabilities, trade credit and discounts* *11. Leasing (optional): sensible and dubious reasons for leasing, financial and operating leases, when do financial leases pay* *After finishing this course students should:* *- know sources of capital and methods of its raising;* *- be able to calculate cost of capital;* *- be able to evaluate investment projects* *- understand conflicts of interest and agency problems in a listed company;*

<table>
<tr><td></td><td colspan="11">- know in what circumstances a company should merge, pay dividend or repay its debt;
- be acquainted with problems concerning working capital management.</td></tr>
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Sposoby weryfikacji efektów uczenia się	egzamin pisemny

Computational Finance				30					30	5	K_W01, K_W02, K_W05, K_W06, K_W07 K_U01, K_U03, K_U04, K_U05, K_U06, K_S03	ekonomia i finanse, informatyka

Treści programowe	*The course focuses on practical aspects of using MS Excel and VBA in computational finance. Participants will learn how to write simple macros and user-defined functions that improve efficiency of calculations.* *1. Introduction to VBA in Excel: Advanced Excel functions and procedures, data tables, access to Data Analysis and Solver, matrix algebra, VBA editor in Excel, simple macros, using Excel functions and VBA functions in code, communications between macros and spreadsheets. Writing VBA user-defined functions, manipulating arrays, pros and cons of developing VBA functions.* *2. Equities models: Portfolio optimization: risk-return representation of portfolios, generating the efficient frontier, combining risk-free and risky assets. Asset pricing: the single-index model, estimating beta coefficient, the CAPM model.* *3. Options on equities: Intro to options on equities: the Black-Scholes formula, hedge portfolios, risk-neutral valuation, simple one-step binomial tree, call-put parity, dividends.* *4. Monte Carlo simulations: Geometric Brownian Motion, simulation with antithetic variables.* *5. Value at Risk: Different methods of calculating VaR.* *6. Other: Distance-to-Default, GARCH(1,1) estimation, Vasicek model, volatility models.* *After finishing this course student should:* *- know how to use selected advanced Excel functions;* *- be able to write simple macros, and user-defined functions;* *- be able to perform simple Monte Carlo simulations;*

Sposoby weryfikacji efektów uczenia się	egzamin praktyczny, projekt

Reproducible Research		30							30	3	K_W01, K_U01, K_U02, K_U03, K_U04, K_U05, KS_01, K_U06, K_U07	ekonomia i finanse, informatyka

Treści programowe	*The main objective of the course is to present the key concepts of the research reproducibility, its importance in scientific and commercial R&D processes, and to provide students with the basic practical knowledge of a few most popular in the industry modern reproducibility tools.*

			1. Introduction:Importance of reproducibility in the R&D process, Consequences of lack of reproducibility, Best practices, reproducibility in academic research, how to reproduce an academic paper								

2. Reporting tools: introduction to RMarkdown and Bookdown, how to navigate through Jupyter notebooks, prototyping fast and powerful dashboards (R Shiny and Python Streamlit), best programming practices
3. Networking & Security: introduction to linux shell, network security on the example of public/private key pairs, connecting to remote computers
4. Version control systems: introduction to git, worst & best practices with git, practical remarks
5. Remote repositories & Utility tools: introduction to github, basics of project workflow, project management tools, CI/CD your code
6. Popular cloud environment: introduction to Amazon Web Services, cloud based or standalone service?
7. Model training and serving in the cloud: MLFlow and similar solutions, how to automate the training process, how to deploy your model to the cloud, how to monitor your model's performance
8*. optionally: Working in scrum: boards, tasks, issues, automation, daily, weekly, retrospective

Upon the completion of the course, student:
1. understands the general concept of research reproducibility; knows the reproducibility tools classification; understands which tool can be used in a given context;
2. has basic skills in computer tools allowing to achieve research reproducibility and replicability; has basic skills in modern best programming practices; has basic skills in the cloud development environment; is able to employ skills gained during the course while participating in modern scientific and commercial data science projects;
3. is aware of the importance of reproducibility in data science, as well as in science and development in general; is aware that reproducibility tools are evolving rapidly and that constant training in this area is required to keep skills up to date; is aware of the trends in modern data science and IT development;

Sposoby weryfikacji efektów uczenia się	projekt

Master Thesis Seminar			30						30	3	K_W01, K_W02, K_W04,K_W05, K_W06, K_W07, K_U01, K_U03, K_U04, K_U05, K_U06, K_S01, K_S02, K_S03	ekonomia i finanse, matematyka informatyka

Treści programowe	*The main objective of this seminar is to assist students with their theses' preparation. They are expected to prepare a research project with heavy empirical contents on macroeconomic or financial issues of their interest. Hence, the first part of the course is devoted to critical review of major economic and financial concepts that are eligible for empirical modelling exercises.*
Sposoby weryfikacji efektów uczenia się	egzamin ustny/projekt

Łączna liczba punktów ECTS (w semestrze): 30
Łączna liczba godzin zajęć (w semestrze): 285
Łączna liczba godzin zajęć określona w programie studiów dla danego kierunku, poziomu i profilu (dla całego cyklu): 1000

Rok studiów: drugi

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<th rowspan="3">Nazwa przedmiotu</th>
<th colspan="8">Forma zajęć – liczba godzin</th>
<th rowspan="3">Razem: liczba godzin zajęć</th>
<th rowspan="3">Razem: punkty ECTS</th>
<th rowspan="3">Symbole efektów uczenia się dla programu studiów</th>
<th rowspan="3">Dyscyplina / dyscypliny, do których odnosi się przedmiot</th>
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<th rowspan="2">Wykład</th>
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<th rowspan="2">Seminarium</th>
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<th rowspan="2">Laboratorium</th>
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<th rowspan="2">Projekt</th>
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<tr>
<td>**Quantitative Strategies. High Frequency Data**</td>
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<td>K_W01, K_W02, K_W06, K_W07, K_U01, K_U02, K_U03, K_U04, K_U05, K_U06, K_S01, K_S03</td>
<td>ekonomia i finanse, matematyka informatyka</td>
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<tr>
<td>**Treści programowe**</td>
<td colspan="13">*The aim of this lecture is to give a theoretical background for high frequency data analysis, which is used to prepare, test and implement quantitative trading strategies. Students will acquire knowledge about characteristics of high frequency data and tools used to evaluate trading strategies. Successful strategies for different intraday investment horizons will be discussed. The role of practical sections is to build and verify own trading strategies on high-frequency data. Students will learn to prepare the data, aggregate it to desired frequency, backtest the strategy and verify the strategies from different perspectives (returns, risk, etc.). Topics discussed during the lecture will be illustrated with practical examples and exercises. R environment will be used - its previous knowledge is not required.*

Lectures:
1. Organizational matters, introduction to R.
2. Introduction to quantitative trading, evolution of high-frequency trading, types of high-frequency trading strategies.
3. Characteristics of intra-day data, data sources, working with tick data, data adjustments.
4. Review of the statistical and econometric foundations of the common types of high-frequency strategies: linear regressions.
5. Review of the statistical and econometric foundations of the common types of high-frequency strategies: time series.
6. Backtesting and evaluating performance of trading strategies.
7. Strategies of the highest frequency, with position-holding periods of one minute or less.
8. Market microstructure models.
9. "Event arbitrage" strategies.
10. Statistical arbitrage strategies.
11. Portfolio construction, multi strategy portfolios.</td>
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12. Factor models and factor based trading strategies.
13. Execution systems.

Lab sections
1. Introduction to R
2. Dealing with time series data of different frequency, frequency conversion, data aggregation, plotting the series.
3. Statistical and econometric analyses - correlation, regression, etc.
4. Rolling analyses, storing partial results of analyses, loops and own functions.
5. Backtesting of trading strategies, calculating evaluation statistics.
6. Portfolio construction and evaluation.
7. Students' presentations.

Students will be able to analyze and aggregate high-frequency time series data. They will know how to prepare and backtest trading strategies, calculate appropriate evaluation statistics and select the best performing strategy. In addition, students will be able to indicate successful strategies for different data frequencies.

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<td>Sposoby weryfikacji efektów uczenia się</td>
<td colspan="9">egzamin pisemny, projekt, prezentacja</td>
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<td>Machine Learning in Finance II</td>
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<td>Treści programowe</td>
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The course covers more advanced methods of machine learning: boosting models, neural networks, and Bayesian time series models. Both theoretical background and practical empirical applications in finance are discussed. Practical part covers problems of regression and classification problems, processing and forecasting of sequences, time-series analysis and deployment of methods in the cloud environment.

The course consists of 3 parts: 1) boosting models 2) (deep) neural network models 3) Bayesian time series models. It is conducted in the form of interactive laboratories with the use of case studies which are carried out in parallel with the lecture part.

1. Boosting models
 - *Adaptive Boosting – primary idea of boosting, weak learners, meta-estimator*
 - *Gradient Boosting – next generation idea of boosting, weak learners trained on residuals*
 - *top 3 leading Gradient Boosting Decision Tree models: eXtreme Gradient Boosting, Light Gradient Boosting Machine, CatBoost*
 - *elements of a practical case study: testing multiple gradient boosting machine learning models, comparing their performance against classical machine learning models, empirical experiencing the advantages and disadvantages of specific gradient boosting models, comparing the results of the models in the business context*
2. Neural network models
 - *Multilayer Perceptrons - artificial neurons, topology of the neural networks, input layers, hidden layers, output layers, weights, bias, activation functions, backpropagation algorithm, methods of weights modification*
 - *Recurrent Neural Networks: sequence processing, idea of internal loop, recurrent connection, state variable, vanishing gradient problem, LSTM/GRU layers, carry dataflow, recurrent dropout, recurrent layers stacking, bidirectional recurrent networks*

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	-	*Attention mechanism in Neural Network: sequence to sequence, transformer*										

- *Attention mechanism in Neural Network: sequence to sequence, transformer*
- *Convolutional Neural Networks: filters, receptive fields, activation maps, structure of CNN, convolutional layers, ReLu layers, pooling layers, dropout layers, stride, padding, transfer learning, methods of data augmentation*
- *elements of a practical case study: testing multiple gradient boosting machine learning models, comparing their performance against classical machine learning models, empirical experiencing the advantages and disadvantages of specific gradient boosting models, comparing the results of the models in the business context*

3. Bayesian time series models
- *Facebook Prophet - point forecast, uncertainty intervals, seasonality modelling, trend modelling, saturating forecasts*
- *Uber Orbit (as a framework) - Damped Local Trend model, Local Global Trend model, Kernel-based Time-varying Regression model*

4*. optionally: Ensembling methods - simple and weighted averaging, majority voting, weighted voting, stacking of bottom-layer models and top-layer model

After completing the course, the students will have structured and reliable knowledge on boosting models, neural networks, and Bayesian time series models. They will be able to apply them for both regression and classification problems. They will know the theoretical foundations of these algorithms, as well as have programming skills allowing them to deploy the models in practice, also in the cloud framework. They will also know how to interpret results and explain how they work to other non-technical people.

Sposoby weryfikacji efektów uczenia się	egzamin pisemny, projekt, prezentacja

Risk Analysis and Modelling I		30							30	5	K_W01, K_W02, K_W06, K_W07, K_U01, K_U03, K_U04, K_U05, K_U06, K_S01, K_S03	ekonomia i finanse informatyka

Treści programowe	*The purpose of the seminar is the presentation of the modern financial risk evaluation. On this part of the course we consider: liquidity risk and interest rate risks. Especially we concentrate on: gap analysis, costs of liquidity, prediction of liquidity requirement; interest rate gap, duration, convexity, improvements of duration's calculation, goals of management based on the duration analysis, simulations of interest rates behavior. The seminar takes place in a computer lab. The final exam consists of "true/false" questions with explanation.*

The seminar focuses on modern risk evaluation and management. We consider: liquidity risk, interest rate risk. Additionally the normative aspect of supervisory regulation in financial institutions is briefly mentioned. Especially we concentrate on:
1. liquidity gap analysis, costs of liquidity (alternative costs of funds and risk neutral probability premium), forecast of liquidity with simple and advanced methods, like for example ARIMA, replicating portfolio approach, liquidity indicators.
On computers we execute: liquidity forecast, estimation of core deposits in the bank, calculation of replicating portfolio, calculation and investigation of liquidity adjusted value at risk.
2. measurement of interest rate risk: interest rate gap, duration, convexity (other advanced measures), interest rate modeling: spot rate curve estimation (Nelson-Siegel approach), introduction to modeling short rate evolution via stochastic models (e.g. Vasicek model), interest rate risk management: goals of management based on the duration analysis.
On computers we execute: simulation of net income affected by interest rate changes, duration analysis with extensions (for example, scenario simulations), impact of normative regulations on the choice of interest risk evaluation in financial institutions, estimation of yield curve based on stochastic evolution of spot rates.

