

XXX Санкт-Петербургская олимпиада
по Астрономии
Практический тур
12. III. 2023г.

We draw a vertical line through the middle of the dark area. It crosses the horizontal axis at 0:50. The dark area ~~is~~ is the night, therefore the vertical line corresponds to midnight (in Local time).

- ⇒ Midnight in Local time is 0:50 UTC+1h
- ⇒ UTC+1 is 50 minutes ahead of local time
- ⇒ The point of observation is west from the central meridian of UTC+1

Longitude of the central meridian:

$$\lambda_{UTC+1} = \frac{1}{24} \cdot 360^\circ = 15^\circ \text{ (East)}$$

- ⇒ Longitude of the point of observation:

$$\lambda = \lambda_{UTC+1} - \frac{50}{24 \cdot 60} \cdot 360^\circ =$$

$$= 15^\circ - 12,5^\circ =$$

$$= 2,5^\circ \text{ East}$$

We draw a horizontal line corresponding to the spring equinox (21 March).

The picture is dark where $E < 0,03 \text{ lx}$.

$$\lg 0,03 \text{ lx} = -1,5$$

$$\Rightarrow E < -1,5$$

From the graph we see that the dark area is the part of the night where the zenith distance is:

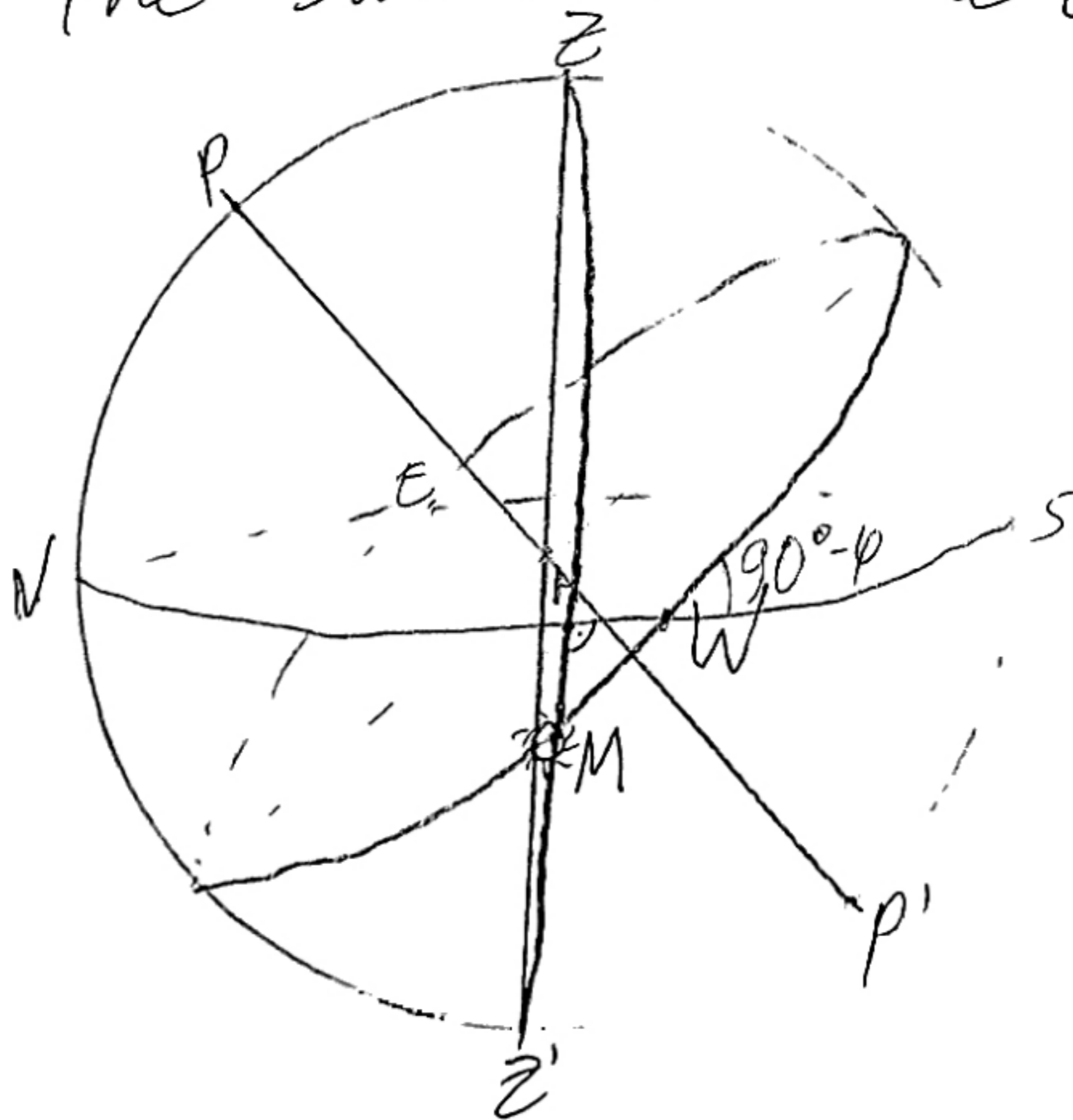
$$Z > 100,5$$

This part of the night begins on 20:00 UTC+1 and ends on 5:40 UTC+1.

