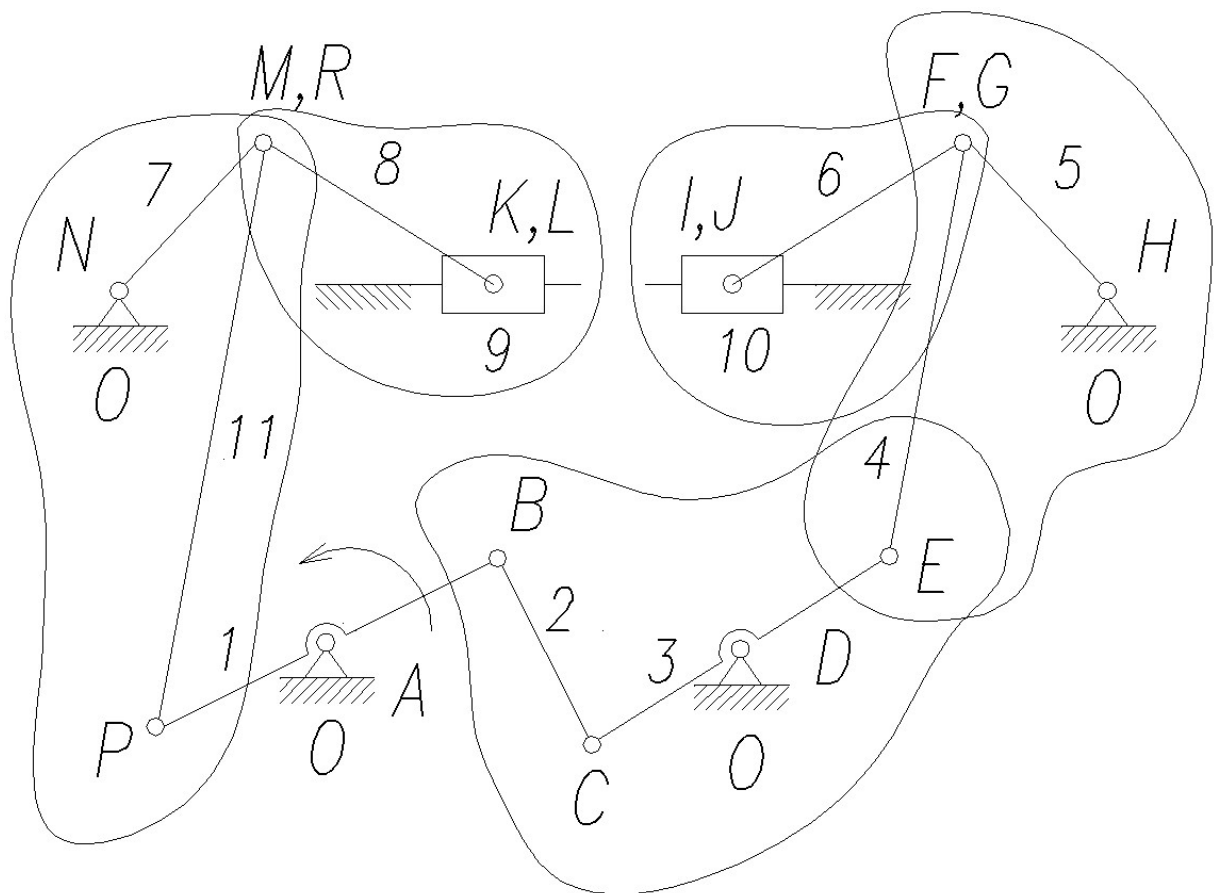


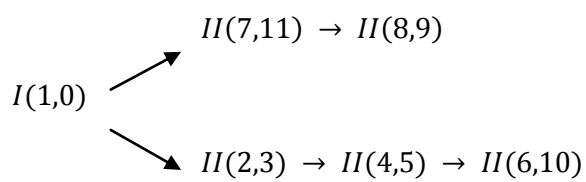
Задача № 1



$$n = 11 \quad W = 3n - 2p_5 - p_4 = 3 \cdot 11 - 2 \cdot 16 = 33 - 32 = 1$$

$$p_5 = 16$$

$$p_4 = 0$$

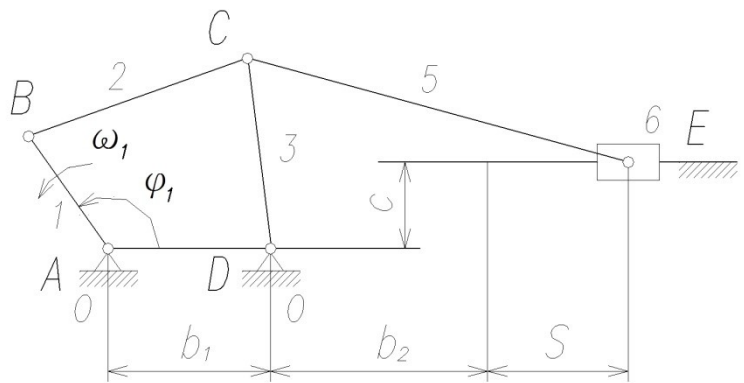


Механизм 2-го класса!

Задача № 2

Дано:

- $\omega_1 = 20 \text{ с}^{-1}$;
- $\varphi_1 = 90^\circ$;
- $l_1 = 0.06 \text{ м}$; $l_2 = 0.15 \text{ м}$;
 $l_3 = 0.11 \text{ м}$; $l_5 = b_1 = 0.12 \text{ м}$;
 $b_2 = 0.08 \text{ м}$; $c = 0.02 \text{ м}$.



Решение:

Задача о положениях:

$$\mu_e = \frac{l_1}{AB} = \frac{0.06}{60} = 0.001 \frac{\text{м}}{\text{мм}};$$

