Ministry of Education and Science of Ukraine
National Aviation University

# AEROHYDROGASDYNAMICS
# AND FLIGHT DYNAMICS
# PART II. A: FLIGHT DYNAMICS

## SELF-STUDY METHOD GUIDE

Part II. A

FLIGHT DYNAMICS
Trajectory Problems. A
for the Students of the
Field of Study 27 "Transport",
Specialty 272 "Aviation Transport"

Kyiv 2020

Compiler *A. V. Goncharenko*

Містять декілька рекомендацій для самостійної роботи, щодо виконання розрахунково-графічної роботи з дисципліни «Аерогідрогазодинаміка та динаміка польоту», в Частині ІІ. А, що стосується розділу «Динаміка польоту» при розв'язанні траєкторних задач повітряного судна.

Для студентів 3-го курсу галузі знань 27 «Транспорт», спеціальності 272 «Авіаційний транспорт».

The **Method Guide** contains a few recommendations on the Self-Study in regards with the completion of the Calculation and Graphic Work on the academic subject of "Aerohydrogasdynamics and Flight Dynamics", in Part II. A, concerning the section of "Flight Dynamics" at solving the aircraft trajectory problems.

Designed for the 3$^{rd}$ year students of the Field of Study 27 "Transport", Specialty 272 "Aviation Transport".

# CONTENTS

# INTRODUCTION

This **METHOD GUIDE ON THE SELF-STUDY** (SS) is contemplated in response to the needs of our students in more detailed elaborations concerning problems stated, set or given for the students' independent work on this subject for the specified **CALCULATION AND GRAPHIC WORK** (CGW), possibly used in their **TERM PAPERING** (TP), **COURSE PROJECTING** (CP), further **GRADUATION PAPERS** or even **PH.D. STUDIES.** The whole material is split into portions. Each portion is intended to cover a fraction of probable applications aimed at **AERO-HYDRO-GAS-DYNAMICS AND FLIGHT DYNAMICS** or their adjacent problems.

The presented in this, **Second Part. A, PART II. A** of the **METHOD GUIDE ON the SS** problems are dedicated, and a special attention is drawn here, to the scientific component of the SS work. Specifically, the objectives of the **PART II. A** are to help students cope with the challenging problems relating to the **AIRCRAFT** (A/C) **TRAJECTORY (PATH) PROBLEMS** (T(P)/P) in regards with the A/C and its elements **AERODYNAMIC CHARACTERISTIC** (AC) determined in accordance with the **First Part, PART I,** of the **METHOD GUIDE** on the SS in the framework of the **MATERIAL PARTICLE MOTION THEORY.**

The set of the considered problems is based upon the **ACADEMIC SUBJECT PROGRAM** on **"AEROHYDROGASDYNAMICS AND FLIGHT DYNAMICS"**, as well as upon the **RECOMMENDED LITERATURE SOURCES** (the list is presented, but not limited to it). The **LIST OF LITERATURE** at the end of the **METHOD GUIDE** is basic (major) and compiled partially in the alphabetic order with respect to the matter of the supposed (assumed) importance.

The **REFERENCE LIST** is selected, set in the order [1-212], does not pretend for completeness, but instead it is aimed at developing the students' abilities of thinking and to analyze, contemplate in the specified directory field rather than their abilities to know and memorize. However, these are very significant too. Actually, in the contemporary informative boom world, the needed or required data can easily be retrieved from the internet, found in multiple references, studies, guidance materials [1-17], dictionaries [10], comprehensive books [11] or monographs etc. The **METHOD GUIDE** is designed for the 3rd year students of the Field of Study: 27 "Transport", Specialty: 272

"Aviation Transport". It includes detailed solutions for several (some, a few) examples of the A/C P/P.

It is proposed to select the **VARIANTS** for the CGW, as well as for TP or CP completion in accordance with the recommendations of [12, 18, 19]:

1. If the last figure of the number of the **STUDENT'S CREDIT BOOK** is "5" and more, then it is the A/C with the **TURBOJET ENGINE** that must be taking for consideration.

2. If the last figure of the number of the **STUDENT'S CREDIT BOOK** is less than "5", then it is the A/C with the **TURBOPROP ENGINE** that must be taking for consideration.

3. The **VARIANT** itself is selected by the last figure of the number of the **STUDENT'S CREDIT BOOK.**

4. For the **WING** calculation it is also by the last figure of the number of the **STUDENT'S CREDIT BOOK.**

5. For the **WING MECHANIZATION** calculation it is by the third from the end figure of the number of the **STUDENT'S CREDIT BOOK.**

In fact, the presented **PART II. A** of the **METHOD GUIDE** on the SS is a development of the **PART I**, of which results are the initial data for the problems considered (set, formulated, stated) herewith.

# I. Start & Acceleration down the Runway before Takeoff

*The principal theoretical provisions can be found out in references [1-17].*

In assumption that **Aircraft** is an **Absolutely Rigid Body**, with the **Constant Mass**, the **Differential Equations** of the **Aircraft Motion** in the **Vector Form** will be, [2, p. 18, (1.2)]:

$$m\frac{d\vec{V}}{dt} = \vec{F},\tag{1}$$

$$m\frac{d\vec{K}}{dt} = \vec{M},\tag{2}$$

where $m$ – the **Mass** of the **Aircraft**; $\vec{V}$ – the **Speed** of the **Aircraft's Centre of Mass**; $t$ – **Time**; $\vec{F}$ – the **Main Vector of the External Forces**; $\vec{K}$ – the **Summarized Angular Momentum (Kinetic Moment) Vector** with respect to the **Aircraft's Centre of Mass**; $\vec{M}$ – the **Main Moment of the External Forces** with respect to the **Aircraft's Centre of Mass.**

## § 1. Parameters essential for the motion evaluation during accelerating down the runway

At the **Start** and **Acceleration of Aircraft** for the **Takeoff,** the system of (1, 2) (in the idealized assumption of: the **Balanced Aircraft** motion (therefore, $\vec{K} = \vec{M} = 0$); and the **Aircraft** runs **Rectilinearly** along the $(Ox)$ **Axis;** and in the **Translational Way;** plus neglecting the **Friction** or supposing it to be included into the **Thrust)** will get the view of

$$m\ddot{x} = T - D,\tag{3}$$

$$m\ddot{y} = -mg + L, \qquad (4)$$

where:

$$\ddot{x} = \frac{dV_x}{dt} = \frac{d\dot{x}}{dt} = \frac{d^2x}{dt^2} \qquad (5)$$

– **HORIZONTAL PROJECTION** of the **ACCELERATION** of the **AIRCRAFT'S CENTRE OF MASS**;

$$V_x = \dot{x} = \frac{dx}{dt} \qquad (6)$$

– **HORIZONTAL PROJECTION** of the **SPEED** of the **AIRCRAFT'S CENTRE OF MASS** $\vec{V}$; $x$ – displacement of (distance run by) the **AIRCRAFT'S CENTRE OF MASS** along the **RUNWAY (HORIZONTAL AXIS OF** $(Ox)$**)**;

$T$ – the **AIRCRAFT'S ENGINES THRUST**; $D$ – the **AERODYNAMIC DRAG FORCE**:

$$D = C_x \frac{\rho V^2}{2} S, \qquad (7)$$

where $C_x$ – the **AERODYNAMIC DRAG FORCE COEFFICIENT** at the **AIRCRAFT'S ACCELERATION (PRE-TAKEOFF) CONFIGURATION AND CONDITIONS**; $\rho$ – the **DENSITY OF THE AIR** at the **AIRCRAFT'S ACCELERATION CONDITIONS**; $S$ – the **CHARACTERISTIC AREA**;

$$\ddot{y} = \frac{dV_y}{dt} = \frac{d\dot{y}}{dt} = \frac{d^2y}{dt^2} \qquad (8)$$

– **VERTICAL PROJECTION** of the **ACCELERATION** of the **AIRCRAFT'S CENTRE OF MASS**;

$$V_y = \dot{y} = \frac{dy}{dt} \qquad (9)$$

– **VERTICAL PROJECTION** of the **SPEED** of the **AIRCRAFT'S CENTRE OF MASS** $\vec{V}$; $y$ – displacement of the **AIRCRAFT'S CENTRE OF MASS** perpendicularly to the **RUNWAY (VERTICAL AXIS OF** $(Oy)$**)**;

$g$ – acceleration of the **FORCE OF GRAVITY**; $L$ – the **AERODYNAMIC FORCE OF LIFT**:

$$L = C_y \frac{\rho V^2}{2} S \,, \tag{10}$$

where $C_y$ – the **AERODYNAMIC LIFT FORCE COEFFICIENT** at the **AIRCRAFT'S ACCELERATION CONFIGURATION AND CONDITIONS.**

## § 2. Determination of the speed when accelerating down the runway

Then, based on (1-10), supposing: the assumed above simplifications about the **HORIZONTAL AIRCRAFT'S CENTRE OF MASS MOTION ALONG THE HORIZONTAL AXIS OF** $(Ox)$**,** which results in the simplifying equation of $V_x = V$ ; plus idealizations for the zero **LIFT** and **FRICTION,** or the **FRICTION** being included into the **THRUST;** and the constant **THRUST;** one can write down

$$m \frac{dV_x}{dt} = m \frac{dV}{dt} = T - C_x \frac{\rho V^2}{2} S \,. \tag{11}$$

In accordance with [7, Volume 1, Chapter X, § 2, p. 318, item # 12], the **ANALYTICAL SOLUTION** to the **DIFFERENTIAL EQUATION** of (11) will be as it follows:

$$\frac{dV}{T - C_x \frac{\rho S}{2} V^2} = \frac{dt}{m} \,. \qquad \frac{\dfrac{dV}{C_x \frac{\rho S}{2}}}{\dfrac{T}{C_x \frac{\rho S}{2}} - \dfrac{C_x \frac{\rho S}{2}}{C_x \frac{\rho S}{2}} V^2} = \frac{dt}{m} \,. \tag{12}$$

Deliberately ommited for the perceptional ease formulas of (13-23) lead to

$$V(t) = \dot{x}(t) = \sqrt{\frac{T}{C_x \frac{\rho S}{2}} \left( \frac{e^{\frac{\sqrt{2C_x \rho S T}}{m} t} - 1}{e^{\frac{\sqrt{2C_x \rho S T}}{m} t} + 1} \right)} \,. \tag{24}$$

## § 3. Determination of the distance when accelerating down the runway

The **DISTANCE RUN BY THE AIRCRAFT DOWN THE RUNWAY WITH RESPECT TO TIME** can be found from equation (24):

$$\int dx = \sqrt{\frac{T}{C_x \dfrac{\rho S}{2}}} \int \left( \frac{e^{\frac{\sqrt{2C_x\rho ST}}{m}t} - 1}{e^{\frac{\sqrt{2C_x\rho ST}}{m}t} + 1} \right) dt \ . \tag{25}$$

Deliberately ommited formulas of (26-51) yield

$$x(t) = \frac{m}{C_x\rho S}\left[ 2\ln\left( \frac{e^{\frac{\sqrt{2C_x\rho ST}}{m}t} + 1}{2} \right) - \ln\left| -e^{\frac{\sqrt{2C_x\rho ST}}{m}t} \right| \right]. \tag{52}$$

Both, the **ANALYTICAL** and **NUMERICAL SOLUTIONS** for (1-52) are going to be illustrated down the **TEXT** in the corresponding **SECTIONS.**

## § 4. Determination of the takeoff speed

For the conventionally **HORIZONTAL ACCELERATION** before the **TAKEOFF** of the **AIRCRAFT** down the **RUNWAY**, from the differential equation of (4), one can obtain, through the evident derivation of (53, 54),

$$V = \sqrt{\frac{2mg}{C_y\rho S}} \ . \tag{55}$$

Here, at the approach of (53-55), the **LIFT FORCE COEFFICIENT** value of $C_y$ ought to be taken into account from the **POLAR FOR THE TAKEOFF AIRCRAFT CONFIGURATION** found and plotted in the **FIRST PART OF THE CGW** completed in accordance with the **FIRST PART OF THE METHOD GUIDE** [12, 18, 19]. Moreover, the **SPEED** of $V$ obtained from relation of (55) should be ensured in the **RENEWED CONDITIONS** due to the **TAKEOFF AIRCRAFT RE-CONFIGURATION,** that is for the

corresponding increased $C_x$ value and because of that increased **DRAG FORCE.**

In the presented simplified consideration, since the real **TAKEOFF FROM THE GROUND PERIOD** takes not much time, it is acceptable for the **EDUCATIONAL EASE** to apply the **AIRCRAFT SPEED** just **GRATER** than the **SPEED** of $V$ yielded by the expression of (55).

### § 5. Plotting the diagrams of the aircraft start and acceleration down the runway

Equation (11) can be integrated either numerically or analytically (12-24).

In the case when the accepted data are:

$$T = 500 \cdot 10^3 \text{ N}; \qquad m = 100 \cdot 10^3 \text{ kg}; \qquad \rho = 1.225 \text{ kg/m}^3;$$
$$C_x = 0.02; \qquad S = 200 \text{ m}^2; \tag{56}$$

both results (analytical and numerical) are shown in Fig. 1.

The numerical integration result diagram is designated as $y(t)$: solid red bold curve. The analytical solution by (24) plot is depicted as $V(t)$: dashed cyan curve (see Fig. 1).

The **TAKEOFF SPEED** (see Fig. 1) is represented as Vtof : portrayed with the green dashed line; and it equals to 151.24 m/s calculated by formula (55) on the conditions of (56) and

$$C_y = 0.35; \qquad g = 9.807 \text{ m/s}^2; \tag{57}$$

at the **AIRCRAFT'S TAKEOFF CONFIGURATION AND CONDITIONS.**

Integration of the differential equation (4) solution (24), or double integration of the differential equation (4), yields the result represented with the diagram of the run distance illustrated in Fig. 2.

In the demonstrated case, the **TAKEOFF FROM THE GROUND** occurs after the **SPEED** of approximately 160 m/s, which equals 576 km/h, achieved at the **DISTANCE RUN** of 2,500 … 3,000 m, and at the timing of 32 … 35 s (see Fig. 1 and 2).
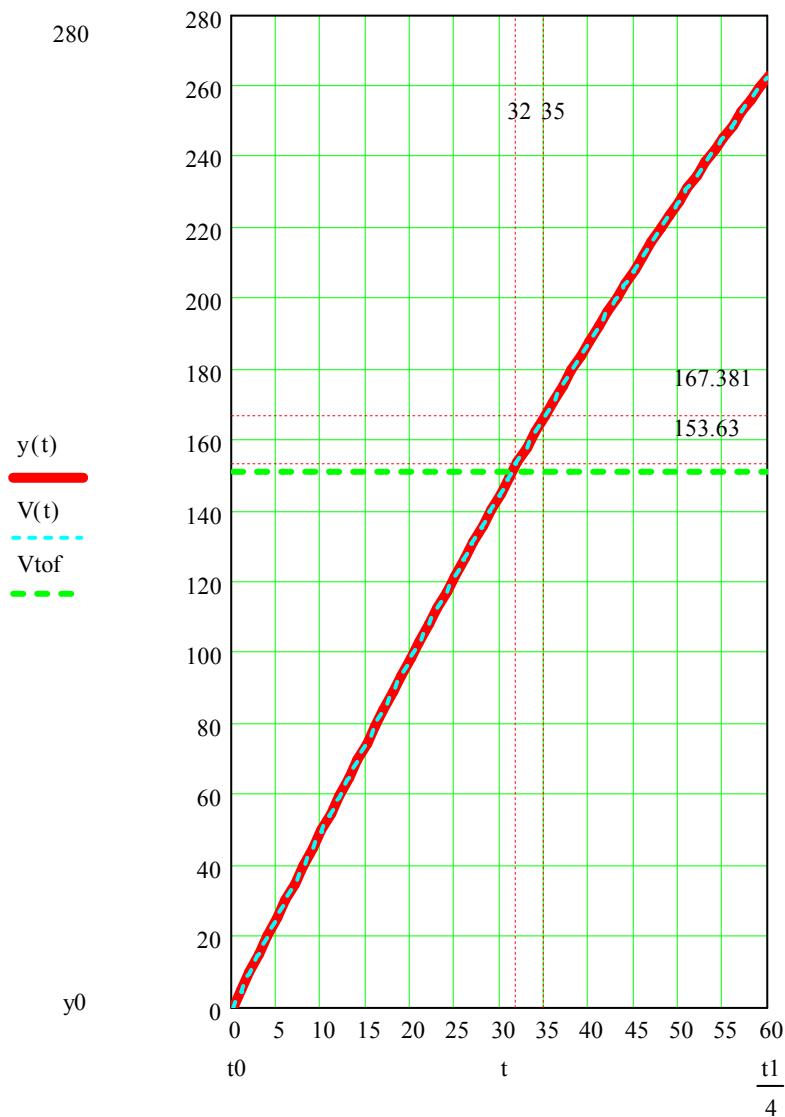
Fig. 1 – The diagram of the **AIRCRAFT'S SPEED** at the **ACCELERATION** down the **RUNWAY** after the **AIRCRAFT'S START**
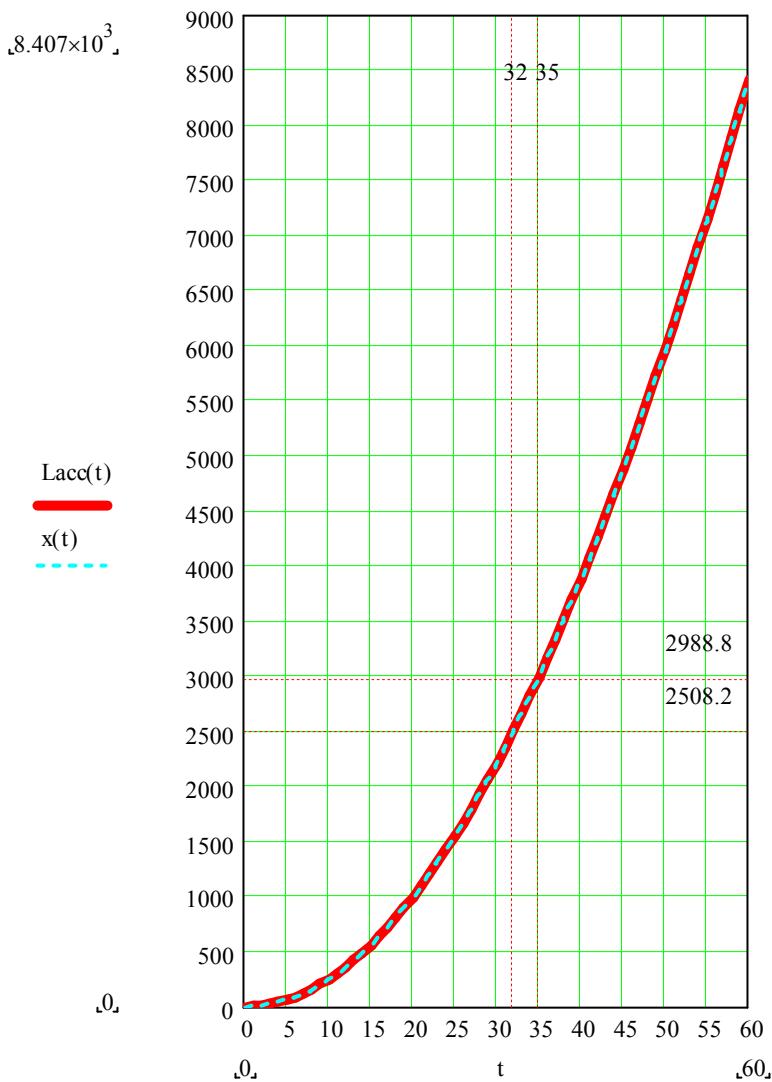
Fig. 2 – The diagram of the **AIRCRAFT'S SPEED** at the **ACCELERATION** down the **RUNWAY** after the **AIRCRAFT'S START**

In Fig. 2, the numerical integration result diagram for the equation of (24) is designated as $Lacc(t)$: solid red bold curve. The analytical solution plot obtained by the formula of (52) is depicted as $x(t)$: dashed cyan curve (see Fig. 2).

