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92-40-81-45
(114.2)

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вернулся в 14:59 ТМ

МОСКОВСКИЙ ГОСУДАРСТВЕННЫЙ УНИВЕРСИТЕТ
имени М.В.ЛОМОНОСОВА

Вариант 10

город Москва

ПИСЬМЕННАЯ РАБОТА

Олимпиада школьников „Покори воробьёвы горы!"

по физике

Шапчица Михаила Александровича
фамилия, имя, отчество (в родительном падеже)

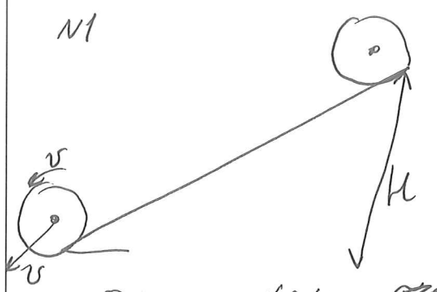
ЛЕШИФР.

Дата
«04» апреля 2025 года

Подпись участника

Черновик

№1

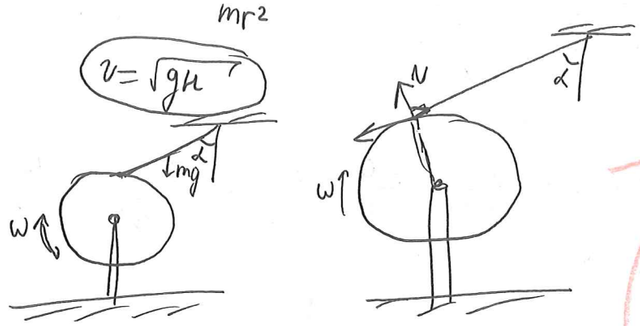


① $mgH = E_k = E_{ум} + E_{в\,со\,ум} =$

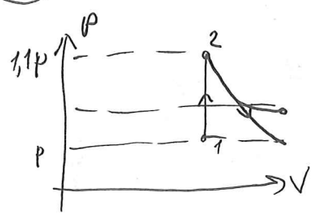
$= \frac{mv^2}{2} + \frac{J\cdot\omega^2}{2} = mv^2$

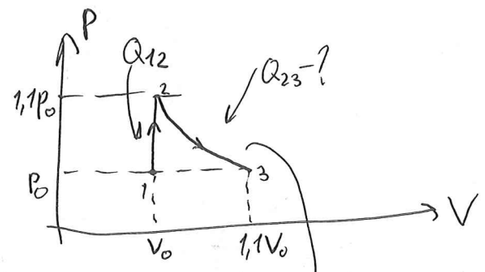
mr^2

② $v = \sqrt{gH}$



№2





$Q_{12} = C_V \nu R \Delta T = C_V \cdot 0{,}1 PV = \frac{3}{2} 0{,}1 P_0 V_0$

$P \cdot V = 1{,}1 P_0 V_0$

$Q_{23} = A_{23} = \int P dV = 1{,}1 P_0 V_0 \int_{V_0}^{1{,}1V_0} \frac{dV}{V} = 1{,}1 P_0 V_0 \cdot \ln 1{,}1$

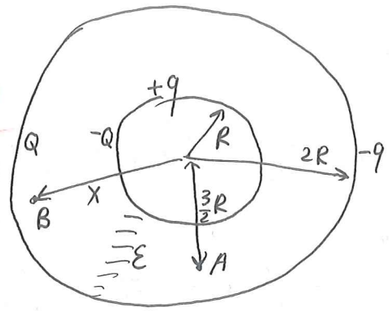
$Q_{23} = Q_{12} \cdot \frac{1{,}1 \cdot \ln 1{,}1}{\frac{3}{2}} = \frac{Q_{12}}{3} \cdot 22 \cdot \ln 1{,}1$

Подписывать лист-вкладыш запрещается! Писать на полях листа-вкладыша запрещается!

92-40-81-45 (114.2)

Чистовик

№3



①

1) $\pm Q \rightarrow$ поляризованные заряды диэлектрика

2) $E_B(x) = \frac{kq}{x} - \frac{kQ}{x} = \frac{kq}{x \cdot \varepsilon}$

$q - Q = \frac{q}{\varepsilon}$

3) $\varphi_A = \frac{kq}{\frac{3}{2}R} - \frac{kQ}{\frac{3}{2}R} + \frac{kQ}{2R} - \frac{kq}{2R} = \frac{2}{3}\frac{k}{R}(q - Q) - \frac{k}{2R}(q - Q) =$

$= \frac{k}{6R} \cdot \frac{q}{\varepsilon}$

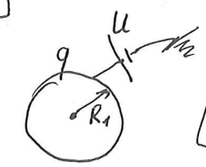
Ответ: $\varphi_A = \frac{1}{6} \frac{kq}{R \cdot \varepsilon}$

