AUTONOMOUS ORGANIZATION OF EDUCATION
NAZARBAYEV UNIVERSITY

MASTER OF SCIENCE IN PHYSICS

Approved by the resolution of the Academic Council of
the autonomous organization of education “Nazarbayev University”
Minutes # __ of _____ 2015

Astana
2015

1. Program Information

1. Program Name:	MSc in Physics
2. Program Type:	**EMBA** ☐ **MBA** ☐ Tick as appropriate **MA** ☐ **MSc** X **MEd** ☐ **MPP** ☐ **PhD** ☐ **Other** ☐ Write degree name
3. Level of Qualification:	Bologna Cycle: 2nd cycle Master's degrees – 2nd Cycle Doctoral degrees – 3rd Cycle Total ECTS Credits: 120 Master's degrees: 90-120 ECTS Doctoral degrees: no ECTS Level in the European Qualifications Framework **(EQF):** Level 7 Master's Degrees: Level 7 Doctoral degrees: Level 8
4. Intended Implementation Date:	August 2015
5. Administrative Unit:	School of Science and Technology
6. Contact Person:	Vladimir Brusic, Dean, School of Science and Technology Vassilios Tourassis, Vice Dean of Academic Affairs SST Professor Georgios Tsironis (Physics Department, SST) Professor Vassilios Kovanis (Physics Department, SST) (Program leader) Assistant Professor Alexander Tikhonov (Physics Department, SST) Assistant Professor Zhandos Utegulov (Physics Department, SST) Assistant Professor Dmitriy Beznosko (Physics Department, SST)

7. Program Overview:	The MSc Program in Physics and quantum technologies (henceforth "MSc program") is designed to train a small number of graduate students as competent physicists that would continue either with their Ph.D. studies for future academic appointments or turn to professional careers in industry within R&D companies, or public sector within think tanks, nonprofits, and government organizations. The students will gain deep and systematic knowledge of the laws of physics, methods of practice and develop the ability to identify and use these laws in the context of real-life phenomena and engineering applications and 21rst century technology ecosystem, including technology innovation and entrepreneurship. The graduates are expected to acquire advanced analytical, mathematical, computational or experimental skills as relevant to the subjects of their Master projects. They are further expected to become exposed to the international research environment and to acquire strong scientific communication skills. The program is designed to take advantage of the faculty expertise and the laboratory resources of the School of Science and Technology, Nazarbayev University Research and Innovation System and School of Engineering. The MSc program is designed to be in Compliance with the Graduate Programs Framework of Nazarbayev University (Annex 1). Graduates of the program will have advanced research skills that will enable them to explore relevant and important questions in communications and make significant ongoing contributions in technologically diverse and dynamic economic environments, both in Kazakhstan and abroad.

2. Program Justification

8. Market Need	Physics is the most fundamental of natural sciences. Energy generation and transmission, computer hardware, synthesis of high-technology materials, advanced medical technologies - all rest on physical discoveries and require deep physics expertise for further progress. Nuclear energy, transistors, laser, superconductors, magnetic resonance imaging, graphene and topological insulators were all discovered by physicists. Physics knowledge is also an important part of today's civilization. The international standing of countries, their ability to attract the best talents is judged, among others, by their level of physics research enterprise. At present, Kazakhstan experiences an acute shortage of properly prepared physicists as can be easily seen during recruitment at NU. Universities across Kazakhstan, including NU, are not featured in any of the higher education comparative lists and in what regards physics they need a new generation of physicists to become internationally competitive. That will be accomplished by generating and publishing research in high impact journals, actively participating in professional

	societies such as American Physical Society, Optical Society of America, SPIE, IEEE and others, garner invitations to collaborate and actively participate in proposal source selections within the European Union Research system. President Nazarbayev in his *Strategy "Kazakhstan 2050"* declared, "*the most important component of our development is the creation of innovative scientifically intensive industries*." These ambitious plans require further significant increase of the number and intellectual potency of physicists in the country. Energy, new material technologies, biology and medical technologies – all require active participation and agenda seating technology paths historically delivered from physicists. The strategic research plans of Nazarbayev University alone cannot be satisfied by the existing supply of Kazakh citizens educated in physics both in Kazakhstan and abroad. At present, the SST Physics Department and NURIS experience very serious challenges staffing their ongoing projects with qualified junior level physicists within Kazakhstan. The MSc program at Nazarbayev University is designed to serve as a stepping-stone towards a Physics Ph.D. study for some of the students, while preparing others to a wide range of intellectually challenging activities in industry and public service that do not require physics Ph.D. The Physics MSc provides versatile education with potentially strong market value. Experience from the US and the European Union over the last two decades demonstrates that when physics education focusing on "problem solving" is coupled to education at the Masters level leads to professionals that may function and lead in areas of the private sector relating to science, technology, education, the financial sector, etc. Our MSc program, in addition to providing high level physics education it also offers courses and practical experience that will be useful and competitive in the "real world". President Nazarbayev's Kazakhstan 2050 Strategy specifically addresses educational vision and focuses on developing a science and technology education system with modern teaching methods, capable of innovative research, technology transfer and entrepreneurship. The Strategy explicitly mentions the need to focus on transformative technologies, which are the pillars of the "Third Industrial Revolution" and dictates "Digital and nanotechnology, robotics, regenerative medicine and many other kinds of scientific progress will become an ordinary part of life and transform not only the environment, but also human beings." The mentioned thrust areas are tightly aligned with the proposed MSc program as well as with the NU Strategy 2013-2020, which explicitly mentions robotics, computational sciences and energy among the national priorities of Kazakhstan. Furthermore, the recent Ministry of Education and Science tender for research grant funding for 2015-2017 details Kazakhstan's priorities in this area. The justification for the proposed MSc Program is also in tune with current international trends and priority areas for Central Asia. The OECD Eurasia Competitiveness Program was launched in 2008 to support Eurasian economies in developing more vibrant and competitive

	markets – both at the national and regional level – in order to generate sustainable growth. The Program focuses on a comprehensive approach that includes regional dialogue, peer review, definition of reform priorities and assistance in implementation and design of policies. This Central Asia Initiative, covering Afghanistan, Kazakhstan, Kyrgyz Republic, Mongolia, Tajikistan, Turkmenistan, and Uzbekistan, aims to help create a sound business climate for investment, enhance productivity, support entrepreneurship, develop the private sector, and build knowledge-based economies to make the region more competitive and attractive to foreign investment. During the recent OECD EURASIA WEEK "Enhancing Competitiveness in Eurasia" (24-27 November 2014) a Eurasia Competitiveness Roundtable was devoted to a peer review of Kazakhstan on competitiveness reforms. The roundtable was attended by a high-level ministerial representation of Kazakhstan that included NU President Shigeo Katsu and SST Vice Dean Vassilios Tourassis. During the deliberations on the Economic Diversification and Industrialization and on the Economic Integration and Linkages with Global Value Chains in the Eurasia Region the area of [Robotics] emerged as a key technological area for competitiveness in Kazakhstan.
9. Student Demand	The enrollment into the Physics MSc program is expected to be at the level of 15 students per year. Potential candidates are graduates of NU Physics Bachelor program as well as several current NURIS research staff members already possessing Bachelor degrees in physics-related disciplines. The best graduates of physics Bachelor programs from other universities in Kazakhstan may also qualify. The demand for Physics MSc training will rise in 2018 once the graduation rate of the NU Physics Bachelor program would increase to the planned level of about 30 students per year. Continuing from Bachelor to Master is likely to be the first preference of Physics students. This is because the Physics Bachelor degree alone is unlikely to be sufficient for successful career in natural sciences or engineering. In this regard, the existence of a MSc program will enable talented students to study in Kazakhstan. At the same time, an effort will be made to recruit international MSc candidates into NU Physics program, subject to the development of the appropriate policy by Nazarbayev University.
10. Existing Degree Programs in Kazakhstan	Currently in Kazakhstan there are several MSc programs in Physics. Specifically: (a) The Kazakh National University in Almaty offers MSc degrees in physics, nuclear physics, physics and astronomy, standardization and certification, technical physics, material science and engineering of new materials, metrology, radio engineering, electronics and telecommunications, thermal engineering,