The middle (local midnight) is at 0:50 UTC+1.

On the spring equinox, $\delta_0 = 0^\circ$.

\Rightarrow The Sun moves on the Celestial Equator.



The sun moves 360° for 24^h .

The lighter stripe next to the dark area is the time between sunset and the moment where $E=0,03 \text{ lx}$.

We measure that the time is $x=1,8 \text{ cm}$ on the picture.

$2,9 \text{ cm}$ corresponds to 4 hours .

$$\Rightarrow \frac{1,8}{2,9} = \frac{t}{24^h}$$

$$t = 3,52 \text{ h}$$

Let M be the point of the Celestial sphere where the Sun is at a zenith distance of $100,5^\circ$.

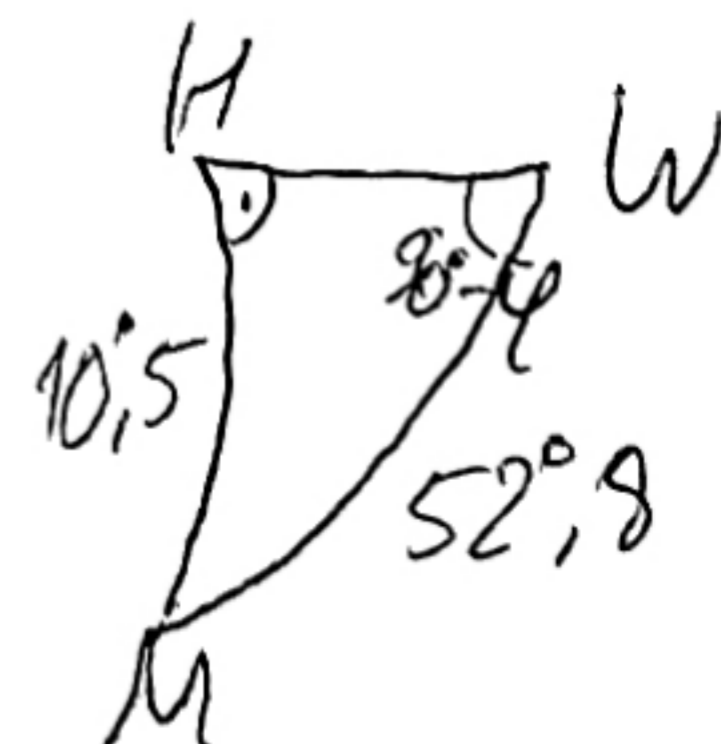
Let the big circle arcs ZZ' and NS intersect at H

$$\Rightarrow HM = 10,5$$

$$\frac{MW}{360^\circ} = \frac{3,52}{24}$$

$$\Rightarrow MW = 52,8$$

$$\angle MWH = 90^\circ - \varphi$$

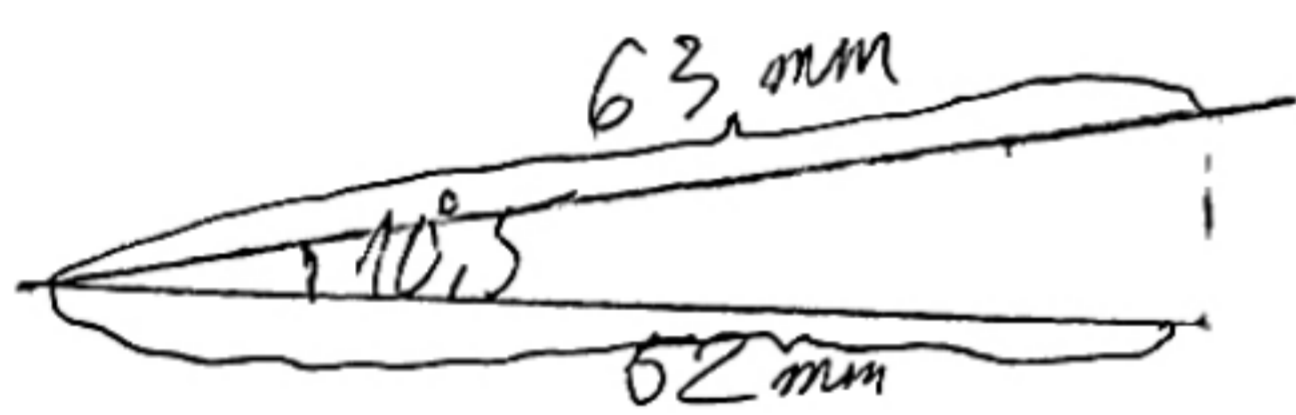


We use the Spherical Cosine Theorem:

