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«15» _____ 2023 . 1810 _____

2. _____ : 02.10.2023 _____ 15.12.2023 . _____

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1		02.10.23 - 06.10.23	
2		07.10.23- 15.10.23	
3		15.10.23– 18.10.23	
4		18.10.23-21.10.23	
5	1.	18.10.23-01.11.23	
6	2.	01.11.23-15.11.23	
7	3.	15.11.23-25.11.23	
8	4-5	25.11.23--05.12.23	
9		29.11.23-05.12.23	
10	.	06.12.23- 14.12.23	

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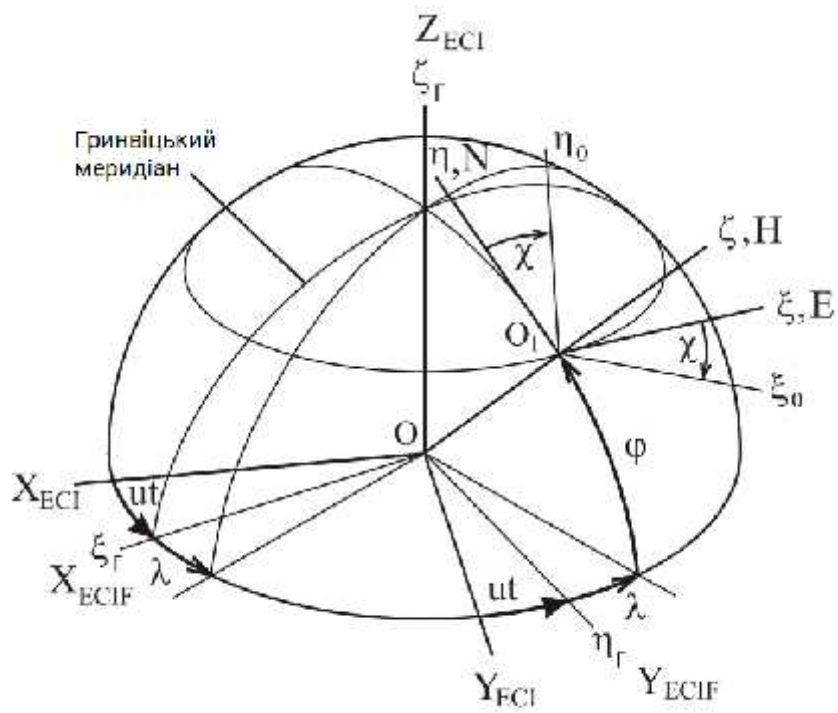
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<i>Контрол.</i>		Дивнич. М.П					
<i>Зав.каф.</i>		Мельник Ю.В					

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 OZ OY OX OZ
 OY OX OZ



. 1.1

ECI (Earth-centred inertial -), i . ((Earth-Centered Inertial)

ECI

, ECI

ECI

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ECI

$O\xi\eta\zeta$, ECIF (Earthcentered earth-fixed),
 e. (ECEF) -
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 ECEF (Earth-Centered Earth-Fixed) GPS,
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ut , u - , t - . $O\eta\Gamma$
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 O (O_1 ENH) : $O_1\xi$
 , $O_1\eta$, $O_1\zeta$.
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 , $O_1\xi_0\eta_0\zeta$ — .
 , $O_1 0 0$ - .
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 $O_1x y z$, O_1y - , O_1x - ()
) , O_1z - () .
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$$\begin{aligned}
 \omega_\xi &= \frac{-v_N}{R_2 + h} ; & h &= h_0 + v_\zeta t \\
 \omega_\eta &= \frac{-v_E}{R_2 + h} + u ; & & \\
 \omega_\zeta &= \frac{-v_E}{R_2 + h} * t_1 \varphi + u ; & \omega_\zeta &= \omega_\eta t_1
 \end{aligned}
 \tag{1.1}$$

$v_N = v \cos \alpha$, $v_E = v \sin \alpha$, h , t .
 $\vec{\omega} = \vec{u} + \vec{W}^0$, $\vec{u} = [0, u_y, u_x]^T$, $\vec{W}^0 = [\omega_\xi^0, \omega_\eta^0, \omega_\zeta^0]^T$.

$$(1.2) \quad \vec{u} = [0, u_y, u_x]^T; \quad \vec{W}^0 = [\omega_\xi^0, \omega_\eta^0, \omega_\zeta^0]^T$$

$$(1.3) \quad V_N = V \cos \chi, V_E = V \sin \chi, V_N = v_N, V_E = v_e + (R_1 + h)u$$

$$(1.4) \quad \begin{aligned} \omega_{\xi 0} &= -u \sin \chi - \frac{v}{(R+h)} \\ \omega_{\eta 0} &= u \cos \chi; \\ \omega_{\zeta 0} &= u \sin \chi; \end{aligned}$$

$$0 \quad 0 \quad 0 \quad (1.4) \quad :$$

1.2.

$C^{\theta\epsilon}$	ζ_{Γ}	η_{Γ}	ζ'_{Γ}
ζ_0	$c_1 =$	$c_1 =$	$c_1 = c_1$
	$-s$	$-s$	$+s$
η_0	$c_2 =$	$c_2 =$	$c_2 = c_2$
	$-s$	$-s$	$-c$
ζ'_0	$c_3 = s$	$c_3 = s$	$b_3 = s$

$C^{\theta\epsilon}$,

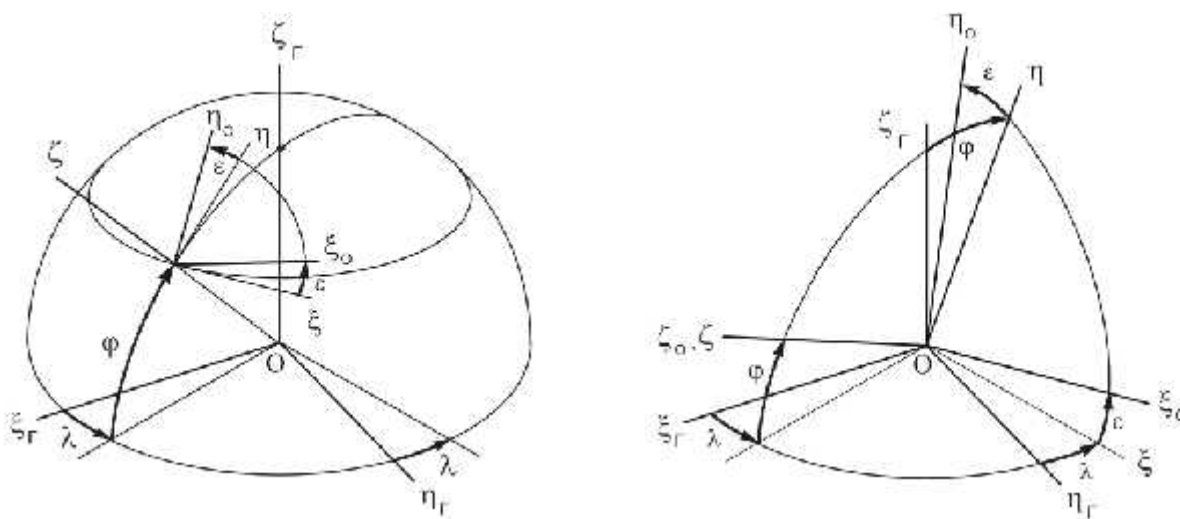


Рис. 1.2 Гринвіцький та ортодромічний тригранники

$$\vec{v} = \vec{\omega}^0 * \vec{R}$$

$$\omega_{\xi 0}^0 = -\frac{V_{r0}}{R_{\eta 0}} - \frac{v_{\xi 0}}{a} e^2 b_1 b_2, \quad \omega_{\eta 0}^0 = -\frac{V_{\xi 0}}{R_{\xi 0}} - \frac{v_{r0}}{a} e^2 b_1 b_2, \quad (1.5)$$

