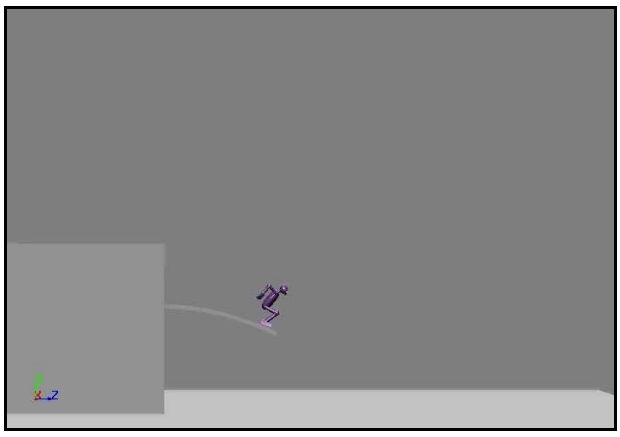
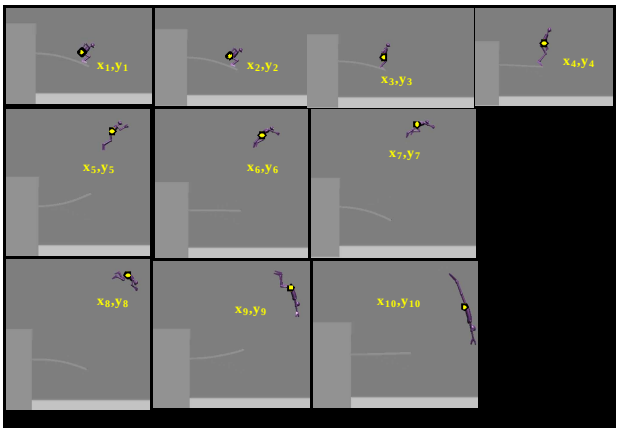
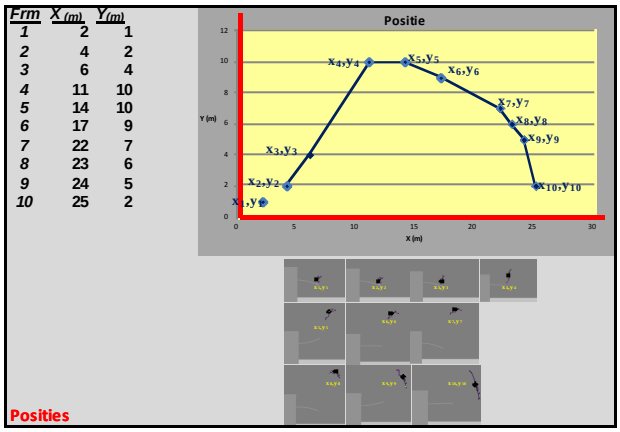



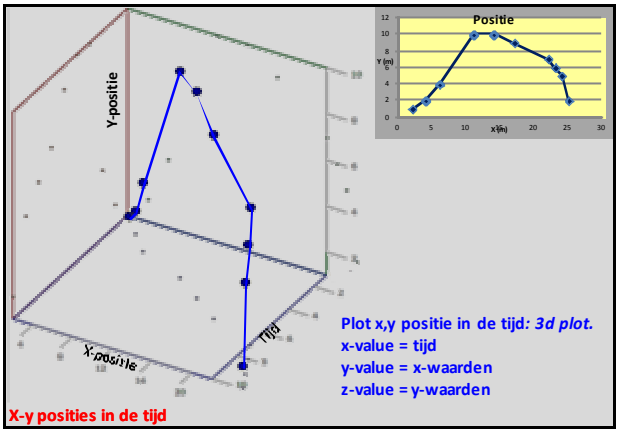


| Frm | X (m) | Y (m) |
|---|---|---|
| 1 | 2 | 1 |
| 2 | 4 | 2 |
| 3 | 6 | 4 |
| 4 | 11 | 10 |
| 5 | 14 | 10 |
| 6 | 17 | 9 |
| 7 | 22 | 7 |
| 8 | 23 | 6 |
| 9 | 24 | 5 |
| 10 | 25 | 2 |

