Часть 1

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

Шифр: **21202850**

ID профиля: **854324**

Вариант 7

№1

Дано:

$\cos\alpha = \frac{5}{13}$

$m, \frac{m}{2}, M$

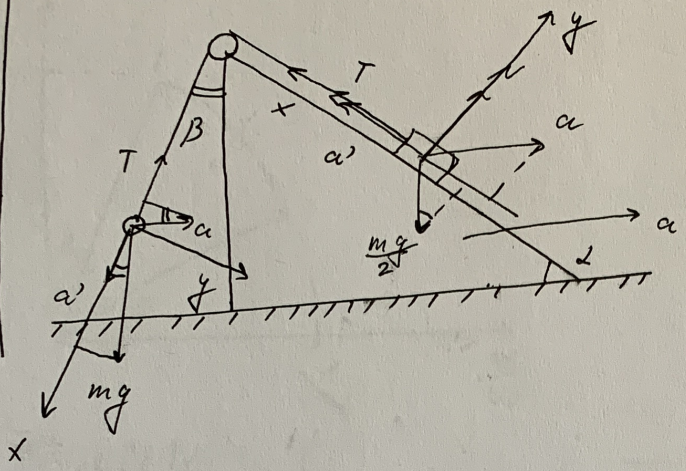
$\cos\beta = \frac{3}{5}$

$a - ?$

$a' - ?$

$t - ?$

Решение:



a' - собственное ускорение бруска и шарика, они равны, т.к. нить не растягивается.

a - ускорение клина

$Ox: \; T - \frac{mg}{2}\sin\alpha = \frac{m}{2}(a' - a\cos\alpha)$

$Ox': \; mg\cos\beta - T = m(a' - a\sin\beta)$

$Oy: \; mg\sin\beta = ma\cos\beta$

$a = g\,tg\beta \qquad \sin\beta = \frac{4}{5} \qquad \sin\alpha = \frac{12}{13}$

$$\boxed{a = \frac{4}{3}g}$$

$$mg\cos\beta - \frac{mg}{2}\sin\alpha = m(a' - a\sin\beta) + \frac{m}{2}(a' - a\cos\alpha)$$

$$g(2\cos\beta - \sin\alpha) = 2a' - 2a\sin\beta + a' - a\cos\alpha$$

$$a' = \frac{1}{3}(g(2\cos\beta - \sin\alpha) + a\cos\alpha + 2a\sin\beta)$$

$$a' = \frac{1}{3}g(2\cos\beta - \sin\alpha + tg\beta\cos\alpha + 2tg\beta\sin\beta)$$

$$a' = \frac{1}{3}g\left(2\frac{1}{\cos\beta} - \sin\alpha + tg\beta\cos\alpha\right)$$

$$a' = \frac{1}{3}g\left(\frac{10}{3} - \frac{12}{13} + \frac{4}{3}\cdot\frac{5}{13}\right) = g\,\frac{130 - 36 + 20}{3\cdot 3\cdot 13}$$

$$\boxed{a' = \frac{38}{39}g}$$

$$\frac{a\cos\beta t^2}{2} = H$$

$$t^2 = \frac{2H}{g\frac{38}{39}\cdot\frac{3}{5}}$$

$$\boxed{t = \sqrt{\frac{65H}{19g}}}$$

Ответ: 1) $a = \frac{4}{3}g$

2) $a_1 = \frac{38}{39}g$

3) $t = \sqrt{\frac{65H}{19g}}$

№2

Дано:

$\alpha = 30°$

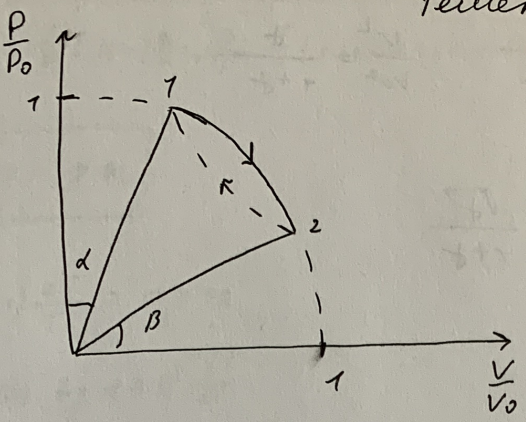
$\beta = 15°$

$\frac{\Delta T}{T_2} - ?$

$e - ?$

$\eta - ?$

Решение:



$P_1 V_1 = \nu R T_1$

$P_2 V_2 = \nu R T_2$

$P_1 = P_0 \cos\alpha$

$V_1 = V_0 \sin\alpha$

$P_2 = P_0 \sin\beta$

$V_2 = V_0 \cos\beta$

$T_1 = \frac{P_0 V_0 \sin 2\alpha}{2\nu R}$

$T_2 = \frac{P_0 V_0 \sin 2\beta}{2\nu R}$

$\frac{\Delta T}{T} = \frac{T_1 - T_2}{T_2}$

$\frac{\Delta T}{T} = \frac{\sin 2\alpha}{\sin 2\beta} - 1$

$\frac{\Delta T}{T} = 0{,}732$

$C = 0 \Rightarrow Q = 0 \Rightarrow PV^\gamma = const$

$dPV^\gamma + \gamma V^{\gamma-1} dV P = 0$

$\frac{dP}{dV} = -\gamma \frac{P}{V}$

$\left(\frac{P}{P_0}\right)^2 + \left(\frac{V}{V_0}\right)^2 = 1$

$\frac{2P_0 dP}{P_0^2} + \frac{2V dV}{V_0^2} = 0$

$\frac{dP}{dV} = -\frac{V P_0^2}{P V_0^2}$

$$-\frac{\nu P_0^2}{P \nu_0^2} = -\gamma \frac{P}{V}$$

$$\frac{P^2}{P_0^2} = \frac{1}{1+\gamma} \qquad \frac{V^2}{V_0^2} = \frac{\gamma}{1+\gamma}$$

$$\gamma \frac{P^2}{P_0^2} = \frac{V^2}{V_0^2}$$

$$\operatorname{tg}\varphi = \frac{\frac{P}{P_0}}{\frac{V}{V_0}} \qquad T = \frac{P_0 V_0}{\nu R} \frac{\sqrt{\gamma}}{1+\gamma}$$

$$\operatorname{tg}\varphi = \frac{1}{\sqrt{\gamma}}$$

$$\gamma = \frac{5}{3}$$

$$\operatorname{tg}\varphi = \sqrt{\frac{3}{5}}$$

$$\varphi = 37{,}76^\circ$$

$$Q_n = \int P\,dV + C_V \nu\,\Delta T \qquad Q_{2,1} = 0$$

$$A = \int P\,dV$$

$$P = P_0 \sin\gamma$$

$$V = V_0 \cos\gamma$$

$$dV = V_0(-\sin\gamma)\,d\gamma$$

$$A = -P_0 V_0 \int \sin^2\gamma\,d\gamma = -\frac{P_0 V_0}{2}\int (1-\cos 2\gamma)\,d\gamma$$

$$A = -\frac{P_0 V_0}{2}\left(\gamma - \frac{\sin 2\gamma}{2}\right)$$

$$A_1 = -\frac{P_0 V_0}{2}\left(\varphi - \left(\frac{\pi}{2} - \alpha\right)\right) + \frac{P_0 V_0}{4}(\sin 2\varphi - \sin 2\alpha)$$

$$A_2 = -\frac{P_0 V_0}{2}(\beta - \varphi) + \frac{P_0 V_0}{4}(\sin 2\beta - \sin 2\varphi)$$

$$Q_n = -\frac{P_0 V_0}{2}\left(\varphi - \left(\frac{\pi}{2} - \alpha\right)\right) + \frac{P_0 V_0}{4}(\sin 2\varphi - \sin 2\alpha) + \frac{C_V}{R} P_0 V_0 \left(\frac{\sqrt{\gamma}}{1+\gamma} - \frac{\sin 2\alpha}{2}\right)$$

$$Q_0 = -\frac{P_0 V_0}{2}(\beta - \varphi) + \frac{P_0 V_0}{4}(\sin 2\beta - \sin 2\varphi) + \frac{C_V}{R} P_0 V_0 \left(\frac{\sin 2\beta}{2} - \frac{\sqrt{\gamma}}{1+\gamma}\right)$$