$$\cos MW = \cos HW \cdot \cos HM + \sin HW \cdot \sin HM \cdot \cos \angle MHW$$

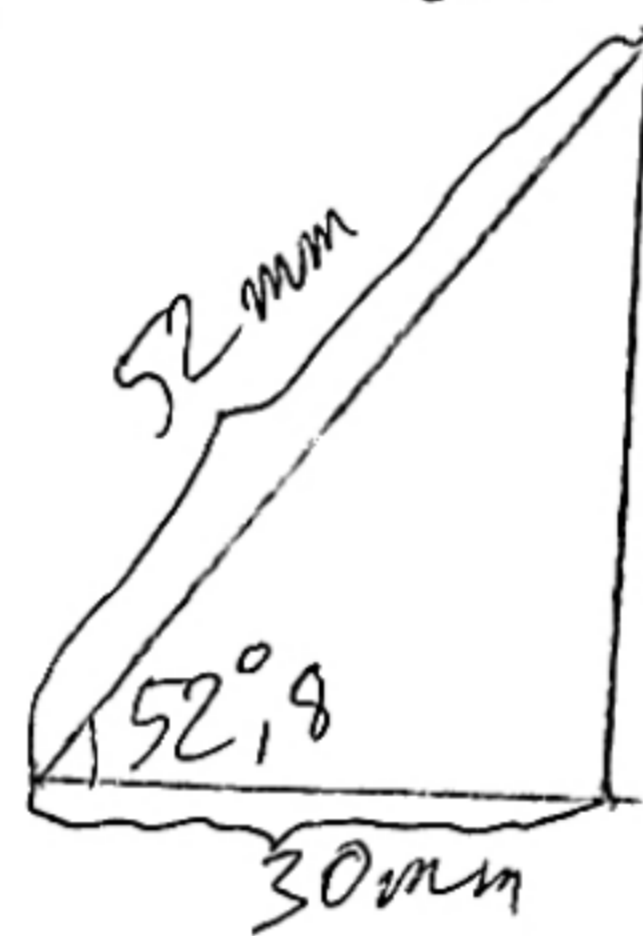
$$\begin{aligned} \Rightarrow \cos MW &= \cos HW \cdot \cos HM + \sin HW \cdot \sin HM \cdot \cos 90^\circ = \\ &= \cos HW \cdot \cos HM = \\ &= \cos 52^\circ,8 \cdot \cos 10^\circ,5 \end{aligned}$$

We draw right triangles with these angles:



$$\cos 10^\circ,5 = \frac{62}{63} \approx 0,98$$

$$\cos 52^\circ,8 = \frac{30}{52} \approx 0,59$$



$$\Rightarrow \cos MW = 0,98 \cdot 0,59 \approx 0,58$$

We use the Spherical Cosine Theorem:

$$\cos HM = \cos HW \cdot \cos MW + \sin HW \cdot \sin MW \cdot \cos \angle MHW$$

$$\cos HM = \cos HW \cdot \cos MW + \sin HW \cdot \sin MW \cdot \cos(90^\circ - \varphi)$$