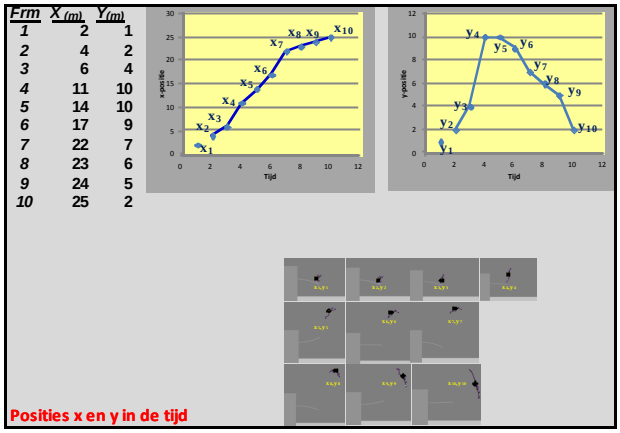


Posities




Plot x,y positie in de tijd: *3d plot.*
x-value = tijd
y-value = x-waarden
z-value = y-waarden

X-y posities in de tijd

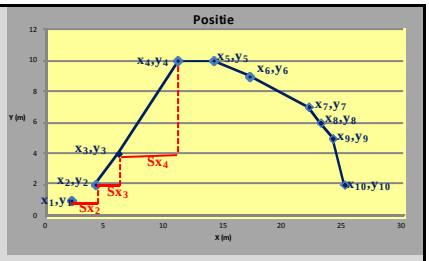


| Frm | X (m) | Y (m) |
|---|---|---|
| 1 | 2 | 1 |
| 2 | 4 | 2 |
| 3 | 6 | 4 |
| 4 | 11 | 10 |
| 5 | 14 | 10 |
| 6 | 17 | 9 |
| 7 | 22 | 7 |
| 8 | 23 | 6 |
| 9 | 24 | 5 |
| 10 | 25 | 2 |



Posities x en y in de tijd

| Frm | X (m) | Y (m) | Sx |
|---|---|---|---|
| 1 | 2 | 1 | ? |
| 2 | 4 | 2 | 2 |
| 3 | 6 | 4 | 2 |
| 4 | 11 | 10 | 5 |
| 5 | 14 | 10 | 3 |
| 6 | 17 | 9 | 3 |
| 7 | 22 | 7 | 5 |
| 8 | 23 | 6 | 1 |
| 9 | 24 | 5 | 1 |
| 10 | 25 | 2 | 1 |



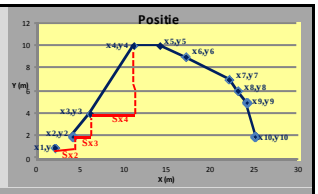

$Sx_2 = x_2 - x_1$
$Sx_3 = x_3 - x_2$
$Sx_4 = x_4 - x_3$
etc.

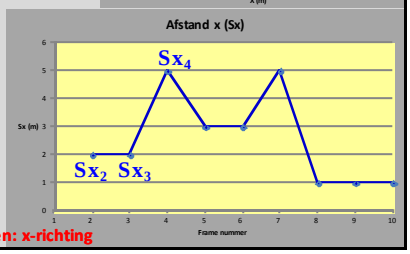

3 paaltjes = 2 gaatjes
2 posities leveren 1 afstand

**Waar is afstand $Sx_1$?**

Van posities naar afstanden: x-richting

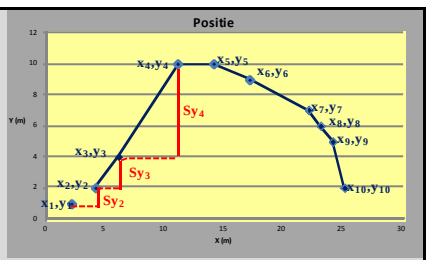
| Frm | X (m) | Y (m) | Sx |
|---|---|---|---|
| 1 | 2 | 1 | |
| 2 | 4 | 2 | 2 |
| 3 | 6 | 4 | 2 |
| 4 | 11 | 10 | 5 |
| 5 | 14 | 10 | 3 |
| 6 | 17 | 9 | 3 |
| 7 | 22 | 7 | 5 |
| 8 | 23 | 6 | 1 |
| 9 | 24 | 5 | 1 |
| 10 | 25 | 2 | 1 |