	Students have knowledge about types of financial risk, basic methods of measuring and managing the risk in financial institutions and enterprises. Students can evaluate basic types of risk with simple models created in spreadsheets. He or she is able to recognize the impact of regulatory requirements on risk assessment. Students can apply different risk measures to the purposes of risk analysis, for example to calculate the gains or losses on the position or to increase the net income of the investment without rapid growth of risk. *Students are aware of how risk management can reduce the regulatory capital requirements and ensure the compliance with risk standards. The student implements the credit requirements on time.*										
Sposoby weryfikacji efektów uczenia się	egzamin pisemny										
C++ in Quantitative Finance I				30					30	4	K_W01, K_W06, K_W07, K_U01, K_U05, K_U06	informatyka

Treści programowe	*The course is designed as a gentle introduction to C++ and the world of object-oriented programming with special emphasis on the problem of derivatives valuation.* *1. Creating a Basic Program: Basic C++ Syntax. Compiling a C++ Program. Printing Text. Running a Compiled Program, Pausing Execution. Understanding White Space. Adding Comments to the Source Code. Using an IDE* *2. Simple Variables and Data Types: Declaring Variables. Assigning Values to Variables. Printing Variables. Formatting Numbers. Understanding Type Conversion. Introduction to Characters. Introduction to Strings. Introduction to Constants.* *3. Operators and Control Structures: Arithmetic Operators. If Conditionals. Using else and else if. The Ternary Operator. Logical and Comparison Operators. Increment and Decrement Operators. While Loop. For Loop* *4. Input, Output, and Files: Taking Character Input. Discarding Input. Taking Numeric Input. Taking String Input. Taking Multiple Inputs. Reading in a Whole Line. Validating Input. Creating File Output. Using File Input* *5. Defining Your Own Functions: Creating Simple Functions. Creating Functions that Take Arguments. Setting Default Argument Values. Creating Functions that Return a Value. Overloading Functions. Understanding Variable Scope* *6. Complex Data Types: Working with Arrays. Working with Pointers. Structures. Revisiting User-Defined Functions* *7. Introducing Objects: Creating a Simple Class. Adding Methods to a Class. Creating and Using Objects. Defining Constructors. Defining Destructors. The this Pointer* *8. Class Inheritance: Basic Inheritance. Inheriting Constructors and Destructors. Access Control. Overriding Methods. Overloading Methods. Making Friends* *9. Namespaces & Modularization: Working with Included Files. The C Preprocessor. Understanding Namespaces. Linkage and Scope* *10. Working with Templates* *After the course students will be able to write and compile their own basic C++ applications. They will be able to design and deploy simple Monte-Carlo simulations which can approximate the theoretical prices of both non-path dependent and path-dependent options.*
Sposoby weryfikacji efektów uczenia się	egzamin praktyczny, projekt

Course													ECTS	Effects	Discipline
Theory and practice of option pricing				30						30	6			K_W01, K_W07, K_U03, K_U04, K_U06, K_S01	ekonomia i finanse

Treści programowe	*The main goal of the course is to deepen the knowledge of Black-Scholes-Merton option pricing theory in its formal, intuitive and purely practical dimension. During the course, students learn the exact assumptions of the model and its theoretical and practical limitations (transaction costs, the price discontinuity of the process, discrete adjustment of hedging positions), and reflect on pricing biases occurring when individual assumptions are not satisfied. Students will also learn how the market values options and what is required of a good valuation model. In this light, we will discuss possible improvements to the BSM theory, which should facilitate greater understanding of actual option prices quoted by the market. Theoretical considerations will be illustrated using practical examples and C++/VBA codes.* *The detailed content of the course is presented below.* *• Review of option pricing* *• Theory and practice of dynamic replication: implied and realized volatility* *• P&L of a delta-hedged portfolio* *• Practical limitations of replication: transaction costs and discrete time steps* *• Volatility smile – causes and consequences* *• Volatility smile and pricing vanilla and exotic options* *• Calibration and model risk* *• Pricing models accounting for volatility smile* *Upon completion of the course the student:* *- knows how to price call and put options within the Black-Scholes framework, and understands the main assumptions underlying the theory* *- knows basic conventions used in option markets, as well as knows and understands the concept of implied volatility* *- correctly identifies the main risk factors underlying investment in options* *- knows how to analyze theoretically and model quantitatively the results of the main option trading strategies, including dynamic hedging/replication* *- is familiar with the main numerical techniques used for pricing and analyzing options (Monte Carlo simulation, finite difference schemes)*
Sposoby weryfikacji efektów uczenia się	egzamin pisemny, projekt

Course													ECTS	Effects	Discipline
Advanced Macroeconomics	30										30	3		K_W02, K_W05, K_U05, K_S01	ekonomia i finanse

Treści programowe	*The aim of this 30-hours lecture is to present modern macroeconomic methods and models used both by researchers and analysts to understand and predict macroeconomic phenomena. Upon completion students will be able to use acquired tools to explain and interpret the workings of the macroeconomy at an advanced level.* *The course is composed of three parts. The first part is devoted to the microfoundations of modern macroeconomic models. The second part covers core growth facts and theories. The third part is devoted to analyzing and modeling business cycles phenomena* *Part I: Microfoundations* *1. Introduction to dynamic macroeconomics*

			2. Consumption and labor supply choice *3. Q-theory of investment* *Part II: Neoclassical Growth* *4. Growth facts. Solow model* *5. Ramsey-Cass-Koopmans model* *6. Optimal taxation [Wickens (2008)* *Part III: Business Cycles:* *7. Introduction to business cycles modeling* *8. Real business cycles model* *9. Extensions to RBC model* *10. Unemployment in RBC model* *11. Monetary models* *12. New Keynesian model* *13. Monetary policy design* *14. Financial frictions*										

Sposoby weryfikacji efektów uczenia się	egzamin pisemny

Master Thesis Seminar			30								30	3	K_W01, K_W02, K_W04,K_W05, K_W06, K_W07, K_U01, K_U03, K_U04, K_U05, K_U06, K_S01, K_S02, K_S03	ekonomia i finanse, matematyka, informatyka

Treści programowe	*The main objective of this seminar is to assist students with their theses' preparation. They are expected to prepare research projects with heavy empirical contents on macroeconomic or financial issues of their interest. The second part of the course is devoted to designing own empirical study, data collection and choosing the appropriate methodology.*

Sposoby weryfikacji efektów uczenia się	egzamin ustny/projekt

Łączna liczba punktów ECTS (w semestrze): 30
Łączna liczba godzin zajęć (w semestrze): 240
Łączna liczba godzin zajęć określona w programie studiów dla danego kierunku, poziomu i profilu (dla całego cyklu): 1000

Rok studiów: drugi

Semestr: **czwarty**

Nazwa przedmiotu	Forma zajęć – liczba godzin								Razem: liczba godzin zajęć	Razem: punkty ECTS	Symbole efektów uczenia się dla programu studiów	Dyscyplina / dyscypliny, do których odnosi się przedmiot
	Wykład	Konwersatorium	Seminarium	Ćwiczenia	Laboratorium	Warsztaty	Projekt	Inne				
Risk Analysis and Modelling II		30							30	4	K_W01, K_W02, K_W06, K_W07, K_U01, K_U03, K_U04, K_U05, K_U06, K_S01, K_S03	ekonomia i finanse, informatyka
Treści programowe	*The purpose of the seminar is the presentation of the modern financial risk evaluation. On this part of the course we calculate: value at risk calculation, currency limits, portfolio analysis in currency basket modification, capital requirement for the currency and credit risk; different forms of credit scoring and credit rating, credit default models, models of credit risk based on options pricing, migrations matrices and its further augmentation. The seminar takes place in a computer lab. The final exam consists of "true/false" questions with explanation.* *The seminar focuses on modern risk evaluation and management. We consider: value at risk, currency risk, and credit risk. Additionally the normative aspect of supervisory regulation in financial institutions is briefly mentioned. Especially we concentrate on calculation of:* *1. value at risk, expected shortfalls, portfolio analysis in currency basket modification. On computers we execute: calculation of value at risk with three basic methods, reduction of currencies in basket portfolio, modelling correlations and volatilities in Monte Carlo simulation, Cholesky decomposition, introduction to use of copulas, calculation of VaR with GARCH models.* *2. different forms of credit scoring (Altman's model, logit model, methods of classification, neural network, genetic algorithms). The most important models quantifying contemporary risk exposure, such as: credit default models (both in default mode - DM, and in marking to market mode - MTM), models of credit risk based on options pricing (e.g. KMV Model), credit migration's matrices (Credit metrics, Credit Portfolio) and its further augmentations. On computers we execute: scoring rating of retail customers sample, migration matrix calculation, estimation of the default probability in KMV model and distance to default, Credit Risk Plus mass-of-probability-change over time.* *Students have knowledge about types of financial risk, basic methods of measuring and managing the risk in financial institutions and enterprises. Students can evaluate basic types of risk with simple models created in spreadsheets. Students are able to recognize the impact of regulatory requirements on risk assessment. Students can apply different risk measures to the purposes of risk analysis, for example to calculate the value at risk or to increase the net income of the investment without rapid growth of risk. Students are aware of how risk management can reduce the regulatory capital requirements and ensure the compliance with risk standards. The student implements the credit requirements on time.*											

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Sposoby weryfikacji efektów uczenia się	egzamin pisemny											
C++ in Quantitative Finance II		30							30	4	K_W01, K_W06, K_W07, K_U01, K_U05, K_U06	informatyka

Treści programowe

The course is a continuation of its 1st part. It provides more advanced elements of object-oriented programming. Practical examples of using Monte-Carlo simulations in valuations of exotic derivatives are presented. Also students will learn how to integrate C++ with MS Excel and R language.

1. Advanced OPP: Static Attributes and Methods. Virtual Methods. Abstract Methods. Operator Overloading. The << Operator. Multiple Inheritance. Virtual Inheritance
2. Inheritance: Class inheritance: basic inheritance, inheriting constructors and destructors, access control, overriding and overloading methods. Virtual functions. Passing of arguments. Using overloading operators. Private and public data. Defining constructors and destructors.
3. Error Handling and Debugging: Debugging Techniques. Returning Error Codes. Using assert(). Catching Exceptions
4. Dynamic Memory Management: Static and Dynamic Memory. Allocating Objects. Allocating Arrays of Dynamic Size. Returning Memory from a Function or Method. The Copy Constructor and the Assignment Operator. Static Object Type Casts. Performing Dynamic Object Type Casts. Avoiding Memory Leaks
5. More advanced methods of OPP: Virtual constructors and the bridge pattern. Separating interface and implementation. More complicated design patterns. Use of templates. Advanced OOP: static/virtual/abstract methods, multiple and virtual inheritance.
6. Random number class: Developing random number class with reusable interface and adequate random number generator. Implementation of antithetic sampling.
7. Pricing of exotic derivatives: Monte-Carlo for path dependent exotic derivatives. Template pattern. Pricing of Asian options.
8. Interfacing C++ and Excel: The object model in Excel. Accessing Excel objects from C++. Getting data into C++ from Excel. Display vector and matrix data in Excel.
9. Integration of C++ with R: Rcpp package, Inline package, core data types, plotting from C++ via R

After the course students will be able to create more advanced C++ applications, using the idea of object inheritance. They will be also able to integrate their efficient C++ option pricers with MS Excel and R language environment.

Sposoby weryfikacji efektów uczenia się	egzamin praktyczny, projekt											
Empirics of Financial Markets		30							30	4	K_W01, K_W02, K_W05, K_W07, K_U03, K_05, K_S01	ekonomia i finanse

Treści programowe

Students should get a basic knowledge and practical skills of formal econometric analysis of major financial markets (equity, fx, fixed income). The course presents basic theoretical framework and samples of empirical work modelling prices and/or returns from major financial instruments. Both active attendance and positive assessment of individual students' assignments are required to pass the course.

1.Introduction - basic concepts in quantitative finance

	2. Efficiency of financial markets: the concept and its empirical testing *3. Are returns forecastable? Random walk as a model and its empirical verification.* *4. Model definition of normal and excessive returns: CAPM and its extensions, APT. Empirical examples.* *5. Volatility modelling: ARCH and GARCH models* *6. Term structure of the interest rates (yield curve)* *7. FX market: exchange rate theories and their tests.* *8. Students' presentation of their assignments.* *Students are able to model and to forecast prices and returns of basic financial assets (equity, debt instruments, fx) in a comprehensive manner, including designing the research, building and estimating the proper model, interpreting its results and reporting the outcome of the whole exercise.*												

Sposoby weryfikacji efektów uczenia się	projekt i prezentacja

Automatic Transactional Systems				30					30	4	K_W01, K_W06, K_W07, K_U01, K_U02, K_U03, K_U04, K_U06, K_S03	ekonomia i finanse, informatyka

Treści programowe	*The general aim of this course is to familiarize students with development of trading strategies using Python language. Students are expected to become familiar with the mechanics of quantitative trading in the financial markets, characteristics of financial data and measures of trading strategies evaluation. The specific aim of this course is to give a practical background for the process of preparing advanced quantitative trading strategies.* *Course content:* *1. Short introduction to Python and its syntax. Preparation of the PyCharm environment/ Installation of Anaconda Python distribution.* *2. Advanced topics in Python: Object Oriented Programming (OOP) in Python, files operation, regular expressions, lambda function, time series visualization with matplotlib, use of automatic http requests.* *3. Linear algebra with NumPy, Data handling and wrangling with Pandas* *4. Solving mathematical problems in Python (root-finding algorithm, factorial calculation). Use of recursive functions.* *5. Python for finance. The role of normal distribution (and its alternatives) in financial markets (normality tests on examples). Empirical properties of asset returns (stylized facts).* *6. Option pricing models.* *7. Back testing Minimum Variance portfolios, Maximum Sharpe Portfolio. Measures of trading strategy performance.* *8. Trading systems based on Technical Analysis methods.* *9. Strategies based on Machine Learning techniques.* *10. Statistical Arbitrage strategies. Pair Trading.* *Knowledge: Students know how to use Python and its packages to prepare and analyze data to solve financial problems and build their own investment strategies. Skills: Students are able to prepare a Python programming environment and install required packages. Students are able to implement in Python their own investment strategies. Social Competence: Participant understands that the expert use of Python requires continuous practice and improvement of his own skills. This course gives him the skills to seek knowledge, and update it to constantly changing Python libraries.*

