



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

ОЛИМПИАДНАЯ РАБОТА

Наименование олимпиады школьников: **«Ломоносов»**

Профиль олимпиады: **Инженерные науки**

ФИО участника олимпиады: **Белецкий Максим Олегович**

Класс: **10**

Технический балл: **78**

Дата проведения: **01 марта 2022 года**

РЕЗУЛЬТАТ ПРОВЕРКИ

Задача 1	Задача 2	Задача 3	Задача 4	Всего
24	20	25	9	78

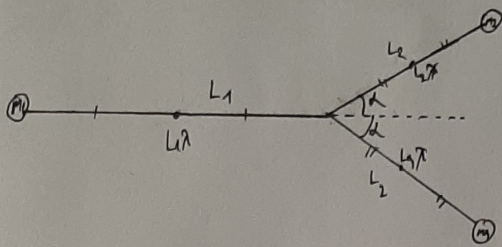
Задача 1 Чистовик

Граница 1

Отсутствует горизонтальной накрутки на ось означает, что сила, действующая на центр масс катушки находится на оси вращения катушки.

Полюса:

$$L_1 m_1 + L_2 \lambda \cdot \frac{L_1}{2} = 2 L_2 \cos(\alpha) m_2 + L_2 \lambda \frac{L_2 \cos(\alpha)}{2} + L_2 \cos(\alpha) m_3 + L_2 \lambda \frac{L_2 \cos(\alpha)}{2} = 2 \cos(\alpha) \left(L_2 m_2 + \frac{L_2^2 \lambda}{2} \right)$$



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

$$\frac{\lambda}{2} L_2^2 + m_2 L_2 - \frac{L_1 (m_1 + \frac{\lambda L_1}{2})}{2 \cos(\alpha)} = 0$$

$$L_2 = \frac{-m_2 + \sqrt{m_2^2 + 4 \cdot \frac{\lambda}{2} \cdot \frac{L_1 (m_1 + \frac{\lambda L_1}{2})}{2 \cos(\alpha)}}}{\lambda} = \frac{-m_2 + \sqrt{m_2^2 + \lambda \cdot \frac{L_1 (m_1 + \frac{\lambda L_1}{2})}{\cos(\alpha)}}}{\lambda}$$

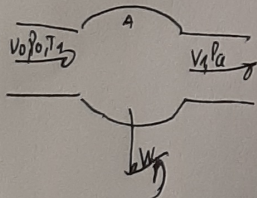
$$\tan(\alpha) = \frac{3}{4} \Rightarrow \cos(\alpha) = \frac{4}{\sqrt{25}} = \frac{4}{5}$$

$$L_2 = \frac{-30 + \sqrt{30^2 + 20 \cdot \frac{1(50 + 20 \cdot 1)}{\frac{4}{5}}}}{20} = \frac{\sqrt{30^2 + \frac{5000}{4}} - 30}{20} = \frac{\sqrt{30^2 + 1250} - 30}{20}$$

$$= \frac{\sqrt{24} - 30}{20} = \sqrt{6} - \frac{3}{2} \approx 1,15 \text{ метра}$$

Ответ: L_2 должно быть равно $(\sqrt{6} - \frac{3}{2})$ метра $\approx 1,15$ метра

Задача 2



$$\Delta Q = \Delta U + A$$

$$\Delta Q = \frac{W}{\eta}$$

$$\Delta U = \frac{1}{2} \nu R \nu \Delta T$$

$$C_V = \frac{1}{2} \nu R \Rightarrow \Delta U = C_V \nu \Delta T$$

$$\Delta T = T_2 - T_1 = \frac{V_2 p_2}{\nu R} - T_1 \quad \left. \begin{array}{l} \Delta T = T_2 - T_1 = \frac{V_2 p_2}{\nu R} - T_1 \\ \nu R = \frac{V_0 p_1}{T_1} \end{array} \right\} \Delta T = T_1 \left(\frac{V_2 p_2}{V_0 p_1} - 1 \right)$$

