



**МОСКОВСКИЙ ГОСУДАРСТВЕННЫЙ УНИВЕРСИТЕТ
имени М.В. ЛОМОНОСОВА**

ОЛИМПИАДНАЯ РАБОТА

Наименование олимпиады школьников: **«Ломоносов»**

Профиль олимпиады: **Инженерные науки**

ФИО участника олимпиады: **Барташук Антон Николаевич**

Класс: **11**

Технический балл: **65**

Дата проведения: **01 марта 2022 года**

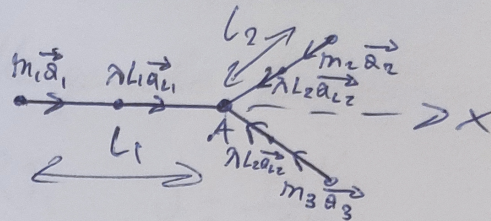
РЕЗУЛЬТАТ ПРОВЕРКИ

| Задача 1 | Задача 2 | Задача 3 | Задача 4 | Всего |
|----------|----------|----------|----------|-------|
| 20 | 20 | 25 | 0 | 65 |

Условие

н.п.

Решение:



Дано:

$$m_1 = 50 \text{ кг}$$

$$m_2 = m_3 = 30 \text{ кг}$$

$$L_1 = 1 \text{ м}$$

$$\text{tg } \alpha = \frac{3}{4}$$

$$\lambda = 20 \frac{\text{кг}}{\text{м}}$$

$$L_2 = ?$$

Чтобы не возникло трения, результирующая сила в точке A в проекции на OX должна быть равна 0:

(Проверить, что $a_{1x} = \frac{a_1}{2}$ и $a_{1z} = \frac{a_2}{2} = \frac{a_3}{2}$)
 (т.к. т.п. ускорения направлены к середине стержня)

$$m_1 \frac{v^2}{L_1} + \lambda \frac{L_1}{2} \cdot \frac{v^2}{2L_1} = m_2 \frac{v^2}{L_2} \cos \alpha + \lambda \frac{L_2}{2} \frac{v^2}{2L_2} \cos \alpha + m_3 \frac{v^2}{L_2} \cos \alpha + \lambda \frac{L_2}{2} \frac{v^2}{2L_2} \cos \alpha$$

$$\cancel{v^2} \left(\frac{m_1}{L_1} + \frac{\lambda L_1}{2} \right) = \cos \alpha \cancel{v^2} \left(\frac{2m_2}{L_2} + \lambda \right)$$

$$\frac{2m_1 + L_1 \lambda}{2L_1 \cos \alpha} = \frac{2m_2}{L_2} + \lambda$$

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

$$\cos \alpha = \frac{1}{\sqrt{\frac{9}{16} + 1}} = \frac{4}{5}$$

$$\frac{2m_1 + L_1 \lambda - 2L_1 \cos \alpha \lambda}{2L_1 \cos \alpha} = \frac{2m_2}{L_2}$$

$$L_2 = \frac{4m_2 L_1 \cos \alpha}{2m_1 + L_1 \lambda - 2L_1 \cos \alpha \lambda}$$

$$L_2 = \frac{4 \cdot 30 \text{ кг} \cdot 1 \text{ м} \cdot \frac{4}{5}}{2 \cdot 50 + 1 \text{ м} \cdot 20 \frac{\text{кг}}{\text{м}} - 2 \cdot 1 \text{ м} \cdot \frac{4}{5} \cdot 20 \frac{\text{кг}}{\text{м}}} = \frac{96}{88} \text{ м} = \frac{12}{11} \text{ м} \approx 1,09 \text{ м}$$

Ответ: $L_2 = \frac{12}{11} \text{ м} \approx 1,09 \text{ м}$.

(1)

Числовик

№2.