Sposoby weryfikacji efektów uczenia się	egzamin pisemny, projekt, aktywność												
Master Thesis Seminar			30							30	3	K_W01, K_W02, K_W04,K_W05, K_W06, K_W07, K_U01, K_U03, K_U04, K_U05, K_U06, K_S01, K_S02, K_S03	ekonomia i finanse, matematyka, informatyka
Treści programowe	*The main objective of this seminar is to assist students with their theses' preparation. They are expected to prepare research projects with heavy empirical contents on macroeconomic or financial issues of their interest. The second part of the course is devoted to designing own empirical study, data collection and choosing the appropriate methodology.*												
Sposoby weryfikacji efektów uczenia się	złożenie pracy magisterskiej												
Preparation of the thesis for the diploma examination										0	8	K_W01, K_W02, K_W04,K_W05, K_W06, K_W07, K_U01, K_U03, K_U04, K_U05, K_U06, K_S01, K_S02, K_S03	ekonomia i finanse, matematyka, informatyka
Treści programowe	*Preparation of the thesis for the diploma examination*												
Sposoby weryfikacji efektów uczenia się	obrona pracy magisterskiej												
Elective course (OGUN)	30									30	3	K_U03, K_U05	
Treści programowe	*Elective course (OGUN) (humanistic profile)*												
Sposoby weryfikacji efektów uczenia się	różne formy: egzamin ustny, egzamin pisemny, test, esej, projekt												

Łączna liczba punktów ECTS (w semestrze): 30

Łączna liczba godzin zajęć (w semestrze): 180
Łączna liczba godzin zajęć określona w programie studiów dla danego kierunku, poziomu i profilu (dla całego cyklu): 1000

Zajęcia lub grupy zajęć w ramach specjalności przypisane do danego etapu studiów

(tabela dotyczy kierunku studiów, na którym prowadzona jest specjalność; tabelę należy przygotować dla każdego semestru studiów i dla każdej specjalności odrębnie)

Na kierunku Quantitative Finance nie są prowadzone specjalności.

Procentowy udział liczby punktów ECTS w łącznej liczbie punktów ECTS dla każdej z dyscyplin, do których przyporządkowano kierunek studiów.

Dziedzina nauki	Dyscyplina naukowa	Procentowy udział liczby punktów ECTS w łącznej liczbie punktów ECTS dla każdej z dyscyplin
Dziedzina nauk społecznych	Ekonomia i finanse	52%
Dziedzina nauk ścisłych i przyrodniczych	Matematyka	15%
Dziedzina nauk ścisłych i przyrodniczych	Informatyka	33%

CZĘŚĆ III

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Przedmioty do wyboru

(tabelę należy wypełnić, jeśli proponowane zmiany w programie studiów
spowodują zmiany w łącznej liczbie punktów ECTS obejmującej zajęcia do wyboru)

Proponowane zmiany nie powodują zmiany w łącznej liczbie punktów ECTS obejmującej zajęcia do wyboru.
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Przedmiot (zajęcia lub grupa zajęć)
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Liczba punktów ECTS
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Łączna liczba punktów ECTS obejmująca zajęcia do wyboru:
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**Przedmioty związane z prowadzoną w uczelni działalnością naukową w dyscyplinie lub dyscyplinach
– studia o profilu ogólnoakademickim**

(tabelę należy wypełnić, jeśli proponowane zmiany w programie studiów spowodują zmiany w łącznej liczbie punktów ECTS obejmującej przedmioty
związane z prowadzoną w uczelni działalnością naukową w dyscyplinie / dyscyplinach)

**Proponowane zmiany nie powodują zmiany w łącznej liczbie punktów ECTS obejmującej przedmioty związane z prowadzoną na uczelni
działalnością naukową w dyscyplinie/dyscyplinach.**
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<tr><td style="text-align:center">

Przedmiot (zajęcia lub grupa zajęć)
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Liczba punktów ECTS
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Łączna liczba punktów ECTS obejmująca przedmioty związane z prowadzoną w uczelni działalnością naukową w dyscyplinie/dyscyplinach:	

Przedmioty kształtujące umiejętności praktyczne – studia o profilu praktycznym (tabelę należy wypełnić, jeśli proponowane zmiany w programie studiów spowodują zmiany w łącznej liczbie punktów ECTS obejmującej przedmioty kształtujące umiejętności praktyczne) **Proponowane zmiany nie powodują zmiany w łącznej liczbie punktów ECTS obejmującej przedmioty kształtujące umiejętności praktyczne.**	
Przedmiot (zajęcia lub grupa zajęć)	**Liczba punktów ECTS**
Łączna liczba punktów ECTS obejmująca przedmioty kształtujące umiejętności praktyczne:	

…………………………………
(data i podpis Wnioskodawcy)

WNIOSEK O ZMIANY W PROGRAMIE STUDIÓW

kierunek: QUANTITATIVE FINANCE
(studia niestacjonarne drugiego stopnia)

CZĘŚĆ I

ZMIANY W PROGRAMIE STUDIÓW		
LP.	**DOTYCHCZASOWY ELEMENT PROGRAMU**	**PROPONOWANA ZMIANA**
1	Asset Allocation and Investment Strategies II	zastąpienie przedmiotem: Reproducible Research
2	Macroeconomics for Finance	zastąpienie przedmiotem: Machine Learning in Finance I i zmiana liczby punktów ECTS z 3 do 4
3	Advanced Microeconomics	zastąpienie przedmiotem: Machine Learning in Finance II
4	Mathematical Methods for Finance	zmiana liczby punktów ECTS z 7 do 6
5	Risk Analysis and Modelling II	zmiana liczby punktów ECTS z 5 do 4
6	Empirics of Financial Markets	zmiana liczby punktów ECTS z 5 do 4
7	C++ in Quantitative Finance II	zmiana liczby punktów ECTS z 5 do 4
8	Automatic Transactional Systems	zmiana liczby punktów ECTS z 5 do 4
9	Time Series Analysis	drobna korekta treści programowych
10	Automatic Transactional Systems	drobna korekta treści programowych
11	C++ in Quantitative Finance II	drobna korekta treści programowych
12	Preparation of the thesis for the diploma examination	zmiana liczby punktów ECTS

LP.	**UZASADNIENIE PROPONOWANYCH ZMIAN**
-	Wszystkie zmiany związane są z potrzebą uatrakcyjnienia kierunku studiów oraz dostosowania treści programowych do standardów uwzględniających zastosowania najnowszych metod uczenia maszynowego w finansach ilościowych. Zmiany mają także na celu pogłębienie wiedzy studentów z zakresu praktycznych finansów ilościowych, rozszerzenie ich umiejętności warsztatowych oraz ułatwienie im podjęcia pracy w szeroko rozumianym sektorze finansowym po zakończeniu studiów. W efekcie wprowadzenia zmian zmieniają się nieznacznie (2-3%) procentowe udziały poszczególnych dyscyplin. Przed zmianami: ekonomia i finanse 54%, matematyka 16%, informatyka 30%, po zmianach: ekonomia i finanse 52%, matematyka 15%, informatyka 33%
1	Usunięcie przedmiotu Asset Allocation and Investment Strategies II. Jego treści w znakomitej większości są realizowane dotychczasowej jego pierwszej części (Asset Allocation and Investment Strategies I). Przedmiot jest zastąpiony kursem Reproducible Research, który oferuje studentom

	poznanie nowoczesnych metod prowadzenia własnych badań oraz tworzenia raportów w sposób powtarzalny i z wykorzystaniem rozwiązań chmurowych.
2	Usunięcie przedmiotu Macroeconomics for Finance, którego treści nie są bezpośrednio związane z finansami ilościowymi i w części są realizowane na kursie Advanced Macroeconomics. Przedmiot jest zastąpiony kursem Machine Learning in Finance I, który oferuje studentom poznanie nowoczesnych metod uczenia maszynowego i data science oraz ich praktycznych zastosowań we współczesnych problemach w obszarze finansów ilościowych.
3	Usunięcie przedmiotu Advanced Microeconomics, którego treści nie są bezpośrednio związane z finansami ilościowymi i nie są istotne dla absolwenta kierunku Quantitative Finance. Przedmiot jest zastąpiony kursem Machine Learning in Finance II, który oferuje studentom poznanie nowoczesnych metod uczenia maszynowego i data science oraz ich praktycznych zastosowań we współczesnych problemach w obszarze finansów ilościowych.
4	zmiana punktacji wynikająca z przeszacowania czasu pracy niezbędnego do zaliczenia przedmiotu
5	zmiana punktacji wynikająca z przeszacowania czasu pracy niezbędnego do zaliczenia przedmiotu
6	zmiana punktacji wynikająca z przeszacowania czasu pracy niezbędnego do zaliczenia przedmiotu
7	zmiana punktacji wynikająca z przeszacowania czasu pracy niezbędnego do zaliczenia przedmiotu
8	zmiana punktacji wynikająca z przeszacowania czasu pracy niezbędnego do zaliczenia przedmiotu
9	Usunięcie metod dekompozycji szeregów czasowych, zwiększenie znaczenia wielowymiarowego modelowania zmienności (multivariate GARCH models)
10	Doprecyzowano treści dotyczące języka python.
11	Usunięto treści związane z wyceną opcji za pomocą drzew. Większy nacisk położono na integrację C++ z R oraz MS Excel.
12	Zmiana punktów wynikająca z przeszacowania czasu niezbędnego do przygotowania się do obrony pracy dyplomowej

CZĘŚĆ II

ZMIENIONY PROGRAM STUDIÓW

nazwa kierunku studiów	**Quantitative Finance**
nazwa kierunku studiów w języku angielskim / w języku wykładowym	**Quantitative Finance**
język wykładowy	angielski
poziom kształcenia	studia II stopnia
poziom PRK	VII poziom Polskiej Ramy Kwalifikacji
profil studiów	Profil ogólnoakademicki
liczba semestrów	**4**
liczba punktów ECTS konieczna do ukończenia studiów	**120 ECTS**
forma studiów	niestacjonarne
tytuł zawodowy nadawany absolwentom (nazwa kwalifikacji w oryginalnym brzmieniu, poziom PRK)	magister
liczba punktów ECTS, jaką student musi uzyskać w ramach zajęć prowadzonych z bezpośrednim udziałem nauczycieli akademickich lub innych osób prowadzących zajęcia	**115 ECTS** (co stanowi 96% łącznej liczby punktów ECTS)
liczba punktów ECTS w ramach zajęć z dziedziny nauk humanistycznych lub nauk społecznych (nie mniej niż 5 ECTS)	**6 ECTS** w ramach przedmiotów ogólnouniwersyteckich (co stanowi 5% łącznej liczby punktów ECTS)

Studia przygotowują do zawodu nauczyciela			
pierwszego przedmiotu:	nie	w szkole:	nie
drugiego przedmiotu:	nie	w szkole:	nie

Przyporządkowanie kierunku studiów do dziedzin nauki i dyscyplin naukowych, w których prowadzony jest kierunek studiów

Dziedzina nauki	Dyscyplina naukowa	Procentowy udział dyscyplin	Dyscyplina wiodąca (ponad połowa efektów uczenia się)
Dziedzina nauk społecznych	Ekonomia i finanse	52%	Ekonomia i finanse
Dziedzina nauk ścisłych i przyrodniczych	Matematyka	15%	Matematyka
Dziedzina nauk ścisłych i przyrodniczych	Informatyka	33%	Informatyka
Razem:	-	100%	-

Efekty uczenia się zdefiniowane dla programu studiów odniesione do charakterystyk drugiego stopnia Polskiej Ramy Kwalifikacji dla kwalifikacji na poziomach 6-7 uzyskiwanych w ramach systemu szkolnictwa wyższego i nauki po uzyskaniu kwalifikacji pełnej na poziomie 4