Σ = 99

3	4	5	20
	5		20
2	4		20
1	5		20
11	1		20
	1		3

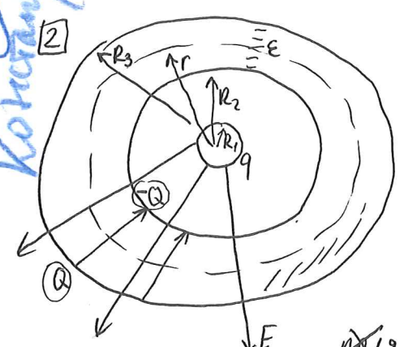
Комментарии (замечания)

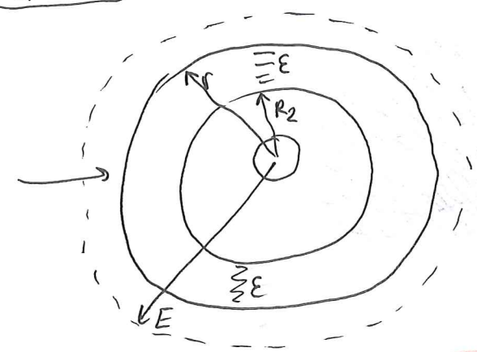
②



[1] $\frac{kq}{R_1} = U$

[2]





1) W_1 → энергия удалённого куска

$W_1 = \int_r^{R_3} w dV = \int_r^{R_3} \frac{\varepsilon_0 \cdot \varepsilon}{2} \cdot E^2(R) d\left(\frac{4}{3}\pi R^3\right) = \int_r^{R_3} \frac{\varepsilon_0 \varepsilon}{2} \cdot 4\pi R^2 \cdot dR \cdot \frac{kq}{\varepsilon R^2} =$

$= \frac{\varepsilon \cdot kq}{2k}(R_3 - r)$

$W_2 = \frac{kq}{2k}(R_3 - r)$

$A = -\Delta W = \frac{(\varepsilon - 1)}{2k}(R_3 - r) \cdot R_1 U =$

Подписывать лист-вкладыш запрещается! Писать на полях листа-вкладыша запрещается!

1) W_1 — энергия поля в удалённом куске.

$$W_1 = \int_r^{R_3} w \cdot dV = \int_r^{R_3} 4\pi R^2 \cdot dR \cdot \frac{\varepsilon_0 \varepsilon}{2} \cdot E^2(R) = \int_r^{R_3} 4\pi R^2 dR \cdot \frac{\varepsilon_0 \varepsilon}{2} \cdot \left(\frac{kq}{\varepsilon R^2}\right)^2 =$$

$$= \int_r^{R_3} 4\pi R^2 \cdot \frac{\varepsilon_0}{2} \cdot dR \cdot \frac{k^2 q^2}{\varepsilon^2 R^4} = \int_r^{R_3} \frac{kq^2}{2\varepsilon} \cdot \frac{1}{R^2} dR = \frac{kq^2}{2\varepsilon} \cdot \left(\frac{1}{r} - \frac{1}{R_3}\right) =$$

$$= \frac{kq^2}{2\varepsilon} \cdot \frac{R_3 - r}{r R_3}$$

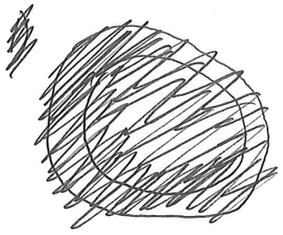
W_2 — энергия поля после удаления

$$W_2 = \frac{kq^2}{2} \frac{R_3 - r}{r R_3}$$

$$A = \Delta W = \frac{\varepsilon - 1}{\varepsilon} \cdot \frac{kq^2}{2} \frac{R_3 - r}{R_3 r} = \left[kq = U R_1\right] = \frac{\varepsilon - 1}{2\varepsilon \cdot k} \cdot U^2 \cdot \frac{R_3 - r}{R_3 r} \cdot R_1^2 =$$

$$= \frac{3}{8 \cdot 9 \cdot 10^9} \cdot 120^2 \cdot \frac{0{,}1}{6 \cdot 0{,}5} \cdot \frac{1}{25} = \frac{1}{8 \cdot 3 \cdot 10^9} \cdot 120^2 \cdot \frac{1}{25 \cdot 3} = \frac{(8 \cdot 4 \cdot 10)^2}{8 \cdot 8 \cdot 25 \cdot 10^9} =$$

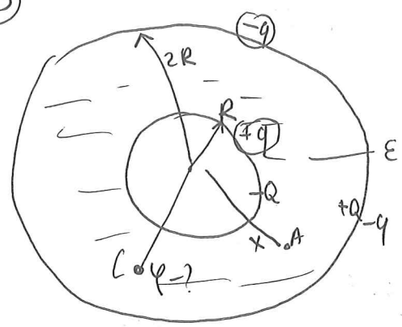
$$= \frac{10^4 \cdot 2}{25 \cdot 10^9} = 8 \cdot 10^{-9}\ \text{Дж}$$



Подписывать лист-вкладыш запрещается! Писать на полях листа-вкладыша запрещается!

