Federal State Autonomous Educational Institution of Higher Education "Moscow Institute of Physics and Technology (National Research University)"

APPROVED
Head of the Phystech School of Biological and Medical Physics
D.V. Kuzmin

Work program of the course (training module)

course:	Physiology/Физиология
major:	Biotechnology
specialization:	Biomedical Engineering/Биомедицинская инженерия
	Phystech School of Biological and Medical Physics
	Center for educational programs in bioinformatics
term:	4
qualification:	Bachelor

Semester, form of interim assessment: 7 (fall) - Grading test

Academic hours: 30 AH in total, including:
lectures: 30 AH.
seminars: 0 AH.
laboratory practical: 0 AH.

Independent work: 60 AH.

In total: 90 AH, credits in total: 2

Authors of the program:

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A.S. Dukh

The program was discussed at the Center for educational programs in bioinformatics 04.06.2020

Annotation

The purpose of this discipline is the mastering by students of basic knowledge related to the physiology of the visceral systems. Familiarization of students with the mechanisms of normal functioning of the body, the principles of regulation of various systems of the body and with the consequences of deviations in the work of regulation systems (elements of pathological physiology). Determination of the range of the most pressing modern physiological issues and problems, in the solution of which specialists with fundamental education in physics and mathematics can take an active part and the development of basic knowledge by students in the field of creating the physiology of the nervous system, basic fundamental concepts, laws and theories of modern neurophysiology.

After mastering the course, the student will understand the basic fundamental concepts, laws and theories of modern neurophysiology, the general principles of the structure of the nervous system of vertebrates and invertebrates, the history of the development of ideas about human physiology, modern ideas about the principles of functioning of the systems that form the human body, basic fundamental concepts, laws and theories modern physiology, general principles of regulation of functions in the human body.

1. Study objective

Purpose of the course

The course is divided into two modules:

- physiology of the visceral systems
- physiology of the nervous system

The purpose of the first module is the mastering by students of basic knowledge related to the physiology of the visceral systems. Familiarization of students with the mechanisms of normal functioning of the body, the principles of regulation of various systems of the body and with the consequences of deviations in the work of regulation systems (elements of pathological physiology). Determination of the range of the most urgent modern physiological issues and problems, in the solution of which specialists with fundamental education in the field of physics and mathematics can take an active part.

The purpose of the second module is the mastering by students of basic knowledge in the field of creating the physiology of the nervous system, basic fundamental concepts, laws and theories of modern neurophysiology.

Tasks of the course

The objectives of the first module are:

- Familiarization of students with the main mechanisms of functioning of the most important internal systems of the body - blood circulation, respiration, excretion, digestion.
- Familiarization of students with medical terminology, which should enable them to effectively collaborate with doctors and work in medical research laboratories.
- A detailed analysis of the mechanisms of regulation of the activity of the internal systems of the body.
- Analysis of mathematical models of physiological processes.
- Familiarization of students with the basic methods of physiological research and the equipment used for this.
- Development of students' ability to navigate in the assessment of quantitative relationships and patterns of body functioning in normal conditions and in the most common types of pathology.
- Critical analysis of a number of existing physiological and clinical concepts of the mechanisms of occurrence of pathological conditions.

The objectives of the second module are:

- Teaching students the basics of modern concepts in the field of laws, theories and models that underlie modern physiology of the nervous system.
- Mastering neurophysiological terminology.
- Mastering the skills of independent work and mastering new sections of physiology.
- Familiarization of students with the basic methods of neurophysiological research and the equipment used for this.
- Developing the ability to navigate in classical and modern formulations of fundamental and applied problems in the field of neurophysiology; evaluate the correctness of the problem setting and the reliability of the conclusions.

