Часть 1

Олимпиада: **Физика, 11 класс (1 часть)**

Шифр: **21202701**

ID профиля: **343921**

Вариант 1

Чистовик

2. Дано:

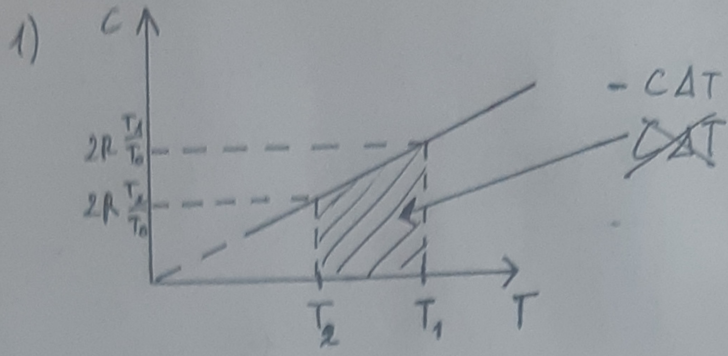
ν, T_0

$C(T) = 2R\dfrac{T}{T_0}$

1) $Q_1 = ?$
2) $T_2 = ?$
3) $A_{min} = ?$

Решение:

1)



$$-C\Delta T = \frac{C_1 + C_2}{2}(T_1 - T_2) = \frac{\frac{2R}{T_0}(T_1 + T_2)}{2}(T_1 - T_2) = \frac{R(T_1^2 - T_2^2)}{T_0}$$

$$Q_1 = -C\Delta T\,\nu = \frac{\nu R(T_1^2 - T_2^2)}{T_0}; \quad T_1 = T_0; \quad T_2 = \frac{5}{6}T_0 \Rightarrow$$

$$\Rightarrow Q_1 = \frac{\nu R\left(T_0^2 - \frac{25T_0^2}{36}\right)}{T_0} = \frac{11\nu R T_0}{36}$$

2) $$Q_1 = \Delta U + A_2 \Rightarrow A_2 = Q_1 - \Delta U = \nu C\Delta T - \frac{3}{2}\nu R\Delta T = \frac{3}{2}\nu R(-\Delta T) - \nu C(-\Delta T) =$$

$$= \frac{3\nu R(T_1 - T_2)}{2} - \frac{\nu R(T_1^2 - T_2^2)}{T_0} = \nu R(T_1 - T_2)\left(\frac{3}{2} - \frac{T_1 + T_2}{T_0}\right) = \nu R(T_1 - T_2)\left(\frac{3T_0 - 2T_1 - 2T_2}{2T_0}\right)$$

$$T_1 = T_0 \Rightarrow A_2 = \nu R(T_0 - T_2)\left(\frac{3T_0 - 2T_0 - 2T_2}{2T_0}\right) = \frac{\nu R(T_0 - T_2)(T_0 - 2T_2)}{2T_0} =$$

$$= \frac{\nu R(T_0^2 - 2T_2T_0 - T_2T_0 + 2T_2^2)}{2T_0} = \frac{\nu R}{2T_0}\underbrace{(2T_2^2 - 3T_0T_2 + T_0^2)}_{y}; \quad y'(T_2) = 4T_2 - 3T_0 = 0$$

$$T_2 = \frac{3T_0}{4}$$

y': $-$, $\frac{3T_0}{4}$, $+$; T_2

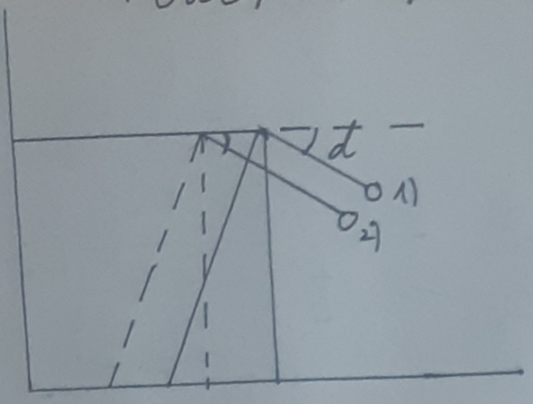
y: $\searrow$ $\nearrow$

3) $$A_2\left(\frac{3T_0}{4}\right) = \frac{\nu R}{2T_0}\left(\frac{2 \cdot 9T_0^2}{16} - \frac{9T_0^2}{4} + T_0^2\right) = \frac{\nu R}{2T_0}\left(\frac{9T_0^2}{8} - \frac{9T_0^2}{4} + T_0^2\right) = \frac{\nu R}{2T_0}\cdot\left(\frac{9T_0^2}{8} - \frac{5T_0^2}{4}\right) =$$

