Часть 1

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

Шифр: **21201211**

ID профиля: **276733**

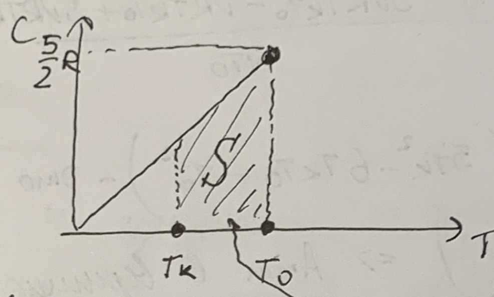
Вариант 2

11

Чистовик

№2 Гелий – одноатомный газ

построим график $C(T)$:



$$C(T) = \frac{5}{2} R \frac{T}{T_0}$$

$Q = \nu C \Delta T$ – определение молярной теплоемкости

T_k – температура в конце

Заметим, что Q это площадь под графиком умноженная на ν.

1) $T_k = T_0/2 \Rightarrow S = \frac{1}{2}(T_0 - T_k)\cdot(C_н + C_к) = \frac{T_0}{4}\cdot\left(\frac{5}{2}R + \frac{5}{4}R\right) = \frac{15RT_0}{16}$

$\boxed{Q = S \cdot \nu = \frac{15\nu R T_0}{16}}$ – тепло отданное газом

2) при понижении температуры внутр. энергия идет на выделение тепла и работу

$|\Delta U| = |Q| + |A|$. Пусть в конце $T = T_k$

$$\frac{3}{2}\nu R(T_н - T_к) = \frac{\nu}{2}(C_к + C_н)(T_0 - T_к) + \Delta A$$

$\boxed{T_н - T_к \text{ так как } |\Delta U|}$

1

$$\frac{3}{2}\nu R(T_0 - T_k) = \left(\frac{5\nu R T_k}{4T_0} + \frac{5\nu R}{4}\right)(T_0 - T_k) + \Delta A$$

$$\Delta A = \left(\frac{6\nu R}{4} - \frac{5\nu R T_k}{4T_0} + \frac{5\nu R}{4}\right)(T_0 - T_k)$$

Чистовик

№2 продолжение:

$$\Delta A = \frac{\nu R T_0^2 - 5\nu R T_k T_0 - \nu R T_k T_0 + 5\nu R T_k^2}{4T_0}$$

$\Delta A = \frac{\nu R}{4T_0}\left(5T_k^2 - 6T_kT_0 + T_0^2\right)$ – это парабола ветвями вверх: => A_{min} в вершине

1) $T_k = -\frac{b}{2a} = \boxed{\frac{6T_0}{10} = \frac{3}{5}T_0}$ – ответ на 2 пункт

3)

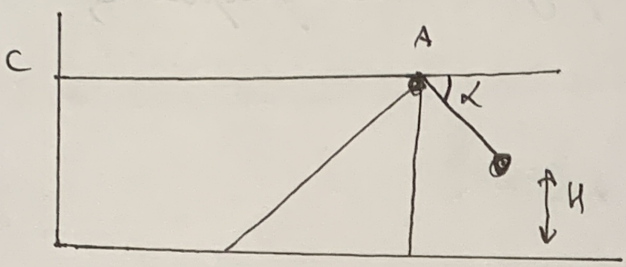
$$|A| = \left|\frac{\nu R}{4T_0}\left(\frac{9T_0^2}{5} - \frac{18}{5}T_0^2 + T_0^2\right)\right| = \frac{\nu R T_0}{5}$$

$\boxed{\text{Ответ: } \frac{15\nu R T_0}{16};\ \frac{3}{5}T_0;\ \frac{\nu R T_0}{5}}$

2

Чистовик

№1



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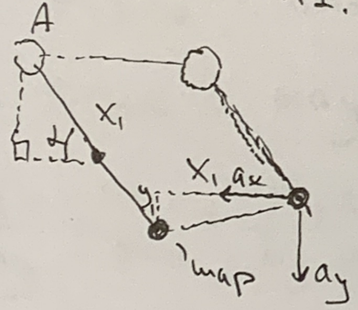
Т.к. угол между нитью и горизонтом постоянно α, то горизонтальные проекции ускорений клина и шара равны.

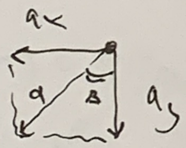
1) пусть прошло Δt, тогда клин подвинулся на

$x_1 = \frac{a_{клx} \cdot t^2}{2}$ => нить между точкой A и шаром удлинилась на X_1. Шар опустился на y_1, то есть на



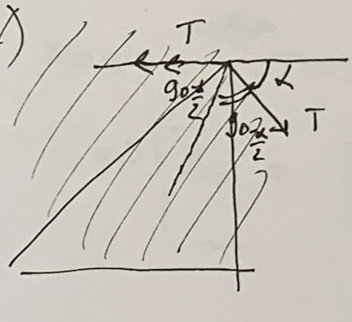
$x_1 \sin\alpha = y_1$

$\frac{a_x t^2}{2} \sin\alpha = \frac{a_y t^2}{2}$ => $\frac{a_x}{a_y} = \frac{1}{\sin\alpha}$



$tg\beta = \frac{a_x}{a_y} = \frac{1}{\sin\alpha}$ => $\boxed{\beta = arctg\left(\frac{1}{\sin\alpha}\right)} = \boxed{arctg\left(\frac{5}{3}\right)}$