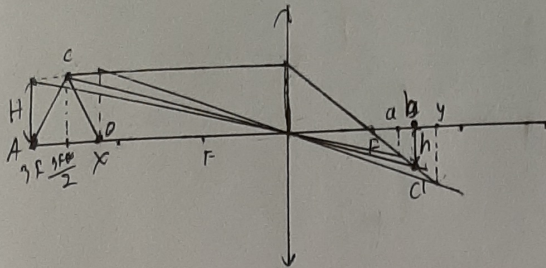
$$\nu = \frac{V_0 p_1}{R T_1} \Rightarrow \Delta U = C_V \frac{V_0 p_1}{R T_1} T_1 \left(\frac{V_2 p_2}{V_0 p_1} - 1 \right) = C_V \frac{V_2 p_2 - V_0 p_1}{R}$$

$$\frac{W}{\eta} = C_V \frac{V_2 p_2 - V_0 p_1}{R} + A \Rightarrow V_2 = V_0 \frac{p_1}{p_2} - \frac{(\eta A W) R}{\eta C_V p_2}$$

$$= 22 \cdot 10^3 \cdot \frac{54000}{100} - \frac{(0,8 \cdot 113 \cdot 10^7 + 0,775 \cdot 10^3 \cdot 2400) \cdot 8,314}{0,8 \cdot 26,54 \cdot 100 \cdot 10^3} \approx 866,1 \cdot 10^7 \text{ м}^3$$

Ответ: за час передается $866,1 \cdot 10^7 \text{ м}^3$ газа

Угловая
Задача 13



Из формулы тонкой линзы:

$$\frac{3F+x}{2H} = \frac{b}{h} \quad \left. \begin{array}{l} 3F+x = \frac{b}{h}H \\ \frac{F}{H} = \frac{b-F}{h} \end{array} \right\} \Rightarrow \frac{3F+x}{2} = \frac{b-F}{h} \Rightarrow (3F+x)(h) = 2b(F) \Rightarrow$$

$$\frac{F}{H} = \frac{b-F}{h} \Rightarrow b = F \frac{3F+x}{F+H}$$

$$\frac{3F}{a} = \frac{F}{a-F} \Rightarrow 3aF - 3F^2 = aF \Rightarrow a = \frac{3F}{2}$$

$$\frac{x}{y} = \frac{F}{y-F} \Rightarrow xy = F(x+y) \Rightarrow y = \frac{xF}{x-F}$$

Угловая левая в показе:

$$(3F-x)H = h(y-a)$$

$$\frac{3F-x}{y-a} = \frac{h}{H} = \frac{2b}{3F+x}$$

$$\frac{3F-x}{\frac{xF}{x-F} - \frac{3F}{2}} = \frac{2F \frac{3F+x}{F+x}}{3F+x}$$

$$\frac{2(3F-x)(x-F)}{3F^2 - xF} = \frac{2F}{F+x}$$

$$\frac{2(x-F)}{F} = \frac{2F}{F+x}$$

$$2(x-F)(x+F) = 2F^2$$

$$x^2 - F^2 = F^2$$

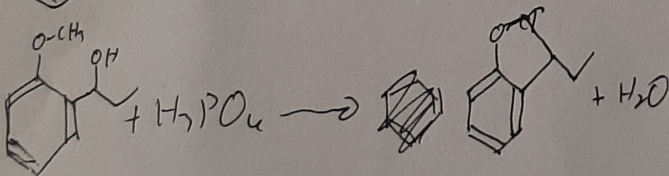
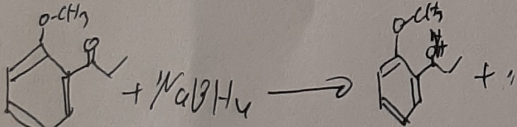
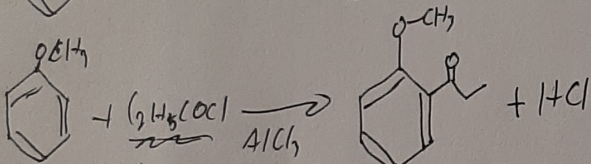
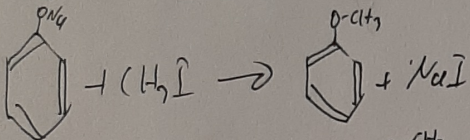
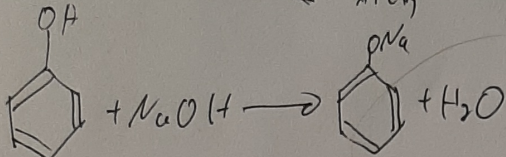
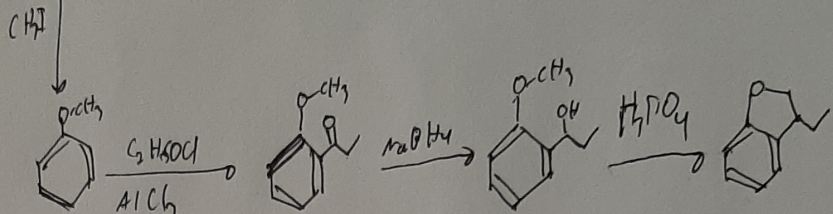
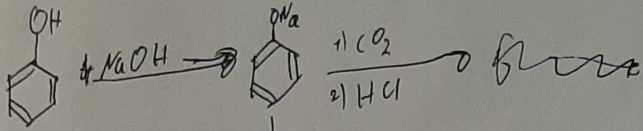
$$x^2 = 2F^2$$