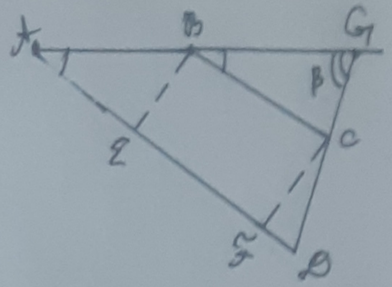
$$= -\frac{\nu R T_0^2}{8 \cdot 2T_0} = -\frac{\nu R T_0}{16}$$

Ответ: $Q_1 = \dfrac{11\nu R T_0}{36}$; $T_2 = \dfrac{3T_0}{4}$; $A_{min} = -\dfrac{\nu R T_0}{16}$

1. Чистовик



1) При переходе из точки 1 в точку 2:



$AD = AB + BC$ (т.к. нить нерастяжима)

ускорение шара направлено туда же куда и $\vec{CD}$

Пусть $AB = x$; $BC = y$; тогда: $AD = x + y$

$AE = AB\cos\alpha = x \cdot \frac{3}{5} = \frac{3x}{5}$; $EF = BC = y \Rightarrow FD = AD - AE - EF = x + y - \frac{3x}{5} - y =$
$= \frac{2x}{5}$; $CF = BE = AB\sin\alpha = x \cdot \frac{4}{5} = \frac{4x}{5} \Rightarrow \operatorname{tg}\angle CDF = \frac{CF}{FD} = 2$

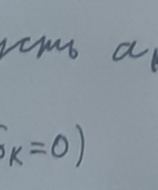
$\angle AGB = \beta$ − искомый $\Rightarrow \angle\beta = 180^\circ - \angle GAD - \angle ADG =$
$= 180^\circ - \arccos\frac{3}{5} - \operatorname{arctg} 2 \approx 63{,}5^\circ$

2) $CD = \sqrt{FC^2 + FD^2} = \sqrt{\frac{16x^2}{25} + \frac{4x^2}{25}} = x\sqrt{\frac{20}{25}} = x\sqrt{\frac{4}{5}} = \frac{2x}{\sqrt{5}}$

За одно и тоже время клин и шар проходят расстояния AB и CD соответственно, пусть $a_к$ − ускорение клина; $a_ш$ − ускорение шара $\Rightarrow$

$$\begin{cases} x = \frac{a_к t^2}{2} \ (V_{0к} = 0) \\ \frac{2x}{\sqrt{5}} = \frac{a_ш t^2}{2} \ (V_{0ш} = 0) \end{cases} \Rightarrow \frac{a_к}{a_ш} = \frac{\sqrt{5}}{2}$$

На шар действуют сила тяжести и сила натяжения нити $\Rightarrow \vec{T} + m\vec{g} = m\vec{a_ш}$



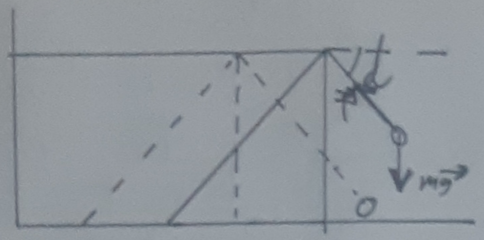
$\angle 1 = 90^\circ - \arccos\alpha =$
$= 90^\circ - 53{,}1^\circ = 36{,}9^\circ$

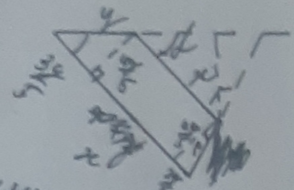
$ma_ш = mg\sin\angle 1$

$a_ш = g\sin\angle 1 \approx 6 \ (м/с^2) \Rightarrow$

$\Rightarrow a_к = \frac{\sqrt{5}}{2} \cdot 6 = 6{,}7 \ (м/с^2)$

Черновик





$tg\,\beta = \frac{1}{2}$

$x + y - x - \frac{3y}{5} = \frac{2y}{5}$

$\cos = \frac{3}{5} \Rightarrow \sin = \sqrt{1 - \cos^2} = \sqrt{1 - \frac{9}{25}} = \frac{4}{5}$