2)



продолжение №1

↓

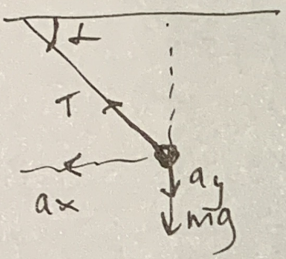
↓

Чистовик

№1

продолжение:

2) рассмотрим шар | ускорение a_x шара равно ускорению клина



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Второй з-н Ньютона:

$$T\cdot\cos\alpha = ma_x$$

$$mg - T\cdot\sin\alpha = ma_y \Rightarrow \frac{a_x}{a_y} = \frac{T\cos\alpha}{mg - T\sin\alpha}$$

$$\frac{a_x}{a_y} = \frac{1}{\sin\alpha} = \frac{T\cos\alpha}{mg - T\sin\alpha} \Rightarrow mg - T\sin\alpha = T\sin\alpha\cos\alpha$$

$$mg = T\sin\alpha(\cos\alpha + 1) \Rightarrow T = \frac{mg}{\sin\alpha(\cos\alpha+1)} = \frac{5mg}{3\cdot\frac{9}{5}} = \frac{25mg}{27}$$

$\Downarrow$

$$ma_x = \cancel{25m}\, T\cos\alpha = \frac{25mg}{27}\cdot\frac{4}{5} = \frac{20mg}{27}$$

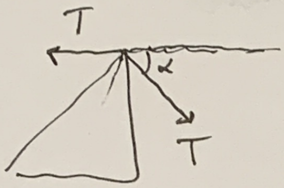
$$\Rightarrow \boxed{a_x = \frac{20}{27}g}$$

продолжение №1 ↓

Чистовик

№1 продолжение:

3)



5

для клина:

$$T - T\cos\alpha = M_{кл} \cdot a_x$$

для шара:

$$T\cos\alpha = m_ш a_x$$

$$\frac{m_ш}{M_{кл}} = \frac{T\cos\alpha}{T - T\cos\alpha} = \frac{\cos\alpha}{1-\cos\alpha} = \frac{\frac{4}{5}}{1-\frac{4}{5}} = \boxed{4}$$

4)

$\cancel{a_y = mg - T\sin\alpha}$

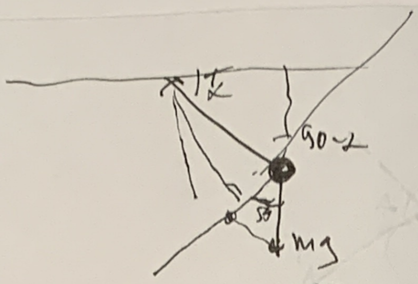
$$a_y = tg\beta \cdot a_x = \frac{5}{3} \cdot \frac{20}{27} g = \frac{100}{81} g$$

Равноускоренное движение вниз:

$$\frac{a_y t^2}{2} = H$$

$$t^2 = \frac{2H}{a_y} = \frac{2H \cdot 81}{100 \cdot g} \Rightarrow \boxed{t = \frac{9}{10}\sqrt{\frac{2H}{g}}}$$

$$\boxed{\text{Ответ: } arctg\left(\frac{5}{3}\right);\ \frac{20}{27} g;\ 4;\ \frac{9}{10}\sqrt{\frac{2H}{g}}}$$

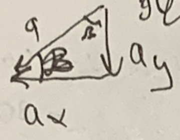


$$\begin{cases} T\sin\alpha - mg = ma_y \\ T\cos\alpha = ma_x \end{cases}$$

$\cancel{180}$

$\cancel{90-\beta}$

$a_x \cancel{= \frac{T\cos\alpha}{}}$

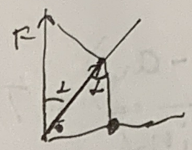


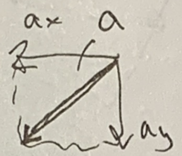
$$\boxed{\frac{T\cos\alpha}{T\sin\alpha - mg} = tg\beta}$$

