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26-41-82-34
(4.6)

МОСКОВСКИЙ ГОСУДАРСТВЕННЫЙ УНИВЕРСИТЕТ
имени М.В.ЛОМОНОСОВА

Вариант №2

ПИСЬМЕННАЯ РАБОТА

Олимпиада школьников "Ломоносов"

по физике

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фамилия, имя, отчество участника (в родительном падеже)

Дата
«9» февраля 2024 года

Подпись участника

26-41-82-34
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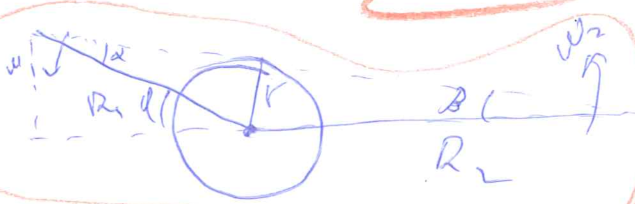
Чистовик.
Задание 1.4.2

Рассмотрим момент ~~вых~~ "входа" в "слепую" зону



$\Delta\varphi = \alpha + \beta$

тогда выход из слепой зоны будет при условии $\omega_1\tau - \omega_2\tau = 2\varphi$.

$\alpha \approx \sin\alpha = \frac{r}{R_1}$

$\frac{\omega_1}{\omega_2} = \left(\frac{R_2}{R_1}\right)^{\frac{3}{2}} = \frac{125}{64}$

$\beta \approx \sin\beta = \frac{r}{R_2}$

$\omega_1 = \frac{125}{64}\omega_2$

$125 - 64 = 61$

$\tau = \frac{2\left(\frac{r}{R_1} + \frac{r}{R_2}\right)}{\omega_1 - \omega_2} = \frac{2r\left(\frac{1}{R_1} + \frac{1}{R_2}\right)}{\frac{61}{125}\omega_1}$

$\omega_2 = \frac{64}{125}\omega_1 = \left(\frac{R_1}{R_2}\right)^{\frac{3}{2}}$

$v_0 = \sqrt{\frac{MG}{r}}$ $\quad v_0$, v – у поверхности

$\frac{v_0^2}{r} = g \Rightarrow g = \frac{MG}{r^2} \Rightarrow MG = gr^2$

$\omega_1 = \sqrt{\frac{MG}{R_1^3}} = \sqrt{\frac{gr^2}{R_1^3}} = \frac{r}{R_1}\sqrt{\frac{g}{R_1}}$

~~$\tau = \frac{2r\left(\frac{1}{R_1} + \frac{1}{R_2}\right)}{\frac{61}{64}\frac{r}{R_1}\sqrt{\frac{g}{R_1}}} = \frac{128}{61}\frac{R_1+R_2}{R_2}\sqrt{\frac{R_1}{g}} = \frac{128}{61}1{,}64\cdot 100\cdot\sqrt{\frac{6{,}4}{g}}$~~

~~$= \frac{128}{61}1{,}64\cdot 100\sqrt{\frac{6{,}4}{3}}$~~

$\tau = \frac{2\frac{R_1+R_2}{R_1 R_2}r}{\frac{r}{R_1}\sqrt{\frac{g}{R_1}}\left(1-\left(\frac{R_1}{R_2}\right)^{\frac{3}{2}}\right)} = \frac{2\frac{R_1+R_2}{R_2}}{\sqrt{\frac{g}{R_1}}\left(1-\left(\frac{R_1}{R_2}\right)^{\frac{3}{2}}\right)} = \frac{2\cdot 1{,}64}{\sqrt{\frac{g}{6{,}4}}\cdot\frac{1}{100}\cdot\frac{61}{125}} =$

~~$= \frac{3{,}128\cdot 125\sqrt{6{,}4}}{3\cdot 100\cdot 61} = \frac{10{,}4\sqrt{6{,}4}}{732} = \frac{16{,}4\cdot 8\sqrt{10}}{183\cdot 10} = \frac{32{,}8\sqrt{10}}{1830}$~~

Ответ: $\tau = \frac{2\frac{R_1+R_2}{R_2}}{\sqrt{\frac{g}{R_1}}\left(1-\left(\frac{R_1}{R_2}\right)^{\frac{3}{2}}\right)}$ ~~$\approx 587{,}4$ с~~ $\approx 1{,}74\cdot 10^3$ с $\approx 1{,}7\cdot 10^3$ с.