$$\cos HW \approx \cos MW$$

$$\Rightarrow \cos HM = \cos^2 HW + \sin^2 HW \cdot \cos(90^\circ - \varphi)$$

~~$$0,58 = (0,59)^2 + 1$$~~

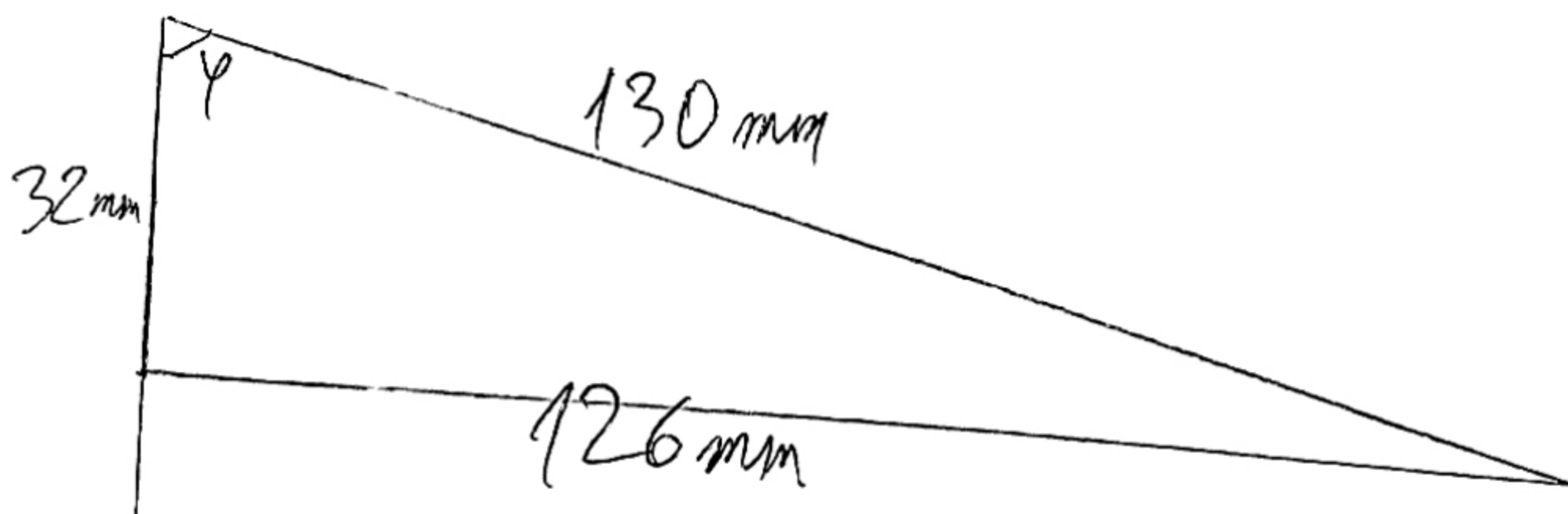
$$\cos HM = \cos^2 HW + (1 - \cos^2 HW) \cdot \sin \varphi$$

$$0,98 = (0,59)^2 + (1 - 0,59^2) \cdot \sin \varphi$$

$$0,98 = 0,35 + 0,65 \cdot \sin \varphi$$

$$\Rightarrow \sin \varphi = \frac{63}{65} \approx 0,97$$

$$\begin{aligned} \cos \varphi &= \sqrt{1 - \sin^2 \varphi} = \\ &= \sqrt{\frac{65^2 - 63^2}{65^2}} = \\ &= \sqrt{\frac{2 \cdot 128}{65^2}} = \frac{16}{65} \end{aligned}$$



$$\varphi = 75^\circ$$

$$\lambda = 2,5^\circ$$

The light stripes are the time between sunset and the dark part of the night, respectively between the dark part and sunrise. They are inclined because this time is relatively the same at all times of the year, and the time of sunrise and sunset changes relatively linear way.

in a

The dark area is asymmetrical
because of the equation of time.

The sun can rise (or set) ^{up to} 19 minutes
before it is supposed to.

Draft

$\approx 0,03 \cdot x \rightarrow$ субцифурна точка на гра

$\lg 0,03 \approx -2$

$2,5 \cdot 2,5 \cdot \sqrt{25} = 6,25 \cdot 1,6 = \frac{5^2}{100} \cdot \frac{2^4}{100} = 10$

$10^{0,5} = \sqrt{10} \approx 3,16$

$10^{0,4} = 2,512$

$2,5 \cdot 2,5 \cdot 2,5 = 6,25 \cdot 2,5 > 10$
 $2,2 \cdot 2,2 \cdot 2,2 = \frac{1331,8}{1000} = 1,3318$