Дано:

$$V_0 = 22 \cdot 10^3 \text{ м}^3$$

$$T_1 = 293 \text{ К}$$

$$p_0 = 54 \cdot 10^5 \text{ Па}$$

$$p_A = 10^5 \text{ Па}$$

$$\eta = 0,8$$

$$W = 775 \cdot 10^3 \text{ Вт} \cdot \text{ч}$$

$$c_v = 26,54 \frac{\text{Дж}}{\text{моль} \cdot \text{К}}$$

$$A_{\text{расш}} = 113 \cdot 10^9 \text{ Дж}$$

$$V_1 = ?$$

Решение:

Упр-ние Менделеева-Клапейрона:

$$p_0 V_0 = \nu R T_1 \quad \nu = \frac{p_0 V_0}{R T_1}$$

$$p_A V_1 = \nu R T_2$$

$$V_1 = \frac{\nu R T_2}{p_A} = \frac{R T_2}{p_A} \cdot \frac{p_0 V_0}{R T_1} = \frac{p_0 V_0 T_2}{p_A T_1}$$

$$Q_3 = 3600 \text{ Вт} \quad (\text{переводим Вт} \cdot \text{ч в Вт} \cdot \text{с} = \text{Дж})$$

$$\eta = \frac{Q_3}{Q_n} = \frac{3600 \text{ Вт}}{Q_n}$$

$$Q_n = \Delta U + A_{\text{расш}} = \frac{i}{2} \frac{p_0 V_0}{R T_1} R (T_2 - T_1) + A_{\text{расш}}$$

$$c_v = \frac{i}{2} R$$

$$i = \frac{2 c_v}{R}$$

$$= \frac{c_v p_0 V_0}{R T_1} (T_2 - T_1) + A_{\text{расш}}$$

$$Q_n = \frac{Q_3}{\eta} = \frac{3600 \text{ Вт}}{0,8} = 4500 \text{ Вт}$$

$$(T_2 - T_1) = \frac{R T_1 (4500 \text{ Вт} - A_{\text{расш}})}{c_v p_0 V_0} \quad | \cdot (-1)$$

$$T_2 = T_1 - \frac{R T_1 (4500 \text{ Вт} + A_{\text{расш}})}{c_v p_0 V_0} = T_1 \left(1 - \frac{R (A_{\text{расш}} + 4500 \text{ Вт})}{c_v p_0 V_0} \right)$$

$$V_1 = \frac{p_0 V_0}{p_A T_1} \cdot T_1 \left(1 - \frac{R (A_{\text{расш}} + 4500 \text{ Вт})}{c_v p_0 V_0} \right) = \frac{1}{p_A} \left(p_0 V_0 - \frac{R (A_{\text{расш}} + 4500 \text{ Вт})}{c_v} \right)$$

2

$$V_1 = \frac{1}{10^5 \frac{\text{Dnc}}{\text{мол} \cdot \text{к}}} \cdot \left(54 \cdot 10^5 \frac{\text{Dnc}}{\text{мол} \cdot \text{к}} \cdot 22 \cdot 10^3 \text{м}^3 - \frac{8,31 \frac{\text{Dnc}}{\text{мол} \cdot \text{к}} \cdot (113 \cdot 10^9 \text{Dnc} - 4500 \cdot 775 \cdot 10^3 \text{Dnc})}{26,54 \frac{\text{Dnc}}{\text{мол} \cdot \text{к}}} \right)$$

$$= \left(54 \cdot 22 \cdot 10^8 \text{м}^3 - \frac{8,31 \frac{\text{Dnc}}{\text{мол} \cdot \text{к}} \cdot (113 \cdot 10^9 \text{Dnc} - 4500 \cdot 775 \cdot 10^3 \text{Dnc})}{26,54 \frac{\text{Dnc}}{\text{мол} \cdot \text{к}} \cdot 10^5} \right) =$$

$$= \left(54 \cdot 22 \cdot 10^8 - \frac{1095125 \cdot 831}{2654} \right) \text{м}^3 \approx 1188000 - 342897,09 =$$

$$= 845102,91 \text{м}^3$$

Ответ: $V_1 \approx 845102,91 \text{м}^3$.

Дано: n_3 .

