Ministry of Education and Science of Ukraine
National Aerospace University
"Kharkiv Aviation Institute"

Department of Aircraft Control Systems

APPROVED:
Guarantor of Educational Program
_____ A. S. Kulik
«_27_» _08_____ 2021

WORKING PROGRAM OF EDUCATIONAL DISCIPLINE

AUTONOMOUS NAVIGATION SYSTEMS DESIGN

Field of Study: 17 – Electronics and Telecommunication

Program Subject Area: 173 «Avionics»

Educational Program: Systems of Autonomous Navigation and Adaptive Control of Aircrafts

Education Level: 2nd (master degree)

Kharkiv 2021

Work program of compulsory discipline «Autonomous Navigation Systems Design» is for English-speaking students of training direction 173 – Avionics

«_27_» __August_ 2021, _9 p.

Prepared: Subbota A.M., professor of department 301, Candidate of Science (Engineering)

(sign)

Sokol D.V., assistant of department 301

(sign)

The work program has been examined at the meeting of dept. 301 «Aircraft Control Systems».

Record of proceeding: No. __1___ from "_27_" _August_2021

Head of the department
PhD (Engineering), Candidate of Science (sign) K. Yu. Dergachov

1. Course description

<table>
<tr><td>Indices</td><td>Branch of education, learning direction, education level</td><td>Course specification</td></tr>
<tr><td>ECTS credits – 6</td><td rowspan="3">Field of Study:
17 – Electronics and Telecommunication</td><td>Full-time study</td></tr>
<tr><td>Modulus – 3</td><td>Professional training area</td></tr>
<tr><td>Semantic modulus – 3</td><td rowspan="2">Calendar year:</td></tr>
<tr><td rowspan="2">Research into the topic
_____
(name)</td><td rowspan="3">Program Subject Area:
173 – Avionics</td></tr>
<tr><td>2021/22</td></tr>
<tr><td>Total hours – 180</td><td rowspan="3">Educational Program:
Systems of Autonomous Navigation and Adaptive Control of Aircrafts</td><td>Semester
10</td></tr>
<tr><td>Weekly hours for full-time study:</td><td>Lectures[1)]
18 hrs.</td></tr>
<tr><td colspan="2">Semester 10</td><td>Practice classes</td></tr>
<tr><td>classroom
56 hrs.</td><td>self-study
124 hrs.</td><td rowspan="6">Education level:
2nd (master degree)</td><td>18 hrs.</td></tr>
<tr><td colspan="2" rowspan="5"></td><td>Lab classes
20 hrs.</td></tr>
<tr><td></td></tr>
<tr><td>Self-study (unaided) work
124 hrs.</td></tr>
<tr><td>Assessment form</td></tr>
<tr><td>exam</td><td>estimated pass</td></tr>
</table>

Note: ratio of classroom working and unaided (self-study) work makes:
(under full-time education)
– 56/124 (under full-time education).

[1)] depending on timetable, classroom studies can decrease or enlarge by one hour in a week

2. Purpose and objectives of academic discipline

Learning Aims – arming students with principles and basic applied techniques of designing flying objects control systems using data on the object's position getting by measuring devices.

Training Objectives – the study of theoretical foundations of construction and technical characteristics of measuring devices in the aircraft control systems, the MEMS sensors application when solve the flying object control problem.

Learning Outcomes

On successful completion of the subject, students

should know:

- operation principles of the main types of sensors measuring physical parameters;
- methods and means of measuring flying object parameters;
- methods of analog-digital and digital-analog conversions of sensors signals;
- operation principles of modern measuring modules.

should be able to:

- create block diagram of the flying object control system;
- carry out verbal, graphical, mathematical and machine descriptions of signals, sensors;
- connect modern measuring modules with the object control channel, process the received data, use it to solve the control problem.

have a general notion:

- about classical methods of getting the flying object's position and using its information solving navigation problem.

3. Content of the course

Module 1.

