1 Формулы

$$l_1 \cdot \cos(\phi) + l_2 \cdot \cos\left(\arcsin\left(\frac{e_1 - l_1 \cdot \sin(\phi)}{l_2}\right)\right) = x(\phi) \tag{1}$$

TODO: разобраться, как называется этот график в питоне и техе

$$l_1 \cdot \cos(\phi_n) + l_2 \cdot \cos\left(\arcsin\left(\frac{e_1 - l_1 \cdot \sin(\phi_n)}{l_2}\right)\right) = x_{c_1} \tag{2}$$

$$\begin{aligned} 0.02 \cdot \cos(\pi) + 0.035 \cdot \cos\left(\arcsin\left(\frac{0.25 \cdot 0.02 - 0.02 \cdot \sin(\pi)}{0.035}\right)\right) = \\ = -0.02 + 0.035 \cdot 0.0285714 = 0.014641 = x_{c_1} \end{aligned} \tag{3}$$

$$y_{c_1} = 0 \tag{4}$$

$$l_1 \cdot \cos(\phi_k) + l_2 \cdot \cos\left(\arcsin\left(\frac{e_1 - l_1 \cdot \sin(\phi_k)}{l_2}\right)\right) = x_{c_2} \tag{5}$$

$$y_{c_2} = 0 \tag{6}$$

Координаты A:

$$x_A = l_1 \cdot \cos(\phi) \tag{7}$$

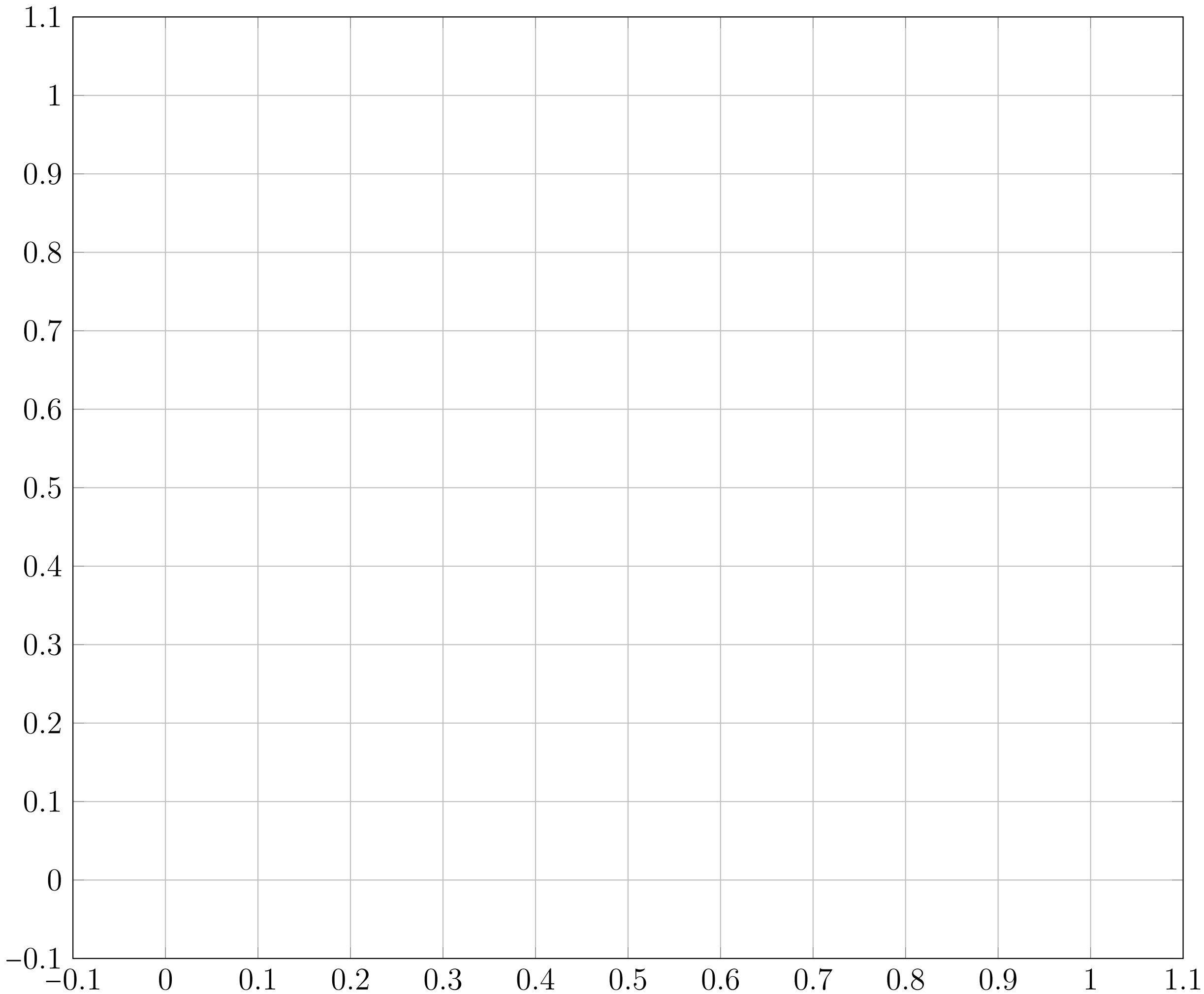

Рисунок 1. x_A

$$y_A = l_1 \cdot \sin(\phi) \tag{8}$$

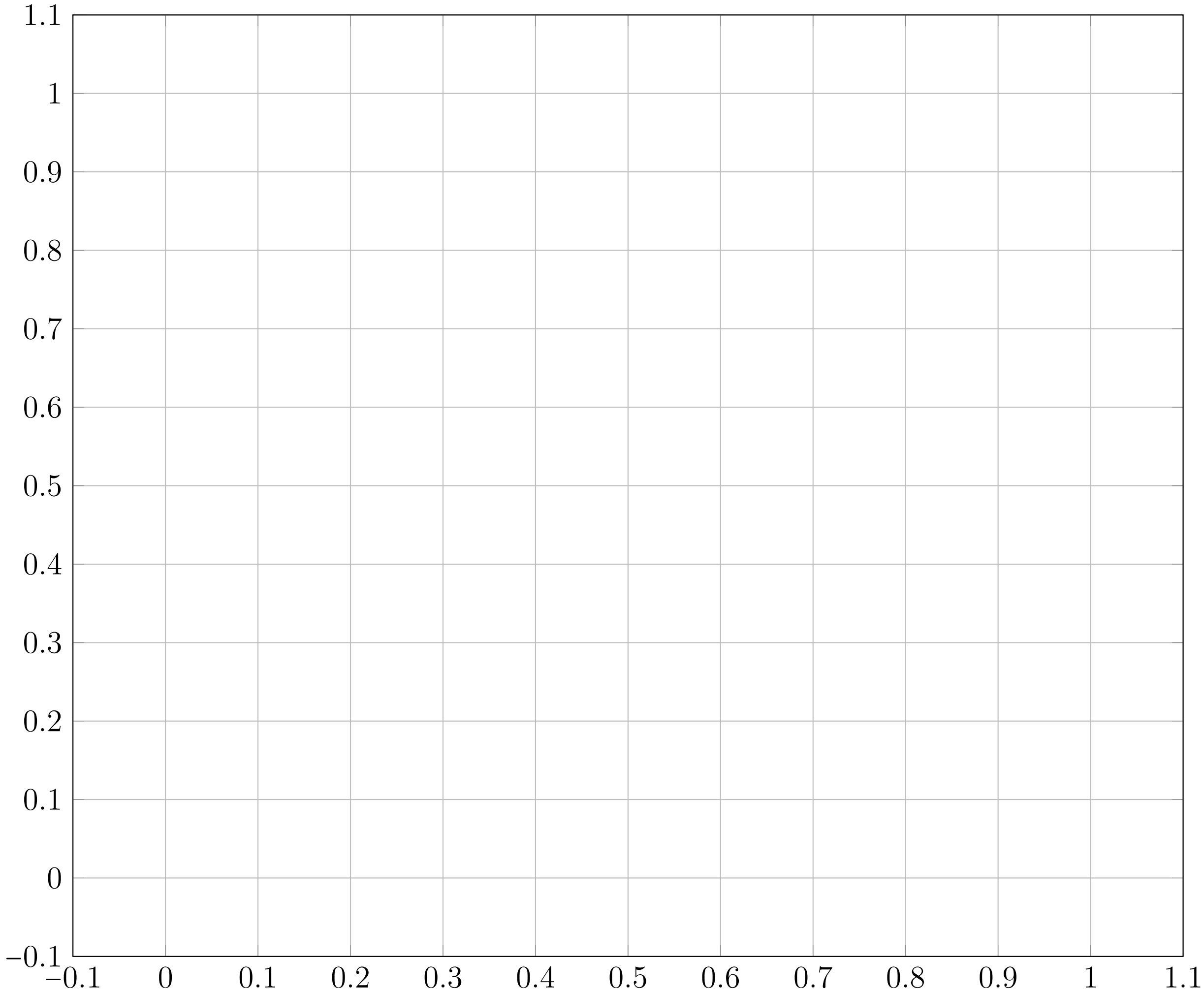

Рисунок 2. y_A

Changed

$$x_B = l_1 \cdot \cos(\phi_n) + \sqrt{l_2^2 - (l_1 \cdot \sin(\phi_n) - e_1)^2} = \frac{-1 + \sqrt{3}}{50} \approx 0.014641 \tag{9}$$