Symbol efektów uczenia się dla programu studiów	Efekty uczenia się	Odniesienie do charakterystyk drugiego stopnia PRK
Wiedza: absolwent zna i rozumie		
K_W01	Zna w pogłębionym stopniu teorię finansów, a także zaawansowane metody ilościowe, w szczególności znajdujące zastosowanie w wycenie instrumentów pochodnych, zarządzaniu ryzykiem portfela inwestycyjnego, procesie alokacji aktywów oraz prognozowania finansowych szeregów czasowych.	P7S_WG
K_W02	Zna i rozumie zjawiska finansowe, poszerzone o podstawy ekonomiczne oraz posiada umiejętność ich rygorystycznego analizowania i prognozowania.	P7S_WG
K_W03	Zna i rozumie cele, kontekst oraz znaczenie standardów etycznych i regulacji prawnych na rynkach finansowych.	P7S_WK
K_W04	Zna zasady ochrony własności intelektualnej i porządku prawnego.	P7S_WK
K_W05	Zna najnowsze osiągnięcia analityczne i trendy w światowej literaturze finansowej.	P7S_WG, P7S_WK
K_W06	Zna najnowsze narzędzia analityczne, informatyczne i programistyczne pozwalające na obróbkę danych empirycznych oraz praktyczną implementację modeli stosowanych w rozmaitych zagadnieniach z obszaru finansów ilościowych, w tym m. in. w wycenie instrumentów pochodnych, procesie alokacji aktywów, zarządzaniu ryzykiem portfela inwestycyjnego, tworzenia automatycznych strategii inwestycyjnych czy też prognozowania finansowych szeregów czasowych.	PS7_WG
K_W07	Zna i rozumie od strony matematycznej zasadę działania modeli analitycznych stosowanych w zagadnieniach z obszaru finansów ilościowych, w tym wyceny instrumentów pochodnych, modelowania zmienności, zarządzania ryzykiem portfela inwestycyjnego, procesów stochastycznych, symulacji Monte-Carlo i podobnych.	PS7_WG
Umiejętności: absolwent potrafi		
K_U01	Posiada umiejętność praktycznego zastosowania, implementacji i oprogramowania modeli statystycznych, ekonometrycznych i matematycznych adresujących problemy z obszaru finansów, w tym modelowania ekonometrycznego, prognozowania szeregów czasowych, modelowania zmienności, wyceny instrumentów pochodnych, zarządzania ryzykiem portfela inwestycyjnego z wykorzystaniem narzędzi analityczno-informatycznych i języków programowania, w tym R, C++, Python i/lub VBA.	PS7_UW
K_U02	Posiada umiejętność opracowania i optymalizowania systemu inwestycyjnego bazującego na sygnałach generowanych automatycznie. Umiejętność wdrożenia takiego systemu w praktyce, właściwej jego oceny i sprawnego zarządzania ryzykiem z nim związanym.	PS7_UW

K_U03	Potrafi tworzyć raporty i komunikatywnie prezentować wyniki samodzielnych analiz w języku angielskim.	PS7_UK, PS7_UW
K_U04	Potrafi prawidłowo zaplanować badanie empiryczne, skutecznie kierować pracą zespołu i dostarczyć poprawne rozwiązanie problemu w określonych ramach czasowych.	PS7_UW, PS7_UK, PS7_UO
K_U05	Potrafi posługiwać się językiem angielskim na poziomie B2+ z użyciem terminologii specjalistycznej potrzebnej do pracy i prowadzenia badań w obszarze finansów ilościowych (*Quantitative Finance*)	PS7_UK
K_U06	Potrafi zoptymalizować działanie modeli statystycznych, ekonometrycznych i matematycznych, dokonać wyboru ich właściwych parametrów i wykorzystać te modele do rozwiązania problemu i/lub wykonania prognozy.	PS7_UW
Kompetencje społeczne: absolwent jest gotów do		
K_S01	Jest gotów do krytycznej oceny dorobku, teorii i najnowszych koncepcji finansów ilościowych.	PS7_KK
K_S02	Jest przygotowany do objęcia stanowisk analitycznych i wykonawczych w sektorze finansowym w kraju i zagranicą.	PS7_KO, PS7_KR
K_S03	Jest przygotowany do realizacji samodzielnych i zespołowych projektów badawczych i analitycznych.	PS7_KO, PS7_KR

OBJAŚNIENIA

Symbol efektu uczenia się dla programu studiów tworzą:

- litera K – dla wyróżnienia, że chodzi o efekty uczenia się dla programu studiów,
- znak _ (podkreślnik),
- jedna z liter W, U lub K – dla oznaczenia kategorii efektów (W – wiedza, U – umiejętności, K – kompetencje społeczne),
- numer efektu w obrębie danej kategorii, zapisany w postaci dwóch cyfr (numery 1-9 należy poprzedzić cyfrą 0).

Efekty uczenia się zdefiniowane dla specjalności z odniesieniem do efektów uczenia się zdefiniowanych dla kierunku studiów

(należy wypełnić, jeżeli na kierunku studiów prowadzona jest specjalność; w przypadku kilku specjalności dla każdej z nich należy wypełnić odrębną tabelę)

Na kierunku Quantitative Finance nie są prowadzone specjalności.

Zajęcia lub grupy zajęć przypisane do danego etapu studiów

(tabelę należy przygotować dla każdego semestru studiów odrębnie)

Rok studiów: pierwszy

Semestr: pierwszy

Nazwa przedmiotu	Forma zajęć – liczba godzin								Razem: liczba godzin zajęć	Razem: punkty ECTS	Symbole efektów uczenia się dla programu studiów	Dyscyplina / dyscypliny, do których odnosi się przedmiot
	Wykład	Konwersatorium	Seminarium	Ćwiczenia	Laboratorium	Warsztaty	Projekt	Inne				
Statistics & Econometrics	30								30	1	K_W07, K_U01, K_S03	ekonomia i finanse, matematyka
Treści programowe	*The lecture gives a theoretical basis for basic statistics analysis and econometrics modelling. Participants will acquire theoretical knowledge about basic concepts and tools used in statistics and econometrics. Every topic discussed during the lecture will be illustrated with case study examples and exercises to be solved by students. The course is obligatory for students of Quantitative Finance.* *1. Introduction & organizational tasks* *2. Evaluation Exam* *3. Introduction to statistics* *a. Descriptive statistics,* *i. Population versus sample,* *ii. Measures of central tendency, variation & position,* *b. Probability, Random Variable & Probability distributions,* *i. Discrete and continuous variables,* *ii. Central Limit Theorem,* *iii. Main discrete and continuous probabilistic distributions: normal, lognormal, geometric, binomial, Poisson, Student's t, F, chi-square, gamma, normal multivariate distribution.* *4. Basics of statistical inference* *a. Essential concepts of statistical inference,* *b. Point estimation and confidence intervals,*											

	c. Statistical tests about parameters, *d. Tests about frequencies,* *e. Testing hypotheses of independence, normality, and symmetry for returns,* *f. Nonparametric tests of goodness-of-fit, independence, two-sample comparison,* *g. One-factor and multiple ANOVA,* *h. Nonparametric ANOVA,* *i. Covariance, correlation.* *5. Introduction to Econometrics* *a. What is Econometrics?* *b. Econometrics model & estimation of parameters,* *c. Regression analysis: estimation, OLS, Likelihood functions, Tests of fit,* *d. Elementary stochastic processes,* *e. Simple Monte-Carlo simulations.* *Students will learn how to perform the main procedures of statistical inference, such as point estimation, interval estimation, parametric and nonparametric statistical tests, and to give a statistically correct interpretation of the results. Additionally, they will learn how to prepare basic econometric models using basic approaches (such as OLS).*													

Sposoby weryfikacji efektów uczenia się	egzamin pisemny

Introduction to Quantitative Finance	30								30	3	K_W01, K_W02,K_W03, K_W04, K_W05, K_S01, K_S03	ekonomia i finanse

Treści programowe	*The aim of this course is to familiarize students with the key topics in modern finance. The first part of the course introduces key "underlying" instruments – stocks, bonds, FX etc. – and discusses the main theories developed for thinking about the relationship between risk and return, and the pricing of assets more generally. The second part of the course develops tools and techniques used for the valuation of financial derivatives, i.e. claims that promise some payment contingent on the behavior of a given underlying instrument. Finally, the third part of the course investigates theoretical and empirical arguments for market efficiency and behavioral finance.* *The detailed contents of the course:* *• Preliminaries: basic financial arithmetic* *• No arbitrage axiom: the bedrock of modern finance* *• Risk and return principles: the Markowitz framework* *• Capital Asset Pricing Model: theory and applications* *• Derivatives: more sophisticated instruments call for more sophisticated tools* *• Replication and risk neutrality: binomial trees* *• Martingales and the fundamental theorem of finance* *• From binomial trees to continuous-time limit: the Black-Scholes formula* *The student after completion of this course should:*

	• *know the concept of mean-variance portfolio efficiency;* • *distinguish between idiosyncratic and systematic risk factors and understand why investors are only rewarded for taking systematic risk;* • *understand that the expected value of something is not a good guide to its price;* • *understand the difference between risk-neutral and real-world probability measure;* • *be able to derive the Black-Scholes option pricing formula and explain the idea behind it.*													
Sposoby weryfikacji efektów uczenia się	egzamin pisemny, projekt												
Machine Learning in Finance I	15				15				30	4	K_W01, K_W02, K_W05, K_U01, K_U03, K_U04, K_U05, K_U06, K_S03	ekonomia i finanse, informatyka, matematyka	

| **Treści programowe** | *1. Python - lightning fast course: preparation of the environment, variables, data type, operators and control structure, functions, modules, data science toolkit: numpy, pandas, matplotlib, scikit-learn*
2. Introduction to Machine Learning: Types of Machine Learning, Introduction to Supervised Statistical Learning, Types of predictions, types of models, types of tabular data structures, Notations and general concepts - loss function, cost function, gradient descent, Simple Supervised Learning models - linear regression and logistic regression
3. Assessing model accuracy, machine learning diagnostics: Evaluation metrics- regression and classification, Learning curves, Training, validation and testing sets, Cross-validation technique, The concept of bias and variance and their trade-off, Possible remedies of underfitting or overfitting
4. Basic Supervised Learning models: K-nearest neighbours, Support Vector Machines, Decision trees and Random Forest (bagging idea)
5. Important machine learning techniques: Dataset preparation steps, Initial feature selection methods, Feature engineering, Regularization, Rebalancing, Explainable Artificial Intelligence*
6. Elements of a practical case study: construction of the first classification machine learning end-to-end pipeline, solving the problem of unbalanced data set, Testing multiple machine learning models, comparing the results of the models in the business context,

After completing the course, the student will have reliable, structured knowledge on a wide range of supervised learning algorithms for regression and classification problems, such as linear and logistic regression, linear discriminant analysis, kNN, ridge regression, LASSO, Support Vector Machine, decision trees, and random forest. They will know the theoretical foundations of these algorithms, as well as have programming skills allowing their application in finance. They will be able to select predictive modelling algorithms that are best suited to the specific research problem, perform reliable validation of models, select and transform variables, and perform an independent research project using the methods learned. |

Sposoby weryfikacji efektów uczenia się	egzamin pisemny, projekt												
Mathematical Methods for Finance	30			30					60	6	K_W07, K_U06, K_S03	ekonomia i finanse, matematyka	

| Treści programowe | 1.The purpose of this course is to help students develop advanced skills for formulating and analyzing mathematical models in economics and finance. Rigorous mathematical analysis of theoretical models can lead to a better understanding of economic problems.
2. Basic content: nonlinear programming, differential and difference equations, optimal control, dynamic programming, stochastic differential equations, partial differential equations.

Detailed content:
I. Nonlinear programming
Constrained optimization. Equality constraints and the theorem of Lagrange. The constraint qualification. The Lagrangean multipliers. Inequality constraints and the theorem of Kuhn and Tucker. The constraint qualification. The Kuhn-Tucker multipliers.
II. Differential and difference equations.
Constant coefficient linear differential equation (ODE) systems. Jordan canonical form of ODE systems. Fundamental matrix. Qualitative solution: phase portrait diagrams. Nonlinear systems. Fixed points. Linearization of the dynamic system in the plane. Linearization theory in higher dimensions. Hyperbolic points. Theorem of Hartman and Grobman. Phase diagrams of nonlinear dynamical systems.
Review of difference equations. Linear difference equations. Non-linear difference equations and phase diagrams. First order difference equations systems. Jordan canonical form. Discrete time version of linearization theory.
III. Optimal control
Pontryagin's maximum principle. Transversality conditions. Transversality conditions in infinite horizon problem. Second variations and sufficient conditions.
IV. Dynamic programming
Dynamic programming problems. The Principle of Optimality. The value function. Bellman equation. Euler equations.
V. Stochastic differential equations and partial differential equations
Probability spaces, random variables and stochastic processes. Brownian motion. Construction of the Ito integral. The Ito integral. Properties of the Ito integral. 1-dimensional Ito processes. 1-dimensional Ito formula. The martingale representation theorem. Stochastic differential equations - examples and some solution methods. Existence and uniqueness theorem for stochastic differential equations. Weak and strong solutions. Partial differential equations.