O_0 , $2e^-$,

$$\frac{1}{R_{\xi 0}} = \frac{1 - \frac{1}{2} e^2 b_3^2 + \frac{1}{2} e^2 b_1^2 - \frac{h}{a}}{a}$$

$$\frac{1}{R_{r0}} = \frac{1 - \frac{1}{2} e^2 b_3^2 + \frac{1}{2} e^2 b_2^2 - \frac{h}{a}}{a} \quad (1.6)$$

h^- , -

$$F = G \frac{M}{r^2}, \quad (1.7)$$

F - , M i T - ,
 . () ; r - ; G - ,

m

$$\vec{F} = m\vec{g}, \quad (1.8)$$

$-\vec{g}$ -

$F r$

$$(1.7)$$

(1.8),

$$g = G \frac{M}{r^2}$$

g

$$g_r = -\frac{K}{r^2} \left[1 + \frac{3\mu}{2} \left(\frac{a}{r} \right)^2 (1 - 3\sin^2 \varphi) \right] \quad (1.9)$$

$$\mu = 1,09 \cdot 10^{-10}$$

()

$$g_\varphi = -\frac{K}{r^2} \left[\frac{3\mu}{2} \left(\frac{a}{r} \right)^2 \sin 2\varphi \right] \quad (1.10)$$

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$$\vec{W}_{\text{nc}} = \vec{u} * (\vec{u} * \vec{R}).$$

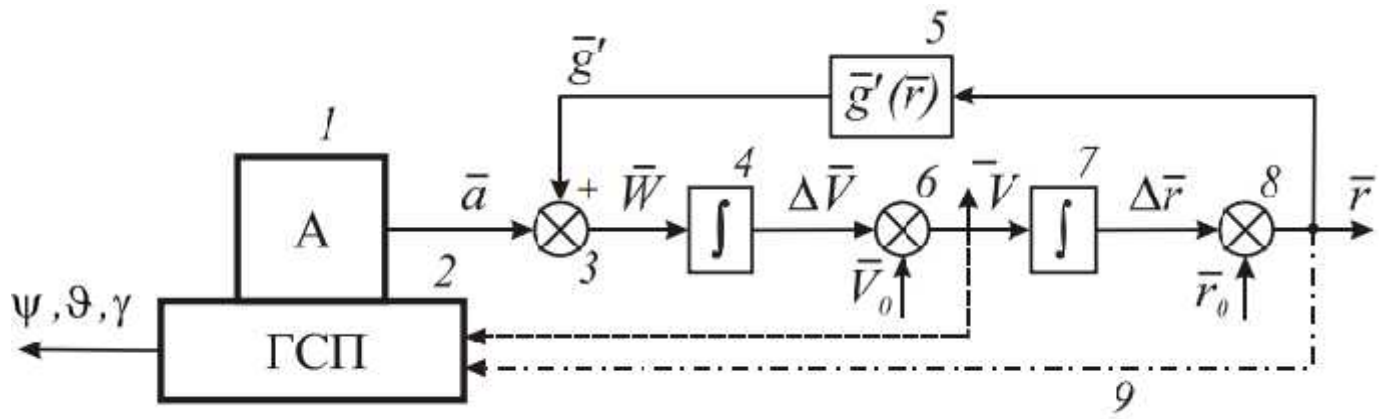
$$\vec{g} = \vec{g}^1 - \vec{u} * (\vec{u} * \vec{R}) \quad (1.11)$$

$$\vec{W}_{\text{nc}} = u^2 R$$

$$g(h) = \frac{g_\varphi}{(1+h/R)}$$

$$\Delta g = -\frac{2g}{R} \Delta h$$

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; 9 -

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: \vec{a}, \vec{g}' r r -

; $\vec{W} \vec{V}$ -

; $\Delta \vec{V} \Delta \vec{r}$ -

- ; \vec{r} -

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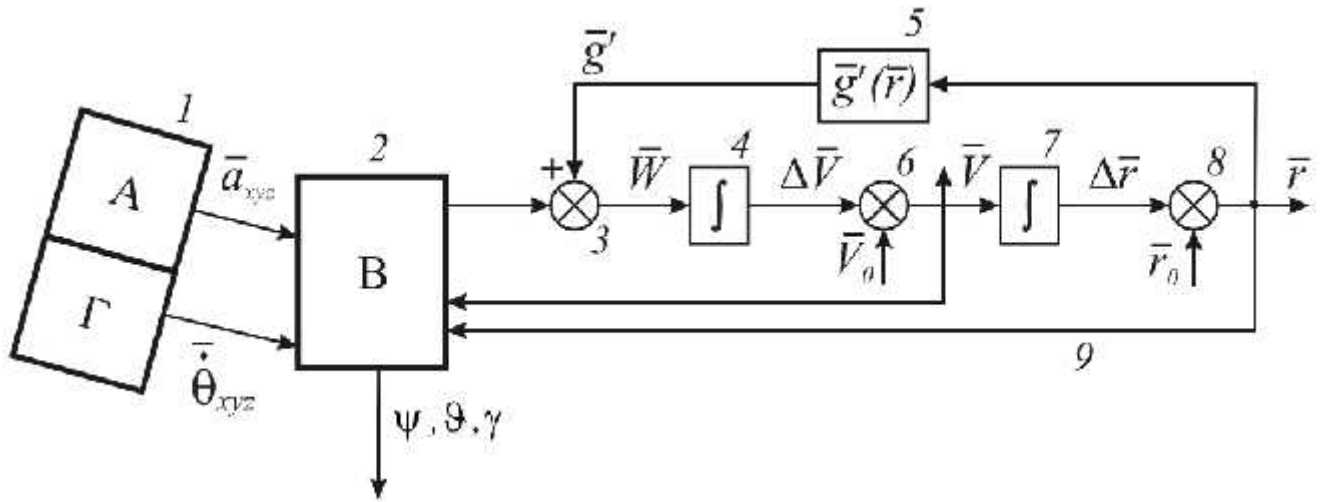
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\vec{a}_x

