Часть 1

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

Шифр: **21104385**

ID профиля: **159158**

Вариант 21

№1

Чистовик. 21 вариант

Лист №1

$a_1; a_2; \ldots$ – арифм. пр-ия

$a_n = a_1 + (n-1)d$, где d – разность пр-ии.

$d > 0$, т.к. пр-ия возрастающая $a_1 - ?$

d – целое, т.к. $a_1; a_2 \ldots$ – целые

$$\begin{cases} (a_8 \cdot a_{17}) > S + 27 \\ (a_{11} \cdot a_{14}) < S + 60 \end{cases}$$

$S = a_1 + a_2 + \ldots + a_7 =$

$= \frac{a_1 + a_7}{2} \cdot 7 = \frac{2a_1 + 6d}{2} \cdot 7 = 7a_1 + 21d$

$$\begin{cases} (a_1 + 7d)(a_1 + 16d) > 7a_1 + 21d + 27 \\ (a_1 + 10d)(a_1 + 13d) < 7a_1 + 21d + 60 \end{cases}$$

$$\begin{cases} a_1^2 + 23da_1 + 112d^2 > 7a_1 + 21d + 27 \\ 7a_1 + 21d + 60 > a_1^2 + 23da_1 + 130d^2 \end{cases} (+)$$

$112d^2 + 60 > 130d^2 + 27$

$d^2 < \frac{33}{18}$ т.к. d – целое и $d > 0 \Rightarrow d = 1$

$$\begin{cases} a_1^2 + 23a_1 + 112 > 7a_1 + 21 + 27 \\ a_1^2 + 23a_1 + 130 < 7a_1 + 21 + 60 \end{cases}$$

$$\begin{cases} a_1^2 + 16a_1 + 64 > 0 \Rightarrow (a+8)^2 > 0 \Rightarrow a \neq -8 \\ a_1^2 + 16a_1 + 49 < 0 \end{cases}$$

$a_1^2 + 16a_1 + 49 < 0$

$D' = 64 - 49 = 15$

$a_1 = -8 \pm \sqrt{15}$

$\Rightarrow a_1 \in (-8-\sqrt{15}; -8+\sqrt{15})$

$-12 < -8 - \sqrt{15} < -11$

$-5 < -8 + \sqrt{15} < -4$

т.к. a_1 – целое

$\Rightarrow a_1 \in \{-11\} \vee \{-10\} \vee \{-9\} \vee \{-7\} \vee$

$\vee \{-6\} \vee \{-5\}$

Ответ: $-11; -10; -9; -7; -6; -5$

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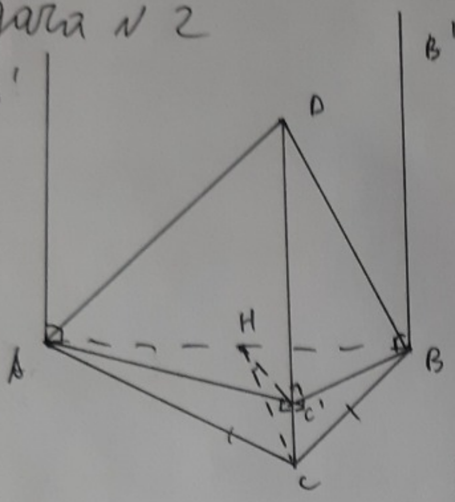
Чистовик — 21 вариант

Лист №2

Задача № 2



Дано:

ABCD - тетраэдр. вписан в цилиндр.

$AB = 4$

$AC = CB = 5$

$AD = DB = 6$

A; B; C; D ∈ бок. п-ти

$CD \parallel$ оси

$R_{осн}$ - наим.

⇓

CD - ?

Решение:

$AA'; BB' \parallel CD \Rightarrow$ образующие цилиндра

цилиндр - прямой $\Rightarrow \alpha_{осн} \perp AA'$

$AC'B \perp AA_1 \Rightarrow \angle AC'C = \angle BC'C = 90$

$C' \in CD$

т.к. CC' - общая и $AC = CB$

$\Delta AC'B$ - вписан в окружн. равную основанию

$\Delta AC'C = \Delta BC'C \Rightarrow AC' = BC'$

H - середина AB

т.к. $AC' = C'B$ $\quad C'H \perp AB$ $\quad$ Th о 3х

т.к. $CC' \perp AC'B$ $\quad CH \perp AB$ $\quad$ перпенд.

$CAB \wedge C'AB = \angle CHC' = \alpha$

ΔBCH - прямоуг $\Rightarrow CH = \sqrt{BC^2 - BH^2} = \sqrt{25 - 4} = \sqrt{21}$

Введём $R_{осн} = R_{ABC'} = \dfrac{AC' \cdot BC' \cdot AB}{4 S_{ABC'}}$

$C'H = CH \cdot \cos\alpha$ $\quad (\angle CC'H = 90)$

$= \sqrt{21} \cos\alpha$

$C'B = \sqrt{C'H^2 + HB^2} = \sqrt{21\cos^2\alpha + 4} = AC'$

$S_{AC'B} = \frac{1}{2} HC' \cdot AB = \frac{1}{2} \cdot 4 \cdot \sqrt{21} \cos\alpha = 2\sqrt{21} \cos\alpha$

Чистовик

21 вариант

Лист №3

Задача №2

$R = \frac{AC' \cdot BC' \cdot AB}{4 S_{ABC'}} = \frac{(21\cos^2\alpha + 4)\cdot 4}{4 \cdot 2\sqrt{21}\cos\alpha} = \frac{\sqrt{21}}{2}\cos\alpha + \frac{2}{\sqrt{21}\cos\alpha}$

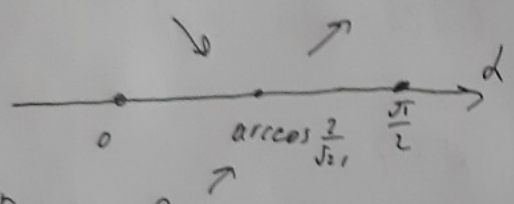
$R'(\alpha) = -\frac{\sqrt{21}}{2}\sin\alpha + \frac{2}{\sqrt{21}}\left(\frac{-\sin\alpha}{\cos^2\alpha}\right) = \frac{2}{\sqrt{21}}\frac{\sin\alpha}{\cos^2\alpha} - \frac{\sqrt{21}}{2}\sin\alpha = 0$