A student should be able to:
- solve constrained optimization problems,
- solve simple differential and difference equations,
- analyze nonlinear differential and difference equations and systems of equations,
- solve and analyze optimal control problems,
 solve basic stochastic differential equations,
- calculate Ito integrals,
- solve basic linear parabolic partial differential equations,
- use the above techniques in economic modeling and finance. |

Treści programowe	1.The purpose of this course is to help students develop advanced skills for formulating and analyzing mathematical models in economics and finance. Rigorous mathematical analysis of theoretical models can lead to a better understanding of economic problems. 2. Basic content: nonlinear programming, differential and difference equations, optimal control, dynamic programming, stochastic differential equations, partial differential equations. Detailed content: I. Nonlinear programming Constrained optimization. Equality constraints and the theorem of Lagrange. The constraint qualification. The Lagrangean multipliers. Inequality constraints and the theorem of Kuhn and Tucker. The constraint qualification. The Kuhn-Tucker multipliers. II. Differential and difference equations. Constant coefficient linear differential equation (ODE) systems. Jordan canonical form of ODE systems. Fundamental matrix. Qualitative solution: phase portrait diagrams. Nonlinear systems. Fixed points. Linearization of the dynamic system in the plane. Linearization theory in higher dimensions. Hyperbolic points. Theorem of Hartman and Grobman. Phase diagrams of nonlinear dynamical systems. Review of difference equations. Linear difference equations. Non-linear difference equations and phase diagrams. First order difference equations systems. Jordan canonical form. Discrete time version of linearization theory. III. Optimal control Pontryagin's maximum principle. Transversality conditions. Transversality conditions in infinite horizon problem. Second variations and sufficient conditions. IV. Dynamic programming Dynamic programming problems. The Principle of Optimality. The value function. Bellman equation. Euler equations. V. Stochastic differential equations and partial differential equations Probability spaces, random variables and stochastic processes. Brownian motion. Construction of the Ito integral. The Ito integral. Properties of the Ito integral. 1-dimensional Ito processes. 1-dimensional Ito formula. The martingale representation theorem. Stochastic differential equations - examples and some solution methods. Existence and uniqueness theorem for stochastic differential equations. Weak and strong solutions. Partial differential equations. A student should be able to: - solve constrained optimization problems, - solve simple differential and difference equations, - analyze nonlinear differential and difference equations and systems of equations, - solve and analyze optimal control problems, solve basic stochastic differential equations, - calculate Ito integrals, - solve basic linear parabolic partial differential equations, - use the above techniques in economic modeling and finance.
Sposoby weryfikacji efektów uczenia się	egzamin pisemny, prace domowe

Asset Allocation and Investment Strategies		30							30	3	K_W01, K_W02, K_U01, K_U02, K_U03, K_S01	ekonomia i finanse

Treści programowe	*The course presents state-of-the-art methods of asset management as well as techniques of analysis and design of investment strategies in the equity, forex, option and derivatives markets used by major institutional investors and hedge funds through the discussion of current research papers. Major areas covered include: active and passive asset management, investment performance attribution and analysis, empirical and practical analysis of investment portfolios, practical applications of quantitative methods in the design of market strategies and new investment products. The target audience of the course are students interested in asset management.* *1. Basic investment models and characteristics of financial time series* *2. Basic methods of security analysis and their investment applications* *3. Multifactor models and their practical applications* *4. Microstructure of financial markets and its role in strategy execution* *5. Active and passive asset management. Performance attribution and analysis* *6. Momentum strategies and their implementation* *7. Event driven and merger arbitrage strategies* *8. Carry trade strategies and portfolios* *9. Long-short strategies in the equity markets* *10. Analysis of option investments* *Students are expected to become familiar at an advanced level with: 1. fundamental investments models, characteristics of financial data and microstructure of financial markets from the perspective of asset management, 2. methods of construction and implementation of major classes of investment strategies used by actively managed funds, 3. risk and cost analysis of investment strategies, 4. performance attribution and analysis.*										

Sposoby weryfikacji efektów uczenia się	projekt, prezentacja										

Financial Statement Analysis	30			15					45	6	K_W02, K_W03, K_W04, K_U03, K_S01, K_S03	ekonomia i finanse

Treści programowe	*The purpose of the course is to familiarize students with general principles of the financial reporting system, underscoring the critical role of analysis of financial reports in investment decision making, including the principal financial statements (the income statement, balance sheet, cash flow statement and statement of changes in owners' equity) which allows a financial analyst to evaluate trends in performance of different companies over the same period. In addition, specific categories of assets and liabilities that are particularly susceptible to the impact of alternative accounting policies and estimates will be discussed.* *1. Financial reporting mechanics: Describing the three groups into which business activities are classified for financial reporting purposes. Introduction of the linkages among the financial statements. Consequences of timing differences between the elements of a transaction. An overview of how information flows through a business's analysis.* *2. Financial statement analysis: Scope of financial statement analysis, sources of information used in financial statement analysis, including the primary financial statements (income statement, balance sheet and cash flow statement), a framework for guiding the process of financial statement analysis.* *3. Financial reporting standards: The objective of financial statements and the importance of financial standards. Describing trends toward convergence of global financial reporting standards and characteristics of an effective financial reporting framework. Presentation of International Financial Reporting Standards (IFRS) framework. Comparison of IFRS with alternative reporting systems.* *4. Balance sheet: Structure and components of the balance sheet, measurement bases for assets and liabilities, components of equity.*										

	5. Income statement: Description and analysis of income statement components, basic principles and selected applications related to the recognition of revenue and expenses, calculation of earnings per share. *6. Cash flow statement: Components and format of the cash flow statement, classification of cash flows under IFRS and U.S. GAAP, linkages of the cash flow statement with the income statement and balance sheet, direct and indirect methods of cash flow statement preparation.* *7. Statement of changes in shareholders' equity and Additional information* *Structure and components of these statements and its usefulness in financial statement analysis.* *8. Financial analysis techniques: Description of analytical tools and techniques, calculating, analyzing and interpreting financial data.* *9. Financial statement analysis: application, Description of the use of financial statement analysis to evaluate a company's past financial performance and basic approaches to projecting a company's future financial performance.* *10. Inventories: Definition, classification and scope of inventories, initial valuation, valuation at the balance sheet date, the rules of measurement of inventories during an accounting period, impairment of inventories and its reversal.* *11. Long-term assets: Accounting for the acquisition and disposal of long-term tangible and intangible assets, allocation of those assets over their useful lives, impairment and revaluation.* *12. Long-term liabilities and leases: Accounting for long-term bonds and leases, description of the debt treatment with equity features.* *13. Conclusion and examination.* *Students will be provided with intermediate knowledge of financial accounting procedures and the rules that govern disclosure.* *Students should be able to record business transactions in books of accounts, prepare the following financial statements:* *- balance sheet,* *- income statement,* *- cash flow.* *They will be provided with knowledge of depreciation of tangible assets, impairment of inventory and financial investment, deferred taxes and on- and off - balance sheet debt techniques, application and International Standards convergence.* *The student has knowledge of the financial reporting and differences between Polish and international financial reporting standards. The student has knowledge of basic categories on financial statements (balance sheet, profit and loss account, cash flow statement, account of changes in equity and notes to financial statements), which may have a significant impact on the information presented in the reports and therefore decisions made by stakeholders on the basis of these reports. The student has knowledge of the preparation of financial statement analysis using indicators of profitability, efficiency, debt, market value and liquidity.*												
Sposoby weryfikacji efektów uczenia się	egzamin pisemny											
Ethical Standards and Financial Law	30								30	3	K_W02, K_W03, K_W04, K_U03, K_S01, K_S03	ekonomia i finanse
Treści programowe	*The main course objective is a presentation of backgrounds and significance of ethical and professional standards and legal regulations in the financial market. The basic expected result of instruction is getting knowledge of existing regulations and standards and ability to apply them to factual situations. The course is focused both on regulations and standards of international scope as well as those applicable in Poland. The course is conducted as a lecture in English and it is intended for first-year students of II degree studies, major: Quantitative Finance. The final grade is based on the written exam.*											

	The lecture focus is to show students significance of ethical and professional standards and legal regulations in the financial market and present their backgrounds and consequences. The course introduces an overview of main existing regulations and standards, both applicable in Poland and of international scope, as well as it shows how to apply them to factual situations. The following topics will be covered: *- The course content in a big picture - its economic, social and philosophical context.* *- Significance of formal and informal norms in economy - an institutional approach.* *- Morality and speculations - a historical preview.* *- Historical backgrounds of ethical standards and legal regulations regarding financial markets. Financial frauds versus financial crises. Reputational capital and the role of trust. Review, aims and significance of professional standards regulating behaviors of financial market's actors.* *- Professionalism: knowledge of the law, independence and objectivity, honesty. Case studies and standard application.* *- Nonpublic information and market manipulation. Case studies and standard application.* *- Duties to clients, employees and employers. Case studies and standard application.* *- Investment analyses, investment recommendations and financial statements. Case studies and standard application.* *- Conflicts of interest. Case studies and standard application.* *- International ethical and professional standards, e.g. Global Investment Performance Standards.* *- Polish ethical standards applying to investment advisors (DI) and stock brokers (MPW).* *- Corporate governance.* *- Compliance and internal corporate ethical standards and code of conduct.* *- Corporate social responsibility.* *- Legal basis of the financial market in Poland. Financial law institutions. Basics of legal regulations related to financial system supervision.* *- Protection of financial institutions' clients, e.g. MiFID. Complementarity of legal regulations and ethical and professional standards.* *- Ethical and professional standards, laws and regulations in the financial market - trends and perspectives.* *After the course, students will understand aims, context and significance of ethical standards and legal regulations in the financial market. They will have a general knowledge of ethical standards and will be able apply them to business situations. They will get to know the basic codes of conduct regarding management of conflicts of interest. They will gain knowledge of basic issues regarding corporate governance. They will get an orientation of legal basis applicable to the Polish financial market, including regulations regarding protection of financial institutions' clients. They will understand the implications of violating regulations of financial law and applicable standards.*											
Sposoby weryfikacji efektów uczenia się	egzamin pisemny										
Intellectual Property Protection								6	6	0,5	K_W04	-
Treści programowe	*The aim of the course is to familiarize students with the basic information in the field of copyright and certain general aspects of industrial property rights. Course participants will acquire knowledge about the sources of law and fundamental concepts relating to intellectual property rights and will be able to apply them at a basic level. Students will be aware of protection of intellectual property rights (in particular in the field of copyright) and the complexity of these issues.* *The course is designed to familiarize students with the basic information on copyright and indicate some issues of industrial property protection. Special attention will be paid to copyright protection in the context of studying at university and research. Course participants will acquire knowledge about the sources of law and fundamental concepts relating to intellectual property rights and will be able to apply them at a basic level. Students will be aware of protection of intellectual property rights (in particular in the field of copyright) and the complexity of these issues.*										

	The following topics will be covered: *1) National (Polish) legal acts of intellectual property rights protection* *2) The general concepts of intellectual property rights - the scheme of intellectual property rights* *3) Some aspects of industrial property rights (patents, trademarks, /industrial/ designs)* *4) Right-holder, subject and content of the copyright - moral and economic rights, the idea of neighboring rights, specific rules for computer software* *5) The practical aspects of copyright law - how to use the third parties works (e.g. copying, bibliographical references), use of third parties research results and databases, the concept of plagiarism, how to protect own works - copyright issues in scientific papers and dissertations.* *6) The copyright protection and the Internet* *Student has knowledge about the sources of law, the general concepts and issues in the field of legal protection of intellectual property* *Participants know the basic rules and the consequences of the use of copyright protection (in particular in terms of functioning at university) and the elements of industrial property protection.* *Student has the ability to use in everyday life general concepts relating to the protection of intellectual property* *Participants know at a basic level how to apply the provisions of copyright protection, in particular concerning the use of third parties works in terms of studies and research work, taking into account specific issues of copyright protection on the Internet.* *Students have a general awareness of protection of intellectual property rights (in particular in the field of copyright) and the complexity of these issues.* *Students recognize the importance of intellectual property protection in various aspects of society.* *Participant is aware of their actions in relation to the subject of intellectual property rights (in particular in the subject of copyright) and rights in relation to the works of his own authorship.*
Sposoby weryfikacji efektów uczenia się	egzamin pisemny

Occupational Safety and Health (OSH)								4	4	0,5	K_U05	

Treści programowe	*The subject of the course is the acquisition of basic knowledge in the field of occupational safety and health, elements of labor law, fire protection as first aid in the event of an emergency.* *Occupational health and safety are all legal norms and means of research aimed at creating an employee's working conditions so that they can work in a productive way without exposing themselves to unjustified risk of accident or occupational disease and excessive physical and mental strain. The specificity of the higher education institution requires the provision of safe and hygienic working conditions not only to the employees employed by the university, but also to the trainees.* *The condition of completing the occupational health and safety training is:* *1) get acquainted with materials placed on the platform,* *2) get the right number of points from the selection test.*
Sposoby weryfikacji efektów uczenia się	egzamin pisemny

Elective course (OGUN)	30							30	3	K_U03, K_U05	

Treści programowe	*Elective course (OGUN) (humanistic profile)*
Sposoby weryfikacji efektów uczenia się	różne formy: egzamin ustny, egzamin pisemny, test, esej, projekt

Łączna liczba punktów ECTS (w semestrze): 30
Łączna liczba godzin zajęć (w semestrze): 295
Łączna liczba godzin zajęć określona w programie studiów dla danego kierunku, poziomu i profilu (dla całego cyklu): 1000

Rok studiów: pierwszy

Nazwa przedmiotu	Forma zajęć – liczba godzin								Razem: liczba godzin zajęć	Razem: punkty ECTS	Symbole efektów uczenia się dla programu studiów	Dyscyplina / dyscypliny, do których odnosi się przedmiot
	Wykład	Konwersatorium	Seminarium	Ćwiczenia	Laboratorium	Warsztaty	Projekt	Inne				
Time Series Analysis	30			30					60	6	K_W01, K_W02, K_W05, K_U01, K_U03, K_U04, K_U05, K_U06, K_S03	ekonomia i finanse, informatyka, matematyka
Treści programowe	*The lecture gives a theoretical basis for time series modeling. Participants will acquire theoretical knowledge about concepts and tools used in time series analysis and forecasting. The role of practical sections is to practice econometric analysis of time series: preparing the data, estimation and post estimation procedures, model verification and diagnostics, forecasts building and evaluation. Every topic discussed during the lecture will be illustrated with case study examples and exercises to be solved by students. R software will be used - its previous knowledge is not required.* *1. Univariate time series – modeling and forecasting* *- stochastic process, deterministic process and time series – definitions,* *- weak and strong stationarity of time series,* *- random walk (with/without drift), white noise,* *- stationarity testing, unit root tests: DF/ADF, KPSS* *- autocorrelation and partial autocorrelation functions, correlograms,* *- autoregressive process AR(p) and its features,* *- moving average process MA(q) and its characteristics,* *- ARMA(p,q) models, stationarity conditions, Box-Jenkins procedure, information criteria AIC, SBC (BIC), parameter estimation and model diagnostics,* *- Portmanteau test, Box-Pierce and Ljung-Box tests,* *- integrated series, integration level, differentiation of series,* *- ARIMA models for integrated series,* *- forecasting in ARMA/ARIMA models, ex-ante forecast error, confidence intervals for the forecast, ex-post measures of forecast quality (absolute and percentage)* *- seasonal SARIMA models – estimation and forecasting,* *- univariate smoothing methods*											