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Зав.каф.		Мельник Ю.В					

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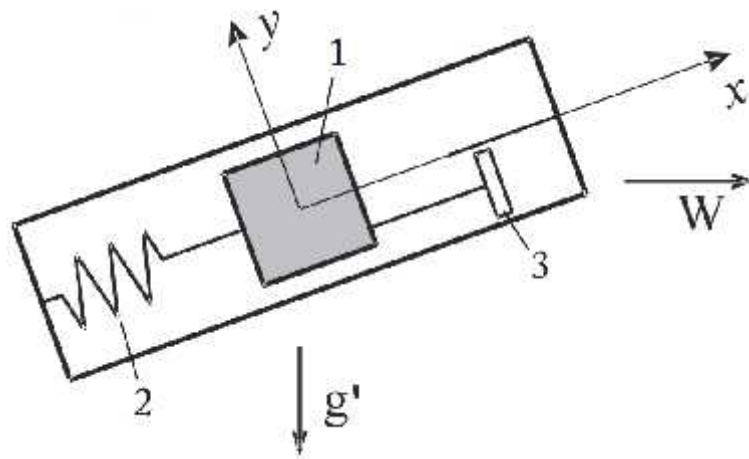
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W

x

.2.1

W

g'

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$$\vec{F}_a + \vec{F}_R + \vec{F}_u = 0$$

x ,

:

$F_a = mg_x$ – сили тяжіння

$F_R = -c \cdot -fx$ – реакція зв'язку (пружини і демфера)

$F_u = -m(W_x + \ddot{x})$ – сили інерції

m - , - , f -
 , - ()

:

$$-m(W_x + \ddot{x}) - c \cdot -fx + mg_x = 0,$$

$$m\ddot{x} + f\dot{x} + c \cdot = -m(W_x - g_x) = -ma_x \quad (1.12)$$

$a_x = W_x - g_x$ – називають уявним прискоренням

$$\vec{a} = \vec{W} - \vec{g}'$$

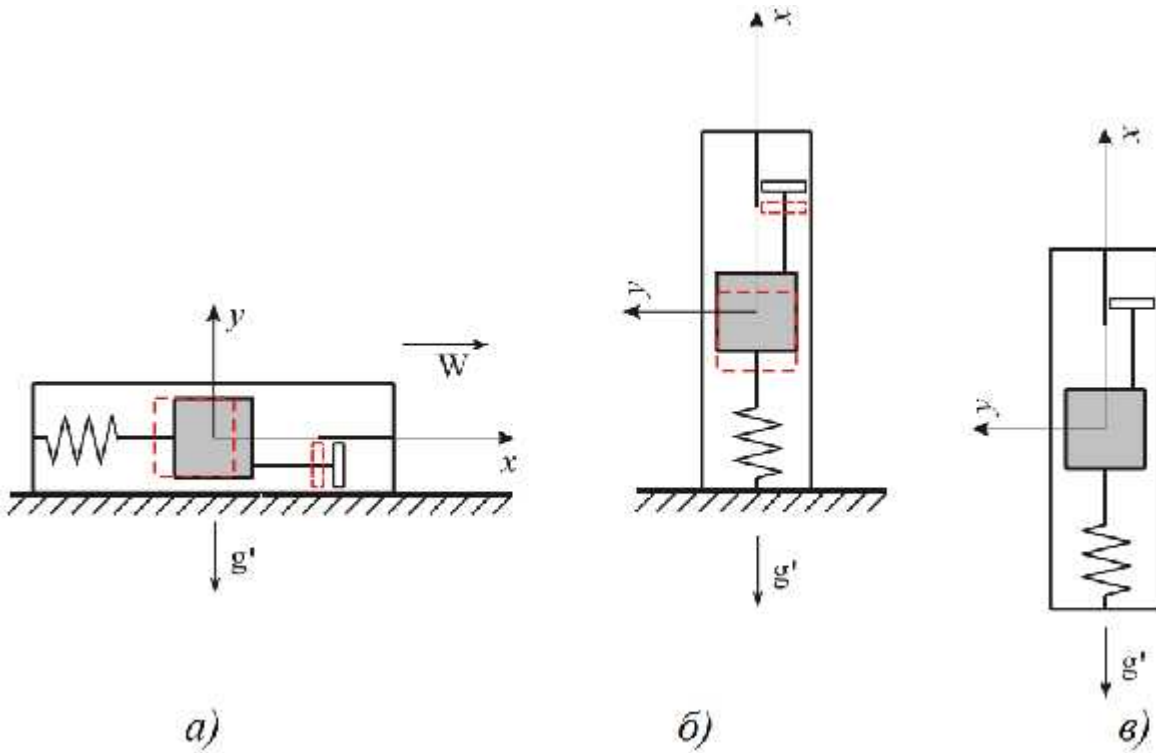
(1.12)

$$x = -\frac{m}{c} a_x$$

1.4

W ,

$$W_x = W g'_x = 0 \quad x = -\frac{m}{c} W a_x = W - 0$$



. 1.4

$$W_x = 0 \quad g'_x = -g'x = -\frac{m}{c} g' a_x = 0 - g'$$

. 1.4

$$x = 0 \quad a_x = -g' + g'W_x = -g' g'_x = -g'$$

. 2.2

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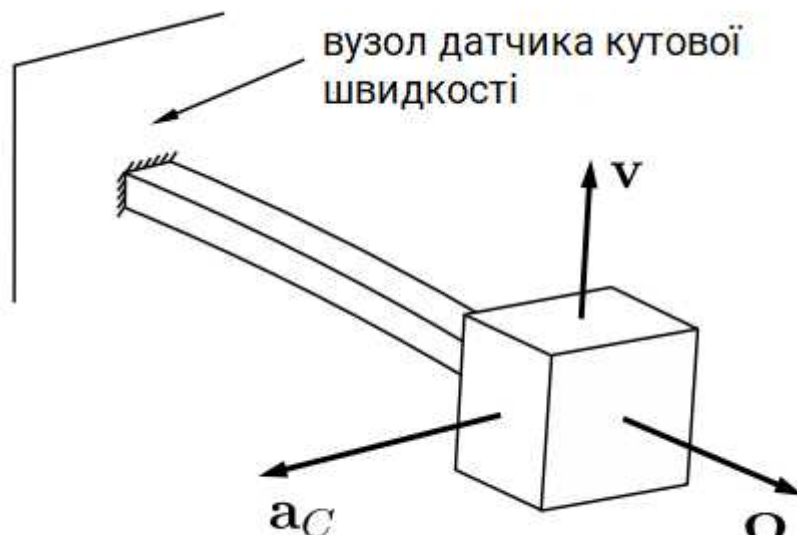
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$$a_c = 2\Omega * v$$

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. 2.3.