A few seconds later the **TAKEOFF FROM THE GROUND,** the **AIRCRAFT** should have the **RE-CONFIGURATION** for the **CLIMBING MODE.**

# II. TAKEOFF

*The principal theoretical provisions can be found out in references [1-17].*

The results of the previous **CHAPTER** symbolize that at the **SPEED** of approximately 160 m/s, which equals 576 km/h, achieved at the **DISTANCE RUN** of 2,500 … 3,000 m, and at the timing of 32 … 35 s (see Fig. 1 and 2), the **AIRCRAFT** should take the **TAKEOFF CONFIGURATION** and **TAKEOFF FROM THE GROUND.**

This short **STAGE** of the **AIRCRAFT'S FLIGHT** is characterized with a several second **TRANSITION PROCESS** from the **TAKEOFF FROM THE GROUND** to the **CLIMBING AIRCRAFT CONFIGURATION.**

## § 6. Determination of the takeoff equations of motion

After acquiring the **TAKEOFF CONFIGURATION** the **AIRCRAFT'S CENTER OF MASS** motion is not considered to be a **HORIZONTAL** any more (up to the **HORIZONTAL FRAGMENT OF THE FLIGHT).**

Supposedly, the controlling influence is organized in such way that the projections of the main vector of the external forces $\vec{F}$ upon the reference (coordinate) system $(xOy)$ axes: $F_x$ and $F_y$, depend proportionally upon the corresponding coordinates of the **AIRCRAFT'S CENTER OF MASS:** $x$ and $y$; and the main vector's of the external forces $\vec{F}$ projections are given with the following equations of

$$F_x = -a(x - X_c), \tag{58}$$
$$F_y = -a(y - Y_c), \tag{59}$$

where $a$ – the proportionality coefficient; $X_c$ and $Y_c$ – the coordinates of the center of the main vector $\vec{F}$ attraction.

A prototypic problem can be found in reference [5, pp. 201, 202, Problem # 26.34].

Then, the differential equations of motion in projections upon the axes of the reference (coordinate) system:

$$m\frac{d^2x}{dt^2} = F_x = -a(x - X_c),$$ (60)

$$m\frac{d^2y}{dt^2} = F_y = -a(y - Y_c).$$ (61)

Equations of (60, 61), dropping out their detailes of solution (62-90), will result, in accordance with [8, Volume 2, Chapter XIII, §§ 21-24, pp. 74-90], the **ANALYTICAL SOLUTION** to the **DIFFERENTIAL EQUATIONS:**

$$x(t) = V_{tof}\sqrt{\frac{m}{a}}\sin\left(\sqrt{\frac{a}{m}}t\right) + X_c\left[1 - \cos\left(\sqrt{\frac{a}{m}}t\right)\right],$$ (91)

$$y(t) = Y_c\left[1 - \cos\left(\sqrt{\frac{a}{m}}t\right)\right].$$ (92)

### § 7. Plotting the diagrams of the takeoff

Implementing the provisions of (1-92) it is possible to visualize the acquired dependencies. The data for the computer simulation are obtained from the previous modeling and calculations (including in the **FIRST PART OF THE CGW** completed in accordance with the **FIRST PART OF THE METHOD GUIDE** [12, 18, 19]) as follows:

$$V_{tof} = 160 \text{ m/s}; \qquad m = 100 \cdot 10^3 \text{ kg}; \qquad a = 100 \text{ N/m or } \left(\frac{kg}{s^2}\right);$$

$$X_c = 4000 \text{ m}; \qquad Y_c = 4000 \text{ m}.$$ (93)

The results for coordinates are shown in Fig. 3-5.
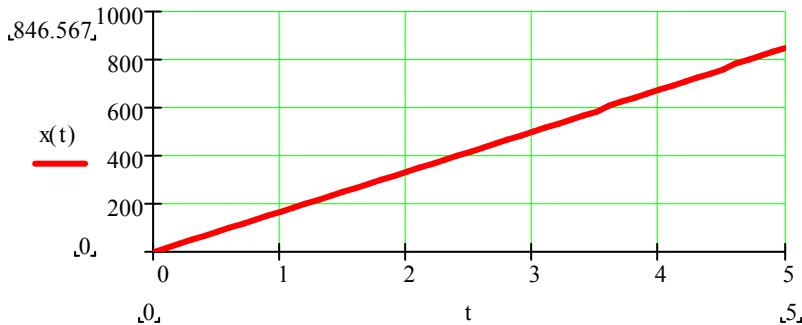
Fig. 3 – The horizontal coordinate diagram of the **AIRCRAFT'S TAKEOFF FROM THE GROUND**
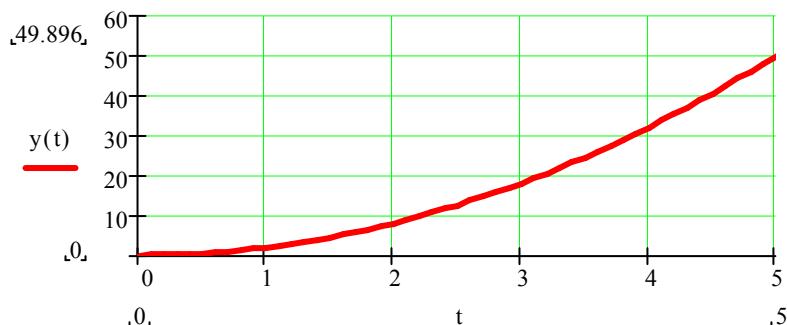


Fig. 4 – The vertical coordinate diagram of the **AIRCRAFT'S TAKEOFF FROM THE GROUND**
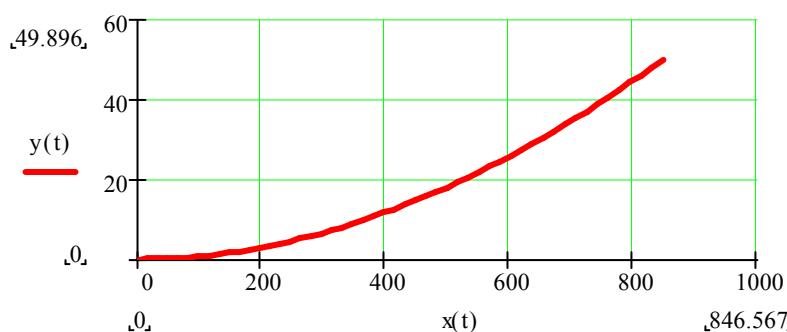


Fig. 5 – The vertical plane trajectory (path) diagram of the **AIRCRAFT'S TAKEOFF FROM THE GROUND**

The **SPEED** diagrams are shown in Fig. 6-9.

177.921

Vx(t)

160

0

t

5
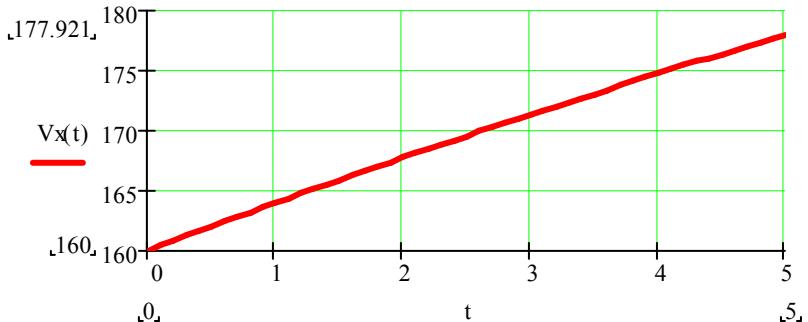
Fig. 6 – The horizontal **SPEED** diagram of the **AIRCRAFT'S TAKEOFF FROM THE GROUND**
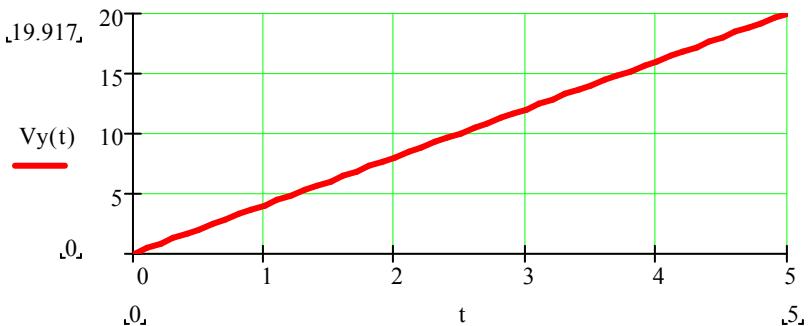
19.917

Vy(t)

0

0

t

5

Fig. 7 – The vertical **SPEED** diagram of the **AIRCRAFT'S TAKEOFF FROM THE GROUND**

19.917

Vy(t)

0

160

Vx(t)

177.921
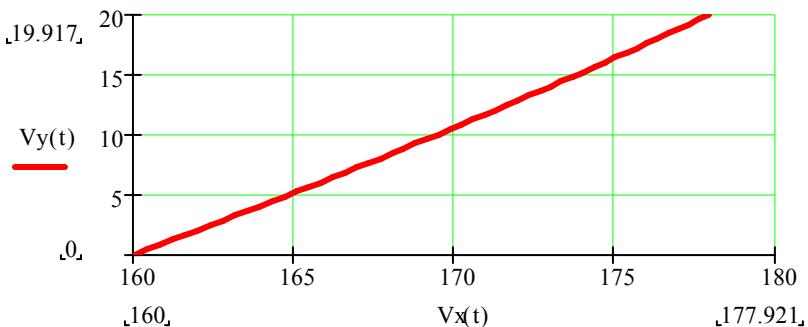
Fig. 8 – The vertical versus horizontal **SPEED** diagram of the **AIRCRAFT'S TAKEOFF FROM THE GROUND**

18
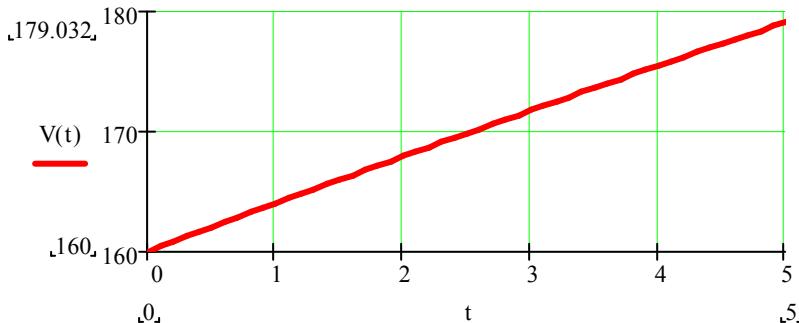
Fig. 9 – The **SPEED** diagram of the **AIRCRAFT'S TAKEOFF FROM THE GROUND**

The **ACCELERATION** diagrams are shown in Fig. 10-13.
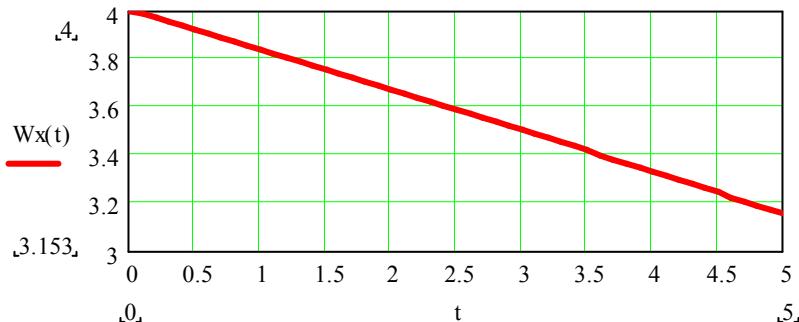


Fig. 10 – The horizontal **ACCELERATION** diagram of the **AIRCRAFT'S TAKEOFF FROM THE GROUND**



Fig. 11 – The vertical **ACCELERATION** diagram of the **AIRCRAFT'S TAKEOFF FROM THE GROUND**
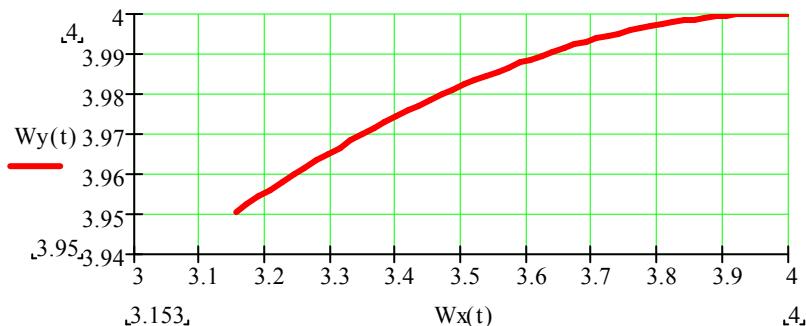
Fig. 12 – The vertical versus horizontal **ACCELERATION** diagram of the **AIRCRAFT'S TAKEOFF FROM THE GROUND**
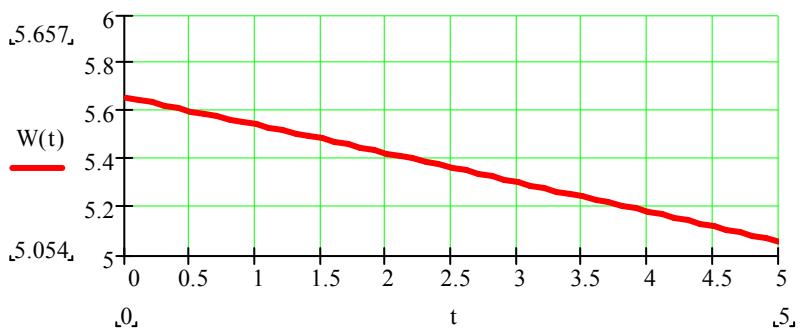


Fig. 13 – The **ACCELERATION** diagram of the **AIRCRAFT'S TAKEOFF FROM THE GROUND**

Determination of the equations expressions for the **AIRCRAFT'S TAKEOFF FROM THE GROUND PATH (TRAJECTORY),** as well as **SPEEDS** and **ACCELERATIONS,** is the task for the students. That is, it is the students' concern, as a portion of the independent extra work. Surely, they will not put too much effort in that. Moreover, we do not anticipate much trouble for them in the computerized calculations and diagrams plotting either.

The total **AIRCRAFT'S TAKEOFF FROM THE GROUND SPEED** (see Fig. 9) and **ACCELERATION** (see Fig. 13) are determined by the obvious formulas following the **PYTHAGOREAN THEOREM.**

The **FORCE** diagrams are simply mass times the **ACCELERATION** ones shown in Fig. 10-13.

Next to the **TAKEOFF** is the **CLIMBING MODE.**

# III. Climbing

*The principal theoretical provisions can be found out in references [1-17].*

## § 8. Determination of the climbing equations of motion

The supposed equations of the **AIRCRAFT'S CENTER OF MASS MOTION** in a **VERTICAL PLANE** are as follows:

$$x(t) = k_1 t + at^2 \qquad \text{and} \qquad y(t) = k_2 t + k_3 at^2, \qquad (94)$$

where $k_1$, $k_2$, $k_3$, and $a$ – parameters of the motion, their identification and interpretation (including dimensions and measurement units) are ordered and ought to (should) be performed by the students independently.