Van posities naar afstanden: x-richting

| Frm | X (m) | Y (m) | Sy |
|---|---|---|---|
| 1 | 2 | 1 | |
| 2 | 4 | 2 | 1 |
| 3 | 6 | 4 | 2 |
| 4 | 11 | 10 | 6 |
| 5 | 14 | 10 | 0 |
| 6 | 17 | 9 | -1 |
| 7 | 22 | 7 | -2 |
| 8 | 23 | 6 | -1 |
| 9 | 24 | 5 | -1 |
| 10 | 25 | 2 | -3 |

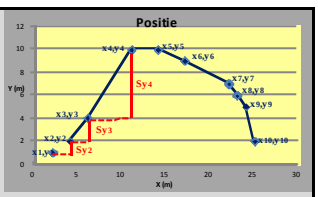


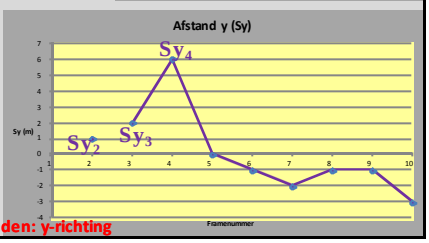

$Sy_2 = y_2 - y_1$
$Sy_3 = y_3 - y_2$
$Sy_4 = y_4 - y_3$
etc.

Idem voor de afstand in de y-richting

Van posities naar afstanden: y-richting

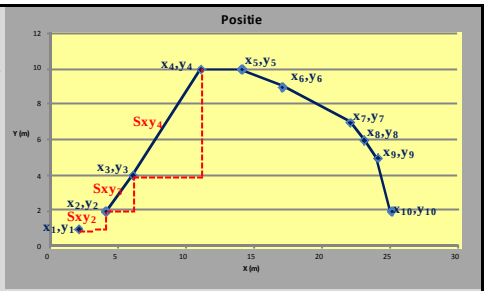
| Frm | X (m) | Y (m) | Sy |
|---|---|---|---|
| 1 | 2 | 1 | |
| 2 | 4 | 2 | 1 |
| 3 | 6 | 4 | 2 |
| 4 | 11 | 10 | 6 |
| 5 | 14 | 10 | 0 |
| 6 | 17 | 9 | -1 |
| 7 | 22 | 7 | -2 |
| 8 | 23 | 6 | -1 |
| 9 | 24 | 5 | -1 |
| 10 | 25 | 2 | -3 |




Van posities naar afstanden: y-richting

| Frm | X (m) | Y (m) |
|---|---|---|
| 1 | 2 | 1 |
| 2 | 4 | 2 |
| 3 | 6 | 4 |
| 4 | 11 | 10 |
| 5 | 14 | 10 |
| 6 | 17 | 9 |
| 7 | 22 | 7 |
| 8 | 23 | 6 |
| 9 | 24 | 5 |
| 10 | 25 | 2 |




$Sxy_2 = \sqrt{(x_2-x_1)^2 + (y_2-y_1)^2}$

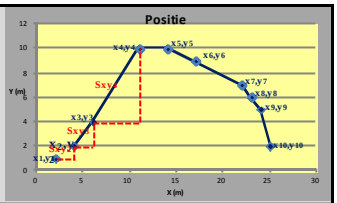
$Sxy_3 = \sqrt{(x_3-x_2)^2 + (y_3-y_2)^2}$

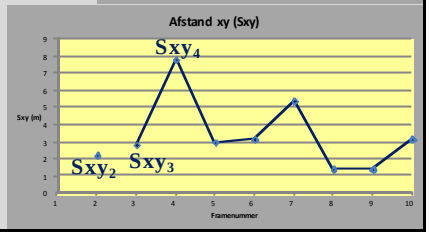
$Sxy_4 = \sqrt{(x_4-x_3)^2 + (y_4-y_3)^2}$

etc.