$10^{0,2} = \sqrt[5]{10} \approx 1,6$

$10^{0,5} \approx 2,2$

$1,5^5 = 2,25 \cdot 2,25 \cdot 1,5 = \frac{3^5}{2^5} = \frac{243}{32} = 7$

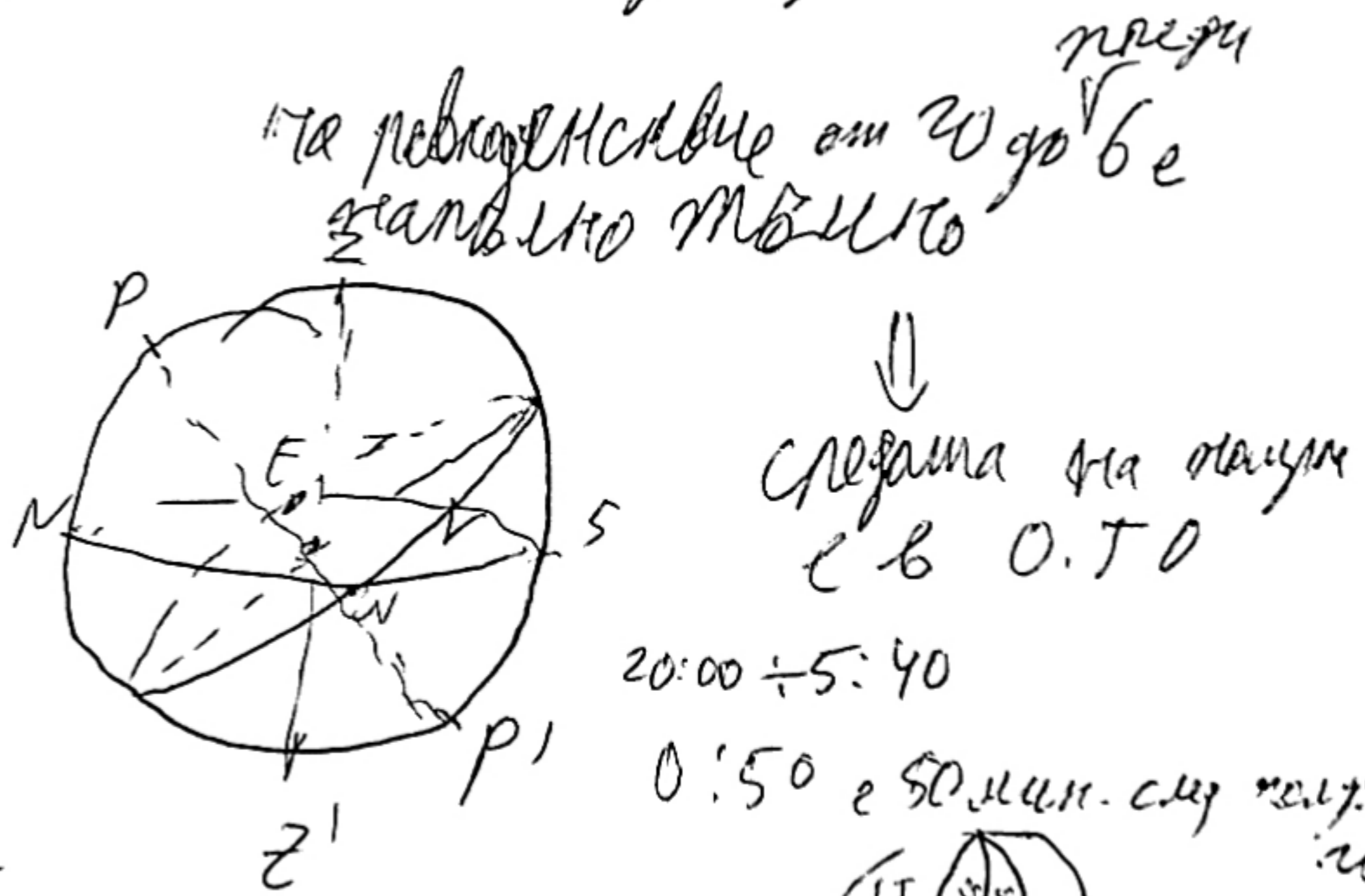
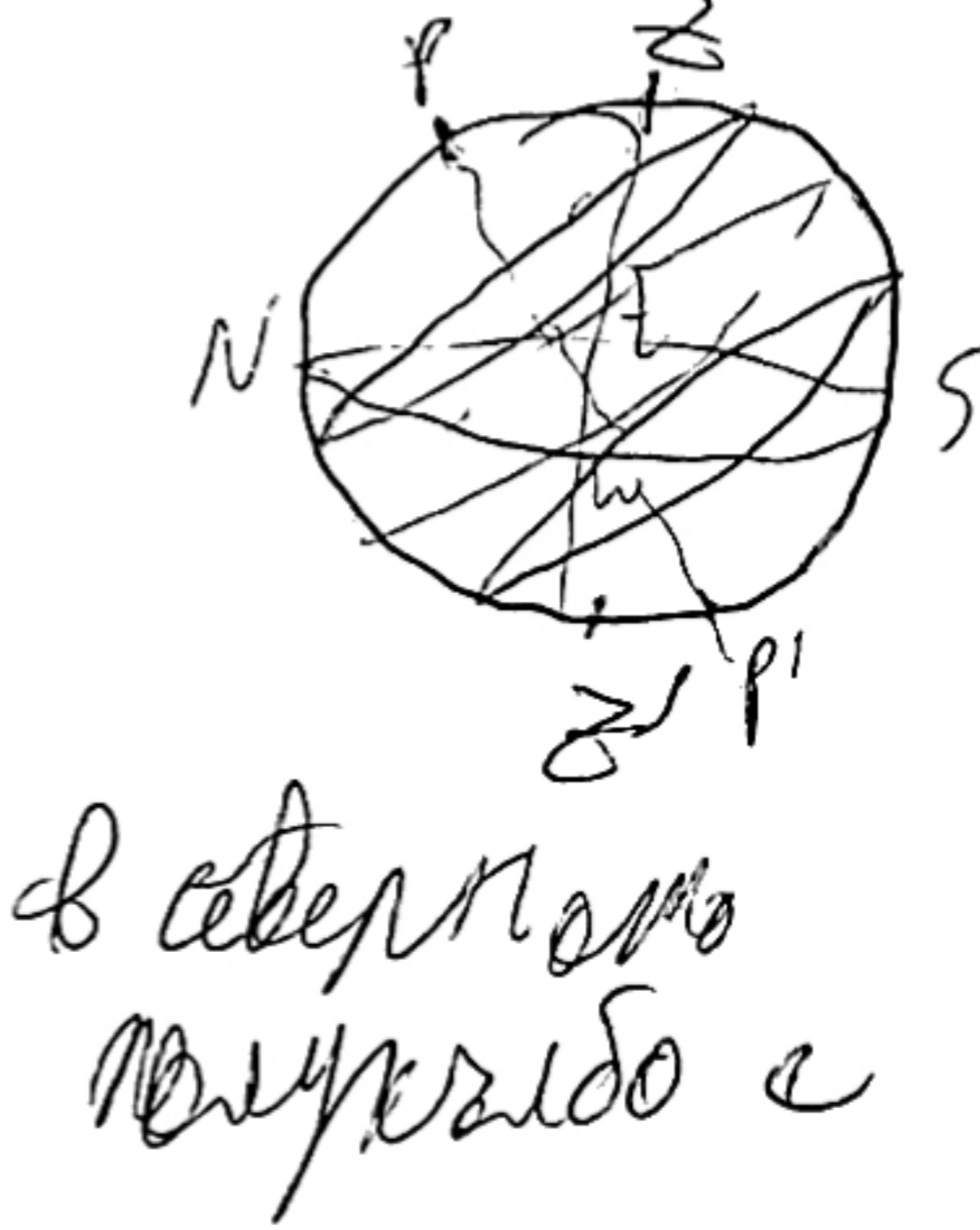
$1,6^5 = \frac{8^5}{5^5} = 2,56 \cdot 2,56 \cdot 1,6 = 6,5536 \cdot 1,6 = 10,48576$