To find the **AIRCRAFT'S CENTER OF MASS MOTION PATH EQUATION,** one should exclude the parameter of time from the motion equations like (94). For the case when

$$\frac{y(t)}{k_3} = \frac{k_2}{k_3} t + at^2 \qquad \text{and} \qquad \frac{k_2}{k_3} = k_1, \qquad (95)$$

then,

$$\frac{y(t)}{k_3} = k_1 t + at^2 = x(t) \qquad \text{and} \qquad y(t) = k_3 x(t). \qquad (96)$$

If the parameter of

$$k_3 = \text{const}, \qquad (97)$$

then, the **AIRCRAFT'S CENTER OF MASS MOTION PATH (TRAJECTORY)** is the straight line having the inclination of

$$\text{tg}\theta = \frac{dy}{dx} = k_3. \qquad (98)$$

The **AIRCRAFT'S CENTER OF MASS MOTION SPEED EQUATIONS** in projections to the axes of the reference system will be:

$$V_x = \frac{dx(t)}{dt} = k_1 + 2at \qquad \text{and} \qquad V_y = \frac{dy(t)}{dt} = k_2 + 2k_3 at \qquad (99)$$

if

$$k_1 = \text{const}, \qquad a = \text{const}, \qquad \text{and} \qquad k_2 = \text{const}. \qquad (100)$$

The **AIRCRAFT'S CENTER OF MASS MOTION ACCELERATION EQUATIONS** in projections to the axes of the reference system will be:

$$W_x = \frac{d^2 x(t)}{dt^2} = 2a \qquad \text{and} \qquad W_y = \frac{d^2 y(t)}{dt^2} = 2k_3 a. \qquad (101)$$

The total **AIRCRAFT'S CENTER OF MASS MOTION ACCELERATION EQUATION** will be:

$$W = \sqrt{W_x^2 + W_y^2} = \sqrt{(2a)^2 + (2k_3 a)^2} = 2a\sqrt{1 + k_3^2}. \qquad (102)$$

In projections upon the attached to the **SPEED OF THE AIRCRAFT'S CENTER OF MASS** reference system (speedy, natural reference system), the differential equations of motion (in the case of (94-102) described above) will get the view of:

$$mW_V = T - D - mg\sin\theta, \qquad (103)$$

$$mW_L = L - mg\cos\theta, \qquad (104)$$

where $W_V$ and $W_L$ – projections of the **AIRCRAFT'S CENTER OF MASS ACCELERATION** in the speedy (natural) reference system, i.e. $W_V$ : upon the **SPEED** axis, $W_L$ : upon the **FORCE OF LIFT** axis (perpendicular to the **SPEED** axis).

Since the **AIRCRAFT'S CENTER OF MASS PATH (TRAJECTORY)** is a rectilinear one, see the assumptions of (94-98),

$$0 = L - mg\cos\theta \qquad \text{and} \qquad L = mg\cos\theta. \qquad (105)$$

Knowing the **AIRCRAFT'S THRUST-TO-WEIGHT RATIO:**

$$\mu = \frac{T}{mg} \qquad (106)$$

and **FINENESS:**

$$K = \frac{L}{D}, \qquad (107)$$

one can find

$$D = \mu mg - mW_V - mg\sin\theta, \qquad (108)$$

$$K = \frac{g\cos\theta}{\mu g - W_V - g\sin\theta}. \qquad (109)$$

From (109):

$$W_V = g\left(\mu - \frac{\cos\theta}{K} - \sin\theta\right). \tag{110}$$

Finaly, from (102, 110):

$$W_V = g\left(\mu - \frac{\cos\theta}{K} - \sin\theta\right) = W = 2a\sqrt{1+k_3^2}. \tag{111}$$

$$a = \frac{W_V}{2\sqrt{1+k_3^2}} = \frac{g\left(\mu - \frac{\cos\theta}{K} - \sin\theta\right)}{2\sqrt{1+k_3^2}}. \tag{112}$$

## § 9. Plotting the diagrams of climbing

For the data of:
$$k_1 = 120 \qquad \text{and} \qquad k_2 = 6, \tag{113}$$
the inclination of the **AIRCRAFT'S CENTER OF MASS MOTION PATH (TRAJECTORY)** straight line is measured with (98):

$$\text{tg}\theta = \frac{dy}{dx} = k_3; \tag{114}$$

and from the second formula of (95)

$$k_3 = \frac{k_2}{k_1}. \tag{115}$$

Thus,

$$k_3 = \frac{6}{120} = 0.05. \tag{116}$$

Also, at
$$\mu = 0.25 \qquad \text{and} \qquad K = 8, \tag{117}$$
it is possible to find from (111, 112)

$$a = \frac{9.807\left(0.25 - \frac{\cos[\text{arctg}(0.05)]}{8} - \sin[\text{arctg}(0.05)]\right)}{2\sqrt{1+0.05^2}} = 0.368. \tag{118}$$

$$W_V = 9.807\left( 0.25 - \frac{\cos[\text{arctg}(0.05)]}{8} - \sin[\text{arctg}(0.05)]\right) = 0.738 . \ (119)$$

The diagrams of **CLIMBING** for (94-119) are shown in Fig. 14-20.
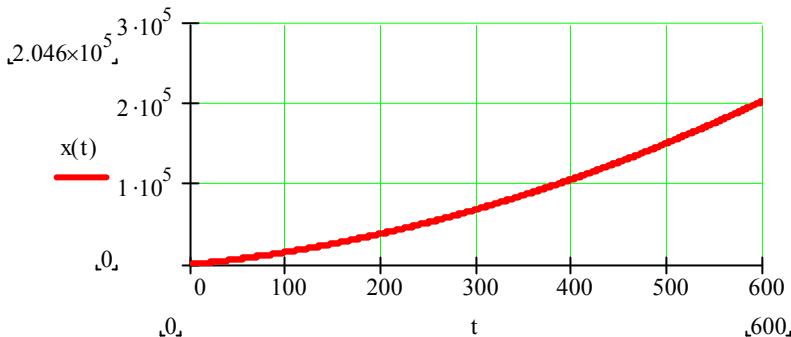


Fig. 14 – The **RANGE** diagram of the **AIRCRAFT'S CLIMBING**
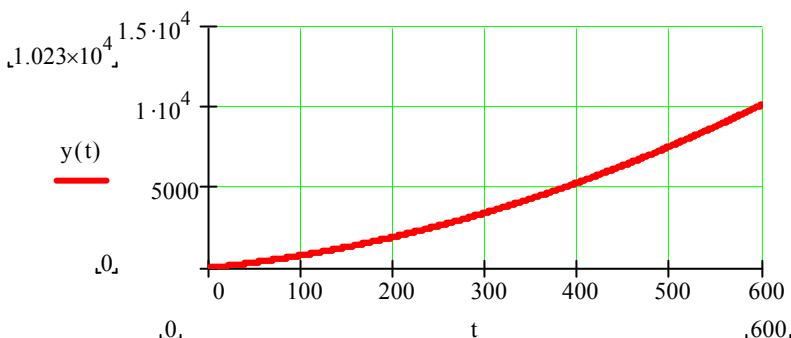


Fig. 15 – The **ALTITUDE** diagram of the **AIRCRAFT'S CLIMBING**

For the **ALTITUDE,** the initial coordinate acquired by the **AIRCRAFT AFTER THE TAKEOFF** is negligible in the presented modeling acceptable suppositions (see Fig. 15).
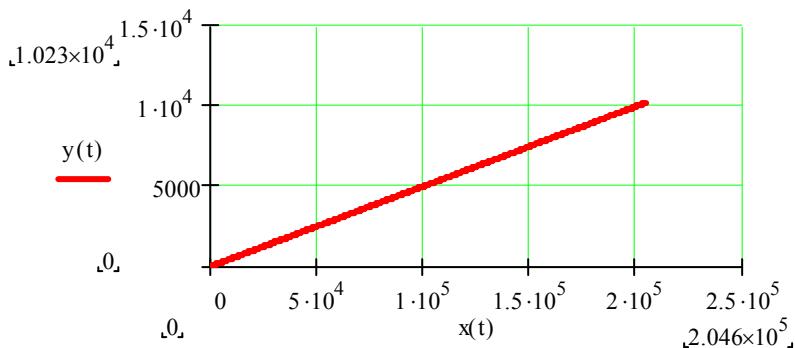
Fig. 16 – The **ALTITUDE** versus **RANGE** diagram of the **AIRCRAFT'S CLIMBING**
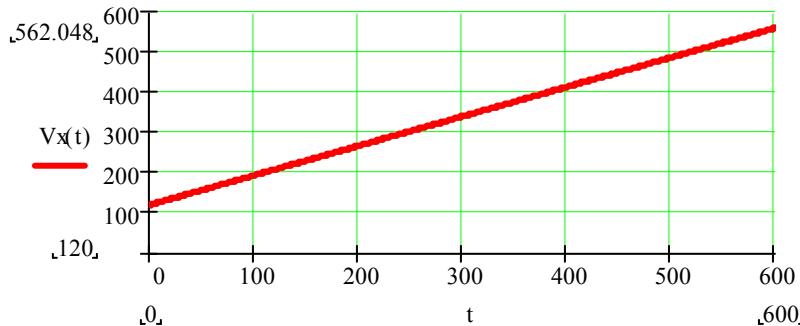


Fig. 17 – The horizontal **SPEED** diagram of the **AIRCRAFT'S CLIMBING**



Fig. 18 – The vertical **SPEED** diagram of the **AIRCRAFT'S CLIMBING**

28.102

Vy(t)

6

120          Vx(t)          562.048
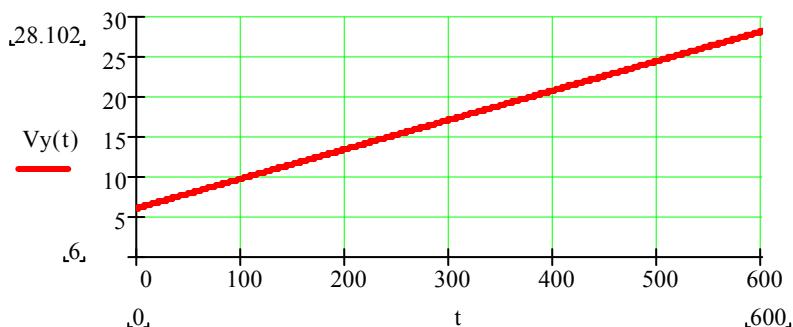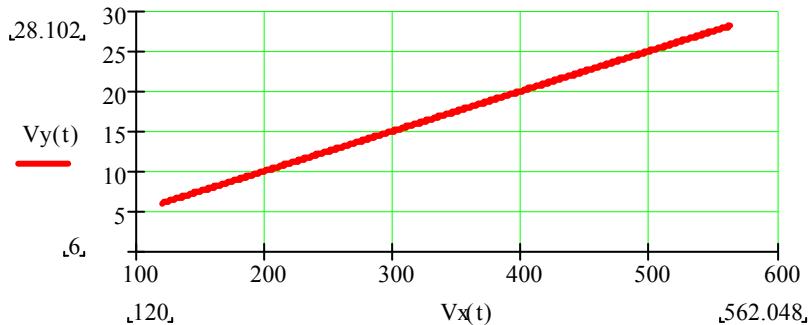
Fig. 19 – The vertical versus horizontal **SPEED** diagram of the
**AIRCRAFT'S CLIMBING**



562.75

V(t)

120.15

0          t          600
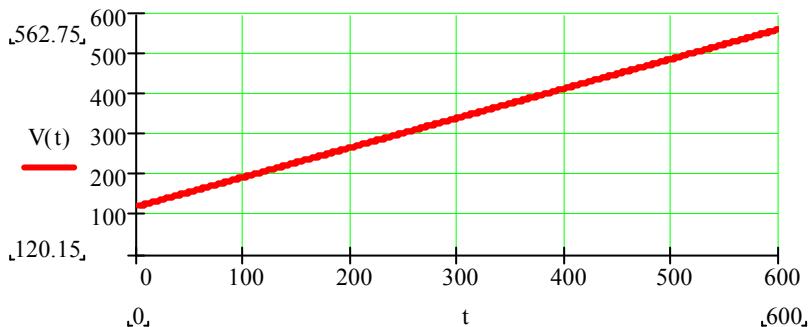
Fig. 20 – The **SPEED** diagram of the **AIRCRAFT'S CLIMBING**

The approach of (94-119) ignores the **AIRCRAFT'S MASS VARIATION WHEN CLIMBING,** therefore, in the framework of such assumption, the supposed **FORCES** are just **MASS** times the **ACCELERATIONS.**

27

# IV. Horizontal Flight

*The principal theoretical provisions can be found out in references [1-17, 51, 82, 121, 122, 161].*

For this **STAGE** the differential equations of the **AIRCRAFT'S CENTRE OF MASS MOTION** will be:

$$m\frac{dV_x}{dt} = m\frac{dV}{dt} = T - C_x \frac{\rho V^2}{2} S, \qquad (120)$$

$$m\frac{dV_y}{dt} = 0 = -mg + C_y \frac{\rho V^2}{2} S. \qquad (121)$$

## § 10. Impact of the angle between the thrust and speed

Taking into account the angle between the engine **THRUST** and the **SPEED** of flight, likewise in reference [5, p. 199, Problem # 26.23]:

$$\beta, \qquad (122)$$

the system of equations of (120, 121) will get the form of:

$$m\frac{dV}{dt} = T\cos\beta - C_x \frac{\rho V^2}{2} S, \qquad (123)$$

$$0 = T\sin\beta - mg + C_y \frac{\rho V^2}{2} S. \qquad (124)$$

This means that from (123) through the simplest transformations of (125, 126)

$$\text{tg}\beta = \frac{mg - C_y \dfrac{\rho V^2}{2} S}{m\dfrac{dV}{dt} + C_x \dfrac{\rho V^2}{2} S}. \qquad (127)$$

For a steady horizontal flight

$$V = \text{const} \qquad \text{and} \qquad \frac{dV}{dt} = 0. \qquad (128)$$

Thus,

$$\operatorname{tg}\beta = \frac{mg - C_y \dfrac{\rho V^2}{2} S}{C_x \dfrac{\rho V^2}{2} S} = \frac{mg}{D} - K .$$
(129)

## § 11. The maximum speed

The maximum **SPEED** will be found from (123), prototypic problem is of the reference [5, p. 204, Problem # 27.13], after (130,131):

$$V_{\max} = \sqrt{\frac{2T \cos\beta}{C_x \rho S}} .$$
(132)

## § 12. Required thrust

Consider the constant **THRUST** required for changing the **SPEED** of the **HORIZONTAL FLIGHT.** It is proposed to study [5, p. 205, Problem # 27.20]

$$m\frac{d^2x}{dt^2} = m\frac{dV}{dt} = m\frac{dV}{dx}\frac{dx}{dt} = T - C_x\frac{\rho V^2}{2} S .$$
(133)

Then, after the derivations and solutions of (134-147)

$$T = C_x \frac{\rho S}{2} \left( \frac{V_1^2 - V_0^2 e^{-\frac{C_x \rho S}{m}x}}{1 - e^{-\frac{C_x \rho S}{m}x}} \right) .$$
(148)

## § 13. Numerical simulation

The results of the numerical simulation for the influence of the angle between the engine **THRUST** and the **SPEED** of flight (122-129) are as follows:

The accepted data for the calculations are, [5, p. 199, Problem # 26.23]:

$$C_x = 0.03, \qquad \rho = 1.1 \text{ kg/m}^3, \qquad S = 30.3 \text{ m}^2, \qquad m = 2000 \text{ kg},$$

$$\frac{dV}{dt} = 5 \text{ m/s}^2, \quad V = 200 \text{ m/s}, \quad \beta = 10 \text{ °}, \quad g = 9.8 \text{ m/s}^2. \quad (149)$$

The parameters of (149) are instantaneous, therefore the immediate necessary **THRUST** and **LIFT** will constitute:

$$T = 30463 \text{ N} \qquad \text{and} \qquad L = 14310 \text{ N}. \qquad (150)$$

The maximum **SPEED,** for example, if the **THRUST** is

$$T = 30760 \text{ N}, \qquad (151)$$

and other values are as above, will be obtained by (130-132), [5, p. 204, Problem # 27.13]:

$$V_{max} = 246.1 \text{ m/s}. \qquad (152)$$

The required **THRUST** by (133-148) can be considered, for example, as a function of the five independent variables, [5, p. 205, Problem # 27.20]:

$$a = C_x \frac{\rho S}{2}, \qquad V_0, \qquad V_1, \qquad m, \qquad s = x. \qquad (153)$$

We leave it for the students to determine the corresponding dimensions and measurement units for the values of (153).

The results of the numerical simulation for (133-148) in the suppositions of (153) are represented in Fig. 21.

The graph labels:

$\mathrm{T}\left(5, 100, 150, 1{\cdot}10^{4}, s\right)$

$\mathrm{T}\left(2, 70, 150, 1.25{\cdot}10^{4}, s\right)$

$\mathrm{T}\left(0.7, 50, 200, 3{\cdot}10^{3}, s\right)$
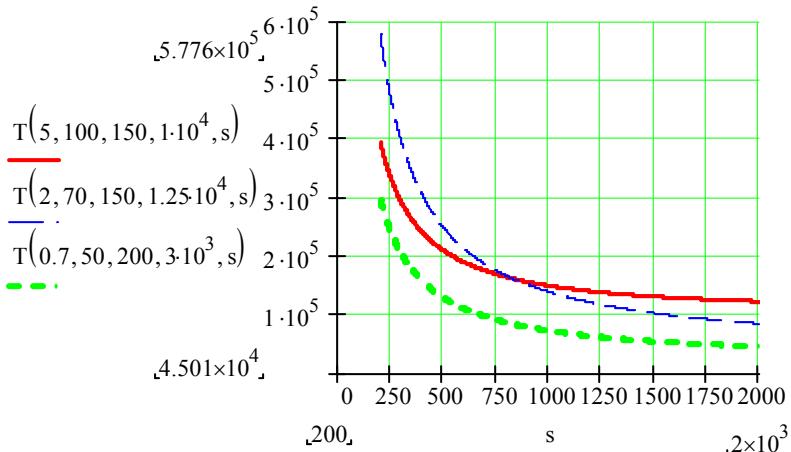
Fig. 21 – The required **THRUST** for the specified **SPEED** variation depending upon the **AERODYNAMIC CHARACTERISTIC, SPEED RANGE, AIRCRAFT'S MASS, AND FLOWN DISTANCE**

## § 14. The variable mass maximum endurance and range horizontal flights

In fact, during the flight, the **AIRCRAFT'S MASS** changes because, first of all, the mass of the fuel on board decreases [6, pp. 198-215], [51, 82, 121, 122, 161]. In order to maintain the **HORIZONTAL RECTILINEAR FLIGHT** the **VARIATION** of the **FLIGHT SPEED** is needed in accordance with the amount of the **FUEL CONSUMPTION.**

**MAXIMUM ENDURANCE** and **RANGE** of the **HORIZONTAL RECTILINEAR FLIGHT** is one of the very important characteristics of the **AIRCRAFT'S STRUCTURE** perfection as well as the **AIRCRAFT'S OPERATIONAL** excellence. Hence, **MAXIMUM ENDURANCE** and **RANGE** problem is an eternal (everlasting) one; and it continuously instigates the search of the optimality: [6, pp. 198-215], [51, 82, 121, 122, 161].