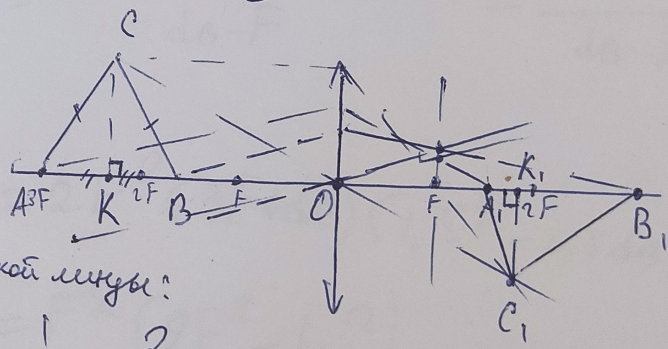
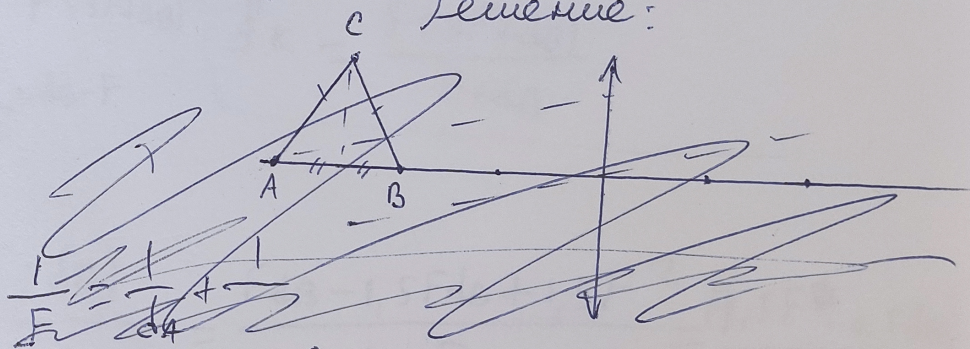
$$F = 0,1 \text{м}$$

$$S_{ABC} = S_{A_1B_1C_1}$$

$$d_A = 3F$$

$$AB = (d_A - d_B) - ?$$

Решение:



$$d_K = \frac{3F - d_B}{2} + d_B =$$

$$= \frac{3F + d_B}{2}$$

Формула тангаж кривой:

$$\frac{1}{f_A} = \frac{1}{F} - \frac{1}{d_A} = \frac{2}{3F}$$

$$f_A = 1,5F$$

Усиков 3

Условие

$$S_{ABC} = S_{A_1B_1C_1}$$

$$\frac{(3F - dB) \cdot KC}{2} = \frac{(f_B - f_A) \cdot K_1 C_1}{2} \quad | \cdot 2 \quad f_B = \frac{F dB}{dB - F}$$

Из подобия $\triangle KCO$ и $\triangle K_1C_1O$:

$$\frac{KC}{K_1C_1} = \frac{dK}{fK}$$

$$\frac{1}{fK} = \frac{1}{F} - \frac{1}{dK} = \frac{1}{F} - \frac{2}{3F + dB} = \frac{3F + dB - 2F}{F(3F + dB)} = \frac{F + dB}{F(3F + dB)}$$

⊗:

$$(3F - dB) \cdot \frac{3F + dB}{2} \cdot \frac{(F + dB)}{F(3F + dB)} = fK = \frac{F(3F + dB)}{F + dB}$$
$$= \frac{F dB}{dB - F} - 1,5F$$

$$\frac{(9F^2 - dB^2)(F + dB)}{2F(3F + dB)} = \frac{F dB - 1,5F dB + 1,5F^2}{dB - F} = \frac{F(1,5F - 0,5dB)}{dB - F}$$

$$(9F^2 - dB^2)(dB^2 - F^2) = 2F^2(3F + dB)(1,5F - 0,5dB) = F^2(9F^2 - dB^2)$$

~~$(9F^2 - dB^2)(3F + dB)(1,5F - 0,5dB) = 2F^2(3F + dB)(1,5F - 0,5dB)$~~

$$(9F^2 - dB^2)(dB^2 - F^2) - F^2(9F^2 - dB^2) = 0$$

Числовик) $(9F^2 - d_B^2)(d_B^2 - F^2 - F^2) = 0$
 $(9F^2 - d_B^2)(d_B^2 - 2F^2) = 0$

$$d_B^2 = 9F^2$$

$$d_B = 3F = d_A$$

$$d_B^2 = 2F^2$$

$$d_B = F\sqrt{2}$$

∅ (d_B не может быть равно d_A)

$$AB = 3F - F\sqrt{2} = F(3 - \sqrt{2})$$

$$AB = 0,1 \text{ м} \cdot (3 - \sqrt{2}) =$$

$$= \left(0,3 - \frac{\sqrt{2}}{10}\right) \text{ м} = (30 - 10\sqrt{2}) \text{ см}$$

Ответ: $AB = \left(0,3 - \frac{\sqrt{2}}{10}\right) \text{ м} = (30 - 10\sqrt{2}) \text{ см}$.