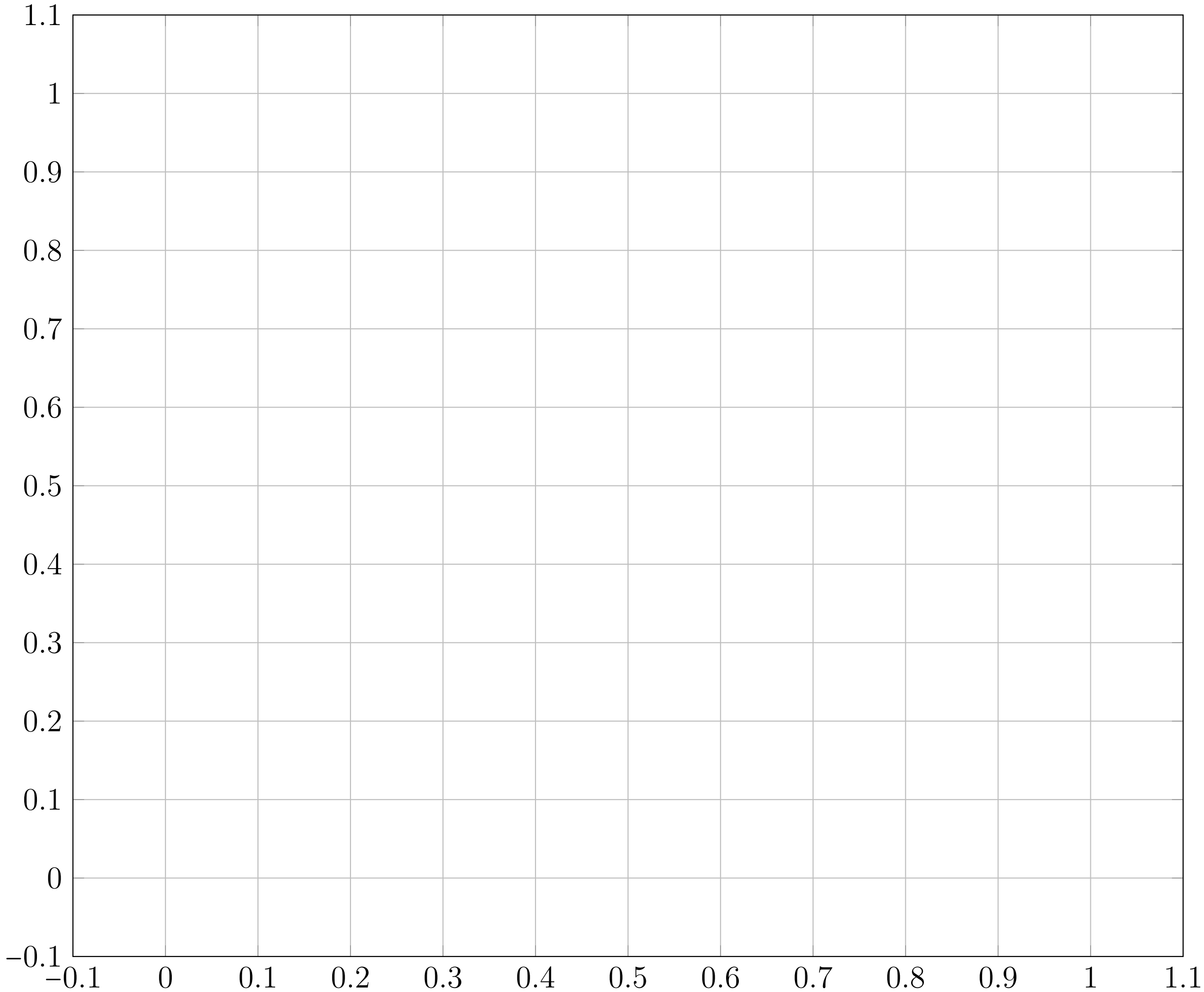

Рисунок 3. x_B

Changed

$$y_B = e_1 = 0.005 \tag{10}$$

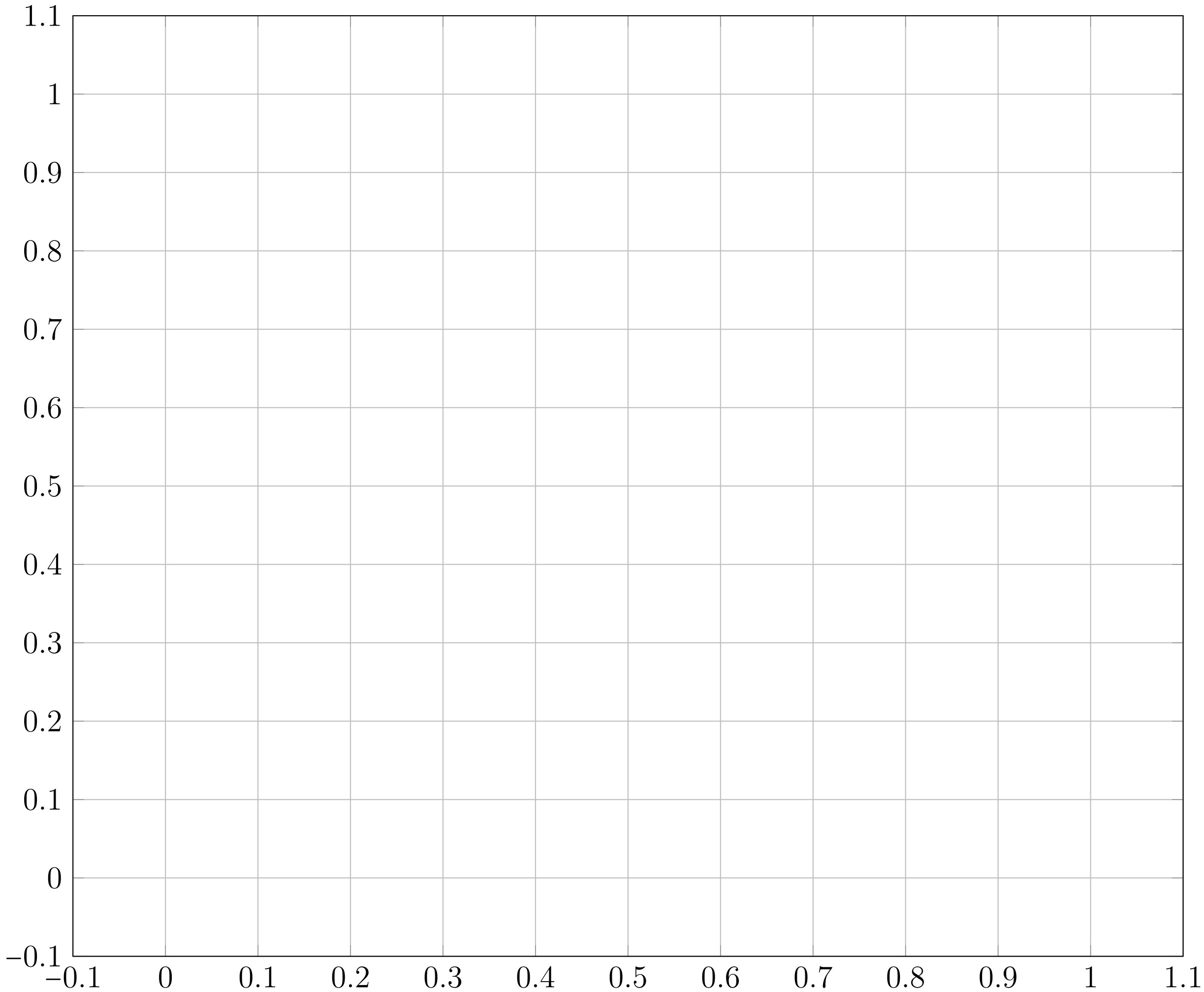

Рисунок 4. y_B

Середина первого звена OA: TODO

$$x_{OA} = \frac{x_O + x_A}{2} = \frac{0 + l_1 \cdot \cos(\phi)}{2} = \frac{l_1 \cdot \cos(\phi)}{2} \tag{11}$$

TODO

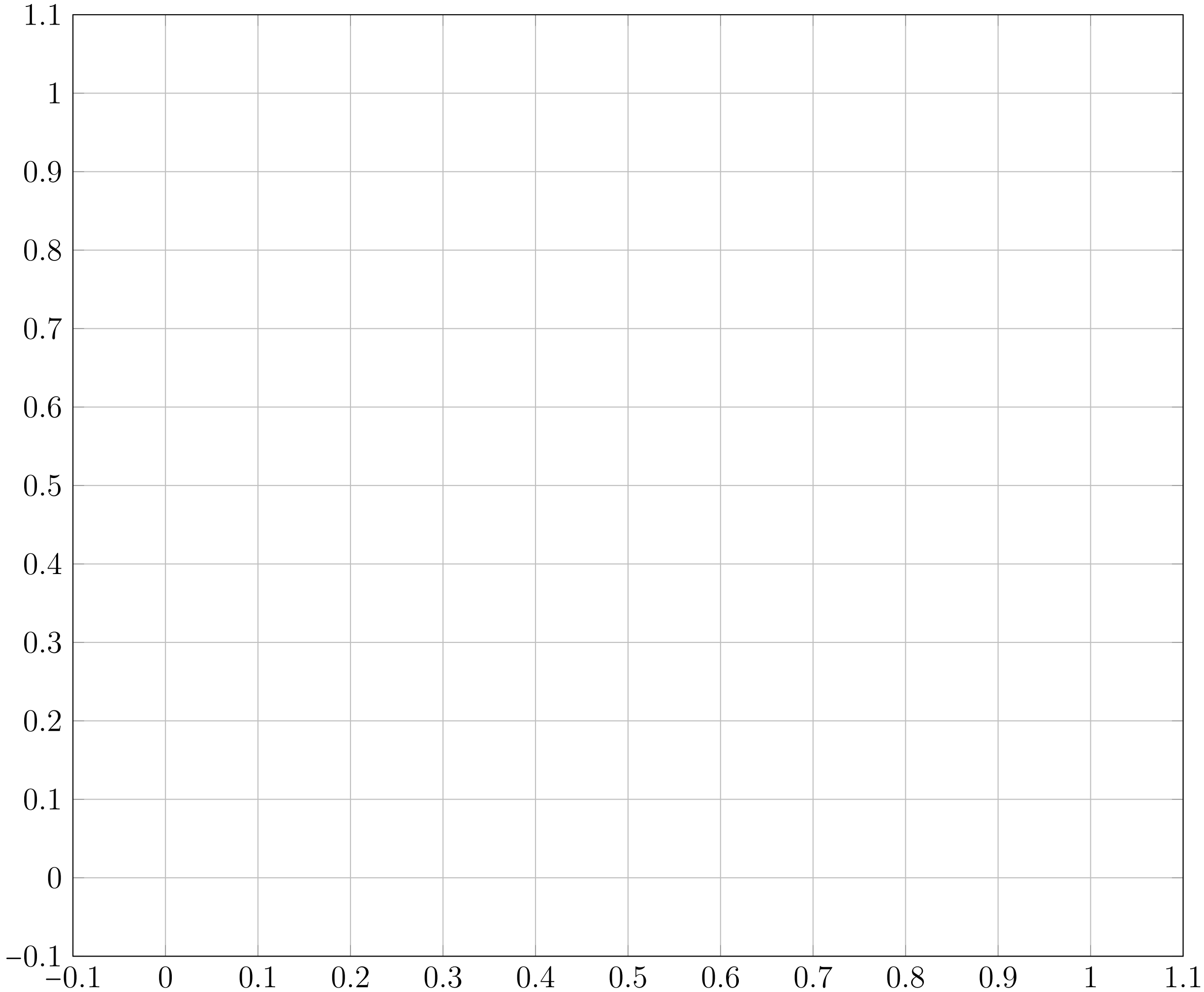

Рисунок 5. x_{OA}

$$y_{OA} = \frac{y_O + y_A}{2} = \frac{0 + l_1 \cdot \sin(\phi)}{2} = \frac{l_1 \cdot \sin(\phi)}{2} \quad (12)$$

