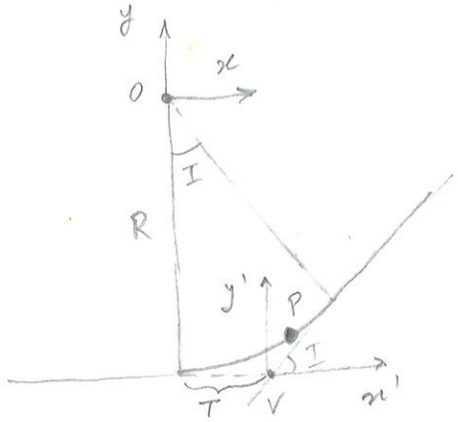
1.

a)



no ref. oxy a eq. da circunferência é $x^2+y^2=R^2$

com $x_P^2+y_P^2=R^2$;

no ref $vx'y'$ o ponto P tem coordenadas (42, 27);

tem-se $\begin{cases} x = T + x' \\ y + y' = R \end{cases}$ $\begin{cases} x = R\tan 15 + x' \\ y = R - y' \end{cases}$

$$(R\tan 15 + 42)^2 + (R-27)^2 = R^2$$

$$R^2\tan^2 15 + 42^2 + 2R\times\tan 15\times 42 + \cancel{R^2} + 27^2 - 2R\times 27 = \cancel{R^2}$$

$$R^2\tan^2 15 + (2\tan 15\times 42 - 54)R + 2493 = 0$$

$$R = \frac{31.492267 \pm \sqrt{991.762933 - 4\times 0.071797\times 2493}}{0.143593} \begin{cases} 334.971705 \Rightarrow \underline{R = -335} \\ 103.659772 \end{cases}$$

b) $V = 1234.567$, $PC = V - T = 1234.567 - R\tan\frac{I}{2} = 1146.144$ $(R=-330)$

$PT = PC + l_a = 1146.144 + 330\,\frac{30}{180}\times\pi = 1318.932$

c) $R = 330\,m$, $T = R\tan\frac{I}{2} = 88.423$

$$R = \frac{T}{\tan\frac{I}{2}} \begin{cases} T = 100,\ R = 373.205\,m \\ T = 110,\ R = 410.526 \end{cases} \Rightarrow D_a = \frac{36000}{2\pi R} = \begin{cases} 15^\circ.352 \\ 13^\circ.957 \end{cases}$$

os valores inteiros de Da são $D_a = 14^\circ$ e $D_a = 15^\circ$, conduzindo o valor $D_a = 14^\circ$ a uma curva com maior raio de curvatura: $R = \frac{36000}{2\pi D_a} = 409.255$

$T = R\tan\frac{I}{2} = 109.660\,m$; $PC = V - T = 1124.907$; $l_a = RI = 214.285$; $PT = PC + l_a = 1339.192$;

Estação: PC = 1124.907

estaca	s = estaca − PC	$\theta = s/R$	$\delta = \theta/2$	$d = 2R\sin\delta$
1125	0.093	$0^\circ.0130$	$0^\circ.0065$	0.093 m
1150	25.093	$3^\circ.5130$	$1^\circ.7565$	25.089 m
⋮				
1325	200.093	$28^\circ.0130$	$14^\circ.0065$	198.106 m
PT	214.285	$30^\circ.0000$	$15^\circ.0000$	211.846 m

d) $I - 2\Delta = 0 \Rightarrow \Delta = \frac{I}{2} = 15$; $L_s = 2R\Delta = 214.285\,m$

2.

a) $\frac{d^2Y}{dx^2} = -2.5\times10^{-4}$, $\frac{dY}{dx} = -2.5\times10^{-4}x + C$, $\begin{cases} \text{em } T_1,\ x=0,\ \frac{dY}{dx} = C \Rightarrow C = \frac{33.263-31.891}{1678.18-1632.46} \simeq 0.03 = 3\% \quad (i_1) \\ \text{em } T_2,\ x=L,\ \frac{dY}{dx} = -2.5\times10^{-4}L + i_1 \Rightarrow L = \Big(\underbrace{\frac{31.635-32.702}{1830.58-1777.24}}_{i_2=-0.02} - 0.03\Big)/(-2.5\times10^{-4}) = 200\text{m} \end{cases}$