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

Составим $\triangle ABC$, по в.м. $3F-x = (3-\sqrt{2})F \approx (3-\sqrt{2}) \cdot 10 \text{ см} \approx 13,85 \text{ см}$

Отв: $AB = (3-\sqrt{2})F \approx 13,85 \text{ см}$

Установи
последовательность

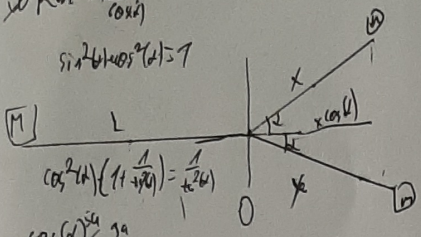


лусі-1

Червонок стл 1

$$\frac{2m \cos(\alpha) X + 2\lambda \cos(\alpha) X}{2} = \frac{1}{2} L + \frac{1}{2} L \lambda$$

$$\frac{2m^2 R_m \sin(\alpha)}{\cos(\alpha)}$$



$$\cos^2(\alpha) \left(1 + \frac{1}{\lambda}\right) = \frac{1}{\lambda^2}$$

$$LML \neq \frac{L^2 \lambda}{2} = 2 \left(\frac{m \lambda \cos(\alpha)}{2} + \frac{\lambda^2 \cos(\alpha)}{2} \right)$$

$$2ML + L^2 \lambda = 4m \lambda \cos(\alpha) + 2\lambda^2 \cos(\alpha)$$

$$x = \frac{-2m \cos(\alpha) + \sqrt{(2m \cos(\alpha))^2 + 2\lambda \cos(\alpha) \cdot (2ML + L^2 \lambda)}}{2\lambda \cos(\alpha)}$$

$$\cos(\alpha) = \frac{4}{5} = 0.8$$

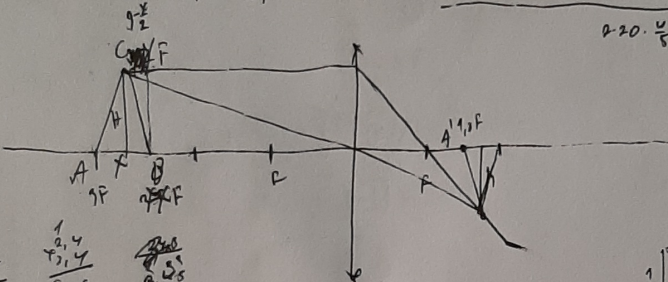
$$2 \cdot 90 \cdot \frac{4}{5} x + 2x^2 \cdot 20 \cdot \frac{4}{5} = 504 + \frac{4x^2 \cdot 20}{2}$$

$$80 \cdot 48x + 16x^2 = 60$$

$$4x^2 + 12x + 15 = 0$$

$$x = \frac{-6 \pm \sqrt{6^2 + 15}}{4} = \frac{-6 + \sqrt{36 + 15}}{4} = \frac{-6 + \sqrt{51}}{4} = \frac{-6 + 7.14}{4} = \frac{1.14}{4} = 0.285$$

$$x = \frac{-2 \cdot 90 \cdot \frac{4}{5} + \sqrt{(2 \cdot 90 \cdot \frac{4}{5})^2 + 2 \cdot 20 \cdot \frac{4}{5} \cdot (2 \cdot 504 + 20 \cdot L^2)}}{2 \cdot 20 \cdot \frac{4}{5}}$$



