Часть 1

Олимпиада: **Физика, 10 класс (1 часть)**

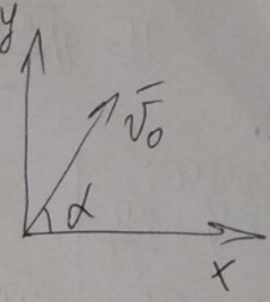
Шифр: **21205731**

ID профиля: **845926**

Вариант 4

1.

Дано:
$\alpha = 45^\circ$
$H = 10$ м



Решение

1) $v_0 \cos\alpha = const$

$$\begin{cases} H = v_0 \sin\alpha \, t - \dfrac{gt^2}{2} \\ 0 = v_0 \sin\alpha - gt \end{cases}$$

$$v_0 \sin\alpha = gt$$

$$H = gt^2 - \frac{gt^2}{2}$$

$$H = \frac{gt^2}{2}$$

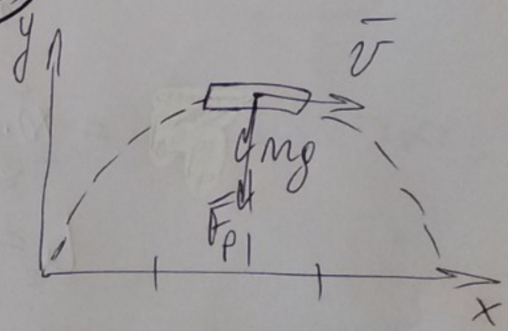
$$t = \sqrt{\frac{2H}{g}} = \sqrt{\frac{2\cdot\cancel{10}}{\cancel{10}}} = \sqrt{2} \ (c)$$

$$v_0 \sin\alpha = gt = \sqrt{2}\cdot 10$$

$$\sin\alpha = \frac{\sqrt{2}}{2}$$

$$v_0 = \frac{gt}{\sin\alpha} = \frac{10\cancel{\sqrt{2}}\cdot 2}{\cancel{\sqrt{2}}} = 20 \left(\frac{м}{с}\right)$$

2) $|\bar{F}_p| = \dfrac{|m\bar{g}|}{2}$



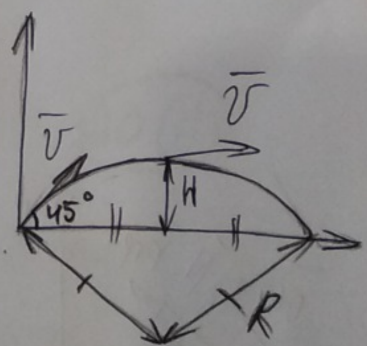
$F_c \sim v^2$ или $F_c \sim v$

$|\bar{v}| = const \Rightarrow |\bar{F}_c| = const$

$$F_p = ma = \frac{mg}{2}$$

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

$$\frac{\cancel{m}g}{2} = \cancel{m}\frac{v^2}{R}$$

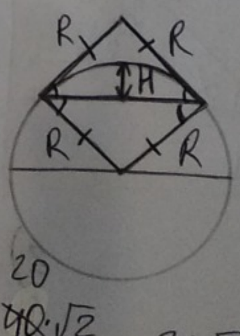


Найдём длину траектории по O_x из предыдущего пункта:

$$L = v_0 \cos\alpha \cdot t_{пол}$$

$$t_{пол} = 2t = 2\sqrt{2}$$

$$L = 20\cdot\frac{\sqrt{2}}{\cancel{2}}\cdot\cancel{2}\sqrt{2} = 40 \ (м)$$



т.к. $\bar{v}$ – направлен по касательной к окружности, то $R = L\cdot\cos\alpha = \dfrac{\overset{20}{\cancel{40}}\cdot\sqrt{2}}{\cancel{2}} = 20\sqrt{2} \ (м)$