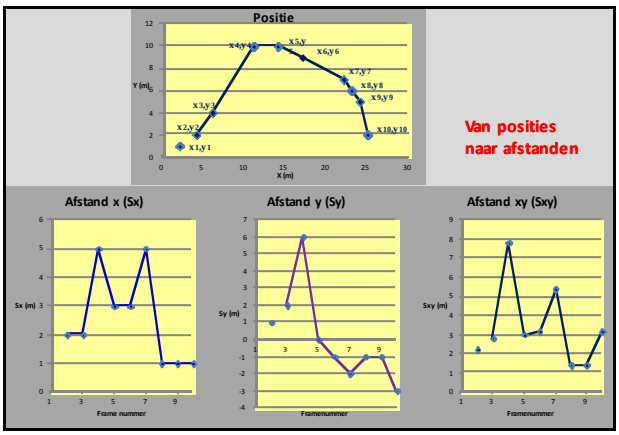
Van positie naar afstand: xy-richting ("baan-afstanden")

| Frm | X (m) | Y (m) | Sxy |
|---|---|---|---|
| 1 | 2 | 1 | |
| 2 | 4 | 2 | 2.2 |
| 3 | 6 | 4 | 2.8 |
| 4 | 11 | 10 | 7.8 |
| 5 | 14 | 10 | 3.0 |
| 6 | 17 | 9 | 3.2 |
| 7 | 22 | 7 | 5.4 |
| 8 | 23 | 6 | 1.4 |
| 9 | 24 | 5 | 1.4 |
| 10 | 25 | 2 | 3.2 |




Van posities naar afstanden in xy-richting ("baan-afstanden")




Snelheid = afstand / tijd
(als er sprake is van een continue snelheid in een bepaald tijdsinterval)

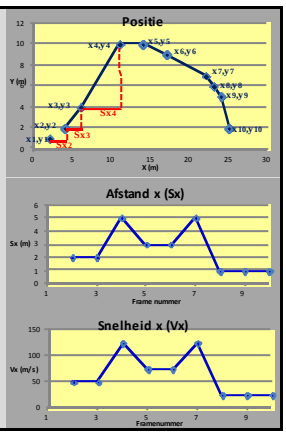
Stel: framerate = 25 fps

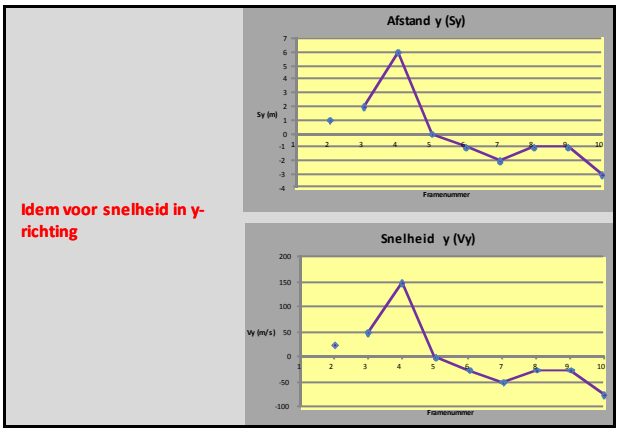
Frame-duur = 0.04 sec.

Vx = Sx / 0.04.

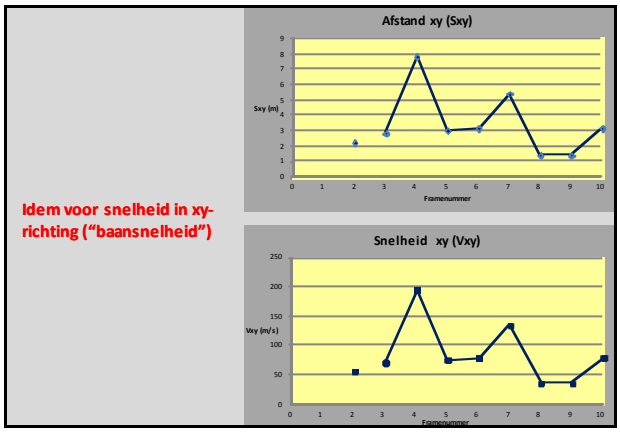
Van afstand naar snelheid. Bepalen van de eerste afgeleide.

| Frm | Sx | Vx |
|---|---|---|
| 1 | | |
| 2 | 2 | 50 |
| 3 | 2 | 50 |
| 4 | 5 | 125 |
| 5 | 3 | 75 |
| 6 | 3 | 75 |
| 7 | 5 | 125 |
| 8 | 1 | 25 |
| 9 | 1 | 25 |
| 10 | 1 | 25 |




Idem voor snelheid in y-richting




Idem voor snelheid in xy-richting ("baansnelheid")

De stap van positie naar afstand kan worden "weggelaten".

