Уход: 13:56
Пери. 14:01

0 514917 960000

51-49-17-96
(4.7)

МОСКОВСКИЙ ГОСУДАРСТВЕННЫЙ УНИВЕРСИТЕТ
имени М.В.ЛОМОНОСОВА

Вариант 2 класс 11

Место проведения Москва
город

ПИСЬМЕННАЯ РАБОТА

Олимпиада школьников Ломоносов
наменование олимпиады

по физике
профиль олимпиады

Юдина Степана Николаевича
фамилия, имя, отчество участника (в родительном падеже)

Дата

«09» февраля 2024 года

Подпись участника

51-49-17-96 (4.7)

Чистовик.

① $R_1 = 6{,}4\cdot10^4$ км
$R_2 = 10^5$ км
$g = 9$ м/с²

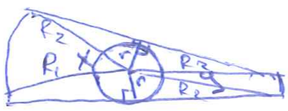
$T - ?$

1) $mg = \frac{GmM}{r^2} \Rightarrow g = \frac{GM}{r^2} \Rightarrow$

$\Rightarrow gr^2 = GM$ (r – радиус планеты)

2) $\frac{mv^2}{R} = \frac{GmM}{R^2}$ (F = ma)

$v^2 = \frac{GM}{R} \Rightarrow \begin{cases} v_1 = \sqrt{\frac{GM}{R_1}} = r\sqrt{\frac{g}{R_1}} \\ v_2 = \sqrt{\frac{GM}{R_2}} = r\sqrt{\frac{g}{R_2}} \end{cases}$

3) 

$\leftarrow x + y = 2\pi - 2\arccos\frac{r}{R_1} - 2\arccos\frac{r}{R_2}$
(x, y – углы в рад)

$\arccos\frac{r}{R_1} = \frac{\pi}{2} - \arcsin\frac{r}{R_1}$; $\arccos\frac{r}{R_2} = \frac{\pi}{2} - \arcsin\frac{r}{R_2}$

$x + y = 2\left(\pi - \frac{\pi}{2} - \frac{\pi}{2} + \arcsin\frac{r}{R_1} + \arcsin\frac{r}{R_2}\right) =$

$= 2\left(\arcsin\frac{r}{R_1} + \arcsin\frac{r}{R_2}\right) = 2\left(\frac{r}{R_1} + \frac{r}{R_2}\right) = 2r\frac{R_1 + R_2}{R_1R_2} \Rightarrow$

$\Rightarrow y = 2r\frac{R_1+R_2}{R_1R_2} - x$.

4) $\begin{cases} l_1 = v_1T = R_1x \\ l_2 = v_2T = R_2y \end{cases} \Rightarrow \begin{cases} x = \frac{v_1T}{R_1} \\ y = \frac{v_2T}{R_2} \end{cases} \Rightarrow$

$\Rightarrow \frac{v_2T}{R_2} = 2r\frac{R_1+R_2}{R_1R_2} - \frac{v_1T}{R_1} \quad | \cdot R_1$

$\frac{R_1}{R_2}v_2T + v_1T = 2r\frac{R_1+R_2}{R_2}$

Подставим v_1 и v_2 из п(2):

$\frac{R_1}{R_2}r\sqrt{\frac{g}{R_2}}T + r\sqrt{\frac{g}{R_1}}T = 2r\frac{R_1+R_2}{R_2} \quad | : r$

$\sqrt{g}T\left(\frac{R_1}{R_2\sqrt{R_2}} + \frac{1}{\sqrt{R_1}}\right) = 2\frac{(R_1+R_2)}{R_2}$

$\sqrt{g}T\frac{R_1\sqrt{R_1} + R_2\sqrt{R_2}}{R_2\sqrt{R_1R_2}} = \frac{2(R_1+R_2)}{R_2} \quad | \cdot R_2\sqrt{R_1R_2}$

$\sqrt{g}T\left(R_1\sqrt{R_1} + R_2\sqrt{R_2}\right) = 2(R_1+R_2)\cdot\sqrt{R_1R_2} \Rightarrow$