Черновик

№1.

$m_1 = 50 \text{ кг}$

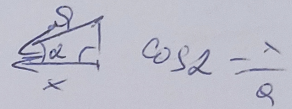
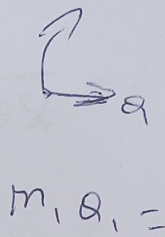
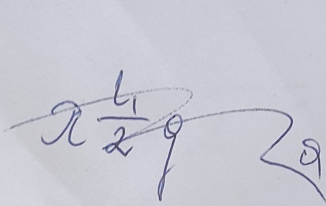
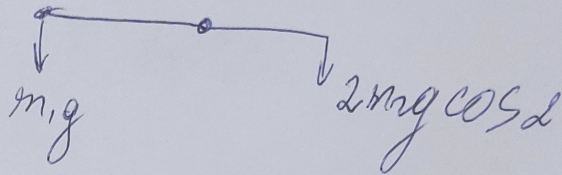
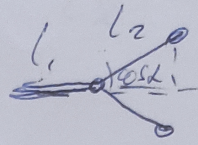
$m_2 = m_3 = 30 \text{ кг}$

$L_1 = 1 \text{ м}$

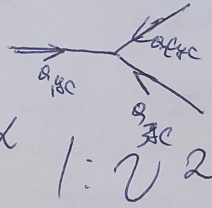
$\text{tg } \alpha = \frac{3}{4}$

$\lambda = 20 \frac{\text{кН}}{\text{м}}$
 упр. пружина.

$L_2 = ?$



$m_1 a_1 = m_2 a_2 \cos \alpha + m_3 a_3 \cos \alpha$



$M_1 = \lambda \frac{L_1}{2}$

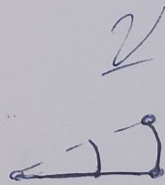
$m_1 \frac{v^2}{L_1} = m_2 \cos \alpha \left(\frac{v^2}{L_2} + \frac{v^2}{L_2} \right)$

$m_1 a_1 + \lambda \frac{L_1}{2}$

$a_1 = \frac{v^2}{R}$

$m_1 \frac{v^2}{L_1} + \lambda \frac{L_1}{2} =$

~~Упругая пружина~~



$\frac{2v^2}{4R} =$
 $= \frac{v^2}{2R}$

$= m_2 \frac{v^2}{L_2} \cos \alpha + \lambda L_2 \frac{v^2}{2L_2} \cos \alpha +$

$+ m_3 \frac{v^2}{L_2} \cos \alpha + \lambda L_2 \frac{v^2}{2L_2} \cos \alpha =$

$= 2 m_2 \frac{v^2}{L_2} \cos \alpha + \lambda \frac{L_2}{2} \frac{v^2}{L_2} \cos \alpha =$

$= v^2 \cos \alpha \left(\frac{2m_2}{L_2} + \lambda \right)$

(1)

$$v^2 \left(\frac{m_1}{L_1} + \frac{\lambda}{2} \right) = v^2 \cos d \left(\frac{2m_2}{L_2} + \lambda \right) \quad \text{Черковский}$$

$$\frac{m_1}{L_1} + \frac{\lambda}{2} = \cos d \left(\frac{2m_2}{L_2} + \lambda \right)$$

$$\operatorname{tg} d = \frac{\sin d}{\cos d} = \sin d = \sqrt{1 - \cos^2 d}$$

$$= \frac{\sqrt{1 - \cos^2 d}}{\cos d}$$

$$120 \cdot \frac{4}{5} = 24 \cdot 4 =$$

$$\operatorname{tg}^2 d = \frac{1 - \cos^2 d}{\cos^2 d} = \frac{1}{\cos^2 d} - 1$$