$Sx_2 = X_2 - X_1$

$Vx_2 = Sx_2 / 0.04$

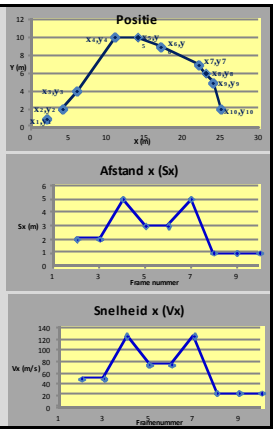
} $Vx_2 = (X_2 - X_1) / 0.04$

Algemene gedaante:

$Vx_i = (X_i - X_{i-1}) / \Delta t$

Voor de y-richting geldt hetzelfde.

$Vy_i = (Y_i - Y_{i-1}) / \Delta t$




Voor de baansnelheid (xy) geldt:

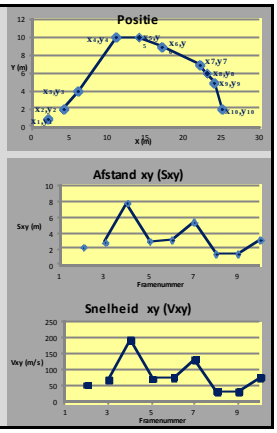
$Sxy_2 = \sqrt{(x_2-x_1)^2 + (y_2-y_1)^2}$

$Vxy_2 = Sxy_2 / 0.04$

} $Vxy_2 = \left(\sqrt{(x_2-x_1)^2 + (y_2-y_1)^2}\right) / 0.04$

Algemene gedaante:

$Vxy_i = \left(\sqrt{(x_i-x_{i-1})^2 + (y_i-y_{i-1})^2}\right) / \Delta t$



**Versnelling is het veranderen van de snelheid in de tijd.**

**Van frame 2 naar frame 3 blijft de snelheid gelijk** $Vx_3 - Vx_2 = 0$.

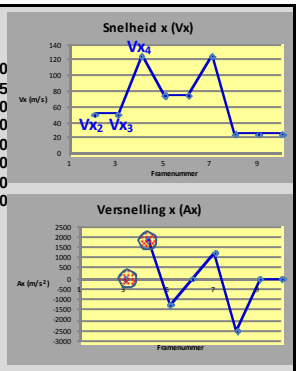
**De versnelling is dus 0.**

**Van frame 3 naar frame 4 verandert de snelheid (van 50 naar 125 m/s)**

**De verandering bedraagt: 125 – 50 = 75 m/s**

**De tijd waarin deze verandering optreedt bedraagt 0.04 sec**

| Frm | Vx | Ax |
|---|---|---|
| 1 | | |
| 2 | 50 | |
| 3 | 50 | 0 |
| 4 | 125 | 1875 |
| 5 | 75 | -1250 |
| 6 | 75 | 0 |
| 7 | 125 | 1250 |
| 8 | 25 | -2500 |
| 9 | 25 | 0 |
| 10 | 25 | 0 |

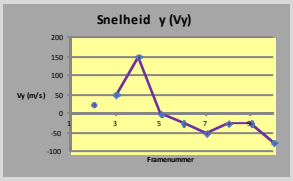


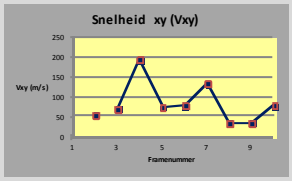


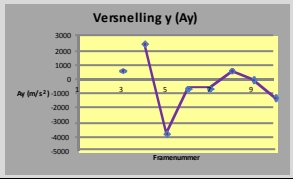


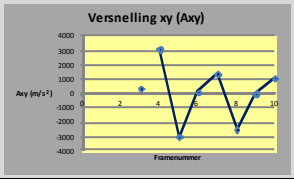
**De versnelling is dan: 75 m/s / 0.04 sec = 1875 m/s²**

