Master Degree Programme

CRYOGENIC ENGINEERING

FIELD OF STUDY

141200 – REFRIGERATION, CRYOGENIC TECHNICS AND LIFE SUPPORT SYSTEMS

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CONTENT

PROGRAMME OVERVIEW

Institution	Bauman Moscow State Technical University (BMSTU)
Programme	Cryogenic Engineering
Field of study	141200 – Refrigeration, cryogenic technics and life support systems
Degree awarded	Master of Engineering
Department	Faculty of Power Engineering, Department of Refrigerating, cryogenics and life support systems
Coordinator	Dr. Ivan Arkharov Professor
Address	5, 2-nd Baumanskaya, Moscow, 105005, Russia
Notional duration	2 years
Workload	120 ECTS credits
Classes start	September 2012
Mode of study	Full-time
Language of instruction	Russian
Date of approval	June 5, 2012

1. PROGRAMME AIMS

Master's Programme in Cryogenic Engineering is aimed at teaching students to meet modern science and industry demands. Learners should be able to carry out theoretical, computational and practical work in the field of cryogenic engineering. The study programme enables industry- and research-oriented graduates to be able to make analysis, design, manufacture and use machinery, plants, equipment, and devices of cryogenic engineering. The programme also allows professionals to investigate processes in cryogenic systems and plants and have an access to the doctoral school.

Graduates demonstrate modern methods to examine, design, and apply new cryogenic machinery, plants, appliances using recent information technologies as well as they are skilled to develop and introduce new models of cryogenic engineering and apply the high-tech processes in their analysis, design and manufacturing.

O.1. Conduct activities with research and development (R&D) related to the innovation techniques for calculation and design and to the experimental study of low-temperature plant facilities and related industries;

O.2. Conduct manufacturing, R&D, and innovation activities to create new CAD-based and environmentally safe cryogenic facilities;

O.3. Perform value engineering of research and industry projects including multidisciplinary ones;

O.4. Carry out consulting and expert activities, analyze and compare and generalize research and industrial outcomes, prepare presentations and publications including those of in foreign language;

O.5 Show skills to organize and manage different profile specialists' teamwork from different countries;

O.6.Carry out research and teaching activities both in the secondary schools of physics and mathematics and HEIs;

O.7. Upgrade professional knowledge and skills, including further studies at doctoral school.

2. KEY PROGRAMME LEARNING OUTCOMES (COMPETENCIES)

The programme learning outcomes are elaborated to ensure the programme objectives achievement. They correspond to the requirements of the Federal Education Standards of Russia (FES) in Heat and Power Engineering and of the AEER (Association for Engineering Education of Russia) accreditation criteria for engineering programmes.

Code	Learning outcomes The programme graduates are able to
	Professional skills
P1	Show sound knowledge of physical processes in machines, apparatus, and plants of cryogenic engineering; identify challenges and demands of the industry in terms of cutting-edge technology achievements and world tendencies
P2	Apply physicomathematical tools, theory- and computation-based methods of analysis, mathematical and computer modeling to design machines, apparatus, and plants of cryogenic engineering
P3	Design low-temperature systems and machinery to meet the requirements for their maximum performance and durability, safety of life
P4	Apply CAD-systems to design components for cryogenic machines and systems
P5	Elaborate a feasibility study to design competitive ecologically safe cryogenic machines and plants
P6	Display new contemporary methods and tools to carry out thermo-physical and mechanical investigations, analysis, and processing of cryogenic machines, plants and equipment
P7	Demonstrate skills in running the modern cryogenic machines and plants, integrating innovative approaches, to ensure their high performance, cost-effectiveness and health and environment safety
P8	Advise cost-engineers, designers, technologists and examine the theoretical and experimental cryogenic engineering work in terms of science and technology
	Personal skills
P9	Have a good command of Russian and foreign languages with the ability for appropriate business communication, correspondence, documents circulation and for making presentations and papers, writing articles and reports
P10	Apply basic principles of social, humanitarian, and economic sciences to solve social and professional problems and follow legislation in activities

P11	Use practical experience and skills to manage professional activities of an individual, a team worker and an international team's leader of specialists with different profile
P12	Upgrade a qualification independently through life-long learning, hold studies for students at different levels both in cryogenic engineering, and in physics and mathematics

Teaching/learning methods

Lectures, tutorials, laboratory and field works, group design project, case studies, presentations, practical trainings, and theses. IT and web, textbooks, periodicals, patents, etc.

- Lectures to cover design and product development principles.
- In-company practical training to give the students an understanding of the industrial context of their work.
- A group design project focusing on an aspect of new and renewable energy engineering. This assignment will develop the student's knowledge of the implementation and management of the design process and their team-working skills. The assessment of this assignment will involve an element of student peer assessment. The mark will be made up from a team component and an individual component.
- Examinations to assess knowledge, understanding and application.

Assessment

Student performances are assessed by applying grading criteria that indicate what level a student has achieved while taking examinations and tests, analyzing investigation results, doing course papers and projects, completing theses and making conference reports, analytical papers, presentations, and essays. Student ability for critical evaluation of different activities, holding debate, interpreting and applying results is of significance in assessment.

3. CURRICULUM STRUCTURE

Notional duration of the programme is two years (full-time study), the programme syllabus carries 120 ECTS credits.

Code	Cycle /Module/Discipline	ECTS credits
GS	**General Sciences**	**26**
GSB	*Core subjects/modules*	**8**
GSB01	Foreign Language (special course)	4
GSB02	History and Philosophy of Science and Technology	4
GS	*Minors*	**18**
GSV01	Strategy and innovation management	3
GSV02	Similarity and mathematical modeling methods	3
GSV03E	Elective №1	6
GSV04E	Elective №2	6
PS	**Majors**	**48**
PSB	*Core subjects*	**13**
PSB01	Cryogenic systems: special chapters of thermodynamics	4
PSB02	Mathematical modeling	9
PSV	*Minors*	**35**
PSV01	Cryogenic facility design engineering	9
PSV02	Cutting-edge cryogenic systems and plants	7
PSV03	Computational gas and fluid dynamics, heat and mass transfer	7
PSV04E	Elective №1 (“Cryogenic transport systems”)	4
PSV05E	Elective №2 (“Contemporary superconducting devices”)	4
PSV06E	Elective №3 (“Emergency Protection”)	4
PR	**Practical training and Research activities**	**31**
SC01	**Final state attestation** (Master's thesis defense)	**15**

4. ALLOCATION OF CREDITS TO LEARNING OUTCOMES AND PROGRAMME MODULES

Module	Credits	P1	P2	P3	P4	P5	P6	P7	P8	P9	P10	P11	P12
Foreign language	4									3	1		
History and Philosophy of Science and Technology	**4**	2									2		
Strategic and innovation management	3					1		1			1		
Similarity and mathematical modeling methods	**3**	1	1		1								
Cryogenic systems: special chapters of thermodynamics	**4**	1	2				1						
Mathematical modeling	**8**	4	3					2					
Cryogenic facility design engineering	**9**	2	1		3			3					
Cutting-edge cryogenic systems and plants	**7**	3	3		1								
Gas and fluid computational dynamics, heat and mass transfer	**7**	4	2				1						
Elective №1 (for example, "Cryogenic Transport Systems")	**4**	1		1	1		1						
Elective №2 (for example, "Contemporary superconducting devices")	**4**	2	1		1								
Elective №3 (for example, "Emergency Protection")	**4**	2		2		2							
Elective №4,5	**10**		2	3	2	1	2						
Practical training and Research activities	**31**					2	7	7	4	2	1	4	4
Final state attestation (Master's thesis defense)	**15**		1	1	1	1	1		2	2	2	4	

5. CHANGING A CURRICULUM VS CHANGING REQUIREMENTS

By the legislation the RF, majors of the curriculum 141200 "Refrigeration, cryogenic engineering and life support systems" are unchangeable.

Minor disciplines depend on the study programme which is essentially defined by the employers of the future master degree-holders in Cryogenic Engineering and can be, for example, as follows:

- Helium technologies and facilities
- Hydrogen technologies and facilities
- Oxygen technologies and facilities
- Nitrogen Technologies and facilities
- Technology of rare gases and facilities
- Technology of natural gas and facilities
- Transport cryogenic systems
- Space cryogenic systems
- Superconducting system.

Electives are defined both by the auxiliary programme of education and by employers' needs and research specialiseds of theses. It is a type of applied electives.

Master programme enables degree-holders to have access to doctoral school. So master level students may learn fundamental sciences as electives, and sometimes they may have individual curricula.

Lectures of both home and international visiting professor may be considered as electives.

At the department "Refrigerating, cryogenics and life support systems" there are full-time and part-time faculty staff. The latter, mostly BMSTU graduates, now being the heads of divisions and deputy-directors in low temperature industries deliver lectures within the curriculum and enable students to have placements and later after graduating the employment in their companies. This allows the part-time teachers to modify curricula and content of lectures in basic and variation parts, to include the new electives thus linking learning to industrial and research activities.

6. ALLOCATION OF CREDITS TO LEARNING OUTCOMES

FES*	**Professional skills**								**Personal skills**			
Credits	95								25			
EUR-ACE	Knowledge and understanding	Engineering Analysis	Engineering Design			Research	Engineering Practice		Personal skills			
Credits	25	16	21			13	20		25			
Learning Outcomes	P1	P2	P3	P4	P5	P6	P7	P8	P9	P10	P11	P12
Credits	25	16	7	8	6	13	14	6	7	6	8	4

*FES – Federal Educational Standards of the RF

7. SYLLABI

The Section contains brief description of programme's modules (syllabi). The topics to study, classes, textbooks, and credits carried by module are specified.