$S = L_2 + L_1$

$$\begin{cases} L_1 = \dfrac{a_1 t^2}{2} \\ v_{max} = a_1 t \end{cases}$$

$$t = \frac{v_{max}}{a_1} = \frac{4,47}{2,224} \approx 2,01 \text{ (с)}$$

$$L_1 = \frac{a t^2}{2} = \frac{2,224 \cdot 4,04}{2} \approx 4,5 \text{ (м)}$$

$$S = L_1 + L_2 = 4,5 + 5 = 9,5 \text{ (м)}$$

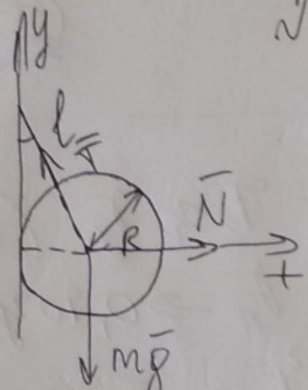
Ответ: 9,5 м; 4,47 $\frac{м}{с}$.

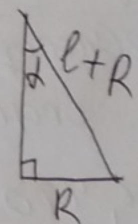
3.

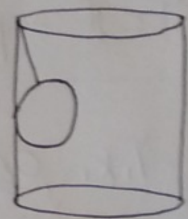
Дано:
$R = 0,08$ м
$l = 0,08$ м
$m = 5,2$ кг

Решение

1)







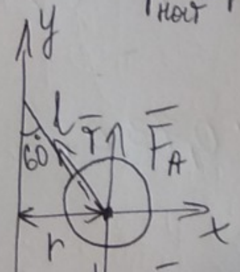
т.к. $l = R$, то $\sin\alpha = \frac{1}{2} \Rightarrow \alpha = 30°$

$$\begin{cases} O_y: mg = T\cos\alpha \\ O_x: N = T\sin\alpha \end{cases}$$

$\alpha = 60°$

$$F_{нат} = T = \frac{mg}{\cos\alpha} = \frac{5,2 \cdot 10 \cdot 2}{\sqrt{3}} \approx 60 \text{ (Н)}$$

2)



$$\begin{cases} O_y: F_A + T\cos\alpha = mg \\ O_x: T\sin\alpha = ma \end{cases}$$

$$a = \frac{v^2}{r} = \omega^2 r = \frac{4\pi^2 r}{T^2}$$

$$\omega = \frac{2\pi}{T}$$

$$F_A = \rho_в g V_ш = \frac{4\rho_в g R^3 \pi}{3}$$

$$V_ш = \frac{4}{3}\pi R^3$$

$$\frac{4\rho_в g R^3 \pi}{3} + T\cos\alpha = mg$$

$$v=\sqrt{\frac{gR}{2}}=\sqrt{\frac{10\cdot 20\sqrt{2}}{2}}=\sqrt{100\sqrt{2}}=10\sqrt[4]{2}\approx 10{,}9\left(\frac{м}{с}\right)$$

Ответ: $10{,}9\frac{м}{с}$; $20\frac{м}{с}$.

2.

Дано:
$v=0$
$\cos\alpha=\frac{24}{25}$
$\mu_2=0{,}5$ ← после h
$\mu_1=0{,}06$ ← до h
$h=1{,}4м$
$v_0=0$

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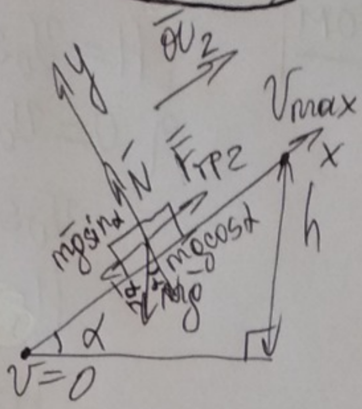
v_{max} - ?
S - ?