2	1	2
20,5	2,4	20,5
20,5	2,4	20,5
12,5	9,6	12,5
50	48	50
6,25	5,96	6,25

$$\frac{H}{2} = \frac{2H}{(2+x)} = \frac{h}{4}$$

$$\frac{985,5462}{-89,62} = \frac{126,54}{137,1380}$$

$$\frac{189,54}{185,78} = \frac{3,566}{2,604}$$

$$\frac{0,4722}{0,7962} = \frac{116,00}{106,16}$$

$$\frac{0,4722}{1,1600} = \frac{106,16}{99,840}$$

$$\frac{1,1600}{1,1600} = \frac{106,16}{106,16}$$

$$\frac{1,1600}{1,1600} = \frac{106,16}{106,16}$$

$$\frac{1,1600}{1,1600} = \frac{106,16}{106,16}$$

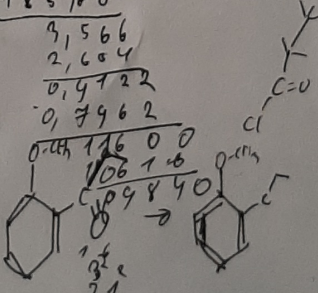
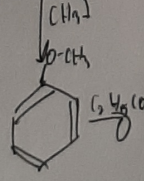
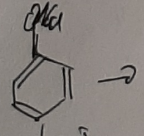
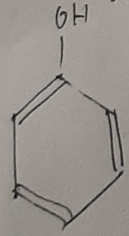
$$\frac{1,1600}{1,1600} = \frac{106,16}{106,16}$$

$$\frac{1,1600}{1,1600} = \frac{106,16}{106,16}$$

$$\frac{1,1600}{1,1600} = \frac{106,16}{106,16}$$

$$\frac{1,1600}{1,1600} = \frac{106,16}{106,16}$$

$$S = Hx = h x'$$



$$\frac{54}{22} = \frac{108}{44}$$

$$\frac{108}{1188}$$

$$\frac{12}{1,13} = \frac{98}{107,14}$$

$$90,4 \cdot 10^9 + 27,9 \cdot 10^9$$

$$= 118,3 \cdot 10^9$$

$$\frac{221}{441} = \frac{275}{26}$$

$$\frac{4650}{2105} = \frac{12964}{12964}$$

$$\frac{12964}{12964} = \frac{12964}{12964}$$

$$\frac{12964}{12964} = \frac{12964}{12964}$$

$$\frac{26,54}{53,08} = \frac{78,62}{106,16}$$

$$\frac{78,62}{106,16} = \frac{132,70}{159,24}$$

$$\frac{132,70}{159,24} = \frac{185,78}{210,92}$$

$$\frac{185,78}{210,92} = \frac{238,86}{312,40}$$

$$\frac{238,86}{312,40} = \frac{478,2}{624,8}$$

$$\frac{478,2}{624,8} = \frac{1183}{1562}$$

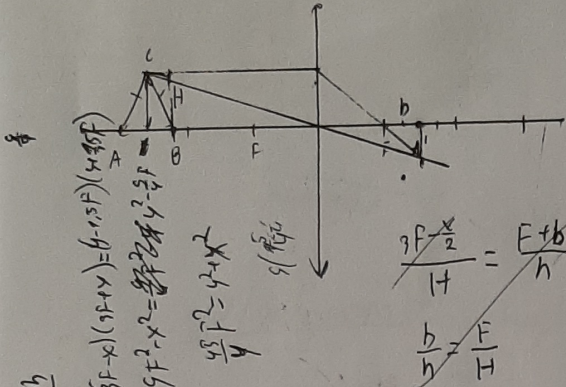
$$\frac{1183}{1562} = \frac{3549}{4784}$$