$$v = A\omega_{rl} \sin(\omega_{rl}t)$$

A -

$$V = k_c |a_c| = 2k_c |\Omega * v|$$

Ω

v

$$|\Omega * v| = \Omega |v|$$

$$V_{\text{ripo}} = 2k_c \Omega |A\omega_{rl} \sin(\omega_{rl}T)| = 2k_c A\omega_{rl} \Omega = K_c \Omega$$

K_c

, Ω

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$$\gamma_{\text{ripo}} = k_{\text{ripo}} \Omega + \beta_{\text{ripo}} + \eta'_{\text{ripo}}$$

$$\gamma_{\text{ripo}} = k_{\text{ripo}} \Omega + \beta_{\text{ripo}} + \eta'_{\text{ripo}}$$

$$\beta_{\text{ripo}}$$

$$(\Omega = 0)$$

100

$$i^b j^b k^b$$

p, q

r

$$Y_{\text{ripo},x} = p + \eta_{\text{ripo},x}$$

$$Y_{\text{ripo},y} = p + \eta_{\text{ripo},y}$$

$$Y_{\text{ripo},z} = p + \eta_{\text{ripo},z}$$

$$\begin{matrix} Y_{\text{ripo},x} & Y_{\text{ripo},y} & Y_{\text{ripo},z} & \dots & \eta_{\text{ripo},x}, \\ \eta_{\text{ripo},y} & \eta_{\text{ripo},z} & & & \\ & \sigma_{\text{ripo},x}^2 & \sigma_{\text{ripo},y}^2 & \sigma_{\text{ripo},z}^2 & \dots \\ & & & & T_s \end{matrix}$$

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$$C = \begin{pmatrix} c_1 \theta \psi & c_1 \gamma \psi s_1 + s_1 n \psi & s_1 \gamma c_1 \theta + c_1 \gamma s_1 \\ s_1 \theta & c_1 \gamma c_1 \theta & s_1 \gamma c_1 \theta \\ -c_1 \theta \psi & \theta + s_1 \gamma c_1 & -s_1 \gamma s_1 \theta + c_1 \gamma c_1 \end{pmatrix}$$

$\omega_x, \omega_y, \omega_z$

OXYZ

OXYZ.

$OX_g Y_g Z_g$ [3.5].

(3.1)

$$\psi = a \frac{-c_3}{c_1}$$

$$\theta = a c_2$$

$$\gamma = a \frac{-c_2}{c_2}$$

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Консульт.		Сущенко О. А.			-213 48		
Контрол.		Дивнич. М.П					
Зав.каф.		Мельник Ю.В					

ij C , r, - OXYZ (, , z),

$$v = \frac{d}{dt} r$$

v_x, v_y, v_z 0 .

$$v = \frac{d}{dt} r = \frac{d}{dt} r + \omega \times r$$

OXYZ,

$\langle \eta \zeta$

$$\left. \begin{aligned} v_x &= x + \omega_y z - \omega_z y \\ v_y &= y + \omega_z x - \omega_x z \\ v_z &= z + \omega_x y - \omega_y x \end{aligned} \right\}$$

r

$\langle \eta \zeta$

$$v = \frac{d}{dt} r = \left\| \begin{matrix} \zeta \\ \eta \\ \zeta \end{matrix} \right\|$$

$\langle , \eta, \zeta -$

$\langle \eta \zeta$

r

OXYZ

$$[\omega] = \begin{vmatrix} 0 & \omega_z & -\omega_y \\ \omega_z & 0 & -\omega_x \\ \omega_y & \omega_x & 0 \end{vmatrix}$$

$$r = \begin{vmatrix} x \\ y \\ z \end{vmatrix}$$

$$v = \begin{vmatrix} v_x \\ v_y \\ v_z \end{vmatrix} = \begin{vmatrix} x \\ y \\ z \end{vmatrix} + \begin{vmatrix} 0 & \omega_z & -\omega_y \\ \omega_z & 0 & -\omega_x \\ \omega_y & \omega_x & 0 \end{vmatrix} \begin{vmatrix} x \\ y \\ z \end{vmatrix}$$

$$\begin{vmatrix} x \\ y \\ z \end{vmatrix} = \begin{vmatrix} a_1 & a_1 & a_1 \\ a_2 & a_2 & a_2 \\ a_3 & a_3 & a_3 \end{vmatrix} \begin{vmatrix} \zeta \\ \eta \\ \zeta \end{vmatrix}$$

<ηζ

OXYZ.

$$a_i \ (i, j = 1, 2, 3)$$

OXYZ

<ηζ

$$C=A^T$$

$$r = C$$

$\omega_x, \omega_y, \omega_z$

$$r = Cr' + Cr$$

$$A = E$$

$$A = r' + ACr$$

$$Ar$$

$$AC = [\omega]$$

$$C = -[\omega]A$$

ω

OXYZ

$\langle \eta \zeta \rangle$

OXYZ

$\omega_x, \omega_y, \omega_z$

$\langle \eta \zeta \rangle$

$$\begin{vmatrix} c_1 & c_1 & c_1 \\ c_2 & c_2 & c_2 \\ c_3 & c_3 & c_3 \end{vmatrix} = \begin{vmatrix} c_1 & c_1 & c_1 \\ c_2 & c_2 & c_2 \\ c_3 & c_3 & c_3 \end{vmatrix} \begin{vmatrix} 0 & \omega_z & -\omega_y \\ \omega_z & 0 & -\omega_x \\ \omega_y & \omega_x & 0 \end{vmatrix}$$

$$\begin{aligned}
c_1 &= c_1 \omega_z - c_1 \omega_y, & c_1 &= c_1 \omega_x - c_1 \omega_z, & c_1 &= c_1 \omega_y - c_1 \omega_x \\
c_2 &= c_1 \omega_z - c_1 \omega_y, & c_1 &= c_2 \omega_x - c_2 \omega_z, & c_2 &= c_2 \omega_y - c_2 \omega_x \\
c_3 &= c_3 \omega_z - c_3 \omega_y, & c_3 &= c_1 \omega_x - c_1 \omega_z, & c_1 &= c_3 \omega_y - c_3 \omega_x
\end{aligned}$$

$$c_1 \ c_1 \ c_1, \quad -c_2 \ c_2 \ c_2, \quad -c_3 \ c_3 \ c_3$$

$$\omega = \|\omega_x \ \omega_y \ \omega_z\|$$

$[\omega]$

$$[\omega_{ij}] = -\varepsilon_{ij} \ \omega_l$$

$\langle \eta \zeta$

L.