$\gamma = 180° - 90° - \alpha\, tg\,\beta = 90° - \alpha\, tg\,\beta$

$\frac{16y^2}{25} + \frac{4y^2}{25} = \frac{20y^2}{25} = \frac{4y^2}{5}$

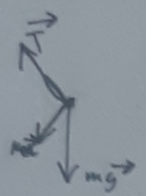
$\frac{2y}{\sqrt{5}} = \frac{2\sqrt{5}y}{5}$

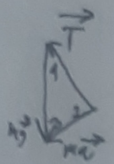
$S_1 = \frac{a_1 t^2}{2}$ $\quad y = \frac{a_2 t^2}{2}$

$\frac{2\sqrt{5}y}{5} = \frac{a_2 t^2}{2}$ $\quad \frac{U}{V} = \frac{a_1}{a_2} = \frac{5}{2\sqrt{5}} = \frac{\sqrt{5}}{2}$

$U = \frac{\sqrt{5}V}{2}$

$mgH = \frac{mV_0^2}{2} + \frac{MU^2}{2}$





$\angle 2 = 90° + \beta = 90° + 63{,}4°$

$\angle 1 = 90° - \alpha = 90° - 53{,}1° = 36{,}9°$

$\angle 3 = \alpha - \beta = 63{,}4° - 53{,}1° = 10{,}3°$

$g \cos\angle 3 = a = 9{,}8$ (м/с²)

$a_1 = 10{,}9$

$T = mg \sin\angle 3 = 0{,}17\, mg$

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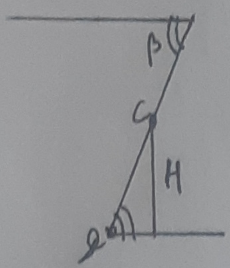
Чистовик

На клин действует $T \Rightarrow \bar{T} = M a_к$ (M – масса клина)

$T = mg\cos\angle 1 = mg \cdot 0{,}\overset{8}{\cancel{79}} = Mg \Rightarrow \frac{m}{M} = \frac{10}{8} = \frac{5}{4} = 1{,}25$



$\Rightarrow \ell \sin\beta = H \Rightarrow \cancel{\frac{2x}{\sqrt{5}}} \cdot \ell = \frac{H}{\sin\beta} = 1{,}12H$

$\ell = \frac{a_m t^2}{2} \Rightarrow t = \sqrt{\frac{2\ell}{a_m}} = \sqrt{\frac{2{,}24H}{6}} = 0{,}6\sqrt{H}$ (с)

Ответ: $\beta = 180° - \arccos\frac{3}{5} - \operatorname{arctg} 2 \approx 63{,}5°$; $a_к = 6{,}7$ м/с^2; $\frac{m}{M} = 1{,}25$; $t = 0{,}6\sqrt{H}$ с

Чистовик

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Черновик

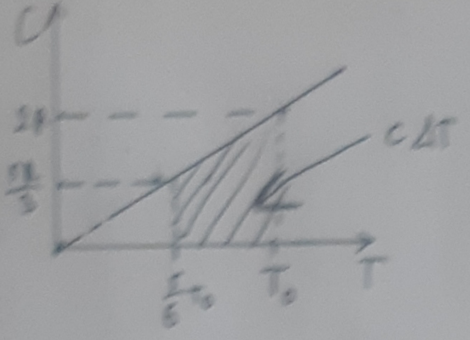
2. Дано:

ν, T_0

$C(T) = 2R\frac{T}{T_0}$

1) $\frac{5}{6}T_0$, $Q_1 - ?$

Решение:



$Q = C\nu\Delta T$

$Q = \Delta U + A_г = \frac{3}{2}\nu R\Delta T + p\Delta V =$

$= \frac{5}{2}p\Delta V = \frac{5}{2}\nu R\Delta T$

$$C\Delta T = \frac{\left(\frac{5R}{3} + 2R\right)}{2}\cdot\left(T_0 - \frac{5}{6}T_0\right) = \frac{11R}{6}\cdot\frac{T_0}{6} = \frac{11RT_0}{36}$$

$$Q = \nu C\Delta T = \frac{11\nu RT_0}{36}$$

$$C\Delta T\,\nu = \Delta U + A_г = \cancel{\tfrac{3}{2}\nu R\Delta T} + \cancel{\nu R\Delta T}$$