$\cancel{tg\beta = \frac{a_y}{a_x}}$

$$tg\beta = \frac{a_x}{a_y}$$

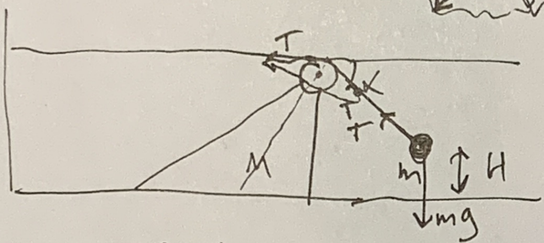
$\boxed{90+\alpha-\beta}$

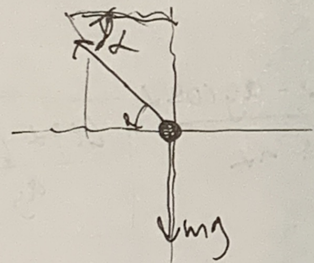




$\cancel{90-\alpha+\beta}$

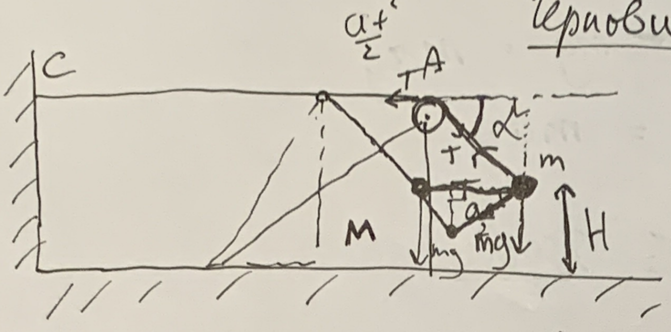
$\boxed{-\alpha+\beta}$

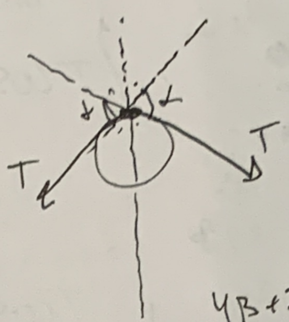




$$\begin{cases} ma_y = mg - T\sin\alpha \\ ma_x = T\cos\alpha \end{cases}$$

Черновик:

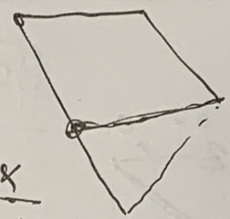




$4\beta+2\alpha=360$

$2\beta+\alpha=180$

$\beta = 90-\frac{\alpha}{2}$



ак шара = А кшма

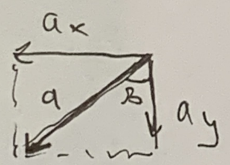
1) $\begin{cases} mg - T\sin\alpha = ma_y \\ ma_x = T\cos\alpha \end{cases}$

$$\frac{m(g-a_y)}{\sin\alpha} = T = \frac{ma_x}{\cos\alpha}$$

$$g\cos\alpha - a_y\cos\alpha = a_x\sin\alpha$$

$$a_x = \frac{g\cos\alpha - a_y\cos\alpha}{\sin\alpha}$$

$$tg\beta = \frac{a_x}{a_y} = \frac{g\cos\alpha - a_y\cos\alpha}{a_y\sin\alpha} = \boxed{\frac{ctg\alpha\,(g-a_y)}{a_y}}$$



$$\frac{(g-a_y)}{a_x} = tg\alpha$$

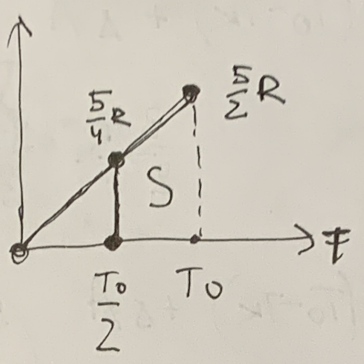
$$a_x = (g-a_y)\,ctg\alpha$$

21201211 (U276733 M1266712)

№2 Черновик

$$C(T) = \frac{5}{2} R \frac{T}{T_0}$$

$$Q = C\nu \Delta T$$

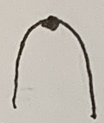


$$\Delta U = A + Q$$

$$S = \frac{1}{2} \cdot \frac{T_0}{2} \cdot \left(\frac{5}{4} + \frac{10}{4}\right) R = \frac{T_0}{4} \cdot \frac{15}{4} R = \boxed{\frac{15 T_0 R}{16}}$$

1) $Q = \nu C \Delta T = \boxed{\frac{15 T_0 R}{16} \nu}$

2) $\boxed{Q = \Delta U + A}$



$$Q = \nu \cdot \frac{1}{2} (C_н + C_к) \cdot (T_0 - T_к) = \frac{3}{2} \nu R (T_0 \cancel{-T_к}) + \Delta A$$

$$Q = \frac{\nu}{2} \left(\frac{5}{2} R + \frac{5 R T_к}{2 T_0}\right) (T_0 - T_к) = \frac{3}{2} \nu R (T_0 - T_к) + \Delta A$$

$$\Delta A = \left(\left(\frac{5 \nu R}{4} + \frac{5 \nu R T_к}{4 T_0}\right) - \frac{3}{2} \nu R\right) (T_0 - T_к)$$

$$\Delta A = \left(\frac{5 \nu R T_к}{4 T_0} - \frac{\nu R}{4}\right) (T_0 - T_к) = \frac{5 \nu R T_к - 11 \nu R T_0}{4 T_0} \cdot (T_0 - T_к) =$$

$\cancel{-6T_0^2 + 6T_0^2}$

$$= \frac{\nu R}{4} \cdot \left(\frac{5 T_к - T_0}{T_0}\right) \cdot (T_0 - T_к) =$$

$$= \frac{\nu R}{4} \left(\frac{5 T_к T_0 - 5 T_к^2 - T_0^2 + T_0 T_к}{T_0}\right) = \boxed{\frac{-5 T_к^2 + 6 T_0 T_к - T_0^2}{T_0} \cdot \frac{\nu R}{4}}$$

$$\frac{3}{2}\nu R(T_K - T_H) = \frac{\nu}{2}(C_K + C_H)(T_0 - T_K) + \Delta A$$

$$\frac{3\nu R}{8} \cdot \frac{8T_0}{5} = \boxed{\frac{3\nu R T_0}{5}}$$

$$\frac{\cancel{3}}{\cancel{2}}\cancel{\nu R}(\cancel{T_K - T_0}) = \frac{\nu}{2}$$