Черновик

№3



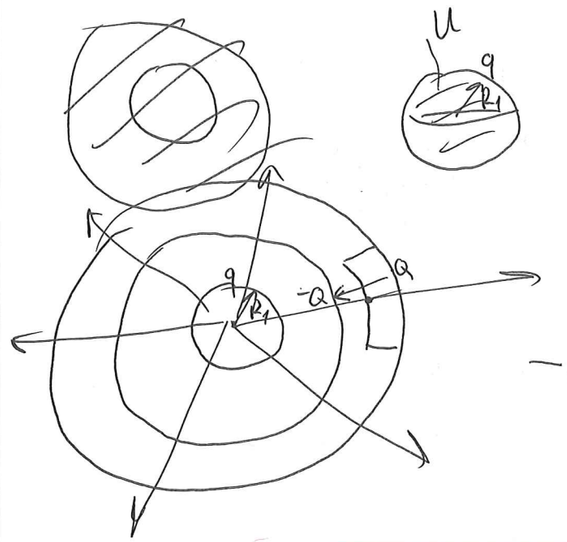
$$\varphi_A = \frac{kq}{xR} - \frac{kQ}{x} = \frac{kq}{Rx \cdot \varepsilon}$$

$$q - Q = \frac{q}{\varepsilon}$$

$$Q = q - \frac{q}{\varepsilon} = q\frac{\varepsilon - 1}{\varepsilon}$$

$$\varphi_C = \frac{kq}{\frac{3}{2}R} - \frac{kq}{2R} + \frac{kQ}{2R} - \frac{kQ}{\frac{3}{2}R} = \frac{kq \cdot 2}{\varepsilon \cdot \frac{3}{2}R} - \frac{k \cdot q}{2R \cdot \varepsilon} =$$

$$\frac{2^2}{3} - \frac{1^3}{2} = \frac{1}{6}\frac{kq}{R\varepsilon}$$



$$\varphi = \frac{kq}{R_1} = U$$

$$\frac{\varepsilon_0 \varepsilon E^2}{2}$$

$$\mathcal{E}_1 = \int w dV$$

$$F = \frac{U}{d}$$

$$W = \frac{U^2 C}{2}$$

$$C = \frac{\varepsilon_0 \varepsilon S}{d}$$

$$W = \frac{\varepsilon_0 \varepsilon E^2}{2}$$

Подписывать лист-вкладыш запрещается! Писать на полях листа-вкладыша запрещается!

Гершовик

№3

W-?

$W_C = \frac{Q^2}{2C}$

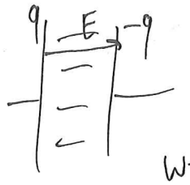
$C = \frac{Q}{\varphi} =$

$\Delta\varphi = \int_r^R \frac{KQ}{x^2}\cdot dx =$

$= \frac{Q}{KQ\cdot\frac{R_3-r}{rR_3}}$

$= KQ\cdot\left(\frac{1}{r}-\frac{1}{R}\right)$

$W_C = \frac{Q^2}{2}\cdot K\,\frac{R_3-r}{rR_3}$



$C = \frac{\varepsilon\varepsilon_0 S}{d}$

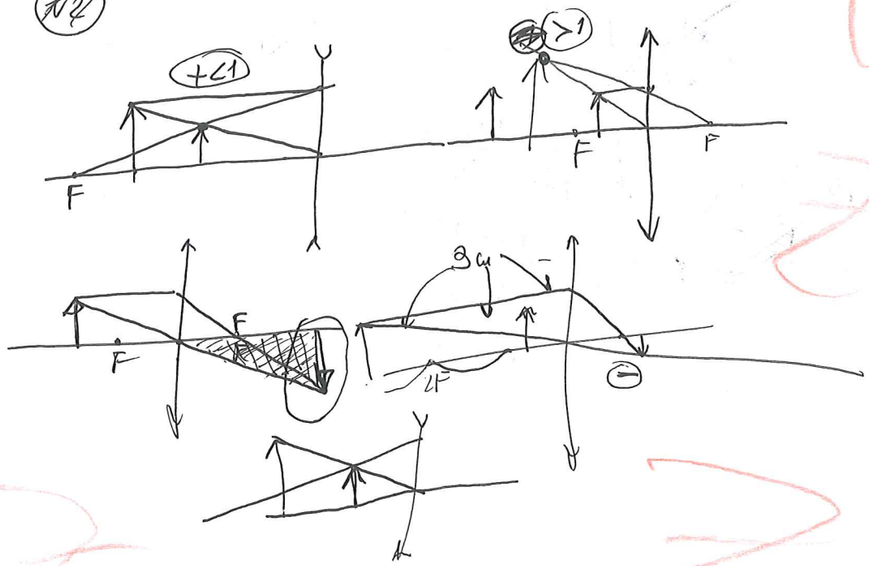
$W = \frac{q^2}{2C} = \frac{q^2\cdot d}{2\varepsilon_0\varepsilon S}$