$$\underline{96}$$

$$\operatorname{tg}^2 d + 1 = \frac{1}{\cos^2 d}$$

$$\cos^2 d = \frac{1}{\operatorname{tg}^2 d + 1}$$

$$120 - 32 =$$

$$\cos d = \frac{1}{\sqrt{\operatorname{tg}^2 d + 1}} = 28$$

$$= \frac{1}{\sqrt{\frac{9}{16} + 1}}$$

$$= 1 : \sqrt{\frac{25}{16}} = \frac{16}{16}$$

$$\frac{16}{16}$$

$$= \sqrt{\frac{16}{25}} = \left(\frac{4}{5} \right)$$

$$\frac{50 \cdot 2}{1} + \frac{20}{2} = \frac{4}{5} \left(\frac{60}{L_2} + 20 \right)$$

$$\frac{120}{2} = 60$$

$$60 = \frac{4}{5} \left(\frac{60}{L_2} + 20 \right) \quad | \cdot \frac{5}{4}$$

$$\frac{300}{4} = 75 = \frac{60}{L_2} + 20$$

$$55 = \frac{60}{L_2}$$

$$L_2 = \frac{60}{55} = \frac{12}{11} \text{ м}$$

Черковский 2

$$V_0 = 22 \cdot 10^3 \mu^3$$

$$T_1 = 293 \text{ K}$$

$$p_0 = 5400 \cdot 10^3 \text{ Па}$$

$$p_a = 100 \cdot 10^3 \text{ Па} = 10^2 \cdot 10^3 = 10^5 \text{ Па}$$

$$\eta = 0,8$$

$$W = 775 \cdot 10^3 \text{ Дж} \cdot \tau$$

$$C_v = 26,54 \frac{\text{Дж}}{\text{кг} \cdot \text{К}}$$

$$A_{расч} = 1,130 \cdot 10^{-4} \text{ м}^2$$

$V = ?$

$$W = A \cdot c$$

$$Q = c_v \Delta T$$

$$Q = C_v W \Delta T$$

$$p_0 V_0 = \Delta T R T_1$$

$$p_a V_a = \Delta T R T_2$$

$$\eta = \frac{A_{расч} Q}{W}$$

$$Q = 1,130 \cdot 10^{-4} \cdot 0,8 = 113 \cdot 10^{-9} \cdot 0,8 = 904 \cdot 10^{-8}$$

$$\eta = \frac{Q}{Q_2}$$

$$Q_2 = \Delta U + A_{расч}$$

$$\Delta U = 3 \Delta T R$$

$$\Delta U = \frac{C_v \Delta T}{Q} \Delta T R = \frac{C_v \Delta T^2 R}{Q}$$

$$C_v = \frac{i Q}{2 \Delta T}$$

$$i = \frac{2 C_v \Delta T}{Q}$$

Черновик 3

$$B_{T, F} \frac{D_{inc}}{c} \cdot \eta$$

$$\eta = 3600 \text{ c}$$

$$B_{T, F} \cdot \eta = 3600 D_{inc}$$

$$0,8 = \frac{3600 W}{Q_2}$$

$$V_A = \frac{D RT_2}{P_A} = \frac{RT_2}{P_A} \cdot \frac{P_0 V_0}{RT_1} =$$

$$D = \frac{P_0 V_0}{RT_1} = \frac{P_0 V_0 T_2}{P_A T_1}$$

$$Q_2 = \frac{3600 W}{0,8} = \frac{36000 W}{8} = \frac{36000 \text{ W}}{8} = 4500 W$$

| | |
|-------|---|
| 36000 | 8 |
| 32 | |
| 40 | |
| 40 | |
| 0 | |
| 0 | |

4500

$$Q_2 \frac{C_V D^2 \Delta T^2 R}{Q_2} + A = Q_2 \quad | \cdot Q_2$$

$$Q_2^2 - A Q_2 - C_V D^2 \Delta T^2 R = 0$$

$$D = A^2 + 4 \cdot C_V D^2 \Delta T^2 R$$

$$Q_{2,1} = \frac{A + \sqrt{A^2 + 4 C_V D^2 \Delta T^2 R}}{2}$$

$$\frac{A + \sqrt{A^2 + 4 C_V D^2 \Delta T^2 R}}{2} = 4500 W$$

$$\sqrt{A^2 + 4 C_V D^2 \Delta T^2 R} = 9000 W - A$$

чертовик η

$$A^2 + 4Cv^2 \Delta T^2 R = (9000W - A)^2 - A^2$$

$$4Cv^2 \Delta T^2 R = (9000W - A - A)(9000W - A + A)$$

$$4Cv^2 \Delta T^2 R = 9000W(9000W - 2A)$$

$$\Delta T = \sqrt{\frac{9000 \cdot 775 \cdot 10^8 - 2 \cdot 113 \cdot 10^9}{4 \cdot 9000}}$$