In the simplest setting, such problem is formulated in the framework of calculus of variations: [6, pp. 198-215], [51, 82, 121, 122, 161].

In principle, conditions of the **HORIZONTAL FLIGHT** are as above, for example, likewise (120, 121):

$$m\frac{dV_x}{dt} = m\frac{dV}{dt} = T - C_x\frac{\rho V^2}{2}S, \qquad (154)$$

$$m\frac{dV_y}{dt} = 0 = -mg + C_y\frac{\rho V^2}{2}S. \qquad (155)$$

Considering the **SPEED** variation negligibly small for the **ACCELERATION**, the system of the initial equations of (154, 155) can be reduced to, [51, 82, 121, 122, 161]:

$$0 = T - C_x\frac{\rho V^2}{2}S, \qquad (156)$$

$$0 = -mg + C_y\frac{\rho V^2}{2}S. \qquad (157)$$

Then

$$T = C_x\frac{\rho V^2}{2}S, \qquad (158)$$

where

$$T = -\eta_T\frac{dm}{dt}, \qquad (159)$$

where $\eta_T$ – coefficient of the proportionality between the developed by the **AIRCRAFT'S ENGINES THRUST** and the **RATE OF THE BURNT FUEL:**

$$\frac{dm}{dt}. \qquad (160)$$

The coefficient of the proportionality between the **THRUST** and the **FUEL CONSUMPTION RATE**

$$\eta_T = \eta\frac{Q}{V}, \qquad (161)$$

where $\eta$ – **EFFICIENCY** (coefficient of the useful action) of the **AIRCRAFT'S PROPULSION COMPLEX,** $Q$ – **CALORIFIC VALUE OF THE AVIATION FUEL BY ITS WORKING MASS.**

Therefore

$$-\eta \frac{Q}{V} \frac{dm}{dt} = C_x \frac{\rho V^2}{2} S . \qquad (162)$$

Now,

$$C_x = C_{x_0} + bC_y^2 , \qquad (163)$$

where $C_x$, $C_{x_0}$, $b$, and $C_y$ – aerodynamic coefficients determined at a specified diapasons of the air speeds, for instance, in the wind tunnels blowing (could be implemented from the **FIRST PART OF THE CGW** completed in accordance with the **FIRST PART OF THE METHOD GUIDE** [12, 18, 19]).

The transformations of (162), with the use of (163) and via (164-169) will lead to

$$dt = -\frac{2\eta Q \rho V S}{C_{x_0}\left(\rho V^2 S\right)^2 + 4b(mg)^2} dm . \qquad (170)$$

The **OBJECTIVE INTEGRAL (FUNCTIONAL)** of the **FLIGHT ENDURANCE (DURATION)** will get the view of [51, 82, 121, 122, 161]:

$$T = -\int_{M_0}^{M_E} \frac{2\eta Q \rho V S}{C_{x_0}\left(S\rho V^2\right)^2 + b(2mg)^2} dm , \qquad (171)$$

where $M_0$ – mass of the **AIRCRAFT** at the **INITIAL MOMENT OF TIME** (at the point of the **AIRCRAFT** "horizontal" flight trajectory/path beginning), $M_E$ – mass of the **AIRCRAFT** at the end of the active "horizontal" flight fragment.

For the **HORIZONTAL FLIGHT RANGE** covered by the **AIRCRAFT,** the **OBJECTIVE INTEGRAL (FUNCTIONAL)** will be obtained based upon the condition of the differential ratio connecting the necessary values for the purposed parameters of the **FLIGHT DISTANCE, SPEED,** and **TIME:**

$$dr = Vdt , \qquad (172)$$

where $dr$ – **RANGE** differential.

Hence, [51, 82, 121, 122, 161]:

$$dr = -\frac{2\eta Q \rho V^2 S}{C_{x_0}\left(\rho V^2 S\right)^2 + 4b(mg)^2} dm . \qquad (173)$$

$$R = -\int_{M_0}^{M_E} \frac{2\eta Q\rho V^2 S}{C_{x_0}\left(S\rho V^2\right)^2 + b\left(2mg\right)^2}\, dm \ . \tag{174}$$

The **OBJECTIVE FUNCTIONALS** of (171, 174) **OPTIMAL SOLUTIONS** are the **EXTREMALS** (solutions) to the **SIMPLEST VARIATIONAL PROBLEM** from the **CALCULUS OF VARIATIONS.**

The **EXTREMALS** for (171, 174) are to be found in the view of a function:

$$V_{\text{opt}}\left(m\right) \tag{175}$$

delivering a maximum (extremum, optimum) value to the **OBJECTIVE FUNCTIONALS** of (171, 174).

The necessary conditions for the **EXTREMALS** of (171, 174) existence are the **EULER-LAGRANGE EQUATIONS:**

$$\frac{\partial F_T^*}{\partial V} - \frac{d}{dm}\left(\frac{\partial F_T^*}{\partial V_m'}\right) = 0\,, \qquad \frac{\partial F_R^*}{\partial V} - \frac{d}{dm}\left(\frac{\partial F_R^*}{\partial V_m'}\right) = 0\,, \tag{176}$$

where $F_T^*$ and $F_R^*$ – the underintegral functions (integrands) of the **OBJECTIVE FUNCTIONALS** of (171, 174) correspondingly;

$$V_m' = \frac{dV}{dm}\,; \tag{177}$$

satisfaction.

Those solutions of the **EULER-LAGRANGE EQUATIONS** (176), for instance, for (171), therefore the first of the (176) equations is applied, will be:

$$\frac{\partial F_T^*}{\partial V_m'} \equiv 0\,, \qquad \frac{d}{dm}\left(\frac{\partial F_T^*}{\partial V_m'}\right) \equiv 0\,, \qquad \frac{\partial F_T^*}{\partial V} = 0\,, \tag{178}$$

and through (179-181) for the **ENDURANCE EXTREMAL,** [51, 82, 121, 122, 161]:

$$V_{\text{opt}}^{(T)}\left(m\right) = \sqrt[4]{\frac{4}{3}\frac{b\left(mg\right)^2}{C_{x_0}\left(\rho S\right)^2}} \ . \tag{182}$$

For the **RANGE OPTIMAL SOLUTION,** [51, 82, 121, 122, 161], bypassing (183-186):

$$V_{\text{opt}}^{(R)}(m) = \sqrt[4]{4\,\frac{b(mg)^2}{C_{x_0}(\rho S)^2}}\;. \qquad (187)$$

Solving differential equations of (170, 173) with the **EXTREMALS (OPTIMAL SOLUTIONS)** of (182, 187), in respect, will yield optimal functions of:

$$m_{\text{opt}}^{(T)}(t) \qquad \text{and} \qquad m_{\text{opt}}^{(R)}(r). \qquad (188)$$

For obtaining

$$m_{\text{opt}}^{(T)}(r) \qquad \text{and} \qquad m_{\text{opt}}^{(R)}(t), \qquad (189)$$

the differential equations of (173, 170) ought to (should, must) be solved with the **EXTREMALS (OPTIMAL SOLUTIONS)** of (182, 187), in their respect.

Substituting the **OPTIMAL FUNCTIONS** of (188, 189), for their corresponding values, for the **EXTREMALS** of (182, 187), one can get **OPTIMAL SPEED FUNCTIONS** as of either time or distance. But, careful, pay attention that for the **EXTREMALS** of (182, 187) to yield the correct (plausible, reasonable, sensible, rational) result, the superscript (upper index, top indication) of the (182, 187) and (188, 189) should coincide (be the same, match) in respect.

In order to get the **ENDURANCE** and **RANGE VALUES** the **OBJECTIVE FUNCTIONALS (INTEGRALS)** of (171, 174) are to be solved with the **SPEED FUNCTIONS** investigated. For having the integral values of (171, 174) as functions of some independent variable, it can be proposed to implement that variable as the upper (top) end of the integration, the mass possibly being correctly replaced (substituted) throughout the integral with the variable under the investigation.

Thus, [51, 82, 121, 122, 161], after substitution of (182) for (171), the latter yields for the **ENDURANCE**

$$T(m) = \left(\frac{3}{4}\right)^{\frac{3}{4}} \frac{\eta Q \sqrt{\rho S}}{\sqrt[4]{C_{x_0}} \left[bg^2\right]^{\frac{3}{4}}} \left(\frac{1}{\sqrt{m}} - \frac{1}{\sqrt{M_0}}\right). \qquad (190)$$

For the **RANGE**, using (187) in (174), one can have, [51, 82, 121, 122, 161]:

$$R(m) = \frac{\eta Q}{2g\sqrt{bC_{x_0}}} \ln\left(\frac{M_0}{m}\right). \tag{191}$$

### § 15. Visualization of the variable mass maximum endurance and range horizontal flight simulations

The accepted data for conducting the **HORIZONTAL FLIGHT MAXIMUM RANGE** and **ENDURANCE COMPUTER SIMULATIONS** are as follows:

$$b = 0.045, \quad \eta = 0.25, \quad Q = 32 \cdot 10^6, \quad M_0 = 45 \cdot 10^3, \quad M_E = 30 \cdot 10^3,$$
$$g = 9.8, \quad C_{x_0} = 0.036, \quad S = 34, \quad \rho = 1.1. \tag{192}$$

The dimensions and measurement units in (192) are left for the students' concern. **EXTREMALS (OPTIMAL SOLUTIONS)** obtained by (182, 187) are shown in Fig. 22.
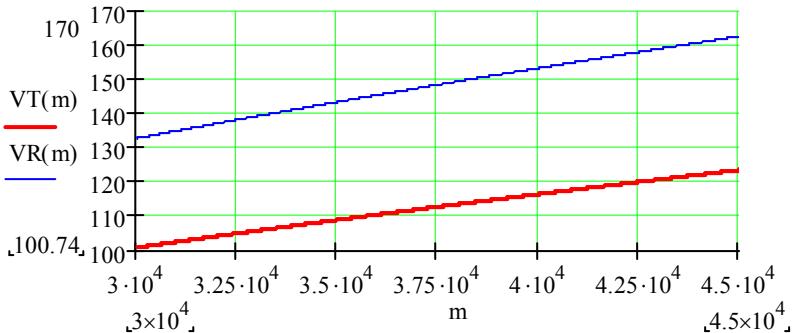


Fig. 22 – The **EXTREMALS** for the **AIRCRAFT'S SPEED** at **HORIZONTAL FLIGHT** for **MAXIMUM ENDURANCE** and **RANGE**

The conditions of (176) are just the necessary ones. To ensure (be sure) that the **EXTREMALS** of (182, 187) really deliver **MAXIMUM** values to the **OBJECTIVE FUNCTIONALS** of **ENDURANCE** and **RANGE** of (171, 174), it is possible to variate the **EXTREMALS.**

Let us say, the variations are made in the type of

$$V(m) = am^2 + dm + c,\qquad(193)$$

where $a$, $d$, and $c$ – the unknown so far coefficients that have to be determined on condition of the **SPEED** variation with the fixed terminal values.

Matrix-vector method gives:

$$\mathbf{V}_{-\delta} = \left\| V\!\begin{pmatrix} V(M_0) \\ \left(\dfrac{M_0 + M_E}{2}\right) \\ V(M_E) \end{pmatrix} - \delta \right\|,\qquad(194)$$

where $\mathbf{V}_{-\delta}$ – the vector-column of **SPEEDS,** variated with $\delta$ – the value of the **SPEED** variation;

$$\mathbf{M} = \left\| \begin{matrix} M_0^2 & M_0^1 & M_0^0 \\ \left(\dfrac{M_0 + M_E}{2}\right)^2 & \left(\dfrac{M_0 + M_E}{2}\right)^1 & \left(\dfrac{M_0 + M_E}{2}\right)^0 \\ M_E^2 & M_E^1 & M_E^0 \end{matrix} \right\|,\qquad(195)$$

where $\mathbf{M}$ – the matrix of **MASSES.**

In the vector-matrix notation, the system of the equations for the unknown coefficients of: $a$, $d$, and $c$ determination has the view of

$$\mathbf{V}_{-\delta} = \mathbf{M} \cdot \mathbf{C}_{-\delta},\qquad(196)$$

where $\mathbf{C}_{-\delta}$ – the vector-column of the unknown coefficients of: $a$, $d$, and $c$ for the **SPEEDS** values lower than optimal, i.e.

$$\mathbf{C}_{-\delta} = \left\| \begin{matrix} a \\ d \\ c \end{matrix} \right\|.\qquad(197)$$

Then, from (196)

$$\mathbf{C}_{-\delta} = \mathbf{M}^{-1} \cdot \mathbf{V}_{-\delta}.\qquad(198)$$

The accepted variation is

$$\delta = 5.\qquad(199)$$

The dimensions and measurement units in (199) are to be determined by the students independently.

The obtained by the procedures likewise (193-199) parameters for the **SPEEDS** values are as follows:

$$\mathbf{M^{-1}} = \begin{Vmatrix} 8.889 \cdot 10^{-9} & -1.778 \cdot 10^{-8} & 8.889 \cdot 10^{-9} \\ -6 \cdot 10^{-4} & 1.333 \cdot 10^{-3} & -7.333 \cdot 10^{-4} \\ 10 & -24 & 15 \end{Vmatrix}, \qquad (200)$$

$$\mathbf{C_{-\delta}} = \begin{Vmatrix} 7.875 \cdot 10^{-8} \\ -4.397 \cdot 10^{-3} \\ 161.77 \end{Vmatrix}. \qquad (201)$$

Continuing with the variations for the **SPEED** values for both **ENDURANCE** and **RANGE,** both lower and greater than the **OPTIMAL** ones (for that purpose the obvious replacements for the variation (199) sign in formulas like (194) should be made), it is obtained the curves illustrated in Fig. 23.
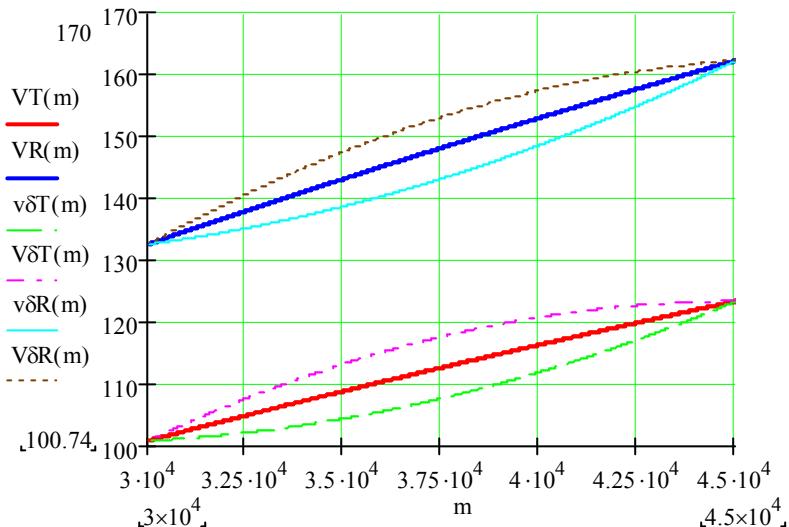


Fig. 23 – The **AIRCRAFT'S OPTIMAL SPEEDS** at **HORIZONTAL FLIGHT** for **MAXIMUM ENDURANCE** and **RANGE** with their variations

The **EXTREMALITY CHECK** is portraited in Fig. 24 and 25.
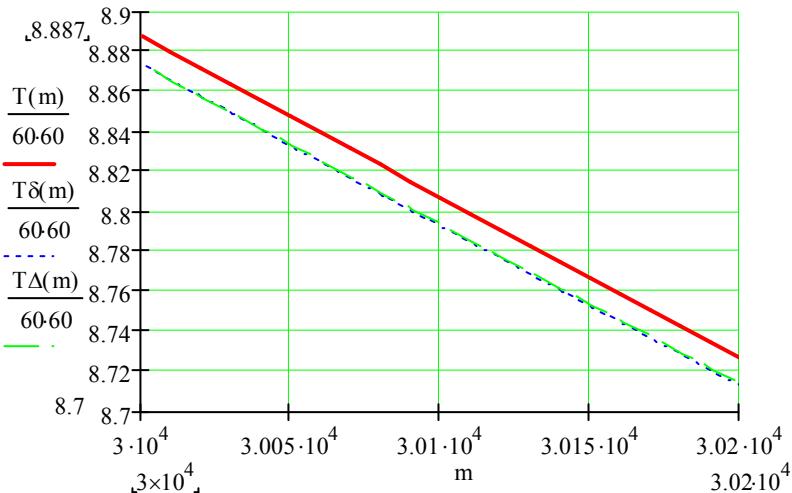
Fig. 24 – The **MAXIMALITY** of the **AIRCRAFT'S OPTIMAL SPEED** at the **HORIZONTAL FLIGHT** for **MAXIMUM ENDURANCE** compared with the variated **SPEED ENDURANCES**
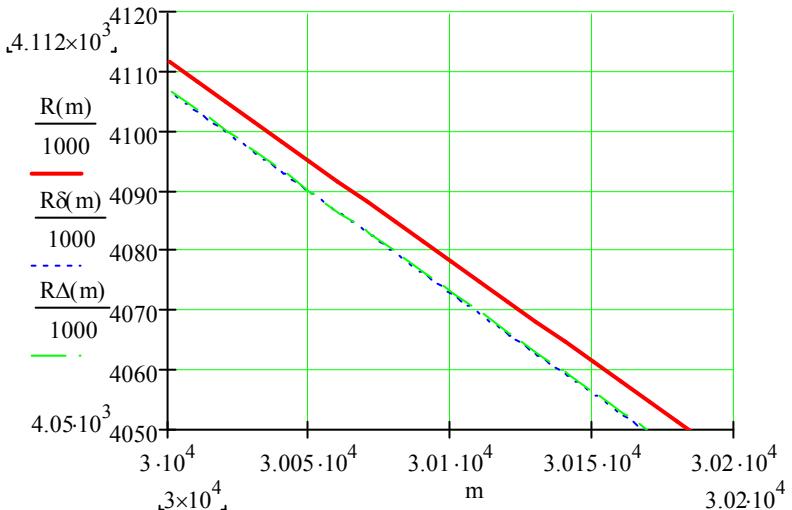


Fig. 25 – The **MAXIMALITY** of the **AIRCRAFT'S OPTIMAL SPEED** at the **HORIZONTAL FLIGHT** for **MAXIMUM RANGE** compared with the variated **SPEED RANGE**

The **EXTREMALS** (182, 187) **OPTIMALITY** (delivering **MAXIMUM** values to the **OBJECTIVE FUNCTIONALS** of (171, 174), that is (190, 191), in comparison with the **ENDURANCE** and **RANGE** values for the variated **SPEEDS** (see Fig. 23) above) can be noticed and traced with the curves represented in Fig. 24 for the **ENDURANCE** and Fig. 25 for the **RANGE.**

It is clear from the curves in Fig. 24 and 25, that the larger variation that can be made, the greater effect of the optimization that could be obtained.