$W = d\cdot\frac{E^2\cdot\varepsilon_0\varepsilon S}{2}$

$W = d\cdot\frac{q^2}{2}\cdot\frac{1}{S\varepsilon_0\varepsilon}$

$E = \frac{\sigma}{\varepsilon\varepsilon_0} = \frac{q}{S\varepsilon_0\varepsilon}$

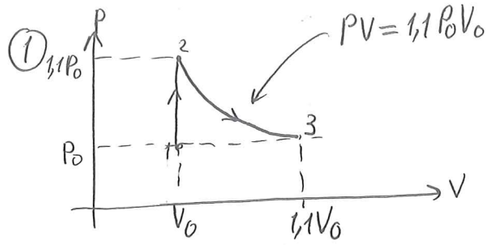
№2



92-40-81-45 (114.2)

Чистовик

№2



1) $Q_{12} = C_V\cdot 0{,}1P_0V_0 = \frac{3}{20}P_0V_0$

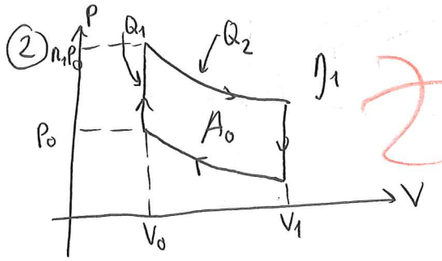
2) $Q_{23} = \int_{V_0}^{1{,}1V_0} P\,dV = \int_{V_0}^{1{,}1V_0} 1{,}1P_0V_0\cdot\frac{dV}{V} = 1{,}1\cdot\ln 1{,}1\cdot P_0V_0$

$P_0V_0 = \frac{20}{3}Q_{12}$

$Q_{23} = 1{,}1\cdot\ln 1{,}1\cdot\frac{20}{3}\cdot Q_{12} = \ln 1{,}1\cdot 1{,}1\cdot\frac{20}{3}\cdot 333 =$

$= \ln(1{,}1)\cdot 22\cdot 111 = 2442\cdot\ln 1{,}1$ Дж

(-)



η_1

1) $Q_1 = C_V\cdot(n_1-1)P_0V_0$

$Q_2 = n_1P_0V_0\cdot\ln\frac{V_1}{V_0}$ →

$A_0 = (n_1-1)P_0V_0\cdot\ln\frac{V_1}{V_0}$

→ $\frac{Q_1}{A_0} = \frac{C_V}{\ln\frac{V_1}{V_0}} = \text{const} = \alpha$

2) $\eta_1 = \frac{A_0}{Q_1+Q_2} = \frac{(n_1-1)\cdot\ln\frac{V_1}{V_0}}{(n_1-1)C_V + n_1\cdot\ln\frac{V_1}{V_0}} = \frac{(n_1-1)}{(n_1-1)\cdot\alpha+n_1}$

$\begin{cases}\eta_2 = \frac{n_2-1}{(n_2-1)\alpha+n_2}\\ \eta_1 = \frac{n_1-1}{(n_1-1)\alpha+n_1}\end{cases}$ → $\begin{cases}\eta_2 = \frac{0{,}8}{1{,}8+0{,}8\alpha} = \frac{4}{9+4\alpha}\\ \frac{1}{5} = \frac{0{,}5}{1{,}5+0{,}5\alpha} = \frac{1}{3+\alpha}\end{cases}$ →

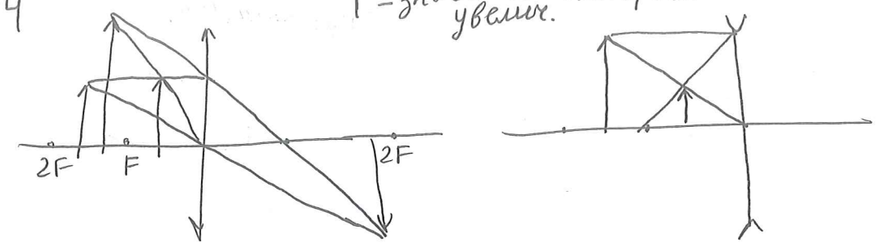
→ $\begin{cases}3+\alpha = 5 \to \alpha = 2\\ \eta_2 = \frac{4}{9+4\alpha}\end{cases}$ → $\boxed{\eta_2 = \frac{4}{9+8} = \frac{4}{17}}$

Ответ: $\frac{4}{17} = \eta_2$

(+)

№4

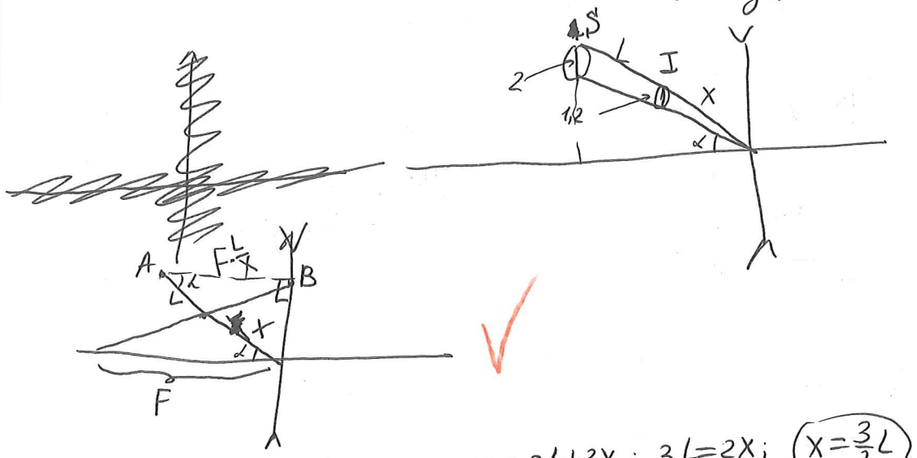
Г – значение увелич. поперечн.

