Часть 1

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

Шифр: **21201135**

ID профиля: **195727**

Вариант 1

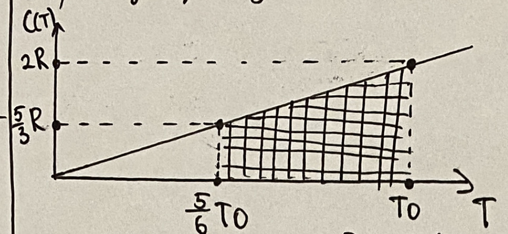
Чиликова [redacted]

№2

Дано:
T_0, ν,
$C(T) = 2R\frac{T}{T_0}$

1) Q_1 — ?
2) T' — ?
3) A_{min} — ?

1) Изобразим график $C(T) = 2R\frac{T}{T_0}$ — (прямая)



$C(T_0) = 2R$

$C(\frac{5}{6}T_0) = \frac{5}{3}R$

$Q_1 = C\nu\Delta T = \nu S_{\text{под граф.}}$

$S_{\text{под граф.}} = \frac{2R + \frac{5}{3}R}{2}\cdot\frac{1}{6}T_0 = \frac{1}{6}T_0(R + \frac{5}{6}R) = \frac{11}{36}RT_0$

$Q_1 = \nu\frac{11}{36}RT_0 = \frac{11}{36}\nu RT_0$

2) $A + \Delta U = Q \qquad Q = \int\limits_{T_0}^{T}\nu C\Delta T \qquad \Delta U = \frac{3}{2}\nu R(T - T_0)$

$A(T) = \nu\int\limits_{T_0}^{T}\frac{2R}{T_0}T\Delta T - \frac{3}{2}\nu R(T - T_0) = \frac{2\nu R}{T_0}\left(\frac{T^2}{2} - \frac{T_0^2}{2}\right) - \frac{3}{2}\nu R(T - T_0)$

$A(T) = \frac{\nu RT^2}{T_0} - \nu RT_0 - \frac{3}{2}\nu RT + \frac{3}{2}\nu RT_0 = \frac{\nu RT^2}{T_0} - \frac{3}{2}\nu RT + \frac{1}{2}\nu RT_0$

$A'(T) = \frac{2\nu RT}{T_0} - \frac{3}{2}\nu R$ Найдем точку экстремума:

$A'(T) = 0 \qquad \frac{2\nu RT}{T_0} = \frac{3}{2}\nu R \qquad T = \frac{3}{4}T_0$

$A'(T)$: — , + ; $A(T)$: ↘ $\frac{3}{4}T_0$ ↗ T

$T = \frac{3}{4}T_0$ — т. лок. мин. $\Rightarrow T' = \frac{3}{4}T_0 \qquad A(\frac{3}{4}T_0)$ — $\min A(T)$

Газ нужно охладить до температуры $T' = \frac{3}{4}T_0$, чтобы газ совершил минимальную работу.

3) $A_{min} = A(\frac{3}{4}T_0) = \frac{\nu R\frac{9}{16}T_0^2}{T_0} - \frac{3}{2}\nu R\frac{3}{4}T_0 + \frac{1}{2}\nu RT_0 = \cancel{\frac{35}{16}\nu RT_0}$

$A(T) = \frac{\nu RT^2}{T_0} - \frac{3}{2}\nu RT + \frac{1}{2}\nu RT_0$

$A_{min} = \nu RT_0\left(\frac{9}{16} + \frac{8}{16} - \frac{18}{16}\right) = -\frac{1}{16}\nu RT_0$

Ответ: 1) $\frac{11}{36}\nu RT_0$; 2) $\frac{3}{4}T_0$; 3) $\cancel{\frac{35}{16}\nu RT_0}$ $-\frac{1}{16}\nu RT_0$

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21201135 (U195727 M1266103)

Чистовик

№1

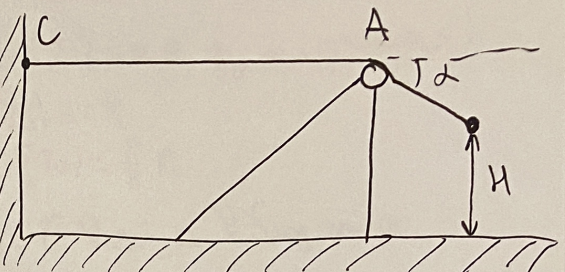
Дано:

α, $\cos\alpha = 0{,}6$.