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	3. Modeling volatility *- stylized facts in financial time series, leptokurtic series, "fat tails", leverage effect,* *- homoscedasticity vs. heteroskedasticity,* *- conditional vs. unconditional variance,* *- ARCH(q) process and its features, testing for conditional heteroskedasticity,* *- estimation of ARCH models,* *- generalized ARCH models (GARCH), estimation methods,* *- GARCH extensions: IGARCH, GARCH-M, GARCH-t, asymmetric GARCH models: EGARCH, GJR-GARCH, TGARCH* *- multivariate volatility models: multivariate smoothing with EWMA, Diagonal-VEC model, BEKK model, CCC-GARCH model, Cholesky decomposition, DCC-GARCH model* *4. Multivariate time series models* *- long-term relationships in financial time series* *- cointegration – definition and testing, estimation of cointegrating vector, Johansen test, error correction mechanism models (ECM),* *- Granger causality testing,* *- vector autoregression models (VAR),* *- impulse response functions,* *- variance decomposition,* *- vector error correction mechanism models (VECM),* *5. Switching models* *- Markov switching models* *- Threshold autoregressive models* *Students will be able to identify features of time series and select the best modeling method. They will know how to decompose time series into its components, identify, estimate and interpret models in univariate and multivariate time series framework (for macroeconomic and financial data), produce and evaluate forecasts and verify research hypotheses. In addition, students will know how to apply a wide range of models, including modeling non-stationary time series and long-run relationships between economic variables.*											

Sposoby weryfikacji efektów uczenia się	egzamin pisemny, projekt

Equity and Fixed Income	30			15					45	5	K_W01, K_W02, K_U01, K_U02, K_U03, K_S01	ekonomia i finanse

Treści programowe	*Main objective of the course is to discuss problems of equity/corporate value and fixed income securities from a practical perspective: construction, valuation and application in the field of financial markets. Course is comprised of two main building-blocks (preceded by one introductory lecture):* *1) corporate valuation,* *2) overview of fixed income securities, its valuation and application.* *1. Revision of basic concepts: time value of money, incorporation of risk into the model.* *PART I Corporate Valuation* *2. Introduction to Company Valuation*

	3. Discounted Cash Flows Method in detail *4. Weighted Average Cost of Capital* *5. DCF in practice* *PART II Fixed Income Securities* *6. Overview of Fixed Income Securities and Bond Valuation: basic fixed income securities: bonds and their features, fixed income derivatives: futures, options, swaps, swaptions, bond valuation methods.* *7. Theory of Interest Rates: yield curve (possible shapes, theories of yield curve), kinds of interest rates: spot rates, forward rates, simple and compounded interest (incl. logarithmic rates), short rates* *8. Risk associated with investing in bonds and its measurement: kinds of risks (incl. interest rate risk, reinvestment risk, liquidity risk, credit risk), duration, convexity and other methods in quantifying interest rate risk.* *9. Forward Rate Agreements* *10. Interest Rate Swaps* *11. Modeling Option-like Fixed Income Securities: Binomial Trees, Black's Model* *12. Caplets, Floorlets/Caps, Floors* *13. Swaptions* *14. Bonds with Embedded Derivatives* *Students with given credit for this course can demonstrate knowledge at intermediate level concerning company valuation and fixed income securities and have acquired practical skills related to the subject of pricing and application of securities in question. The course encompasses concepts that are required for (and in some cases goes beyond) CFA examination (related to the Fixed Income Analysis), nevertheless should not be treated as a preparatory course for CFA examination.*												
Sposoby weryfikacji efektów uczenia się	egzamin pisemny											
Derivatives Markets	30		15					45	4	K_W01, K_W02, K_W07, K_U01, K_U03, K_S01	ekonomia i finanse, informatyka	
Treści programowe	*The course aims at profound understanding of the specifics of derivative markets.* *Vast scope of real derivative instruments traded on world exchanges will be described: starting with plain futures/forwards, through swaps, vanilla options, exotic instruments, ending with advanced financial derivatives like CDS. Both theoretical (pricing) and practical (trading, risk management) aspects are going to be addressed with reference to various asset classes: stocks, commodities, currencies. Derivatives markets will be analyzed also in the context of recent macroeconomic developments and growing role of speculation in pricing the assets. The lecture will be conducted mainly via multimedia slideshows. Upon starting the course students are expected to have micro- and macroeconomic background as well as intermediate skills in mathematics and probability/statistics.* *The lecture starts with an overview of main classes of tradable assets, such as stocks, indices, bonds, commodities (with subsectors), currency pairs and some alternative assets. These assets serve as underlying for derivative instruments. Leading stock and/or derivative exchanges will be introduced and described: NYSE, Euronext/Liffe, NYMEX, COMEX, CBOE, NYBOT, ICE and most liquid local exchanges. Highlighting their brief history and developments, consolidation processes. Detailed description of various types of derivatives: plain futures/forwards; vanilla options; swaps, exotic options. Vital practical issues will be tackled: pricing, real trade, commercial usage for risk management, arbitrage or speculation. In case of options practical aspects of Greek analysis will be presented. Discussing the volatility, nonlinearities and term structures. The contents of the lecture will be successively enriched with case studies and rooted in*											

	current market development context (monetary politics, boom-bust cycles, dominant role of speculation, etc.). Students will learn the empirics of derivatives markets, studying specific behaviors of respective underlying segments (e.g. agricultural commodities, emerging markets currencies. The course in general is intended to cast a multicolor light on derivatives world but with no in-depth analysis of formal regulations and juridical solutions. *Students will acquire profound knowledge about derivative instruments, including: specifics of futures, various classes of options, swaps and alternative derivatives. The course's main aim is to popularize the specifics of derivatives with their broad practical usage possibilities (hedging, diversification, speculation). Theoretical aspects as pricing are to be confronted with real market trade. On finishing the course students possess versatile knowledge encompassing theoretical and practical aspects of derivatives markets. They also gain up-to-date multi-aspect familiarity coupled with current macroeconomic background. Classes perform a complementary role of enhancing practical aspects.*										
Sposoby weryfikacji efektów uczenia się	egzamin pisemny, projekt										
Corporate Finance	30			15					45	4	K_W01, K_W02, K_U01, K_U02, K_U03, K_S01	ekonomia i finanse, informatyka
Treści programowe	*Attendants to this course will get acquainted with theory and practice of financial management in a modern corporation. They will learn where a company can get financing and which financial instruments it should use. They will know instruments that are helpful in making key financial decisions on strategic and operational level. This course will be held as a lecture with classes. It is expected that students have intermediate knowledge in finance and accounting and some mathematical background. Credit will be given after three written exams - one from the lecture and two from classes.* *To fully participate in this lecture basic knowledge in finance is necessary. Mathematical analysis and some accounting intuitions will also be helpful.* *1. Goals and governance of the firm: basic principles of functioning of a listed company (board, management, shareowners, limited liability)* *role of financial manager, incentive and agency problems, different conflicts of interest and ways of managing them* *2. Investment decisions: popular investment criteria (NPV, IRR, MIRR and other), their advantages, disadvantages* *NPV rule in different applications, practical problems in capital budgeting, risk in capital budgeting and methods of its evaluation* *3. Risk and cost of equity capital: choosing a risk model, risk-free rate, general risk premium, country risk premium, estimating betas, estimating lambdas.* *4. Overview of corporate financing. Equity and debt as a source of capital: equity issuance step by step procedure, underwriting, private placement, IPOs, capital dilution and privileged subscription, bonds issuance step by step, bank credit as an alternative source of long term financing* *5. Lessons of market efficiency: Efficient Market: theory and evidence, Six lessons for financial managers* *6. Dividend policy: types of dividends, reasons to pay dividends, taxation and dividends, optimal dividend model* *7. Optimal capital structure: traditional approach, Modigliani-Miller theorems, tradeoff theory, pecking order theory* *8. Calculating cost of capital of the firm: value of corporate debt, foreign capital cost and yield spread, WACC, financing and valuation - APV* *9. Mergers: reasons to merge and types of mergers, cost and gains of a merger, mergers financing and tactics, corporate restructuring* *10. Working capital management: cash management, inventory management, managing liquidity of assets and liabilities, trade credit and discounts* *11. Leasing (optional): sensible and dubious reasons for leasing, financial and operating leases, when do financial leases pay* *After finishing this course students should:* *- know sources of capital and methods of its raising;* *- be able to calculate cost of capital;* *- be able to evaluate investment projects* *- understand conflicts of interest and agency problems in a listed company;*										

	- know in what circumstances a company should merge, pay dividend or repay its debt; - be acquainted with problems concerning working capital management.												
Sposoby weryfikacji efektów uczenia się	egzamin pisemny												
Computational Finance				30						30	5	K_W01, K_W02, K_W05, K_W06, K_W07 K_U01, K_U03, K_U04, K_U05, K_U06, K_S03	ekonomia i finanse, informatyka
Treści programowe	The course focuses on practical aspects of using MS Excel and VBA in computational finance. Participants will learn how to write simple macros and user-defined functions that improve efficiency of calculations. 1. Introduction to VBA in Excel: Advanced Excel functions and procedures, data tables, access to Data Analysis and Solver, matrix algebra, VBA editor in Excel, simple macros, using Excel functions and VBA functions in code, communications between macros and spreadsheets. Writing VBA user-defined functions, manipulating arrays, pros and cons of developing VBA functions. 2. Equities models: Portfolio optimization: risk-return representation of portfolios, generating the efficient frontier, combining risk-free and risky assets. Asset pricing: the single-index model, estimating beta coefficient, the CAPM model. 3. Options on equities: Intro to options on equities: the Black-Scholes formula, hedge portfolios, risk-neutral valuation, simple one-step binomial tree, call-put parity, dividends. 4. Monte Carlo simulations: Geometric Brownian Motion, simulation with antithetic variables. 5. Value at Risk: Different methods of calculating VaR. 6. Other: Distance-to-Default, GARCH(1,1) estimation, Vasicek model, volatility models. After finishing this course student should: - know how to use selected advanced Excel functions; - be able to write simple macros, and user-defined functions; - be able to perform simple Monte Carlo simulations;												
Sposoby weryfikacji efektów uczenia się	egzamin praktyczny, projekt												
Reproducible Research		30								30	3	K_W01, K_U01, K_U02, K_U03, K_U04, K_U05, KS_01, K_U06, K_U07	ekonomia i finanse, informatyka
Treści programowe	The main objective of the course is to present the key concepts of the research reproducibility, its importance in scientific and commercial R&D processes, and to provide students with the basic practical knowledge of a few most popular in the industry modern reproducibility tools.												

	1. Introduction:Importance of reproducibility in the R&D process, Consequences of lack of reproducibility, Best practices, reproducibility in academic research, how to reproduce an academic paper											

2. Reporting tools: introduction to RMarkdown and Bookdown, how to navigate through Jupyter notebooks, prototyping fast and powerful dashboards (R Shiny and Python Streamlit), best programming practices
3. Networking & Security: introduction to linux shell, network security on the example of public/private key pairs, connecting to remote computers
4. Version control systems: introduction to git, worst & best practices with git, practical remarks
5. Remote repositories & Utility tools: introduction to github, basics of project workflow, project management tools, CI/CD your code
6. Popular cloud environment: introduction to Amazon Web Services, cloud based or standalone service?
7. Model training and serving in the cloud: MLFlow and similar solutions, how to automate the training process, how to deploy your model to the cloud, how to monitor your model's performance
8*. optionally: Working in scrum: boards, tasks, issues, automation, daily, weekly, retrospective

Upon the completion of the course, student:
1. understands the general concept of research reproducibility; knows the reproducibility tools classification; understands which tool can be used in a given context;
2. has basic skills in computer tools allowing to achieve research reproducibility and replicability; has basic skills in modern best programming practices; has basic skills in the cloud development environment; is able to employ skills gained during the course while participating in modern scientific and commercial data science projects;
3. is aware of the importance of reproducibility in data science, as well as in science and development in general; is aware that reproducibility tools are evolving rapidly and that constant training in this area is required to keep skills up to date; is aware of the trends in modern data science and IT development;

Sposoby weryfikacji efektów uczenia się	projekt

Master Thesis Seminar			30							30	3	K_W01, K_W02, K_W04,K_W05, K_W06, K_W07, K_U01, K_U03, K_U04, K_U05, K_U06, K_S01, K_S02, K_S03	ekonomia i finanse, matematyka informatyka

Treści programowe	*The main objective of this seminar is to assist students with their theses' preparation. They are expected to prepare a research project with heavy empirical contents on macroeconomic or financial issues of their interest. Hence, the first part of the course is devoted to critical review of major economic and financial concepts that are eligible for empirical modelling exercises.*
Sposoby weryfikacji efektów uczenia się	egzamin ustny/projekt