2. List of the planned results of the course (training module), correlated with the planned results of the mastering the educational program

Mastering the discipline is aimed at the formation of the following competencies:

Code and the name of the competence	Competency indicators
UC-1 Search and identify, critically assess, and synthesize information, apply a systematic approach to problem-solving	UC-1.1 Analyze problems, highlight the stages of their solution, plan the actions required to solve them
	UC-1.2 Find, critically assess, and select information required for the task in hand
	UC-1.3 Consider various options for solving a problem, assess the advantages and disadvantages of each option
	UC-1.4 Make competent judgments and estimates supported by logic and reasoning
	UC-1.5 Identify and evaluate practical consequences of possible solutions to a problem
Gen.Pro.C-4 Collect and process scientific and technical and/or technological data for fundamental and applied problem-solving	Gen.Pro.C-4.1 Apply scientific research and intellectual analysis methods for professional problem-solving
	Gen.Pro.C-4.2 Search for primary sources of scientific and technical and/or technological information in professional settings
	Gen.Pro.C-4.3 Prepare abstracts, reports, bibliographies, and reviews of information in professional settings
	Gen.Pro.C-4.4 Use computer and network skills to obtain, store, and process scientific (technical, technological) information
Gen.Pro.C-5 Participate in fundamental and applied research and development activities; independently develop new theoretical research methods (including mathematical research methods)	Gen.Pro.C-5.1 Perform tasks in the field of theoretical and experimental research and development activities
	Gen.Pro.C-5.2 Apply new knowledge through the study of literature, scientific articles, and other sources
Pro.C-3 Select the necessary devices, tools, and research methods for problem-solving in a selected subject area	Pro.C-3.1 Apply functional principles and operating ranges of scientific equipment
	Pro.C-3.2 Apply theory to evaluate the accuracy of analytical calculations
	Pro.C-3.3 Estimate the accuracy of numerical methods used on a computer, learn the computational complexity of the applied algorithms and the number of required computing resources

3. List of the planned results of the course (training module)

As a result of studying the course the student should:

know:

- basic fundamental concepts, laws and theories of modern neurophysiology;
- general principles of the structure of the nervous system of vertebrates and invertebrates;
- the history of the development of ideas about human physiology;
- modern ideas about the principles of functioning of the systems that form the human body;
- basic fundamental concepts, laws and theories of modern physiology, general principles of regulation of functions in the human body.

be able to:

- to distinguish the normal physiological functions of organs and individual functional systems from pathological;
- use various research methods: the nervous system, the cardiovascular system, the digestive system, the respiratory system, the excretory system, etc., and, in particular, the functions of the brain, heart, lungs, kidneys, etc.

master:

- neurophysiological terminology;
- skills of independent work and mastering new sections of physiology;
- the foundations of modern concepts in the field of laws, theories and models that underlie the modern physiology of the nervous system;
- the culture of formulating, analyzing and solving fundamental and applied problems, the skills of competently describing the solution of problems and presenting the results obtained;
- physiological and medical terminology;
- skills of independent work and mastering new sections of physiology;
- the culture of setting, analyzing and solving fundamental and applied physiological problems.

4. Content of the course (training module), structured by topics (sections), indicating the number of allocated academic hours and types of training sessions

4.1. The sections of the course (training module) and the complexity of the types of training sessions

№	Topic (section) of the course	Types of training sessions, including independent work			
		Lectures	Seminars	Laboratory practical	Independent work
1	Physiology is the science of life of the organism	1			3
2	Physiological properties of striated and smooth muscles	2			4
3	Physiological bases of humoral-hormonal regulation	2			4
4	Motor functions of the body	2			3
5	Physiology of the heart	2			4
6	The internal environment of the body, its physiological significance	2			4
7	Breath. Physiological mechanisms of external respiration	2			4
8	Digestion	2			4
9	Energy exchange	2			3
10	Highlighting	2			4
11	Physiology of sensory systems	2			4
12	Behavior. Reflex theory	2			4
13	Central architecture of the behavioral act from the perspective of the theory of functional systems P.K. Anokhin	2			4
14	Psychophysiology	2			3
15	Sleep	1			4
16	Mental activity of the brain: consciousness, emotions, feelings	2			4
AH in total		30			60
Exam preparation		0 AH.			
Total complexity		90 AH., credits in total 2			

4.2. Content of the course (training module), structured by topics (sections)

Semester: 7 (Fall)

1. Physiology is the science of life of the organism

General principles of the functioning of the whole organism. Physiology of excitable tissues. The structure and function of membranes of cells of excitable tissues. Excitability and arousal. Bioelectric processes in excitable cells. Mechanisms of transport of substances through the membrane. Characterization of membrane ion channels. Resting potential and action potential. Change in membrane excitability during a single excitation cycle.