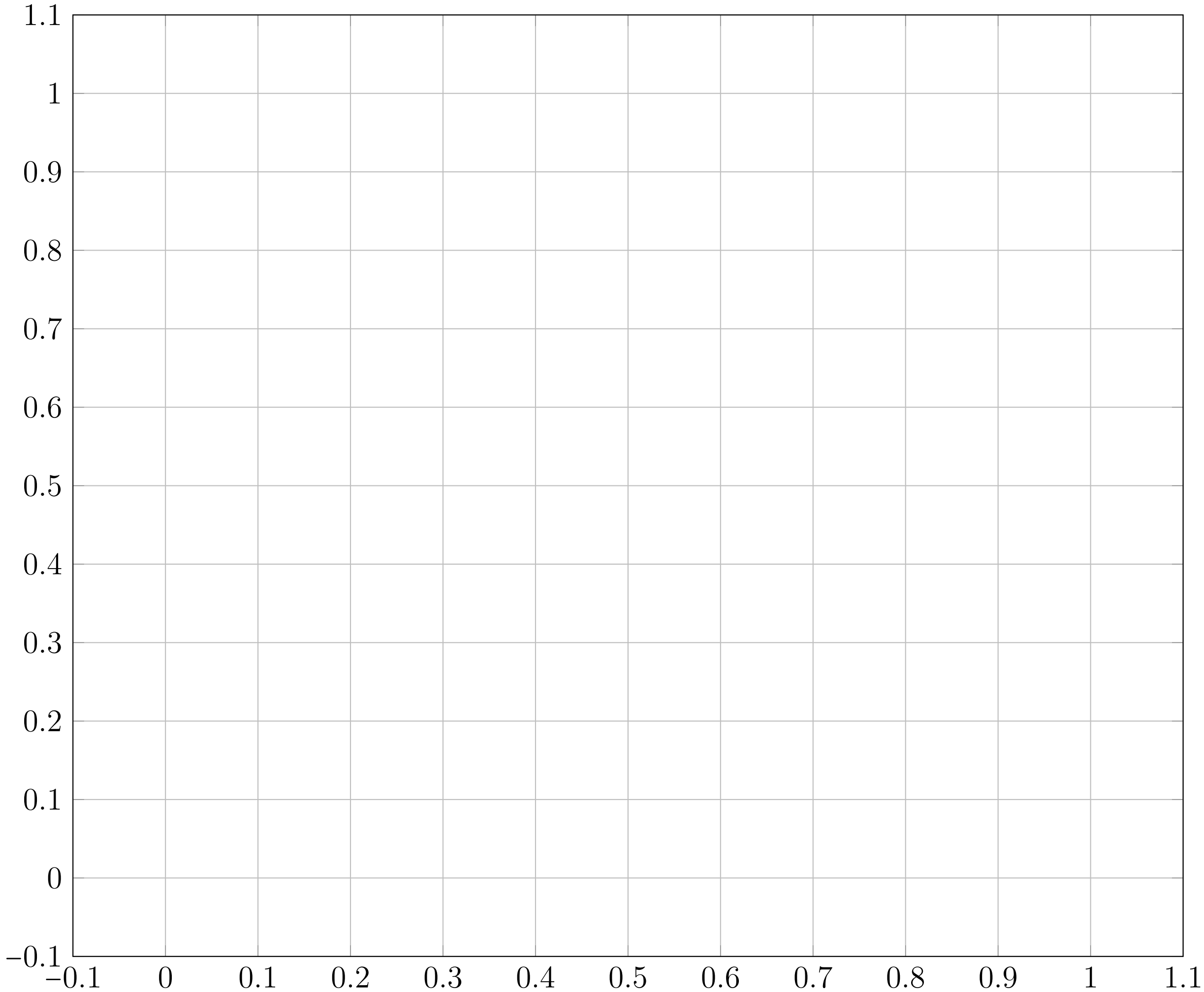

Рисунок 6. y_{OA}

Середина второго звена AB: OLD

$$x_{AB} = \frac{l_1 \cdot \cos(\phi) + l_1 \cdot \cos(\phi) + l_2 \cdot \cos\left(\arcsin\left(\frac{e_1 - l_1 \cdot \sin(\phi)}{l_2}\right)\right)}{2} = \\ = \frac{2 \cdot l_1 \cdot \cos(\phi) + l_2 \cdot \cos\left(\arcsin\left(\frac{e_1 - l_1 \cdot \sin(\phi)}{l_2}\right)\right)}{2} \quad (13)$$

NEW

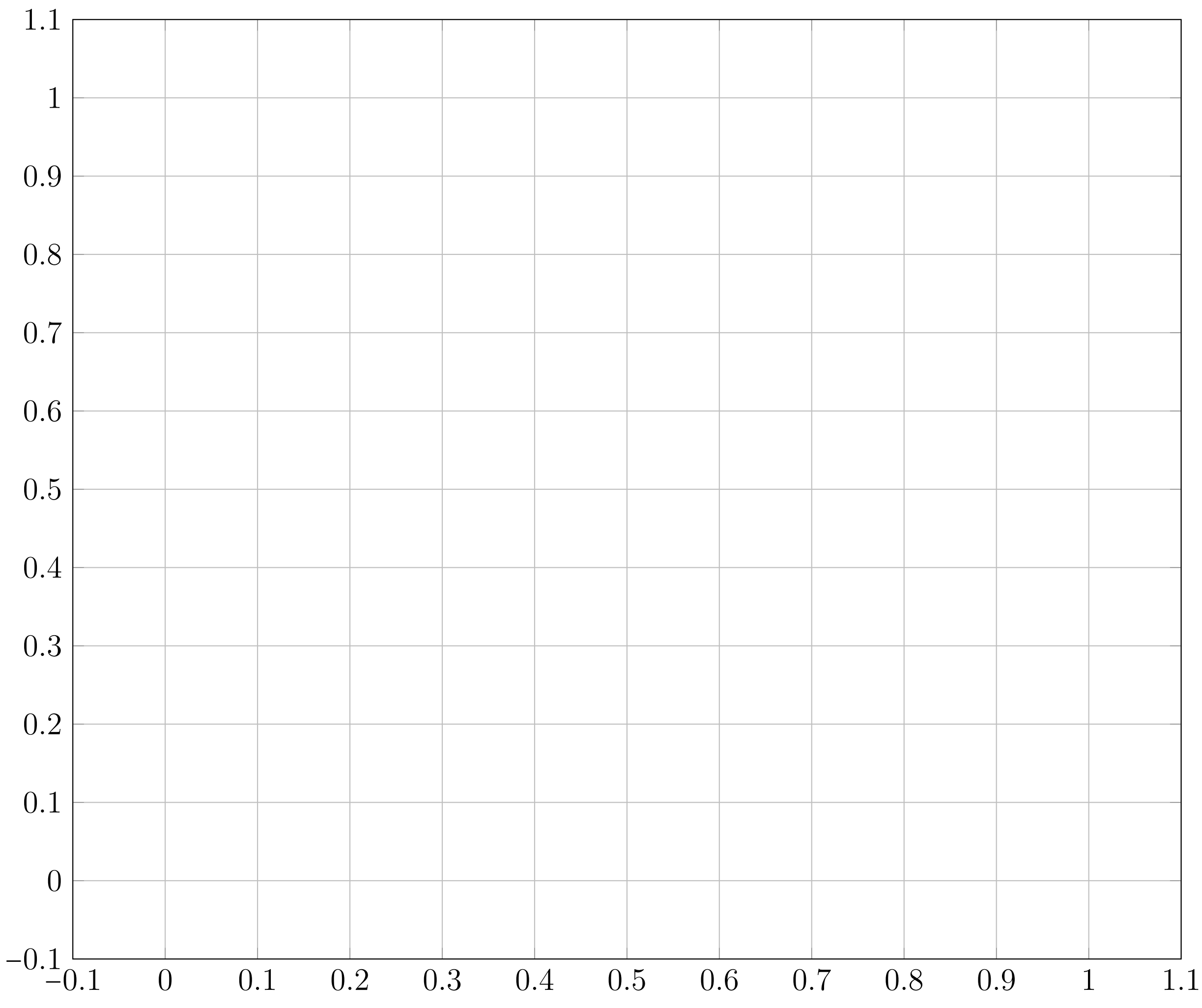

Рисунок 7. x_{AB}

$$y_{AB} = \frac{y_A + y_{c_1}}{2} = \frac{l_1 \cdot \sin(\phi) + 0}{2} = \frac{l_1 \cdot \sin(\phi)}{2} \quad (14)$$