*A syllabus includes list of module learning outcomes (**M1, M2,**...). Each module learning outcomes has to contribute into achievement of appropriate programme learning outcome (**P1, P2**,...) indicated in parentheses. It is assumed (if other not specified) that 1 ECTS credit is allocated to each module learning outcome. The student workload associated with achievement of module learning outcome is to be planned in accordance with its credit value.*

GS General Sciences

Foreign language

Department:	***English language, Faculty of Linguistics***
Code:	**GSB01**
Level:	**master)**
Credits:	**4 ECTS**
Pre-requisites:	**None**
Developer:	**V. Verbitskaia, Ass. Prof. N.Lavrov**
Lecturers:	**V. Verbitskaia**

Learning outcomes:

M1. Demonstrate a good command of the foreign language both in oral and in writing

M2. Identify, select, interpret and evaluate a range of sources with general and specialised texts in the foreign language.

M3. Demonstrate the ability to communicate effectively with appropriate use of specialist vocabulary on general and specialised topics

M4. Demonstrate developing ability to make presentations and articles for periodicals and conferences in cryogenic engineering in the foreign language

M5. Apply a range of relevant grammar to provide a well-structured general and specialised description of whatever required

M6. Reflect to the cross-cultural aspects in the country with the language learned

Alignment of Module learning outcomes (MLO) and Programme learning outcomes (PLO)

PLO	P1	P2	P3	P4	P5	P6	P7	P8	P9	P10	P11	P12
Credits	-	-	-	-	-	-	-	-	3	1	-	-
MLO	-	-	-	-	-	-	-	-	M1, M2,M3	M4, M5,M6	-	-

Brief Description of Module:

- Listening general and specialised material in the foreign language to understand its content
- Translation and interpretation of general and specialised material into and from the foreign language
- Speaking exercises to increase and enhance vocabulary to hold discussions and negotiations, communicate, and express opinions and ideas, make a report or speech on general and specialised topics
- Reading to understand content of general and specialised material in a variety of sources such as web-based material, journals, books, brochures, leaflets, etc.
- Writing exercises and assays to give a description whatever is required
- Practical aspects of searching for general and specialised information in the foreign language

TYPES OF LEARNING ACTIVITY:

LECTURES	0/0 hrs. (class/self.)
PRACTICAL CLASSES	68/102 hrs. (class/self.)
IN-CLASS LEARNING	68 hrs.
SELF-LEARNING	102 hrs.
TOTAL	170 hrs.
ASSESSMENT:	Test

References:

1. Longman Dictionary of Contemporary English.-Third edition with new words supplement.-Essex:Longman, 2001.-XXIV,1668 p.:ill.+64 pages of new words colour headwords.-ISBN 0-582-45639-8.

2. I.*V.Orlovskaya, L.S. Samsonova, A.I. Skubrieva*
English for Technical Universities and Institutions:2-nd Edition, reviewed and complemented. – M.: BMSTU Press2001. 389p. - ISBN 5-7038-1646-7.

Projects:

1. PR1. Small project “Dialogues and issues concerning the life and activities”
2. PR2. Small project “Draw up a paper for student’s scientific conference”
3. PR3. Small project “Make a questionnaire to interview experts in cryogenic technology”.
4. PR4. Small project “Round table discussions about cryogenic engineering problems and development”

History and Philosophy of Science and Technology

Department:	***Faculty of Social Science and Humanities***
Code:	**GSB02**
Level:	**master**
Credits:	**4 ECTS**
Pre-requisites:	**None**
Developer:	**E.N Kuznetsov, Ass. Prof. N.Lavrov**
Lecturers:	**E.N Kuznetsov, Dept. of Philosophy**

Learning outcomes:

M1 .Identify the development features of science and technology at different times.

M2 Demonstrate the ability to use the gained historical and philosophical knowledge to solve today's problems

M3 Think critically and independently

M4 Retrieve information

Alignment of Module learning outcomes (MLO) and Programme learning outcomes (PLO)

PLO	P1	P2	P3	P4	P5	P6	P7	P8	P9	P10	P11	P12
Credits	2	-	-	-	-	-	-	-	-	2	-	-
MLO	M1, M2	-	-	-	-	-	-	-	-	M3,M4	-	-

Brief Description of the Module:

- Introduction to the development of science and technology in ancient Mesopotamia and Egypt and to the philosophical aspects of the "exact" sciences in ancient Greece and Rome, Byzantium and the Arab East.
- Illustration of mathematics and mechanics development in antiquity and military and construction application of knowledge in practice.
- Industrial revolution commencement in Western Europe
- First machines, steam engines used as a power source, electric power and electric cars applications to discovery and application of electromagnetic waves, the law of conservation of energy and charge and identity of all forms of energy
- Philosophical point of view on the structure of matter using the planetary model of the atom, use of entropy as a measure of disorder, science and technology philosophy due to appearing the weapons of mass destruction used during the World Wars of the 20th Century, an appearance of nuclear weapons and philosophical explanation of this phenomenon

- Depleted natural resources of energy, philosophical aspects of the economic crisis and of the aerospace development, accelerated mobility of people and of data transfer, mass-media to cultivate certain views in people's consciousness, wide use of computers as a facility of data accumulation, processing and application, Internet and cellar phone to provide the universal communication, and philosophical aspect of the continuously increased mankind energy consumption of material resources.

TYPES OF LEARNING ACTIVITY:

LECTURES	17/34 h. (class/self.)
PRACTICAL CLASSES	34/51 h. (class/self.)
CLASS HOURS	51 h.
SELF-LEARNING	85 h.
TOTAL	136 h.
ASSESSMENT:	**Test**

References:

1. *V. Khyosle* "Philosophy and Ecology", 1991
2. «Philosophy in the culture system". Contemporary scientifically philosophical presentation of globe" H.. 2. BMSTU Press 2001, 10 author's sheets.
3. Toulmin, S. (1967) *The Philosophy of Science*, London: Hutchinson.

List of labs and projects:

1. PR1. Small project "Development of engineering sciences in the ancient world".
2. PR2. Small project "Creation of the first low-temperature systems".
3. PR3. Small project "Industrial revolution in Europe".
4. PR4. Small project "Population size of the Earth vs development of low-temperature technology".
5. PR5 Small Project "Development of low-temperature technology in ancient times".
6. PR6. Small project: "Low-temperature growth of energy systems".
7. PR7. Small project: "Relationship between the ultralow and ultrahigh temperature processes"

Strategic and innovation management

Department:	**Management**
Code:	**GSV01**
Level:	**Master**
Credit:	**3 ECTS**
Pre-requisites:	**None**
Developer:	**Ass. Prof. N.Lavrov**
Lecturers:	**Ass. Prof. J.Kokyeva**

Learning outcomes:

M1 Demonstrate knowledge and understanding of the main principles of strategy management

M2 Be able to apply the contemporary management techniques and technologies

M3 Select and employ sophisticated techniques for project management

M4 Assess the importance of brand and risk management

M5 Propose main marketing strategies for different engineering business models

M6 Evaluate the effects of innovation management on business development

M7 Differentiate between budgeting business entity and investment management.

Alignment of Module learning outcomes (MLO) and Programme learning outcomes (PLO)

PLO	P1	P2	P3	P4	P5	P6	P7	P8	P9	P10	P11	P12
Credits	2	-	-	-	-	-	-	-	-	2	-	-
MLO	M1, M2	-	-	-	-	-	-	-	-	M3,M4	-	-

Brief Description of the Module:

- Introduction to the principles of strategy management: statement of purpose, analysis of organisation environment, setting up the strategy alternatives, followed by their analysis and choice
- Contemporary management techniques as an integrated management to learn the role of modern management technologies in manager's activity
- Structuring the object of management and choice of the optimal management structure
- Marketing management as one of the main tools of modern management technologies
- Brand- and risk management
- Project management techniques required for industrial engineering, planning and project management
- Budgeting business entity management, management of investment, capital, shares and company restructuring
- Business planning and monitoring of business plans

- Innovation management
- Total quality management
- Crisis management
- Team practices, corporate culture
- Conflict management.
- Choice of the optimal management structure

TYPES OF LEARNING ACTIVITY:

LECTURES	17/34 h. (class/self.)
PRACTICAL CLASSES	17/17 h. (class/self.)
CLASS HOURS	34 h.
SELF-LEARNING	51 h.
TOTAL	85 h.
ASSESSMENT:	**Test**

References:

1. *Kokueva Zh. M.* Project: from idea to the implementation . – BMSTU Press, 2008.-168p.
2. *Kokueva Zh. M . Yatsenko V.V.* Hi Tech Human resource management.- BMSTU Press, 2008.-254p.
3. *An'shinV.M. Dagaev A.A.* Innovation management: multilevel concepts, strategies, and mechanisms of innovation development.- Delo (Business),2003.-527p.
4. Fedoseev V.N. Marketing management.- MarT, 2006.-401p.

Projects:

1. PR1. Small project 'Risk Management in cryogenic engineering'.
2. PR2. Small project 'Investment Management in cryogenic engineering'.
3. PR3. Small project 'Innovation Management in cryogenic engineering'.
4. PR4. Small project 'Crisis Management in cryogenic engineering'.
5. PR5. Small project 'Conflict Management in cryogenic engineering'.