$243 : 32 = 7,593$
 $\begin{array}{r} 243 \\ -224 \\ \hline 190 \\ -160 \\ \hline 300 \\ -256 \\ \hline 440 \\ -416 \\ \hline 24 \end{array}$

$\begin{array}{r} 3323 \\ 65536 \cdot 16 \\ + 393216 \\ + 65536 \\ \hline 10,48576 \end{array}$

$\lg 0,01 = -2 \Rightarrow \lg 0,03 \approx -1,5$

\Rightarrow азг $\Sigma = 100^\circ$ на гра



$\frac{1}{10} \cdot 105 = 0,5$
 $\Rightarrow 100,5$
 $\Rightarrow 201^\circ$

$\frac{201 \cdot 24}{360 \cdot 15} = \frac{40}{3} \approx 13,3$



кордоните на мълнието са дугата на неболоните, зашто се на изгрев и зашто се на залив и зашто се на северната полукуло е границата на мълнието. Зашто се на залив и зашто се на северната полукуло е границата на мълнието.

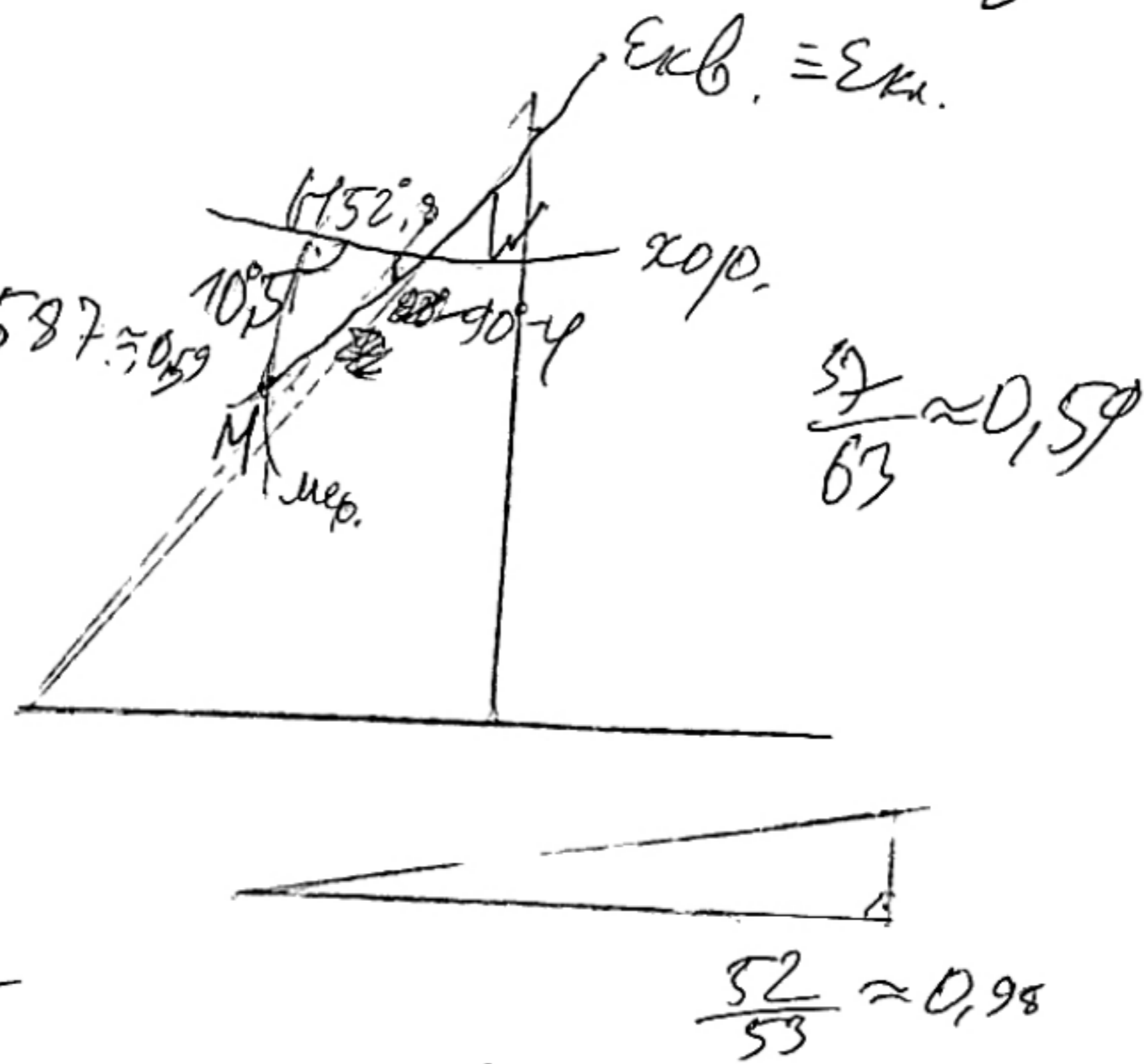
МЗК кама област е кесилченгиринга
 узревом ефо-борзун залеза?
 уривнене на вачето?

50^{min} след 0^h UTC+1
 $\Rightarrow \frac{50}{1440} \cdot 360 = 12,5$

$\lambda = \frac{60}{1440} \cdot 360 - \frac{50}{1440} \cdot 360 = 2,5$



разул. диаметер след залез



$\frac{1,8 \text{ cm}}{2,9 \text{ cm}} = \frac{x}{4 \text{ h}}$
 $x = \frac{7,2}{2,9}$

$72 : 29 = 3,52 \approx 3,52 \text{ h}$

$\frac{57}{750} = \frac{145}{50} = \frac{29}{210}$

$\frac{3,52}{24} = \frac{y}{360,15}$

$y = 3,52 \cdot 15 = 35,2 + 17,6 = 52,8$

$\cos \angle MW = \cos \angle MW \cdot \cos \angle MM + \sin \angle MW \cdot \sin \angle MM \cdot \cos 90^\circ$



$\cos \angle A = \cos \angle b \cdot \cos \angle c + \sin \angle b \cdot \sin \angle c \cdot \cos A$

$\cos 10,5 = 1 - \left(\frac{1}{6}\right)^2 = \frac{35}{36} \approx 0,97$

$\cos 52,8 = 0,59$

$\cos \angle MW = 0,98 \cdot 0,59 \approx 0,58$

$\cos 10,5 = \cos 52,8 \cdot \cos 51 + \sin 52,8 \cdot \sin 51 \cdot \cos (90^\circ - \varphi)$