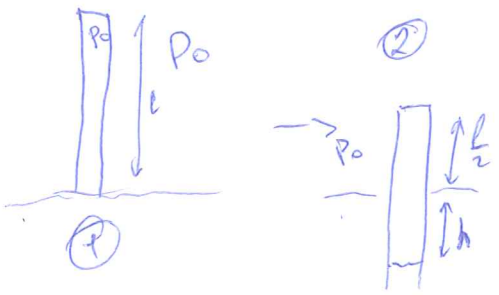
1	2	3	4	5	Σ
10	20	20	20	20	90 (девяносто)

Иванов, Орлова, Никонов

Оценка не изменилась 80

Числовец.

Задача 2.5.2.



$P_{1г} = P_0 - P_{нас}$

$P_{нас} = const$

$P_0 + \rho_0 g h = P_{нас} + P_{г2}$

$\frac{P_{г2}}{P_{г1}} = \frac{V_1}{V_2}$

$P_{г2} = P_{г1} \frac{l}{\frac{l}{2}+h}$

$P_0 + \rho_0 g h = P_{нас} + P_0 \frac{l}{\frac{l}{2}+h} - P_{нас} \frac{l}{\frac{l}{2}+h}$

$\rho_0 g h + P_{нас}\left(\frac{l}{\frac{l}{2}+h} - 1\right) = P_0\left(\frac{l}{\frac{l}{2}+h} - 1\right)$

$P_0 = P_{нас} + \frac{\rho_0 g h}{\frac{l}{\frac{l}{2}+h} - 1} = 14500 + \frac{10 \cdot 1000 \cdot 0{,}45}{\frac{1}{0{,}95} - 1} =$

$= 14500 + \frac{4500 \cdot 0{,}95}{0{,}05} = 14500 + 85500 = 100000$ Па

Ответ: $P_0 = 10^5$ Па ; $P_0 = P_{нас} + \frac{\rho_0 g h \left(\frac{l}{2}+h\right)}{\frac{l}{2}-h}$

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Чистовик.
Задача 3.10.2.

$l \gg R$

Q – заряд сферы

~~условие~~ Заземление:

$$k\frac{q_1}{R} + k\frac{q_2}{l} + k\frac{Q}{R} = 0$$

$$\Downarrow$$

$$Q = -q_1$$

Шары соединены, заряды установились, тока нет, потенциалы равны. $\varphi_1 = \varphi_2$ (+)

$\varphi_1 = k\frac{q_1}{r} - k\frac{q_1}{R}$ (+)

$\varphi_2 = k\frac{q_2}{r}$ (+)

$\varphi_1 = \varphi_2$

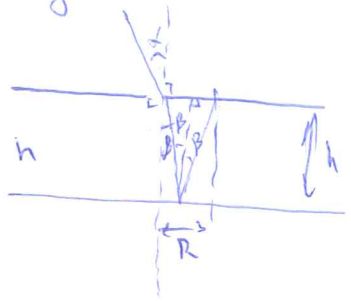
$k\frac{q_1}{r} - k\frac{q_1}{R} = k\frac{q_2}{r}$

$\frac{1}{r}(q_1 - q_2) = \frac{q_1}{R} \Rightarrow r = \frac{(q_1 - q_2)}{q_1}R = \frac{2}{3}R = 2см$ (+)

Ответ: $r = 2см$. $r = \frac{q_1 - q_2}{q_1}R$ (+)

Чистовик.

Задача 4.10.2.



Рассмотрим предельный угол падения лучей (α)