Łączna liczba punktów ECTS (w semestrze): 30
Łączna liczba godzin zajęć (w semestrze): 285
Łączna liczba godzin zajęć określona w programie studiów dla danego kierunku, poziomu i profilu (dla całego cyklu): 1000

Rok studiów: drugi

Nazwa przedmiotu	Forma zajęć – liczba godzin								Razem: liczba godzin zajęć	Razem: punkty ECTS	Symbole efektów uczenia się dla programu studiów	Dyscyplina / dyscypliny, do których odnosi się przedmiot
	Wykład	Konwersatorium	Seminarium	Ćwiczenia	Laboratorium	Warsztaty	Projekt	Inne				
Quantitative Strategies. High Frequency Data	30			30					60	6	K_W01, K_W02, K_W06, K_W07, K_U01, K_U02, K_U03, K_U04, K_U05, K_U06, K_S01, K_S03	ekonomia i finanse, matematyka informatyka
Treści programowe	*The aim of this lecture is to give a theoretical background for high frequency data analysis, which is used to prepare, test and implement quantitative trading strategies. Students will acquire knowledge about characteristics of high frequency data and tools used to evaluate trading strategies. Successful strategies for different intraday investment horizons will be discussed. The role of practical sections is to build and verify own trading strategies on high-frequency data. Students will learn to prepare the data, aggregate it to desired frequency, backtest the strategy and verify the strategies from different perspectives (returns, risk, etc.). Topics discussed during the lecture will be illustrated with practical examples and exercises. R environment will be used - its previous knowledge is not required.* *Lectures:* *1. Organizational matters, introduction to R.* *2. Introduction to quantitative trading, evolution of high-frequency trading, types of high-frequency trading strategies.* *3. Characteristics of intra-day data, data sources, working with tick data, data adjustments.* *4. Review of the statistical and econometric foundations of the common types of high-frequency strategies: linear regressions.* *5. Review of the statistical and econometric foundations of the common types of high-frequency strategies: time series.* *6. Backtesting and evaluating performance of trading strategies.* *7. Strategies of the highest frequency, with position-holding periods of one minute or less.* *8. Market microstructure models.* *9. "Event arbitrage" strategies.* *10. Statistical arbitrage strategies.* *11. Portfolio construction, multi strategy portfolios.*

12. Factor models and factor based trading strategies.
13. Execution systems.

Lab sections
1. Introduction to R
2. Dealing with time series data of different frequency, frequency conversion, data aggregation, plotting the series.
3. Statistical and econometric analyses - correlation, regression, etc.
4. Rolling analyses, storing partial results of analyses, loops and own functions.
5. Backtesting of trading strategies, calculating evaluation statistics.
6. Portfolio construction and evaluation.
7. Students' presentations.

Students will be able to analyze and aggregate high-frequency time series data. They will know how to prepare and backtest trading strategies, calculate appropriate evaluation statistics and select the best performing strategy. In addition, students will be able to indicate successful strategies for different data frequencies.

Sposoby weryfikacji efektów uczenia się	egzamin pisemny, projekt, prezentacja

Machine Learning in Finance II				30			30	3	K_W01, K_W02, K_W05, K_U01, K_U03, K_U04, K_U05, K_U06, K_S03	ekonomia i finanse, matematyka, informatyka

| **Treści programowe** | *The course covers more advanced methods of machine learning: boosting models, neural networks, and Bayesian time series models. Both theoretical background and practical empirical applications in finance are discussed. Practical part covers problems of regression and classification problems, processing and forecasting of sequences, time-series analysis and deployment of methods in the cloud environment.*

The course consists of 3 parts: 1) boosting models 2) (deep) neural network models 3) Bayesian time series models. It is conducted in the form of interactive laboratories with the use of case studies which are carried out in parallel with the lecture part.

1. Boosting models
  - Adaptive Boosting – primary idea of boosting, weak learners, meta-estimator
  - Gradient Boosting – next generation idea of boosting, weak learners trained on residuals
  - top 3 leading Gradient Boosting Decision Tree models: eXtreme Gradient Boosting, Light Gradient Boosting Machine, CatBoost
  - elements of a practical case study: testing multiple gradient boosting machine learning models, comparing their performance against classical machine learning models, empirical experiencing the advantages and disadvantages of specific gradient boosting models, comparing the results of the models in the business context
2. Neural network models
  - Multilayer Perceptrons - artificial neurons, topology of the neural networks, input layers, hidden layers, output layers, weights, bias, activation functions, backpropagation algorithm, methods of weights modification
  - Recurrent Neural Networks: sequence processing, idea of internal loop, recurrent connection, state variable, vanishing gradient problem, LSTM/GRU layers, carry dataflow, recurrent dropout, recurrent layers stacking, bidirectional recurrent networks |

- *Attention mechanism in Neural Network: sequence to sequence, transformer*
- *Convolutional Neural Networks: filters, receptive fields, activation maps, structure of CNN, convolutional layers, ReLu layers, pooling layers, dropout layers, stride, padding, transfer learning, methods of data augmentation*
- *elements of a practical case study: testing multiple gradient boosting machine learning models, comparing their performance against classical machine learning models, empirical experiencing the advantages and disadvantages of specific gradient boosting models, comparing the results of the models in the business context*

3. Bayesian time series models
- *Facebook Prophet - point forecast, uncertainty intervals, seasonality modelling, trend modelling, saturating forecasts*
- *Uber Orbit (as a framework) - Damped Local Trend model, Local Global Trend model, Kernel-based Time-varying Regression model*

4*. optionally: Ensembling methods - simple and weighted averaging, majority voting, weighted voting, stacking of bottom-layer models and top-layer model

After completing the course, the students will have structured and reliable knowledge on boosting models, neural networks, and Bayesian time series models. They will be able to apply them for both regression and classification problems. They will know the theoretical foundations of these algorithms, as well as have programming skills allowing them to deploy the models in practice, also in the cloud framework. They will also know how to interpret results and explain how they work to other non-technical people.

Sposoby weryfikacji efektów uczenia się	egzamin pisemny, projekt, prezentacja											
Risk Analysis and Modelling I		30								30	5	K_W01, K_W02, K_W06, K_W07, K_U01, K_U03, K_U04, K_U05, K_U06, K_S01, K_S03	ekonomia i finanse informatyka
Treści programowe	*The purpose of the seminar is the presentation of the modern financial risk evaluation. On this part of the course we consider: liquidity risk and interest rate risks. Especially we concentrate on: gap analysis, costs of liquidity, prediction of liquidity requirement; interest rate gap, duration, convexity, improvements of duration's calculation, goals of management based on the duration analysis, simulations of interest rates behavior. The seminar takes place in a computer lab. The final exam consists of "true/false" questions with explanation.* *The seminar focuses on modern risk evaluation and management. We consider: liquidity risk, interest rate risk. Additionally the normative aspect of supervisory regulation in financial institutions is briefly mentioned. Especially we concentrate on:* *1. liquidity gap analysis, costs of liquidity (alternative costs of funds and risk neutral probability premium), forecast of liquidity with simple and advanced methods, like for example ARIMA, replicating portfolio approach, liquidity indicators.* *On computers we execute: liquidity forecast, estimation of core deposits in the bank, calculation of replicating portfolio, calculation and investigation of liquidity adjusted value at risk.* *2. measurement of interest rate risk: interest rate gap, duration, convexity (other advanced measures), interest rate modeling: spot rate curve estimation (Nelson-Siegel approach), introduction to modeling short rate evolution via stochastic models (e.g. Vasicek model), interest rate risk management: goals of management based on the duration analysis.* *On computers we execute: simulation of net income affected by interest rate changes, duration analysis with extensions (for example, scenario simulations), impact of normative regulations on the choice of interest risk evaluation in financial institutions, estimation of yield curve based on stochastic evolution of spot rates.*											

	Students have knowledge about types of financial risk, basic methods of measuring and managing the risk in financial institutions and enterprises. Students can evaluate basic types of risk with simple models created in spreadsheets. He or she is able to recognize the impact of regulatory requirements on risk assessment. Students can apply different risk measures to the purposes of risk analysis, for example to calculate the gains or losses on the position or to increase the net income of the investment without rapid growth of risk. *Students are aware of how risk management can reduce the regulatory capital requirements and ensure the compliance with risk standards. The student implements the credit requirements on time.*										
Sposoby weryfikacji efektów uczenia się	egzamin pisemny										
C++ in Quantitative Finance I				30					30	4	K_W01, K_W06, K_W07, K_U01, K_U05, K_U06	informatyka

Treści programowe	*The course is designed as a gentle introduction to C++ and the world of object-oriented programming with special emphasis on the problem of derivatives valuation.* *1. Creating a Basic Program: Basic C++ Syntax. Compiling a C++ Program. Printing Text. Running a Compiled Program, Pausing Execution. Understanding White Space. Adding Comments to the Source Code. Using an IDE* *2. Simple Variables and Data Types: Declaring Variables. Assigning Values to Variables. Printing Variables. Formatting Numbers. Understanding Type Conversion. Introduction to Characters. Introduction to Strings. Introduction to Constants.* *3. Operators and Control Structures: Arithmetic Operators. If Conditionals. Using else and else if. The Ternary Operator. Logical and Comparison Operators. Increment and Decrement Operators. While Loop. For Loop* *4. Input, Output, and Files: Taking Character Input. Discarding Input. Taking Numeric Input. Taking String Input. Taking Multiple Inputs. Reading in a Whole Line. Validating Input. Creating File Output. Using File Input* *5. Defining Your Own Functions: Creating Simple Functions. Creating Functions that Take Arguments. Setting Default Argument Values. Creating Functions that Return a Value. Overloading Functions. Understanding Variable Scope* *6. Complex Data Types: Working with Arrays. Working with Pointers. Structures. Revisiting User-Defined Functions* *7. Introducing Objects: Creating a Simple Class. Adding Methods to a Class. Creating and Using Objects. Defining Constructors. Defining Destructors. The this Pointer* *8. Class Inheritance: Basic Inheritance. Inheriting Constructors and Destructors. Access Control. Overriding Methods. Overloading Methods. Making Friends* *9. Namespaces & Modularization: Working with Included Files. The C Preprocessor. Understanding Namespaces. Linkage and Scope* *10. Working with Templates* *After the course students will be able to write and compile their own basic C++ applications. They will be able to design and deploy simple Monte-Carlo simulations which can approximate the theoretical prices of both non-path dependent and path-dependent options.*
Sposoby weryfikacji efektów uczenia się	egzamin praktyczny, projekt

Theory and practice of option pricing				30						30	6	K_W01, K_W07, K_U03, K_U04, K_U06, K_S01	ekonomia i finanse

Treści programowe	*The main goal of the course is to deepen the knowledge of Black-Scholes-Merton option pricing theory in its formal, intuitive and purely practical dimension. During the course, students learn the exact assumptions of the model and its theoretical and practical limitations (transaction costs, the price discontinuity of the process, discrete adjustment of hedging positions), and reflect on pricing biases occurring when individual assumptions are not satisfied. Students will also learn how the market values options and what is required of a good valuation model. In this light, we will discuss possible improvements to the BSM theory, which should facilitate greater understanding of actual option prices quoted by the market. Theoretical considerations will be illustrated using practical examples and C++/VBA codes.* *The detailed content of the course is presented below.* *• Review of option pricing* *• Theory and practice of dynamic replication: implied and realized volatility* *• P&L of a delta-hedged portfolio* *• Practical limitations of replication: transaction costs and discrete time steps* *• Volatility smile – causes and consequences* *• Volatility smile and pricing vanilla and exotic options* *• Calibration and model risk* *• Pricing models accounting for volatility smile* *Upon completion of the course the student:* *- knows how to price call and put options within the Black-Scholes framework, and understands the main assumptions underlying the theory* *- knows basic conventions used in option markets, as well as knows and understands the concept of implied volatility* *- correctly identifies the main risk factors underlying investment in options* *- knows how to analyze theoretically and model quantitatively the results of the main option trading strategies, including dynamic hedging/replication* *- is familiar with the main numerical techniques used for pricing and analyzing options (Monte Carlo simulation, finite difference schemes)*
Sposoby weryfikacji efektów uczenia się	egzamin pisemny, projekt

Advanced Macroeconomics	30									30	3	K_W02, K_W05, K_U05, K_S01	ekonomia i finanse

Treści programowe	*The aim of this 30-hours lecture is to present modern macroeconomic methods and models used both by researchers and analysts to understand and predict macroeconomic phenomena. Upon completion students will be able to use acquired tools to explain and interpret the workings of the macroeconomy at an advanced level.* *The course is composed of three parts. The first part is devoted to the microfoundations of modern macroeconomic models. The second part covers core growth facts and theories. The third part is devoted to analyzing and modeling business cycles phenomena* *Part I: Microfoundations* *1. Introduction to dynamic macroeconomics*

		2. Consumption and labor supply choice *3. Q-theory of investment* *Part II: Neoclassical Growth* *4. Growth facts. Solow model* *5. Ramsey-Cass-Koopmans model* *6. Optimal taxation [Wickens (2008)* *Part III: Business Cycles:* *7. Introduction to business cycles modeling* *8. Real business cycles model* *9. Extensions to RBC model* *10. Unemployment in RBC model* *11. Monetary models* *12. New Keynesian model* *13. Monetary policy design* *14. Financial frictions*												