$$A_г = C\Delta T\,\nu - \Delta U$$

$$C\Delta T = \frac{C_1 + C_2}{2}(T_1 - T_2) = \frac{R}{T_0}(T_1 + T_2)(T_1 - T_2) = \frac{R(T_1^2 - T_2^2)}{T_0}$$

$$Q = \nu C\Delta T = \frac{\nu R(T_1^2 - T_2^2)}{T_0} = \Delta U + A_г = \frac{3}{2}\nu R(T_1 - T_2) + A_г$$

$$A_г = \nu R(T_1 - T_2)\left(\frac{T_1 + T_2}{T_0} - \frac{3}{2}\right) = \nu R(T_1 - T_2)\left(\frac{2T_1 + 2T_2 - 3T_0}{2T_0}\right) =$$

$$= \nu R(T_0 - T_2)\left(\frac{2T_0 + 2T_2 - 3T_0}{2T_0}\right) = \nu R(T_0 - T_2)\cdot\frac{2T_2 - T_0}{2T_0} = \frac{\nu R}{2T_0}\cdot$$

$$\cdot(T_0 - T_2)(2T_2 - T_0) = \frac{\nu R}{2T_0}(2T_2T_0 - T_0^2 - 2T_2^2 + T_0T_2) = \frac{\nu R}{2T_0}(-2T_2^2 + 3T_0T_2 - T_0^2)$$

$$= -\frac{\nu R}{2T_0}\underbrace{(2T_2^2 - 3T_0T_2 + T_0^2)}_{y}\;;\quad y'(T_2) = 4T_2 - 3T_0 = 0 \Rightarrow T_2 = \frac{3}{4}T_0$$

$-$ $+$

$\searrow$ $\frac{3}{4}T_0$ $\nearrow$ T_2

$$A_г = -\frac{\nu R}{2T_0}\left(2\cdot\frac{9}{16}T_0^2 - \frac{9}{4}T_0^2 + T_0^2\right) = -\frac{\nu R}{2T_0}\left(\frac{9}{8}T_0^2 - \frac{5}{4}T_0^2\right) = -\frac{\nu R}{2T_0}\cdot\left(-\frac{T_0^2}{8}\right) =$$

$$= \frac{\nu RT_0}{16}$$

$$\left(\frac{2T_0}{16} - \frac{3T_0}{4} + T_0^2 =\right.$$

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Часть 2

Олимпиада: **Физика, 11 класс (2 часть)**

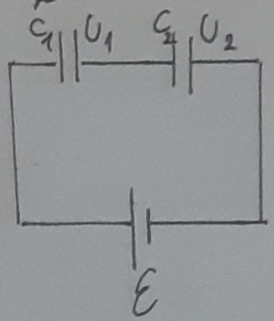
Шифр: **21202701**

ID профиля: **343921**

Вариант 1

Чистовик

3. 1)

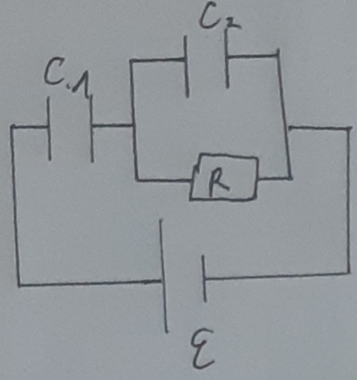


$q = const \Rightarrow C_1U_1 = C_2U_2 = C_0\mathcal{E}$

$2CU_1 = CU_2 = \frac{2C}{3}\mathcal{E}$

$U_2 = \frac{2\mathcal{E}}{3}$; $U_1 = \frac{\mathcal{E}}{3}$

2)



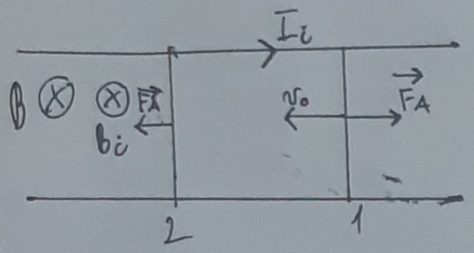
U_R сразу после замык. ключа $= U_2 = \frac{2\mathcal{E}}{3} \Rightarrow$

$\Rightarrow I_R = \frac{U_R}{R} = \frac{2\mathcal{E}}{3R}$

3) $Q = W_1 + W_2 = \frac{C_1U_1^2}{2} + \frac{C_2U_2^2}{2} = \frac{2C\cdot\mathcal{E}^2}{2\cdot 9} + \frac{C\cdot 4\mathcal{E}^2}{2\cdot 9} = \frac{C\mathcal{E}^2}{9} + \frac{2C\mathcal{E}^2}{9} = \frac{C\mathcal{E}^2}{3}$

Ответ: $I_R = 2\mathcal{E}/3$; $Q = C\mathcal{E}^2/3$

4.