$\sin\alpha = n \sin\beta$. $\sin\beta \in [0;1]$ $\sin\alpha \in [0;1]$

Тогда ~~$R = 2h \sin\beta$~~ $R = 2h \cdot tg\beta$

~~max $\sin\beta = \frac{1}{n}$~~

$\sin\beta = \frac{\sin\alpha}{n}$ max при $\sin\alpha = 1$

$\sin\beta = \frac{1}{n}$

$tg\beta = \frac{1}{\sqrt{n^2-1}}$

~~$R = 2h \frac{1}{n} \Rightarrow h = \frac{Rn}{2} = \frac{8}{2} 1{,}5 = 6$ см~~

$R = 2h \cdot tg\beta$

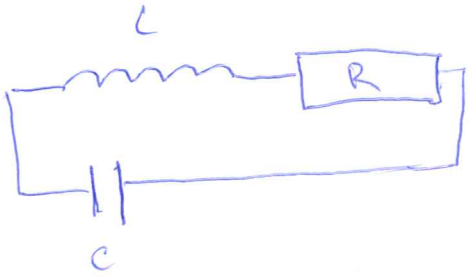
~~Ответ: $h = 6$ см.~~

$h = \frac{R}{2tg\beta} = \frac{R}{2}\sqrt{n^2-1}$

$h = \frac{R}{2}\sqrt{n^2-1} = 4\sqrt{2{,}25-1} = 4\sqrt{1{,}25} \approx 4{,}4$ см

Ответ: $h = \frac{R}{2}\sqrt{n^2-1} \approx 4{,}4$ см.

Задача 5.4.2.



$I_{max} \Rightarrow \dot{I} = 0 \Rightarrow Q_{max} =$ ЧС

$\omega = \sqrt{\frac{1}{LC}}$

$Q(t) = UC$

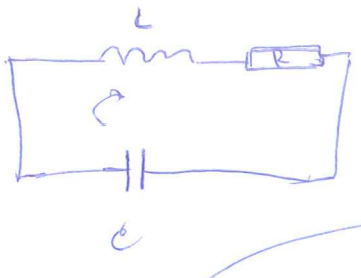
$\frac{q}{C} - L\dot{I} - RI = 0$ $\quad I_{max} \Rightarrow \dot{I} = 0$

$\frac{q}{C} = RI_{max}$

$Q = \left(\frac{I_{max}}{\sqrt{2}}\right)^2 R \cdot T = \frac{U^2}{R} \pi\sqrt{LC}$

$R = \frac{U^2 \pi\sqrt{LC}}{Q} = \frac{4 \cdot 10^{-2} \cdot 3{,}14 \sqrt{30 \cdot 0{,}3 \cdot 10^{-6}}}{0{,}38 \cdot 10^{-3}} = \frac{18{,}84}{19} \approx 1$ Ом

Ответ: $R = \frac{U^2 \pi\sqrt{LC}}{Q} \approx 1$ Ом



$Q =$

$I_{max} \Rightarrow \dot{I} = 0$

$$\frac{Q}{C} - L\dot{I} - RI = 0$$

$$I_m = \frac{q}{C}R = \frac{U}{R}$$

$$\frac{Q}{C} = I_m R$$

$$Q = \left(\frac{I_m}{\sqrt{2}}\right)^2 \cdot R \cdot T \Rightarrow Q = \frac{I_m^2}{2} R \cdot \frac{2\pi}{\omega}$$

$$Q = I_m^2 R \pi \sqrt{LC}$$

$$R = \frac{U^2}{Q}\pi\sqrt{LC}$$

$$R = \frac{U^2 \cdot \pi \sqrt{LC}}{Q}$$

$$R = \frac{4 \cdot 10^{-2} \cdot 3{,}14 \sqrt{30 \cdot 10^{-6} \cdot 0{,}3}}{38 \cdot 10^{-4}} = \frac{4 \cdot 3{,}14 \cdot 10^{-3} \cdot 3}{38 \cdot 10^{-2}} = \frac{4 \cdot 3{,}14 \cdot 3}{38 \cdot 10}$$

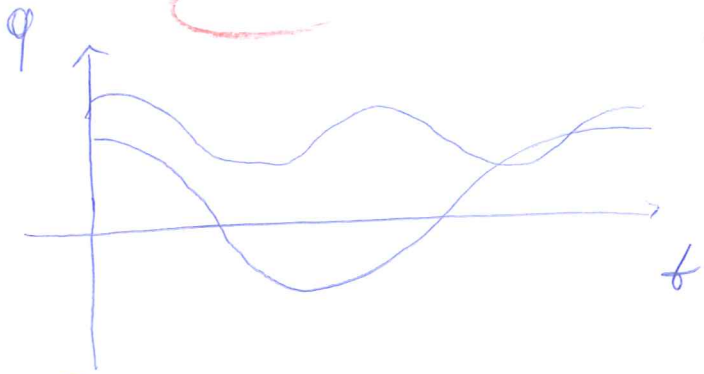
$$= \frac{12 \cdot 3{,}14}{38 \cdot 10} = \frac{18{,}84}{190} \approx 0{,}1 \text{ Ом}$$