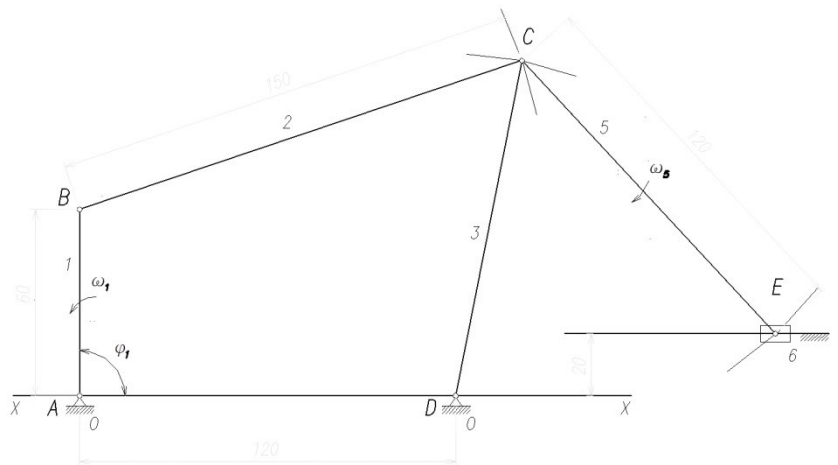
$$AD = \frac{b_1}{\mu_e} = \frac{0.12}{0.001} = 120 \text{ мм};$$

$$BC = \frac{l_2}{\mu_e} = \frac{0.15}{0.001} = 150 \text{ мм};$$

$$CD = \frac{l_3}{\mu_e} = \frac{0.11}{0.001} = 110 \text{ мм};$$

$$CE = \frac{l_5}{\mu_e} = \frac{0.12}{0.001} = 120 \text{ мм};$$

$$l_c = \frac{c}{\mu_e} = \frac{0.02}{0.001} = 20 \text{ мм};$$



Структурный анализ:

$$n = 5 \quad W = 3n - 2p_5 - p_4 = 3 \cdot 5 - 2 \cdot 7 = 15 - 14 = 1$$

$$p_5 = 7$$

$$p_4 = 0 \quad I(1,0) \rightarrow II(2,3) \rightarrow II(5,6) \quad \underline{\text{Механизм 2-го класса!}}$$

Задача о скоростях:

(1) $\bar{v}_C = \bar{v}_B + \bar{v}_{CB}$

Величина	?	$\omega_1 \cdot l_1$?
Направление	?	$\perp AB$	$\perp CB$

(2) $\bar{v}_C = \bar{v}_D + \bar{v}_{CD}$

Величина	?	0	?
Направление	?	0	$\perp CD$

(3) $\bar{v}_E = \bar{v}_C + \bar{v}_{EC}$

Величина	?	$(pc) \cdot \mu_v$?
Направление	$\parallel XX$	$\perp DC$	$\perp CE$

$$\mu_v = \frac{\bar{v}_B}{pb} = \frac{\omega_1 \cdot l_1}{pb} = \frac{1.2}{120} = 0.01 \frac{\text{м}}{\text{мм}} \cdot \frac{\text{сек}}{\text{сек}};$$

$$\bar{v}_C = (pc) \cdot \mu_v = 130 \cdot 0.01 = 1.3 \frac{\text{м}}{\text{сек}};$$

$$\bar{v}_{CB} = (bc) \cdot \mu_v = 27 \cdot 0.01 = 0.27 \frac{\text{м}}{\text{сек}};$$

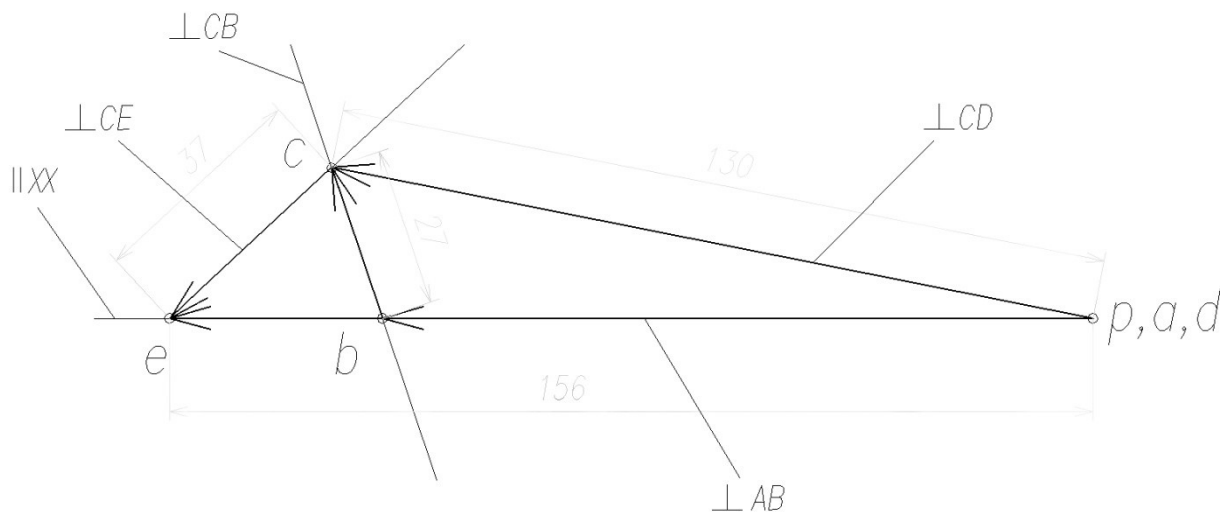
$$\bar{v}_{CD} = (dc) \cdot \mu_v = 130 \cdot 0.01 = 1.3 \frac{\text{м}}{\text{сек}};$$

$$\bar{v}_E = (pe) \cdot \mu_v = 156 \cdot 0.01 = 1.56 \frac{\text{м}}{\text{сек}};$$

$$\bar{v}_{EC} = (ec) \cdot \mu_v = 37 \cdot 0.01 = 0.37 \frac{\text{м}}{\text{сек}};$$

$$\omega_5 = \frac{\bar{v}_{CE}}{l_{CE}} = \frac{(ce) \cdot \mu_v}{l_5} = \frac{37 \cdot 0.01}{0.12} = 3 \frac{1}{\text{сек}};$$

$$\omega_6 = 0 \frac{1}{\text{сек}}.$$



Задача об ускорениях:

$$(1) \quad \bar{a}_C = \bar{a}_B + \bar{a}_{CB}^n + \bar{a}_{CB}^r$$

Величина	?	$\omega_1^2 \cdot l_1$	v_{CB}^2/l_2	?
Направление	?	$\parallel AB$	$\parallel CB$	$\perp CB$