Решение



1) O_x: $F_{тр2}-mg\sin\alpha=ma_2$

O_y: $mg\cos\alpha=N$

$F_{тр2}=N\mu_2=\mu_2 mg\cos\alpha$

$\mu_2 \cancel{m}g\cos\alpha-\cancel{m}g\sin\alpha=\cancel{m}a$

$a_2=g(\mu_2\cos\alpha-\sin\alpha)$

$\cos^2\alpha+\sin^2\alpha=1$

$\sin\alpha=\sqrt{1-\cos^2\alpha}=\sqrt{1-\frac{576}{625}}=\frac{7}{25}$

$a_2=g(\mu_2\cos\alpha-\sin\alpha)=10\left(\frac{0{,}5\cdot 24}{25}-\frac{7}{25}\right)=$

$=\frac{\cancel{10}^{2}\cdot\cancel{5}}{\cancel{25}_{5}}=2\left(\frac{м}{с^2}\right)$

$L_2=\frac{h}{\sin\alpha}=\frac{\cancel{1{,}4}^{0{,}2}\cdot 25}{\cancel{7}}=5(м)$

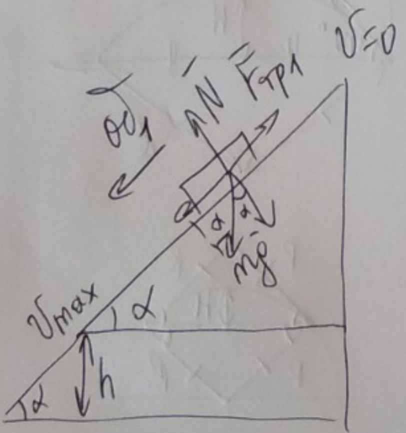
$\begin{cases} L_2=v_{max}t-\frac{a_2t^2}{2} \\ 0=v_{max}-a_2t \end{cases}$

$v_{max}=a_2t$

$L_2=a_2t^2-\frac{a_2t^2}{2}$

$L_2=\frac{a_2t^2}{2}$

$t^2=\frac{2L_2}{a_2} \Rightarrow t=\sqrt{\frac{2L_2}{a_2}}=\sqrt{\frac{\cancel{2}\cdot 5}{\cancel{2}}}=\sqrt{5}\,(с)$



$v_{max}=a_2t=2\sqrt{5}\left(\frac{м}{с}\right)=4{,}47\left(\frac{м}{с}\right)$

2) $a_1=g(\sin\alpha-\mu_1\cos\alpha)=10\cdot\left(\frac{7}{25}-\frac{0{,}06\cdot 24}{25}\right)=\frac{\cancel{10}^{2}\cdot 5{,}56}{\cancel{25}_{5}}=$

$=2{,}224\left(\frac{м}{с^2}\right)$

$$T = \frac{\left(mg - \frac{4\rho_B g R^3 \pi}{3}\right)}{\cos\alpha} = 2\left(mg - \frac{4\rho_B g R^3 \pi}{3}\right) =$$

$$= 2\cdot\left(5{,}2\cdot 10 - \frac{4\cdot 10^3\cdot 10\cdot 0{,}08^3\pi}{3}\right) = 2\cdot(52 - 21{,}45) \approx 61{,}1\ (H)$$

$$T\sin\alpha = \frac{m\cdot 4\pi^2 r}{T'^2}$$

$$r = (l+R)\cdot\sin\alpha = \frac{0{,}16\cdot\sqrt{3}}{2} \approx 0{,}1386\ (м)$$

$$T' = \sqrt{\frac{4m\pi^2 r}{T\sin\alpha}} = \sqrt{\frac{4\pi^2 m\cdot(l+R)\cancel{\sin\alpha}}{\cancel{T\sin\alpha}}} = \sqrt{\frac{4\cdot\pi^2\cdot 5{,}2\cdot 0{,}16}{61{,}1}} \approx$$

T' – период

$\approx 0{,}73\ (c)$

$T = F$ – равнодействующая

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2 способ

Т.к. ρ_B нам не дано, $T_2 \approx T_1$ ($61{,}1 \approx 60$ Н), то будем считать, что $F_A \to 0$, тогда

$$T\sin\alpha = m\cdot\frac{4\pi^2 r}{T'^2}, \quad T = 60\,H$$

$$T' = \sqrt{\frac{4m\pi^2(l+R)\cdot\cancel{\sin\alpha}}{\cancel{T\sin\alpha}}} = \sqrt{\frac{4\cdot 5{,}2\cdot\pi^2\cdot 0{,}16}{60}} \approx 0{,}7399 \approx$$

$\approx 0{,}74\ (c)$

$0{,}74 \approx 0{,}73$

Ответ: 60 Н; 0,73 с.