L.

$$\begin{aligned}
 \dot{x} &= A x + B u + \zeta \\
 y[n] &= C x[n] + \eta[n]
 \end{aligned}$$

$y[n] = y(t_n)$ n -
 $x[n] = x(t_n)$ n -
 t_n , -
 Q , $[n]$ -
 R .

$$\begin{aligned}
 \dot{\hat{x}} &= A \hat{x} + B u \\
 \hat{x}^+ &= \hat{x}^- + L(y(t_n) - C \hat{x}^-) \\
 \tilde{x} &= x - \hat{x}.
 \end{aligned}$$

t

$$P(t) = E\{\tilde{x}(t)\tilde{x}(t)^T\}$$

$P(t)$ -
 $P(t)$

L(t),

P(t).

$$\text{tr}(P) = \sum_{i=1}^n \lambda_i$$

tr(P) - P,

P.

tr(P)

L,

tr(P)

\tilde{x} ,

$$\tilde{x} = x - \hat{x} = A + B + \dots - A\hat{x} - B = A\tilde{x} + \dots$$

\tilde{x}_0 ,

$$\tilde{x}(t) = e^{At} \tilde{x}_0 + \int_0^t e^{A(t-\tau)} \langle(\tau) d$$

P

$$P = \frac{d}{dt} \{ \tilde{x} \tilde{x}^T \} = E \{ x \tilde{x}^T + \tilde{x} \tilde{x}^T \} = E \{ A \tilde{x} \tilde{x}^T + \langle \tilde{x}^T + \tilde{x} \tilde{x} A^T + \tilde{x} \langle^T \} = A + PA^T + E \{ \langle \tilde{x}^T \} + E \{ \langle \tilde{x}^T \}$$

$$E \{ \langle \tilde{x}^T \}$$

$$E \{ \langle \tilde{x}^T \} = E \{ e^{A(t)} \tilde{x}_0 \langle^T(T) \} + \int_0^t e^{A(t-\tau)} \langle(\tau) \langle^T(\tau) d = \int_0^t e^{A(t-\tau)} Q (t - \tau) d = \frac{1}{2} Q$$

1/2

Q

P

$$\hat{x} = \hat{x} + B$$

$$P = A + PA^T + Q$$

\hat{x}

, P -

i-

$$L_i = P^- C_i^T (R_i + C_i P^- C_i^T)^{-1}$$

$$P^+ = (I - L_i C_i) P^-$$

$$\hat{x}^+ = \hat{x}^- + L_i (y_i(t_n) - C_i \hat{x}^-)$$

L_i

i-

(8.19),

$$x = f(x, u) + o$$

$$y[n] = h(x[n], y[n]) + 3[n]$$

$$q = a + b + c + d$$

a, b, c, d

i, j, k -

$$q = \cos\left(\frac{\theta}{2}\right) + \sin\left(\frac{\theta}{2}\right)(x + y + z)$$

θ , x, y, z -

i, j, k.

$$p_0 + p_1i + p_2j + p_3k \quad q = q_0 + q_1i + q_2j + q_3k$$

$$p \cdot q = (p_0q_0 - p_1q_1 - p_2q_2 - p_3q_3) + (p_0q_1 + p_1q_0 + p_2q_3 - p_3q_2)i + (p_0q_2 - p_1q_3 + p_2q_0 + p_3q_1)j + (p_0q_3 - p_1q_2 + p_2q_1 + p_3q_0)k$$

(x, y, z)

q

:

$$v' = q q^{-1}$$

v -

, q^{-1}

q

(slerp)

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,

,

$q_0 q_1$

,

t

[0.1]

SLERP

:

$$(q_0, q_1, t) = \frac{\sin((1-t)\theta)}{\sin(\theta)} q_0 + \frac{\sin(t\theta)}{\sin(\theta)} q_1$$

- θ

.

θ

$q_0 q_1$

:

$$\cos(\theta) = q_0 q_1$$

SLERP

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$q_0 q_1$

SLERP.

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$\cos(\theta)$.

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SLERP

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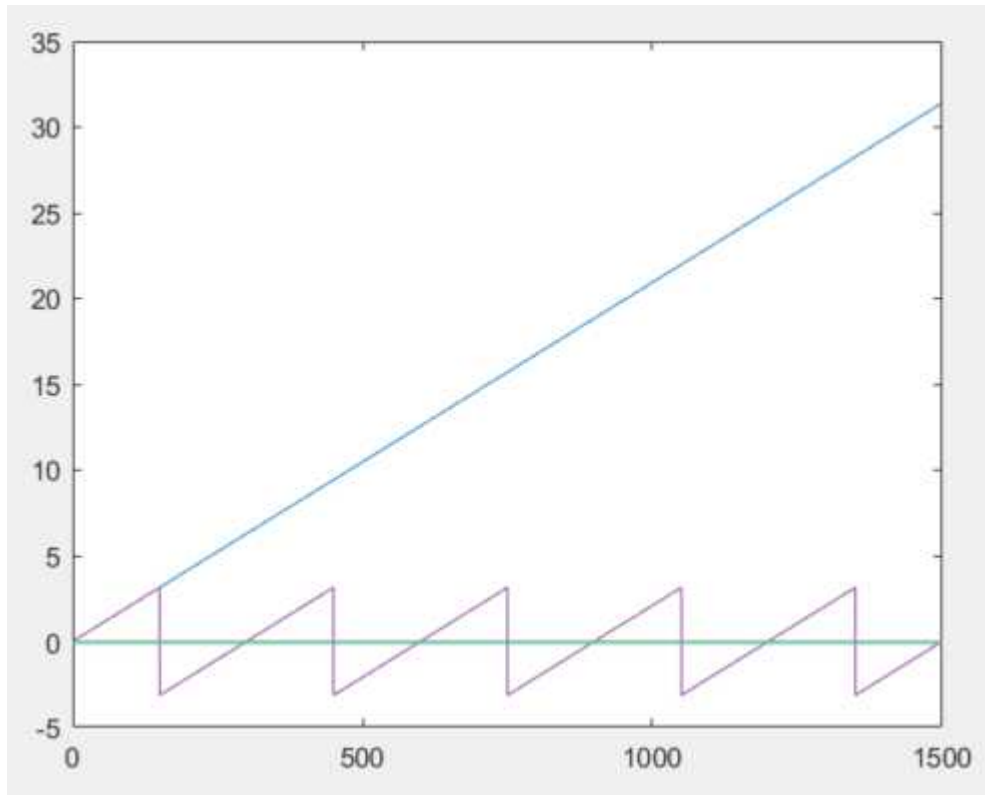
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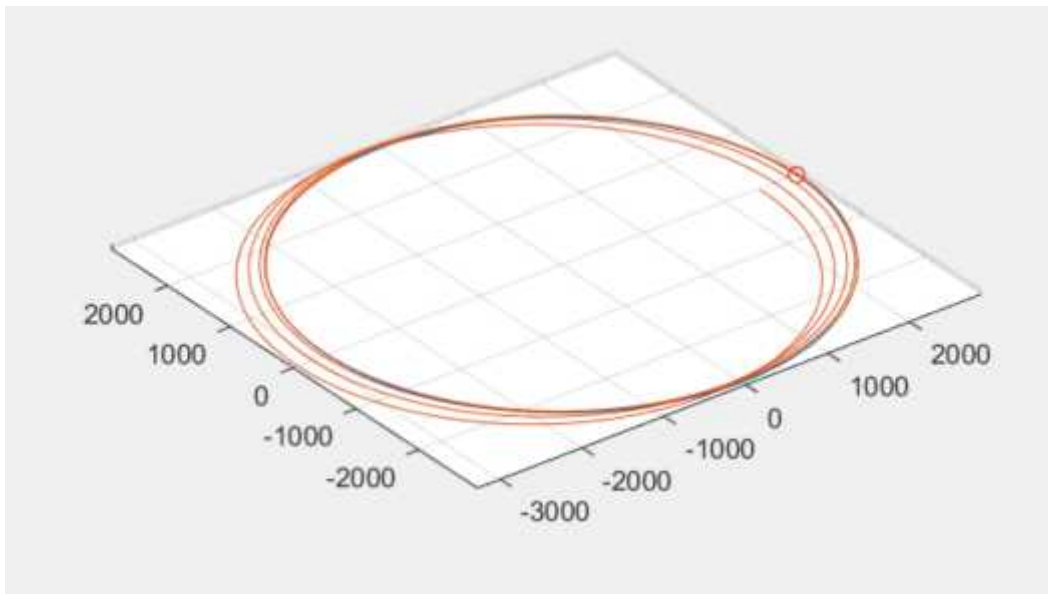
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Squad (Spherical Quadrangle)