$$\frac{3}{2}\nu R(T_0 - T_K) = \frac{\nu}{2}\left(\frac{5RT_K}{2T_0} + \frac{5}{2}R\right)(T_0 - T_K) + \Delta A \qquad \left(\frac{5\nu R \cdot 3}{4 \cdot \cancel{5}} + \frac{5\nu R}{4}\right) \cdot \frac{2T_0}{5}$$

$$\frac{3}{2}\nu R(T_0 - T_K) = \left(\frac{5\nu R T_K}{4T_0} + \frac{5\nu R}{4}\right)(T_0 - T_K) + \Delta A$$

$$\frac{3}{2}\cancel{\nu R (T_0 - T_K)}$$

$$\cancel{8\nu R}$$

$$\frac{8\nu R}{4} \cdot \frac{2T_0}{5} =$$

$$(T_0 - T_K)\left(\frac{6\nu R}{4} - \frac{5\nu R T_K}{4T_0} - \frac{5\nu R}{4}\right) = \Delta A \qquad = \frac{16\nu R T_0}{4 \cdot 5} = \frac{4\nu R T_0}{5}$$

$$(T_0 - T_K)\left(\frac{\nu R T_0 - 5\nu R T_K}{4T_0}\right) = \Delta A \qquad Q = \Delta U + A$$

$$Q = \Delta U + A$$

$$\frac{\cancel{T_0}\,\nu R T_0^2 - 5\nu R T_K T_0 - \nu R T_K T_0 + 5\nu R T_K^2}{4T_0} = \Delta A$$

$$Q = \Delta U + A$$

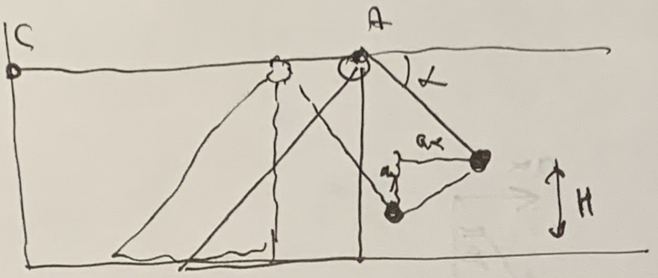
$$\cancel{5T_K^2} - \cancel{6T_K T_0}$$

$$Q - A = \Delta U$$

$$\frac{\nu R}{4T_0}\left(5T_K^2 - 6\,T_K T_0 + T_0^2\right) = \Delta A$$

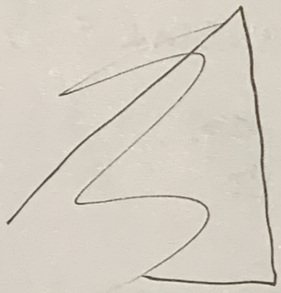
$$\boxed{T_K = \frac{6\,T_0}{10}} = \boxed{\frac{3}{5}T_0}$$

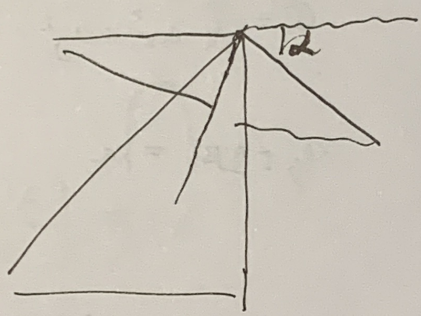
$$\frac{\nu R}{4T_0}\left(-\frac{9T_0^2}{5} + T_0^2\right) = \frac{\nu R}{4T_0} \cdot \frac{4T_0^2}{5} = \frac{\nu R T_0}{5}$$