$$\begin{array}{r} \cdot 10,10 \\ 5308 \quad | \quad 831 \\ -4986 \quad | \quad 63 \\ \hline 3220 \quad | \quad 1 \\ -2493 \\ \hline 831727 \\ \times \quad 6 \quad 831 \\ \hline 4986 \end{array}$$

$$\begin{array}{r} 9000 \\ -775 \\ \hline 45000 \\ +63000 \\ +63000 \\ \hline 6975000 \end{array}$$

$$\begin{array}{r} 45 \\ 54 \\ 63 \end{array}$$

$$= 6,975 \cdot 10^9 - 226 \cdot 10^9$$

$$\sqrt{A^2 + 4Cv^2 \Delta T^2 R} = (A - 9000W)$$

$$53,08$$

$$4Cv^2 \Delta T^2 R = (A - 9000W)^2 - A^2$$

$$\begin{array}{r} 26,54 \\ \times 2,00 \\ \hline \end{array}$$

$$4Cv^2 \Delta T^2 R = (A - 9000W - A)(A - 9000W + A)$$

~~$$i = \frac{2Cv}{R}$$~~

$$Cv = \frac{i}{2} R$$

$$i = \frac{2Cv}{R} = \frac{53,08}{8,31}$$

Черковик
5

$$\begin{array}{r} 5308 \\ 831 \\ \hline \end{array}$$

$$\begin{array}{r|l} 5308 & 2 \\ \hline 2654 & 2 \\ 1327 & \end{array}$$

$$25001154$$

$$\begin{array}{r|l} 831 & 3 \\ \hline 277 & \end{array}$$

$$\begin{array}{r} 8313 \\ \hline 6 \quad 277 \\ \hline 23 \\ -21 \\ \hline 21 \end{array}$$

$$17 \quad 107$$

$$C = \frac{i+2}{2} R$$

$$Q_2 = 4500W$$

$$\frac{C v p_0 V_0 (T_1 - T_2)}{R T_1} = A - 4500W$$

$$Q_2 = \Delta U + A_{расш} = \frac{j}{2} \Delta R \Delta T + A = \frac{C v}{R} \Delta R \Delta T + A$$

$$j = \frac{2 C v}{R}$$

$$C v = \frac{j}{2} R$$

$$\frac{j}{2} = \frac{2 C v}{R} \cdot \frac{1}{2} = \frac{C v}{R}$$

$$\Delta T = T_2 - T_1$$

$$\frac{C v}{R} \Delta R \Delta T + A = 4500W =$$

$$\Delta = \frac{p_0 V_0}{R T_1}$$

$$\frac{C v}{R} \cdot \frac{p_0 V_0}{R T_1} \cdot R \cdot \Delta T + A = 4500W$$

$$\frac{C v p_0 V_0 \Delta T}{R T_1} = 4500W - A$$

Черновик
6

$$(T_1 - T_2) = \frac{RT_1(A - 4500W)}{c_v p_0 V_0}$$

$$T_2 = T_1 - \frac{RT_1(A - 4500W)}{c_v p_0 V_0} = T_1 \left(1 - \frac{R(A - 4500W)}{c_v p_0 V_0} \right)$$

$$V_A = \frac{p_0 V_0}{p_A T_A} \cdot T_1 \left(1 - \frac{R(A - 4500W)}{c_v p_0 V_0} \right) = \cancel{p_0 V_0}$$

$$= \frac{1}{p_A} \left(p_0 V_0 - \frac{R(A - 4500W)}{c_v} \right) = \frac{1}{10^5 \frac{\text{Dnc}}{\text{m}^2 \cdot \text{K}}} \left(54 \cdot 10^5 \frac{\text{Dnc}}{\text{m}^2 \cdot \text{K}} \cdot 22 \cdot 10^3 \text{m}^3 - \right.$$