$$(2) \quad \bar{a}_C = \bar{a}_D + \bar{a}_{CD}^n + \bar{a}_{CD}^r$$

Величина	?	0	v_{CD}^2/l_3	?
Направление	?	0	$\parallel CD$	$\perp CD$

$$(3) \quad \bar{a}_E = \bar{a}_C + \bar{a}_{EC}^n + \bar{a}_{EC}^r$$

Величина	?	$\omega_3^2 \cdot l_3$	v_{EC}^2/l_5	?
Направление	$\parallel xx$	$\parallel CD$	$\parallel EC$	$\perp EC$

$$\mu_a = \frac{\bar{a}_B}{\Pi b} = \frac{\omega_1^2 \cdot l_1}{\Pi b} = \frac{24}{48} = 0.5 \frac{\text{м}}{\text{сек}^2};$$

$$bn_{CB} = \frac{\bar{a}_{CB}^n}{\mu_a} = \frac{v_{CB}^2/l_2}{\mu_a} = \frac{0.27^2/0.15}{0.5} = 1 \text{ мм};$$

$$dn_{CD} = \frac{\bar{a}_{CD}^n}{\mu_a} = \frac{v_{CD}^2/l_3}{\mu_a} = \frac{1.3^2/0.11}{0.5} = 15 \text{ мм};$$

$$\bar{a}_C = (\Pi c) \cdot \mu_a = 18 \cdot 0.5 = 9 \frac{\text{м}}{\text{сек}^2};$$

$$\varepsilon_1 = 0;$$

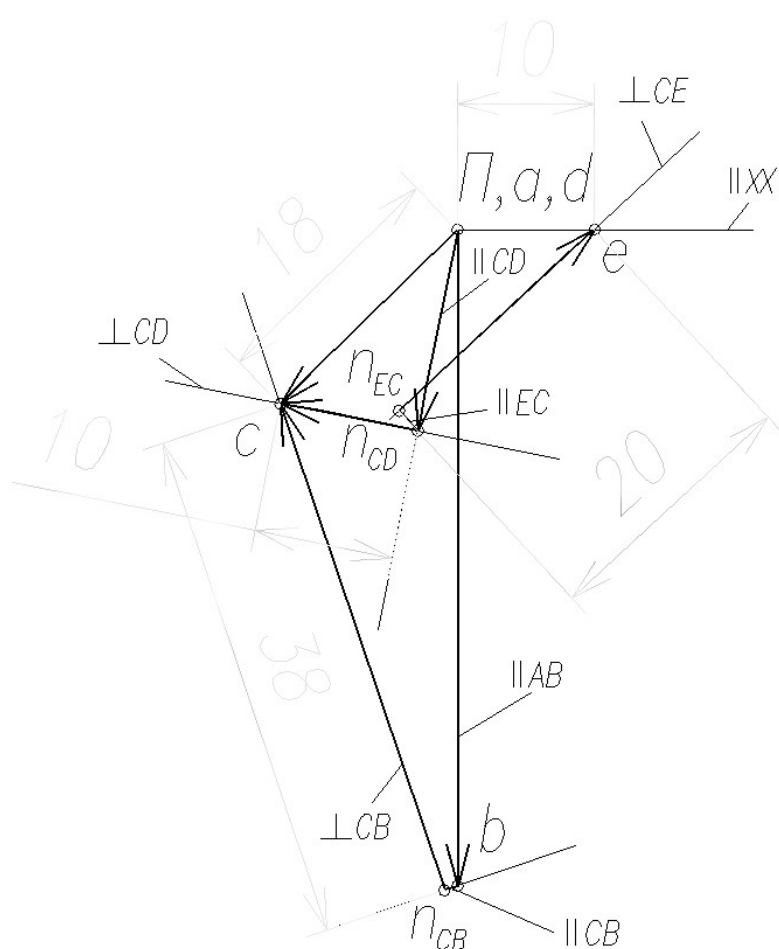
$$\varepsilon_2 = \frac{\bar{a}_{CB}^r}{l_2} = \frac{(n_{CB}c) \cdot \mu_a}{l_2} = 127 \frac{1}{\text{сек}^2};$$