$\left[\begin{array}{l} \sin\alpha = 0 \Rightarrow \alpha = 0 \\ \cos^2\alpha = \frac{4}{21} \end{array}\right.$

$\sin\alpha(4 - 21\cos^2\alpha) = 0$

$\alpha \in [0; \frac{\pi}{2}]$

$\cos\alpha = \frac{2}{\sqrt{21}} \Rightarrow \alpha = \arccos\frac{2}{\sqrt{21}}$



$R(0) = \frac{\sqrt{21}}{2} + \frac{2}{\sqrt{21}} = \frac{23}{2\sqrt{21}}$

$R(\arccos\frac{2}{\sqrt{21}}) = 1 + 1 = 2$

$R(0) > R(\arccos\frac{2}{\sqrt{21}}) \Leftarrow$

$2 < \frac{23}{2\sqrt{21}}$

$4\sqrt{21} < 23 \quad |^2$

$16 \cdot 21 < 23 \cdot 23$

$\Downarrow$

$\alpha = \arccos\frac{2}{\sqrt{21}}$

$\cos\alpha = \frac{2}{\sqrt{21}} \Rightarrow \sin\alpha = \frac{\sqrt{17}}{\sqrt{21}} \Rightarrow CC' = CH \cdot \sin\alpha = \sqrt{17}$

~~$DH = \sqrt{D}$~~

DH - высота в △ADB т.к. AD = DB

$DH = \sqrt{DB^2 - HB^2} = \sqrt{36 - 4} = 4\sqrt{2}$

△DC'H - прямоуг. $C'H \perp DC'$ ($\triangle C'B \perp C'D$)