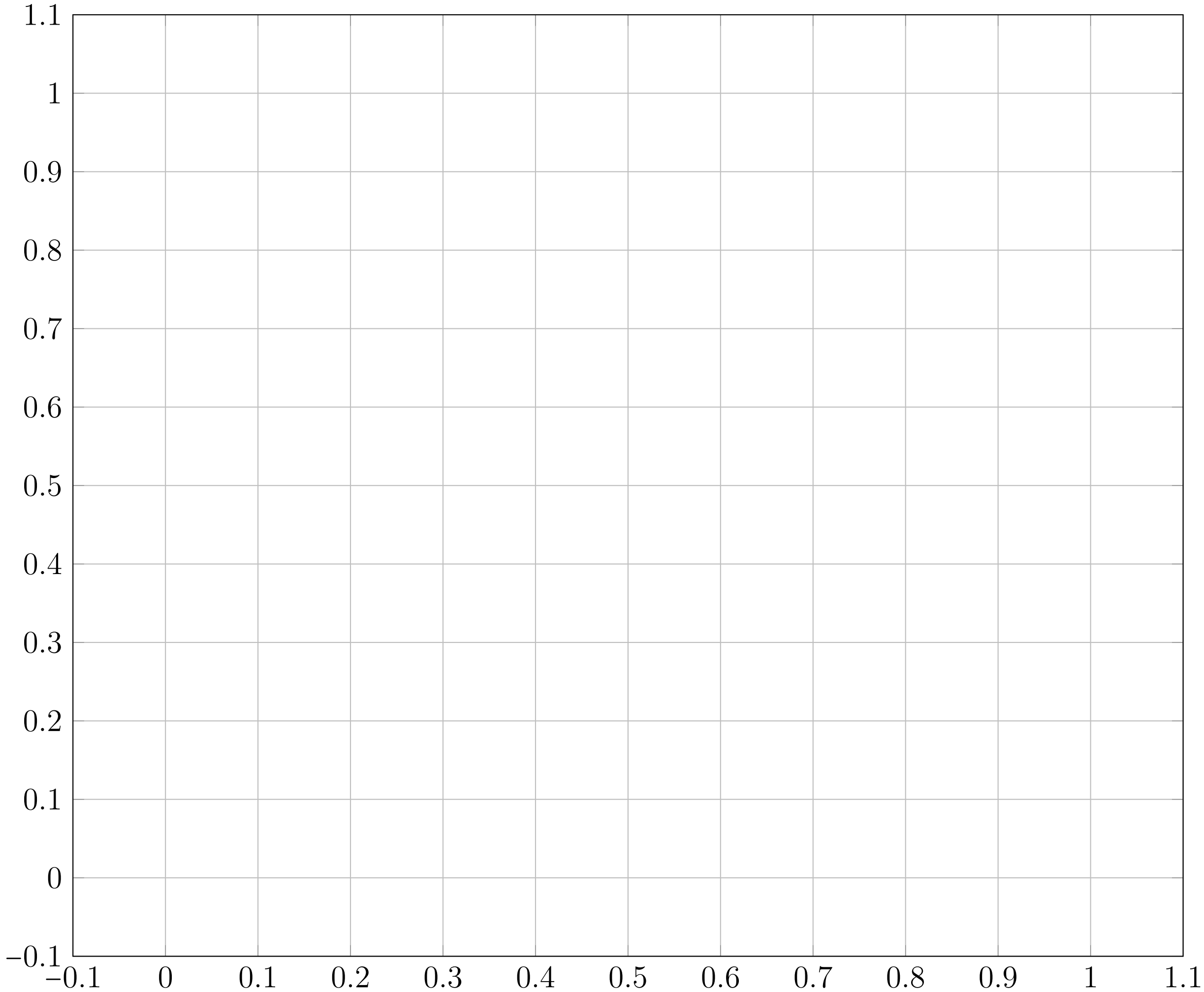

Рисунок 8. y_{AB}

Найдём производные A, OA, AB по ϕ:

$$x'_A = -l1 \cdot \sin(\phi) \tag{15}$$

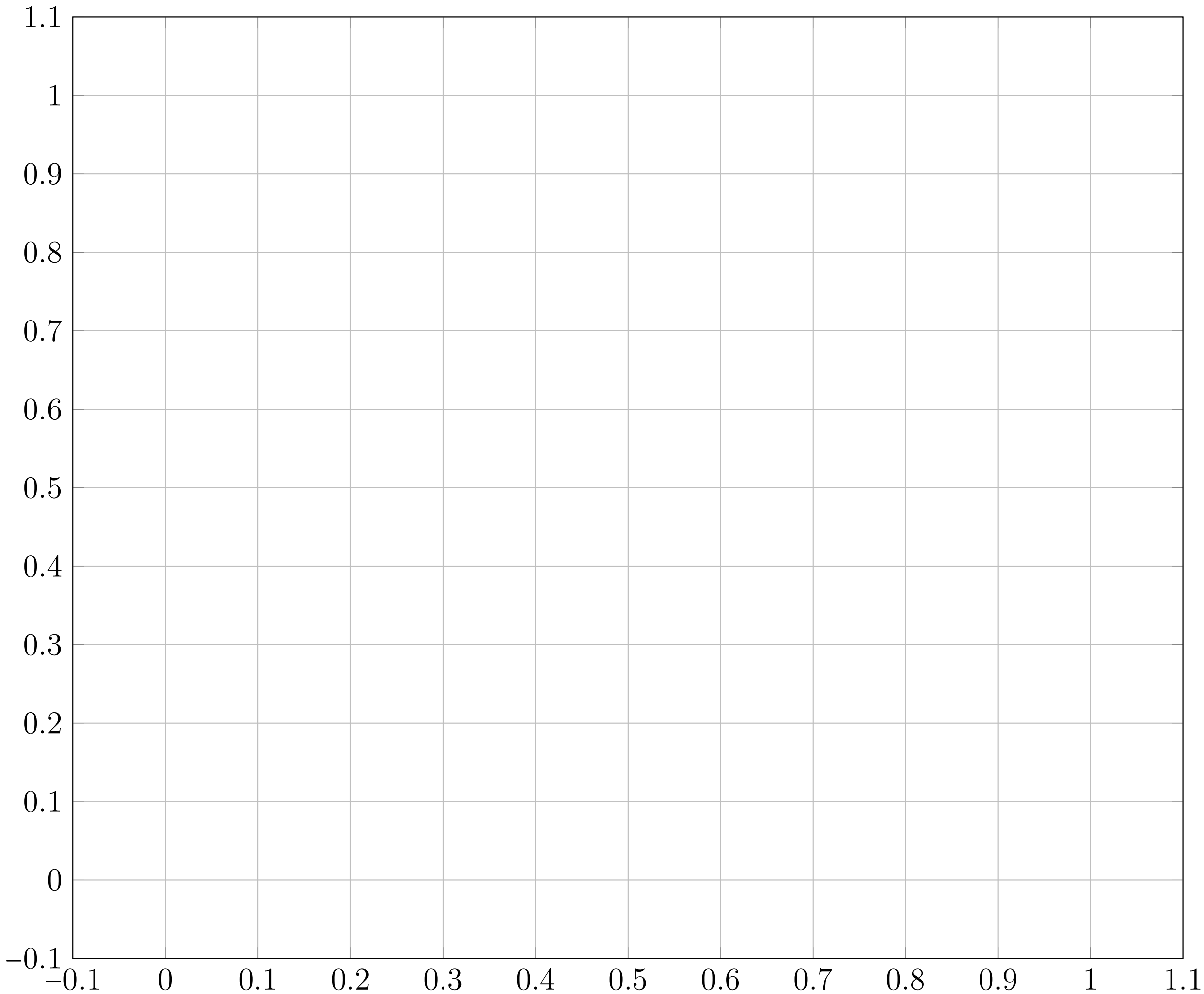

Рисунок 9. x'_A

$$y'_A = l1 \cdot \cos(\phi) \tag{16}$$

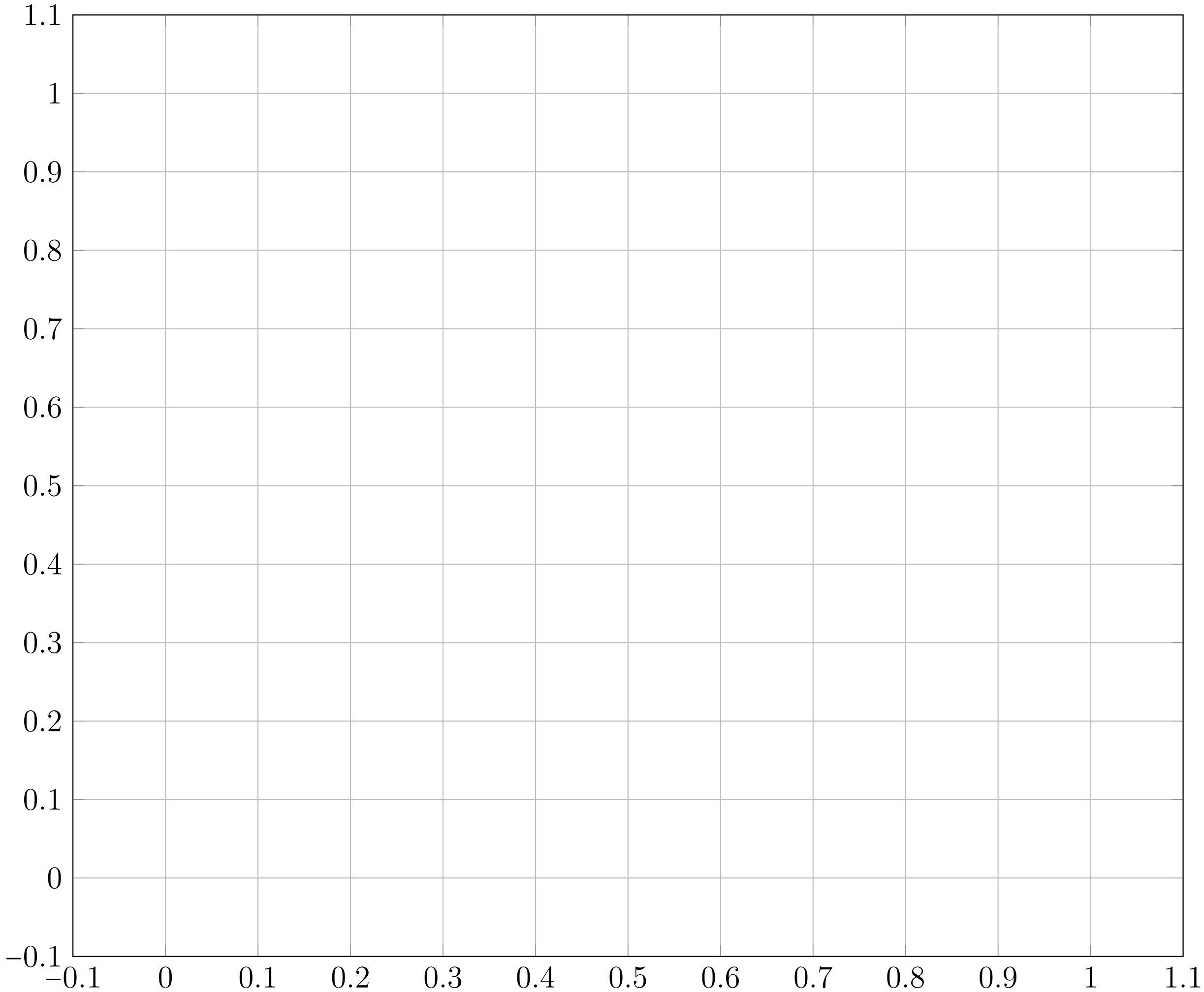

Рисунок 10. y'_A

$$x'_{OA} = \frac{-l1 \cdot \sin(\phi)}{2} \tag{17}$$

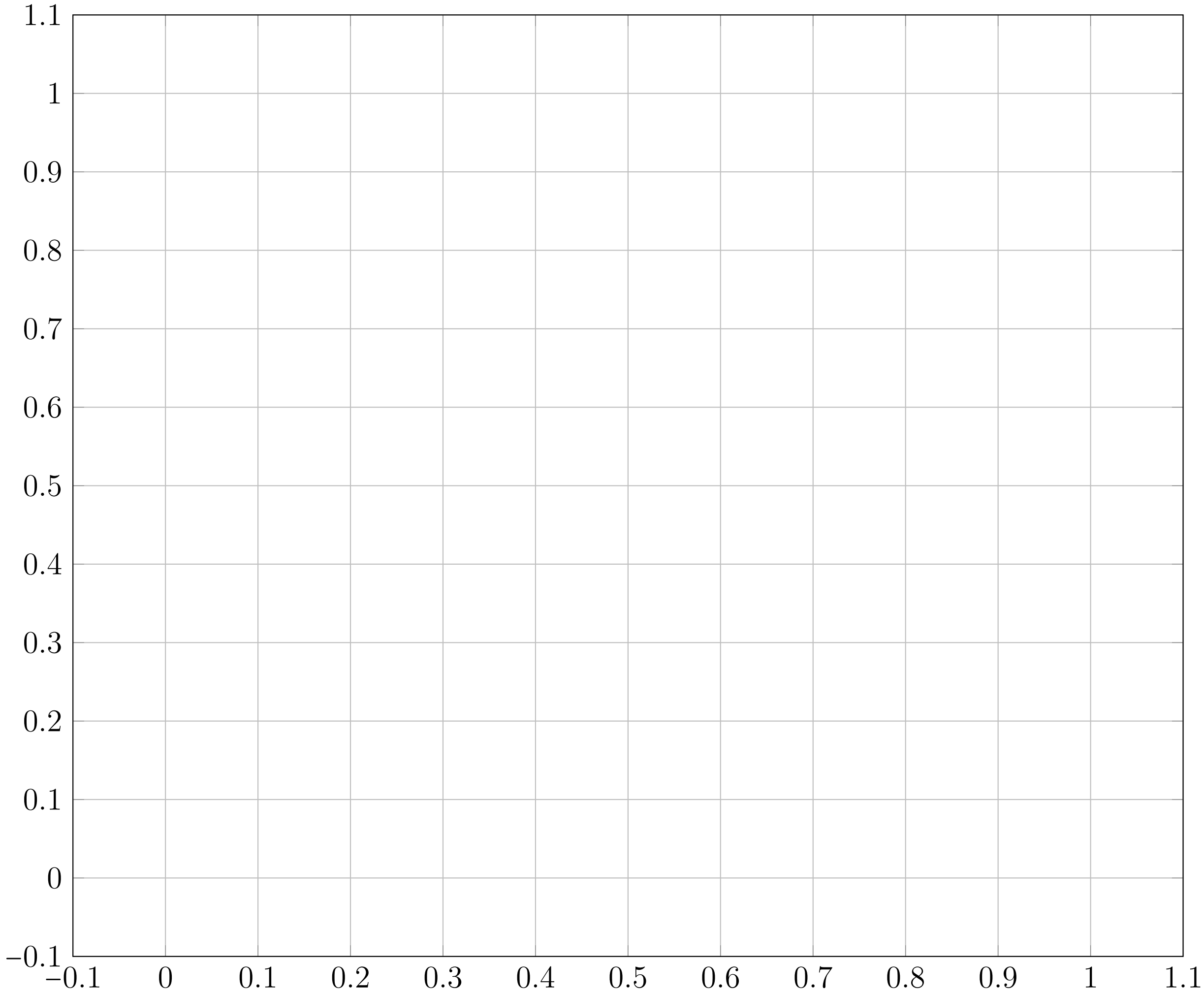

Рисунок 11. x'_{OA}

$$y'_{OA} = \frac{l1 \cdot \cos(\phi)}{2} \tag{18}$$

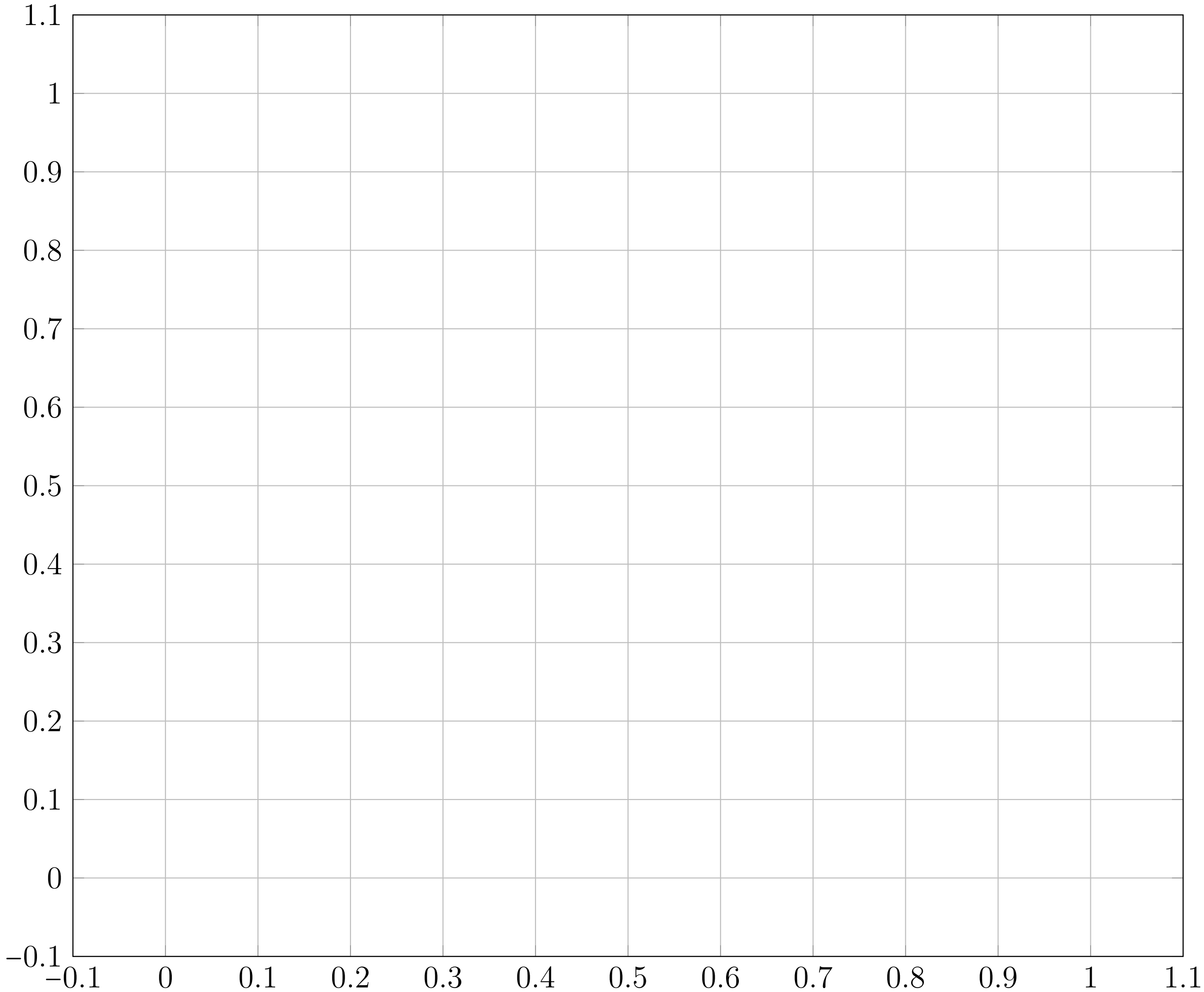

Рисунок 12. y'_{OA}

OLD

$$x'_{AB} = -l1 \cdot \sin(\phi) + \frac{{l_2}^2 \cdot \left(\frac{e_1}{2} - \frac{1}{2} \cdot l_2 \cdot \sin(\phi)\right) \cdot \cos(\phi)}{4 \cdot \sqrt{1 - \left(\frac{e_1}{2} - \frac{1}{2} \cdot l_2 \cdot \sin(\phi)\right)^2}} \tag{19}$$

NEW

$$\begin{multline} x_{AB}(\frac{1}{2}\sqrt{l_2^2 - (l_1 \sin(x) - e_1)^2} + l_1 \cos(x)) = \\ \frac{1}{2}(-(l_1^2 \cos^2(x))/\sqrt{l_2^2 - (l_1 \sin(x) - e_1)^2} - \frac{l_1^2 \cos^2(x)(l_1 \sin(x) - e_1)^2}{(l_2^2 - (l_1 \sin(x) - e_1)^2)^{\frac{3}{2}}} + \\ \frac{l_1 \sin(x)(l_1 \sin(x) - e_1)}{\sqrt{l_2^2 - (l_1 \sin(x) - e_1)^2}) - l_1 \cos(x)} \end{multline} \tag{20}$$