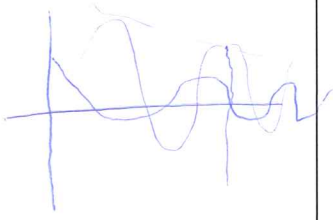
$1884 \mid 19000$
$18840 \mid 0{,}1$

$0{,}38 \text{ мОм} = 0{,}38 \cdot 10^{-3} \text{ Ом}$

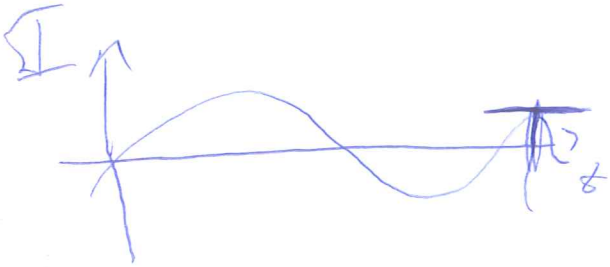
$$\frac{4 \cdot 10^{-2} \cdot 3{,}14 \cdot 10^{-3} \cdot 3}{0{,}38 \cdot 10^{-3}} = \frac{4 \cdot 3 \cdot 3{,}14}{38} = \frac{18{,}84}{19} \approx 1$$

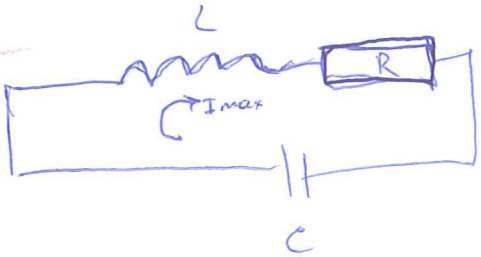
Черновик.





3,14
× c
18,84





~~$I(t) = \frac{1}{LC} q \cos(\omega t)$~~

$q(t) =$

$I(t) = \omega q \cos(\omega t)$

$q(t) = q \sin(\omega t) + C$.

$q(t) = -q \sin(\omega t) + CU$

$q_c(t) = CU - q \sin(\omega t)$

$\frac{C}{C} = U$

$T = 2\pi\sqrt{LC}$

$Q = \left(\frac{I_м}{\sqrt{2}}\right)^2 R \cdot 2\pi\sqrt{LC}$

~~$Q = 2\pi\sqrt{LC} R$~~

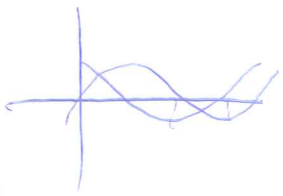
$Q = \left(\frac{\omega q}{\sqrt{2}}\right)^2 R \cdot T$

$Q = 2\pi\sqrt{LC} R \frac{\omega^2 q^2}{4} = \pi \omega R q^2 = \pi \omega R (CU)^2$

$R = \frac{Q\sqrt{LC}}{\pi C^2 U^2} = \frac{380,000 \cdot \sqrt{0,08} \cdot 10^{-3} \sqrt{30 \cdot 0,3}}{3,14 \cdot 10^{-12} \cdot 900 \cdot 0,04} =$

$= \frac{38 \cdot 10^4 \cdot 10^{-3} \cdot 3}{3,14 \cdot 10^{-12} \cdot 36} = \frac{10^{13} \cdot 13}{3,14 \cdot 6} = 10$ Ом

Черновик:

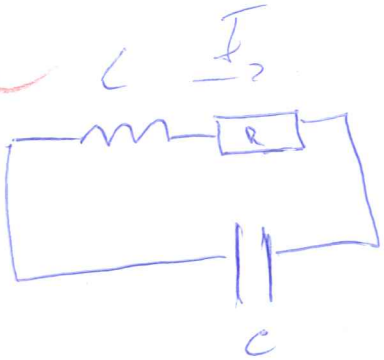


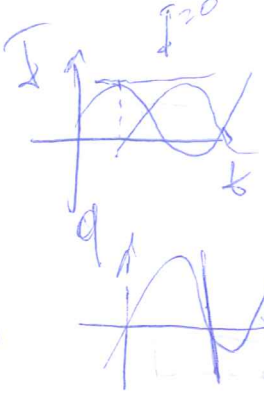
4200

$$\frac{2 \cdot 1{,}64 \sqrt{6400}}{3} \cdot 100 = \frac{61}{125}$$

3,28

$$\frac{125 \cdot 2 \cdot 1{,}64 \sqrt{8000}}{3 \cdot 61} = \frac{4200 \cdot 8000}{3 \cdot 61} = \frac{112}{61} 10^3$$