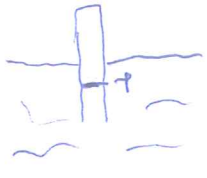
$\Rightarrow T = \frac{2(R_1+R_2)\sqrt{R_1R_2}}{\sqrt{g}\left(R_1\sqrt{R_1} + R_2\sqrt{R_2}\right)} = \frac{32800\sqrt{10}}{567} \approx 183$

Отв

+

1	2	3	4	5	Σ
18	20	20	20	5	83

(2)



1) 1: $\rho g h + p_0 = p_2$

2) $\begin{cases} p_{б1} l S = \nu R T \\ p_{б2} \left(\frac{l}{2} + h\right) S = \nu R T \end{cases} \Rightarrow p_{б1} l = p_{б2}\left(\frac{l}{2} + h\right)$

3) $p_2 = p_{б2} + p_{нас}$

4) $p_0 = p_{нас} + p_{б1} - g_0$ погруж. в ниж. части трубки $\Rightarrow$

$\Rightarrow p_{б1} = p_0 - p_{нас}$ (в п(2))

5) $p_2 = \frac{(p_0 - p_{нас}) l 2}{L + 2h} = p_{б2}$ (в п(3))

6) ~~$p_0 - p_{нас} +$~~ $p_2 = \frac{2 L p_0}{L+2h} - \frac{2 L p_{нас}}{L+2h} + p_{нас} =$

$= \frac{2Lp_0}{L+2h} + p_{нас}\left(1 - \frac{2l}{L+2h}\right)$ - Подставим в п(1)

7) $\rho g h + p_0 = \frac{2Lp_0}{L+2h} + p_{нас}\left(1 - \frac{2l}{L+2h}\right)$

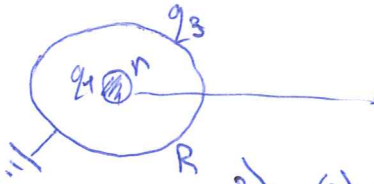
$p_0\left(1 - \frac{2l}{L+2h}\right) = p_{нас}\left(1 - \frac{2l}{L+2h}\right) - \rho g h$

$p_0\left(\frac{2h-l}{2h+l}\right) = p_{нас}\left(\frac{2h-l}{2h+l}\right) - \rho g h$

$p_0 = p_{нас} - \rho g h \left(\frac{2h+l}{2h-l}\right) = 10^5$ Па

ОТВ

(3)



1) $\begin{cases} q_1 + q_{31} = q_2 \text{ - устан. режим} & (1) \\ q_{13} + q_3 = 0 \text{ - заземл.} & (2) \end{cases}$

2) (2): $\frac{k q_3}{R} + \frac{k q_1}{R} = 0 \Rightarrow q_3 = -q_1$

3) (1): $\frac{k q_2}{r} = \frac{k q_1}{r} + \frac{k q_3}{R} \Rightarrow \frac{q_2}{r} = \frac{q_1}{r} - \frac{q_1}{R}$

~~$\frac{q_2}{r} - \frac{q_1}{r}$~~ $= \frac{q_1}{r} - \frac{q_2}{r} = \frac{q_1}{R} = \frac{(q_1 - q_2)}{r} \Rightarrow$

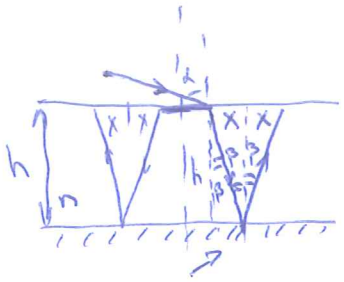
$\Rightarrow r = \frac{R(q_1 - q_2)}{q_1} = 2$ см

ОТВ

+

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

④



1) $\sin\alpha = n\sin\beta$

2) Предельный случай (для максимизации β):

$\alpha \to \frac{\pi}{2} \Rightarrow \sin\alpha \to 1$.

$1 = n\sin\beta \Rightarrow \sin\beta = \frac{1}{n} = \frac{2}{3}$.

2) $tg\beta = \frac{x}{h} \Rightarrow x = h\,tg\beta$

3) Т.к $\sin\beta = \frac{2}{3} \Rightarrow \cos\beta = \sqrt{1 - \frac{4}{9}} = \frac{\sqrt{5}}{3}$ и

$tg\beta = \frac{2 \cdot 3}{3\sqrt{5}} = \frac{2}{\sqrt{5}}$.