nanomaterial and nanotechnology.

(b) The Kazakh National Technical University in Almaty offers MSc degree in technical physics and physics.

(c) The East Kazakhstan State Technical University in Semey offers MSc degrees in Applied Physics such as physics of metals and alloys, development of new material and nanotechnologies jointly with Otto-von-Guericke University (Magdeburg, Germany).

(d) Karaganda State University offers MS degrees in physics, technical physics and thermal energy engineering.

What is the competitive advantage of our newly proposed Masters program compared to the numerous existing ones? The following items are relevant:

(a) The NU Physics Masters program will be exclusively in English, linking thus directly its graduates to the broader scientific community that uses English as the basic language. This aspect will make it easier for our students and graduates to participate and interact on the global scientific and financial communities.

(b) The NU Physics Department consists of highly trained academics. The Department is becoming competitive on the international scale and this gives a competitive advantage to its graduates.

(c) The Department has attracted already significant research funding demonstrating its scientific status.

(d) The existing and planned research laboratories are state of the art and thus the education provided to the potential students is modern and of the highest quality.

(e) The international status of the department will enable the placement of its graduates in very good Ph.D. programs across the globe should they decide to seek a more advanced degree elsewhere.

(f) The MSc program, in addition to the undergraduate program will also offer entrepreneurship, market oriented leadership and practical scientific innovation. This aspect of the program is unique not only within Kazakhstan but also in comparison with many European Physics Masters programs.

11. Student Enrolment Projections

	2014-2015	2015-2016	2016-2017	2017-2018	2018-2019
Students Admitted	15	15	15	20	20
Continuing Students (Year 2)	-	28	28	33	33
MSc Students Graduating	-	13	13	13	18

The above projections are tentative. The SST Physics Department will be prepared to handle a larger number of MSc students.

12. Business Case	At present, the MSc program will be funded primarily by the Kazakhstan government. Students admitted to the program will receive a stipend for 2 years and may be provided with limited support as research and teaching assistants in the School. Government funding is also to be used to fund brief visits of the MSc candidates to the leading international centers of physics research. The approved budget lines within SST have sufficient slots available to execute the program.
13. Degree Requirements	Satisfactory completion of the MSc program requires 120 ECTS credits and that the student progress through a number of distinct stages, each of which is characterized by a key evaluation point (see Annex 2). The necessary stages are: 1) Satisfactory application to the program. 2) Completing all required coursework in the program. 3) Completing a MSc research project. 4) Writing MSc thesis. 5) Reports on the MSc thesis by the primary supervisor and another independent expert 6) Public presentation of the MSc project. An MSc thesis aspiring to high grades should produce technical results potentially publishable in peer-reviewed journals.
14. Faculty Requirement	The current team of faculty available within the SST Physics Department has the proper research experience to supervise MSc candidates and deliver Master-level courses. At least three more experienced faculty members will be hired before the Fall semester of 2015. External experts will be invited to give lectures within the program on special topics relevant to ongoing MSc projects and collaborate within the students and their advisors. The majority of faculty listed below (13 of 16) have prior experience with graduate-level teaching and supervision of graduate project or thesis work. The faculty for this program currently includes: **1) Dr. Vassilios Kovanis,** Professor (SST, Acting Chair of Physics Dept) PhD from the University of New Mexico, Albuquerque, USA **Expertise :** Photonics, nonlinear dynamics, Metamaterials, optical signal prossesing **2) Dr. Georgios Tsironis,** Professor (SST, Physics Dept) PhD from University of Rochester, Rochester, USA **Expertise :** Theory / Condensed matter physics, statistical physics, nonlinear dynamics, Metamaterials. Has supervised 12 PhD theses and 5 MSc theses. **3) Dr. Vassilios D. Tourassis,** Professor

(SST, Robotics and Mechatronics Dept)
PhD from Carnegie Mellon University, USA
Expertise : Dynamic modeling of robotic systems, intelligent manufacturing systems and artificial intelligence.

4) Dr. Ernazar Abdikamalov, Assistant Professor
(SST, Physics Dept)
PhD from SISSA, International School of Advanced Studies, Trieste, Italy
Expertise : Theory / Astrophysics

5) Dr. Dmitriy Beznosko, Assistant Professor
(SST, Physics Dept)
PhD from State University of New York, Stony Brooks, USA
Expertise : Experiment / High-Energy and Elementary particle physics

6) Dr. Sergiy Bubin, Assistant Professor
(SST, Physics Dept)
PhD from University of Arizona, Tucson, USA
Expertise : Theory / Chemical physics, atomic physics

7) **Dr. Mithun Bhowmick**, Assistant Professor
(SST, Physics Dept)
PhD from Virginia Polytechnic Institute and State University, Blacksburg, USA
Expertise : Experiment / Condensed matter physics

8) Dr. Michael Good, Assistant Professor
(SST, Physics Dept)
PhD from University of North Carolina, Chapel Hill, USA
Expertise : Theory / Quantum field theory, cosmology

9) **Dr. Daniele Malafarina**, Assistant Professor
(SST, Physics Dept)
PhD from Polytechnic University, Milan, Italy
Expertise : Theory / General relativity

10) **Dr. Aikaterini Mandilara**, Assistant Professor
(SST, Physics Dept)
PhD from Washington University, St. Louis, USA
Expertise : Theory / Quantum Information Science

11) **Dr. Alexander Tikhonov**, Assistant Professor
(SST, Physics Dept / NURIS)
PhD from University of Pittsburg, Pittsburg, USA
Expertise : Theory – Experiment / Chemical physics, Photonics

12) **Dr. Zhandos Utegulov**, Assistant Professor
(SST, Physics Dept)
PhD from Oklahoma State University, Oklahoma, USA
Expertise : Experiment / Material science, Optics.