$$\frac{3549}{4784} = \frac{9484}{9855462} \cdot 10^9$$

$$\frac{9484}{9855462} \cdot 10^9 = 28204$$

Чертовое сгн 2

лус 2



$$\frac{(3F-x)H}{2} = \frac{(4-1.5F)h}{2}$$

$$\frac{H}{h} = \frac{4-1.5F}{3F-x}$$

$$(3F-x)h = (4-1.5F)H$$

$$3Fh - xh = 4H - 1.5FH$$

$$3Fh - xh + 1.5FH = 4H$$

$$4.5Fh - xh = 4H$$

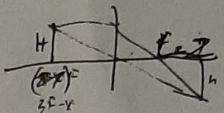
$$h(4.5F - x) = 4H$$

$$h = \frac{4H}{4.5F - x}$$

$$\frac{3F-x}{4} = \frac{F+z}{h}$$

$$\frac{h}{4} = \frac{F+z}{3F-x}$$

$$\frac{h}{F} = \frac{F+z}{3F-x}$$

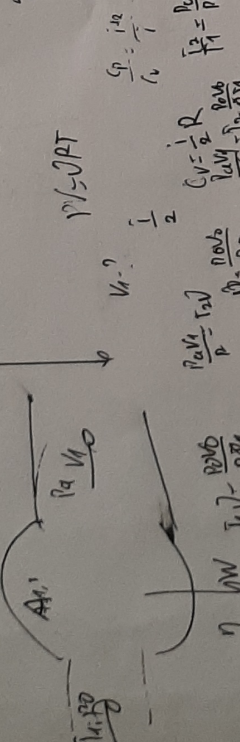
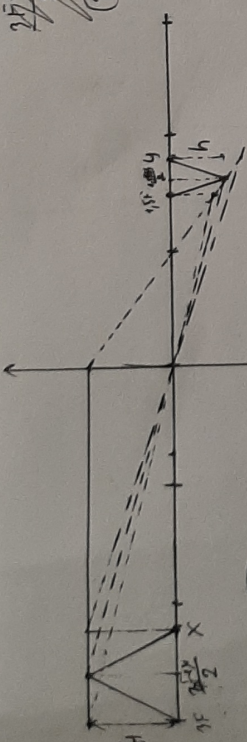