$$\varepsilon_3 = \frac{\bar{a}_{CD}^r}{l_3} = \frac{(n_{CD}c) \cdot \mu_a}{l_3} = 45 \frac{1}{\text{сек}^2};$$

$$bn_{EC} = \frac{\bar{a}_{EC}^n}{\mu_a} = \frac{v_{EC}^2/l_5}{\mu_a} = \frac{0.37^2/0.12}{0.5} = 2 \text{ мм};$$

$$\bar{a}_E = (\Pi e) \cdot \mu_a = 10 \cdot 0.5 = 5 \frac{\text{м}}{\text{сек}^2};$$

$$\varepsilon_5 = \frac{\bar{a}_{CE}^r}{l_5} = \frac{(n_{CE}e) \cdot \mu_a}{l_5} = \frac{20 \cdot 0.5}{0.12} = 83 \frac{1}{\text{сек}^2};$$



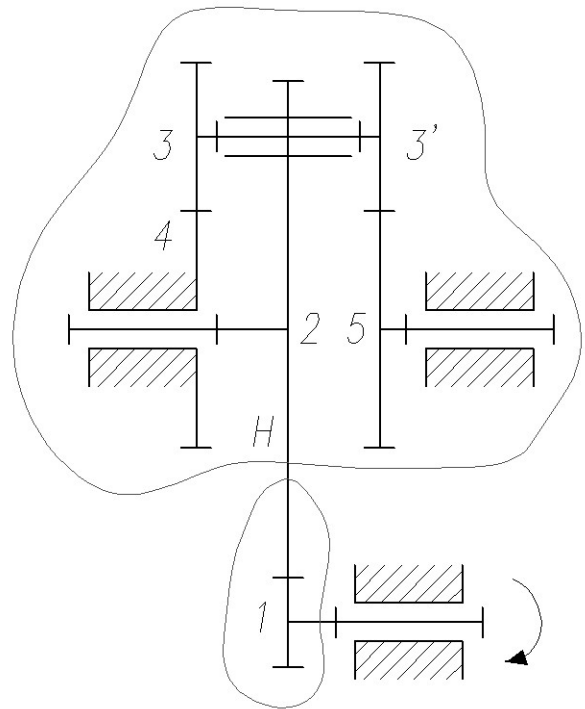
Задача № 3

Дано:

$$n_1 = 400 \frac{\text{об}}{\text{мин}};$$

$$Z_1 = 20; Z_2 = 80; Z_3 = Z_{3'} = 45;$$

$$Z_4 = 59; Z_5 = 60.$$



Решение:

$$l = 3 \text{ (стойки)}; \quad p = l - 1 = 2 \text{ (ступени)};$$

Одна ступень простая:

$$U_{12} = -\frac{Z_2}{Z_1} = -\frac{80}{20} = 4;$$

Другая сателлитная.

(Используем метод обращения движения)

$$U_{5H} = 1 - U_{54}^H = 1 - U_{53'}^H \cdot U_{34}^H = 1 - \left(-\frac{Z_{3'}}{Z_5}\right) \cdot \left(-\frac{Z_4}{Z_3}\right) = 1 - \frac{45 \cdot 59}{60 \cdot 45} = \frac{1}{60};$$

$$U_{H5} = \frac{1}{U_{5H}} = 60;$$

$$\boxed{U_{15}} = U_{12} \cdot U_{H5} = 4 \cdot 60 = 240;$$

$$U_{12} = \frac{n_1}{n_2} \rightarrow \boxed{n_2} = \frac{n_1}{U_{12}} = \frac{400}{4} = 100 \frac{\text{об}}{\text{мин}}; \quad \boxed{n_H} = n_2 = 100 \frac{\text{об}}{\text{мин}}; \quad \boxed{n_4} = 0;$$