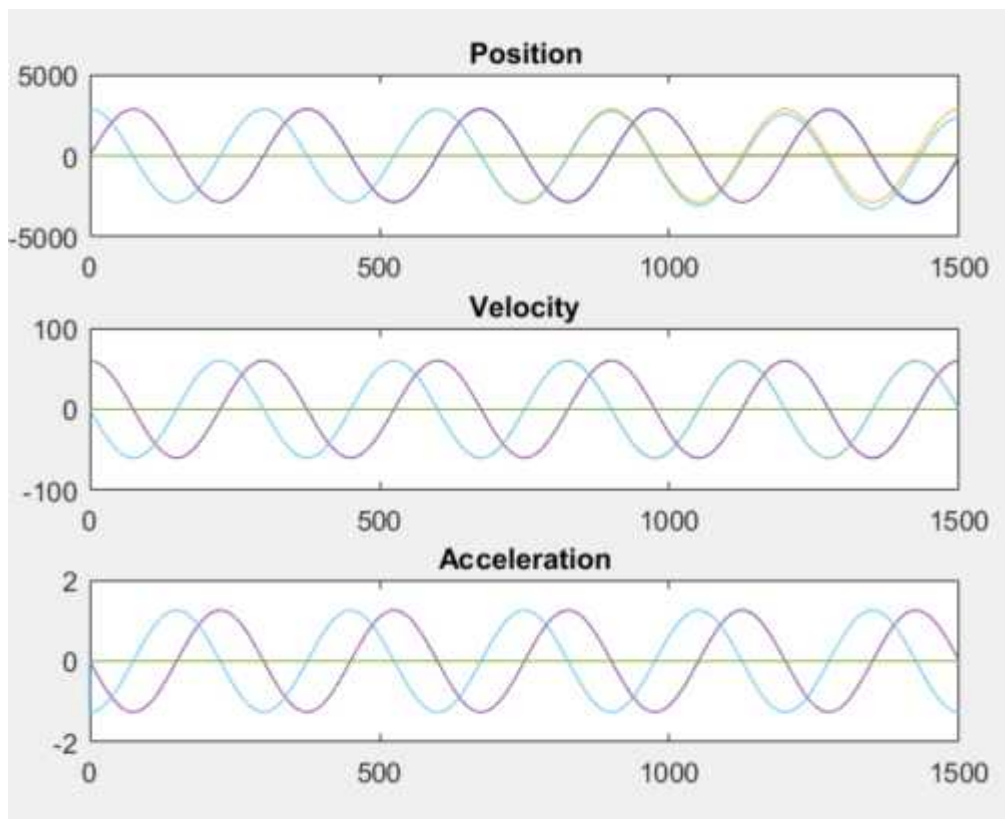
. 3.1



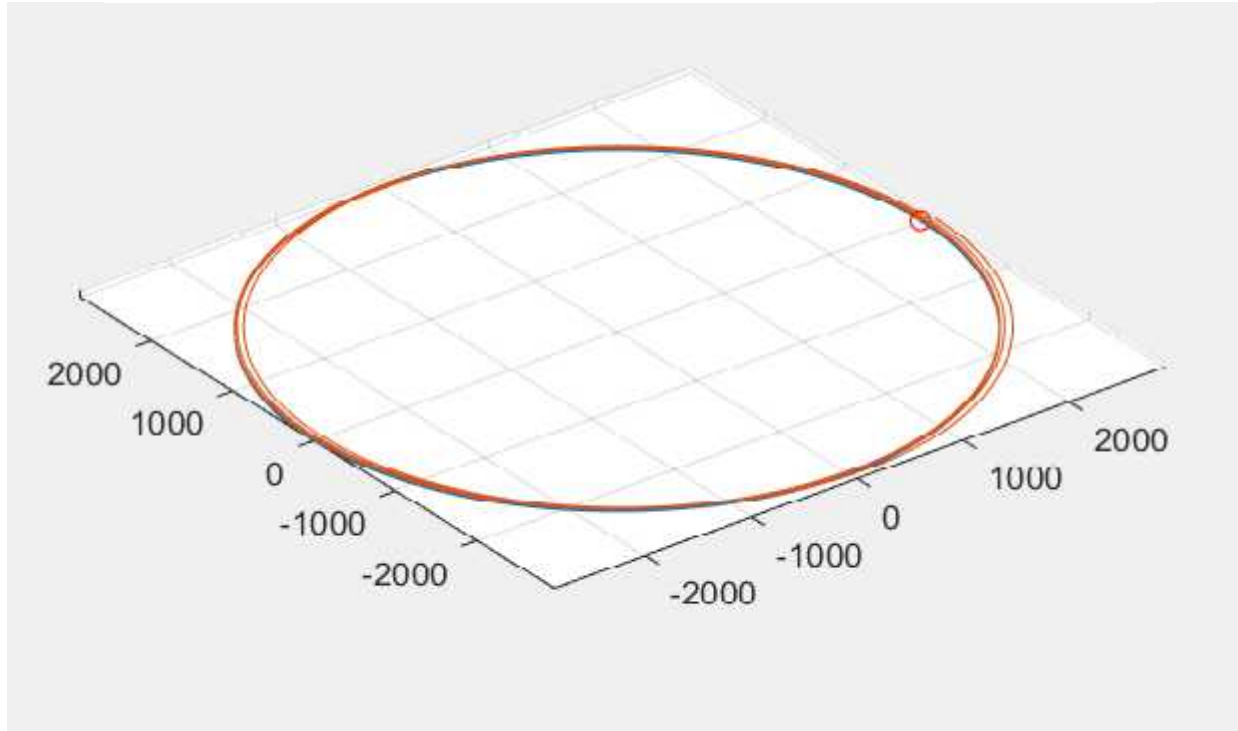
. 3.2

()