2. Physiological properties of striated and smooth muscles

The mechanism of muscle contraction. Physiology of nerves and nerve fibers. The laws of the conduction of excitation along the nerves. The mechanism of the propagation of excitation along myelinic and nonmyelinated fibers. Physiology of synapses: properties of synapses, the mechanism of transmission of excitation in synapses.

3. Physiological bases of humoral-hormonal regulation

Nervous regulation of physiological functions. Structural and functional organization of the nervous system. Research methods of the central nervous system. Brain functions. Neuron. Systemic organization of nerve centers and their properties. Inhibition in the central nervous system. Types and mechanisms of braking. Integrative activity of the central nervous system.

4. Motor functions of the body

Maintaining muscle tone, posture formation and voluntary movement. The autonomic nervous system. Structural and functional features. Mediators and receptors. The sympathoadrenal system. Vegetative reflexes and vegetative tone.

5. Physiology of the heart

Cardiac cycle. Properties of the heart muscle. Regulation of the heart. Hemodynamics of the systemic and pulmonary circulation. Basic hemodynamic parameters. The mechanism of transcapillary exchange. Features of regional blood circulation. A functional system that determines the optimal blood pressure level for metabolism. Clinical and physiological methods for studying the cardiovascular system in humans.

6. The internal environment of the body, its physiological significance

Composition of blood, its functions, basic blood parameters. Functional systems that maintain blood pH and osmotic pressure at an optimal level for metabolism. Coagulation and anticoagulant blood systems. Blood groups. Physiological bases of blood transfusion.

7. Breath. Physiological mechanisms of external respiration

Physiological mechanisms of external respiration. Gas exchange between alveolar air and blood. Transport of gases by blood. Oxyhemoglobin dissociation curve. Breathing at altered atmospheric pressure. Nervous and humoral regulation of respiration. A functional system that provides an optimal blood gas composition for metabolism.

8. Digestion

Digestive tract functions, mechanisms of their regulation. Features of digestion in various parts of the digestive tract. Liver function. A functional system that maintains the level of nutrients in the blood at an optimal level for metabolism. The mechanism of hunger and satiety.

9. Energy exchange

Basic and general exchange. Methods for assessing human energy metabolism. Principles of drawing up food rations. Thermoregulation. Body temperature scheme. Physiological fluctuations in human body temperature. A functional system that maintains body temperature at an optimal level for metabolism. Heat production and heat transfer paths. Physiological bases of hypothermia.

10. Highlighting

Excretory organs, their participation in maintaining the most important parameters of homeostasis. Kidney, its functions. Nephron as a structural and functional unit of the kidney. Processes of urine formation, their regulation. A functional system that maintains the constancy of the osmotic pressure of the blood.

11. Physiology of sensory systems

Physiology of analyzers. Characteristics of the individual links of the analyzer. Private physiology of analyzers. Physiology of pain. The role of analyzers in the operation of functional systems.

12. Behavior. Reflex theory

Congenital and acquired forms of behavior. An unconditioned reflex, an instinct. Conditioned reflexes. Classification, development rules. Dynamic stereotype. Types and inhibition in higher nervous activity.

13. Central architecture of the behavioral act from the perspective of the theory of functional systems P.K. Anokhin

Nodal stages of the central architecture of the behavioral act. Vegetative and endocrine support of the behavioral act.

14. Psychophysiology

Systemic organization of emotional reactions. The biological role of emotions. Theories of emotions. Emotional stress, resistance and predisposition to it. Prevention of emotional stress.

15. Sleep

The biological significance and structure of sleep. Modern concepts of sleep mechanisms.

16. Mental activity of the brain: consciousness, emotions, feelings

Systemic organization of sexual functions. Mechanisms of regulation of sexual functions. The ratio of social and biological factors in the implementation of sexual functions.

5. Description of the material and technical facilities that are necessary for the implementation of the educational process of the course (training module)

Classroom equipped with a computer and multimedia equipment (projector, sound system).

6. List of the main and additional literature, that is necessary for the course (training module) mastering

Main literature

Provided at the department:
Human physiology. Ed. V.M. Smirnov. Textbook. M., Medicine, 2002. 608 p .: ill. ISBN 5-225-04175-2.
Physiology. Foundations and functional systems. Lecture course. Authors: E.A. Yumatov et al. Ed. K.V. Sudakova M., 2000, 784 p.
K.V.Sudakov. Textbook "Normal physiology". M. "Medicine", 2006.
Textbook. "Human physiology". Ed. R. Schmidt and G. Tevs. M. "Mir", 2005, volume 1-3.