Часть 2

Олимпиада: **Физика, 10 класс (2 часть)**

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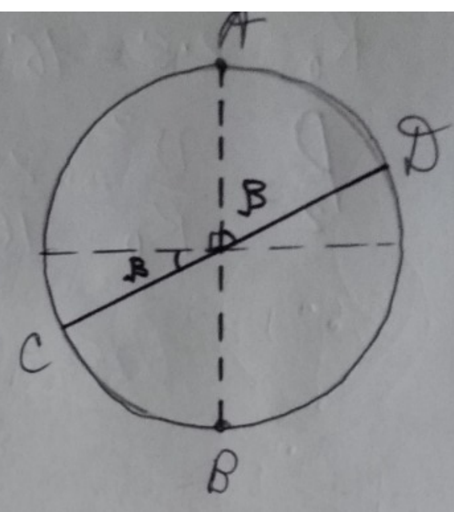
Вариант 4

$R_0 = 2 \cdot 8 = 16$ (Ом)

$P_2 = \frac{U^2}{R_0} = \frac{24^2}{16} = 36$ (Вт)

Ответ: 36 Вт, 30°, 36 Вт.

Подставим числа:



$$\frac{1}{2} = \frac{360° \cdot 24 \cdot \beta}{72 \cdot (90° - \beta^2)}$$

$$24 \cdot 360° \cdot \beta = 72 \cdot 90° - 72\beta^2$$

$$72\beta^2 - 8640\beta + 6480 = 0$$

$$\beta^2 - 120\beta + 90 = 0$$

$$D = 14400 - 360 = 14040$$

$$\beta_1 = \frac{120 - 118{,}5}{2} = 0{,}75°$$

$$\beta_2 = \frac{120 + 118{,}5}{2} = 119{,}25° > 90° \text{ — не подходит}$$

$$I_{CD} = I_{AD} - I_{CD} = \frac{U \cdot 360°}{2 \cdot R \cdot (90° - \beta)} - \frac{U \cdot 360°}{2R(90° + \beta)} = \frac{U \cdot 360°}{2R} \times$$

$$\times \left(\frac{90° + \beta - 90° + \beta}{90°^2 - \beta^2}\right)$$

$$\frac{1}{\cancel{2}} = \frac{24 \cdot 360° \cdot 2\beta}{\cancel{2} \cdot 72 \cdot (90^2 - \beta^2)} \text{ — правильно}$$

$$\cancel{17280\beta = 4723920000 - 72\beta^2}$$

$$\cancel{\beta^2 - 65610000 + 240\beta = 0}$$

$$\cancel{D = 57600 + 262440000} =$$

$$240\beta = 8100 - \beta^2$$

$$\beta^2 - 240\beta - 8100 = 0$$

$$D = 57600 + 32400 = 90000$$

$$\beta = \frac{240 + 300}{2} = \frac{540}{2} = 270° \text{ — } > 90° \text{ — не подходит}$$

$$\beta = \frac{240 - 300}{2} = -30°$$

$$\beta = 30°$$

3) $R_{CB} = \frac{R(90° - 30°)}{360°} = \frac{60° \cdot R}{360°} = \frac{R}{} = 12\,(Ом)$

$R_{AC} = \frac{R}{2} - R_{CB} = 24\,(Ом)$

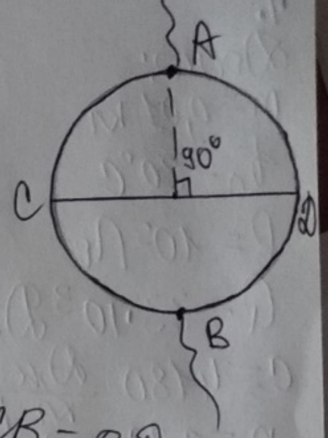
$R_{ACD} = R_{CBD} = \frac{R_{CB} \cdot R_{AC}}{R_{CB} + R_{AC}} = \frac{12 \cdot 24}{12 + 24} = 8\,(Ом)$

5.