$\alpha + 2\beta = 180$

$\beta =$

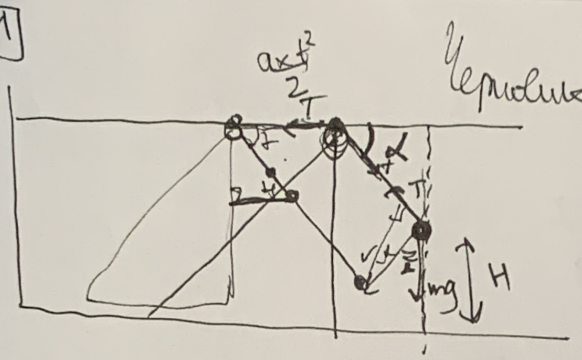


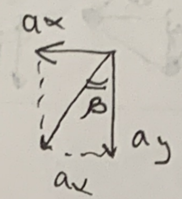


$\cos\left(90 - \frac{\alpha}{2}\right) \cdot T$

М

Черновик





$$\begin{cases} ma_x = T\cos\alpha \\ ma_y = mg - T\sin\alpha \end{cases}$$

$$\frac{a_x t^2}{2}\cdot\sin\alpha = \frac{a_y t^2}{2}$$

$$a = \sqrt{a_x^2 + a_y^2}$$

$$a_x \sin\alpha = a_y$$

$$a\cdot\cos\alpha = a_2\cdot\cos\beta$$

$$a_y\, tg\beta = a_x$$

$$a_x \cdot \cos\alpha = a\cos\beta$$

$$a_x\cos\alpha = \sqrt{a_x^2 + \frac{a_x^2}{tg^2\beta}}\cos\beta$$

$$tg\beta = \frac{\sin\beta}{\cos\beta}$$

$$\cos\alpha = \sqrt{\cos^2\beta + \frac{\cos^2\beta}{tg^2\beta}}$$

$$\cos^2\beta = \frac{\sin^2\beta}{tg^2\beta}$$

$$\cos\alpha = \sqrt{\frac{1}{tg^2\beta}}$$

$$\frac{T\cos\alpha}{mg - T\sin\alpha} = \frac{1}{\cos\alpha}$$

$$\cos\alpha = \frac{1}{tg\beta}$$

$$T\cos^2\alpha = mg - T\sin\alpha$$

$$a_x = a\sin\beta$$

$\cancel{tg\beta = a}$

$$\boxed{tg\beta = \frac{1}{\cos\alpha}}$$

$$a\sin\beta = a_x$$

$$\sin\beta\sqrt{a_x^2 + \frac{a_x^2}{tg^2\beta}} = a_x$$

Часть 2

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

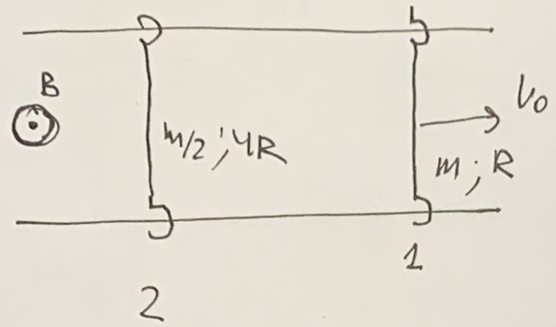
Шифр: **21201211**

ID профиля: **276733**

Вариант 2

Чистовик

№4



1

1) т.к. 1 движется со скоростью $V_0 \Rightarrow \mathcal{E}_{c.инд} = -\frac{\Delta\Phi}{\Delta t} =$

$= BV_0L$ в этом контуре

$$\Downarrow$$

$$I_{общ} = \frac{\mathcal{E}_{инд}}{R_{общ}} = \frac{BV_0L}{5R}$$

$$\Downarrow$$

$$F_{Амп} = BIL = \frac{B^2V_0L^2}{5R}$$

$$F = ma \Rightarrow F_{Амп} = \frac{m}{2}a \Rightarrow \boxed{a = \frac{2B^2V_0L^2}{5mR}}$$

2) В конце их скорости сравняются

~~Откуда~~ На 2 действует ускорение a, а на 1 $a/2$.

$$\Downarrow$$

$$V_k = at = V_0 - \frac{at}{2} \Rightarrow at = \frac{2}{3}V_0 = V_k$$

$$\boxed{V_k = \frac{2}{3}V_0} \Rightarrow t = \frac{2V_0}{3a}$$

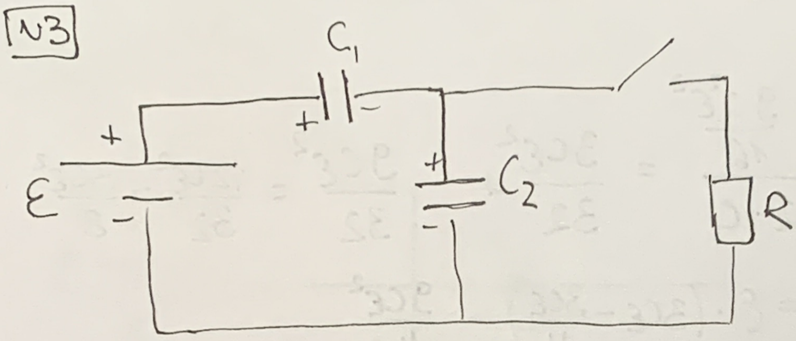
3) $S_2 = \frac{at^2}{2} = \frac{a}{2} \cdot \frac{4V_0^2}{9a^2} = \frac{2V_0^2}{9a}$ - прошла 2

$S_1 = V_0t - \frac{at^2}{2} = \frac{2V_0^2}{3a} - \frac{a}{2} \cdot \frac{4V_0^2}{9a^2} = \frac{2V_0^2}{3a} - \frac{2V_0^2}{9a} = \frac{4V_0^2}{9a}$ - прошла 1

$S_1 - S_2 = \frac{2V_0^2}{9a} = \frac{2V_0^2}{9} \cdot \frac{5mR}{2B^2V_0L^2} = \boxed{\frac{5V_0mR}{9B^2L^2}} \Rightarrow$ $\boxed{\text{Ответ: } \frac{2B^2V_0L^2}{5mR};\ \frac{2}{3}V_0;\ \frac{5V_0mR}{9B^2L^2}}$

Чистовик

№3



2

$C_1 = 3C$

$C_2 = C$

1) Заметим, что $q_1 = q_2$, т.к.

$$U_1 + U_2 = \mathcal{E}$$

$$\frac{q}{C_1} + \frac{q}{C_2} = \mathcal{E}$$

$$\frac{q}{3C} + \frac{q}{C} = \mathcal{E}$$

$$q = \frac{3C\mathcal{E}}{4}$$

$$U_2 = \frac{q}{C_2} = \frac{3\mathcal{E}}{4}$$

$$\boxed{I_R = \frac{3\mathcal{E}}{4R}}$$

ток в начале

2) $A_{ст} = W_к - W_н + Q$

в конечном состоянии конденсатор C_2 разряжен =>

$U_{C_1} = \mathcal{E}$ => $q = \mathcal{E} \cdot 3C = 3C\mathcal{E}$ – заряд конденсатора C_1.

$$W_к = \frac{q^2}{2C_1} = \frac{9C^2\mathcal{E}^2}{6C} = \frac{9C\mathcal{E}^2}{6} = \frac{3C\mathcal{E}^2}{2}$$