Matlab

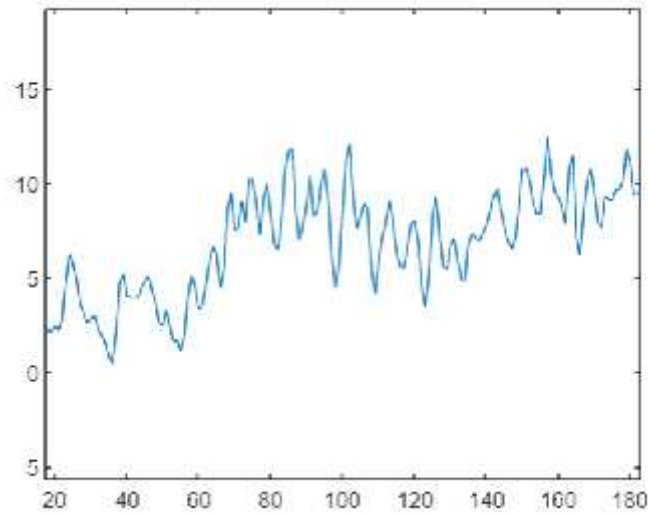


. 3.3

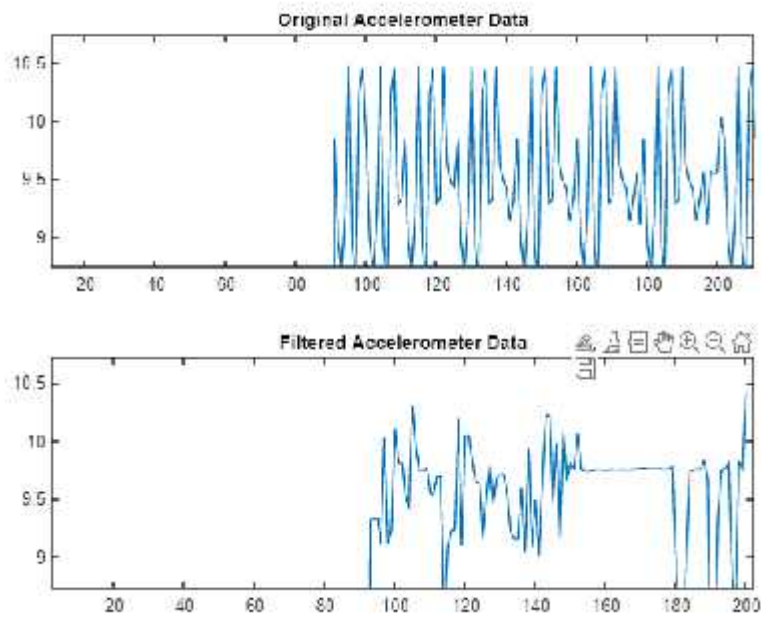


. 3.4 ()

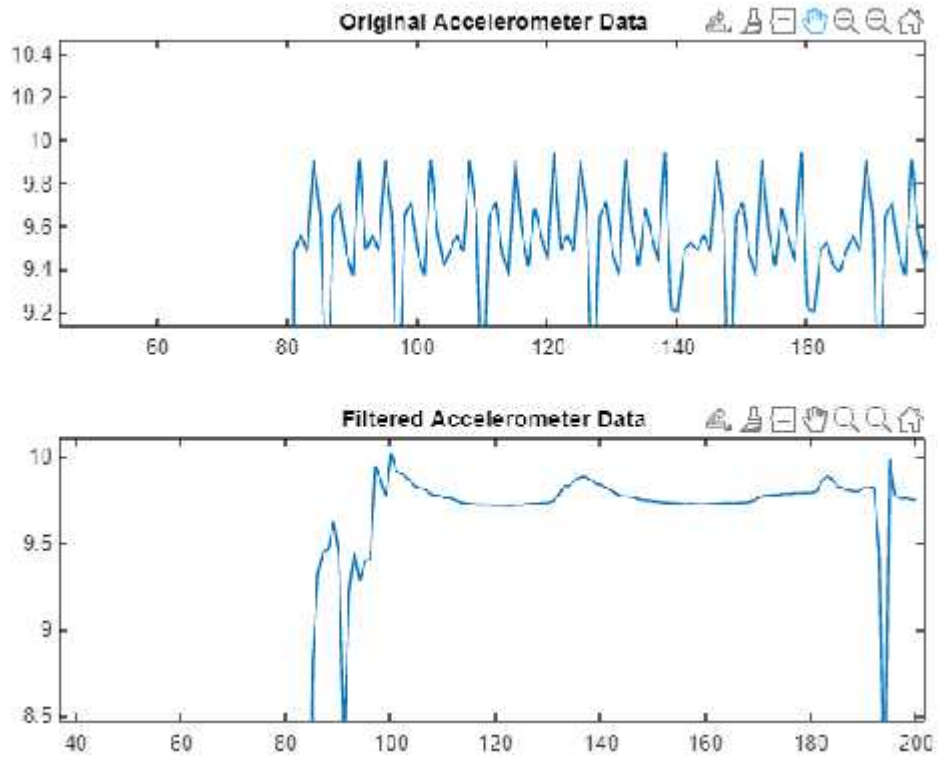
Matlab



. 3.4



. 3.5



. 3.6

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РОЗДІЛ 4

ОХОРОНА НАВКОЛИШНЬОГО СЕРЕДОВИЩА

(CO),

(NOx),

()

(NOx)

					НАУ 23 04 95 000 ПЗ					
<i>Змн.</i>	<i>Арк.</i>	<i>№ докум.</i>	<i>Підпис</i>	<i>Дата</i>	ОХОРОНА НАВКОЛИШНЬОГО СЕРЕДОВИЩА					
<i>Виконав.</i>	Донець.В.Ю							<i>Літ.</i>	<i>Арк.</i>	<i>Архівів</i>
<i>Керівник</i>	Сущенко О. А.								63	94
<i>Консульт.</i>	Дмитруха.Т.І							-213 66		
<i>Контрол.</i>	Дивнич. М.П									
<i>Зав.каф.</i>	Мельник Ю.В									

),

(SO₂),

(H₂SO₄),

(HNO₃).

pH

()

. CO2

(NOx).