Дано:
$R = 72$ Ом
$U = 24$ В
$\alpha = 90°$

$P - ?$
$\beta - ?$
$P_2 - ?$

Решение



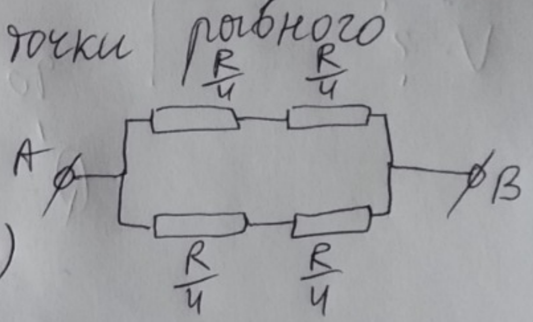
1) Пусть точки C и D — концы перемычки

$\cup AC = \cup AD = \cup CB = \cup BD \Rightarrow$

$R_{AC} = R_{AD} = R_{DB} = R_{CB}$ т.к. $AC = AD = CB = BD$ проволоки изготовлены из однородного металла

$R_{AC} = \ldots = \frac{R}{4}$

т.к. $\frac{R_{AC}}{R_{AD}} = \frac{R_{BD}}{R_{CB}}$, то CD — точки равного потенциала



$R_0 = \frac{\frac{R}{4} + \frac{R}{4}}{2} = \frac{R}{4} = 18$ (Ом)

$P = \frac{U^2}{R_0} = \frac{24^2}{18} = 32$ (Вт)

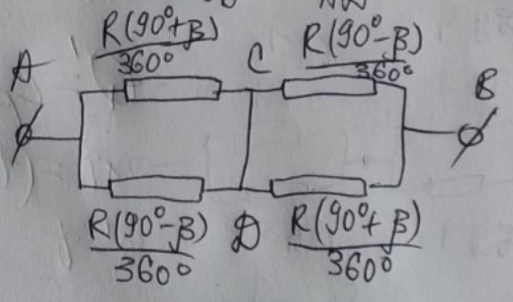
2) Составим пропорцию

$R - 360°$

$R_{CB} = R_{AD} - 90° - \beta$

$R_{CB} = R_{AD} = \frac{R(90° - \beta)}{360°}$

$R_{AC} = R_{DB} = \frac{R(90° + \beta)}{360°}$



$$\begin{cases} I_{AC} + I_{AD} = I_{CB} + I_{DB} \\ \frac{R_{AC}}{R_{AD}} = \frac{R_{DB}}{R_{CB}} \end{cases}$$

$I_{AD} = I_{CB}$ и $I_{AC} = I_{DB}$

$I_{CD} = |I_{AC} - I_{AD}| = \left| \frac{U \cdot 360°}{2 \cdot R(90° + \beta)} - \frac{U \cdot 360°}{2R(90° - \beta)} \right|$

$U_{AC} = U_{AD} = U_{DB} = U_{CB} = \frac{U}{2}$

$I_{CD} = \left| \frac{180° U}{R} \left(\frac{1}{90° + \beta} - \frac{1}{90° - \beta} \right) \right| = \frac{180° U}{R} \left(\frac{90° + \beta - 90° + \beta}{(90° + \beta)(90° - \beta)} \right) =$

$= \frac{180° \cdot U \cdot 2\beta}{R(90°^2 - \beta^2)}$

4.