$$\frac{3F-x}{4} = \frac{F+z}{h}$$

$$\frac{h}{4} = \frac{F+z}{3F-x}$$

$$\frac{h}{F} = \frac{F+z}{3F-x}$$

0.01. 9. 5. 4. 6 = 0.01. 0. 5. 4. 6



$$\frac{3F-x}{4} = \frac{F+z}{h}$$

$$\frac{h}{4} = \frac{F+z}{3F-x}$$

$$\frac{h}{F} = \frac{F+z}{3F-x}$$

$$10F^2x - 12Fx^2 + 2x^3 = 6F^2x - 8F^3$$

$$4F^2x - 12Fx^2 + 2x^3 = 6F^2x - 8F^3$$

$$-8F^2x - 12Fx^2 + 2x^3 = 6F^2x - 8F^3$$

$$-14F^2x - 12Fx^2 + 2x^3 = 6F^2x - 8F^3$$

$$-20F^2x - 12Fx^2 + 2x^3 = 6F^2x - 8F^3$$

$$-26F^2x - 12Fx^2 + 2x^3 = 6F^2x - 8F^3$$

$$-32F^2x - 12Fx^2 + 2x^3 = 6F^2x - 8F^3$$

$$-38F^2x - 12Fx^2 + 2x^3 = 6F^2x - 8F^3$$

$$-44F^2x - 12Fx^2 + 2x^3 = 6F^2x - 8F^3$$

$$-50F^2x - 12Fx^2 + 2x^3 = 6F^2x - 8F^3$$

$$-56F^2x - 12Fx^2 + 2x^3 = 6F^2x - 8F^3$$

$$-62F^2x - 12Fx^2 + 2x^3 = 6F^2x - 8F^3$$

$$-68F^2x - 12Fx^2 + 2x^3 = 6F^2x - 8F^3$$

$$-74F^2x - 12Fx^2 + 2x^3 = 6F^2x - 8F^3$$

$$-80F^2x - 12Fx^2 + 2x^3 = 6F^2x - 8F^3$$

$$-86F^2x - 12Fx^2 + 2x^3 = 6F^2x - 8F^3$$

$$-92F^2x - 12Fx^2 + 2x^3 = 6F^2x - 8F^3$$

$$-98F^2x - 12Fx^2 + 2x^3 = 6F^2x - 8F^3$$

$$-104F^2x - 12Fx^2 + 2x^3 = 6F^2x - 8F^3$$

$$-110F^2x - 12Fx^2 + 2x^3 = 6F^2x - 8F^3$$

$$-116F^2x - 12Fx^2 + 2x^3 = 6F^2x - 8F^3$$

$$-122F^2x - 12Fx^2 + 2x^3 = 6F^2x - 8F^3$$

$$-128F^2x - 12Fx^2 + 2x^3 = 6F^2x - 8F^3$$

$$-134F^2x - 12Fx^2 + 2x^3 = 6F^2x - 8F^3$$

$$-140F^2x - 12Fx^2 + 2x^3 = 6F^2x - 8F^3$$

$$-146F^2x - 12Fx^2 + 2x^3 = 6F^2x - 8F^3$$

$$-152F^2x - 12Fx^2 + 2x^3 = 6F^2x - 8F^3$$

$$-158F^2x - 12Fx^2 + 2x^3 = 6F^2x - 8F^3$$

$$-164F^2x - 12Fx^2 + 2x^3 = 6F^2x - 8F^3$$

$$-170F^2x - 12Fx^2 + 2x^3 = 6F^2x - 8F^3$$

$$-176F^2x - 12Fx^2 + 2x^3 = 6F^2x - 8F^3$$

$$-182F^2x - 12Fx^2 + 2x^3 = 6F^2x - 8F^3$$

$$-188F^2x - 12Fx^2 + 2x^3 = 6F^2x - 8F^3$$

$$-194F^2x - 12Fx^2 + 2x^3 = 6F^2x - 8F^3$$

$$-200F^2x - 12Fx^2 + 2x^3 = 6F^2x - 8F^3$$

$$\Delta Q = pU + A$$

$$\frac{-W}{\eta} = \frac{pU + A}{\eta}$$

$$\frac{-W}{\eta} = \frac{pU + A}{\eta}$$

$$\frac{-W}{\eta} = \frac{pU + A}{\eta}$$

$$\frac{pU + A}{\eta} = \frac{pU + A}{\eta}$$

$$54V_0 - 84V_0 = 54V_0 - 84V_0$$

$$54V_0 - 84V_0 = 54V_0 - 84V_0$$

$$\begin{array}{r} 22 \\ 1188 \end{array}$$

$$\begin{array}{r} 1,13 \\ 1,08 \\ \hline 0,05 \end{array}$$

$$\begin{array}{r} 2,27 \\ 4650 \\ \hline 2325 \\ 98 \end{array}$$

$$\begin{array}{r} 21,4 \\ 24,2 \\ 24,2 \\ \hline 48,4 \\ 26,54 \\ 0,8 \\ \hline 21,2724706 \\ 48,54 \\ \hline 31,90929 \\ 2,47 \\ \hline 34,379 \\ 48,6 \\ \hline 0,46 \end{array}$$

$$\begin{array}{r} 1247 \\ 484 \\ \hline 968 \\ 484 \\ \hline 584 \\ 1188 \\ \hline 321,9 \\ \hline 166,1 \end{array}$$

$$1188 \cdot 10^3 - (6,504 \cdot 10^{11} + 2750 \cdot 10^9) \cdot 2325 = 21,272 \cdot 10^5$$

$$3F - 1,761F = 1,299F = 1,299 \cdot 10^4$$

$$585,64$$

$$1188 \cdot 10^3 - \frac{10^9(904 + 2750)}{21,272 \cdot 10^5} = 10^3(1188 - \frac{831,9}{21,272}) = 10^3(1188 - 39,1) = 866,1 \cdot 10^3$$

$$\frac{3F}{4} =$$

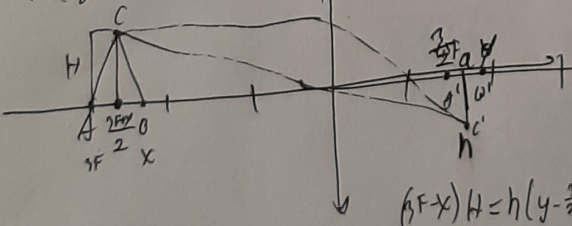
$$\frac{4a}{3F-x} = \frac{F+y}{b} = \frac{F}{b-F}$$