① 

$\begin{cases} \Gamma < 0 \\ \Gamma > 1 \end{cases}$ ⟷ $0 < \Gamma < 1$

↓ нет пересечений, поэтому можно определ. тип линзы

② $\begin{cases} SI \to$ не пересек. линзу
$\Gamma = \frac{12}{2} = \frac{3}{9}\ \frac{12}{20} = \frac{3}{5} < 1 \Rightarrow$ рассеивающая линза



1) $\frac{X}{L+X} = \frac{12}{2} = \frac{3}{5} \to 5X = 3L + 3X;\ 3L = 2X;$ $X = \frac{3}{2}L$

2) $\frac{AB}{F} = \frac{L}{X} = \frac{2}{3} \to$ ~~AB~~ $F = \frac{3}{2}AB = \frac{3}{2}(L+X)\cdot\cos\alpha =$

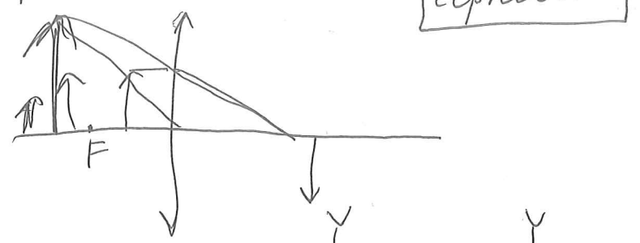
$= \frac{3}{2}\cdot\frac{5}{2}L\cdot\cos\alpha$

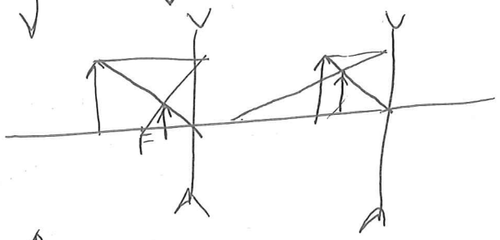
3) $\cos^2\alpha = 1 - \frac{13^2}{85^2} = \frac{85^2 - 13^2}{85^2} = \frac{72\cdot 98}{85^2} = 2\cdot\frac{49\cdot 9\cdot 8}{85^2} = \frac{49\cdot 9\cdot 16}{85^2}$

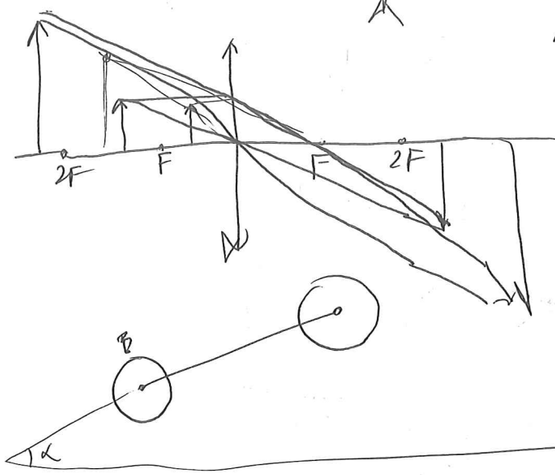
$\cos\alpha = \frac{4\cdot 3\cdot 7}{85} = \frac{84}{85}$

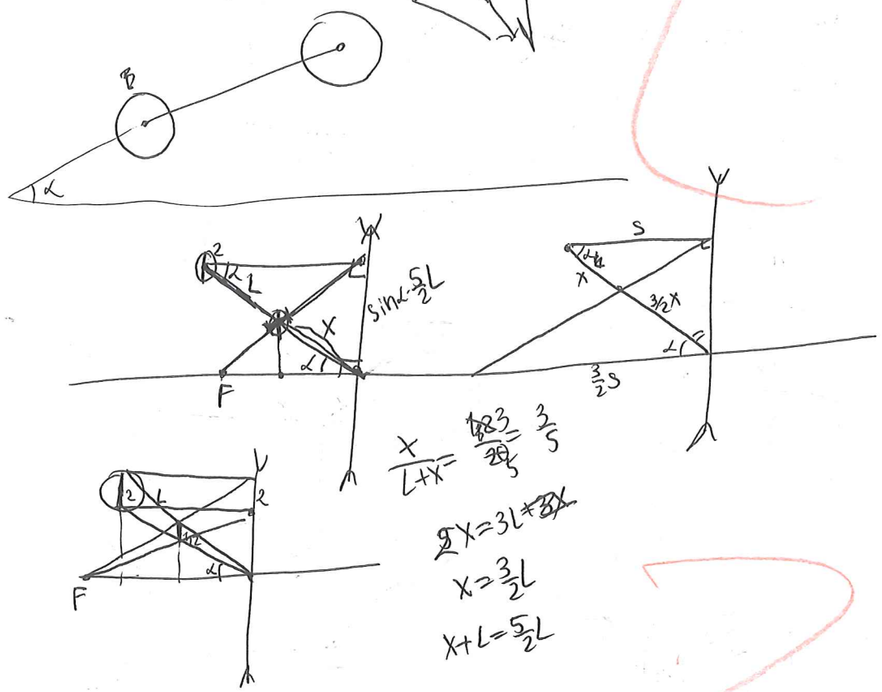
4) $F = \frac{15}{4}\cdot 85\cdot\frac{84}{85} = 15\cdot 21 = 315$ см