4) $R = 2x + \frac{r}{2}$ (из рис). $R \approx 2x$ ($r \to 0$, т.к отверстие маленькое)

Тогда $R = 2h\,tg\beta \Rightarrow h = \frac{R}{2\,tg\beta} = \frac{R\sqrt{5}}{4} = 2\sqrt{5}$

ОТВ.

⑤ $L = 0{,}3$ Гн

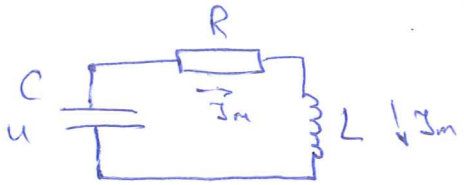
$C = 30$ мкФ

$u = 0{,}2$ В

$Q = 0{,}38$ мДж

$\pi = 3{,}14$

$R - ?$



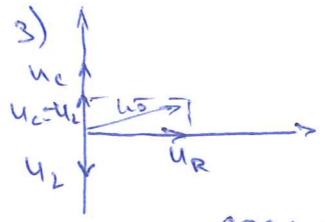
1) $W_{систо} = \frac{Cu^2}{2} + \frac{LJ_m^2}{2}$

2) $u_c = u$, $u_L = J_m x_L = J_m \frac{1}{\omega L}$

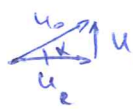
$u_R = J_m R$

$u = J_m x_C = J_m \omega C \Rightarrow J_m = \frac{u}{\omega C}$.

3)



$\to$



и

$\cos\alpha = \frac{u_R}{u_0} = \frac{P_R}{P_0} \Rightarrow P_0 = P_R \frac{u_0}{u_R} = \frac{P_R}{\cos\alpha}$

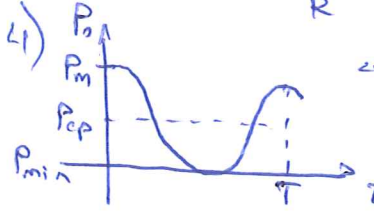
$u_0 = \sqrt{u_R^2 + (u_c - u_L)^2} = \sqrt{J_m^2 R^2 + J_m^2 (x_c - x_L)^2} =$

$= J_m \sqrt{R^2 + \left(\omega C - \frac{1}{\omega L}\right)^2}$.

$\cos\alpha = \frac{J_m R}{J_m \sqrt{R^2 + \left(\omega C - \frac{1}{\omega L}\right)^2}} = \frac{R}{\sqrt{R^2 + \left(\omega C - \frac{1}{\omega L}\right)^2}} \Rightarrow$

$\Rightarrow P_0 = \frac{P_R}{R} \sqrt{R^2 + \left(\omega C - \frac{1}{\omega L}\right)^2}$.

4)



$P_{min} = 0$ (когда $P_R = 0$ ($t = \frac{T}{2}$))