$$\eta = 1 - \frac{Q_0}{Q_n}$$

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$$\eta = 1 - \frac{-\frac{1}{2}(\beta - \varphi) + \frac{1}{4}(\sin 2\beta - \sin 2\varphi) + \frac{3}{2}\left(\frac{\sin 2\beta}{2} - \frac{\sqrt{4}}{1+4}\right)}{-\frac{1}{2}\left(\varphi - \left(\frac{\pi}{2} - \alpha\right)\right] + \frac{1}{4}(\sin 2\varphi - \sin 2\alpha) + \frac{3}{2}\left(\frac{\sqrt{4}}{1+4} - \frac{\sin 2\alpha}{2}\right)}$$

$$\boxed{\eta = 0{,}09 = 9\%}$$

Ответ: 1) $\frac{\Delta T}{T} = 0{,}732$

2) $\operatorname{tg}\varphi = \sqrt{\frac{3}{5}}$

$\varphi = 37{,}76^\circ$

3) $\eta = 9\%$

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Часть 2

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

Шифр: **21202850**

ID профиля: **854324**

Вариант 7

Числовик

№ 3

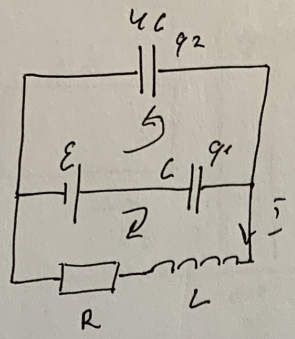
Дано:

$C, 4C, L, R, \mathcal{E}$

$\dot{I}_{(0)} - ?$

$Q - ?$

$I - ?$



Решение:

1) $\mathcal{E} = \frac{q}{C} + \frac{q}{4C}$

$\mathcal{E} = \frac{5q}{4C}$

$\mathcal{E} = \frac{q}{C} + L\dot{I}_{(0)}$

$\mathcal{E} = \frac{4}{5}\mathcal{E} + L\dot{I}_{(0)}$

$$\boxed{\dot{I}_{(0)} = \frac{\mathcal{E}}{5L}}$$

$E_0 = \frac{q^2}{2C} + \frac{q^2}{8C} = \frac{5q^2}{8C} = \frac{5 \cdot 16^2 \mathcal{E}^2 C^2}{25 \cdot 8} = \frac{2}{5}\mathcal{E}^2 C$

$\dot{I} = 0 \quad \dot{I} = 0 \Rightarrow \mathcal{E} = \frac{q_1}{C} \quad \frac{q_2}{C} = 0$

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

$A = \mathcal{E}(q_1 - \frac{4}{5}\mathcal{E}C)$

$A = \mathcal{E}(\mathcal{E}C - \frac{4}{5}\mathcal{E}C) = \frac{\mathcal{E}^2 C}{5}$

$A = E - E_0$

$\frac{\mathcal{E}^2 C}{5} = \frac{\mathcal{E}^2 C}{2} + Q - \frac{2}{5}\mathcal{E}^2 C$

$\left(\frac{3}{5} - \frac{1}{2}\right)\mathcal{E}^2 C = Q$

$$\boxed{Q = \frac{\mathcal{E}^2 C}{10}}$$

$\dot{q}_1 = \dot{I}_1$

$\dot{q}_2 = \dot{I}_2$

$\dot{q}_1 = \dot{q}_2 + \dot{I}$

$\mathcal{E} = \frac{q_1}{C} + \frac{q_2}{4C}$

$\frac{\dot{q}_1}{C} + \frac{\dot{q}_2}{4C} = 0$

$\dot{q}_2 = -4\dot{q}_1$

Чистовик

$\dot{q}_1 = -4\dot{q}_1 + \underline{I}$

$\underline{I} = 5\dot{q}_1$

$\dot{q}_1 = \underline{I}_0$

$\boxed{\underline{I} = 5\underline{I}_0}$

Ответ: 1) $\dot{\underline{I}}_{(0)} = \frac{\mathcal{E}}{5L}$

2) $Q = \frac{\mathcal{E}^2 C}{10}$

3) $\underline{I} = 5\underline{I}_0$

Чистовик

и 4

Дано:

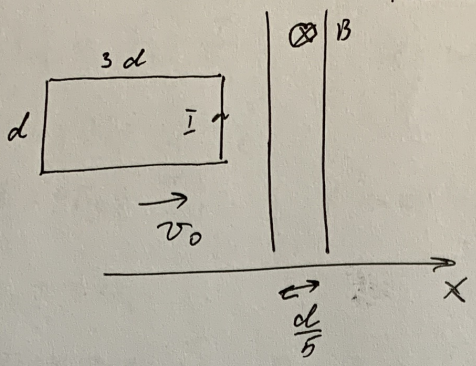
m, d, v_0, R, B

$a - ?$

$v_1 - ?$

$v_2 - ?$

Решение:



$$d\Phi = d\,v\,dt\,B$$

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

$$\mathcal{E}_i = d\,v\,B$$

$$\mathcal{E}_i = R\,I$$

$$I = \frac{d\,v\,B}{R}$$

$$F_A = -d\,B\,I$$

$$F_A = -\frac{d^2 B^2 v}{R}$$

$$F_A = ma$$

$$\boxed{a = -\frac{B^2 d^2 v}{mR}}$$

Направлено влево

$$a = \frac{dv}{dt}$$

$$\frac{dv}{dt} = -\frac{B^2 d^2 v}{mR}$$

$$v\,dt = dx$$

$$\int_{v_0}^{v_1} dv = -\frac{B^2 d^2}{mR} \int_0^{\frac{d}{5}} dx$$

$$v_1 - v_0 = -\frac{B^2 d^2}{mR} \cdot \frac{d}{5}$$

$$\boxed{v_1 = v_0 - \frac{B^2 d^3}{5mR}}$$

Чистовик

$$\int_{v_1}^{v_2} dv = -\frac{B^2 a l^2}{mR} \int_0^{a} dx$$

$$v_2 - v_1 = -\frac{B^2 a l^3}{5 m R}$$

$$\boxed{v_2 = v_0 - \frac{2B^2 a l^3}{5 m R}}$$

Ответ: 1) $a = -\frac{B^2 a l^2 v_0}{mR}$

2) $v_1 = v_0 - \frac{B^2 a l^2}{5 m R}$

3) $v_2 = v_0 - \frac{2B^2 a l^2}{5 m R}$

Чистовик

№5

Дано:
$e = 25$ см
$x - ?$ $D_2 - ?$
$D - ?$

Решение:

$d = const$

$D_0 = \frac{1}{d} + \frac{1}{x}$

$D_0 + D_1 = \frac{1}{d} + \frac{1}{e}$

$D_0 + D_2 = \frac{1}{d}$

$f \to \infty \quad \frac{1}{f} \to 0$

$D_2 = 3 D_1$

~~$D_1 + D_2 = \frac{1}{e}$~~ $\quad D_1 - D_2 = \frac{1}{e}$

~~$2 D_1 = \frac{1}{e}$~~ $\quad -2 D_1 = \frac{1}{e}$

~~$D_1 = \frac{1}{2e}$~~ $\quad D_1 = -\frac{1}{2e}$

$D_2 = -\frac{3}{2e}$

$D_0 = \frac{1}{d} - D_2$

$D_0 = \frac{1}{d} + \frac{3}{2e}$

$\frac{1}{x} = \frac{3}{2e}$

$x = \frac{2}{3} e$

$x = 16{,}7$ см

~~$D_2 = -0{,}06$ ДПТР~~ $\quad D_2 = -6$ ДПТР

$D_0 + D = \frac{1}{d} + \frac{1}{2e}$

$D_0 = D_2 + \frac{1}{2e}$

$D_0 = \frac{1}{2e} - \frac{3}{2e}$

$D_0 = -\frac{1}{e}$

~~$D_0 = -0{,}04$ ДПТР~~ $\quad D = -4$ ДПТР

Ответ: 1) $x = \frac{2}{3} e$ $\quad x = 16{,}7$ см

2) ~~$D_2 = -0{,}06$~~ $D_2 = -6$ ДПТР

3) $D = -4$ ДПТР

Черновик

№3

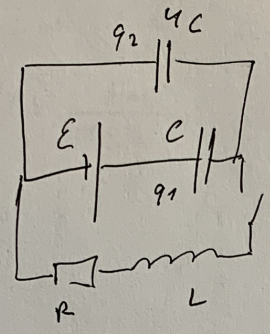
Дано:

$C, 4C, L, R, \mathcal{E}$

$\dot{I}_{01} - ?$

$Q - ?$

$I - ?$



Решение:

1) $\mathcal{E} = \frac{q}{C} + \frac{q}{4C}$

$\mathcal{E} = \frac{5q}{4C}$

$q = \frac{4}{5}\mathcal{E}C$

2) $\mathcal{E} = \frac{q}{C} + L\dot{I}_{01}$

$L\dot{I}_{01} = \mathcal{E} - \frac{4}{5}\mathcal{E}$

$\boxed{\dot{I}_{01} = \frac{\mathcal{E}}{5L}}$

$E_0 = \frac{q^2}{2C} + \frac{q^2}{8C} = \frac{5q^2}{8C} = \frac{5 \cdot 16\mathcal{E}^2C^2}{8 \cdot 25} = \frac{2}{5}\mathcal{E}^2C$

$I_1 = \dot{q}_1$

$I_2 = \dot{q}_2$

$\mathcal{E} = \frac{q_1}{C}$ $\quad q_2 = 0$

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

$\mathcal{E} = \frac{q_1}{C} + \frac{q_2}{4C}$

$\dot{q}_1 = \dot{q}_2 + I$

$\mathcal{E} = \frac{q_1}{C} + L\dot{I} + RI$

$\dot{q}_1 4 = -\dot{q}_2$

$I = 5\dot{q}_1$

$\frac{\dot{q}_1}{C} + L\ddot{I} + R\dot{I} = 0$

$\frac{I}{5C} + L\ddot{I} + R\dot{I} = 0$

$5CL\ddot{I} + 5CR\dot{I} + I = 0$

$\mathcal{E}(C - \frac{4}{5}C) = \frac{\mathcal{E}^2C}{2} + Q - \frac{2}{5}\mathcal{E}^2C$

$\frac{\mathcal{E}^2C}{5} + \frac{2}{5}\mathcal{E}^2C - \frac{\mathcal{E}^2C}{2} = Q$

$\boxed{\frac{\mathcal{E}^2C}{10} = Q}$

$\boxed{I = 5\dot{I}_0}$

$r = \frac{-5CR \pm \sqrt{25C^2R^2 - 20CL}}{10CL}$

1 из 4

~ 4 Черняева

Дано:

$m, d, 3d$

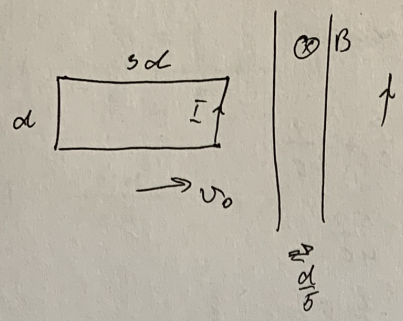
$v_0, R, B, \frac{d}{5}$

$a - ?$

$v_1 - ?$

$v_2 - ?$

Решение:



$\frac{d}{5}$

$d\Phi = d v d t B$

$\frac{d\Phi}{dt} = d v B = \mathcal{E}_i$

$d v B = I R$

$F_A = I B d = \frac{B^2 d^2 v}{R}$

$a = -\frac{B^2 d^2 v_0}{m R}$

$\frac{dv}{dt} = -\frac{B^2 d^2 v}{m R}$

$\int dv = -\frac{B^2 d^2}{m R} \int v dt$

$v_1 - v_0 = -\frac{B^2 d^2}{m R} \frac{d}{5}$

~~$v_0 = v$~~ $v_1 = v_0 - \frac{B^2 d^3}{5 m R}$

~~$v_2 = v_0$~~

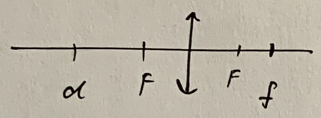
$v_2 = v_0 - \frac{2 B^2 d^2}{5 m R}$

2 из 4

Черновик №5

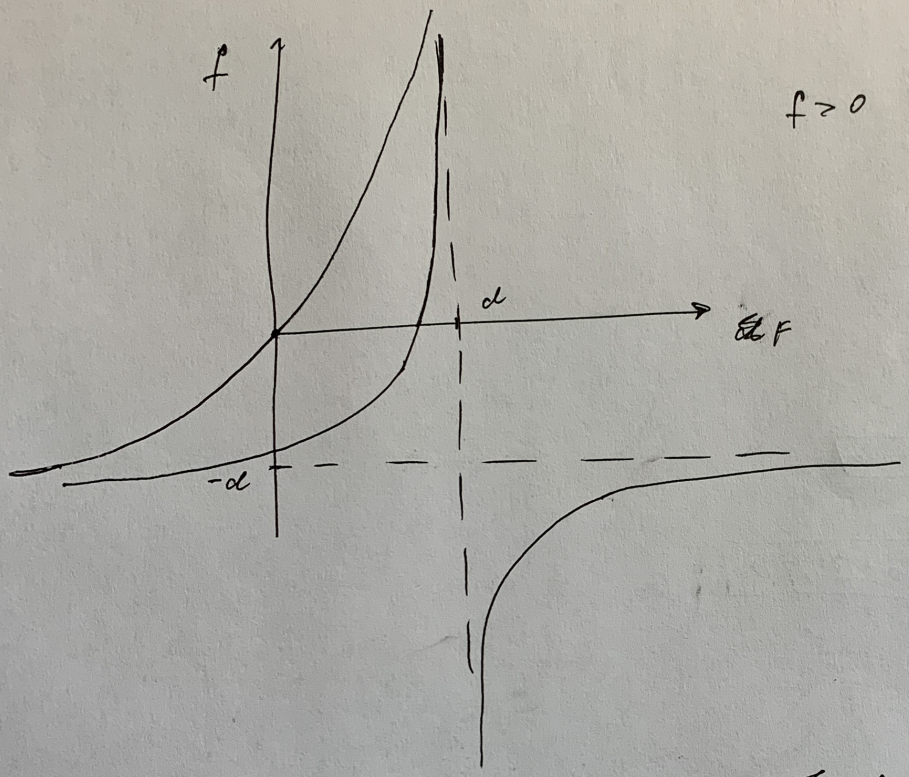
Дано:
$l_1 = 25$ см

Решение:



$\frac{1}{F} = \frac{1}{d} + \frac{1}{f}$ $\quad d = \text{const}$

$$f = \frac{Fd}{d-F} = -d + \frac{d^2}{d-F} = -d - \frac{d^2}{F-d}$$



$f > 0$

$D = \frac{1}{d} + \frac{1}{e}$

$D_2 = \frac{1}{d}$

$\frac{3}{d} = \frac{1}{d} + \frac{1}{e}$

$\frac{2}{d} = \frac{1}{e}$ $\quad d = 2e$ ~~$d = 50$ см~~

$-D_1 + D_0 = \frac{1}{d} + \frac{1}{e}$

$-D_2 + D_0 = \frac{1}{d}$

$D_0 = \frac{1}{d} + \frac{1}{f}$ $\quad f - ?$

~~$D_1 = 3D_2$~~

$D_2 = 3D_1$

$-D_1 + D_2 = \frac{1}{e}$

$2D_2 = \frac{1}{e}$

$D_2 = \frac{1}{2e}$

$D_1 = \frac{3}{6e}$

$D_0 = \frac{1}{d} + \frac{1}{2e}$

$D_0 = \frac{1}{d} + \frac{1}{e} + \frac{3}{6e}$

3 су

Черновик

$-D_1 + D_0 = \frac{1}{d} + \frac{1}{e}$

$-D_2 + D_0 = \frac{1}{d}$

$D_2 = 3D_1$

$-D_1 + D_2 = \frac{1}{e}$

$2D_1 = \frac{1}{e}$ $\quad D_1 = \frac{1}{2e}$

$D_2 = \frac{3}{2e}$

$D_0 = \frac{1}{d} + \frac{3}{2e}$

$D_0 = \frac{1}{d} + \frac{1}{e} + \frac{1}{2e} = \frac{3}{2e} + \frac{1}{d}$

$f = \frac{2}{3}e$ $\quad \boxed{F = 16{,}67\text{ см}}$

$D_2 = -\frac{3}{2e}$ $\quad \boxed{D_2 = -0{,}06\text{ дптр}}$

$-D + D_0 = \frac{1}{d} + \frac{1}{2e}$

$-D = -D_2 + \frac{1}{2e} = \frac{1}{2e} - \frac{3}{2e}$

$-D = -\frac{1}{e}$

$D = \frac{1}{e}$

$\boxed{D = -0{,}04\text{ дптр}}$

Чуч