**Voor de versnellingen in y en xy richting geldt hetzelfde als voor de x-richting**




**In het hiervoorgaande werd gebruik gemaakt van twee opvolgende datapunten.**
**We noemen dit "Extrapoleren"**

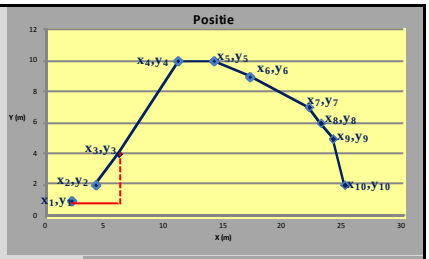
**Omdat er meestal geen sprake is van constante snelheden / versnellingen, wordt meestal gebruikgemaakt van *inter*poleren i.p.v. *extra*poleren.**

**Hierbij wordt zowel informatie uit het "verleden" als uit de "toekomst" gebruikt.**

**Extrapoleren van positie naar snelheid, b.v in x-richting:**

$(X_2 - X_1) / \Delta t$

**Interpoleren van positie naar snelheid, b.v in x-richting:**

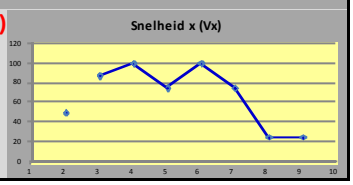



$(X_3 - X_2) + (X_2 - X_1) / (2\ \Delta t)$

$(X_3 - X_1) / (2\ \Delta t)$

**Algemene gedaante:**
**(P is een willekeurig datapunt)**

$V_i = (P_{i+1} - P_{i-1}) / (2\ \Delta t)$




$Vx_i = (x_{i+1} - x_{i-1}) / (2\ \Delta t)$

$Vx_2 = (x_3 - x_1) / (2\ \Delta t)$

$Vx_2 = (6 - 2) / (2 \times 0.04)$

$Vx_2 = 50$

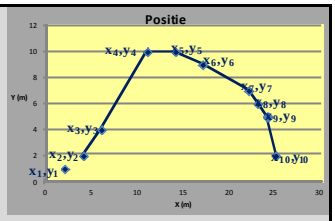
$Vx_3 = (x_4 - x_2) / (2\ \Delta t)$

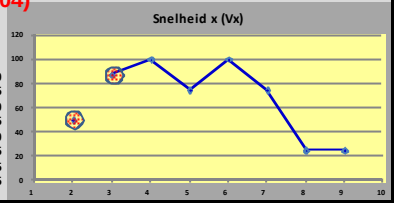
$Vx_3 = (11 - 4) / (2 \times 0.04)$

$Vx_3 = 87.5$

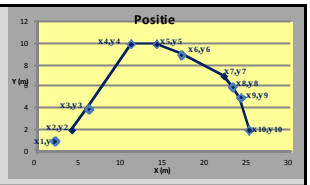
**Stel:**
**Framerate = 25 fps**
**Frameduur = 0.04 sec**

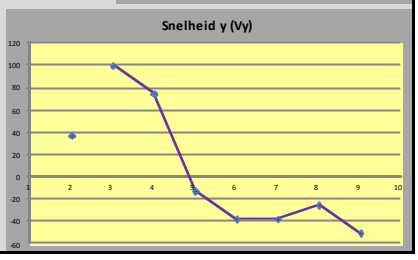
| Frm | X | Vx |
|---|---|---|
| 1 | 2 | |
| 2 | 4 | 50 |
| 3 | 6 | 87.5 |
| 4 | 11 | 100 |
| 5 | 14 | 75 |
| 6 | 17 | 100 |
| 7 | 22 | 75 |
| 8 | 23 | 25 |
| 9 | 24 | 25 |
| 10 | 25 | |



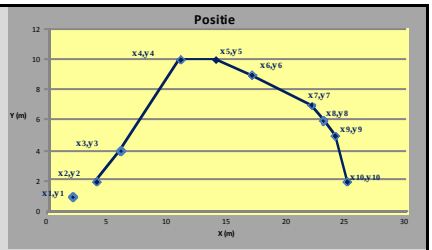




**Idem voor snelheid in y-richting**

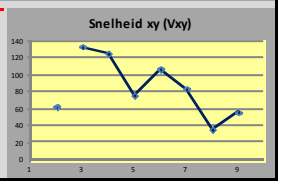


**Snelheid in xy-richting**




$$Vxy_i = \frac{S\sqrt{(x_{i+1} - x_{i-1})^2 + (y_{i+1} - y_{i-1})^2}}{2\Delta t}$$