$P_{ср} = \frac{P_m}{2}$

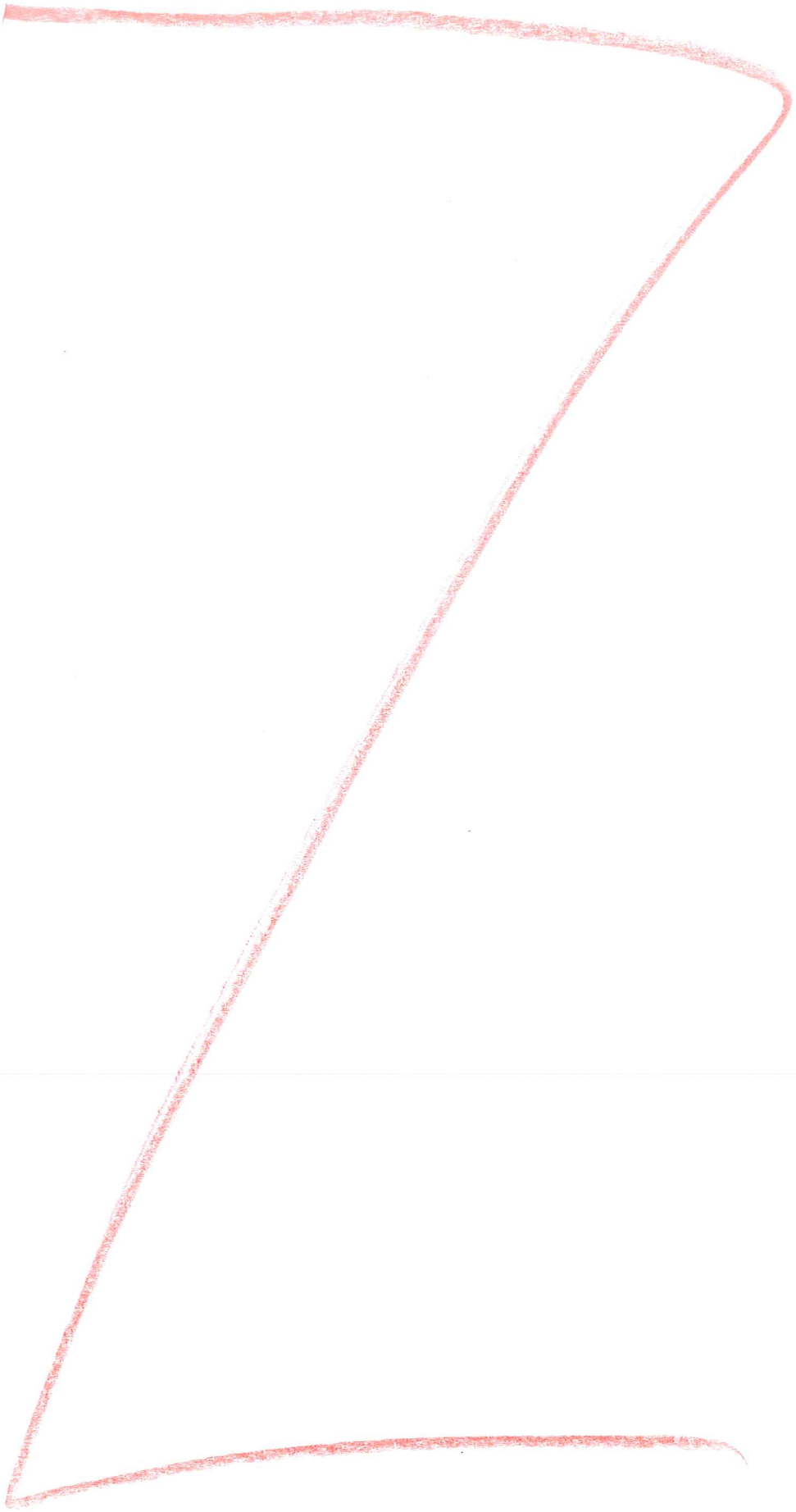
5) $P_{ср} T = Q$. Подставим $T = \frac{2\pi}{\omega} = \frac{2\pi e I_m}{u}$ (из п.(2))

$\frac{P_{ср}}{2} \frac{m \cdot 2\pi C I_m}{u} = Q = \frac{2\pi C I_m P_m}{4}$

~~$P_{ср}$~~ $P_m = u I_m$)

$Q = \pi e I_m^2 \Rightarrow I_m = \sqrt{\frac{Q}{\pi e}}$

$u = u_R = I_m R = \sqrt{\frac{Q}{\pi e}} R \Rightarrow R = \frac{u\sqrt{\pi e}}{\sqrt{Q}}$ - ОТ



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

$\cos\varphi = \frac{U_R}{U_0} = \frac{P_R}{P_0} \Rightarrow P_0 = P_R \frac{U_0}{U_R} = \frac{P_R}{\cos\varphi}$

$U_0 = \sqrt{U_R^2 + (U_C - U_L)^2} = \sqrt{I_m^2 R^2 + I_m^2 (X_C - X_L)^2} =$

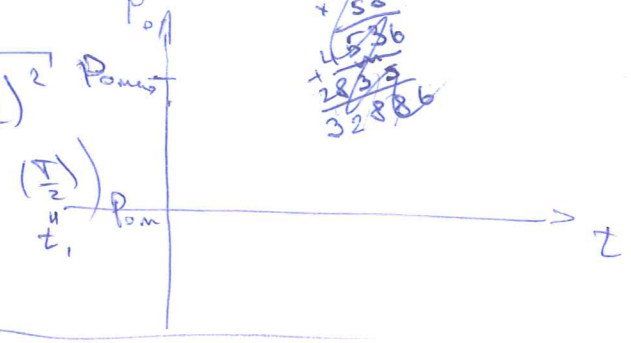
$= I_m \sqrt{R^2 + \left(\omega C - \frac{1}{\omega L}\right)^2} = I_m \sqrt{R^2 + \left(\omega C - \frac{1}{\omega L}\right)^2} =$