# V. Prospective Developments of Trajectory Problems

*The principal theoretical provisions can be found out in references [1-17].*

As that was described above, the problems of a **Material Particle Motion** is applicable to the **Aircraft's Path (Trajectory) Problems.** However, a more complex **Motion of Aircraft** also needs (requires, demands) some attention.

Another kind of the considered herewith problems development would be some problem settings (statements, formulations, solutions) for other **Stages of the Aircraft's Flight,** as well as for the **Aircraft's Flight Configurations, Maneuvers, Flight Situations,** with respect to their **External** and **Internal Conditions, Conflicts** between them etc.

Those **Objective Subjects** are going to be covered in the **Following Editions and Issues** of the presented **Second Part** of the **Method Guide** on the **Academic Subject** of **AeroHydroGasDynamics and Flight Dynamics**, which in turn follows the **First Part** [12, 18, 19].

Nonetheless, a few **Paragraphs** dedicated to such problems are presented herein downwards.

## § 16. Aircraft descent motions

In some respect the **Aircraft's Descent** could be considered as a reverse **Flight Stage** to the **Climbing Mode.** The students are suggested to develop the problems of the **Aircraft's Descent** independently making necessary modifications to the differential equations of motion.

## § 17. Touchdown

Similarly to the simplified considerations of the **AIRCRAFT'S DESCENT** as an antagonistic **MODE** to **CLIMBING** (which have been instructed in the **PARAGRAPH** above), the **TOUCHDOWN STAGE OF THE FLIGHT** could be, with the surely necessary modifications, treated as the antagonistic **MODE** to the **AIRCRAFT'S TAKEOFF FROM THE GROUND.**

It is going to be covered in further issues of the **METHOD GUIDE.** For the moment, it is for the students' self work considerations, which are highly and truly welcome, by the way.

## § 18. Deceleration to stop

The run of the **AIRCRAFT** along the **RUNWAY** after the **TOUCHDOWN** occurs in a **DECELERATING MANNER.** It is suggested for the students' self consideration either, in regards to the required models development of course.

## REFERENCES

1. **Остославский И. В.** Динамика полета. Траектории летательных аппаратов / И. В. Остославский, И. В. Стражева. – М.: Машиностроение, 1963. – 430 с. [**Ostoslavskiy I. V.** Flight Dynamics. Aircraft Trajectories / I. V. Ostoslavskiy, I. V. Strazheva. – M.: Machinebuilding, 1963. – 430 p.] **[in Russian]**.

2. **Ударцев Е. П.** Эксплуатационная аэродинамика. Траекторные задачи: Учебное пособие / Е. П. Ударцев, А. М. Переверзев, С. А. Ищенко. – Киев: КМУГА, 1998. – 136 с. [**Udartsev E. P.** Operational Aerodynamics. Trajectory Problems: Study Guide / E. P. Udartsev, A. M. Pereverzev, S. A. Ishchenko. Kyiv: KIUCA, 1998. – 136 p.] **[in Russian]**.

3. **Динамика** полета: Учебник / Под редакцией Мхитаряна А. М. – М.: Машиностроение, 1978. – 424 с. [**Flight** Dynamics: Study Guide / Editor Mkhitarian A. M. – M.: Machinebuilding, 1978. – 424 p.] **[in Russian]**.

4. **Котик М. Г.** Динамика взлета и посадки самолетов / М. Г. Котик. – М.: Машиностроение, 1984. – 256 с. [**Kotik M. G.** Aircraft Takeoff and Landing Dynamics / M. G. Kotik. – M.: Machinebuilding, 1984. – 256 p.] **[in Russian]**.

5. **Мещерский И. В.** Сборник задач по теоретической механике: Учеб. пособие. – 36-е изд., исправл. / Под. ред. Н. В. Бутенина, А. И. Лурье, Д. Р. Меркина. – М.: Наука. Гл. ред. физ.-мат. лит., 1986. – 448 с. [**Meshcherskiy I. V.** Collection of Problems on Theoretical Mechanics: Study Guide. 36$^{th}$ Ed., corrected / Editors N. V. Butenin, A. I. Lurye, D. R. Merkin. – M.: Science. Main Editorial Office of Physical and Mathematical Literature, 1986. – 448 p.] **[in Russian]**.

6. **Космодемьянский А. А.** Курс теоретической механики. Часть II / А. А. Космодемьянский. – М.: Просвещение, 1966. – 398 с. [**Kosmodemyanskiy A. A.** The Course on Theoretical Mechanics. Part II / A. A. Kosmodemyanskiy. – M.: Education, 1966. – 398 p.] **[in Russian]**.

7. **Пискунов Н. С.** Дифференциальное и интегральное исчисления для втузов / Н. С. Пискунов, т. 1: Учебное пособие для втузов. – 13-е изд. – М.: Наука, Главная редакция физико-математической литературы, 1985. – 432 с. [**Piskunov N. S.** Differential and Integral Calculus for Higher Engineering Educational Institutions / N. S. Piskunov, vol. 1: Study Book for Higher Engineering Educational Institutions. – 13$^{th}$ edition. – M.: Science, 1985. – 432 p.] **[in Russian]**.

8. **Пискунов Н. С.** Дифференциальное и интегральное исчисления для втузов / Н. С. Пискунов, т. 2: Учебное пособие для втузов. – 13-е изд. – М.: Наука, Главная редакция физико-математической литературы, 1985. – 560 с. [**Piskunov N. S.** Differential and Integral Calculus for Higher Engineering Educational Institutions / N. S. Piskunov, vol. 2: Study Book for

Higher Engineering Educational Institutions. – 13th edition. – M.: Science, 1985. – 560 p.] **[in Russian]**.

9. **Авиационные** правила. Часть 25. Нормы летной годности самолетов транспортной категории (АП-25). – М.: Межведомственный авиационный комитет, 1994. – 342 с. [**Aviation** Regulations. Part 25. Transport Category Aircraft Airworthiness Norms (AR-25). M.: Interdepartmental Aviation Committee, 1994. – 342 p.] **[in Russian]**.

10. **Emery H.** Aviation English for ICAO Compliance / H. Emery, A. Roberts, with R. Goodman and L. Harrison. – Oxford: Macmillan, 2012. – 130 p.

11. **Houghton E. L.** Aerodynamics for Engineering Students : 5th Ed. / E. L. Houghton, P. W. Carpenter. – Burlington MA: Butterworth-Heinemann, 2003. – 614 p.

12. **Аэромеханика** : Методические указания и задания по выполнению курсовой работы / Составители: А. Г. Баскакова, В. Д. Трубенок. – К.: КМУГА, 1995. – 52 с. [**Aeromechanics** : Method Guide and Tasks on Course Work Completion / Compilers: A. G. Baskakova, V. D. Trubenok. – K. : KIUCA, 1995. – 52 p.] **[in Russian]**.

13. **Аеродинаміка** літальних апаратів: Підручник / Г. Н. Котельников, О. В. Мамлюк, В. І. Сілков, Ю. Г. Терещенко. – К.: Вища школа, 2002. – 255 с. [**Aerodynamics** of Aircraft: Study Guide / G. N. Kotelnikov, O. V. Mamlyuk, V. I. Silkov, Y. G. Tereshchenko. – K.: Higher Education, 2002. – 255 p.] **[in Ukrainian]**.

14. **Мхитарян А. М.** Аэродинамика / А. М. Мхитарян. – М. : Машиностроение, 1976. – 446 с. [**Mkhitarian A. M.** Aerodynamics / A. M. Mkhitarian. – M. : Mashynostroyeniye, 1976. – 446 p.] **[in Russian]**.

15. **Аэрогидромеханика** / Под ред. А. М. Мхитаряна. – М. : Машиностроение, 1984. – 352 с. [**Aerohydromechanics** / Editor: A. M. Mkhitarian. – M. : Mashynostroyeniye, 1984. – 352 p.] **[in Russian]**.

16. **Расчет** поляр самолета: Методические указания / Сост.: А. Н. Базилевский, В. Д. Трубенок, В. В. Ушаков. – Киев: КИИГА, 1982. – 43 с. [**Calculation** of Aircraft Polars: Method Guide / Compilers: A. N. Bazilevskiy, V. D. Trubenok, V. V. Ushakov. – Kiev: KIICA, 1982. – 43 p.] **[in Russian]**.

17. **Базилевский А. Н.** Воздушные винты : Учебное пособие / А. Н. Базилевский, А. М. Переверзев, В. В. Ушаков. – Киев: КИИГА, 1982. – 80 с. [**Bazilevskiy A. N.** Air Propellers : Study Guide / A. N. Bazilevskiy, A. M. Pereverzev, V. V. Ushakov. – Kiev: KIICA, 1982. – 80 p.] **[in Russian]**.

18. **Aerohydrogasdynamics** and Flight Dynamics. Part I : Aerohydrogasdynamics : Self-Study Method Guide . Part I . Aerohydrogasdynamics . Plotting the Aircraft Polar / compiler: A. V. Goncharenko. – K. : NAU, Electronic Repository. – 2020. – 57 p. https://er.nau.edu.ua/handle/NAU/44734,

Aero_Hydro_Gas_Dynamics_&_Flight_Dynamics_Calculation_&_Graphic_W
ork_Part_I_Aircraft_Polar.pdf.

19. **Аэрогидрогазодинамика** и динамика полета. Часть I : Аэрогидрогазодинамика : Методические рекомендации для самоподготовки . Часть I . Аэрогидрогазодинамика . Построение поляры самолета / составитель: А. В. Гончаренко. – К. : НАУ, Электронный репозитарий. – 2020. – 54 с. https://er.nau.edu.ua/handle/NAU/44743, Spoilt_Ukr_Aero_Hydro_Gas_Dynamics_&_Flight_Dynamics_Calculation_&_Graphic_Work_Part_I_Aircraft_Polar.pdf.

20. **Aerodrome** professional practices : self-study method guide . Part I. / compiler: A. V. Goncharenko. – K. : NAU, 2020. – 32 p. https://er.nau.edu.ua/handle/NAU/43896, 2_Course_Aerodrome_Professional_Practices_Self_Study_Guide.doc.

21. **Continuing** Aircraft Airworthiness (ICAO Doc 9760) : Self-study method guide . Part II . Application of the multi-optional functions entropy doctrine to assess the aircraft maintenance process improvements / compiler: A. V. Goncharenko. – K. : NAU, 2018. – 48 p. http://er.nau.edu.ua/handle/NAU/35891

22. **Continuing** Aircraft Airworthiness (ICAO Doc 9760) : Self-study method guide . Part I . Reliability measures to assess the aircraft maintenance process improvements / compiler: A. V. Goncharenko. – K. : NAU, 2018. – 48 p. http://er.nau.edu.ua/handle/NAU/35890

23. **Continuing** Aircraft Airworthiness (ICAO Doc 9760) : Term paper method guide / compiler: A. V. Goncharenko. – K. : NAU, 2018. – 48 p. http://er.nau.edu.ua/handle/NAU/35889

24. **Druch O.** Basics of Ecology. Synopsis of lectures / *O. Druch, A. Honcharenko, G. Franchuk.* – Kyiv: NAU, 2005. – 124 p.

25. **Entropy** paradigm in the theory of hierarchical active systems. Elements of conflict theory / V.A. Kasianov, K. Szafran, A.V. Goncharenko, T.V. Shipitiak // Prace Instytutu Lotnictwa Transactions of the institute of aviation. – Warszawa Warsaw, Poland: Institute of Aviation Scientific Publications, 2013. – № 5-6 (232-233), pp. 115-128.

26. **Goncharenko A. V.** A basic example of the mathematical logics interpretations to the tribological processes characteristics revealing / A. V. Goncharenko // Problems of friction and wear. – 2018. – № 4(81). – pp. 50-53.

27. **Goncharenko A. V.** A concept of ballast water treatment on the basis of multi-alternativeness / A. V. Goncharenko, V. A. Evdokimova // Сучасні інформаційні та інноваційні технології на транспорті (MINTT-2014) [Збірка матеріалів VI Міжнародної науково-практичної конференції. (27-29 травня 2014 р., Херсон)]. – Херсон: Херсонська державна морська академія, 2014. – pp. 18-21.

28. **Goncharenko A. V.** A concept of entropy approach to the problem of multi-alternative operational modes control / A. V. Goncharenko // Науковий вісник ХДМА. – 2013. – № 2(9). – pp. 26-34.

29. **Goncharenko A. V.** A concept of multi-optional optimality at modeling ideal gas isothermal processes / A. V. Goncharenko // Electronics and control systems. – 2017. – № 2(52). – pp. 94-97.

30. **Goncharenko A. V.** A diagnostics problem of a-posterior probability determination via Bayes' formula obtained in the multi-optional hybrid functions entropy conditional optimization way / A. V. Goncharenko // Problems of friction and wear. – 2017. – № 4(77). – pp. 95-99.

31. **Goncharenko A. V.** A hybrid approach to the optimal aeronautical engineering maintenance periodicity determination / A. V. Goncharenko // Proceedings of the NAU. – 2017. – № 3(72). – pp. 42-47.

32. **Goncharenko A. V.** A hybrid pseudo-entropy function for a decision making in conditions of uncertainty / A. V. Goncharenko // Інтелектуальні системи прийняття рішень та проблеми обчислювального інтелекту: міжнародна наукова конференція, Залізний Порт, Україна, 25-28 травня 2015 р.: матеріали конф. – Херсон: Видавництво ХНТУ, 2015. – pp. 174-176. (ISBN 978-966-2207-24-8)

33. **Goncharenko A. V.** A multi-optional hybrid functions entropy as a tool for transportation means repair optimal periodicity determination / A. V. Goncharenko // Aviation. – 2018. Volume 22(2). – pp. 60-66.

34. **Goncharenko A. V.** A neuron stochastic sigmoid firing function model constructed on the multi-optional functions entropy conditional optimality doctrine / A. V. Goncharenko // Problems of friction and wear. – 2019. – № 1(82). – pp. 58-62. DOI: 10.18372/0370-2197.1(82).13487 (ISSN 0370-2197 print)

35. **Goncharenko A. V.** A particular case of a variational problem of control in an active aviation system / A. V. Goncharenko // Transactions of the institute of aviation. – 2013. – № 228, pp. 3-12.

36. **Goncharenko A. V.** Active systems communicational control assessment in multi-alternative navigational situations / A. V. Goncharenko // 2018 IEEE 5th International Conference "Methods and Systems of Navigation and Motion Control (MSNMC)" Proceedings. October, 16-18, 2018, Kyiv, Ukraine. – 2018. – pp. 254-257.

37. **Goncharenko A. V.** Aeronautical and aerospace material and structural damages to failures: theoretical concepts / A. V. Goncharenko // International Journal of Aerospace Engineering. – Volume 2018 (2018), Article ID 4126085, 7 pages https://doi.org/10.1155/2018/4126085; 2018. – pp. 1-7.

38. **Goncharenko A. V.** Aeronautical engineering degrading state maximal probability determination as a proof for the hybrid-optional functions entropy conditional optimality doctrine application / A. V. Goncharenko //

Proceedings of The Eighth World Congress "Aviation in the XXI-st Century" "Safety in Aviation and Space Technologies". Kyiv, Ukraine, October 10-12, 2018: матеріали конгр. – Київ, NAU; 2018. – pp. 1.2.11-1.2.15.

39. **Goncharenko A. V.** Aeronautical engineering maintenance periodicity optimization with the help of subjective preferences distributions / A. V. Goncharenko // Proceedings of the NAU. – 2017. – № 2(71). – pp. 51-56.

40. **Goncharenko A. V.** Aircraft engines. Lecture notes (first preliminary edition). Chapter 10. Heat Capacities / A. V. Goncharenko // NAU electronic repository. – http://er.nau.edu.ua/handle/NAU/37936 – March 01, 2019. – 12 p.

41. **Goncharenko A. V.** Aircraft engines. Lecture notes (first preliminary edition). Chapter 9. Calculus Methods / A. V. Goncharenko // NAU electronic repository. – http://er.nau.edu.ua/handle/NAU/37936 – March 01, 2019. – 6 p.

42. **Goncharenko A. V.** Aircraft engines. Lecture notes (first preliminary edition). Chapter 8. Law of Energy Conservation in Thermodynamics / A. V. Goncharenko // NAU electronic repository. – http://er.nau.edu.ua/handle/NAU/37936 – March 01, 2019. – 6 p.