Semantic Modulus 1. Objectives, methods and tools of the autonomous navigation system design

Topic 1. Introduction to discipline «Autonomous navigation system design». Subject and problems of discipline. The basic concepts. Task and aim of control system designing.

Topic 2. Classification and basic characteristics of the objects and systems. Classification of the automatic control systems, its properties. Dynamic and frequency quality parameters of system.

Topic 3. Choice and matching of the elements of autonomous navigation systems. Selection of sensors and actuators for system, information and power coordination of elements of the autonomous navigation systems.

Module 2.

Semantic Modulus 2. Sensors in the control systems

Topic 4. Angle position sensors. Gyroscopes. The operation principles, design features, specifications, applications.

Topic 5. Angular rate sensors. The operation principles, design features, specifications, applications.

Topic 6. Acceleration sensors. The operation principles, design features, specifications, applications.

Topic 7. Modern sensor modules. MPU-6050. The operation principles, functionality, applications, data processing.

Module 3.

Semantic Modulus 3. Autonomous navigation system design

Topic 8. Development of the technical task for course project. Formation of the structure of the technical task. Matching of the technical task. Assessing the design problem state.

Topic 9. Study of the control object. Block diagram creation of the autonomous navigation system.

Topic 10. Selection of sensors and actuators for designed system. Implementation of the measuring channel for the control system.

Topic 11. Analysis of the designed navigation control system.

Topic 12. The choice of control law. Approach to the choice of control principle.

4. Course structure

Semantic modules and topics	Hours					
	full-time					
	total	among them				
		Lect	Pr	Lab	Ind	S.I.
1	2	3	4	5	6	7
Module 1						
Semantic Modulus 1. Objectives, methods and tools of the autonomous navigation system design						
Topic 1. Introduction to discipline «Autonomous navigation system design».	6	2	-	-	-	4
Topic 2. Classification and basic characteristics of the objects and systems.	10	2	-	-	-	8
Topic 3. Choice and matching of the elements of autonomous navigation systems.	16	2	-	-	-	14
Total for semantic modulus 1	32	6	-	-	-	26
Module 2						
Semantic Modulus 2. Sensors in the control systems						
Topic 4. Angle position sensors.	22	4	-	4	-	14
Topic 5. Angular rate sensors.	18	2	-	4	-	12
Topic 6. Acceleration sensors.	18	2	-	4	-	12
Topic 7. Modern sensor modules.	30	4	-	8	-	18
Total for semantic modulus 2	88	12	-	20	-	56
Module 3						
Semantic Modulus 3. Autonomous navigation system design						
Topic 8. Development of the technical task for course project.	8	-	2	-	-	6
Topic 9. Study of the control object.	10	-	4	-	-	6
Topic 10. Selection of sensors and actuators for designed system.	8	-	2	-	-	6
Topic 11. Analysis of the designed navigation control system.	18	-	6	-	-	12
Topic 12. The choice of control law.	16	-	4	-	-	12
Total for semantic modulus 3	60	-	18	-	-	42
Course total	180	18	18	20	-	124

5. Topics of practice classes

№ a/o	Topic name	Hours
1	Development, matching and approval of the technical task.	2
2	Assessment of the state problem.	4
3	Choice of elements and block diagram creation for system.	2
4	Implementation of the measuring channel for the control system.	6
5	System research, control law implementation.	4
Total		**18**

6. Topics of lab classes

№ a/o	Topic name	Hours
1	Research of the angular rate sensor characteristics.	4
2	Research of the gyroscope with gimbals and its basic properties.	4
3	Research of the linear acceleration sensors.	4
4	Realization and configuration of the MPU-6050. Algorithm implementation for the data obtaining.	4
5	Processing and analysis of data from MPU-6050.	4
Total		**20**

7. Self-study (unaided) work

№ a/o	Topic name	Hours
1	Topic 1. Introduction to discipline «Autonomous navigation system design».	4
2	Topic 2. Classification and basic characteristics of the objects and systems.	8
3	Topic 3. Choice and matching of the elements of autonomous navigation systems.	14
4	Topic 4. Angle position sensors.	14
5	Topic 5. Angular rate sensors.	12
6	Topic 6. Acceleration sensors.	12
7	Topic 7. Modern sensor modules.	18
8	Topic 8. Development of the technical task for course project.	6
9	Topic 9. Study of the control object.	6
10	Topic 10. Selection of sensors and actuators for designed system.	6
11	Topic 11. Analysis of the designed navigation control system.	12
12	Topic 12. The choice of control law.	12
Total		**124**

8. Teaching methods

Lectures delivering, conducting lab classes, independent work of students on materials issued by the department (learning the manuals).

