

# Часть 1

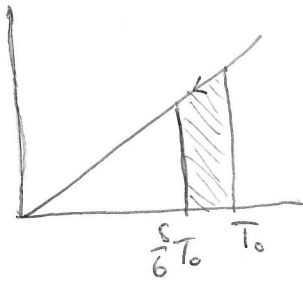
Олимпиада: **Физика, 11 класс (1 часть)**

Шифр: **21203167**

ID профиля: **89625**

Вариант 1

# Черновик



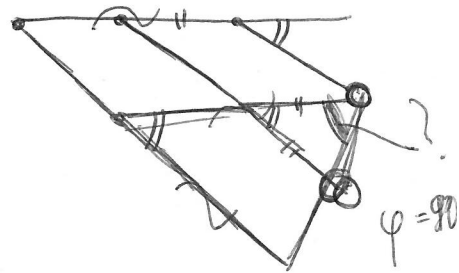
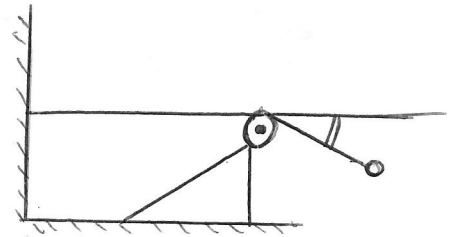
$$Q_1 = -\frac{1}{6} T_0 \cdot \frac{1}{2} (2R + \frac{5}{6} \cdot 2R) V$$

$$\Delta U = \frac{3}{2} V R (T - T_0)$$

$$A = Q - \Delta U = \frac{11}{36} V R T_0$$

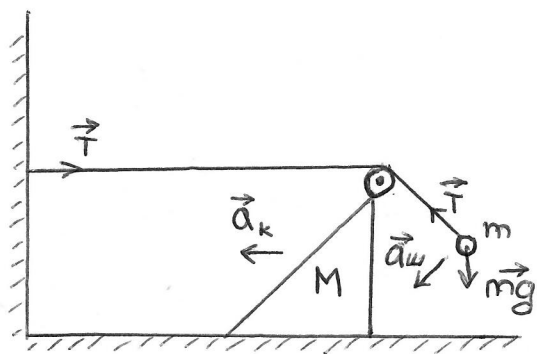
$$Q = (T - T_0) \frac{1}{2} \left( \frac{2RT}{T_0} + 2R \right) V$$

$$A = (T - T_0) \frac{RV}{T_0} \left( T + T_0 - \frac{3}{2} T_0 \right) = (T - T_0) \left( T - \frac{T_0}{2} \right) \cdot \frac{RV}{T_0}$$



Задача 1.

1) Пусть через небольшое время  $\Delta t$  блок сместился из положения  $A$  в положение  $A'$ , а шар — из  $B$  в  $B'$ . Тогда  $A'B' = A'D + DB' = AB + AA' \Rightarrow \Rightarrow BD = AA' = B'D$  и  $\angle EAB = \angle BDB' = \alpha$ , а  $\angle DBB' = \frac{1}{2}(180^\circ - \alpha) = 90^\circ - \frac{\alpha}{2}$  — не зависит от  $\Delta t \Rightarrow \Rightarrow$  ускорение шара направлено по  $BB'$



$$\sin \varphi = \cos(90^\circ - \varphi) = \cos \frac{\alpha}{2} = \sqrt{\frac{1 + \cos \alpha}{2}}$$

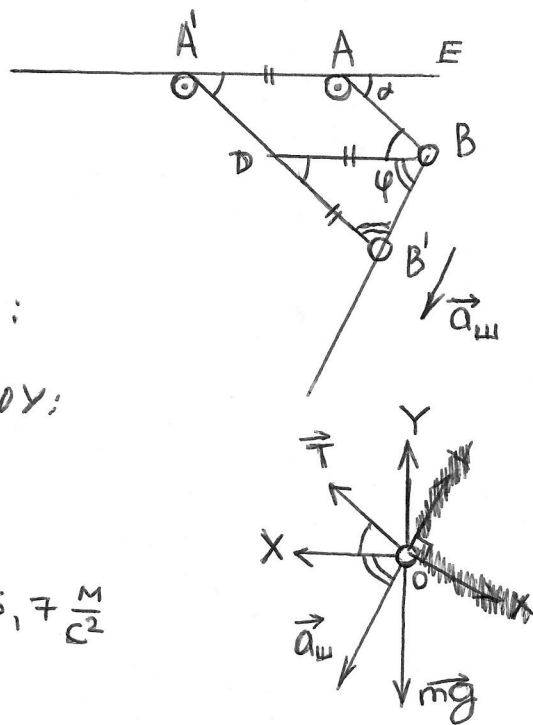
$$\sin \varphi = \sqrt{\frac{1 + \frac{3}{5}}{2}} = \frac{2}{\sqrt{5}}; \cos \varphi = \frac{1}{\sqrt{5}}$$