Additional literature
Provided at the department:
1.C. Caro, T. Schroter, R. Pedley, W. Seed. Mechanics of blood circulation. M., Mir, 1980.
2. McDonald D.A. Blood flow in arteries. Fifth edition. 2008.
3. Levtov V.A., Regirer S.A., Shadrina N.Kh. Blood rheology. M. Medicine, 1982, p. 270.
4. Furchgott R.F., Zawadzki J.V. The obligatory role of endothelial cells in the relaxation of arterial smooth muscle by acetylcholine. Nature 1980, v. 288, p. 373-376.
5. Furchgott R. F., Cherry P.D., Zawadzki J. V., Jothianandan D. Endothelial cells as mediators of vasodilation of arteries. J. Cardiovasc. Pharmacol. 1984, v. 6, p. S336-S343.

7. List of web resources that are necessary for the course (training module) mastering

Издательство IOP Publishing, сайт издательства: http://iopscience.iop.org/
Журналы World Scientific: http://www.worldscientific.com/page/worldscinet
Издательство Шпрингер: SpringerLink – http://link.springer.com
Издательство Ельсивир: http://www.elsiever.com
Издания Американского кардиологического общества: http://www.aha.org

8. List of information technologies used for implementation of the educational process, including a list of software and information reference systems (if necessary)

For some of the lessons, you will need Zoom. Google Drive to access course materials. The presence of smartphones / laptops during classes is encouraged to participate in interactive exercises.

9. Guidelines for students to master the course

A student studying a discipline must, on the one hand, master the general conceptual apparatus, and on the other hand, must learn to apply theoretical knowledge in practice.
As a result of studying the discipline, the student must know the basic definitions of the discipline, be able to apply the knowledge gained to solve various problems.
Successful completion of the course requires:
- attendance of all classes provided for by the curriculum for the discipline;
- keeping a synopsis of classes;
- student's intense independent work.
Independent work includes:
- reading recommended literature;
- study of educational material, preparation of answers to questions intended for independent study;
- solving problems offered to students in the classroom;
- preparation for the performance of tasks of the current and intermediate certification.
An indicator of mastery of the material is the ability to answer questions on the topics of the discipline without a synopsis.
It is important to achieve an understanding of the material being studied, not its mechanical memorization. If you find it difficult to study certain topics, questions, you should seek advice from a teacher.
Intermediate control of students' knowledge is possible in the form of solving problems in accordance with the topic of classes.

SUPPLEMENT

Assessment funds for course (training module)

major:	Biotechnology
specialization:	Biomedical Engineering/Биомедицинская инженерия Phystech School of Biological and Medical Physics Center for educational programs in bioinformatics
term:	4
qualification:	Bachelor

Semester, form of interim assessment: 7 (fall) - Grading test

Authors:

O.Y. Belogurova-Ovchinnikova, phd (candidate of biological sciences)
A.S. Dukh

1. Competencies formed during the process of studying the course

Code and the name of the competence	Competency indicators
UC-1 Search and identify, critically assess, and synthesize information, apply a systematic approach to problem-solving	UC-1.1 Analyze problems, highlight the stages of their solution, plan the actions required to solve them
	UC-1.2 Find, critically assess, and select information required for the task in hand
	UC-1.3 Consider various options for solving a problem, assess the advantages and disadvantages of each option
	UC-1.4 Make competent judgments and estimates supported by logic and reasoning
	UC-1.5 Identify and evaluate practical consequences of possible solutions to a problem
Gen.Pro.C-4 Collect and process scientific and technical and/or technological data for fundamental and applied problem-solving	Gen.Pro.C-4.1 Apply scientific research and intellectual analysis methods for professional problem-solving
	Gen.Pro.C-4.2 Search for primary sources of scientific and technical and/or technological information in professional settings
	Gen.Pro.C-4.3 Prepare abstracts, reports, bibliographies, and reviews of information in professional settings
	Gen.Pro.C-4.4 Use computer and network skills to obtain, store, and process scientific (technical, technological) information
Gen.Pro.C-5 Participate in fundamental and applied research and development activities; independently develop new theoretical research methods (including mathematical research methods)	Gen.Pro.C-5.1 Perform tasks in the field of theoretical and experimental research and development activities
	Gen.Pro.C-5.2 Apply new knowledge through the study of literature, scientific articles, and other sources
Pro.C-3 Select the necessary devices, tools, and research methods for problem-solving in a selected subject area	Pro.C-3.1 Apply functional principles and operating ranges of scientific equipment
	Pro.C-3.2 Apply theory to evaluate the accuracy of analytical calculations
	Pro.C-3.3 Estimate the accuracy of numerical methods used on a computer, learn the computational complexity of the applied algorithms and the number of required computing resources