H [illegible]

1) β – ?; 2) $a_{ш}$ – ?;

3) $\frac{m_{ш}}{m_{к}}$ – ?; 4) τ – ?



1) $\sin^2\alpha + \cos^2\alpha = 1$

$\Downarrow$ $\sin\alpha = 0{,}8$

Ускорение шара центростремительное, значит оно направлено к точке A, значит $\beta = \alpha \Leftrightarrow \cos\beta = \cos\alpha = 0{,}6$

Ответ: 1) ~~cos β~~ 0,6

$\cos\alpha = 0{,}6 \Rightarrow \sin\alpha = 0{,}8$

$mg\Delta H + \frac{mv^2}{2}$

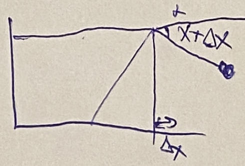
$\beta - ?$

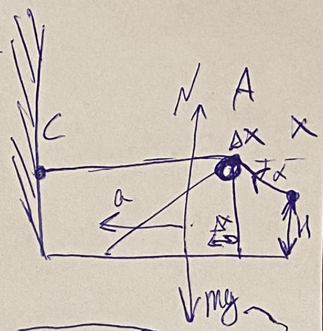
$a_{кл} - ?$

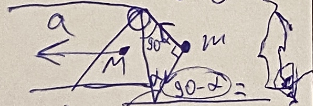
$\frac{m}{M} - ?$

$\tau - ?$

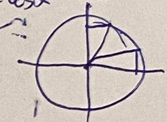
Неинерц. сист. отсч.







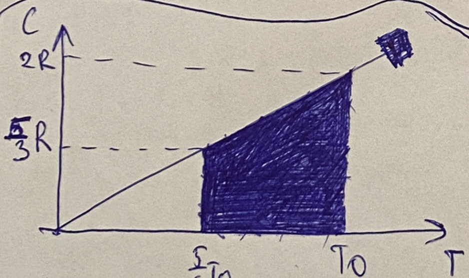
$\sin\beta = \sin(90-\alpha) = \cos\alpha = 0{,}6$



$C_{ср} = \frac{\frac{5}{3}R + 2R}{2} = R + \frac{5}{6}R = 1\frac{5}{6}R$

$9 + 18 + 8 = 35$

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



$Q = \nu C\Delta T = \frac{11}{6}R\cdot\nu\cdot\frac{1}{6}T_0 = \boxed{\frac{11}{36}R\nu T_0}$

2) $A + \Delta U = Q$

$Q = \int_{T_0}^{T} \nu c\, dT$

$\Delta U = \frac{3}{2}\nu R(T - T_0)$

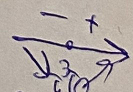
$A(T) = \nu\int_{T_0}^{T}\frac{2R}{T_0}T\,dT - \frac{3}{2}\nu R(T-T_0) = \frac{2\nu R}{T_0}\left(\frac{T^2}{2} - \frac{T_0^2}{2}\right) - \frac{3}{2}\nu R(T-T_0)$

$A(T) = \frac{\nu RT^2}{T_0} - \nu RT_0 - \frac{3}{2}\nu RT + \frac{3}{2}\nu RT_0 = \frac{\nu RT^2}{T_0} - \frac{3}{2}\nu RT + \frac{1}{2}\nu RT_0$

$A'_T = \frac{2\nu RT}{T_0} - \frac{3}{2}\nu R$

Экстр.

$\frac{2\nu RT'}{T_0} - \frac{3}{2}\nu R = 0 \quad T' = \frac{3}{4}T_0$



$A\left(\frac{3}{4}T_0\right) - \min A(T) \Rightarrow$ охлад до $T' = \frac{3}{4}T_0$

3) $A\left(\frac{3}{4}T_0\right) = \frac{\nu R\frac{9}{16}T_0^2}{T_0} - \frac{3}{2}\nu R\frac{3}{4}T_0 + \frac{1}{2}\nu RT_0 = \nu RT_0\left(\frac{9}{16} - \frac{18}{16} + \frac{8}{16}\right) =$

$= \boxed{\frac{35}{16}\nu RT_0}$

Часть 2

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

Шифр: **21201135**

ID профиля: **195727**

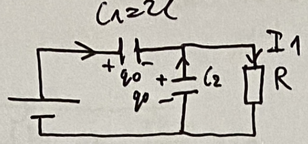
Вариант 1

Чистовик №3

Дано: $C_2=C$, $C_1=2C$

$I_1=?$ $Q=?$ $I_2=?$

1) начало



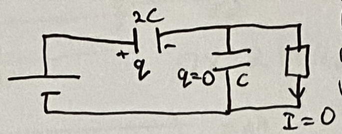
$$\frac{q_0}{2C}+\frac{q_0}{C}=\mathcal{E}$$