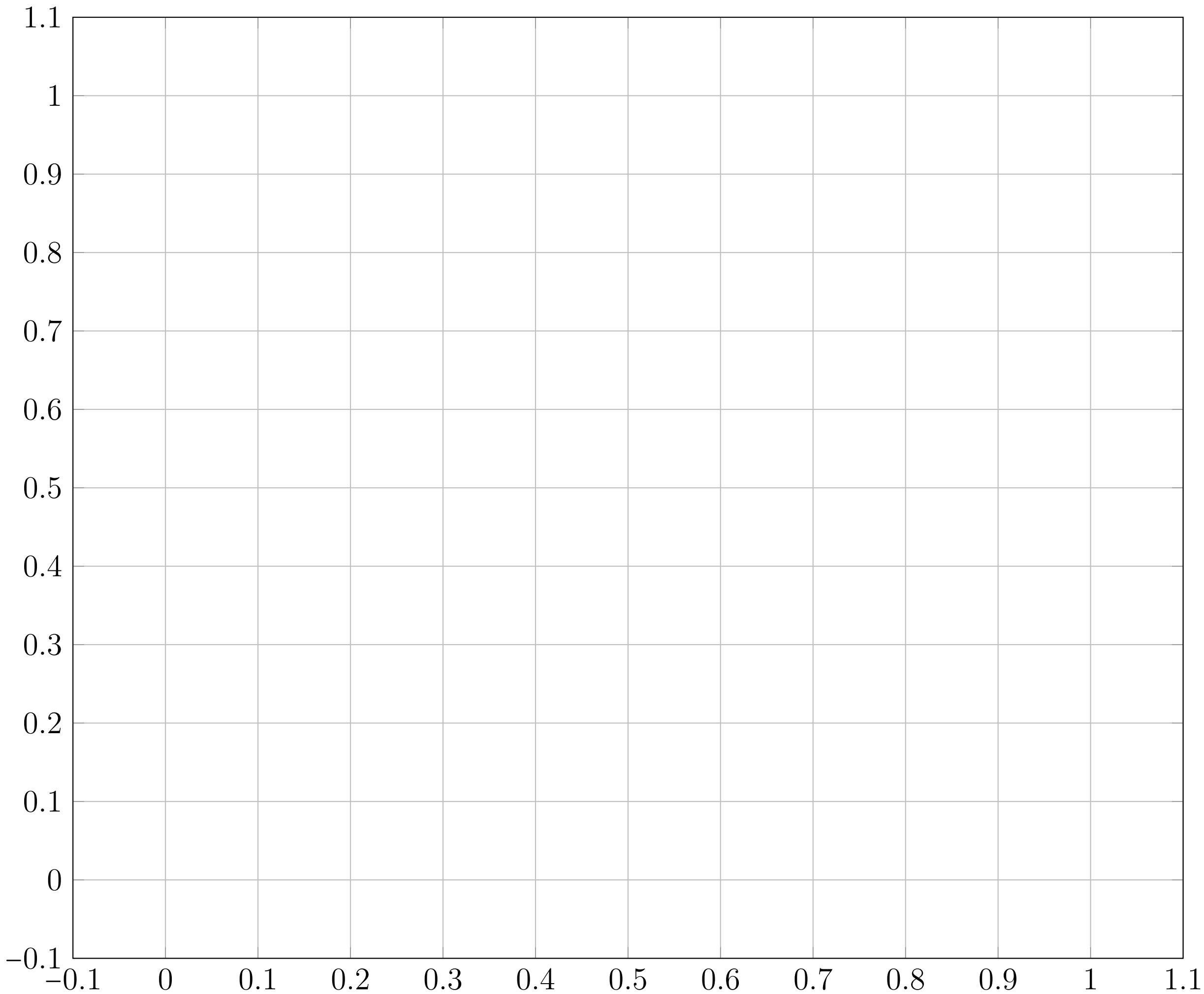

Рисунок 13. x_{AB}

$$y'_{AB} = \frac{l_1 \cdot \cos(\phi)}{2} \tag{21}$$

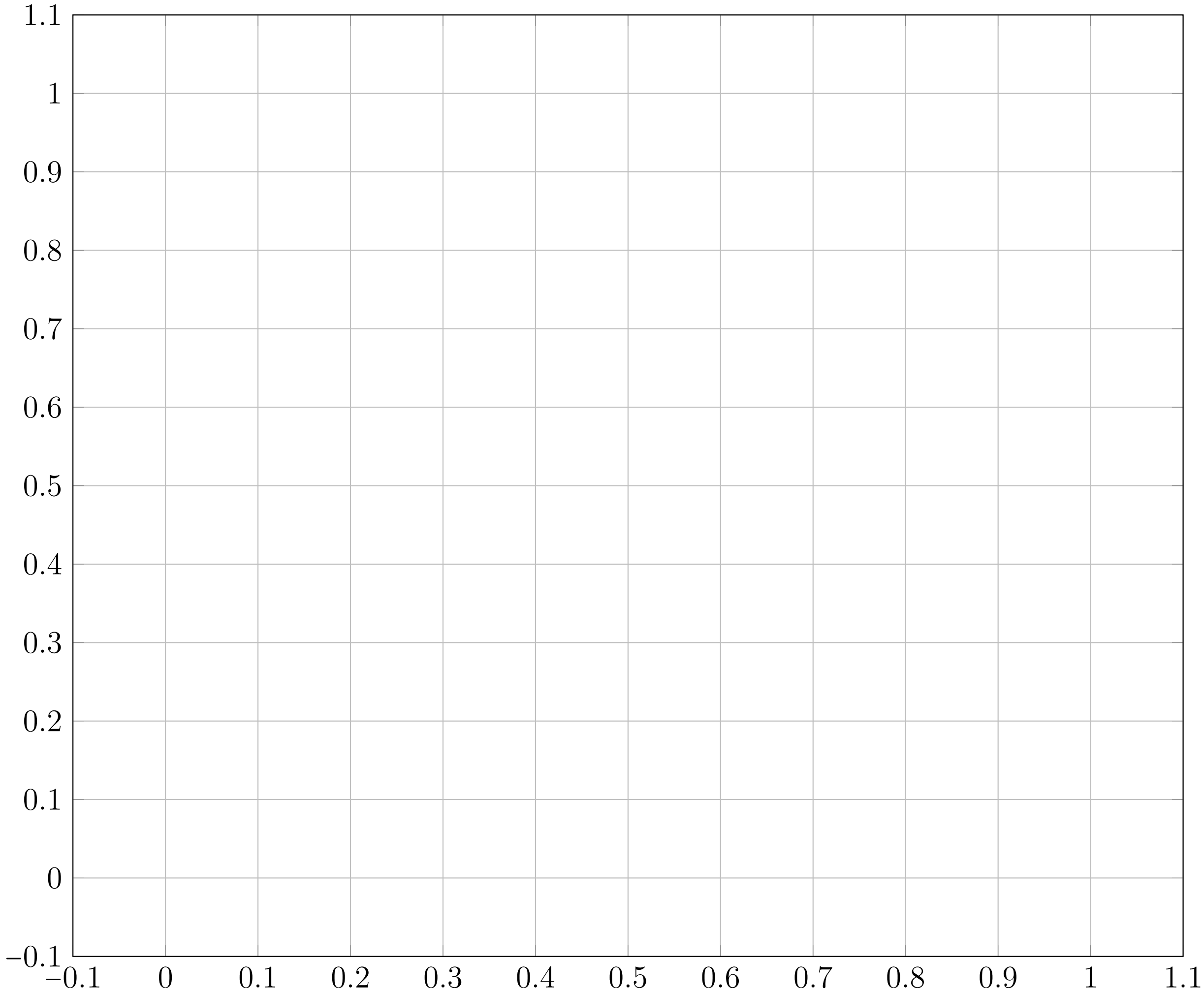

Рисунок 14. y'_{AB}

Найдём вторые производные:

$$x_A'' = -l_1 \cdot \cos(\phi) \tag{22}$$

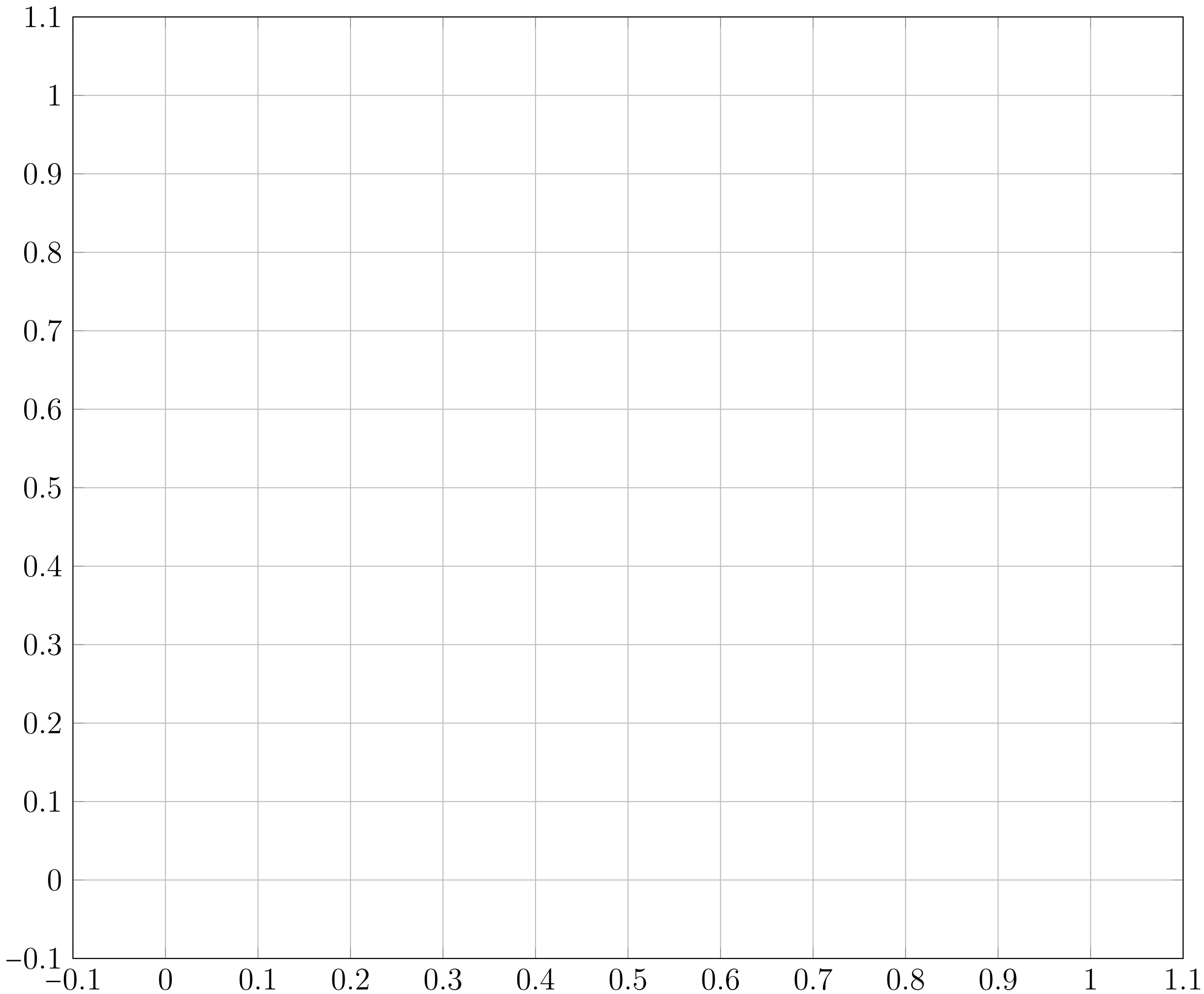

Рисунок 15. x_A''