№4 (Черновик)









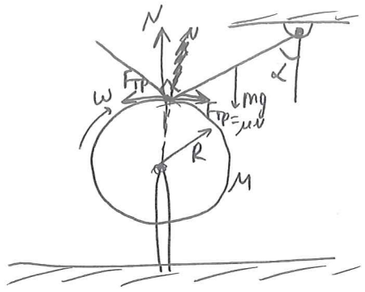
$\frac{X}{L+X} = \frac{\frac{183}{25}}{\frac{5}{5}} = \frac{3}{5}$

$2X = 3L + 3X$

$X = \frac{3}{2}L$

$X + L = \frac{5}{2}L$

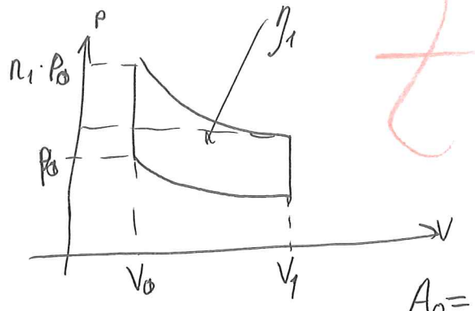
черновик



~~1) $E_{кин} = \frac{mv^2}{2}$~~

$(N-2mg)$

№2



~~A~~ $PV = n_1 P_0 V_0$

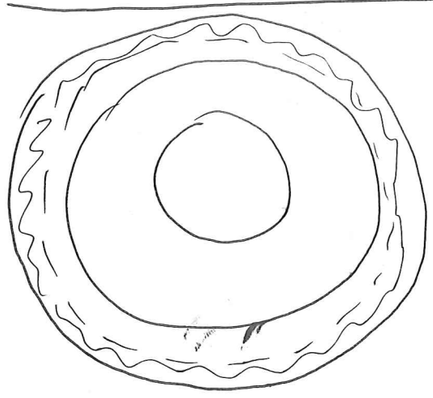
$Q_1 = C_V \cdot (n_1 - 1) P_0 V_0$

$Q_2 = \ln\frac{V_1}{V_0} \cdot n_1 P_0 V_0$

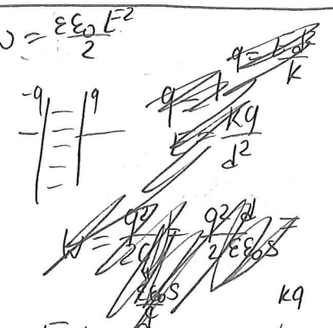
$A_0 = (n_1 - 1) P_0 V_0 \cdot \ln\frac{V_1}{V_0}$

$\frac{Q_1}{A_0} = \frac{C_V}{\ln\frac{V_1}{V_0}} = const \Rightarrow \ln\frac{V_1}{V_0} = const$

$$\begin{cases} \eta_1 = \frac{A_0}{Q_1 + Q_2} = \frac{(n_1-1)\cdot\ln\frac{V_1}{V_0}}{\ln\frac{V_1}{V_0}\cdot n_1 + C_V(n_1-1)} = \frac{(n_1-1)\alpha}{\alpha n_1 + C_V(n_1-1)} \\ \eta_2 = \frac{(n_2-1)\alpha}{\alpha n_2 + C_V(n_2-1)} \end{cases}$$



$w = \frac{\varepsilon\varepsilon_0 E^2}{2}$



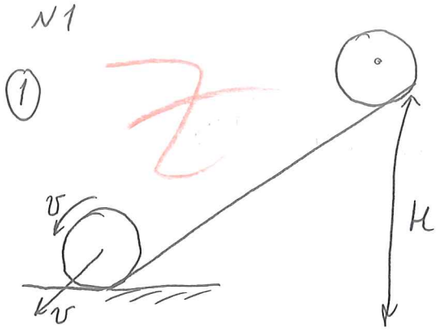
$E \cdot d = U$

$W = \frac{U^2 C}{2} = \frac{\varepsilon_0 \varepsilon \cdot S}{2} \cdot E^2 d$

Чистовик

92-40-81-45 (114.2)