$$U_{H5} = \frac{n_H}{n_5} \rightarrow \boxed{n_5} = \frac{n_H}{U_{H5}} = \frac{n_2}{U_{H5}} = \frac{100}{60} = 1.7 \frac{\text{об}}{\text{мин}}; \quad \left(\text{Проверка: } n_5 = \frac{n_1}{U_{15}} = \frac{400}{240} = 1.7 \frac{\text{об}}{\text{мин}} \right)$$

$$\frac{n_5 - n_H}{n_{3'} - n_H} = U_{53'} = -\frac{Z_{3'}}{Z_5} \rightarrow \boxed{n_{3'}} = -\frac{Z_5 \cdot (n_5 - n_H)}{Z_{3'}} + n_H = -\frac{60 \cdot (1.7 - 100)}{45} + 100 = 231 \frac{\text{об}}{\text{мин}};$$

$$\boxed{n_3} = n_{3'} = 231 \frac{\text{об}}{\text{мин}}.$$

Задача № 4

Дано:

$$M_d(t) = \text{const}; I_{\Pi} = 0,1 \text{ кг} \cdot \text{м}^2; \omega_0 = 50 \frac{1}{\text{с}};$$

Решение:

$$A_c = \frac{40\pi}{2} + \frac{20\pi}{2} = 30\pi;$$

$$A_d = A_c \rightarrow M_d \cdot 2\pi = 30\pi \rightarrow M_d = 15;$$

$$T_0 = \frac{I_{\Pi} \cdot \omega_0^2}{2} = \frac{0,1 \cdot 2500}{2} = 125; \quad \omega_0 = \sqrt{\frac{2 \cdot T_0}{I_{\Pi}}} = \sqrt{20 \cdot T_0} = 50;$$

$$T_1 = T_0 + \Delta T_{01} = 125 + \frac{0,6 \cdot 15}{2} = 129,5; \quad \omega_1 = \sqrt{20 \cdot T_1} = 50,9;$$

$$T_2 = T_0 - \Delta T_{12} = 129,5 - \frac{1 \cdot 25}{2} = 117; \quad \omega_2 = \sqrt{20 \cdot T_2} = 48,4;$$

$$T_3 = T_0 - \Delta T_{23} = 117 - \frac{1 \cdot 25}{2} = 104,5; \quad \omega_3 = \sqrt{20 \cdot T_3} = 45,7;$$

$$T_4 = T_0 + \Delta T_{34} = 104,5 + \frac{0,6 \cdot 15}{2} = 109; \quad \omega_4 = \sqrt{20 \cdot T_4} = 46,7;$$

$$T_5 = T_0 + \Delta T_{45} = 109 + \frac{1,2 \cdot 15}{2} = 118; \quad \omega_5 = \sqrt{20 \cdot T_5} = 48,6;$$

$$T_6 = T_0 - \Delta T_{56} = 118 - \frac{0,4 \cdot 5}{2} = 117; \quad \omega_6 = \sqrt{20 \cdot T_6} = 48,4;$$

$$T_7 = T_0 - \Delta T_{67} = 117 - \frac{0,4 \cdot 5}{2} = 116; \quad \omega_7 = \sqrt{20 \cdot T_7} = 48,2;$$

$$T_8 = T_0 + \Delta T_{78} = 116 + \frac{1,2 \cdot 15}{2} = 125; \quad \omega_8 = \sqrt{20 \cdot T_8} = 50.$$

$$\varepsilon_0 = \frac{M_d - M_c}{I_{\Pi}} = \frac{15 - 0}{0,1} = 150; \quad \varepsilon_3 = \frac{15 - 20}{0,1} = -50;$$

$$\varepsilon_1 = \frac{15 - 40}{0,1} = -250; \quad \varepsilon_4 = \frac{15 - 0}{0,1} = 150.$$

$$\varepsilon_2 = \frac{15 - 0}{0,1} = 150;$$

$$\omega_{\min} = 45,7; \quad \omega_{\max} = 50,9; \quad \omega_{\text{cp}} = 48,5.$$

$$\delta = \frac{\omega_{\max} - \omega_{\min}}{\omega_{\text{cp}}} = \frac{50,9 - 45,7}{48,5} = 0,1; \quad N_{\text{cp}} = M_d \cdot \omega_{\text{cp}} = 15 \cdot 48,5 = 727,5$$