Similarity and mathematical modeling methods

Department:	***Refrigerating, cryogenics and life-support systems***
Code:	**GSV02S**
Level:	**Master**
Credits:	**7 ECTS**
Pre-requisites:	**None**
Developers:	**Ass. Prof. N.Lavrov**
Lecturers:	**Prof. I.Arharov, prof. Yu.Shevich, ass. Prof. V.Shishov, ass. Prof. V.Leonov, ass. Prof. E.Navasardjan**

Learning outcomes:

M1 To know the different kind of heat and mass transfer, their criteria and dimensionless numbers, dimensionless analysis; criterial dependence for the main processes of heat and mass transfer

M2 To be able to use the criterial dependence for the calculation of heat and mass transfer

M3 To know the numerical methods for solving the basic equations of heat and mass transfer, especially of the boundary conditions, methods of constructing the approximating difference schemes, computer modeling problems of heat conduction, fluid flow and heat transfer

M4 To be able to apply the finite-difference methods for solving problems of continuum mechanics, to solve the heat conduction problem by finite element method

Alignment of Module learning outcomes (MLO) and Programme learning outcomes (PLO)

PLO	P1	P2	P3	P4	P5	P6	P7	P8	P9	P10	P11	P12
Credits	1	1	-	1	-	-	-	-	-	-	-	-
MLO	M1,M3	M2,M4	-	M3,M4	-	-	-	-	-	-	-	-

Brief Description of the Module:

- The similarity of the different processes, criteria and the dimensionless numbers. Criterial dependence for the main processes of heat and mass transfer.
- Numerical methods for solving systems of Heat and Mass Transfer Processes equations.
- Finite differences method. The simplest means of approximating difference schemes constructing.
- The main methods of difference schemes stability studying. Methods for constructing high-order approximation schemes. Additional properties of difference schemes. The concept of the variational-difference schemes and projection-difference schemes. Finite difference methods for solving problems of continuum mechanics. Compact finite difference schemes for problems of heat conduction, fluid flow and heat transfer.

- The finite element method for stationary problems. The solution of heat conduction problems by finite element method. The solution of problems in deformable bodies mechanics by finite element method.

Time-dependent problems. Flow field calculation. Features of the boundary conditions. Computer simulation of heat conduction, fluid flow and heat transfer.

TYPES OF LEARNING ACTIVITY:

LECTURES	34/51 h. (class/self.)
LABORATORY WORK	17/34 h. (class/self.)
PRACTICAL CLASSES	34/51 h. (class/self.)
CLASS HOURS	85 h.
SELF-LEARNING	136 h.
TOTAL	221 h.
ASSESSMENT:	**Exam**

References:

1. *Arkharov A.M., Marfenina I.V., Mikulin Ye.I.* Cryogenic systems. V.1. Basics of theory and design. Textbook. – M.: Machinostroeniye (Mechanical engineering), 1996. – 575 p.

2. *Arkharov A.M., et al*. Cryogenic systems. Textbook for HEI students in «Low temperature physics and engineering" and «Refrigeration cryogenic engineering and conditioning»: V.2. Design of apparatus, plants, systems. A.M. Arkharov, I.A. Arkharov, V.P. Belyakov, et al.; Edited by A.M. Arkharov, I.A. Arkharov and A.I. Smorodin. – 2-e edition, reviewed and revised. – M.: Machinostroeniye, 1999. – 720 p.: illustrated.

3. *Baron R F*. Cryogenic systems. M.: Energoatomizdat (Energy and atom edition), 1989.- 410 p.

4. *Samarsky A.A*. Difference scheme theory. - M.: Nauka (Science), 1977. - 656 p.

5. *Alexeev V.P.,* Gerasimov *P.V., Winestein G.Ye*. Design and modeling of cryogenic apparatus and systems. - Leningrad: Energoatomizdat, 1987. - 290 p.

6. Handbook of physics and technology basics of cryogenic engineering. /Ed. by.Malkov M.P, M:- Energoatomizdat, 1985 г.

7. *I.S. Zhitomirsky*. Physico-mathematical principles of cryostatting system. Kiev: Naukova dumka. – 1990. - 222p.

8. Nonsteady heat exchange / *V.K. Koshkin, Eh.K. Kalinin and et al.*/ Moscow: Machinostroeniye , 1973, 328p.

9. *V.A. Grigor'ev, Yu.M. Pavlov, Ye.V. Ametistov*. Boiling of cryogenic liquids. Moscow: Energy, 1977. - 287p.

10. Heat transfer at low temperatures. Collection of papers. /Ed. by U. Frost/. Moscow: Mir (World). - 1977, 390p.

11. *V.G. Fastovsky and et al*. Cryogenic Engineering. Moscow: Energy, 1967, 414p

12. Handbook of Heat engineering . /Ed. by V.A. Grigor'ev, Yu.M./ vol 2, Moscow: Energy, 1978, 828p.

13. Heat engineering apparatus. /Translated from English and edited by A.Spolding. Handbook. Vol. 1,2. Moscow: Mir (World), 1988, 524p.

14. Clark D.D. Cryogenic heat transfer. Moscow: Mir (World), 1971. - 576p.

List of labs and projects:

1. LR1. Computer simulation of heat conduction, fluid flow and heat transfer.
2. PR1. Small project "The similarity of the heat and mass processes in cryogenics".
3. PR2. Small project "Finite differences method for calculation of machines and apparatus cryogenic engineering processes".
4. PR3. Small project "The finite element method for calculation of machines and apparatus cryogenic engineering processes".
5. PR4. Small project "Flow field calculation for calculation of machines and apparatus cryogenic engineering processes".

PS MAJORS

Cryogenic systems: special chapters of thermodynamics

Department:	***Refrigerating, cryogenics and life-support systems***
Code:	**PSB01**
Level:	**Master**
Credits:	**4 ECTS**
Pre-requisites:	**None**
Developers:	**Ass. Prof. N.Lavrov**
Lecturers:	**Prof. A.Arkharov, Prof. V.Bondarenko, ass. Prof. E.Navasardjan, ass. Prof. V.Shishov, ass. Prof. N.Lavrov**

Learning outcomes:

M1 Know the basics of the phase equilibria thermodynamic theory for single and multi-agents working cryogenic engineering

M2 Know the calculation and compilation methods for phase equilibria and thermodynamic properties

M3 To be able to use existing data banks and computer programs for practical calculations

M4 Know the basics and the thermodynamic calculations of processes with multicomponent working substances.

M5 To be able to theoretically and experimentally investigate the equilibrium in two-component systems.

Alignment of Module learning outcomes (MLO) and Programme learning outcomes (PLO)

PLO	P1	P2	P3	P4	P5	P6	P7	P8	P9	P10	P11	P12
Credits	1	2	-	-	-	1	-	-	-	-	-	-
MLO	M1	M2,M3,M4	-	-	-	M5	-	-	-	-	-	-

Brief Description of the Module:

- The subject, objectives and areas of multicomponent solutions thermodynamics and heterogeneous systems in the cryogenics. The characteristic thermodynamic functions and potentials.
- Chemical potential, fugacity and fugacity coefficient. The principle and the conditions of heterogeneous systems equilibrium. Conditions for stability. The phase rule. The law of corresponding states, the critical parameters. Individual and generalized equation of state used in the calculation of the thermodynamic cryogenic processes.

- Elasticity of volatility and density calculation methods for the saturated phases. Heat capacities database for ideal-gas state. Caloric properties of phases and the phase transition heat.
- Calculation methods for thermodynamic properties of single-component cryogenic substances. Assessment of the possibilities for its application to multicomponent systems calculation.
- Definitions and distinctive thermodynamic properties of an ideal, infinitely dilute and non-ideal solutions. Components phase equilibrium constants and methods for its determination. The analysis recommended by state equations for the calculation of phase equilibria of multicomponent systems liquid - vapor for cryogenic engineering practical problems.
- Parameter estimation for models of the liquid phase. Calculation methods for basic thermodynamic processes of multi-component processes in heterogeneous condition and a constant overall composition: isobaric, isochoric, adiabatic, throttling with phase transitions vapor-liquid, vapor - solid, liquid-liquid, liquid - solid.

Software programs for determine the substance properties and modeling

TYPES OF LEARNING ACTIVITY:

LECTIRES	34/17 h. (class/self.)
LABORATORY WORK	17/17 h. (class/self.)
PRACTICAL CLASSES	17/17 h. (class/self.)
CLASS HOURS	68 h.
SELF-LEARNING	51 h.
TOTAL	119 h.
ASSESSMENT:	Exam

References:

1. *Arkharov A.M., Marfenina I.V., Mikulin Ye.I.* Cryogenic systems. V.1. Basics of theory and design. Textbook. – Moscow: Machinostroeniye (Mechanical engineering), 1996. – 575 p.

2. *Arkharov A.M., et al*. Cryogenic systems. Textbook for HEI students in «Low temperature physics and engineering" and «Refrigeration cryogenic engineering and conditioning»: V.2. Design of apparatus, plants, systems. A.M. Arkharov, I.A. Arkharov, V.P. Belyakov, et al.; Edited by A.M. Arkharov, I.A. Arkharov and A.I. Smorodin. – 2-e edition, reviewed and revised. – Moscow: Machinostroeniye, 1999. – 720 p.: illustrated.

3. *Dyrov V.A., Ageev E.P.* Thermodynamic theory of solutions. - Moscow: URSS, 2010. - 246p.

4. *Gerasimov J.I., Geiderikh V.A.* Thermodynamic of solutions. - Moscow: MSU press, 1980, -184p.

5. *Kirillin V.A., Sheindlin A.E., Shpilrain E.E.* Thermodynamic of solutions. – Moscow: Energy, 1980, -281p.

6. *Morachevskii A.G.,Smirnova N.A., Piotrovskaya E.M. et al*. Thermodynamic of vapor-liquid equilibria. - Leningrad: Chemistry, 1989, -344p.

7. *V.G. Fastovsky and et al*. Cryogenic Engineering. Moscow: Energy, 1967, 414p.

8. Handbook of Heat engineering . /Ed. by V.A. Grigor'ev, Yu.M./ vol 2, Moscow: Energy, 1978, 828p.

9. Weles S. Phase equilibriain chemistry tecnology / Translated from English. - Moscow: Mir (World), -1989, Part 1. - 304p., Part 2. -360 c.