Чистовик

Чистовик

№3 продолжение

(3)

$$W_н = \frac{q^2}{2C_1} + \frac{q^2}{2C_2} = \frac{\frac{9C^2\mathcal{E}^2}{16}}{2\cdot 3C} + \frac{\frac{9C^2\mathcal{E}^2}{16}}{2\cdot C} = \frac{3C\mathcal{E}^2}{32} + \frac{9C\mathcal{E}^2}{32} = \frac{12C\mathcal{E}^2}{32} = \frac{3C\mathcal{E}^2}{8}$$

$$A_{ист} = \mathcal{E}\cdot\Delta q = \mathcal{E}\cdot(q_{1к} - q_{1н}) = \mathcal{E}\cdot\left(3C\mathcal{E} - \frac{3C\mathcal{E}}{4}\right) = \frac{9C\mathcal{E}^2}{4}$$

$$A_{ист} = \Delta W + Q$$

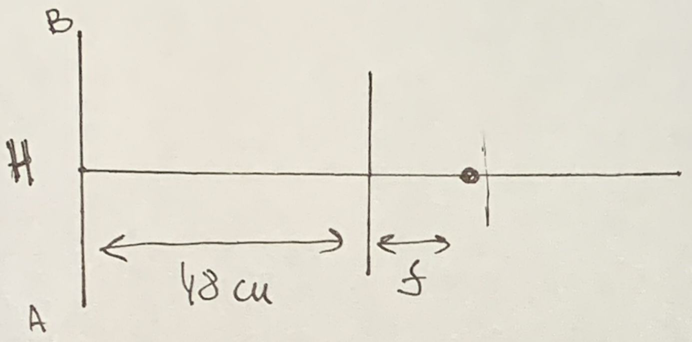
$$\frac{9C\mathcal{E}^2}{4} = \frac{3C\mathcal{E}^2}{2} - \frac{3C\mathcal{E}^2}{8} + Q$$

$$\frac{18C\mathcal{E}^2}{8} = \frac{9C\mathcal{E}^2}{8} + Q \Rightarrow \boxed{Q = \frac{9C\mathcal{E}^2}{8}}$$

$$\boxed{\text{Ответ: } \frac{3\mathcal{E}}{4R};\ \frac{9C\mathcal{E}^2}{8}}$$

Чистовик

$\boxed{N5}$



4

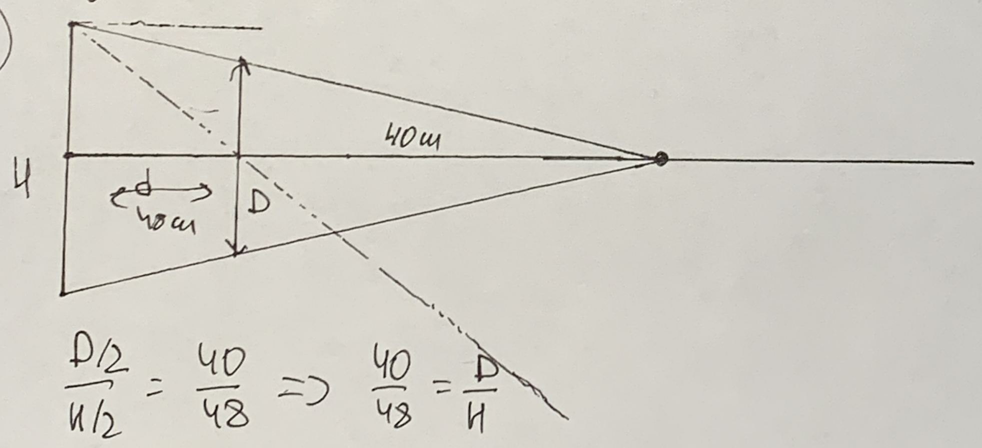
1) Формула тонкой линзы:

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

$$\frac{1}{48} + \frac{1}{f} = \frac{1}{12} \Rightarrow \frac{1}{f} = \frac{3}{48} = \frac{1}{16} \Rightarrow f = 16 \text{ см}$$ от линзы $\Rightarrow$

Глаз расположен на расстоянии $16 + 24 = \boxed{40 \text{ см}}$ от линзы.

2)



$$\frac{D/2}{H/2} = \frac{40}{48} \Rightarrow \frac{40}{48} = \frac{D}{H}$$

$$\frac{5}{6} = \frac{D}{H} \Rightarrow D = \frac{5}{6}H = \frac{45}{6} = \frac{15}{2} = \boxed{7{,}5 \text{ см}}$$

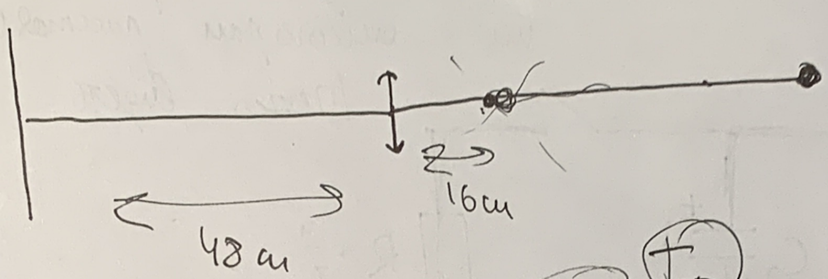
Чистовик

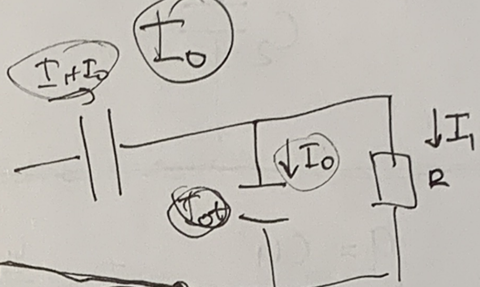
3) ~~в~~ нужно поместить лампу на расстоянии 16 см от линзы, т.к. все выходящие лучи ~~в~~ там проходят