43. **Goncharenko A. V.** Aircraft engines. Lecture notes (first preliminary edition). Chapter 7. Heat and Work Consideration / A. V. Goncharenko // NAU electronic repository. – http://er.nau.edu.ua/handle/NAU/37936 – March 01, 2019. – 2 p.

44. **Goncharenko A. V.** Aircraft engines. Lecture notes (first preliminary edition). Chapter 6. Internal Energy Characteristic of Thermodynamics / A. V. Goncharenko // NAU electronic repository. – http://er.nau.edu.ua/handle/NAU/37936 – March 01, 2019. – 2 p.

45. **Goncharenko A. V.** Aircraft engines. Lecture notes (first preliminary edition). Chapter 5. Thermal Coefficients / A. V. Goncharenko // NAU electronic repository. – http://er.nau.edu.ua/handle/NAU/37936 – March 01, 2019. – 5 p.

46. **Goncharenko A. V.** Aircraft engines. Lecture notes (first preliminary edition). Chapter 4. Approaches for a Real Gas Dependencies Derivation / A. V. Goncharenko // NAU electronic repository. – http://er.nau.edu.ua/handle/NAU/37936 – March 01, 2019. – 19 p.

47. **Goncharenko A. V.** Aircraft engines. Lecture notes (first preliminary edition). Chapter 3. Theoretical Dependencies for an Ideal Gas / A. V. Goncharenko // NAU electronic repository. – http://er.nau.edu.ua/handle/NAU/37936 – March 01, 2019. – 7 p.

48. **Goncharenko A. V.** Aircraft engines. Lecture notes (first preliminary edition). Chapter 2. Basic Considerations of Thermodynamic Processes / A. V. Goncharenko // NAU electronic repository. – http://er.nau.edu.ua/handle/NAU/37936 – March 01, 2019. – 4 p.

49. **Goncharenko A. V.** Aircraft engines. Lecture notes (first preliminary edition). Chapter 1. General Characteristic of Thermodynamic System and Heat

and Work Mutual Conversions / A. V. Goncharenko // NAU electronic repository. – http://er.nau.edu.ua/handle/NAU/37936 – March 01, 2019. – 8 p.

50. **Goncharenko A. V.** Aircraft engines. Lecture notes (first preliminary edition) / A. V. Goncharenko // NAU electronic repository. – http://er.nau.edu.ua/handle/NAU/37936 – March 01, 2019. – 12 p.

51. **Goncharenko A. V.** Aircraft maximal distance horizontal flights in the conceptual framework of subjective analysis / A. V. Goncharenko // Proceedings of the NAU. – 2013. – № 4(57). – pp. 56-62.

52. **Goncharenko A. V.** Aircraft operation depending upon the uncertainty of maintenance alternatives / A. V. Goncharenko // Aviation. – 2017. Vol. 21(4). – pp. 126-131.

53. **Goncharenko A. V.** Airworthiness support measures analogy to the prospective roundabouts alternatives: theoretical aspects / A. V. Goncharenko // Journal of Advanced Transportation. – Volume 2018 (2018), Article ID 9370597, 7 pages https://doi.org/10.1155/2018/9370597; 2018. – pp. 1-7.

54. **Goncharenko A. V.** Alternativeness of control and power equipment repair versus purchasing according to the preferences of the options / A. V. Goncharenko // Electronics and control systems. – 2016. – № 4(50). – pp. 98-101.

55. **Goncharenko A. V.** An alternative method of the main psychophysics law derivation / A. V. Goncharenko // Clin. and Exp. Psychol. – 2017. – 3: 155. – pp. 1-5. doi: 10.4172/2471-2701.1000155. (ISSN: 2471-2701)

56. **Goncharenko A. V.** An entropy model of the aircraft gas turbine engine blades restoration method choice / A. V. Goncharenko // International Conference on Advanced Computer Information Technologies (ACIT-2018). – June 1-3, 2018. – Ceske Budejovice, CZECH REPUBLIC, 2018. – pp. 2-5.

57. **Goncharenko A. V.** An example of an alternative method of the normal distribution density derivation via a concept of a multi-optional optimality / A. V. Goncharenko // Electronics and control systems. – 2017. – № 3(53). – pp. 95-99. DOI: 10.18372/1990-5548.53.12149 (ISSN: 1990-5548)

58. **Goncharenko A. V.** An optional hybrid functions method of an ideal gas adiabatic process equation derivation / A. V. Goncharenko // Electronics and control systems. – 2017. – № 4(54). – pp. 109-112.

59. **Goncharenko A. V.** Applicability of the multi-optional uncertainty conditional optimality doctrine to the neuron firing model / A. V. Goncharenko // Матеріали XIV міжнародної науково-технічної конференції "AВIA-2019". (23-25 квітня 2019 р., Київ). – К.: НАУ, 2019. – pp. 17.11-17.15.

60. **Goncharenko A. V.** Applicable aspects of alternative UAV operation / A. V. Goncharenko // 2015 IEEE 3rd International Conference "Actual Problems of Unmanned Aerial Vehicles Developments (APUAVD)"

Proceedings. October, 13-15, 2015, Kyiv, Ukraine. – К.: Освіта України, 2015. – pp. 316-319.

61. **Goncharenko A. V.** [Application of the first problem of the material particle Dynamics](https://er.nau.edu.ua/handle/NAU/42064) [video] / A. V. Goncharenko // Tallinna Tehnikakõrgkool. – 07 December, 2006. – 13:18 minutes. NAU Electronic Repository. – https://er.nau.edu.ua/handle/NAU/42064

62. **Goncharenko A. V.** Artificial versus natural intellect in control of optimality / A. V. Goncharenko // Інтелектуальні системи прийняття рішень та проблеми обчислювального інтелекту: міжнародна наукова конференція, Євпаторія, 20-24 травня 2013 р.: матеріали конф. – Херсон: ХНТУ, 2013. – pp. 20-22. (ISBN 978-966-8912-70-2)

63. **Goncharenko A. V.** Bayes criterion modified with subjective preferences functions densies distributions used at the choosing of the decision making thresholds / A. V. Goncharenko // Матеріали XIII міжнародної науково-технічної конференції "AVIA-2017". (19-21 квітня 2017 р., Київ). – К.: НАУ, 2017. – pp. 17.17-17.21.

64. **Goncharenko A. V.** Cartesian vector direction cosines as the multi-optional hybrid functions optimal distribution / A. V. Goncharenko // Electronics and control systems. – 2020. – № 1(63). – pp. 53-57. DOI: 10.18372/1990-5548.63.14523 **(ISSN: 1990-5548)**

65. **Goncharenko A. V.** Concentrations formula conditional optimality with respect to their entropy / A. V. Goncharenko // Problems of friction and wear. – 2018. – № 1(78). – pp. 85-88. (ISSN 0370-2197)

66. **Goncharenko A. V.** Conceptual optimization in preferable advances of aeroengines blades restoration alternative technology / A. V. Goncharenko // International Research and Practical Conference "The development of technical sciences: problems and solutions". – April 27-28, 2018. – Brno, the Czech Republic, Volume/Part 3, 2018. – pp. 144-148.

67. **Goncharenko A. V.** Conflictability of operational situations in terms of entropy paradigm / A. V. Goncharenko // Сучасні інформаційні та інноваційні технології на транспорті (MINTT-2013) [Збірка матеріалів V Міжнародної науково-практичної конференції. У 2-х тт. (28-30 травня 2013 р., Херсон]. – Т. 1. – Херсон: Херсонська державна морська академія, 2013. – pp. 115-118.

68. **Goncharenko A. V.** Considerations for the aeronautical engineering degrading state probability determination / A. V. Goncharenko // Proceedings of The Eighth World Congress "Aviation in the XXI-st Century" "Safety in Aviation and Space Technologies". Kyiv, Ukraine, October 10-12, 2018: матеріали конгр. – Київ, NAU; 2018. – pp. 1.2.6-1.2.10.

69. **Goncharenko A. V.** Control of flight safety with the use of preferences functions / A. V. Goncharenko // Electronics and control systems. – 2013. – № 3(37). – pp. 113-119. (ISSN: 1990-5548)

70.     **Goncharenko A. V.** Cyber object state maximal probability timing obtained through multi-optional technique / A. V. Goncharenko // Proceedings of the International Workshop on Cyber Hygiene (CybHyg-2019) co-located with 1st International Conference on Cyber Hygiene and Conflict Management in Global Information Networks (CyberConf 2019). November 30, 2019, Kyiv, Ukraine. – 2019. – pp. 132-143. http://ceur-ws.org/Vol-2654/

71.     **Goncharenko A. V.** Decision making in conditions of multi-alternativeness and uncertainty. Part I / A. V. Goncharenko // NAU Electronic Repository. – http://er.nau.edu.ua/handle/NAU/40249 – June 22, 2019. – 21 p.

72.     **Goncharenko A. V.** Decision making in conditions of multi-alternativeness and uncertainty.ppt / A. V. Goncharenko // NAU Electronic Repository. – http://er.nau.edu.ua/handle/NAU/40361 – June 22, 2019. – 54 posters.

73.     **Goncharenko A. V.** Development of a theoretical approach to the conditional optimization of aircraft maintenance preference uncertainty / A. V. Goncharenko // Aviation. – 2018. Volume 22(2). – pp. 40-44.

74.     **Goncharenko A. V.** Distinguishing minimal engineering diagnosis risks via preferences functions / A. V. Goncharenko // Proceedings of The Seventh World Congress "Aviation in the XXI-st Century" "Safety in Aviation and Space Technologies". Kyiv, Ukraine, September 19-21, 2016: матеріали конгр. – Київ, NAU; 2016. – pp. 1.2.6-1.2.10.

75.     **Goncharenko A. V.** Example applications of the algebra of logics to the decision making problems of the aircraft airworthiness support technologies (aviation legislation and operational documentation concern) / A. V. Goncharenko // Матеріали XIV міжнародної науково-технічної конференції "AVIA-2019". (23-25 квітня 2019 р., Київ). – К.: НАУ, 2019. – pp. 17.16-17.20.

76.     **Goncharenko A. V.** Expediency of an improvement for a diesel-geared propulsion with respect to subjectively preferred operational factors / A. V. Goncharenko // Науковий вісник ХДМІ. – 2011. – № 1(4). – pp. 30-41.

77.     **Goncharenko A. V.** Expediency of unmanned air vehicles application in the framework of subjective analysis / A. V. Goncharenko // 2013 IEEE 2nd International Conference "Actual Problems of Unmanned Air Vehicles Developments" Proceedings. – October, 15-17, 2013, Kyiv, Ukraine. – 2013. – pp. 129-133.

78.     **Goncharenko A. V.** Exponential distribution density derived with the help of the multi-optional hybrid functions entropy conditional optimization / A. V. Goncharenko // Problems of friction and wear. – 2017. – № 4(77). – pp. 90-94. (ISSN 0370-2197)

79.     **Goncharenko A. V.** Extremality of control and preferences distributions "goodness" / A. V. Goncharenko // Electronics and control systems. – 2014. – № 4(42). – pp. 84-90. (ISSN: 1990-5548)

80. **Goncharenko A. V.** Fuel oil atomization characteristics smoothed by a logarithm normal distribution for marine diesel engines / A. V. Goncharenko // Двигатели внутреннего сгорания. – 2010. – № 2. – pp. 34-40. (ISSN 0419-8719)

81. **Goncharenko A. V.** Generalization for the degrading state maximal probability in the framework of the hybrid-optional entropy conditional optimality doctrine / A. V. Goncharenko // Problems of friction and wear. – 2018. – № 1(78). – pp. 89-92. (ISSN 0370-2197)

82. **Goncharenko A. V.** Horizontal flight for maximal distance at presence of conflict behavior (control) of the aircraft control system active element / A. V. Goncharenko // Матеріали XI міжнародної науково-технічної конференції "AVIA-2013". (21-23 травня 2013 р., Київ). – Т. 4. – К.: НАУ, 2013. – pp. 22.30-22.33.

83. **Goncharenko A. V.** Human factor aspect applicably to aeronautical engineering maintenance / A. V. Goncharenko // Матеріали XIII міжнародної науково-технічної конференції "AVIA-2017". (19-21 квітня 2017 р., Київ). – К.: НАУ, 2017. – pp. 17.9-17.13.

84. **Goncharenko A. V.** Hybrid combined relative pseudo-entropy / A. V. Goncharenko // NAU Electronic Repository. – http://er.nau.edu.ua/handle/NAU/40277 – September 22, 2019. – 8 p.

85. **Goncharenko A. V.** Hybrid relative combined pseudo-entropy function as a tool for a transport system management / A. V. Goncharenko // Electronics and control systems. – 2019. – № 3(61). – pp. 50-54. DOI: 10.18372/1990-5548.61.14220

86. **Goncharenko A. V.** Hybrid-Optional Effectiveness Functions Entropy Conditional Extremization Doctrine Contributions into Engineering Systems Reliability Assessments / A. V. Goncharenko // Transactions on Aerospace Research. – 2019. – № 2(255). – pp. 90-100. DOI: https://doi.org/10.2478/tar-2019-0012 (ISSN 2545-2835)

87. **Goncharenko A. V.** Initial considerations for the multi-optional doctrine implementation to the aircraft airworthiness support effectiveness estimations / A. V. Goncharenko // Proceedings of The Eighth World Congress "Aviation in the XXI-st Century" "Safety in Aviation and Space Technologies". Kyiv, Ukraine, October 10-12, 2018: матеріали конгр. – Київ, NAU; 2018. – pp. 1.2.1-1.2.5.

88. **Goncharenko A. V.** Introduction to Dynamics (Theoretical Mechanics) [video] / A. V. Goncharenko // Tallinna Tehnikakõrgkool. – 07 December, 2006. – 14:47 minutes. – NAU Electronic Repository. – https://er.nau.edu.ua/handle/NAU/42059

89. **Goncharenko A. V.** Main components and stages of the hybrid-optional doctrine development.ppt / A. V. Goncharenko // NAU Electronic

Repository. – http://er.nau.edu.ua/handle/NAU/40368 – October 03, 2019. – 55 posters.

90. **Goncharenko A. V.** Mathematical modeling of the ship's main engine random operational process / A. V. Goncharenko // Двигатели внутреннего сгорания. – 2012. – № 2. – pp. 117-125. (ISSN 0419-8719)

91. **Goncharenko A. V.** Measures for estimating transport vessels operators' subjective preferences uncertainty / A. V. Goncharenko // Scientific Bulletin of Kherson State Maritime Academy. – 2012. – № 1(6). – pp. 59-69.

92. **Goncharenko A. V.** Methodology of applied research. Lectures 1-4 [video] / A. V. Goncharenko // National Aviation University. – 13 October, 2020. – 45:56 minutes. NAU Electronic Repository. – https://er.nau.edu.ua/handle/NAU/44514

93. **Goncharenko A. V.** Methodology of applied research. Lectures 5-7 [video] / A. V. Goncharenko // National Aviation University. – 04 December, 2020. – 39:41 minutes. NAU Electronic Repository. – https://er.nau.edu.ua/handle/NAU/44747

94. **Goncharenko A. V.** Modeling aviation legislation influence upon airworthiness support technologies via preferences functions / A. V. Goncharenko // Proceedings of The Seventh World Congress "Aviation in the XXI-st Century" "Safety in Aviation and Space Technologies". Kyiv, Ukraine, September 19-21, 2016: матеріали конгр. – Київ, NAU; 2016. – pp. 1.2.11-1.2.15.

95. **Goncharenko A. V.** Multi-optional doctrine with the uncertainty degree evaluation for the aircraft airworthiness support technologies / A. V. Goncharenko // Proceedings of The Eighth World Congress "Aviation in the XXI-st Century" "Safety in Aviation and Space Technologies". Kyiv, Ukraine, October 10-12, 2018: матеріали конгр. – Київ, NAU; 2018. – pp. 1.2.16-1.2.20.

96. **Goncharenko A. V.** Multi-optional hybrid effectiveness functions optimality doctrine for maintenance purposes / A. V. Goncharenko // 14th IEEE International Conference on Advanced Trends in Radioelectronics, Telecommunications and Computer Engineering (TCSET-2018). – February, 20-24, 2018, Lviv-Slavske, Ukraine. – 2018. – pp. 771-775.

97. **Goncharenko A. V.** Multi-Optional Hybrid Functions Entropy Doctrine Advantages for a State Maximal Probability Determination / A. V. Goncharenko // Transactions on Aerospace Research. – 2020. – № 1(258). – pp. 53-65. DOI: https://doi.org/10.2478/tar-2020-0004, https://content.sciendo.com/view/journals/tar/2020/1/article-p53.xml.

98. **Goncharenko A. V.** Multi-optional hybridization for UAV maintenance purposes / A. V. Goncharenko // 2019 IEEE 5th International Conference "Actual Problems of Unmanned Aerial Vehicles Developments

(APUAVD)" Proceedings. – October, 22-24, 2019, Kyiv, Ukraine. – 2019. – pp. 48-51.

99. **Goncharenko A. V.** Navigational alternatives, their control and subjective entropy of individual preferences / A. V. Goncharenko // 2014 IEEE 3rd International Conference "Methods and Systems of Navigation and Motion Control (MSNMC)" Proceedings. – October, 14-17, 2014, Kyiv, Ukraine. – 2014. – pp. 99-103.

100. **Goncharenko A. V.** Neuron model sigmoid activation function based on multi-optional functions entropy conditional optimization doctrine / A. V. Goncharenko // Electronics and control systems: Scientific journal. – Kyiv: Publishing house "Osvita Ukraini", 2018. – № 4(58). – pp. 108-114. DOI: 10.18372/1990-5548.58.13518 **(ISSN: 1990-5548)**

101. **Goncharenko A. V.** One theoretical aspect of entropy paradigm application to the problems of tribology / A. V. Goncharenko // Problems of friction and wear. – 2017. – № 1(74). – pp. 78-83. (ISSN 0370-2197 print)

102. **Goncharenko A. V.** Operational reliability measures for marine propulsion diesel engines / A. V. Goncharenko // Сучасні енергетичні установки на транспорті і технології та обладнання для їх обслуговування: Всеукраїнська науково-практична конференція, Херсон, 12-14 жовтня 2011 р.: матеріали конф. – Херсон, 2011. – pp. 23-27.