$C'D = \sqrt{DH^2 - C'H^2} = \sqrt{32 - 4} = 2\sqrt{7}$

$C'H = \sqrt{21}\cos\alpha = 2$

Чистовик

Задача №2

21 вариант

лист №4

C' ∈ лучу DC

C' может лежать как между D C, так и за C

1) C' между D C

$CD = CC' + C'D = \sqrt{17} + 2\sqrt{7}$

2) C' за C

$CD = C'D - CC' = 2\sqrt{7} - \sqrt{17} > 0$ $(\sqrt{28} - \sqrt{17} > 0)$

Ответ: $\sqrt{17}+2\sqrt{7}$; $2\sqrt{7} - \sqrt{17}$

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Задача №3 Чистовик Лист №5

$$\begin{cases}(x-a)^2+(y-b)^2 \le 20 \\ a^2+b^2 \le \min(8a-4b;20)\end{cases}$$

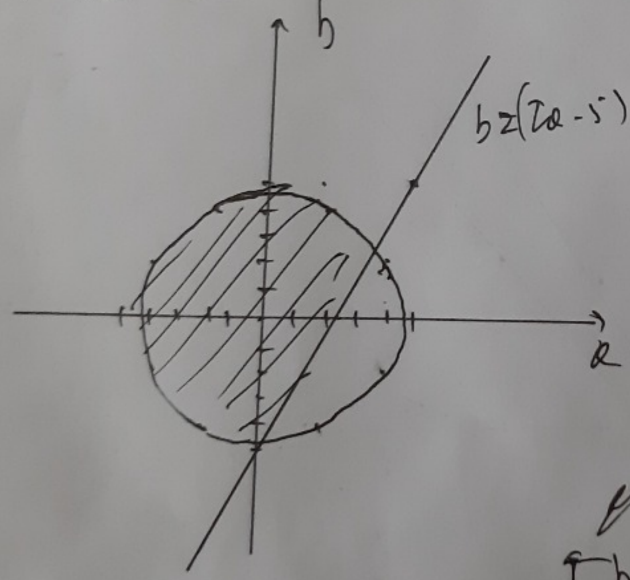
$(a;b)$ – центр окр. с радиусом 20

$a^2+b^2 \le \min(8a-4b;20)$

1) $8a-4b > 20$

$a^2+b^2 \le 20$ – круг $R=\sqrt{20}$ с ц. $(0;0)$

$b > 2a-5$



2) $8a-4b \geq 20$

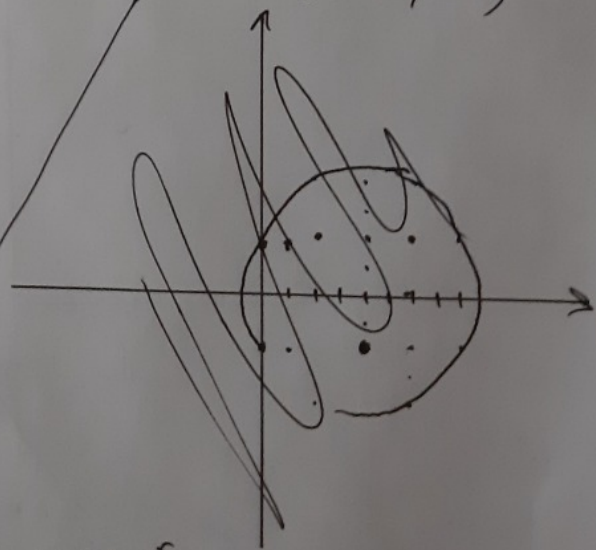
$b < 2a-5$

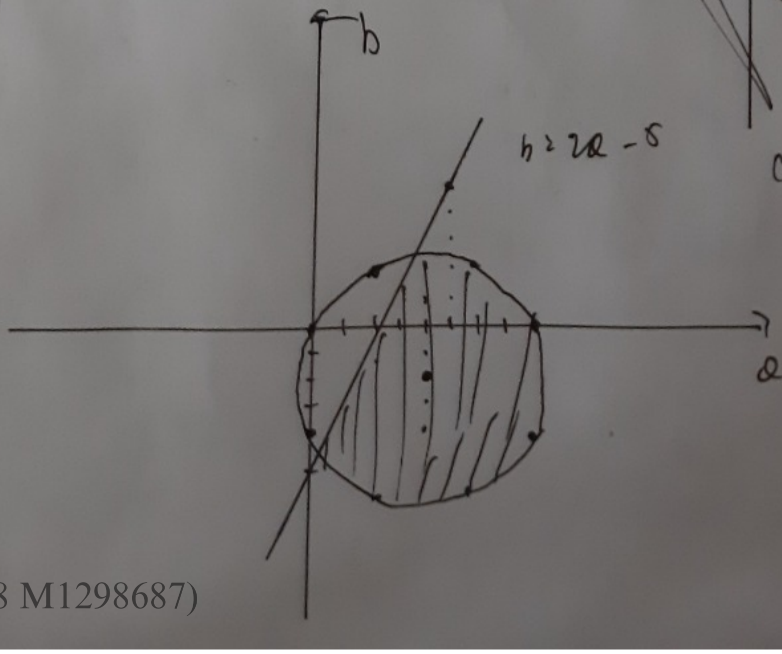
$a^2+b^2 \le 8a-4b$

$(a-4)^2+(b+2)^2 \le 20$

круг $R=\sqrt{20}$

с ц $(4;-2)$





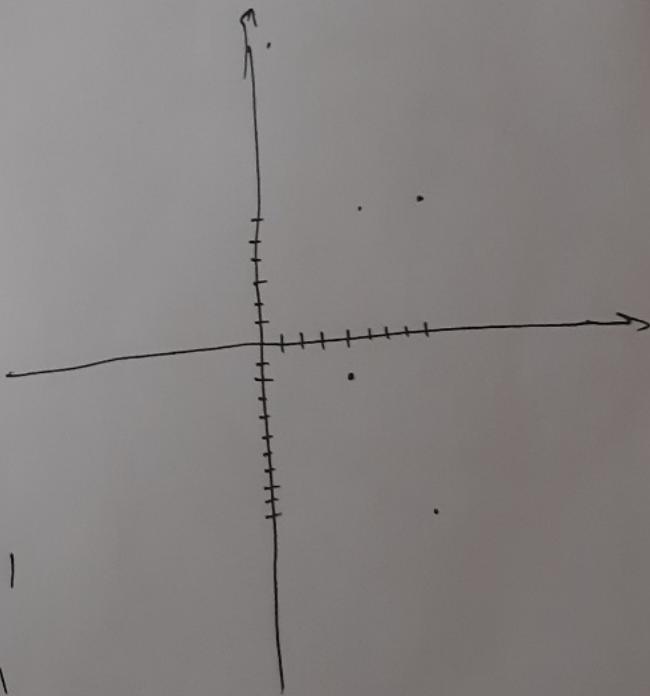
с учётом, a и b – коорд. x и y центра круга $(x-a)^2+(y-b)^2 \le 20$

Чистовик Лист №6 7

Задача №3

Значит, что M - пересечение двух кругов с радиусами $2\sqrt{20}$ и центрами $(0;0)$ и $(4;-2)$ (т.к. a и b это x и y центров кругов $R=\sqrt{20}$)

$$\begin{cases} x^2+y^2=20 \\ y=2x-5 \end{cases}$$



$x^2+4x^2-20x+25=20$

$5x^2-20x+5=0$

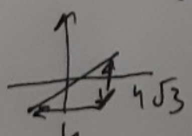
$x^2-4x+1=0$

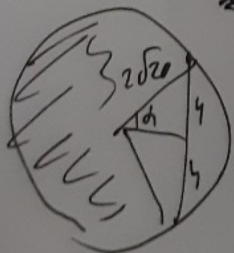
$D: 4-1=3$

$x = 2\pm\sqrt{3}$

$x_1=2+\sqrt{3} \quad y_1=2\sqrt{3}-1$

$x_2=2-\sqrt{3} \quad y_2=-2\sqrt{3}-1$

$l_{дуги}=$  $\Rightarrow l_{дуги}=\sqrt{16+16-3}=8$



$\sin\alpha=\frac{4}{2\sqrt{20}}=\frac{4}{4\sqrt{5}}=\frac{1}{\sqrt{5}}$

$\alpha=\arcsin\frac{1}{\sqrt{5}}$

$S_{сект}=$ ~~$\frac{2\alpha}{2\pi}$~~ ~~л.к. угла~~

$=\pi r^2\left(1-\frac{2\alpha}{2\pi}\right)=\pi\cdot 80\left(1-\frac{\arcsin\frac{1}{\sqrt{5}}}{\pi}\right)$

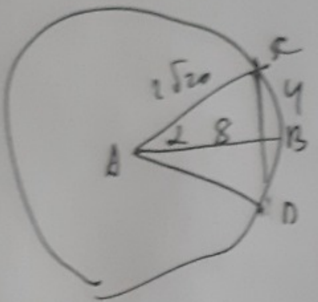
~~$S_M=2S_{сект}=$~~
~~$=160\pi\left(1-\frac{\arcsin\frac{1}{\sqrt{5}}}{\pi}\right)$~~

~~Ответ~~

Задача N 3 Чистовик Лист N 2

$S_M = 2S_{сект} + 2S_\Delta =$

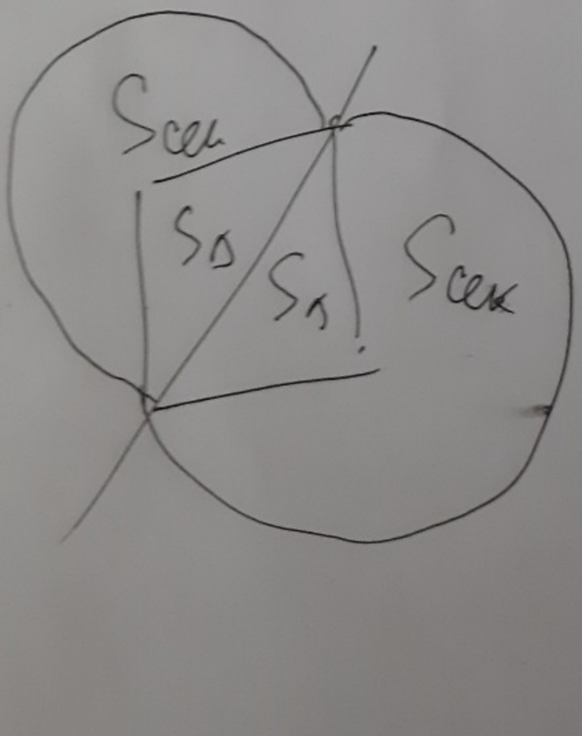
$= 160\pi\left(1 - \frac{\arcsin\frac{1}{\sqrt5}}{\pi}\right) + 64$



$S_{ABCD} = 2S_{ABC} =$ $S_\Delta = S_{ACD}$

$AB = \sqrt{80-16} = 8$

$S_{ACD} = \frac{8 \cdot 8}{2} = 32$



Ответ:

$160\pi\left(1 - \frac{\arcsin\frac{1}{\sqrt5}}{\pi}\right) + 64$

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$$\left(\frac{f(x)}{g(x)}\right)' = \frac{f'(x)\cdot g(x) - g'(x)\cdot f(x)}{g^2(x)} =$$

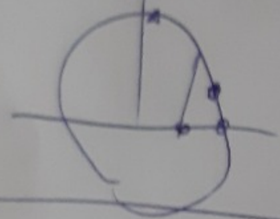
Чертовски

$x^2 = 2x$

$$= \frac{+\sqrt{21}\sin\alpha \cdot 2}{21\cos^2\alpha}$$

$$\frac{2}{\sqrt{21}\cos\alpha} = \frac{2}{\sqrt{21}}(\cos\alpha)^{-1} = +\frac{2\cdot\cos^2\alpha}{\sqrt{21}\cdot+\sin\alpha}$$

$\cos\alpha < \frac{1}{2}$



$$R = \frac{\sqrt{21}}{2}\cos\alpha + \frac{2}{\sqrt{21}\cos\alpha}$$

$\cos\alpha = \frac{2}{\sqrt{21}}$

$R = 1 + 1 = 2$

$\sin\alpha = 0 \quad \cos\alpha = 1$

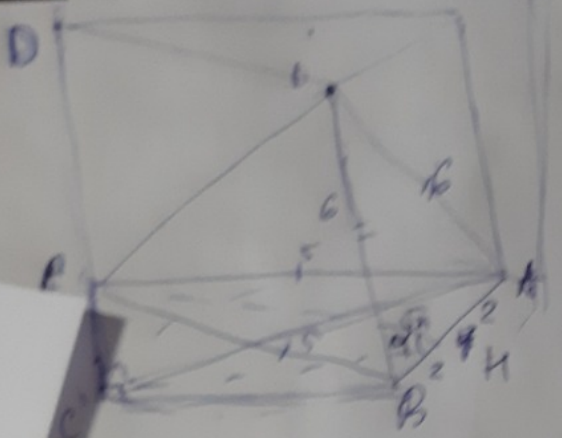
$$R = \frac{\sqrt{21}}{2} + \frac{2}{\sqrt{21}} = \frac{21+2}{2\sqrt{21}} = \frac{23}{2\sqrt{21}}$$

$\cos\alpha = \frac{2}{\sqrt{21}}$

$\frac{23}{2\sqrt{21}} > 2$

$23 > 4\sqrt{21}$

$23\cdot 23 > 16\cdot 21$



Черновик

$R = \frac{abc}{4S} = \frac{C'B \cdot C'A \cdot AB}{4 \cdot \frac{1}{2} C'A \cdot C'B \cdot \sin\angle AC'B} = \frac{AB}{2\sin\angle AC'B}$

$C'B = C'A$ Доказать!

$R = \ldots = \frac{C'B \cdot C'A \cdot AB}{4 S_{C'BA}} =$

$CH = \sqrt{25-4} = \sqrt{21}$

$\sqrt{21\cos^2\alpha + 4} = BC'$

$C'H = \sqrt{21}\cos\alpha$

~~$S = S_{ABC} \cdot \cos\alpha =$~~

$S_{ABC'} =$

$R = \frac{(21\cos^2\alpha + 4)\cdot 4}{4 \cdot \frac{1}{2} \cdot 4 \cdot \sqrt{21}\cos\alpha} = \frac{21\cos^2\alpha + 4}{2\sqrt{21}\cos\alpha} = \frac{\sqrt{21}}{2}\cos\alpha + \frac{2}{\sqrt{21}\cos\alpha} \Rightarrow$

~~$\Rightarrow$ R наим. cos α -~~

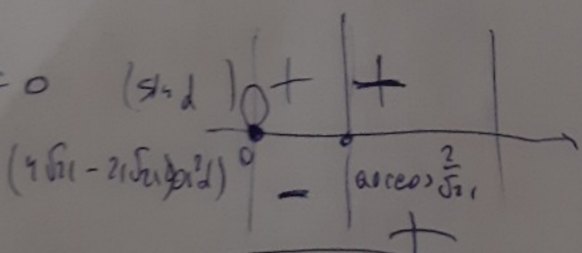
$R'(\alpha) = -\frac{\sqrt{21}}{2}\sin\alpha + \frac{2\sqrt{21}\sin\alpha}{21\cos^2\alpha} = 0$

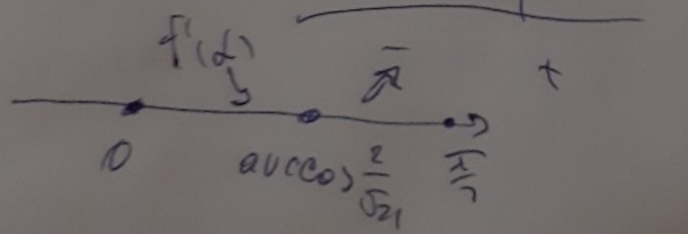
$4\sqrt{21}\sin\alpha - 21\sqrt{21}\cos^2\alpha \cdot \sin\alpha = 0$

$4\sqrt{21} - 21\sqrt{21}\cos^2\alpha = 0$

$\cos^2\alpha = \frac{4}{21}$

$\cos\alpha = \frac{2}{\sqrt{21}}$





~~Чистовик~~ Черновик

Задача №3.

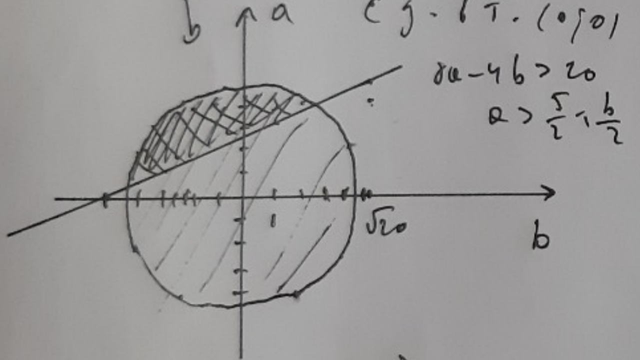
$$\begin{cases} (x-a)^2 + (y-b)^2 \le 20 \\ a^2+b^2 \le \min(8a-4b; 20) \end{cases}$$

$(x-a)^2 + (y-b)^2 \le 20$ – круг с радиусом $2\sqrt{5}$

$a^2+b^2 \le \min(8a-4b; 20)$

1) $8a-4b > 20$.