Дано:

$m = 0{,}01$ кг

$t_0 = 20°C$

$p = 10^5$ Па

$Q = 33 \cdot 10^3$ Дж

$c = 4180 \frac{\text{Дж}}{\text{кг} \cdot \text{К}}$

$r = 2{,}26 \cdot 10^6 \frac{\text{Дж}}{\text{кг}}$

$c_p = 2200 \frac{\text{Дж}}{\text{кг} \cdot \text{К}}$

$t = 100°C$

$Q_1 - ?$

$V - ?$

Решение

1) $|Q_1| = Q_{пол}$

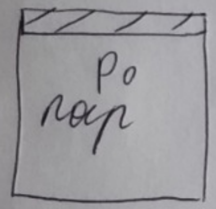
$Q_1 = c_в m_в (t - t_0) = 4180 \cdot 0{,}01 \cdot (100 - 20) = 3344$ (Дж)

2) $Q = Q_1 + Q_{пар} + Q'$

$Q_{пар} = r \cdot m_в = 2260000 \cdot 0{,}01 = 22600$ (Дж)

т.к. поршень легкоподвижный, p_0

то $p_{пар} = p_0 = const$

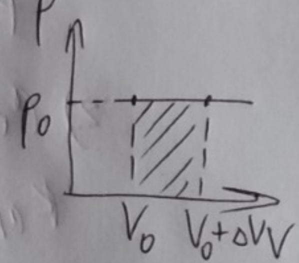


$Q' = Q - Q_1 - Q_{пар} = 33 \cdot 10^3 - 22{,}6 \cdot 10^3 - 3344 = 7056$ (Дж)

$Q' = \Delta U + A$

$A = p \Delta V$

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



$Q' = c_p m_{пара} \Delta t$

$\Delta t = (t' - t)$

$t' - t = \frac{Q'}{c_p m_{пара}}$

$t' = \frac{Q'}{c_p m_{пара}} + t = \frac{7056}{0{,}01 \cdot 2200} + 100 \approx 320 (°C)$

$p_0 = \frac{m R T'}{M V}$

$V = \frac{m R T'}{p_0 M} = \frac{0{,}01 \cdot 8{,}31 \cdot (320 + 273)}{10^5 \cdot 0{,}018} \approx 0{,}0274$ ($м^3$)

$V \approx 27{,}4$ (л)

Ответ: 27,4 $дм^3$.

1

Черновик

Проверим

3 382 5 75

$$R_{CB} = \frac{R \cdot (90 - 0{,}75)}{360°} = 17{,}85$$

$$R_{AC} = \frac{R}{2} - R_{CB} = 18{,}15°$$

$$I_{CD} = \frac{v}{2R_{CB}} - \frac{v}{2R_{AC}} = \frac{24}{2}\left(\frac{1}{1785} - \frac{1}{1815}\right) =$$

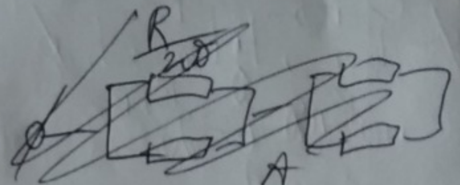
$$= \frac{12 \cdot (1815 - 1785)}{} = \quad 12 \cdot 30$$

$$\bar{I}_{CD} = \frac{v}{2R_{CB}} - \frac{v}{2R_{AC}} = \frac{24}{2}\left(\frac{1}{12} - \frac{1}{24}\right) =$$

$$= 12 \cdot \left(\frac{24-12}{12 \cdot 24}\right) = \frac{\cancel{12 \cdot 12}}{\cancel{12} \cdot \cancel{24}} = \frac{1}{2}$$