$\boxed{\text{Ответ: } 40; 7{,}5; 16}$

5

N5

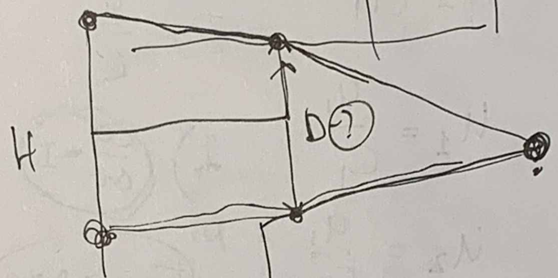




$F=12$

$H=9$

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



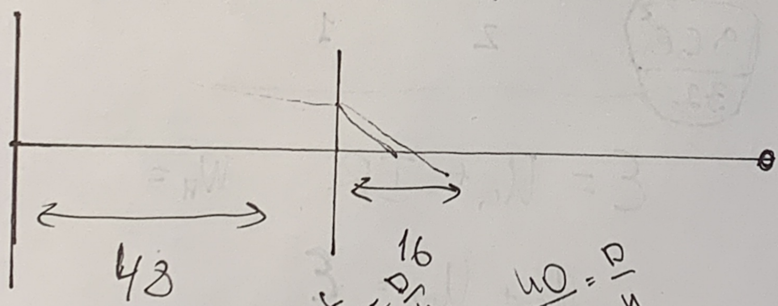
$\frac{1}{48}+\frac{1}{f}=\frac{1}{12}$

$\frac{1}{f}=\frac{3}{48}=\frac{1}{16}$

$I=\frac{\Delta q}{\Delta t}$

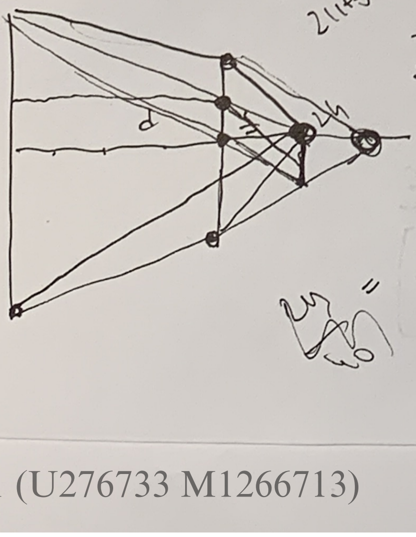
S_1-S_2

1) $f=16$ cm $+24=40$ cm



$\frac{24+f}{24+f+d}=\frac{D}{H}$ $\quad \frac{40}{40+48}=\frac{D}{H}$

$\frac{f}{f+d}=\frac{D}{H}$

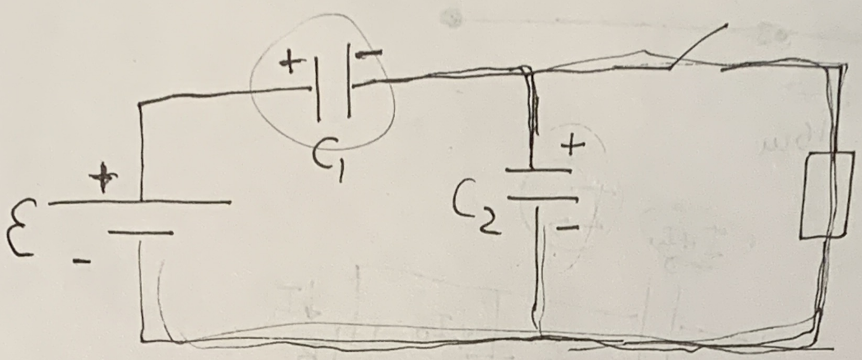


$\frac{16}{16+48}=\frac{16}{64}=\frac{1}{4}=\frac{D}{H}$ $\quad D=\frac{9}{4}$

$\frac{24}{40}=$

№3

Настроить глаз на рассматривание на некоторых расстояниях четко видеть



$C_1 = 3C$

$C_2 = C$

$q_1 = q_2$

$q_1 = \frac{3C\varepsilon}{4} \to 3C\varepsilon$

$q_2 = \frac{3C\varepsilon}{4} \to 0$

1) $\frac{q_1}{C_1} + \frac{q_1}{C_2} = \varepsilon$

$\frac{q}{3C} + \frac{3q}{3C} = \varepsilon$

$\boxed{q = \frac{3C\varepsilon}{4}}$

$U_2 = \frac{q}{C_2} = \frac{3\varepsilon}{4}$

$\boxed{I = \frac{3\varepsilon}{4R}}$

$q = CU$

$U_1 = \frac{q_1}{C_1}$

$U_2 = \frac{q_1}{C_2}$

$I = \frac{U}{R}$

2) $\frac{\Delta q}{\Delta t} = I$

$\varepsilon = B v \ell$

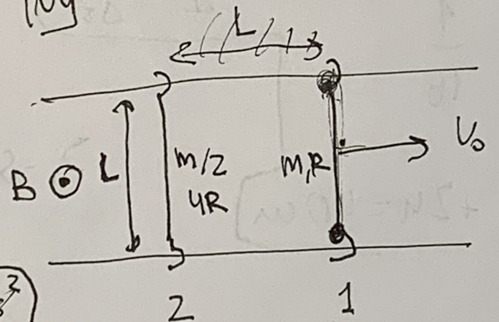
$\varepsilon = -\frac{d\Phi}{dt}$

$F_{Амп} = BI\ell$

$\boxed{d\Phi = B\,dS}$