10. Thermodynamic properties of helium, nitrogen, oxygen, hydrogen. Monographies. Moscow: Standart Press, 1982-1989.

List of labs and projects:

1. LR1. Using of software programs for determine the substance properties.
2. LR2. Using of software programs for modeling of cryogenic processes.
3. PR1. Small project "The use of characteristic thermodynamic functions and potentials in cryogenic processes".
4. PR2. Small project "Elasticity of volatility and density calculation methods for the saturated phases in cryogenic processes".
5. PR3. Small project "Calculation methods for thermodynamic properties of single-component cryogenic substances".
6. PR4. Small project "Calculation methods for basic thermodynamic processes of multi-component cryogenic substances".

Mathematical modeling

Department:	***Refrigerating, cryogenics and life-support systems***
Code:	**PSB02**
Level:	**Master**
Credits:	**8 ECTS**
Pre-requisites:	**None**
Developer:	**Ass. Prof. N.Lavrov**
Lecturer:	**Prof. I.Arkharov, ass. Prof. N.Lavrov, ass. Prof. V.Shishov**

Learning outcomes:

M1 Know the details of modeling of heat transfer processes at low temperatures.

M2 To be able to simulate the processes of low-temperature heat transfer in cryogenic systems with the help of computer programs.

M3 Know the details of modeling of mass transfer processes at low temperatures.

M4 To be able to simulate the thermal and hydraulic processes in heat transfer and mass exchangers.

M5 To be able to use computer programs to simulate the operation of cryogenic systems.

Alignment of Module learning outcomes (MLO) and Programme learning outcomes (PLO)

PLO	P1	P2	P3	P4	P5	P6	P7	P8	P9	P10	P11	P12
Credits	3	5	-	-	-	-	-	-	-	-	-	-
MLO	M1,M3	M2,M4,M5	-	-	-	-	-	-	-	-	-	-

Brief Description of the Module:

- Occurrence of non-stationary regime and unrated regime of cryogenic systems working. Separation of non-stationary processes: quasi-stationary and essentially non-stationary. Concentrated and distributed parameters models, one-dimensional and multidimensional models. The thermal inertia of the machines and plant equipment.
- The heat exchanger - the most inertial joint. The general equation of heat transfer between the stream and the wall. Dual-coil exchanger one-dimensional dynamic equation with the influence of the outer casing and insulation. Its impact on the character of non-stationary process.
- Different methods of concentration parameters in obtaining analytical solutions without taking into account the spatial distribution. Methods for obtaining analytical solutions by means of integral transforms. Numerical finite-difference methods of solution.
- Equations system for describing of cryogenic systems steady-state and non-stationary operating. Analytical, numerical and approximate solutions.

- Modeling of cryogenic plant operating during large mass object cooling. Regulate of refrigerant flow rate for cooling superconducting circulation system the and the calculation of cooling time.
- Application of linear and nonlinear programming to determine the optimal redistribution of flows in low-temperature apparatus of cryogenic plant.

*M*odeling heat and mass transfer processes during the motion of gas bubbles through the liquid layer. Particular modeling of freezing bodies of biological origin

TYPES OF LEARNING ACTIVITY:

LECTURES	34/85 h (class/self)
PRACTICAL CLASSES	68/85 h (class/self.)
CLASS HOURS	102 h.
SELF-LEARNING	170 h.
TOTAL	272 h.
ASSESSMENT:	Exam

References:

1. *Arkharov A.M., Marfenina I.V., Mikulin Ye.I.* Cryogenic systems. V.1. Basics of theory and design. Textbook. – Moscow: Machinostroeniye (Mechanical engineering), 1996. – 575 p.

2. *Arkharov A.M., et al*. Cryogenic systems. Textbook for HEI students in «Low temperature physics and engineering" and «Refrigeration cryogenic engineering and conditioning»: V.2. Design of apparatus, plants, systems. A.M. Arkharov, I.A. Arkharov, V.P. Belyakov, et al.; Edited by A.M. Arkharov, I.A. Arkharov and A.I. Smorodin. – 2-e edition, reviewed and revised. – Moscow: Machinostroeniye (Mechanical engineering), 1999. – 720 p.: illustrated.

3. Machineries of low temperature engineering. Cryogenic machineries and instruments. Edited by *A.M. Arkharov and I.K. Bytkevitch*. - Moscow: BMSTU Press, 2011. - 582 p.

4. **Reading list:**

5. *I.S. Zhitomirsky*. Physico-mathematical principles of cryostatting system. Kiev: Naukova dumka. – 1990. - 222p.

6. *Borzenko E.I., Zaitcsev A.V.* Plants and systems flow temperature. Automated analysis and modeling cryogenic plants and systems processes: Textbook . – SPb.: SPbSUL and FT press, 2006. – 232 p.

7. Heat engineering apparatus. /Translated from English and edited by A.Spolding. Handbook. Vol. 1,2. Moscow: Mir (World), 1988, 524p.

List of labs and projects:

1. LR1. Using of software programs for heat exchangers simulation.
2. LR2. Using of software programs for Refrigeration Systems simulation.
3. LR3. Using of software programs for modeling of cooling and mass transfer.
4. PR1. Small project “Methods for obtaining analytical solutions by means of integral transforms”.
5. PR2. Small project “Application of linear and nonlinear programming to determine the optimal redistribution of flows in low-temperature apparatus of cryogenic plant”.
6. PR3. Small project “Modeling of freezing biological origin bodies”.

Cryogenic facility design engineering

Department:	***Refrigerating, cryogenics and life-support systems***
Code:	**PSV01**
Level:	**Master**
Credits:	**9 ECTS**
Pre-requisites:	**PSB01, PSB02**
Developer:	**Ass. Prof. N.Lavrov**
Lecturers:	**Prof. I.Arharov, prof. Yu.Shevich, ass. Prof. V.Shishov, ass. Prof. V.Leonov, ass. Prof. E.Navasardjan**

Learning outcomes:

M1 Know how to determine the degree of thermodynamic perfection of the low-temperature systems.

M2 Know the methods for material and energy balances of machinery, equipment and plants.

M3 To be able to determine the parameters of the working substances by the equations and computer programs.

M4 To be able to develop algorithms and software for machines and cryogenic apparatus engineering design.

M5 Create mathematical models of physical processes occurring in low-temperature plants.

M6 To be able to use modern methods of analysis and design of various types heat transfer and mass transfer devices, including computer modeling sotware systems

Alignment of Module learning outcomes (MLO) and Programme learning outcomes (PLO)

PLO	P1	P2	P3	P4	P5	P6	P7	P8	P9	P10	P11	P12
Credits	2	2	-	3	-	-	2	-	-	-	-	-
MLO	M1,M2	M5		M3,M4	-		M6	-	-	-	-	-

Brief Description of Module:

- Major machinery and apparatus of cryogenic systems. The main parameters of cryogenic plant and its basic elements.
- Compressibility factor and the enthalpy of real substance. Real substance parameters on the boundary curve and the vapor-liquid region.
- Outlet of the expander gas enthalpy. Throttle, expander and external cooling stage, and cryogenic ejector cooling stage.
- Ideal mixtures phase equilibria. Phase equilibria of binary and ternary mixtures composed of air main components. The parameters of multicomponent mixtures phase equilibria. The calculation of the rectification process in air column. Composition of the streams after the throttle valve.

- Design features of turbomachinery. Flow of the compression and expansion stages. Impellers, diffusers, nozzle apparatus, the velocity triangles. Simulation of the machine cycle, and the individual elements and processes: current volume of the cylinder, the expiry of the gas through leaks, the plates self-acting valves, heat exchange agent, working with the walls of the chamber, sealing elements.
- Heat exchangers and their modelling. A mathematical model of countercurrent regenerative heat exchanger and heat exchanger with a boiling liquids.
- Computer simulation and design of machines and equipment of cryogenic systems.

TYPES OF LEARNING ACTIVITY:

LECTURES	51/68 hrs. (class/self)
PRACTICAL CLASSES	51/154 hrs. (class/self)
LABORATORY WORK	17/34 hrs. (class/self)
IN-CLASS LEARNING	119 hrs.
SELF-LEARNING	255 hrs.
TOTAL	374 hrs.
ASSESSMENT:	**Exam, Test**

References:

1. *Arkharov A.M., Marfenina I.V., Mikulin Ye.I.* Cryogenic systems. V.1. Basics of theory and design. Textbook. – Moscow: Machinostroeniye (Mechanical engineering), 1996. – 575 p.

2. *Arkharov A.M., et al*. Cryogenic systems. Textbook for HEI students in «Low temperature physics and engineering" and «Refrigeration cryogenic engineering and conditioning»: V.2. Design of apparatus, plants, systems. A.M. Arkharov, I.A. Arkharov, V.P. Belyakov, et al.; Edited by A.M. Arkharov, I.A. Arkharov and A.I. Smorodin. – 2-e edition, reviewed and revised. – Moscow: Machinostroeniye (Mechanical engineering), 1999. – 720 p.: illustrated.

3. Machineries of low temperature engineering. Cryogenic machineries and instruments. Edited by *A.M. Arkharov and I.K. Bytkevitch*. - Moscow: BMSTU Press, 2011. - 582 p.

4. *Belyakov V.P*. Cryogenic engineering. Moscow: Machinostroeniye (Mechanical engineering), 1983. -211p.

5. *Filin N.V., Bylanov A.B.* Liquid cryogenic systems. Leningrad: Machinostroeniye (Mechanical engineering), 1985. - 206 p.

6. *Baron R F*. Cryogenic systems. Moscow: Energoatomizdat (Energy and atom edition), 1989.-410 p.

7. *Alexeev V.P.,* Gerasimov *P.V., Winestein G.Ye*. Design and modeling of cryogenic apparatus and systems. - Leningrad: Energoatomizdat (Energy and atom edition), 1987. - 290 p.