$a^2+b^2 \le 20$ – круг радиуса $\sqrt{20}$ с ц. в т. $(0;0)$



$8a-4b > 20$

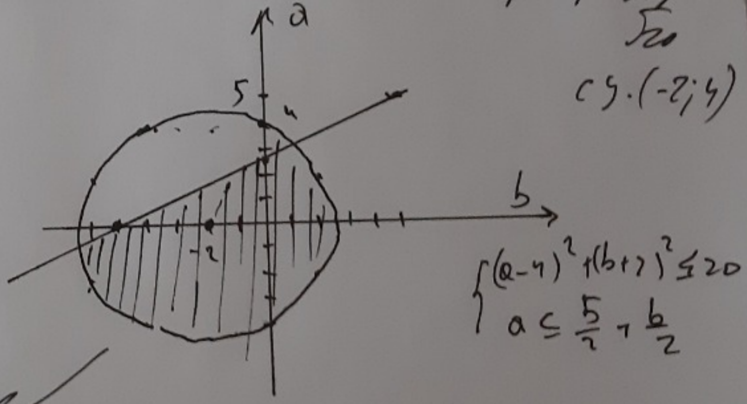
$a > \frac{5}{2} + \frac{b}{2}$

2) $8a-4b \le 20$ $\quad a \le \frac{5}{2} + \frac{b}{2}$

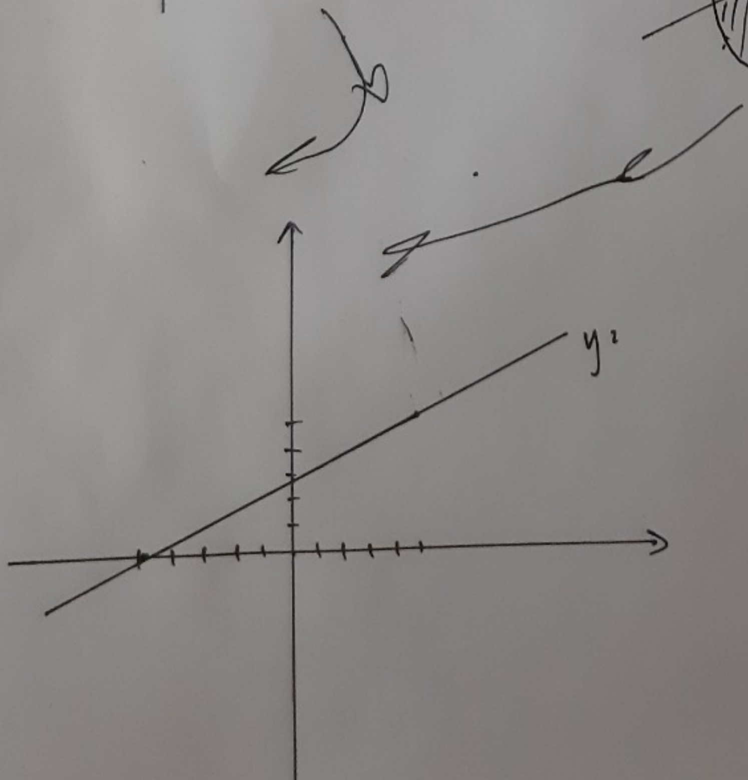
$a^2+b^2 \le 8a-4b$

$a^2-8a+16+b^2+4b+4 \le 20$

$(a-4)^2 + (b+2)^2 \le 20$ – круг радиуса $\sqrt{20}$ с ц. $(-2;4)$



$$\begin{cases} (a-4)^2+(b+2)^2 \le 20 \\ a \le \frac{5}{2} + \frac{b}{2} \end{cases}$$



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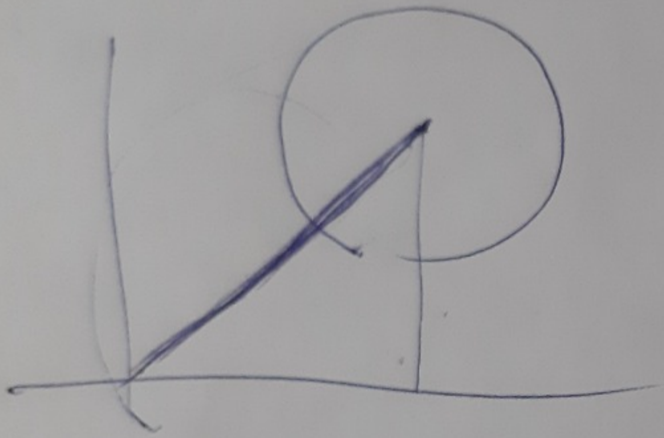
Черновик.