2) 2.3. Ньютона для шара:  $\vec{T} + \vec{mg} = m\vec{a}_ш$ . На  $Ox$ :

$$ma_ш \cos \varphi = T \cos \alpha; T = \frac{ma_ш \cos \varphi}{\cos \alpha}; \text{ на } Oy:$$

$$ma_ш \sin \varphi = mg - T \sin \alpha;$$

$$a_ш \left( \sin \varphi + \frac{\cos \varphi \sin \alpha}{\cos \alpha} \right) = g; a_ш = \frac{10 \frac{M}{c^2}}{\frac{2}{\sqrt{5}} + \frac{\frac{1}{\sqrt{5}} \cdot \frac{4}{5}}{\frac{3}{5}}} = 6,7 \frac{M}{c^2}$$



Если за время  $\Delta t$  клин прошёл  $AA' = \frac{a_k \Delta t^2}{2}$ , то шар сдвинулся на  $BB' = \frac{a_ш \Delta t^2}{2}$ ;  $a_k = a_ш \cdot \frac{BB'}{AA'} = a_ш \cdot \frac{2BD \cos \varphi}{AA'} = 2a_ш \cos \varphi \Rightarrow$

$$a_k = 2 \cdot 6,7 \frac{M}{c^2} \cdot \frac{1}{\sqrt{5}} = 6 \frac{M}{c^2}$$

$$4) T = \sqrt{\frac{2 \cdot H}{a_ш \sin \varphi}} = \sqrt{\frac{2H}{a_ш \sin \varphi}} - \text{время движения шара}; T = \sqrt{\frac{H \cdot c^2}{3M}}$$

3) 3. Сохр. энергии:

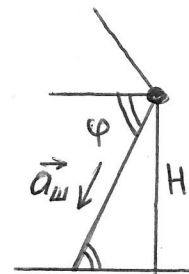
$$E_{кк}(t) + E_{кш}(t) + E_{рш}(t) = \text{const} = E_{рш}(t=0)$$

$t = T$ :

$$\frac{(a_k T)^2 M}{2} + \frac{(a_ш T)^2 m}{2} + 0 = mgH; a_k^2 \cdot \frac{H}{a_ш \sin \varphi} M + \frac{a_ш \cdot m H}{\sin \varphi} = mgH;$$

$$\frac{M}{M} = \frac{a_k^2}{a_ш^2 + a_ш g \sin \varphi} = \frac{a_ш g \sin \varphi - a_ш^2}{a_k^2}; \frac{m}{M} = 0,42$$

стр. 1 Ответ:  $\cos \varphi = \frac{1}{\sqrt{5}}; a_k = 6 \frac{M}{c^2}; \frac{m}{M} = 0,42; T = \sqrt{\frac{H \cdot c^2}{3M}} = \sqrt{\frac{H \cdot c^2}{3M}} \cdot 1c$

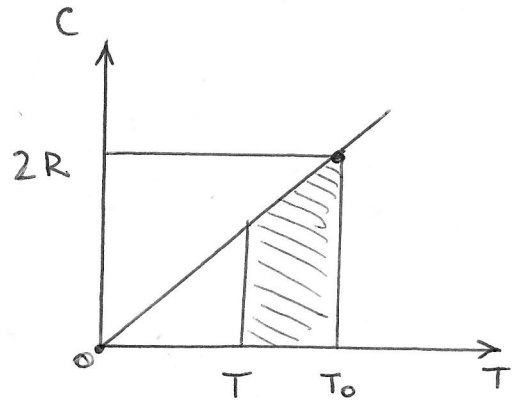


Задача 2

$$1) \frac{Q_1}{V} = \left| \int_{T_0}^{\frac{5}{6}T_0} c(T) dT \right| = \int_{\frac{5}{6}T_0}^{T_0} \frac{2RT}{T_0} dT =$$

$$= \frac{R}{T_0} (T^2) \Big|_{\frac{5}{6}T_0}^{T_0} = \frac{R}{T_0} (T_0^2 - (\frac{5}{6}T_0)^2) = \frac{11 T_0 R}{36}$$