103. **Goncharenko A. V.** Optimal controlling path determination with the help of hybrid optional functions distributions / A. V. Goncharenko // Radio Electronics, Computer Science, Control. – 2018. – № 1(44). – pp. 149-158.

104. **Goncharenko A. V.** Optimal dividing between purchasing and fabrication / A. V. Goncharenko // Сучасні енергетичні установки на транспорті, технології та обладнання для їх обслуговування: Республіканська науково-практична конференція, Херсон, 5-7 жовтня 2010 р.: матеріали конф. – Херсон, 2010. – pp. 54-55.

105. **Goncharenko A. V.** Optimal maintenance periodicity for aeronautical engineering operation determined on the theoretical platform of subjective analysis / A. V. Goncharenko // XIIIth International Conference "AVIA-2017". (April 19-21, 2017, Kyiv). – Kyiv: National Aviation University, 2017. – pp. 17.29-17.33.

106. **Goncharenko A. V.** Optimal managerial and control values for active operation / A. V. Goncharenko // Electronics and control systems. – 2016. – № 3(49). – pp. 112-115. (ISSN: 1990-5548)

107. **Goncharenko A. V**. Optimal optional-hybrid functions distribution for a reliability problem within the "multi-optionality" uncertainty degree evaluation doctrine / A. V. Goncharenko // Матеріали XIV міжнародної науково-технічної конференції "АВІА-2019". (23-25 квітня 2019 р., Київ). – К.: НАУ, 2019. – pp. 17.6-17.10.

108. **Goncharenko A. V.** Optimal Price Choice through Buyers' Preferences Entropy [video] / A. V. Goncharenko // The 2020 10th International Conference on Advanced Computer Information Technologies. Deggendorf, GERMANY. – 14 June, 2020. – 15:45 minutes. NAU Electronic Repository. – https://er.nau.edu.ua/handle/NAU/43439

109. **Goncharenko A. V.** Optimal Price Choice through Buyers' Preferences Entropy / A. V. Goncharenko // 2020 10th International Conference on Advanced Computer Information Technologies (ACIT'2020). – September 16-18, 2020. – Deggendorf, Germany, 2020. – pp. 537-540.

110. **Goncharenko A. V.** Optimal UAV maintenance periodicity obtained on the multi-optional basis / A. V. Goncharenko // 2017 IEEE 4th International Conference "Actual Problems of Unmanned Aerial Vehicles Developments (APUAVD)" Proceedings. – October, 17-19, 2017, Kyiv, Ukraine. – 2017. – pp. 65-68.

111. **Goncharenko A. V.** Preferences distributions densities for a common continuous alternative / A. V. Goncharenko // Науковий вісник ХДМА. – 2014. – № 2(11). – pp. 22-27. (ISSN 2313-4763)

112. **Goncharenko A. V.** Prospects of alternative sources of energy and engines used in ships propulsion and power plants / A. V. Goncharenko // Сучасні енергетичні установки на транспорті, технології та обладнання для їх обслуговування: Республіканська науково-практична конференція, Херсон, 5-7 жовтня 2010 р.: матеріали конф. – Херсон, 2010. – pp. 115-116.

113. **Goncharenko A. V.** Rational modes of operation for a four-arm tiller electro-hydraulic steering gear with respect to multi-alternativeness and preferences / A. V. Goncharenko // Науковий вісник ХДМА. – 2013. – № 1(8). – С. 28-34. (ISSN 2077-3617)

114. **Goncharenko A. V.** Relative Pseudo-Entropy Functions and Variation Model Theoretically Adjusted to an Activity Splitting / A. V. Goncharenko // 2019 9th International Conference on Advanced Computer Information Technologies (ACIT'2019). – June 5-7, 2019. – Ceske Budejovice, Czech Republic, 2019. – pp. 52-55.

115. **Goncharenko A. V.** Research of operational effectiveness changes / A. V. Goncharenko // Сучасні енергетичні установки на транспорті, технології та обладнання для їх обслуговування: Республіканська науково-практична конференція, Херсон, 5-7 жовтня 2010 р.: матеріали конф. – Херсон, 2010. – pp. 20-23.

116. **Goncharenko A. V.** Safe maneuvering of a ship in a multi-alternative operational situation / A. V. Goncharenko // Bezpieczeństwo na lądzie, morzu i w powietrzu w XXI wieku. – 2014. – pp. 207-210. (ISBN 978-83-61520-02-3)

117. **Goncharenko A. V.** Safety and its entropy measures of certainty or uncertainty / A. V. Goncharenko // Безпека життєдіяльності на транспорті і

виробництві – освіта, наука, практика (SLA-2014) [збірник матеріалів Міжнародної науково-практичної конференції. (18-19 вересня 2014 р., Херсон)]. – Херсон: Херсонська державна морська академія, 2014. – pp. 44-46.

118. **Goncharenko A. V.** Several models of artificial intelligence elements for aircraft control / A. V. Goncharenko // 2016 IEEE 4th International Conference "Methods and Systems of Navigation and Motion Control (MSNMC)" Proceedings. – October, 18-20, 2016, Kyiv, Ukraine. – 2016. – pp. 224-227.

119. **Goncharenko A. V.** Several models of physical exercise subjective preferences / A. V. Goncharenko // Clin. and Exp. Psychol. – 2016. – 2: 121. – pp. 1-6. doi:10.4172/2471-2701.1000121. (ISSN: 2471-2701 CEP)

120. **Goncharenko A. V.** Some identities of subjective analysis derived on the basis of the subjective entropy extremization principle by Professor V.A. Kasianov / A.V. Goncharenko // Automatic Control and Information Sciences. – 2014. – Vol. 2, No. 1. – pp. 20-25.

121. **Goncharenko A. V.** Speedy aircraft horizontal flight maximal distance to duration dilemma / A. V. Goncharenko // VIII Міжнародна науково-практична конференція «Управління високошвидкісними рухомими об'єктами та професійна підготовка операторів складних систем». (20 грудня 2019 р., Кропивницький). – Кропивницька льотна академія, Національний авіаційний університет. – Кропивницький: Вид-во ЛА НАУ, 2019. – pp. 402-406.

122. **Goncharenko A. V.** Subjective entropy extremization principle as a tool of an aircraft maximal duration horizontal flight control / A. V. Goncharenko // Авиационно-космическая техника и технология. – 2013. – Вып. 8(105). – pp. 229-234.

123. **Goncharenko A. V.** Subjective entropy maximum principle for preferences functions of alternatives given in the view of logical conditions / A. V. Goncharenko // Штучний інтелект. – 2013. – № 4(62). – 1 G. pp. 4-9.

124. **Goncharenko A. V.** Subjective preferences for optimal economy continuous rating of MaK 9M453C / A. V. Goncharenko // Сучасні інформаційні та інноваційні технології на транспорті: ІІІ Міжнародна науково-практична конференція, Херсон, 23-25 травня 2011 р.: матеріали конф. У 2-х тт. Том 2. – Херсон: Видавництво Херсонського державного морського інституту, 2011. – pp. 114-119.

125. **Goncharenko A. V.** Symmetrical solution for a reliability problem within the multi-optional uncertainty degree evaluation doctrine / A. V. Goncharenko // Матеріали XIV міжнародної науково-технічної конференції "АВІА-2019". (23-25 квітня 2019 р., Київ). – К.: НАУ, 2019. – pp. 17.1-17.5.

126. **Goncharenko A. V.** The Ant Colony Probabilistic Model Equivalency to the Options Uncertainty Extremized One [video] / A. V. Goncharenko // The 2020 10th International Conference on Advanced Computer Information Technologies. Deggendorf, GERMANY. – 16 June, 2020. – 14:30 minutes. NAU Electronic Repository. – https://er.nau.edu.ua/handle/NAU/43537

127. **Goncharenko A. V.** The Ant Colony Probabilistic Model Equivalency to the Options Uncertainty Extremized One / A. V. Goncharenko // 2020 10th International Conference on Advanced Computer Information Technologies (ACIT'2020). – September 16-18, 2020. – Deggendorf, Germany, 2020. – pp. 541-544.

128. **Goncharenko A. V.** The Bayes' formula in terms of the multi-optional uncertainty conditional optimality doctrine / A. V. Goncharenko // Proceedings of The Eighth World Congress "Aviation in the XXI-st Century" "Safety in Aviation and Space Technologies". Kyiv, Ukraine, October 10-12, 2018: матеріали конгр. – Київ, NAU; 2018. – pp. 1.4.34-1.4.38.

129. **Goncharenko A. V.** The first problem of Dynamics [video] / A. V. Goncharenko // Tallinna Tehnikakõrgkool. – 07 December, 2006. – 14:51 minutes. – NAU Electronic Repository. – https://er.nau.edu.ua/handle/NAU/42063

130. **Goncharenko A. V.** The lecture fragment on the certifying staff – maintenance, Licenses A, B [video] / A. V. Goncharenko // NAU Electronic Repository. – https://er.nau.edu.ua/handle/NAU/38384 – April 09, 2019. – 15:06 minutes.

131. **Goncharenko A. V.** The optimal commercial speed of a transport vessel with respect to operators' subjective preferences / A. V. Goncharenko // Науковий вісник ХДМІ. – 2011. – № 2(5). – pp. 12-20.

132. **Goncharenko A. V.** The optimal internal "shadow" taxation on condition of a firm external economic activity / A. V. Goncharenko, O. A. Zaporozchenko // Proceedings of the NAU. – 2013. – № 2(55). – pp. 251-257.

133. **Goncharenko A. V.** The User-Preferred Optimal Flight Parameters in an Active Navigational System in a Multi-Alternative Situation / A. V. Goncharenko // Transactions on Aerospace Research. – 2020. – № 2(259). – pp. 1-12. DOI: https://doi.org/10.2478/tar-2020-0006

134. **Goncharenko A. V.** The value of the kinetic reaction order determined based upon the conditional optimality doctrine for the multi-optional functions entropy / A. V. Goncharenko // Problems of friction and wear. – 2019. – № 2(83). – pp. 37-40. DOI: 10.18372/0370-2197.2(83).13690

135. **Goncharenko A. V.** Tribological process characteristics on the basis of a neuron activation model obtained through the multi-optional

functions entropy doctrine / A. V. Goncharenko // Problems of friction and wear. – 2018. – № 3(80). – pp. 32-35.

136. **Goncharenko A. V.** Two Entropy Theory Wings as a New Trend for the Modern Means of Air Transport Operational Reliability Measure / A. V. Goncharenko // Transactions on Aerospace Research. – 2020. – № 3(260). – pp. 64-74. DOI: https://doi.org/10.2478/tar-2020-0017

137. **Kasianov V. A.** A Recursive Model of a Quasi-Isolated Elementary Social System Dynamics / V. A. Kasianov, A. V. Goncharenko // NAU electronic repository. - http://dspace.nau.edu.ua/handle/NAU/37759 - January 01, 2015. – 5 p.

138. **Kasianov V. A.** Alternatives and subjective entropy paradigm context in regards with the conflicts theory / V. A. Kasianov, A. V. Goncharenko // Матеріали XIV міжнародної науково-технічної конференції "AVIA-2019". (23-25 квітня 2019 р., Київ). – К.: НАУ, 2019. – pp. 37.1-37.5.

139. **Kasianov V. A.** Conceptual Framework of the Entropy Theory of Conflicts: monograph / V. A. Kasianov, A. V. Goncharenko. – Kyiv, Ukraine: NAU Electronic Repository. – https://er.nau.edu.ua/handle/NAU/42079 – April 02, 2020. – 131 p.

140. **Kasianov V. A.** Connection of subjective entropy maximum principle to the main laws of psych / V.A. Kasianov, A.V. Goncharenko // Research in Psychology and Behavioral Sciences. – 2014. – Vol. 2, No. 3. – pp. 59-65.

141. **Kasianov V. A.** Control in a hierarchical active system on the basis of entropy paradigm of subjective analysis / V.A. Kasianov, A.V. Goncharenko, K. Szafran // Prace Instytutu Lotnictwa Transactions of the institute of aviation. – Warszawa Warsaw, Poland: Institute of Aviation Scientific Publications, 2014. – № 4 (237), pp. 30-38.

142. **Kasianov V. A.** Dynamical rating forecast / V. A. Kasianov, A. V. Goncharenko // NAU electronic repository. - http://er.nau.edu.ua/handle/NAU/39559 - April 1, 2019. – 12 p.

143. **Kasianov V. A.** Elements of entropy conflict theory. Applications to the military conflicts / V. A. Kasianov, A. V. Goncharenko // NAU Electronic Repository. – http://er.nau.edu.ua/handle/NAU/40727 – October 31, 2019. – 12 p.

144. **Kasianov V. A.** Entropy methods of human factor analysis applied to the problem of safety of aviation / V. A. Kasianov, A. V. Goncharenko // Proceedings of The Eighth World Congress "Aviation in the XXI-st Century" "Safety in Aviation and Space Technologies". Kyiv, Ukraine, October 10-12, 2018: матеріали конгр. – Київ, NAU; 2018. – pp. 13.2.14-13.2.18.

145. **Kasianov V. A.** Entropy theory of conflicts (Presentation of a new monograph) / V. A. Kasianov, A. V. Goncharenko // Індивідуальність у

психологічних вимірах спільнот та професій: збірник наукових праць / за заг. ред. Л. В. Помиткіної, О. М. Ічанської. – К. : ТОВ «Альфа-ПІК», 2020. – pp. 49-51.

146. **Kasianov V. A.** Entropy Theory of Conflicts. Conflict Management: monograph / V. A. Kasianov, A. V. Goncharenko. – Publishing House "LAP LAMBERT Academic Publishing", 2020. – 180 p. (ISBN-13: 978-620-2-51558-0) http://www.morebooks.shop/bookprice_offer_82619b0ca79cbb0662e45c44adf a9650bc33b239?locale=gb¤cy=EUR

147. **Kasianov V. A.** Entropy theory of subjective conflicts (etsc). some basic provisions / V. A. Kasianov, A. V. Goncharenko // NAU electronic repository. - http://dspace.nau.edu.ua/handle/NAU/37758 - February 15, 2019. – 8 p.

148. **Kasianov V. A.** Estimation of rating splitting at the final stage of an election campaign based upon the subjective entropy theory / V. A. Kasianov, A. V. Goncharenko // Авіаційна та екстремальна психологія у контексті технологічних досягнень: збірник наукових праць / за заг. ред. Л.В. Помиткіної, Т.В. Вашеки, О.М. Ічанської. – К. : ТОВ «Альфа-ПІК», 2019. – pp. 101-107.

149. **Kasianov V. A.** Extremal Principle of Subjective Analysis. Light and Shadow. Proportions of Shadow Economy. Entropy Approach. Екстремальний принцип суб'єктивного аналізу. Світло і тінь. Пропорції тіньової економіки. Ентропійний підхід (англійською мовою): monograph / V. A. Kasianov, A. V. Goncharenko. – Kyiv, Ukraine: Publishing House "Kafedra", 2017. – 90 p. (ISBN 978-617-7301-41-6)

150. **Kasianov V. A.** Invariants and first integrals for a special case of a controlled process in an active aviation system / V.A. Kasianov, A.V. Goncharenko // Восточно-Европейский журнал передовых технологий. Системы управления. – Харьков: Технологический Центр, 2013. – Т. 3, №3(63), С. 10-13.

151. **Kasianov V. A.** Light and shadow economy proportions and entropy approach to principal laws of psychodynamics / V.A. Kasianov, A.V. Goncharenko // Інтелектуальні системи прийняття рішень та проблеми обчислювального інтелекту: міжнародна наукова конференція, Залізний Порт, Україна, 28-31 травня 2014 р.: матеріали конф. – Херсон: ХНТУ, 2014. – С. 9-11. (ISBN 978-966-8912-90-0)

152. **Kasianov V. A.** Modeling of control in a hierarchical active system on the basis of entropy paradigm of subjective analysis / V.A. Kasianov, A.V. Goncharenko, K. Szafran // Transactions of the institute of aviation. Selected problems of air transport. – Warsaw, Poland: Institute of Aviation Scientific Publications, 2014. – № 4(237), pp. 39-48.

153. **Kasianov V. A.** Multi-alternativeness of aircraft airworthiness support modern technologies / V. A. Kasianov, A. V. Goncharenko // Proceedings of The Seventh World Congress "Aviation in the XXI-st Century" "Safety in Aviation and Space Technologies". Kyiv, Ukraine, September 19-21, 2016: матеріали конгр. – Київ, NAU; 2016. – pp. 1.2.1-1.2.5.

154. **Kasianov V. A.** Principle of subjective entropy maximum at the aircraft operation and maintenance staff selection / V. A. Kasianov, A. V. Goncharenko // NAU Electronic Repository. – http://er.nau.edu.ua/handle/NAU/40345 – September 22, 2019. – 8 p.

155. **Kasianov V. A.** Recursive models of psychodynamics in the framework of subjective entropy of preferences paradigm / V.A. Kasianov, A.V. Goncharenko // Proceedings of The Sixth World Congress "Aviation in the XXI-st Century" "Safety in Aviation and Space Technologies". Kyiv, Ukraine, 23-25 вересня, 2014 p.: матеріали конгр. – Київ, NAU; 2014. – Vol. 3, pp. 9.5-9.10.

156. **Kasianov V. A.** Social Aspects and Subjective Entropy Paradigm Application to the Problems of Light and Shadow Economy / V. A. Kasianov, A. V. Goncharenko // NAU electronic repository. - http://dspace.nau.edu.ua/handle/NAU/37760 - February 01, 2018. – 15 p.

157. **Kasianov V. A.** Social justice as a subjective analysis category. Numerical estimations / V. A. Kasianov, A. V. Goncharenko // Interdisciplinary Studies of Complex Systems. – 2018. – No 13. – pp. 27-40.