	13) **Dr. Jean-Jacques Zondy,** Associate Professor (April 2015) (SST, Physics Dept) PhD from University of Paris, France **Expertise :** Experiment / Nonlinear Optics and Photonics 14) **Dr. Konstantinos Valagiannopoulos**, Assistant Professor (August 2015) PhD from National Technical University of Athens, Greece **Expertise :** Experiment / Computational Photonics and Electromagnetics **15) Dr. Anton Desyatnikov,** Associate Professor (August 2015) PhD from Moskow State University, Russia **Expertise :** Theory / Nonlinear Dynamics, Photonics 16) **Dr. Jenifer Lewis**, Assistant Professor (SST, Communication Program) PhD from University of Kansas, USA **Expertise** : Research Methods, Pedagogy, Leadership Two recent publications for each of the above faculty members are provided in Annex 3.
15. Student Recruitment	Student recruitment will be conducted by the Graduate Admissions Office, working closely and collaboratively with the School of Science and Technology. The Physics Department will assign a faculty member to coordinate MSc program and MSc recruitment. We will prepare a leaflet/poster and distribute it in other departments in Kazakhstan where we will explain the basic advantages of our program and give all details. This information will be included in the Web page of the Department and also to social media related to Kazakhstan. At the same time we will inform NU graduates both from SST and the School of Engineering as well as junior NURIS researchers about our program through email, leaflet/poster distribution and direct contact.
16. Student Financial Assistance	All students admitted to the MSc program are eligible for tuition and stipend funding by the government. In addition self-funded students may be admitted, in accordance with NU student enrollment policies. Possibilities will be explored to fund research assistantships of MSc candidates from grant funding of individual research projects at the SST Physics Department and NURIS.
17. Admission Process, Procedures and Standards	Applicants to the program must have an undergraduate degree in a discipline relative to the program. The 2-year, 120 ECTS program allows for the admission of graduate students with a basic degree that may differ from that of the program at hand.

	Admission will be handled on a case-by-case basis by evaluating the student's undergraduate curriculum, English proficiency, motivation and references. The initial cohort will consist of 15 students and will progressively increase as the resources of the School allow. Admissions decisions will be based on consideration of the following factors: 1) completion of the on-line application form by the applicant; 2) evidence of completion of an undergraduate degree program in a relevant field or discipline with a minimum CGPA of at least 2.75 (on a 4.0 scale); 3) evidence of sufficient English language skills to be able to function effectively in a graduate level, English-medium environment as demonstrated by a minimum IELTS test score of 6.5 (with subscore requirements no less than 6.0), or the equivalent TOEFL score as posted on the ETS website; 4) at the discretion of the Admissions Committee, applicants can be exempted from submitting the language proficiency test report if: one of their earlier academic degrees was earned in a country with English as the language of official communication, academic instruction and daily life; or an undergraduate degree was earned in a program which was officially taught in English; or the applicant is a graduate of Nazarbayev University. 5) a statement of purpose for graduate studies; and 6) two letters of reference. All of these factors will be taken into account in the final recommendation of the Admissions Committee with respect to admission to the MSc program. When necessary, selected applicants will be invited for a personal interview with the Admissions Committee, either on campus or via Skype. The compliance of the admissions process with the corresponding subsection of the "Graduate Programs Framework" approved by the Academic Council is detailed in Annex 1.

3. Program Specification

18. Program Aims	The aims of this program are two: 1) prepare competent physicists capable of progressing towards Ph.D. study and taking part in science and technology projects; 2) prepare individuals for a broader range of careers in high-tech industry, business and public domain who will be able to capitalize on their physics education. 3) empower academics, researchers and tertiary sector educators in

	physics to be the drivers of industrial and educational reform in Kazakhstan;	
19. Nazarbayev University Graduate Attributes	Graduate Attribute	How Addressed
	1. Possess an in-depth and sophisticated understanding of their domain of study.	Presentations by Guests and Faculty Discussions Student Presentations Master project Writing Master thesis Presentation of Master thesis
	2. Be intellectually agile, curious, creative and open-minded.	Presentations by Guests and Faculty Discussions Student Presentations Master project Writing Master thesis Presentation of Master thesis
	3. Be thoughtful decision-makers who know how to involve others.	Master project
	4. Be entrepreneurial, self-propelling and able to create new opportunities.	Attending interdisciplinary presentations by Guests and Faculty. Discussions Student Presentations Master project
	5. Be fluent and nuanced communicators across languages and cultures.	Presentations by Guests and Faculty Discussions Student Presentations Master project Writing Master thesis Presentation of Master thesis

	6. Be cultured and tolerant citizens of the world.	Presentations by Guests and Faculty Discussions
	7. Demonstrate high personal integrity.	Presentations by Guests and Faculty. Discussions Master project Writing Master thesis Presentation of Master thesis
	8. Be prepared to take a leading role in the development of their country.	Interviews during the admission process Presentations by Guests and Faculty. Discussions Student Presentations Master project
20. Program Learning Outcomes	By the end of the MSc program successful students will be able to : 1) present research to specialized as well as broader audiences; 2) execute research projects in their area of expertise, author possible research publications, present posters and/or oral presentations in conferences prepare, coherent reports of research findings; 3) demonstrate strong understanding of the fundamentals of experimental and theoretical physics, complete successfully courses as well as seminar courses; 4) search, discover and master contemporary research literature in their field of expertise, include relevant literature in the Masters project; 5) apply research methodology in successful execution of experiments in a research laboratory or implement analytical and/or numerical solutions of a theoretical question related to an unsolved physics research problems; 6) demonstrate familiarity with the phases and stages of the research process through successful presentation of a research seminar and/or proposal writing; 7) evaluate the relation between physical concepts and modern-day technologies, communicate competently with expert audiences; 8) demonstrate the ability to explain scientific concepts and research findings, using various modalities of communication, with particular emphasis on tertiary education instruction.	

Tabulated Program Learning Outcomes against NU Graduate Attributes:

	Program Learning Outcomes								
NU Graduate Attributes		1	2	3	4	5	6	7	8
	1	X	X	X	X			X	
	2	X	X		X			X	
	3		X			X	X		X
	4	X	X			X	X	X	
	5			X	X			X	X
	6			X	X	X			X
	7		X			X	X		
	8	X	X						X

21. Curriculum

The curriculum of the program is summarized in the table below:

Year One - Semester 1	**ECTS credits**	**Year One - Semester 2**	**ECTS credits**
PHYS 505 Classical Mechanics	6	PHYS 510 Quantum Mechanics	6
PHYS 515 Classical Electrodynamics	6	PHYS 520 Statistical Physics	6
Physics Elective I	6	SST 504 Innovation and Entrepreneurship	6
SST 501 Teaching and Learning	6	SST 502 Teaching Practicum	6
PHYS 591 Research Methods	6	PHYS 592 Research Seminar	6
Year Two – Semester 1	**ECTS credits**	**Year Two – Semester 2**	**ECTS credits**
Physics Elective II	6	PHYS 692 Thesis	30
Physics Elective III	6		
Physics Elective IV	6		
SST 503 Laboratory Practicum	6		
PHYS 691 Thesis Proposal	6		

The Core Curriculum for the MSc program in physics is:

Placement test: Initial test after admission to program that evaluates the students and advises them on the course materials to follow. Tests basic physics knowledge (Classical Mechanics, Classical Electrodynamics, Quantum Mechanics, Statistical Physics).– see Annex 3.