$$\left. - 8,31 \frac{\text{Dnc}}{\text{mole} \cdot \text{K}} \cdot (113 \cdot 10^9 - 4500 \cdot 775 \cdot 10^3 \text{Dnc}) \right)$$

$$26,54 \frac{\text{Dnc}}{\text{mole} \cdot \text{K}}$$

$$\begin{array}{r} 3 \\ 2 \\ 4500 \\ \times 775 \\ \hline 22500 \\ 31500 \\ \hline 3487500 \end{array}$$

$$(113 \cdot 10^9 - 3,4875 \cdot 10^9) =$$

$$= \frac{8,31 \cdot 10^9 (113 - 3,4875)}{26,54}$$

$$\frac{109,5125 \cdot 8,31 \cdot 10^9}{26,54} = \frac{1095125 \cdot 831 \cdot 10^3}{26,54} =$$

$$= \frac{1095125 \cdot 831 \cdot 10^3}{2654}$$

Церковник
7

$$V_A = 54.22 \cdot 10^3 - \frac{1095125 \cdot 831}{2654} = 1188000 -$$

$$\begin{array}{r} 1095125 \\ -10616 \\ \hline 3352 \\ -2654 \\ \hline 6985 \end{array} \quad \begin{array}{r} 2654 \\ \hline 41 \end{array}$$

$$\begin{array}{r} 74 \\ 21124 \\ \times 1095125 \\ \hline 831 \end{array}$$

$$\begin{array}{r} 1095125 \\ +3285375 \\ +8761000 \\ \hline 910048875 \end{array}$$

$$\begin{array}{r} 543 \\ 2654 \\ \times 9 \\ \hline 23886 \end{array} \quad \begin{array}{r} 543 \\ 2654 \\ \times 8 \\ \hline 21232 \end{array}$$

$$\begin{array}{r} 332 \\ 2654 \\ \times 6 \\ \hline 15924 \end{array} \quad \begin{array}{r} 432 \\ 2654 \\ \times 7 \\ \hline 18578 \end{array}$$

$$\begin{array}{r} 54 \\ \times 22 \\ \hline 321 \\ 2654108 \\ \hline 41188 \\ \times 221 \\ \hline 22816 \\ 2654 \\ \hline 10616 \end{array} \quad \begin{array}{r} 111 \\ 2654 \\ \times 3 \\ \hline 7962 \end{array}$$

$$8 \quad 16+4 = 20 \quad \begin{array}{r} 11 \\ 2654 \\ \times 2 \\ \hline 5308 \end{array}$$

$$\begin{array}{r} 910048875 \\ -7962 \\ \hline 11384 \\ -10616 \\ \hline 7688 \\ -5308 \\ \hline 23888 \\ -21232 \\ \hline 25767 \\ -23886 \\ \hline 18815 \\ -18578 \\ \hline 237010 \\ 23700 \\ -21232 \\ \hline 24680 \end{array} \quad \begin{array}{r} 2654 \\ \hline 342897,089 \approx \\ \hline \approx 342897,09 \end{array}$$

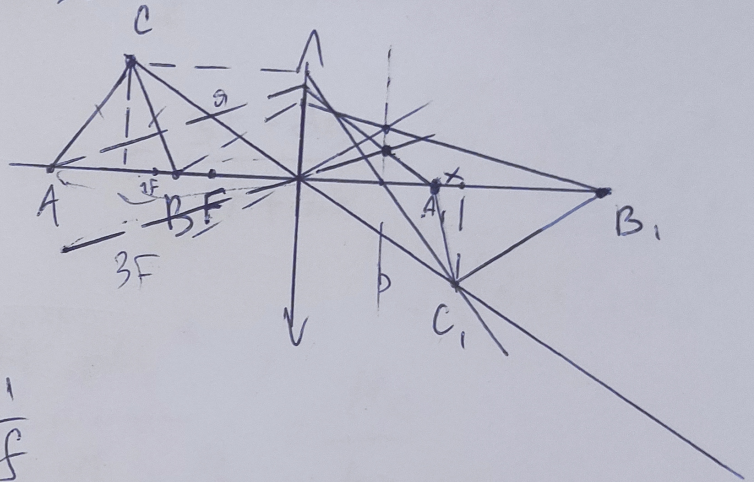
Черновик
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$$\begin{array}{r}
 \overset{10}{1} \overset{10}{8} \overset{10}{0} \overset{10}{0} \overset{10}{0} \overset{10}{0} \\
 - 342897,09 \\
 \hline
 845102,91
 \end{array}$$

Ответ: $\approx 845102,91 \mu^3$

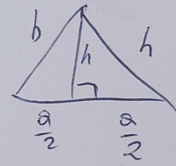
$F = 0,1 \mu$

1/3.