9. Forms of control

Current test points that score submitted lab reports, evaluation (grades) of semantic topics, final examination, report of the course project.

10. Assignment of grade points obtaining by a student (credit passed)

<table>
<tr><td colspan="7">Current tests and unaided work</td><td rowspan="3">Summative test (examination) due to refusing the received current points and intent taking the exam if allowed</td></tr>
<tr><td colspan="3">Semantic Modulus №1 (weight)</td><td colspan="3">Semantic Modulus №2 (weight)</td><td rowspan="2">Sum</td></tr>
<tr><td>T1</td><td>T2</td><td>T3</td><td>T4</td><td>T5</td><td>T6</td><td>T7</td></tr>
<tr><td>5</td><td>5</td><td>5</td><td>20</td><td>20</td><td>20</td><td>25</td><td>100</td><td>100</td></tr>
</table>

<table>
<tr><td colspan="5">Current tests and unaided work</td><td rowspan="3">Summative test (estimated pass) due to refusing the received current points and intent taking the exam if allowed</td></tr>
<tr><td colspan="4">Semantic Modulus №3 (weight)</td><td rowspan="2">Sum</td></tr>
<tr><td>T8</td><td>T9</td><td>T10</td><td>T11</td><td>T12</td></tr>
<tr><td>15</td><td>20</td><td>20</td><td>25</td><td>20</td><td>100</td><td>100</td></tr>
</table>

T1, T2, …, T12 – topics of Semantic Modulus

11. Methodical support

1. Electronic abstracts of lectures.
2. Summary notes of lectures.
3. Methodical instructions for practice work.
4. Methodical instructions for laboratory work.
5. Topics for self-study (unaided) work.
6. Checklist.

12. Recommended reading

Basic

1. David A. Caughey Sibley School of Mechanical & Aerospace Engineering Cornell University Ithaca / New York, 153p., 2011
2. David G. Hull Fundamentals of Airplane Flight Mechanics / The University of Texas at Austin Austin, Aerospace Engineering and Engineering Mechanics, Springer Berlin Heidelberg New York, 310p., 2007
3. Mario N. Armenise, Caterina Ciminelli, Vittorio M. N. Passaro, Francesco Dell'Olio, Advances in Gyroscope Technologies / Kindle Edition, 117p., 2011
4. M.V. Cook., Flight Dynamics Principles / Elsevier's Science &Technology Rights Department in Oxford, UK, 491 p.,2007
5. Kai N. Lee, Compass and Gyroscope: Integrating Science And Politics For The Environment / Island Press, 255p., 1994
6. Paulo Sergio de Brito Andre, Humberto Varum Accelerometers: Principles, Structure and Applications / Nova Science Publishers, 295 p., 2013
7. Ville Kaajakari, Practical MEMS: Design of microsystems, accelerometers, gyroscopes, RF MEMS, optical MEMS, and microfluidic systems / Small Gear Publishing, 496p., 2009

Complementary reading

1. Anton H.J. de Ruiter, Christopher J. Damaren and James R. Forbes, Spacecraft Dynamics and Control - An Introduction/John Wiley & Sons, Ltd. Published, 450p.,2013
2. Macdonald Malcom, B. Viorel, The International Handbook of Space Technology, Springer Praxis Books, Berlin, 715p., 2014
3. Gloria Menegaz, Basics of Signals and System/ 91p., 2012.

13. Information resources

1. Site of department 301: k301.info.
2. Official site of the cross-platform documentation: www.doc.crossplatform.ru