24 ECTS credits of MSc-level basic physics courses: Classical Mechanics, Classical Electrodynamics, Quantum Mechanics, Statistical Physics. (These courses can be fully or partially substituted by research and/or specialized

	elective courses) ***24 ECTS credits for electives*** taken from physics or other departments of SST. 6 ECTS credits for Innovation and Entrepreneurship ***36 ECTS credits for research courses,*** i.e. seminar, research project and thesis proposal development 30 ECTS credits for the Masters thesis. List of MSc Level Physics Courses PHYS 433 Introduction to biophysics PHYS 443 Introduction to chemical physics PHYS 453 Introduction to particle physics PHYS 463 Topics in astronomy and astrophysics PHYS 474 Lasers and photonics PHYS 475 Introduction to Quantum Technologies PHYS 476 Advanced Quantum Technologies PHYS 477 Topics in material science PHYS 505 Classical mechanics – graduate level-Core course PHYS 515 Classical electrodynamics – graduate level-Core course PHYS 510 Quantum mechanics – graduate level-Core course PHYS 520 Statistical physics – graduate level-Core course PHYS 525 Nonlinear physics PHYS 530 Solid-state physics PHYS 535 General relativity PHYS 540 Quantum Field Theory PHYS 545 Advanced Instrumentation Methods PHYS 591 Research Methods PHYS 592 Research Seminar PHYS 691 Thesis Proposal PHYS 692 Thesis The description of the above courses in given in Annex 5. SST 501 Teaching and Learning SST 502 Teaching Practicum SST 503 Laboratory Practicum The SST common courses are listed in Annex 6. Not all physics elective courses will be offered every year. The elective courses may be taken also from other SST departments. The teaching and learning courses are distinctively pedagogical by design and thus not assessed based on final exam. The requisite senior faculty is currently available and present at SST to mentor the students. The structure and content of these courses will be developed in consultation with the

<table>
<tr><td></td><td>Graduate School of Education, which has agreed to share human resources on an ad hoc basis. English academic writing support will be sought from the English Language Center as called for.</td></tr>
<tr><td>22. Teaching and Learning Methods</td><td>
1) Independent role in research projects
2) Regular meetings with the MSc supervisor and other research group members
3) Research seminars with presentations by local and visiting researchers and by students, including the MSc candidate
4) Graduate courses
5) Self-study, literature reviews
6) Interaction with a broader group of peers
7) Interaction with scientific visitors
8) Laboratory and teaching practicums

The teaching methods and strategies will map to the learning outcomes of the MS program as follows:

<table>
<tr><td>Program learning outcomes</td><td>Teaching methods and strategies</td></tr>
<tr><td>Competence in the subject of their Master project</td><td>In depth teaching of subject, class discussions, student presentations, possible participation in conferences, seminar presentations, research projects, literature search</td></tr>
<tr><td>Capacity to execute a research project in the area of their expertise</td><td>Successful design and execution of experiments, modelling a relevant physical phenomenon in the computer, analytical study of a model related to the research topic.</td></tr>
<tr><td>Develop a strong understanding of the fundamentals of experimental and theoretical physics</td><td>Course projects, class discussions, participation in Departmental seminars and colloquium, laboratory presence, computer code development.</td></tr>
<tr><td>Familiarity with the contemporary research literature in their field of expertise</td><td>Literature search, in class research paper presentation, arXiv database search.</td></tr>
<tr><td>Initial training in research methodology</td><td>Demonstration in class and seminar course how to model a physical system, approximation schemes, solution procedures, error analysis, conjecture and refutation processes.</td></tr>
<tr><td>Familiarity with the phases and stages of the research process</td><td>Seminars on research methods, presentation of the development of specific disciplines such as Brownian motion, electromagnetism, relativity, etc, project completion.
Visits to other leading national and international laboratories</td></tr>
</table>
</td></tr>
</table>

	Understanding of the relation between physical concepts and modern-day technologies	In class description of devices and physics they are based on, project assignment and presentations.
	Ability to communicate their research findings both orally and in written form	Development of communication and instruction skills through presentations and written skills through thesis writing, laboratory and teaching practicums.

23. Assessment	Program learning outcome	Assessment point
	Competence in the subject of their Master project	Seminar presentations by the MSc candidate Evaluation reports on the MSc thesis Presentation of the MSc thesis
	Capacity to execute a research project in the area of their expertise	Supervisor's feedback in the course of the Master project Evaluation reports on the MSc thesis
	Develop a strong understanding of the fundamentals of experimental and theoretical physics	Interview during the admission stage Grades for the graduate-level physics courses Evaluation reports on the MSc thesis Presentation of the MSc thesis
	Familiarity with the contemporary research literature in their field of expertise	Seminar presentations by the MSc candidate Supervisor's feedback in the course of the Master project Evaluation reports on the MSc thesis Presentation of the MSc thesis
	Initial training in research methodology	Supervisor's feedback in the course of thesis research

	Presentation of the MSc thesis
Familiarity with the phases and stages of the research process	Supervisor's feedback in the course of thesis research Presentation of the MSc thesis
Understanding of the relation between physical concepts and modern-day technologies	Elective natural sciences/technology course Supervisor's feedback in the course of thesis research Presentation of the MSc thesis
Ability to communicate their research findings both orally and in written form	Teaching and laboratory practicums Seminar presentations by the MSc candidate Evaluation reports on the MSc thesis Presentation of the MSc thesis

Tabulated Assessment Methods against the Program Learning Outcomes

		Program Learning Outcomes							
		1	2	3	4	5	6	7	8
Assessment	Exam			X		X			
	Coursework		X	X		X			
	Assignments			X		X			
	Presentations		X	X			X	X	
	Projects	X	X	X	X		X		X
	Thesis	X	X	X	X		X	X	X

24. Student Support

Students are assigned an advisor upon matriculation to the program; the advisor provides the guidance for first-year course selection and progression.

At a point prior to the completion of the first year, the student must secure a Thesis Advisor, from the SST faculty. The Thesis Advisor will provide an oversight and supervision of the student's thesis proposal, investigation, preparation, and defense.