$= \frac{U}{\omega C} \sqrt{R^2 + \left(\omega C - \frac{1}{\omega L}\right)^2}$

$\cos\varphi = \frac{R}{\sqrt{R^2 + \left(\omega C - \frac{1}{\omega L}\right)^2}} =$

$P_0 = \frac{P_R}{R} \sqrt{R^2 + \left(\omega C - \frac{1}{\omega L}\right)^2}$

$P_{min} = 0$ (Когда $P_R = 0$ $\left(\frac{T}{2}\right)$)



$T = \frac{2\pi C I_m}{U}$ $\frac{P_{max} - P_{min}}{2} T = Q$

$\left(\frac{P_{max} - P_{min}}{2}\right) \frac{2\pi C I_m}{U} =$

$= \frac{(P_{max} - P_{min}) \pi C I_m}{U} = Q$

$\frac{P_{max}}{U} \pi C I_m = Q$

$U_{0max} = I_m \sqrt{R^2 + \left(\omega C - \frac{1}{\omega L}\right)^2}$

$U_{0max} I_m = I_m^2 \sqrt{R^2 + \left(\omega C - \frac{1}{\omega L}\right)^2} = P_{0m}$

$U I_m = P_m$

$\frac{U \pi C I_m^2}{U} = Q = \pi C I_m^2 \Rightarrow I_m = \sqrt{\frac{Q}{\pi C}}$

$U = U_R = I_m R = \sqrt{\frac{Q}{\pi C}} R = U \Rightarrow R = \frac{U \sqrt{\pi C}}{\sqrt{Q}}$

$\frac{\sqrt{3} \sqrt{1{,}4}}{\sqrt{3} \cdot 2 \cdot \sqrt{3} \sqrt{4}}$ $\frac{1}{3}$ Ju t

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

$= 3\cdot(0{,}64\cdot 8 + 10)\,10^{\not 2}\; 10^5\cdot 10^{\frac{3}{2}}$

$10^5\cdot 10^{\frac{3}{2}} = 10^{\frac{13}{2}}$

$0{,}64 \times 8 = 5{,}12 + 10 = 15{,}12\cdot 3\cdot 10^{\not 5}\cdot 10^{\frac{3}{2}}$

$\dfrac{2624\cdot 10^{\not 7 2}}{15{,}12\cdot 3\cdot 10^{\not 5}\cdot 10^{\frac{3}{2}}} = \dfrac{2624\sqrt{10}}{15{,}12\cdot 3} =$

$\dfrac{10^2}{10^{\frac{3}{2}}} = 10^{2-\frac{3}{2}} = 10^{\frac{1}{2}} = \sqrt{10}$

$= \dfrac{2624\sqrt{10}}{1512\cdot 3\cdot 10^{-2}} = \dfrac{656\sqrt{10}}{378\cdot 3\cdot 10^{-2}}$

656 1312 756 378 328 189

500 + 250 + 6

500 + 150 + 6 = = 656

350 + 25 + 3

375

300 + 25 + 3

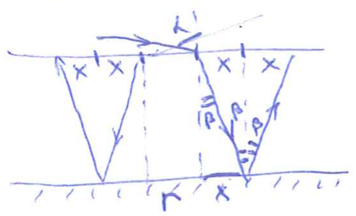
150 + 35 + 24

$189 \times 3 = 567$

$= \dfrac{32800\sqrt{10}}{567}$

---

(4)



$\sin\beta = \dfrac{\sin\alpha}{n}$

~~$\sin\alpha = n\sin\beta$~~

чтобы β – max, надо $\sin\beta \to \max \Rightarrow \sin\alpha \to \max$ ($n = const$)

$\Rightarrow \alpha = \frac{\pi}{2}$ и $\sin\alpha = 1$.