$$\begin{cases}(x-a)^2+(y-b)^2\le 20\\ a^2+b^2\le \min(8a-4b;20)\end{cases}$$

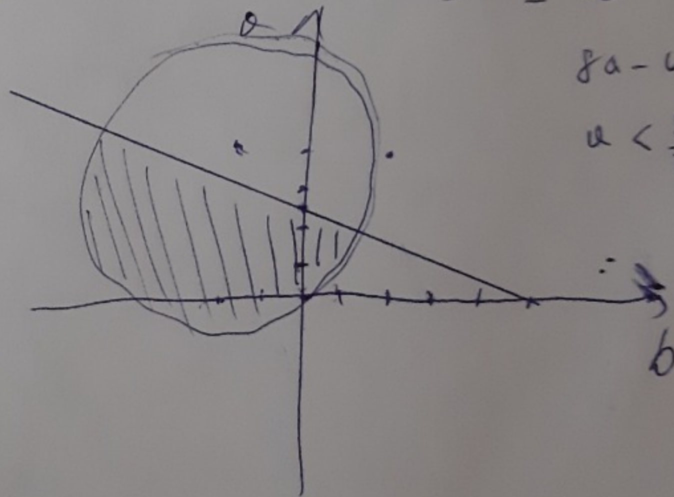


$a^2+b^2\le 8a-4b$

$a^2-8a+b^2+4b\le 0$

$a^2-8a+16+b^2+4b+4\le 20$

$(a-4)^2+(b+2)^2\le 20$



$8a-4b<20$

$a<\frac{5}{2}-\frac{b}{2}$

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Часть 2

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

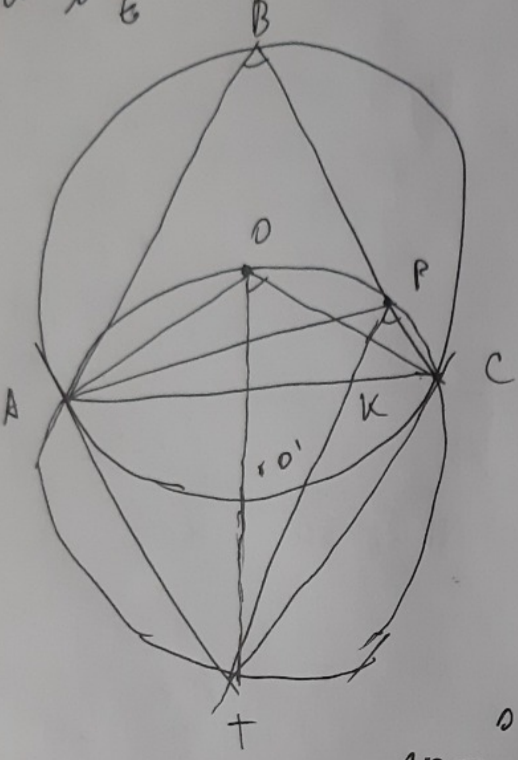
Шифр: **21104385**

ID профиля: **159158**

Вариант 21

Чистовик Лист №2 №6

Задача №6



Решение

$\angle OAT + \angle OCT = 180°$ (AT и CT - кас-е)

⇓

OATC - вписан в $\omega'(O')$

$T \in \omega'$

Пусть $\angle ABC = \alpha \Rightarrow$

$\Rightarrow \angle AOC = 2\alpha$

т.к. $AO = OC$

OT - общ.

$\angle OAT = \angle OCT = 90$

⇓

$\triangle OAT = \triangle OCT$

$\angle COT = \alpha \Rightarrow \angle CPT = \alpha$

$$\frac{S_{APK}}{S_{PKC}} = \frac{AK}{KC} = \frac{12}{9} = \frac{4}{3} \Rightarrow \frac{KC}{AC} = \frac{3}{7} \Rightarrow KC = \frac{3}{7}AC$$

$\triangle PKC \sim \triangle BAC$ т.к. $\angle C$ - общий; $\angle ABC = \angle KPC$

⇓

$$\frac{S_{ABC}}{S_{PKC}} = \left(\frac{AC^2}{KC^2}\right) \Rightarrow S_{ABC} = 9 \cdot \frac{49}{9} = 49 \quad (1)$$

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2) $\angle APC = \angle AOC = 2\alpha$, $\angle TPC = \alpha \Rightarrow PK$ - бис $\angle APC \Rightarrow$ [illegible] $\angle ABC = \alpha$

$\Rightarrow \frac{PC}{AP} = \frac{KC}{AK} = \frac{3}{4} \Rightarrow PC = 3y$, $AP = 4y$ $\Rightarrow S_{APC} = \frac{1}{2}\sin 2\alpha \cdot AP \cdot PC = 6y^2 \sin 2\alpha = 21$ ($S_{APK} + S_{CPK} = 12 + 9 = 21$)

$$y^2 = \frac{21}{6\sin 2\alpha} = \frac{7}{2\sin 2\alpha}$$

По Т. cos $\triangle APC$

$$AC^2 = AP^2 + PC^2 - 2\cos 2\alpha \cdot AP \cdot PC = 25y^2 - 2\cos 2\alpha \cdot 12y^2 =$$

$$= \frac{7}{2\sin 2\alpha}(25 - 24\cos 2\alpha)$$

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Чистовик

Лист № 3

21б.

Задание № 6.

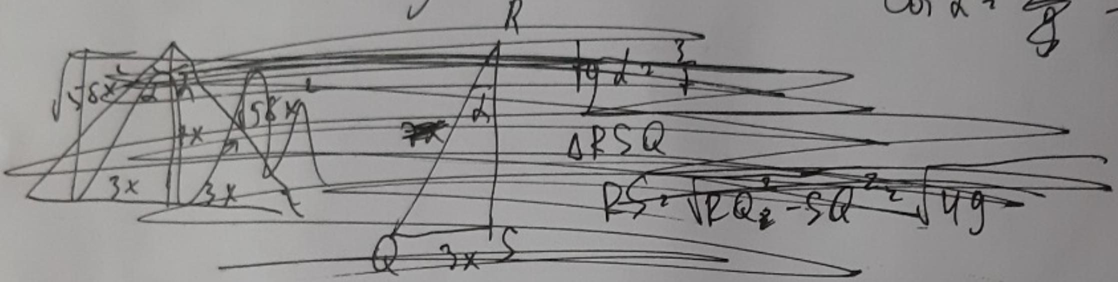
$AC = \sqrt{\frac{7}{2\sin 2\alpha}(25 - 24\cos 2\alpha)}$

$\alpha = \angle ABC = arcctg\frac{3}{7}$

$tg^2\alpha + 1 = \frac{1}{\cos^2\alpha}$

$\frac{9}{49} + 1 = \frac{1}{\cos^2\alpha}$

$\cos^2\alpha = \frac{49}{58}$



$\cos\alpha = \frac{7}{\sqrt{58}} \Rightarrow \sin\alpha = \frac{3}{\sqrt{58}} \Rightarrow \sin 2\alpha = 2\sin\alpha\cdot\cos\alpha = \frac{42}{58} = \frac{21}{29}$

$\cos 2\alpha = 2\cos^2\alpha - 1 = \frac{49}{29} - 1 = \frac{20}{29}$

$AC = \sqrt{\frac{7\cdot 29}{2\cdot 21}\left(25 - \frac{24\cdot 20}{29}\right)} = \sqrt{\frac{5}{6}} = 7\sqrt{\frac{5}{6}}$

Ответ: а) 49; б) $\sqrt{\frac{5}{6}}$

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№5 Чистовик Лист №1 11б

$a = \log_{\sqrt{2x-3}}(x+1)$, $b = \log_{2x^2-3x+5}(2x-3)^2$, $c = \log_{(x+1)}(2x^2-3x+5)$