8. *Grigoriev V.A., Krokhin J.I.* Heat and masstransfer apparatus of cryogenic engineering. Moscow: Energoatomizdat (Energy and atom edition), 1982. – 212 p.

9. Analysis of cryogenic plants. Textbook for HEI students / Edited by S.S.Bydnevitch. – Leningrad: Machinostroeniye (Mechanical engineering), 1979. – 367 p.

10. *Krasnikova O. K.* Coiled heat exchange apparatus of cryogenic and heat energy plants. Moscow: Coloss, 2008. – 176 p.

11. Handbook of physics and technology basics of cryogenic engineering. /Ed. by.Malkov M.P, M:- Energoatomizdat, 1985 г.

12. Nonsteady heat exchange / *V.K. Koshkin, Eh.K. Kalinin and et al.*/ Moscow: Machinostroeniye , 1973, 328p.

13. *V.A. Grigor'ev, Yu.M. Pavlov, Ye.V. Ametistov.* Boiling of cryogenic liquids. Moscow: Energy, 1977. - 287p.

14. Heat transfer at low temperatures. Collection of papers. /Ed. by U. Frost/. Moscow: Mir (World). - 1977, 390p.

15. Kaganer M.G. Heat insulation in low temperature engineering. Moscow: Machinostroeniye Mechanical engineering), 1966, 275c.

16. Heat transfer at low temperatures. Collection of papers. /Ed. by U. Frost/. Moscow: Mir (World). - 1977, 390p.

17. *V.G. Fastovsky and et al*. Cryogenic Engineering. Moscow: Energy, 1967, 414p.

18. Handbook of Heat engineering . /Ed. by V.A. Grigor'ev,./ vol 2, Moscow: Energy, 1978, 828p.

19. Heat engineering apparatus. /Translated from English and edited by A.Spolding. Handbook. Vol. 1,2. Moscow: Mir (World), 1988, 524p.

20. *Keltscev N.V.* Adsorb engineering fundamentals. Moscow: Chemistry, 1984 - 592 p.

21. *Golovko G.A.* Cryogenic production of rare gases. Leningrad: Machinostroeniye (Mechanical engineering), 1983. – 416 p.

22. *Grezin A. K., Zinov'ev V.S.* Microcryogenic engineering. Moscow: Machinostroeniye Mechanical engineering), 1977. – 232 p.

23. *Syslov A. D., Gorshkov A. M., Maslakov V. A.* Throttle microrefrigerators. Moscow: Machinostroeniye Mechanical engineering), 1978. – 144 c.

List of labs and projects:

1. LR1. Using of software programs for modeling of cryogenic machines.
2. LR2. Using of software programs for modeling of cryogenic apparatus.
3. LR3. Experimental investigation of cryogenic machines work.
4. LR4. Experimental investigation of cryogenic apparatus work.
5. LR5. Experimental investigation of cryogenic plants work.
6. PR1. Project “Cryogenic facility design engineering”.

Cutting- edge cryogenic systems and plants

Department:	***Refrigerating, cryogenics and life-support systems***
Code:	**PSV02**
Level:	**Master**
Credits:	**7 ECTS**
Pre-requisites:	**PSB01, PSB02, PSV01**
Developer:	**Ass. Prof. N.Lavrov**
Lecturers:	**Prof. A.Arkharov, the prof. V.Bondarenko, ass. Prof. N.Lavrov, ass. Prof. E.Navasardjan, ass. Prof. V.Shishov**

Learning Outcomes:

M1 Knowledge of the cryogenic plants practical problems in different areas of industrial, scientific and humanitarian activities.

M2 The ability to apply the principles of thermodynamics to the analysis and design of work processes in cryogenic systems.

M3 Knowledge of the heat and entropy analysis for cryigenic systems and its parts.

M4 Using the skills of the heat and entropy analysis for hydrogen systems and their parts.

M5 The use of effective and environmentally safe cryogenic technology for applications in industry, construction, agriculture, medicine, methods of heat removal from the objects, environments, materials, living organisms.

Alignment of Module learning outcomes (MLO) and Programme learning outcomes (PLO)

PLO	P1	P2	P3	P4	P5	P6	P7	P8	P9	P10	P11	P12
Credits	2	3	-	2	-	-	-	-	-	-	-	-
MLO	M1,M3	M2, M4	-	M5	-	-	-	-	-	-	-	-

Brief Description of the Module

- Low-temperature system and installation. Current status, problems and the need for gas separation products, oxygen, nitrogen, argon, rare gases obtained from air: neon, krypton, xenon, and their isotopes. Requirements for clean separation of gaseous products.
- Processes and apparatuses of air separation plants, storage and transportation of separation products. Film evaporators, evaporators and new types of structured tips for rectifying devices. Production, storage and transportation of inert gases: neon, krypton, xenon, and their isotopes.
- Adsorption systems for oxygen and nitrogen production from the air. The use of energy-saving technologies for cryogenic air separation.

- The production, storage, transportation and gasification of liquefied natural gas. Natural gas processing to produce new products. Reduction of the helium irreversible loss during the natural gas processing. The problem of helium preservation.
- Liquid hydrogen and hydrogen technologies. Hydrogen Energy. Methods for producing hydrogen. Transportation of hydrogen. The use of cryogenic fuels in aviation and rocketry. Production of liquid parahydrogen. Parahydrogen.
- Accumulation of cold as a way of energy consumption saving and optimization. Freezing the ground: the objectives, conditions and methods of implementation, energy, the choice of method.
- Experience in the use of cryogenic techniques and technologies in agriculture, medicine, and the processing industry. Application packages of computer programs for analysis and design of cryogenic systems.

TYPES OF LEARNING ACTIVITY:

LECTURES	51/68 h. (class/self.)
LABORATORY WORK	17/34 h. (class/self.)
PRACTICAL CLASSES	34/34 h. (class/self.)
CLASS HOURS	102 h.
SELF-LEARNING	136 h.
TOTAL	238 h.
ASSESSMENT:	Exam

References:

1. *Arkharov A.M., Marfenina I.V., Mikulin Ye.I.* Cryogenic systems. V.1. Basics of theory and design. Textbook. – Moscow: Machinostroeniye (Mechanical engineering), 1996. – 575 p.

2. *Arkharov A.M., et al*. Cryogenic systems. Textbook for HEI students in «Low temperature physics and engineering" and «Refrigeration cryogenic engineering and conditioning»: V.2. Design of apparatus, plants, systems. A.M. Arkharov, I.A. Arkharov, V.P. Belyakov, et al.; Edited by A.M. Arkharov, I.A. Arkharov and A.I. Smorodin. – 2-e edition, reviewed and revised. – Moscow: Machinostroeniye (Mechanical engineering), 1999. – 720 p.: illustrated.

3. Machineries of low temperature engineering. Cryogenic machineries and instruments. Edited by *A.M. Arkharov and I.K. Bytkevitch*. - Moscow: BMSTU Press, , 2011. - 582 p.

4. *Filin N.V., Bylanov A.B.* Liquid cryogenic systems. Leningrad: Machinostroeniye (Mechanical engineering), 1985. - 206 p.

5. *Baron R F*. Cryogenic systems. Moscow: Energoatomizdat (Energy and atom edition), 1989.- 410 p.

6. Handbook of physics and technology basics of cryogenic engineering. /Ed. by *M.P.Malkov*, Moscow: Energoatomizdat, 1985 г.

7. Heat engineering apparatus. /Translated from English and edited by *A.Spolding*. Handbook. Vol. 1,2. Moscow: Mir (World), 1988, 524p.

8. *Clark D.D.* Cryogenic heat transfer. Moscow: Mir (World), 1971. - 576p.

9. *Clark D.D.* Cryogenic heat transfer. Moscow: Mir (World), 1971. - 576p.

10. *Akylov L.A., Borzenko E.I., Novotel'nov V.N., Zaitcsev A.V.* Thermophisical properties of cryoagents: Textbook for institutes – SPb.: Polytechnics, 2001. – 243 p.

11. *R.C. Reid, J.M. Prausnitz and B.E. Poling,* The properties of gases and liquids, 4th ed., McGraw-Hill, New York, 1987. – 753 p.

List of labs and projects:

LR1. Using of software programs for modeling of cryogenic plants.

PR1. Small project "Separation of air"

PR2. Small project "Liquefaction of natural gas"

PR3. Small project "Hydrogen Technology".

PR4. Small project "Helium Technology".

PR4. Small project "Application of Cryogenic Technologies".

Gas and fluid computational dynamics, heat and mass transfer

Department:	**Refrigerating, cryogenics and life-support systems**
Code:	**PSV03**
Level:	**Master**
Credits:	**7 ECTS**
Pre-requisites:	**PSB01, PSB02**
Developer:	**Ass. Prof. N.Lavrov**
Lecturers:	**Prof. I.Arharov, prof. Yu.Shevich, ass. Prof. V.Shishov, ass. Prof. V.Leonov, ass. Prof. E.Navasardjan**

Learning outcomes:

M1 Basic knowledge of differential and integral calculus, the equations of liquid and gas motion, the conservation laws of mass and energy in various gas-hydrodynamic systems, programming languages.

M2 Using the knowledge gained to explore and describe the basic processes gas dynamics and hydrodynamics, to formulate the boundary and initial conditions, compile and debug computer programs and analyze the results of calculations, develop computer software systems design, engineering analysis and computer systems engineering.

M3 Basic knowledge of differential and integral calculus, the laws of thermodynamics, the basic processes of heat and mass transfer under different conditions, the laws of mass and energy conservation in the various thermodynamic systems, programming languages.

M4 Using the knowledge gained to explore and describe the basic processes and heat and mass transfer, to formulate the boundary and initial conditions, compile and debug computer programs and to analyze the results of calculations, to develop computer software systems design, engineering analysis and computer systems engineering.