	In addition, there are several institutional services available to students: 1) Counselling, through the Office of Student Affairs; 2) Internships and Professional Opportunities, through the Office of Career Services; 3) English Language and Writing workshops, the Language Center.
25. Resources	The Physics Department researchers work closely with other SST Departments, the School of Engineering, NURIS, and the Center of Life Sciences for the development of the program. The laboratory facilities in Nazarbayev University can be availed for the physics researchers engaged with the MSc projects. The Nazarbayev University library is well equipped with the online research collections required for the program. The existing laboratories at the Center for Energy Research at NURIS will be able to host some MSc students depending on their interests.
26. Quality Assurance and Enhancement Mechanisms	A variety of different methods of program evaluation are already in place for all programs in the School of Science and Technology, and the School of Engineering, which will be also employed for the present MSc program. **Internal quality assurance:** Quality assurance measures will involve an initial placement test, by the involvement of a second reviewer in the evaluation of the MSc thesis and by the open presentations of the MSc thesis. The submitted MSc thesis will be available online. Student representatives will be asked to participate in the Masters committee and provide feedback both on the general structure of the program but also on the specific courses and organization and quality of instruction and research. Students will be asked to evaluate their experiences with the overall MSc program every year, with special emphasis on the order of course elements, the consistency of the program, the academic depth of the program, etc. Also probed is their opinion on the Master project as preparation for their professional career. As this MSc program is meant to be a high-quality program with a strong western dimension, the aspect of international focus will also be evaluated. Students are asked to evaluate each course element on aspects including content, required time to perform the course element, examination, teaching and learning facilities, lecturer's quality, etc. Evaluations of individual course elements are carried out via questionnaire, completed by students at the end of each course element. From each course element, a report will be written with a summary of the outcome, a reaction of the lecturer in the form of proposed changes to the course element and of the effect of previous measures, undertaken following a previous evaluation.

There will be an annual progress monitoring that will be reported to the physics faculty.

External quality assurance:

An external panel of international experts will be invited periodically to assess the quality of the Physics MSc program and make recommendations on further improvement.

The following external and internal review processes for quality assurance and control will be in place for all MSc programs in the School of Science and Technology.

External processes include:

1) Peer review by a future partner institution (ideally a global top 30 university) or other independent external reviewers. The peer review will focus on all aspects of curricular structure, delivery and assessment and will be implemented systematically at each anniversary of the program.
2) Continuous benchmarking of program metrics with respect to a competitive group of worldwide institutions in the program's thematic area. The Department will decide the appropriate list of institutions after discussion with all the stakeholders.
3) A School-level Industrial Advisory Board (IAB) to interact with the department faculty, students, and staff in an advisory capacity, with particular emphasis on shaping the educational facets of the program.

Internal processes include:

4) A Steering Committee chaired by the Head of the Department, including senior faculty members and a student representative. The Steering Committee will prepare the Strategic Plan and the Risk Management Plan of the MSc Program for approval by the School, and will review its execution systematically at each anniversary of the program.
5) Continuous assessment of the quality of program delivery via student feedback, faculty peer review and exit survey of graduates upon completion of the program by each cohort.
6) Continuous oversight by the School-level Teaching and Learning Committee of curricular structure, new course syllabi, and general compliance with NU's Quality Assurance Framework.

ANNEX 1

Master of Science in Physics

Compliance with the *Graduate Programs Framework*

The MSc program has been designed to be consistent with the revised Graduate *Programs Framework* of Nazarbayev University (2014). The following chart provides a comparison of *Master's Degree Programs Framework* requirements and how and where these requirements are met in the Master of Science program.

Comparative Analysis of *Framework* and MSc Program		
Element	***Framework***	***MSc Program***
The Bologna Process and Issues of Accreditation	Master's degree programs are Second Cycle programs. In the First and Second Cycles taken together, a student must accumulate a total of 300 ECTS credits. This means that at Nazarbayev University, master's degrees may vary in length from one to two (or more) years, but must be two years in duration for students whose undergraduate degree was a 3-year one. Although in principle generally desirable, decisions about seeking accreditation are left to the individual Schools and specific program areas.	The program requires a total of 120 ECTS credits. The program's duration is 4 semesters. Graduates of an undergraduate program with a Bachelor's degree from a reputable university with a minimum CGPA of 2.75 or above (on a 4.0 scale) are eligible for admission to the SST Graduate programs. At this stage, no accreditation is planned as SST is planning to get the full accreditation (where applicable) at the undergraduate level.
The Admission Process	Nazarbayev University seeks to recruit gifted and talented students for our graduate degree programs. Commonly recognized quantitative measures should play an important role in the admissions process: the GRE, GMAT, etc., depending on what the discipline-specific norms would suggest. The TOEFL or IELTS should also be required, except for applicants who have graduated from an English-medium university. In both	Applicants to the program must have an undergraduate degree in a discipline relative to the program. The 2-year, 120 ECTS program allows for the admission of graduate students with a basic degree that may differ from that of the program at hand. Admission will be handled on a case-by-case basis by evaluating the student's undergraduate curriculum, English proficiency, motivation and references. The initial cohort will consist of 15

	cases, minimum required scores for admission should be set at an appropriate level. Additionally, applicants should be able to articulate their reasons for seeking a master's degree at Nazarbayev University, and discuss their qualifications for admission. Finally, letters of recommendation from credible academic referees should be submitted and considered (although in some program areas, letters from non-academics might also be required). The penultimate decision about whether or not an applicant is admitted to a graduate degree program rests with the department, program area, or school. The ultimate decision rests with the President of the University.	students and will progressively increase as the resources of the School allow. Admissions decisions will be based on consideration of the following factors: 1) completion of the on-line application form by the applicant; 2) evidence of completion of an undergraduate degree program in a relevant field or discipline with a minimum CGPA of at least 2.75 (on a 4.0 scale); 3) evidence of sufficient English language skills to be able to function effectively in a graduate level, English-medium environment as demonstrated by a minimum IELTS test score of 6.5 (with subscore requirements no less than 6.0), or the equivalent TOEFL score as posted on the ETS website; 4) at the discretion of the Admissions Committee, applicants can be exempted from submitting the language proficiency test report if: a. one of their earlier academic degrees was earned in a country with English as the language of official communication, academic instruction and daily life; or b. an undergraduate degree was earned in a program which was officially taught in English; or c. the applicant is a graduate of Nazarbayev University. 5) a statement of purpose for

		graduate studies; and 6) two letters of reference. All of these factors will be taken into account in the final recommendation of the Admissions Committee with respect to admission to the MSc program. When necessary, selected applicants will be invited for a personal interview with the Admissions Committee, either on campus or via Skype.
Role of Advisors and Advisory Committee	The academic advisor for master's degree students typically plays an important role in the development of the student's program of study, although this will vary depending on the amount of flexibility in the program. Advisors of master's degree students should be experienced scholars and researchers, who are familiar with the process of supervising graduate students and who have served on Advisory Committees in the past. At a minimum, an Advisor (or at least one of the Co-Advisors) for the student in a master's degree program should: - hold a full-time faculty appointment in a School at Nazarbayev University, and undertake duties agreed to with the Dean of that School;	Individual faculty members in SST serve as Professional Development Tutors and as Advisors to graduate students. In this role, they are expected to provide both intellectual and professional guidance, advice about courses and program and other support that their advisees require Major Advisors in SST Graduate programs must meet all of the minimal requirements listed in the *Framework.* Faculty members of advisory committees in SST Graduate programs must meet all of the minimal requirements listed in the *Framework.*