158. **Kasianov V. A.** Some possible principles of the fast-speed UAV active control systems design / V. A. Kasianov, A. V. Goncharenko // VIII Міжнародна науково-практична конференція «Управління високошвидкісними рухомими об'єктами та професійна підготовка операторів складних систем». (20 грудня 2019 p., Кропивницький). – Кропивницька льотна академія, Національний авіаційний університет. – Кропивницький: Вид-во ЛА НАУ, 2019. – pp. 52-53.

159. **Kasianov V. A.** Subjective entropy approach applicability to aeronautical engineering operational problems / V. A. Kasianov, A. V. Goncharenko // Матеріали XIII міжнародної науково-технічної конференції "ABIA-2017". (19-21 квітня 2017 p., Київ). – К.: НАУ, 2017. – pp. 17.5-17.8.

160. **Kasianov V. A.** Subjective entropy maximum principle and its applications / V. A. Kasianov, A. V. Goncharenko // Авіаційна та екстремальна психологія у контексті технологічних досягнень: збірник наукових праць / за заг. ред. Л. В. Помиткіної, Т. В. Вашеки, О. В. Сечейко. – К.: Аграр Медіа Груп, 2017. – 317 с. pp. 116-120.

161. **Kasianov V. A.** Subjectively preferred optimally controlled modes of operation for an aircraft maximal duration horizontal flight / V.A. Kasianov, A.V. Goncharenko // Авиационно-космическая техника и технология: сб.

науч. тр. / М-во образования и науки Украины, Нац. аэрокосм. ун-т им. Н. Е. Жуковского «ХАИ». – Х., 2013. – Вып. 10 (107). – С. 112-117.

162.  **Kasianov V. A.** [Theoretical description of military conflicts based upon the subjective entropy paradigm](#) / V. A. Kasianov, A. V. Goncharenko // Матеріали науково-практичної конференції "Філософсько-соціологічні та психолого-педагогічні проблеми підготовки особистості до виконання завдань в особливих умовах". (31 жовтня 2019 р., Київ). – Міністерство оборони України, Національний університет оборони України імені Івана Черняховського. – К.: НУОУ, 2019. – pp. 116-120.

163.  **Kasianov V. A.** Theory of Conflicts. Entropy Paradigm. Теорія конфліктів. Ентропійна парадигма (англійською мовою): monograph / V. A. Kasianov, A. V. Goncharenko. – Kyiv, Ukraine: Publishing House "Kafedra", 2020. – 172 p. (ISBN: 978-617-7301-78-2)

164.  **Kasianov V. A.** Variational principle of psychology / V.A. Kasianov, A.V. Goncharenko // Proceedings of The Seventh World Congress "Aviation in the XXI-st Century" "Safety in Aviation and Space Technologies". Kyiv, Ukraine, September 19-21, 2016: матеріали конгр. – Київ, NAU; 2016. – pp. 9.187-9.190.

165.  **Kasjanov V.** Quantitative models of influence of subjective factors on flight safety / *V. Kasjanov, A. Goncharenko* // Proceedings of The Second World Congress "Aviation in the XXI st Century", Kyiv, September 19-21, 2005. – Kyiv, Ukraine: NAU, 2005. – pp. 6.38-6.42.

166.  **Kasjanov V.** Theoretical mechanics. Statics. Kinematics: Summary of lectures / *V. Kasjanov, V. Karachun, A. Goncharenko.* – Kyiv: NAU, 2005. – 148 p.

167.  **Kasjanov V. O.** Models of competitors' preferences influence upon the number of seafarers on board and ashore / V.O. Kasyanov, A.V. Goncharenko // Науковий вісник ХДМІ: Науковий журнал. – Херсон: Видавництво ХДМІ, 2010. – №2(3). – С. 231-237.

168.  **Kasyanov V. A.** The concept of SPPP operational processes multi-alternativeness in terms of subjective analysis / V.A. Kasyanov, A.V. Goncharenko // Сучасні інформаційні та інноваційні технології на транспорті (MINTT-2012): збірка матеріалів IV Міжнародної науково-практичної конференції. У 2-х тт. Т. 1. – Херсон: Херсонська державна морська академія, 2012. – С. 106-108.

169.  **Kasyanov V. O.** Approach to flight safety in terms of the subjective analysis / V.O. Kasyanov, A.V. Goncharenko // Proceedings of The Fourth World Congress "Aviation in the XXI-st Century". "Safety in Aviation and Space Technologies". Kyiv, September 21-23, 2010. – Kyiv, Ukraine: NAU, 2010. – Vol. 1, pp. 14.20-14.23.

170.  **Kasyanov V. O.** Problems of specialists training in the field of ships propulsion and power plants operation on the principles of the subjective

analysis / V.O. Kasyanov, A.V. Goncharenko // Сучасні енергетичні установки на транспорті, технології та обладнання для їх обслуговування: Республіканська науково-практична конференція, Херсон, 5-7 жовтня 2010 р.: матеріали конф. – Херсон, 2010. – С. 131-133.

171. **Kasyanov V. O.** Variational principle in the problem of ship propulsion and power plant operation with respect to subjective preferences / V.O. Kasyanov, A.V. Goncharenko // Науковий вісник Херсонської державної морської академії: Науковий журнал. – Херсон: Видавництво ХДМА, 2012. – № 2(7). – С. 56-61. (ISSN 2077-3617)

172. **Kasyanov V.,** *Goncharenko A*. Modelling of technical and economical aspects of flight safety // The World Congress "Aviation in the XXI-st Century" press-release. K, Ukraine: NAU, 2003. – pp. 2.63-2.66.

173. **Operational** Documentation (ICAO Doc 9760) : Self-Study Method Guide . Part I . / compiler: A. V. Goncharenko. – K. : NAU, Electronic Repository. – 2020. – 38 p. https://er.nau.edu.ua/handle/NAU/35357, Operational_Documentation_(ICAO_9760)_Self_Study_Guide.doc.

174. **Pluzhnikov B. O.** Construction Machinery, Equipment and Road Machines. Earth-moving Machines: The course of lectures / *B.O. Pluzhnikov, A.V. Goncharenko, V.I. Lychik*. – K.: NAU, 2002. – 40 p.

175. **Pre-diploma** practices : self-study method guide . Part I . / compiler: A. V. Goncharenko. – K. : NAU, Electronic Repository. – 2020. – 33 p. https://er.nau.edu.ua/handle/NAU/44179, 2_Course_Pre_Diploma_Practices_Self_Study_Guide (1)-перетворено.pdf.

176. **Scientific** research practices : self-study method guide . Part I . / compiler: A. V. Goncharenko. – K. : NAU, Electronic Repository. – 2020. – 33 p. https://er.nau.edu.ua/handle/NAU/44161, 2_Course_Scientific_Research_Practices_Self_Study_Guide.doc.

177. **Sushchenko O.** Design of Robust Systems for Stabilization of Unmanned Aerial Vehicle Equipment / O. Sushchenko, A. Goncharenko // International Journal of Aerospace Engineering. – Volume 2016 (2016), Article ID 6054081, 10 pages http://dx.doi.org/10.1155/2016/6054081; 2016. – pp. 1-10.

178. **Гончаренко А. В.** Аналіз гвинтової характеристики двигуна 5 ДКРН 70/226,8 за питомою витратою палива / А. В. Гончаренко // Науковий вісник ХДМІ. – 2009. – № 1(1). – С. 16-24.

179. **Гончаренко А. В.** Аналіз параметричних досліджень реологічних властивостей водовугільних суспензій для застосування у суднових двигунах внутрішнього згоряння / А. В. Гончаренко // Авиационно-космическая техника и технология. – 2009. – № 8(65). – С. 90-95.

180. **Гончаренко А. В.** Аэрогидрогазодинамика и динамика полета. Введение [видео] / А. В. Гончаренко // Национальный авиационный

університет. – 14 декабря, 2020. – 21:19 минуты. NAU Electronic Repository. – https://er.nau.edu.ua/handle/NAU/44768

181. **Гончаренко А. В.** Варіанти вибору стратегії підтримання безпеки функціонування транспортної системи / А. В. Гончаренко // Вісник НАУ. – 2009. – № 2(39). – С. 30-35.

182. **Гончаренко А. В.** Вибір оптимальної комерційної швидкості транспортного судна / А. В. Гончаренко // Науковий вісник ХДМІ. – 2010. – № 1(2). – С. 41-49.

183. **Гончаренко А. В.** Вплив суб'єктивних переваг на показники роботи суднової енергетичної установки / А. В. Гончаренко // Автоматика, автоматизация, электротехнические комплексы и системы. – 2008. – № 2(22). – С. 105-111.

184. **Гончаренко А. В.** Дослідження характеристики двигуна стосовно зміни оптимальних значень / А. В. Гончаренко // Сучасні інформаційні та інноваційні технології на транспорті (MINTT-2009). [Збірка наукових праць у п'яти томах. (25-27 травня 2009 р., Херсон)]: Матеріали Міжнародної науково-практичної конференції. – Том 4. – Херсон: Видавництво Херсонського державного морського інституту, 2009. – С. 45-48.

185. **Гончаренко А. В.** Експлуатація активних транспортних систем в умовах багатоальтернативності та невизначеності: автореф. … докт. техн. наук: 05.22.20 / А. В. Гончаренко. – К.: НАУ, 2016. – 39 с.

186. **Гончаренко А. В.** Керування підтриманням безпеки польотів через технічні та витратні чинники: автореф. … канд. техн. наук: 05.13.03 / А. В. Гончаренко. – К.: НАУ, 2005. – 20 с.

187. **Гончаренко А. В.** Методичні рекомендації до дипломного проектування / А.В. Гончаренко. – Херсон: Видавництво ПП Тріфонов, друкарня «Графіка», 2010. – 63 с. (ISBN: 978-966-2997-06-4)

188. **Гончаренко А. В.** Моделювання впливу ентропії суб'єктивних переваг на прийняття рішень стосовно ремонту суднової енергетичної установки / А. В. Гончаренко // Автоматика, автоматизация, электротехнические комплексы и системы. – 2009. – № 1(23). – С. 123-131.

189. **Гончаренко А. В.** Моделювання впливу профілактичних замін на показники безпеки польотів / А. В. Гончаренко // Вісник НАУ. – 2004. – № 3(21). – С. 74-77.

190. **Гончаренко А. В.** Обоснование величины инвестиций в безопасность полетов с учетом коэффициента технического использования / А. В. Гончаренко // Наука і молодь. Прикладна серія: Збірник наукових праць. – К.: НАУ, 2004. – Вип. 4. – С. 15-18.

191. **Гончаренко А. В.** Оптимальне внутрішнє тіньове оподаткування за умови зовнішньоекономічної діяльності фірми /

А. В. Гончаренко, О. А. Запорожченко // Вісник НАУ. – 2013. – № 2(55). – С. 251-257.

192. **Гончаренко А. В.** Оформлення звітності з плавальної практики судномеханіка (заповнення книги реєстрації практичної підготовки) за спеціальністю «Експлуатація суднових енергетичних установок» усіх форм навчання: навчальний посібник для ВНЗ / А.В. Гончаренко. – Херсон: Видавництво ПП Вишемирський В.С., 2010. – 128 с.

193. **Гончаренко А. В.** Показники безпеки функціонування транспортної системи в умовах зростання цін на пальне / А. В. Гончаренко // Вісник НАУ. – 2009. – № 1(38). – С. 35-39.

194. **Гончаренко А. В.** Постановка задачі про вибір оптимального рівня витрат на підтримання безпеки польотів / А. В. Гончаренко // НАУКА І МОЛОДЬ: Матеріали міжнародної наукової конференції. – К.: НАУ, 2001. – С. 110.

195. **Гончаренко А. В.** Принципові питання змісту та методики виконання дипломної роботи за спеціальністю «Експлуатація суднових енергетичних установок» усіх форм навчання: навчальний посібник для ВНЗ / А. В. Гончаренко. – Херсон: Видавництво ПП Тріфонов, друкарня «Графіка», 2010. – 165 с. (ISBN: 978-966-2997-08-8)

196. **Гончаренко А. В.** Типи задач рекомендованих до опрацювання при виконанні дипломної роботи за спеціальністю «Експлуатація суднових енергетичних установок» усіх форм навчання: навчальний посібник для ВНЗ / А. В. Гончаренко. – Херсон: Видавництво ПП Тріфонов, друкарня «Графіка», 2010. – 192 с. (ISBN: 978-966-2997-07-1)

197. **Експлуатація** авіаційної наземної техніки. Лабораторні роботи 1-4. / Уклад.: *О.М. Білякович, Г.М. Гелетуха, А.В. Гончаренко.* – К.: НАУ, 2002. – 32 с.

198. **Запорожец В. В.,** *Олефир А. И., Смирнов Ю. И., Билякович О. Н., Закиев И. М., Гончаренко А. В.* Геометрическое проектирование базовых шасси спецмашин: Учебно-методическое пособие для студентов специальности 7.100108 «Эксплуатация авиационной наземной техники» по курсу «Теория и конструкция базовых шасси спецмашин». – Киев: КМУГА, 1998. – 12 с.

199. **Запорожец В. В.,** *Олефир А. И., Смирнов Ю. И., Билякович О. Н., Закиев И. М., Гончаренко А. В.* Весовое проектирование базовых шасси спецмашин: Учебно-методическое пособие для студентов специальности 7.100108 «Эксплуатация авиационной наземной техники» по курсу «Теория и конструкция базовых шасси спецмашин». – Киев: КМУГА, 1998. – 12 с.

200. **Касьянов В. А.** Вариационные принципы субъективного анализа. Модифицированный вариационный принцип Эйлера-Лагранжа.

Энтропийный подход: монография / В.А. Касьянов, А.В. Гончаренко. – К.: ДП НВЦ «Приорітети», 2015. – 112 с. (ISBN 978-966-8809-67-5)

201. **Касьянов В. А.** Рекурсивные модели психодинамики для прогнозирования поведения активных систем управления с памятью / В.А. Касьянов, А.В. Гончаренко // ScienceRise. Технічні науки. – Харків: ПП «Технологічний Центр», 2014. – № 2 (2). – С. 72-78.

202. **Касьянов В. А.** Свет и тень. Пропорции теневой экономики. Энтропийный подход: монография / В.А. Касьянов, А.В. Гончаренко. – К.: Кафедра, 2013. – 86 с. (ISBN 978-966-2705-36-2)

203. **Касьянов В. А.** Эволюция активных изолированных систем с точки зрения принципа максимума субъективной энтропии / В.А. Касьянов, А.В. Гончаренко // Міжнародний науковий форум: соціологія, психологія, педагогіка, менеджмент [Текст] : збірник наукових праць. Вип. 17 / Нац. пед. ун-т ім. М.П. Драгоманова ; ред. колегія В. Б. Євтух [і др.]. – Київ : Інтерсервіс, 2015. – С. 207-226. **(ISSN 2307-4825)**

204. **Касьянов В. А.,** *Гончаренко А. В.* Оценка характеристик функционирования системы в условиях, допускающих возникновение техногенных катастроф // Сучасні авіаційні технології: Матеріали IV Міжнародної науково-технічної конференції "AВIA-2002". - Т.3. - К.: НАУ, 2002. – С. 31.23-31.26.

205. **Касьянов В. А.,** *Гончаренко А. В.* Субъективный анализ и безопасность активных систем // Кибернетика и вычислительная техника. – 2004. – Вып. 142. – С. 41-56.

206. **Касьянов В. О.,** *Гончаренко А. В.* Визначення оптимальної швидкості витрат ресурсів, які спрямовуються безпосередньо на підтримку безпеки польотів // Виробництво та експлуатація авіаційної техніки: Матеріали V Міжнародної науково - технічної конференції "AВIA-2003". - Т.3. - К.: НАУ, 2003. – С. 31.7-31.11.

207. **Касьянов В. О.,** *Гончаренко А. В.* Параметричні дослідження комплексного техніко-економічного критерію безпеки // Вісник НАУ. 2004. №1(19). – К.: НАУ, 2004. – С. 109-112.

208. **Касьянов В. О.,** *Гончаренко А. В.* Статистичні оцінки частоти катастроф // Вісник НАУ. 2004. №4(22). – К.: НАУ, 2004. – С. 16-20.

209. **Касьянов В.А.** Субъективные предпочтения и правовое воздействие как факторы развития двигателестроения / В.А. Касьянов, А.В. Гончаренко, С.В. Кружкова // Авиационно-космическая техника и технология. Информационные технологии: сб. науч. тр. / М-во образования и науки Украины, Нац. аэрокосм. ун-т им. Н.Е. Жуковского «ХАИ». – Х., 2010. – Вып. № 7(74). – С. 182-189.

210. **Овчарук О. М.** Загальна формула розподілу осереднених швидкостей рідини в круглоциліндричній трубі / О. М. Овчарук, А. В. Гончаренко // Науковий вісник ХДМІ. – 2010. – №1(2). – С. 198-210.

211. **Пат. 94181** Україна, МПК B63H 25/00. Спосіб вибору оптимальної комбінації режимів експлуатації суднової рульової машини / А. В. Гончаренко; заявник та власник патенту Національний авіаційний університет. – № u 2013 09054; заявл. 19.07.2013; опубл. 10.11.2014, Бюл. № 21.

212. **Теорія** та конструкція теплових двигунів: Лабораторні роботи / Уклад.: *О.В. Кулініч, А.А. Воробйов, А.В. Гончаренко.* – К.: НАУ, 2002. – 72 с.

*Навчальне видання*

# АЕРОГІДРОГАЗОДИНАМІКА
# ТА ДИНАМІКА ПОЛЬОТУ

Частина ІІ. А

ДИНАМІКА ПОЛЬОТУ

Методичні рекомендації
до виконання самостійної роботи
для студентів 3-го курсу галузі знань 27 «Транспорт»,
спеціальності 272 «Авіаційний транспорт»

(Англійською мовою)

Укладач ГОНЧАРЕНКО Андрій Вікторович

В авторській редакції

Технічний редактор
Комп'ютерна верстка