1) По правилу Ленца определяем направление I_i ($\Delta\Phi$ в начале <0)

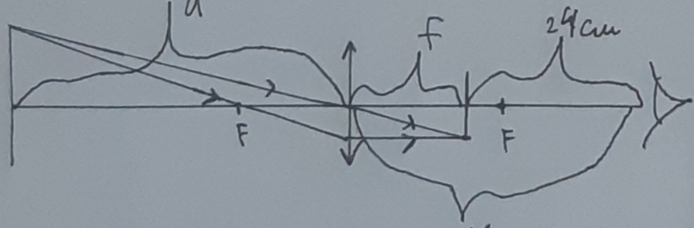
2) Определяем направления F_A

3) $a_0 = \frac{F_A}{2m} = \frac{BI_iL}{2m} = \frac{\cancel{2}B\mathcal{E}L}{2m\cdot 3R} = \frac{BL|\Delta\Phi|}{\cancel{2}6mR\Delta t} =$

$= \frac{B^2L|\Delta S|}{6mR\Delta t} = \frac{B^2L^2|\Delta l|}{6mR\Delta t} = \frac{B^2L^2v_0}{6mR}$

4) Через продолжительное время скорости перемычек будут равны (т.к. ускорение 2-ой меньше ускорения 1-ой)

5. 1)



$\frac{1}{F} = \frac{1}{d} + \frac{1}{f} \Rightarrow \frac{1}{f} = \frac{1}{9} - \frac{1}{36} = \frac{3}{36}$

$F = 12$ (см)

$x = f + 24 = 36$ (см)

2) Dл – любое, т.к. лучи падают во все стороны

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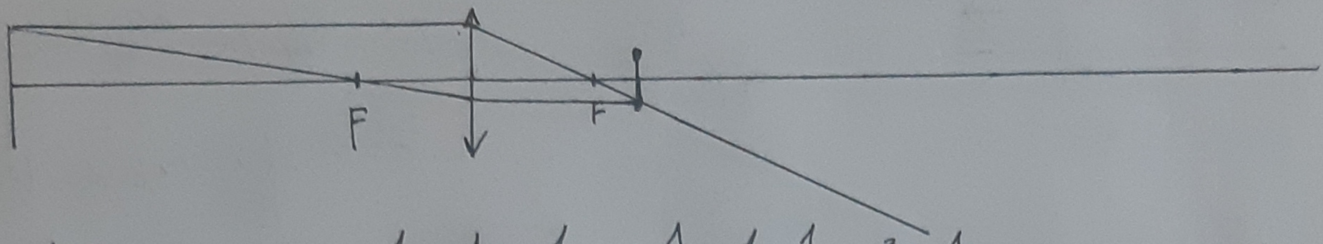
Ответ: $x = 36$ см; Dл – любое

Черновик



$d = 36 \quad F = 9 \Rightarrow \frac{1}{36} + \frac{1}{f} = \frac{1}{9} \Rightarrow \frac{1}{f} = \frac{1}{9} - \frac{1}{36} = \frac{3}{36} = \frac{1}{12} \Rightarrow f = 12 \text{ (см)}$

$x = 36$ см

$a_2 = \frac{BIL}{2m}$

$a_1 = \frac{BIL}{m}$ $\Rightarrow \frac{a_2}{a_1} = \frac{1}{2} \Rightarrow a_1 = 2a_2$

$\cancel{a_2 = a}$

$\cancel{a_1 = 2a}$

$v_1 = v_0 - 2a_1 t$

$v_2 = a_1 t$

$v_{отн_1} = |v_1 - v_2| = |v_0 - 2a_1 t - a_1 t| = |v_0 - 3a_1 t|$

$v_{отн_2} = |v_0 - 2a_1 t - 2a_2 t - a_1 t - a_2 t| = |v_0 - 3a_1 t - 3a_2 t| =$