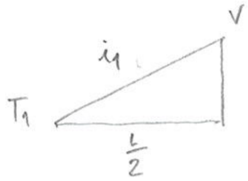
b) o ponto V obtém-se da intersecção dos segmentos AB e CD:

$$\begin{cases} \frac{x_B-x_A}{x_V-x_A} = \frac{y_B-y_A}{y_V-y_A} \Rightarrow (x_B-x_A)(y_B-y_A) = (y_B-y_A)(x_V-x_A) \Rightarrow x_V = \frac{(x_B-x_A)(y_V-y_A)}{y_B-y_A} + x_A \\ \frac{x_D-x_C}{x_V-x_C} = \frac{y_D-y_C}{y_C-y_C} \Rightarrow (x_D-x_C)(y_V-y_C) = (y_D-y_C)(x_V-x_C) \Rightarrow x_V = \frac{(x_D-x_C)(y_V-y_C)}{y_D-y_C} + x_C \end{cases}$$

$$\frac{(x_B-x_A)(y_V-y_A)}{y_B-y_A} + x_A = \frac{(x_D-x_C)(y_V-y_C)}{y_D-y_C} + x_C \Rightarrow y_C = \frac{(x_C-x_A)(y_B-y_A)(y_D-y_C) + (x_B-x_A)(y_D-y_C)y_A - (x_D-x_C)(y_B-y_A)y_C}{(x_B-x_A)(y_D-y_C) - (x_D-x_C)(y_B-y_A)}$$

$\Rightarrow Y_V = 34.115$ m, $X_V = 1706.57$ m

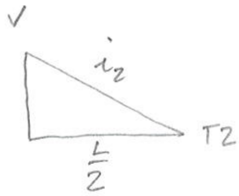
c)



$i_1 = 0.03 = \frac{dy}{dx} = \frac{dy}{100} \Rightarrow dy = 3$ m

$X_{T1} = X_V - \frac{L}{2} = 1606.57$ m

$y_{T1} = y_V - 3 = 31.115$ m



$i_2 = -0.02 = \frac{dy}{100} \Rightarrow dy = 2$ m

$X_{T2} = X_V + \frac{L}{2} = 1806.57$ m

$y_{T2} = y_V - 2 = 32.115$ m

d) $\frac{dy}{dx} = -2.5\times10^{-4}x + 0.03$, $y = -2.5\times10^{-4}\frac{x^2}{2} + 0.03x + y_{T1} = -1.25\times10^{-4}x^2 + 0.03x + 31.115$

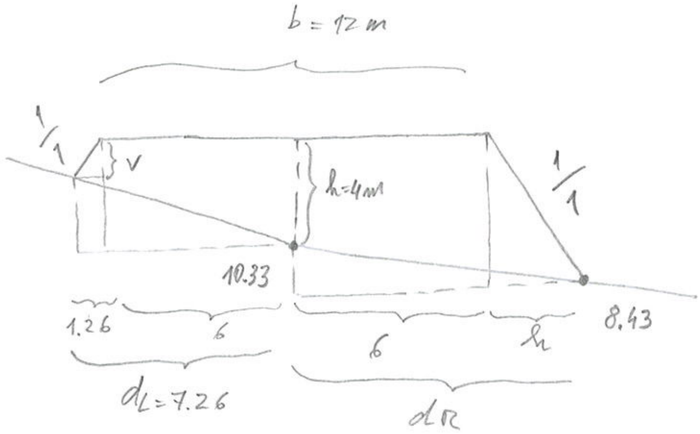
Estação T_1: $X_{T1} = 1\,606.57$	$x = X - X_{T1}$	$y = -1.25\times10^{-4}x^2 + 0.03x + 31.115$
X = 1625 m	x = 18.43 m	y = 31.625 m
X = 1650 m	x = 43.43 m	y = 32.182 m
X = 1675 m	x = 68.43 m	y = 32.583 m
X = 1700 m	x = 93.43 m	y = 32.827 m
X = 1725 m	x = 118.43 m	y = 32.915 m
X = 1750 m	x = 143.43 m	y = 32.846 m
X = 1775 m	x = 168.43 m	y = 32.622 m
X = 1800 m	x = 193.43 m	y = 32.241 m
X = 1806.57 m	x = 200.00 m	y = 32.115 m

e) de $\frac{dy}{dx} = -2.5\times10^{-4}x + 0.03 = 0$ tem-se $x_M = \frac{0.03}{2.5\times10^{-4}} = 120$ m

$y_M = y(x_M) = 32.915$ m

$X_M = X_{T1} + x_M = 1606.57 + 120 = 1726.57$ m

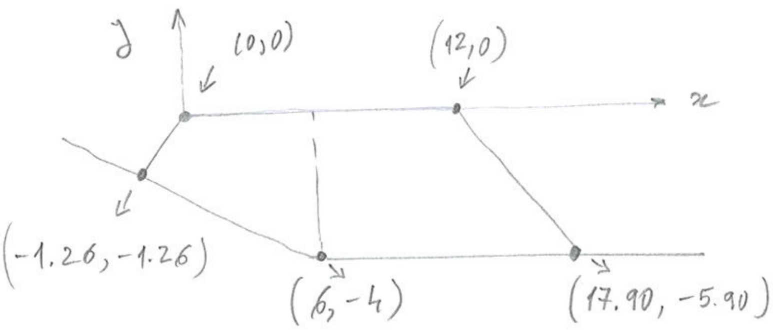
3.