1) $\sin\alpha = n\sin\beta$

Для погр. случ.: $\alpha \to \frac{\pi}{2} \Rightarrow \sin\alpha \to 1$

$1 = \frac{3}{2}\sin\beta \Rightarrow \sin\beta = \frac{2}{3}$.

2) $tg\beta = \dfrac{x}{h} \Rightarrow x = h\,tg\beta$

3) $R = 2x + \dfrac{r}{2} \approx 2x$ ($r \to 0$, т.к отверстие маленькое).

$R = 2h\,tg\beta$

Т.к $\sin\beta = \frac{2}{3} \Rightarrow \cos\beta = \sqrt{1-\frac{4}{9}} = \dfrac{\sqrt{5}}{3}$

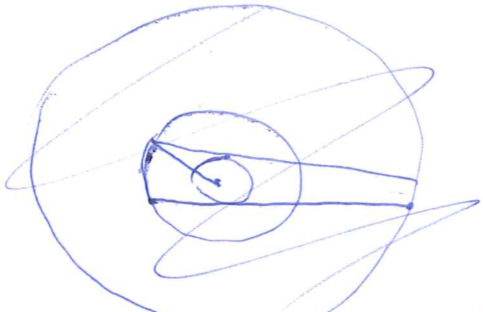
и $tg\beta = \dfrac{\sin\beta}{\cos\beta} = \dfrac{2}{3}\cdot\dfrac{3}{\sqrt{5}} = \dfrac{2}{\sqrt{5}}$

$h = \dfrac{R}{2tg\beta} = \dfrac{R\sqrt{5}}{4} = 2\sqrt{5}$

Отв.

(5) $\dfrac{LI_m^2}{2} = \dfrac{Cu_0^2}{2} \Rightarrow$ ~~$LI_m^2 = Cu_0^2$~~

$\ddot{x} + \omega\dot{x} = 0$



$\sqrt{\frac{L}{C}}\, I_m = u_0$

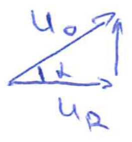
~~$\sqrt{\frac{L}{C}}\,\dot{q} - \frac{q}{C} = 0.$~~

~~$\sqrt{\frac{L}{C}}\,\dot{q} - \frac{1}{C}\dot{q} = 0.$~~

$u = x_C I_m$

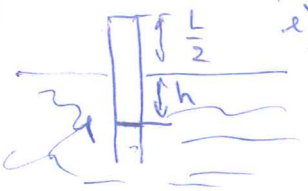
$u = \omega C I_m = \dfrac{2\pi C I_m}{T}$

$S = \sqrt{P_1^2 + P_2^2} =$



~~$\cos\alpha =$~~

(2)



После

1) $pgh + p_0 = p_2$

2) $\begin{cases} p_{b1} l S = \nu R T \\ p_{b2}\left(\frac{L}{2} + h\right) S = \nu R T \end{cases} \Rightarrow$

$\Rightarrow p_{b1} l = p_{b2}\left(\frac{L}{2} + h\right)$.

3) $p_2 = p_{b2} + p_{нас}$

4) $p_0 = p_{нас} + p_{b1} \Rightarrow p_{b1} = p_0 - p_{нас}$

5) $\frac{(p_0 - p_{нас}) l_2}{L + 2h} = p_{b2}$

6) $p_2 = \frac{2Lp_0}{L+2h} - \frac{2lp_{нас}}{L+2h} + p_{нас} = \frac{2Lp_0}{L+2h} + p_{нас}\left(1 - \frac{2l}{L+2h}\right)$

7) $pgh + p_0 = \frac{2Lp_0}{L+2h} + p_{нас}\left(1 - \frac{2l}{L+2h}\right)$

$1 - \frac{2L}{L+2h} = \frac{L+2h-2L}{L+2h} = \frac{2h-l}{2h+l}$

$p_0\left(1 - \frac{2l}{L+2h}\right) = p_{нас}\left(1 - \frac{2L}{L+2h}\right) - pgh$

$p_0\left(\frac{2h-l}{2h+L}\right) = p_{нас}\left(\frac{2h-l}{2h+1}\right) - pgh$