CO2

CO2

Exhaust Manifold)

(),

(Integrated

(NOx)

(Variable Valve Lift, VVL) -

()

VVL

(NOx)

VVL

(Variable Geometry Turbochargers, VGT

VNT) -

()

VGT

VGT

VGT

VGT

(NOx),

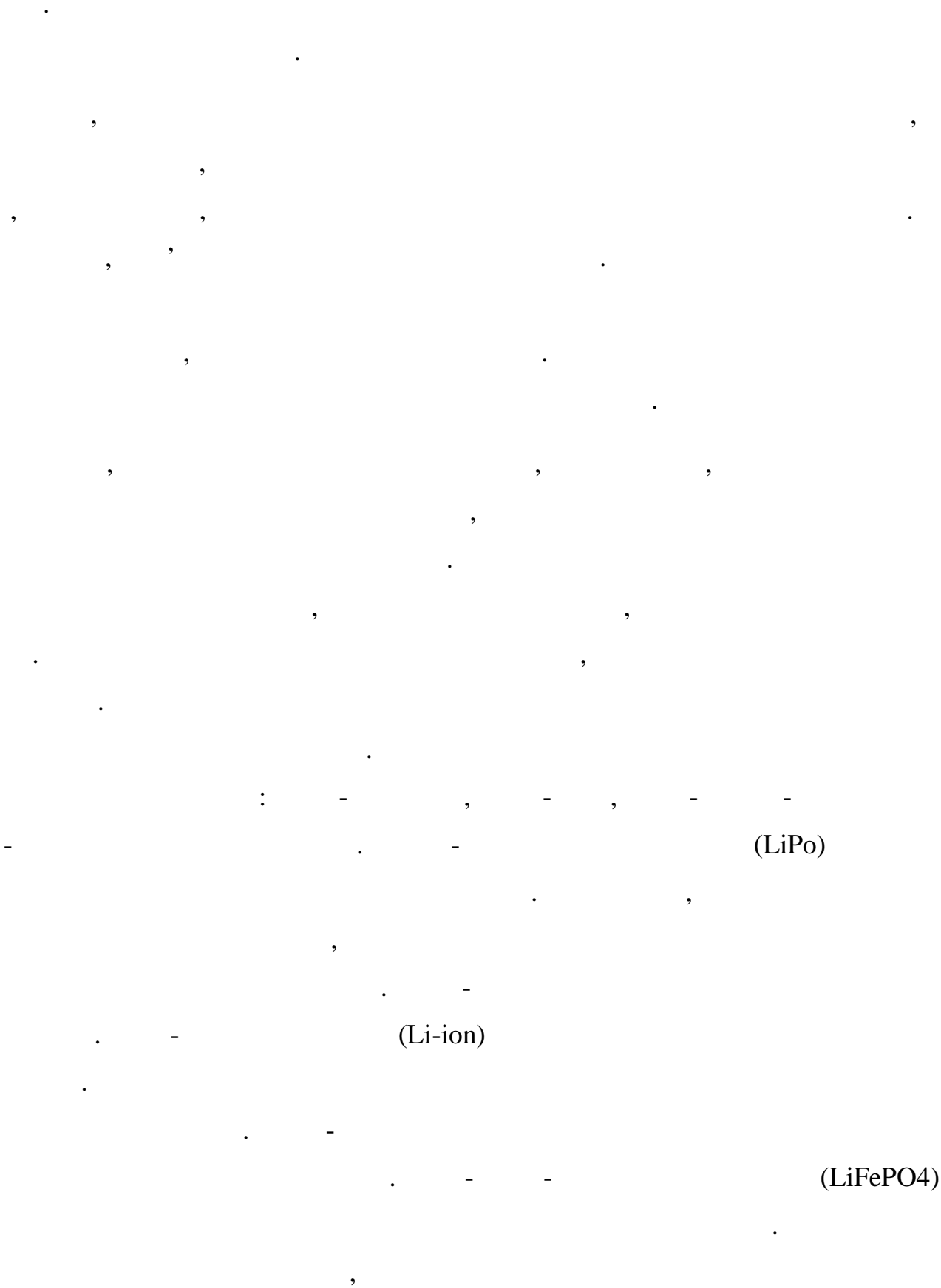
VGT

VGT

CDA, —

.CDA

(Variable Compression Ratio) -



).

LIB

LIB

EoL

LIB

EoL

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60%

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14

LIB

LIBs

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2022

LIB.

40%

2016

30%

, 33%

, 23%

5%

2006

31

2020

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EoL LIB

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Co, Cu, Fe Ni.

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LIB

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LIB, (

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. LIB

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10 2,5 [(1/6-em) (PM 10 PM 2,5)

LIBs

25 ,

(PVDF).

LIB

LIB

LIB,

LIB

HF, HCl SO₂ (

)

« »,

98758 $P = 740$

$h = 0.7$., $t^\circ = 24.1$
 $V=0.08$ -, 55%.

$$=36.3^\circ ,$$

$$k=0.3,$$

$$t = 24.1^\circ .$$

$$K_c =$$

$$\left[1 + \frac{5 - 5}{1} \right] - \frac{3 - 2}{8 \cdot 0.3} \left(1 + \frac{5 - 5}{2} \right) = 0.54$$

$$K_c$$

$$= 4 \quad K_c^2 = 4 \quad 0.2916 = 1.17$$

1

$$1 = W_1 + F_1 (K - 1) = 32 + 0.9(1.17 - 1) = 32.153^\circ$$

2

$$2 = W_2 + F_2 (K - 1) = 36.3 + 0.3(1.17 - 1) = 36.351^\circ$$

3

$$3 = W_3 + F_3 (K - 1) = 65. + 8(1.17 - 1) = 66.36 \text{ —}$$

4

$$4 = W_4 + F_4 (K - 1) = 90 + 100(1.17 - 1) = 107 \text{ —}$$

$$-0.01 \frac{m^3}{m^3}$$

-2.

$$= 0.002.$$

24 ,

$$P = 98758 \text{ Pa}$$

- 293 ,

101.3 (760 mmHg)

$$= \frac{273 + t}{293} K = 0.002 \frac{273 + 14}{293} \frac{101.3}{736 \cdot 0.113} \cdot 1.14 = 0.0023$$

$$Q = \frac{W}{C} = \frac{\mu V_m}{C} = \frac{2 \cdot 150 \cdot 0.002}{(0.8 \cdot 0.01) - (0.3 \cdot 0.001)} = 120 \frac{m^3}{m^3}$$

2.5 .

1.18

$$\rho = 0$$

$$\rho = 0$$

$$\rho = 0$$

1.7

$$i = \frac{A \ B}{h_p(A + B)} = \frac{6 \ 3}{1.7(6 + 3)} = \frac{6 \ 3}{1.7(6 + 3)} = 1.18$$

F=590

3

$$E = \frac{F \ N \ n \ \eta}{S \ K \ Z}$$

$$E = \frac{590 \ 3 \ 3 \ 1.8}{18 \ 1.7 \ 1.18} = 264$$

.2.5-28-2006.

" 2" () " O2- "

"

"

120³—.

.2.5-28-2006.

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<i>Консулт.</i>		Сущенко О. А.					92
<i>Контрол.</i>		Дивнич М.П					
<i>Зав.каф.</i>		Мельник Ю.В					
							-213

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