ОДЗ: $2x-3>0$, $x>\frac{3}{2}$; $2x-3 \neq 1$, $x \neq 2$

$2x^2-3x+5>0$, $D=9-40<0$

$2x^2-3x+5 \neq 1$, $2x^2-3x+4 \neq 0$, $D=9-48<0$

$\Rightarrow a \neq 0$, $b \neq 0$, $c \neq 0$

$x \in (\frac{3}{2}; 2) \cup (2; \infty)$

П-ть два из чисел $a; b; c$ равны d, тогда третье равно $(d-1)$

$a \cdot b \cdot c = d^2(d-1)$

$\log_{\sqrt{2x-3}}(x+1) \cdot \log_{2x^2-3x+5}(2x-3)^2 \cdot \log_{(x+1)}(2x^2-3x+5) = d^2(d-1)$

$4 \log_{2x^2-3x+5}(x+1) \cdot \log_{(x+1)} 2x^2-3x+5 = d^2(d-1)$

$4 = d^3-d^2 \Rightarrow d^3-d^2-4=0$ $d^3-2d^2+d^2-4=$

$=(d-2)d^2+(d-2)(d+2) = (d-2)(d^2+d+2)=0$, $D<0$

$d=2$

1) П-ть $a=2$

$\log_{\sqrt{2x-3}}(x+1)=2$

$x+1=2x-3$

$x=4$

2) П-ть $b=2$

$\log_{2x^2-3x+5}(2x-3)^2=2$

$2x-3=2x^2-3x+5$

$2x^2-5x+8=0$

$D=25-64<0$

$\varnothing$

3) П-ть $c=2$

$\log_{(x+1)}(2x^2-3x+5)=2$

$2x^2-3x+5=x^2+2x+1$

$x^2-5x+4=0$

$x=\left[\begin{matrix}4\\1\end{matrix}\right.$

при $x=\frac{11}{4}$ $\Rightarrow \log_{2x^2-3x+5}(2x-3)^2=1$

$a=c=2$

$2x^2-3x+5=4x^2-12x+9 \Rightarrow$

$2x^2-9x+4=0$

при $x=4$ ...

$x=4$

Ответ: 4

$AC - ?$

$OT = 2r \Rightarrow \cos\alpha = \frac{R}{2r}$

$OC = R$

$\frac{AC}{\sin\alpha} = 2R \qquad \frac{AC}{\sin 2\alpha} = 2r$

$\frac{\sin 2\alpha}{\sin\alpha} = \frac{R}{r}$

$441 + 400 = 2\cos\alpha = \frac{R}{r}$

$841 \qquad 841$

$S = \frac{1}{2}\sin 2\alpha \cdot 12y^2 = 6y^2 \sin 2\alpha = 15$

$y^2 = \frac{5}{2\sin 2\alpha}$

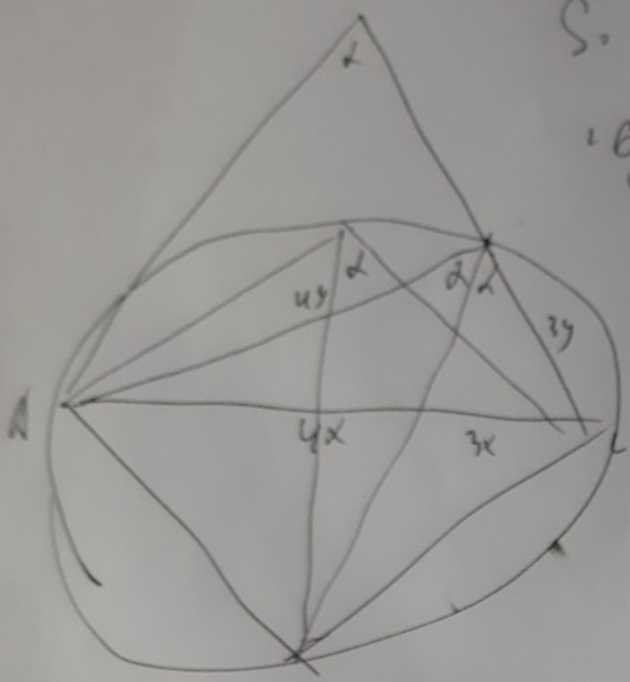
$AC^2 = AB^2 + BC^2 - 2\cos 2\alpha\, AB \cdot BC =$

$= 25y^2 - 2\cos 2\alpha \cdot 12y^2 =$

$= y^2(25 - 24\cos 2\alpha) = \frac{5}{2\sin 2\alpha}(25 - 24\cos 2\alpha)$

$a \cdot a(a-1) = a^3 - a^2$

$\log_{5x-3}(x+1) = \log_{(x+1)}(2x^2 - 3x + 5)$



$S = 15 = \frac{1}{2}\sin 2\alpha \cdot 12y^2 =$

$= 6y^2 \cdot \sin 2\alpha$

$AC^2 = 25y^2 - 2\cos 2\alpha \cdot 12y^2 =$

$= y^2(25 - 24\cos 2\alpha) =$

$= \frac{5}{2\sin 2\alpha}(25 - 24\cos^2\alpha)$

$\operatorname{tg}\alpha = \frac{3}{7}$. $\operatorname{tg}^2\alpha + 1 = \frac{1}{\cos^2\alpha}$

$\frac{9}{49} + 1 = \frac{1}{\cos^2\alpha}$ $\Rightarrow \cos\alpha = \frac{7}{\sqrt{58}}$