$p_0 = p_{нас} - pgh\left(\frac{2h+l}{2h-l}\right) = 14{,}5 \cdot 10^3 -$

$- 10^4 \cdot 0{,}45 \left(\frac{2 \cdot 0{,}45 + 1}{2 \cdot 0{,}45 - 1}\right) = 14{,}5 \cdot 10^3 - 4{,}5 \cdot 10^3 \cdot$

$\cdot \frac{1{,}9}{(-0{,}1)} = 14{,}5 \cdot 10^3 - 4{,}5 \cdot 10^3 \cdot \left(-\frac{19}{1}\right) =$

$= 10^3 (14{,}5 + 4{,}5 \cdot 19) = 10^2 (145 + 45 \cdot 19) =$

$= 10^2 \cdot 10^3 = 10^5$ Па

$1{,}64 \cdot 2 \cdot 10^5 \sqrt{64 \cdot 10^8} =$

$= 164 \cdot 2 \cdot 10^3 \cdot 8 \cdot 10^4 = 2624 \cdot 10^7$

$3(0{,}64 \cdot 8 \cdot 10^{\frac{3}{2}} + 10^{\frac{5}{2}}) \cdot 10^5 =$

$10^{\frac{3}{2}} \cdot 10^{\frac{2}{2}}$

$\frac{3}{2} + \frac{2}{2} = \frac{5}{2}$

$855 + 145 = 1000$

164 × 16 = 984 + 164 = 2624

855 + 145 = 1000

45 × 19 = 405 + 45

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

$$\frac{1}{R_{общ}} = \frac{1}{R_1} + \frac{R_1}{R_2\sqrt{R_2}} = \frac{1}{\sqrt{R_1}} + \frac{R_1}{R_2\sqrt{R_2}} =$$

$$= \frac{R_2\sqrt{R_2} + R_1\sqrt{R_1}}{R_2\sqrt{R_1R_2}}$$

Тогда $\frac{2(R_1+R_2)}{R_2} = \sqrt{g}\,L\,\frac{R_2\sqrt{R_2} + R_1\sqrt{R_1}}{R_2\sqrt{R_1R_2}} \quad | \cdot R_2$

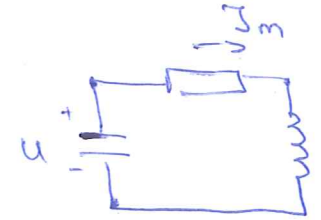
$$2(R_1+R_2) = \sqrt{g}\,L\,\frac{R_1\sqrt{R_1} + R_2\sqrt{R_2}}{\sqrt{R_1R_2}}$$

$$\frac{2(0{,}64+1)10^5\sqrt{6{,}4\cdot10^5}}{3(0{,}64\sqrt{64\cdot10^3} + \sqrt{10^5})10} =$$

$$L = \frac{2(R_1+R_2)\sqrt{R_1R_2}}{\sqrt{g}\,(R_1\sqrt{R_1} + R_2\sqrt{R_2})} \rightarrow =$$

164 × 16 = 984 + 164 = 2624

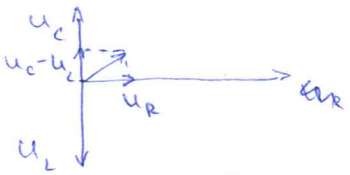
5 $L = 0{,}3$ Гн
$C = 30$ мкФ
$u = 0{,}2$ В
$\vartheta = 0{,}38$ мОм
$R - ?$



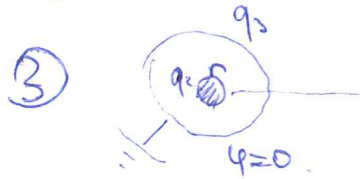
$$W_{сист} = \frac{Cu^2}{2} + \frac{LJ_m^2}{2}$$

$u_c = u$, $q_c = uC$, $u_R = J_mR$

$$u_L = \frac{1}{\omega L} J_m$$



3 Пусть $q_2 = 7{,}5\cdot10^{-10}$; $q_1 = 2{,}5\cdot10^{-10}$ Кл (наоборот)