	- possess a terminal degree in an appropriate field (normally a doctoral degree) from an accredited institution; - have successful experience serving on postgraduate Advisory Committees (or the equivalent); and - have published at least two major research articles in appropriate academic peer-reviewed journal (or the equivalent). Faculty members at our Partner universities and in the Nazarbayev University research centers will be welcome to serve as Co-Advisors and as members of Advisory Committees for master's degree students with the approval of the Dean of the relevant School The Advisory Committee for master's degree students should consist of a minimum of three members, including the student's Advisor. All Advisory Committees *must* include at least two Faculty members from the School and one external member (e.g., from a Partner university), and *may* include a member from one of the research centers. The members of the Advisory Committee should be determined by	

	the student and Advisor, and must be approved by the Dean of the relevant School in consultation with the department head. All CE members of an Advisory Committee *must* normally hold a terminal degree in an appropriate field of study. Members of the Advisory Committee may change or be changed, with the approval of the Advisor and the Dean at any point.	
Structure of Curriculum	Master's degrees at Nazarbayev University will vary considerably by discipline and School. Programs at the master's degree level will typically be one to two years in duration. The core features of all Nazarbayev University master's degree programs should include: - at least four taught academic courses; - involve a core examination or research project of some sort, which results in a 'Thesis' (most often a thesis) experience. It is up to each School to determine how the evaluation of major student work (e.g., thesis, inquiry project, comprehensive examinations, etc.) will be conducted, and whether external reviewers shall be used.	The program is designed for students to devote 4 semesters to the program. The program also requires completion of a comprehensive design/research project, which serves as the Master Thesis project of the program. Submission of a Master Thesis Project (30 ECTS) with letter grade is a graduation requirement.

ANNEX 2

Curriculum Framework of the MSc Program in Physics			
Stage of Program	Significance	Possible Results	Evaluation Point
ADMISSION TO PROGRAM	Initial Evaluation		Key Evaluation Point
COURSEWORK	Determination of Student Competence in Fundamentals of Discipline	Continue in Program Continue on Probation Severed from Program	
EXTERNAL REVIEW with PUBLIC PRESENTATION	Demonstration of student's research expertise in the subject of Master Thesis and ability to clearly present the methodology and conclusions.	Grade awarded Resubmit Master Thesis Severed from Program	Key Evaluation Point
APPROVAL BY DEAN	The Dean of School of Science and Technology in situations in which there is an unresolved difference between the Supervisor and External Reader(s) and/or the Student.	Grade awarded Resubmit the Master Thesis Severed from Program	

ANNEX 3

Placement Physics Test

This is an initial placement test administered in August after the students are accepted in the Masters program. It serves the purpose of evaluating the knowledge of the students and through it advising the students on how to proceed in their studies. Specifically, thought this test the Department evaluates the detailed strengths and weaknesses of the students and advises them which courses to take.

The placement physics test is administered in August and covers material from four basic physics courses:

1) Classical Mechanics
2) Thermodynamics and Statistical Physics
3) Electrodynamics
4) Quantum Mechanics

The test may be done also orally in front of the appropriate examination committee that will administer the test.

Recent Publications of SST Physics Faculty

17) Dr. Georgios Tsironis, Professor (SST, Physics Department)

I. Molina, N. Lazarides and **G. P. Tsironis**, *Optical surface modes in the presence of nonlinearity and disorder*, Physical Review E, 85, 017601 (2012).
N. Lazarides and **G. P. Tsironis**, *Gain driven Parity-Time symmetric breathers in nonlinear metamaterials,* Physical Review Letters 110, 053901 (2013).

18) Dr. Vassilios Kovanis, Professor (SST, Physics Dept)

Limit-Cycle Dynamics with Reduced Sensitivity to Perturbations, Thomas B. Simpson, Jia-Ming Liu, Mohammad AlMulla, Nicholas G. Usechak, and **Vassilios Kovanis**, Physical Review Letters, 112, 023901 (2014).
Nonlinear Dynamics of an Injected Quantum Cascade Laser, Thomas Erneux, **Vassilios Kovanis** and Athanasios Gavrielides, Physical Review E, 032907 (2013).

19) Dr. Ernazar Abdikamalov, Assistant Professor (SST, Physics Department)

E. Abdikamalov, A. Burrows, C. D. Ott, F. Lffler, E. O'Connor, J. Dolence, E. Schnetter, *A New Monte Carlo Method for Time-dependent Neutrino Radiation Transport*, The Astrophysical Journal, 755:111, (2012)
C. Reisswig, C. D. Ott, **E. Abdikamalov**, R. Haas, P. Mosta, and E. Schnetter, *Formation and Coalescence of Cosmological Supermassive Black Hole Binaries in Supermassive Star Collapse*, Physical Review Letters, 111:151101, (2013).

20) Dr. Dmitriy Beznosko, Assistant Professor, (SST, Physics Dept)

K. Abe, G. J. Barker, F. Bay, B. E. Berger, I. Bertram, **D. Beznosko** et al., *Measurement of the Inclusive NuMu Charged Current Cross Section on Carbon in the Near Detector of the T2K Experiment,* T2K Collaboration, Feb20 2013, arXiv:1302.4908 [hep-ex]
D. Beznosko, T. Beremkulov, A. Duspayev, A. Iakovlev, A. Tailakov, M. Yessenov "A Physical Principle for Fast and Miniature Random Number Hardware Generator Using MPPC Photo Detector", Journal of Advances in Physics, Vol 7, No 3, February 2015, ISSN 2347-3487

21) Dr. Sergiy Bubin, Assistant Professor (SST, Physics Dept)

S. Bubin, M. Atkinson, K. Varga, X. Xie, S. Roither, D. Kartashov, A. Baltuˇska, and M. Kitzler, *Strong laser-pulse-driven ionization and Coulomb explosion of hydrocarbon molecules,*, Physical Review A 86, 043407 (2012).
S. Bubin and O. V. Prezhdo, *Excited States of Positronic Lithium and Beryllium,* Physical Review Letters 111, 193401 (2013).

22) Dr. Mithun Bhowmick, Assistant Professor (SST, Physics Dept)

B. Ullrich, D. Ariza-Flores, **M. Bhowmick**, *Intrinsic photoluminescence Stokes shift in semiconductors demonstrated by thin-film CdS formed with pulsed-laser deposition,* Thin Solid Films 558, 24 (2014)

M. A. Meeker, B. A. Magill, T. R. Merritt, **M. Bhowmick**, K. McCutcheon et al., *Dynamics of photoexcited carriers and spins in InAsP ternary alloys***,** Applied Physics Letters 102, 222102 (2013).

23) Dr. Michael Good, Assistant Professor (SST, Physics Dept)

Michael R. R. Good, Paul R. Anderson, and Charles R. Evans, Time dependence of particle creation from accelerating mirrors, Physical Review D 88, 025023 (2013).
Michael R. R. Good, On spin statistics and Bogoliubov transformations in flat space-time with acceleration conditions, International Journal of Modern Physics A **28**, 1350008 (2013).

24) Dr. Daniele Malafarina, Assistant Professor (SST, Physics Dept)

Cosimo Bambi, **Daniele Malafarina**, and Leonardo Modesto, *Non-singular quantum-inspired gravitational collapse*, Phys. Rev. D 88, 044009 (2013).
Cosimo Bambi and **Daniele Malafarina**, Kα iron line profile from accretion disks around regular and singular exotic compact objects, Phys. Rev. D, 88, 064022 (2013).