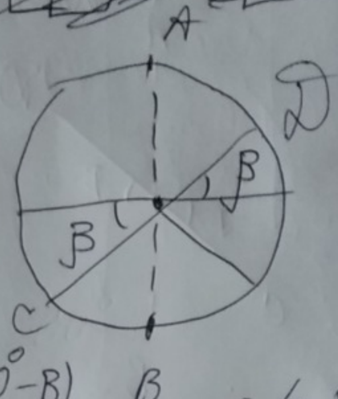
Черновик

$$R = \frac{2 R_{AC} R_{CB}}{R_{AC} + R_{CB}} = \frac{4 R^2 \left(\frac{\vartheta^2}{4} - \beta^2\right)}{R \cdot 4 \vartheta^2}$$

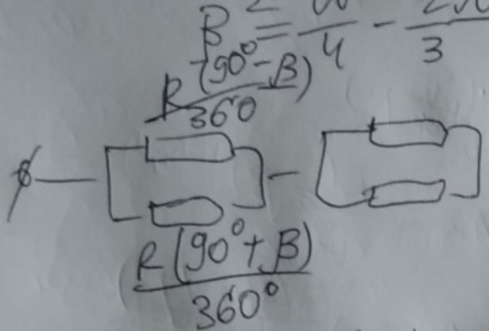


$$I = \frac{U}{R_0} = \frac{U \cdot \vartheta^2}{R\left(\frac{\vartheta^2}{4} - \beta^2\right)}$$

$$\frac{\vartheta^2}{4} - \beta^2 = \frac{U \vartheta^2}{IR} = \frac{2}{3}\vartheta^2$$



$$\beta^2 = \frac{\vartheta^2}{4} - \frac{2\vartheta^2}{3} = \frac{5\vartheta^2}{12}$$



$$\frac{R(90^\circ-\beta)}{360^\circ} \qquad \frac{R(90^\circ+\beta)}{360^\circ}$$

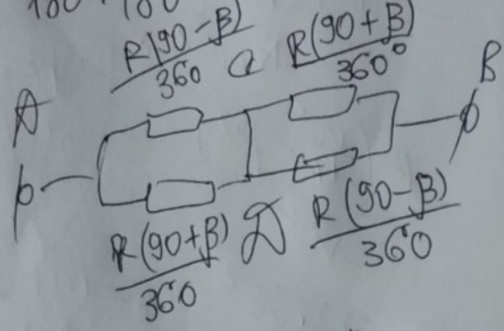
$$\frac{R(90^\circ-\beta)}{360^\circ} + \frac{R(90^\circ+\beta)}{360^\circ}$$

$\frac{24}{18}$

$$\frac{R(90^\circ-\beta+90^\circ+\beta)}{360^\circ} = \frac{180^\circ R}{360^\circ} = \frac{R}{2}$$

$$R_0 = \frac{2 \cdot 2 \cdot R^2 (90^\circ-\beta)(90^\circ+\beta)}{R \cdot 360^\circ \cdot 360^\circ} = \frac{(90^{\circ 2} - \beta^2) \cdot R}{180^\circ \cdot 180^\circ}$$

$$I = \frac{U_0}{R_0} = \frac{180^{\circ 2} U}{R(90^{\circ 2} - \beta^2)} =$$



$$90^{\circ 2} - \beta^2 = \frac{180^{\circ 2} U}{IR} = \frac{180^{\circ 2} \cdot 2}{3}$$

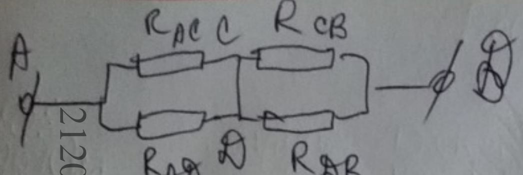
$$8100 - \beta^2 = 21600$$

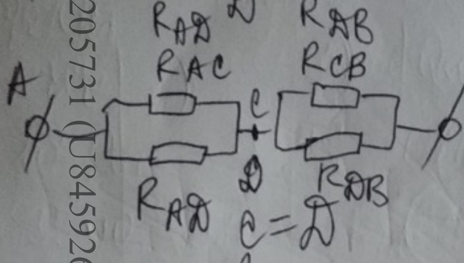
$$\frac{I_{AC}}{I_{AD}} = \frac{I_{BD}}{I_{CB}}$$