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

$$U_R=U_{C_2} \Rightarrow I_1R=\frac{q_0}{C}$$

$$\Downarrow \quad I_1=\frac{2\mathcal{E}C}{3CR}=\frac{2\mathcal{E}}{3R}$$

2) конец



$$\frac{q}{2C}=\mathcal{E} \qquad q=2\mathcal{E}C$$

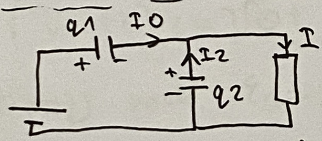
Через э.д.с. прошло $\Delta q=q-q_0=2\mathcal{E}C-\frac{2\mathcal{E}C}{3}=\frac{4\mathcal{E}C}{3}$

З.С.Э.: $\frac{q^2}{2(2C)}-\frac{q_0^2}{2(2C)}-\frac{q_0^2}{2C}+Q=A_\mathcal{E}$ $\qquad A_\mathcal{E}=\mathcal{E}(q-q_0)$

$$\frac{4\mathcal{E}^2C^2}{4C}-\frac{4\mathcal{E}^2C^2}{9\cdot 4C}-\frac{4\mathcal{E}^2C^2}{9\cdot 2C}+Q=\frac{4\mathcal{E}^2C}{3} \qquad Q=\frac{4\mathcal{E}^2C}{3}+\frac{3\mathcal{E}^2C}{9}-\mathcal{E}^2C$$

$$Q=\frac{2\mathcal{E}^2C}{3}$$

3)



$$\frac{q_1}{2C}+\frac{q_2}{C}=\mathcal{E}$$

$$\frac{q_1}{2}+q_2=const \qquad \underbrace{\frac{q_1'}{2}+q_2'=0 \quad q_2'=-I_2 \quad q_1'=I_0}$$

$$\Downarrow \quad I_2=\frac{I_0}{2} \Rightarrow I=1{,}5I_0$$

Ответ: 1) $\frac{2\mathcal{E}}{3R}$; 2) $\frac{2\mathcal{E}^2C}{3}$; 3) $\frac{3}{2}I_0$

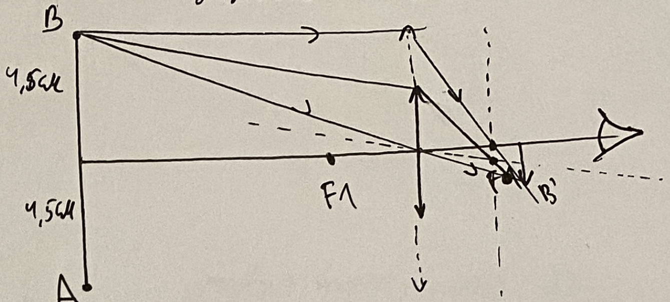
Чистовик

№5

Дано: $F_1 = 9$ см, $H = 9$ см, $d_1 = 36$ см, $y = 24$ см.

1) x − ? ; 2) $D_м$ − ?; 3) x' − ?

Изобр. AB в линзе: Д; 9↓; ум.



Решение:

1) $x = f_1 + y$ $\frac{1}{F_1} = \frac{1}{d_1} + \frac{1}{f_1}$ $f_1 = \frac{d_1 F_1}{d_1 - F_1}$ $f_1 = 12$ см

$x = \frac{d_1 F_1}{d_1 - F_1} + y$ $x = \left(\frac{36 \cdot 9}{36 - 9} + 24\right)$ см $= 36$ см

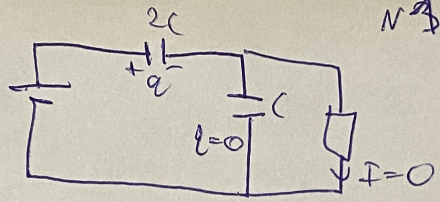
2) Если диаметр линзы будет меньше диаметра картины, то лучи не сойдутся на расстоянии 24см от глаза, значит $D_м = H = 9$ см

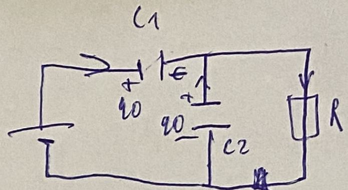
Ответ: 1) 36см; 2) 9 см

3

№ 1

2) конец:





$\frac{q}{2C} = \mathcal{E}$ $\quad q = 2\mathcal{E}C$

$\frac{q_0}{2C} + \frac{q_0}{C} = \mathcal{E}$

через $\mathcal{E}$ прошло $q - q_0 = 2\mathcal{E}C - \frac{2\mathcal{E}C}{3} = \frac{4\mathcal{E}C}{3}$

З.С.Э: $\frac{q^2}{2(2C)} - \frac{q_0^2}{2(2C)} - \frac{q_0^2}{2C} + Q = A_{\mathcal{E}} = \mathcal{E}(q - q_0)$

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

$\frac{4\mathcal{E}^2C^2}{4C} - \frac{4\mathcal{E}^2C^2}{9\cdot 4C} - \frac{4\mathcal{E}^2C^2}{9\cdot 2C} + Q = \frac{4\mathcal{E}^2C}{3}$

$IR = \frac{q_0}{C}$

$I = \frac{2\mathcal{E}C}{3CR} = \boxed{\frac{2\mathcal{E}}{3R}}$

$Q = \frac{4\mathcal{E}^2C}{3} - \frac{4\mathcal{E}^2C}{4} + \frac{\mathcal{E}^2C}{9} + \frac{2\mathcal{E}^2C}{9}$

$Q = \frac{4\mathcal{E}^2C}{3} + \frac{3\mathcal{E}^2C}{9} - \mathcal{E}^2C = \boxed{\frac{2\mathcal{E}^2C}{3}}$

$|F_{A1}| = |F_{A2}| = \frac{(v_1 - v_2)B^2l^2}{3R}$

$$\left.\begin{aligned} a_1 &= \frac{(v_1-v_2)B^2l^2}{3Rm} = \\ a_2 &= \frac{(v_1-v_2)B^2l^2}{3R\,2m} \end{aligned}\right\} \Rightarrow \frac{a_1}{2} = a_2$$

$$\left.\begin{aligned} v_1 &= v_0 - \int a_1\,dt \\ v_2 &= 0 + \int a_2\,dt \end{aligned}\right| \times 2$$

$2v_2 = \int 2a_2\,dt$

$v_1 + 2v_2 = v_0 + \int \underbrace{(2a_2 - a_1)}_{=0} dt = v_0 = const$

$v_1 + 2v_2 = v_0$

при $t \to \infty$ $v_1 = v_2 = v$ т.к. $\overset{I=0}{(\mathcal{E}_1 = \mathcal{E}_2)}$

$v + 2v = v_0$ $\quad v = \frac{v_0}{3}$ $\quad v_1 = v_2 = \frac{v_0}{3}$

3) $a_1dt = -dv_1$

$a_2dt = dv_2$

$dv_1 - dv_2 = \frac{(v_1-v_2)B^2l^2}{Rm}\left(-\frac{1}{3} - \frac{1}{6}\right)dt$

$(v_1 - v_2)dt = -dS(t)$

S(t) – расст. мет. перем.

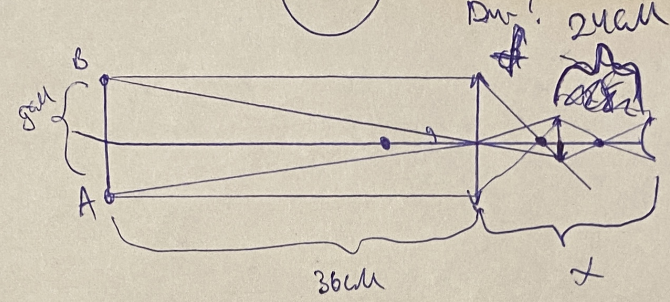
$\int_{v_0}^{v} dv_1 - \int_0^{v} dv_2 = \frac{B^2l^2}{2Rm}\int_{S_0}^{S} dS$

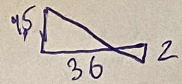
$v - v_0 - v + 0 = \frac{B^2l^2}{2Rm}(S - S_0)$