25) Dr. Aikaterini Mandilara, Assistant Professor (SST, Physics Dept)

A. Mandilara, E. Karpov, and N. J. Cerf, *Purity and Gaussianity bounded uncertainty relation*, Journal of Physics A. 47, 045302 (2014)
A. Mandilara, and N. J. Cerf, *Quantum Bit Commitment under Gaussian Constraints*, Physical Review A 85, 062310 (2012).

26) Dr. Alexander Tikhonov, Assistant Professor (SST, Physics Dept / NURIS)

Tikhonov, N. Kornienko, J. Zhang, L. Wang and S. A. Asher, *Reflectivity Enhanced 2D Dielectric Particle Array Monolayer Diffraction***,** Journal of Nanophotonics 6, 063509 (2012).
J. Zhang, L. Wang, J. Luo, **A. Tikhonov**, N. Kornienko and S. A. Asher, *2-D Array Photonic Crystal Sensing Motif*, Journal of Americal Chemical Society, 133, 9152 (2011).

27) Dr. Zhandos Utegulov, Assistant Professor (SST, Physics Dept)

S. J. Reese **Z. N. Utegulov**, F. Farzbod, R. S. Schley, and D. H. Hurley, *Examination of the epicentral waveform for laser ultrasound in the melting regime*, Ultrasonics 53, 799 (2013).
A.G. Every, **Z. N. Utegulov**, I. A. Veres, *Laser surface thermoelastic generation above melt threshol"*, Journal of Applied Physics, 114, 203508 (2013).

28) Dr. Jean-Jacques Zondy, Associate Professor (April 2015) (SST, Physics Dept)

Andrieux, Emeline, Thomas Zanon, Malo Cadoret, Abdallah Rihan, and **Jean-Jacques Zondy**. "500 GHz mode-hop-free idler tuning range with a frequency-stabilized singly resonant optical parametric oscillator." *Optics letters* 36, no. 7 (2011): 1212-1214.
Courtillot, Irene, Audrey Quessada, Richard P. Kovacich, Anders Brusch, Dmitri Kolker, **Jean-Jacques Zondy**, Giovanni D. Rovera, and Pierre Lemonde. "Clock transition for a future optical frequency standard with trapped atoms." *Physical Review A* 68, no. 3 (2003): 030501.

29) **Dr. Konstantinos Valagiannopoulos,** Assistant Professor (August 2015)) (SST, Physics Dept)

C.A. Valagiannopoulos, and Pekka Alitalo. "Electromagnetic cloaking of cylindrical objects by multilayer or uniform dielectric claddings."Physical Review B 85, no. 11 (2012): 115402.
C.A. Valagiannopoulos, M. S. Mirmoosa, I. S. Nefedov, S. A. Tretyakov, and C. R. Simovski. "Hyperbolic-metamaterial antennas for broadband enhancement of dipole emission to free space." Journal of Applied Physics116, no. 16 (2014): 163106

30) **Dr. Anton Desyatnikov**, Associate Professor (August 2015)) (SST, Physics Dept)

Detangling flat bands into Fano lattices Sergej Flach, Daniel Leykam, Joshua D. Bodyfelt, Petter Matthies, and **Anton S. Desyatnikov**, EPL (Europhysics Letters) 105, 30001-6 (2014).
Self-Induced Mode Transformation in Nonlocal Nonlinear Media Y. V. Izdebskaya, **A. S. Desyatnikov**, and Y. S. Kivshar, Physical Review Letters 11, 123902-4 (2013).

ANNEX 5

Description of Physics Courses to be offered to MSc students

PHYS 433 Introduction to Biophysics: This course deals with the physical aspects of biological phenomena. The topics may include the structure and the function of biomolecules, the experimental techniques for investigating biomolecules, cellular transport, neural networks, population dynamics, etc. The selection of topics is to be made by the instructor.

PHYS 443 Introduction to Chemical Physics: This course deals with the physical aspects of chemical phenomena. The topics may include quantum principles behind chemical bonding, molecular dynamics, principles of molecular spectroscopy, etc. The selection of topics is to be made by the instructor.

PHYS 453 Introduction to Particle Physics: The course covers the classification and the interaction of fundamental particles existing in nature. The topics include the overview of the Standard Model, accelerators and particle detection techniques with the discussion of the latest discoveries in this field.

PHYS 463 Topics in Astronomy and Astrophysics: This course offers an overview of the fields of astronomy and astrophysics. The topics include a review of the history of astronomy, present knowledge of the astronomical facts, modern observation techniques, current theories of stellar evolution, galaxy formation and the large-scale structure of the universe.

PHYS 474 Lasers and Photonics: This course covers topics of lasers, photonics and the broader subject of the interaction of laser radiation with matter. The topics may include an overview of research and industrial applications of photonics.

PHYS 475 Introduction to Quantum Technologies: This course covers applied quantum mechanics and basic superconductivity and subsequently focuses on the physics of basic quantum devices such as SQUIDS both single and in metamaterial configurations. The analogy of quantum mechanics with wave motion in the paraxial approximation is introduced and basic photonic devices are also detailed.

PHYS 476 Advanced Quantum Technologies: The course covers the physics of materials in extreme conditions. Effects of high pressure, very large magnetic fields, very low temperatures, etc. are explained. Quantum magnets, quantum phase transitions and quantum thermodynamics processes are covered. Depending on student interest this course may also focus on Quantum Information and Quantum Computing.

PHYS 477 Topics in Material Science: This course focuses on science and technology related to micro- and nano-fabrication and characterization of new and advanced materials and techniques. The topics may include overview of nanoscale-related science, nanotechnology of advanced materials and advanced characterization techniques with high spatio-temporal resolution.

PHYS 505 Classical Mechanics: The course covers Lagrangian and Hamiltonian formulations of classical mechanics, rigid body motion and classical scattering theory.

PHYS 515 Classical Electrodynamics: The course systematically covers electromagnetic fields in vacuum and matter in non-relativistic and relativistic limits.

PHYS 510 Quantum Mechanics: The course systematically covers nonrelativistic quantum mechanics and introduces elements of relativistic quantum theory. The focus of the course is on the applications of quantum mechanics to experimentally relevant physical settings and a set of key applications.

PHYS 520 Statistical Physics: The course covers intermediate-level topics of statistical physics. Possible choices may include fluctuations, susceptibilities and transport in the linear-response regime near thermodynamic equilibrium, Landau theory of second-order phase transitions, critical phenomena, Boltzmann kinetic equation and its applications to non-equilibrium phenomena.

PHYS 525 Nonlinear Physics: The course will cover manifestations of nonlinearity in classical and quantum systems. The topics may include perturbation theory for nonlinear systems, ergodicity, bifurcations, Poincare sections, Lyapunov exponents, quantum chaos, solitons, etc as well a set of key applications. The selection of topics is to be made by the instructor.

PHYS 530 Solid-state Physics: The course will cover advanced topics of the physics of metals, insulators and semiconductors. The topics include Fermi-liquid, electronic screening in metals and semiconductors, kinetics of charge carriers, phonons and magnetic excitations, superconductivity, localization, materials with strong electronic correlations.