14 × 8 = 112

112 | 61
− 61 | 1,739
510
− 487
230
− 183
570

$$\frac{LI^2}{2} + \frac{cu^2}{2} = Q$$

$$IR = u$$

$$u_c + \dot{I}L - IR = 0$$

$I_{max} \Rightarrow \dot{I} < 0$

$$u + \dot{I}L = IR$$

$$Q_c = u \cdot c$$

$$\frac{LI^2}{2} + \frac{q^2}{2c} = \text{const}$$

$$\ddot{q} + \frac{1}{Lc} q = 0$$

$$q(t) = q_m \sin\left(\sqrt{\frac{1}{Lc}}\, t + \dots\right)$$

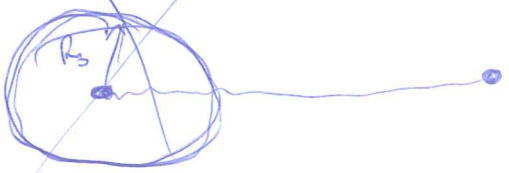
$$I(t) = q_m \sqrt{\frac{1}{Lc}} \cos\left(\sqrt{\frac{1}{Lc}}\, t + \dots\right)$$

$$Q = \int \left(\frac{I_M}{\sqrt{2}}\right)^2 \cdot R \cdot dt = \frac{I_M \cdot q}{2} R$$

~~$Q = I^2 R$~~

$P = I^2 R \Rightarrow Q = qIR$

Черновик

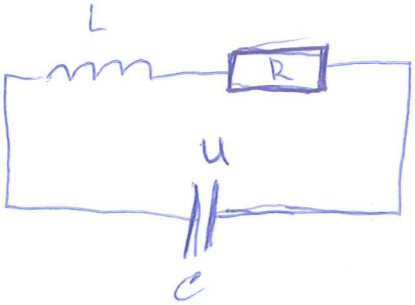


Черновик

$W = \frac{CU^2}{2}$

$\frac{q^2}{2C}$

$\frac{LI^2}{2} + \frac{q^2}{2C} = const$



$\frac{2I}{2} L + \frac{2q}{2C} = 0$

$\ddot{q} + \frac{1}{2LC} q = 0$

$I_m \Rightarrow$

$2 \cdot \frac{\frac{16,4}{10} \cdot 100\sqrt{6,4}}{3\left(1 - \frac{64}{125}\right)} = \frac{3,28 \cdot 10\sqrt{6,4} \cdot 125}{3 \cdot 61} = \frac{4200 \cdot 10\sqrt{6,4}}{3 \cdot 61}$

$\frac{14000\sqrt{6,4}}{64} = \frac{14000}{61} \cdot 8\frac{\sqrt{10}}{10}$

$\frac{32,8 \cdot 3,2}{1830} =$

32,8
× 3,2
756
984
105,86

1830 | 0,05
−9015
1810

32,8
× 125
164
756
328
4052,4

32,8
× 125
1640
756
328
4200,0

112 00
× 32
224
336
358400

358400 | 61
−305 | 587,3
534
488
460
−427
33

14 × 8 = 112

11200√10 / 61

32
× 32
74
96
1034

Черновик.

$mg = G\frac{Mm}{R^2}$

$\frac{mv^2}{R} = \frac{Mm}{R^2}G$

$v = \sqrt{\frac{MG}{R}}$

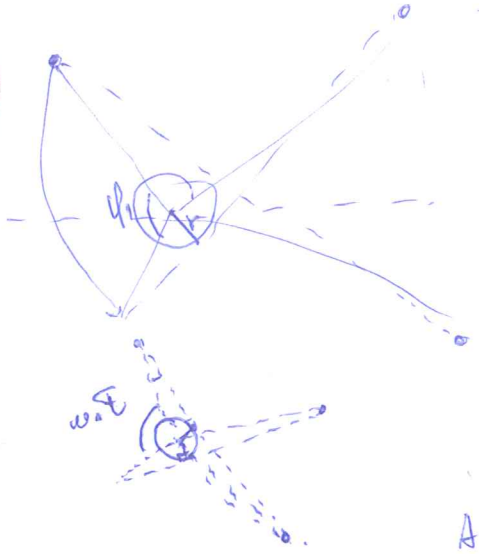
732 | 4
-4 | 183
33
-32
12

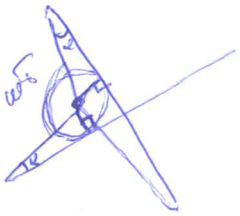
$\omega_1 = \frac{v_1}{R_1} = \sqrt{\frac{MG}{R_1^3}}$