2. Competency assessment indicators

As a result of studying the course the student should:

know:

- basic fundamental concepts, laws and theories of modern neurophysiology;
- general principles of the structure of the nervous system of vertebrates and invertebrates;
- the history of the development of ideas about human physiology;
- modern ideas about the principles of functioning of the systems that form the human body;
- basic fundamental concepts, laws and theories of modern physiology, general principles of regulation of functions in the human body.

be able to:

- to distinguish the normal physiological functions of organs and individual functional systems from pathological;
- use various research methods: the nervous system, the cardiovascular system, the digestive system, the respiratory system, the excretory system, etc., and, in particular, the functions of the brain, heart, lungs, kidneys, etc.

master:

- neurophysiological terminology;
- skills of independent work and mastering new sections of physiology;
- the foundations of modern concepts in the field of laws, theories and models that underlie the modern physiology of the nervous system;
- the culture of formulating, analyzing and solving fundamental and applied problems, the skills of competently describing the solution of problems and presenting the results obtained;
- physiological and medical terminology;
- skills of independent work and mastering new sections of physiology;
- the culture of setting, analyzing and solving fundamental and applied physiological problems.

3. List of typical control tasks used to evaluate knowledge and skills

During the current control, the student should be able to answer the following questions:

1. Estimate the value of the average blood flow velocity in the ascending aorta of a person.
2. Can a person's blood pressure be equal to 880/840 mm Hg? Is it dangerous?
3. Some authors report that the time of one complete turnover of blood in the human systemic circulation is approximately 23 seconds. Do you agree with this statement? If so, prove it to be true. If not, explain where this value might come from.
4. Estimate the maximum left ventricular volume if it is known that the cardiac output is 5 L / min, the heart rate is 1 Hz, and the ejection fraction is 65%.
5. Atherosclerotic plaque covers 80% of the artery cross-section. Estimate the pressure behind the narrowing site if the pressure before the stenosis is known to be 100 mm Hg, and in the absence of stenosis, the pressure behind the "narrowing" site was 98 mm Hg. (Assume that Poiseuille's law is applicable at the site of stenosis.)
6. Assuming that the blood in the left ventricle is 100% oxygenated, estimate the oxygen saturation of the blood in the right ventricle. (The person is at rest.)
7. Explain that oxygen saturation of arterial blood never reaches 100%.
8. It is known that the arterial endothelium "breaks down" when the shear stress on the wall exceeds 400 dynes / cm2. At what speed of blood flow this can happen in a vessel with a diameter of 4 mm. (The flow is considered Poiseuille.)
9. It is known that the osmotic pressure of plasma is approximately 200 times higher than the colloidal osmotic pressure. Why exactly colloidal osmotic pressure determines the rate of transcapillary fluid exchange?
10. Can the respiratory quotient of a mammal be greater than 1.0? Less than 0.7?
11. Performing aerobatics is usually accompanied by significant overloads. Pilots who overload too much can temporarily lose their sight. Why?
12. What is the "price of breathing"? How much is the breath of a person at rest?
13. Blood pH is one of the most "hard" constants in our body. What systems make it possible to maintain this value at a fairly stable level? (By the way, which one?)
14. Who are the "universal donor" and "universal recipient"? What circumstances provide these people with their remarkable status?
15. The erythrocyte lives in the human circulatory system for about 100-120 days, after which it must be destroyed. For what? What goes wrong in it?

During the class, interactive discussions can take place in the course chats, which are homework. It is possible to perform patent search as an independent task. Successful completion of all tasks of the course and completion of the knowledge control sections gives an advantage on differential credit.