**Versnelling:** interpoleren (x-richting)

$Ax_i = (Vx_{i+1} - Vx_{i-1}) / (2\Delta t)$

Voorbeeld:

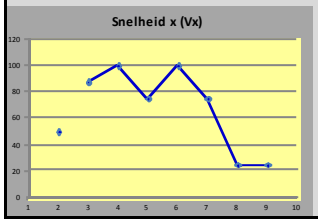
$Ax_7 = (Vx_8 - Vx_6) / (2\Delta t)$

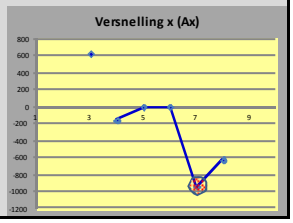
$Ax_7 = (25 - 100) / (2 \times 0.04)$

$Ax_7 = -937.5\ m/s^2$

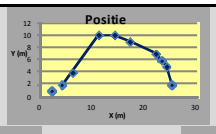
Stel:
Framerate = 25 fps
Frameduur = 0.04 sec

| Frm | Vx | Ax |
|---|---|---|
| 1 | | |
| 2 | 50 | |
| 3 | 87.5 | 625 |
| 4 | 100 | -156.25 |
| 5 | 75 | 0 |
| 6 | 100 | 0 |
| 7 | 75 | -937.5 |
| 8 | 25 | -625 |
| 9 | 25 | |
| 10 | | |