№1



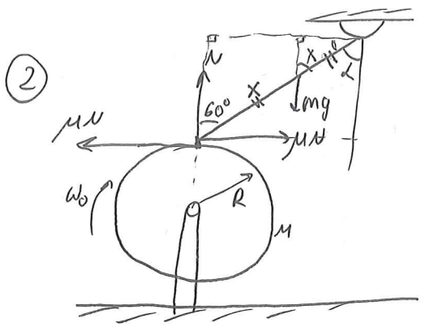
1) $mgH = E_{кин}$

$mgH = E_{ум} + E_{вс.ум}$

$mgH = \frac{mv^2}{2} + \frac{J\omega^2}{2} =$

$= \frac{mv^2}{2} + \frac{mv^2}{2} = mv^2$

$\boxed{v = \sqrt{gH}}$



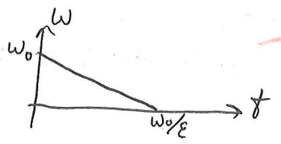
1) $mgX\sin\alpha + \mu N \cdot 2X\cos\alpha = N \cdot 2X \cdot \sin\alpha$

$mg\sin\alpha + \mu N \cdot 2\cos\alpha = 2N\sin\alpha$

$mg \cdot \frac{\sqrt{3}}{2} + \frac{1}{\sqrt{3}} \cdot N = 2N \cdot \frac{\sqrt{3}}{2}$

$mg \cdot \frac{3}{2} + N = 3N$

$\boxed{N = \frac{3}{4}mg}$



2) $M = \mu N R = \frac{\sqrt{3}}{4}mgR$ (момент)

$J\varepsilon = M = \frac{\sqrt{3}}{4}mgR$

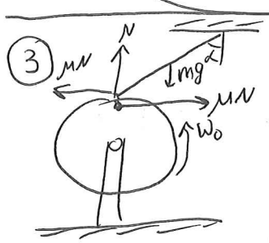
$MR^2 \cdot \varepsilon = \frac{\sqrt{3}}{4}mgR$

$\boxed{\varepsilon = \frac{\sqrt{3}\,mg}{4MR}}$

3) $S = \frac{1}{2}\frac{\omega_0^2}{\varepsilon} = 160 \cdot 2\pi$

$\boxed{\frac{\omega_0^2}{4\pi} = 160 \cdot \varepsilon =}$

$= 160 \cdot \frac{\sqrt{3}mg}{4MR} = \boxed{40\sqrt{3}\,\frac{mg}{MR}}$



1) $mgX\sin\alpha = N \cdot 2X\sin X + \mu N \cdot 2X\cos\alpha$

$mg \cdot \frac{\sqrt{3}}{2} = N \cdot \sqrt{3} + \frac{1}{\sqrt{3}}N$

$\frac{3}{2}mg = 3N + N$

$\boxed{N = \frac{3}{8}mg}$

2) $M = \mu N R = \frac{\sqrt{3}}{8}mgR$

$\varepsilon_1 = \frac{\sqrt{3}}{8}\frac{mg}{MR}$

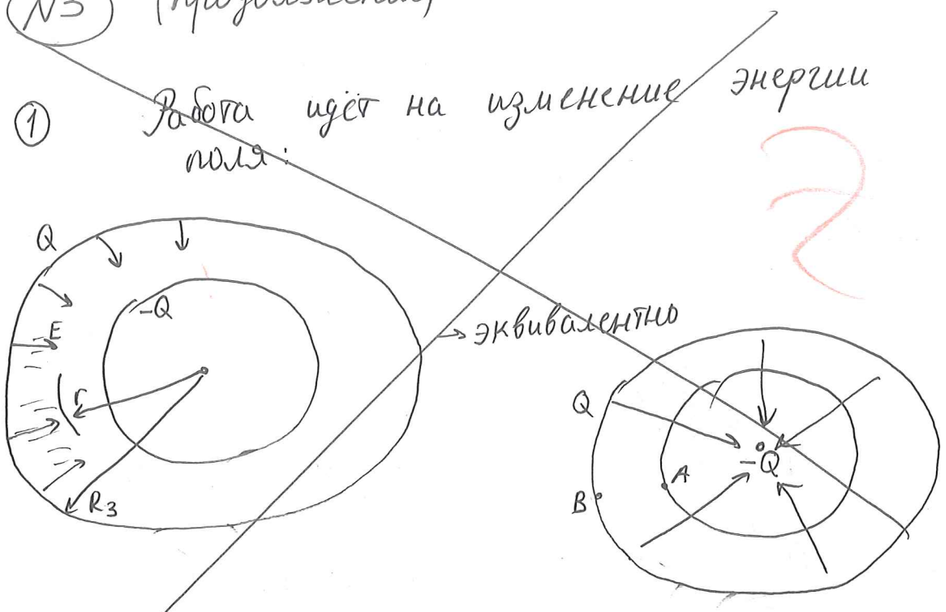
3) $\frac{\omega_0^2}{4\pi} = N \cdot \varepsilon_1$