PHYS 535 General Relativity: The course will introduce Einstein's theory of general relativity and then describes various gravitational phenomena using this theory in the regimes of small and large deviations from the Newtonian theory of gravity. Experimental evidence of the validity of the theory of general relativity is also to be presented.

PHYS 540 Quantum Field Theory: The course will introduce the formalism and the techniques of quantum field theory with applications to the physics of elementary particles and to condensed matter systems.

PHYS 545 Advanced Instrumentation Methods: This course covers the advanced techniques working with complex instrumentation in a physics laboratory with practical exercises at particle accelerators, magnetrons, laser facilities, medical facilities and other available instruments at the time the course is given.

PHYS 591 Research Methods: This course deals with the methodology in research. Masters students will learn how a research problem may be set and modeled and use the appropriate tools for solution. There will be search for relevant literature and final oral and written presentaiton of results.

PHYS 592 Research Seminar: The course intends to expose students to different areas, topics, and methods of research in Physics.

PHYS 691 Thesis Proposal: In this course, students will find their thesis advisors and write their thesis proposals.

PHYS 692 Thesis: Student will conduct independent work under the direction of a supervisor on a research problem in the student's designated area of research. The student will prepare and defend the thesis.

ANNEX 6

Description of Common SST Graduate Courses to be offered to MSc students

SST 501 Teaching and Learning: This course introduces the students to best-practice pedagogical methods and innovations in teaching, under the mentorship of senior faculty. The students will conduct classroom and laboratory observations of prominent instructors, using a variety of teaching and learning styles. They will present their observations and experience in a final report.

SST 502 Teaching Practicum: Students will apply educational, instructional, and assessment methodologies in recitation sections of their respective disciplines under the supervision of an experienced faculty member. They will summarize their observations and experience in a final report.

SST 503 Laboratory Practicum: Students will apply educational and instructional methodologies in laboratory and practical sessions of their respective disciplines under the supervision of an experienced faculty member. They will summarize their observations and experience in a final report.

SST 504 Innovation and Entrepreneurship: This course presents aspects of how basic and/or applied physics phenomena and research can lead to innovation, the development of new devices and services. There will be presentation of both successful and unsuccessful test cases and the methodology followed in innovation. Additionally there will be instruction on entrepreneurship and how to turn new produces into business on the global scale.

External Review Reports:

Nazarbayev University *Physics and Quantum Technologies* Masters Program Endorsement

Steven M. Anlage

Physics Department

University of Maryland, USA

26 February, 2015

The proposal makes a very strong case for the establishment of a *Physics and Quantum Technologies* Masters program in the School of Science and Technology at Nazarbayev University. A very good case is made that the stature of Kazakhstan depends in part on the training of Physicists at the graduate level. These graduates will go on to be the leaders of technology-based industry in Kazakhstan, and will make a substantial contribution to the development of the country. The problem solving mentality of a trained MSc. or Ph.D. physicist is essential for attacking the large and complex issues that face Kazakhstan as it moves forward to become a developed country.

The advantages of the NU MSc. Program include the fact that it is conducted in English, allowing the graduates to interface easily with the global research enterprise (not just physics but also computer science, medicine, engineering, etc.), which is conducted in the English language. The NU Physics faculty have strong connections with the global scientific community as well. This will enhance the research opportunities for the students, as well as give them excellent placement opportunities in Europe, Asia, and the Americas.

The MSc. requirements are in line with international standards. The requirement of a research project is very important, and will make graduates of this program very attractive for international Ph.D. programs. I have interviewed many of the current faculty members of the Physics department and it is clear that they are very well qualified to supervise research at both the MSc. and Ph.D. level.

I like the emphasis on quantum technologies, which is clearly an important technological focus for the 21st century. Overall I strongly endorse this proposal to establish an MSc. Program in *Physics and Quantum Technologies* at Nazarbayev University. It is up to international standards, and stands to be of great benefit to the nation of Kazakhstan. I would be happy to serve on the external panel to evaluate the quality of the program after it has been established.

Alexandre Zagoskin
To: George Tsironis
Endorsement of Proposal for an MSc in Physics and Quantum Technologies

Dear Professor Tsironis,

I have read the Proposal for an MSc in Physics and Quantum Technologies at the Physics Department, SST, University of Astana with a great interest and satisfaction. I fully agree with the purpose of the proposal, as the development of quantum technologies (especially "quant. Tech. 2.0") is going to be in the centre of technological progress for the foreseeable future, and it will require experts with a deep knowledge of fundamental quantum physics, understanding of its applications and ability to solve the related engineering problems. I believe that the proposed programme will meet these requirements, and endorse it wholeheartedly.

Sincerely yours,

Alexandre Zagoskin PhD FInstP FHEA
Reader in Quantum Physics
Loughborough University

Siddharth Saxena <sss21@cam.ac.uk>

to me

Dear Professor Tsironis,

I did review your proposal for Master's Degree in Physics and Quantum Technologies to be submitted to the Nazarbayev University Academic Council.

I find the graduate courses that will be offered are the classic ones in similar programs in North American and British Institutions. Such courses in classical mechanics, quantum mechanics, statistical physics and electromagnetism provide a solid foundation for any future career in physics and relater problem solving areas. Focus on a master's thesis with 30 ECTS credits with publishable results, at the the end to the degree, will also strength the enhance the research enterprise within NU and incubate a very strong research culture among the graduate students and provide a proper environment for junior faculty to direct cutting edge research and move forward their research portfolios.

The roster of the 14 oh physics faculty is strong and well poised to deliver an existing and robust program. Their publication records show case multiple Physical Review Letters in theoretical and experimental topics. Their research portfolios span fundamental and applied physics area with special emphasis in quantum technologies.

I strongly support the establishment of the Physics Masters program within NU.

Dr. Siddharth S. Saxena

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MASTERS OF SCIENCE IN PHYSICS / “ФИЗИКА” БАҒДАРЛАМАСЫ БОЙЫНША МАГИСТРАТУРА / МАГИСТРАТУРА ПО ПРОГРАММЕ “ФИЗИКА”

Item/ Атауы/ Наименование	Structural subdivision/ Құрылымдық бөлімшенің атауы/ Наименование структурного подразделения	Name and signature of a responsible person, date of approval/ Т.А.Ж., жауапты тұлғаның қолы, визаның қойылған күні / Ф.И.О., подпись ответственного лица, дата визирования	Position, name and signature of a resp. person, date of approval / Лауазымы, Т.А.Ж., нақты орындаушының қолы, визаның қойылған күні / Должность, Ф.И.О., подпись конкретного исполнителя, дата визирования
DEVELOPMENT/ ӘЗІРЛЕУ/ РАЗРАБОТКА	School of Science and Technology Школа наук и технологий Ғылым және технологиялар мектебі		
Review/ Келісу/ Согласование	Legal Department Заң департаменті Юридический департамент	Bakyt Abisheva Б.К. Абишева	
	Department of Documentation Support Құжаттамамен қамтамасыз ету департаменті Департамент документационного обеспечения	Leila Nurgaziyeva Л.С. Нургазиева	