$S = S_0 - \frac{2Rm}{B^2l^2}v_0$

№ 5

9



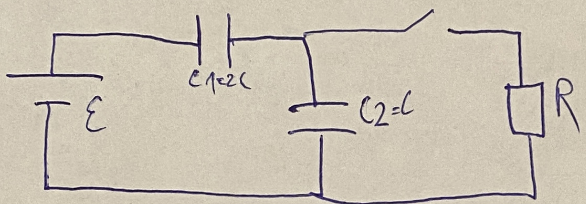


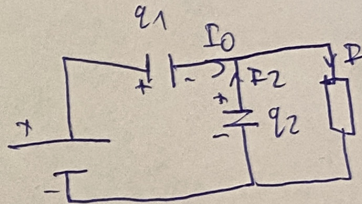
$\frac{36\cdot \cancel{9}}{\cancel{9}\cdot 3}$

$\frac{f}{d}=\frac{2}{4,5}=\frac{F}{d-F}$

$\frac{1}{f}=\frac{1}{F}-\frac{1}{d}$

$f=\frac{Fd}{d-F}$





$\frac{q_1}{2}+q_2=const$

$\frac{\dot q_1}{2}+\dot q_2=0 \quad \dot q_2=-I_2$

$I_2=\frac{I_0}{2} \quad \dot q_1=I_0$

$\frac{q_1}{2C}+\frac{q_2}{C}=\varepsilon$

$I=\frac{3I_0}{2}$

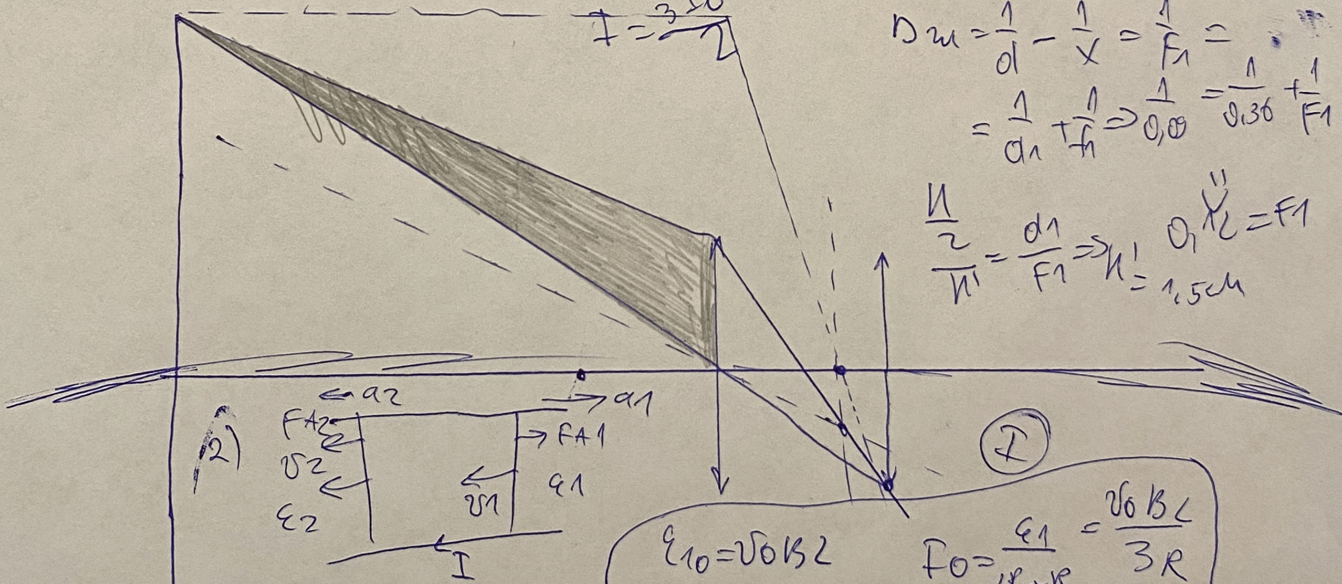
$D_л=\frac{1}{d}-\frac{1}{x}=\frac{1}{F_1}=$

$=\frac{1}{d_1}+\frac{1}{f_1}\Rightarrow\frac{1}{0,0}=\frac{1}{0,36}+\frac{1}{F_1}$

$\frac{h/2}{h'}=\frac{d_1}{F_1}\Rightarrow h'=1,5см$

$O_1 X_2''=F_1$

2)



при $t\to\infty$

$v_1=v_2=v$ т.к. $F=0$

$\varepsilon_1=\varepsilon_2\Rightarrow v_1 v_2$

$I=\frac{\varepsilon_1-\varepsilon_2}{3R}$ $\quad \varepsilon_1=v_1BL \quad \varepsilon_2=v_2BL$