$\sin\alpha = \frac{3}{\sqrt{58}}$

$\sin 2\alpha = \frac{42}{58} = \frac{21}{29}$

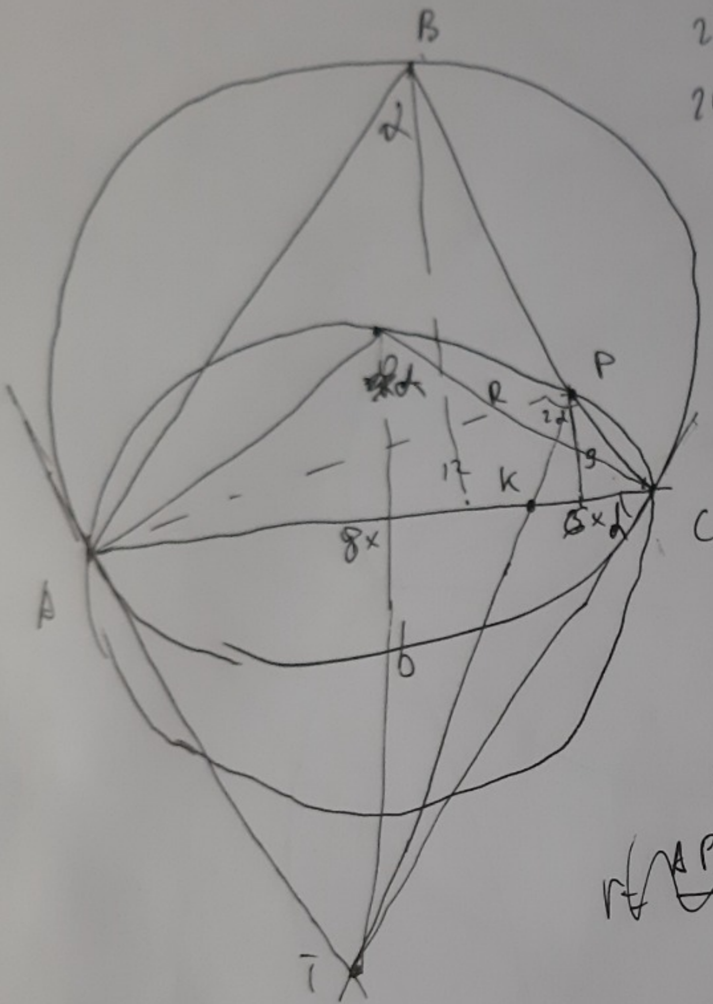
$\cos 2\alpha = 2\cos^2\alpha - 1 = \frac{49}{29} - 1 = \frac{20}{29}$

$\sqrt{\frac{5 \cdot 29}{2 \cdot 21}\left(25 - \frac{24 \cdot 20}{29}\right)} = \sqrt{\frac{5 \cdot 245}{2 \cdot 21}} = \sqrt{\frac{5^2 \cdot 7}{2 \cdot 3}} = 5\sqrt{\frac{7}{6}}$

$\begin{array}{r} 25 \\ \times 29 \\ \hline 225 \\ +50 \\ \hline 725 \\ -480 \\ \hline 245 \end{array}$

Ответ

21104385 (U159158 M1298688)



$2R = \frac{a}{\sin\alpha}$

$2r = \frac{a}{2\sin\alpha \cdot \cos\alpha}$

$\frac{R}{r} = 2\cos\alpha$

$\sin\alpha = \frac{7x}{R}$

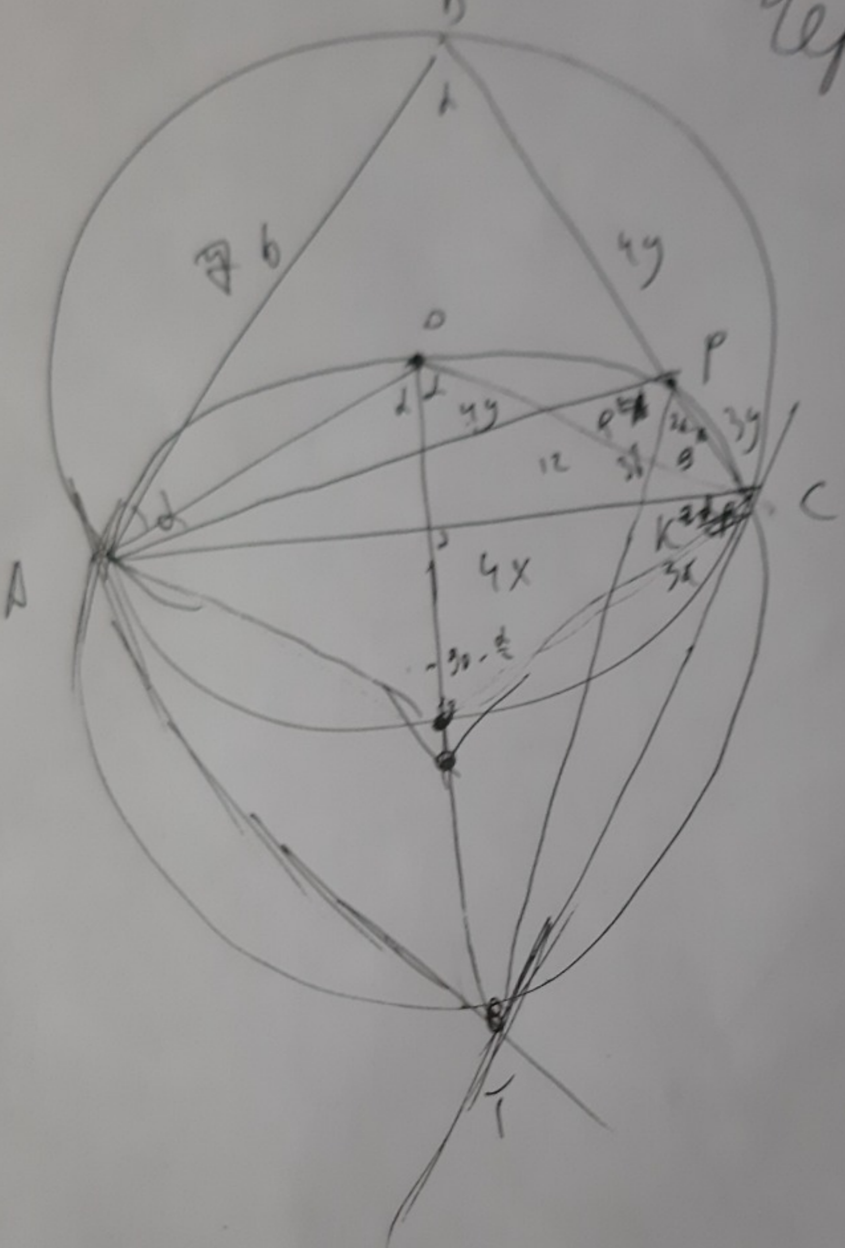
$R = \frac{abc}{4S}$

$S = \frac{1}{2}ab \cdot \sin\alpha$

$2R = \frac{a}{\sin\alpha}$

$r = \frac{AP \cdot PC \cdot AC}{4S}$

Черновик.



$S = \frac{\sin \alpha}{2} \cdot 3b \cdot 3y$

$S = \frac{\sin 2\alpha}{2} \cdot 3y \cdot 4y = 15$

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