$$\frac{xF}{3F-x} = \frac{F}{b-F} = \frac{y}{b-F}$$

$$\frac{2xF - 3F(x-F)}{(3F-x)(x-F)} = \frac{F}{b-F} = \frac{y}{b-F}$$

$$\frac{3F - Fa}{2(3F-x)(x-F)} = \frac{F}{b-F} = \frac{y}{b-F}$$

$$F^2(x-F) = 2$$



$$\frac{x}{F} = \frac{y}{7F}$$

$$xy - xF = yF$$

$$xy = F(x+y)$$

$$y(x-F) = xF$$

$$y = \frac{xF}{x-F}$$

$$(F-x)H = h(y - \frac{3}{2}F)$$

$$\frac{3F+x}{2H} = \frac{a}{h}$$

$$\frac{F}{h} = \frac{a-F}{h}$$

$$\frac{3F+x}{2a} = \frac{h}{a-F} = \frac{F}{a-F} = \frac{y-3F}{2F-x}$$

$$(3F+x)(a-F) = 2Fa$$

$$3Fa + xa - 3F^2 - xF = 2Fa$$

$$a(F+x) = F(3F+x)$$

$$a = F \frac{3F+x}{F+x}$$

$$\begin{array}{r} 2,27 \\ 69 \\ \hline 46 \\ 524 \\ \hline 524 \end{array}$$

$$\begin{array}{r} 2,27 \\ 69 \\ \hline 46 \\ 524 \\ \hline 524 \end{array}$$

$$3563 \quad 5x^2 - 12Fx - 3F^2 = -4x^2 + 10x + \frac{1}{2}F$$

$$9x^2 - 14x - 75F^2 = 0$$

$$\frac{3F+x}{2} = F \frac{3F+x}{F+x} \quad x = \frac{2F \pm \sqrt{4F^2 + 50F^2}}{5} = \frac{2F \pm \sqrt{54}F}{5}$$

$$\frac{3F+2x}{4} = F \frac{3F+x}{F+x} \quad 58,5$$

$$\frac{3F(x-F) + 2xF}{4} = F \frac{3F+x}{F+x} \quad 400$$

$$(x-F - 3F^2)(F+x) = F \cdot 4 \cdot (3F+x)$$

$$F(x-3F)(F+x) = 4F(3F+x)$$

Черновик с/р 4

Лист 4

$$\frac{3F-x}{4-a} = \frac{3F+x}{2b}$$

$$\frac{3F-x}{4-a} = \frac{2b}{3F+x}$$

$$\frac{3F-x}{\frac{4F-x}{2}} = \frac{3F+x}{\frac{2F+x}{2}} = \frac{F+x}{2F}$$

$$\frac{3F-x}{\frac{4F-x}{2}} = \frac{2F \cdot \frac{3F+x}{F+x}}{2F+x} = \frac{2F}{F+x}$$

$$\frac{(3F-x)(x-F)}{2xF - 3Fx + 3F^2} = \frac{F+x}{2F}$$

$$\frac{2(3F-x)(x-F)}{9F^2 - 2xF} = \frac{2F}{F+x}$$

$$\begin{array}{r} 9 \\ \times 3 \\ \hline 1,76 \\ \times 1,76 \\ \hline 1098 \\ 1232 \\ 176 \\ \hline 30976 \end{array}$$

$$\frac{(3F-x)(x-F)}{9F^2 - 2xF} = \frac{F+x}{2F}$$

$$\frac{2(x-F)}{F^2} = \frac{2F}{F+x}$$

$$\frac{4(x-F)}{F^2} = \frac{F+x}{2F}$$

$$4(x-F) = F+x$$

$$3x = 3F$$

$$x = F$$

$$2x^2 - 2F^2 = 2F^2$$

$$2x^2 = 4F^2$$

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

$$\begin{array}{r} 1,41 \\ \times 1,41 \\ \hline 141 \\ 564 \\ 141 \\ \hline 1,9881 \end{array}$$

$$\begin{array}{r} 1,42 \\ \times 1,42 \\ \hline 142 \\ 568 \\ 142 \\ \hline 2,0164 \end{array}$$

1,585

$$\begin{array}{r} 22 \\ \times 22 \\ \hline 44 \\ 44 \\ \hline 484 \end{array}$$

$$\begin{array}{r} 1415 \\ \times 1415 \\ \hline 1415 \\ 5660 \\ 1415 \\ \hline 2002225 \end{array}$$