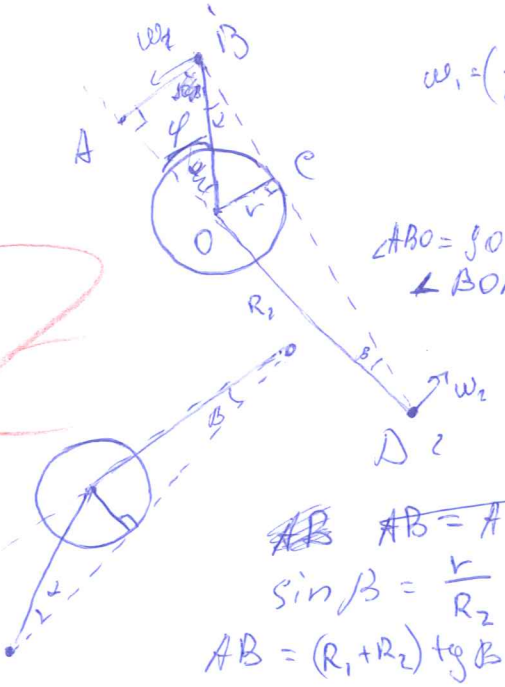
$\omega_2 = \sqrt{\frac{MG}{R_2^3}}$

$\frac{\omega_1}{\omega_2} = \left(\frac{R_2}{R_1}\right)^{\frac{3}{2}}$

$\omega_1 = \left(\frac{R_2}{R_1}\right)^{\frac{3}{2}}\omega_2$







$\omega_1 = \left(\frac{100}{64}\right)^{\frac{3}{2}}\omega_2$ ~~10 по 10~~

$\omega_1\left(\frac{10}{8}\right)^3\omega_2 = \frac{125}{64}\omega_2$

$\angle ABO = 90 - \beta - \alpha$

$\angle BOA = \beta + \alpha = \varphi$

$\frac{AB}{\sin\angle BOA} = \frac{OA}{\sin\angle ABO}$

~~$\varphi = \frac{OA}{AB}\sin\angle BOA$~~

~~$AB = AD \cdot tg\beta$~~

$\sin\beta = \frac{r}{R_2}$

$AB = (R_1 + R_2)tg\beta$

$\sin\angle BOA = \varphi$

$\varphi = \frac{AB}{OA}\sin(90 - (\beta+\alpha))$

~~$\frac{AB}{\sin^2\angle BOA}$~~ $= \cos\beta\cdot\cos\alpha - \sin\beta\cdot\sin\alpha$

$\varphi = \frac{AB}{OA}\cdot\cos(\beta+\alpha) = \frac{(R_1+R_2)tg\beta}{R_1}(\cos\beta\cdot\cos\alpha - \sin\beta\cdot\sin\alpha)$

$\varphi = \frac{R_1+R_2}{R_1}\frac{OC}{DC}\left(\frac{DC}{OD}\cdot\frac{BC}{OB} - \frac{OC}{OD}\cdot\frac{OC}{OB}\right)$

$DC = \sqrt{R_2^2 - OC^2}$

$\varphi = \frac{R_1+R_2}{R_1^2\cdot R_2}\frac{OC}{DC}\left(DC\cdot BC - OC^2\right)$

$\varphi = \frac{R_1+R_2}{R_1^2 R_2}OC\left(BC - \frac{OC^2}{DC}\right)$

$\varphi = \alpha + \beta = OC\left(\frac{1}{R_1} + \frac{1}{R_2}\right)$

$\omega_1 t - \omega_2 t = 2\varphi$

$t = \frac{2\varphi}{\omega_1 - \omega_2}$

Подписывать лист-вкладыш запрещается! Писать на полях листа-вкладыша запрещается!