$$Q_1 = \frac{11 T_0 V R}{36}$$



$$2) \textcircled{Q}(T) = (T^2 - T_0^2) \cdot \frac{RV}{T_0} \text{ - из (1)}$$

$$\Delta U(T) = U(T) - U(T_0) = \frac{3}{2} \nu R T - \frac{3}{2} \nu R T_0 = \frac{3}{2} \nu R (T - T_0)$$

$$A + \Delta U = Q \Rightarrow A(T) = Q(T) - \Delta U(T);$$

$$A(T) = (T - T_0)(T + T_0) \frac{RV}{T_0} - \frac{3}{2} \nu R (T - T_0) = (T - T_0) \frac{RV}{T_0} (T + T_0 - \frac{3}{2} T_0) =$$

$$= \frac{RV}{T_0} (T^2 - \frac{3}{2} T_0 T + \frac{1}{2} T_0^2)$$

$$A'(T) = \frac{RV}{T_0} (2T - \frac{3}{2} T_0) = 0 \text{ при } T = \frac{3}{4} T_0 \text{ - это точка}$$

min, а не max, так как  $A(T)$  - парабола ветвями вверх.

$$3) A(\frac{3}{4} T_0) = \frac{RV}{T_0} ( \frac{9 T_0^2}{16} - \frac{3}{2} \cdot \frac{3}{4} T_0^2 + \frac{T_0^2}{2} ) = - \frac{RV T_0}{16}$$

Ответ:  $-\frac{RV T_0}{16}$  при  $T = T_0 \cdot \frac{3}{4}$

# Часть 2

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

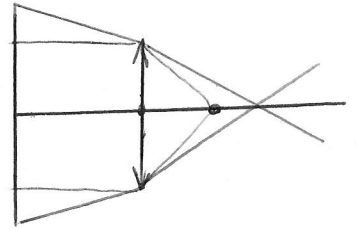
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Вариант 1

Чертовик  
Вар. 11-01

Задача 3



# УПРОБНИК

$$\mathcal{E}_1 = Bv_1L$$

$$F_A = BIL$$

$$a_2 = \frac{BIL}{2m} = \frac{B \frac{\mathcal{E}_1}{3R} L}{2m} = \frac{B^2 v_1 L^2}{6mR}$$

$$\mathcal{E}_2 = Bv_2L$$

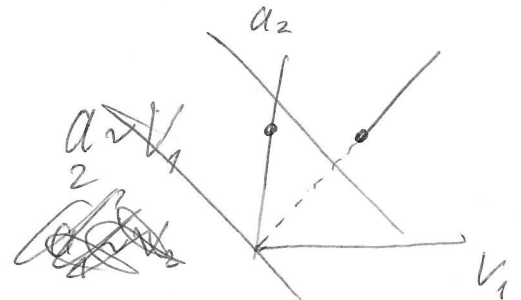
$$\mathcal{E}_1 = Bv_1L$$

$$F_A = BIL$$

~~$$BIL = m v_1' = m \left( \frac{\mathcal{E}_1}{BL} \right) = \frac{m \mathcal{E}_1}{BL}$$~~

~~$$v_2 = \frac{B^2 L^2}{6mR} v_1 t$$~~

~~$$a_2(v_1) = \frac{B^2 L^2}{6mR} v_1$$~~
~~$$v_2(v_1) = \frac{B^2 L^2}{6mR} v_1 t$$~~



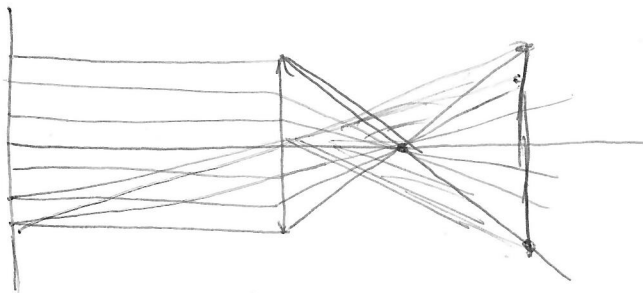
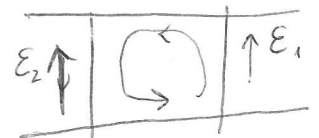
$$a_2 = \frac{BIL}{2m} = \frac{B \frac{\mathcal{E}_1 - \mathcal{E}_2}{3R} L}{2m} = \frac{BL}{6mR} (Bv_1L - Bv_2L) = \frac{B^2 L^2}{6mR} (v_1 - v_2)$$

$$a_1 = \frac{B^2 L^2}{3mR} (v_1 - v_2)$$

$$(v_1 - v_2)' = a_1 - a_2 = (v_1 - v_2) \frac{B^2 L^2}{6mR} \Rightarrow v_1 - v_2 = e^{-\frac{B^2 L^2}{6mR} t} \cdot v_0$$