1) $\begin{cases} \varphi_1 = \varphi_2 + \varphi_{32} \\ \varphi_{23} + \varphi_3 = 0 \end{cases}$

$$\frac{kq_3}{R} + \frac{kq_2}{R} = 0.$$

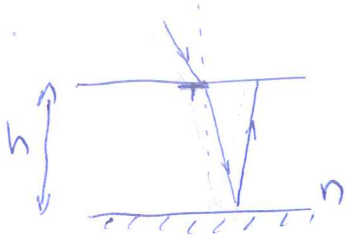
$q_3 = -q_2$

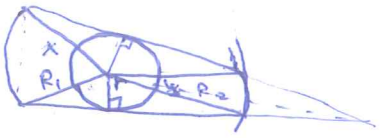
$$\frac{kq_1}{r} = \frac{kq_2}{r} + \frac{kq_3}{R} \Rightarrow \frac{q_1}{r} = \frac{q_2}{r} - \frac{q_2}{R}$$

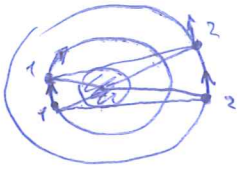
$$\frac{q_2}{r} - \frac{q_1}{r} = \frac{q_2}{R} = \frac{1}{r}(q_2 - q_1) = \frac{q_2}{R} \Rightarrow r = \frac{R(q_2-q_1)}{q_2} =$$

$$= 3\,\frac{5\cdot10^{-10}}{7{,}5\cdot10^{-10}} = \frac{15}{7{,}5} = \frac{150}{75} = 2 \text{ см}$$ Отв

4.







② $GM = gr^2$

① $R_1 = 6{,}4 \cdot 10^4$ км

$R_2 = 10^5$ км

$g = 9$ м/с²

$T - ?$

1) $mg = \frac{GmM}{r^2} \Rightarrow g = \frac{GM}{r^2}$

2) $\frac{mv^2}{R} = \frac{GmM}{(r+R)^2 R^2}$

$v^2 = \frac{GmM}{R} \Rightarrow$

$$\begin{cases} v_1 = \sqrt{\frac{GM}{R_1}} = r\sqrt{\frac{g}{R_1}} \\ v_2 = \sqrt{\frac{GM}{R_2}} = r\sqrt{\frac{g}{R_2}} \end{cases}$$

3) $$\begin{cases} L_1 = v_1 T = R_1 x \\ L_2 = v_2 T = R_2 y \end{cases}$$

4) $x + y = 2\pi - 2\arccos\frac{r}{R_1} - 2\arccos\frac{r}{R_2}$

$x + y = 2\left(\pi - \arccos\frac{r}{R_1} - \arccos\frac{r}{R_2}\right)$

$\arccos\frac{r}{R_1} = \frac{\pi}{2} - \arcsin\frac{r}{R_1}$; $\arccos\frac{r}{R_2} = \frac{\pi}{2} - \arcsin\frac{r}{R_2}$

$x + y = 2\left(\pi - \frac{\pi}{2} + \arcsin\frac{r}{R_1} - \frac{\pi}{2} + \arcsin\frac{r}{R_2}\right) =$

$= 2\left(\arcsin\frac{r}{R_1} + \arcsin\frac{r}{R_2}\right) = 2\left(\frac{r}{R_1} + \frac{r}{R_2}\right) = 2r\left(\frac{1}{R_1} + \frac{1}{R_2}\right) =$

$= 2r\frac{R_1 + R_2}{R_1 R_2} \Rightarrow y = 2r\frac{R_1 + R_2}{R_1 R_2} - x$

5) $\left(2r\frac{R_1 + R_2}{R_1 R_2} - \frac{v_1 T}{R_1}\right) R_2 = v_2 T$

$\left(2r\frac{R_1 + R_2}{R_2} - v_1 T\right)\frac{R_2}{R_1} = v_2 T$

$2r\frac{R_1 + R_2}{R_2} - r\sqrt{\frac{g}{R_1}}\,T = r\sqrt{\frac{g}{R_2}}\,T\frac{R_1}{R_2} \quad | : r$

$2\frac{R_1 + R_2}{R_2} = \sqrt{\frac{g}{R_1}}\,T + \sqrt{\frac{g}{R_2}}\,T\frac{R_1}{R_2}$

$2\frac{R_1 + R_2}{R_2} = \sqrt{g}\,T\left(\frac{1}{\sqrt{R_1}} + \frac{1}{\sqrt{R_2}}\frac{R_1}{R_2}\right)$