4. Evaluation criteria

1. Estimate the value of the average blood flow velocity in the ascending aorta of a person.
2. Can a person's blood pressure be equal to 880/840 mm Hg? Is it dangerous?
3. Some authors report that the time of one complete turnover of blood in the human systemic circulation is approximately 23 seconds. Do you agree with this statement? If so, prove it to be true. If not, explain where this value might come from.
4. Estimate the maximum left ventricular volume if it is known that the cardiac output is 5 L / min, the heart rate is 1 Hz, and the ejection fraction is 65%.

5. Atherosclerotic plaque covers 80% of the artery cross-section. Estimate the pressure behind the narrowing site if the pressure before the stenosis is known to be 100 mm Hg, and in the absence of stenosis, the pressure behind the "narrowing" site was 98 mm Hg. (Assume that Poiseuille's law is applicable at the site of stenosis.)

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7. Explain that oxygen saturation of arterial blood never reaches 100%.

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9. It is known that the osmotic pressure of plasma is approximately 200 times higher than the colloidal osmotic pressure. Why exactly colloidal osmotic pressure determines the rate of transcapillary fluid exchange?

10. Can the respiratory quotient of a mammal be greater than 1.0? Less than 0.7?

11. Performing aerobatics is usually accompanied by significant overloads. Pilots who overload too much can temporarily lose their sight. Why?

12. What is the "price of breathing"? How much is the breath of a person at rest?

13. Blood pH is one of the most "hard" constants in our body. What systems make it possible to maintain this value at a fairly stable level? (By the way, which one?)

14. Who are the "universal donor" and "universal recipient"? What circumstances provide these people with their remarkable status?

15. The erythrocyte lives in the human circulatory system for about 100-120 days, after which it must be destroyed. For what? What goes wrong in it?

The mark is excellent (10 points) - it is given to a student who has shown comprehensive, systematic, deep knowledge of the curriculum of the discipline, who has an interest in this subject area, has demonstrated the ability to confidently and creatively put them into practice in solving specific problems, and a free and proper substantiation of decisions.

The mark is excellent (9 points) - it is given to a student who has shown comprehensive, systematic, in-depth knowledge of the curriculum of the discipline and the ability to confidently put them into practice in solving specific problems, free and proper substantiation of the decisions made.

The mark is excellent (8 points) - given to a student who has shown comprehensive, systematic, in-depth knowledge of the curriculum of the discipline and the ability to confidently apply them in practice in solving specific problems, correct justification of decisions made, with some shortcomings.

A mark is good (7 points) - it is put up for a student, if he knows the material firmly, sets it up competently and in essence, knows how to apply the knowledge gained in practice, but does not competently substantiate the results obtained.

Evaluation is good (6 points) - it is put up to a student, if he knows the material firmly, sets it up correctly and in essence, knows how to apply this knowledge in practice, but admits some inaccuracies in the answer or in solving problems.

A mark is good (5 points) - it is given to a student, if he basically knows the material, correctly and essentially sets it out, knows how to apply this knowledge in practice, but allows a sufficiently large number of inaccuracies to answer or solve problems.

Grade satisfactorily (4 points) is given to a student who has shown the fragmented, fragmented nature of knowledge, insufficiently correct formulations of basic concepts, violations of the logical sequence in the presentation of program material, but at the same time he has mastered the main sections of the curriculum necessary for further education and can apply knowledge is modeled in a standard situation.

Grade satisfactorily (3 points) - given to a student who showed the fragmented, scattered nature of knowledge, making mistakes in formulating basic concepts, disrupting the logical sequence in presenting program material, poorly masters the main sections of the curriculum required for further education and even applies the knowledge gained in a standard situation.

The rating is unsatisfactory (2 points) - is given to a student who does not know most of the main content of the curriculum of the discipline, makes gross mistakes in the wording of the basic principles and does not know how to use this knowledge when solving typical tasks.

Unsatisfactory mark (1 point) - is given to a student who does not know the main content of the discipline’s curriculum, makes gross errors in the wording of the basic concepts of the discipline and does not have any skills to solve typical practical problems.

5. Methodological materials defining the procedures for the assessment of knowledge, skills, abilities and/or experience

When conducting an oral differential credit, the student is given 60 minutes to prepare. The poll of a student on a ticket for an oral differential credit should not exceed one astronomical hour.