$F_{A1}=IBL=BL\left(\frac{(v_1-v_2)BL}{3R}\right)$

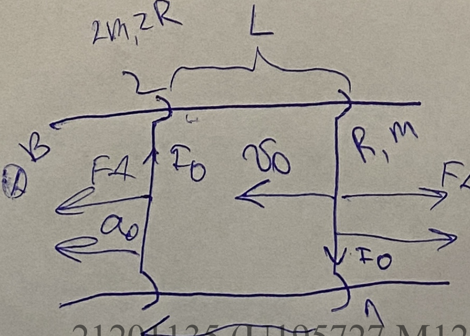
$F_{A2}=IBL$

1)

$\varepsilon_{10}=v_0BL \qquad I_0=\frac{\varepsilon_1}{2R+R}=\frac{v_0BL}{3R}$

$F_A=I_0BL=\frac{v_0B^2L^2}{3R}$

$Ox: 2ma_0=F_A \qquad a_0=\frac{v_0B^2L^2}{6Rm}$

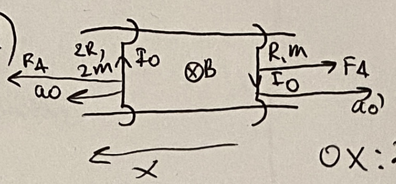


21201135 (U195727 M1266104)

Чистовик

№4

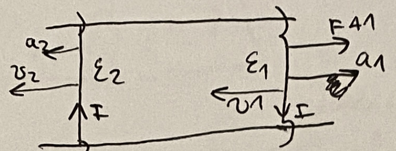
Дано:
$L, R, 2R,$
$m, 2m, v_0$
1) $a_0 = ?$
2) $v_1 = ?, v_2 = ?$
3) $S = ?$

1) 

$\varepsilon_1 = v_0BL \quad I_0 = \frac{\varepsilon_1}{2R+R} = \frac{v_0BL}{3R}$

$F_A = I_0BL = \frac{v_0B^2L^2}{3R}$

$OX: 2ma_0 = F_A \quad a_0 = \frac{v_0B^2L^2}{6Rm}$

2) 

при $t \to \infty \quad v_1 = v_2 = v$

$I = \frac{\varepsilon_1 - \varepsilon_2}{3R} \quad \varepsilon_1 = v_1BL \quad \varepsilon_2 = v_2BL$

$F_{A1} = IBL = BL\left(\frac{v_1 - v_2}{3R}\right)BL \qquad |F_{A1}| = |F_{A2}| = \frac{(v_1 - v_2)B^2L^2}{3R}$, тогда

$F_{A2} = IBL = BL\left(\frac{v_1 - v_2}{3R}\right)BL \qquad \left.\begin{matrix} 2ma_2 = F_{A2} \\ ma_1 = F_{A1} \end{matrix}\right\} \Rightarrow \frac{a_1}{2} = a_2$

$\left.\begin{matrix} v_1 = v_0 - \int a_1\,dt \\ v_2 = 0 + \int a_2\,dt \end{matrix}\right| \times 2 \Rightarrow 2v_2 = \int 2a_2\,dt$

$v_1 + 2v_2 = v_0 \qquad \left(v_1 + 2v_2 = v_0 + \int \underbrace{(2a_2 - a_1)}_{0}\,dt = v_0\right)$

при $t \to \infty \quad v_1 = v_2 = v$ т.к. $\varepsilon_1 = \varepsilon_2 \Rightarrow I = 0$

$v + 2v = v_0 \quad v = \frac{v_0}{3} \Rightarrow v_1 = v_2 = \frac{v_0}{3}$

3) $\begin{matrix} a_1dt = -dv_1 \\ a_2dt = dv_2 \end{matrix} \qquad dv_1 - dv_2 = \frac{(v_1 - v_2)B^2L^2}{Rm}\left(-\frac{1}{3} - \frac{1}{6}\right)dt$

Пусть $S(t)$ = функция, показывающ. расст. между перем.

$(v_1 - v_2)dt = -dS(t) \qquad \int_{v_0}^{v} dv_1 - \int_{0}^{v} dv_2 = \frac{B^2L^2}{2Rm}\int_{S_0}^{S} dS$

$v - v_0 - v + 0 = \frac{B^2L^2}{2Rm}(S - S_0) \qquad S = S_0 - \frac{2Rm}{B^2L^2}v_0$

Ответ: 1) $\frac{v_0B^2L^2}{6Rm}$; 2) $\frac{v_0}{3}$; 3) $S_0 - \frac{2Rm}{B^2L^2}v_0$