Alignment of Module learning outcomes (MLO) and Programme learning outcomes (PLO)

PLO	P1	P2	P3	P4	P5	P6	P7	P8	P9	P10	P11	P12
Credits	3	2	-	-	-	2	-	-	-	-	-	-
MLO	M1,M2,	M3	-	-	-	M4	-	-	-	-	-	-

Brief Description of the Module:

- The area of computational fluid dynamics. Comparison of experimental, theoretical and computational approaches. Classification of partial differential equations: hyperbolic, parabolic and elliptic equations of second order. The correct formulation of the problem. Boundary, initial conditions. Systems of differential equations.
- The classification of numerical methods: finite differences, finite volumes, finite elements, using the probability distribution function. Fundamentals of the finite difference method: the

finite-difference approximation to the derivative of finite-difference approximation of partial differential equations, various methods for constructing finite difference schemes, the application of irregular grids, the stability of finite difference schemes. The equation of continuity, momentum and energy conservation, the equation of state.

- Diffusion equation for the mixture components. Modeling of various processes by using the basic equations for turbulent flows, boundary layer equations. Application of the finite difference method for solving the wave equation and heat equation.
- Numerical methods for solving equations for inviscid flow: the method of characteristics, through calculation, the splitting of the coefficients matrix, solution-building equation of small perturbations. Simulation of boundary layer. Finite difference methods for calculating the two-dimensional stationary and axisymmetric internal and external flows. Three-dimensional boundary layers. Unsteady boundary layers.
- Computer modeling of thermal processes.

TYPES OF LEARNING ACTIVITY:

LECTURES	51/51 hrs. (class/self)
LABORATORY WORK	17/17 hrs. (class/self)
PRACTICAL CLASSES	51/51 hrs. (class/self)
IN-CLASS LEARNING	119 hrs.
SELF-LEARNING	119 hrs.
TOTAL	238 hrs.
ASSESSMENT:	Exam

References:

1. *Anderson D., Tannehill J., Pletcher R.* Fluid computationalniks mekhanics and heat exchange: Volumes 1 and 2. / Translated from English. – Moscow: Mir (World), 1990.

2. *Loitsianskii L.G.* Mechanic of liquid and gas: Textbook for students. – 7-th edition, reviewed and revised. – Moscow: Drofa, 2003.

3. *Rouoch P.* Fluid computational dynamics. – Moscow: Mir (World), 1980

4. *Arkharov A.M., et al*. Cryogenic systems. Textbook for HEI students in «Low temperature physics and engineering" and «Refrigeration cryogenic engineering and conditioning»: V.2. Design of apparatus, plants, systems. A.M. Arkharov, I.A. Arkharov, V.P. Belyakov, et al.; Edited by A.M. Arkharov, I.A. Arkharov and A.I. Smorodin. – 2-e edition, reviewed and revised. – Moscow: Machinostroeniye (Mechanical engineering), 1999. – 720 p.: illustrated.

5. *Filin N.V., Bylanov A.B.* Liquid cryogenic systems. Leningrad: Machinostroeniye (Mechanical engineering), 1985. - 206 p.

6. *Baron R F*. Cryogenic systems. Moscow: Energoatomizdat (Energy and atom edition), 1989.- 410 p.

7. *Samarsky A.A.* Difference scheme theory. - Moscow: Nauka (Science), 1977. - 656 p.

8. *Laptev G.I., Laptev G.G.* Equations of mathematical physics. - Moscow: Nauka (Science), 2003. -327 p.

List of labs and projects:

LR1. Using of software programs for hydrodynamics modeling in cryogenic machines and apparatuses.

LR2. Using of software programs for thermal conductivity and convection modeling in cryogenic machines and apparatuses.

LR3. Using of software programs for mass transfer modeling in cryogenic apparatuses.

Elective №1 (for example, «Cryogenic Transport Systems»)

Department:	***Refrigerating, cryogenics and life-support systems***
Code:	**PSV04E**
Level:	**Master**
Credits:	**4 ECTS**
Pre-requisites:	**PSB01, PSB02, PSV01**
Developer:	**Ass. Prof. N.Lavrov**
Lecturers:	**Prof. Yu.Shevich, prof. Yu.Peshti, ass. Prof. V.Shishov, ass. Prof. N.Lavrov**

Learning outcomes:

M1 To be able to choose the thermal insulation for concrete conditions.
M2 Know the characteristics of cryogenic liquids transport and storage.

M3 To be able to use the methods of protection during liquid oxygen and hydrogen storage.

M4 Know how to clean cryogenic liquids.

M5 To be able to use computer programs to simulate the processes in the transportation of cryogenic systems.

Alignment of Module learning outcomes (MLO) and Programme learning outcomes (PLO)

PLO	P1	P2	P3	P4	P5	P6	P7	P8	P9	P10	P11	P12
Credits	1	-	1	1	-	1	-	-	-	-	-	-
MLO	M1,M4	-	M2	M5	-	M3	-	-	-	-	-	-

Brief Description of Module:

- Insulating properties of the basic materials used in cryogenic technology, methods for their preparation. Influence of moisture, temperature, density of packing of the insulating material on the effective thermal conductivity. Vacuum-cored, and screen-vacuum insulation. Design features of the named type of thermal insulation. Uncooled and cooled by "thermal bridges".
- Methods of fixing on a platform of cryogenic storage tanks transportation, transported by road and rail. Rail and road transport cryogenic containers of various shapes. Design features of pipelines for liquid cryogenic products transportation. Storage and transport of low-temperature fluids in slush state. Refrigeration system for compensate the heat leakage from the environment.
- Security measures in the storing and transporting gases devices. Features storage of cryogenic liquids. The phenomena of temperature stratification and the boiling of cryogenic liquids in storage tanks. The processes of hazardous impurities accumulation during liquid oxygen and hydrogen storage, limits their accumulation. Methods to prevent release of toxic gases from the tanks. Methods of cryogenic concentration preservation during storage.

- Preserving the cryogenic products purity after completing cryogenic tanks. Removal of dirt, residues in cryogenic equipment manufacture and installation. Removal of moisture, air and other possible contaminants. Using filters to remove solid particles in liquid cryogenic products pipelines. Computer simulation of transport processes in cryogenic systems.

TYPES OF LEARNING ACTIVITY:

LECTURES	34/34 hrs. (class/self)
LABORATORY WORK	0/0 hrs. (class/self)
PRACTICAL CLASSES	34/34 hrs. (class/self)
CONTACT HOURS	68 hrs.
SELF-LEARNING	68 hrs.
TOTAL	136 hrs.
ASSESSMENT:	Test

References:

1. *Arkharov A.M., Marfenina I.V., Mikulin Ye.I.* Cryogenic systems. V.1. Basics of theory and design. Textbook. – Moscow: Machinostroeniye (Mechanical engineering), 1996. – 575 p.

2. *Arkharov A.M., et al*. Cryogenic systems. Textbook for HEI students in «Low temperature physics and engineering" and «Refrigeration cryogenic engineering and conditioning»: V.2. Design of apparatus, plants, systems. A.M. Arkharov, I.A. Arkharov, V.P. Belyakov, et al.; Edited by A.M. Arkharov, I.A. Arkharov and A.I. Smorodin. – 2-e edition, reviewed and revised. – Moscow: Machinostroeniye (Mechanical engineering), 1999. – 720 p.: illustrated.

3. *Belyakov V.P.* Cryogenic engineering. Moscow: Machinostroeniye (Mechanical engineering), 1983. -211p.

4. Machineries of low temperature engineering. Cryogenic machineries and instruments. Edited by *A.M. Arkharov and I.K. Bytkevitch*. - Moscow: BMSTU Press, 2011. - 582 p.

5. *Kozlov V.N., MarfeninaI.V.* Storage systems for cryogenic liquids. Textbook. - Moscow: BMSTU Press,1983 г. - 82 с.
6. *Filin N.V., Bylanov A.B.* Liquid cryogenic systems. Leningrad: Machinostroeniye (Mechanical engineering), 1985. - 206 p.

7. *Baron R F*. Cryogenic systems. Moscow: Energoatomizdat (Energy and atom edition), 1989.- 410 p.

8. Handbook of physics and technology basics of cryogenic engineering. /Ed. by *M.P.Malkov*, Moscow: Energoatomizdat, 1985 г.

9. *I.S. Zhitomirsky*. Physico-mathematical principles of cryostatting system. Kiev: Naukova dumka. – 1990. - 222p.

10. *Kaganer M.G.* Heat insulation in low temperature engineering. - Moscow: Machinostroeniye (Mechanical engineering), 1966. – 275p.

11. Heat transfer at low temperatures. Collection of papers. /Ed. by U. Frost/. Moscow: Mir (World). - 1977, - 390p.

12. Heat engineering apparatus. /Translated from English and edited *by A.Spolding*. Handbook. Vol. 1,2. Moscow: Mir (World), 1988, - 524p.

13. *Clark D.D.* Cryogenic heat transfer. Moscow: Mir (World), 1971. - 576p.

14. *Bydnevitch S.S., Kholodkovskii S.V.* Transportation and storage of liquid gases. Textbook Part I. – Leningrad: LINTT Press, - 1978 – 116 p.

15. *Bydnevitch S.S., Kholodkovskii S.V.* Transportation and storage of liquid gases. Textbook Part II. – Leningrad: LINTT Press, - 1979. – 50 p.

16. *Akylov L.A., Borzenko E.I., Novotel'nov V.N., Zaitcsev A.V.* Thermophisical properties of cryoagents: Textbook for institutes – SPb.: Polytechnics, 2001. – 243 p.

List of labs and projects:

1. PR1. Small project "Features of thermal insulation".
2. PR2. Small project "The phenomena of temperature stratification and the boiling of cryogenic liquids in storage tanks".
3. PR3. Small project "Methods to prevent release of toxic gases from the tanks".
4. PR4. Small project "Using filters to remove solid particles in liquid cryogenic products pipelines".