~~$$a_1 = v_1' \Rightarrow v_1 = 2e^{-\frac{B^2 L^2}{6mR} t} v_0 \sim 2v_0$$~~

$$\frac{BL^2}{3mR} e^{-\frac{B^2 L^2}{6mR} t} v_0$$



$$\mathcal{E} = U + IR$$

$$\mathcal{E} = \frac{q}{c} + q'R$$

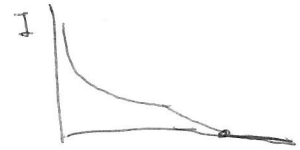
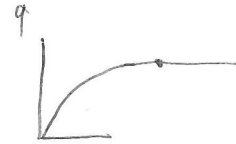
# Черновик



$$\varepsilon = U$$

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

$$I = \frac{dq}{dt} = (C \dot{\varepsilon}) = C \dot{\varepsilon}'$$



$$U = \frac{q}{C}$$

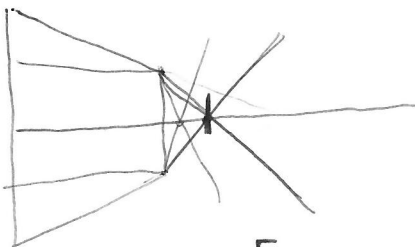
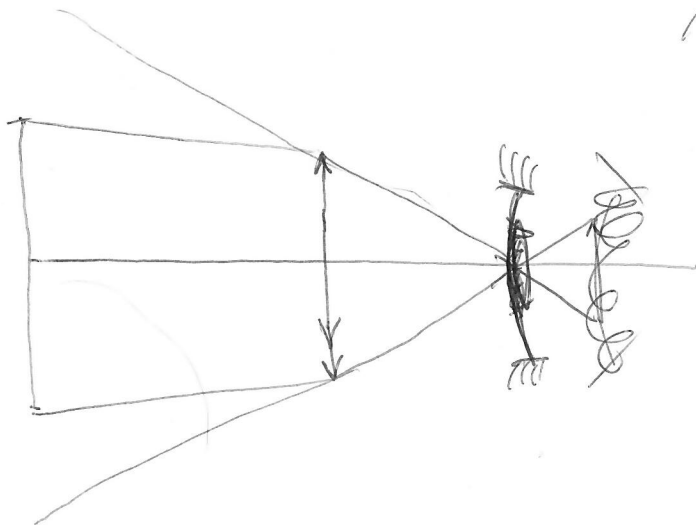
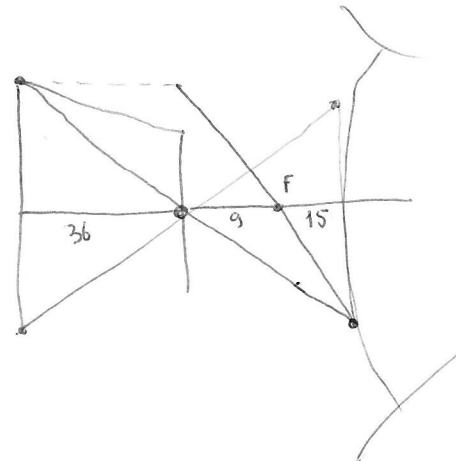
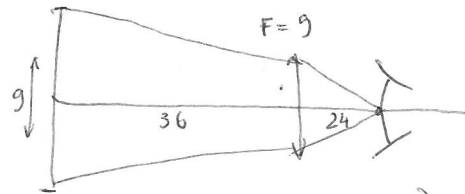
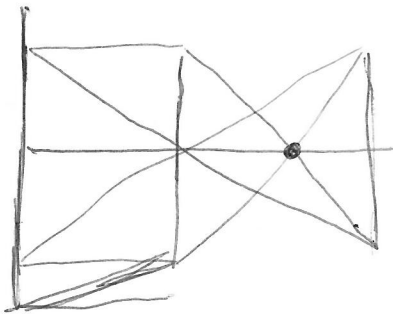
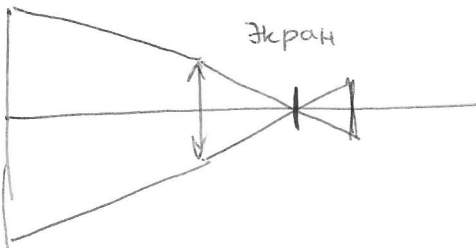
$$I = \dot{q} = \frac{dU}{dt}$$

~~$$I = \frac{dU}{dt}$$~~

~~$$U$$~~

~~$$\varepsilon - U = \dots$$~~

$$\varepsilon_i = -I'Z$$



стр. 5.