$$y''_A = -l_1 \cdot \sin(\phi) \tag{23}$$

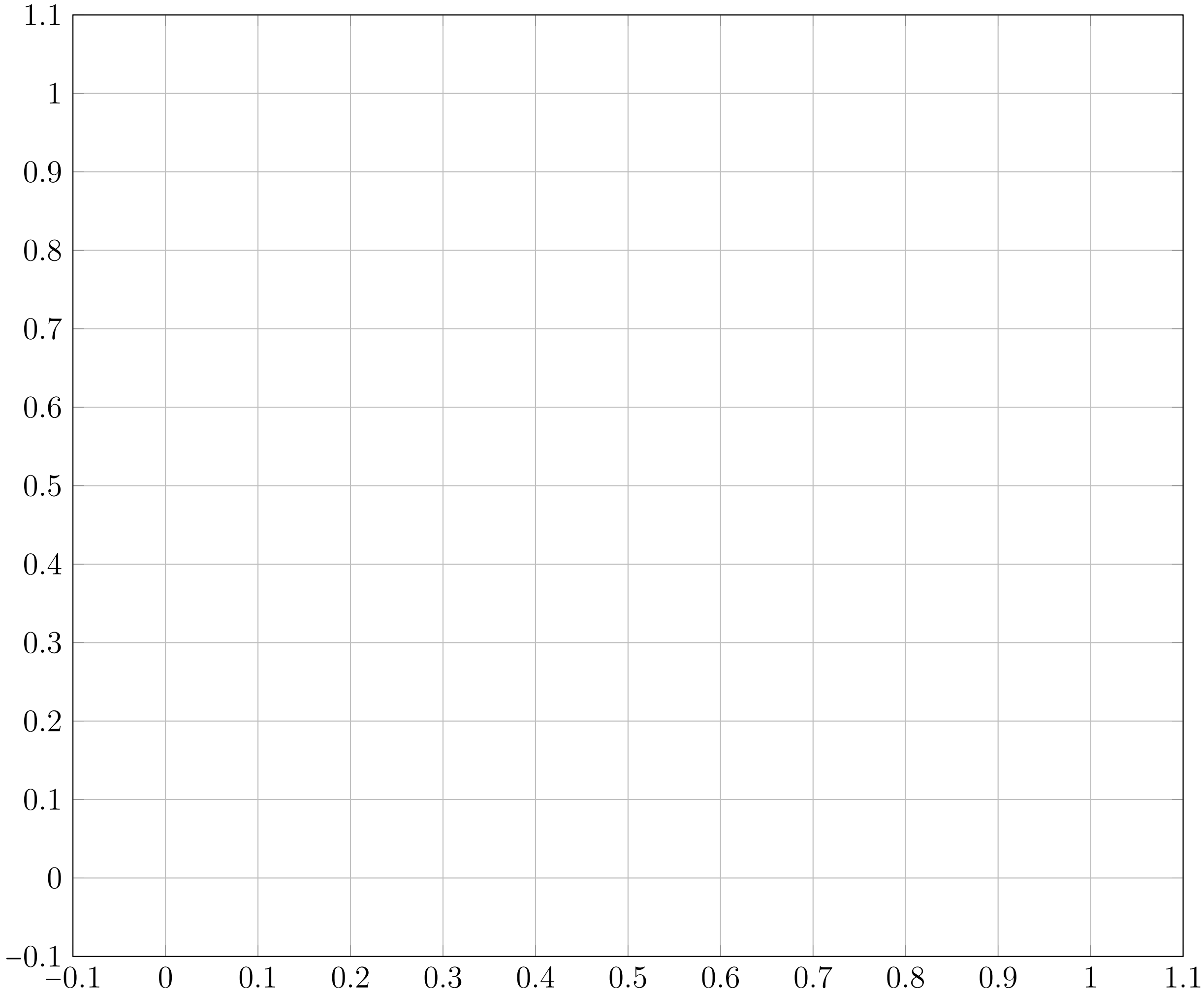

Рисунок 16. y''_A

$$x''_{OA} = \frac{-l_1 \cdot \cos(\phi)}{2} \tag{24}$$

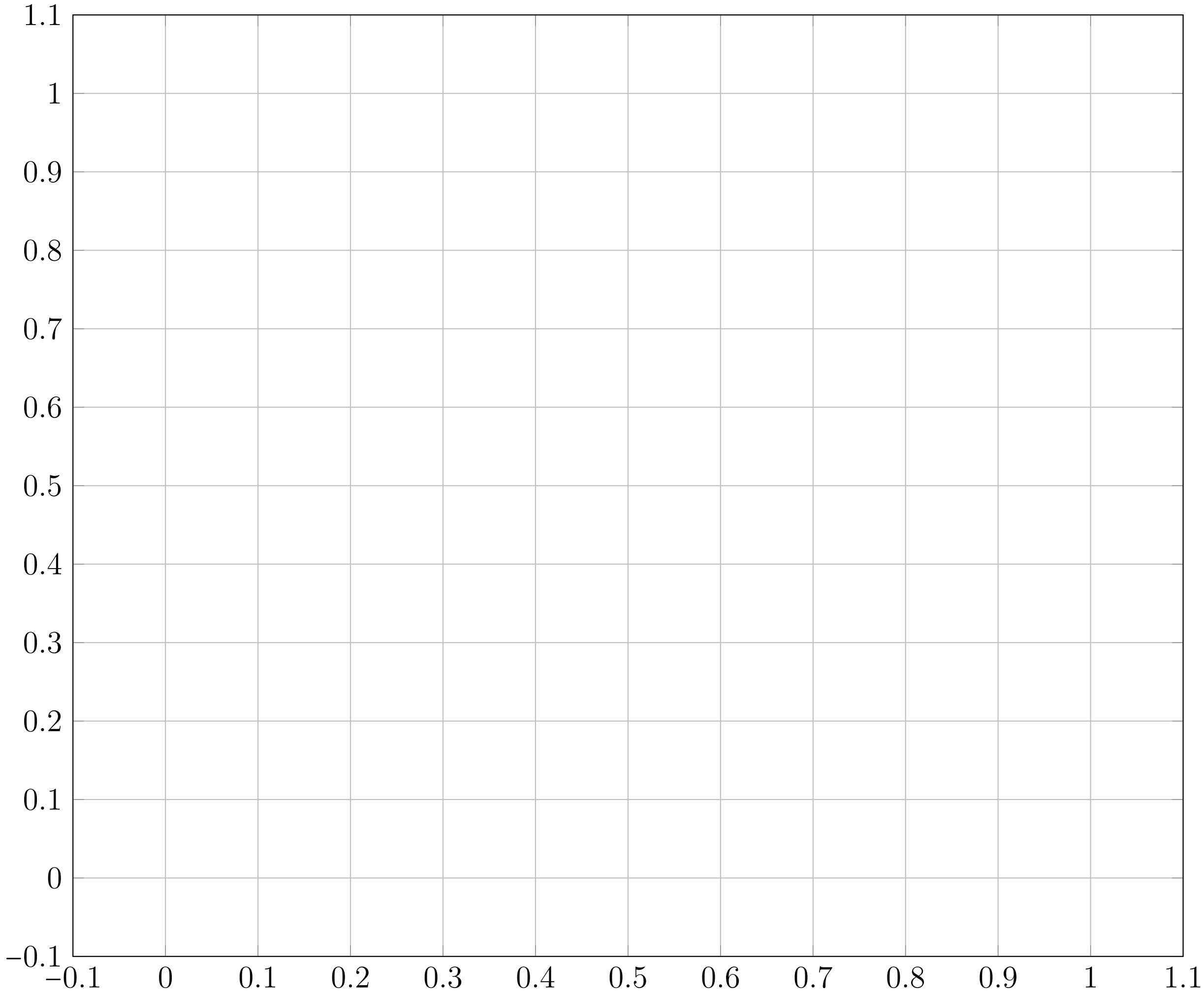

Рисунок 17. x''_{OA}

$$y''_{OA} = \frac{-l_1 \cdot \sin(\phi)}{2} \tag{25}$$

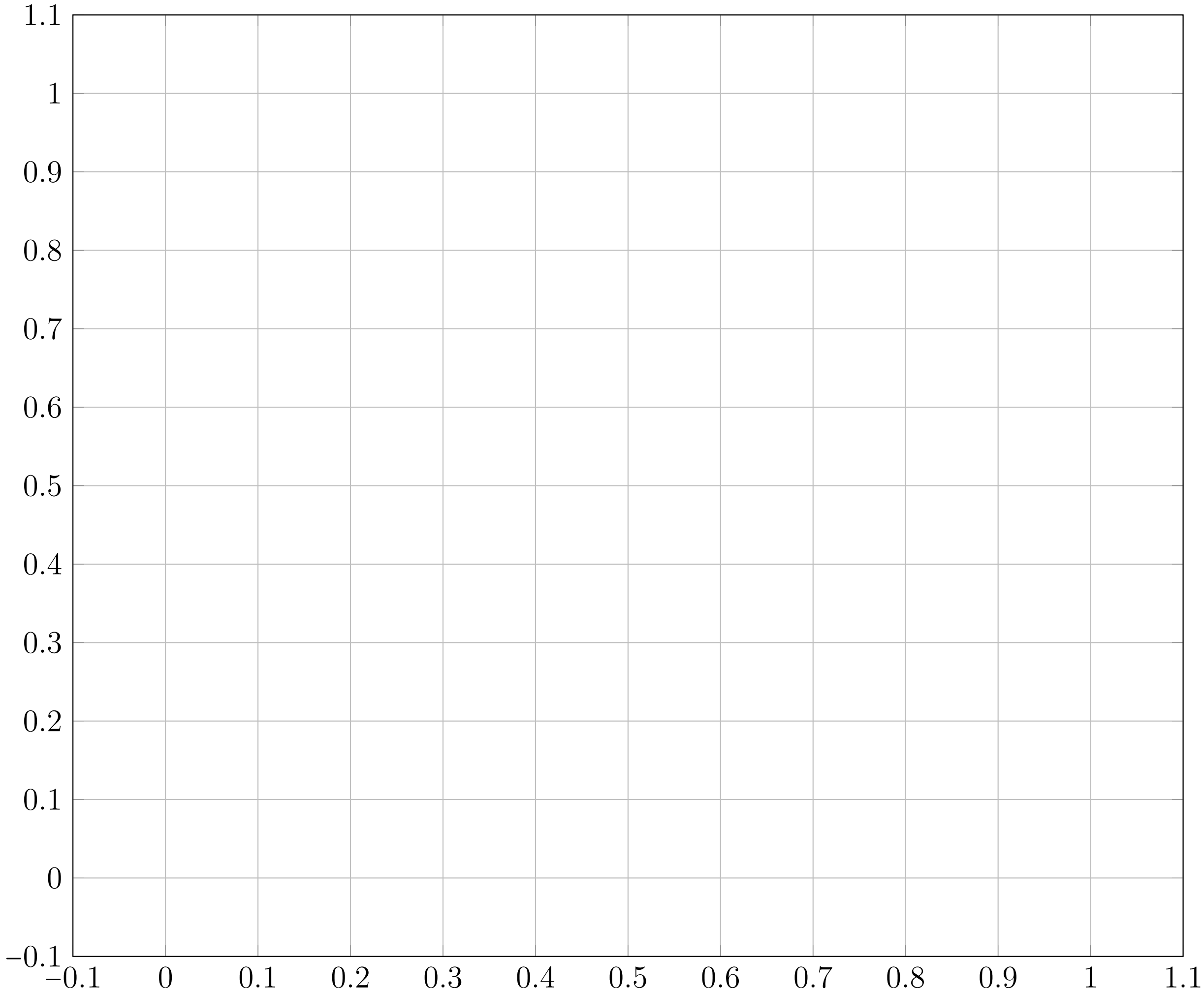

Рисунок 18. y''_{OA}

$$x''_{AB} = \frac{1}{2} \cdot \left(- \frac{{l_2}^3 \cdot \cos^2(x)}{4 \cdot \sqrt{1 - \frac{1}{4} \cdot (e_1 - l_2 \cdot \sin(x))^2}} - \right. \tag{26}$$