$\boxed{N = \frac{160 \cdot \frac{\sqrt{3}mg}{4MR}}{\frac{\sqrt{3}}{8}\frac{mg}{MR}} = 320 \text{ оборот.}}$

Ответ: 320

№3 (продолжение)

① Работа идёт на изменение энергии поля:



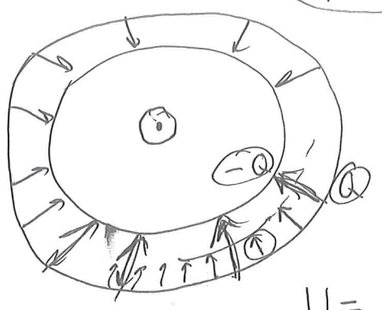
1) $W = \frac{U \cdot Q}{2}$

2) $U = \Delta\varphi = \varphi$

черновик

Подписывать лист-вкладыш запрещается! Писать на полях листа-вкладыша запрещается!

черновик

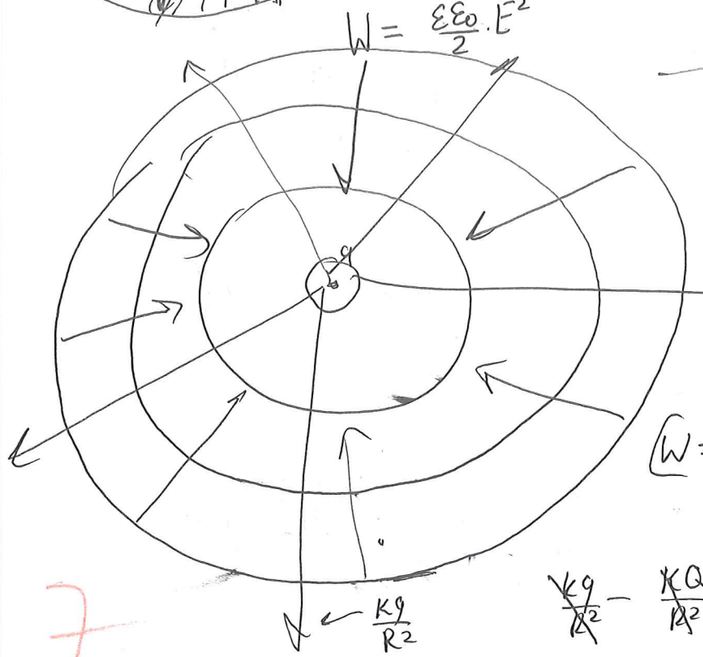


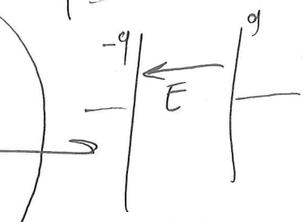
W-?

$W = \frac{q^2}{2C}$

$\left(\frac{kq}{R \cdot \varepsilon}\right)^2$

$W = \frac{\varepsilon\varepsilon_0}{2} \cdot E^2$

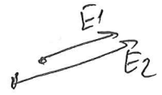


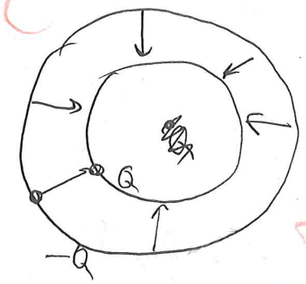


$W = \frac{q^2}{2C} = \frac{q^2 \cdot d}{2 \cdot \varepsilon_0 \cdot S}$

$\frac{kq}{R^2} - \frac{kQ}{R^2} = \frac{kq}{\varepsilon R^2}$

$Q = \frac{\varepsilon - 1}{\varepsilon} q$



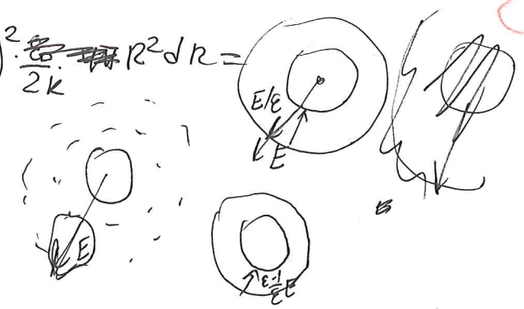


$W = \frac{UQ}{2} = \frac{Q}{2} \cdot Q\left(\frac{1}{R} - \frac{1}{r}\right) =$

$= \left(\frac{\varepsilon - 1}{\varepsilon}\right)^2 \cdot \frac{q^2}{2} \cdot \frac{R - r}{Rr}$

$W = \left(\frac{KQ}{R^2}\right)^2 \cdot \frac{\varepsilon\varepsilon_0}{2k} R^2 dR =$

$= \frac{kQ^2 \cdot \varepsilon\varepsilon_0}{2}$



Подписывать лист-вкладыш запрещается! Писать на полях листа-вкладыша запрещается!