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

$$S_{\text{тр}} = \frac{(3F - dB) \cdot Hc}{2} = \frac{hc \cdot (f_B - f_A)}{2}$$



$$\frac{\frac{a}{2} \cdot h}{2} = \frac{ah}{4}$$

$$(3F - dB) Hc = hc \cdot (f_B - f_A)$$

$$\frac{Hc}{hc} = \frac{3F - dB}{f_A + x}$$

$$\frac{1}{f_A} = \frac{1}{F} - \frac{1}{3F} = \frac{2}{3F}$$

$$f_A = \frac{3F}{2} = 1,5F$$

$$\frac{1}{f_B} = \frac{1}{F} - \frac{1}{dB} = \frac{dB - F}{FdB}$$

$$f_B = \frac{FdB}{dB - F}$$

Черковик
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$$(3F - dB)Mc = hc \approx \left(\frac{FdB}{dB - F} - 1,5F \right)$$

$$a = \sqrt{\left(\frac{3F + dB}{2} \right)^2 + Mc^2}$$

$$b = \sqrt{\left(f_{A+X} \right)^2 + hc^2}$$

$$\frac{3F - dB}{2} : (f_{A+X}) = \frac{3F - dB}{2(f_{A+X})} =$$

$$= \frac{3F - dB}{3F + 2X} = \frac{\sqrt{\left(\frac{3F - dB}{2} \right)^2 + Mc^2}}{\sqrt{\left(f_{A+X} \right)^2 + hc^2}}$$

$$\frac{(3F - dB)^2}{(3F + 2X)^2} = \frac{\left(\frac{3F - dB}{2} \right)^2 + Mc^2}{\left(f_{A+X} \right)^2 + hc^2} = \frac{Mc}{hc}$$

$$(3F - dB) \cdot \frac{3F - dB}{3F + 2X} = \frac{FdB}{dB - F} - 1,5F$$

$$x = f_c$$

$$\frac{1}{f_c} = \frac{1}{F} - \frac{1}{\frac{3F - dB}{2} + dB}$$

$$\frac{1}{f_c} = \frac{1}{F} - \frac{2}{3F + dB} = \frac{3F + dB - 2F}{F(3F + dB)}$$

$$f_c = \frac{3F^2 + dB F}{F + dB} = \frac{F(3F + dB)}{F + dB} : \frac{3F + dB}{2} = \frac{2}{3F + dB}$$

$$\frac{3F - dB + 2dB}{2} = \frac{3F + dB}{2}$$

Меркуев
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$$(3F - dB) \cdot \frac{3F - dB}{3F + 2 \cdot \frac{F(3F + dB)}{F + dB}} = \frac{F dB}{dB - F} - 1,5F$$

$$\frac{(F + dB) \cdot 2F(3F + dB)}{3F + \frac{F(3F + dB)}{F + dB}} = \frac{3F^2 + 3F dB + F^2 + 2F dB}{F + dB}$$

$$\frac{(3F - dB)^2 (F + dB) \cancel{(3F - dB)}}{9F^2 + 5F dB} = \frac{F dB - 1,5F dB + 1,5F^2}{dB - F}$$

$$(dB - F)(dB + F)$$

$$(dB^2 - F^2)(3F - dB)^2 = F(9F + 5dB)F(dB - 1,5dB + 1,5F)$$

$$(dB^2 - F^2)(3F - dB)^2 = F^2(9F + 5dB)(1,5F - 0,5dB)$$

$$\frac{12}{11} \approx 1,0909 \approx 1,091 \approx 1,09$$

$$\begin{array}{r} 10 \\ 100 \\ -99 \\ \hline 10 \\ 100 \\ -99 \\ \hline 1 \end{array}$$

Мерников

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