$$- \frac{{l_2}^3 \cdot \cos^2(x) \cdot (e_1 - l_2 \cdot \sin(x))^2}{16 \cdot \left(1 - \frac{1}{4} \cdot (e_1 - l_2 \cdot \sin(x))^2\right)^{\frac{3}{2}}} - \tag{27}$$

$$\left. - \frac{{l_2}^2 \cdot \sin(x) \cdot (e_1 - l_2 \cdot \sin(x))}{4 \cdot \sqrt{1 - \frac{1}{4} \cdot (e_1 - l_2 \cdot \sin(x))^2}} - 2 \cdot l_1 \cdot \cos(x) \right) \tag{28}$$

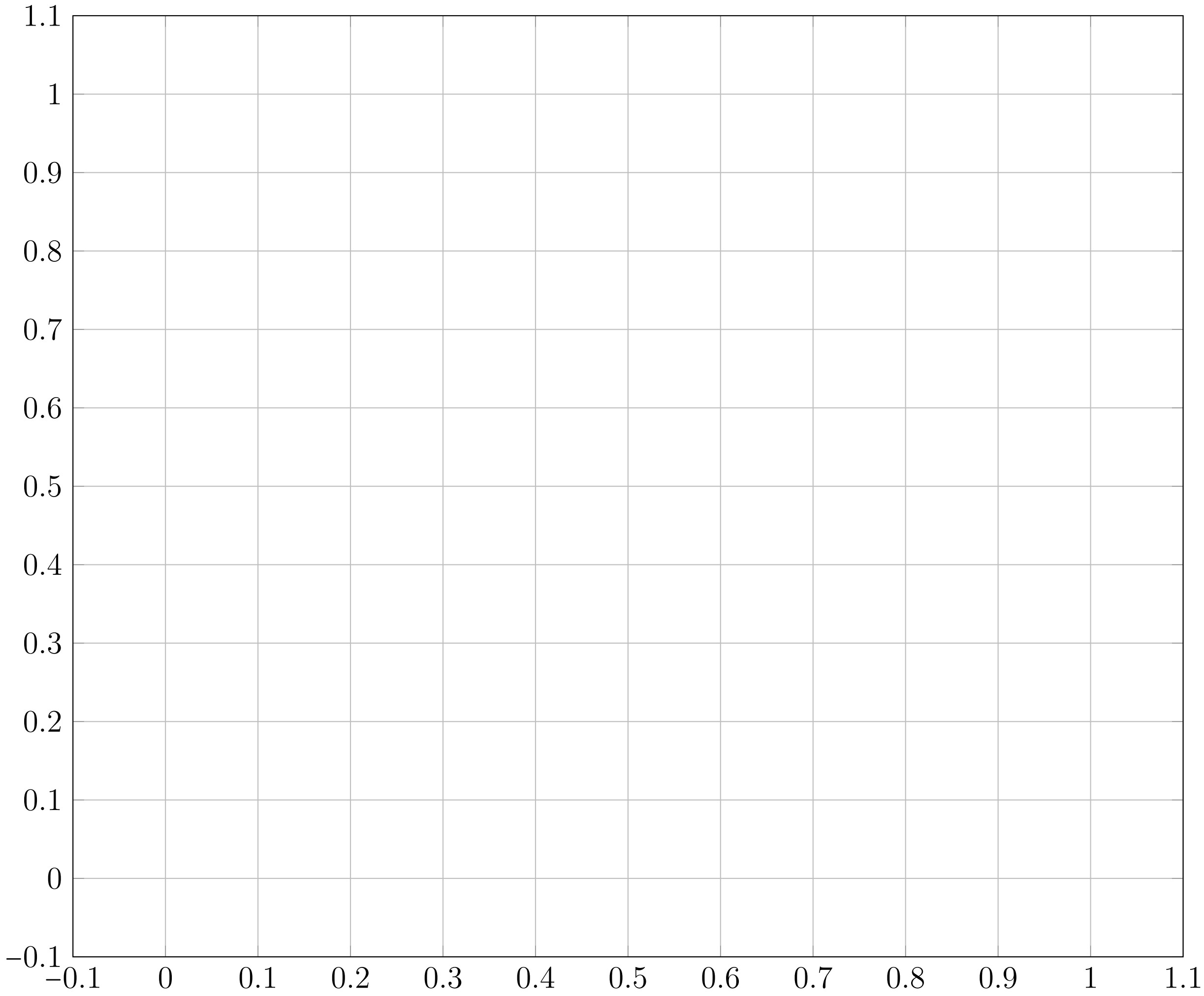

Рисунок 19. x''_{AB}

$$y''_{AB} = \frac{-l_1 \cdot \sin(\phi)}{2} \tag{29}$$

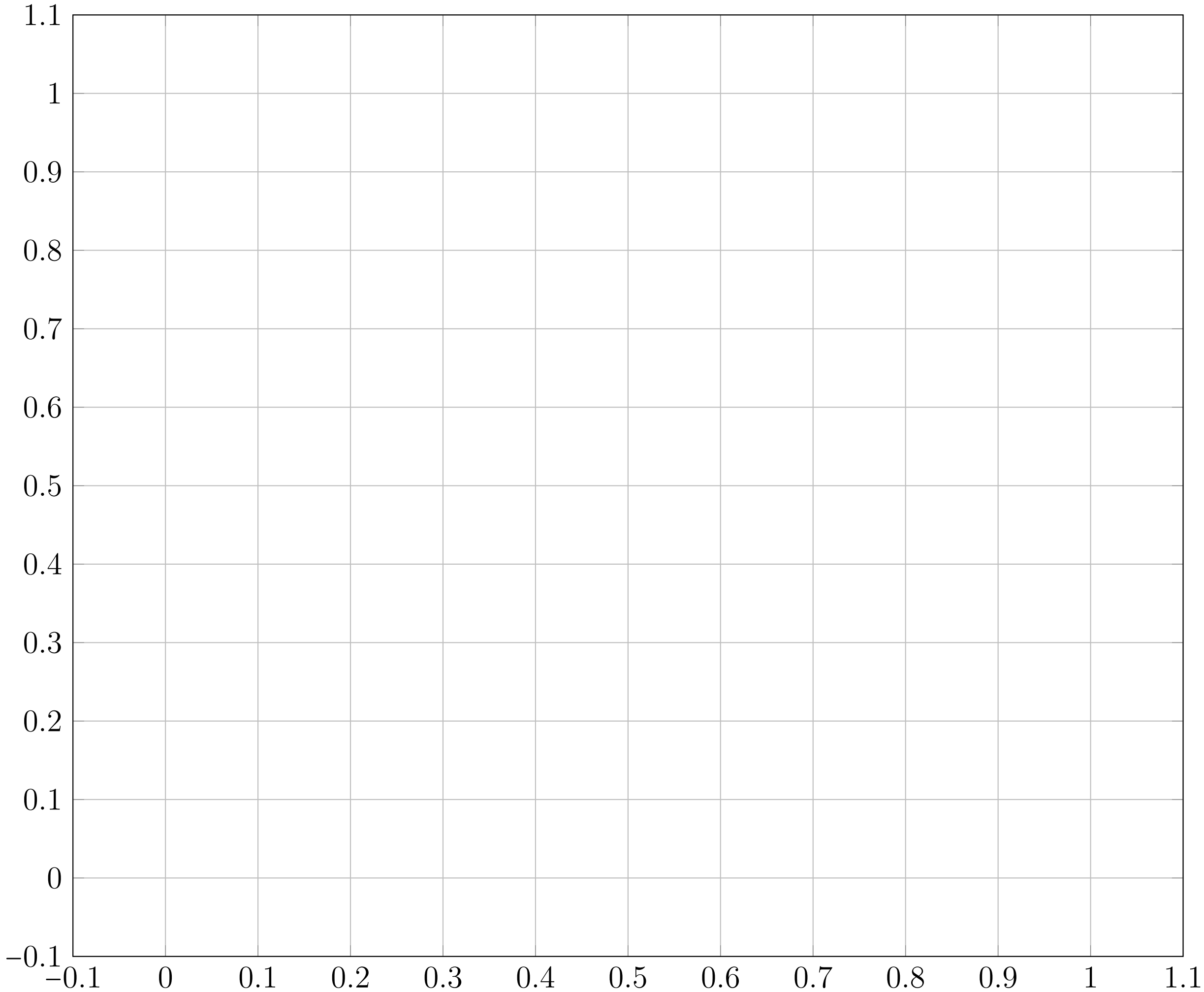

Рисунок 20. y''_{AB}