Draft

$$\cos 10,5 = \frac{0,59^2}{0,65^2} +$$

$$0,59^2 = 0,3481$$

$$0,65^2 \rightarrow 0,4225$$

$$0,98 = 0,35 + 0,65 \cdot \sin \varphi$$

$$\sin \varphi = \frac{0,63}{0,65} = \frac{63}{65}$$

$$\cos \varphi = \frac{65^2 - 63^2}{65^2} = \frac{128 \cdot 2}{65^2} \approx 0,39$$

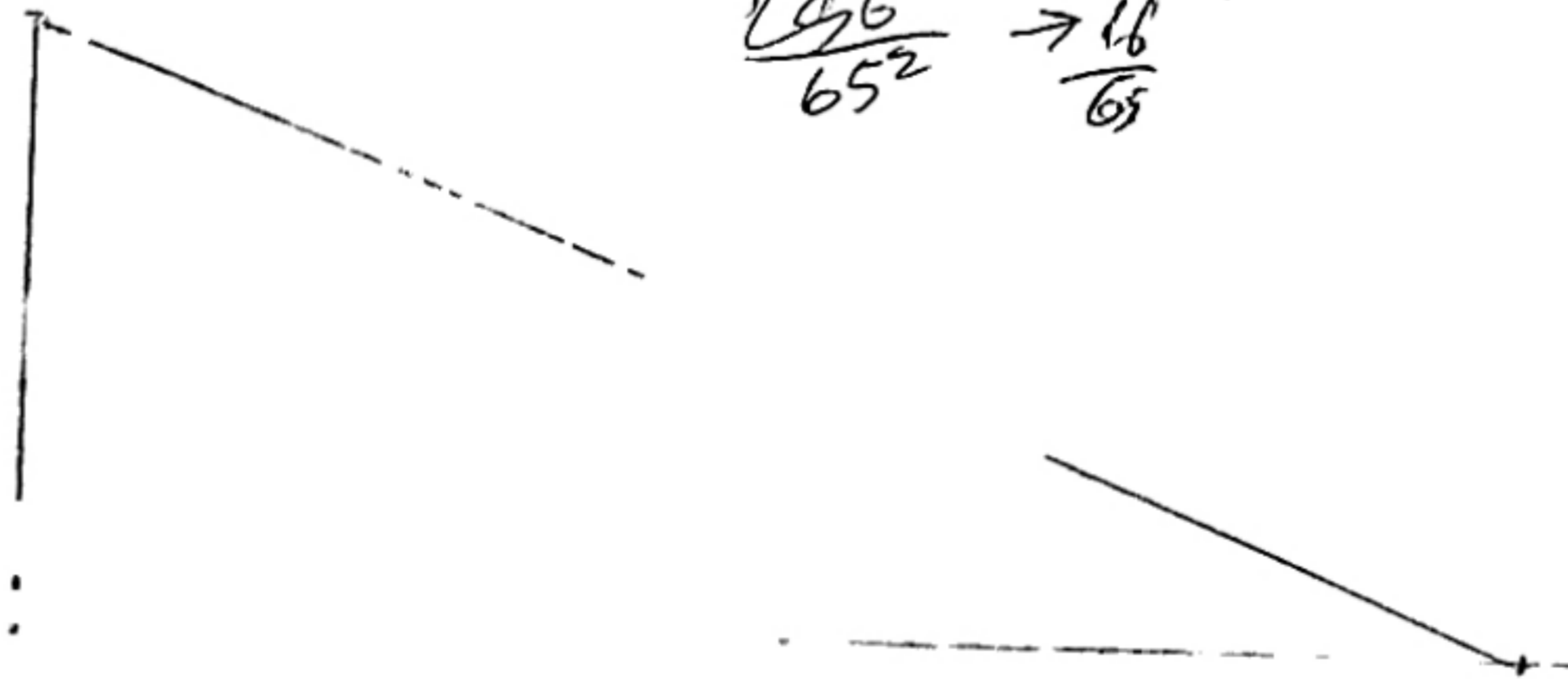
$$\begin{array}{r} 256 : 65 = 3,938 \\ \underline{195} \\ 610 \\ \underline{585} \\ 250 \\ \dots \end{array}$$

$$\frac{630}{65} = 9,69 \approx 9,7$$

$$0,393 : 65 = 0,0062$$

$$\begin{array}{r} 630 : 65 = 9,69 \approx 9,7 \\ \underline{585} \\ 450 \\ \underline{390} \\ 600 \end{array}$$

$$\frac{256}{65^2} \rightarrow \frac{16}{65}$$



$$\varphi = 67^\circ$$

$$\lambda = 20,5$$