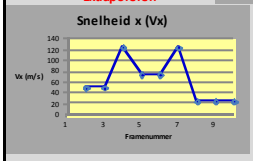


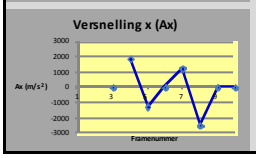




**Extrapoleren en Interpoleren vergeleken**

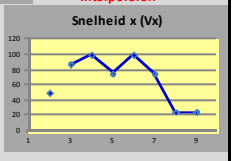


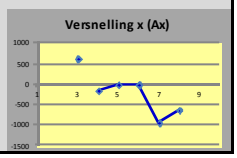

Extrapoleren



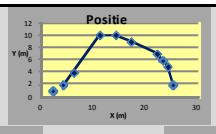




Interpoleren

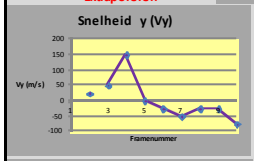


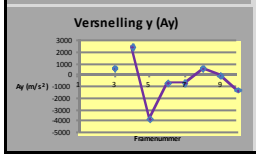




**Extrapoleren en Interpoleren vergeleken**

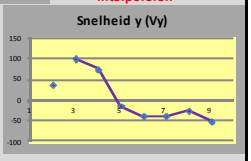


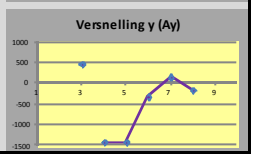

Extrapoleren



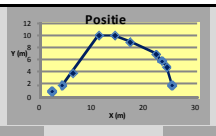




Interpoleren

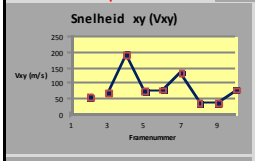


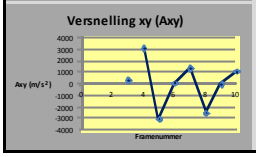




**Extrapoleren en Interpoleren vergeleken**




Extrapoleren

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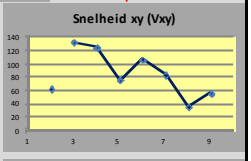
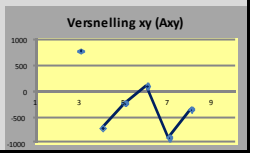
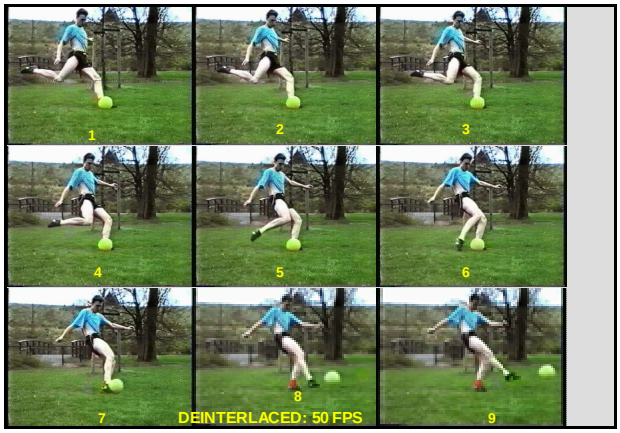
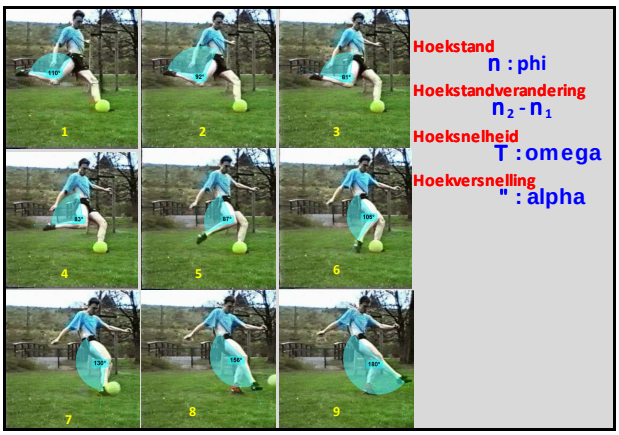


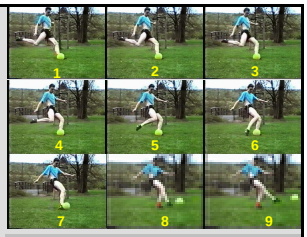


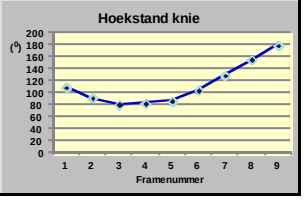

Hoekstand
n : phi
Hoekstandverandering
$n_2 - n_1$
Hoeksnelheid
T : omega
Hoekversnelling
" : alpha

## KNIE

| Frame | Hoek-stand n (°) |
|---|---|
| 1 | 110 |
| 2 | 92 |
| 3 | 81 |
| 4 | 83 |
| 5 | 87 |
| 6 | 105 |
| 7 | 130 |
| 8 | 156 |
| 9 | 180 |

n : phi




## KNIE

Interpoleren

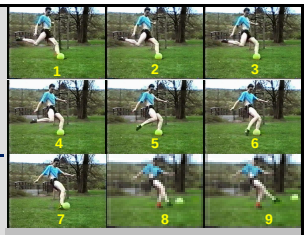
| Frame | Hoek-stand n (°) | Hoek-snelheid T (°/s) |
|---|---|---|
| 1 | 110 | |
| 2 | 92 | -725 |
| 3 | 81 | -225 |
| 4 | 83 | 150 |
| 5 | 87 | 550 |
| 6 | 105 | 1075 |
| 7 | 130 | 1275 |
| 8 | 156 | 1250 |
| 9 | 180 | |

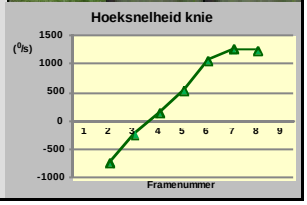
$$T_2 = \frac{n_3 - n_1}{2)\,t}$$

$$T_2 = \frac{81 - 110}{2 \times 0.02}$$

n : phi
T : omega

$$T_i = \frac{n_{i+1} - n_{i-1}}{2)\,t}$$




## KNIE

Interpoleren

| Frame | Hoek-stand n (°) | Hoek-snelheid T (°/s) | Hoek-versnelling T (°/s) |
|---|---|---|---|
| 1 | 110 | | |
| 2 | 92 | -725 | |
| 3 | 81 | -225 | 21875 |
| 4 | 83 | 150 | 19375 |
| 5 | 87 | 550 | 23125 |
| 6 | 105 | 1075 | 18125 |
| 7 | 130 | 1275 | 4375 |
| 8 | 156 | 1250 | |
| 9 | 180 | | |

n : phi
T : omega
" : alpha

$$"_i = \frac{T_{i+1} - T_{i-1}}{2)\,t}$$