$\frac{9C^2\varepsilon^2}{2 \cdot 16\,C} = \frac{9C\varepsilon^2}{32}$

№4



$A = (W_к - W_н) + Q$

$\varepsilon = U_{C_1} + IR$

$W_н =$

$U_{C_1} + U_{C_2} = \varepsilon$

$\frac{q_1}{C_1} = \varepsilon$

$q_1 = 3C\varepsilon$

$W_к = \frac{q^2}{2C} = \boxed{\frac{9\varepsilon^2 \cdot C}{2}}$

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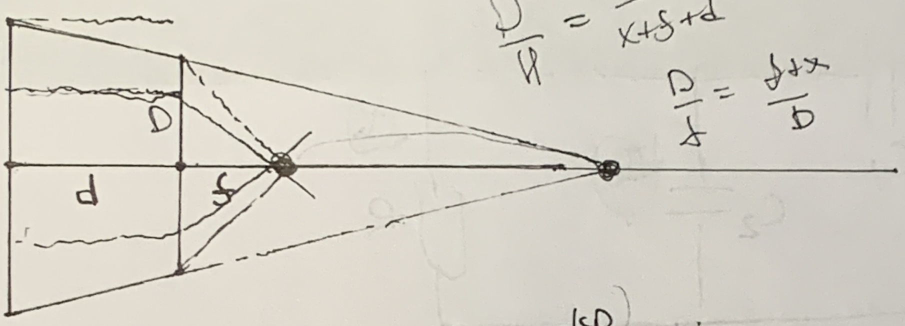
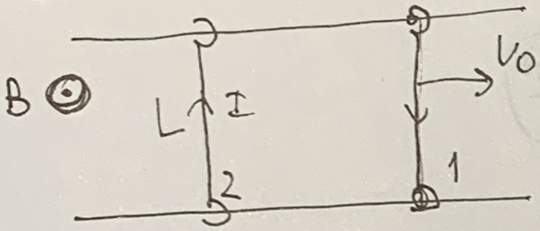


$$\frac{D}{H} = \frac{x+f}{x+f+d}$$

$$\frac{D}{f} = \frac{f+x}{D}$$

№4



$$\mathcal{E} = -\frac{d\Phi}{dt}$$

$$\mathcal{E} = \frac{B \cdot V \cdot \Delta t L}{\Delta t} = BVL$$

BV_0L

$U = BV_0L$

$R = 5R$

$$I = \frac{BV_0L}{5R}$$

$$F_{Ами} = B I L = \frac{B^2 L^2 \cdot V_0}{5R} = \frac{m}{2} a$$

$$\boxed{a = \frac{2B^2L^2 \cdot V_0}{5mR}}$$

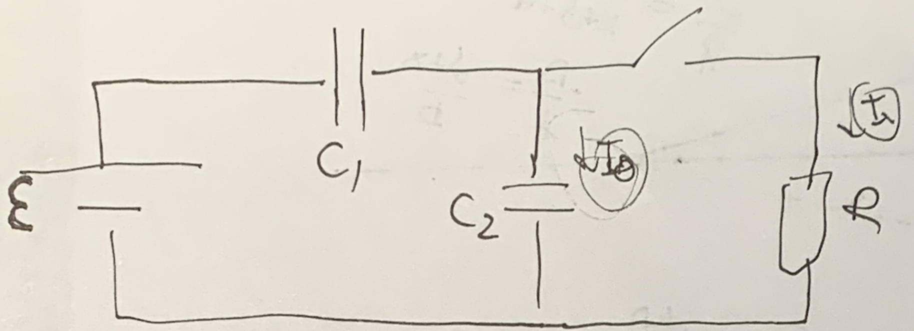
$\xrightarrow{a}$ $\xleftarrow{g/2}$

$$at = V_0 - \frac{at}{2}$$

~~at~~

$1{,}5 V_K = V_0$

$$V_K = \frac{2}{3} V_0$$



$\Delta q = I_0 \Delta t$

$V - \frac{2B^2 V_i L^2}{5mR}$ $\qquad \Delta u = \frac{\Delta q}{C} = \frac{I_0 \cancel{\Delta t}}{C}$

$\frac{\Delta u}{\Delta t} = \frac{I_0}{C}$

$\mathcal{E} = -\frac{d\Phi}{dt}$

$d\Phi = B\cdot L\left(V\cdot t - \frac{at^2}{2} + \frac{at^2}{2}\right) = BL\left(Vt - at^2\right) =$

$\mathcal{E} = BL(V-at)$

$\frac{\mathcal{E}}{5R} = \frac{B^2L^2(V-a\cancel{t})}{5R} = ma$