Sposoby weryfikacji efektów uczenia się	egzamin pisemny

Master Thesis Seminar			30									30	3	K_W01, K_W02, K_W04,K_W05, K_W06, K_W07, K_U01, K_U03, K_U04, K_U05, K_U06, K_S01, K_S02, K_S03	ekonomia i finanse, matematyka, informatyka

Treści programowe	*The main objective of this seminar is to assist students with their theses' preparation. They are expected to prepare research projects with heavy empirical contents on macroeconomic or financial issues of their interest. The second part of the course is devoted to designing own empirical study, data collection and choosing the appropriate methodology.*

Sposoby weryfikacji efektów uczenia się	egzamin ustny/projekt

Łączna liczba punktów ECTS (w semestrze): 30
Łączna liczba godzin zajęć (w semestrze): 240
Łączna liczba godzin zajęć określona w programie studiów dla danego kierunku, poziomu i profilu (dla całego cyklu): 1000

Rok studiów: drugi

Semestr: **czwarty**

Nazwa przedmiotu	Forma zajęć – liczba godzin								Razem: liczba godzin zajęć	Razem: punkty ECTS	Symbole efektów uczenia się dla programu studiów	Dyscyplina / dyscypliny, do których odnosi się przedmiot
	Wykład	Konwersatorium	Seminarium	Ćwiczenia	Laboratorium	Warsztaty	Projekt	Inne				
Risk Analysis and Modelling II		30							30	4	K_W01, K_W02, K_W06, K_W07, K_U01, K_U03, K_U04, K_U05, K_U06, K_S01, K_S03	ekonomia i finanse, informatyka
Treści programowe	*The purpose of the seminar is the presentation of the modern financial risk evaluation. On this part of the course we calculate: value at risk calculation, currency limits, portfolio analysis in currency basket modification, capital requirement for the currency and credit risk; different forms of credit scoring and credit rating, credit default models, models of credit risk based on options pricing, migrations matrices and its further augmentation. The seminar takes place in a computer lab. The final exam consists of "true/false" questions with explanation.* *The seminar focuses on modern risk evaluation and management. We consider: value at risk, currency risk, and credit risk. Additionally the normative aspect of supervisory regulation in financial institutions is briefly mentioned. Especially we concentrate on calculation of:* *1. value at risk, expected shortfalls, portfolio analysis in currency basket modification. On computers we execute: calculation of value at risk with three basic methods, reduction of currencies in basket portfolio, modelling correlations and volatilities in Monte Carlo simulation, Cholesky decomposition, introduction to use of copulas, calculation of VaR with GARCH models.* *2. different forms of credit scoring (Altman's model, logit model, methods of classification, neural network, genetic algorithms). The most important models quantifying contemporary risk exposure, such as: credit default models (both in default mode - DM, and in marking to market mode - MTM), models of credit risk based on options pricing (e.g. KMV Model), credit migration's matrices (Credit metrics, Credit Portfolio) and its further augmentations. On computers we execute: scoring rating of retail customers sample, migration matrix calculation, estimation of the default probability in KMV model and distance to default, Credit Risk Plus mass-of-probability-change over time.* *Students have knowledge about types of financial risk, basic methods of measuring and managing the risk in financial institutions and enterprises. Students can evaluate basic types of risk with simple models created in spreadsheets. Students are able to recognize the impact of regulatory requirements on risk assessment. Students can apply different risk measures to the purposes of risk analysis, for example to calculate the value at risk or to increase the net income of the investment without rapid growth of risk. Students are aware of how risk management can reduce the regulatory capital requirements and ensure the compliance with risk standards. The student implements the credit requirements on time.*											

Sposoby weryfikacji efektów uczenia się	egzamin pisemny											
C++ in Quantitative Finance II		30								30	4	K_W01, K_W06, K_W07, K_U01, K_U05, K_U06	informatyka

Treści programowe	The course is a continuation of its 1st part. It provides more advanced elements of object-oriented programming. Practical examples of using Monte-Carlo simulations in valuations of exotic derivatives are presented. Also students will learn how to integrate C++ with MS Excel and R language. 1. Advanced OPP: Static Attributes and Methods. Virtual Methods. Abstract Methods. Operator Overloading. The << Operator. Multiple Inheritance. Virtual Inheritance 2. Inheritance: Class inheritance: basic inheritance, inheriting constructors and destructors, access control, overriding and overloading methods. Virtual functions. Passing of arguments. Using overloading operators. Private and public data. Defining constructors and destructors. 3. Error Handling and Debugging: Debugging Techniques. Returning Error Codes. Using assert(). Catching Exceptions 4. Dynamic Memory Management: Static and Dynamic Memory. Allocating Objects. Allocating Arrays of Dynamic Size. Returning Memory from a Function or Method. The Copy Constructor and the Assignment Operator. Static Object Type Casts. Performing Dynamic Object Type Casts. Avoiding Memory Leaks 5. More advanced methods of OPP: Virtual constructors and the bridge pattern. Separating interface and implementation. More complicated design patterns. Use of templates. Advanced OOP: static/virtual/abstract methods, multiple and virtual inheritance. 6. Random number class: Developing random number class with reusable interface and adequate random number generator. Implementation of antithetic sampling. 7. Pricing of exotic derivatives: Monte-Carlo for path dependent exotic derivatives. Template pattern. Pricing of Asian options. 8. Interfacing C++ and Excel: The object model in Excel. Accessing Excel objects from C++. Getting data into C++ from Excel. Display vector and matrix data in Excel. 9. Integration of C++ with R: Rcpp package, Inline package, core data types, plotting from C++ via R After the course students will be able to create more advanced C++ applications, using the idea of object inheritance. They will be also able to integrate their efficient C++ option pricers with MS Excel and R language environment.

Sposoby weryfikacji efektów uczenia się	egzamin praktyczny, projekt											
Empirics of Financial Markets		30								30	4	K_W01, K_W02, K_W05, K_W07, K_U03, K_05, K_S01	ekonomia i finanse

Treści programowe	Students should get a basic knowledge and practical skills of formal econometric analysis of major financial markets (equity, fx, fixed income). The course presents basic theoretical framework and samples of empirical work modelling prices and/or returns from major financial instruments. Both active attendance and positive assessment of individual students' assignments are required to pass the course. 1.Introduction - basic concepts in quantitative finance

				2. Efficiency of financial markets: the concept and its empirical testing 3. Are returns forecastable? Random walk as a model and its empirical verification. 4. Model definition of normal and excessive returns: CAPM and its extensions, APT. Empirical examples. 5. Volatility modelling: ARCH and GARCH models 6. Term structure of the interest rates (yield curve) 7. FX market: exchange rate theories and their tests. 8. Students' presentation of their assignments. *Students are able to model and to forecast prices and returns of basic financial assets (equity, debt instruments, fx) in a comprehensive manner, including designing the research, building and estimating the proper model, interpreting its results and reporting the outcome of the whole exercise.*						
Sposoby weryfikacji efektów uczenia się	projekt i prezentacja											
Automatic Transactional Systems				30					30	4	K_W01, K_W06, K_W07, K_U01, K_U02, K_U03, K_U04, K_U06, K_S03	ekonomia i finanse, informatyka
Treści programowe	*The general aim of this course is to familiarize students with development of trading strategies using Python language. Students are expected to become familiar with the mechanics of quantitative trading in the financial markets, characteristics of financial data and measures of trading strategies evaluation. The specific aim of this course is to give a practical background for the process of preparing advanced quantitative trading strategies.* *Course content:* *1. Short introduction to Python and its syntax. Preparation of the PyCharm environment/ Installation of Anaconda Python distribution.* *2. Advanced topics in Python: Object Oriented Programming (OOP) in Python, files operation, regular expressions, lambda function, time series visualization with matplotlib, use of automatic http requests.* *3. Linear algebra with NumPy, Data handling and wrangling with Pandas* *4. Solving mathematical problems in Python (root-finding algorithm, factorial calculation). Use of recursive functions.* *5. Python for finance. The role of normal distribution (and its alternatives) in financial markets (normality tests on examples). Empirical properties of asset returns (stylized facts).* *6. Option pricing models.* *7. Back testing Minimum Variance portfolios, Maximum Sharpe Portfolio. Measures of trading strategy performance.* *8. Trading systems based on Technical Analysis methods.* *9. Strategies based on Machine Learning techniques.* *10. Statistical Arbitrage strategies. Pair Trading.* *Knowledge: Students know how to use Python and its packages to prepare and analyze data to solve financial problems and build their own investment strategies. Skills: Students are able to prepare a Python programming environment and install required packages. Students are able to implement in Python their own investment strategies. Social Competence: Participant understands that the expert use of Python requires continuous practice and improvement of his own skills. This course gives him the skills to seek knowledge, and update it to constantly changing Python libraries.*											

Sposoby weryfikacji efektów uczenia się	egzamin pisemny, projekt, aktywność											
Master Thesis Seminar			30						30	3	K_W01, K_W02, K_W04,K_W05, K_W06, K_W07, K_U01, K_U03, K_U04, K_U05, K_U06, K_S01, K_S02, K_S03	ekonomia i finanse, matematyka, informatyka
Treści programowe	*The main objective of this seminar is to assist students with their theses' preparation. They are expected to prepare research projects with heavy empirical contents on macroeconomic or financial issues of their interest. The second part of the course is devoted to designing own empirical study, data collection and choosing the appropriate methodology.*											
Sposoby weryfikacji efektów uczenia się	złożenie pracy magisterskiej											
Preparation of the thesis for the diploma examination									0	8	K_W01, K_W02, K_W04,K_W05, K_W06, K_W07, K_U01, K_U03, K_U04, K_U05, K_U06, K_S01, K_S02, K_S03	ekonomia i finanse, matematyka, informatyka
Treści programowe	*Preparation of the thesis for the diploma examination*											
Sposoby weryfikacji efektów uczenia się	obrona pracy magisterskiej											
Elective course (OGUN)	30								30	3	K_U03, K_U05	
Treści programowe	*Elective course (OGUN) (humanistic profile)*											
Sposoby weryfikacji efektów uczenia się	różne formy: egzamin ustny, egzamin pisemny, test, esej, projekt											

Łączna liczba punktów ECTS (w semestrze): 30

Łączna liczba godzin zajęć (w semestrze): 180
Łączna liczba godzin zajęć określona w programie studiów dla danego kierunku, poziomu i profilu (dla całego cyklu): 1000

Zajęcia lub grupy zajęć w ramach specjalności przypisane do danego etapu studiów

(tabela dotyczy kierunku studiów, na którym prowadzona jest specjalność; tabelę należy przygotować dla każdego semestru studiów i dla każdej specjalności odrębnie)

<p style="text-align:center;color:red;">Na kierunku Quantitative Finance nie są prowadzone specjalności.</p>

Procentowy udział liczby punktów ECTS w łącznej liczbie punktów ECTS dla każdej z dyscyplin, do których przyporządkowano kierunek studiów.

Dziedzina nauki	Dyscyplina naukowa	Procentowy udział liczby punktów ECTS w łącznej liczbie punktów ECTS dla każdej z dyscyplin
Dziedzina nauk społecznych	Ekonomia i finanse	52%
Dziedzina nauk ścisłych i przyrodniczych	Matematyka	15%
Dziedzina nauk ścisłych i przyrodniczych	Informatyka	33%

CZĘŚĆ III

<table>
<tr><td colspan="2" align="center">Przedmioty do wyboru

(tabelę należy wypełnić, jeśli proponowane zmiany w programie studiów
spowodują zmiany w łącznej liczbie punktów ECTS obejmującej zajęcia do wyboru)

Proponowane zmiany nie powodują zmiany w łącznej liczbie punktów ECTS obejmującej zajęcia do wyboru.</td></tr>
<tr><td align="center">Przedmiot (zajęcia lub grupa zajęć)</td><td align="center">Liczba punktów ECTS</td></tr>
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<tr><td align="center">Łączna liczba punktów ECTS obejmująca zajęcia do wyboru:</td><td></td></tr>
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<tr><td colspan="2" align="center">Przedmioty związane z prowadzoną w uczelni działalnością naukową w dyscyplinie lub dyscyplinach
– studia o profilu ogólnoakademickim

(tabelę należy wypełnić, jeśli proponowane zmiany w programie studiów spowodują zmiany w łącznej liczbie punktów ECTS obejmującej przedmioty
związane z prowadzoną w uczelni działalnością naukową w dyscyplinie / dyscyplinach)

Proponowane zmiany nie powodują zmiany w łącznej liczbie punktów ECTS obejmującej przedmioty związane z prowadzoną na uczelni działalnością naukową w dyscyplinie/dyscyplinach.</td></tr>
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Łączna liczba punktów ECTS obejmująca przedmioty związane z prowadzoną w uczelni działalnością naukową w dyscyplinie/dyscyplinach:	

Przedmioty kształtujące umiejętności praktyczne – studia o profilu praktycznym (tabelę należy wypełnić, jeśli proponowane zmiany w programie studiów spowodują zmiany w łącznej liczbie punktów ECTS obejmującej przedmioty kształtujące umiejętności praktyczne) **Proponowane zmiany nie powodują zmiany w łącznej liczbie punktów ECTS obejmującej przedmioty kształtujące umiejętności praktyczne.**	
Przedmiot (zajęcia lub grupa zajęć)	**Liczba punktów ECTS**
Łączna liczba punktów ECTS obejmująca przedmioty kształtujące umiejętności praktyczne:	

…………………………………
(data i podpis Wnioskodawcy)