a) $\frac{1}{1} = \frac{10.33+4-8.43}{h} \Rightarrow h = 5.90\ m \Rightarrow d_R = 11.90\ m$

b) $\frac{1}{1} = \frac{v}{1.26} \Rightarrow v = 1.26\ m \Rightarrow$ cota da base do talude = $14.33 - 1.26 = 13.07\ m$

c)



$$A = \frac{1}{2}\left[\frac{0}{0}\ \frac{12}{0}\ \frac{17.90}{-5.90}\ \frac{6}{-4}\ \frac{-1.26}{-1.26}\ \frac{0}{0}\right] = \frac{1}{2}\left(12\times(-5.90) + 17.90\times(-4) + 6\times(-1.26) - (-5.90)\times 6 - (-4)\times(-1.26)\right) =$$

$$= 59.8\ m^2$$

4. $R_{BE} = \text{atan}\,\frac{M_E - M_B}{P_E - P_B} = \text{atan}\,\frac{7709.336 - 8478.139}{2263.411 - 2483.826} = \text{atan}\,\frac{-768.803}{-220.415} = 254^\circ.002459$

Supondo $\underline{RF_B = 180^\circ}$

$$\begin{cases} M_C = M_B + d_1 \sin RF_B = 8478.139 + 281.832 \underbrace{\sin 180}_{0} = 8478.139 \\ P_C = P_B + d_1 \cos RF_B = 2483.826 + 281.832 \underbrace{\cos 180}_{-1} = 2201.994 \end{cases}$$

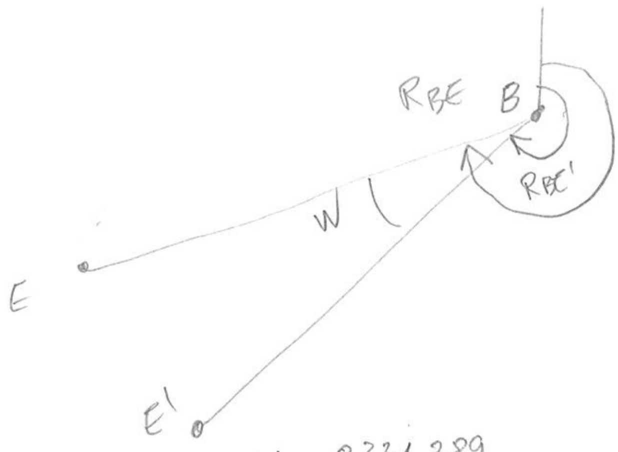
$$\underline{RF_C} = RF_B - 180 + \alpha_1 = \underline{185^\circ.370556}$$

$$\begin{cases} M_D = M_C + d_2 \sin RF_C = 8478.139 + 271.300 \sin 185^\circ.370556 = 8452.746 \\ P_D = P_C + d_2 \cos RF_C = 2201.994 + 271.300 \cos 185^\circ.370556 = 1931.885 \end{cases}$$

$$RF_D = RF_C - 180 + \alpha_2 = 213^\circ.809167$$

$$\begin{cases} M_E' = M_D + d_3 \sin RF_D = 8452.746 + 274.100 \sin 213.809167 = 8300.229 \\ P_E' = P_D + d_3 \cos RF_D = 1931.885 + 274.100 \cos 213.809167 = 1704.137 \end{cases}$$

$$R_{BE}' = \text{atan}\,\frac{M_E' - M_B}{P_E' - P_B} = \text{atan}\,\frac{8300.229 - 8478.139}{1704.137 - 2483.826} = \text{atan}\,\frac{-177.910}{-779.689} = 192^\circ.853725$$



$R_{BE}' + W = R_{BE}$

$W = 61^\circ.148734$

$$\begin{cases} M_C = M_B + d_1 \sin(180 + 61.148754) = 8231.289 \\ P_C = P_B + d_1 \cos(180 + 61.148754) = 2347.832 \\ M_D = M_C + d_2 \sin(185.370556 + 61.148754) = 7982.454 \\ P_D = P_D + d_2 \cos(185.370556 + 61.148754) = 2239.735 \\ M_E = M_D + d_3 \sin(213.809167 + 61.148754) = 7709.379 \\ P_E = P_D + d_3 \cos(213.809167 + 61.148754) = 2263.423 \end{cases}$$