### Задача 3

1) До замыкания ключа:

$$C_{\text{экв}} = \frac{C_1 C_2}{C_1 + C_2} = \frac{2}{3} C; \quad U = E = \varphi_B - \varphi_C =$$

$$= (\varphi_B - \varphi_A) + (\varphi_A - \varphi_C) = U_2 + U_1;$$

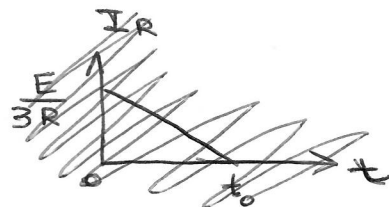
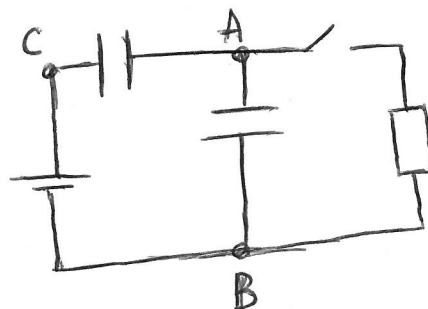
$$q_{\text{жв}} = U C_{\text{экв}} = \frac{2}{3} EC;$$

$$q_1 = q_2 \Rightarrow q_1 = q_2 = \frac{1}{3} EC \Rightarrow \varphi_B - \varphi_A = \frac{\frac{1}{3} EC}{C} = \frac{E}{3}$$

Сразу после замыкания ключа:

$$I_R = \frac{\varphi_B - \varphi_A}{R} = \frac{E}{3R}$$

Ответ:  $\frac{E}{3R}$



Задача 4

$$F_{A1} = F_{A2} = F_A = BIL = B \frac{\mathcal{E}L}{3R} = \frac{BL(\mathcal{E}_2 - \mathcal{E}_1)}{3R}$$

$$a_1 = \frac{F_A}{m} = \frac{BL(\mathcal{E}_2 - \mathcal{E}_1)}{3mR}; \quad a_2 = \frac{BL(\mathcal{E}_2 - \mathcal{E}_1)}{6mR}$$

$$\mathcal{E} = BvL \Rightarrow \mathcal{E}_1 - \mathcal{E}_2 = BL(v_1 - v_2) \Rightarrow a_1 = \frac{B^2L^2(v_2 - v_1)}{3mR}; \quad a_2 = \frac{B^2L^2(v_2 - v_1)}{6mR};$$

$$a_1 - a_2 = \frac{B^2L^2(v_2 - v_1)}{6mR}$$

$$a_1 - a_2 = (v_1 - v_2)' \Rightarrow (v_1 - v_2) \sim -(v_1 - v_2)' \Rightarrow (v_1 - v_2) = v_0 \cdot e^{-\frac{B^2L^2}{6mR}t};$$

при  $t=0$   $v_1 - v_2 = v_0$ ; при  $t \rightarrow \infty$   $v_1 - v_2 \rightarrow 0$

$$a_1 = \frac{B^2L^2 \cdot (-v_0 e^{-\frac{B^2L^2}{6mR}t})}{3mR} = v_1' \Rightarrow v_1 = \cancel{\frac{B^2L^2 v_0}{6mR}} 2v_0 e^{-\frac{B^2L^2}{6mR}t} - v_0, \text{ тогда}$$

$$v_1(t=0) = v_0$$

$$\text{Аналогично } a_2 = \frac{B^2L^2(-v_0 e^{-\frac{B^2L^2}{6mR}t})}{6mR}; \quad v_2 = v_0 e^{-\frac{B^2L^2}{6mR}t} - v_0; \quad a_2(t=0) = \frac{B^2L^2 v_0}{6mR}$$

При  $t \rightarrow \infty$   $v_1 = v_2 = v_0$

Пусть  $S$  - расст. между перемычками:

$$S' = (v_1 - v_2) \Rightarrow |S| = -\frac{6mRv_0 e^{-\frac{B^2L^2}{6mR}t}}{B^2L^2} + \left( S_0 + \frac{6mRv_0}{B^2L^2} \right)$$

$$\text{При } t \rightarrow \infty \quad S \rightarrow \frac{6mRv_0}{B^2L^2} - S_0$$

$$\text{Ответ: } a_2(t=0) = \frac{B^2L^2 v_0}{6mR}; \quad v(t \rightarrow \infty) = v_0; \quad S(t \rightarrow \infty) = \left| \frac{6mRv_0}{B^2L^2} - S_0 \right|$$