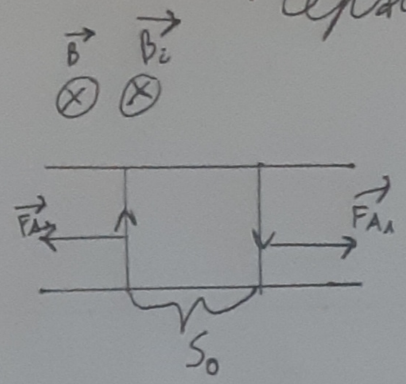
$= |v_0 - 3t(a_1 + a_2)|$

$v_{отн} = |v_0 - 3t\Sigma a| = 0 \Rightarrow v_0 = 3t\Sigma a$

$\Sigma a = \frac{v_0}{3t}$

$\frac{BL\Sigma I}{2m} = \frac{v_0}{3t}$

4. Черновик



$F_A = BIL$

$a_1 \quad \frac{BIL}{2m}$

$a_2 \quad \frac{BIL}{m}$

$I = \frac{\mathcal{E}_i}{3R} = \frac{B\Delta S}{3R\Delta t} = \frac{BL\Delta S}{3R\Delta t}$

$\Delta S = v_{отн}\Delta t = (v_2 - v_1)\Delta t =$

$= (a_2 - a_1)\Delta t \Delta t = (a_2 - a_1)\Delta t^2$

$a_2 - a_1 = \frac{BIL}{2m}$ $\qquad \Delta S = \frac{BIL\Delta t^2}{2m}$

$I = \frac{B^2L^2 I \Delta t^2}{2m} \Rightarrow B^2L^2\Delta t^2 = 2m \Rightarrow \Delta t = \frac{\sqrt{2m}}{BL}$

$F_A = \cancel{BIL = \frac{B^3L^3I\Delta t^2}{2m} \Rightarrow BL = \frac{B^2L^3\Delta t^2}{2m}}$

$I_0 = \frac{BLv_0}{3R}$ $\qquad F_{A_0} = \frac{B^2L^2v_0}{3R}$ $\qquad a_{20} = \frac{F_{A_0}}{2m} = \frac{B^2L^2v_0}{6mR}$

$a_{10} = \frac{F_{A_0}}{m} = \frac{B^2L^2v_0}{3mR}$

1) $v_{21} = v_0 - a_{10}\Delta t = v_0 - \frac{B^2L^2v_0}{3mR}\Delta t$

$v_{22} = 0 + a_{20}\Delta t = \frac{B^2L^2v_0}{6mR}\Delta t$

$v_{отн} = |v_{21} - v_{22}| = \left|v_0 - \frac{B^2L^2v_0\Delta t}{2mR}\right| =$

$= v_0\left|1 - \frac{B^2L^2\Delta t}{2mR}\right|$

2) $I = \frac{BLv_{отн}}{3R} \Rightarrow F_{A_2} = \frac{B^2L^2v_{отн}}{3R}$

$a_{21} = \frac{F_A}{2m} = \frac{B^2L^2v_{отн}}{6mR}$

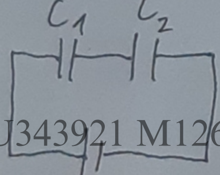
$a_{11} = \frac{B^2L^2v_{отн}}{3mR}$

$v_{31} = v_0 - \frac{B^2L^2v_0}{3mR}\Delta t - \frac{B^2L^2v_{отн}}{3mR}\Delta t =$

$= v_0 - \frac{B^2L^2\Delta t}{3mR}(v_0 - v_{отн}) = v_0 - \frac{B^2L^2\Delta t}{3mR}\cdot$

$\cdot\left(v_0 - v_0\left|1 - \frac{B^2L^2\Delta t}{2mR}\right|\right) = v_0 - \frac{B^2L^2\Delta t}{3mR} v_0 \cdot \frac{B^2L^2\Delta t}{2mR}$

3. 1)



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$q = const \Rightarrow \cancel{q_{C_1} = q_{C_2}}$ $C_1U_1 = C_2U_2 = C_0\mathcal{E}$

$CU_1 = 2CU_2 = \frac{2C}{3}\mathcal{E}$

$U_1 = \frac{2}{3}\mathcal{E}$

$U_2 = \frac{\mathcal{E}}{3}$

$q_0 = \frac{2C\mathcal{E}}{3}$ $\qquad I = \frac{\mathcal{E}}{3R}$

$W_1 + W_2 = \frac{2C\mathcal{E}^2}{9} + \frac{2C\mathcal{E}^2}{9} = \frac{C\mathcal{E}^2}{3}$