$$R_0 = \frac{R(180-\beta) R \cdot \beta \cdot 4}{360^\circ \cdot 360^\circ \cdot R}$$

$$R_0 = \frac{R(180-\beta)\beta}{180^2}$$

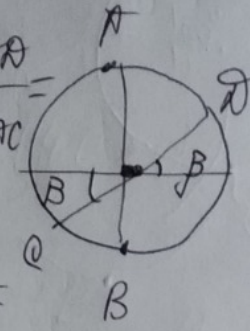
2



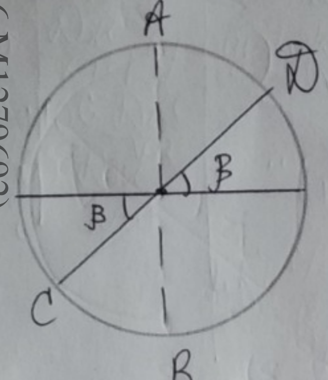


$$R_{AC}+R_{AD}=R_{CB}+R_{BD}=\frac{R}{2}$$

$$R_0=\frac{R_{CB}R_{BD}}{R_{CB}+R_{BD}}+\frac{R_{AC}R_{AD}}{R_{AD}+R_{AC}}=$$



$$=\frac{R_{CB}R_{BD}\cdot 2}{R}+\frac{R_{AC}R_{AD}\cdot 2}{R}=$$



$$=\frac{2(R_{CB}R_{BD}+R_{AC}R_{AD})}{R}$$

$$R_{CB}=\frac{R\cdot(\frac{\pi}{2}-\beta)}{2\pi}$$

$$R_{CB}=R_{AD}=\frac{R(\frac{\pi}{2}-\beta)}{2\pi}$$

$$R_{AD}=R_{CB}=\frac{R(\frac{\pi}{2}-\beta)}{2\pi}$$

$$R_{BD}=R_{AC}=\frac{R(\frac{\pi}{2}+\beta)}{2\pi}$$

$$R_{BD}=R_{AC}=\frac{R(\frac{\pi}{2}+\beta)}{2\pi}$$

$$R_0=\frac{\cancel{2}\cdot\cancel{2}\,\frac{R(\frac{\pi}{2}-\beta)}{\cancel{2}\pi}\cdot\frac{R(\frac{\pi}{2}+\beta)}{\cancel{2}\pi}}{\cancel{R}}=$$

$$R_0=\frac{2R_{AC}R_{CB}\cdot 2}{R}=$$

$$=\frac{\cancel{4}\cdot \cancel{R}^2(\frac{\pi}{2}-\beta)\times(\frac{\pi}{2}+\beta)}{\cancel{4}\pi^2\cancel{R}}=\frac{R(\frac{\pi}{2}-\beta)(\frac{\pi}{2}+\beta)}{R}$$

$$=\frac{R(\frac{\pi^2}{4}-\beta^2)}{\pi^2}$$

$$I=\frac{U}{R_0}=\frac{U}{R(\frac{\pi}{2}-\beta)(\frac{\pi}{2}+\beta)}=\frac{U}{R(\frac{\pi^2}{4}-\beta^2)}$$

$$\frac{\pi^2}{4}-\beta^2=\frac{U}{IR}=\frac{24}{0{,}5\cdot 72}=\frac{24}{36}=\frac{6}{9}=\frac{2}{3}$$

$$\beta=\sqrt{\frac{\pi^2}{4}-\frac{2}{3}}$$

$$I=\frac{U\cdot\pi^2}{R(\frac{\pi^2}{4}-\beta^2)}$$

$$\frac{8-3}{12}=\frac{5}{12}$$

Черновик

$$\frac{\pi^2}{4}-\beta^2=\frac{U\pi^2}{IR}$$

$$\beta=\pi\sqrt{\frac{1}{4}-\frac{U}{IR}}=\pi\sqrt{\frac{1}{4}-\frac{2}{3}}$$

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