Elective №2 (for example, «Contemporary superconducting devices»)

Department:	***Refrigerating, cryogenics and life-support systems***
Code:	**PSV05E**
Level:	**Master**
Credits:	**4 ECTS**
Pre-requisites:	**PSB01, PSB02, PSV01**
Developer:	**Ass. Prof. N.Lavrov**
Lecturers:	**Prof. V.Romanovsky, ass. Prof. N.Lavrov, ass. Prof. M.Kolosov, ass. Prof. V.Shishov**

Learning Outcomes:

M1 Know the physical and thermodynamic basis of the processes in superconductors.
M2 To be able to carry out thermal calculations for the selection of superconducting materials and assess their stability.

M3 Know the mathematical models for analyzing the thermal and electrical processes in superconducting materials.

M4 To be able to use mathematical models to analyze the thermal and electrical processes in the elements of superconducting systems.

M5 To be able to use computer programs for modeling of superconducting systems.

Alignment of Module learning outcomes (MLO) and Programme learning outcomes (PLO)

PLO	P1	P2	P3	P4	P5	P6	P7	P8	P9	P10	P11	P12
Credits	2	1	-	1	-	-	-	-	-	-	-	-
MLO	M1, M3	M4		M5	-	-	-	-	-	-	-	-

Brief Description of the Module:

- The phase transition to the superconducting state. Magnetic vortex theory. Magnetic flux quantization in a superconducting ring. The critical current of superconducting channel, wide thin superconducting film.
- The superconductors of the first and second kind. The development in time of processes of destruction and recovery of the superconducting state. The resistive state of superconducting circuit. High-temperature superconductivity. Physical properties of high temperature superconducting materials.
- The charge carriers in high-temperature superconducting materials. The critical magnetic field of high-temperature superconducting materials. Switches transmission lines based on the transition from the superconducting to normal state.

- The switching element based on the quality of the transition from the superconducting to normal state. The use of superconducting systems in power engineering, communications, medicine, transport and physical studies.
- Superconducting materials of system for electric power conservation. Electrical machinery and magnetic systems with low-temperature and high-temperature superconducting coils cooled by liquid refrigerants. Stability of superconductors.
- Methods for the withdrawal of the superconducting devices stored electrical energy. Protection of superconducting devices in the transition from the superconducting to the resistive state. The use of computer programs for design and simulation.

TYPES OF LEARNING ACTIVITY:

LECTURES	34/34 h. (class/self.)
LABORATORY WORK	0/0 h. (class/self.)
PRACTICAL CLASSES	34/34 h. (class/self.)
CONTACT HOURS	68 h.
SELF-LEARNING	68 h.
TOTAL	132 h.
ASSESSMENT:	Exam

References:

1. *Arkharov A.M., Marfenina I.V., Mikulin Ye.I.* Cryogenic systems. V.1. Basics of theory and design. Textbook. – Moscow: Machinostroeniye (Mechanical engineering), 1996. – 575 p.

2. *Arkharov A.M. et al*. Cryogenic systems. Textbook for HEI students in «Low temperature physics and engineering" and «Refrigeration cryogenic engineering and conditioning»: V.2. Design of apparatus, plants, systems. A.M. Arkharov, I.A. Arkharov, V.P. Belyakov, et al.; Edited by A.M. Arkharov, I.A. Arkharov and A.I. Smorodin. – 2-e edition, reviewed and revised. – Moscow: Machinostroeniye (Mechanical engineering), 1999. – 720 p.: illustrated.

3. *Belyakov V.P.* Cryogenic engineering. - Moscow: Machinostroeniye (Mechanical engineering), 1983. -211p.

4. *Ginzburg V.L., Andryshin E.A*. Superconductivity. – Moscow: Alfa, 2006.

5. *Ametistov E.V., Grigor'ev V.A*. Heatexchange with He-II. Moscow: Energoatomizdat, 1986. -144 p.

6. *Glebov I.A. et al*. Electrophysical problems of superconductivity. Leningrad: Nauka (Science), 1980. – 256 p.

List of labs and projects:

1. PR1. Small project “Low-temperature superconductivity”.
2. PR2. Small project “High-temperature superconductivity”.
3. PR3. Small project “Electrical machinery and magnetic systems with low-temperature and high-temperature superconducting coils cooled by liquid refrigerants”.
4. PR4. Small project “Protection of superconducting devices in the transition from the superconducting to the resistive state”.

Elective №3 (for example, «Emergency Protection»)

Department:	***Refrigerating, cryogenics and life-support systems***
Code:	**PSV06E**
Level:	**Master**
Credits:	**4 ECTS**
Pre-requisites:	**PSB01, PSB02**
Developer:	**Ass. Prof. N.Lavrov**
Lecturers:	**Prof. I.Arharov, ass. Prof. V.Shishov, ass. Prof. N.Lavrov, ass. Prof. E.Navasardjan**

Learning Outcomes:

M1 Know the principles of organization and control of production processes in low-temperature installations related to the protection of personnel in emergency situations.

M2 Assess the degree of hazard when using coolants and refrigerants used in cryogenic systems.

M3 Apply knowledge for the safe organization and management of production processes in the operation of cryogenic systems.

M4 Know the methods of protecting personnel in emergency situations resulting from the action as a natural and industrial disasters.

M5 Use the legal acts in the design and operation of gas separation systems used to produce oxygen.

Alignment of Module learning outcomes (MLO) and Programme learning outcomes (PLO)

PLO	P1	P2	P3	P4	P5	P6	P7	P8	P9	P10	P11	P12
Credits	1	-	1	-	2	-	-	-	-	-	-	-
MLO	M1,M4	-	M5	-	M2,M3	-	-	-	-	-	-	-

Brief Description of the Module:

- Concepts, definitions and classification of emergency situations. Systems and methods that ensure the protection of technological processes and staff in emergency situations.
- Organization and technology for the operation and service of security systems in emergency situations. Safety features of cryogenic equipment.
- The main risk factors: low temperature, fire hazard oxygen plants, explosion of hydrogen systems, high pressure gas.
- Means to drain quickly evaporated liquid cooling agent from the tank for storage. Safety of gas and liquid lines. The electrical safety of superconducting systems.
  Modeling of emergencies processes, and to eliminate and prevent its.

TYPES OF LEARNING ACTIVITY:

LECTURES	34/34 h. (class/self.)
LABORATORY WORK	0/0 h. (class/self.)
PRACTICAL CLASSES	34/34 h. (class/self.)
CONTACT HOURS	68 h.
SELF-LEARNING	68 h.
TOTAL	132 h.
ASSESSMENT:	

References:

1. *Arkharov A.M., et al*. Cryogenic systems. Textbook for HEI students in «Low temperature physics and engineering" and «Refrigeration cryogenic engineering and conditioning»: V.2. Design of apparatus, plants, systems. A.M. Arkharov, I.A. Arkharov, V.P. Belyakov, et al.; Edited by A.M. Arkharov, I.A. Arkharov and A.I. Smorodin. – 2-e edition, reviewed and revised. – Moscow: Machinostroeniye (Mechanical engineering), 1999. – 720 p.: illustrated.

2. *Belyakov V.P*. Cryogenic engineering. Moscow: Machinostroeniye (Mechanical engineering), 1983. -211p.

3. Life safety: Textbook / Edited by *S.V.Belov* - Moscow: Machinostroeniye (Mechanical engineering), 2006 - 485 c.

4. Environmental protection: Textbook / Edited by *S.V.Belov*.- Moscow: Vishaya shola (High school), 1991.-319 p.

5. Safety in Engineering: Textbook for Mechanical engineering students / Edited by *E.J.Youdin, S.V.Belov* /- Moscow: Machinostroeniye (Mechanical engineering), 1983.- 432 p.

6. Remedies in engineering: The calculation and design: Handbook / Edited by *S.V.Belov* /- Moscow: Machinostroeniye (Mechanical engineering), 1989.- 213p.

7. The technical operation of electrical installations. - Moscow: Energoservis (Energy services) - 2000.-280 p.

List of labs and projects:

1. PR1. Small project "Safety features of cryogenic equipment".
2. PR2. Small project "The safety of oxygen systems".
3. PR3. Small project "The safety of hydrogen systems".
4. PR4. Small project "The electrical safety of superconducting systems".

8. ESTIMATED DISTRIBUTION OF SUBJECTS FOR TERMS

Master curriculum «Cryogenic engineering»

Term 1												
Name of subject	Department	Credits	ASSESSMENT			Time expenses					in week	
			test	dif	exm	total	lec	prac	lab	self	cont	self
Foreign Language	L2,3,4	2	test			68		34		34	2	2
Science and Technology History and Philosophy	SGN4	4	test			136	17	34		85	3	5
Mathematical modeling	FN2	4			exm	136	17	34		85	3	5
Cryogenic systems: special chapters of thermodynamics	E4	4			exm	136	34	17	17	68	4	4
Similarity and mathematical modeling methods	E4	3			exm	85	17	17		51	2	3
Elective	E4	6	test			187	34	34		119	4	7
Research work and Practice	E4	7		test		170				170		10
Total		**30**	**4**	**0**	**3**	**918**	**102**	**170**	**17**	**612**	**18**	**36**

Term 2												
Name of subject	Department	Credits	ASSESSMENT			Time expenses					in week	
			test	dif	exm	total	lec	prac	lab	self	cont	self
Foreign Language	L2,3,4	2	test			68		34		34	2	2
Mathematical modeling	E4	5			exm	136	17	34		85	3	5
Elective №1	E4	6			exm	204	51	51		102	6	6
Cryogenic facility design engineering	E4	3	test			102	34	17		51	3	3
Elective №2	E4	4			exm	136	34	34		102	4	6
Research work and Practice	E4	10		test		204				204		12
Total		**30**	**2**	**1**	**3**	**850**	**136**	**153**		**578**	**18**	**34**

Term 3												
Name of subject	Department	Credits	ASSESSMENT			Time expenses					in week	
			test	dif	exm	total	lec	prac	lab	self	cont	self
Gas and fluid computational dynamics, heat and mass transfer	E4	7			exm	238	51	51	17	119	7	7
Cryogenic facility design engineering - project	E4	3		test		102				102	0	6
Cryogenic facility design engineering	E4	3			exm	102	17	17	17	51	3	3
Elective №1	E4	4			exm	136	34	34		68	4	4
Elective №2	E4	4	test			136	34	34		68	4	4
Research work and Practice	E4	9	test			170				170		18
Total		**30**	**2**	**1**	**3**	**884**	**136**	**136**	**34**	**578**	**18**	**34**

Term 4												
Name of subject	Department	Credits	ASSESSMENT			Time expenses					in week	
			test	dif	exm	total	lec	prac	lab	self	cont	self
Cutting-edge cryogenic systems and plants	E4	7			exm	196	42	28	14	112	6	8
Research work and Practice	E4	8		test		224				224		16
Total		**15**	**0**	**1**	**1**	**420**	**42**	**28**	**14**	**336**	**6**	**24**
Final Degree Project	**E4**	**15**										

9 LIST OF "REFRIGERATING, CRYOGENICS AND LIFE SUPPORT SYSTEMS" DEPARTMENT TEACHERS

Full-time teachers of the department

1. Professor (Dr.Sc) A. Arkharov - Head of Department
2. Associate Professor (Ph.D) S.Glukhov
3. Assistant (Dipl.Eng) E.Dontsova
4. Associate Professor (Ph.D) M.Kolosov
5. Associate Professor (Ph.D) N. Lavrov
6. Associate Professor (Ph.D) V. Leonov
7. Associate Professor (Ph.D) E.Navasardyan
8. Professor (Dr.Sc) Yu. Pesty
9. Associate Professor (Ph.D) Yu.Frolov
10. Professor (Dr.Sc) Yu. Shevich
11. Associate Professor (Ph.D) V. Shishov

Teachers - part-time of the department

Internal part-time teachers

1. Professor (Dr.Sc) I.Arkharov - BMSTU, vice-rector for International Relations.
2. Professor (Dr.Sc) A.Zherdev - BMSTU, dean of Power engineering Faculty.
3. Senior Lecturer (Dipl.Eng) N.Solovov - BMSTU, engineer.

External part-time teachers

1. Professor (Dr.Sc) V.Bondarenko - OMZ (Uralmash - Izhora), Deputy Director of Business Development.
2. Professor (Dr.Sc) I.Butkevich - The Institute of Physical Problems n.a. P. Kapitsa, a leading researcher.
3. Associate Professor (Ph.D) L.Volokitin - JSC "HolodGazInzhiniring ', general director.
4. Associate Professor (Ph.D) S.Garanov - Scientific Research Institute of Railway Transport, head of the laboratory.
5. Professor (Dr.Sc) G.Goncharova - LLC "GP Refrigeration and Engineering Center", a leading researcher.
6. Associate Professor (Ph.D) A. Zharov - JSC "Lantep", the chief engineer.
8. Associate Professor (Ph.D) D.Kuderko - JSC Scientific and Production Association "Science", the chief designer.
9. Associate Professor (Ph.D) A.Mikhailov - LLC "SETEK engineering," the head of the department.
10. Assistant (Dipl.Eng) Parkin A. - Public corporation "Institute of HOLODMASHHOLDING" team

leader.
11. Associate Professor (Ph.D) T.Rozenoer - The Institute of Mechanics, a leading engineer.
12. Professor (Dr.Sc) V.Romanovsky - National Research Centre Kurchatov - Institute of Superconductivity, a senior researcher.
13. Associate Professor (Ph.D) Eu.Savel'ev - JSC "Ostrov- SKV", chief executive officer.
14. Professor (Dr.Sc) M.Savinov - LLC "Chrome," chief executive officer.
15. Associate Professor (Ph.D) V.Semenov - Scientific and Production Company "EKIP", deputy chief executive officer.
16. Professor (Dr.Sc) A.Smorodin - JSC "Cryogenmash", the leading researcher.
17. Associate Professor (Ph.D) I.Tishchenko - JSC Scientific and Production Association "Science", the head of the department.

10 ADMISSION CRITERIA

Both Russian citizens and foreign nationals are eligible to apply for a Master programme "Cryogenic Engineering" provided that they are either the Bachelor degree holders or possess the Engineering degree in low-temperature technologies or relevant subject areas such as power engineering, thermal physics, thermal engineering.

A selection process is defined by internal regulations and the Law of Higher Education of the RF.

11 MASTER'S THESIS

Master study programme is completed by writing Master's thesis and by the state examinations, if required, to make an assessment of learning outcomes.

Master's thesis aim is to identify and develop graduate's potential for creativity and professional capability with desire for specific activities in research, engineering and industrial management, emphasizing on the gaining skills to solve complicated engineering problems independently.

Master's thesis is focused either on a project or on an investigation for further industrial application. Its public presentation demonstrates graduate's competence-based professional abilities and soft skills.

At the beginning of studies a graduate chooses a topic of his thesis which must meet the contemporary research and engineering challenges. It must be also cutting-edge, quite realistic in terms of problem-solving, independently and logically completed with some research activities to lead to a

new achievement. So a graduate is supposed to conduct professional teaching, research and development activities in engineering.

Master's thesis topics arise from the following:

- direct proposals of research institutions, industrial corporations and companies in the field concerned;
- research activities conducted by the faculty staff of the department of cryogenic engineering;
- research priority of graduate's supervisor.

. Master's thesis should describe:

- statement of purpose;
- state-of the-art analysis and arguments in support of choice;
- deign-theoretical and/or experimental research;
- generalization of results with conclusions and specific recommendations formulated on their basis;
- feasibility of expected effect of master's thesis.

A graduate is awarded a qualification (degree) by decision of the National Certifying Commission after having defended master's thesis.

12 QUALITY ASSURANCE

***Department of refrigerating, cryogenics and life support systems of BMSTU**:*

1. Sessions of Methodology Commission to assess curriculum quality, discuss teaching technologies using IT, make modifications of syllabus, arrange practical trainings, etc.

Responsible: Chairman of Methodology Commission - Professor Yuliy Pesty

2. Follow up to make sure that all the teaching activities such as lectures, practicum, lab works, seminars etc. are held appropriately.

Responsible: Head of the Department - Alexei ARKHAROV

3. Sessions to have discussions and make amendments and modifications in study programme/modules/other academic activities.

Responsible: Head of the Department - Alexei ARKHAROV

- ***Faculty of power engineering:***

1. Sessions of Methodology Commission to have discussions and amendments in the curricula, common disciplines, number of credit points within the study programmes/modules/disciplines.

Responsible: Chairman of Methodology Commission - Professor Vladimir MARKOV

2. Sessions of the Academic Council to discuss a general strategy of educational process both at the Faculty and at the Departments. Reports on the quality assurance provided by the Heads of Departments.

Responsible: Chairman of the Academic Council of the Faculty - Professor Anatoly Zerdev.

- ***Methodological department of BMSTU:***

1. Meetings and individual work with the chairmen of the methodology commissions of departments to make curricula corrections to meet requirements both for internal educational standards and for research fields of BMSTU as a Research University. Curriculum review by employers.

Responsible: Head of the Methodological Department – Associate Professor Nikolay VASILEV

- ***Department of education of BMST:***

1. Follow up Follow up to make sure that all the teaching activities such as lectures, practical trainings, lab works, seminars etc. are held according to curricula and appropriately
2. Follow up that documentation on teaching process is done properly and in due time.

Responsible: Head of the Department of Studies of BMSTU – Valentina Avdeeva

- ***Association of Academic Methodology for Polytechnic University Education of the RF***

1. Sessions of the Council and Panel of the Association of Academic Methodology for Polytechnic University Education of the RF to elaborate drafts of the state educational standards and curriculum models. Co-ordination activities of academic and research societies with companies, institutions, and bodies to provide quality assurance and higher professional education development. Proposals for higher professional education development structure and syllabus of main study programmes. Expertise of teaching materials to have specialists in engineering sciences (technologists and engineers).

Vice-Chairman - Sergey KORSHUNOV

- ***Commission for Academic Methodology in the field 141200 "Refrigeration and cryogenics engineering and life support systems":***

1. Sessions of Commission to discuss amendments and changes in the structure of study programme, a relationship of credit points of module disciplines and syllabus.

Chairman of the Commission – Professor Alexey ARKHAROV

- ***Department of quality assurance of BMSTU***

1. Arrangements to screen a department of refrigeration and cryogenics engineering and life support systems and discuss legislation issues to run education activities, define profiles of specialists according to labor market demand. Professional content of study programme, curriculum and teaching technology analysis. Academic methodology, faculty staff, logistic support of study programmes. Research activities, student enrollment, international cooperation.

Head of the department – A. TRETIAKOV

The Master Degree Programme “Cryogenic engineering” is developed by Bauman Moscow State Technical University within the TEMPUS project N°511121-TEMPUS-1-2010-1-DE-TEMPUS-JPCR: “***ECDEAST: Engineering Curricula Design aligned with EQF and EUR-ACE Standards”***.
Information about the project is available on: http://ecdeast.tpu.ru

Developed by:

Bauman Moscow State Technical University
Faculty of Power Engineering
Department of Refrigerating, cryogenics and life support systems

Authors:

Nikolay Lavrov, Associate Professor;
Viktor Shishov, Associate Professor.

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